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MIOSPORE TAXONOMY AND STRATIGRAPHY OF UPPER DEVONIAN AND LOWERMOST CARBONIFEROUS IN WESTERN POMERANIA (NW POLAND)

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Abstract: Five local miospore zones, six subzones and two assemblages are distinguished for the Frasnian to lower Tournaisian deposits in the Kołobrzeg region (western Pomerania): assemblage I, *Membrabaculisporis radiatus-Tholisporites densus* (RD), *Membrabaculisporis radiatus-Cymbosporites boafeticus* (RB), *Lagenoisporites immensus-Diducites poljessicus* (IP) Zone, assemblage II, *Tumulispora rarituberculata* (Ra) and *Convolutispora major* (Ma) Zone. The first three biozones and the two assemblages are new in this region. The local miospores zones distinguished in western Pomerania are correlated with the European standard miospore and conodont zonations. Two new miospore species and one new variety are described, two species is emended.

Key words: Frasnian, Famennian, lowermost Carboniferous, NW Poland, miospores, stratigraphy.

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INTRODUCTION

The main purpose of this study was to determine, using palynological methods, the stratigraphical position of the Człuchów, Kłanino, Sąpolno Calcareous Shale, and Gozd Arkose formations of western Pomerania. The zones of the miospore zonal scheme for Famennian and Lower Carboniferous of that area established by Turnau (1978, 1979) are rather wide. The present studies have allowed to establish a provisional zonation for the Frasnian and lower part of the Famennian, and to subdivide some of the previously erected zones. The studied borehole sections are dated on conodonts, which permits to define the boundaries of the miospore zones in terms of the "standard" conodont zonation. The preliminary results of my studies, concerning the upper Famennian and lowermost Carboniferous have been published in the paper by Matyja & Stempień-Sałek (1994), and those on the Frasnian and lowermost Famennian are summarised in Stempień-Sałek (2000).

The palynological material on which this work is based is derived from the Strzeżewo 1, Gorzysław 8, Gorzysław 9, Gorzysław 11, Gorzysław 14 and Karcino 2 boreholes drilled in the area near Kołobrzeg, and from Chmielno 1 and Rzeczenica 1 boreholes from the area to south-east from Kołobrzeg (Fig. 1).

PREVIOUS PALYNOLOGICAL STUDIES OF UPPER DEVONIAN AND LOWER CARBONIFEROUS OF WESTERN POMERANIA

The earliest results of palynological studies concerning the Devonian–Carboniferous succession of western Pomerania were published in the seventies of the twenty century. The evolution of palynostratigraphical divisions of the Upper Devonian–lowermost Carboniferous is shown in figure 2. The first account of the Carboniferous miospore assemblages from the study area was that by Krawczyńska-Grocholska (1975), who included the deposits from the Sarbinowo 1 borehole in the Namurian and Westphalian. Subsequently, the strata included by this author in the Namurian were assigned by Turnau (1979) to the Visean. Turnau (1975, 1978, 1979) studied miospore assemblages from more than thirty borehole sections and proposed a miospore zonal scheme including eleven zones, five for the Famennian, two for the Tournaisian, three for the VisJan and one for the Westphalian. The youngest Tournaisian zone of this scheme, i.e. the *Prolycospora claytonii* (Cl) Zone was divided into three subzones. Avkhimovitch & Turnau (1994) revised that division, distinguishing only two subzones, and presented a new proposal of palynological correlation of the

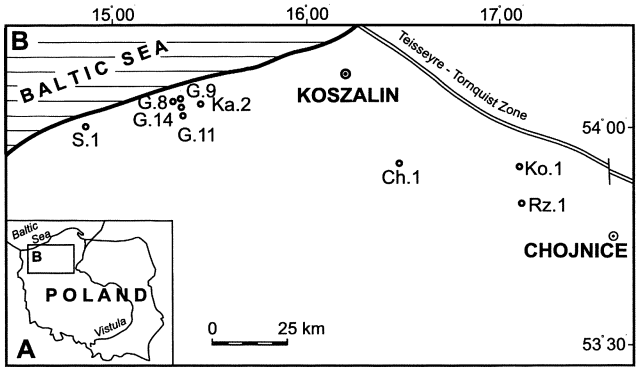


Fig. 1 Position of western Pomerania (**A**) and location of studied boreholes (**B**): S.1 – Strzeżewo 1, G.8 – Gorzysław 8, G.9 – Gorzysław 9, G.11 – Gorzysław 11, G.14 – Gorzysław 14, Ka. 2 – Karcino 2, Ch.1 – Chojnice 1, Ko.1 – Koczała 1, Rz.1 – Rzeczenica 1

lower zonal boundary (Fig. 2). The present author (in Matyja & Stempień-Sałek, 1994) upgraded the scheme proposed by Turnau (1978, 1979) introducing two subzones of the *Tumulispora rarituberculata* (Ra) Zone, and four of the *Convolutispora major* (Ma) Zone (Fig. 2). This subdivision allows a more precise correlation of the local scheme with that for northwestern Europe (Higgs *et al.*, 1988).

Other contributions to the miospore stratigraphy of the upper Famennian and Carboniferous of the study area are those by Górecka & Parka (1980), and Kmiecik (1991, 1995). The former authors included in the Westphalian the deposits from the Koszalin IG 1 borehole assigned by Turnau (1979) to the Viséan. The latter author studied some upper Famennian to Stephanian deposits, and distinguished 8 miospore zones of the northwestern European scheme. This results are not shown in figure 2 as they were published in a brief conference abstract, without photographic documentation and species range charts.

In sum the miospore stratigraphic scheme in western Pomerania for the Devonian and Carboniferous, includes more than ten zones distinguished for the Famennian to Stephanian (Turnau, 1978, 1979; Kmiecik, 1986). Some of the zones, however, are very wide, especially those for the Famennian. The Frasnian in Pomerania has not been, till now, studied by palynologists.

The problem of the presence and extent of the stratigraphic gap at the Devonian–Carboniferous boundary has been the concern of biostratigraphers for a long time. Varying opinions on this matter are illustrated in figure 2. The presence of a gap was first suggested by Turnau (1978), and it was discussed, in the terms of miospore zonations, in Clayton & Turnau (1990) and Avkhimovitch *et al.* (1993a). The extent of the gap was first defined in terms of the conodont zonation in Matyja & Turnau (1989), it was also discussed in Matyja & Stempień-Sałek (1994) and Matyja *et al.* (2000). In Matyja & Stempień-Sałek paper, the present author suggested that the upper extent of the gap coincides with the lower boundary of the *Krauselisporites hibernicus-Umbonatisporites distinctus* (HD) Zone of the division of Higgs *et al.* (1988). Previously, it was considered that the gap ends slightly below (Clayton & Turnau, 1990), or slightly above (Avkhimovitch *et al.*, 1993a) this level.

MATERIAL AND METHODS

The palynological samples were black, dark grey and grey shales, claystones and mudstones some of which were intercalations within carbonates. Standard laboratory methods were employed. Samples were crushed and immersed in hydrochloric acid to remove carbonates. Subsequently, the mineral matter was dissolved in hydrofluoric acid, and the organic residues were oxidated using fuming nitric acid. This was followed by heavy liquid flotation using solution of cadmium-jodate + potassium-jodate of specific weight 2.2 g/cm^3. Slides were prepared using elvacite or glycerine gelly. The number of the samples processed was 125, and 83 of these contained determinable spores. Two hundred sixty five slides were prepared.

GEOLOGICAL BACKGROUND

GEOLOGICAL SITUATION

Western Pomerania is dissected by the Teisseyre tectonic zone called within its Polish part the Teisseyre–Tornquist zone (Dadlez, 1990, 1993; see also Fig. 1). The zone forms also the south-eastern limit of the East European Platform. The Teisseyre–Tornquist zone is characterized by high mobility expressed by high rate of sedimentation, errosion and tectonics. In the younger Palaeozoic, these processes increased gradually and rhythmically from the Late Devonian up to the Late Carboniferous (Dadlez, 1978).

In western Pomerania, the Devonian–Carboniferous succession rests unconformably on the Ordovician and Silurian graptolite shales strongly folded due to the Caledonian orogeny. In the region of Kołobrzeg the Devonian rests on steeply deeping Caradocian shales (Dadlez, 1993). The Caledonian deformation in that area may be due to the oblique collision of small crustal blocks, related to the Baltica or Gondwana, with the East European craton (Dadlez, 1993). None of the boreholes studied reaches this older Palaeozoic substratum.

Sedimentation of the Devonian–Carboniferous cycle started probably in Early Devonian (Dadlez, 1978, 1990, 1993), and not later than the Eifelian (Łobanowski, 1968; Pajchlowa, 1968; Turnau, 1995), covering different units of the Silurian (Teller, 1974), and Ordovician (Bednarczyk, 1974). The Devonian deposits are developed in various facies. Generally, those older than the Upper Devonian are mostly siliciclastic rocks (Dadlez, 1978). In Late Devonian, or at the close of the Givetian, the discussed area was invaded by marine transgression leaving clastic and carbonate sediments. The next widening of the marine basin took place in the early Famennian, and regressive tendencies reigned during the late Famennian (Dadlez, 1993). The Carboniferous deposits, resting concordantly on the Devonian vary both vertically and laterally in facies development. They are represented by three main types of sediments. Starting from the oldest, they are clayey shales, arkosic sandstones and various limestones (marly, oolitic, dolomitic and other). Vertical displacements (the diastrophic movements toward the close of the Early Carboniferous) caused

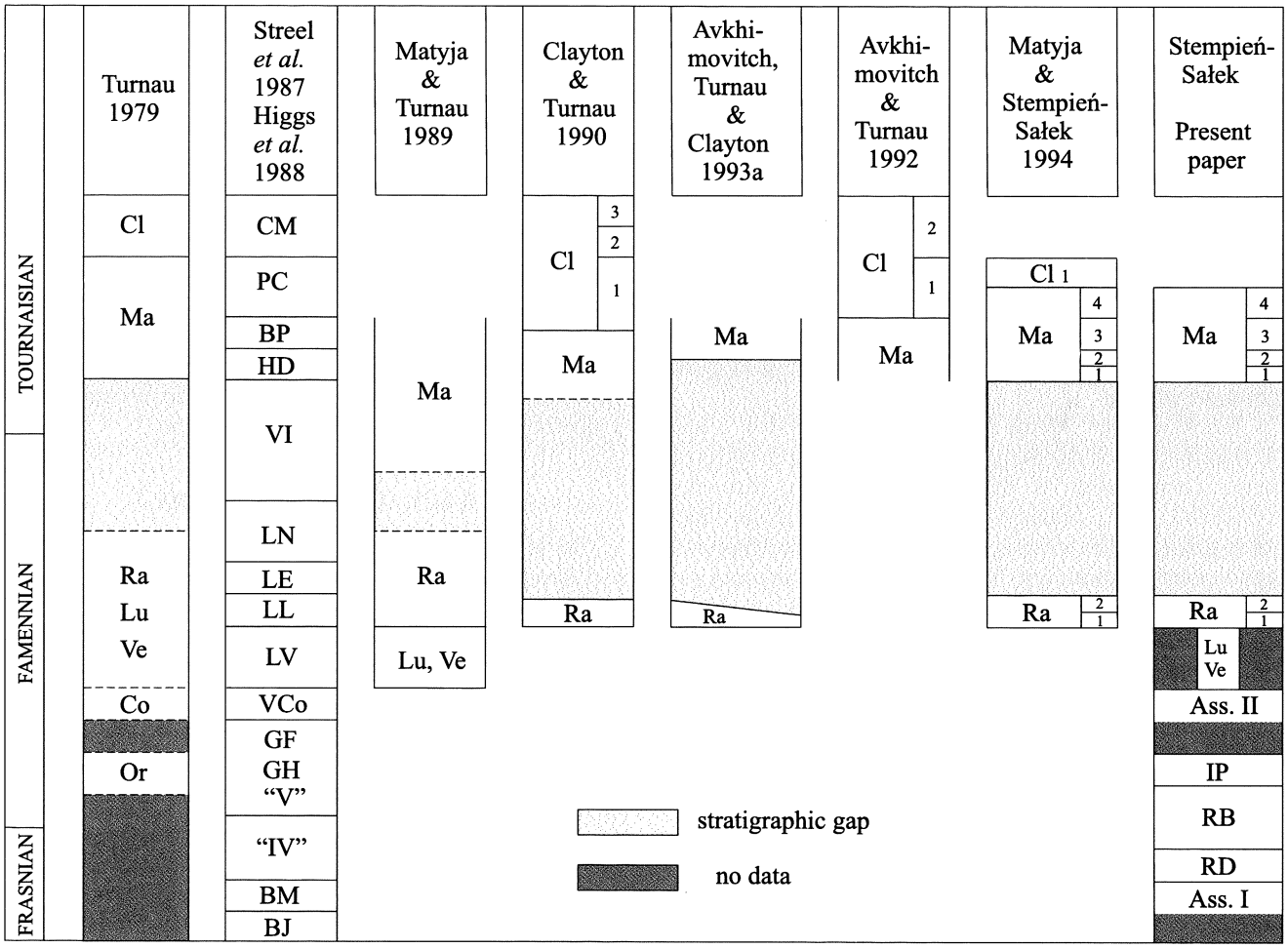


Fig. 2. Evolution of palynostratigraphical divisions of the Upper Devonian–lowermost Carboniferous in western Pomerania

the regional absence of the Namurian and Westphalian and the variable truncation of the Lower Carboniferous sediments. The Upper Carboniferous grey limnic sediments of coal-bearing association pass upwards into clastic sediments of red-bed association. The thickness of the Lower Carboniferous is at least 1500 m (Dadlez, 1993) or about 1300 m (Żelichowski, 1983, 1987).

Starting from the Late Devonian, there was a gradual and rhythmical intensification of erosional processes and tectonic movements. The main phases of these processes took place (1) at the beginning of the Carboniferous, and (2) at the end of the Early and the beginning of the Late Carboniferous. The main structural reorganisation and strongest erosion of the Devonian–Carboniferous succession took place at the Carboniferous–Permian transition, after the block movements in the area. Due to these movements, the discussed region is divided into tectonic blocks of various sizes, one of which is the Kołobrzeg block (Dadlez, 1990, 1993). The erosion removed, first of all, the Upper Carboniferous deposits, subsequently, to a lesser extent, the Lower Carboniferous ones. The Devonian deposits are still less affected, but erosion has reached in places the Middle Devonian (Dadlez, 1978). The Devonian–Carboniferous succession of complicated structure is overlain discordantly by red, clastic deposits of the Lower Permian, Zechstein clastic-carbonate-evaporitic rocks, and the Mesozoic successions.

LITHOSTRATIGRAPHY

The first, informal lithostratigraphic division of the Devonian–Carboniferous succession of western Pomerania was proposed by Dadlez (1978) who distinguished several lithostratigraphic units called complexes and sub-complexes. The division by Dadlez was subsequently modified and complemented by Miłaczewski (1979, 1980, 1986, 1987), Żelichowski (1983, 1987), and Matyja (1993) who distinguished in the Upper Devonian sequence five (informal) formations and four members. Most of these formations correspond to the "complexes" of Dadlez (1978), and have the same names, but the members are new units. Recently, Lipiec (Lipiec & Matyja, 1998) introduced a lithostratigraphic scheme for the Lower Carboniferous. It includes seven formations and two members.

The lithostratigraphic division adopted in this paper (Figs 3 and 4) is that by Matyja (1993, 1998) and Lipiec & Matyja (1998).

In Człuchów Formation (boreholes: Strzeżewo 1, Gorzysław 8, Gorzysław 11 and Gorzysław 14) Matyja (1993) distinguished five members, namely the Unisław, Strze-

żewo, Gorzysław, Bielica, and Gościno members. The Unisław and Gościno members are not represented in the boreholes studied (Fig. 3). The thicknes of the Człuchów Formation in this region varies from 400 m trough 700 m.

The Strzeżewo Member, lowest of the investigated units, has been pierced in the Strzeżewo 1, and Gorzysław 8, 11, 14 boreholes. The unit includes monotonous, thin bedded, almost black bituminous shales and marly shales and subordinate micritic, more or less marly, limestones. The shales include pyrite aggregates and rare fossils characteristic mainly of pelagic environment, such as entomozoacean ostracods and tentaculitids. Plant detritus and land plant spores are present.

The Gorzysław Member (boreholes Gorzysław 8 and 14, Karcino 2) includes mainly grey marls and nodular limestones. Contribution of shales in this unit is distinctly smaller than in the underlying member. The nodular limestones often contain crinoid debris, articulate brachiopods, agglutinated foraminifers, benthic and entomozoacean ostracods as well as cephalopods, tentaculitids and conodonts. In some sections, crinoid-bryozoan wackestone with rare coral debris and chaetetid fragments are present. Thin shale partings are rich in miospores and acritarchs.

The Bielica Member (borehole Gorzysław 8) includes light micritic limestones with accumulations of bryozoan debris, brachiopods, ostracods, and crinoids, as well as massive micritic limestones with dispersed crinoid detritus, bryozoans, coral colonies, less commonly with stromatoporoids, algae, conodonts and miospores.

In the region of Kołobrzeg, the Kłanino Formation (boreholes Gorzysław 8 and 9) is typified by predominance of carbonates, mainly laminated, sandy grainstones with algae, foraminifers, gastropods, ostracods, crinoidal detritus, conodonts and miospores, and dasycladacean grainstones with intraclasts and almost devoid of organic remains. The thickness of the Kłanino Formation in the region of Kołobrzeg is 150 m.

The Sąpolno Calcareous Shale Formation (boreholes: Gorzysław 8 and 9, Karcino 2, Rzeczenica 1 and Chmielno 1) includes the uppermost Devonian and lowermost Carboniferous deposits. Grey, marly limestones and marls prevail within the lower, Devonian part of the formation. They contain abundant fossils of which the most important are foraminifers, ostracods, stromatoporoids, crinoids, brachiopods, conodonts and miospores (Matyja & Stempień-Sałek, 1994), also acritarchs (Stempień-Sałek, 1996). Such deposits are characteristic for shallow environment of marly-carbonate ramp developed below the wave base level but within the photic zone (Matyja, 1998). The younger, Carboniferous part of the formation includes mainly dark grey and black, finely laminated claystones, calcareous claystones, marls and limestones (Lipiec & Matyja, 1998; Matyja *et al.*, 2000) containing abundant spores and infrequent acritarchs. Fauna is rare. The thickness of the Carboniferous part of the Sąpolno Calcareous Shale Formation may exceed 300 m.

The Devonian–Carboniferous system boundary lies within this formation. This is a hidden stratigraphic gap. Its extent defined in the terms of the conodont zonation is from middle *praesulcata* to part of *sandbergi* zones (Fig. 4). The boundary runs within a bed of black claystone and is not marked by any characteristic sedimentary features (Matyja 1993, 1998; Matyja & Stempień-Sałek, 1994).

The Lower Carboniferous Gozd Arkose Formation, the deposits of which have been pierced in the Chmielno 1 borehole, includes mainly clastic rocks. As a rule, the base of the formation is placed at the base of the first bed of arkosic sandstone. Various sandstones of grey colour, arkosic sandstones including pyroclastic material, dark grey mudstones and black claystones are common. Thin beds of shale, claystone and oolitic limestone occur subordinately. They contain rare foraminifers, crinoids, brachiopods, conodonts, miospores and acritarchs. The present paper concerns only the basal part of the formation.

