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Biostratigraphy of the Emsian to Eifelian in the Holy Cross Mountains (Poland)

Anna FIJAŁKOWSKA-MADER and Jan MALEC

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The paper give a biostratigraphic interpretation of the Emsian to Eifelian in the Łysogóry and Kielce regions of the Holy Cross Mountains, based on the different groups of microfossils: miospores, conodonts, ostracods and foraminifers. Four miospore zones were identified in the uppermost Pragian, Emsian and lowermost Eifelian: *Verrucosisporites polygonalis–Dibolisporites wetteldorfensis* (PW), *Emphanisporites annulatus–Brochotriletes bellatulus* (AB), *Emphanisporites foveolatus–Verruciretusispora dubia* (FD) and *Acinosporites apiculatus–Grandispora protea* (AP). In the Łysogóry region, the Emsian and lowermost Eifelian comprises four conodont zones: *serotinus*, *patulus*, *partitus* and *costatus*, three ostracod assemblages and several foraminifer assemblages. In the Kielce region, deposits from the Emsian/Eifelian boundary interval yield conodonts from the *patulus* and *partitus* zones, two ostracod assemblages and assemblages of agglutinated foraminifers. The joint biostratigraphic analysis allows a tentative correlation of the lithostratigraphic units from both areas. It also provides independent control/calibration on the different biostratigraphical systems. The Pragian/Emsian boundary is located in the lower part of the Barcza Formation and in the lower part of the Haliszka Formation, whereas the Emsian/Eifelian boundary lies in the upper part of the Grzegorzowice Formation and in the upper part of the Winna Formation.

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Key words: Holy Cross Mountains, palynomorphs, conodonts, ostracods, foraminifers, biostratigraphic correlation.

INTRODUCTION

The paper summarizes the biostratigraphic investigations over the last 40 years based on palynomorphs, conodonts, ostracods and foraminifers in the uppermost Pragian, Emsian and lowermost Eifelian of the Holy Cross Mountains (HCM), Poland (Fig. 1). The rich but often unordered material from published papers and unpublished archival reports has been systematized (Table 1) and completed with new palynodata obtained by the author from the Kielce region. This led to the first attempt at comprehensive biostratigraphic correlation between Kielce and Łysogóry regions. The significance of miospores in the biostratigraphy of the deposits from this part of the upper Pragian–lower Eifelian interval, developed in terrigenous facies, results from their presence in rocks that are commonly barren of marine fauna.

Microflorsal studies of the Lower Devonian in the HCM were started by Jakubowska and continued by Turnau, Fijałkowska-Mader and Filipiak (for references see Table 1). As a result, a palynostratigraphic scheme in accordance with the spore zonation of Streel *et al.* (1987) has been worked out for the upper Pragian, Emsian and lower Eifelian of the HCM.

For the upper Emsian and lower Eifelian of the HCM, developed as marine clay and carbonate facies, the palynological analysis has been supplemented by conodont, ostracod and foraminifer data compiled by Adamczak and Malec (for references see Table 1).

LITHOSTRATIGRAPHY

In the Łysogóry region, the lowermost part of the Lower Devonian succession is represented by the upper part of the Bostów Formation, structurally belonging to the late Caledonian complex (Malec, 1993, 2001, 2006; Kowalczewski *et al.*, 1998; Kozłowski, 2008). In this area, deposits of the Bostów Formation include a stratigraphic gap encompassing the upper Lochkovian and lower Pragian overlain by a Variscan succession composed of the “old-red” facies of the informal Barcza and Zagórze formations representing the upper Pragian and Emsian (Czarnocki, 1950; Łobanowski, 1971, 1981, 1990; Szulczewski and Porębski, 2008; Malec, 2010). The Emsian-Eifelian boundary succession encompasses eight various lithological units of the Grzegorzowice Formation occuring

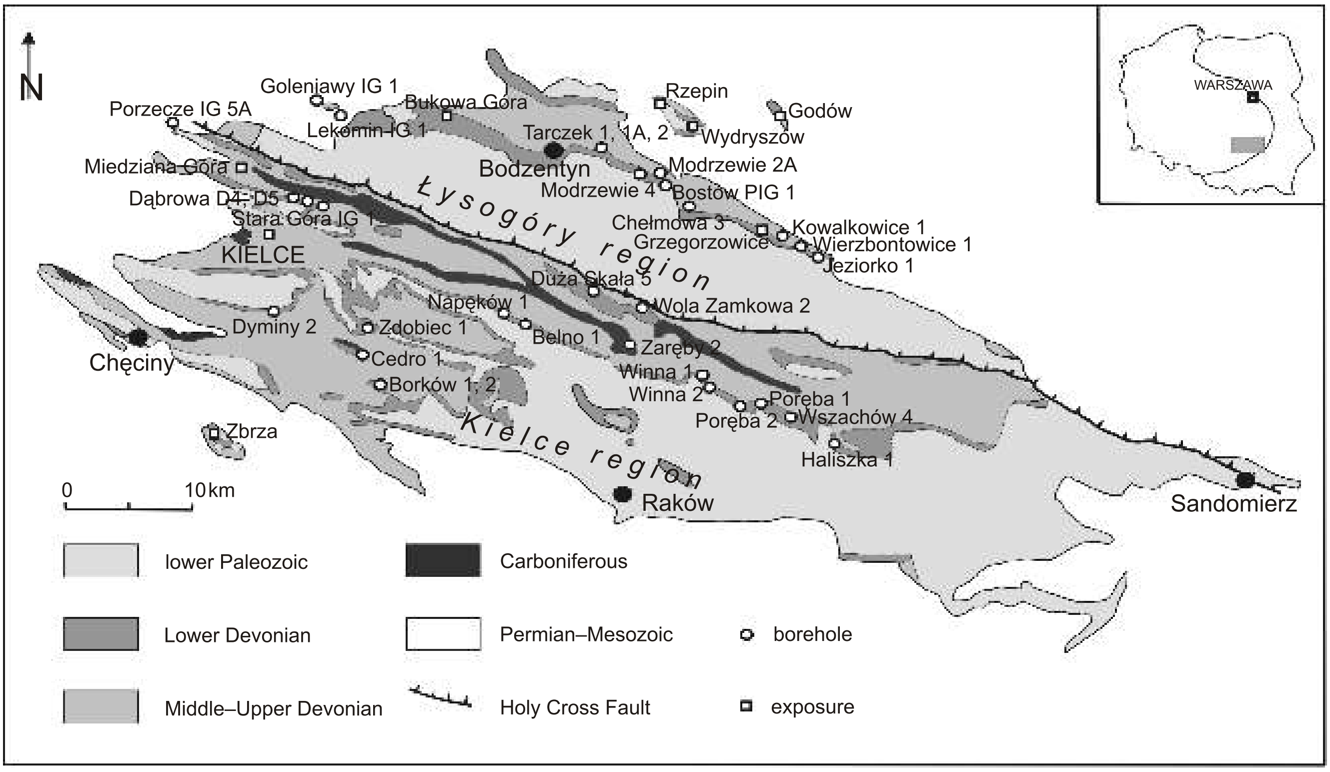


Fig. 1. Location of the sections investigated on a simplified geological map of the Paleozoic core of the Holy Cross Mts. (after Filonowicz, 1961)

across the Łysogóry region between the upper Emsian clastic deposits of the Zagórze Formation and the lower Eifelian dolomites of the Wojciechowice Formation (Czarnocki, 1950; Pajchlowa, 1959). These are: the Bukowa Góra Claystone Member, the Kapkazy Sandstone Member and the Zachełmie Mudstone and Sandstone Member in the western part of the Łysogóry region and the Warszówek Dolmite Member, the Godów Marl Member, the Wydryszów Limestone Member, the Rzepin Dolomite Member as well as the Dąbrowa Limestone Member in the eastern part of the Łysogóry region (Malec, 2005; Fig. 2).

In the Kielce region, the Lower Devonian succession composed mainly of clastic deposits and subordinate claystones and limestones, encompassing the lowermost Pragian and Emsian, lies unconformably with a stratigraphic gap on various lithological units of the lower Paleozoic (Czarnocki, 1936; Kowalczewski, 1971; Tarnowska, 1976; Głazek *et al*., 1981; Szulczewski, 1995; Turnau and Tarnowska, 1997). The terrigenous deposits were subdivided into informal lithostratigraphic units by Tarnowska (1976, 1981, 1987, 1988, 1995), i.e. the Haliszka and Winna formations, with three subordinate units at the rank of members: lower sandstone member, mudstone member and upper sandsone member. Above the Winna Formation occur: the pyrite-bearing and sideritic claystone member; the dolomite member; the Dąbrowa Limestone Member and the bioturbated dolomite member (Gürich, 1896; Czarnocki, 1951; Tarnowska, 1976; Narkiewicz and Olkowicz-Paprocka, 1983; Malec, 1993; Fig. 2).

PALYNOLOGY

MATERIAL AND METHODS

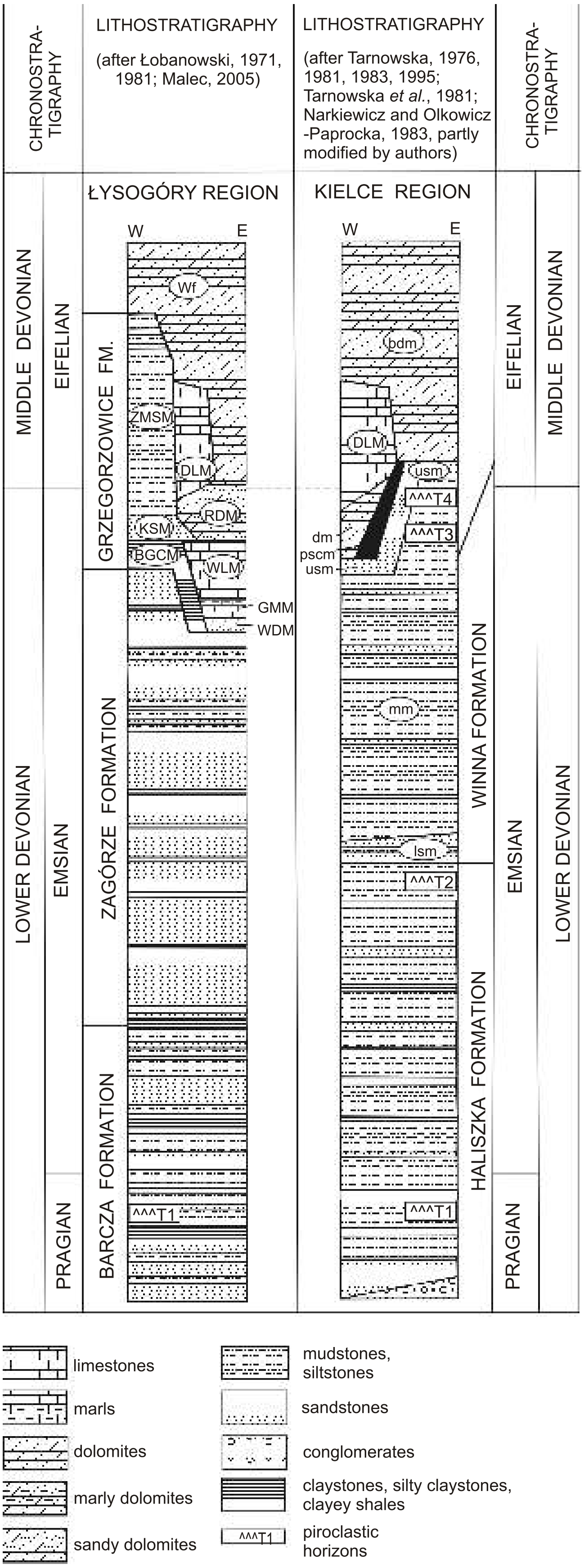
A total of 190 samples for palynological analysis were collected by the author from the uppermost Pragian, Emsian and lowermost Eifelian from 11 core sections of the Borków 1, Bostów PIG 1, Duża Skała 5, Dyminy 2, Haliszka 1, Poręba 1, Poręba 2, Winna 1, Winna 2, Wszachów 4 and Zaręby 2 boreholes (Fig. 1). 132 samples contained palynomorphs. The samples were subject to the maceration techniques described by Orłowska-Zwolińska (1983) in the Stratigraphic Laboratory of the Holy Cross Branch of the Polish Geological Institute in Kielce. Samples were crumbled mechanically and then treated with following reagents: HCl, HF in the cold state and heavy liquid with a specific gravity of 2.1.

The studies were supplemented with results obtained by Jakubowska (1968, 1971, 1972, 1974) from the Emsian–lowermost Eifelian of the Zaręby 2, Haliszka 1, Dyminy 2, Cedro 1, Napęków 1 and Belno 1 boreholes, by Turnau (1994, 1995*a*, *b*) from the upper Pragian–lowermost Eifelian of the Modrzewie 2A, Modrzewie 4, Dąbrowa D4, Dąbrowa D5 and Dyminy 2 boreholes, by the author (Fijałkowska-Mader *et al*., 1997; Fijałkowska-Mader, 2011) from the upper Pragian–lowermost Eifelian of the Tarczek 1, Tarczek 1A and Tarczek 2 boreholes as well as by Filipiak (2011) from the Emsian–lower Eifelian of the Dyminy 2A, Chełmowa 3, Jeziorko 1, Kowalkowice 1, Modrzewie 2A, Tarczek 1 and Tarczek 1A boreholes, the Bukowa Góra Quarry and the Zbrza I trench.

Table 1

Reivew of the biostratigraphic study of the upper Pragian–lower Eifelian in the Holy Cross Mountains

Paper/unpublished report	Chronostratigraphic unit	Biostratigraphic method	Boreholes/outcrops (o)
Jakubowska (1968)	Emsian	palynomorphs	Zaręby 2
Jakubowska (1971, 1972)	Emsian	palynomorphs	Belno 1, Cedro 1, Dyminy 2, Haliszka 1, Napęków 1
Jakubowska (1974)	Emsian–l. Eifelian	palynomorphs	Borków 1, Borków 2, Cedro 1
Turnau in: Malec *et al*. (1990)	Emsian	palynomorphs	Goleniawy IG 1
Turnau (1994, 1995*a*, *b*); Turnau in: Fijałkowska-Mader *et al*. (1997); Turnau in: Kowalczewski and Turnau (1997); Turnau in: Turnau and Tarnowska (1997)	u. Pragian–l. Eifelian	palynomorphs	Dąbrowa D4, Dąbrowa D5, Dyminy 2, Modrzewie 2A, Modrzewie 4, Zdobiec 1
Fijałkowska (1995*a*, this paper)	u. Pragian–l. Eifelian	palynomorphs	Borków 1, Duża Skała 5, Dyminy 2, Haliszka 1, Poręba 1,Poręba 2, Winna 1, Winna 2, Wszchów 4, Zaręby 2
Fijałkowska (1995*b*) Fijałkowska-Mader in: Fijałkowska-Mader *et al*. (1997); Fijałkowska-Mader (2011)	u. Pragian–l. Eifelian	palynomorphs	Tarczek 1, Tarczek 1A, Tarczek 2
Filipiak (2009, 2011)	u. Emsian–l. Eifelian	palynomorphs	Bukowa Góra (o), Chełmowa 3, Dyminy 2, Jeziorko 1, Kowalkowice 1, Modrzewie 2A, Tarczek 1, Tarczek 1A, Zbrza (o)
Malec (1984*b*)	l. Eifelian	conodonts	Zaręby 2
Malec (1986*a*, 1989)	u. Emsian–l. Eifelian	conodonts	Chełmowa 3, Jeziorko 1, Wierzbontowice 1, Grzegorzowice (o)
Malec (1990*a*)	u. Emsian	conodonts	Modrzewie 2A
Malec (1986*b*, 1992, 1993)	u. Emsian–l. Eifelian	conodonts	Dyminy 2, Kowalkowice 1, Porzecze IG 5A, Stara Góra IG 1, Zaręby 2, Grzegorzowice (o), Kielce (o), Zbrza (o)
Malec (2001, 2002, 2005)	u. Emsian–l. Eifelian	conodonts	Chełmowa 3, Jeziorko 1, Kowalkowice 1, Modrzewie 2A, Tarczek 1, Wierzbontowice 1, Bukowa Góra (o), Grzegorzowice (o), Godów (o), Rzepin (o), Wydryszów (o)
Adamczak (1968, 1976)	u. Emsian	ostracods	Grzegorzowice (o), Wydryszów (o)
Malec (1979, 1980, 1992)	Emsian	ostracods	Porzecze IG 5A
Malec (1984*c*)	u. Emsian	ostracods	Chełmowa 3, Jeziorko 1, Wierzbontowice 1, Grzegorzowice (o)
Malec (1986*a*)	u. Emsian	ostracods	Chełmowa 3, Jeziorko 1, Wierzbontowice 1, Grzegorzowice (o)
Malec (1986*b*)	l. Eifelian	ostracods	Wola Zamkowa 2
Malec in: Tarnowska and Malec (1987)	l. Eifelian		Dąbrowa D5
Malec (1989)	l. Eifelian	ostracods	Kielce (o), Grzegorzowice (o), Zbrza (o)
Malec (1990*a*)	u. Emsian–l. Eifelian	ostracods	Modrzewie 2A
Malec (1990*b*)	u. Emsian	ostracods	Bukowa Góra (o)
Malec in: Malec *et al*. (1990)	Emsian	ostracods	Goleniawy IG 1, Lekomin IG 1
Malec (2002, 2003*a*, 2007, 2008)	u. Emsian–l. Eifelian	ostracods	Chełmowa 3, Jeziorko 1, Kowalkowice 1, Lekomin IG 1, Modrzewie 2A, Tarczek 1, Wierzbontowice 1, Bukowa Góra (o), Godów (o), Grzegorzowice (o), Rzepin (o), Wydryszów (o)
Duszyńska (1959)	u. Emsian	foraminifers	Wydryszów (o)
Malec (1979, 1984*a*)	u. Emsian–l. Eifelian	foraminifers	Porzecze IG 5A
Malec (1984*b*)	l. Eifelian	foraminifers	Zaręby 2
Malec (1984*c*)	u. Emsian	foraminifers	Chełmowa 3, Jeziorko 1, Wierzbontowice 1, Grzegorzowice (o)
Malec (1986*b*)	l. Eifelian	foraminifers	Dąbrowa D5, Wola Zamkowa 2, Kielce (o), Miedziana Góra (o)
Malec in: Tarnowska and Malec (1987)	u. Emsian	foraminifers	Dąbrowa D5
Malec in: Malec and Studencki (1988)	u. Emsian	foraminifers	Kielce (o)
Malec (1992)	u. Emsian	foraminifers	Dąbrowa D5
Malec (2002, 2003*b*)	u. Emsian–l. Eifelian	foraminifers	Chełmowa 3, Jeziorko 1, Kowalkowice 1, Modrzewie 2A, Tarczek 1, Tarczek 1A, Wierzbontowice 1, Bukowa Góra (o), Godów (o), Grzegorzwice (o), Wydryszów (o)



RESULTS

In total 184 spore species were recognized in the upper Pragian, Emsian and lowermost Eifelian of the HCM; the species belong to 49 genera, of which 20 are recorded in Poland for the first time (Tables 2 and 3; Appendix). Three new species, one new variety and one combination were created by the author.

