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Cambrian phytoplankton of the Brunovistulicum – taxonomy and biostratigraphy

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I dedicate this work to the Memory of Prof. Aleksander Jachowicz (1928–1989) great palynologist and my loving Father who passed away too soon.

Pracę dedykuję Pamięci Prof. Aleksandra Jachowicza (1928–1989), wspaniałego palinologa i kochającego Ojca, który odszedł za wcześnie.

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Abstract. The paper presents the results of detailed palynological studies carried out on the Cambrian deposits of the Brunovistulicum, a characteristic regional unit distinguished in sub-Devonian geology in southern Poland and NE Czech Republic. The material studied consists of drillcore samples collected from 22 boreholes that have penetrated Cambrian in southern and north-eastern parts of the Upper Silesian Block (USB) and 3 boreholes located in the Moravia region (Czech Republic). Within those boreholes, complexes of lithologically differentiated clastic rocks have been encountered below Jurassic, and Lower or Middle Devonian deposits. The age of these sediments, apart from the Goczałkowice IG 1 profile, was determined only on the basis of palynological studies. Majority of the investigated rock samples yielded very rich usually well preserved microfloristic material that allowed to make taxonomic revisions of analysed acritarch associations. Five new genera, nineteen new species and eleven species new combinations are proposed. The new and revised taxa include mainly those that appear in the Cambrian Series 2 and forms characteristic for the Cambrian Series 3. These are the following important new genera as: *Ichnosphaera*, *Lechistania*, *Eklundia*, *Parmasphaeridium* and *Turrisphaeridium*. The taxonomic revision and systematic analysis of acritarch associations described from the Cambrian of Brunovistulicum allowed to establish the succession of microfloral assemblages. As a result of the present studies nine distinct regional assemblage acritarch zones have been recognised – BAMA I to BAMA IX, correlated with the Cambrian series: Terreneuvian, Series 2, and Series 3. The BAMA I – *Pulvinosphaeridium antiquum–Pseudotasmanites* and the BAMA II *Asteridium tornatum–Comasphaeridium velvetum* zones are distinguished in the oldest Cambrian deposits of the Brunovistulicum and are correlated with the *Platysolenites* Zone. Acritarch assemblages characteristic for the older one were documented in the Borzęta Formation in the eastern margin of the Upper Silesian Block. The acritarch association of the BAMA II constrains the biostratigraphic position of the Mogilany Member of Goczałkowice Formation in the USB area. The BAMA III–VI acritarch assemblage zones: *Ichnosphaera flexuosa–Comasphaeridium molliculum*, *Skiagia–Eklundia campanula*, *Skiagia–Eklundia varia* and *Volkovia dentifera–Liepaina plana* are recognised in the Goczałkowice Formation of both the Upper Silesian and Brno blocks and comprise deposits of *Schmidtiellus*, *Holmia* and *Protolenus* trilobite zones in the studied area. The BAMA VII to BAMA IX zones are correlated with Series 3 of the Cambrian System and were established in the Sosnowiec Formation known only from the Sosnowiec IG 1 borehole in the Upper Silesian Block area. The BAMA VII *Ammonidium bellulum–Ammonidium notatum* Zone is here correlated with trilobite *Acadoparadoxides oelandicus* Zone, while BAMA VIII *Turrisphaeridium semireticulatum* and BAMA IX *Adara alea–Multiplicisphaeridium llynense* zones are regarded as equivalents of the *Paradoxides paradoxissimus* Zone. The present study indicates that the oldest Cambrian (Terreneuvian) sediments containing BAMA I Zone assemblages were deposited only in the eastern part of the Upper Silesian Block. Younger sediments, from the Terreneuvian and Series 2 with BAMA II–VI Zones assemblages were developing over much larger areas of the Upper Silesian and Brno blocks. Sediments of the Series 3 with BAMA VII–IX assemblages are known only from the northern part of the USB. The Furongian sediments, not yet found in the study area, potentially may occur in the northern part of the Block, where the Ordovician strata were found. Nevertheless, a reliable reconstruction of the Early Palaeozoic deposition within the Brunovistulicum still remains an open question, which can be solved only by new borehole data.

Key words: acritarchs, palynology, stratygraphy, Cambrian, Brunovistulicum.

Abstrakt. W pracy przedstawiono wyniki szczegółowych badań palinologicznych wykonanych dla utworów kambryjskich rozpoznanych na obszarze Brunovistulicum, regionalnej jednostki tektonicznej położonej na południu Polski i w północno-wschodnich Czechach. Materiał do badań stanowiły próbki skał z 22 otworów wiertniczych zlokalizowanych w obszarze bloku górnośląskiego oraz z 3 wierceń wykonanych na Morawach (blok Brna). W wierceniach tych pod utworami jury, dewonu dolnego lub środkowego nawiercono zróżnicowane litologicznie kompleksy skał klastycznych, które poza jednym profilem – Goczałkowce IG 1 – pozbawione są przewodnich mikroskamieniałości, a ich kambryjski wiek został ustalony na podstawie badań palinologicznych. Uzyskany w trakcie badań bogaty i w większości dobrze zachowany materiał mikroflorystyczny umożliwił przeprowadzenie rewizji wielu taksonów akritarch, w tym wykreowania 5 nowych rodzajów oraz wyróżnienia 19 nowych gatunków i 11 nowych kombinacji gatunkowych. Nowe i rewidowane taksony to głównie gatunki występujące w utworach oddziału 2 i formy charakterystyczne dla oddziału 3 systemu kambryjskiego. Do najważniejszych należą następujące nowe przewodnie rodzaje: *Ichnosphaera*, *Lechistania*, *Eklundia*, *Parmasphaeridium* i *Turrisphaeridium*. Przeprowadzone analizy taksonomiczne zespołów akritarch udokumentowanych w utworach kambru Brunovistulicum pozwoliły na wyznaczenie w tym obszarze 9 regionalnych poziomów mikroflorystycznych – BAMA I do BAMA IX, które datują trzy kolejne oddziały kambru: terenew, oddział 2 i 3. Poziomy BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites* i BAMA II *Asteridium tornatum–Comasphaeridium velvetum* rozpoznano w najstarszych utworach kambru Brunovistulicum, gdzie zostały skorelowane z poziomem *Platysolenites*. Zespoły akritarch charakterystyczne dla poziomu BAMA I stwierdzono w utworach formacji z Borzęty udokumentowanych we wschodniej brzeżnej części bloku górnośląskiego. Kolejna asocjacja BAMA II datuje wiek kompleksu skalnego wyróżnionego w obszarze bloku górnośląskiego jako ogniwo piaskowców skolitusowych z Mogilan formacji z Goczałkowic. Zespoły akritarch charakterystyczne dla poziomów BAMA III–VI: *Ichnosphaera flexuosa–Comasphaeridium molliculum*, *Skiagia–Eklundia campanula*, *Skiagia–Eklundia varia* i *Volkovia dentifera–Liepaina plana*, które korelowane są z poziomami *Schmidtiellus*, *Holmia* i *Protolenus* udokumentowano w osadach formacji z Goczałkowic, rozpoznanych w obszarach bloku górnośląskiego i bloku Brna. Utwory odddziału 3 kambru w analizowanym obszarze dokumentują trzy poziomy akritarchowe BAMA VII–IX, stwierdzone w osadach formacji z Sosnowca, udostępnionych otworem wiertniczym Sosnowiec IG 1 na bloku górnośląskim. Poziom BAMA VII *Ammonidium bellulum–Ammonidium notatum* należy wiązać z poziomem *Acadoparadoxides oelandicus*, natomiast dwa pozostałe poziomy BAMA VIII *Turrisphaeridium semireticulatum* i BAMA IX *Adara alea–Multiplicisphaeridium llynense* z poziomem *Paradoxides paradoxissimus*. Z przeprowadzonych badań wynika, że najstarsze osady kambryjskie – terenewu – zawierające zespoły BAMA I tworzyły się tylko w części wschodniej bloku górnośląskiego. Osady młodsze, terenewu i oddziału 2 z zespołami BAMA II–VI rozwijały się na znacznie większym obszarze bloku górnośląskiego i bloku Brna. Osady oddziału 3 z zespołami BAMA VII–IX tworzyły się w północnej części bloku górnośląskiego. Obecność osadów furongu w analizowanym obszarze jest wielce prawdopodobna, mogą one występować w północnej części bloku, tym bardziej, że zostały tam już udokumentowane utwory ordowiku. Wiarygodne i prawidłowe odtworzenie rozwoju sedymentacji osadów dolnopaleozoicznych na obszarze Brunovistulicum pozostaje zagadnieniem otwartym, które można rozwiązać jedynie za pomocą nowych otworów wiertniczych pozwalających na poznanie pełniejszych profili tych utworów.

Słowa kluczowe: akritarchy, palinologia, stratygrafia, kambr, Brunovistulicum.

INTRODUCTION

For the last several years, the present author has been carrying out systematic and detailed palynological studies of the Lower Palaeozoic deposits of the Upper Silesian and Brno blocks that constitute the regional unit of the Brunovistulicum in southern Poland and north-eastern part of the Czech Republic (Fig. 1). During the early stages of the studies in the 1990s, the main objective was to determine the age of the clastic strata occurring below Devonian and above Precambrian rocks (Jachowicz, 1994; Jachowicz, Moryc, 1995; Buła, Jachowicz, 1996; Jachowicz, Přichystal, 1996, 1997). The age of these, mostly palaeontologically barren, sediments has been variably defined as Precambrian to Carboniferous (*vide*: Buła, Jachowicz, 1996; Buła, 2000).

In the Upper Silesian Block (USB), assemblages of the Cambrian acritarchs have been recognised within individual boreholes since 1970s and 1980s (Konior, Turnau, 1973; Turnau, 1974; Harańczyk, 1982, 1983; Brochwicz-Lewiński *et al*., 1986). During the next years, many microfossil assemblages, recovered from the stratotype Cambrian Goczałkowice IG 1 and Sosnowiec IG 1 boreholes, were attributed to various Cambrian subdivisions and even to Ordovician (Kowalczewski *et al*., 1984; Kowalczewski, 1990; Moczydłowska, 1998). Consequently, resulting stratigraphical interpretations and correlations led to many doubts and discussions (Buła, Jachowicz, 1996; Vanguestaine, 2000; Jachowicz, 2006; Vanguestaine, Brück, 2008). Also geological models of the USB based on

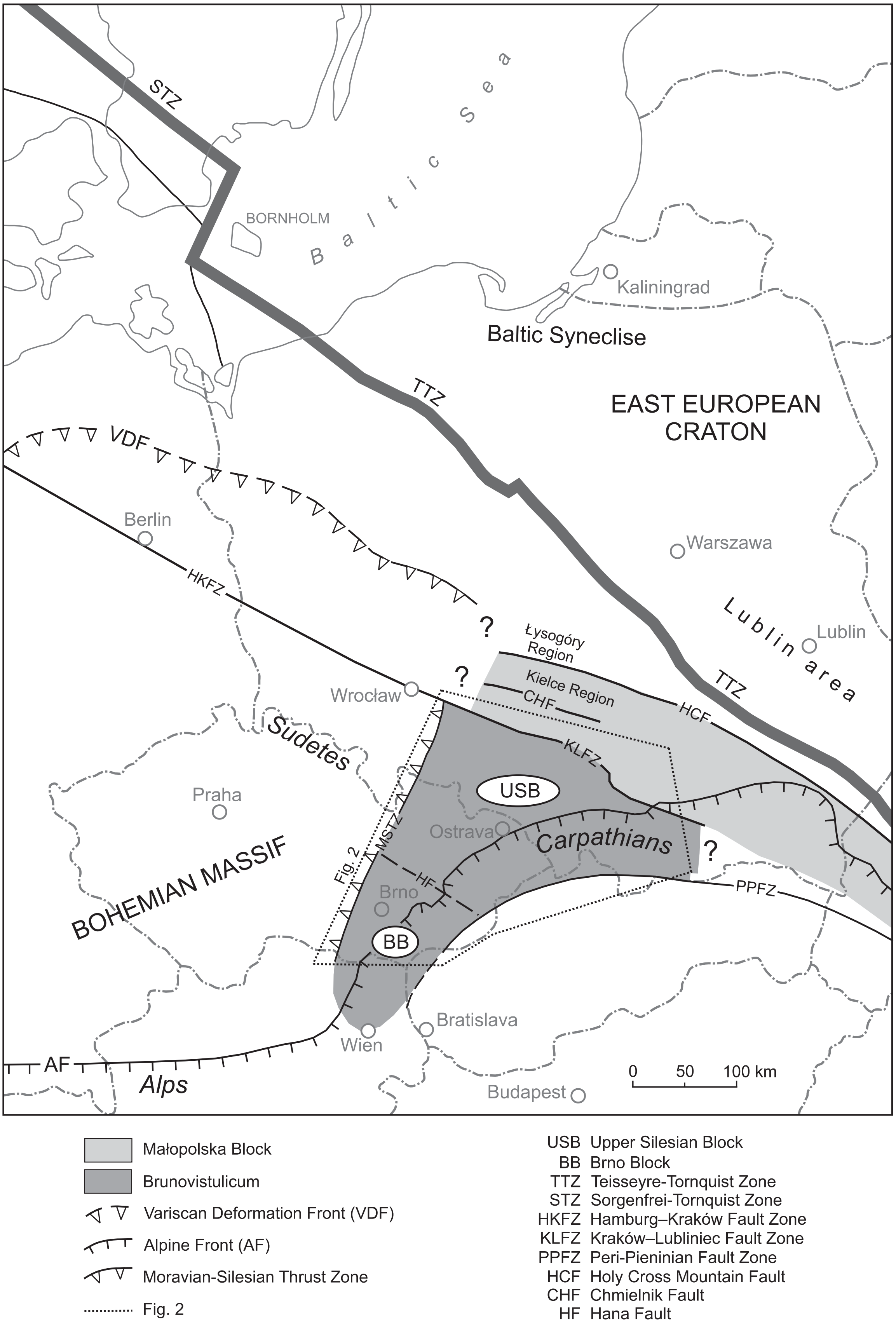


Fig. 1. Tectonic sketch showing the location of the Brunovistulicum terrane relative to the Teisseyre-Tornquist Zone margin of the East European Craton (Baltica) and orogenic belts in Central Europe (after Buła *et al*., 1997b; Buła, Habryn, eds., 2008; modified)

these early (Kowalczewski, 1990; Geyer *et al*., 2008) results have been disputable (Buła, 2000; Buła, Habryn, eds., 2008).

This paper summarizes all the available palynological data collected from 22 boreholes that have penetrated Cambrian in southern and north-eastern parts of the USB, and from three boreholes located in the Moravia region of the Czech Republic (Brno Block). The present author performed first detailed investigations of acritarchs in more than a dozen boreholes in the USB. Results of these studies have been already partly published (Jachowicz, 1994; Jachowicz, Moryc, 1995; Buła, Jachowicz, 1996; Moryc, Jachowicz, 2000), or have been included in the unpublished archival reports (Jachowicz, 1995, 1998, 1999, 2000). The preliminary results from the Moravian sections were published by Jachowicz and Přichystal (1996, 1997) and later by Fatka (1997) and Fatka and Vavrdová (Fatka, Vavrdová, 1998; Vavrdová, Bek, 2001; Vavrdová *et al*., 2003; Vavrdová, 2004, 2008; Mikuláš *et al*., 2008).

In order to obtain credible comparative material, palynological investigations have been carried out additionally in boreholes from which the microflora older than Devonian (Konior, Turnau, 1973; Turnau, 1974) or attributed to Cambrian (Harańczyk, 1982, 1983; Brochwicz-Lewiński *et al*., 1986) has been reported. Finally, detailed palynological analyses have been performed in the previously examined Cambrian profiles of the key Goczałkowice IG 1, Sosnowiec IG 1 and Potrójna IG 1 boreholes, whose stratigraphical positions, established by Kowalczewski *et al*. (1984), Kowalczewski (1990) and Moczydłowska (1993, 1995b, 1997, 1998; Moczydłowska-Vidal, 2003), raised some doubts.

Very rich microfloristic data collected during the previous investigations of the Cambrian deposits from the Brunovistulicum enabled the present author to carry out detailed taxonomic studies of microfossil assemblages. This further allowed to revise selected acritarch taxa, and eventually, to erect new genera and species. This paper summarizes previous data and presents the results of new palynological studies aiming at taxonomic re-evaluation of documented microfossil associations, their detailed definition and assesment of their stratigraphic significance for the correlation of the Lower and Middle Cambrian in the study area and possibly also in other regions.

GEOLOGICAL SETTING AND LITHOSTRATIGRAPHY

The Brunovistulicum is a characteristic regional unit distinguished in the sub-Devonian geology in southern Poland and NE Czech Republic (Fig. 1; Dudek, 1980; Buła *et al*., 1997a). The basement of the unit is composed of various Archean to Neoproterozoic crystalline and weakly metamorphosed sedimentary rocks, which underwent Cadomian orogenic consolidation (Finger *et al.*, 2000). The NW and NE boundaries are distinct tectonic zones whereas to the south Brunovistulicum plunges under the Carpathian orogen (Fig. 1). The basement is overlain by a discontinuous cover of the Lower Palaeozoic (Fig. 2) drilled beneath Devonian, Mesozoic or Neogene along the SE and E margin. In central parts, the Lower Palaeozoic is concealed by the thick Devonian-Carboniferous deposits in the Upper Silesian Coal Basin area (Buła, Żaba, 2005, 2008).

The Brunovistulicum is interpreted by most authors as exotic terrane of a Gondwanan or Peri-Gondwanan origin, accreted to Laurussia probably near the Silurian-Devonian transition (e.g. Dadlez *et al*., 1994; Bełka *et al*., 2002; Nawrocki *et al*., 2004). Cambrian palaeogeographic position of the terrane is subject to a discussion. Its Cambrian trilobite fauna is typical for both Baltic and Gondwanan zoogeographical provinces (Nawrocki *et al.*, 2004) while the Cambrian acritarch microflora has a cosmopolitan character. According to palaeomagnetic data for the Cambrian, the Brunoistulicum terrane could have been located within the Cadomian orogen between Baltica and Gondwana, and presumably occupied a nearly equatorial position (Nawrocki *et al.*, 2004; Nawrocki, Poprawa, 2006).

Most of the studied material was obtained from boreholes located in the northern part of Brunovistulicum, defined as the Upper Silesian Block (USB). Only a few studied boreholes are located in the southern, Moravian (Czech Republic) part – the Brno Block separated from the USB by the Hana Fault Zone (Fig. 2).

Development of the Early Palaeozoic sedimentary cover within the study area is not yet fully understood. A significant progress has been accomplished in the USB area, where presence of the Lower to Middle Cambrian and Ordovician deposits has been documented (Gładysz *et al*., 1990; Jachowicz, 1994; Buła, Jachowicz, 1996; Buła *et al*., 1997b; Buła, 2000; Jachowicz, 2005) (Fig. 3). In Moravia, the clastic sediments underlying the Middle to Upper Devonian carbonates were earlier attributed entirely to the Lower Devonian (Dvořak, 1998) and called “the Lower Devonian Basal Clastics”. However, the palynological studies of this rock complex in a few boreholes, have documented the Early Cambrian or the Early Devonian age (Purkňova *et al.*, 2004; Mikuláš *et al*., 2008).

The Lower Palaeozoic strata have been recognised in 47 boreholes located in southern, south-eastern, and northern parts of the USB (Buła, 2000). In 42 boreholes only parts of the Lower Cambrian have been acquired. The whole Lower Cambrian profiles have been fully penetrated only within few boreholes located entirely in the southern part of the USB. In its northern part, a fragment of the Middle Cambrian profile has been recognised in one borehole (Sosnowiec IG 1), and fragmentary Ordovician profiles have been found in four boreholes (Buła, Jachowicz, 1996; Buła *et al*., 1997b; Buła, 2000; Jachowicz, 2005) (Fig. 2). The Upper Cambrian has not been discovered so far in the northern part of the USB and the nature of the Cambrian–Ordovician boundary is still unresolved.

Buła (*in* Buła, 2000; Buła, Żaba, 2005) noticed that the Early Palaeozoic cover in southern and north-eastern parts of the USB is built only of the Lower Cambrian sediments

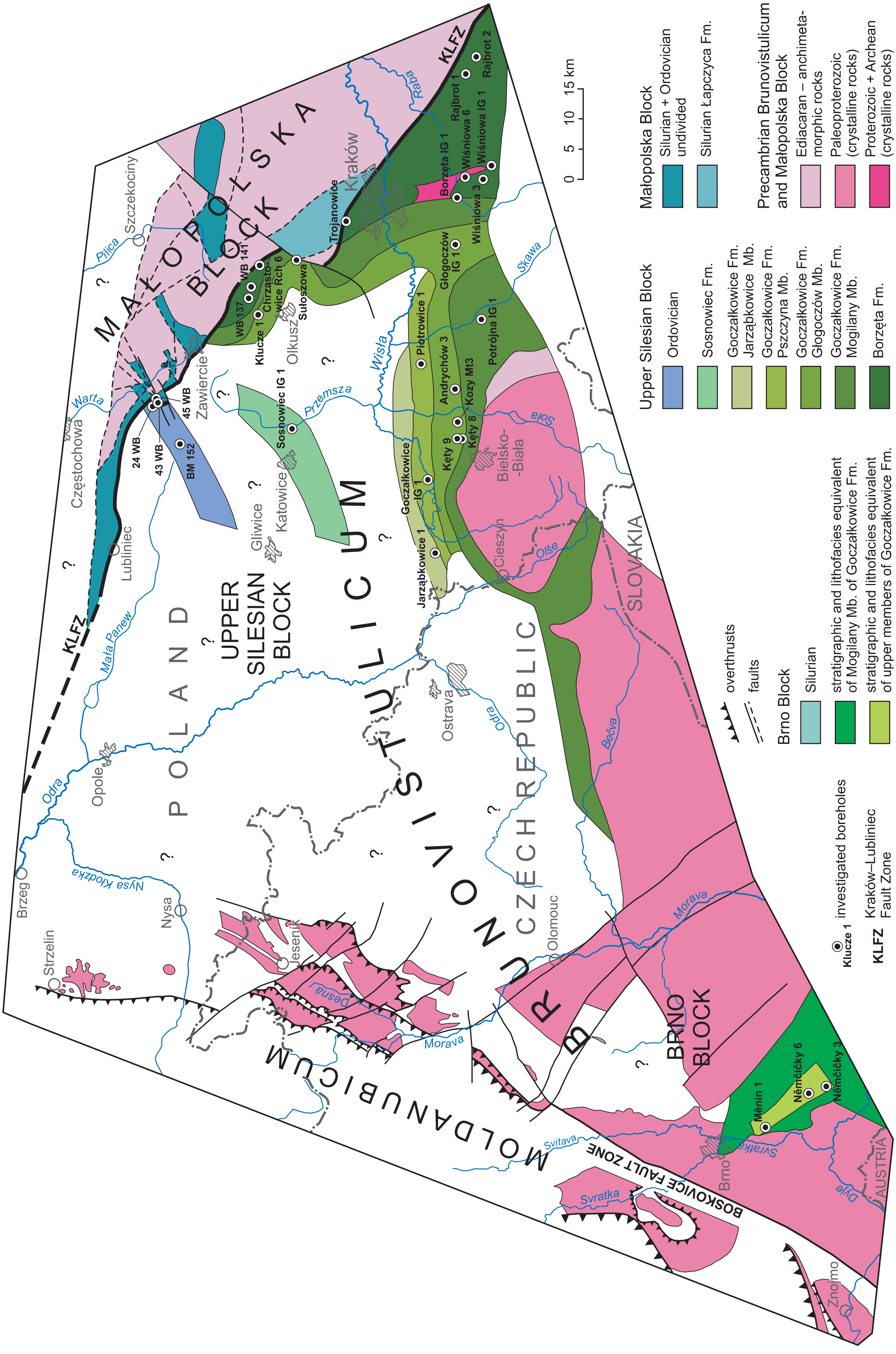


Fig. 2. Sub-Devonian map showing the location of the studied borehole sections against the distribution of the Lower Palaeozoic sediments in the Brunovistulicum and SW part of the Małopolska Block (after Buła, Żaba, 2005)

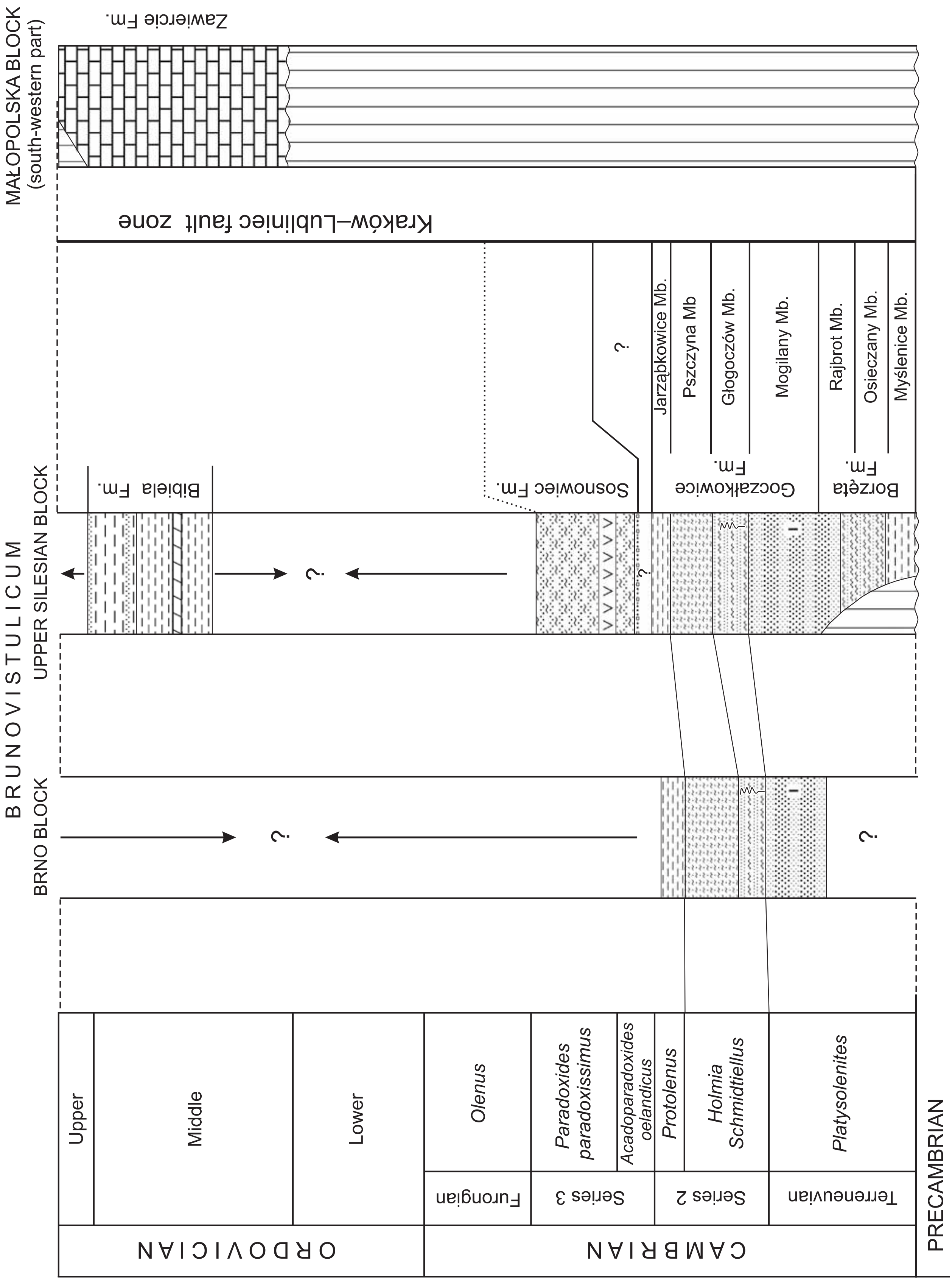
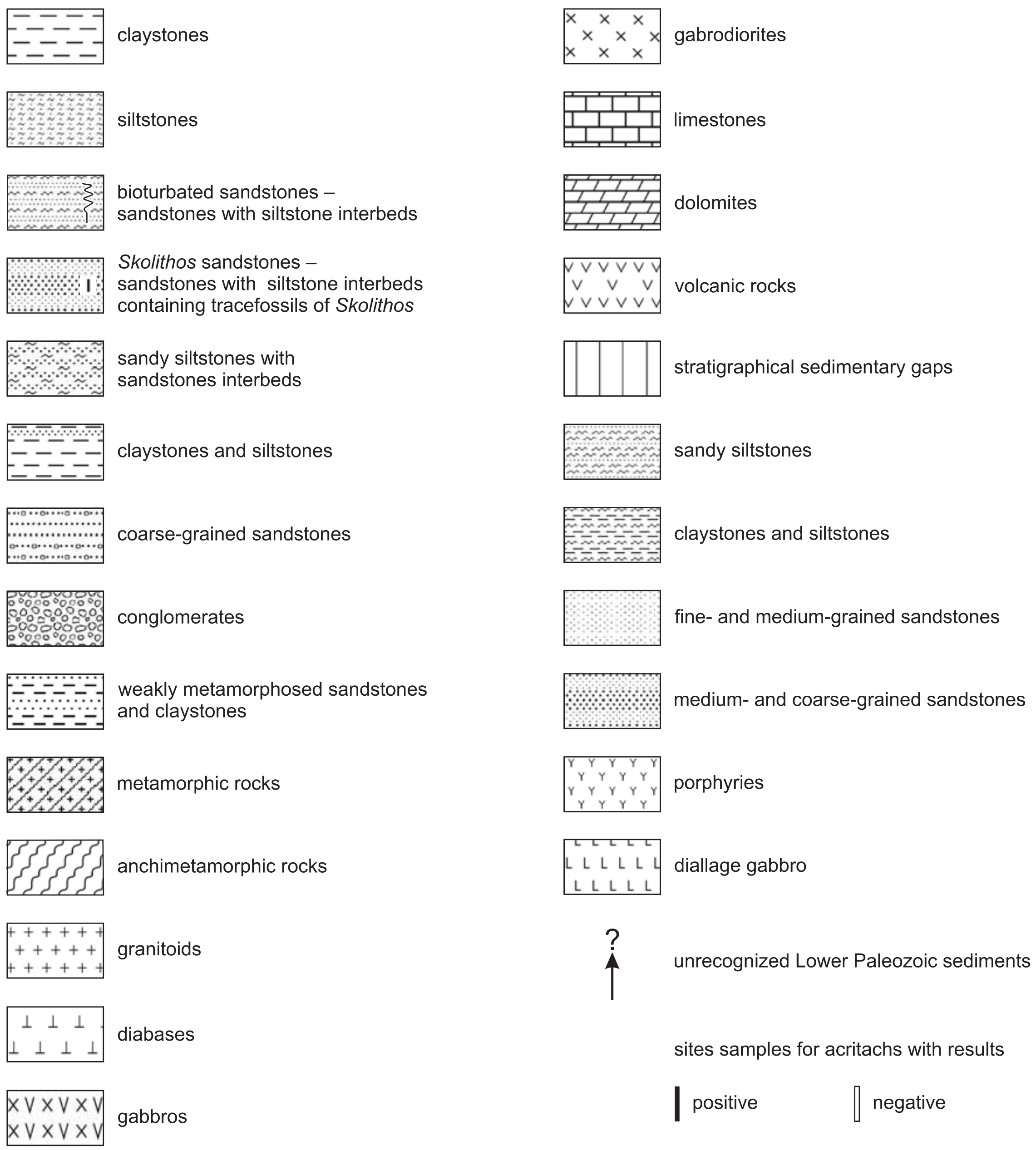


Fig. 3. Lithostratigraphic framework of the Lower Palaeozoic of the Brunovistulicum and SW Małopolska Block (after Bula, 2000)

Explanations for Figs. 3, 6–10



while towards the north younger Middle Cambrian and Ordovician strata appear (Figs. 2, 3). According to Buła (*op.cit.*) this pattern results from the migration of Middle Cambrian and Ordovician depocentres from S towards N and NW. Buła *et al.* (1997a) established a correlation of the Lower Cambrian deposits in the whole Brunovistulicum area, based on new stratigraphical data and on detailed lithological-sedimentological observations. The Lower Cambrian in the USB area rests unconformably upon the Precambrian basement (Buła, Żaba, 2005). It forms a continuous cover in the southernmost part (Cieszyn–Bielsko Biała area), except the areas where the Devonian or Miocene deposits lie directly on the uplifted Precambrian rocks. The sediment thickness increases northwards and, particularly, towards the north-east, up to 2500.0–3000.0 m (Buła, Jachowicz, 1996; Buła 2000).