FAUNAL STRATIGRAPHY

In western Pomerania, the rocks of the Devonian–Carboniferous succession contain diverse fossils that make dating of these sediments possible. Ammonoids are rare and accordingly the ammonoid stages have not been distinguished. Biostratigraphy is based on conodonts, brachiopods, entomozoids, and miospores. In the following text, the author gives the borehole names only if they are concerned in the present paper (Fig. 1). Unless otherwise stated, all conodont data given below are after Matyja (1993) and Matyja *et al.* (2000).

The Człuchów Formation is dated on conodonts (Figs 3, 4), entomozoacean ostracods and brachiopods. The oldest part of the Strzeżewo Member is dated as the conodont *punctata* Zone, and the top part as the Middle *triangularis* Subzone. In the region of Kołobrzeg, conodonts indicative of the Upper *hassi, jameiae*, or Lower *rhenana* zones/subzones have been found within this member (Figs 3, 4; boreholes Strzeżewo 1 and Gorzysław 8, 11). The overlying Gorzysław Member is dated in the Kołobrzeg region as the Upper *triangularis* and *crepida* zones (Figs 3, 4; boreholes Gorzysław 8, 14 and Karcino 2). In other regions of Pomerania, the lower part of the Gorzysław Member is dated as Middle *triangularis* Subzone, and its top part as the Upper *rhomboidea* Subzone. In the higher part of the Bielica Member, in the region of Kołobrzeg, there occur conodonts of the *marginifera* Zone (Figs 3, 4; borehole Gorzysław 8). In other parts of Pomerania, the Lower and the Upper *marginifera* subzones have been distinguished within this member. Entomozoacean ostracods have been recorded from the Człuchów Formation by Żbikowska (1992). In the Strzeżewo Member, this author distinguished the *cicatricosa* Zone (the boreholes Gorzysław 8 and 11), the *sarteńaeri* Zone (the borehole Gorzysław 8) and the *serratostriata-nehdensis* Zone (the boreholes Gorzysław 8, 11 and Koczała 1). In the Gorzysław Member, the zones *sartenaeri* and *sigmoidale* have been distinguished. Brachiopods from the Człuchów Formation have also been determined. Matyja (1972) recorded several Devonian and Famennian species from the Bielica Member.

The Kłanino Formation is, in the region of Kołobrzeg, dated by means of conodonts as upper Famennian *expansa* Zone (Figs 3, 4). No other fauna has been recorded here. In other regions of Pomerania, the dating is more precise. The

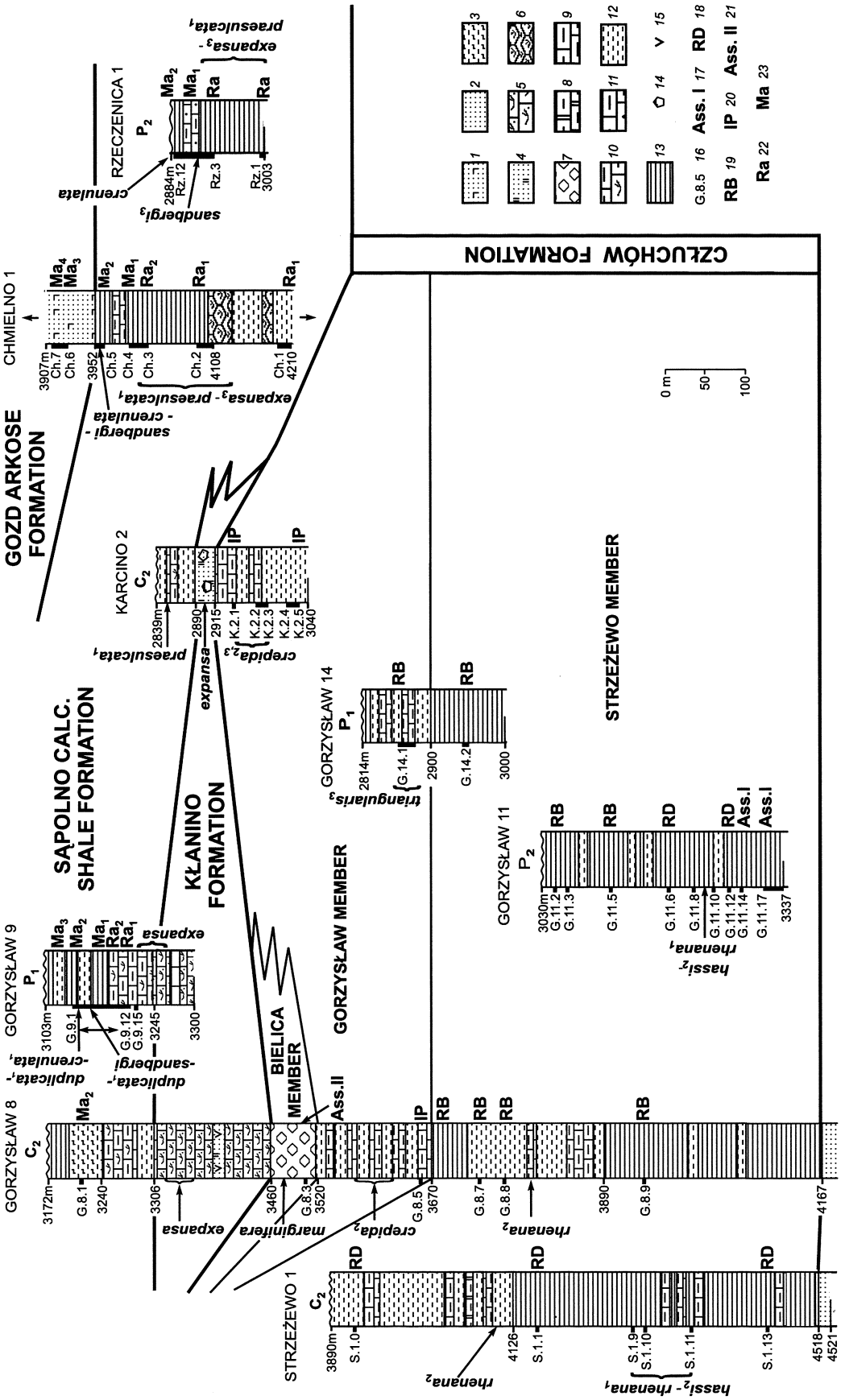


Fig. 3. Lithology, lithostratigraphy and stratigraphic biozonation (conodont and palynological zones) of studied boreholes. *1* – arcosic sandstone, *2* – fine-grained quartz sandstone, *3* – mudstone, *4* – dolomitic sandstone, *5* – algal-foraminiferal-peloidal grainstone, *6* – nodular algal-foraminiferal-crinoid, packstone/grainstone, *7* – massive micritic limestone, *8* – marly dolomite, *9* – marly limestone, *10* – marly algal wackestone to packstone, *11* – marly brachiopod-crinoid wackestone, *12* – marl, *13* – marly shale, *14* – conglomerate, *15* – anhydrite nodules, *16* – palynological sample, *17* – Assemblage I, *18* – **RD** – *Membrabaculisporis radiatus - Tholisporites densus* Zone, *19* – **RB** – *Membrabaculisporis radiatus - Cymbosporites boafeticus* Zone, *20* – **IP** – *Lagenoisporites immensus - Diducites poljessicus* Zone, *21* – Assemblage II, *22* – **Ra** – *Tumulispora rarituberculata* zone, *23* – **Ma** – *Convolutispora major* zone

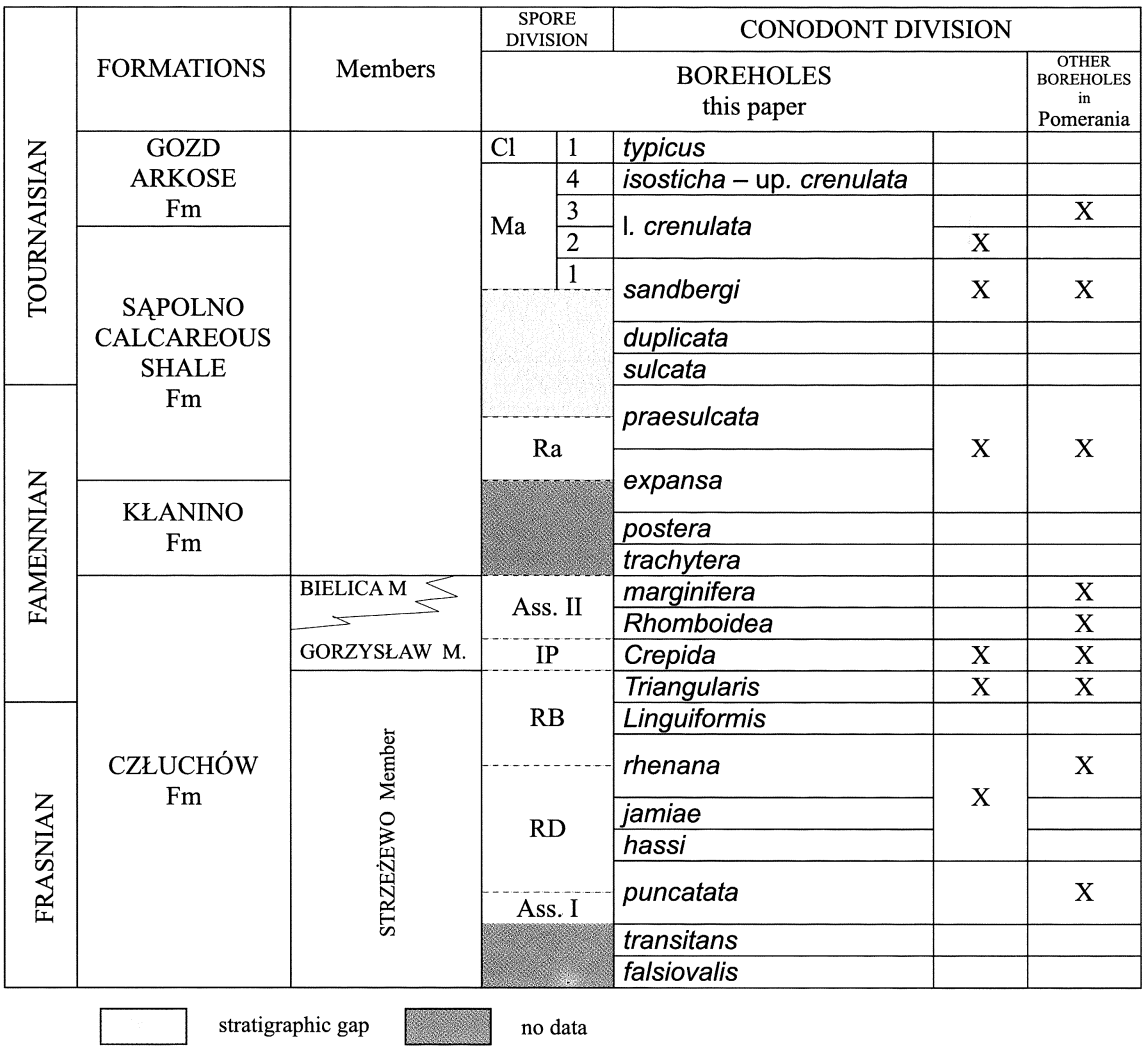


Fig. 4. Generalized lithostratigraphy and biostratygraphy of Upper Devonian–lowermost Carboniferous in Western Pomerania

lower part of the formation corresponds to the Lower *expansa* Zone, though the basal part may belong to the *marginifera* Zone (Matyja, 1993). The top part of the formation is not younger than the Middle *expansa* Zone.

The stratigraphic position of the Sąpolno Calcareous Shale Formation that belongs to the Famennian and Hastarian has been established on goniatites, brachiopods, conodonts, ostracods and trilobites. Goniatites are rare. Only Tournaisian *Pseudoarietites dorsoplanus dorsoplanus* Schmidt, *P.* ex gr. *dorsoplanus dorsoplanus* Schmidt, and *Gattenpleura* sp. have been recorded in Wierzchowo 10 borehole, near the Chmielno 1 borehole (Korejwo, 1979, 1993). Brachiopods from the Famennian and Carboniferous part of the Sąpolno Calcareous Shale Formation are described by Matyja (1976) and Korejwo (1993). In the region of Kołobrzeg, the basal part of the Sąpolno Formation is dated on conodonts as *expansa-praesulcata* zones, and the top part as *sandbergi* or Lower *crenulata* Zone (Matyja *et al.*, 2000). In other regions of Pomerania, the dating is more precise – the lower part of the formation corresponds to the Upper *expansa* or Lower *praesulcata* subzones, and the upper to the Lower *crenulata* Subzone. Entomozoids date the Devonian part of the formation as the *hemispherica-dichotoma* Zone (Żbikowska, 1992). Among trilobites, single specimens of *Moschoglossis* sp. indicate the lower and middle Tournaisian (Korejwo, 1976).

The present paper concerns only the basal part of the Gozd Arkose Formation. In this part no conodont faunas have been found. Brachiopods fauna is described by Korejwo (1993). Entomozoids indicate *latior* Entomozoid Zone (Żbikowska, 1992).

PALYNOSTRATIGRAPHY

The miospore assemblages studied contain numerous stratigraphically important species known from the Devonian and the Lower Carboniferous of western and eastern Europe. However, it would have been difficult to adopt one of the zonal schemes for western (Streel *et al.*, 1987; Higgs *et al.*, 1988) or eastern Europe (Avkchimovitch, 1993; Avkhimovitch *et al.*, 1993a) because of quantitative and qualitatite differences between the assemblages studied and those from the regions mentioned.

LOCAL MIOSPORE ZONES / SUBZONES	SELECTED MIOSPORE SPECIES																																													
	Samarisporites triangulatus	*Ancyrospora* sp.	*Cristatisporites deliquescens*	*Corystisporites pomeranius*	*Hystricosporites* sp.	*Archaeoperisaccus oncinnus*	*Convolutispora subtilis*	*Tolisporites densus*	*Membrabaculisporis radiatus*	*Aneurospora greggsii*	*Cymbosporites vetlasjanicus*	*C. boafeticus*	*Corbulispora viminеus*	*Lagenoisporites immensus*	*Diducites poljessicus*	*Grandispora villosa*	*Diducites versabilis*	*Diducites commutatus*	*Spelaeotriletes resolutus*	*Auroraspora macra*	*Retispora macroreticulata*	*Grandispora lupata*	*Retispora lepidophyta*	*Geminospora condensa*	*Knoxisporites literatus*	*Tumulispora malevkensis*	*T. rarituberculata*	*T. obscura*	*Umbonatisporites abstrusus*	*Verrucosisporites nitidus*	*Auroraspora aspella*	*Convolutispora major*	*Cymbosporites acutus*	*Cymbosporites acutus*	*Lophozonotriletes excisus*	*Murospora dubitata*	*Pustulatisporites gibberosus*	*Raistrickia corynoges*	*Crassispora trychera*	*Spelaeotriletes obtusus*	*Schopfites delicatus*	*Umbonatisporites distinctus*	*Spelaeotriletes balteatus*	*S. pretiosus*	*Raistrickia condylosa*	*Prolycospora claytonii*
Cl_1																				X					X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
Ma_4																				X					X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	
Ma_3																				X					X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Ma_2																			X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Ma_1																		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
Ra_2																	X	X	X	X	X	X	X	X	X	X	X	X	X	X																
Ra_1																	X	X	X	X	X	X	X	X	X	X	X	X																		
Ass II					X					X				X	X	X	X	X	X	X																										
IP				X	X					X		X	X	X	X																															
RB		X	X	X	X				X	X	X	X																																		
RD	X	X	X	X	X	X	X	X	X																																					
Ass I	X	X	X	X	X																																									

Fig. 5. Range chart of selected most stratigraphically useful miospore species referred to in the present paper

In the deposits studied, the author distinguished three miospore zones, two assemblages and six subzones (Fig. 2) of the previously established zones in order to extend the previous division and to make it more precise. The five oldest zones/assemblages for the Frasnian and lower Famennian, i.e. the assemblage I, *Membrabaculisporis radiatus-Tholisporites densus* (RD), *Membrabaculisporis radiatus-Cymbosporites boafeticus* (RB), and *Lagenoisporites immensus-Diducites poljessicus* (IP) zones, and assemblage II, have been defined for the first time. The two younger zones – *Tumulispora rarituberculata* (Ra) and *Convolutispora major* (Ma) belong to the zonation scheme proposed by Turnau (1978). The present author introduced six subzones of these zones (Stempień-Sałek, 1994).

The core recovery in the boreholes studied was incomplete, and the lithology of the rocks was often unfavourable for preservation of palynological material. For these reasons, the palynological data obtained are in many cases fragmentary. Nevertheless, the distinguished zones are distinct, and their age inferred from palynological data is, in most cases, confirmed by direct conodont data (after Matyja, 1993), also by some ostracod data (after Żbikowska, 1992).

DESCRIPTION OF ZONES

The zones and assemblages for the Frasnian and lower Famennian of western Pomerania introduced here are of assemblage-zone character. They are not formally defined as the author feels that the number of samples and the diversity of some assemblages are not sufficient, and there are barren intervals of significant thickness between some of the biostratigraphic units. In the following text, the units are described in ascending order.

In this section, names of miospore species are given without the creator's names. The list of complete names is given at the appendix 1. Quantitative and qualitative data from the studied boreholes are given at the appendix 2.

Assemblage I

The miospore associations basal part of the deposits studied are poor in taxa and they lack index species. For this reason they are included in an assemblage, not a zone. The assemblage I was distinguished in the Gorzysław 11 borehole (Figs 1, 3). The lower boundary of the assemblage is not known. The following species are characteristic for this unit: *Ancyrospora fidus*, *A. furcul*, *A. langi*, *Apiculiretusispora nitida*, *Cristatisporites deliquescens*, *Geminospora nalevkinii*, *G. notata*, *G. rugosa*, *Hymenozonotriletes argutus*, *Hystricosporites furcatus*, *H. multifurcatus*, *H. porrectus*, *Perotrilites magnus*, *P. minor*, *Samarisporites acanthyrugosus*, *S. triangulatus* and *Verrucosisporites* cf. *evlanenis* (Fig. 5). These are mostly species of a long stratigraphic range, and there are no stratigraphically important taxa known from the Ardenne–Rhine regions, such as *Verrucosisporites bulliferus*, *Cirratriradites jekhovskii* or *Lophozonotriletes media*. On the other hand, the author recorded the presence of *Cristatisporites deliquescens*, which appears at the base of the eastern European *Geminospora semilucensa-Perotrilites donensis* (SD) Zone (Avkhimovitch *et al.*, 1993b). This indicates that the assemblage I is not older, and probably corresponds, to this zone, or to a part of it. The di-

rect conodont data inddicate that the SD Zone corresponds to the *punctata-hassi* zones. Thus, the base of the assemblage I is not older than the *punctata* Zone (Fig. 4). In the region of Kołobrzeg, the basal part of the Człuchów Formation is not dated on conodonts. In other regions of Pomerania, this part (included in the Unisław Member) corresponds to the *falsiovalis-punctata* zones and the basal part of the overlying Strzeżewo Member is thought to belong to the *punctata* Zone (Matyja, 1998).