DESCRIPTIONS OF NEW FORMS

Hystricosporites brevispinosus sp. nov.
(Fig. 3G)

H o l o t y p e. – Museum of the Polish Geological Institute – National Research Institute, Holy Cross Mts. Branch 3073/94, Figure 3G.

T y p e h o r i z o n. – Lower Devonian, upper Emsian, Winna Formation.

T y p e l o c a l i t y. – Borków 1 borehole, depth 38.7 m, Kielce region of the HCM.

D e r i v a t i o n o f t h e n a m e. – *brevis* [lat.] short, *spina* [lat.] spine; forms with short spines.

D i a g n o s i s. – Suturae accompanied by folds, contact areas laevigate, characteristic short spines ended with small hooks and anchors.

D e s c r i p t i o n. – Amb circular; suturae straight, extending at 2/3 of radius, accompanied by 10 µm high and 4–6 µm broad folds. Contact areas laevigate, about 2/3 of radius in extent. Exine 4–10 µm thick, laevigate, distally and equatorially sculptured with irregular cone-shaped spines, dilated at the base and ended with small hooks or anchors, 3–12 µm high and 4–8 µm basal diameter.

S i z e. – Spore body diameter: 110–114 µm, size with spines: 125–130 µm (holotype 114 and 129 µm respectively) (3 specimens measured).

C o m p a r i s o n. – The species differs from other species of *Hystricosporites* in shorter and more massive spines.

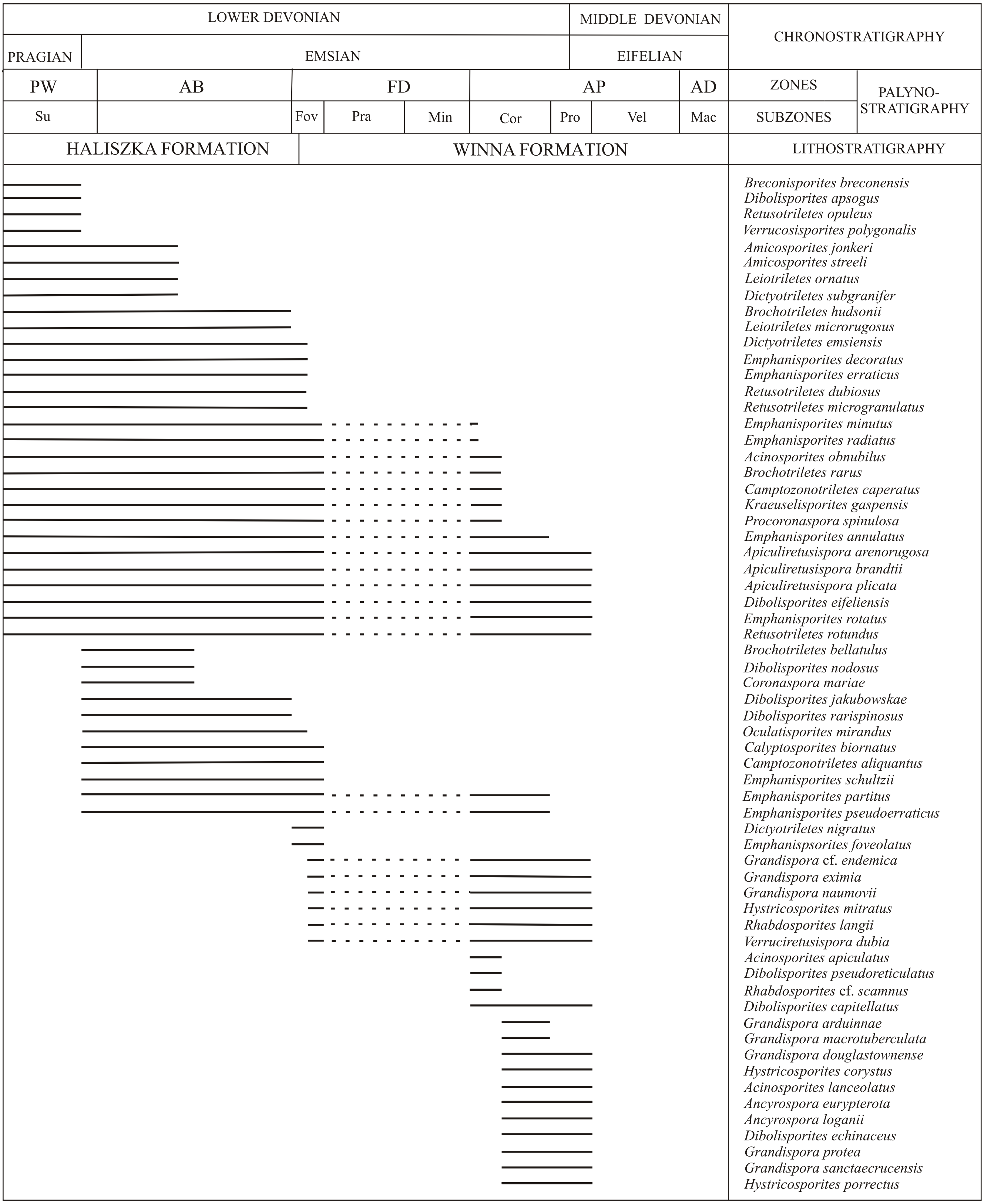
O c c u r r e n c e. – Poland, HCM: upper Emsian.

Fig. 2. Corrrelation of lithological profiles of the upper Pragian to Eifelian in the Holy Cross Mts.

bdm – bioturbated dolomite member, BGCM – Bukowa Góra Claystone Member, DLM – Dąbrowa Limestone Member, dm – dolomite member, GMM – Godów Marl Member, KSM – Kapkazy Sandstone Member, lsm – lower sandstone member, mm – mudstone member, pscm – pyrite-bearing and sideritic claystone member, RDM – Rzepin Dolomite Member, usm – upper sandstone member, WDM – Warszówek Dolomite Member, Wf – Wojciechowice Formation, WLM – Wydryszów Limestone Member, ZMSM – Zachełmie Mudstone and Sandstone Member

Table 2

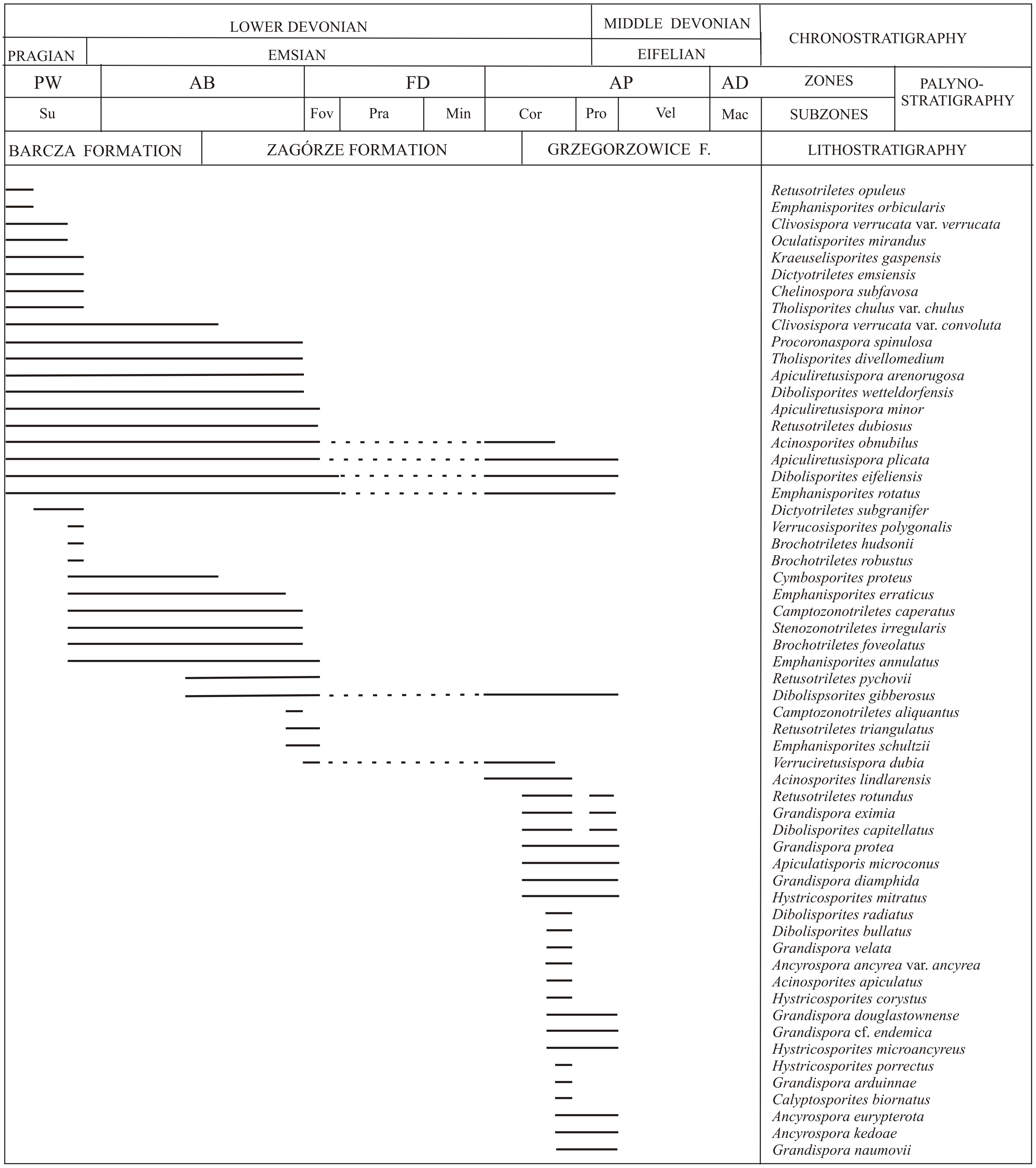
Stratigraphic ranges of selected miospores in the lower Pragian to Eifelian in the Kielce region of the Holy Cross Mts.



Combined after: Jakubowska (1968, 1971, 1972, 1974); Turnau (1994, 1995*a*, *b*); Fijałkowska (1995*a*, this paper); Turnau and Tarnowska (1997); Filipiak (2011); zones: PW – *Verrucosisporites polygonalis–Dibolisporites wetteldorfensis*, AB – *Emphanisporites annulatus–Brochotriletes bellatulus*, FD – *Emphanisporites foveolatus–Verruciretusispora dubia*, AP – *Acinosporites apiculatus–Grandispora protea*; subzones: Su – *Dictyotriletes subgranifer*, Fov – *Emphanisporites foveolatus*, Pra – *Samarisporites praetervisus*, Min – *Rhabdospories minutus*, Cor – *Hystricosporites corystus*, Pro (P) – *Grandispora protea*, Vel – *Grandispora velata*, Mac – *Acinosporites macrospinosus*

Table 3

Stratigraphic ranges of selected miospores in the upper Pragian to Eifelian in the Łysogóry region of the Holy Cross Mts.



Combined after: Turnau in: Malec *et al*. (1990); Turnau (1994, 1995*a*, *b*); Fijałkowska (1995*b*); Fijałkowska-Mader *et al*. (1997); Kowalczewski and Turnau (1997); Filipiak (2009, 2011); Fijałkowska-Mader (2011); explanations as in Table 2

Verrucosisporites rariverrucosus sp. nov.
(Fig. 3J)

H o l o t y p e. – Museum of the Polish Geological Institute – National Research Institute, Holy Cross Mts. Branch 3383/94, Figure 3J.

T y p e h o r i z o n. – Lower Devonian, upper Pragian, Haliszka Formation.

T y p e l o c a l i t y. – Zaręby 2 borehole, depth 1192.1 m, Kielce region of the HCM.

D e r i v a t i o n o f t h e n a m e. – *rarus* [lat.] sparse; forms with sparse verrucae.

D i a g n o s i s. – Suturae weekly visible, sparse, irregular verrucae.

D e s c r i p t i o n. – Amb subcircular; suturae straight, extending from the radius, poorly visible. Contact areas delimited by fine curvaturae. Exine 3–4 µm thick, covered with irregular verrucae, 2–4 µm in diameter.

S i z e. – 50–96 µm (holotype 80 µm; 4 specimens measured).

C o m p a r i s o n. – The large size of the spores and sparse, irregularly spaced verrucae distinguish this species from *V. polygonalis* Lanninger and *V. grumosus* (Naumova) Taug.

O c c u r r e n c e. – Poland, HCM: upper Pragian–lower Emsian).

Verruciretusispora dubia
(Eisenack, 1944) Richardson et Rasul, 1978,
var. *multituberculata* var. nov.
(Fig. 3L)

H o l o t y p e. – Museum of the Polish Geological Institute – National Research Institute, Holy Cross Mts. Branch 3271/95, Figure 3L.

T y p e h o r i z o n. – Lower Devonian, upper Emsian, Winna Formation.

T y p e l o c a l i t y. – Dyminy 2 borehole, depth 138.0 m, Kielce region of the HCM.

D e r i v a t i o n o f t h e n a m e. – *Multum* [lat.] many; forms with numerous tubercula.

D i a g n o s i s. – Suturae well developed, curvaturae perfecta, numerous verrucae.

D e s c r i p t i o n. – Amb subtriangular; suturae straight, extending at 5/6 of radius, accompanied by 6 µm broad folds. Contact areas delimited by curvaturae perfecta, about 5/6 of radius in extent. Exine 3–5 µm thick, sub-grained in the contact areas, distally and equatorially sculptured with numerous verrucae 1–4 µm high and 4–10 µm in basal diameter.

S i z e. – 147–150 µm (holotype 147 µm; 2 specimens measured).

C o m p a r i s o n. – The larger number and density of the verrucae distinguish this species from *V. dubia* (Eisenack) Richardson et Rasul.

O c c u r r e n c e. – Poland, HCM: upper Emsian.

Dictyotriletes delicatus sp. nov.
(Fig. 4C)

H o l o t y p e. – Museum of the Polish Geological Institute – National Research Institute, Holy Cross Mts. Branch 3308/95, Figure 4C.

T y p e h o r i z o n. – Lower Devonian, upper Pragian–lower Emsian, Haliszka Formation.

T y p e l o c a l i t y. – Wszachów 4 borehole, depth 55.5 m, Kielce region of the HCM.

D e r i v a t i o n o f t h e n a m e. – Forms with thin, delicate muri.

D i a g n o s i s. – Suturae weekly visible, delicate muri forming polygonal or oval net.

D e s c r i p t i o n. – Amb subcircular to subtriangular; suturae straight extending to 3/4 of radius, weekly visible, accompanied by 2 µm broad folds. Exine 2–4 µm thick, distally and equatorially sculptured with delicate, 0.5–3 µm broad and 1–2 µm high muri, which form an irregularly polygonal or oval network with mesh diameter of 0.5–7 µm.

S i z e. – 54–58 µm (holotype 54 µm; 3 specimens measured).

C o m p a r i s o n. – Smaller and more irregular meshes of the network distinguish his species from *D. subgranifer* McGregor, whereas the thinner exine and more delicate muri distinguish it from *D. nigratus* Naumova.