The Lower Cambrian of the USB has been subdivided into the Borzęta and Goczałkowice formations (Buła, Jachowicz, 1996; Buła, 2000) (Fig. 3).The stratotype of the Borzęta Formation was established in the Borzęta IG 1 borehole by Buła (2000). Various clastic rocks encountered below Jurassic deposits at the depth of 2383.0–3700.0 m were initially ascribed partly to the Permo-Carboniferous (2383.0–3373.0 m), and, in the lower part, to the Cambrian (Gucik, 1973). As a result of new studies, the sandstones underlying the Jurassic at the depth 2383.0–3030.0 m, were ascribed to the Mogilany Member of the Goczałkowice Formation. The underlying strata were defined as the Borzęta Formation subdivided into the Myślenice Claystones Member, the Osieczany Siltstones Member, and the Rajbrot Sandstones Member (Buła, 2000) (Fig. 3).

The Myślenice Member, at least 225 m thick, is composed of black claystones interbedded with mudstones and with a few intercalations of marly limestones. Rare trace fossils include fodinichnia *Planolites beverleyensis* (Billings) representing a fairly deep-water environment with oxygen deficiency (Paczeŝna, Poprawa, 2001). The Osieczany Member is more than 300 m thick and is composed mainly of grey and grey-green siltstones interbedded with fine-grained sandstones. Sparse trace fossils in its upper part indicate a distant offshore depositional environment (Paczeŝna, Poprawa, 2001). The Rajbrot Member, 120 m thick, is represented mainly by medium- to fine-grained sandstones with mudstone intercalations. Sedimentary structures indicate deposition above the minimum wave-base, related to a nearshore depositional system (Paczeŝna, Poprawa, 2001). Overall, the Borzęta Formation has been recognised in 10 boreholes at the eastern margin of the USB. Stratigraphical and lithofacies equivalents of the formation are absent in the SW part of the USB and in the Brno Block (Buła, 2000; Buła, Żaba, 2005) (Fig. 2).

The Goczałkowice Formation, up to 2000 m thick, is widely distributed in the USB area (Buła, 2000). The stratotype was established in the Goczałkowice IG 1 borehole where various clastic sediments have been encountered below the Devonian deposits (Kotas, 1973a, b, 1982; Buła, 2000). The trilobites characteristic of the Lower Cambrian *Holmia* Zone were found near the complex top (Biernat, Baliński, 1973; Orłowski, 1975). The section displays a clearly tripartite transgressive succession (Kotas, 1982) that was subdivided by Buła (2000) and Buła and Żaba (2005) into four members (from bottom to top): Mogilany *Skolithos* Sandstones Member, Głogoczów Bioturbated Sandstones Member, Pszczyna Siltstones with Trilobites Member, and Jarząbkowice Claystones Member (Fig. 3).

The characteristic feature of of the Mogilany Member, which is above 90 m thick, is the presence of abundant *Skolithos* burrows. The lower part is composed of fine pebbly conglomerates, sandy gritstones and variably grained sandstones. Its upper part is represented by variably grained sandstones with intercalations of conglomerates and sandy mudstones. The lower part of the member developed, according to Paczeŝna (2005), in an alluvial-deltaic environment, while the upper part, in a marginal-marine environment.

The Głogoczów Member is 82 m thick and is composed of fine- and medium-grained quartz arenites or greywackes, light- and green-grey-coloured, and with mudstone laminae. Abundant and diverse trace fossils including *Bergaueria*, *Diplocraterion*, *Monocraterion* and *Planolites* are characteristic features of these sediments. Sedimentological and ichnological analyses indicate shallow-marine depositional systems of upper and middle offshore zones (Paczeŝna, 2005).

The Pszczyna Member (thickness 192 m) is composed of laminated sandy, grey and green-grey siltstones, and fine-grained sandstones displaying dark colour, presence of pyrite, and sporadic trace fossils that point to a deep-water oxygen-deficient deposition (Paczeŝna, 2005). The strata contain Lower Cambrian trilobites of *Holmia* Zone (Orłowski, 1975) and poorly preserved inarticulate brachiopods (Biernat, Baliński, 1973).

The above described three members of the Goczałkowice Formation from the stratotype section (Goczałkowice IG 1), have been recognised in several tens of boreholes mainly in southern and south-eastern parts of the USB area (Buła, 2000).

Recently, massive claystones, encountered in the Jarząbkowice 1 borehole at the depth 3980.0–4028.0 m were defined as the Jarząbkowice Claystones Member by Buła and Żaba (2005).

The Lower Cambrian sediments, recognised in Měnín 1, Němčičky 3 and Němčičky 6 boreholes, in the Brno Block (Jachowicz, Přichystal, 1996, 1997; Fatka, Vavrdová, 1998) are, according to Buła *et al.* (1997a) and Buła and Żaba (2005), age- and lithofacies-equivalents of the Goczałkowice Formation (Buła, 2000) (Fig. 3). This correlation is supported by the following evidence: (1) presence of similar lithotypes with similar petrographic characteristics, (2) clear fining-upward pattern in siliciclastic sediments, (3) presence of similar sedimentary structures and occurrence of similar trace-fossil genera, indicating comparable depositional conditions, (Paczeŝna, Poprawa, 2001; Paczeŝna, 2005; Mikulaš *et al*., 2008) and (4) the presence of acritarch assemblages with similar genera and species (Buła *et al*., 1997a).

The Middle Cambrian has been encountered so far only in the northern part of the USB, in the Sosnowiec IG 1 borehole (Fig. 2), where a complex of clastic and intrusive rocks has been penetrated below the Lower Devonian at the depth of 3156.0–3442.6 m. The thickness of the complex is 194 m excluding a gabbrodioritic-gabbrodiabase intrusion at the depth 3244.0–3336.2 m (Cebulak *et al*., 1973). The sediments contain long-ranging taxa of inarticulate brachiopods from Lingullidae and Acrotroidae families (Biernat, Baliński, 1973). Kowalczewski (1990) described these deposits as “mudstones and sandstones of the Sosnowiec Formation”. Their upper part is composed of mudstones and fine-grained sandstones while variably grained and conglomeratic sandstones (Radocha Member) occur in the lower part. The detailed lithological and petrographical characteristics of the above strata are provided by Cebulak *et al*., (1973), Kotas (1973a), Kotas and Rożkowski (1973), Kowalczewski (1990), Buła and Jachowicz (1996) and Buła (2000). The sediments are attributed to generally littoral, tidal-influenced depositional systems (Kotas, Różkowski, 1973; Kowalczewski, 1990; Buła, 2000).

Fragmentary Ordovician sections found in four boreholes in the northern part of the USB are composed of claystones intercalated with quartz sandstones and silicified dolomites, defined as the Bibiela Formation (Buła, 2000) (Figs. 2, 3). Their age has been established on the basis of conodonts (Siewniak-Madej, Jeziorowska, 1978) and acritarchs (Linczowska-Makowska, 1978; Gładysz *et al*., 1990; Jachowicz, 2005).

SUMMARY OF CAMBRIAN CHRONOSTRATIGRAPHY AND ACRITARCH BIOSTRATIGRAPHY

For over 170 years, the Cambrian System, defined by Sedgwick (Sedwick, Murchison, 1835) on the basis of Welsh profiles, was subdivided into the Lower, Middle, and Upper Cambrian mainly basing on the index trilobite fauna. Small shelly fossils, archaeocyaths, and trace fossils have been very helpful in characterizing biostratigraphic horizons lacking trilobites. The base of the Cambrian system was defined at the first appearance of *Trichophycus pedum* ichnospecies (Babcock, Peng, 2007; Landing *et al*., 2007; Peng, Babcock, 2011). New geochronological data allowed to date this boundary precisely at 541 ±1 million years, i.e. much later than previously assumed (Gradstein *et al*., 2012) (Fig. 4).

During the last years, a new chronostratigraphic subdivision of the Cambrian System has been approved by the International Commission on Stratigraphy. Four new series and ten new stages replaced the traditional units (Fig. 4) (Babcock *et al*., 2005; Babcock, Peng, 2007; Peng, Babcock, 2011; Gradstein *et al*., 2012). So far, only two Cambrian Series (the youngest, Furongian, and the oldest, Terreneuvian) and five Stages (Fortunian, Drumian, Guzhangian, Paibian, and Jiangshanian) have been officially established (Gradstein *et al*., 2012) (Fig. 4). The base of the Fortunian Stage in the Fortune Head stratotype in Newfoundland was used to define the Cambrian–Ediacaran boundary. The Cambrian upper boundary was defined at the first appearance of the conodont *Iapetognathus fluctivagus* in the same stratotype (Cooper *et al*., 2001).

The new Cambrian subdivisions do not correspond to the former units and are based on different trilobite fauna which leads to difficulties in correlation with older schemes. According to the most recent results (Babcock, Peng, 2007; Peng, Babcock, 2011), it can be accepted that the Terreneuvian and Series 2 encompass the traditionally understood Lower Cambrian deposits, the Series 3 is an equivalent of the Middle Cambrian, and the Furongian corresponds to the classical Upper Cambrian (Fig. 4).

Besides the index trilobites, small shelly fossils, archaeocyaths or trace fossils, commonly also distinct assemblages of organic microfossils are successfully used for a biostratigraphic correlation of the Cambrian successions. The microfossils mostly belong to the Acritarcha group containing forms with unusually acid-resistant organic walls (Evitt, 1963), whose origin and systematic position is not yet fully understood. Majority of Proterozoic and Palaeozoic acritarchs have been interpreted as eukaryotic unicellular photosynthesizing organisms, mostly marine, and most probably planktonic. However, part of them might represent multicellular algae, fungi, or even animals (Mendelson, 1993; Butterfield, 2004, 2005). Those microorganisms, representing in their majority the oldest eukaryotes, dominated among the Cambrian microfossils (Huntley *et al*., 2006). Their remains provided the first credible information on the early history of phytoplankton evolution and differentiation.

During the Cambrian, the acritarchs underwent a very rapid evolution leading to a development of rich, distinctly morphologically differentiated assemblages. This helped to establish a fairly detailed zonations of the Cambrian, based on quickly changing acritarch associations (Fig. 5). These microfossils have been in some cases the only available stratigraphical tool for the oldest Palaeozoic deposits often devoid of other fossils.

The Cambrian acritarchs do not demonstrate any clear geographic preferences, and, therefore, they provide means for inter-regional correlations. On the other hand, in many Cambrian basins, the established acritarch biozones have been closely correlated with the faunal ones (Martin, Dean, 1984, 1988; Moczydłowska, 1991, 1999; Jankauskas, Lendzion, 1992; Jankauskas, 2002).

In the Brunovistulicum area only three oldest Cambrian series have been recognised so far. Therefore, this study is limited to the time interval of about 40 million years, between the Terreneuvian base and the top of the Series 3. Several acritarch zones, recognised in other areas of the world, have been distinguished within deposits of that Cambrian section (Molyneux *et al*., 1996) (Fig. 5).

The new decisions of the International Commission on Stratigraphy have to be taken into consideration when applying acritarch zonation schemes established within the traditional subdivision of the Cambrian system. As the lower Cambrian boundary was raised to the base of the *Platysolenites* Zone, some taxa appearing in the *Sabellidites* Zone, previously regarded as the oldest Cambrian horizon, presently are attributed to the highest Ediacaran of the upper Neoproterozoic (Knoll, 1996; Knoll *et al.*, 2006). A good example is the characteristic genus *Ceratophyton*, whose first appearance for many years has been related to the Cambrian base (Jankauskas, Lendzion, 1992) and now it is moved to Neoproterozoic (Moczydłowska, 2008).

The definition of the Terreneuvian is given by Babcock *et al*. (2005), Babcock, Peng (2007) and Landing *et al*. (2007). Microfloral assemblages of the series are characterized by a weak morphological differentiation, and majority of the taxa are simple spherical forms with a poorly developed morphology. Many of them continue from the Ediacaran Period.

So far, two acritarch zones have been distinguished within that time interval, basing on their generic composition (Moczydłowska, 1991; Jankauskas, Lendzion, 1992) (Fig. 5). *Asteridium tornatum–Comasphaeridium velvetum* Assemblage Zone was defined in the Lublin area in SE Poland (Moczydłowska, 1991) with the index species *Comasphaeridium agglutinatum*, *C. formosum*, *C. velvetum*, and *Pterospermella velata*. *Asteridium* and *Comasphaeridium* species are forms with a distinct morphology characterized by delicate processes. This feature is regarded as the "Cambrian character" of a microflora (Moczydłowska, 1991). Those numerous Cambrian taxa do not appear in associations charac-

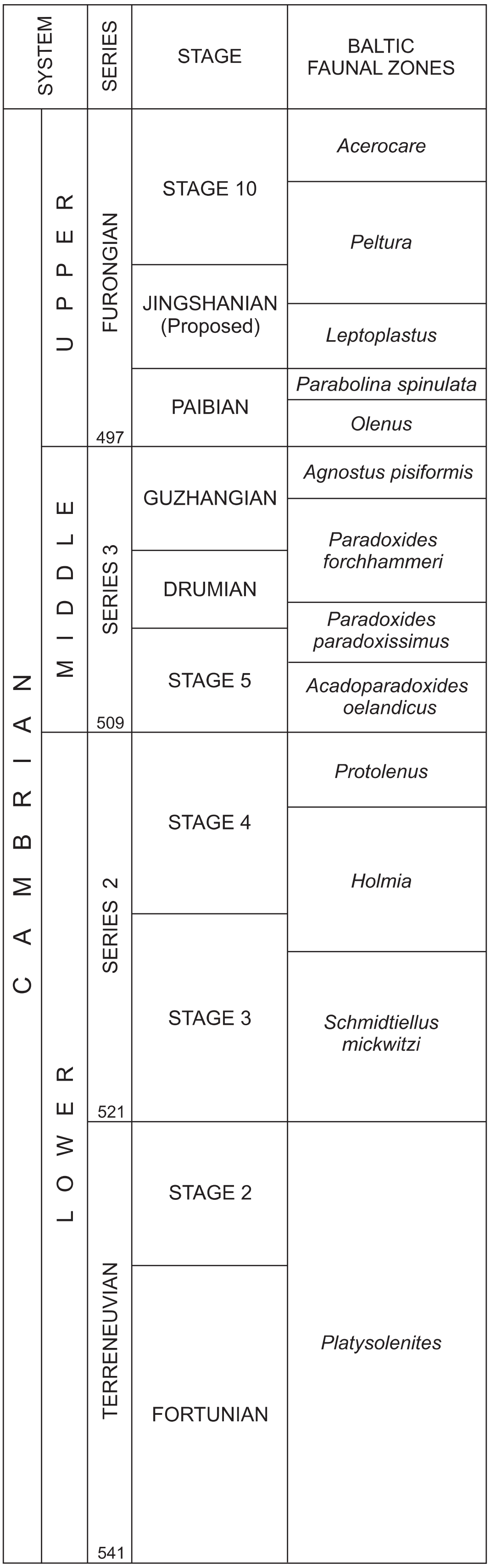


Fig. 4. The chronostratigraphic scheme of the Cambrian System (after Peng, Babcock, 2011; Gradsteina *et al.*, 2012)

teristic of *Granomarginata prima* Zone (Jankauskas, Lendzion, 1992) from the *Platysolenites* Zone in the Baltic Syneclise and adjacent areas (NW part of the East European Craton) (Jankauskas, Lendzion, 1992; Jankauskas, 2002). The first appearance of the *Granomarginata prima* species was an important event in the discussed zone. These associations include also *G. squamacea*, *Pulvinosphaeridium antiquum*, *Tasmanites tenellus*, *Ceratophyton vernicosum*, multiple representatives of genus *Leiosphaeridia* and thready cyanophytes fragments. The only sculptured acritarchs (the "Cambrian type") are represented by *Asteridium tornatum*. The *Granomarginata prima* Zone was regarded by its authors (*op. cit.*) as an equivalent of the *A. tornatum–C. velvetum* Zone of Moczydłowska (1991). They noted, however, that *Granomarginata prima* has been much more widely distributed than associations showing the "Cambrian character" which are known only from the *Platysolenites* Zone of the southeastern Poland (Moczydłowska, 1991). In this case, the notable differences in the taxonomic composition of the acritarch assemblages of the same age were interpreted as facies-controlled (Jankauskas, Lendzion, 1992; Jankauskas, 2002).

The base of the Series 2 (Ogg *et al.*, 2008) is defined by the appearance of trilobites. This boundary is marked by clear changes in acritarch assemblages due to appearance of numerous forms with differentiated morphology, belonging mostly the Acanthomorphitae group (Downie *et al.*, 1963). The index genus *Skiagia* is very characteristic and widespread (Volkova, 1968, 1969a, b; Downie, 1982; Volkova *et al.*, 1983, Hagenfeldt, 1989a; Moczydłowska, 1991; Moczydłowska, Zang, 2006). It is represented by several species that dominated assemblages in the Stages 3 and 4, equivalent to the traditionally understood *Schmidtiellus mickwitzi*, *Holmia*, and *Protolenus* zones. Several acritarch assemblage zones have been distinguished in that interval (Vanguestaine, Van Looy, 1983; Moczydłowska, 1991; Jankauskas, Lendzion, 1992; Volkova, Kirjanov, 1995; Jankauskas, 2002; Raevskaya, 2005) (Fig. 5). Although differently named by various authors, those zones characterise microfloral associations with similar generic and specific composition. In the Series 2 assemblages, numerous species of *Asteridium*, *Heliosphaeridium*, *Comasphaeridium*, *Globosphaeridium*, *Pterospermella*, *Pterospermopsimorpha*, *Multiplicisphaeridum*, *Lophosphaeridium* or *Estiastra* may appear along with the index *Skiagia* species. Their ranges comprise several acritarch assemblage zones of the Series 2. Other, whose appearance is limited to one microfloristic horizon only, are designated as index forms, together with species appearing for the first time at the bottom of the defined zone (Moczydłowska, 1991; Jankauskas, Lendzion, 1992; Jankauskas, 2002).

Three acritarch assemblage zones, established in the Lower Cambrian of southeastern Poland by Moczydłowska (1991; see Fig. 5) have been widely applied to the biostratigraphy of the Lower Cambrian deposits in other regions of the world. *Skiagia ornata–Fimbriaglomerella membranacea* Assemblage Zone is characterised by a massive appearance of new taxa (Moczydłowska, 1991) which party extend into the younger zones. *Asteridium pallidum* and *Skiagia pura* were defined as the index species of the above mentioned zone. Abundant associations of morphologically differentiated genus *Skiagia* include also other species such as *S. ornata*, *S. orbiculare*, and *S. compressa*. Other accompanying species are *Comasphaeridium molliculum*, *C. brachyspinosum*, *Fimbriaglomerella membranacea*, *F. minuta*, *Tasmanites bobrowskae* and *Ceratophyton vernicosum*.

Heliosphaeridium dissimilare–Skiagia ciliosa Assemblage Zone (Moczydłowska, 1991) contains most differentiated assemblages of the Series 2. Dominant forms are nominal species as well as *Skiagia ornata*, *S. scottica*, and *Estiastra minima*. Unfortunately, none of the distinguished key taxa ranges are limited to that zone. For instance, *Heliosphaeridium dissimilare*, *H. lubomlense*, *H. obscurum*, *H. radzynicum*, *Asteridium spinosum*, *Skiagia scottica*, *S. ciliosa*, *Goniosphaeridium varium*, *G. implicatum*, *Multiplicisphaeridium dendroideum*, *Pterospermella solida* and *Cymatiosphaera postae* have their first appearance in the described zone but they range into the younger deposits as well.

The *Volkovia dentifera–Liepaina plana* Zone, the uppermost acritarch zone of the Series 2 (Moczydłowska, 1991), is characterised by the appearance of the nominal species, and other index forms such as *Heliosphaeridium notatum* and *H. longum*. It includes, however, many forms continuing from older deposits. Identification of this assemblage zone is often very difficult, as the index taxa appear very rarely (Moczydłowska, 1991). Moreover, the uppermost acritarch assemblages of the traditional Lower Cambrian display significantly impoverished taxonomic composition, despite containing, in places, precursors of the Series 3, such as genus *Eliasum* (Jankauskas, Lendzion, 1992).

Acritarch associations with taxa comparable to those occuring in the above acritarch zones have been reported also from the Cambrian Series 2 in many other areas. On this basis, some local zones have been distinguished, for instance: *Archeodiscina umbonulata – Skiagia compressa* (Vanguestaine, Van Looy, 1983), *Globosphaeridium. cerinum*, *Estiastra minima–Heliosphaeridium dissimilare* and *Volkovia dentifera* (Jankauskas, Lendzion, 1992) or NK 3, NK 4, and NK 5 (Volkova, Kirjanov, 1995; Raevskaya, 2005) (Fig. 5).

A common feature of the succeeding assemblages from the Stage 3 is the domination of acritarchs with straight, variably terminated appendices, such as *Globosphaeridium cerinum*, and *Lophosphaeridium dubium*, as well as forms with delicate, hair-thin processes, such as genus *Comasphaeridium* or *Asteridium lanatum*. *Skiagia* is rare, represented by *S. ornata*, *S. orbiculare* or *S. compressa*. On the other hand, Stage 4 acritarch associations are characterised by abundant *Skiagia* with clearly widened appendices. This genus was represented at that time by all species accompanied by subsequent index forms of other genera, such as *Multiplicisphaeridium dendroideum*, *Estiastra minima* or *Heliosphaeridium dissimilare*. In turn, absence of many *Skiagia* species has been noted from the Stage 4 top (Jankauskas, Lendzion, 1992; Jankauskas, 2002).

A notable impoverishment in number of genera and species is characteristic for the upper part of the Stage 4. In addition, such genera as newly appearing *Volkovia* or *Liepaina*, occur very rarely (Moczydłowska, 1991). Therefore, it may be very difficult to document youngest deposits of this stage, corresponding to the acritarch *Volkovia dentifera–Liepaina plana* Zone (Moczydłowska, 1991; Szczepanik, 2000). Microfossil assemblages with numerous *Volkovia* specimens that were recently found in the Kielce Region of the Holy Cross Mountains are unique on a global scale (Żylińska, Szczepanik, 2009).

During the Middle Cambrian, acritarch associations underwent very distinct successive changes of the taxonomic composition. Many early Cambrian forms extinguished: the index *Skiagia* genus, for example, almost disappeared. Nevertheless, its individual representatives were encountered in the basal Series 3 deposits (Moczydłowska, 1998), although their redeposition from older strata cannot be excluded.

The Cambrian Series 3 is subdivided into the Stage 5, Drumian, and Guzhangian (Peng, Babcock, 2011) corresponding to four traditional trilobite zones (Fig. 4). In the previous subdivision the uppermost horizon was placed in the lower part of the Upper Cambrian. Acritarch assemblages of the Series 3 have been studied in detail worldwide, for instance in the Czech Republic (Slaviková, 1968), Spain (Cramer, Diez Cramer, 1972; Fombella, 1977, 1978, 1987; Palacios *et al*., 2006; Palacios, 2010), Canada (Martin, Dean, 1981, 1983, 1988; Parsons, Anderson, 1996, 2000; Palacios *et al.*, 2009), Turkey (Erkmen, Bozdoğan, 1981), Scandinavia (Bagnoli *et al*., 1988; Hagenfeldt, 1989b), Tunisia (Albani *et al*., 1991), Wales (Young *et al*., 1994), or in the East European Craton (Volkova, 1990; Jankauskas, Lendzion, 1992; Moczydłowska, 1999; Szczepanik, 2000) (Fig. 5).

Generally, the development of the Cambrian Series 3 microflora appears to correspond to three distinct successive acritarch assemblages. The oldest of these occurs in the trilobite *Acadoparadoxides oelandicus* Zone, and is dominated by such taxa as *Eliasum*, *Cristallinium*, *Solisphaeridium implicatum*, *Heliosphaeridium notatum* or *H. bellulum* (Jankauskas, Lendzion, 1992; Moczydłowska, 1998, 1999; Palacios, 2008, 2010). The second assemblage consists of microflora of the *Adara alea* = A1 acritarch Zone (Martin, Dean, 1984, 1988), correlatable partly with the *Paradoxides paradoxissimus* Zone (Martin, Dean, 1981, 1983, 1988) (Fig. 5). Species of the genus *Timofeevia* appear in the upper part of the *Paradoxides paradoxissiumus* Zone (Martin, Dean, 1988) through the successive *Paradoxides forchhammeri* and *Agnostus pisiformis* zones and further on in the Furongian deposits. Besides those characteristic forms, the genus *Vulcanisphaera* appears for the first time in the highest part of the Series 3. This genus, similarly to the genus *Timofeevia* was represented by successively introduced new species through the Furongian and up to the Ordovician (Martin, Dean, 1988; Jachowicz-Zdanowska, 2011).

Several acritarch zones, correlated with particular faunal horizons, have been established in the Cambrian Series 3 (Fig. 5). The *Acadoparadoxides oelandicus* Zone is, entirely or in part, the equivalent of the acritarch zones *Eliasum–Cristallinium* (Moczydłowska, 1999), *Heliosphaeridium notatum–Lophosphaeridum variabile* (Jankauskas, Lendzion, 1992; Jankauskas, 2002), KB (Volkova, Kirjanov, 1995; Raevskaya, 2005), *Archeodiscina umbonulata–Skiagia compressa* and *Cristallinium–Eliasum* (Vanguestaine, Van Looy, 1983) or IMC 1 (Palacios, 2010). It is difficult to assign index forms for associations of this age, as nearly all distinguished taxa are also known from older or younger acritarch assemblages. For

SYSTEM	SERIES	BALTIC FAUNAL ZONES	Brunovistulicum Acritarch Microflora Assemblage Zones (present paper)	Moczydłowska, 1991, 1999	Jankauskas, Lendzion,1992; Jankauskas,2002		Volkova, Kirjanov,1995; Raevskaya, 2005	Vanguestaine, Van Looy, 1983	Palacios, 2008, 2010		Martin, Dean,1988
C A M B R I A N	S E R I E S 3	*Paradoxides forchhammeri*	?			*C. strigosum–T. lancarae*	SK 2	*T. pentagonalis–V. turbata*	*T. lancare*	IMC 5	Lower A 2 *T. phosphoritica*
		Paradoxides paradoxissimus	BAMA IX *A. alea–M. liynense*			Interzone ?		*C. cambriense–Eliasum/Timofeevia*	*A. alea*	IMC 4	A 1 *A. alea*
							SK 1			IMC 3	
			BAMA VIII *T. semireticulatum*						*C. silesiense*	IMC 2	A 0 *R. terranovana*
			?				?				
		Acadoparadoxides oelandicus	BAMA VII *A. bellulum–A. notatum*	*Eliasum–Cristallinium*		*H. notatum–L. variabile*	KB	*A. umbonulata–S. compressa*		IMC 1	A 0–1 *E. jennessii*
	S E R I E S 2	*Protolenus*	BAMA VI *V. dentifera–L. plana*	*V. dentifera–L. plana*	*V. dentifera*	*E. llaniscum–H. dendroideum*	NK 5		*H. notatum*		
						G. implicatum	NK 4				
		Holmia	BAMA V *Skiagia–E. varia*	*H. dissimilare–S. ciliosa*	*E. minima–H. dissimilare*				*S. ciliosa*		
			BAMA IV *Skiagia–E. campanula*		*B. cerinum*	*S. ciliosa*					
		Schmidtiellus mickwitzi	BAMA III *I. flexuosa–C. molliculum*	*S. ornata–F. membranacea*		*S. compressa*	NK 3	*G. squamaccea–A. tornatum*			
			?								
	T E R R E N E U V I A N	*Platysolenites*	BAMA II *A. tornatum–C. velvetum*	*A. tornatum–C. velvetum*	*Granomarginata prima*		NK 2				
			?								
			BAMA I *P. antiquum–Pseudotasmanites*								
EDIACARAN		*Sabellidites*		*Cyanobacteria–Leiosphaeridia*	*Teophipolia lancerata*		NK 1				

Fig. 5. Comparison of most important acritarch biozonations of the Lower–Middle Cambrian

example, the first appearance of the genus *Eliasum* was traced near the top of the Series 2 (Jankauskas, Lendzion, 1992), whereas characteristic genus *Cristallinium* appeared in the Series 3, and continued in the Upper Cambrian and up to Ordovician sediments (Moczydłowska, 1998). In such cases, particular species as *Eliasum jennessi*, *E. asturicum* or *Cristallinium randomense* are very helpful in determining the age of the studied associations.

Several species were present in limited small areas, where they appeared in great numbers. For example, within the broadly understood genus *Heliosphaeridium*, only one form classified earlier as *H. bellulum*, and presently as *Ammonidium bellulum* n.comb. is characterised by relatively narrow distribution, limited so far to only one association in the Cambrian of the USB. In this case, the massive appearance should be regarded as an additional biostratigraphic criterium, together with the clear dominance of *Ammonidium bellulum* (= *H. bellulum*) and *A. notatum* n.comb. (= *H. notatum*), the latter species appearing already in the *Protolenus* trilobite zone.

Acritarch zones of the successive faunal level, *Paradoxides paradoxissimus* Zone, have been well correlated with the standard trilobite subdivision. The acritarch zonation was studied in detail in the Cambrian of Newfoundland (Martin, Dean, 1981, 1984, 1988).