***Membrabaculisporis radiatus-Tholisporites densus* (RD) assemblage Zone**

The zone has been distinguished in the Strzeżewo 1 and Gorzysław 11 boreholes (Figs 1, 3). The lower zonal boundary is marked by the first appearance of *Membrabaculisporis radiatus*. Other species appearing close to and above this boundary are *Archaeoperisaccus concinnus*, *Convolutispora subtilis*, *Tholisporites densus*, *Laevigatosporites ovalis* and *Aneurospora greggsii*. Species *A. concinnus*, *C. subtilis*, *T. densus*, *S. triangulatus* and *S. acanthyrugosus* disappear at the upper zonal boundary. The characteristic assemblage includes the species mentioned above, and *Samarisporites triangulatus*, *Cristatisporites deliquescens* and *Cymbosporites acanthaceus*, also some forms of *Ancyrospora*, *Geminospora* and *Hystricosporites* (Fig. 5).

In eastern Europe, *M. radiatus* first appears in the *Archaeoperisaccus ovalis-Verrucosisporites grumosus* (OG) Zone, and, more precisely, in its middle subzone *Cymbosporites vetlasjanicus* (CVe). It may be concluded that the RD zone for Pomerania corresponds to a higher part of the eastern European OG Zone. The miospore assemblages of the CVe Subzone occur in association with conodonts of the Lower *rhenana* Zone. It may be thus inferred that the base of the Pomeranian RD zone is not older than the *rhenana* Zone. This conclusion is in agreement with the results published by Matyja (1993) as in the boreholes studied the RD zonal assemblages are associated with conodont faunas indicative of Upper *hassi* or Lower *rhenana* zones (Fig. 3). Considering the conodont data, one can suppose than the RD zone may be the equivalent of a part of the "IV" zone of Streel *et al.* (1987) that corresponds to upper *hassi*-lower *triangularis* conodont zones.

***Membrabaculisporis radiatus-Cymbosporites boafeticus* (RB) Zone**

The zone has been distinguished in the Gorzysław 8, G. 11 and G. 14 boreholes (Figs. 1, 3). The lower boundary of the zone is marked by the first appearance of *Cymbosporites boafeticus* and *C. vetlasjanicus*. *Membrabaculisporites radiatus* and do not range above the upper boundary of the zone and *Cristatisporites deliquescens* disappears in the lower part of the zone. The characteristic assemblage includes the index species and *Cristatisporites deliquescens*, *Laevigatosporites ovalis*, *Aneurospora greggsii*, *Apiculiretusispora nitida, Diducites radiatus, Perotrilites magnus*, *Retusotriletes planus*, *R. incohatus*, *R. pychovi* and also forms belonging to *Ancyrospora*, *Geminospora* and *Hystricosporites* (Fig. 5).

In Belorussia, *Cymbosporites boafeticus* first appears in an upper part of the *Archaeoperisaccus ovalis-Verrucosisporites grumosus* (OG) Zone (Obukhovskaya, 1986) which corresponds to the conodont *rhenana* Zone. The stratigraphic distribution of *Cristatisporites deliquescens* is wide. On the Russian Platform, the species disappears at the top of the *Cristatisporites deliquescens-Verrucosisporites evlanensis* (DE) Zone that ranges to the uppermost *gigas* Zone (Avkhimovitch *et al.* 1993b). In Canada, the range of *C. deliquescens* extends into the lowermost part of the *torquata-gracilis* Zone, i.e. also to the conodont Lower *triangularis* Zone (Richardson & McGregor, 1986). It may be thus conjectured that the lower boundary of the RB zone is not older than the conodont *rhenana* Zone and the upper one is not younger than the *triangularis* Zone.

This is consistent with the direct conodont data (see Fig. 3) which indicate that the RB zone corresponds to the Upper *rhenana* and *triangularis* zones, and to Entomozoacean *cicatricosa-sartenaeri* zones (Matyja, 1993).

The RB miospore assemblages do not contain species which would allow palynological correlation with the Ardenne–Rhine regions, but on conodont data one may suppose that the zone is the equivalent of a higher part of the zone "IV" and with zone "V" of the division by Streel *et al.* (1987).

***Lagenoisporites immensus-Diducites poljessicus* (IP) Zone**

The zone has been distinguished in the Gorzysław 8, and Karcino 2 boreholes (Figs 1, 3). The lower boundary of the IP zone is marked by the first appearance of *Lagenoisporites immensus* and *Diducites poljessicus*. Other species appearing above and close to the boundary are *Corbulispora vimineus* and *Lophozonotriletes curvatus*. The last occurrence of *Laevigatosporites ovalis*, *Cymbosporites boafeticus* and *Corbulispora vimineus* has been recorded from the upper part of the zone. The characteristic assemblage includes, beside the species listed above, *Aneurospora greggsi* and *Hystricosporites* spp (Fig. 5).

On the Russian Platform *Lagenoisporites immensus* first appears in the *Convolutispora zadonica* (Za) Subzone of the *Cyrtospora cristifer-Diaphanospora zadonica* (CZ) Zone, and the acme of its occurrence is in the *Lagenoisporites immensus* (Im) Zone. *Diducites poljessicus* appears also in the Im Zone. It seems plausible that the IP zone is the equivalent of the eastern European Za Subzone and the Im Zone. These are approximately correlated with the conodont *crepida* and *rhomboidea* zones (Avkhimovitch *et al.*, 1993b). In western Pomerania, the miospore assemblages of the IP Zone occur below and in association with conodonts of the Middle and Middle-Upper *crepida* Subzones (Fig. 3).

In the Ardenne–Rhine regions, *L. immensus* is absent, and *D. poljessicus* appears in the "IV" zone, which is obviously earlier than in eastern Europe as the zone "IV" corresponds to the *jamiae* Zone (Streel *et al.*, 1987). The presented conodont data suggests that the IP zone is a part equivalent of the *Grandispora gracilis-Acanthotriletes hirtus* (GH) Zone that is considered to correspond to Upper *crepida* - lowermost *marginifera* Subzones (Streel *et al.*, 1987).

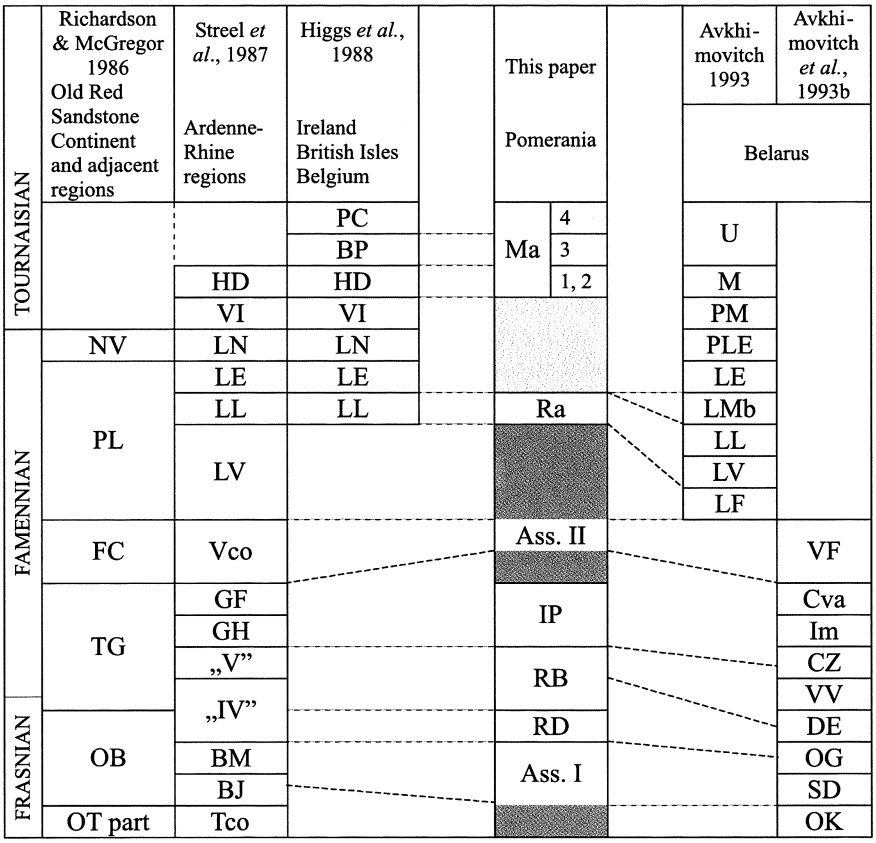


Fig. 6. Correlation of the zonal schemes for Upper Devonian and lowermost Carboniferous of western Europe, eastern Europe and western Pomerania

Assemblage II

The miospore associations of the assemblage II were recovered only from the Gorzysław 8 borehole (Figs 1, 3). The assemblages were reasonably rich in specimens and taxa, but they have been recovered from few samples only and thus establishing a zone would not be justified. The lower boundary of the assemblage is marked by the first appearance of *Diducites versabilis*, *Grandispora villosa* and *Spelaeotriletes resolutus*. They are accompanied by *Aneurospora greggsii*, *Auroraspora macra*, *D. commutatus*, *D. poljessicus*, *Lagenoisporites immensus*, *Lophozonotriletes curvatus* and *Hystricosporites* spp (Fig. 5).

In eastern Europe, *Diducites versabilis* first appears at the base of the *Discernisporites golubinicus* (DG) Subzone of the *Diducites versabilis-Grandispora famenensis* (VF) Zone. This subzone is correlated on indirect data with the Uppermost *marginifera* to Middle *expansa* conodont zones (Avkhimovitch *et al.*, 1993b). The miospore associations of the assemblage II were found 35 m below conodont fauna indicative of the *marginifera* Zone, and thus it is not younger than this conodont zone and is equivalent of the miospore VF Zone.

Avkhimovitch *et al.* (1993b) supposed that VF Zone is the equivalent of the Ardenne–Rhine *Rugospora versabilis-Grandispora cornuta* (Co) Zone that is dated as *trachytera-expansa* conodont zones (Streel *et al.*, 1987). In the Ardenne–Rhine regions, *Diducites versabilis* appears earlier than in eastern Europe i.e. it appears in the zone "V".

***Diducites versabilis* (Ve) and *Grandispora lupata* (Lu) Zones**

Turnau (1978) established *Diducites versabilis* (Ve) Zone. The base of this zone was defined on the first appearance of *D. versabilis* (synonym *Rugospora versabilis*) and *Retispora lepidophyta*. In the region of Kołobrzeg, *D. versabilis* has been found in associations lacking *R. lepidophyta*. Thus, the assemblage II is considered older than the zone Ve of Turnau. The latter zone is succeeded by the *lupata* (Lu) Zone characterized by the presence of *Grandispora lupata* and *R. lepidophyta*, and by the absence of *Tumulispora rarituberculata*. Such associations have not been encountered by the author. The reasons why, in the region of Kołobrzeg, the zones Ve and Lu have not been distinguished may be the incomplete coring of the boreholes and unfavourable lithology of the Kłanino Formation.

***Tumulispora rarituberculata* Zone**

Turnau (1978) has established the *Tumulispora rarituberculata* Zone. The present author distinguished this zone in the Gorzysław 9, Chmielno 1 and Rzeczenica 1 boreholes. The assemblages include: *Knoxisporites literatus*, *Raistrickia minor*, *Tumulispora rarituberculata*, *T. malevk-*

ensis, *T. obscura*, *Umbonatisporites abstrusus* and *Verrucosisporites nitidus*. The two last mentioned species first appear in the higher part of the zone. The assemblages include also species which appear earlier, such as: *Diducites commutatus*, *D. versabilis*, *Auroraspora macra*, *Grandispora lupata* and *Retispora lepidophyta* (Fig. 5).

The author subdivided the Ra Zone into two subzones named Ra_1 and Ra_2. The base of the Ra_2 subzone is marked by the first appearance of *U. abstrusus* and *V. nitidus*.

The Ra Zone was first correlated by Turnau (1978) with part of the *Vallatisporites pussillites-Spelaeotriletes lepidophytus* (PL) Zone established for the British Isles and subsequently (Turnau, 1979) with the upper part of *Vallatisporites pussillites-Spelaeotriletes lepidophytus* (PL) and lower part of *Verrucosisporites nitidus-Vallatisporites vallatus* (NV) zones. At present, the Ra zone is considered to be older than the *R. lepidophyta-I. explanatus* (LE) Zone, because the Ra associations lack several species present in the LE Zone (Clayton & Turnau, 1990; Avkhimovitch *et al.*, 1993a). The species not found in the Ra Zone are *Indotriradites explanatus*, *Vallatisporites vallatus*, *V. verrucosus*, *V. pussilites* and *Rugospora flexuosa*.

It has been noted, that in Pomerania, *Verrucosisporites nitidus* appears earlier than in other regions of Europe, in the level Lower or Middle *praesulcata* Zone (Matyja & Turnau, 1989). In Ireland, the first appearance of the species is belived to be Upper *praesulcata* Zone (Higgs *et al.*, 1988), and in Sauerland – Middle *praesulcata* or Upper *praesulcata* (Streel *et al.*, 1987).

To sum up – the Ra Zone is of late Famennian age, it correspons to the conodont Upper *expansa* and Lower to Middle *praesulcata* zones.

***Convolutispora major* (Ma) Zone**

The Ma Zone established by Turnau (1978) has been distinguished by the author in deposits from the Gorzysław 8 and 9, Chmielno 1 and Rzeczenica 1 boreholes. The miospore associations of the zone include several species which have not been recorded from the preceding Ra Zone. These are: *Convolutispora major*, *Auroraspora asperella*, *Cymbosporites acutus*, *Lophozonotriletes excisus*, *Murospora dubitata*, *Pustulatisporites gibberosus*, *Rastrickia corynoges* and *Spelaeotriletes obtusus*. The characteristic assemblage includes also some older species: *Tumulispora malevkensis*, *T. rarituberculata*, *T. obscura*, *Verrucosisporites nitidus* and *Umbonatisporites abstrusus* (Fig. 5).

The succession of some first appearances within the Ma Zone has permitted to distinguish four interval subzones (Matyja & Stempień-Sałek, 1994). They have been designated Ma_1, Ma_2, Ma_3, and Ma_4.

The lowermost *Convolutispora major* (Ma_1) Subzone has been distinguished in deposits from Gorzysław 9, Chmielno 1 and Rzeczenica 1 (Figs 1, 3, 5). The characteristic of the subzone is as that given for the entire zone. Notably, *Umbonatisporites distinctus* is absent. In the boreholes Rzeczenica 1 the assemblages of the Ma_1 subzone are accompanied and in the borehole Gorzysław 9 – by conodonts of the *duplicata*$_1$ - *sandbergi* Conodont Zone

The Lower *Convolutispora major* (Ma_2) Subzone has been distinguished in Gorzysław 8 and 9, Chmielno 1 and Rzeczenica 1 boreholes. The lower boundary of the zone is marked by the first appearance of *Umbonatisporites distinctus*. *Crassispora trychera* and *Schopfites delicatus* appear close to this boundary. In the Rzeczenica 1 borehole, the miospore assemblages of the Ma_2 subzone are accompanied by conodont faunas of the Lower *crenulata* Zone and in the Chmielno 1 boreholes – by unseparated *sandbergi-isosticha* Upper *crenulata* zones (Matyja *et al.*, 2000).

In the Ardenne–Rhine regions, the lower boundary of the *Kraeuselisporites hibernicus-Umbonatisporites distinctus* (HD) Zone is marked by the first appearance of *Krauselisporites hibernicus* and *Cymbosporites acutus*. *Umbosporites distinctus* appears some distance above the first appearance level of *Krauselisporites hibernicus* (Higgs *et al.*, 1992). In Pomerania, *U. distinctus* also appears above the base of the Ma Zone, such as *Cymbosporites acutus*, *Convolutispora major*, *Auroraspora asparella*, *Lophozonotriletes excisus*, *Murospora dubitata*, *Pustulatisporites gibberosus*, *Raistrickia corynoges* and *Spelaeotriletes obtusus*. In the Ardenne–Rhine regions, the lower boundary of the HD zone has no faunal control, but the first appearance of *U. distinctus* is dated as the *sandbergi* conodont Zone (Higgs *et al.*, 1992). Thus, it appears, that the Ma_1 and Ma_2 subzones are equivalents of the western European HD Zone, and they may be correlated with the *sandbergi-crenulata* Zones.

The Middle *Convolutispora major* (Ma_3) Subzone has been distinguished in the Gorzysław 9 and Chmielno 1 boreholes. Its lower boundary is marked by the first appearance of *Spelaeotriletes balteatus*. The characteristic assemblage is the same as for the entire Ma Zone enriched with *Spelaeotriletes balteatus*. In western Europe, *S. balteatus* appears in the *Spealeotriletes balteatus-Rugospora polyptycha* (BP) Zone (Higgs *et al.*, 1988, 1992). It is suggested that the lower boundaries of the Ma_3 Subzone and the BP Zone are time equivalents. The base of the BP Zone is within the Lower *crenulata* conodont Zone (Higgs *et al.*, 1992). In the Gorzysław 9 borehole, the assemblages of the Ma_3 subzone are accompanied by conodont faunas of *sulcata* or Lower *crenulata* zones.

The Upper *Convolutispora major* (Ma_4) Subzone has been distinguished in the Chmielno 1 borehole. Its lower boundary is marked by the first appearance of *Spelaeotriletes pretiosus*. The characteristic assemblage includes *S. pretiosus* and the species characteristic of the entire Ma Zone, except for *S. obtusus*.

In western Europe, *S. pretiosus* marks the base of the *Spelaeotriletes pretiosus-Raistrickia clavata* (PC) Zone (Neves *et al.*, 1973, Higgs *et al.*, 1988). The lower boundary of the zone is dated as Lower *crenulata* conodont Zone. This level is close below the base of the *isosticha* Lower *crenulata* conodont Zone, at the base of Tn2b (Higgs *et al.*, 1992). On the Russian Platform *S. pretiosus* first appears at the base of the *Colatisporites multisetus-Spelaeotriletes pretiosus* (MP) Zone which is also dated as the *isosticha*-Upper *crenulata* Zone (Avkhimovitch & Turnau, 1994). Thus it may be supposed that the base of the Ma_4 Subzone may also correspond to a level within the conodont zone mentioned above. So far, no conodont faunas have been found in association with the Ma_4 miospore assemblages.

SYSTEMATIC DESCRIPTIONS

The suprageneric classification adopted in this section is that introduced by Potonié & Kremp (1954), with the subsequent modifications by Dybova & Jachowicz (1957), Butterworth & Williams (1958), Dettman (1963), Neves & Owens (1966), Smith & Butterworth (1967) and Potonié (1970).

Described are species defining the zonal boundaries, and some other, reasonably represented forms (at least 4 specimens found) which have not been described from the study area before. The type and figured specimens are housed in the Institute of Geological Sciences, Polish Academy of Sciences, Warszawa.