O c c u r r e n c e. – Poland, Kielce region of the HCM: upper Pragian–lower Emsian.

PALYNOSTRATIGRAPHY

In the section studied four Oppel zones of Streel *et al.* (1987) are identified: the *Verrucosisporites polygonalis–Dibolisporites wetteldorfensis* (PW) Zone, the *Emphanisporites annulatus–Brochotriletes bellatulus* (AB) Zone, the *Emphanisporites foveolatus–Verruciretusispora dubia* (FD) Zone and the *Acinosporites apiculatus–Grandispora protea* (AP) Zone. Moreover six interval zones of Streel *et al*. (1987), determined by the author as subzones, were recognized: the *Dictyotriletes subgranifer* (Su) Subzone in the uppermost part of the PW Zone, the *Emphanisporites foveolatus* (Fov), the *Rhabdosporites minutus* (Min) subzones in the FD Zone, the *Hystricosporites corystus* (Cor), the *Grandispora protea* (Pro) subzones and the *Grandispora velata* (Vel) in the AP Zone (Tables 2 and 3).

The Su Subzone of the PW Zone was described in the Kielce region as assemblage I in the Haliszka Formation from the Cedro 1 (at the depth of 51.4–96.5 m) and Dyminy 2 (168.1–184.8 m) boreholes (Jakubowska, 1972). Fijałkowska-Mader (1995*a*, this paper) determined this subzone, in deposits belonging to the Haliszka Formation in the Haliszka 1 (145.7 m), Zaręby 2 (1186.9–1199.9 m; Fig. 5), Wszachów 4 (55.1–55.5 m), Borków 1 (139.1–118.4 m) and Dyminy 2 (184.6–168.5 m) boreholes. Turnau (Turnau and Tarnowska, 1997) distinguished it within the Haliszka Formation in the Dyminy 2 (168.5 m) borehole (Turnau, 1995*a*, *b*). Filipiak (2011) described this subzone in the Dyminy 2

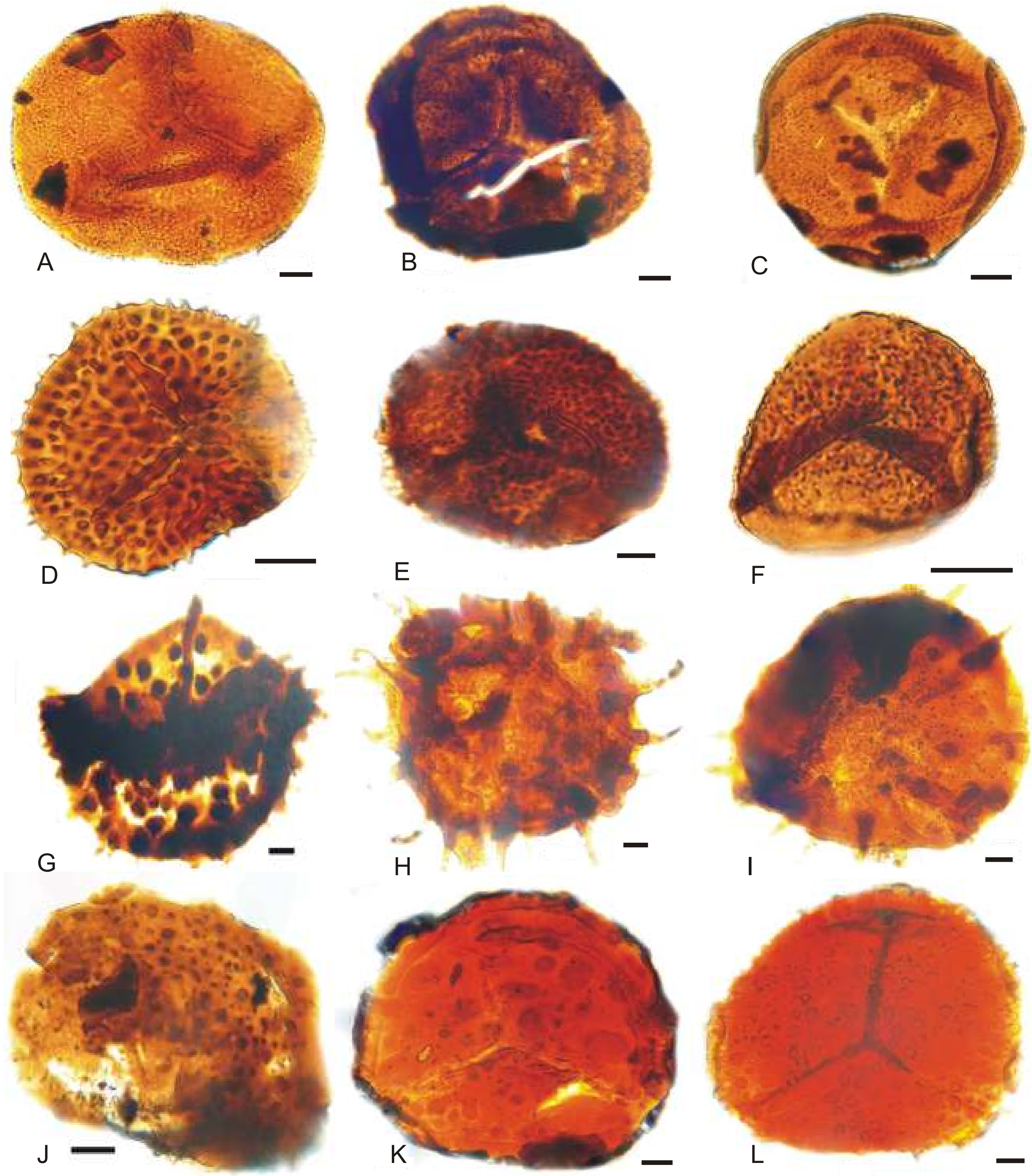


Fig. 3. Apiculate spores from the upper Pragian–lower Eifelian of the Holy Cross Mts.

A – *Apiculiretusispora arenorugosa* McGregor, Haliszka 1 borehole, depth 53.5 m; **B** – *A. brandtii* Streel, Tarczek 2 borehole, depth 393.0 m; **C** – *A. plicata* (Allen) Streel, Haliszka 1 borehole, depth 53.5 m; **D** – *Dibolisporites eifeliensis* (Lanninger) McGregor, Haliszka 1 borehole, depth 53.5 m; **E** – *D. verrucosus* (Kedo) comb. nov., Tarczek 2 borehole, depth 130.8 m; **F** – *D. wetteldorfensis* Lanninger, Haliszka 1 borehole, depth 80.2 m; **G** – *Hystricosporites brevispinosus* sp. nov., Borków 1 borehole, depth 38.7 m; **H** – *H. corystus* Richardson, Poręba 1 borehole, depth 69.8 m; **I** – *H. mitratus* Allen, Tarczek 1 borehole, depth 151,7 m; **J** – *Verrucosisporites rariverrucosus* sp. nov., Zaręby 2 borehole, depth 1192.1 m; **K** – *Verruciretusispora dubia* (Eisenack) Richardson et Rasul, Dyminy 2 borehole, depth 138.0 m; **L** – *V. dubia* Richardson et Rasul var. *multituberculata* var. nov., Dyminy 2 borehole, depth 138.0 m; scale bar – 10 μm

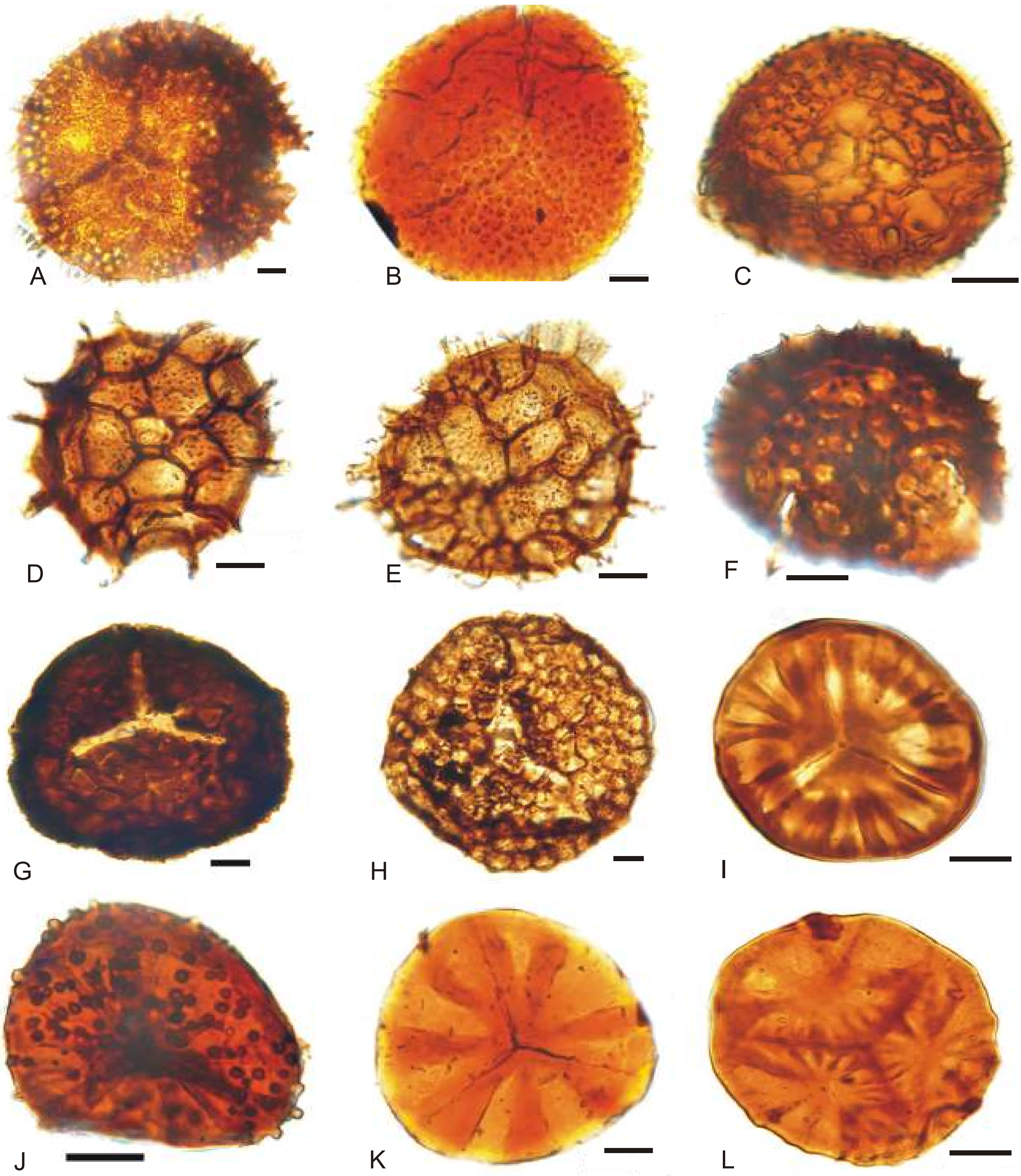


Fig. 4. Murornate spores from the upper Pragian–lower Eifelian of the Holy Cross Mts.

A – *Acinosporites lanceolatus* Streel, Poręba 1 borehole, depth 69.8 m; **B** – *A. lindlarensis* Riegel var. *lindlarensis* McGregor et Camfield, Borków 1 borehole, depth 35.7 m; **C** – *Dictyotriletes delicatus* sp. nov., Wszachów 4 borehole, depth 55.5 m; **D** – *D. emsiensis* (Allen) McGregor, Zaręby 2 borehole, depth 1192.1 m; **E** – *D. subgranifer* McGregor, Wszachów 4 borehole, depth 55.1 m; **F** – *Brochotriletes bellatulus* Steemans, Zaręby 2 borehole, depth 2116.1 m; **G** – *B. foveolatus* Naumova, Borków 1 borehole, depth 86.5 m; **H** – *B. hudsonii* McGregor et Camfield, Tarczek 2 borehole, depth 327.9 m; **I** – *Emphanisporites annulatus* McGregor, Haliszka 1 borehole, depth 80.2 m; **J** – *E. foveolatus* Schultz, Winna 2 borehole, depth 16.9 m; **K** – *E. radiatus* (Schultz) Jakubowska, Dyminy 2 borehole, depth 138.0 m; **L** – *E. schultzii* McGregor, Haliszka 1 borehole, depth 76.5 m; scale bar – 10 μm

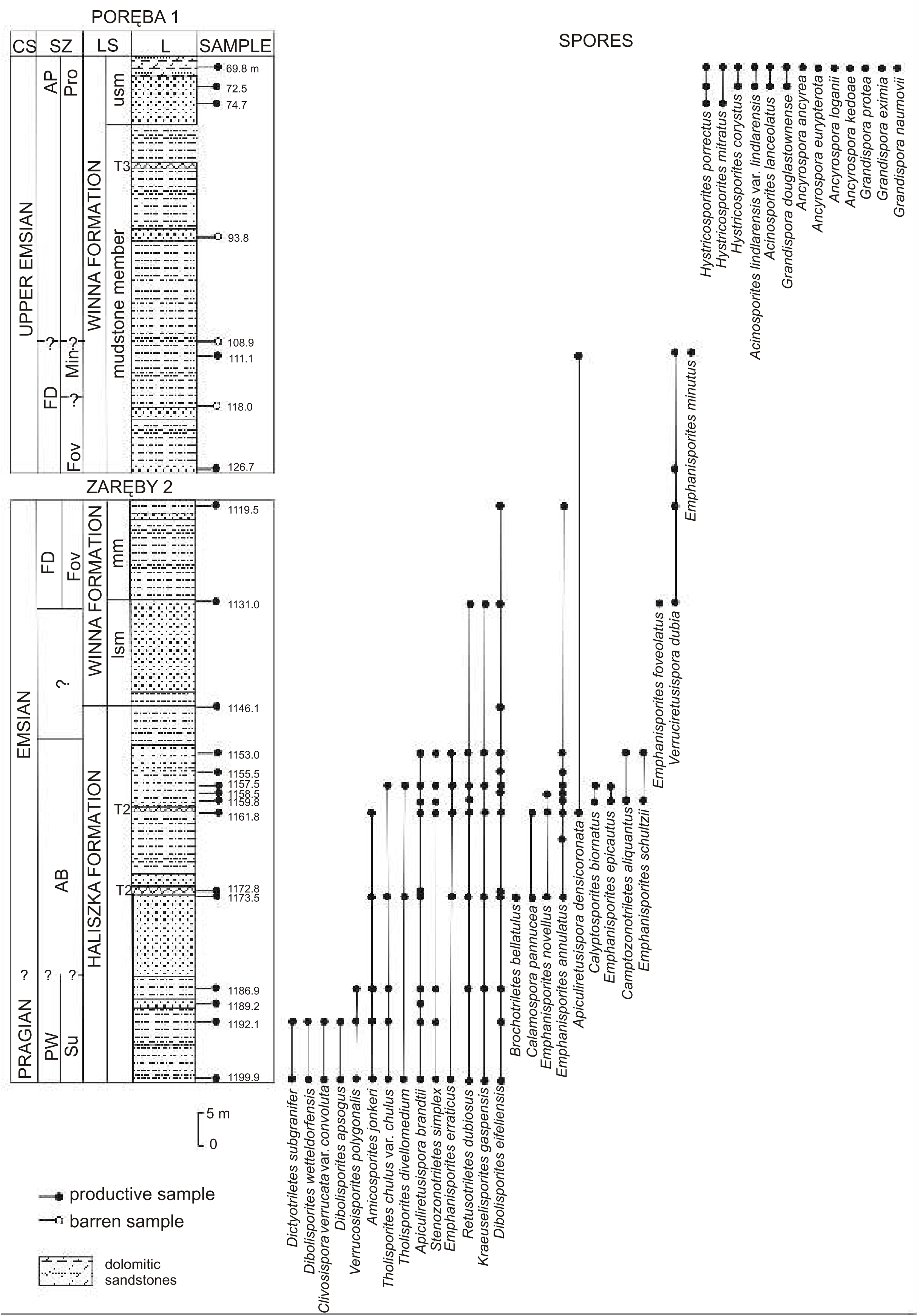


Fig. 5. Occurrence of selected spores in the Poręba 1 and Zaręby 2 boreholes (Kielce region)

CS – chronostratigraphy; SZ – spore zones and subzones after Streel *et al*. (1987), for explanations see Table 2; LS – lithostratigraphy after Tarnowska (1995); L – lithology after Tarnowska (1995); explanations as in Figure 2

(169.0–157.2 m) borehole. It covers the lower part of the Haliszka Formation and in some boreholes (Wszachów 4, Dyminy 2) also its upper part. In the Łysogóry region, the subzone was described in the lower and middle part of the Barcza Formation in the Tarczek 2 (327.9–399.9 m; Fig. 6) and Modrzewie 4 (59.0–30.4 m) boreholes (Fijałkowska-Mader *et al*., 1997) and in the Bostów PIG 1 (140.1–198.0 m) borehole. The pyroclastic horizon T1 described by Tarnowska (1983, 1988, 1995, 1999) lies within this subzone.