The oldest zone, A0-1– *Eliasum jennessii*–Acritarcha gen. *et* sp., was established below the *Paradoxides paradoxissimus* Zone (Martin, Dean, 1984, 1988). In addition to the index taxa the zonal assemblage contains numerous other species, such as *Eliasum llaniscum* and *Retisphaeridium dichamerum* or *R. howelii*. The A0-1 microflora has been correlated, based on the index macrofauna, with the local *Paradoxides benetti* Zone, which can be further correlated with the *Ptychagnostus gibbus* Zone. Nevertheless, closer inspection of the described acritarch association reveals that stratigraphic ranges of a majority of the constituent forms in some areas exceed the ranges established in the type area.

The successive zone, A0-*Rugasphaera terranovana* (Martin, Dean, 1988), has been distinguished based on two index taxa with short stratigraphic ranges: *R. terranovana* and *Vulcanisphaera lanugo*. Besides, numerous specimens of *Eliasum llaniscum*, *Cristallinum cambriense*, and *Retisphaeridium* genera appeared in this zone. The zone is partly correlatable with the trilobite *Paradoxides hicksi* Zone (equivalent to the *Tomagnotus fissus* Zone), which corresponds to the lower part of the *Paradoxides paradoxissimus* Zone.

The next zone, *Adara alea* (Martin, Dean, 1988) = A1 (Martin, Dean, 1981, 1984), is based on the stratigraphic range of the index species that appeared in the upper part of the *Paradoxides hicksi* Zone. Its upper range has been referred to the *Paradoxides davidis* Zone, and more precisely, to its lower part, which corresponds to the *Ptychagnostus punctuosus* Zone (Martin, Dean, 1988). In Newfoundland, the index species is accompanied by numerous specimens of the *Cristallinium cambriense* and *Eliasum llaniscum*, as well as rare forms classified as *E.* cf. *asturicum* (Martin, 1988). The *Adara alea* Zone may be thus correlated with the higher part of the *Paradoxides paradoxissimus* Zone (Martin, Dean, 1988).

The last of the described zones (Fig. 5), Lower A2 (with *Timofeevia phosphoritica* but without *Vulcanisphaera turbata*) (Martin, Dean, 1988), includes the interval of the highest *Paradoxides paradoxissimus* and almost whole *Paradoxides forchhammeri* zones. The base is associated with the first appearance of characteristic specimens of the genus *Timofeevia*, whose species appeared successively in younger Cambrian. Also, characteristic Upper Cambrian, so-called "galeate" and "diacrodians" acritarch morphotypes subsequently made their massive appearance allowing to distinguish the Furongian associations from the older Cambrian assemblages.

In other areas, outside Newfoundland, several acritarch assemblages were recognised within the *Paradoxides paradoxissimus* and the *Paradoxides forchhammeri* zones, and including the latter zone interval. For example, the SK 1 and SK 2 assemblages (Volkova, Kirjanov, 1995; Raevskaya, 2005) was established in the East European Craton; or IMC 2–IMC 5 (Palacios, 2008, 2010) microflora was found in Spain (Fig. 5). The same time-span corresponds partly also to *Comasphaeridium strigosum*–*Timofeevia lancarae* and *Cristallinum cambriense*–*Eliasum*/*Timofeevia* zones (Vanguestaine, Van Looy, 1983; Jankauskas, Lendzion, 1992; Jankauskas, 2002) (Fig. 5).

REVIEW OF PREVIOUS PALYNOLOGICAL STUDIES

The presence of the Early Cambrian acritarchs in the USB was reported for the first time in 1970s (Konior, Turnau, 1973; Turnau, 1974). Algal microfossil assemblages clearly different from the Devonian ones have been found in clastic deposits underlying the documented Devonian strata in Wysoka 1, Kęty 9, Andrychów 3 and Piotrowice 1 boreholes (Turnau, 1974).

The Early Cambrian age of clastics occurring below the Lower Devonian has been determined by Brochwicz--Lewiński *et al*. (1986) in Andrychów 3 and Piotrowice 1 boreholes. Well preserved, morphologically differentiated assemblages were found in 8 samples from bioturbated sandstones of the Głogoczów Member in the Andrychów 3 borehole (depth interval of 2230.9–2250.7 m). Sparse, poorly preserved acritarchs were found in the Piotrowice 1 borehole at the depth 2410.0–2411.0 m.

The age of the acritarch assemblages from Goczałkowice IG 1, Sosnowiec IG 1, and Potrójna IG 1 boreholes was determined for the first time during the 1980s (Kowalczewski *et al*., 1984; Moczydłowska, 1985). *Timofeevia phosphoritica* and *T. lancarae* were described from the top of the anchimetamorphic rocks in the Goczałkowice IG 1 profile (depth interval 3177.6– 3180.2 m). On this basis the Middle Cambrian and Lower Tremadocian age of the enclosing deposits was suggested. Assemblages dated as the Lower Cambrian (*Holmia* B)–Middle Cambrian were recognised in samples from the depth interval 2766.0–2973.7 m. Various acritarch assemblages have been found in the Sosnowiec IG 1 profile (Kowalczewski *et al*., 1984; Moczydłowska, 1993, 1995a) Their age has been dated as the Early Cambrian *Protolenus* up to the Middle Cambrian, the Middle Cambrian up to the Early Tremadocian, and the early Middle Cambrian. There was no stratigraphical order in the sequence of the association encountered in the above mentioned profile. Sporadic acritarchs have been recognised in the Potrójna IG 1 borehole at the depth of 3356.3–3363.5 m only. Based on those acritarchs, the age of the studied deposits has been determined as Middle Cambrian up to Tremadocian or even Arenigian. (Kowalczewski *et al*., 1984; Moczydłowska, 1997, 1998).

Age and succession of the acritarch assemblages from the Cambrian of Goczałkowice IG 1 and Sosnowiec IG 1 boreholes (Kowalczewski *et al*., 1984), have been reinterpreted during the successive years by Moczydłowska (1993, 1997, 1998). The newly established stratigraphical ranges of the analysed assemblages differed from the former determinations. Cambrian acritarch assemblages from Goczałkowice IG 1 have been described as rather poor but stratigraphically differentiated. Main part of the section was included into the Lower Cambrian, the age indicated by trilobites determined earlier by Orłowski (1975). The highest part of the studied profile was included into the Middle Cambrian, based on the microfossil assemblages. A transition between the Lower and Middle Cambrian was suggested to occur within the lowest part of the Sosnowiec IG 1 borehole section. The higher part of the section was included in the Middle Cambrian, and the highest one in the Upper Cambrian.

The detailed palynological studies of the Cambrian from the Goczałkowice IG 1, Sosnowiec IG 1 and Potrójna IG 1 boreholes, carried out by the author (Buła, Jachowicz, 1996) allowed to verify the results of earlier investigations conducted by Moczydłowska (Kowalczewski *et al*., 1984; Moczydłowska, 1993). Taxonomic revisions of selected acritarch taxa from the Cambrian of the USB and Brno Block and stratigraphical interpretations based on new data on the occurrence and differentiation of microflora have been partly published by the author of this study (Jachowicz, 1994; Jachowicz, Moryc, 1995; Buła, Jachowicz, 1996; Jachowicz-Zdanowska, 2010b). The results were presented also during many Polish and international scientific conferences (among others, Jachowicz, 1994, 1996, 2006, 2007, 2009, Jachowicz-Zdanowska, 2010a).

The key Moravian borehole sections Měnín 1, Němčičky 3, and Němčičky 6 have been investigated in the Upper Silesian Branch of the PGI-NRI in Sosnowiec (Jachowicz, Přichystal, 1996, 1997) and in the Charles University in Prague (Fatka, 1997; Vavrdová, 1997; Fatka, Vavrdová, 1998). Based on the data obtained, the first correlation of the Lower Cambrian deposits from the USB area with their Moravian equivalents was proposed by Buła *et al*. (1997a). The additional information on the appearance of the Early Cambrian microflora assemblages within the above mentioned profiles were published in the following years (Vavrdová, Bek, 2001; Vavrdová *et al.*, 2003; Vavrdová, 2004, 2008; Mikuláš *et al*., 2008).

The section recognised in the Měnín 1 borehole in the depth interval 473.0–2100.0 m is the most complete Lower Cambrian profile examined in the Brno Block area. In the remaining three boreholes, the appearance of Early Cambrian microflora assemblages has been documented in individual rock samples (Jachowicz, Přichystal, 1996, 1997; Vavrdová, 1997; Vavrdová, Bek, 2001; Mikuláš *et al*., 2008), collected from the following depths: Němčičky 3 – 5396.0–5401.0 m, and Němčičky 6 – 5157.0–5184.5 m.

APPLIED TECHNIQUES AND MATERIAL STUDIED

The present palynological investigations are based on over 280 samples collected from 22 boreholes from the USB area and 3 boreholes from Brno Block in Moravia (Fig. 2). The total length of the Cambrian sections investigated is more than 6500 m. In general, studied borehole sections are incomplete, in many cases comprising only a fraction of a full thickness of particular Cambrian lithostratigraphic units. In most boreholes a core recovery was fragmentary, and cores are only partly preserved, in some cases merely as single rock samples. The sampling density obviously depended on the state of cores available. Therefore, the intervals between the analysed samples range between several centimetres to even several dozens of metres.

All investigated boreholes were drilled in the second half of the twentieth century. The boreholes with signatures IG were drilled by the Polish Geological Institute and the cores are stored in the National Geological Archive of the Polish Geological Institute – National Research Institute, in its Upper Silesian and Carpathian Branches. The remaining Polish boreholes were drilled by the Polish Oil and Gas Company and the materials are stored in their core facility. The boreholes from the Czech Republic were drilled by Moravian Oil Mines, Hodonín (Zádrapa, Skoček, 1983).

The Cambrian sections recognised in the USB area in the Borzęta IG 1, Goczałkowice IG 1 and Sosnowiec IG 1 boreholes should be regarded as stratotypes of a key importance for the studies of a microfloral succession in the whole Brunovistulicum (Fig. 2). In the first two boreholes, the Lower Cambrian (Terreneuvian and Series 2) has been almost fully documented, whereas the Middle Cambrian (Series 3) has been encountered in the Sosnowiec IG 1 borehole only.

The following 10 boreholes are located in the eastern margin of the Upper Silesian Block, where the Borzęta Formation hase been encountered: Borzęta IG 1, Chrząstowice RCh6, Rajbrot 1, Rajbrot 2, Trojanowice, WB 141, WB 137, Wiśniowa IG 1, Wiśniowa 3 and Wiśniowa 6.

In the Borzęta IG 1 borehole 54 samples were collected from partly cored section (Fig. 6), mainly from the Osieczany Member (43 samples). The remaining samples were obtained from mudstone intercalations in the Rajbrot Member (8 samples), and from the Myślenice Member (3 samples).

The Rajbrot 1 and Rajbrot 2 boreholes were drilled ca. 15 km south of Bochnia, where the Borzęta Formation was encountered below the Middle Devonian carbonates (Jachowicz, Moryc, 1995). In the Rajbrot 1 section three members are distinguished (Fig. 6; Buła, 2000): Myślenice Mb. (9 samples), Osieczany Mb. (3 samples) and Rajbrot Mb. (11 samples). In the Rajbrot 2 borehole, only the Rajbrot Mb. in the upper part of the formation was encountered (Buła, 2000), yielding 12 samples (Fig. 6).

The Wiśniowa IG 1, Wiśniowa 3 and Wiśniowa 6 boreholes pierced thin, erosionally reduced successions of the Myślenice Member discordantly overlying Ediacaran sediments of the Potrójna Formation (Kowalczewski, 1990; Buła, 2000), which rests upon the crystalline Precambrian basement (Wiśniowa 6 borehole). Only a few samples from these boreholes were available for the present study (Fig. 6) because of a very limited quantity of core material.

In the Trojanowice borehole located 8 km north of Kraków, the Jurassic deposits rest upon black shales of the Myślenice Member which yielded 11 acritarch samples (Fig. 6). The rocks are dipping 45° and are strongly tectonised while their upper part shows brownish-red colouration, most probably as a result of weathering (Bukowy, 1960). Partial profiles of the Osieczany and Rajbrot members encountered in the WB 137, WB 141 and Chrząstowice RCh 6 boreholes yielded 5, 3 and 6 samples, respectively.

Complete or partial sections of the Goczałkowice Formation have been recognised in several tens of boreholes located mainly in southern and south-eastern parts of the USB (Buła, 2000). For the purposes of this study they have been investigated in 12 boreholes located mainly in the southern part (Figs. 2, 7, 8). In the type Goczałkowice IG 1 section the palynological samples were studied from the Pszczyna Member (34 samples) and the Głogoczów Member (9 samples) (Figs. 7, 8). Studied palynological samples were also collected from nine boreholes from the area east and north-east of Bielsko Biała (Kęty 8, Kęty 9, Andrychów 3, Piotrowice 1, Kozy Mt 3, Potrójna IG 1 and Głogoczów IG 1), and from the Olkusz region in the north-eastern USB (Sułoszowa and Klucze 1 boreholes).

Of all three members documented in the Piotrowice 1 borehole only two uppermost have been sampled, yielding 4 samples from the Głogoczów Mb. and 1 from the Pszczyna Mb. (Fig. 7). The Sułoszowa borehole pierced the Lower Cambrian at the depth of 110.0–330.0 m, and 17 palynological samples were recovered from the depth interval 198.0–330.0 m. Unfortunately, cores from the higher, over a 80 meter-thick interval have not been preserved. In the Klucze 1 borehole, because of scarcity of a core material available, only 11 samples were collected from 10 cored intervals, 10 meters each (Fig. 7).

The Głogoczów Mb. has been sampled in the Kęty 8, Kęty 9, Andrychów 3, Głogoczów IG 1, and Kozy Mt 3 boreholes, all of which pierced the base of the member, except the last one (Fig. 8). A fully cored 13-meter section in the Kozy Mt 3 borehole yielded 26 samples. Palynological analyses of other boreholes were based on a few samples of still available rocks: 3 samples from Kęty 8, one from Kęty 9, 6 samples from Andrychów 3, and 9 samples from Głogoczów IG 1.

The uppermost part of the Goczałkowice Formation, the Jarząbkowice Member, was sampled in the Jarząbkowice 1 borehole, located west of Goczałkowice (9 samples; Fig. 9). Additionally, 10 samples were studied from the Potrójna IG 1 borehole from the depth interval 3309.0–3393.0 m (Fig. 7).

The Middle Cambrian strata in the Sosnowiec IG 1 borehole were rather densely sampled (23 samples) in order to definitely clarify the age of the Sosnowiec Formation. The samples have been collected from above and below the intrusive rocks cross-cutting the Cambrian clastics (Fig. 10).

The number of the Cambrian profiles analysed palynologicaly in the Brno Block area is distinctly smaller in comparison with the USB, and includes only samples from Měnín 1 (14 samples), Němčičky 3 (2 samples) and Němčičky 6 (3 samples) (Fig. 9).

The standard maceration techniques of clastic rocks were adapted for all the analysed samples, based on application of concentrated hydrochloric and hydrofluoric acids (Wood *et al*., 1996). The obtained residues were sieved through the nylon sieve with holes of 11 microns in diameter. The cleansed and condensed residues provided material for standard, microscopic slides that were analysed planimetrically in a transmitted light using the Olympus BX 50 microscope. For each sample 3 to 15 microscopic slides were made, each containing several dozens to several hundred microfossil specimens. The organic remains from the selected samples were also analysed in the scanning electron microscope.

Organic microfossil assemblages were documented in most samples. Only the samples from the Potrójna IG 1 (Fig. 7) borehole and single samples from other sections appeared barren.

The Cambrian microflora from the Brunovistulicum area is usually characterised by a good and very good state of preservation. In some cases even very delicate surface sculpture details are preserved, which helped much during the taxonomic studies.

The analysed Cambrian microfossils are usually characterised by colours ranging from dark-yellow, orange, to light- and dark-brown. The brightest colours have been noticed for the southern and south-eastern parts of the Upper Silesian Block, e.g., in the Andrychów 3, Głogoczów IG 1, Kęty 8, Kęty 9, Borzęta IG 1, Trojanowice, Rajbrot 1 and Rajbrot 2 boreholes. This indicates only a slight thermal alteration of the Cambrian deposits in these areas, not exceeding a temperature range 80–140°C. Very similar, good preservation and a relatively low degree of thermal alterations characterise also the microfossils from the Brno Block, where the depths of the Cambrian deposits may exceed 5000 m (Němčičky 3 and 6 boreholes). A slightly higher degree of thermal alterations has been observed in the acritarchs collected in the Sułoszowa, Goczałkowice IG 1, WB 137, and Sosnowiec IG 1 boreholes. Such alterations were caused, first of all, by the influence of magmatic intrusions of various ages (Nawrocki *et al*., 2010). The effects of a contact metamorphism are visible in the Cambrian rocks occurring near the intrusions, where they are im-

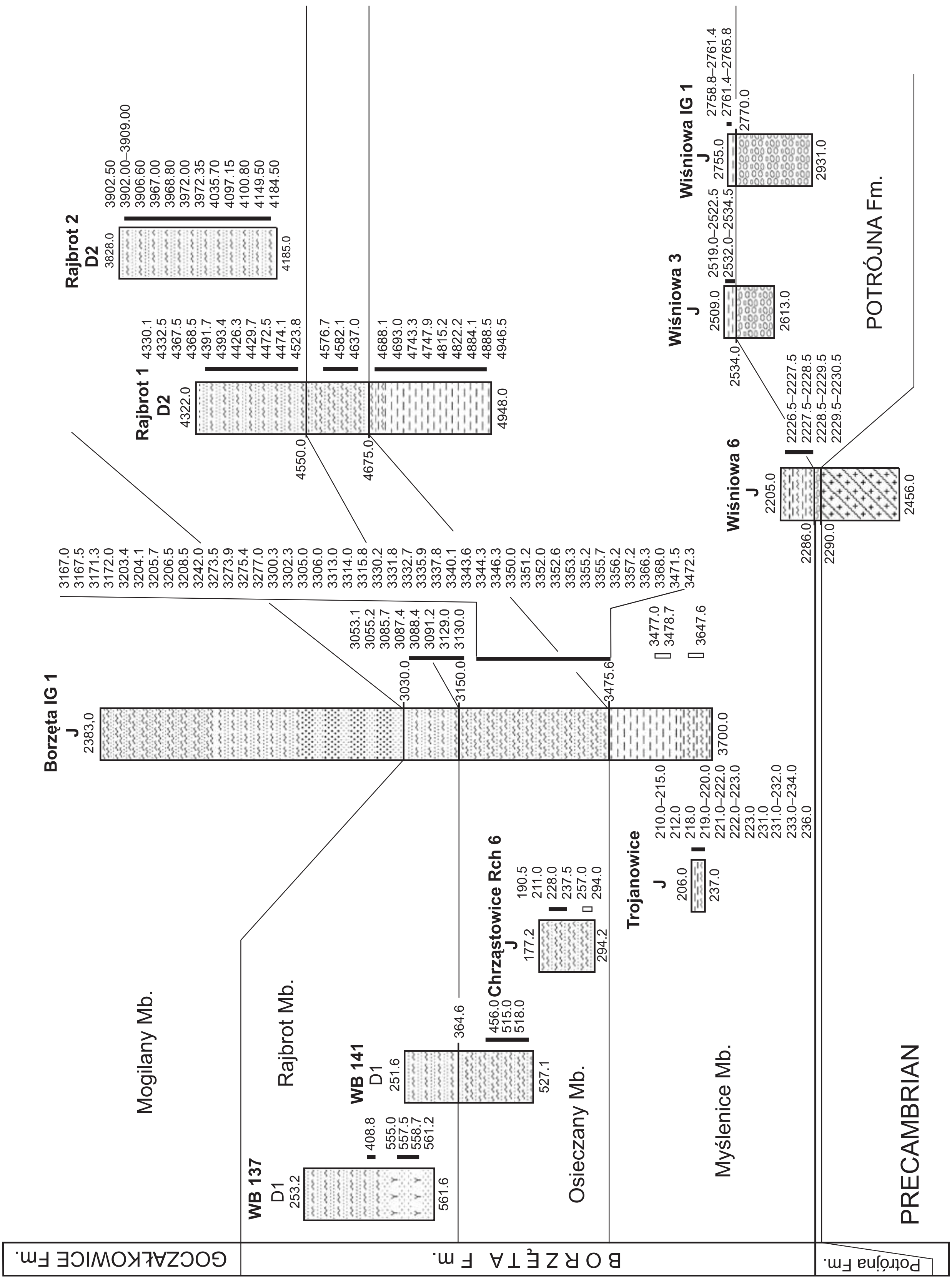


Fig. 6. Correlation of the studied borehole sections of the Borzęta Formation with a location of investigated samples (lithostratigraphic correlation and simplified lithology after Buła, 2000)

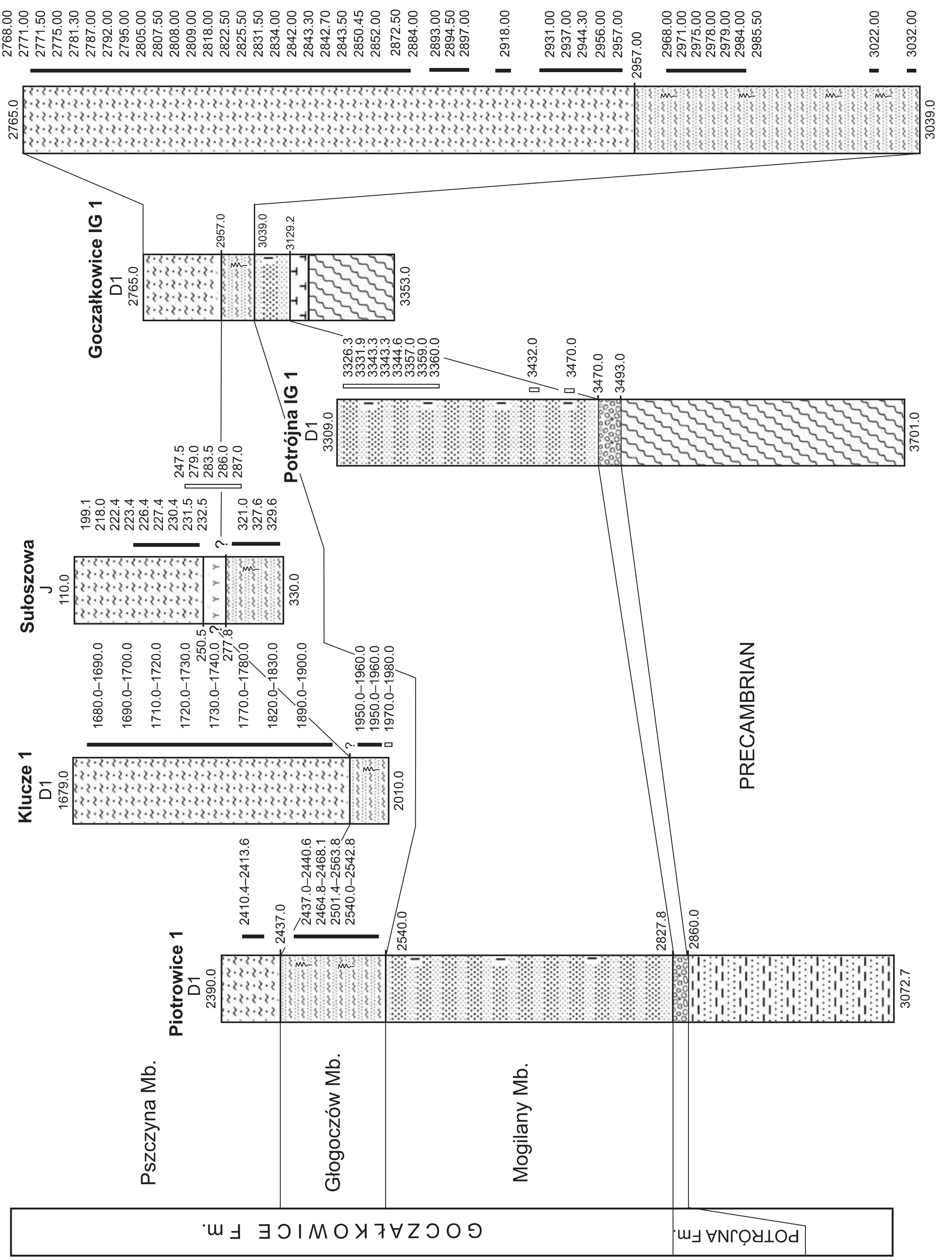


Fig. 7. Correlation of the Goczałkowice Formation selected profiles with a location of investigated samples (lithostratigraphic correlation and simplified lithology – after Buła, 2000)

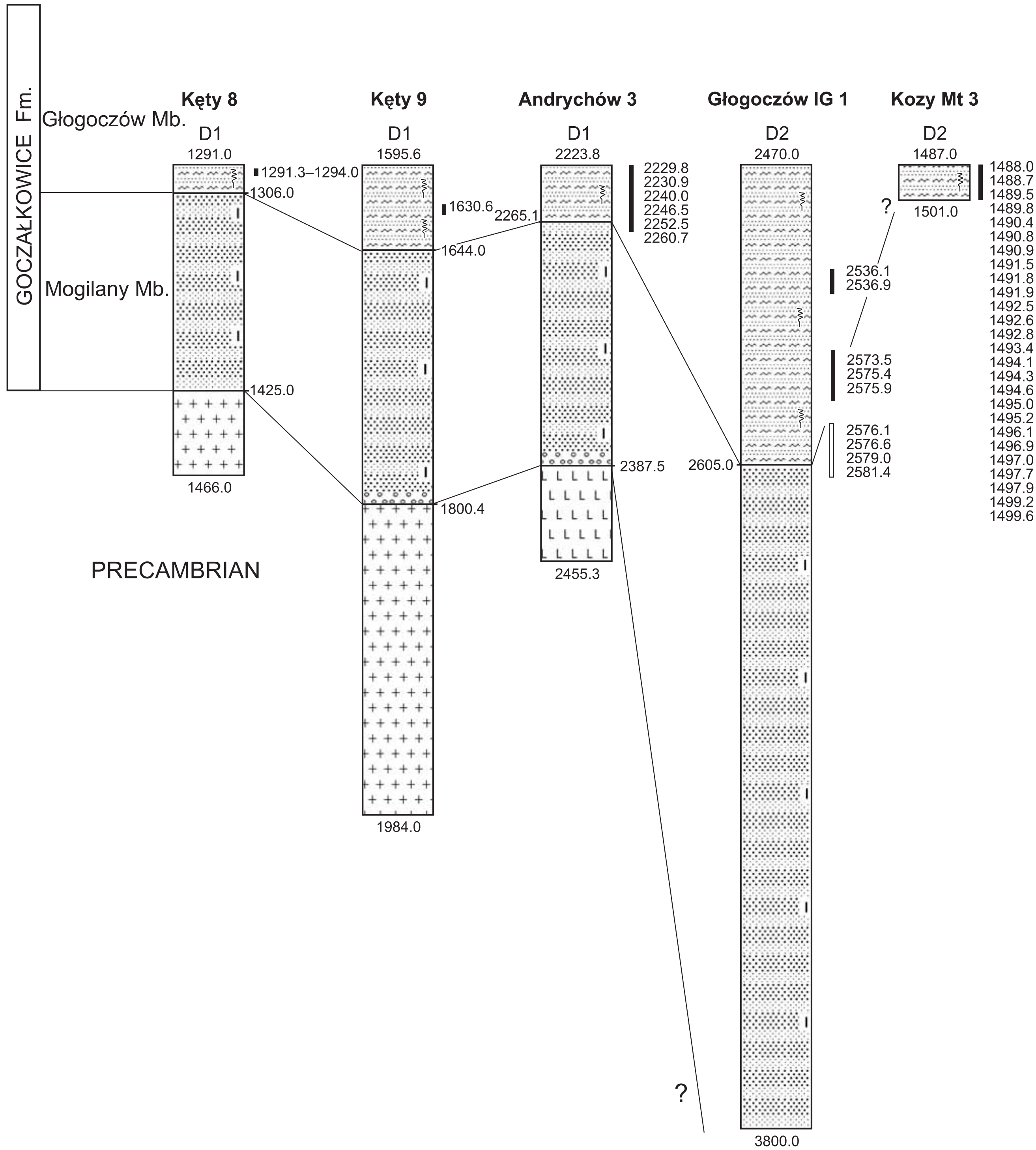


Fig. 8. Correlation of the Głogoczów Member selected profiles with a location of investigated samples (lithostratigraphic correlation and simplified lithology – after Buła, 2000)

poverished in recognizable organic remains due to high temperatures. Besides, it has been observed that microfossil preservation improves with the increasing distance from the intrusion, for instance, in the Sosnowiec IG 1 borehole. The most poorly preserved acritarchs were obtained from the Jarząbkowice 1 borehole. They are usually partly damaged while dark brown or even black colours indicate that the Cambrian deposits were subject to temperatures above 180°C.