Anteturma SPORITES Potonié, 1893
Turma TRILETES Reinsch, 1881, emend. Potonié et Kremp1954
Suprasubturma ACAVATITRILETES Dettman 1963
Subturma AZONOTRILETES (Luber) Dettman 1963
Infraturma APICULATI (Bennie et Kidston) Potonié 1956
Subinfraturma NODATI Dybova et Jachowicz 1957, *sensu* Potonié 1960

Genus *Corystisporites* Richardson 1965
Type species *Corystisporites pomeranius* Stempień-Sałek, new species
Fig. 7 (A–C)

Holotype: ING PAN, slide G.8.5.1, Fig. 7A.
Etymology: (Latin) *pomeranius* – derived from Pomerania.
Material: 22 specimens.
Dimension: 80 μm.
Diagnosis: Azonate miospores with sculpture consisting of spinose processes with pointed apices. Triradiate mark with elevated lips.
Description: Miospores 75–90 μm in diameter, of circular, oval or subtriangular amb. Trilete rays 3/4 of spore radius in length, accompanied by elevated, sinuous labra 7 μm high at the proximal pole, diminishing in height toward equator, often poorly visible due to density of ornamentation. Exine of the distal hemisphere ornamented with densely set, translucent conical elements terminated with darker, massive spinose tips. Elements of ornamentation are 6 μm in length, 4–6 μm wide at base, and their massive terminal spines are up to 2 μm in length. The bases of these elements are often interconnected with irregular, triangular wrinkles to form a reticulate pattern. At equator, the overlapping basal parts of ornamentation elements appear as a deeply incised zona.
Remarks: The described species differs from *Corystisporites multispinosus* Richardson (1965) in having shorter ornamentation elements terminated with solid spines.
Type-locality: Gorzysław 8 borehole, western Pomerania.
Type-level: Człuchów Formation; IP Zone, sample G.8.5, depth 3667 – 3669 m.
Stratigraphic distribution: Gorzysław 8 and 11 boreholes, assemblage I, zones RD-IP, Frasnian, lower Famennian (this paper).
Deposition of types: slide G.8.5.1.

Genus *Hystricosporites* McGregor 1960

Hystricosporites furcatus Owens 1971
Fig. 7J

1971. *Hystricosporites furcatus* Owens: p. 28, tab. 6, figs. 7-9.

Material: 15 specimens.
Description: Miospores 71–87 μm in diameter, of circular amb. Trilete rays not always visible due to prominent ornamentation, 1/2–3/4 of spore radius in length, accompanied by elevated, slightly sinuous labra about 15 μm high at the proximal pole, terminating at curvatural ridges. Contact faces covered with radial, flat ridges 6–8 μm in width. Exine outside contact faces ornamented with regularly distributed cylindrical, bifurcate processes 18–25 μm in length, 5–8 μm wide at base. Tips of the bifurcation "extended" (*sensu* Owens, 1971). About 20 processes cross the equator.
Remarks: The specimens from Pomerania are smaller than those described by Owens (1971), which are 82.5 –174.9 μm in diameter.
Distribution: Poland – western Pomerania, Gorzysław 8 and 11, Karcino 2 boreholes, zones RB, IP, assemblage II, Uppermost Frasnian, lower Famennian (this paper); Arctic Canada – Queen Elizabeth Islands, lower Frasnian (Owens, 1971).

Hystricosporites multifurcatus (Winslow) Mortimer et Chaloner 1967
Fig. 7 (E, F)

1967. *Hystricosporites multifurcatus* (Winslow) Mortimer et Chaloner: p. 195-196, tab. 26, figs 5-9.

Material: 5 specimens.
Description: Miospores 68–86 μm in diameter. Amb circular or triangular with convex sides. Triradiate rays 2/3 of spore radius in length, accompanied by elevated, sinuous labra up to 15 μm high at the proximal pole, not always visible due to dense ornamentation. Contact faces smooth, exine outside contact faces ornamented with regularly distributed appendages 20–22 μm in length, up to 8 μm wide at base, with reflexed, multifurcate terminations. Width of appendages at the base of multifurcation about 6 μm. About 15 appendages cross the equator.
Distribution: Poland – western Pomerania, Gorzysław 8 and 11 boreholes, assemblage I, zones DT, RD, assemblage II, Frasnian, lower Famennian (this paper); France, middle and Upper Frasnian (Taugourdeau-Lantz, 1971), Frasnian and lower Famennian (Loboziak & Streel, 1988), Frasnian (Streel *et al.*, 1987); USA – Ohio, Middle Devonian, basal part of Mississippian (Winslow, 1962).

Hystricosporites porrectus (Balme et Hassel) Allen 1965
Fig. 7 (D, L)

1962. *Archaeotriletes porrectus* Balme et Hassel: p. 10, tab. 5, figs 1-4.
1965. *Hystricosporites porrectus* (Balme et Hassel), Allen: p. 698, tab. 95, figs 1-3.

Material: 31 specimens.
Description: Miospores 80–105 μm in diameter. Amb circular or triangular with convex sides. Triradiate rays 2/3 of spore radius in length, accompanied with elevated, sinuous labra up to 20 μm high at the proximal pole, not always visible due to dense ornamentation. Contact faces smooth. Exine outside contact faces ornamented with regularly distributed cylindrical, densely set appendages 20–35 μm in length, 5–6 μm wide at base, with bifurcate termination. Tips of the bifurcation "reflexed" are curved toward the spore body. About 28 appendages cross the equator.

Distribution: Poland – western Pomerania, Gorzysław 8 and 11, Strzeżewo 1 and Karcino 2 boreholes, zones RD, RB and IP, Upper Frasnian, lower Famennian (this paper); Spitsbergen, Givetian (Allen, 1965); France – Boulonnais, middle Frasnian (Taugourdeau-Lantz, 1971); western Australia, Upper Devonian (Playford, 1982).

Hystricosporites suborlovicus (Kedo) comb. nov.
Fig. 7K

Basionym: 1974. *Archeozonotriletes suborlovicus* Kedo: p. 58, tab. 13, fig. 19.
Material: 8 specimens.
Description: Miospores 70–78 μm in diameter. Amb circular or subtriangular with convex sides. Triradiate rays not always visible due to dense ornamentation, about 1/2 of spore radius in length, accompanied by labra up to 4 μm wide. Contact faces smooth, exine outside contact faces ornamented with regularly distributed, cylindrical, densely set, bifurcate processes 10–12 μm in length, 2–3 μm wide at base, narrowing to 1.5 μm below the bifurcation at which point they are often broken off. Tips "reflexed or extended". Up to 30 appendages project at the equator.
Remarks: According to the original description of *Archaeozonotriletes suborlovicus* these spores posses a central body. This feature has not been observed in our material, probably because our specimens are much darker (more mature). Otherwise, the described specimens are closely comparable with those from the Pripyat Depression.
Distribution: Poland – western Pomerania, Gorzysław 8 and Karcino 2 boreholes, zone IP, assemblage II, lower Famennian (this paper); Belarus – Pripyat Depression, lower and middle Famennian (Kedo, 1974).

Genus *Umbonatisporites* (Hibbert et Lacey) Clayton 1971

Umbonatisporites abstrusus (Playford) Clayton 1971
Fig. 8 (B, C)

1971. *Umbonatisporites abstrusus* (Playford) Clayton: p. 591.

Material: 8 specimens.
Description: Miospores 60–68 μm in diameter. Amb circular. Trilete rays straight, 1/3 to 1/2 of spore radius in length. Contact faces smooth, exine outside contact faces ornamented with small appendages up to 2 μm in diameter, about 1.5 μm wide at base, and about 2 μm apart. Terminations of the appendages are dome-shaped or flattened, their width equals the appendage length. Some terminations bear a small spine.
Distribution: Poland – western Pomerania, Gorzysław 8 and 9, Rzeczenica 1 boreholes, Subzones Ra_2 and Ma_2, Uppermost Famennian, lowermost Tournaisian (this paper), Holy Cross Mountains, Zone LN, Uppermost Famennian (Turnau, 1990), Pomerania and Holy Cross Mountains, zones LN-Cl, Uppermost Famennian, Tournaisian (Clayton & Turnau, 1990); Brazil, zones LN-BP, Uppermost Famennian, lower Tournaisian (Loboziak *et al.*, 1988). The species is common in western and eastern Europe in Uppermost Famennian and lower Tournaisian.

Umbonatisporites distinctus Clayton 1971
Fig. 8A

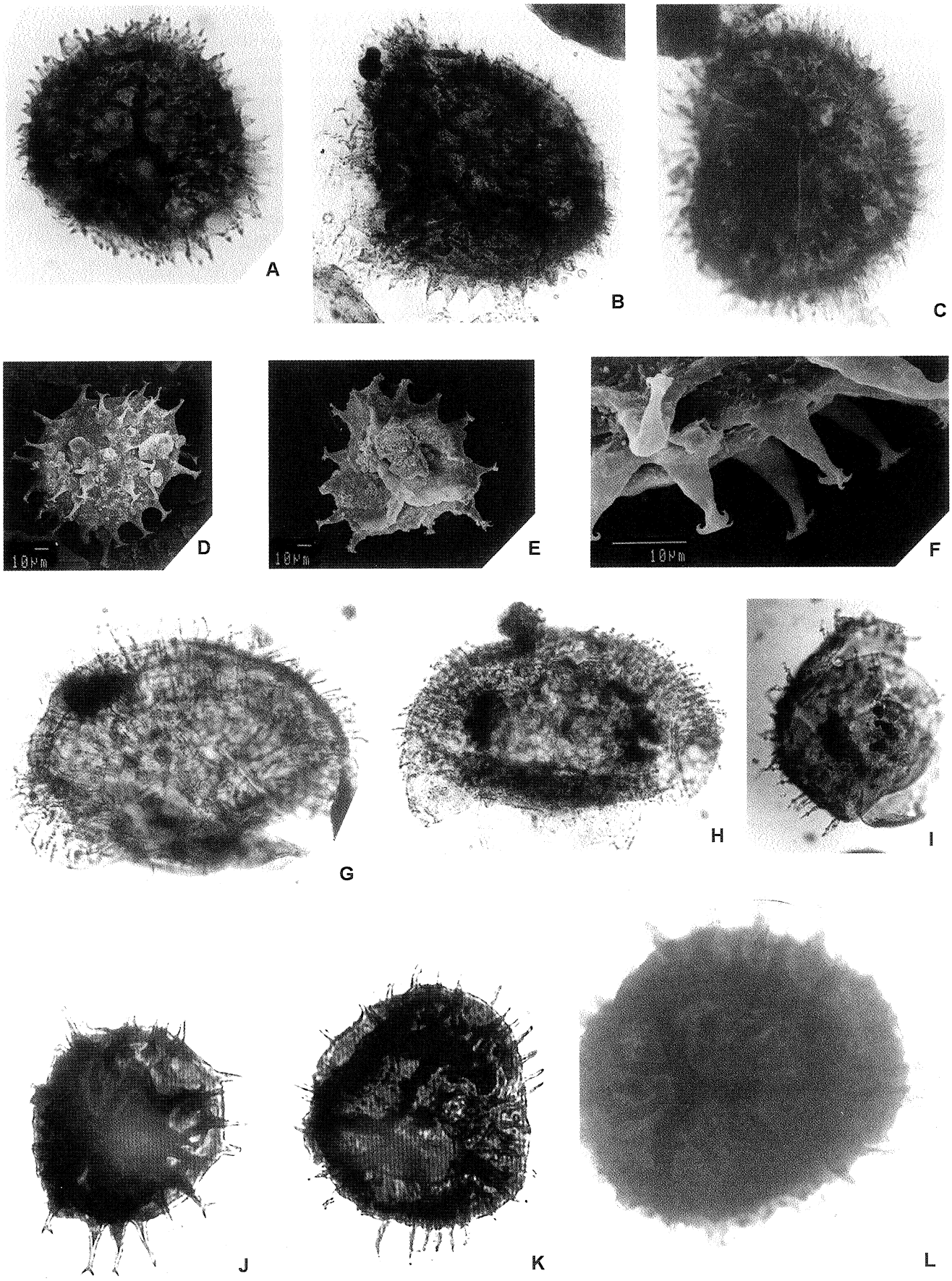
1971. *Umbonatisporites distinctus* Clayton: tab. 5, figs 16-17.

Material: 18 specimens.
Description: Miospores 55–75 μm in diameter. Amb circular. Trilete rays straight, 1/3 to 1/2 of spore radius in length. Contact faces smooth, the remaining exine surface ornamented with discrete, cylindrical appendages 8–15 μm in length, 2–3 μm in width, terminated by a wide, dome-shaped tip up to 4 μm in width surmounted by a spine up to 4 μm in length.
Distribution: Poland – western Pomerania, Gorzysław 9, Chmielno 1, and Rzeczenica 1 boreholes, Subzones Ma_2, Ma_3 and Ma_4, lower Tournaisian (this paper), zones Ma-Cl, Tournaisian (Turnau, 1978, 1979); Belarus – Pripyat Depression, zone U, Tournaisian (Avkhimovitch, 1993), common in western Europe, from Zone HD.

Type species *Umbonatisporites distinctus* var. *crinitus* var. nov.
Fig. 7 (G–I)

Holotype: ING PAN, slide G.9.5.1., Fig. 7H.
Etymology: (Latin) *crinitus* – with long hair.
Material: 10 specimens.
Dimension: 65 μm in diameter.
Diagnosis: Azonate miospores with fine hair-like processes.
Description: Miospores 55–85 μm in diameter.Amb circular. Trilete rays straight, 3/4 of spore radius in length. Contact faces smooth, the remaining exine surface covered by densely set, cylindrical appendages 6–13 μm in length, 0.5–1 μm wide at base, 2–3 μm apart. Appendages have a 2.5 μm wide thickening situated at half of their length and a dome shaped tip up to 4 μm in width, surmounted by a spine about 4 μm in length.
Remarks: *Umbonatisporites distinctus* var. *crinitus* differs from *U. distinctus* Clayton (1971) in having more closely spaced, thinner and longer in relation to spore radius appendages.
Type-locality: Gorzysław 9 borehole, western Pomerania.
Type-level: Sąpolno Formation, Subzone Ma_2, sample G.9.5, depth 3149–3150 m.
Stratigraphic distribution: Gorzysław 8 and 9, Chmielno 1 boreholes, Subzone Ma_2, Tournaisian (this paper).
Deposition of types: slide G.9.5.1.

Fig. 7. Miospores from Upper Frasnian, Famennian and lower Carboniferous in western Pomerania. Specimens **C, E, F** are from Gorzysław 11.14, 3284–3285 m DT Zone, other specimens as indicated below. All magnifications × 500 except when indicated. **A** – *Corystisporites pomeranius* n. sp., holotype, Gorzysław 8.5, 3667–3669 m, IP Zone; **B** – *Corystisporites pomeranius* n. sp., Gorzysław 11.10, 3246–3247 m, RD Zone; **C** – *Corystisporites pomeranius* n. sp.; **D** – *Hystricosporites porrectus* (Balme *et* Hassel) Allen, Gorzysław 11.10, 3246–3247 m, RD Zone, magnification × 300. **E, F** – *Hystricosporites multifurcatus* (Winslow) Mortimer *et* Chalomer, magnification × 300 and x 1400; **G** – *Umbonatisoporites distinctus* var. *crinitus* var. nov., holotype, Gorzysław 9.5, 3149–3150 m, Ma_2 Zone; **H** – *Umbonatisoporites distinctus* var. *crinitus* var. nov., *ibidem*; **I** – *Umbonatisoporites distinctus* var. *crinitus* var. nov., Gorzysław 9.4, 3148–3149 m, Ma_2 Zone, magnification × 400; **J** – *Hystricosporites furcatus* Owens, Gorzysław 8.3, 3514–3516 m, magnification × 400, assemblage II; **K** – *Hystricosporites suborlovicus* (Kedo) comb. nov., *ibidem*; **L** – *Hystricosporites porrectus* (Balme *et* Hassel) Allen, Gorzysław 8.5, 3667–3669 m, IP Zone


A
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10µm
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Subinfraturma BACULATI Dybova et Jachowicz 1957
Genus *Raistrickia* (Schopf, Wilson et Bentall) Potonié et Kremp 1954

Raistrickia ramiformis (Kedo) Avkhimovitch et Higgs 1988
Fig. 8D

1978. *Raistrickia variabilis* Dolby et Neves: Somers et Streel, p. 149, tab.1, fig. 2.
1988. *Raistrickia ramiformis* (Kedo) Avkhimovitch et Higgs: Avkhimovitch, Byvsheva, Higgs, Streel & Umnova, tab.1, fig. 16.
1988. *Raistrickia minor* (Kedo) Neves et Dolby: Higgs, Clayton & Keegan, p. 59, tab. 4: 14, 17.

Material: 7 specimens.
Description: Miospores 33–58 μm in diameter. Amb circular. Trilete rays not visible due to dense ornament covering the entire exine surface. The ornamentation elements are cylindrical, 1/2 to 3/4 of spore radius in length, 2–6 μm wide at base, 10–15 μm apart, with flattened and laterally extended, ramified terminations which in some specimens are as wide as the appendages are long. The terminations of neighbouring appendages are often in contact. Exine about 2 μm thick at equator.
Remarks: *Raistrickia variabilis* Dolby et Neves *sensu* Somers et Streel (1978, tab. 1, fig. 2) and *R. minor* sensu Higgs *et al.* (1988, tab. 4, figs 14, 17) have been considered here as synonymous with the described species as they have identical appendages with laterally extended terminations.
Distribution: Poland – western Pomerania, Gorzysław 8 and 9 boreholes, Subzones Ra_1, Ra_2, Ma_2, Upper Famennian, Tournaisian (this paper); Belarus – Pripyat Depression, Zone PLE, Famennian (Kedo & Golubtsov, 1971); Germany, Famennian (Somers & Streel, 1978).

Infraturma MURONATI Potonié et Kremp 1954
Genus *Convolutispora* Hoffmeister, Staplin et Malloy 1955

Convolutispora subtilis Owens 1971
Fig. 8L

1971. *Convolutispora subtilis* Owens: p. 35, tab. 9, figs 3-6.

Material: 5 specimens.
Description: Miospores 48–58 μm in diameter. Amb circular or subtriangular. Trilete rays straight, 3/4 of spore radius in length. Exine ornamented with fine, sinuous, densely set ridges 2–3 μm in length and width. The profiles of ridges rounded. On contact faces ridges are lower and more spaced. Exine about 2 μm thick at equator.
Distribution: Poland – western Pomerania, Gorzysław 11, Strzeżewo 1 boreholes, zone RD, Upper part of Frasnian (this paper), Zone Ex, Givetian (Turnau, 1995); Belarus – Pripyat Depression, Frasnian (Obukhovskaya, 1986), Zone OG, Frasnian (Avkhimovitch *et al.*, 1993 b); Canada – Queen Elizabeth Islands, Frasnian (Owens, 1971).

Genus *Corbulispora* Bharadwaj et Venkatachala 1961

Corbulispora cf. *cancellata* (Waltz) Bharadwaj et Venkatachala 1961
Fig. 8N

Material: 9 specimens.
Description: Miospores 70–94 μm in diameter. Amb oval, trilete rays straight, 3/4 of spore radius long, accompanied by lips. Exine ornamented with ridges and rare warts; ridges slightly sinuous forming an irregular, imperfect reticulum. Width of ridges and warts 5–7 μm, width of lumina 8–10 μm. Exine about 2 μm wide at equator.
Remarks: The described form differs from *Corbulispora cancellata* (Waltz) Bharadwaj et Venkatachala (1961) in having less distinct lips, more complete reticulum, more straight ridges and lower number of warts.
Distribution: Poland – western Pomerania, Gorzysław 8 borehole, Zone Ra and Ma (Ma_2 i Ma_3), Upper part of Famennian, Tournaisian (this paper).