Beside the index taxa – *Verrucosisporites polygonalis*, *Dibolisporites wetteldorfensis* (Fig. 3F) and *Dictyotriletes subgranifer* (Fig. 4E) the characteristic taxa of this subzone are: *Breconisporites breconensis*, *Retusotriletes opuleus*, *Dibolisporites apsogus*, *Tholisposrites chulus* var. *chulus* (Fig. 7A), *Brochotriletes hudsonii* (Fig. 4H) and *Amicosporites streeli* (Fig. 7F). The spore assemblage is dominated by spores of the genera *Apiculiretusispora*, *Leiotriletes* and *Emphanisporites*.

The assemblages of the AB Zone were described by Jakubowska (1971, 1972, 1974) in the Haliszka Formation from the Cedro 1 (43.5–51.3), Dyminy 2 (157.0–157.3 m), Borków 1 (93.7–139.5 m) and Haliszka 1 (125.0–138.8 m) boreholes, as well as by Turnau (1995*a*) from the Dąbrowa D4 (124.5 m) and Dąbrowa D5 (109.0–112.4 m) boreholes. Fijałkowska-Mader (1995*a*, this paper) identified this zone in the Kielce region in the upper part of the Haliszka Formation in the Borków 1 (93.7–139.2 m), Dyminy 2 (157.1 m), Haliszka 1 (125.8 m), Winna 2 (49.7–62.7 m), Wszachów 4 (44.0 m) and Zaręby 2 (1153.0–1173.5 m; Fig. 5) boreholes. Filipiak (2011) recorded this zone in the Dyminy 2 (151.0 m) borehole. The pyroclastic horizon T2 described by Tarnowska (1983, 1988, 1995, 1999) lies within this zone. In the Łysogóry region the zone was identified in the upper part of the Barcza Formation and in the lower part of the Zagórze Formation (referred earlier to the Tarczek Formation; see Fijałkowska-Mader *et al*., 1997) in the Tarczek 2 (141.1–284.6 m; Fig. 6) and probably in the Modrzewie 3 (130.0–137.2 m) boreholes (Turnau, 1995*a*; Fijałkowska-Mader *et al*., 1997). Recently this zone was recorded by the author in the Bostów PIG 1 (39.0–129.0 m) borehole.

Beside the index taxa – *Emphanisporites annulatus* (Fig. 4I) and *Brochotriletes bellatulus* (Fig. 4F) the characteristic taxa are *Procoronaspora spinulosa*, *Dibolisporites nodosus*, *Dictyotriletes emsiensis* (Fig. 4D), *Oculatisporites mirandus* (Fig. 7L) and *Coronaspora mariae* (Fig. 7D). The assemblage is dominated by spores representing the genera *Apiculiretusispora*, *Retusotriletes* and *Emphanisporites.*

Jakubowska (1972, 1974) described an assemblage that corresponds to the Fov Subzone of the FD Zone in the Winna Formation from the Belno 1 (140.0–147.0 m), Napęków 1 (81.4–87.2 m), Borków 1 (72.2–86.5 m), Borków 2 (38.3–55.0 m) and Cedro 1 (26.1–26.6 m) boreholes in the Kielce region. Turnau (1995*a*) identified an assemblage of this subzone in the Winna Formation in the Dyminy 2 (150.9 m) borehole. Fijałkowska-Mader (1995*a*, this paper) recognized this subzone in the lower sandstone member and in the base of the mudstone member of the Winna Formation in the Duża Skała 5 (57.0–65.2 m), Dyminy 2 (150.8 m), Haliszka 1 (76.8–92.0 m), Poręba 1 (126.7 m; Fig. 5), Winna 2 (16.9–43.6 m) and Zaręby 2 (1119.5–1131.0 m; Fig. 5) boreholes. In the Łysogóry region the subzone occurs in the upper part of the Zagórze Formation in the Tarczek 2 (130.8 m; Fig. 6) and probably Modrzewie 3 (98.1–127.0 m) boreholes (Fijałkowska-Mader *et al*., 1997).

Besides the index taxa – *Emphanisporites foveolatus* (Fig. 4J) and *Verruciretusispora dubia* (Fig. 3K) characteristic are species first appearing in the Pragian and having their last appearance in the HCM within this subzone, such as *Apiculiretusispora brandtii* (Fig. 3B), *Dictyotriletes emsiensis*, *Calyptosporites biornatus* (Fig. 8A), *Camptozonotriletes aliquantus* (Fig. 7J), *Hystricosporites porrectus*, *Grandispora* cf. *endemica* (Fig. 8E), and *Emphanisporites schultzii* (Fig. 4L). The dominat taxa are spores belonging to the genera *Retusotriletes*, *Apiculiretusispora* and *Emphanisporites.*

The assemblage from the upper part of the FD Zone, which can represent the Subzone Min, occurs in the lower part of the mudstone member of the Winna Formation in the Haliszka 1 (65.2–69.4 m), Poręba 1 (111.1 m; Fig. 5) and Duża Skała 5 (45.0 m) boreholes in the Kielce region (Fijałkowska-Mader, 1995*a*, this paper). Filipiak (2011) described this subzone in the Dyminy 2 (147.0–149.0 m) borehole. In the Łysogóry region, Turnau (1995*a*, *b*) described the assemblage from the FD Zone in the lower part of the Zagórze Formation in the Modrzewie 2A (282.9–320.4 m) borehole.

The assemblage differs from that of the Fov Subzone in the slightly higher abundance of the monopseudosaccite forms representing the genera *Grandispora* and *Calyptosporites*. *Dibolisporites capitellatus* and *D. pseudoreticulatus* are characteristic taxa.

The Cor Subzone of the AP Zone was described by Jakubowska (1972, 1974) as assemblage II from the upper part of the Winna Formation in the Borków 1 (28.3–36.0 m), Borków 2 (24.4–24.7 m), Cedro 1 (24.0–24.8 m) and Dyminy 2 (137.2–142.1 m) boreholes. Turnau (1994, 1995*a*) described this subzone in the Dyminy 2 (145.0 m) borehole. Fijałkowska-Mader (this paper) recognized this subzone in the upper part of the mudstone member of the Winna Formation in the Haliszka 1 (53.1–55.0 m) and Borków 1 (28.4–35.7 m) boreholes. In the Haliszka 1 borehole the subzone was identified at the top of the pyroclastic horizon T3 (see Tarnowska, 1999) at a depth of 53.5 m and in the conglomerate bed, containing intraformationally reworked material of the pyroclastic horizon T4 (Turnau, 1995*a*; Tarnowska, 1999), in the Dyminy 2 borehole. In the Łysogóry region the subzone was identified in the upper part of the Zagórze Formation and in the lower part of the Bukowa Góra Member of the Grzegorzowice Formation in the Tarczek 1 (149.2–230.2 m; Fig. 6) and Modrzewie 2A (216.7–278.8 m) boreholes (Turnau, 1995*a*, *b*; Fijałkowska-Mader *et al*., 1997).

Beside the index taxa, *Acinosporites apiculatus*, *Grandispora protea* (Fig. 8F) and *Hystricosporites corystus* (Fig. 3H), characteristic taxa are *Grandispora douglastownense* (Fig. 8D), *G. eximia*, *Hystricosporites porrectus*, *Ancyrospora loganii* (Fig. 8I), *A. eurypterota* and *Acinosporites lanceolatus* (Fig. 4A). The assemblage is dominated by spores of the genera *Grandispora*, *Hystricosporites* and *Emphanisporites.*

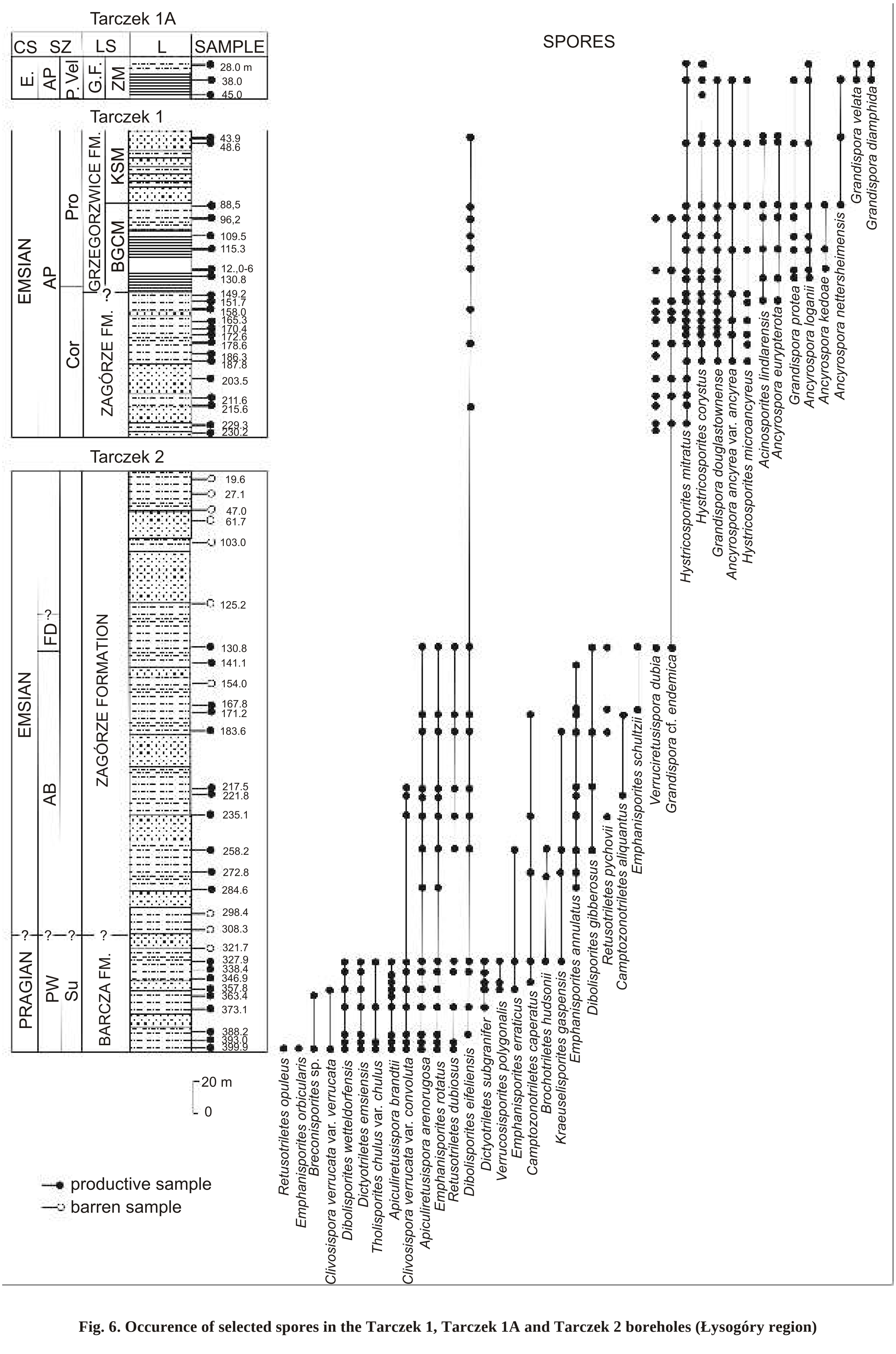


Fig. 6. Occurence of selected spores in the Tarczek 1, Tarczek 1A and Tarczek 2 boreholes (Łysogóry region)

LS – lithostratigraphy after Malec *et al*. (1995); L – lithology after Malec *et al*. (1995); spores after Fijałkowska (1995*b*); E. – Emsian; G.F. – Grzegorzowice Formation; explanations as in Figures 2 and 5

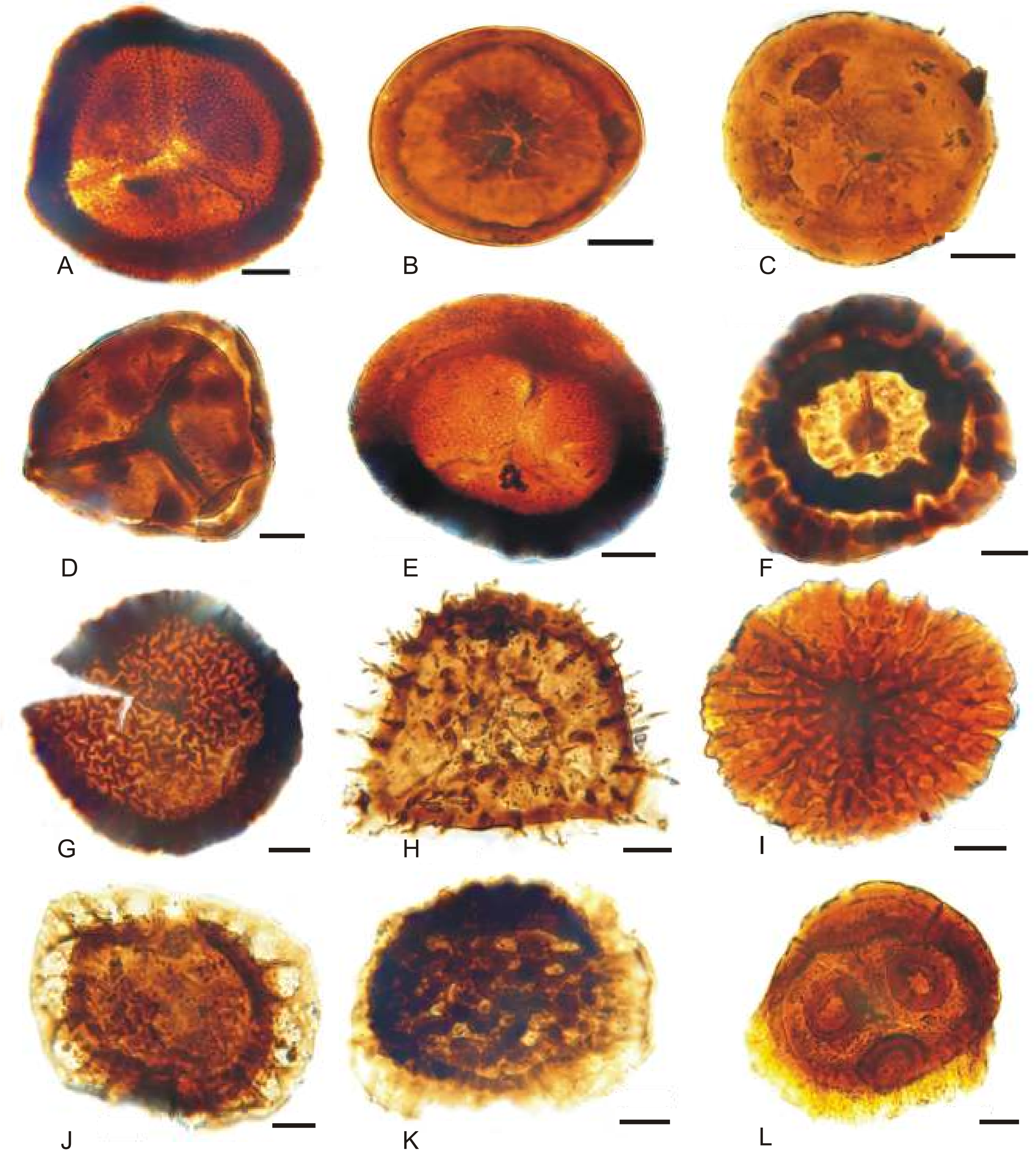


Fig. 7. Patinante, cingulate and zonate spores from the upper Pragian–lower Eifelian of the Holy Cross Mts.