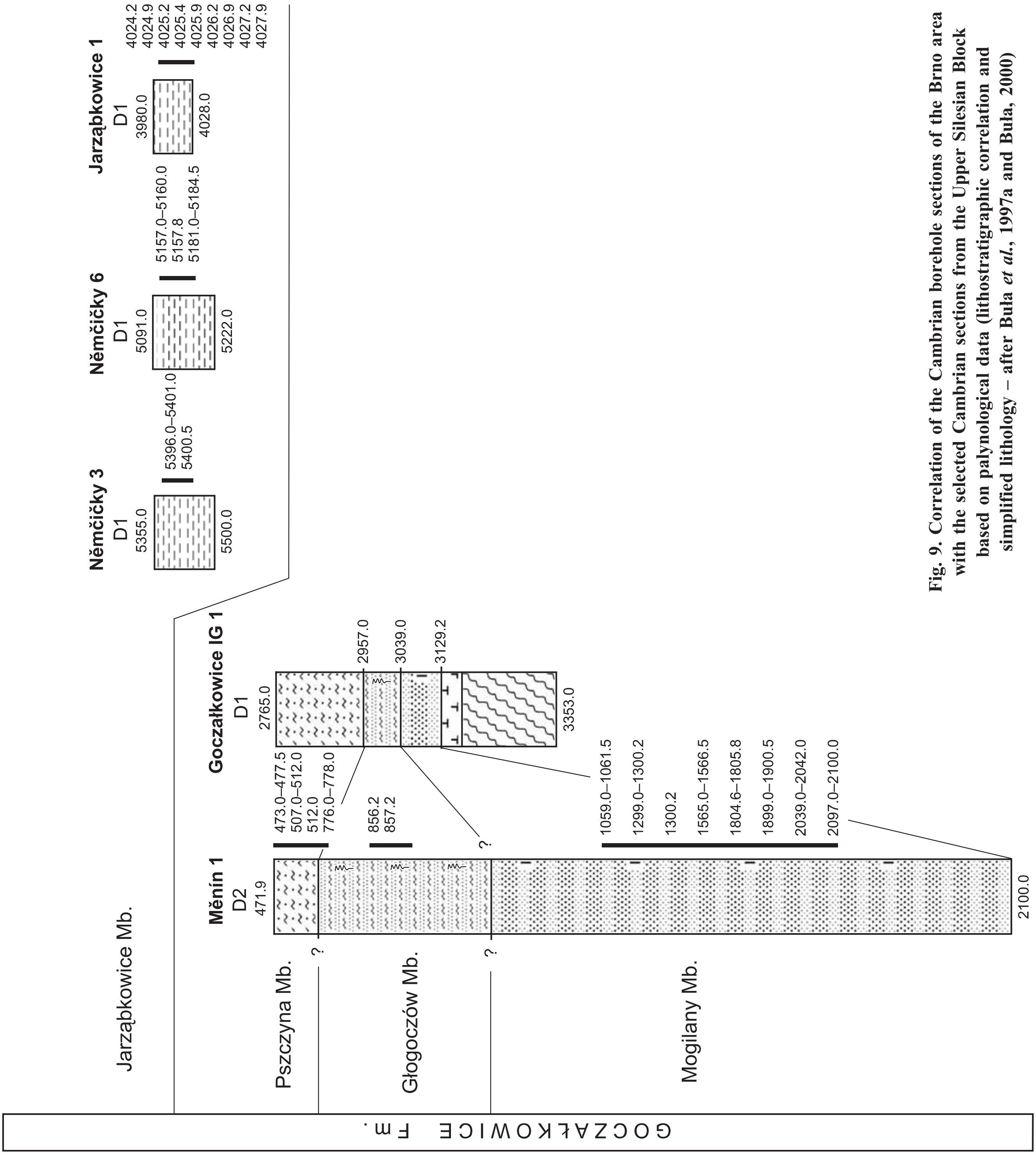


Fig. 9. Correlation of the Cambrian borehole sections of the Brno area with the selected Cambrian sections from the Upper Silesian Block based on palynological data (lithostratigraphic correlation and simplified lithology – after Buła *et al.*, 1997a and Buła, 2000)

BIOSTRATIGRAPHY

The taxonomic revision and systematic analysis of acritarch associations described from the Cambrian of Brunovistulicum allowed to establish the succession of microfloral assemblages. The best recognised and documented assemblages were obtained from the USB area, where the type sections of the Cambrian deposits are located (Buła, Jachowicz, 1996; Buła, 2000). Supplementary material, less abundant but stratigraphically very important, has been collected in the Brno Block region. This ap-

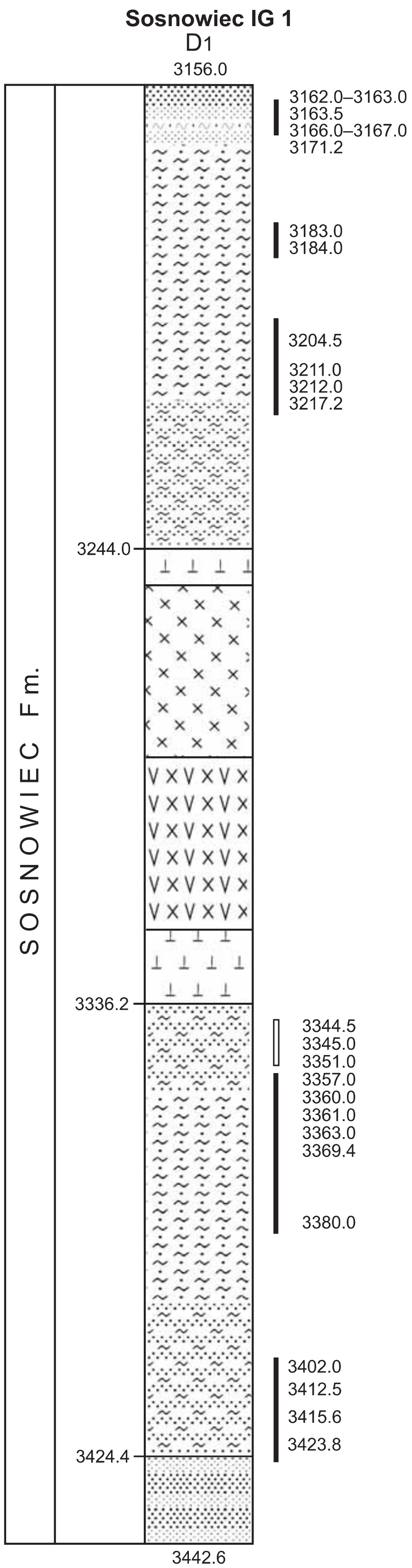


Fig. 10. The Cambrian Series 3 interval in the Sosnowiec IG 1 borehole section with a location of investigated samples (lithostratigraphy and simplified lithology – after Buła, 2000)

peared particularly relevant in the case of the palaeontologicaly barren intervals of the USB profiles. Thus, important information was obtained from the Czech part of the Brunovistulicum from the strata corresponding to the Mogilany Member in the Měnín 1 section, and included also most probable uppermost Series 2 associations, recognised in partial Cambrian profiles of the Němčičky 3 and Němčičky 6 boreholes. Earlier, similarities in the facies development of the Cambrian in the Polish and Czech parts of the Brunovistulicum allowed for accurate correlation of the USB sections with their stratigraphic equivalents in Moravia (Buła *et al*., 1997a; Buła, Żaba, 2005; Pacześna, 2005).

Already the preliminary results of biostratigraphical analyses of the Cambrian from the USB indicated an enormous diversity and good preservation of organic microfossils (Jachowicz, 1994; Buła, Jachowicz, 1996). Majority of the forms encountered in the analysed deposits have been, for many years, classified as specimens of the informal Acritarcha group (Evitt, 1963). However, owing to an intensive research, more and more genera are now being systematically classified based on biological criteria (Talyzina, Moczydłowska, 2000; Talyzina *et al*., 2000; Marshall *et al*., 2005; Willman, Moczydłowska, 2007; Kaźmierczak, Kremer, 2009).

As the aim of the present study is to apply microfossils for biostratigraphy and not to investigate their biological nature, the present author decided to use here the term "acritarchs" to describe and define index assemblages for all the documented organic microfossils. Consequently it was not attempted here to apply a distinction between arcritarchs and other groups of algae.

As a result of the present studies nine distinct regional acritarch assemblage zones have been recognised in the Cambrian deposits of Brunovistulicum (Fig. 5). Two are the equivalents of the well-known acritarch assemblage zones: *Asteridium tornatum–Comasphaeridium velvetum* and *Volkovia dentifera–Liepaina plana* (Moczydłowska, 1991) whereas others have been established for the first time. These associations are similar in their generic and species composition to those of other Cambrian areas. However, they differ significantly in abundance of characteristic taxa which allows their easy identification. Present studies documented occurrence of new genera and species of the Acritarcha group, and allowed taxonomic revision of same acritarch forms. Significant revision of the stratigraphic ranges of certain index acritarch taxa was also possible. The data obtained by the author justify the establishment of the new regional acritarch zonation for the Cambrian deposits of Brunovistulicum. They are characterized according to the Polish principles of stratigraphy (Racki, Narkiewicz, eds., 2006) and are presented in stratigraphical order below.

The term BAMA has been adopted for the described biostratigraphic units as an acronym of the expression **B**runovistulicum **A**critarch **M**icroflora **A**ssemblage. The units are marked in ascending order by Roman numerals I to IX. For each assemblage, characteristic taxa have been indicated. These are, first of all, genera and species appearing for the first time in the given association, quantitatively dominant forms, and important taxa with relatively short durations, possibly limited to a single assemblage. An overwhelming majority of the characteristic taxa is here designated at a species level. A small number of characteristic genera refer mainly to the oldest BAMA I association of the Terreneuvian, this being related to a very weak morphological differentiation of the microflora of this age. The described acritarch assemblages were compared with similar associations recognised in other areas of Poland and worldwide. Especially important are correlations with acritarch zones that have been well dated in other regions basied on index fauna.

Most of recognised acritarch assemblage zones are documented as units superimposed in correlated stratotype sections of Cambrian Borzęta, Goczałkowice and Sosnowiec formations and in the Měnín 1 borehole. The exception is the BAMA VI Zone recognised in the partial profiles in the Jarząbkowice 1, Němčičky 3 and 6 boreholes. Four distinct, palynologically barren intervals are here distinguished. The first two were determined in the *Skolithos* sandstones of the Mogilany Member, whereas the other two just below and above the intrusion cross-cutting the Sosnowiec Formation in the Sosnowiec IG 1 borehole.

BAMA I – *Pulvinosphaeridium antiquum–Pseudotasmanites* Assemblage Zone

Definition and boundaries. – Diagnostic for the BAMA I assemblage is, first of all, the absence of taxa with a differentiated, more complicated morphology. The dominant components are representatives of genus *Leiosphaeridia* with various vesicle diameters (from several up to a few hundreds microns) and numerous filamentous forms representing Cyanophyta. Other important components are specimens of *Pulvinosphaeridium antiquum* and *Pseudotasmanites*. Their stratigraphic ranges in the study area are limited to the BAMA I Zone. The BAMA I Zone is bounded from the bottom and from the top by palynologically barren sediments of Potrójna Formation (Wiśniowa 6, Wiśniowa 3 and Wiśniowa IG 1 boreholes) and *Skolithos* sandstones sediments of the Mogilany Member of Goczałkowice Formation (Borzęta IG 1 borehole) (Figs. 5, 6, 11).

Description. – The diagnostic taxa are accompanied by tiny forms of *Pterospermopsimorpha* and *Granomarginata*. They are rather sparse, represented by a few specimens in a standard microscopic slide. Single, large (several hundred microns in diameter) specimens of the *Chuaria* and *Tawuia* genera are additional elements of this association. The other characteristic components are forms with a somewhat different morphology, representing the genera *Ceratophyton*, *Navifusa* and *Leiovalia*.

Regional occurrence. – Poland, the USB area, Borzęta Formation, boreholes: Borzęta IG 1 (Osieczany Mb. – 43 samples from the depth interval 3167.0–3472.3 m, and Rajbrot Mb. – 8 samples from 3053.1–3130.0 m) (Fig. 6, Table 1); Rajbrot 1 (Myślenice Mb. – 9 samples from 4688.1–4946.5 m, Osieczany Mb. – 3 samples from 4576.7–4637.0 m and Rajbrot Mb. – 11 samples from 4330.1–4523.8 m) (Fig. 6, Table 2), Rajbrot 2 (Rajbrot Mb. – 12 samples from 3902.5–4184.5 m) (Fig. 6, Table 2), Wiśniowa IG 1 (Myślenice Mb. – 2 samples from 2758.8–2765.8 m) (Fig. 6, Table 3), Wiśniowa 3 (Myślenice Mb. – 3 samples from 2519.0–2534.5 m) (Fig. 6, Table 3), Wiśniowa 6 (Myślenice Mb. – 4 samples from 2226.5–2230.5 m) (Fig. 6, Table 3), Chrząstowice RCh 6 (Osieczany Mb. – 4 samples from 190.5–237.5 m) (Fig. 6, Table 3), Trojanowice (Myślenice Mb. – 11 samples from 210.0–236.0 m) (Fig. 4, Table 3), WB 137 (Rajbrot Mb. – 5 samples from 408.8– 561.2 m) (Fig. 6, Table 3) and WB 141 (Osieczany Mb. – 3 samples from 456.0–518.0 m) (Fig. 6, Table 3).

Bio- and chronostratigraphic aspects. – Simple, spherical specimens of the genus *Leiosphaeridia* or successive genera *Pterospermopsimorpha* and *Granomarginata*, dominant in the described assemblage, have been widely recognised in oldest Cambrian deposits (Moczydłowska, 1991; Jankauskas, Lendzion, 1992). The characteristic species *Pulvinosphaeridium antiquum* has been established in the Lithuanian Lower Cambrian deposits (Lontova Formation) being correlated with the *Platysolenites* Zone. They contain representatives of *Leiovalia* and *Navifusa* that were also noted in the BAMA I association. Here documented specimens of the *Chuaria* circularis "megaspheromorphs" and genus *Tawuia* are known from the Lower Cambrian and Proterozoic. Within the latter, they often attain large sizes that allowed even for macroscopic observation (Vidal *et. al*., 1993). *Ceratophyton* appears at the Precambrian–Cambrian boundary and ranges into the Early Cambrian .

The BAMA I assemblage is similar in its taxonomic composition to the *Granomarginata prima* Zone (Jankauskas, Lendzion, 1992), established in the *Platysolenites* Zone deposits in the north-western part of the East European Craton (Jankauskas, Lendzion, 1992; Jankauskas, 2002). In the present stratigraphical division of the Cambrian, the described zone corresponds to the Terreneuvian Series, which in turn is correlated with the *Platysolenites* Zone.

BAMA I assemblages from the successive members of the Borzęta Formation, have a similar generic and species composition. Detailed observations demonstrated only quantitative differences in occurrence of some taxa within individual profiles. For instance, the dominant component of the assemblages from the Wiśniowa 6 borehole samples are fragments of the filamentous Cyanophyta, whereas in the Wiśniowa IG 1 borehole, numerous specimens of the *Granomarginata* and *Pterospermopsimorpha* genera were found. On the other hand, in samples from the Rajbrot 2 borehole profile, quite numerous (from a few up to over a dozen specimens in a standard slide) morphologically differentiated specimens of the genus *Ceratophyton* have been encountered. However, the observed differences are not neccessarily related to evolutionary changes observable along the formation profile. They can also be explained by changing conditions of sedimentation. At the present stage of the investigation, it is impossible to distinguish between the respective evolutionary versus environmental controls.

Table 1

The occurance of selected acritarch species in the Borzęta IG 1 borehole

Borehole	Lithostratigraphy (after Buła, 2000)		Sample depth [m]	*Leiosphaeridia tenuissima*	*Leiosphaeridia* sp.	*Granomarginata prima*	*G. squamacea*	*Pulvinosphaeridium antiquum*	*Pulvinosphaeridium* sp.	*Pseudotasmanites* sp.	*Chuaria circularis*	*Tawuia* sp.	*Leiovalia* sp.	*Navifusa* sp.	*Ceratophyton vernicosum*	Brunovistulicum acritarch assemblages zones	Baltic faunal zones
BORZĘTA IG 1	BORZĘTA FORMATION	Rajbrot Member	3053.1	XX	XX	x	x	x		x	x				x	BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites*	*Platysolenites*
			3055.2	XX	XX	x				x		x	x		x		
			3085.7	XX	XX	x	x		x	x	x				x		
			3087.4	XX	XX	x	x			x					x		
			3088.4	XX	XX	x				x							
			3091.2	XX	XX						x			x	x		
			3129.0	XX	XX								x	x	x		
			3130.0	XX	XX	x	x		x					x			
		Osieczany Member	3167.0	XX	XX						x			x	x		
			3167.5	XX	XX										x		
			3171.3	XX	XX	x					x						
			3172.0	XX	XX								x		x		
			3203.4	XX	XX	x	x		x					x	x		
			3204.1	XX	XX	x	x				x			x			
			3205.7	XX	XX									x	x		
			3206.5	XX	XX	x	x	x			x			x			
			3208.5	XX	XX								x		x		
			3242.0	XX	XX				x						xx		
			3273.5	XX	XX										x		
			3273.9	XX	XX			x									
			3275.4	XX	XX												
			3277.0	XX	XX												
			3300.3	XX	XX	x	x			xx							
			3302.3	XX	XX					xx					x		
			3305.0	XX	XX	x	x							x			
			3306.0	XX	XX			x		x			x		xx		
			3313.0	XX	XX	x				x	x	x		x			
			3314.0	XX	XX					x					xx		
			3315.8	XX	XX								x	x	x		
			3330.2	XX	XX				x	x	x	x		x	x		
			3331.8	XX	XX	x	x	x							x		
			3332.7	XX	XX					x			x		x		
			3335.9	XX	XX					x		x			x		
			3337.8	XX	XX	x	x	x			x			x			
			3340.1	XX	XX					xx				x	x		
			3343.6	XX	XX				x								
			3344.3	XX	XX	x	x	x		xx	x		x				
			3346.3	XX	XX		x	x	x	xx	xx		x		x		

Table 1 continued

Borehole	Lithostratigraphy (after Buła, 2000)		Sample depth [m]	*Leiosphaeridia tenuissima*	*Leiosphaeridia* sp.	*Granomarginata prima*	*G. squamacea*	*Pulvinosphaeridium antiquum*	*Pulvinosphaeridium* sp.	*Pseudotasmanites* sp.	*Chuaria circularis*	*Tawuia* sp.	*Leiovalia* sp.	*Navifusa* sp.	*Ceratophyton vernicosum*	Brunovistulicum acritarch assemblages zones	Baltic faunal zones
BORZĘTA IG 1	BORZĘTA FORMATION	Osieczany Mb.	3350.0	X X	X X									x	x	BAMA I *P. antiquum–Pseudotasmanites*	*Platysolenites*
			3351.2	X X	X X			x		xx	x		x				
			3352.0	X X	X X	x	x			xx							
			3352.6	X X	X X			x			x		x	x			
			3353.3	X X	X X			x		xx				x	xx		
			3355.2	X X	X X			x		xx	x	x	x	x			
			3355.7	X X	X X									x			
			3356.2	X X	X X			x	x	x	x	x		x	xx		
			3357.2	X X	X X			x		x			x	x			
			3366.3	X X	X X	x	x		x	x		x		x	xx		
			3368.0	X X	X X			x		x	x			x	xx		
			3471.5	X X	X X					x				x	xx		
			3472.3	X X	X X			x				x			xx		
		Myśl. Mb.	3477.0														
			3478.7														
			3647.6														

Exlanations for Tables 1–9
X X – abundant – 50–>300 counts; X – common – 11–49 counts; xx – rare – 3–10 counts; x – very rare 1–2 counts

BAMA II – *Asteridium tornatum–Comasphaeridium velvetum* Assemblage Zone

Definition and boundaries. – *Asteridium tornatum*, *A. lanatum* and *Comasphaeridium velvetum* are regarded as the index taxa of the described Zone in the Brunovistulicum area (Vavrdová *et al*., 2003). These tiny sculptured forms appear for the first time in the studied Cambrian deposits, similarly to the representatives of genus *Lophosphaeridium*, which gives a distinctly "Cambrian character" to the microflora (Moczydłowska, 1991). In the Měnín 1 borehole the BAMA II *Asteridium tornatum–Comasphaeridium velvetum* Zone is bounded from the bottom and from the top by palynologically barren sediments correlated with *Skolithos* sandstones deposits of the Mogilany Member of the Goczałkowice Formation (Fig. 9).

Description. – The *Asteridium tornatum–Comasphaeridium velvetum* Assemblage Zone was established by Moczydłowska (1991). The base of this zone was defined at the first appearances of *Comasphaeridium agglutinatum*, *C. formosum*, *C. velvetum* and *Pterospermella velata*. This zone is characterized by appearance of 15 new species, including the nominal species *A. tornatum* and *C. velvetum*.

Regional occurrence. – Czech Republic, Brno Block; Měnín 1 borehole (sample from the depth interval 1565.0–1566.5 m) (Vavrdová *et al*., 2003; Fig. 9, Table 4). In this profile in sediments occurring below the above sample (4 samples from the depth interval 1804.6–2100.0 m; Table 4) and above it (3 samples from the depth interval 1059.0–1300.2 m; Table 4) organic microfossil assemblages designated as Ediacaran in age have been described (Vavrdová *et al*., 2003; Vavrdová, 2006). According to the author of this paper described associations do not include any taxa allowing for a proper identification of their age. Therefore, for the purposes of this study they can be regarded as the age equivalent of the discussed zone. Lack of index associations in the section correlated with the Mogilany Member can be explained by depositional facies conditions (Paczeŝna, 2005; Mikulaš *et al*., 2008).

Table 2

The occurance of selected acritarch species in the Rajbrot 1 and Rajbrot 2 boreholes

Borehole	Lithostratigraphy (after Buła, 2000)		Sample depth [m]	*Leiosphaeridia tenuissima*	*Leiosphaeridia* sp.	*Granomarginata prima*	*G. squamacea*	*Pulvinosphaeridium antiquum*	*Ceratophyton vernicosum*	*Chuaria circularis*	*Tawuia* sp.	*Navifusa* sp.	*Leiovalia* sp.	*Pseudotasmanites* sp.	Brunovistulicum acritarch assemblages zones	Baltic faunal zones
RAJBROT 2	BORZĘTA FORMATION	Rajbrot Mb.	3902.50	XX	XX	x	x	x	xx	x	x	x	x	xx	BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites*	*Platysolenites*
			3902.00–3909.00	XX	XX				xx	x			x	xx		
			3906.60	XX	XX				xx	x				xx		
			3967.00	XX	XX	x			xx	x		x		xx		
			3968.80	XX	XX			x	xx	x				xx		
			3972.00	XX	XX	x	x		xx	x	x	x	x	xx		
			3972.35	XX	XX	x	x		xx	x		x		xx		
			4035.70	XX	XX				xx	x			x	xx		
			4097.15	XX	XX			x	xx	x				x		
			4100.80	XX	XX				xx	x	x			x		
			4149.50	XX	XX				xx	x			x	x		
			4184.50	XX	XX				xx	x				x		
RAJBROT 1		Rajbrot Mb.	4330.10	XX	XX				xx	x				xx		
			4332.50	XX	XX	x			xx	x		x		xx		
			4367.50	XX	XX		x		xx	x	x			xx		
			4368.50	XX	XX	x		x	xx	x		x		xx		
			4391.70	XX	XX				xx	x			x	xx		
			4393.40	XX	XX				xx	x				x		
			4426.30	XX	XX				xx	x	x		x	x		
			4429.70	XX	XX			x	xx	x				xx		
			4472.50	XX	XX	x	x		xx	x		x		x		
			4474.10	XX	XX				xx	x				xx		
			4523.80	XX	XX	x	x		xx	x		x		xx		
		Osiecz.Mb.	4576.70	XX	XX				xx	x			x	xx		
			4582.10	XX	XX		x		xx	x				xx		
			4637.00	XX	XX	x			xx	x		x		x		
		Myślenice Mb.	4688.10	XX	XX				xx	x	x		x	x		
			4693.00	XX	XX			x	xx	x				x		
			4743.30	XX	XX	x	x		xx	x		x		x		
			4747.90	XX	XX				xx	x				x		
			4815.20	XX	XX				xx	x				xx		
			4822.20	XX	XX		x	x	xx	x				xx		
			4884.10	XX	XX				xx	x	x		x	xx		
			4888.50	XX	XX				xx	x				xx		
			4946.50	XX	XX				xx	x	x			xx		

T a b l e 3

The occurance of selected acritarch species in the Chrząstowice, Trojanowice, Wiśniowa IG 1, Wiśniowa 3, Wiśniowa 6, WB 137 and WB 141 boreholes

Borehole	Lithostratigraphy (after Buła, 2000)		Sample depth [m]	*Leiosphaeridia tenuissima*	*Leiosphaeridia* sp.	*Granomarginata prima*	*G. squamacea*	*Pulvinosphaeridium antiquum*	*Chuaria circularis*	*Tawuia* sp.	*Pterospermopsimorpha* sp.	*Leiovalia* sp.	*Navifusa* sp.	*Ceratophyton vernicosum*	Brunovistulicum acritarch assemblages zones	Baltic faunal zones
TROJANOWICE	BORZĘTA FORMATION	Myślenice Mb.	210.0–215.0	XX	XX	x	x	x				x	x	x	BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites*	*Platysolenites*
			212.0	XX	XX				x	x			x			
			218.0	XX	XX	x						x	x			
			219.0–220.0	XX	XX		x	x	x				x			
			221.0–222.0	XX	XX		x					x	x	x		
			222.0–223.0	XX	XX	x				x			x			
			223.0	XX	XX		x	x				x	x	x		
			231.0	XX	XX	x			x				x			
			231.0–232.0	XX	XX		x	x		x			x			
			233.0–234.0	XX	XX									x		
			236.0	XX	XX		x		x				x			
WIŚNIOWA IG 1			2758.8–2761.4	XX	XX	x					x		x	x		
			2761.4–2765.8	XX	XX		x	x	x		x		x			
WIŚNIOWA 3			2519.0–2522.5	XX	XX						x			x		
			2519.0–2522.5	XX	XX		x		x		x			x		
			2532.0–2534.5	XX	XX						x					
WIŚNIOWA 6			2226.5–2227.5	XX	XX						x					
			2227.5–2228.5	XX	XX	x	x				x					
			2228.5–2229.5	XX	XX						x			x		
			2229.5–2230.5	XX	XX						x					
WB 137		Rajbrot Mb.	408.8	XX	XX											
			555.0	XX	XX		x		x							
			557.5	XX	XX							x		x		
			558.7	XX	XX		x		x							
			561.2	XX	XX									x		
WB 141		Osieczany Mb.	456.0	XX	XX		x					x				
			515.0	XX	XX				x					x		
			518.0	XX	XX											
CHRZĄSTOWICE Rch 6			190.5	XX	XX	x	x									
			211.0	XX	XX		x		x					x		
			228.0	XX	XX				x							
			237.5	XX	XX	x	x		x					x		
			257.0													
			294.0													

The occurance of selected acritarch species

Borehole	Sample depth [m]	*Leiosphaeridia* sp.	*Ceratophyton* sp.	*Granomarginata prima*	*G. squamacea*	*Ichnosphaera delicata*	*Pterospermella velata*	*Asteridium lanatum*	*A. tornatum*	*Comasphaeridium agglutinatum*	*C. molliculum*	*C. velvetum*	*Globosphaeridium cerinum*	*Tasmanites tenellus*	*Skiagia ornata*	*S. orbiculare*	*Lophosphaeridium dubium*	*Archeodiscina umbonulata*	*Skiagia ciliosa*	*S. compressa*	*S. scottica*	*Heliosphaeridium dissimilare*	*Skiagia pilosiuscula*	*Heliosphaeridium obscurum*	*Multiplicisphaeridium xianum*	*Estiastra minima*
MÉNÍN-1	473.0–477.5	x	x														X	X	X	XX	x	X	X	X	X	X
	507.0–512.0	x																X	X	X	X	X	xx			
	512.0	x																X	X	X	X	X	xx			
	776.0–778.0	x																X	X	X	X	X	xx			
	856.2	X	xx	xx	xx	xx	xx	xx	xx	x	xx	xx	xx	xx		xx										
	857.2	X	xx	xx	xx	xx	xx	xx	xx	x	xx	xx	xx	xx		xx										
	1059.0–1061.5	x																								
	1299.0–1300.2	x																								
	1300.2	x																								
	1565.0–1566.5	x	x				xx		xx					xx												
	1804.6–1805.8	x																								
	1899.0–1900.5	x																								
	2039.0–2042.0	x																								
	2097.0–2100.0	x																								
NĚMČIČKY 3	5396.0–5401.0	X						x							xx	X	X	X	X	X	X	X	X	X	X	xx
	5400.5	X						x							xx	X	X	X	X	X	X	X	X	X	X	xx
NĚMČIČKY 6	5157.0–5160.0	x						x							xx	X	X	X	X	X	X	X	X	X	X	xx
	5157.8	X						x							xx	X	X	X	X	X	X	X	X	X	X	xx
	5181.0–5184.5	X						x							xx	X	X	X	X	X	X	X	x	x	X	xx

Bio- and chronostratigraphic aspects. – The recognised association is similar to the acritarch assemblages of the *Asteridium tornatum–Comasphaeridium velvetum* Zone (Moczydłowska, 1991; Vavrdová *et al*., 2003; Vavrdová, 2006). This zone corresponds to the *Platysolenites* Zone in the south-western margin of the East European Craton (Moczydłowska, 1991). The discussed assemblage clearly differs from associations described above from the Borzęta Formation. In the study area the BAMA II assemblage occurs above BAMA I assemblage that was not found in the East European Craton area, and therefore the range of the BAMA II Zone correlatable with the *Asteridium tornatum–Comasphaeridium velvetum* Zone (Vavrdová *et al*., 2003; Vavrdová, 2006) should be restricted to an upper part of the Terreneuvian.

BAMA III – *Ichnosphaera flexuosa–Comasphaeridium molliculum* Assemblage Zone – Acme Zone

Definition and boundaries. – The acritarch assemblages of the BAMA III Zone are defined by the domination of a new genus *Ichnosphaera*, which is represented by a few species in the discussed zone. This genus is characterised in the analysed sections by a short stratigraphic range and, therefore, is here regarded as an index form. The lower boundary of the zone is marked by its first appearance. In the stratotype Goczałkowice IG 1 section the BAMA III Zone is bounded from the bottom by palynologically barren sediments of the Mogilany Member and its upper boundary conforms with the base of the BAMA IV Zone (Figs. 5, 11).

Description. – Besides the *Ichnosphaera* n.gen., the described zone is characterized by the first appearance of the new genus *Lechistania* whose stratigraphic range in the study area is

Table 4

in the Měnín 1, Němčičky 3 and 6 boreholes

Eklundia varia	*Pterospermopsimorha rugulosa*	*Comasphaeridium strigosum*	*Leiovalia tenera*	*Alliumella baltica*	*Globus gossipinus*	*Skiagia brachyspinosa*	*Sagatum priscum*	*Goniosphaeridium volkovae*	*Parmasphaeridium implicatum*	*Solisphaeridium elegans*	*Revinotesta* sp.	*Liepaina plana*	*Volkovia dentifera*	Brunovistulicum acritarch assmblages zones	Baltic faunal zones
X	X	X	x	x	xx	xx	xx	X	x	x	x			BAMA V *Skiagia–Eklundia varia*	*Holmia*
	xx	xx	x	x	xx		xx	xx	x						
	xx	xx	x	x	xx		xx	xx	x						
	xx	xx	x	x	x										
														BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum*	*Schmidtiellus* ? *Holmia*
														BAMA II *Asteridium tornatum–Comasphaeridium velvetum*	*Platysolenites*
xx	X	x	x	x	x	xx	x	xx	xx	x	x	x	x	BAMA VI *Volkovia dentifera–Liepaina plana*	*Protolenus*
xx	X	x	x	x	x	xx	x	xx	xx	x	x	x	x		
xx	xx	x	x	x	x	x	x	xx	xx	x	x	x	x		
xx	xx	x	x	x	x	x	x	xx	xx	x	x	x	x		
xx	xx	x	x	x	x	x	x	xx	xx	x	x	x	x		

limited to the desribed zone. The acritarch assemblages of the BAMA III Zone frequently include representatives of the genus *Comasphaeridium* with *C. agglutinatum*, *C. velvetum* and *C. molliculum* species, as well as specimens of *Pterospermella* with *P. gigantea* n.sp. Representatives of the genera *Asteridium, Globosphaeridium* or *Tasmanites* appear more sporadically. Besides the above mentioned forms, only single specimens of the characteristic Early Cambrian genera *Skiagia* and *Archeodiscina* were found in the studied assemblages.