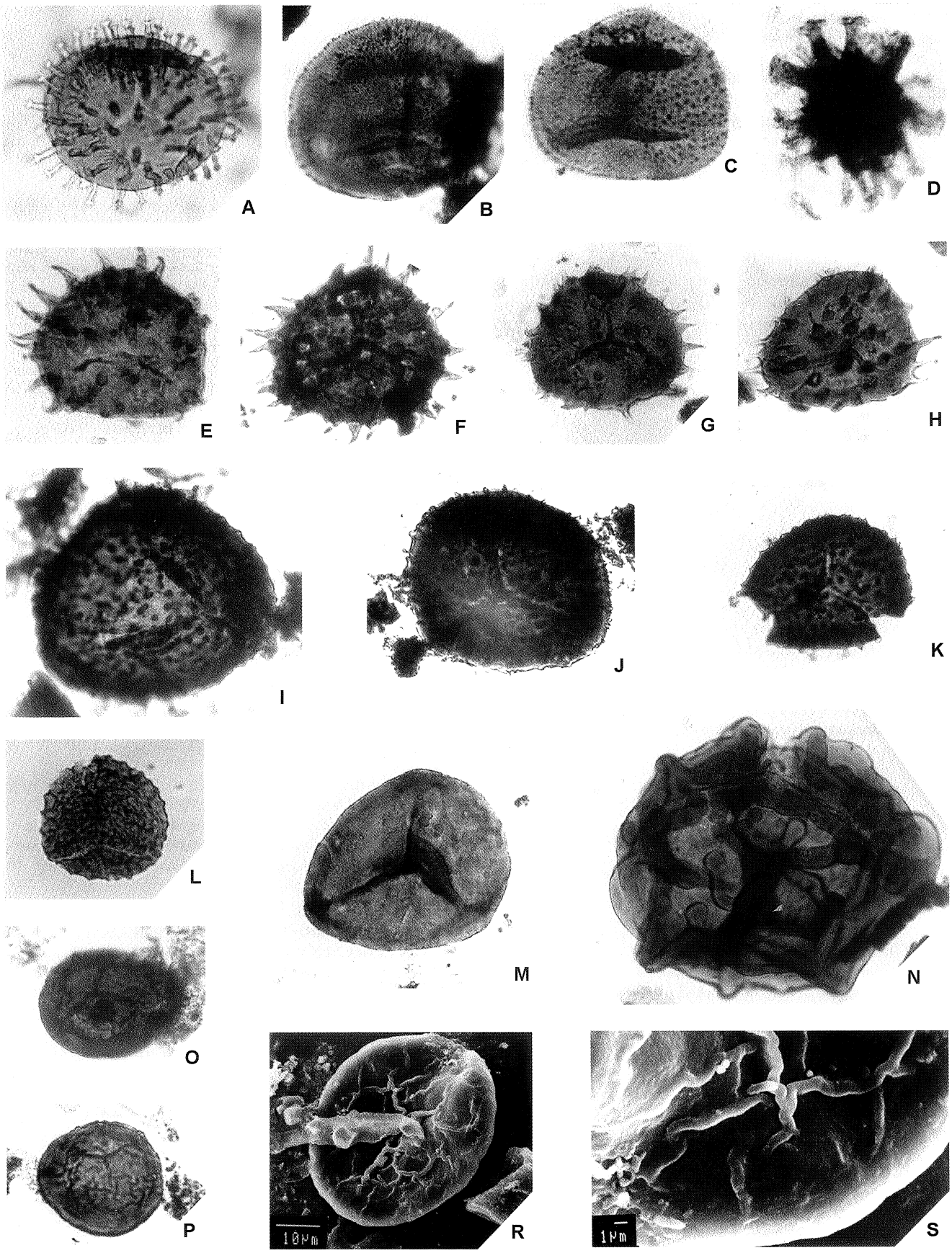
Subturma ZONOTRILETES Waltz 1935
Infraturma PATINATI Butterworth et Williams 1958
Genus *Cymbosporites* Allen 1965

Cymbosporites acutus (Kedo) Byvsheva 1985
Fig. 8 (E–H)

1985. *Cymbosporites acutus* (Kedo) Byvsheva: p. 127, tab. 24, fig. 13
non 1980. *Asperispora acuta* Van der Zwan: p. 227 tab. 13, figs 1-5.
non 2000. *Grandispora acuta* Higgs, Avkhimovitch, Loboziak, Maziane-Serraj, Stempień-Sałek & Streel: pl. 1, figs 1-6.

Material: 48 specimens.
Description: Miospores 48–67 μm in diameter. Amb subtriangular, sides convex, apices broadly rounded. Trilete rays straight or slightly sinuous, about 3/4 of spore radius in length. Proximal surface smooth, distal surface thicker than the proximal one, covered by discrete, closely set spines 5–13 μm in length, which have bulbous bases 5–8 μm in diameter, and acute terminations. Exine about 3 μm thick at equator.

Fig. 8. Miospores from Upper Frasnian, Famennian and Lower Carboniferous in Western Pomerania. All magnifications × 500 except when indicated. **A** – *Umbonatisporites distinctus* Clayton, Chmielno 1.6, 3907–3925 m, Ma_{3-4} Zone; **B** – *Umbonatisporites abstrusus* (Playford) Clayton, Gorzysław 9.3, 3146–3147 m, Ma_2 Zone; **C** – *Umbonatisporites abstrusus* (Playford) Clayton, Gorzysław 8.1, 3216–3218 m, Ma_2 Zone; **D** – *Raistrickia ramiformis* (Kedo) Avkhimovitch *et* Higgs, Gorzysław 9.13, 3207–3208 m, Ra_1 Zone; **E** – *Cymbosporites acutus* (Kedo) Byvsheva, Gorzysław 9.6, 3154–3155 m, Ma_2 Zone; **F, G, H** – *Cymbosporites acutus* (Kedo) Byvsheva, Gorzysław 9.4, 3148–3149 m, Ma_2 Zone; **I** –*Cymbosporites vetlasjanicus* (Medianik *et* Obukhovskaya): Avkhimovitch *et al.*, Gorzysław 14.2, 2943–2950 m, RB Zone, magnification × 700; **J, K** – *Cymbosporites boafeticus* (Tchibrikova) Obukhovskaya, *ibidem*; **L** – *Convolutispora subtilis* Owens, Gorzysław 11.6, 3193–3194 m, RD Zone; **M** – *Aneurospora greggsii* (McGregor) Streel: Becker *et al.*, Gorzysław 8.5, 3667–3669 m, IP Zone; **N** – *Corbulispora* cf. *cancellata* Bharadwaj et Vencatachala, Gorzysław 9.3, 3146–3147 m, Ma_2 Zone; **O, P** – *Tholisporites densus* McGregor, Gorzysław 11.10, 3246–3267 m, RD Zone; **R, S** – *Tholisporites densus* McGregor, 11.12, 3270–3271 m, RD Zone, magnification × 800 and × 2500


A
B
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10µm
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1µm
S

Remarks: Specimens included by Van der Zwan (1980, p. 227, tab. 13, figs 1-5) in *Asperispora acuta* and by Higgs *et al.* (2000, p. 213, pl. 1, figs 1-6) in *Grandispora acuta* are only superficially similar to *Cymbosporites acutus* as they are camerate while *Cymbosporites acutus* from Pomerania and *C. acutus* described from eastern Europe by Kedo (1963) and Byvsheva (1985) are acamerate. In comparison with specimens described in Kedo (1963) and Byvsheva (1985) those from Pomerania have larger spines, which have a wider size range (5–13 μm to 2.5–8 μm given by the above authors).

Distribution: Poland – western Pomerania, Gorzysław 8 and 9, Chmielno 1, Rzeczenica 1 boreholes, Zone Ma, Tournaisian (this paper); Belarus – Pripyat Depression, Upper Famennian–Tournaisian (Kedo, 1963); Russia – Tournaisian (Byvsheva, 1985).

Cymbosporites boafeticus (Tchibrikova) Obukhovskaya 1986
Fig. 8 (J, K)

1972. *Archaeozonotriletes boafeticus* Tchibrikova: p. 128, tab. V, figs 1-2
1993. *Cymbosporites boafeticus* (Tchibrikova) Obukhovskaya: Avkhimovitch, Tchibrikova, Obukhovskaya, Nazarenko, Umnova, Raskatova, Loboziak & Streel, pl.17, fig. 12, pl. 18, fig. 13, pl. 19, fig. 12.

Material: 9 specimens.

Description: Miospores 50–65 μm in diameter. Amb circular or subtriangular with convex sides and broadly rounded apices. Trilete rays slightly sinuosus, accompanied with labra about 1μm in height, extending almost to equator. Ray terminations forked which is often invisible due to dense ornamentation. Proximal surface smooth. Exine of the distal hemisphere distinctly thicker in relation to that of the proximal one, ornamented with discrete, conical elements up to 2 μm in length, up to 4 μm wide at base. Exine about 3 μm thick at equator.

Distribution: Poland – western Pomerania, Gorzysław 11 and 14, Karcino 2 boreholes, zones RB-IP, Upper Frasnian and lower Famennian (this paper); Russia – south Ural and Russian Platform, Frasnian (Tchibrikova, 1972); Belarus – Pripyat Depression, Frasnian (Obukhvskaya, 1986), Pripyat Depression, Frasnian, Famennian, zones DE-CZ (Avkhimovitch *et al.*, 1993b).

Cymbosporites vetlasjanicus Medianik et Obukhovskaya: Avkhimovitch *et al.* 1993
Fig. 8I

1993. *Cymbosporites vetlasjanicus* Medianik et Obukhovskaya: Avkhimovitch, Tchibrikova, Obukhovskaya, Nazarenko, Umnova, Raskatova, Loboziak & Streel: tab. 14, figs 6, 9.

Material: 2 specimens.

Description: Miospores 45–55 μm in diameter. Amb circular or subtriangular, with convex sides and rounded apices. Trilete rays straight, accompanied by labra up to 1 μm in height, extending almost to equator. Proximal surface smooth, exine of distal hemisphere distinctly thicker in relation to the proximal one ornamented with discrete conical elements up to 2 μm wide and high. Exine about 3 μm thick at equator.

Distribution: Poland – western Pomerania, Gorzysław 11 borehole zone RB, Frasnian/Famennian transition beds (this paper); Belarus – Pripyat Depression, Frasnian, zones OG and DE (Medianik &Obukhovskaya: Avkhimovitch *et al.*, 1993b).

Genus *Tholisporites* Butterworth et Williams 1958

Tholisporites densus McGregor 1960
Fig. 8 (O–S)

1960. *Tholisporites densus* McGregor: p. 37, tab. 13, figs 6, 7.
1987. *Archaeozonotriletes densus* Arkhangelskaya: p. 87, 88, tab. 6, fig. 5.

Material: 6 specimens.

Description: Miospores 45–52 μm in diameter. Amb circular or oval. Trilete rays slightly sinuous, accompanied by lips about 1 μm in height, extending 3/4 of spore radius. Exine much thicker distally than proximally. A thin, translucent, irregularly folded membrane extends over the proximal surface; the folds are about 1 μm in width, some of them touch or are fused; they peter out in equatorial region. Spores without ornamentation.

Distribution: Poland – western Pomerania, Gorzysław 11 borehole, zone RD, Upper Frasnian (this paper), Jamno IG 1 borehole, *punctata* conodont Zone (personal information, Turnau, 1995); northern Canada, probably Frasnian (McGregor, 1960), Upper Givetian–middle Frasnian, Zone OB and OT (McGregor & Playford, 1992); Russian Platform, Frasnian (Arkhangelskaya, 1987).

Suprasubturma LAMINATITRILETES Smith et Butterworth 1967
Subturma ZONOLAMINATITRILETES Smith et Butterworth 1967
Infraturma CRASSITI (Bharadwaj et Venkatachala) emend. Utting 1987
Genus *Aneurospora* Streel 1964

Aneurospora greggsii (McGregor) Streel 1974
Fig. 8M

1972. *Archaezonotriletes vasjamicus* Tchibrikova: p.125, Tab. 4, fig. 11-13
1974. *Aneurospora greggsii* (McGregor) Streel: Becker, Bless, Streel & Thorez, p. 24, tab. 16, figs 6-15 *cum synonimis*.
1993. *Geminospora vasjamica* (Tchibrikova) Obukhovskaya et Nekryata: Avkhimovitch, Tchibrikova, Obukhovskaya, Nazarenko, Umnova, Raskatova, Loboziak & Streel, tab. 18, figs 4-5, tab. 19, fig. 5.

Material: 22 specimens.

Description: Miospores 50–65 μm in diameter. Amb subtriangular, sides convex, apices broadly rounded. Trilete rays straight, extending almost to equator, terminating at curvaturae imperfectae. Exine ornamented with densely set cones up to 1 μm in height. On contact faces, cones are more spaced or absent. Exine about 2 μm thick at equator.

Distribution: Poland – western Pomerania, Gorzysław 8 and 14, Karcino 2 boreholes, zones RB, IP, assemblage II, Uppermost Frasnian–lower Famennian (this paper), southeastern Poland, Pionki 4 borehole, Givetian/Frasnian (Turnau, 1985, 1986), Holy Cross Mountains, Zone LN, Upper Famennian (Turnau, 1990); southern Ural, lower Famennian (Tchibrikova, 1972); Belarus – Pripyat Depression, Frasnian–Famennian (Obukhovskaya and Nekryata in Avkhimovitch *et al.*, 1993b); Canada – Alberta, Ghost River Formation, Givetian–Frasnian (McGregor, 1964). Common in Europe from Frasnian to Famennian.

Subturma CINGULICAVATI Smith et Butterworth 1967
Genus *Cristatisporites* (Potonié et Kremp) Butterworth 1967

Cristatisporites deliquescens (Naumova) Arkhangielskaya 1987
Fig. 9O

1953. *Hymenozonotriletes deliquescens* Naumova: p. 67, tab. 9, fig. 8.
1987. *Cristatisporites deliquescens* (Naumova) Arkhangelskaya: p. 89, tab. 6, fig. 4.

Material: 4 specimens.
Description: Miospores 86–96 μm in diameter. Amb subtriangular, sides convex, apices broadly rounded. Trilete rays slightly sinuosus, accompanied by lips 2–3 μm in width, extending 2/3 of spore radius. Amb of the intexine oval or slightly subtriangular. Exoexine extended laterally at equator to form a differentially thickened zona; inner thicker portion 3–4 μm in width, thinner, outer portion 10–15 μm in width. Exine surface finely granulate, distal surface ornamented with spaced mamillate spines 4–6 μm long, 3–4 μm wide at base. Spines often corroded.
Remarks: In our specimens, the trilete rays extend to the inner part of the cingulizona while in those from the Russian Platform, they are longer, extending beyond this part of zona. The zona in specimens from Pomerania is narrower than in those from the Russian Platform. The spines of the specimens from Pomerania are corroded.
Distribution: Poland – western Pomerania, Gorzysław 11 and 14 boreholes, assemblage I, zones RD and RB, Frasnian and lowermost Famennian (this paper); Russian Platform – Voronezh area, Frasnian (Naumova, 1953), eastern part of Russian Platform, Upper Frasnian (Tchibrikova, 1977), Frasnian, equivalents of Zones OG-DE (Arkhangelskaya, 1987); Belarus – Pripyat Depression, Zones OG-DE (Avkhimovitch *et al.*, 1993b).

Samarisporites triangulatus Allen 1965
Fig. 9 (A–D)

1965. *Samarisporites triangulatus* Allen: p. 716, tab. 99, figs 1-6.

Material: 23 specimens.
Description: Miospores 40–58 μm in diameter. Amb subtriangular, sides convex, apices slightly rounded, elongated, reminding of ears. Trilete rays straight, accompanied by slightly sinuous labra about 2 μm in height, extending onto the zona. Intexine circular or subtriangular in outline, closely appressed to exoexine. Contact faces smooth, exine outside contact faces finely granulate, and ornamented with spaced cones and spines up to 5 μm wide at base, 2–5 μm in length. Some cones are surmounted by a spine (the biform elements are up to 6 μm in length). In equatorial view, at intexine margin, bases of spines and cones are fused to form a reticulum.
Distribution: Poland – western Pomerania, Strzeżewo 1, Gorzysław 11 boreholes, assemblage I, zone RD, Frasnian, (this paper), Givetian Subzone Ex_3, (Turnau, 1985, 1986), central Poland, Holy Cross Mountains, Givetian, Subzone Ex_3 (Malec & Turnau, 1997; Turnau et Racki, 1999); France, middle Frasnian (Taugourdeau-Lantz, 1971), Givetian/Frasnian (Loboziak & Streel, 1981, 1988); Belgium, Frasnian (Streel & Loboziak, 1987); Ireland, Givetian/Frasnian (Clayton & Graham, 1974); Spitsbergen, Upper Givetian (Allen, 1965); Tunisia, Libya, Givetian/Frasnian (Loboziak & Streel, 1989); North America, Givetian/Frasnian (McGregor, 1979); Brazil – Parana Basin, Givetian–$Frasnian_1$ (Loboziak *et al.*, 1988).

Samarisporites cf. *triangulatus* Allen 1965
Fig. 9E

Material: 5 specimens.
Description: Miospores 55–68 μm in diameter. Amb subtriangular, sides straight or slightly convex, apices triangular. Trilete rays accompanied with slightly sinuous labra up to 3 μm in height, extending to equator. Contact faces smooth, exine outside contact faces finely granulate and covered by spaced cones and spines up to 5 μm wide at base, 2–5 μm in length. Some cones are surmounted by spines (the total length of biform elements up to 6 μm). In equatorial view, at intexine margin, the bases of spines and cones are joined to form a reticulum.
Remarks: *Samarisporites* cf. *triangulatus* from Pomerania differs from *Samarisporites triangulatus* Allen (1965) in being slightly larger, having less convex sides and less elongated, more acute apices.
Distribution: Poland – western Pomerania, Strzeżewo 1, Gorzysław 11 boreholes, assemblage I, zone RD, Frasnian (this paper).

Suprasubturma CAMERATITRILETES Neves et Owens 1966
Subturma SOLUTITRILETES Neves et Owens 1966
Infraturma DECORATI Neves et Owens 1966
Genus *Grandispora* Hoffmeister, Staplin et Malloy emend. Neves et Owens 1966

Grandispora villosa (Avkhimovitch) comb. nov.
Fig. 9 (G, K, L)

Basionym: 1974. *Hymenozonotriletes villosus* Avkhimovitch: p. 98, tab. 28, fig. 4.
Material: 5 specimens.
Dimension: 30–40 μm in diameter.
Diagnosis: Trilete camerate miospores, exoexine detached from intexine, sculpture consisting of discrete, spinose processes.
Description: Amb subtriangular, sides convex, apices broadly rounded. Trilete rays straight, extending almost to equator. Spores cavate, intexine well delimited, radius 1/2 to 3/4 of spore radius. Exoexine detached from intexine, forming a pseudosaccus appearing as an equatorial zona. Contact faces smooth, the remaining part of exine ornamented with discrete, regularly distributed cones 1–2 μm high and wide at base, 1–2 μm apart.
Remarks: Specimens are listed by Avchimovitch (1974), non described.
Distribution: Poland – western Pomerania, Gorzysław 8 borehole, assemblage II, Famennian (this paper); Belarus – Pripyat Depression, Famennian (Avkhimovitch, 1974).