A – *Tholisporites chulus* (Cramer) McGregor var. *chulus* Richardson et Lister, Winna 2 borehole, depth 16.9 m; **B** – *Chelinospora* cf. *favosa* (McGregor et Camfield) Steemans, Haliszka 1 borehole, depth 80.2 m; **C** – *Stenozonotriletes irregularis* Schultz, Haliszka 1 borehole, depth 78.2 m; **D** – *Coronaspora mariae* Rodriguez, Haliszka 1 borehole, depth 145.7 m; **E** – *Amicosporites jonkeri* (Riegel) Steemans, Tarczek 1 borehole, depth 187.8 m; **F** – *A. streeli* Steemans, Tarczek 2 borehle, depth 327.9 m; **G** – *Clivosispora* sp., Zaręby 2 borehole, depth 1192.1 m; **H** – *Kraeuselisporites gaspensis* McGregor, Tarczek 2 borehole, depth 284.6 m; **I** – *Membrabaculisporis* cf. *radiatus* (Naumova) Arkhangelskaya., Haliszka 1, depth 53.5 m; **J** – *Camptozonotriletes aliquantus* Allen, Zaręby 2 borehole, depth 1159.8 m; **K** – *C. caperatus* McGregor, Tarczek 2 borehole, depth 285.2 m; **L** – *Oculatisporites mirandus* Arkhangelskaya, Haliszka 1 borehole, depth 20.2 m; scale bar – 10 μm

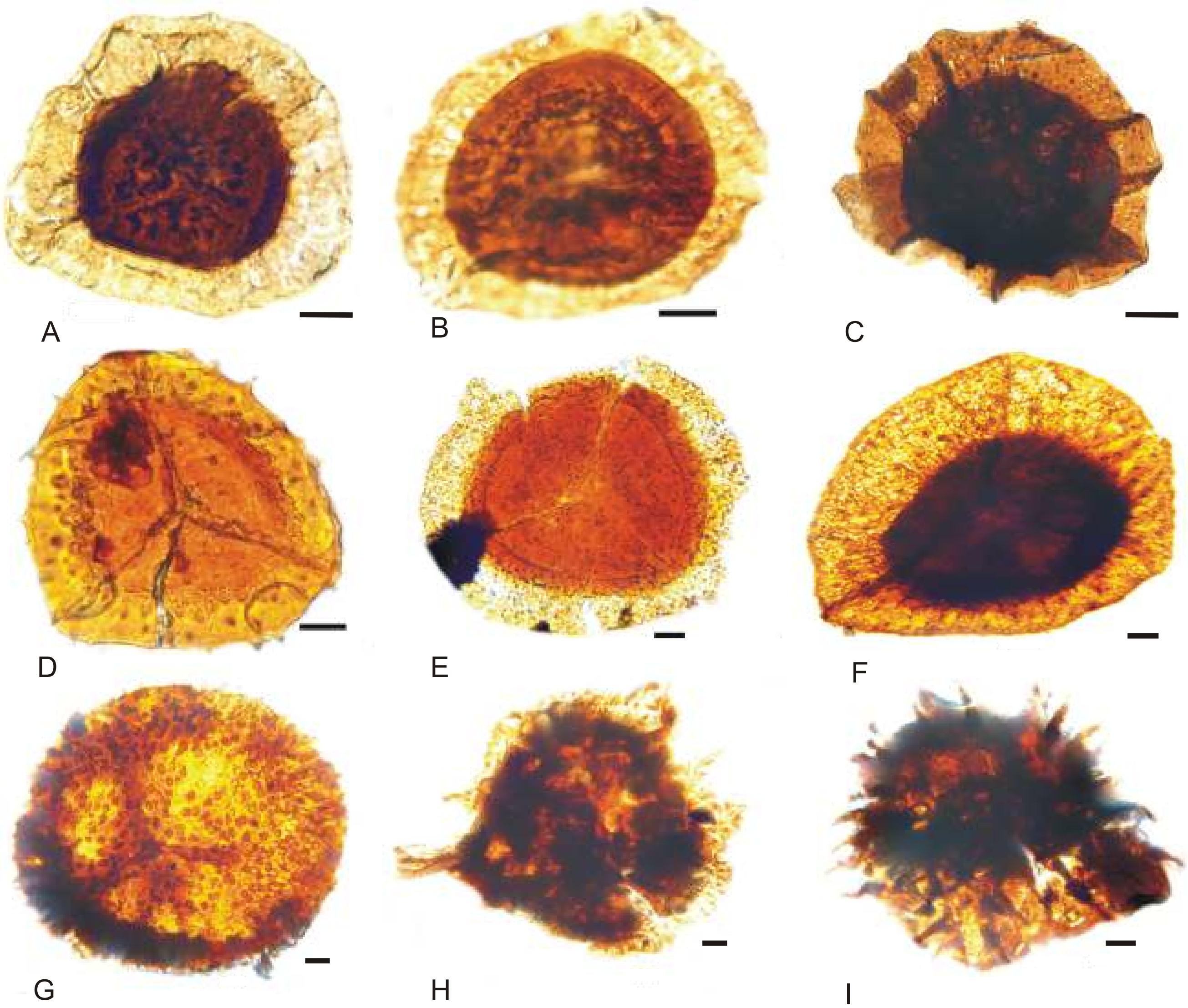


Fig. 8. Monopseudosaccite spores from the Emsian and lower Eifelian of the Holy Cross Mts.

A – *Calyptosporites biornatus* (Lanninger) Richardson, Zaręby 2 borehole, depth 1161.6 m; **B** – *C. heisdorfensis* Riegel, Zaręby 2 borehole, depth 1161.6 m; **C** – *C. radiatus* Riegel, Wszachów 4 borehole, depth 55.1 m; **D** – *Grandispora douglastownense* McGregor, Dyminy 2 borehole, depth 138.0 m; **E** – *G.* cf. *endemica* (Tchibrikova) Tchibrikova, Borków 1 borehole, depth 35.5 m; **F** – *G. protea* (Naumova) Moreau-Benoit, Tarczek 1A borehole, depth 38.5 m; **G** – *G. velata* (Eisenack) Playford, Poręba 1 borehole, depth 69.8 m; **H** – *Ancyrospora kedoae* (Riegel) Turnau, Tarczek 1 borehole, depth 96.2 m; **I** – *A. loganii* McGregor, Tarczek 1 borehole, depth 109.5 m; scale bar – 10 µm

The Pro Subzone of the AP Zone was distinguished in the Kielce region in the upper sandstone member of the Winna Formation in the Poręba 1 (69.8–74.7 m; Fig. 5) and Winna 1 (67.3 m) boreholes (this paper). Filipiak (2011) described this subzone in the upper sandsone member of the Winna Formation, pyrite-bearing and sideritic claystone member and dolomite member from the Zbrza I trench. It was also noted in the upper part of the Bukowa Góra and Kapkazy members, and in the lower part of the Zachełmie Member of the Grzegorzowice Formation (previously referred to the Tarczek Claystone Member) in the Tarczek 1 (43.9–130.8 m), Tarczek 1A (45.0 m; Fig. 6) and Modrzewie 2A (126.4–215.3 m) boreholes (Fijałkowska, 1995*b*; Turnau, 1995*a*, *b*; Fijałkowska-Mader *et al*., 1997; Fijałkowska-Mader, 2011; Filipiak, 2011). Moreover Filipiak (2009, 2011) identified this subzone in the Bukowa Góra Member in the Bukowa Góra Quarry, in the Bukowa Góra and Wydryszów members in the Chełmowa 3 (81.0–136.0 m) and Jeziorko 1 (88.0–179.0 m) boreholes and in the Wydryszów Member in the Kowalkowice 1 (156.0–194.0 m) borehole in the Łysogóry region. The absence of *Ancyrospora kedoae* and *A. nettersheimensis* in the some assemblages described by Filipiak as Pow Subzone may indicate the Subzone Cor.

In comparison to the Cor Subzone, the abundance of spores representing the genera *Grandispora* and *Hystricosporites* is higher, whereas spores belonging to *Emphanisporites* and *Dibolisporites* disappear within the Pro Subzone.

The Vel Subzone of the AP Zone was recorded by Filipiak (2011) in the Dąbrowa Limestone Member in the Dyminy 2 (96.0–110.0 m) borehole, Dąbrowa Limestone Member and bioturbated dolomite member in the Zbrza I trench in the Kielce region as well as in the Zachełmie Mudstone and Sandstone Member in the Tarczek 1A borehole at a depth of 38.0–28.0 m by the author (Fijałkowska, 1995*b*; Fig. 6) and at 17.0–23.0 m by Filipiak (2011) in the Łysogóry region.

CONODONTS

In the Łysogóry region, middle and upper Emsian as well as lower Eifelian conodonts have been documented within the Zagórze Formation and in the Grzegorzowice Formation. The oldest Lower Devonian conodonts *Icriodus* sp. are found in the middle part of the Zagórze Formation in the Modrzewie 2A borehole (Malec, 1986*a*, 1990*a*). Four conodont zones were distinguished in the succession from the Emsian/Eifelian boundary interval in the Grzegorzowice Formation of the Łysogóry region, i.e. *serotinus*, *patulus*, *partitus* and *costatus* (Malec, 2001, 2002; Nehring-Lefeld *et al*., 2003*b*; Figs. 9–11 and Table 4).

Conodonts characteristic of the *serotinus* Zone have been documented in the lower part of the Grzegorzowice Formation. Here, the Warszówek Dolomite Member yields the subspecies *Icriodus corniger ancestralis* Weddige and the species *I. rectirostriatus* (Bultynck). The boundary interval between the Warszówek Dolomite Member and the Godów Marl Member contains *Caudicriodus* cf. *culicellus culicellus* (Bultynck). The lower part of the Warszówek Dolomite Member in the Wydryszów trench contains *I. corniger ancestralis* Weddige (Malec, 2001, 2002; Fig. 11). In the Devonian stratotype section *I. corniger ancestralis* occurs in the upper *inversus* and *serotinus* zones and does not cross the top of the latter zone (Weddige, 1977; Requadt and Weddige, 1978; Weddige and Requadt, 1985). The range of *C. culicellus culicellus* (Bultynck) spanes the upper *inversus* and *serotinus* zones, whereas *I. rectirostriatus* (Bultynck) spanes the *serotinus* and *patulus* zones (e.g., Bultynck, 2003). The co-occurrence of *I. corniger ancestralis* and *I. rectirostriatus* indicates the *serotinus* Zone.

Conodonts of the *patulus* Zone have been recognized in the lower and middle part of the Grzegorzowice Formation (Malec, 1986*a*, 2001). The species *I. rectirostriatus* occurs within the Bukowa Góra Claystone Member in the Grzegorzowice outcrop (Fig. 10) and the Bukowa Góra Quarry as well as within the Bukowa Góra Claystone Member and the Wydryszów Limestone Member in the sections and in the Chełmowa 3, Jeziorko 1, Kowalkowice 1, Modrzewie 2A and Wierzbontowice 1 boreholes. Conodont such as *C. culicellus altus*, *I. corniger leptus* Weddige, *I. werneri* Weddige, *Polygnathus cooperi cooperi* Klapper, *P. costatus* cf. *patulus* Klapper and *P. linguiformis bultyncki* Weddige are recorded mainly in the Wydryszów Limestone Member and to a lesser extent in the Bukowa Góra Claystone Member and the Rzepin Dolomite Member. The assemblage is assigned to the *patulus* Zone based on the presence of *C. culicellus altus* (e.g., Bultynck, 2003) as well as the common occurrence of *I. rectirostriatus* and *I. werneri*. The first taxon disappears in standard Devonian sections at the Emsian/Eifelian boundary in the lowermost part of the *partitus* Zone, whereas the second taxon is known from the lower part of the *patulus* Zone (Weddige, 1977, 1982; Bultynck, 1985; Feist *et al*., 1985; Belka *et al*., 1997).

Conodonts of the *partitus* Zone have been documented in the Grzegorzowice section and in the Kowalkowice 1 borehole, in the lower part of the Dąbrowa Limestone Member (Malec, 1986*a*, 1993, 2002). The limestones contain *P. linguiformis bultyncki*, *I. werneri* and *I. corniger leptus* that are present also in the older members of the Grzegorzowice Formation. The assemblage comprises also taxa represented by *Polygnathus costatus partitus* Klapper, Ziegler et Mashkova, *Icriodus retrodepressus* (Bultynck) and *I. corniger corniger* Wittekindt. The co-occurrence of the latter three taxa is recorded in the lowermost Eifelian in the *partitus* Zone (Weddige, 1977, 1982). The subspecies *P. costatus partitus*, the index taxon of the *partitus* Zone was noted in the lower part of the Dąbrowa Limestone Member in the Grzegorzowice Formation (Fig. 10).

Conodonts of the *costatus* Zone are recorded in the upper part of the Dąbrowa Limestone Member in the Grzegorzowice Formation (Malec, 2001, 2002). The presence of *I. amabilis* in this assemblage places the upper part of the Dąbrowa Limestone Member into the *costatus* Zone (Fig. 10). In the lower Eifelian successions, the species appears for the first time in the lowermost part of the *costatus* Zone (Bultynck, 2003).

In the Kielce region, upper Emsian and lower Eifelian conodonts have been observed in several boreholes (Dyminy 2, Porzecze IG 5A, Zaręby 2, Stara Góra IG 1) and in exposures in the Zbrza and Kielce (Fig. 9 and Table 5). The oldest Devonian conodonts are recorded in the lower part of the pyrite-bearing and sideritic claystone member in the Stara Góra IG 1 borehole (Malec, unpubl.), which yielded *I. rectirostriatus*. Lower Eifelian conodonts *I. retrodepressus* are described from a dolomite bed from the mudstone member of the Winna Formation in the Zaręby 2 borehole (Malec, 1984*b*). They occur also in the lower part of the Dąbrowa Limestone Member in the Zbrza and Kielce successions and in the Porzecze IG 5A borehole (Fig. 12), where they form an assemblage comprising *I. retrodepressus*, *I. corniger corniger* and *I. werneri* (Malec, 1992, 1993), characteristic of the *partitus* Zone (Weddige, 1977, 1982; Bultynck, 2003).

OSTRACODS

In the Lower Devonian of the Łysogóry region, ostracods were observed in the Zagórze Formation and the Grzegorzowice Formation (Adamczak, 1968, 1976; Malec, 1984*c*, 1990*b*, 2002; Nehring-Lefeld *et al.*, 2003*a*). The uppermost part of the latter unit contains also lower Eifelian ostracods (Malec, 1989, 2002; Figs. 9–11 and Table 6). The oldest ostracod assemblage has been documented in the Modrzewie 2A borehole, in dark grey claystones of the middle part of the Zagórze Formation (Malec, 1990*a*). The taxonomic composition of this assemblage is most similar to ostracod as-

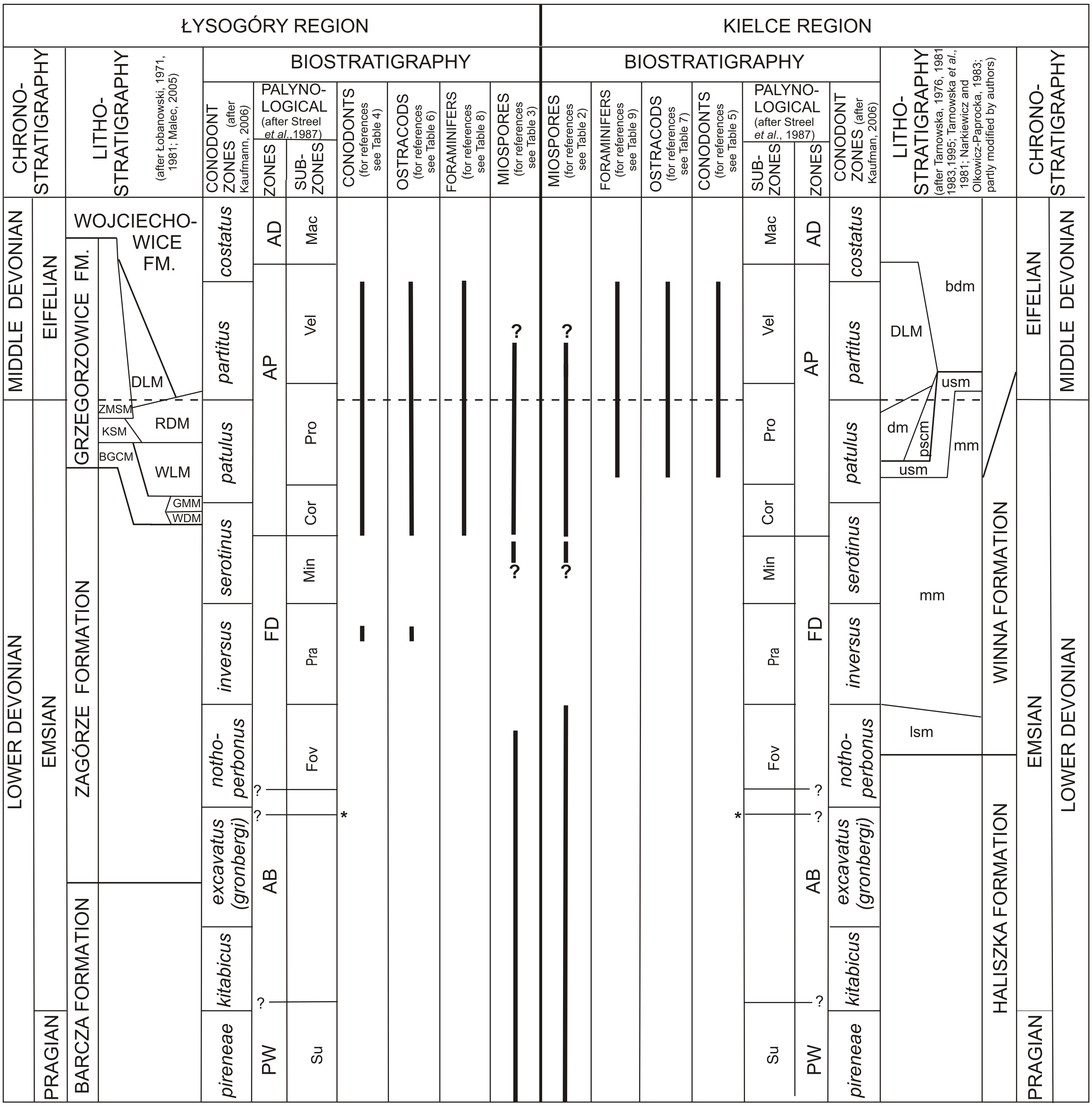


Fig. 9. Biostratigraphy of the upper Pragian to Eifelian in the Holy Cross Mts.

* – boundary suggested by Filipiak (2011); other explanations as in Figure 2 and Table 2

semblages described from the *Tentakulitenschiefer* (Horizon III) in the Devonian of Thuringia, pointing to the upper part of the *Nowakia cancellata* tentaculite Zone (Zagora, 1968; Zagora and Zagora, 1986), lying within the *inversus* Zone of the middle Emsian (see Oliver and Chlupac, 1991).