Regional occurrence. – Poland, the USB area, Goczałkowice Formation, Głogoczów Member, boreholes: Goczałkowice IG 1 (9 samples from the depth interval 2968.0–3032.0 m) (Fig. 7, Table 5), Głogoczów IG 1 (5 samples from 2536.1–2575.9 m) (Fig. 8, Table 6), Klucze 1 (2 samples from 1950.0–1960.0 m) (Fig. 7, Table 8), Sułoszowa (3 samples samples from 321.0–329.6 m) (Fig. 7, Table 8), Kozy MT 3 (26 samples from 1488.0–1499.6 m) (Fig. 8, Table 7), Kęty 8 (3 samples from 1291.3–1294.0 m) (Fig. 8, Table 6), Kęty 9 (1 sample from 1630.6 m) (Fig. 8, Table 6), Andrychów 3 (6 samples from 2229.8–2260.7 m) (Fig. 8, Table 6), Piotrowice 1 (4 samples from 2437.0–2542.8 m) (Fig. 7, Table 8); Czech Republic, Brno Block, Měnín 1, borehole (2 samples from 856.2–857.2 m) (Fig. 9, Table 4).

Bio- and chronostratigraphic aspects. – The index form *Ichnosphaera* n.gen. has been distinguished earlier in other areas of the Cambrian occurrence (Volkova *et al*., 1983; Moczydłowska, Vidal, 1986, 1988; Hagenfeldt, 1989a; Eklund, 1990; Brück, Vanguestaine, 2004). This taxon together with the new species is described in the palaeontological part. Numerous specimens of the *Ichnosphaera* n.gen. have been usually documented from the deposits correlated with the lower part of the trilobite-bearing Early Cambrian successions (Moczydłowska, Vidal, 1986; Moczydłowska, 2011), especially with the *Schmidtiellus* Zone, and with the lower part of the *Holmia* Zone (Volkova *et al*., 1983; Moczydłowska, Vidal, 1986; Hagenfeldt, 1989a; Eklund, 1990; Moczydłowska, 1991; Moczydłowska, 2011). The appearance of these forms is

The occurance of selected acritarch species

Borehole	Lithostratigraphy (after Buła, 2000)		Sample depth [m]	*Leiosphaeridia* sp.	*Ceratophyton vernicosum*	*Ggranomarginata prima*	*G. squamacea*	*Ichnosphaera delicata*	*I. aranea*	*I. stipatica*	*I. flexuosa*	*I. robusta*	*Pterospermella gigantea*	*P. velata*	*Tasmanites bobrowskae*	*Asteridium lanatum*	*A. pallidum*	*A. tornatum*	*Comasphaeridium velvetum*	*C. agglutinatum*	*Globosphaeridium cerinum*	*Comasphaeridium molliculum*	*Lophosphaeridium dubium*	*Globosphaeridium arenulum.*	*Archeodiscina multipunctata*	*A. umbonulata*	*Skiagia brachyspinosa*
GOCZAŁKOWICE IG 1	GOCZAŁKOWICE FORMATION	Pszczyna Member	2768.00	XX			X											X								XX	
			2771.00	XX			X											X								XX	
			2771,50	XX			X																			X	
			2775.00	XX			X							x				X								XX	
			2781.30	XX			X							x				x			x					XX	
			2787.00	XX			X							x												X	
			2792.00	XX			X											x					x			X	
			2795.00	XX			X																x			X	
			2805.00	XX			X							x							x					X	
			2807.50	XX			X											X					x			X	
			2808.00	XX			X											x					xx			X	
			2809.00	XX			X																x			X	
			2818.00	XX			X											X								X	
			2822.50	XX	x		X							x												X	
			2825.50	XX	x		X											X			x		x			X	
			2831.50	XX	x		X																			X	
			2834.00	XX			X							x				X			x					X	
			2842.00	XX			X																				
			2842.30	XX	x		X							x				X			x						
			2842.70	XX			X																x				
			2843.50	XX			X							x												x	
			2850.45	XX			X											x								XX	
			2852.00	XX			X														x		x			XX	
			2872.50	XX	x		X							x				x								XX	
			2884.00	XX			X							X							x		x			XX	
			2893.00	XX			X											x								XX	
			2894.50	XX	x		X							X							X		x				
			2897.00	XX			X											x									
			2918.00	XX	x		XX							X				x			X						
			2931.00	XX			X	x										x					x				
			2937.00	XX	x		X							X				X			X						
			2944.30	XX			X	x										X			X						
			2956.00	XX			X											x									
			2957.00	XX	x		X	x						x							X		x				
		Głogoczów Member	2968.00	XX	x	xx	X	X	x	X	X	xx	x		x	xx	X	X	xx	x	X	x	x	x	x	x	x
			2971.00	XX	x	xx	X	X	x	X	X	xx	xx		x	xx	X	X	xx		X	x	x	x		x	
			2975.00	XX	x	xx	X	X	x	X	X	xx	x			xx	X	X	xx	x	X	x	x	x	xx	x	
			2978.00	XX	x	xx	X	X	x	X	X	xx	xx		x	xx	xx	X	xx		XX	x	x	x	x		
			2979.00	XX	x	xx	xx	X	x	X	xx	xx	x			xx	X	X	xx		xx	x	x			x	
			2984.00	XX	x	xx	xx	XX	x	xx	xx	xx			x	xx	X	X	xx	x	xx				xx		x
			2985.50	XX	x	xx	xx	XX	x	xx	X	xx	xx	xx	x	xx	X	X	xx	x	X	x	x			x	
			3022.00	XX	x	xx	xx	XX	x	xx	X	xx		xx	x	xx	X	X	xx	x	X		x		x		
			3032.00	XX	x	xx	xx	XX	x	xx	X			xx	x	xx	X	X	xx	x	X		x				x

Table 5

in the Goczałkowice IG 1 borehole

S. orbiculare	*S. ornata*	*S. pura*	*Pterospermella inordinata*	*Eklundia pusilla*	*E. campanula*	*Multiplicisphaeridium xianum*	*Parmasphaerid. robustispinosum*	*Skiagia ciliosa*	*S. compressa*	*S. scotica*	*Heliosphaeridium dissimilare*	*Estiastra minima*	*Eklundia varia*	*Pterospermopsimorpha rugulosa*	*Retisphaeridium pusillum*	*Comasphaeridium strigosum*	*C. spinosum*	*Eklundia florentinata*	*Retisphaeridium postae*	*Sagatum priscum*	*Helosphaeridium obscurum*	*Parmasphaeridium implicatum*	*Goniosphaeridium volkovae*	*Globus gossipinus*	*Skiagia pilosiuscula*	*Leliovalia tenera*	*Revinotesta* sp.	Brunovistulicum acritarch assemblage zones	Baltic faunal zones
X	X					X		X	X	X	X	XX	X	X	x	x	X	X	x	x	X	X	X	X	X	X		*BAMA V Skiagia–Eklundia varia*	*Holmia*
x	x					X		x	x	x	x	XX	x	x	x		X	X	x		X	X	x	X	x		x		
X	X					X		X	X	X	X	X	X	X	x	xx		X	x	x	X	X	x	X	X	x			
X	X					X		X	X	X	X	XX	X	X	x						X	X	x		X				
X	X					X		X	X	X	X	X	X	X					x	x					X	X	x		
X	X					X		X	X	X	X	X	X	X	x	x			x			x			X				
X	X					X		X	X	X	X	X	X	X					x			x			X		x		
X	X							X	X	X	X	X	X	X					x	x		x			X	x			
X	X					x		X	X	X	X	X	X	X		x									X		x		
X	X							X	X	X	X	X	X	X								x			X		x		
X	X							X	X	X	X	X	X	X		x						x			X				
X	X					x		X	X	X	X	X	X	X								x			X				
X	X							X	X	X	X	X	X	X		x						x			X	x			
X	X					x		X	X	X	X	X	X	X								x			X		x		
X	X							X	X	X	X	x	X	X		x									X	x			
X	X					x		X	X	X	X	x	X	X											X				
x	x					x		x	x	x	x	x	x	x		x						x			x	x	x		
X	X					x		X	X	X	X	x	X	X											X				
X	X					x		X	X	X	X	x	X	X		x				x					X	x	x		
x	x					x		x	x	x	x		x	x											x				
						x										x										x			
X	X					x		X	X	X	X		X	X						x					X				
						x																				x			
x	x				X	x	x	X	X	X			x															*BAMA IV Skiagia–Eklundia campanula*	
x	x		X	X	X	x	x	X	X	X	X		x			x				x									
x	x			XX	X	X	x	X	X	X	X		x																
x	x			XX	X	x	x	X	X	X	X					x				x									
x	x			XX	X	x	xx	X	X	X	X		x																
x	x		xx	X	X	x	x	X	X	X	x					x													
x	x		XX	XX	X	x	x	x	x	x	X																		
x	x			XX	X	x	x	X	X	X	X					x													
x	x		XX	XX	x	x	x	X	X	X	x																		
x	x		XX	XX	x	x	x	x	x	x						x													
x	x			XX	x						X																		
xx	xx	x																										*BAMA III Ichnosphaera flexuosa–Coomasphaeridium molliculum*	*Schmidtiellus–?Holmia*
xx	xx	x																											
xx	xx																												
xx	xx	x																											
xx	xx	x																											
xx	xx																												
xx	xx	x																											
xx	xx																												
xx	xx	x																											

Table 6

The occurance of selected acritarch species in the Andrychów 3, Głogoczów IG 1, Kęty 8 and Kęty 9 boreholes

Borehole	Lithostratigraphy (after Buła, 2000)		Sample depth [m]	*Leiosphaeridia* sp.	*Ceratophyton* sp.	*Granomarginata prima*	*G. squamacea*	*Ichnosphaera aranea*	*I. delicata*	*I. flexuosa*	*I. stipatica*	*Pterospermella velata*	*Asteridium lanatum*	*Globosphaeridium cerinum*	*Comasphaeridium velvetum*	*Lophosphaeridium dubium*	*Tasmanites bobrowskae*	*Asteridium pallidum*	*Skiagia ornata*	*S. brachyspinosa*	*S. orbiculare*	Brunovistulicum acritarch assemblages zones	Baltic faunal zones
ANDRYCHÓW 3	GOCZAŁKOWICE FORMATION	Głogoczów Member	2229.8	X	x	X	X	X	X	xx	xx	X	x	xx	xx	x	x	xx	xx	xx	xx	BAMA III *Ichnosphaera,flexuosa–Comasphaeridium molliculum*	*Schmidtiellus* ? *Holmia*
			2230.9	X	x	X	X	X	X	xx	xx	X	x	xx	xx	x	x	xx	xx	xx	xx		
			2240.0	X	x	X	X	X	X	xx	xx	X	x	xx	xx	x	x	xx	xx	xx	xx		
			2246.5	X	x	X	X	X	X	xx	xx	X	x	xx	xx	x	x	xx	xx	xx	xx		
			2252.5	X	x	X	X	X	X	xx	xx	X	x	xx	xx	x	x	xx	xx	xx	xx		
			2260.7	X	x	X	X	X	X	xx	xx	X	x	xx	xx		x	xx	xx	xx	xx		
KĘTY 8			1291.0–1294.0	X	x	X	X	X	X	xx	xx	X	x	xx	xx	x	x	xx	xx	x	xx		
			1291.0–1294.0	X	x	X	X	X	X	xx	xx	X	x	xx	xx	x	x	xx	xx	xx	xx		
			1291.0–1294.0	X	x	xx	X	X	X	xx	xx	X	x	xx	xx		x	xx	xx		xx		
KĘTY 9			1630.6	X	x	xx	X	X	X	xx	xx	X	x	xx	xx	x	x	xx	x	x	xx		
GŁOGOCZÓW IG 1			2536.1	X	xx	X		X	XX	xx	xx	X	x	xx	xx	xx	x	X	x	xx	xx		
			2536.9	X	xx	X		X	X	xx	xx	X	x	xx	xx	xx	x	X	x	x	xx		
			2573.5	X	xx	X		X	X	xx	xx	X	x	xx	xx	xx	x	X	x	x	xx		
			2575.4	X	xx	X		X	X	xx	xx	X	x	xx	xx	xx	x	X	x	xx	xx		
			2575.9	X	xx	X		X	X	xx	xx	X	x	xx	xx	xx	x	X	x	xx	xx		
			2576.1																				
			2576.6																				
			2579.0																				
			2581.4																				

well documented in the Lower Cambrian of Scandinavia (Moczydłowska, Vidal, 1986). They frequently occur in "*Mickwiztia* Sandstone" of central and southern Sweden, from which, among others, the typical species *Ichnosphaera flexuosa* n.comb. has been described (= *Elektoriskos flexuosus*) (Eklund, 1990). They are also known from the "Green Shale" Formation from Bornholm (Moczydłowska, Vidal, 1986), from Buen in northern Greenland, and from Bastion in southern Greenland (Moczydłowska, Vidal, 1986). So far, outside Scandinavia, this characteristic genus is represented, first of all, by the species *Ichnosphaera delicata* n.sp = *Comasphaeridium brachyspinosum* (Kirjanov, 1974) Moczydłowska et Vidal, 1988. It has been found in many areas, among others in the Cambrian of the East European Craton (Volkova *et al*., 1983; Moczydłowska, 1991; Jankauskas, Lendzion, 1992, 1994; Jankauskas, 2002; Moczydłowska, 2011), and in the Siberian Platform (Rudavskaya, Vassileva, 1984). A good example of the acritarch associations with numerous specimens of this species are those encountered recently in the Lükati Formation of Estonia (Moczydłowska, 2011), correlated with the *Schmidtiellus mickwitzi* Zone. Of 20 taxa documented there, 16 were documented in the BAMA III Zone. Recently, species *Ichnosphaera robusta* n.sp. (= *Elektoriskos flexuosus*) was described from the Cambrian of southern Ireland (Brück, Vanguestaine, 2004) correlated with the trilobite *Olenellus* Zone (Young *et al*., 1994).

The acritarch assemblages from the above mentioned areas, containing *Ichnosphaera* n.gen., included first of all, representatives of such Early Cambrian taxa as *Asteridium tornatum*, *A. lanatum*, *A. pallium*, *Archeodiscina umbonulata*, *Comasphaeridium molliculum*, *C. strigosum*, *Globosphaeridium cerinum*, *Granomarginata squamacea*, *Lophosphaeridium*, *Leiosphaeridia* spp. and *Tasmanites bobrowskae*. Genus *Skiagia*, diagnostic for late Early Cambrian levels, is rare and is represented by single specimens only. Assemblages with similar taxonomic content occur also north-east and east

Table 7

The occurance of selected acritarch species in the Kozy Mt 3 borehole

Borehole	Lithostratigraphy (after Buła, 2000)		Sample depth [m]	*Leiosphaeridia* sp.	*Ceratophyton* sp.	*Granomarginata prima*	*G. squamacea*	*Ichnosphaera aranea*	*I. delicata*	*I. flexuosa*	*I. stipatica*	*Asteridium lanatum*	*A. tornatum*	*Pterospermella velata*	*P. gigantea*	*Comashaeridium agglutinatum*	*C. molliculum*	*C. velvetum*	*Globosphaeridium cerinum*	*Lophosphaeridium dubium*	*Lechistania magna*	*Globoshaeridium arenulum*	*Skiagia brachyspinosa*	*S. ornata*	*S. orbiculare*	*S. pura*	*Tasmanites bobrowskae*	Brunovistulicu acritarch assemblages zones	Baltic faunal zones
KOZY Mt 3	GOCZAŁKOWICE FORMATION	Głogoczów Member	1488.0	X	x	xx	X	XX	X	X	X	X	xx	X	xx	x	xx	xx	xx	x				x	x		x	BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum*	*Schmidtiellus* ?*Holmia*
			1488.7	X	x	xx	X	XX	X	x	X	X	X	X	x	x	x	xx					x				x		
			1489.5	X	x	xx	X	XX	X	X	X	X	xx	X		x	x	xx	xx						x		x		
			1489.8	X	x	xx	X	XX	X	x	X	X	xx	X	xx	x	x	xx		x				x					
			1490.4	X	x	xx	X	XX	X	x	X	X	xx	X			x	xx					x						
			1490.8	X	x	xx	X	XX	X	X	X	X	xx	X	xx	x		xx	xx	x					x		x		
			1490.9	X	x	xx	X	XX	X	x	X	xx	xx	X	xx			xx		x			x						
			1491.5	X	x	xx	X		X	x	X	X	xx	X		x	x	xx	xx	x		x		x	x				
			1491.8	X	x	xx	X	XX	X	x	X	X	xx	X	xx				xx										
			1491.9	X	xx	xx	X	XX	X	X	X	X	xx	X		x		xx		x			x		x		x		
			1492.5	X	x	xx	X	XX	X	x	X	X	xx	X	xx		x		xx										
			1492.6	X	x	xx	X	XX	X	x	X	X	xx	X		x		xx		x					x				
			1492.8	X	xx	xx	X		X	X	X	X	xx	X	xx		x					X		x					
			1493.4	X	xx	xx	X	XX	X	X	X	X	xx	X		x		xx	x	x			x				x		
			1494.1	X	x	xx	X		X	X	X	X	xx	X			x		x	x		x			x				
			1494.3	X	x	xx	X	XX	X	X	X	X	xx	X	xx	x	x	xx						x	x		x		
			1494.6	X	x	xx	X	XX	X	X	X	X	xx	X		x			xx								x		
			1495.0	X	x	xx	X	XX	X	X	X	X	xx	X			x			x		x	x	x	x		x		
			1495.2	X	x	xx	X	XX	X	X	X	X		X	xx	x		xx				x					x		
			1496.1	X	x	xx	X		X	X	X	X	xx	X			x		xx	x						x	x		
			1496.9	X	x	xx	X	XX	X	X	X	X	xx	X		x				x					x	x	x		
			1497.0	X	x	xx	X	XX	X	X	X	X		X	xx		x	xx				x	x	x		x	x		
			1497.7	X	x	xx	X	XX	X	X	X	X	xx	X		x			xx	x					x				
			1497.9	X	x	xx	X	XX	X	X	X	X		X	xx			xx			XX		x						
			1499.2	X	x	xx	X	XX	X	xx	X	X		xx		x		xx	xx			X		x					
			1499.6	X	x		X	XX	X	xx	X	X	xx	xx				xx	xx								x		

of the USB, i.e. in the Łysogóry Region of the Holy Cross Mountains (Szczepanik, 2009), as well as in the eastern part of the Małopolska Block (Jachowicz-Zdanowska, 2011), where they are correlated also with the *Schmidtiellus* Zone deposits.

The stratigraphical range of *Ichnosphaera* n.gen. in the discussed acritarch assemblages is clearly connected mainly with the strata, which according to the new Cambrian subdivision (Peng, Babcock, 2008), should be correlated with the Stage 3 or the bottom of the Stage 4 (equivalents of the *Schmidtiellus* Zone or lower part of the *Holmia* Zone).

The majority of the *Ichnosphaera* n.gen. species from the USB is documented in the Głogoczów Member only. Single specimens of *Ichnosphaera delicata* n.sp. were encountered in samples from the upper members, although it cannot be excluded that they are reworked from older strata.

The occurance of selected acritarch species in the Jarząbkowice 1,

Borehole	Lithostratigraphy (after Buła, 2000)		Investigeted intervals [m]	*Ceratophyton vernicosum*	*Granomarginata prima*	*G. squamacea*	*Ichnosphaera delicata*	*I. flexuosa*	*I. stipatica*	*I. robusta*	*Pterospermella velata*	*Asteridium pallidum*	*A. lanatum*	*A. tornatum*	*Comasphaeridium agglutinatum*	*C. molliculum*	*C. velvetum*	*Globosphaeridium cerinum*	*Tasmanites bobrowskae*	*Skiagia ornata*	*S. orbiculare*	*S. brachyspinosa*	*Globospinosum arenulum*	*Archeodiscina multipunctata*	*A. umbonulata*	*Alliumella baltica*	*Pterospermella inordinata*	*Eklundia pusilla*	*Multiplicisphaeridium xianum*	*Parmasphaeridium robustispinosum*
SUŁOSZOWA	GOCZAŁKOWICE FORMATION	Pszczyna Mb.	199.1		x	X								x				x		x	XX			xx	XX	x	XX	x	X	XX
			218.0			X												x		x	XX			xx	X		XX	x	X	
			222.4		x	X								x						x				xx	X		XX	x	X	x
			223.4		x	X								x						x				xx	X	x	XX	x	X	X
			226.4		x	X								x						x				xx	X		XX	X	X	
			227.4		x	X								x				x		x					X		XX	X	X	X
			230.4	x	x	X								x				x		x					X	x	XX	X	X	
			231.5	x	x	X								x		X				x					X		X	X	X	XX
			232.5	x	x	X								x		X		x		x					X		X	X	X	X
		?	247.5																											
			279.0																											
			283.5																											
			286.0																											
			287.0																											
		Gł. Mb.	321.0	x		X	X	X	X	X	X	X	XX	X	X	X	X	X	x	x		X	X		x					
			327.6	x	x	X	X	X	X	X	XX	X	XX	X	X	x	X	X	x	x		x	X		x					
			329.6	x	x	X	X	X	X	X	XX	X	XX	X	x	x	X	X	x			x	X		x					
KLUCZE 1		Pszczyna Mb.	1680.0–1690.0			X															XX				XX	x				
			1690.0–1700.0			X								x							X				X	x				
			1710.0–1720.0			X								x							X				X					
			1720.0–1730.0			X								x							X				X	x				
			1730.0–1740.0			X								x							X				X					
			1770.0–1780.0			X								x							X				X					
			1820.0–1830.0			X								x							X				X					
			1890.0–1900.0			X								x							X				X					
		Gł. Mb.	1950.0–1960.0			X								x							X				X					
			1950.0–1960.0	X	x	X	XX		X	XX	X	x	X	x	X				x											
		?	1970.0–1980.0																											
PIOTROWICE 1		Gł./Pszcz.Mb.	2410.4–2413.6			x																			X	x		x	x	
			2437.0–2440.6			x																			X				x	
			2464.8–2468.1			x	X	X	X		X			X		x	X	x	x			x			x					
			2501.4–2563.8	x		x	X	x	x		X			X			X		x		x				x					
			2540.0–2542.8	x		x	X	x	x		X			X			X	x												
JARZĄBKOWICE 1		Jarząbkowice Mb.	4024.2			x																			x					
			4024.9			x																								
			4025.2			x																								
			4025.4																						x					
			4025.9			x																								
			4026.2			x																								
			4026.9																						x					
			4027.2			x																								
			4027.9																											

Table 8

Klucze 1, Piotrowice 1, Sułoszowa boreholes

Skiagia pura	*S. ciliosa*	*S. compressa*	*S. scottica*	*Heliosphaeridium dissimilare*	*Estiastra minima*	*Eklundia varia*	*Pterospermopsimorpha rugulosa*	*Retisphaeridium pusillum*	*Comasphaeridium strigosum*	*C. spinosum*	*Eklundia campanula*	*Retisphaeridium brayense*	*Sagatum priscum*	*Parmasphaeridium implicatum*	*Solisphaeridium elegans*	*Skiagia pilosiuscula*	*Leiovalia tenera*	*Revinotesta* sp.	*Globus gossipinus*	Brunovistulicum acritarch assemblage zones	Baltic faunal zones
	X	XX	XX	XX	X	x	X	X	X	X	XX	X	x	x	x		x		x	BAMA IV *Skiagia–Eklundia campanula*	*Holmia*
	X	X	XX	XX	X		X		x		XX	x	x	x							
	x	X	XX	XX	X		XX		x	x		x		x	x		x		x		
	x	X	XX	XX	X		X		x	x		x									
	x	X	XX	XX	X		X		x			x									
		X	XX	XX	X		X		x	x		x									
	x	X	XX	XX	X		X		x			x					x				
		X	XX	XX	X		X		x			x									
	x	X	XX	XX	X		X		x			x									
																				?	?
x		x																		BAMA III *I. flexuosa–C. molliculum*	? *Holmia* *Schmidtiellus*
x																					
	XX	XX	XX	XX		x	x	x	x					X		X				BAMA V *Skiagia–Eklundia varia*	*Holmia*
	X	X	X	X		X	x	x						X		X					
	X	X	X	X		X	x	x	x					X		X					
	X	X	X	X		X								x		X					
	X	X	X	X		X		x	x					x							
	X	X	X	X		X			x					x						BAMA IV *Skiagia–Eklundia campanula*	
	X	X	X	X		X		x						x							
	X	X	X	X		X								x							
	X	X	X	X		X														BAMA III *I. flexuosa–C. molliculum*	? *Holmia* *Schmidtiellus*
																				?	?
		X			x	x	x												x	BAMA IV *Skiagia–E. campanula*	*Holmia*
		X	X		x		x													BAMA III *Ichnosphaera flexuosa – Comasphaeridium molliculum*	? *Holmia* *Schmidtiellus*
	X	X	X	X	x	x	X		x					x		x			x	BAMA VI *Volkovia dentifera–Liepaina plana*	*Protolenus*
	X	x	X	X	x	x	X		x												
	X	x	x	X	x	x	x														
	x	x	x	X	x				x					x		x					
	x	x	x	x		x	x														
	x	x	x	x										x							
		x	x	X	x	x	x		x					x							
		x	x	x																	
		x	x	x	x	x	x		x					x							

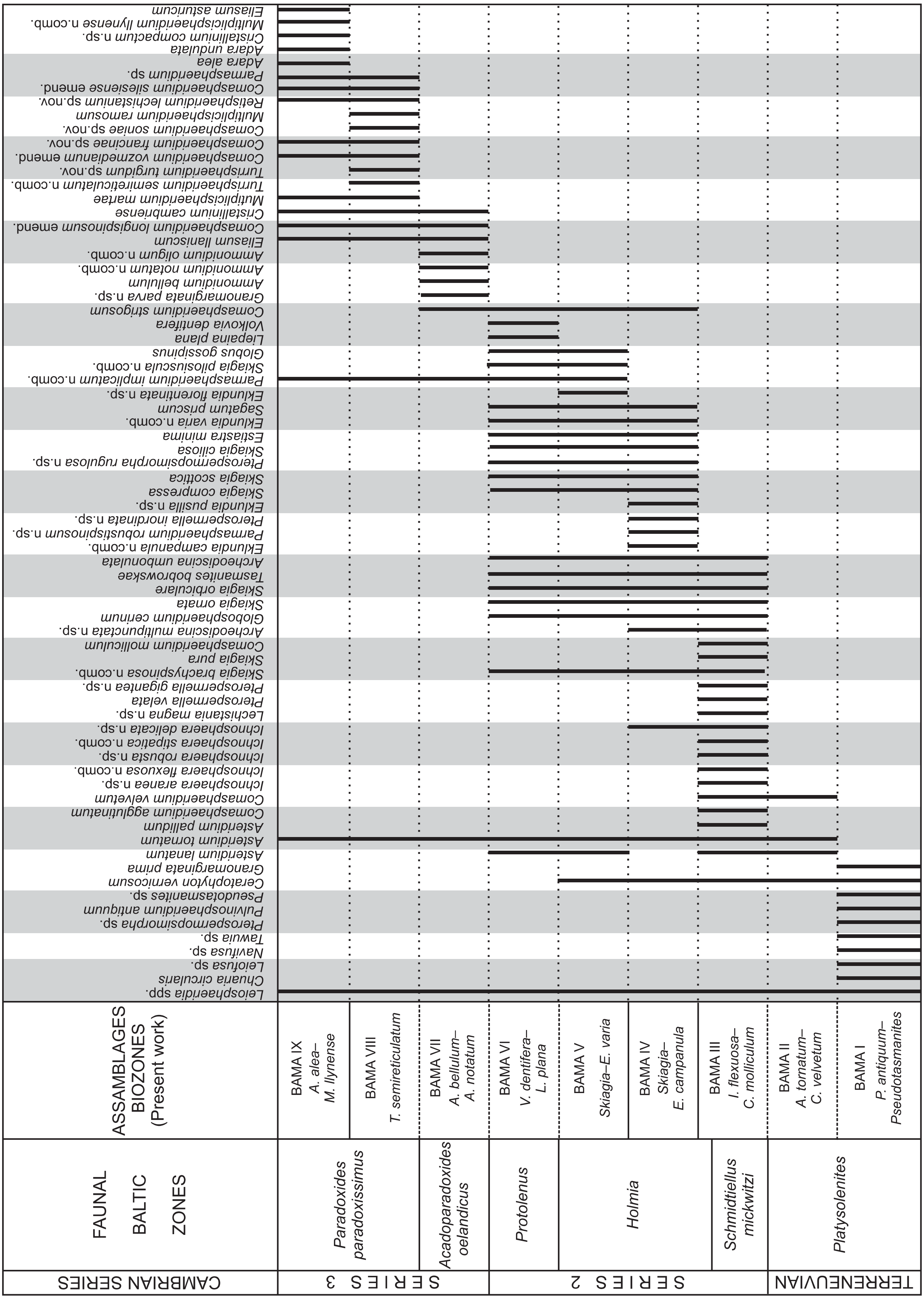


Fig. 11. Stratigraphic ranges of selected acritarch species in the Cambrian of the Brunovistulicum area

BAMA IV – *Skiagia–Eklundia campanula* Assemblage Zone

Definition and boundaries. – A characteristic attribute of the BAMA IV Zone assemblages is the mass appearance of the genus *Skiagia* representatives with the vesicle diameter usually not exceeding 20 µm (without processes). This taxon is represented here by a majority of known species. However, some of them, such as *S. ciliosa*, or *S. scottica*, appear in the analysed profiles for the first time. The lower boundary of the BAMA IV Zone corresponds to the upper boundary of the BAMA III Zone in the stratotype of the Goczałkowice Formation.

Description. – Besides the genus *Skiagia*, the described zone is characterized by the first appearances of the new genus *Eklundia* with *E. pusilla* n.sp., *E. campanula* n.comb. and *E. varia* n.comb. species. *E. varia* n.comb. is represented by single specimens while other forms, especially *E. campanula* n.comb., occur fairly abundantly, often in numbers exceeding 100 specimens in a standard microscopic slide. Representatives of other newly appearing species, *Pterospermella inordinata* n.sp., *Parmasphaeridium robustispinosum* n.sp., or *Pterospermopsimorpha rugulosa* n.sp. are also abundant (over 200 specimens per slide). The first two forms have been identified only in the described zone. Other accessory taxa include *Archeodiscina umbonulata*, *Heliosphaeridium dissimilare*, *Multiplicisphaeridium xianum*, *M. primarium*, *Estiastra minima*, *Alliumella baltica*, *Globus gossipinus*, *Retisphaeridium pusillum*, *R. brayense*, *Comasphaeridium strigosum*, *C. spinosum*, *Sagatum priscum*, *Solisphaeridium elegans* and *Leiovalia tenera*.