Genus *Rugospora* Neves et Owens 1966

Rugospora granulatipunctata (Hoffmeister, Staplin et Malloy) Higgs *et al.* 1988
Fig. 9F

1988. *Rugospora granulatipunctata* (Hoffmeister, Staplin et Malloy) Higgs, Clayton & Keegan: p. 72, tab. 12, figs 4-5, *cum synonimis*.

Material: 10 specimens.
Description: Miospores 33–44 μm in diameter. Amb circular or subtriangular, sides convex, apices broadly rounded. Trilete rays straight, extending almost to equator, accompanied by slightly sinuous, wide lips up 3 μm in height. Exine detached from intexine. Intexine distinct, outline conformable with amb, usually forming 5/6 of the total spore diameter, laevigate or finely granulate.

Exoexine densely ornamented by small wrinkles and rugulae. Wrinkles 1–2 μm in width, closely spaced, radially, sinuous arranged radialy.

Distribution: Poland – western Pomerania, Gorzysław 8 and 9 boreholes, Zone Ma (Ma_1, Ma_2, Ma_3), (this paper), Zone Ma, (Turnau, 1975); Belarus – Pripyat Depression, Tournaisian (Kedo, 1963); Russian Platform, Lower Carboniferous (Byvsheva, 1976); Ireland, Upper Famennian–Tournaisian (Van der Zwan, 1980), Zones LL-PC, Upper Famennian, Tournaisian (Higgs *et al.*, 1988); USA – Illinois, Kentucky, Mississipian (Hoffmeister *et al.*, 1955).

Genus *Retispora* Staplin 1960

Retispora macroreticulata (Kedo) Byvsheva 1985
Fig. 9N

1985. *Retispora macroreticulata* (Kedo) Byvsheva: p. 141, tab. 28, fig. 11, *cum synonimis.*

Material: 6 specimens.

Description: Spores 95–160 μm in diameter. Amb circular, oval or subtriangular. Trilete rays straight, extending to equator, often obscured by ornamentation. Exine cavate. Intexine oval in outline, radius 1/2–3/4 of spore radius. Exoexine reticulate, muri 2 μm high and wide, lumina polygonal, up to 15 μm in diameter.

Distribution: Poland – western Pomerania, Gorzysław 9 and Rzeczenica 1 boreholes, Zone Ra, Upper Famennian (Turnau, 1978; this paper) Holy Cross Mountains, Zone LL, upper part of Famennian (Turnau, 1990); Belarus – Pripyat Depression, Upper Famennian (Kedo & Golubtsov, 1971; Kedo, 1974); Russian Platform, Upper Famennian (Byvsheva, 1985); Ireland, Upper Famennian (Higgs, 1975), Zones LL-LE, Upper Famennian (Higgs & Russel, 1981; Higgs *et al.*, 1988); Germany – Rheinisches Schiefergebirge, zone LL, Upper Famennian (Higgs & Streel, 1984).

Genus *Spelaeotriletes* Neves et Owens, 1966

Spelaeotriletes obtusus Higgs 1975
Fig. 9H

1975. *Spelaeotriletes obtusus* Higgs: p. 400, tab. 6, figs 1-3.

Material: 26 specimens.

Description: Miospores 56–72 μm in diameter. Amb circular, oval or subtriangular. Trilete rays straight, accompanied by sinuous lips ending at curvaturae imperfectae. Exine cavate. Intexine not always visible due to dense ornamentation, radius 1/2 to 3/4 of spore radius. Outside contact faces exine ornamented with densely set, discrete pila and bacula 2–4 μm long, 1–3 μm wide at base.

Distribution: Poland – western Pomerania, Gorzysław 8 and 9, Rzeczenica 1, Chmielno 1 boreholes, Zone Ma (Ma_1, Ma_2, Ma_3), Tournaisian (this paper); Ireland, Zones VI-BP, Tournaisian (Higgs *et al.*, 1988).

Spelaeotriletes resolutus Higgs
Fig. 9 (I, J)

1975. *Spelaeotriletes resolutus* Higgs: p. 400, tab. 6, figs 4-6, non figs 7-9.

1993. *Spelaeotriletes papulosus* (Sennova) Avkhimovitch: Avkhimovitch, Tchibrikova, Obukhovskaya, Nazarenko, Umnova, Raskatova, Loboziak & Streel, tab. 21, fig. 4, tabl. 22, figs 7, 8, tabl. 24, fig. 4.

Material: 33 specimens.

Description: Miospores 40–57 μm in diameter. Amb subtriangular, sides convex, apices broadly rounded. Trilete rays accompanied by slightly sinuous lips up to 3 μm in height, extending almost to equator where they merge with short arcuate ridges. Exine cavate. Radius of intexine 3/4 of spore radius. Contact faces smooth, the remaining part of exine surface covered with elements varying in form in the same specimen. These are grana, cones and bacula with bulbous bases. Some cones are surmounted by a spine. The ornamentation elements are up to 4 μm in height, 1.5–2.5 μm wide at base; some bases of elements are in contact. Exoexine about 2 μm thick.

Distribution: Poland – western Pomerania, Gorzysław 8 and 9, Rzeczenica 1 boreholes, assemblage II, subzones Ra_1, Ra_2, Ma_1, Ma_2, Upper part of Famennian, Tournaisian (this paper); Ireland, Upper Famennian (Higgs, 1975), Zones VI-PC, Tournaisian (Higgs *et al.*, 1988); Russian Platform, Upper Famennian–Tournaisian, Zones Im-VF, Famennian (Avkhimovitch *et al.*, 1993b).

Infraturma PLANATI Neves et Owens 1966
Genus *Auroraspora* (Hacquebard, Staplin et Malloy) Richardson 1960

Auroraspora hyalina (Naumova) Streel 1974
Fig. 9R

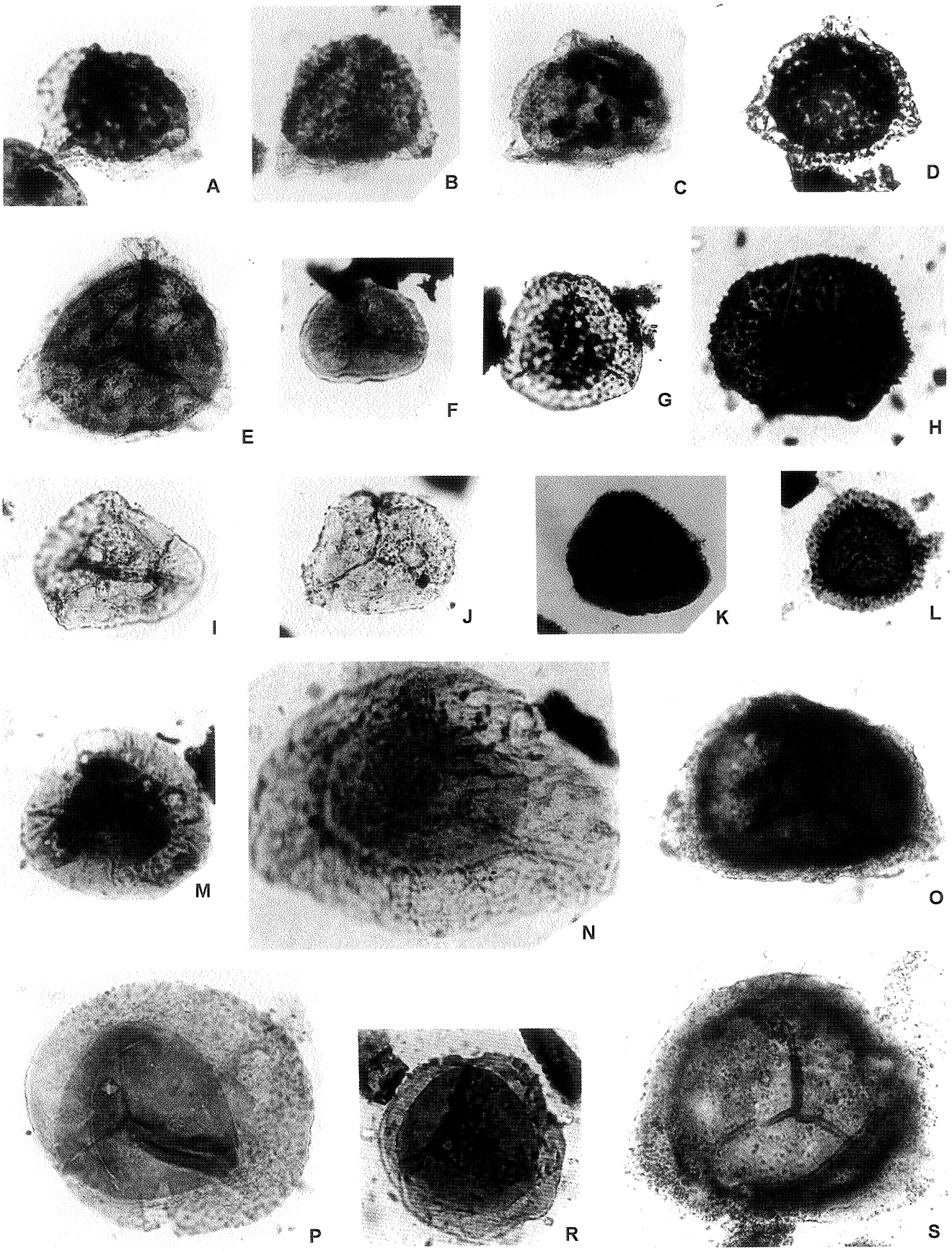
1974. *Auroraspora hyalina* (Naumova) Streel: Becker *et al.*, p. 26, *cum synonimis.*

Material: 16 specimens.

Description: Miospores 30–50 μm in diameter. Amb circular or subtriangular. Triletes rays straight, 1/2 of spore radius in length, accompanied by labra about 3 μm in height. Exine cavate. Intexine small, radius 1/2 of spore radius, exoexine smooth or finely granulate, about 2 μm thick.

Distribution: Poland – western Pomerania, Gorzysław 8 and 9 boreholes, Subzones Ra_1, Ra_2, Ma_1, Ma_2, Upper Famennian–Tournaisian (this paper); Russian Platform, Famennian (Naumova, 1953), Famennian–Tournaisian (Byvsheva, 1985); France – Bou-

Fig. 9. Miospores from Upper Frasnian, Famennian and Lower Carboniferous in western Pomerania. Specimens **A, C, D, O** are from Gorzysław 11. 17, 3319–3337 m, DT Zone, other specimens as indicated below. All magnifications × 500. **A, C, D** – *Samarisporites triangulatus* Allen; **B** – *Samarisporites triangulatus* Allen, Gorzysław 11.12, 3270–3271 m, RD Zone; **E** – *Samarisporites* cf. *triangulatus* Allen, Gorzysław 11.8, 3226–3227 m, RD Zone; **F** – *Rugospora granulatipunctata* (Hacquebard, Staplin *et* Malloy) Higgs *et al.*, Gorzysław 9.9, 3187–3188 m, Ma_1 Zone; **G, K, L** – *Grandispora villosa* (Avkhimovitch) comb. nov., Gorzysław 8.3, 3514–3516 m, assemblage II; **H** – *Spelaeotriletes obtusus* Higgs, Chmielno 1.5, 3952–3962 m, Ma_2 Subzone; **I, J** – *Spelaeotriletes resolutus* Higgs, Gorzysław 9.11, 3198–3199 m, Ra_1 Subzone; **M** – *Diducites versabilis* (Kedo) Van Veen, Gorzysław 9.13, 3207–3208 m, Ra_1 Subzone; **N** – *Retispora macroreticulata* (Kedo) Byvsheva, Gorzysław 9.11, 3198–3199 m, Ra_1 Subzone; **O** – *Cristatisporites deliquescens* (Naumova) Arkhangielskaya; **P** – *Diducites poljessicus* (Kedo) Van Veen, Karcino 2.1, 2939–2940 m, IP Zone; **R** – *Auroraspora hyalina* (Naumova) Streel: Becker *et al.*, Gorzysław 9.4, 3148–3149 m, Ma_2 Subzone; **S** – *Cristatisporites* cf. *deliquescens* (Naumova) Arkhangielskaya, Gorzysław 11.14, 3284–3285 m, DT Zone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lonnais, Frasnian/Famennian transition (Loboziak & Streel, 1988); Belgium, Upper Frasnian–Famennian (Becker *et al.*, 1974); Brazil, palynozone IV, Frasnian (Loboziak *et al.*, 1988); Libya, palynozone 11, Upper Famennian (Massa & Moreau-Benoit, 1976; Moreau-Benoit, 1980, 1989).

Diducites poljessicus (Kedo) Van Veen 1981
Fig. 9P

1957. *Hymenozonotriletes poljessicus* (Kedo): p. 25, tab. 3, figs 6-8.
1974. *Auroraspora poljessica* (Kedo) Streel: Becker *et al.*, p. 26, tab. 20, figs 8-14.
1981. *Diducites poljessicus* (Kedo) Van Veen: p. 271, tab. 4, figs 1-4, 6.

Material: 4 specimens.
Description: Miospores 67–75 μm in diameter. Amb circular or oval. Trilete rays straight, extending to the intexine margin. Exine cavate. Intexine attached to exoexine proximally, often situated out of centre, outline subtriangular, sides convex, apices rounded, surface bearings few irregular folds. Radius of intexine 2/3–3/4 of spore radius. Exoexine bilayered, smooth or finely granulate. Outer exoexine thinner than the inner one, visible at equatorial margin.
Distribution: Poland – western Pomerania, Gorzysław 8, Karcino 2, zone IP, assemblage II, Famennian (this paper); Ireland, zones LL, LE, LN, Famennian (Van Veen, 1981; Van Veen et Van der Zwan, 1978), Zone PL (Higgs, 1975); Ardennes, Famennian (Streel in Becker *et al.*, 1974); Germany, LL, LE, LN zones (Higgs & Streel, 1984); France – Boulonnais, Frasnian and Famennian, from zone "IV" (Streel *et al.*, 1987; Loboziak & Streel, 1988); Belarus – Pripyat Depression, Famennian (Kedo, 1957); Famennian from Zone Im (Avkhimovitch *et al.*, 1993b).

Diducites versabilis (Kedo) Van Veen 1981
Fig. 9M

1981. *Diducites versabilis* (Kedo) Van Veen: p. 268, tab. 2, figs 5-6, tab. 3, figs 1-6, 9, *cum synonimis*.

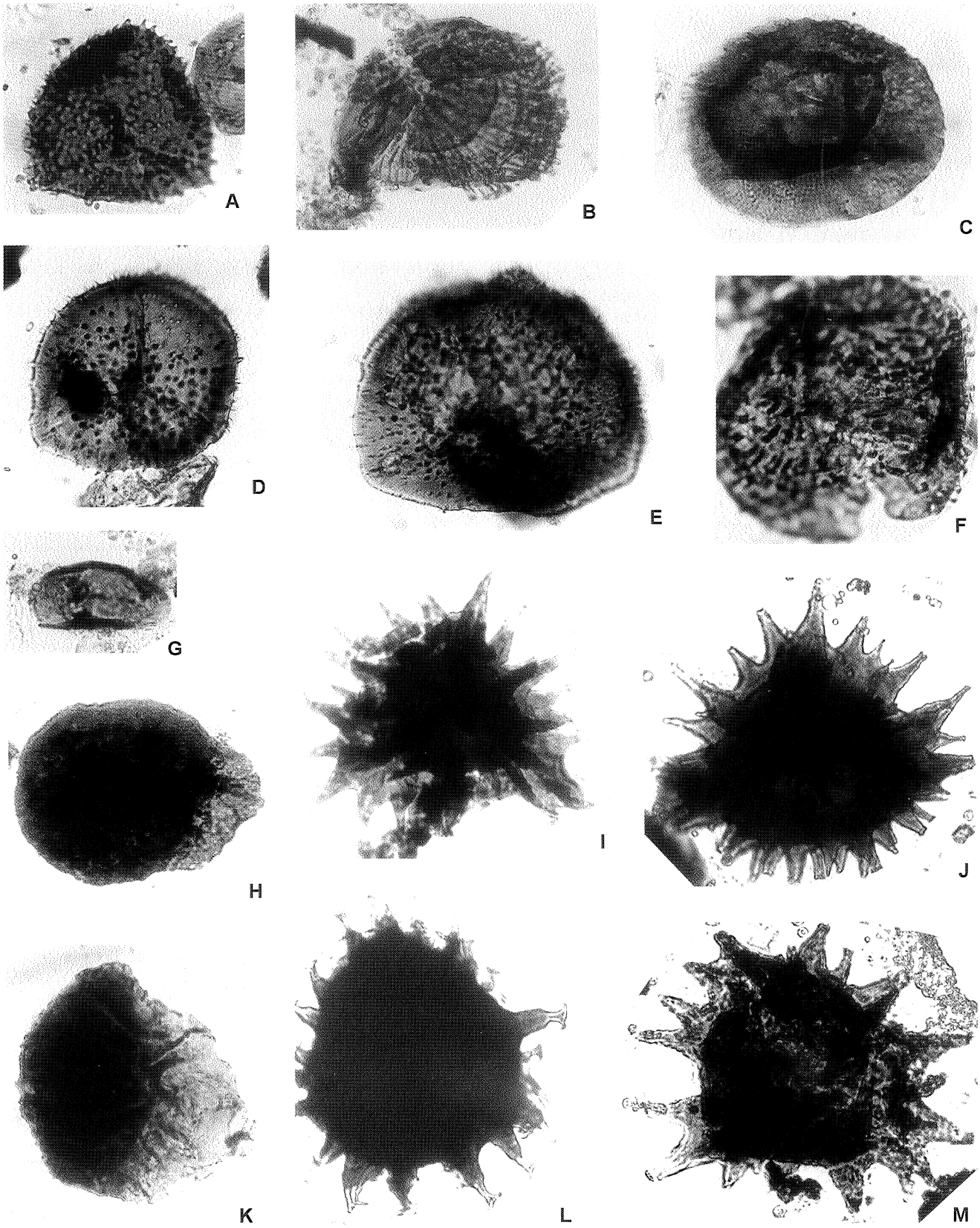
Material: 17 specimens.
Description: Miospores 45–60 μm in diameter. Amb oval or subtriangular, sides convex, apices broadly rounded. Trilete rays extend almost to intexine margin, accompanied by labra up to 5 μm in height. Exine cavate. Intexine outline conformable with amb, radius 1/2–2/3 of spore radius. Exoexine smooth, bilayered, outer layer visible at equatorial margin, thinner than the inner one, translucent, radially folded, folds 2–6 μm in height.
Distribution: Poland – western Pomerania, Gorzysław 8 and 9, Chmielno 1 boreholes, assemblage II, Zone Ra, Famennian (this paper), Zones Ve, Lu, Ra, Upper Famennian (Turnau, 1979), Holy Cross Mountains, Famennian (Turnau, 1990); Belarus – Pripyat Depression, Devonian/Carboniferous transition (Kedo, 1974; Avkhimovitch *et al.*, 1988b); Ireland, Zones LL-VI, Upper Famennian, Tournaisian (Van Veen, 1981), Zones LL-LN, Upper Famennian (Van der Zwan, 1980); France –Boulonais, Upper Famennian (Streel *et al.*, 1987; Loboziak & Streel, 1988); Belgium – Ardennes, Famennian (Streel in Becker *et al.*, 1974); Germany – Rheinisches Schiefergebirge, Zones LL-LN, Upper Famennian (Higgs & Streel, 1984).