Numerous ostracod assemblages have been described from the upper Emsian of the Łysogóry region (Adamczak, 1968, 1976). Four local ostracod zones have been distinguished in the upper Emsian of the Grzegorzowice Formation (Adamczak, 1976): *Kozlowskiella corbis* (C), *Bairda cultrijugati–Bairdiocypris lamellaris* (CL), *Arikloedenia magna* (M) and *Poniklacella abnormis* (Ab.; Table 6). Three informal, younger ostracod zones have been distinguished in the upper members of the Grzegorzowice Formation (Malec, 2002, 2003*a*), i.e. *Kozlowskiella spriestersbachi* (S), *Bythocyproidea polaris* (P) and "*Acratia*" (Ac.). The first zone is marked by the FAD of *Kozlowskiella spriestersbachi* (Dahmer), documented in the uppermost Emsian at the top of the Rzepin Dolomite Member in the Grzegorzowice Formation (Fig. 10). The zone yields also large leperditicopids representing the genus *Herrmannina*. The lower boundary of the second zone is marked by the FAD of *Bythocyproidea polaris* (Gürich), along with the ostracod as-

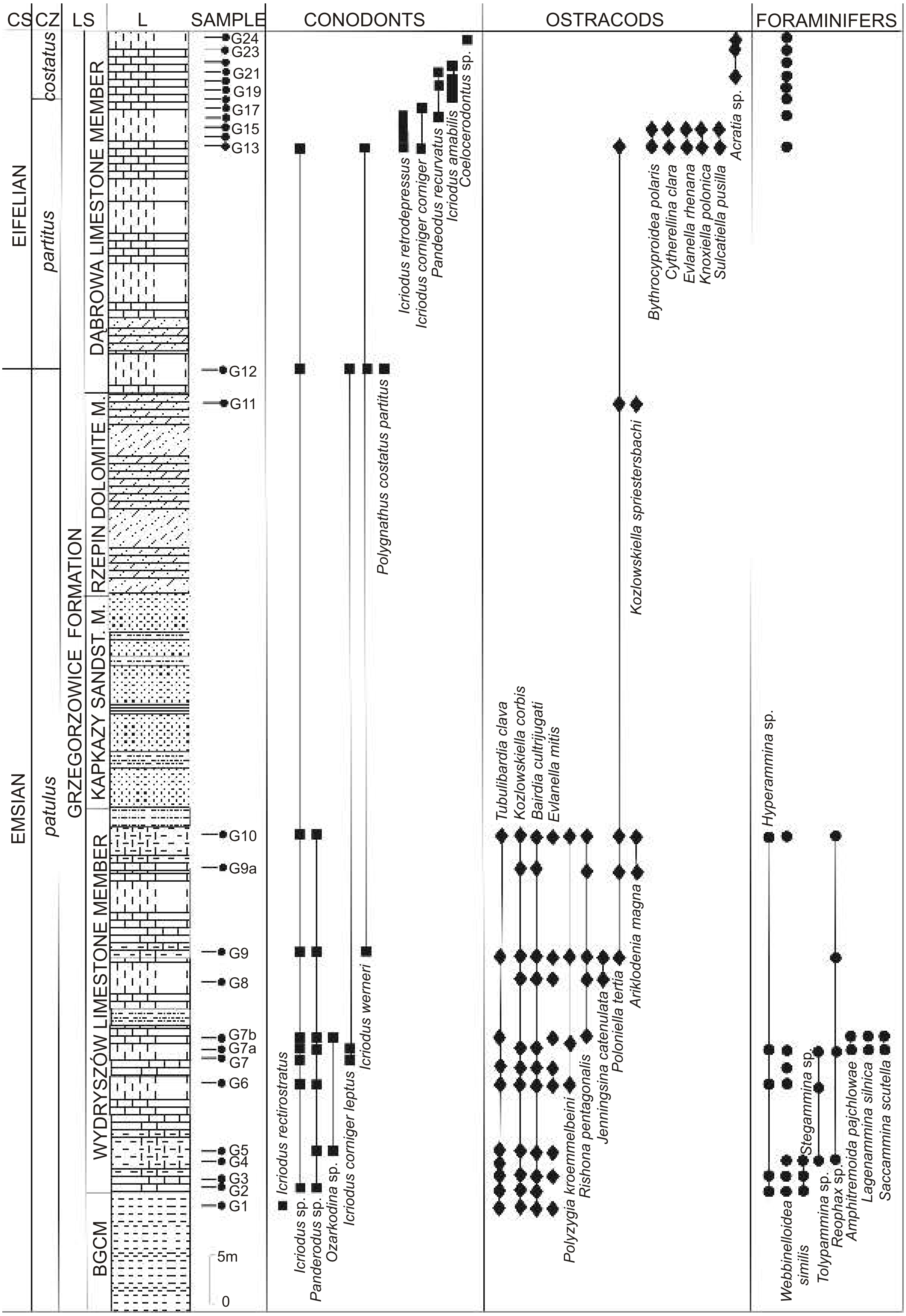


Fig. 10. Co-occurence of selected microfossils in the Grzegorzowice outcrop (Łysogóry region)

CZ – conodont zones after Kaufmann (2006); LS – lithostratigraphy after Malec (2005); L – lithology after Malec (2002); conodonts after Malec (2002); ostracods and foraminifers after Malec (1984*c*); Kapkazy Sandst. M. – Kapkazy Sandstone Member; Rzepin Dolomite M. – Rzepin Dolomite Member; other explanations as in Figures 2 and 5

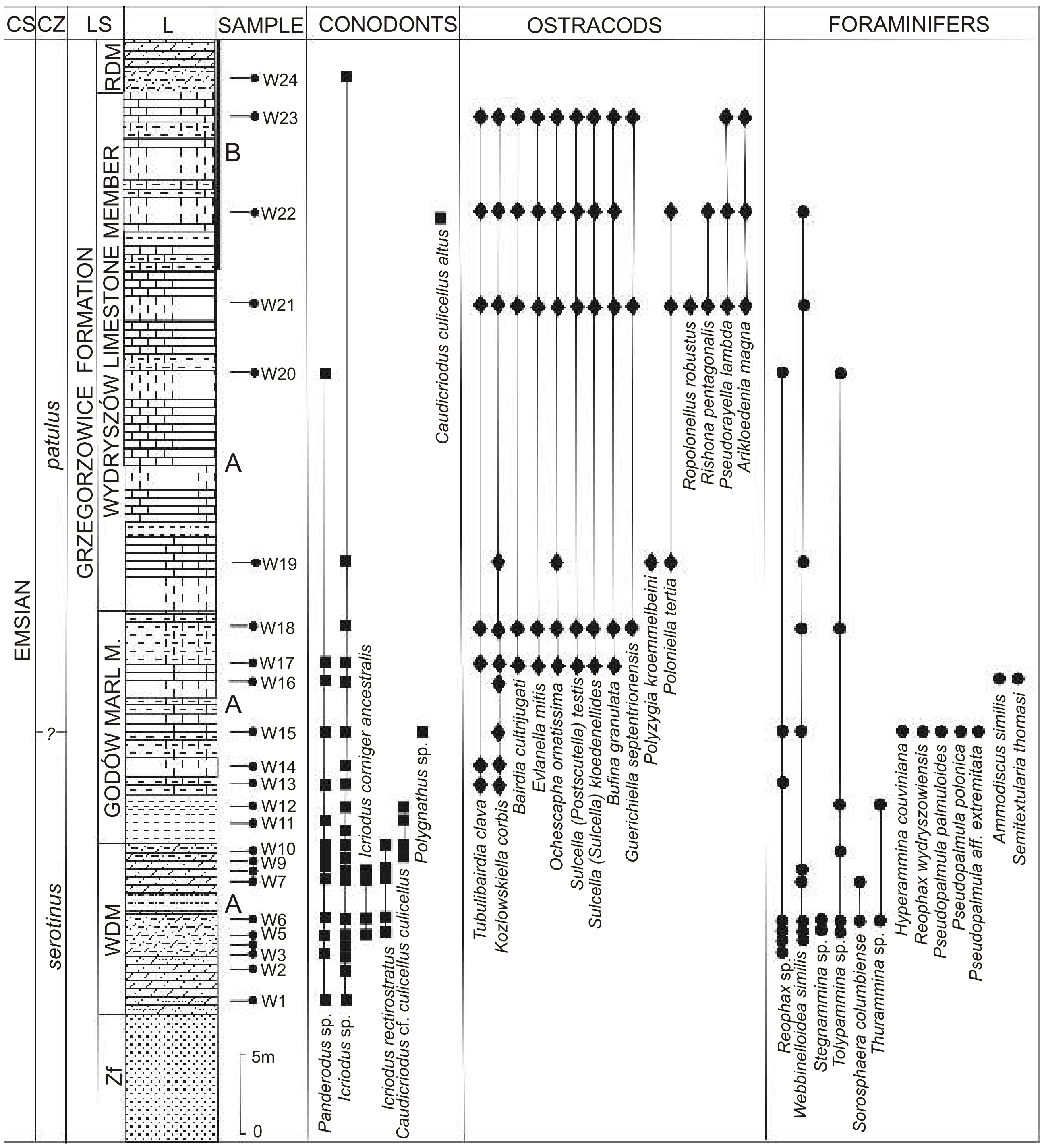


Fig. 11. Co-occurence of selected microfossils in the Wydryszów outcrop (A) and Wydryszów trench (B) (Łysogóry region)

Zf – Zagórze Formation; Godów Marl M. – Godów Marl Member; other explanations as in Figure 10

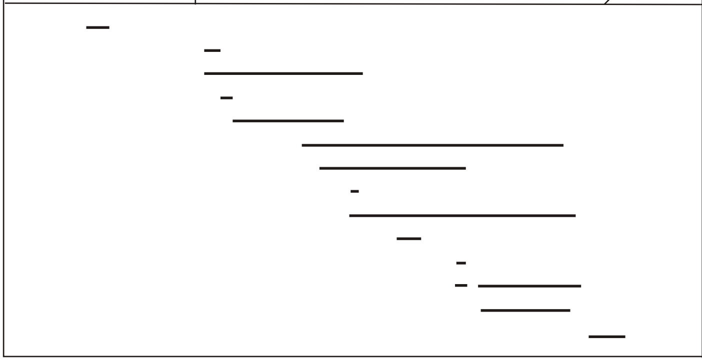
semblage found in the lower part of the Dąbrowa Limestone Member, which is assigned to the *partitus* Zone. The lower boundary of the "*Acratia*" Zone is marked by the appearance of an abundant ostracod assemblage of the genus *Acratia* in the upper part of the Dąbrowa Limestone Member, assigned to the lower part of the *costatus* Zone (Malec, 2002).

At the base of the Bukowa Góra Claystone Member in the Wierzbontowice 1 borehole *Zygobeyrichia onusta* (Kummerow) was found (Malec, 1986*a*, 2002), a species characteristic of the upper Emsian of the Eifel Hills and the Rhenish Schiefergebirge (Becker and Groos-Uffenorde, 1982; Groos-Uffenorde, 1982*a*). In the Eifel Hills, it occurs in the Wetteldorf and lowermost part of the Heisdorf formations (Groos-Uffenorde, 1982*b*), assigned to the *serotinus* and lowermost part of the *patulus* zones interval (Weddige and Ziegler, 1977; Weddige *et al*., 1979; Weddige, 1982, 1988).

Table 4

Stratigraphic ranges of selected conodonts in the Emsian/Eifelian boundary interval from the Łysogóry region of the Holy Cross Mts.

LOWER DEVONIAN			MIDDLE DEVONIAN		CHRONOSTRATIGRAPHY
EMSIAN			EIFELIAN		
?inversus	*serotinus*	*patulus*	*partitus*	*costatus*	CONODONT ZONES
ZAGÓRZE FM.	GRZEGORZOWICE FORMATION			W. FM.	LITHOSTRATIGRAPHY



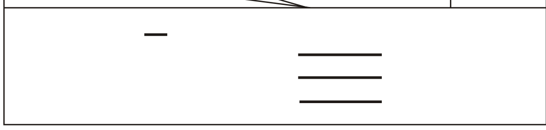
Icriodus sp.
Icriodus corniger ancestralis Weddige
Icriodus rectirostratus Bultynck
Caudicriodus cf. *culicellus culicellus* (Bultynck)
Caudicriodus culicellus altus (Weddige et Requadt)
Polygnathus linguiformis bultyncki Weddige
Icriodus corniger leptus Weddige
Polygnathus cooperi cooperi Klapper
Icriodus werneri Weddige
Polygnathus costatus cf. *patulus* Klapper
Polygnathus costatus partitus Klapper, Ziegler et Mashkova
Icriodus corniger retrodepressus Bultynck
Icriodus corniger corniger Wittekindt
Icriodus amabilis Bultynck et Hollard

W. FM. – Wojciechowice Formation, ZAGÓRZE FM. (Z. FM.) – Zagórze Formation; combined after: Malec (1986*a*, 1989, 1990*a*, 1993, 2001, 2002, 2005)

Table 5

Stratigraphic ranges of selected conodonts in the Emsian/Eifelian boundary interval from the Kielce region of the Holy Cross Mts.

LOWER DEVONIAN		MIDDLE DEVONIAN		CHRONOSTRATIGRAPHY
EMSIAN		EIFELIAN		
serotinus	*patulus*	*partitus*	*costatus*	CONODONT ZONES
WINNA FM.	pscm	dm	bdm	LITHOSTRATIGRAPHY



Icriodus rectirostratus Bultynck
Icriodus retrodepressus Bultynck
Icriodus corniger corniger Wittekindt
Icriodus werneri Weddige

WINNA FM. – Winna Formation; combined after Malec (1984*b*, 1986*b*, 1992, 1993); other explanations as in Figure 2

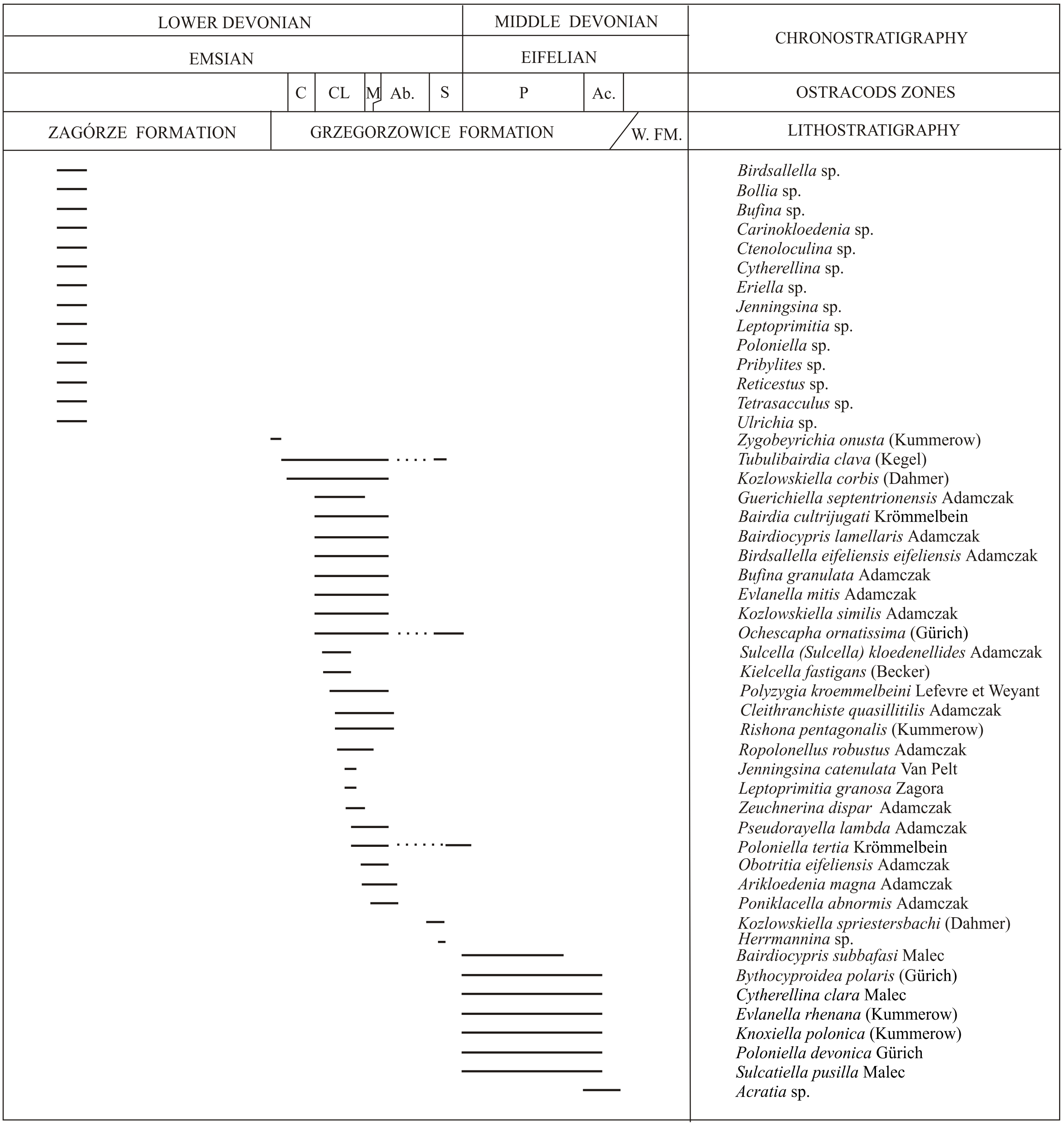
In the Kielce region, ostracod assemblages have been recognized in the upper Emsian and lower Eifelian (Fig. 9 and Table 7). The upper Emsian taxa, occurring in the *patulus* conodont Zone are recorded in the Porzecze IG 5A borehole (Fig. 12) in the western part of the area (Malec, 1980, 1992). The species *Kozlowskiella spriestersbachi* (Dahmer), characteristic of the uppermost Emsian, is recorded in the Kielce region in the Zbrza section, in the lower part of the marly shales between the dolomite member and Dąbrowa Limestone Member (Malec, 1995). Abundant ostracod assemblages from the lowermost Eifelian, typical of the *Bythocyproidea polaris* ostracod Zone, occur in the Dąbrowa Limestone Member in the Dąbrowa D5 borehole and in the Zbrza section and in the pyrite-bearing and sideritic member in the Wola Zamkowa 2 borehole (Malec, 1986*b*, 1989, 1995).