Regional occurrence. – Poland, the USB area, Pszczyna Member of the Goczałkowice Formation, boreholes: Goczałkowice IG 1 (11 samples from the depth interval 2872.5–2957.0 m) (Fig. 7, Table 5), Klucze 1 (3 samples from 1770.0–1900.0 m) (Fig. 7, Table 8), Sułoszowa (9 samples from 199.1–232.5 m) (Fig. 7, Table 8), and Piotrowice 1 (1 samples from 2410.4–2413.6 m) (Fig. 7, Table 8).

Bio- and chronostratigraphic aspects. – The flourishing of the *Skiagia* species has been noticed in many Cambrian settings. According to the new Cambrian subdivision (Babcock *et al*., 2005), the BAMA IV deposits are to be correlated with the interval comprising the upper part of the Stage 3 and Stage 4 (Volkova, 1968, 1969b; Hagenfeldt, 1989a; Moczydłowska, 1991; Jankauskas, Lendzion, 1992; Jankauskas, 2002). On the other hand, *Eklundia varia* (*Baltisphaeridium*, *Goniosphaeridium*), represented in this part of the Pszczyna Member by single specimens, has been commonly encountered mainly in the deposits of the *Holmia* and *Protolenus* zones (Volkova, 1969a, b; Volkova *et al*., 1979, 1983; Downie, 1982; Moczydłowska, Vidal, 1986; Vidal, Peel, 1988, 1993; Hagenfeldt, 1989a; Moczydłowska, 1991). A few specimens are also documented from the *Acadoparadoxides oelandicus* and *Paradoxides paradoxissimus* Zones (Volkova *et al*., 1979, 1983).

The type species *Eklundia campanula* n.comb. has been described so far from the sediments of the "glauconitic sandstone", recognised only in the Bårstad 2 borehole in the Östergötland region of southern Sweden, and initially correlated with the ?*Acadoparadoxides oelandicus* level (Eklund, 1990). This form, similar to the new *Eklundia pusilla* n.sp., occurs only in the studied Brunovistulicum area, in the lower part of the Pszczyna Member, whereas *E. varia* n.comb. ranges higher in this member.

In terms of the taxonomic content the acritarch associations of the BAMA IV Zone are close to the assemblages described from the lower part of the *Heliosphaeridium dissimilare–Skiagia ciliosa* Zone (Moczydłowska, 1991) and the *Baltisphaeridium cerinum* Zone of the *Baltisphaeridium cerinum–Skiagia ciliosa* assemblage (Jankauskas, Lendzion, 1992; Jankauskas, 2002). Assemblages of both above-mentioned acritarch zones have been described as taxonomically diverse associations, although lacking any distinct index forms. Stratigraphic ranges of a majority of taxa extend to older and younger trilobite-bearing Lower Cambrian deposits (Moczydłowska, 1991; Jankauskas, Lendzion, 1992, 1994; Jankauskas, 2002). However, it should be mentioned that several most abundant forms from the lower part of the Pszczyna Member, display stratigraphical ranges limited to the discussed part of the Cambrian in the USB. These are: *Parmasphaeridium robustispinosum* n.sp., *Eklundia campanula* n.comb., *E. pusilla* n.sp. and *Pterospermella inordinata* n.sp. Together with the characteristic *Skiagia* specimens of smaller diameters, they compose acritarch assemblage distinctly differing from the associations documented in the higher part of the Pszczyna Member, distinguished as the BAMA V Zone.

BAMA V – *Skiagia–Eklundia varia* Assemblage Zone

Definition and boundaries. – A characteristic feature of the described zone is the appearance of *Skiagia* specimens with much larger diameters than those encountered in the BAMA IV Zone (twice as much in some cases). All known *Skiagia* species except for *S. pura* or *S. brachyspinosa* n.comb. occur in this acritarch zone. Distinct large forms ascribed to *S. pilosiuscula* n.comb. make their first appearances here. New successively appearing components of the analysed associations are *Parmasphaeridium implicatum* n.comb., *Goniosphaeridium volkovae*, and *Eklundia florentinata* n.sp. The lower boundary of the BAMA V Zone corresponds to the upper boundary of the BAMA IV Zone in the stratotype Goczałkowice IG 1 section.

Description. – Besides the forms mentioned above, the assemblages in question comprise a majority of taxa known from the BAMA IV Zone. None of these taxa can be regarded as dominant, as most of them are represented by over a dozen or several scores of specimens per slide. Certain forms, such as *Leiovalia tenera*, *Sagatum priscum*, *Retisphaeridium pusillum*, *Alliumella baltica* or *Globus gossipinus* are represented by single specimens only.

Regional occurrence. – Poland, the USB area, Goczałkowice Formation, Pszczyna Member, boreholes: Goczałkowice IG 1 (23 samples from the depth interval 2768.0–2852.0 m) (Fig. 7, Table 5) and Klucze 1 (5 samples from 1680.0–1740.0 m) (Fig. 7, Table 8); Czech Republic, Brno Block, Měnín 1 borehole (4 samples from 473.0–778.0 m) (Fig. 9, Table 4.).

Bio- and chronostratigraphic aspects. – The BAMA V Zone has the best faunal documentation of all the biostratigraphic units distinguished here. It has been documented, among others, in the upper part of the Cambrian in the Goczałkowice IG 1 section. Trilobites characteristic for the *Holmia* Zone have been discovered in this section in the depth interval 2793.00–2850.45 m (Orłowski, 1975).

Microfossil associations with a similar taxonomic composition are characteristic for the *Heliosphaeridium dissimilare–Skiagia ciliosa* (Moczydłowska, 1991) and *Estiastra minima–Micrhystridium dissimilare* acritarch zones (Jankauskas, Lendzion, 1992; Jankauskas, 2002). The zones were established as correlatives of the *Holmia* Zone and recognised in many areas of the East European Craton (Volkova, 1969b; Volkova *et al.*, 1983; Jankauskas, Lendzion, 1992; Moczydłowska, 1991; Jankauskas, 2002), Scandinavia (Hadenfeldt, 1989a; Eklund, 1990), Scotland, Greenland, and Canada (Downie, 1982; Vidal, 1984), China (Zang, 1992; Moczydłowska, Zang, 2006) as well as in southern Australia (Moczydłowska, Zang, 2006).

In SE Poland, acritarch assemblages of this age have been also documented in the Stalowa Wola–Lubaczów area, in the Małopolska Block (Jachowicz-Zdanowska, 2011) and in the Lublin area (Moczydłowska, 1991). Acritarch associations characteristic for the *Holmia* Zone have been distinguished in Poland also in the western part of the Peribaltic Syneclise (Szczepanik, 2000), and in the Kielce Region of the Holy Cross Mountains (Szczepanik, 2009).

BAMA VI – *Volkovia dentifera–Liepaina plana* Assemblage Zone (Moczydłowska, 1991)

Definition and boundaries. – According to Moczydłowska (1991) the index taxa of this zone are newly appearing species *Liepaina plana*, *Heliosphaeridum notatum*, *Volkovia dentifera* and *Heliosphaeridum longum*. In the Brunovistulicum area the BAMA VI assemblage is characterised by first appearances of single *Liepaina plana* specimens, and representatives of the still very controversial *Volkovia dentifera*. The boundaries of the BAMA VI Zone with both underlying and overlying zones have not been documented in any of the borehole sections investigated by the present author. Thus, although overall position of the zone in the zonation seems correct (Fig. 5) the exact boundaries need to be confirmed by future studies.

Description. – In addition to the index taxa the BAMA VI assemblages comprise taxa known from the lower acritarch zones of the study area (Fig. 11).

Regional occurrence. – Poland, the USB area, Goczałkowice Formation, Jarząbkowice Member, Jarząbkowice 1 borehole (9 samples from the depth interval 3980.0–4028.0 m) (Fig. 9; Table 8); Czech Republic, Brno Block, boreholes: Němčičky 3 (2 samples from the depth interval 5396.0–5400.5 m) (Fig. 9, Table 4), Němčičky 6 (3 samples from 5157.0–5184.5 m) (Fig. 9, Table 4).

Bio- and chronostratigraphic aspects. – The index taxa of the BAMA VI Zone have been found so far only in the Czech part of Brunovistulicum (Vavrdová, Bek, 2001; Mikuláš *et al.*, 2008). On their basis, the age of the analysed sediments has been determined as the *Protolenus* Zone (Mikuláš *et al.*, 2008). In the Jarząbkowice 1 borehole located in the USB area only poorly preserved acritarch specimens have been documented, with strongly thermally altered vesicles and considerably damaged sculpture elements. The assemblages from the analysed interval contain small number of complete forms belonging to *Skiagia scottica*, *S. orbiculare*, *S. ciliosa*, *Heliosphaeridium dissimilare*, *Estiastra minima*, *Pterospermopsimorpha rugulosa* n.sp., *Pterospermella* and *Retisphaeridium*. Generally, the taxonomic composition appears to be very close to the earlier described BAMA V Zone association, characteristic of the upper part of the Pszczyna Member, well dated by trilobites of the *Holmia* Zone. It should be remembered, however, that majority of these acritarch taxa range into the younger *Protolenus* Zone, and usually index forms for the latter appear infrequently (Jankauskas, 2002). It is also well known that *Volkovia–Liepaina* (Moczydłowska, 1991) or *Volkovia dentifera* (Jankauskas, Lendzion, 1992; Jankauskas, 2002) acritarch zones (*cf.* Fig. 5) are generally characterised by a gradual disappearance of the forms known from older deposits as well as the absence of any new distinct taxa. Therefore, it is here assumed that the acritarch assemblages recognised in the fragmentary Cambrian sections from the Brno Block (Němčičky 3, Němčičky 6) and the Jarząbkowice 1 borehole from the Polish Brunovistulicum area are the youngest microfloral associations of the Cambrian Series 2 recognised in the studied area. They should be correlated with the *Volkovia–Liepaina* (Moczydłowska, 1991) or *Volkovia dentifera* (Jankauskas, Lendzion, 1992; Jankauskas, 2002) zones distinguished in the *Protolenus* Zone.

BAMA VII – *Ammonidium bellulum–Ammonidium notatum* Assemblage Zone

Definition and boundaries. – The zonal assemblage is dominated by characteristic small specimens determined as *Ammonidium bellulum*, *A. notatum* n.comb., and *A. oligum* n.comb. Other components are abundant forms of *Helio-*

sphaeridium longum and *Granomarginata parva* n.sp. The above mentioned species are here regarded as the index forms of the described zone whose appearance defines the lower boundary of the zone. In the stratotype section of the Sosnowiec Formation BAMA VII Zone is bounded from the top by palynologically barren sediments.

Description. – In addition to index forms, the described zone is characterised by fairly abundant specimens of *Asteridium tornatum*, *A. spinosum*, *Lophosphaeridium dubium*, *Eliasum llanisum*, *Retisphaeridium howelii* and *R. dichamerum*. The following less abundant forms may occur as single specimens: *Comasphaeridium strigosum*, *C. longispinosum*, *Cristallinium cambriense*, *Cymatiosphaera cramerii*, *Parmasphaeridium implicatum* n.comb., *Retisphaeridium postae* and *R . capsulatum*.

It should be pointed out that acritarch taxa recognised in the lower part of the Sosnowiec IG 1 borehole section are distinctly different from the microflora occurring in the Lower Cambrian of the USB. Similar assemblages appear in other areas at the bottom of the *Acadoparadoxides oelandicus* Zone, replacing Early Cambrian acritarch associations characterised by very abundant specimens of the *Skiagia* genus (Moczydłowska, 1999; see below).

Regional occurrence. – Poland, the USB area, Sosnowiec Formation, Sosnowiec IG 1 borehole (10 samples from the depth interval 3357.0–3423.8 m) (Fig. 10, Table 9).

Bio- and chronostratigraphic aspects. – In the studied area the BAMA VII assemblage has been recognised so far only in the Sosnowiec IG 1 borehole, below the magmatic intrusion (Fig. 10). Specimens of *Ammonidium bellulum* dominate in two samples from the bottom part of the profile (3423,8 and 3415,6 m), whereas more frequent, in places even abundant *A. notatum* n.comb. representatives have been recognised in the upper part, in samples from the depth 3412,5 and 3402 m. *A. oligum* n.comb. is represented in the analysed slides only by single specimens.

A. notatum n.comb. and *A. oligum* n.comb. have been earlier known from the *Protolenus* Zone and they are abundant in the sediments of the *Acadoparadoxides oelandicus* Zone (Volkova *et al*., 1979, 1983; Vanguestaine, Van Looy, 1983; Hagenfeldt, 1989a, b; Moczydłowska, 1991, 1998, 1999; Jankauskas, Lendzion, 1992; Vidal, Peel, 1993; Jankauskas, 2002). *Ammonidium notatum* (= *Heliosphaeridum notatum*) is one of the index taxa of the *Micrhystridium notatum*–*Lophosphaeridium variabile* Zone (Jankauskas, Lendzion, 1992), corresponding to lower parts of the *Acadoparadoxides oelandicus* Zone in the East European Craton (Jankauskas, Lendzion, 1992; Jankauskas, 2002). It was also recognised in the Cambrian of southern Spain as an index taxon of the acritarch *Heliosphaeridium notatum* Zone (Palacios *et al*., 2006), the age equivalent of the Baltic *Protolenus* Zone (Palacios *et al*., 2006). *Ammonidium bellulum* was first described from the Cambrian of the Sosnowiec IG 1 borehole as the *Heliosphaeridium bellulum* (Moczydłowska, 1998). These deposits, lacking the faunal dating, have been correlated with the *Acadoparadoxides oelandicus* Zone, based on their acritarch assemblages (Moczydłowska, 1998). Specimens of *Ammonidium bellulum* were recognised earlier in other contemporaneous deposits, for instance in Lithuania, where they were named *Micrhystridium notatum* (Jankauskas, 2002), or in Morocco, where they were determined as *Micrhystridium* aff. *coniferum* (Vanguestaine, Van Looy, 1983 – Plate 1:16, 17).

Some of the above-mentioned taxa already appear in older deposits of the Cambrian Series 2. However, stratigraphical ranges of forms such as *Eliasum llaniscum*, *Cristallinium cambriense* or *C. longispinosum* can be correlated only with the Cambrian Series 3. On the basis of their first appearance, a new acritarch zone *Eliasum*–*Cristallinium* was proposed by Moczydłowska (1999), including the interval of the *Acadoparadoxides oelandicus* Zone.

BAMA VIII – *Turrisphaeridium semireticulatum* Assemblage Zone – Acme Zone

Definition and boundaries. – The appearance of a very abundant population (acme zone) of the characteristic new genus *Turrisphaeridium* is the basis for distinguishing the BAMA VIII Zone.

Description. – The described zone is also characterised by the first appearance of fairly abundant forms of *Comasphaeridium soniae* n.sp., *C. francinae* n.sp. or *Retisphaeridium lechistanium* n.sp. occuring together with the index genus represented by two basic morphological forms: *Turrisphaeridium semireticulatum* n.comb. and *T. turgidum* n.sp. (Fig. 11). In addition to the above mentioned forms also typical “Middle Cambrian” acritarch species occur in the studied assemblages: *Comasphaeridium vozmedianum*, *Cristallinium cambriense*, *Eliasum llaniscum*, *Multiplicisphaeridium martae*, *M. ramosum*, *Solisphaeridium flexipilosum* and *S. multiflexipilosum*. Besides, species with longer stratigraphical ranges may occur, for instance: *Asteridium spinosum*, *A. tornatum*, *Granomarginata squamacea*, *Lophosphaeridium dubium*, *Parmasphaeridium implicatum* n.comb., *Retisphaeridium capsulatum*, *R. dichamerum*, *R. howelii*, *R. ovillense* and *Revinotesta* sp. (Fig. 11).

Regional occurrence. – Poland, the USB area, Sosnowiec Formation, Sosnowiec IG 1 borehole (4 samples from the depth interval 3204.5–3217.2 m) (Fig. 10, Table 9).

Bio- and chronostratigraphic aspects. – Most of the species from the BAMA VIII Zone are characteristic of acritarch assemblages described from other areas of the Cambrian Series 3 occurrence, where they are correlated with the *Paradoxides paradoxissimus* Zone (Slaviková, 1968; Cramer, Diez Cramer, 1972; Fombella, 1977, 1978, 1979, 1986; Erkmen, Bozdoğan, 1981; Martin, Dean, 1983, 1984; 1988; Hagenfeldt, 1989b; Volkova, 1990; Jankauskas, Lendzion, 1992, 1994; Palacios *et al*., 2006; Palacios, 2008, 2010) (Fig. 5).

The occurance of selected acritarch species

Borehole	Litostratigraphy (after Buła, 2000)	Samples depth [m]	*Ammonidium bellulum*	*Ammonidium oligum*	*A. notatum*	*Solisphaeridium elegans*	*Heliosphaeridium longum*	*Granomarginata parva*	*G. squamacea*	*Heliosphaeridium lanceolatum*	*Asteridium tornatum*	*A. spinosum*	*Comasphaeridium strigosum*	*Lophosphaeridium dubium*	*Revinotesta* sp.	*Retisphaeridium dichamerum*	*Eliasum llaniscum*	*Comasphaeridium silesiense*	*C. longispinosum*	*Parmasphaeridium implicatum*	*Cristallinium cambriense*	*Multiplicisphaeridium martae*	*Turrisphaeridium semireticulatum*	*T. turgidum*	*Comasphaeridium francinae*	*C. soniae*	*Cymatiosphaera cramerii*
SOSNOWIEC IG 1	SOSNOWIEC FORMATION	3162.0–3163.0									x	x						x	x	X	x						
		3163.50							X			x		x		x	X	x	x	x	x						
		3166.0–3167.0							X		x	x				x	X	x	x	X	x						
		3371.20		x					X		x	x		x		x	X	x	x	X	xx	x			x		
		3183.00							X		x	x				x	X	x	x	x	xx	x			x		X
		3184.00		x					X		x	x				x	X	x	x	X	xx	x			x		X
		3204.50		x					X	X	X	X		x	x	X	X	XX	X	X	XX	X	XX	x	X	X	X
		3211.00		x			x		X	X	X	X		x	x	X	X	XX	X	X	XX	X	XX	x	X	X	X
		3212.00					x		X	X	X	X				X	X	XX	X	X	XX	X	XX	x	X	X	X
		3217.20					x		X	X	X	X				x	X	X		x	XX		X	x	X	X	
		3344.50																									
		3345.00																									
		3351.00																									
		3357.00	xx		XX		xx	X	X	x	x	X		x	x	x	X		x	xx			x				
		3360.00	xx	x	XX		xx	X	X	x	x	X		x	x	x	X		x	xx	x						
		3361.00	xx		X		xx	X	X	x	x	X		x	x	x	X		x	xx		x					
		3363.00	xx	x	X		X	X	X	x	x	X	x	x	x	x	X		xx	xx			x				
		3369.40	xx		X		X	X	X	x	x	X		x	x	X	X		xx	xx	x		x				
		3380.00	X	x	X		x	X	X	x	x	X		x	X	X	X		xx	xx		x					
		3402.00	X	x	X		X	X	X	x	X	X	X	xx	X	X	X		xx	xx		x	x				
		3412.50	XX	x	X		X	X	X	X	X	X		xx	X	X	X		x	xx	x	x					
		3415.60	XX	x	x		X	X	X	X	X	X	X	xx	X	X	X		x	xx		x					
		3423.80	XX	x	x	x	X	X	X	X	X	X	X	xx	X	X	X		x	xx	x	x	x				

BAMA IX – *Adara alea–Multiplicisphaeridium llynense* Assemblage Zone – Acme Zone

Definition and boundaries. – The analysed acritarch assemblage zone has been established on the basis of a massive appearance (acme zone) of genus *Adara* represented by *A. alea* and *A. undulata* species. *Multiplicisphaeridium llynense* n.comb. is here regarded as the additional index taxon in the zonal assemblage. In the stratotype section of the Sosnowiec Formation the BAMA IX Zone is limited from the top by the erosional boundary of the Cambrian overlain by Lower Devonian clastics.

Description. – Accompanying taxa in the described assemblage are *Cristallinium compactum* n.sp and the *Eliasum asturicum*. Species appearing here for the first time (compare Fig. 11) are fairly abundant in the analysed material, usually over a dozen specimens per slide.

Regional occurrence. – Poland, the USB area, the uppermost part of the Sosnowiec Formation in the Sosnowiec IG 1 borehole (6 samples from the depth interval 3162.0– 3184.0 m) (Fig. 10, Table 9).

Table 9

in the Sosnowiec IG 1 borehole

Multiplicisphaeridium ramosum	*Comasphaeridium vozmedianum*	*Retisphaeridium lechistanium*	*Parmasphaeridium* sp.	*Solisphaeridium flexipilosum*	*S. multiflexpilosum*	*Adara alea*	*A. undulata*	*Cristallinium compactum*	*Multiplicisphaeridium llynense*	*Eliasum asturicum*	*Retisphaeridium capsulatum*	Brunovistulicum acritarch assemblages zones	Baltic faunal zones
	x	x	x	X	X	X	X	X	X	X	xx	BAMA IX *Adara alea–Multiplicisphaeridium llynense*	*Paradoxides paradoxissimus*
	x	x	x	X	X	X	x	X	X	X	xx		
	x	x	x	X	X	X	x	X	X	X	xx		
	X	x	xx	X	X	X	x	X	X	X	xx		
x	X	x	xx	X	X	X	x	X	X	X	xx		
x	XX	XX	X	X	X	X	x	X	X	X	xx		
XX	XX	XX	X	X	X							BAMA VIII *Turrisphaeridium semireticulatum*	
XX	XX	XX	X	X	X								
XX	XX	XX	X	X	X								
XX	XX	XX	xx	X	X								
												?	?
												BAMA VI *Ammonidium bellulum–Ammonidium notatum*	*Acadoparadoxides oelandicus*

Bio- and chronostratigraphic aspects. – The index form of the *Adara alea* acritarch zone (Martin, Dean, 1988) = A1 (Martin, Dean, 1981, 1984) was established in the Cambrian deposits of Newfoundland characterized by very good faunal records (Martin, Dean, 1981, 1983, 1988). A type species of *Adara* genus *Adara matutina* (= *Buendingiisphaeridum matutinum*), as well as that of *A. undulata* (= *Celtiberium ondulatum*; Fombella, 1979), was first recognised in the Middle Cambrian of the Oville Formation in northern Spain (Fombella, 1977, 1978). Known *Adara* species have fairly short stratigraphical ranges limited to the trilobite *Paradoxides paradoxissimus* Zone (Martin, Dean, 1981, 1983, 1988; Palacios, 2010).

Multiplicisphaeridium llynense n.comb. was found in northern Wales in the lower part of the Nat-y-big Formation (Young *et al*., 1994). It occurs in large numbers in deposits of the *Tomagnostus fissus* Zone well dated by trilobite fauna (Rushton, 1974; Young *et al*., 1994). It co-occurs there with *Adara alea* and with other species characteristic of the Cambrian Series 3: *Comasphaeridium longispinosum*, *Cristallinium cambriense*, *Eliasum llaniscum*, and *Comasphaeridum silesiense* (= *Comasphaeridium* sp.; Young e*t al*., 1994). However, in that area, the earliest appearance of the *Multiplicisphaeridium llynense* n.comb. was noted in the lower part of the *Tomagnostus fissus* Zone (Young *et al*., 1994) followed by the A1 *Adara alea* acritarch assemblage (Young *et al*., 1994).

In conclusion, it should be pointed out that the taxonomic composition of the discussed zonal assemblage is very close to the associations of the *A. alea* Zone, established on the basis of the index taxon appearance. The stratigraphical position of this association is well defined based on the findings of the trilobite fauna and is correlated with the *Hypagnostus pavifrons*, *Ptychagnostus punctuosus* zones, established in the stratotype area of Newfoundland in the strata of the upper *Paradoxides paradoxissimus* Zone. It should be also remembered that wider stratigraphical range of *Adara alea*, suggested by some authors (for instance, Moczydłowska, 1998), is not supported by palaeontological evidence. Detailed palynological studies carried out by the present author on samples from the Sosnowiec Formation Cambrian profile do not confirm presence of such taxa as *Timofeevia phosphoritica*, *T. lancarae* or *Cristallinium randomense*, that were assumed as indicating the Furongian or even Ordovician age of the discussed deposits (Moczydłowska, 1998).

In view of the new acritarch data obtained from the Sosnowiec IG 1 borehole, it can be assumed that the association of the BAMA IX Zone is the youngest Cambrian assemblage documented so far in the Brunovistulicum area.

REGIONAL SIGNIFICANCE OF THE BIOSTRATIGRAPHIC RESULTS

The aim of this study was to describe the acritarch assemblages from the Cambrian of the Brunovistulicum area and to assess their value for the stratigraphical and correlative purposes. Recent palynological analyses have confirmed the corresponding age of the Early Cambrian sediments in the Upper Silesian and the Brno blocks (Buła *et al*., 1997a; Jachowicz, Přichystal, 1997). During the deposition of the Goczałkowice Formation sediments in the USB, similar facies were also developing in the Brno Block, and both areas contain similar microfossil assemblages. Rich and morphologically diverse acritarch associations recognised in the studied deposits indicate conditions favourable for the development of marine phytoplankton in shelf environments.

Acritarch assemblages characteristic for the BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites* Zone were documented only in the Borzęta Formation sediments. According to the present stratigraphical division of the Cambrian System, the acritarch association distinguished in the above strata, correspond to the oldest, i.e. Terreneuvian series, correlated with the *Platysolenites* Zone (Fig. 5).

The acritarch association of the successive BAMA II *Asteridium tornatum–Comasphaeridium velvetum* Zone has been identified so far only in the Brno Block (Vavrdová *et al*., 2003). According to the present knowledge of the Cambrian deposits this zone constrains the biostratigraphic position of the sandstones and conglomerates complex distinguished as the Mogilany Member of the Goczałkowice Formation in the USB area (Buła, 2000). These sediments have variable thicknesses, from several tens to over 1400 m (boreholes Měnín 1, Głogoczów IG 1, and Mogilany 1; Buła *et al*., 1997a; Buła, Żaba, 2005). In the Brno Block, their base is unknown (Fig. 3) and they are interpreted as continental (alluvial) facies with some marine influence (Mikulaš, Nehyba, 2001; Mikulaš *et al*., 2008). The Mogilany Member developed under similar conditions in the USB area where alluvial-deltaic deposits grade upwards into marginal marine facies (Pacześna, Poprawa, 2001; Pacześna, 2005). In the south-western part of the USB they rest upon the Precambrian basement (Figs. 7–9) whereas in the eastern part they are underlain by the palynologically documented Borzęta Formation, attributed here to the BAMA I Zone.

The three younger acritarch assemblage zones – BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum*, BAMA IV *Skiagia–E.campanula* and BAMA V *Skiagia–E. varia*, comprise deposits of *Schmidtiellus–Holmia* trilobite zones in the studied area (Fig. 5). In the USB, they have been best documented in the Goczałkowice IG 1 borehole where they occur in the Goczałkowice Formation. This unit, as the only one within the whole Brunovistulicum area, has a very good faunal documentation (Orłowski, 1975).

The microflora assemblages of the BAMA VI *Volkovia–Liepaina* Zone (Moczydłowska, 1991), correlated with the *Protolenus* Zone, have been recognised only in the partial Cambrian sections from the Brno Block (Němčičky 3, Němčičky 6), and the USB area (Jarząbkowice 1). It is thus assumed that the massive claystones of the Jarząbkowice Member, represent the youngest transgressive sediments of the Goczałkowice Formation, recognised in the USB area. However, the top of the Cambrian in the Goczałkowice IG 1 borehole does not contain the youngest microflora of the Cambrian Series 2 (*Protolenus* Zone), as suggested in previous study by Moczydłowska (1998).

A continuous transition between the Cambrian Series 2 and 3 has not been documented so far in the Brunovistulicum area. The partial profile of the Series 3 was indentified in the Sosnowiec IG 1 borehole where, however, the base of the Sosnowiec Formation was not reached. The acritarch assemblages of the BAMA VII to BAMA IX zones recognised in this borehole are correlated with *Acadoparadoxides oelandicus* and *Paradoxides paradoxissimus* Zones. Results of the author's investigations do not confirm appearance of the younger Cambrian, or even Ordovician acritarch associations in the Sosnowiec IG 1 borehole, suggested by Moczydłowska (1998). This conclusion is of a considerable importance for the correct reconstruction of the Early Palaeozoic sedimentation development in the USB area.

Equally important is the explanation of microfossils found by Moczydłowska (*in* Kowalczewski *et al*., 1984; Moczydłowska, 1998) in sandstones with trace fossils, encountered in the Potrójna IG 1 borehole below Devonian and above anchimetamorphic Precambrian rocks (Fig. 7). On the basis of the discovered acritarch assemblages, the age of the above strata was determined as the Upper Cambrian or even Ordovician (Moczydłowska, 1998). However, the detailed palynological analyses of these deposits carried out by present author did not confirm the presence of any recognisable microfossil assemblages (Buła, Jachowicz, 1996). The Cambrian deposits encountered in Potrójna IG 1 and in over a dozen other boreholes in the southern part of the USB (Ślączka, 1976, 1982; Buła, Jachowicz, 1996, Buła, Żaba, 2005, Pacześna, 2005; Jachowicz-Zdanowska, 2010b) are attributed to the Lower Cambrian Mogilany Member which is generally devoid of microflora.

The biostratigraphical data collected by the present author from the Cambrian in 25 boreholes drilled in various parts of the Brunovistulicum allow for drawing some limited conclusions regarding the Cambrian depositional development of the investigated area. The present study indicates that the oldest Cambrian (Terreneuvian) sediments containing BAMA I Zone assemblages were deposited only in the eastern part of the Upper Silesian Block. Younger sediments, from the Terreneuvian and Series 2 with BAMA II–VI Zones assemblages were developing over much larger areas of the Upper Silesian and Brno blocks. Sediments of the Series 3 with BAMA VII–IX assemblages are known only from the northern part of the USB. The Furongian sediments, not yet found in the study area, potentially may occur in the northern part of the Block, where the Ordovician strata were found (Jachowicz, 2005). Nevertheless, a reliable reconstruction of the Early Palaeozoic deposition within the Brunovistulicum still remains an open question, which can be solved only by new borehole data.

PALAEONTOLOGICAL PART

This chapter provides discussion and descriptions of selected genera and species from the studied sections of the Cambrian. Majority of the encountered forms represents acritarchs belonging to the informal group of microfossils whose nature nor systematic position is not fully known. However, owing to the new research techniques, based on electron microscope and geochemistry (Talyzina *et al*., 2000; Talyzina, Moczydłowska, 2000; Moczydłowska, Willman, 2009; Willman, 2009), knowledge of biology of the forms traditionally included in the group Acritarcha (Downie *et al*., 1963; Evitt, 1963; Loeblich, 1970) is still increasing. For instance, such genera as *Leiosphaeridia*, *Tasmanites*, *Chuaria*, *Cymatiosphaera* or *Pterospermella*, are presently connected with Prasinophyceae, the unicelluar algae from Chlorophyta (Talyzina, Moczydłowska, 2000; Moczydłowska, Willman, 2009). Genus *Ceratophyton*, differing morhologically from most acritarchs, is being recognised as a representative of the animal kingdom (Fatka, Konzalová, 1995).