Subturma MEMBRANATITRILETES Neves et Owens 1966
Infraturma CONTINUATI Neves et Owens 1966
Genus *Geminospora* Balme 1962

Type species *Geminospora condensa* Stempień-Sałek, new species
Fig. 10 (A, D, E)

Holotype: ING PAN, slide G.9.11.2, 26/37, Fig. 10A.
Etymology: (Latin) *condensa* – dense (from densely set elements of ornamentation).
Material: 28 specimens.
Dimension: 52 μm in diameter.
Diagnosis: Miospores cavates, sculpture consisting of dense spinose processes.
Description: Miospores 50–65 μm in diameter. Amb subtriangular, sides convex, apices broadly rounded. Trilete rays straight or slightly sinuous, extending almost to equator, often obscured by dense ornament. Exine cavate, cava visible only in thinner and less densely ornamented specimens. Intexine thick, radius 4/5 of spore radius. Exoexine ornamented distally and proximo-equatorially with densely set, mamillate spines 2 do 3 μm wide at base, up to 3 μm in length. Some spines are fused at base with the neighbouring elements, or are about 1 μm apart.
Remarks: *Geminospora condensa* has similar amb, and size as *Grandispora lupata* Turnau (1975), but has thicker exine, more closely spaced and wider spines, and narrower camera.
Type-locality: Gorzysław 9 borehole, western Pomerania.
Type-level: Sąpolno Calcareous Shale Formation, Subzones Ra_1, Famennian, sample G.9.11., depth 3198 m.
Deposition of types: slide G.9.11.2, 26/37.

Fig. 10. Miospores from Upper Frasnian, Famennian and Lower Carboniferous in estern Pomerania. Specimens 9,12, 13, are from Gorzysław 11.10, 3246–3247 m, RD Zone, other specimens as indicated below. All magnifications × 500, except when indicated. **A** – *Geminospora condensa* n. sp., holotype, Gorzysław 9.11, 3198–3199 m, Ra_1 Zone; **B** – *Membrabaculisporis radiatus* (Naumova) Arkhangelskaya, Gorzysław 11.12, 3270–3271 m, RD Zone; **C, F** – *Membrabaculisporis radiatus* (Naumova) Arkhangelskaya, Gorzysław 14. 2, 2943–2950 m, RB Zone; **D** – *Geminospora condensa* n. sp., *ibidem*; **E** – *Geminospora condensa* n. sp., Gorzysław 9.13, 3207–3208 m, Ra_1 Zone; **G** – *Archaeoperisaccus concinnus* Naumova, Gorzysław 11.12, 3270–3271 m, RD Zone; **H** – *Ancyrospora langii* (Taugourdeau-Lantz) Allen, Gorzysław 11.17, 3319–3337 m, DT Zone, magnification × 400; **I, M** – *Ancyrospora fidus* (Naumova) Obukhovskaya: Avkhimovitch *et al.*, magnification × 400; **J, K** – *Lagenoisporites immensus* (Nazarenko *et* Nekryata) Avkhimovitch et Turnau: Avkhimovitch *et al.*, Karcino 2.1, 2939–2940 m, IP Zone; **L** – *Ancyrospora furcula* Owens, magnification × 400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Genus *Membrabaculisporis* Arkhangelskaya 1985

Membrabaculisporis radiatus (Naumova) Arkhangelskaya 1985
Fig. 10 (B, C, F)

1953. *Hymenozonotriletes radiatus* Naumova: p. 62, tab. 8, fig. 13.
1985. *Membrabaculisporis radiatus* (Naumova) Arkhangelskaya: p. 74.

Material: 10 specimens.
Description: Miospores 78–98 μm in diameter. Amb circular to oval. Trilete rays straight, extending to intexine margin, often obscured by ornamentation. Exine camerate, three layered. Intexine thin, occasionally folded, radius 1/3 of spore radius, attached to exoexine in proximal region. Exoexine of contact faces smooth. The remaining surface ornamented with densely set, narrow bacula with thickened, rounded terminations, up to 5 μm in length, about 2 μm wide at tip, 1–4 μm apart. In compressed spores the bacula have mostly radial orientation. Tips of bacula are covered by a membrane.
Remarks: In Remarks with specimens from the type area, those from Pomerania do not have punctation on the outer exoexine, which is reduced (or damaged).
Distribution: Poland – western Pomerania, Gorzysław 11 and 14, Strzeżewo 1 boreholes, zones RD, RB, Upper Frasnian–lower Famennian (this paper); Russian Platform, Upper Frasnian (Naumova, 1953), Zones OG, DE, Frasnian (Avkhimovitch *et al.*, 1993b).

INCERTAE SEDIS
Genus *Ancyrospora* (Richardson) Richardson 1962

Ancyrospora fidus (Naumova) Obukhovskaya: Avkhmovitch *et al.* 1993
Fig. 10 (I, M)

1953. *Archaeotriletes fidus* Naumova: p. 52, pl. VI, figs 5-6.
1993. *Ancyrospora fidus* (Naumova) Obukhovskaya: Avkhimovitch, Tchibrikova, Obukhovskaya, Nazarenko, Umnova, Raskatova, Loboziak & Streel, tab. 9, fig. 16, tab. 12, fig. 10.

Material: 27 specimens.
Description: Miospores 66–90 μm in diameter. Amb subtriangular, sides straight or slightly convex. Trilete rays straight, extending to equator, accompanied by slightly sinuous labra up to 20 μm high at the pole. Exine extended laterally at equator to form a narrow zona. Contact faces smooth, the remaining surface covered by densely set appendages 10–30 μm in length, 8–10 μm wide at base. The appendages have slightly laterally extended or truncated terminations. Some 20–25 appendages cross the equator.
Distribution: Poland – western Pomerania, Gorzysław 8, 11 and 14, Strzeżewo 1 boreholes, assemblage I, zone RB, Frasnian, lower Famennian (this paper); Russian Platform, Upper Devonian (Naumova, 1953), zones EX-SD, Belarus – Pripyat Depression, Upper Givetian–Frasnian (Avkhimovitch *et al.*, 1993b).

Ancyrospora furcula Owens 1971
Fig. 10L

1971. *Ancyrospora furcula* Owens: p.71, pl. 23, figs 1-4.

Material: 7 specimens.
Description: Miospores 75–98 μm in diameter. Amb subtriangular, sides convex. Trilete rays extending almost to equator, accompanied by slightly sinuous labra up to 20 μm high at the proximal pole (visible only in specimens with thin exine). Contact faces smooth, the remaining surface ornamented with densely set appendages with bulbous bases and tapering stems which have flattened, bifurcate or multifurcate termination. Appendages 10–20 μm in length, 6–10 μm in basal width, about 5 μm wide at half of their length. About 20 appendages with bases in contact are visible around the equator.
Distribution: Poland – western Pomerania, Gorzysław 11 borehole, assemblage I, zone RD, Frasnian (this paper); north Canada, Frasnian (Owens, 1971).

Ancyrospora langii (Taugourdeau-Lantz) Allen 1965
Fig. 10H

1960. *Archaeotriletes langii* Taugourdeau-Lantz: p. 145, pl. 3, figs 33, 34, 39.
1965. *Ancyrospora langii* (Taugourdeau-Lantz) Allen: p. 743, tab. 106, figs 5-7.

Material: 14 specimens.
Description: Miospores 60–110 μm in diameter. Amb subtriangular, sides slightly convex. Trilete rays accompanied by slightly sinuous labra up to 10 μm in height at the proximal pole, extending almost to equator, visible only in specimens with thin exine. Contact faces smooth, the remaining part of exine ornamented with densely set appendages 12–40 μm in length, 10–12 μm wide at base, with tapering stems which are about 1 μm in width at 3/4 of their length and have bifurcate terminations. The appendages are often broken within the thinnest part. Bases of appendages are occasionally fused with the neighbouring ones.
Distribution: Poland – western Pomerania, Gorzysław 11, Strzeżewo 1 boreholes, assemblage I, zones RD-RB, Frasnian–lower Famennian (this paper); France – Boulonnais, Frasnian (Taugourdeau- Lantz, 1971), Givetian, Frasnian (Loboziak & Streel, 1981, 1988); Germany, Eifel, Upper Eifelian–Givetian (Loboziak *et al.*, 1990); Spitsbergen, Givetian (Allen, 1965); Tunisia, Libya, Frasnian (Loboziak & Streel, 1989); Algeria – Givetian–Frasnian (Boumendjel *et al.*, 1988).

Genus *Lagenoisporites* Potonié et Kremp emend. Dybova-Jachowicz *et al.* 1979

Lagenoisporites immensus (Nazarenko et Nekryata) Avkhimovitch et Turnau 1993
Fig. 10 (J, K)

1971. *Hymenozonotriletes immensus* Nazarenko et Nekryata: Kedo, Nazarenko, Nekryata, Raskatova, Sennova &Tchibrikova, p. 188, tab. 16: 1-4.
1993. *Lagenoisporites immensus* (Nazarenko et Nekryata) Avkhimovitch et Turnau: Avkhimovitch V. I., Turnau, E. & Clayton, pl. 21, fig. 1, pl. 22, fig. 12.

Material: 7 specimens.
Description: Miospores 75–100 μm in diameter, usually preserved in lateral compression. Outline irregular. Trilete mark in the form of a gula. Exine cavate, exoexine forms a distal pseudosaccus which in an oblique compression forms an asymmetric zona 1/2 to 1/1 of spore radius in width. Exine finely punctate.
Remarks: *Lagenoisporites* is a megaspore genus (Dybova-Jachowiczowa *et al.*, 1979). *L. immensus* is of miospore size and it should be transferred to some other genus. However, the material from Pomerania is poor in specimens giving insufficient base for a taxonomic evaluation.
Distribution: Poland – western Pomerania, Gorzysław 8, Karcino 2 boreholes, zone IP, assemblage II, Famennian (this paper); Belarus – Prypiat Depression, zone CZ (subzone Za-VF, Famennian (Avkhimovitch *et al.*, 1993b); USA, Zone *torquata-gracilis-fructicosa*, Famennian (Richardson & Ahmed, 1989).

SUMMARY

The presented miospore data and their Remarks with those on conodont faunas from western Pomerania indicate that the first appearances of several stratigraphically important miospore species are isochronous over large areas, and thus, palynology is a good tool for local correlation of Upper Devonian and Tournaisian strata.

The Pomeranian miospore zonal scheme can be correlated, at several stratigraphical levels, with the schemes for the Devonian and Lower Carboniferous of eastern Europe. These levels are marked by the following events: first appearance of *Membrabaculisporis radiatus* (lower boundary of the RD zone), first appearance of *Lagenoisporites immensus* (lower boundary of the IP zone), first appearance level of *Diducites versabilis* (lower boundary of the Assemblage II) and first appearance of *Knoxisporites literatus* (lower boundary of the Ra Zone).

The proposed miospore zonal scheme is also correlatable, at several stratigraphical levels, with the miospore zonal schemes for the type regions for Devonian and Lower carboniferous in western Europe. These levels are marked by the following events: first appearance of *Knoxisporites literatus* (lower boundary of the zone Ra), first appearance of *Umbonatisporites distinctus* (lower boundary of the Ma_2 Subzone), first appearance of *Spelaeotriletes balteatus* (lower boundary of the Ma_3 Subzone), first appearance of *Spelaeotriletes pretiosus* (lower boundary of the Ma_4 Subzone).

The results of the miospore study indicate that (a) the Człuchów Formation represents the frasnian and most of the Famennian (except its Uppermost part), (b) the Sąpolno Calcareous Shale Formation spans the Uppermost Famennian and lowermost Tournaisian, and (c) the Gozd Arkose Formation is of Tournaisian age.

The miospore zones distinguished may be considered equivalents of the conodont zones: Assemblage I = (probably) the *punctata* Zone, RD zone = *hassi-rhenana* zones, RB zone = *rhenana-triangularis* zones, IP zone = *crepida* zone, Assemblage II = (probably) *marginifera* Zone, Ra zone = Upper *expansa*-Lower *praesulcata* zones, Ma_1 and Ma_2 Subzones = middle and Upper part of *sandbergi* Zone, Ma_3 = Lower *crenulata* zone, Ma_4 = propably *isosticha*-Upper *crenulata* zone.

The composition of the Pomeranian miospore assemblages from the Frasnian and Lower Famennian is similar to that of the contemporaneous assemblages described from eastern Europe. On the other hand, the Upper Famennian and Tournaisian assemblages are closely comparable with those described from western Europe.

The stratigraphic gap within the Sąpolno Calcareous Shale Formation includes an Upper part of the Famennian and the lowermost Tournaisian.

Acknowledgements

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APPENDIX 1
List of all miospore species determined

Ancyrospora fidus (Naumova) Obukhovskaya: Avkhimovitch *et al.* 1993b
Ancyrospora langii (Taugourdeau-Lantz) Allen 1965
Ancyrospora furcula Owens 1971
Aneurospora greggsii (McGregor) Streel in Becker *et al.* 1974
Apiculiretusispora nitida Owens 1971
Archaeoperisaccus concinnus Naumova 1953
Archaeozonotriletes variabilis Naumova 1953
Auroraspora asperella (Kedo) Van der Zwan 1980
Auroraspora hyalina (Naumova) Streel: Becker *et al.* 1974
Auroraspora macra Sullivan 1968
Colatisporites multisetus (Luber) Avkhimovitch et Turnau 1994
Convolutispora crassitunicata (Obukhovskaya) Obukhovskaya: Avkhimovitch *et al.* 1993b
Convolutispora major (Kedo) Turnau 1978
Convolutispora mellita Hoffmeister, Staplin et Malloy 1955
Convolutispora subtilis Owens 1971
Corbulispora cf. *cancellata* (Waltz) Bharadway et Venkatachala 1961
Corbulispora vimineus (Nekryata) Obukhovskaya et Nekryata 1983
Corystisporites pomeranius n.sp.
Crassispora trychera Neves et Ioannides, 1974
Cristatisporites deliquescens (Naumova) Arkhangelskaya 1987
Cymbosporites acanthaceus (Kedo) Obukhovskaya: Avkhimovitch *et al.*1993b
Cymbosporites acutus (Kedo) Byvsheva 1985
Cymbosporites boafeticus(Tchibrikova) Obukhovskaya: Avkhimovitch *et al.* 1993b
Cymbosporites eximius(Obukhovskaya) Obukhovskaya: Avkhimovitch *et al.* 1993b
Cymbosporites vetlasjanicus Medianik et Obukhovskaya: Avkhimovitch *et al.* 1993b
Cyrtospora cristifera (Luber) Van der Zwan 1979
Cyrtospora cf. *cristifera* (Luber) Van der Zwan 1979
Diaphanospora platyrugosa (Naumova) Obukhovskaya: Avkhimovitch *et al.* 1993b
Diducites commutatus (Naumova) Avkhimovitch 1988b
Diducites compactus (Nekriata) Nekriata 1979
Diducites mucronatus (Kedo) Van Veen 1981
Diducites poljessicus (Kedo) Van Veen 1981
*Diducites radiatus (*Kedo) Obukhovskaya: Avkhimovitch *et al.* 1993b
Diducites versabilis (Kedo) Van Veen 1981
Diducites vishenensis Obukhovskaya et Avkhimovitch: Avkhimovitch *et al.* 1993b
Discernisporites micromanifestus (Hacquebard) Sabry et Neves 1971
Endoculeospora gradziński Turnau 1975
Geminospora condensa n. sp.
Geminospora micromanifesta (Naumova) Arkhangelskaya 1985
Geminospora nalevkinii (Naumova) Obukhovskaya 1986
Geminospora notata (Naumova) Obukhovskaya: Avkhimovitch *et al.* 1993b
Geminospora notata var. *microspinosa* Tchibrikova 1972
Geminospora rugosa (Naumova) Obukhovskaya: Avkhimovitch *et al.* 1993b
Gorgonispora crassa (Winslow) Higgs *et al.* 1988
Grandispora aspersa (Avkhimovitch) Avkhimovitch 1976
Grandispora cornuta Higgs 1975
Grandispora echinata Hacquebard 1957
Grandispora famenensis (Naumova) Streel var. *minutus* Nekryata 1974

Grandispora lupata Turnau 1975
Grandispora uncata (Hacquebard) Playford 1971
Grandispora villosa (Avkhimovitch) comb. nov.
Hymenozonotriletes argutus Naumova 1953
Hystricosporites corystus Richardson 1962
Hystricosporites furcatus Owens 1971
Hystricosporites multifurcatus (Winslow) Mortimer et Chaloner 1967
Hystricosporites porrectus (Balme et Hassel) Allen 1965
Hystricosporites reflexus Owens 1971
Hystricosporites suborlovicus (Kedo) comb. nov.
Indotriradites explanatus (Luber) Playford 1991
Knoxisporites literatus (Waltz) Playford 1963
Laevigatosporites ovalis Kosanke 1950
Lagenoisporites immensus (Nazarenko et Nekryata) Avkhimovitch et Turnau: Avkhimovitch *et al.* 1993b
Lophozonotriletes excisus Naumova 1953
Lophozonotriletes fursenkoi Nekryata 1979
Lophozonotriletes multiformis Tchibrikova 1972
Membrabaculisporis radiatus (Naumova) Arkhangelskaya 1985
Murospora dubitata Higgs 1975
Plicatispora scolecophora (Neves *et* Ioannides) Higgs *et al.* 1988
Pustulatisporires gibberosus (Hacquebard) Playford 1964
Raistrickia corynoges Sullivan 1968
Raistrickia minor (Kedo) Neves et Dolby 1967
Raistrickia ramiformis (Kedo) Avkhimovitch et Higgs: Avkhimovitch *et al.* 1988b
Raistrickia spathulata (Winslow) Higgs 1975
Raistrickia variabilis Dolby et Neves 1970
Retispora lepidophyta (Kedo) Playford 1976
Retispora macroreticulata (Kedo) Byvsheva 1985
Retusotriletes cohatus Sullivan 1964
Retusotriletes planus Dolby et Neves 1970
Retusotriletes pychovi Naumova 1953
Rugospora radiata, Avkhimovitch *et al.* 1988a
Rugospora granulatipunctata (Hoffmeister, Staplin et Malloy) Higgs *et al.* 1988
Samarisporites triangulatus Allen 1965
Schopfites cf. *delicatus* (Higgs) Higgs *et al.* 1988
Spelaeotriletes balteatus (Playford) Higgs 1975
Spelaeotriletes obtusus Higgs 1975
Spelaeotriletes pretiosus (Playford) Neves et Belt 1971
Spelaeotriletes resolutus Higgs 1975
Tholisporites densus McGregor 1960
Tumulispora malevkensis (Kedo) Turnau 1978
Tumulispora obscura Staplin et Jansonius 1964
Tumulispora rarituberculata (Luber) Playford 1991
Umbonatisporites abstrusus (Playford) Clayton 1971
Umbonatisporites distinctus Clayton 1971
Umbonatisporites distinctus var. *crinitus*, n. var.
Vallatisporites cf. *pussilites* (Kedo) Dolby et Neves 1970
Velamisporites cf. *caperatus* (Higgs) Higgs *et al.* 1988
Velamisporites magnus (Huphes et Hayford) Playford 1971
Verrucosisporites evlanensis (Naumova) Obukhovskaya: Avkhimovitch *et al.* 1993b
Verrucosisporites cf. *evlanensis* (Naumova) Obukhovskaya: Avkhimovitch *et al.* 1993b
Verrucosisporites grumosus (Naumova) Sullivan 1964
Verrucosisporites nitidus Playford 1964
Verrucosisporites oppressus (Higgs) Higgs *et al.* 1988
Verrucosisporites scurrus (Naumova) McGregor et Camfield 1982