FORAMINIFERS

Abundant foraminifer assemblages occur in the upper Emsian of the Łysogóry region (Fig. 9 and Table 8; Duszyńska, 1959; Malec, 1984*c*, 2002, 2003*b*, 2007, 2008; Soboń-Podgórska and Tomaś, 2003). The foraminifers are represented mainly by agglutinated specimens of the genera *Ammodiscus*, *Amphitremoida*, *Hemisphaerammina*, *Hyperammina*, *Lagenammina*, *Psammosphaera*, *Reophax*, *Saccammina*, *Saccarena*, *Sorosphaera*, *Stegnammina*, *Thurammina*, *Tolypammina* and *Webbinelloidea* (Duszyńska, 1959; Malec, 1984*c*, 2003*b*, 2007, 2008). Rare foraminifers with calcareous shells belong to the species *Pseudopalmula palmuloides* Cuchman et Stainbrook, *P. polonica* Duszyńska,

Table 6

Stratigraphic ranges of selected ostracods in the Emsian and Emsian/Eifelian boundary interval from the Łysogóry region of the Holy Cross Mts.



Combined after: Adamczak (1968, 1976), Malec (1984*c*, 1986*a*, 1989, 1990*a*, *b*, 2002, 2003*a*), Malec *et al*. (1990); ostracods zones: C – *Kozlowskiella corbis*, CL – *Bairdia cultrijugati–Bairdiocypris lamellaris*, M – *Arikloedenia magna*, Ab. – *Poniklacella abnormis*, S – *Kozlowskiella spriestersbachi*, P – *Bythocyproidea polaris*, Ac. – "*Acratia*"; other explanations as in Table 4

Table 7

Stratigraphic ranges of selected ostracods in the Emsian/Eifelian boundary interval from the Kielce region of the Holy Cross Mts.

LOWER DEVONIAN		MIDDLE DEVONIAN		CHRONOSTRATIGRAPHY
EMSIAN		EIFELIAN		
WINNA FM.	pscm	dm	bdm	LITHOSTRATIGRAPHY
—				*Bairdia cultrijugati* Krömmelbein
—				*Bairdiocypris lamellaris* Adamczak
—				*Evlanella mitis* Adamczak
—				*Guerichiella septentrionensis* Adamczak
—				*Kummerowia prima* Adamczak
—				*Poniklacella abnormis* Adamczak
—				*Pseudorayella lambda* Adamczak
—				*Ropolonellus robustus* Adamczak
—				*Sulcella* (*Sulcella*) *kloedenellides* Adamczak
—				*Tubulibairdia clava* (Kegel)
	—			*Kozlowskiella spriestersbachi* (Dahmer)
	—	—		*Poloniella devonica* Gürich
	—	—		*Poloniella tertia* Krömmelbein
		—		*Bairdiocypris subbafasi* Malec
		—		*Bythocyproidea polaris* (Gürich)
		—		*Cryptophyllus nidae* Malec
		—		*Cytherellina clara* Malec
		—		*Evlanella humiliformis* (Gürich)
		—		*Evlanella kielcensis* Malec
		—		*Evlanella rhenana* (Kummerow)
		—		*Jefina larga* Malec
		—		*Knoxiella polonica* (Kummerow)
		—		*Ochescapha ornatissima* (Gürich)
		—		*Orthocypris magna* Malec
		—		*Polyzygia kroemmelbeini* Lefevre et Weyant
		—		*Rishona obliqua* (Gürich)
		—		*Sulcatiella pusilla* Malec

Combined after Malec (1979, 1980, 1986*b*, 1989, 1992); Tarnowska and Malec (1987); explanations as in Table 5

P. aff. *extremitata* Bykova and *Semitextularia thomasi* Miller et Carmer. The most diverse foraminifer assemblages occur in the lowermost members of the Grzegorzowice Formation (Bukowa Góra, Warszówek, Godów and Wydryszów members) in the Grzegorzowice and Wydryszów outcrops (Figs. 10 and 11). The lower Eifelian part of the Grzegorzowice Formation (Dąbrowa Limestone Member) is dominated by *Webbinelloidea similis* Stewart et Lampe, whereas *Hyperammina* specimens occur rarrely.

In the Kielce region, agglutinated foraminifers from the upper Emsian and lowermost Eifelian were recognized in Devonian sections from the western and central part of the area in the pyrite-bearing and sideritic claystone member (Fig. 9 and Table 9). They are dominated by numerous morphotypes of *W. similis* Stewart et Lampe distinguished by Conkin and Conkin (1970), with small amounts of specimens of *Amphitremoida*, *Hyperammina*, *Lagenammina* and *Saccammina* (Malec, 1986*b*, 1992; Malec and Studencki, 1988). An assemblage with a similar taxonomic composition was described from the dolomite member and the Dąbrowa Limestone Member in the Porzecze IG 5A borehole (Malec, 1979, 1984*a*; Fig. 12). Diverse morphotypes of *W. similis* Stewart et Lampe were observed in a dolomite bed occurring within the mudstone member of the Winna Formation in the Zaręby 2 borehole (Malec, 1984*b*), dated to the lower Eifelian *partitus* Zone based on conodonts.

BIOSTRATIGRAPHIC CORRELATIONS

The correlation between standard palynological zones and standard conodont zones in the stratotype regions is often indirect and should be treated as tentative, particularly at the Pragian/Emsian boundary and in the Emsian (Turnau *et al*., 2003). The boundary between the PW and AB zones cannot be determined because the base of the AB Zone is correlated to the Emsian (Streel *et al*., 1987), but at this time it was not clear in which formation in the Eifel and Ardenne regions the Emsian boundary is placed. Therefore the base of the AB Zone could be correlated only roughly to the lower part of the *dehicens* Zone, which is correlated to the upper part of the *kitaabicus* Zone (Kaufmann, 2006) and the top of the AB Zone to the lower *nothoperbonus* Zone (Turnau *et al*., 2003; Fig. 9). Filipiak (2011) correlated the top of AB Zone to the uppermost *gronbergii* Zone. The age of the AB Zone is early Emsian. The intercalibration of younger spore zones with conodont zones was given by Streel *et al.* (1987) for the Eifel region. The Fov Subzone of the FD Zone is correlated with the upper part of the *nothoperbonus* Zone. The two remaining subzones Pra and Min correspond to the *inversus* and lower *serotinus* zones. The Cor Subzone of the AP Zone correlates with the upper *serotinus* and lower *patulus* zones and is late Emsian in age.

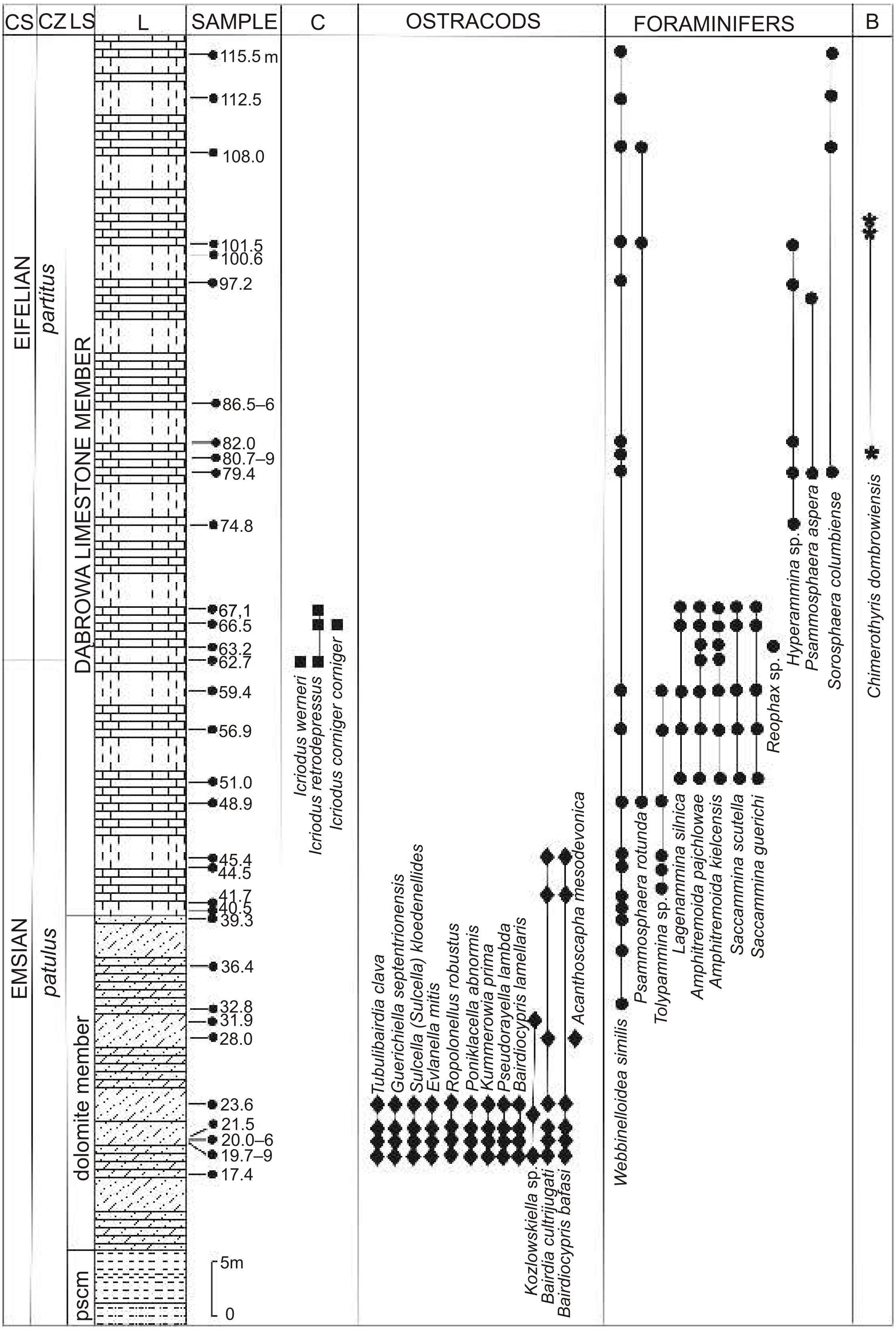


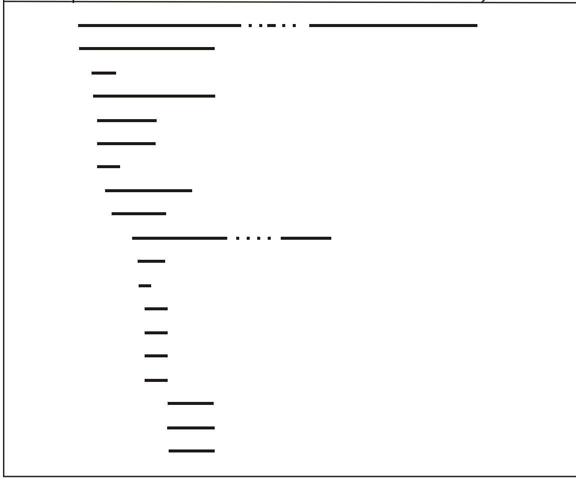
Fig. 12. Co-occurence of selected micro- and macrofossils in the Porzecze IG 5A borehole (Kielce region)

C – conodonts after Malec (2002); ostracods and foraminifers after Malec (1979, 1984*c*, 1992); B – brachiopods after Malec (1984*c*); strata occur in the reversed position in the Porzecze IG 5A borehole; other explanations as in Figure 10

T a b l e 8

Stratigraphic ranges of selected foraminifers in the Emsian/Eifelian boundary interval from the Łysogóry region of the Holy Cross Mts.

LOWER DEVONIAN		MIDDLE DEVONIAN		CHRONOSTRATIGRAPHY
EMSIAN		EIFELIAN		
serotinus	*patulus*	*partitus*	*costatus*	CONODONT ZONES
Z. FM.	GRZEGORZOWICE FORMATION		W. FM.	LITHOSTRATIGRAPHY



Webbinelloidea similis Stewart et Lampe
Psamosphaera cava Moreman
Stegnammina sp.
Tolypammina sp.
Ammodiscus similis Duszyńska
Hyperammina couviniana Duszyńska
Sorosphaera columbiense Stewart et Lampe
Reophax wydryszowiensis Duszyńska
Saccarena sp.
Hyperammina sp.
Thuramminа sp.
Hemisphaerammina sp.
Pseudopalmula palmuloides Cushman et Stainbrook
Pseudopalmula polonica Duszyńska
Pseudopalmula aff. *extremitata* Bykova
Semitextularia thomasi Miller et Carmer
Amphitremoida pajchlowae Malec
Lagenammina silnica Malec
Saccammina scutella Malec

Combined after Duszyńska (1959), Malec (1984*c*, 2002, 2003*b*, 2007, 2008); explanations as in Table 4

T a b l e 9

Stratigraphic ranges of selected foraminifers in the Emsian/Eifelian boundary interval from the Kielce region of the Holy Cross Mts.

LOWER DEVONIAN		MIDDLE DEVONIAN		CHRONOSTRATIGRAPHY
EMSIAN		EIFELIAN		
serotinus	*patulus*	*partitus*	*costatus*	CONODONT ZONES
WINNA FM.	pscm	dm	bdm	LITHOSTRATIGRAPHY

Webbinelloidea similis Stewart et Lampe
Tolypammina sp.
Hyperammina sp.
Amphitremoida kielcensis Malec
Amphitremoida pajchlowae Malec
Lagenammina silnica Malec
Saccammina guerichi Malec
Saccamina scutella Malec
Hemisphaerammina sp.
Sorosphaera columbiense Stewart et Lampe

Combined after Malec (1979, 1984*a*, *b*, 1986*b*, 1992), Tarnowska and Malec (1987), Malec and Studencki (1988); explanations as in Table 5

The Pro Subzone correlates with the upper *patulus* Zone and with the lowermost part of the *partitus* Zone. The Emsian/Eifelian boundary is placed within this subzone. The Vel Subzone is correlated with the upper part of the *partitus* Zone and the lower part of the *costatus* Zone.

A co-occurrence of conodonts of the *patulus* Zone with spores of the Pro Subzone was recorded in the Bukowa Góra Claystone Member of Bukowa Góra Quarry, in the Wydryszów Limestone Member of the Chełmowa 3 (81.0 and 93.0 m) and Kowalkowice 1 (156.0, 166.0, 178.0 and 194.0 m) boreholes as well as in the Bukowa Góra Claystone Member (164.0 and 179.0 m) and Wydryszów Limestone Member (88.0, 112.0 and 125.0 m) of the Jeziorko 1 borehole (e.g., Filipiak, 2011) and Wydryszów Limestone Member of the Modrzewie 2A (81.0, 89.0, 97.0 and 109.0 m) borehole in the Łysogóry region. Conodonts of the *partitus* Zone co-occur with spores of the Vel Subzone in the Dąbrowa Limestone Member of the Dyminy 2A (96.0, 99.0, 102.0, 106.0 and 110.0 m) borehole and Zbrza I trench (e.g., Filipiak, 2011) in the Kielce region.

Three main ostracod assemblages have been recorded in the Emsian and lower Eifelian of the Łysogóry region. The oldest is present in the middle part of the Zagórze Formation, the middle one occurs in the lower part of the Grzegorzowice Formation, in the upper part of the *serotinus* Zone and in the *patulus* Zone from the upper Emsian, and the youngest in the upper part of the Grzegorzowice Formation, within the *partitus* Zone and in the lower part of *costatus* Zone of the lower Eifelian. In the Kielce region, two main ostracod assemblages have been distinguished at the Emsian/Eifelian boundary: in the upper Emsian *patulus* Zone and in the lower Eifelian *partitus* Zone. In both regions, the upper Emsian and lower Eifelian ostracod assemblages have a similar taxonomic composition.