In practice, an artificial systematic division of the discussed microfossils is being used that has no relation with their natural affiliations. Therefore, in the present paper, the recognised genera, species and forms as well traditionally included in acritarchs have been presented together in alphabetical order. Determinations of the encountered taxa are based on their morphological features as the only criterion available.

The presented synonymy lists include every mention of the species name available in the literature on Cambrian acritarchs, and express the autor`s judgement of earlier opinions on taxonomic problems. Stratigraphic ranges of the discussed taxa have also been compared, based on detailed analyses of the data enclosed in the literature possessed. In addition, an attempt to correlate faunistic zones of the traditionally understood Lower and Middle Cambrian relevance, with the current subdivision of the Cambrian System, have also been undertaken.

The studied acritarch assemblages were partly very abundant with particular taxa represented by hundreds, and sometime even by thousands specimens. Such a rich microfloristic material allowed for detailed taxonomic observations that have led to distinguishing new genera and species as well to revisions and new interpretations of the already known species.

Not all acritarch taxa recognised in the analysed Cambrian sections have been formally described here. The author decided to include only newly established genera and species, new generic and species combinations, emended forms and taxa important for defining the assemblages zones established in this report. Among the latter are omitted stratigraphically important forms that do not raise significant author's comments associated with the taxonomy. However, photographs of all the important species encountered are here included (Plates I–XXXIV).

The material studied contained also some filamentous form (Pl. I, Figs. 12–16) probably representing cyanobacteria. Those forms are widely distributed in the Lower Palaeozoic sediments, but they were not the subject of the present study, and are not described here.

Majority of the attached photos have been made in transmitted light, in Olympus BX 50 biologic microscope using an oil-immersion objective ×100. The selected microfossil groups have also been studied under an electron microscope. The collection of the documented microfossils is stored in the Upper Silesian Branch of the Polish Geological Institute – National Research Institute, coll. OG 546/2013.

Genus *Adara* (Fombella, 1977) Martin, 1981

Type species: *Adara matutina* (Fombella, 1977) Martin, 1981

Remarks. – The genus *Adara*, described from Middle Cambrian sediments of Spain (Fombella, 1977), is a very characteristic and easy to recognise index taxon for traditionally understood Middle Cambrian, currently correlated with Series 3 of that System. Systematic attachment of the *Adara matutina*, type species for that genus, has been questioned by Sarjeant and Stancliffe (1994, p. 25), who have moved that species to *Buedingiisphaeridium* (broaden definition Sarjeant, Stancliffe, 1994, p. 44) classifying it as *Buedingiisphaeridium matutinum* (Fombella, 1977, p. 117, pl. 1, fig.16) comb. nov. That new systematic attribution of the discussed type species has not been commonly accepted (Moczydłowska, 1998; Palacios, 2010). The acceptance of the Sarjeant and Stancliffe (1994, p. 25) interpretation would result in the absence of type species for *Adara*. In such case, the authors should assign one but they have not done that. Therefore, in the present study the concept of *Adara* Fombella, 1977 emend. Martin, 1981 with the type species *Adara matutina* (Fombella, 1977) Martin, 1981 has been accepted.

Adara alea Martin, 1981

Pl. XXVIII, Figs. 1–9, 14

1959 *Archaeohystrichosphaeridium angulosum* sp.n.; B.V. Timofeev, p. 46, tabl. III: 66.
1981 *Adara alea* sp. nov; F. Martin *in* F. Martin, W.T. Dean, p. 16, tab. 1, pls. 1: 20-22, 4: 7, 9, 10.
1984 *Adara alea* Martin *in* Martin et Dean; F. Martin *in* F. Martin, W.T. Dean, fig. 57.1, pl. 57.3: 3, 11.
1988 *Adara alea* Martin *in* Martin et Dean; F. Martin, W.T. Dean, fig. 10, pl. 11:3, 5, 6, 8.
1989 *Adara longispinosa* sp. nov.; O. Fatka, p. 364, pl. I:1.
non 1991 *Adara alea* Martin; R. Albani *et al*., p. 265, pl. 1:1.
non 1994 *Adara alea* Martin *in* Martin et Dean; F. Martin *in* T. Young *et al*., p. 343; figs. 7; 11:m, n, p.
1994 *Polygonium aleum* (Martin *in* Martin et Dean, p. 16, pls. 1:20, 21; 4:7, 9,10) comb. nov.; W.A.S. Sarjeant, R.P.W. Stancliffe, p. 43.
non 1996 *Adara alea* Martin; M. Jachowicz *in* Z. Buła, M. Jachowicz, pp. 315, 321, pl. IV: 2, 6.
non 1998 *Adara alea* Martin; M. Moczydłowska, pp. 26, 27, 31, 46–49, figs. 14, 15, 21:A–C.
2001 *Adara* cf. *alea* Martin; Z. Szczepanik, pl. III:13.
2005 *Adara alea* Martin *in* Martin et Dean; M. Vanguestaine, R. Léonard, pp. 134, 138, 139, fig. 7, pl. III:A, B.
2005 *Adara alea* Martin *in* Martin et Dean; P.M. Brück, M. Vanguestaine, pp. 526, 528, 538, figs. 5:1, 2, 9.
2006 *Adara alea*; T. Palacios *et al.*, p. 41.
non 2006 ?*Adara* sp.; E. Raevskaya, E. Golubkova, p. 59, fig. 5, pl. I:7.
non 2008 *Adara alea* Martin; M. Vecoli *et al*., pp. 59, 60, fig. 3, pl. 1:1.
2008 ?*Adara alea Martin in* Martin et Dean; M. Vanguestaine, P.M. Brück, pp. 71, 86–88, 90, figs. 4, 5, 7, pl. 1:3.
2008 *Adara alea* Martin *in* Martin et Dean; T. Palacios, p. 291, figs. 2, 3:G.
2009 *Adara alea*; Z. Szczepanik, p. 26, fig. 2.
2009 *Adara alea* Martin *in* Martin et Dean; A. Żylińska, Z. Szczepanik, pp. 426, 443, text-fig. 9, pl. 8:8–11.
2010 *Adara alea*; T. Palacios, fig. 1.
2011 *Adara alea* Martin; M. Jachowicz-Zdanowska, figs. 5, 8:A–C, E–H.

Material. – Over 300 well preserved specimens.

Dimensions. – Diameter of vesicle 25–50 μm, length of processes 4–7 μm.

Description. – Documented specimens of *Adara alea* are characterised by conical processes with fairly broad bases. Regular wrinkles radiate around these processes. They create delicate network on the specimen's surfaces. The process surface is smooth, the tips are rounded in profile, often covered with short processes or grains. Many specimens possess broad opening structures of the vesicle that run along seams appearing at the processes bases what causes detachment of regular polygonal fragments of the vesicle (see Pl. XXVIII, Fig. 5). That is the first documented opening structure of *Adara alea*.

Remarks. – According to the new taxonomic stratigraphic arrangement, specimens presented in Buła and Jachowicz (1996), and Moczydłowska (1998) as *Adara alea* should be excluded from that species. Those forms represent the lately created *Turrisphaeridium semireticulatum* (Timofeev, 1959) n.comb. On the other hand, *Archaeohystrichosphaeridium angulosum* Timofeev, 1959 from the Middle Cambrian of the Baltic region, from sediments of the traditionally understood Middle Cambrian (Timofeev, 1959), and *Adara longispinosa* Fatka, 1989 from the Cambrian Jince Formation – *Onymagnostus hybridus* Zone, an equivalent of the *Ptychagnostus atavus–Tomagnostus fissus* zoness shuld be included in *Adara alea*.

Specimens morphologically very similar to *A. alea* have been described from the traditionally understood Middle Cambrian often without faunistic documentation. They were assigned to *Multiplicisphaeridium*, *Celtiberium,* or *Adara*. Those are, for instance, *Multiplicisphaeridium ancliforme* Fombella, 1978 and *Multiplicisphaeridium temblorosum* Fombella *in* Fombella Blanco *et al*., 1993, from sediments of the Oville Formation in Spain, or *Celtiberium robustum* Hagenfeldt, 1989b recognised in sediments of the *Ecoparadoxides oelandicus* Zone in Sweden. Strikingly similar to the latter is one of the specimens exemplifying *Adara alea* from Tessini Sandstones, from Öland Island in Sweden (Bagnoli *et al*., 1988, pl. 25:2).

The presence of numerous morphologically similar specimens in sediments of various ages may evidence an evolutionary line of those microfossils. Unfortunately, the absence of a full sequence of particular forms does not actually allow for reconstruction of their true stories. Those disputed forms still require additional detailed taxonomic investigations. A good examples of that are Cambrian forms from southern Tunisia that have been classified as *Adara alea* but illustrated specimen (Albani *et at*., 1991, pl.1:1) was strikingly similar to *Multiplicisphaeridium ancliforme* (Fombella, 1978, pl. III:7).

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA IX *Adara alea–Multiplicisphaeridium llynnense* Zone.

Stratigraphic range. – Cambrian Series 3 – ?*Acadoparadoxides oelandicus*, *Paradoxides paradoxissimus* zones.

Adara undulata Moczydłowska, 1998

Pl. XXVIII, Fig. 13

nomen nudum 1979 *Celtiberium ondulatum* n.sp.; M.A. Fombella, pl. II: 23.

? 1994 *Adara alea* Martin *in* Martin et Dean, 1981; F. Martin *in* T. Young *et al*., p. 343; figs. 7; 11:m, n, p.
1998 *Adara undulata* sp. nov.; M. Moczydłowska, pp. 18, 31, 32, 49, figs. 14, 15, 21:D, E.

Material. – 20 well preserved specimens.

Dimensions. – Diameter of vesicle 20–50 µm, length of processes 3–5 µm.

Remarks. – Vanguestaine (Brück, Vanguestaine, 2005) has proposed assignment of *A. undulata* to broadly understood *A. alea* species because of their high morphological similarities. There certainly exists a necessity of further detailed taxonomic investigations of several morphologically similar acritarch forms encountered in the Cambrian Series 3, as has been pointed out by the present author in the discussion on *Adara alea*. Only then their taxonomic revision would be possible. In the present paper, the taxonomic *Adara undulata* by Moczydłowska (1998) has been accepted. In addition, it is suggested that circular, poorly developed processes, recognised in specimens assigned to *Adara alea* by Young *et al*. (1994; fig. 11:m, n, p) indicate that they represent *Adara undulata*. During the study of palynological material from the Sosnowiec Formation the vesicle opening structures of specimens of *Adara undulata* similar to those of *Adara alea* were documented.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA IX – *Adara alea–Multiplicisphaeridium llynnense* Zone.

Stratigraphic range. – Cambrian Series 3 – ?*Acadoparadoxides oelandicus*, *Paradoxides paradoxissimus* zones.

Genus *Ammonidium* (Lister, 1970)
Sarjeant et Vavrdová, 1997

Type species: *Ammonidium microcladum* (Lister, 1970) Sarjeant et Vavrdová, 1997

Remarks. – The emended diagnosis of *Ammonidium* (Sarjeant, Vavrdová, 1997) has been accepted. Based on that diagnosis, *Heliosphaeridium bellulum* (Moczydłowska, 1998) has been assigned to this genus. Based on the current diagnosis of the genus, the present author suggests new combination of the two following Cambrian species: *Ammonidium notatum* (Volkova, 1969) n.comb. and *Ammonidim oligum* (Jankauskas, 1976) n.comb.

Ammonidium bellulum (Moczydłowska, 1998)
Sarjeant et Stancliffe, 2000

Pl. XXII, Figs. 1–3, 5–12, 16

? 1983 *Micrhystridium* aff. *coniferum* Downie 1982; M. Vanguestaine, J. Van Looy, p. 73, fig. 4, pl. 1: 16–19.
1998 *Heliosphaeridium bellulum* n. sp.; M. Moczydłowska, pp. 70, 71, figs. 14, 15, 30: A–I.
1999 *Heliosphaeridium bellulum* Moczydłowska; M. Moczydłowska, pl. 2: 7, 9.
2000 *Heliosphaeridium bellulum* (Moczydłowska, 1998, pp. 70–72, fig. 30A–I) comb. nov.; W.A.S. Sarjeant, R.P.W. Stancliffe, p. 171.
? 2002 *Micrhystridium notatum* Volkova, 1969, forma A; T.V. Jankauskas, p. 102, pl. 3: 15.

Material. – Over 150 fairly well preserved specimens.

Dimensions. – Diameter of vesicle 15–25 µm, lengths of processes 5–12 µm.

Remarks. – It is possible that *Micrhystridium* aff. *coniferum* from the Cambrian sediments in Techeddirt Valley of the High Atlas Mts. in Morocco (Vanguestaine, Van Looy, 1983; pl. II: 16, 17) as well as *Micrhystridium notatum* Volkova (1969) form A, described from Middle Cambrian sediments in Lithuania (Jankauskas, 2002) represent *Ammonidium bellulum*. Those forms are characterised by short stratigraphic range limited to *Acadoparadoxides oelandicus* Zone. In the Upper Silesian Block *A. bellulum* is usually very abundant. It is represented by over 50 specimens in a standard microscope slide.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA VII *Ammonidium bellulum–Ammonidium notatum* Zone.

Stratigraphic range. – Cambrian Series 3 – *Acadoparadoxides oelandicus* Zone.

Ammonidium notatum (Volkova, 1969) n.comb.

Pl. XXII, Figs. 13–15, 17–24

Basionym: *Micrhystidium notatum* Volkova sp. nov.; N.A. Volkova 1969b, p. 228, pl. LI:16.

1969b *Micrhystidium notatum* Volkova sp. nov.; N.A. Volkova, p. 228, pl. LI:17–19.
1974 *Micrhystidium notatum* Volkova; N.A. Volkova, pl. 17:10, 11.
1979 *Micrhystidium notatum* Volkova; N.A. Volkova *et al*., pl. 9:1–4.
? 1983 *Micrhystidium notatum* Volkova; N.A. Volkova *et al*, p. 20, pl. IX:1–4.
1986 *Micrhystridium notatum* Volkova; M.A. Fombella, pl. 2:12.
1986 *Micrhystridium notatum* Vol.; M. Moczydłowska, G. Vidal, fig. 5.
1989a *Micrhystridium notatum* Volkova; S.E. Hagenfeldt, pp. 77–80, pl. 4:1.
1991 *Heliosphaeridium notatum* (Volkova, 1969) comb. nov. (= *Micrhystridium notatum* Volkova sp. nov. – Volkova, 1969b); M. Moczydłowska, pp., 58.
1992 *Heliosphaeridium notatum* (Volkova) Moczydłowska; T. Palacios, G. Vidal, pp. 428, 433, fig. 6:d.
1994 *Micrhrystridium notatum* Volkova; W.A.S. Sarjeant, R.P.W. Stancliffe, p. 17.
1996 *Micrhystridium notatum* Volkova; M. Jachowicz *in* Z. Buła, M. Jachowicz, p. 315, pl. IV:1, 5.
1998 *Heliosphaeridium notatum* (Volkova) Moczydłowska; M. Moczydłowska, pp. 77, 79, figs. 31:L, 33:A–L.
1998 *Heliosphaeridium notatum* (Volkova) Moczydłowska; T. Palacios, M. Moczydłowska, p. 71–73, figs. 3, 5, 8:A–D.
2006 *Heliosphaeridium notatum*; T. Palacios *et al*., p. 41.
2009 *Heliosphaeridium notatum*; Z. Szczepanik, fig. 2.

Dimensions. – Diameter of vesicle 10–15 µm, length of processes 5–15 µm.

Material. – Over 300 fairly well preserved specimens.

Remarks. – The forms presently classified as *Ammonidium notatum* were initially described as *Micrhystidium* *notatum* (Volkova, 1969). They were encountered in sediments of the Cambrian *Protolenus* and *Acadoparadoxides oelandicus* Zones (Volkova, 1969b, Volkova *et al*., 1979, 1983), from the Lublin area in SE Poland. Subsequently, Moczydłowska (1991) included *Micrhystidium notatum* in newly created genus. However, during the consecutive years, taxonomic revision of the discussed species was suggested (Moczydłowska, 1998) because of the character of the process terminations. The present author suggests that fairly broad, funnel-shaped, occasionally bifurcate process terminations of that species are diagnostic of *Ammonidium*. It is also conceivable that part of the specimens classified as *Micrhystidium notatum* by Volkova *et al*. (1983), belongs to *Ammonidium bellulum*. However, poor quality of the enclosed photos would not allow for taxonomic revision of the controversial forms.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA VII *Ammonidium bellulum–Ammonidium notatum* Zone.

Stratigraphic range. – Cambrian Series 2 – *Holmia*, *Protolenus* zones, Cambrian Series 3 –*Acadoparadoxides oelandicus*, *Paradoxides paradoxissimus* zones

Ammonidium oligum (Jankauskas, 1976) n.comb.

Pl. XXII, Fig. 4

Basionym: *Micrhystridium oligum* Jankauskas, sp.nov; T.V. Jankauskas, E. Posti, 1976; p. 147, fig. 15.

1976 *Micrhystridium oligum* Jankauskas, sp.nov; T.V. Jankauskas, E. Posti; p. 147, figs. 10, 13, 16, 20.
1979 *Micrhystridium oligum* Jankauskas; T.V. Jankauskas *in*: N.A. Volkova *et al*., p. 15, pl. IX:8–10.
non 1982 *Micrhystridium* cf. *oligum* Jankauskas; C. Downie, fig. 6:ee.
1983 *Micrhystridium oligum* Jankauskas; T.V. Jankauskas *in*: N.A. Volkova *et al*., p. 21, pl. IX:8–10.
1998 *Heliosphaeridium oligum* (Jankauskas, 1976) comb.nov.; M. Moczydłowska, p. 80, figs. 14, 15, 31:I–K.
2002 *Micrhystridium oligum* Jankauskas; T.V. Jankauskas, p. 103, pl. 3: 12–14.

Material. – 10 fairly well preserved specimens.

Dimensions. – Diameter of vesicle 8–10 µm, length of processes 4–5 µm.

Remarks. – Those forms were first described from sediments correlated with the Cambrian *Protolenus* Zone, from Lithuania area (Jankauskas, Posti, 1976) as *Micrhystridium oligum.* Subsequently, Moczydłowska (1998) provided a more precise diagnosis and included it into *Heliosphaeridium*. The present autor considers that the character of the process terminations, which are clearly broader, funnel-shaped, occasionally divided, justifies of inclusion this taxon to *Ammonidium*. In the analysed acritarch associations, the *A. oligum* was encountered very rarely, only single specimens were seen in a standard microscope slide.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA VII *Ammonidium bellulum–Ammonidium notatum* Zone.

Stratigraphic range. – Cambrian Series 2 – *Protolenus* Zone, Cambrian Series 3 – *Acadoparadoxides oelandicus* Zone.

Genus *Archeodiscina* (Naumova, 1960)
emend. Volkova, 1968

Type species: *Archeodiscina granulata* Naumova, 1960

Archeodiscina multipunctata n.sp.

Pl. IV, Figs. 7, 12

Derivation of name: from Latin – *multus* abundant, *punctum* – point, from numerous round swellings on the internal surface of the vesicle.
Holotype: Plate IV, Fig. 12; coll. OG 546/2013/prep. 3.
Locus typicus: Poland, Upper Silesian Block, Goczałkowice Formation, Pszczyna Member, Sułoszowa borehole, depth 199.1 m.

Material. – 150 variously preserved specimens.

Diagnosis. – Vesicle of circular or oval outline, with double wall composed of thicker internal one and of very thin velum type external one. The surface of the internal wall is smooth or slightly granulate, the external wall is smooth. The internal wall bears 2–3 small, oval swellings, clearly darker than the wall. Single, short wrinkles radiate from those swellings.

Dimensions. – Diameter of vesicle 20–30 µm, diameter of the internal swellings 3–5 µm.

Remarks. – *Archeodiscina multipunctata* differs from other species of *Archeodiscina* by the number of internal swellings and by the length of the radial wrinkles. Very often, few irregularly connected specimens of that species were encountered (Pl. IV, fig. 12).

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Sułoszowa boreholes, Goczałkowice Formation, Głogoczów and Pszczyna members: BAMA III *I. flexuosa–C.molliculum*, BAMA IV *Skiagia–Eklundia campanula* zones.

Stratigraphic range. – Cambrian Series 2, Stage 3 – *Schmidtiellus*, *Holmia* zones.

Archeodiscina umbonulata Volkova, 1968

Pl. IV, Figs. 1–5, 8, 9

Synonymy. – See O. Fatka, M. Vavrdová, 1998; p. 55–57.

Additionally:
1998 *Archeodiscina umbonulata* Volkova; N.M. Talyzina, pl. II:1–3.
2000 *Archeodiscina umbonulata* Volkova; N.M. Talyzina, M. Moczydłowska, pp. 3, 5, pl. I: 1-6.
2000 *Archeodiscina umbonulata* Volkova; N.M. Talyzina *et al*., p. 50, pl. 1:9, 11, 12.
2000 *Archeodiscina umbonulata* Volkova; Z. Szczepanik, tabl. 1.
2001 *Archeodiscina umbonulata* Volkova; M. Moczydłowska *et al*., p. 439.
2002 ?*Archeodiscina umbonulata* Volkova; M. Vanguestaine *et al*., p. 57, 63, 66, 70, figs. 3–5, pl. III:9.
2001 *Archeodiscina umbonulata* Volkova; M. Vavrdová, J. Bek, pp. 116, 119, tab.1.

2002 *Archeodiscina umbonulata* Volkova; M. Moczydłowska, p. 199, figs. 4; 8:4.
2004 *Archeodiscina umbonulata* Volkova; M. Vavrdová, p. 6.
2004 *Archeodiscina umbonulata* Volkova; P.M. Brück, M. Vanguestaine, p. 205, figs. 3:2–5; 9
2006 *Archeodiscina umbonulata* Volkova; Vavrdová, pp. 118, 120.
2010b *Archeodiscina umbonulata* Volkova; M. Jachowicz-Zdanowska, fig. 4, tabl. VI:1, 2.
2011 *Archeodiscina umbonulata* Naumova 1960 emend. Volkova 1968; M. Moczydłowska, pp. 115, 116, pls. 1:1–6, 2:1–3.
2011 *Archeodiscina umbonulata* Volkova; M. Jachowicz-Zdanowska, figs. 5, 6:L.

Material. – Over 300 usually very well preserved specimens.

Dimensions. – Diameter of vesicle 25–55 µm, diameter of the internal body's 3–7 µm.

Remarks. – Numerous specimens of that species have been documented in the Brunovistulicum area. They have visibly bilayered wall, with thicker internal one and a very delicate, thin external one (Pl. IV, figs. 2, 8). This feature is in agreement with the species diagnosis (Volkova, 1968). The discussed species occurrs most abundantly in the upper part of the Pszczyna Member, and in the Jarząbkowice Member. Beside the typical forms fairly numerous specimens with unilayered wall were encountered (Pl. IV, figs. 5, 9). Those forms were associated mainly with the lower part of the Pszczyna Member, and only single ones were found in the Głogoczów Member. The author proposes at present to include the two discussed forms into one species *Archeodiscina umbonulata* because of their high similarity, and of the fact that the presence of the unilayered wall may be caused by their poor preservation. That species is sometimes represented by numerous specimens in Goczałkowice IG 1, Sułoszowa, and Měnín 1 boreholes. Over 100 well preserved forms used to be encountered in a standard microscope slide.

Present record. – Poland, Upper Silesian Block, Jarząbkowice 1, Goczałkowice IG 1, Klucze 1, Piotrowice 1, Sułoszowa boreholes, Goczałkowice Formation: Głogoczów, Pszczyna, Jarząbkowice members; BAMA III *Ichnosphaera flexuosa –Comasphaeridium molliculum*, BAMA IV *Skiagia–Eklundia campanula*, BAMA V *Skiagia–Eklundia varia* and BAMA VI *Liepaina plana–Volkovia dentifera* zones; Czech Republic, Brno Block, Měnín 1, Němčičky 3, Němčičky 6 boreholes: BAMA V *Skiagia–Eklundia varia*, BAMA VI *Liepaina plana –Volkovia dentifera* zones.

Stratigraphic range. – Cambrian Series 2, *Schmidtiellus*, *Holmia*, *Protolenus* zones, Cambrian Series 3 – *Acadoparadoxides oelandicus*, *Paradoxides paradoxissimus* zones.

Genus *Asteridium* Moczydłowska, 1991

Type species: *Asteridium lanatum* (Volkova, 1969) Moczydłowska, 1991

Asteridium lanatum (Volkova, 1969) Moczydłowska, 1991

Pl. IV, Fig. 10

Synonymy – See M. Moczydłowska, 1998, p. 50.

Additionally:
1983 *Micrhystridium lanatum* Volkova; N.A. Volkova *et al.*, pp. 19, 20, pl. VIII:5–11.
1992 *Asteridium lanatum* (Volkova) Moczydłowska; M. Moczydłowska, G. Vidal, p. 23, fig. 7.
1998 *Asteridium lanatum* (Volkova) Moczydłowska; T. Palacios, M. Moczydłowska, p. 71, figs. 3, 8:H.
2000 *Asteridium lanatum* (Volkova) Moczydłowska; Z. Szczepanik, tabl.1.
2001 *Asteridium lanatum* (Volkova) Moczydłowska; M. Vavrdová, J. Bek, tab.1.
2002 *Micrhystridium lanatum* Volkova; T.V. Jankauskas, pp. 101, 102
2003 *Asteridium lanatum* (Volkova) Moczydłowska; M. Vavrdová *et al.*, p. 73, fig. 8:5.
2008 *Asteridium lanatum* (Volkova) Moczydłowska, 1991; R. Mikuláš, H. Gilíková, M. Vavrdová , tabl. 2.
2010b *Asteridium lanatum* (Volkova) Moczydłowska; M. Jachowicz-Zdanowska, fig. 4, tabl. V:5.

Material. – Over 300 well preserved specimens.

Dimensions. – Diameter of vesicle 11–20 µm, length of processes 5–15 µm.

Remarks. – Initially, these forms were described as *Micrhystridium lanatum*. They were found in sediments of the Radzyń Formation penetrated by Radzyń IG 1 borehole (Volkova, 1968), located in the Lublin area in south-eastern Poland. Subsequently, they were included in *Asteridium* (Moczydłowska, 1991). As was already mentioned, in the original diagnosis (Volkova, 1969b), specimens with shorter (below 2 µm) and longer (far above 3 µm) processes were encountered. Specimens found in the Brunovistulicum area are mostly those with visibly longer processes. In the Upper Silesian Block, that species is closely associated with the Goczałkowice Formation of the Głogoczów Member. *A. lanatum* was also encountered in similar sediments, in the Měnín 1 borehole, in the Brno region, on the Czech side. Its presence was also ascertained in Němčičky 3 and Němčičky 6 boreholes, within the higher Cambrian of the same area. However, the present analyses have not confirmed the occurrence of that species in the Sosnowiec Formation suggested earlier by Moczydłowska (1998).

Present record. – Poland, Upper Silesian Block, Andrychów 3, Głogoczów IG 1, Goczałkowice IG 1, Kęty 8, Kęty 9, Kozy Mt 3, Sułoszowa, boreholes, Goczałkowice Formation Głogoczów Member; BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* Zone; Czech Republic, Měnín 1, Brno Block, Němčičky 3 i Němčičky 6 boreholes: BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* and BAMA VI *Liepaina plana–Volkovia dentifera* zones.

Stratigraphic range. – Terreneuvian – *Platysolenites* Zone, Cambrian Series 2 – *Schmidtiellus, Holmia* and *Protolenus* zones, Cambrian Series 3 – *Acadoparadoxides oelandicus* Zone.

Asteridium pallidum (Volkova, 1968) Moczydłowska, 1991

Pl. IV, Fig. 6

Synonymy. – See M. Moczydłowska, 1991, p. 48.

Additionally:
1978 *Micrhystridium pallidum* Volkova; M. Vanguestaine, pls. I:32; II:41
1983 *Micrhystrdium pallidum* Volkova; N.A. Volkova, V.V. Kirjanov, L.V. Piskun. L.T. Paškevičiene, T.V. Jankauskas, p. 21, pl. IX:17, 18.
1991 *Asteridium pallidum* (Volkova) com. nov.; M. Moczydłowska, pp. 13, 47, 48, fig. 5, pl. 1:I, J.
1992 *Micrhystridium pallidum* Volkova, 1969; M. Vanguestaine, fig. 4.
1992 *Asteridium pallidum* (Volkova) Moczydłowska; M. Moczydłowska, G. Vidal, p. 23 figs.7, 8:e, f.
2011 *Asteridium pallidum* (Volkova) Moczydłowska; M. Jachowicz-Zdanowska, figs. 5, 6:D.

Material. – Over 200 fairly well preserved specimens.

Dimensions. – Diameter of vesicle 8–15 µm, length of processes 2–4 µm.

Remarks. – The species was initially described by Volkova (1968) as *Micrhystridium pallidum*. It was recorded from the Talsy horizon in Estonia, correlated with Baltic *Schmidtiellus mickwitzi* Zone. Subsequently, Moczydłowska (1991) included it in *Asteridium*. In the Brunovistulicum area, that species was found in the Upper Silesian Block, exclusively, in the Głogoczów Member, where it usually appeares in numerous concentrations – very often over 20 specimens connected together. As for other areas, that species was only found in *Schmidtiellus* Zone (Volkova *et al*., 1979, 1983; Moczydłowska, 1991). The forms found in sediments of the younger Cambrian (Gardiner, Vanguestaine, 1971) might require taxonomic revision because of the very bad condition of the documented specimens.

Present record. – Poland, Upper Silesian Block, Andrychów 3, Goczałkowice IG 1, Głogoczów IG 1, Kęty 8, 9, Klucze 1, Sułoszowa boreholes, Goczałkowice Formation: Głogoczów Member; BAMA III *Ichnosphaera flexuosa–Comasphaeridum molliculum* Zone.

Stratigraphic range. – Cambrian Series 2 and 3, *Schmidtiellus*, *Holmia*, *Protolenus* zones, Cambrian Series 3 – ?*Acadoparadoxides oelandicus,* ?*Paradoxides paradoxissimus* zones.

Asteridium sp.

Pl. XVI, Figs. 6, 10; Pl. XXVI, Figs. 9, 11; Pl. XXVII, Fig. 9

Material. – Over 30 variously preserved specimens.

Description. – Acritarchs of circular or oval vesicle. The vesicle's surface densely covered with fairly massive processes.

Dimensions. – Diameter of vesicle 15–25 µm, length of the 3–5 µm.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA VIII *Turrisphaeridium semireticulatum* and BAMA IX *Adara alea–Multiplicisphaeridium llynense* zones.