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Appendix 2

BOREHOLE	Formation	Pomeranian miospore zonation	Depth in metres and number of palynological sample	*Auroraspora asperella*	*A. hyalina*	*A. macra*	*Convolutispora major*	*C. mellita*	*Corbulispora cf. cancellata*	*Corbulispora sp.*	*Crassispora trychera*	*Cymbosporites acutus*	*Diducites commutatus*	*D. versabilis*	*Discernisporites micromanifestus*	*Endoculeospora gradziński*	*Geminospora condensa*	*Gorgonispora crassa*	*Grandispora lupata*	*Knoxisporites literatus*	*Lophozonotriletes excisus*	*Plicatispora scolecophora*	*Pustulatisporites gibberosus*	*Raistrickia corynoges*	*R. minor*	*R. ramiformis*	*R. variabilis*	*Retispora lepidophyta*	*R. macroreticulata*	*Rugospora granulatipunctata*	*R. radiata*	*Schopfites cf. delicatus*	*Spelaeotriletes balteatus*	*SAMPLE obtusus*	*SAMPLE resolutus*	*Tumulispora malevkensis*	*T. obscura*	*T. rarituberculata*	*Umbonatisporites abstrusus*	*U. distinctus*	*U. distinctus var. crinitus*	*Velamisporites cf. caperatus*	*V. magnus*	*Verrucosisporites nitidus*	*V. oppressus*	*V. scurrus*
GORZYSŁAW 9	Sapolno Calcareous Shale Fm	Ma_3	3141,0-3142,0 sample 1	1		1			1			2								3				1						1			1	1												3
		Ma_2	3145,0-3146,0 sample 2			2	1					2			2																			3												
		Ma_2	3146,0-3147,0 sample 3		2	3	1	1	1		2	1								2				2						1	1			3					1	1			2	2		
		Ma_2	3148,0-3149,0 sample 4	1	2	4	2	1			2	2			2									3	1											2					1					
		Ma_2	3149,0-3150,0 sample 5	3	4	5						2			2					2			1							1		4								1	3					
		Ma_2	3154,0-3155,0 sample 6	1	1	3					4	3						1		2	1									1		3		1											1	
		Ma_2	3175,0-3176,0 sample 7			4					2													4												1									1	
		Ma_2	3183,0-3184,0 sample 8			2					2																			1		1				2		1						3		
		Ma_2	3185,0-3186,0 sample 8a			1		1			1																									1		2						2		
		Ma_2	3186,0-3187,0 sample 8b			1					1																					1						1								
		Ma_1	3187,0-3188,0 sample 9	4	1	1														1	2	2	1	1	2					3						4	2	3				1		2	1	1
		Ma_1	3188,0-3189,0 sample 9a	1	1	2									2	1				2	1			2											1	1		2						1		
		Ma? / Ra?	3189,0-3190,0 sample 9b																	1				1												1		2						2		
		Ra_2	3190,0-3191,0 sample 9c			1													2									2	1															1		
		Ra_2	3191,0-3192,0 sample 9d		1	2													1								1	1									1	1								
		Ra_2	3192,0-3193,0 sample 9e							1									2																	3		2								
		Ra_2	3193,0-3194,0 sample 9f			1				1									1	2								2								1										
		Ra_2	3194,0-3195,0 sample 9g																	1								1										2								
		Ra_2	3195,0-3196,0 sample 9h			2														1						1																		1		
		Ra_2	3196,0-3194,0 sample 9i						2										2					3	1		1	1							1	1	1	3								1
		Ra_2	3197,0-3198,0 sample 10			1													1	1							2	3										1						3		
		Ra_1	3198,0-3199,0 sample 11		1				3	1			2	2	2		9		4	2					3		4	4	1						2	3	2	2								
		Ra_1	3199,0-3200,0 sample 11a														2		2	1					1		1	2	1						2	1		1								
		Ra_1	3200,0-3201,0 sample 11b										1				1		1								2	2							1			2								
		Ra_1	3201,0-3203,0 sample 11c											1			1		1	2					1		1	3							1											
		Ra_1	3205,0-3206,0 sample 12			1				1							2		2	2							4	5								2		3								1
		Ra_1	3207,0-3208,0 sample 13										2		1		2		2	1					3	2	2	2							2	1	1					1			2	
		Ra_1	3208,0-3209,0 sample 14						1	1							1		2								1	5	1						2		1	1								
		Ra_1	3213,0-3214,0 sample 15			1			1					1					1	1					5	2	1	2	1						7	1	2	2								

BOREHOLE	FORMATION	Pomeranian miospore zonation	Depth in metres and number of palynological samples	*Auroraspora macra*	*Coatisporites multisetus*	*Convolutispora major*	*Crassispora trychera*	*Cymbosporites acutus*	*Cyrtospora cristifer*	*Diducites versabilis*	*Endoculeaspora gradziński*	*Geminospora condensa*	*Grandispora cornuta*	*Grandispora echinata*	*Grandispora lupata*	*Grandispora uncata*	*Indotriradites explanatus*	*Knoxisporites literatus*	*Lophozonotriletes excisus*	*Pustulatisporites gibberosus*	*Raisrickia condylosa*	*Raisrickia corynoges*	*Raisrickia variabilis*	*Retispora lepidophyta*	*Retispora macroreticulata*	*Rugospora radiata*	*Schopfites cf. delicatus*	*Spelaeotriletes balteatus*	*Spelaeotriletes obtusus*	*Spelaeotriletes pretiosus*	*Spelaeotriletes resolutus*	*Tumulispora malevkensis*	*Tumulispora obscura*	*Tumulispora rarituberculata*	*Umbonatisporites abstrusus*	*Umbonatisporites distinctus*	*Vallatisporites cf. pussilites*	*Verrucosisporites nitidus*	*Verrucosisporites scurrus*
CHMIELNO 1	Gozd Ark. Fm	Cl	3863,0-3870,0 pr. 7	10	2	1	15		3										1		2						10	1										1	
	Gozd Ark. Fm	$Ma_{3,4}$	3907,0-3925,0 pr. 6	8		2	6	1					1			2	1	3	6		3						2	5		6						5		2	
	Sapolno Calc. Sch. Fm	Ma_2	3952,03962,0 pr. 5			2	8	3					1			1		3	1			4							2		2					2			
	Sapolno Calc. Sch. Fm	Ma_1	3999,0-4013,0 pr. 4	1			6	1	2						1	2		2				3					4		1		1	2	2	2				2	
	Sapolno Calc. Sch. Fm	Ra_2	4013,0-4021,0 pr. 3							4													3	2									1	3				1	
	Sapolno Calc. Sch. Fm	Ra_1	4091,0-4108,0 pr. 2							1			1		2	1								4							1	3		5					
	Sapolno Calc. Sch. Fm	Ra_1	4192,0-4210,0 pr. 1						1	5			2		4	2							4	8										1					
RZECZENICA 1	Sapolno Calc. Sch. Fm	Ma_2	2896,0-2899,0 pr.12	5		2	5		2			3		1				2		1		3					3		1					1					1
		Ma_2	2899,0-2901,3 pr. 11	7			3		2		3	4	3			4		4		1		3					5		5										1
		Ma_1	2910,0-2913,0 pr. 10											2		1		2	2	1		1	1	4					1		1	2		1					1
		Ma/Ra	2920,7-2921,0 pr. 9											1	2	3		1				3	2	3	1	3		2			1	3		3	3		2	1	
		Ma/Ra	2921,5-2922,0 pr. 8	10				10	6				2			3		5	6			9					8	1				6	1	8	2			3	
		Ma/Ra	2922,0-2922,5 pr. 7	8				4					1		4	1		1	2			6	1	1		3	1				1	3		5				1	
		Ma/Ra	2922,5-2923,0 pr. 6	4					1		2	1		1	3	3	3	4	4			2	1	4			6							1			1	1	
		Ma/Ra	2923,0-2923,5 pr. 5	8				1	2		1				1	2		3									1				1	4	1	4				1	
		Ma/Ra	2923,5-2924,0 pr. 4	5					3		3		1		1	3		5	1			3					1	1			1	2		1					

Appendix 2

BOREHOLE	Formation	Pomeranian miospore zonation	Depth and number of palynological sample	Ancyrospora fidus	Ancyrospora sp.	Aneurospora greggsii	Auroraspora asperella	A. hyalina	A. macra	Convolutispora major	Corbulispora sp.	Crassispora trychera	Cymbosporites acutus	Cyrthospora cf. cristifer	Diducites commutatus	D. compactus	D. poljessicus	D. versabilis	Discernisporites micromanifestus	Geminospora notata	G. condensa	Grandispora aspersa	G. famenensis var. minutus	G. villosa	Hystricosporites furcatus	H. multifurcatus	H. porrectus	H. suborlovicus	Knoxisporites literatus	Lagenoisporites immensus	Lophozonotriletes excisus	Murospora dubitata	Plicatispora scolecophora	Velamisporites magnus	Raistrickia corynoges	R. minor	R. ramiformis	R. spathulata	Retusotriletes planus	R. pychovi	Rugospora granulatipunctata	Spelaeotriletes obtusus	SAMPLE resolutus	Tumulispora malevkensis	T. obscura	T. rarituberculata	Umbonatisporites abstrusus	U. distinctus	U. distinctus var. crinitus	Velamisporites cf. caperatus	Verrucosisporites evlanensis	V. nitidus	V. oppressus	V. scurrus
GORZYSŁAW 8	Sapolno Calc. Shale Fm	Ma_2	3216,0-3218,0 sample 1				1	3	6	1	2	3	16	2					4		2								3		3	2	2		4	1	2	1			2	8	4	2	1	7	2	9	6	3		2	2	3
	Człuchów Fm	Ass. II	3514,0-3516,0 sample 3			2			3					1	3	3	1	3				3	2	5	4	2		4						3					2	1			1								4	2		
		IP	3667,0-3669,0 sample 5			6										2	2			8			2				1			5				4						4														
		RB	3705,0-3708,0 sample 6	3	2	1														4							2							3						5														
			3735,0-3737,0 sample 7	2	3	1														2							1													2														
			3764,0-3767,0 sample 8	2	3															1							2							2					1															
			3939,0-3943,0 sample 9	1	2	1																					1							1					1															

BOREHOLE	Formation	Pomeranian miospore zonation	Depth in metres and number of palynological sample	Aneurospora greggsii	Corbulispora vimineus	Cymbosporites boafeticus	Diducites poljessicus	D. vishenensis	Geminospora notata	G. rugosa	Grandispora aspersa	Hystricosporites furcatus	H. porrectus	H. suborlovicus	Laevigatosporites ovalis	Lagenoisporites immensus	Lophozonotriletes furssenkoi	L. multiformis	Retusotriletes planus	Velamisporites magnus	Verrucosisporites evlanensis
KARCINO 2	Człuchów Fm	IP	2939,0-2940,0 sample 1	1			1	1	1				2		1	2			3	4	
			2976,0-2977,0 sample 2						1	1	1	2	1		2					1	2
			2977,0-2978,0 sample 3	1	2				2	1		1	1	1			1			2	
			3016,0-3018,0 sample 4										1	2				1		1	
			3018,0-3020,0 sample 5	1	1	1								1			1	1			1

BOREHOLE	Formation	Pomeranian miospore zonation	Depth in metres and number of palynological sample	Ancyrospora fidus	A. furcula	A. langii	Aneurospora greggsii	Apiculiretusispora nitida	Archaeoperisaccus concinnus	Archaeozonotriletes variabilis	Convolutispora crassitunicata	C. subtilis	Corystisporites pomeranius	Cristatisporites deliquescens	Cymbosporites boafeticus	C. eximius	C. vetlasjanicus	Diaphanospora platyrugosa	Diducites radiatus	Geminospora micromanifesta	G. nalevkinii	G. notata	G. rugosa	Hymenozonotriletes argutus	Hystricosporites furcatus	H. multifurcatus	H. porrectus	H. reflexus	Laevigatosporites ovalis	Membrabaculisporis radiatus	Retusotriletes incohatus	Samarisporites triangulatus	Samarisporites cf. triangularis	Tholisporites densus	Velamisporites magnus	Verrucosisporites cf. evlenensis	V. grumosus
GORZYSŁAW 11	Człuchów Fm	RB	3050,0-3051,0 pr.2																			2	1		1		1				1						
			3060,0-3061,0 pr. 3	1				1							3		2			1	1	2	1												3		
		RD	3118,0-3122,0 pr. 5				1	1				1							1		1	2	2							2	1						
			3193,0-3194,0 pr. 6	1			2	1		1		2									2	3	1				1				3	2		1			
			3226,0-3227,0 pr. 8	1	1	1				1						1					2	2	1		1	1	2				3	1	3	1	1		
			3246,0-3247,0 pr. 10			2	1	3					5			1				2	2	3	2		2	1	4	2		1	1	1	1	2	2		1
			3270,0-3271,0 pr. 12	3	2	2	1	3	2		2		2			1		2			2	3	2		1		2	1	1	2		5	1	2			
		Ass. I	3284,0-3285,0 pr. 14	2	1	1		2					5	1							1	2	2	1	1	1	2					6			2	1	
			3319,0-3337,0 pr. 17	2	3	2		3						1							2	3	3		2		3					5					

BOREHOLE	Formation	Pomeranin miospore zonation	Depth in metres and number of palynological sample	Ancyrospora fidus	Aneurospora greggsii	Cristatisporites deliquescens	Cymbosporites acanthaceus	C. boafeticus	Diducites mucronatus	D. radiatus	Geminospora nalevkinii	G. notata	G. notata var. microspinosa	G. rugosa	Membrabaculisporis radiatus	Retusotriletes pychovi
G. 14	Człuchów Fm	RB	2829,0-2847,5 sample 1		3					2	1	2		1		1
			2943,0-2950,0 sample 2	3	1	2	1	5	1		3	5	2	2	2	1

BOREHOLE	Formation	Pomeranian miospore zonation	Depth in metres and number of palynological sample	Ancyrospora fidus	A. langii	Convolutispora subtilis	Cymbosporites acanthaceus	Geminospora micromanifesta	G. nalevkinii	G. notata	G. rugosa	Hystricosporites corystus	H. porrectus	Membrabaculisporis radiatus	Samarisporites triangulatus	Samarisporites cf. triangulatus
STRZEŻEWO 1	Człuchów Fm	RD	3922.0-3924,0 sample 0	1	1				2	2	1		1			
			4165,0-4166,0 sample 1	2	1		2	1	2	3	1	1	1	1	1	
			4290,0-4291,0 sample 9	1	1					1						
			4296,0-4300,0 sample 10		1	1				2			1			
			4355,0-4356,0 sample 11	1						1	1					
			4454,0-4458,0 sample 13	1	2	1	1		1	2	3		1	2	2	1

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Streszczenie

TAKSONOMIA I STRATYGRAFIA MIOSPOROWA GÓRNEGO DEWONU I NAJNIŻSZEGO KARBONU POMORZA ZACHODNIEGO

Marzena Stempień-Sałek

W pracy określono metodą palinologiczną wiek formacji człuchowskiej, kłanińskiej, iłowców wapnistych z Sąpolna i dolnej części piaskowców arkozowych z Gozdu wydzielanych dla górnego dewonu i najniższego karbonu Pomorza Zachodniego (Fig. 1), oraz zaprezentowano lokalny, stratygraficzny schemat miosporowy dla najwyższego dewonu i najniższego karbonu Pomorza Zachodniego (Fig. 2). Posłużono się podziałem litostratygraficznym Matyji (1993, 1998) i Lipca (Lipiec & Matyja, 1998) przedstawionym na figurach 3 i 4. Biostratygrafia powyższych utworów, oparta jest przede wszystkim na badaniach konodontów, a także małżoraczków, brachiopodów oraz miospor.

Stosowany dotychczas schemat miosporowy dla Pomorza Zachodniego (Turnau, 1978, 1979) jest, przynajmniej dla pewnych interwałów, mało szczegółowy, dlatego też wprowadzono podpodziały dla istniejących już zon, a także wydzielono nowe zespoły i zony miosporowe w osadach franu i dolnego famenu (por. Fig. 2). Zbadane materiały pochodziły z 9 otworów wiertniczych (por. Fig. 1). Z wyjątkiem otworów wiertniczych Rzeczenica 1 i Chmielno 1 (Turnau, 1978, 1979, Matyja *et al.*, 2000) utwory z badanych wierceń nie były do tej pory opracowywane pod kątem palinologicznym. Utwory starsze, które należą do dewońskiej formacji człuchowskiej, stały się obiektem zainteresowań palinologicznych po raz pierwszy.

Zespoły gatunków miospor wskaźnikowych dla zon lokalnego schematu miosporowego dla najwyższego dewonu i najniższego karbonu Pomorza Zachodniego zilustrowano na figurze 5. Na podstawie pierwszych pojawień gatunków wskaźnikowych, schemat ten można w części korelować ze schematem miosporowym przyjętym dla Europy Zachodniej (Streel *et al.*, 1987; Higgs *et al.*, 1988) i Wschodniej (Avkhimovitch, 1993; Avkhimovitch *et al.*, 1993b) co przedstawiono na figurze 6.

Zbadane utwory są dość szczegółowo datowane na podstawie konodontów (poziomy *punctata* - dolna *crenulata*). Miospory i konodonty pochodzą z tych samych profili i tych samych lub podobnych przedziałów głębokości (por. Figura 3). Fakt ten umożliwia datowanie granic wyróżnionych zon miosporowych. Próba korelacji stratygraficznego lokalnego schematu miosporowego i zonacji konodontowej zilustrowana została na figurze 4.

Potwierdzono obecność luki stratygraficznej na granicy dewon/karbon (Fig. 6), obejmującej brakujące zony miosporowe: LN i VI.

W części systematycznej opisano 31 gatunków miospor wyznaczających granice zon miosporowych oraz dotychczas nie opisanych z Pomorza Zachodniego. Gatunki te zilustrowane są na figurach 7–10. Listę wszystkich oznaczonych miospor zamieszczono w dodatku (Appendix 1). Dokumentacja ilościowa i jakościowa, oraz dotycząca głębokości pobrania pozytywnych prób na miospory przedstawiona jest w dodatku (Appendix 2).