In the upper Emsian of the Łysogóry region, in the upper part of the *serotinus* Zone and in the *patulus* Zone there occurs a rich assemblage of mainly agglutinated foraminifers with minor calcareous foraminifers. In the Kielce region, agglutinated foraminifers have been documented in the upper Emsian *patulus* Zone within the pyrite-bearing and sideritic claystone member as well as in the lower Eifelian limestones of the Dąbrowa Limestone Member.

CONCLUSIONS

1. Four palynozones: PW, AB, FD and AP have been identified in the uppermost Pragian, Emsian and lower Eifelian in the HCM and correlated to lithostratigraphical units. In the Łysogóry region the middle and upper part of the Barcza Formation is palynologically dated to the Su Subzone of PW Zone and the AB Zone (upper Pragian–lower Emsian), the lower part of the Zagórze Formation is dated to the AB Zone and the Fov Subzone of the FD Zone (lower Emsian), the upper part of the Zagórze Formation can be correlated to the Min Subzone of the FD Zone and the Cor Subzone of the AP Zone (upper Emsian). The Grzegorzowice Formation is dated to the AP Zone and its subzones: the lower part of the Bukowa Góra Claystone Member to the Cor Subzone (upper Emsian), the upper part of the Bukowa Góra Claystone Member, the Wydryszów Limestone Member, the Kapkazy Sandsone Member and the lower part of the Zachełmie Mudstone and Sandstone Member to the Pro Subzone (uppermost Emsian–lowermost Eifelian) and the upper part of the Zachełmie Mudstone and Sandstone Member to the Vel Subzone (lower Eifelian). In the Kielce region the upper part of the Haliszka Formation is correlated to the Su Subzone and the upper part to the AB Zone. The lower sandstone member of the Winna Formation is dated to the Fov Subzone of the FD Zone, the mudstone member can be correlated to the Min and Cor subzones, the upper sandstone member of the Winna Formation as well as the pyrite-bearing and sideritic claystone member, the dolomite member and the lowermost part of the Dąbrowa Limestone Member are dated to the Pro Subzone. The upper part of the Dąbrowa Limestone Member and bioturbated dolomite member can be correlated to the Vel Subzone.

2. There are no differences in the taxonomic composition of miospore assemblages characterizing particular zones and subzones between the Łysogóry and Kielce regions. The older assemblages are strongly dominated by apiculate spores, representing the Rhyniophyta, Trimerophyta and Pteridophyta. In the younger assemblages the number of pseudomonosaccate spores increases, which are the first representatives of the Progymnospermophyta.

3. Four conodont zones have been distinguished in the Emsian/Eifelian boundary interval of the Grzegorzowice Formation in the Łysogóry region: two in the upper Emsian – the *serotinus* and *patulus* zones, and two in the lower Eifelian – the *partitus* and *costatus* zones. In the Kielce region the *patulus* Zone have been recognized in the upper Emsian and the *partitus* Zone in the lowermost Eifelian.

4. The co-occurrence of miospore subzones and conodont zones was documented in the following lithostratigraphic units: the upper part of the Bukowa Góra Claystone Member and the Wydryszów Limestone Member (Pro Subzone and *patulus* Zone) and the Dąbrowa Limestone Member (Vel Subzone and *partitus* Zone).

5. The Emsian and lower Eifelian succession of the Łysogóry region contains three main ostracod assemblages: the oldest within the middle Emsian, the second in the upper part of the *serotinus* Zone and in the *patulus* Zone and the youngest in the *partitus* Zone and in the lower part of the *costatus* Zone. In the Kielce region, two ostracod assemblages have been identified in the Emsian/Eifelian boundary interval, in the *patulus* and *partitus* zones. In both regions the upper Emsian and lower Eifelian ostracod assemblages are characterized by high taxonomic similarity.

6. Within the upper Emsian in the upper part of the *serotinus* Zone and in the *patulus* Zone of the Łysogóry region occurs a rich and diverse assemblage of agglutinated foraminifers with minor calcareous foraminifers. In the Kielce region, agglutinated foraminifers have been documented in the pyrite-bearing and sideritic claystone member of the upper Emsian in the *patulus* Zone and in the lower Eifelian Dąbrowa Limestone Member. In both regions, lower Eifelian carbonates are characterized by the presence of an abundant but low-diversity foraminifer assemblage comprising mainly multicellular, convex shells of *Webbinelloidea similis* Stewart et Lampe.

7. Joint analysis of palynological and microfaunal data show that the Pragian/Emsian boundary lies within the lower part of the Barcza Formation in the Łysogóry region and in the lower part of the Haliszka Formation in the Kielce region. The Emsian/Eifelian boundary in the Łysogóry region lies in the upper part of the Grzegorzowie Formation, in the lower part of the Dąbrowa Limestone Member and Zachełmie Mudstone and Sandstone Member. In turn, in the Kielce region, this boundary is located in several different lithological units related to different contemoporary facies realms in this region: in the upper part of the mudstone member and in the upper part of the upper sandstone member of the Winna Formation, just as in the pyrite-bearing and sideritic claystones member, in the dolomite member and in the lower part of the Dąbrowa Limestone Member.

8. Pyroclastic horizons T1–T4 described in the Lower Devonian of the Kielce region by Tarnowska (1999) are correlated with the following palynological zones and subzones: T1 with the Su Subzone, T2 with the AB Zone, T3 and T4 within the Cor and Pro subzones of the AP Zone.

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APPENDIX

Listing of spores encountered in the upper Pragian–lower Eifelian deposits of the Holy Cross Mountains

Acanthotriletes polygamus Naumova
Acanthotriletes similaris Kedo
Acanthotriletes teniuspinosus Naumova
Acanthotriletes sp.
Acinosporites acanthomammillatus Richardson
Acinosporites apiculatus (Streel) Streel
Acinosporites bellus (Arkhangelskaya) Steemans
Acinosporites crassus Riegel
Acinosporites lanceolatus Streel (Fig. 4A)
Acinosporites lindlarensis Riegel
Acinosporites lindlarensis Riegel var. *lindlarensis* McGregor et Camfield (Fig. 4B)
Acinosporites lindlarensis var. *minor* Riegel
Acinosporites macrospinosus Richardson
Acinosporites műnstereifelensis (Franke) Streel
Acinosporites obnubilus Turnau
Acinosporites sp.
Amicosporites cf. *infraornatus* Rodriguez
Amicosporites jonkeri (Riegel) Steemans (Fig. 7E)
Amicosporites cf. *lobatus* (Rodriguez) Steemans
Amicosporites streeli Steemans (Fig. 7F)
Amicosporites sp.
Anapiculatisporites acerosus (Naumova) Lanninger
Anapiculatisporites echinatus (Hoffmeister, Staplin et Malloy) Lanninger
Anapiculatisporites petilus Richardson
Anapiculatisporites sp.
Anaplanisporites extremus McGregor et Camfield
Ancyrospora ancyrea var. *ancyrea* Richardson
Ancyrospora eurypterota Riegel
Ancyrospora kedoae (Riegel) Turnau (Fig. 8H)
Ancyrospora loganii McGregor (Fig. 8I)
Ancyrospora nettersheimensis Riegel
Ancyrospora sp.
Aneurospora sp.
Apiculatisporis erinaceus (Waltz) Moreau-Benoit
Apiculatisporis microconus Richardson
Apiculatisporites perpusillus (Naumova) McGregor
Apiculatisporites sp.
Apiculiretusispora arenorugosa McGregor (Fig. 3A)
Apiculiretusispora brandtii Streel (Fig. 3B)
Apiculiretusispora densicoronata Tiwari et Schaarschmidt
Apiculiretusispora leberidos McGregor et Camfield
Apiculiretusispora minor McGregor
Apiculiretusispora plicata (Allen) Streel (Fig. 3C)
Apiculiretusispora sp.
Archeozonotriletes sp.
Breconisporites breconensis Richardson, Streel, Hassan et Steemans
Breconisporites sp.
Brochotriletes bellatulus Steemans (Fig. 4F)
Brochotriletes foveolatus Naumova (Fig. 4G)

Brochotriletes hudsonii McGregor et Camfield (Fig. 4H)
Brochotriletes rarus Arkhangelskaya
Brochotriletes robustus (Scott et Rouse) McGregor
Brochotriletes sp.
Calamospora atava (Naumova) McGregor
Calamospora microrugosa (Ibrahim) Schopf, Wilson et Bentall
Calamospora microrugosa (Ibrahim) Schopf, Wilson et Bentall var. *minor* Moreau-Benoit
Calamospora nigrata (Naumova) Allen
Calamospora pannucea Richardson
Calamospora sp.
Calyptosporites biornatus (Lanninger) Richardson (Fig. 8A)
Calyptosporites decorus Tiwari et Schaarschmidt
Calyptosporites heisdorfensis Riegel (Fig. 8B)
Calyptosporites radiatus Riegel (Fig. 8C)
Calyptosporites sp.
Camarazonotriletes sextantii McGregor et Camfield
Camptozonotriletes aliquantus Allen (Fig. 7J)
Camptozonotriletes caperatus McGregor (Fig. 7K)
Camptozonotriletes sp.
Chelinospora concinna Allen
Chelinospora cf. *favosa* (McGregor et Camfield) Steemans (Fig. 7B)
Chelinospora retorida Turnau
Chelinospora sp.
Cirratriradites variverrucatus McGregor
Cirratriradites sp.
Clivosispora verrucata var. *convoluta* McGregor
Clivosispora verrucata var. *verrucata* McGregor
Clivosispora sp. (Fig. 7G)
Convolutispora cerebra Butterworth et Williams
Coronaspora mariae Rodriguez (Fig. 7D)
Coronaspsora sp.
Corystisporites sp.
Cymbosporites fuscus Turnau
Cymbosporites paulus McGregor et Camfield
Cymbosporites proteus McGregor et Camfield
Cymbosporites cf. *senex* McGregor et Camfield
Cymbosporites yorkensis McGregor
Cymbosporites sp.
Densosporites sp.
Dibolisporites antiquus (Kedo) Arkhangelskaya
Dibolisporites apsogus (Tchibrikova) Tchibrikova
Dibolisporites bullatus (Allen) Richardson
Dibolisporites capitellatus (Tchibrikova) Arkhangelskaya
Dibolisporites conoides Moreau-Benoit
Dibolisporites echinaceus (Eisenack) Richardson emend. McGregor
Dibolisporites eifeliensis (Lanninger) McGregor (Fig. 3D)
Dibolisporites gibberosus (Naumova) var. *major* (Kedo) Richardson
Dibolisporites jakubowskae Fijałkowska-Mader
Dibolisporites nodosus Turnau
Dibolisporites pseudoreticulatus Tiwari et Schaarschmidt
Dibolisporites quebecensis McGregor
Dibolisporites radiatus Tiwari et Schaarschmidt
Dibolisporites rarispinosus Fijałkowska-Mader
Dibolisporites subgibberosus (Naumova) Turnau
Dibolisporites cf. *triangulatus* Tiwari et Schaarschmidt
Dibolisporites verrucosus (Kedo) comb. nov. (Fig. 3E)
Dibolisporites wetteldorfensis Lanninger (Fig. 3F)
Dibolisporites sp.
Dictyotriletes delicatus sp. nov. (Fig. 4C)
Dictyotriletes emsiensis (Allen) McGregor (Fig. 4D)
Dictyotriletes favosus McGregor et Camfield
Dictyotriletes cf. *grandis* Lanniger
Dictyotriletes minor Naumova
Dictyotriletes nigratus Naumova
Dictyotriletes subgranifer McGregor (Fig. 4E)
Dictyotriletes sp.
Emphanisporites annulatus McGregor (Fig. 4I)
Emphanisporites decoratus Allen
Emphanisporites epicautus Richardson et Lister
Emphanisporites erraticus (Eisenack) McGregor
Emphanisporites foveolatus Schultz (Fig. 4J)
Emphanisporites mcgregori Cramer
Emphanisporites micrornatus Richardson et Lister
Emphanisporites micrornatus Richardson et Lister f. *micrornatus* Steemans et Gerrinne
Emphanisporites minutus Allen
Emphanisporites neglectus Vigran
Emphanisporites novellus McGregor et Camfield
Emphanisporites obscurus McGregor
Emphanisporites orbicularis Turnau
Emphanisporites partitus Lanninger
Emphansporites patagiatus Allen
Emphanisporites pseudoerraticus Schultz
Emphanisporites radiatus (Schultz) Jakubowska (Fig. 4K)
Emphanisporites rotatus (McGregor) McGregor
Emphanisporites schultzii McGregor (Fig. 4L)
Emphanisporites sp.
Enigmophytospora simplex Virgan
Enigmophytospora sp.
aff. *Foveolatitriletes* sp.
Grandispora aculeata Fuglewicz et Prejbisz
Grandispora arduinnae (Riegel) Knight
Grandispora diamphida Allen
Grandispora douglastownense McGregor (Fig. 8D)
Grandispora cf. *endemica* (Tchibrikova) Tchibrikova (Fig. 8E)
Grandispora eximia (Allen) McGregor et Camfield
Grandispora inculta Allen
Grandispora macrotuberculata (Archangelskaya) McGregor
Grandispora megaformis (Richardson) McGregor
Grandispora micronata Tiwari et Schaarschmidt
Grandispora naumovii (Kedo) McGregor
Grandispora protea (Naumova) Moreau-Benoit (Fig. 8F)
Grandispora sanctaecruciensis Fijałkowska-Mader
Grandispora velata (Eisenack) Playford (Fig. 8G)
Grandispora sp.
Granulatisporites sp.
Hystricosporites brevispinosus sp. nov. (Fig. 3G)
Hystricosporites corystus Richardson (Fig. 3H)
Hystricosporites gravis Owens
Hystricosporites microancyreus Riegel
Hystricosporites mitratus Allen (Fig. 3I)
Hystricosporites porrectus (Balme et Hassel) Allen
Hystricosporites sp.
Iberospora sp.
Kraeuselisporites gaspensis McGregor (Fig. 7H)
Kraeuselisporites sp.
Leiotriletes adnatoides Potonié et Kremp
Leiotriletes marginalis McGregor
Leiotriletes microrugosus (Ibrahim) Naumova
Leiotriletes minutissimus Naumova
Leiotriletes ornatus Ischenko
Leiotriletes pagius Allen
Leiotriletes priddyi Potonié et Kremp
Leiotriletes rotundus Naumova
Leiotriletes simplex Naumova
Leiotriletes sphaerotriangulus (Losse) Potonié et Kremp
Leiotriletes tecta Moreau-Benoit
Leiotriletes sp.
Lycopodiacidites ogygius McGregor
Membrabaculisporis cf. *radiatus* (Naumova) Arkhangelskaya (Fig.7I)
Oculatisporites mirandus Arkhangelskaya (Fig. 7L)
Perotrilites sp.
Procoronaspora spinulosa Turnau et Jakubowska

Procoronaspora sp.
Punctatisporites confussus Richardson
Punctatisporites sp.
Retusotriletes actinomorphus Tschibrikova
Retusotriletes biarealis McGregor
Retusotriletes communis Naumova
Retusotriletes concinuus Kedo
Retusotriletes dilutus (Hoffmeister) Richardson et Lister
Retusotriletes distinctus Richardson
Retusotriletes dubiosus (Eisenack) Richardson emend. McGregor
Retusotriletes goensis Lele et Streel
Retusotriletes greggsi McGregor
Retusotriletes infrapunctatus Schultz
Retusotriletes maculatus McGregor et Camfield
Retusotriletes microgranulatus (Vigran) Streel
Retusotriletes ocellatus McGregor
Retusotriletes opuleus Turnau
Retusotriletes pychovii Naumova
Retusotriletes pychovii Naumova var. *major* Naumova
Retusotriletes rotundus (Streel) Streel
Retusotriletes rugulatus Riegel
Retusotriletes semizonalis McGregor
Retusotriletes simplex Naumova
Retusotriletes cf. *tenerimedium* Tchibrikova
Retusotriletes triangulatus (Streel) Streel
Retusotriletes warringtoni Richardson et Lister
Retusotriletes sp.
Rhabdosporites langii (Eisenack) Richardson
Rhabdosporites cf. *parvulus* Richardson
Rhabdosporites cf. *scamnus* Allen
Rhabdosporites sp.
Rugulatisporites sp.
Samarisporites rhenanus Riegel
Samarisporites sp.
Sinuosisporites sp.
Stenozonotriletes furtivus Allen
Stenozonotriletes incessus Allen
Stenozonotriletes irregularis Schultz (Fig. 7C)
Stenozonotriletes minimus McGregor et Camfield
Stenozonotriletes simplex Naumova
Stenozonotriletes sp.
Tholisporites chulus (Cramer) McGregor var. *chulus* Richardson et Lister (Fig. 7A)
Tholisporites divellomedium (Tchibrikova) Turnau
Tholisporites salantaicus (Arkhangelskaya) Turnau
Tholisporites sp.
Verrucosisporites grumosus (Naumova) Taug
Verrucosisporites polygonalis Lanninger
Verrucosisporites rariverrucosus sp. nov. (Fig. 3J)
Verrucosisporites sp.
Verruciretusispora dubia (Eisenack) Richardson et Rasul (Fig. 3K)
Verruciretusispora dubia (Eisenack) Richardson et Rasul var. *multitubrculata* var. nov.
Verruciretusispora sp.