Stratigraphic range. – Cambrian Series 3 – *Paradoxides paradoxissimus* Zone.

Genus *Ceratophyton* Kirjanov, 1979

Type species: *Ceratophyton vernicosum* Kirjanov, 1979

Ceratophyton vernicosum Kirjanov, 1979

Pl. XVI, Figs. 19–22, 24–28

Synonymy. – See O. Fatka, M. Konzalová, 1995, pp. 58, 59 and M. Moczydłowska, 2008, pp. 85, 86.

Additionally:
1995 *Ceratophyton vernicosum* Kirjanov, 1983; M. Jachowicz *in* M. Jachowicz, W. Moryc, ryc. 5:3, 8, 9.
1995 *Ceratophyton* sp.; M. Jachowicz *in* M. Jachowicz, W. Moryc, ryc. 5: 4, 10.
1996 *Ceratophyton vernicosum* Kirjanov; M. Jachowicz *in* Z. Buła, M. Jachowicz, pl. I:3, 5, 6, 11.

Material. – Over 100 variously preserved specimens.

Dimensions. – Diameter of the vesicle 50 µm–1.5 mm.

Remarks. – In the present paper all specimens representing the genus *Ceratophyton* have been assigned to *C. vernicosum*. However, the author feels that those various conical forms encountered in the Lower Cambrian sediments require additional detailed investigations. That may help to explain biological affinity of those forms. Visible morphological and size differentiation of the specimens may indicate their different biological affinity.

Present record. – Poland, Upper Silesian Block, Andrychów 3, Borzęta IG 1, Chrząstowice Rch 6, Głogoczów IG 1, Goczałkowice IG 1, Kęty 8, Kęty 9, Klucze 1, Kozy Mt 3, Piotrowice 1, Rajbrot 1, Rajbrot 2, Sułoszowa, Trojanowice, WB 137, WB 141, Wiśniowa 3, Wiśniowa 6, Wiśniowa IG 1 boreholes, Borzęta Formation: Myślenice, Osieczany Member, Rajbrot members: BAMA I *Pulvinosphaeridium antiquum –Pseudotasmanites* Zone; Goczałkowice Formation: Głogoczów and Pszczyna members: BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum*, BAMA IV *Skiagia –Eklundia campanula* and BAMA V *Skiagia–Eklundia varia* zones.

Stratigraphic range. – Terreneuvian, *Platysolenites* Zone; Cambrian Series 2 – *Schmidtiellus*, *Holmia* zones.

Genus *Chuaria* Walcott, 1899

Chuaria circularis (Walcott, 1899) Vidal et Ford, 1985

Pl. III, Figs. 9, 11, 12

Synonymy – See N.M. Talyzina, 2000, pp. 126, 127 and S. Dutta *et al*., 2006, p.101

Material. – 30 variously preserved specimens

Dimensions. – Diameter of vesicle 300–1000 µm.

Remarks. – In the study area, the "megaspheromorphs" of the *Chuaria circularis* were encountered in the Borzęta Formation, only. Those characteristic acritarchs, differing from others by much larger size that often exceeds several hundred microns, were usually represented by one or few specimens in a standard microscope slide. Those fossils connected presently with eukaryotic algae (Dutta *et al*., 2006), are known from the Proterozoic and Lower Cambrian where they occur very often together with representatives of *Tawuia*, forming characteristic associations which may be observed even macroscopically because of the fairly large size of some specimens (Vidal *et al*., 1993).

Present record. – Poland, Upper Silesian Block, Borzęta IG 1, Chrząstowice Rch 6, Rajbrot 1, Rajbrot 2, Trojanowice, WB 137 boreholes, Borzęta Formation: Myślenice, Osieczany and Rajbrot members; BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites* Zone.

Stratigraphic range. – Ediacaran, Terreneuvian – *Platysolenites* Zone.

Genus *Comasphaeridium*
Staplin, Jansonius, Pocock, 1965

Type species: *Comasphaeridium cometes* (Valensi, 1949) Staplin, Jansonius, Pocock, 1965

Comasphaeridium agglutinatum Moczydłowska, 1988

Pl. V, Fig. 1

Synonymy. – See M. Moczydłowska, 1991, p. 49, 50.

Additionally:
2003 *Comasphaeridium agglutinatum* Moczydłowska; M. Vavrdová *et al*., p. 73.
2011 *Comasphaeridium agglutinatum* Moczydłowska; M. Jachowicz-Zdanowska, figs. 5, 6:A.

Material. – 15 well preserved specimens.

Dimensions. – Diameter of vesicle 10–30 µm, length of processes 5–15 µm.

Remarks. – This species was described from the Mazowsze Formation (Moczydłowska, 1988, 1991) correlated with the Baltic *Platysolenites* Zone. In Brunovistulicum, it is represented by single specimens only. In the Upper Silesian Block, it was encountered in the Głogoczów Member, only, whereas in the Brno Block, it was found in a single sample from the Měnín 1 borehole (Vavrdová *et al*., 2003, p. 73). Those appearances are closely connected with the BAMA III Zone, which in Brunovistulicum should be correlated with sediments younger than *Platysolenites* Zone. Therefore, the stratigraphic extent of the discussed species should be extended to the successive faunistic *Schmidtiellus* Zone.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Klucze 1, Kozy Mt 3, Sułoszowa boreholes, Goczałkowice Formation: Głogoczów Member; BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* Zone; Czech Republic Brno Block, Měnín 1 borehole, BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* Zone.

Stratigraphic range. – Terreneuvian, *Platysolenites* Zone, Cambrian Series 2, *Schmidtiellus* Zone.

Comasphaeridium francinae n.sp.

Pl. XXXI, Figs. 10, 11, 14

1984 Acritarch gen. et sp.nov.; F. Martin, W.T. Dean, 1984, pl. 57.1:10, 17, 18.
1994 Acritarch gen. et sp.nov. Martin *in* Martin et Dean, 1984; T. Young *et al*., p. 343, figs. 7, 11:e
2008 Acritarch gen. *et* sp. nov. Martin; T. Palacios, figs. 2, 3:B.
2010 *Comasphaeridium* n. sp. A.; T. Palacios, fig. 1.

Derivation of name. – The name of the species: *francinae* came from the first name of prof. Francine Martin, pioneer of the palynological Cambrian stratotype investigations in Newfoundland.
Holotype. – Pl. XXXI, Fig. 14; coll. OG 546/2013/prep. 2.
Locus typicus. – Poland, Upper Silesian Block, Sosnowiec Formation, Sosnowiec IG 1 borehole, depth 3204.5 m.

Material. – Over 50 well preserved specimens.

Diagnosis. – Minute acritarchs with circular or oval vesicle, very densely covered by capillary processes, usually of the same length. The processes are probably solid and not connected with the vesicle cavity. This species very often occurs in clusters of several connected specimens. No opening structure observed.

Dimensions. – Diameter of vesicle 5–8 µm, length of processes 8–12 µm.

Remarks. – Those acritarchs were first documented in Cambrian sediments of Newfoundland. They were at that time classified only as Acritarch gen. et sp. nov (Martin, Dean, 1984). Those characteristic specimens occurred in the acritarch associations of the *Adara alea* = *A1* zone (Martin, Dean, 1981, 1984, 1988) distinquished within the higher part of the *Paradoxides paradoxissimus* Zone. Besides Canada, those forms were encountered in the Cambrian Oville Formation of Spain (Palacios *et al*., 2006; Palacios, 2008, 2010), and in the Nat-y-big Formation of the north-western Wales (Young *et al*., 1994), where they have also a short extent. In Brunovistulicum, that species was encountered in samples from Sosnowiec Formation only where it was often associated with representatives of *Comasphaeridium soniae* n.sp. (see: Pl. XXXI, Fig. 13, 14).

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation; BAMA VIII *Turrisphaeridium semireticulatum* and BAMA IX *Adara alea–Multiplicisphaeridium llynense* zones.

Stratigraphic range. – Cambrian Series 3 – *Acadoparadoxides oelandicus*, *Paradoxides paradoxissimus* zones.

Comasphaeridium longispinosum
(Hagenfeldt, 1989) emend.

Pl. XXIII, Figs. 9–14

1989b *Comasphaeridium longispinosum* n.sp.; S.E. Hagenfeldt, pp. 192–194, pl. 1:5, 6.
non 1993 *Comasphaeridium longispinosum* Vidal n.sp.; G. Vidal, J.S. Peel, pp. 19–21, fig. 6a.
1994 *Comasphaeridium longispinosum* Hagenfeldt; F. Martin *in* T. Young *et al*., fig. 11:f, l.
1997 *Comasphaeridium longispinosum* Hagenfeldt; F. Martin *in* W.T. Dean *et al*., p. 49, fig. 8:k.
1998 *Comasphaeridium longispinosum* Hagenfeldt; M. Moczydłowska, pp. 53, 54, figs. 14, 15, 22:D.
? 1998 *Comasphaeridium longispinosum* Hagenfeldt; T. Palacios, M. Moczydłowska, figs. 3, 9:H.

1999 *Comasphaeridium longispinosum*; M. Moczydłowska, pp. 211, 216, 220.
non 2001 *Comasphaeridium longispinosum* Hagenfeldt; M. Vavrdová, J. Bek, tab. 1, pl. 4: 3.
2006 *Comasphaeridium longispinosum*; T. Palacios *et al*., p. 41.
2009 *Comasphaeridium longispinosum*; A. Żylińska, Z. Szczepanik, p. 426, text-fig. 9.
2010 *Comasphaeridium longispinosum*; T. Palacios, fig. 1.

Material. – Over 50 well preserved specimens.

Original diagnosis. – Hagenfeltd, 1989b, p. 193, pl. 1:5. "A species of *Comasphaeridium* with a spherical vesicle. It is circular in outline, wrinkled, due to compression. The vesicle is single-walled, thin and transparent. No opening structure observed. The processes are numerous, solid, ciliate and very long, sametimes bifurcated distally. At the vesicle surface, thickenings occur occasionally, as well as on the processes. The ornamentation of the vesicle surface is psilate".

Dimensions. – Diameter of vesicle 25–35 µm, length of processes 50–100 µm.

Emended diagnosis. – Acritarchs with oval or circular vesicle, with unilayered smooth or clearly granular wall. The vesicle surface bears numerous, thin processes. In addition, isolated, much broader processes may be observed in some specimens. Processes are very long; their length exceeds many times the vesicle diameter. The thin processes are often strongly tangled around the central vesicle. The distal terminations of the processes are blunt some processes are tapering gradually toward the tips. The surface of the processes is smooth, their bases are closed, isolated from the vesicle cavity. Opening structure of the vesicle is the "median split"

Remarks. – Features new, in comparison with the original diagnosis, such as the granular wall of the vesicle, and additional, visibly broader processes, have been observed in part of the specimens included in the discussed species. In the Upper Silesian Block, specimens of that species have only been documented in the Cambrian Series 3 of the Sosnowiec Formation. Their occurrence in the Brno Block was noted by Vavrdová (Vavrdová, Bek, 2001) in the Měnín 1 and Němčičky 3 boreholes, in deposits correlated with *Holmia* and *Protolenus* zones. The occurrence of *C. longispinosum* in the Brno Block sections has not been confirmed by analyses carried out by the present author. Therefore, in the present work, stratigraphic ranges documented on the Polish side of the Brunovistulicum Unit are accepted. The species was represented by several, or by dozen or so specimens (as in the BAMA VIII associations) in a standard microscope slide.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA VII *Ammonidium bellulum–Ammonidium notatum*, BAMA VIII *Turrisphaeridium semireticulatum* and BAMA IX *Adara alea–Multiplicisphaeridium llynense* zones.

Stratigraphic range. – Cambrian Stage 3 – *Acadoparadoxides oelandicus*, *Paradoxides paradoxissimus* zones.

Comasphaeridium molliculum
Moczydłowska et Vidal, 1988

Pl. XVI, Fig. 23

Synonymy. – See M. Moczydłowska, 1991, p. 50.

Additionally:
1983 *Baltisphaeridium papillosum* (Timofeev, 1959) Volkova, 1968; N.A. Volkova *et al*., p. 11, pl. XIII:13.
1992 *Comasphaeridium molliculum* Moczydłowska et Vidal; M. Moczydłowska, G. Vidal, p. 25, figs. 7, 8:a, b.
1993 *Comasphaeridium molliculum* Moczydłowska et Vidal; G. Vidal, J.S. Peel, p. 19, fig. 7:a, b.
2001 *Comasphaeridium molliculum* Moczydłowska et Vidal; M. Moczydłowska *et al*., pp. 439–441, fig. 3:a–d.
2002 *Comasphaeridium molliculum* Moczydłowska et Vidal; M. Moczydłowska, p. 195, 196, figs. 4; 5:1–3.
2003 *Comasphaeridium molliculum* Moczydłowska et Vidal; M. Vavrdová, R. Mikuláš, S. Nehyba, pp. 73, 74
2004 *Comasphaeridium molliculum* Moczydłowska et Vidal; P.M. Brück, M. Vanguestaine, p. 205, figs. 3:10–13; 9.
2008 *Comasphaeridium molliculum* Moczydłowska *et* Vidal; R. Mikuláš *et al*., p. 341.
2009 *Comasphaeridium molliculum*; Z. Szczepanik, fig. 2.
2010b *Comasphaeridium molliculum* Moczydłowska et Vidal; M. Jachowicz-Zdanowska, fig. 4, tabl. VI:9, 10.
? 2011 *Comasphaeridium molliculum* Moczydłowska et Vidal 1988; M. Moczydłowska, pp. 122, 123, pls. 3:1, 2, 4:1–6.

Material. – Over 50 well preserved specimens.

Dimensions. – Diameter of vesicle 60–75 µm, length of processes 5–8 µm.

Remarks. – Those characteristic acritarchs with large vesicle covered with delicate, short processes are easily distinquishable in the early Cambrian acritarch assemblages. The species *Comasphaeridium molliculum* from Lükati Formation in Estonia (Moczydłowska, 2011) probably requires taxonomic revision. They resemble the new species of *Ichnosphaera*; for instance, 2 specimens in plate 3, figures 1 and 2 resemble *Ichnosphaera delicata* n.sp., and specimens in plate 4, figures 1–6 may represent *Ichnosphaera stipatica* n.sp.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Kozy Mt 3, Piotrowice 1, Sułoszowa, boreholes, Goczałkowce Formation: Głogoczów Member; BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* Zone; Czech Republic, Brno Block, Měnín 1 borehole, BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* Zone.

Stratigraphic range. – Terreneuvian – *Platysolenites* Zone, Cambrian Series 2 – *Schmidtiellus*, *Holmia* zones.

Comasphaeridium silesiense
(Moczydłowska, 1998) emend.

Pl. XXVI, Fig. 3; Pl. XXX, Figs. 1–11

1987 *Comasphaeridium strigosum* (Jankauskas) Downie, 1982; M.A. Fombella, pl. 2:20.
1989a *Comasphaeridium strigosum* (Yankauskas) Downie, 1982; S.E. Hagenfeldt, pl. 2:2.
1991 *Comasphaeridium* sp.; R. Albani *et al*., p. 266, pl. 1:2.

non 1992 *Comasphaeridium* sp. cf. *C. strigosum* (Jankauskas) Downie; F. Martin, pl. 6:6, 7.
1993 *Comasphaeridium strigosum* (Yankauskas *in* Yankauskas, Posti) Downie; M.A. Fombella *et al*., pl. 3:3.
? 1995 *Comasphaeridium* n. sp. A; M. Moczydłowska, T.P. Crimes, p. 119, pl. 1:D.
1998 *Comasphaeridium silesiense* n. sp.; M. Moczydłowska, pp. 26, 31, 33, 54, 55, figs. 14, 15, 22: A–C, E.
1999 *Comasphaeridium silesiense* Moczydłowska; M. Moczydłowska, pp. 215, 216, 220, text-fig. 3, pl. 3: fig. 4.
2000 *Comasphaeridium strigosum* (Jankauskas); Z. Szczepanik, tabl. 1.
2004 *Comasphaeridium silesiense* Moczydłowska; P.M. Brück, M. Vanguestaine, pp. 205, 216, figs. 6:7; 11.
2008 *Comasphaeridium silesiense* Moczydłowska; M. Vanguestaine, P.M. Brück, pp. 75, 86-87, figs. 4, 5, 7, pl. 1:11.
2009 *Comasphaeridium silesiense*; Z. Szczepanik, p. 26, fig. 2.
2009 *Comasphaeridium silesiense* Moczydłowska; A. Żylińska, Z. Szczepanik, pp. 426, 443, 444, text-fig. 9, pls. 8:17, 18; 10:19.

Original diagnosis. – Moczydłowska, 1998, p. 55. "Vesicles circular to oval in outline, originally sphaerical, bearing very numerous, evenly distributed and densely arranged, solid, slender and flexible processes. The processes are filose and approximately of equal length".

Material. – Over 300 very well preserved specimens.

Emended diagnosis. – Acritarchs with circular or oval vesicle, with single wall. Vesicles are densely covered with thin, flexible, capillary processes, of more or less the same length, which causes fairly even specimens margin. Length of the processes usually equals one-half of the vesicle diameter, but it may rary slightly. Processes seem to be solid therefore, there is no connection with the vesicle cavity. No opening structure observed.

Dimensions. – Diameter of vesicle 10–25 µm, length of processes 10–30 µm.

Remarks. – In the original diagnosis of *Comasphaeridum silesiense* by Moczydłowska (1998) features distinguishing that taxon from the morphologically very close *Comaspaeridium strigosum* (Jankauskas, 1976) Downie, 1982, have not been emphasized. The proper recognition of *Comasphaeridium silesiense*, which is by many researchers regarded as the index taxon (Moczydłowska, 1998, 1999; Palacios *et al*., 2006; Palacios, 2010), is very important because its wrong determination could involve incorrect stratigraphic conclusions.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation; BAMA VIII *Turrisphaeridium semireticulatum* and BAMA IX *Adara alea–Multiplicisphaeridium llynense* zones.

Stratigraphic range. – Cambrian Series 3 – *Acadoparadoxides oelandicus*, *Paradoxides paradoxissimus* zones.

Comasphaeridim soniae n.sp.

Pl. XXXI, Figs. 9, 12, 13, 15–18

Derivation of name. – Name of the species has been adopted in order to honour Professor Sonia Dybova-Jachowicz, a Polish palynologist who has studied Carboniferous and Permian microfossils (privately mother of the author).
Holotype. – Pl. XXXI, Fig. 15; coll. OG 546/2013/prep. 2.
Locus typicus. – Poland, Upper Silesian Block, Sosnowiec Formation, Sosnowiec IG 1 borehole, depth 3204.5 m.

Material. – Over 50 well preserved specimens.

Diagnosis. – Acritarchs with very small oval vesicle, with single wall. The vesicle is covered with long, capillary, solid processes. The distal ends of neighbouring processes are connected to form triangles with two strongly elongated sides and narrow base. Usually, four triangles occur on central vesicle arranged diagonally opposite each other. Arrangement of the processes causes a tetragonal outline of the specimens. There is no contact of the vesicle cavity with the processes. No opening structure was observed.

Dimensions. – Diameter of vesicle 3–5 µm, length of processes 10–25 µm.

Remarks. – In the studied material, interconnection of specimens of *Comasphaeridim soniae* n.sp. and *Comasphaeridium francinae* n.sp. have often been seen.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation; BAMA VIII *Turrisphaeridium semireticulatum* Zone.

Stratigraphic range. – Cambrian Series 3 – *Paradoxides paradoxissimus* Zone.

Comasphaeridium spinosum n.sp.

Pl. V, Figs. 7, 8

Derivation of name. – From Latin *spina* – spinae, with reference to thorny, sharply ended processes.
Holotype. – Pl. V, Fig. 7; coll. OG 546/2013/prep. 3.
Locus typicus. – Poland, Upper Silesian Block, Goczałkowice Formation, Pszczyna Member, Sułoszowa borehole, depth 199.1 m.

Material. – 15 well preserved specimens.

Diagnosis. – Acritarchs with circular or sporadically oval vesicle, with unilayered wall. The vesicle densely covered with sharply terminated, hollow processes. Length of the processes varies; it equals one-half to full diameter of the vesicle or more. Bases of the processes are discrete. The processes taper gradually from base to tip. Process cavities contact the vesicles interior. No opening structure observed.

Dimensions. – Diameter of vesicle 15–25 µm, length of processes 10–25 µm.

Remarks. – *C. spinosum* is slightly similar to *Ichnosphaera flexuosa* but it differs by the construction of processes whose cavities connect with the vesicle interior.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Sułoszowa boreholes, Goczałkowice Formation: Pszczyna Member, BAMA IV *Skiagia–Eklundia campanula* and BAMA V *Skiagia–Eklundia varia* zones.

Stratigraphic range. – Cambrian Series 2, Stage 4 – *Holmia* Zone.

Comasphaeridium strigosum
(Jankauskas, 1976) Downie, 1982

Pl. V, Figs. 4, 10

1969b *Baltisphaeridium* sp.2; N.A. Volkova, p. 226, pls. XLIX: 21; LI:38.
1976 *Baltisphaeridium ?strigosum* Jankauskas, sp.nov.; T. Jankauskas, E. Posti, pp. 146, 147, figs. 8, 14.
1979 *Baltisphaeridium ?strigosum* Jankauskas; N.A. Volkova *et al*., p. 12, pl. X:16–18.
1979 *Baltisphaeridium ?strigosum* Yankauskas; G. Vidal, p. 18, pl. 1:a.
1982 *Comasphaeridium* sp. A.; C. Downie, p. 260, fig. 6:m.
1982 *Comasphaeridium strigosum* (Jankauskas) comb. nov.; C. Downie, p. 260, fig. 6:j–l.
1983 *Baltisphaeridium ?strigosum* Jankauskas; N.A. Volkova *et al*., p. 17, pl. X:16–18.
1986 *Comasphaeridium strigosum* (Jankauskas) Downie; M. Moczydłowska, G. Vidal, pp. 212, 217, figs. 4:11; 7, 10:F.
1987 *Comasphaeridium strigosum* (Jankauskas) Downie; A.H. Knoll, K. Sweet, p. 916.
1991 *Comasphaeridium strigosum* (Jankauskas) Downie; M. Moczydłowska, p. 51, figs. 6:13, 19, pl. 1:N, O.
1992 *Comasphaeridium strigosum* (Jankauskas) Downie; T. Palacios, G. Vidal, p. 428.
1998 ?*Comasphaeridium strigosum* (Jankauskas, 1976) Downie; O. Fatka, M. Vavrdová, p. 55.
2000 *Comasphaeridium strigosum* (Jankauskas) Downie; N.M. Talyzina *et al*., pl. I:1.
2001 *Comasphaeridium strigosum*; M. Moczydłowska *et al*., p. 439.
2001 *Comasphaeridium strigosum* (Jankauskas) Downie; M. Vavrdová, J. Bek, p. 119, tab.1
? 2002 *Comasphaeridium strigosum* Jankauskas, 1975; T. Jankauskas, 2002, p. 96.
2011 *Comasphaeridium strigosum* (Jankauskas 1976) Downie 1982; M. Moczydłowska, pp. 123, 124, pl. 3:3–5.
2011 *Comasphaeridium strigosum* (Jankauskas) Downie; M. Jachowicz-Zdanowska, fig. 7:A.

Material. – Over 150 well preserved specimens.

Dimensions. – Diameter of vesicle 15–30 µm, length of processes 8–15 µm.

Remarks. – The species was initially described as *Baltisphaeridium* sp. 2 from Cambrian horizon Vergale sediments in Lithuania, correlated with Baltic *Holmia* Zone (Volkova, 1969b). Subsequently it was named *Baltisphaeridium strigosum* (Jankauskas, Posti, 1976), and later was included in the genus *Comasphaeridium* (Downie, 1982). This species is very similar to *Comasphaeridium silesiense* (see remarks for *C. silesiense*). However, there may be a problem with identification of those two taxa in the case of poor preservation. A part of specimens identified in literature as *Comasphaeridium strigosum* most probably represent *C. silesiense*. That concerns especially specimens described from the Cambrian Series 3 (Volkova, 1969b; Volkova *et al*.; 1979, 1983; Hagenfeldt, 1989b; Jankauskas, 2002).

An important feature of *C. strigosum*, not resulting from bad preservation is, according to the author, distinctly differentiated length of the processes. A part of them is distincly shorter that results in specimen margin being irregular. In addition, the processes length usually does not exceed one third of the vesicle diameter.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG1, Sułoszowa, Klucze 1, Jarząbkowice 1, Sosnowiec IG 1 boreholes, Goczałkowice Formation: Pszczyna Member and Jarząbkowice members; BAMA IV *Skiagia –Eklundia campanula*, BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones; Sosnowiec Formation: BAMA VII *Ammonidium bellulum–Ammonidium notatum* Zone; Czech Republic, Brno Block, Měnín 1, Němčičky 3, Němčičky 6 boreholes: BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones.

Stratigraphic range. – Cambrian Series 2 – *Platysolenites*, *Schmidtiellus*, *Holmia*, *Protolenus* zones; Cambrian Series 3 – *Acadoparadoxides oelandicus*, *Paradoxides paradoxissimus* zones.

Comasphaerdium velvetum Moczydłowska, 1988

Pl. V, Figs. 2, 5

Synonymy. – See M. Moczydłowska, 1991, p. 52.

Additionally:
2003 *C. velvetum*; M. Vavrdová *et al*., p. 73.
2008 *Comasphaeridium velvetum* Moczydłowska; R. Mikuláš *et al*., tab. 2.
2010b *Comasphaeridium velvetum*; M. Jachowicz-Zdanowska, fig. 4.

Material. – Over 100 well preserved specimens.

Dimensions. – Diameter of vesicle 15–30 µm, length of processes 2–5 µm.

Remarks. – Those acritarchs were described from the Mazowsze Formation as the index form of the *Asteridium tornatum–Comasphaeridium velvetum* Zone (Moczydłowska, 1991), correlated with the *Platysolenites* Zone. In the Upper Silesian Block the species *Comasphaeridium velvetum* has a limited extent. It occurs only in the Głogoczów Member correlated with the *Schmidtiellus* Zone and lower part of *Holmia* Zone, whereas in the Cambrian profiles of the Brno Block, it has been documented in a single sample from the Měnín 1 borehole, collected from sediments correlated with the *Platysolenites* Zone. In connection with those data the stratigraphic range of the species should be revised.

Present record. – Poland, Upper Silesian Block, Andrychów 3, Goczałkowice IG 1, Głogoczów IG 1, Kozy Mt 3, Kęty 8, Kęty 9, Piotrowice 1, Sułoszowa boreholes, Goczałkowice Formation: Głogoczów Member; BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* Zone; Czech Republic, Brno Block, Měnín 1, BAMA II *Asteridium tornatum–Comasphaeridium velvetum* Zone.

Stratigraphic range. – Terreneuvian – *Platysolenites* Zone; Cambrian Series 3 – *Schmidtiellus* and *Holmia* zones.

Comasphaerdium vozmedianum (Fombella, 1979) emend.

Pl. XXXI, Figs. 1–8

nomen nudum 1979 *Comasphaeridium vozmedianum* n. sp.; M.A. Fombella, p. 4, pls. I: 9, 15, II:29.

2006 *Comasphaeridium* sp.; E. Raevskaya, E. Golubkova, pp. 59, 61, fig. 5, pl. I: 4.

Derivation of name. – Name of the species proposed by Fombella (1979) came from locality Vozmediano in Oville province, in Spain, where those forms have been for the first time described from.
Holotype. – Fombella, 1979, pl. I, fig. 9.
Locus typicus. – Spain, Oville Formation.

Material. – Over 50 well preserved specimens.

Diagnosis. – Acritarchs with oval, sporadically circular vesicle, and with unilayered wall. The vesicle surface is covered very densely with short, almost equally long processes, that form an outline that reflects the vesicle shape. The processes are solid, parallel-sided over the whole length. Their distal portions are thin and sharp, sometimes blunt. The length of processes does not exceed one-fourth of the vesicle diameter. No opening structure observed.

Dimensions. – Diameter of vesicle 25–40 µm, length of processes 4–8 µm.

Remarks. – The species has been named and illustrated by Fombella (1979), though his diagnosis has not been published, so far. The *Comasphaeridium vozmedianum* differs from other species of that genus by short, equally long processes, very densely distributed over the vesicle surface.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA VIII *Turrisphaeridium semireticulatum* and BAMA IX *Adara alea–Multiplicisphaeridium llynense* zones.

Stratigraphic range. – Cambrian Series 3 – *Paradoxides paradoxissimus* Zone.

Genus *Cristallinium* Vanguestaine, 1978

Type species. – *Cristallinium cambriense* (Slaviková, 1968) Vanguestaine, 1978

Cristallinium cambriense
(Slaviková, 1968) Vanguestaine, 1978

Pl. XXIX, Figs. 10, 17

Synonymy. – See M. Moczydłowska, 1998, p. 56.

Additionally:
1993 *Cristallinium ovillense* (Cramer et Diez) Fensome, Williams, Sedley Barss, Freeman et Hill, 1990; M.A. Fombella *et al*., p. 230, pl. 2: 2.
1996 *Cristallinium cambriense* (Slaviková) Vanguestaine; M. Jachowicz *in* Z. Buła, M. Jachowicz, p. 315, pl. IV:4.
1996 *Cristallinium cambriense* (Slaviková) Vanguestaine; S. Molyneux, R.A. Fendsome, pp. 516, 517.
1997 *Cristallinium cambriense* (Slaviková) Vanguestaine; F. Martin *in* W.T. Dean *et al*., p. 49, fig. 8:s, t.
1998 *Cristallinium randomense* (Martin, 1981) Martin, 1988; M. Moczydłowska, p. 60, pl. 24:A–D.
1999 *Cristallinium cambriense*; M. Moczydłowska, pp. 211, 214–216, 220.
2000 *Cristallinium cambriense* (Slavikova); Z. Szczepanik, tabl. 1.
2002 *Cristallinium cambriense* (Slaviková) Vanguestaine; M. Vanguestaine *et al*., pp. 53, 63, 65, 67, 69, 70, fig. 5.
2002 *Cristallinium cambriense* (Slaviková) Vanguestaine; T. Jankauskas, p. 96, tabl. 8, figs. 5, 6, pl. 4:2, 8–16.
2002 *Cristallinium cambriense*; M. Vanguestaine, p. 271.
2004 *Cristallinium cambriense* (Slaviková) Vanguestaine; P.M. Brück, M. Vanguestaine, pp. 207, 216, figs. 6:1, 2; 10, 11.
2005 *Cristallinium cambriense* (Slaviková) Vanguestaine; M. Vanguestaine, R. Léonard, pp. 133, 136–138, figs. 4, 6, 7, pl. I:1.
2006 *Cristallinium* sp. cf. *C cambriense* (Slaviková) Vanguestaine; E. Raevskaya, E. Golubkova, pp. 59, 61, fig. 5, pl. I:8.
2008 *Cristallinium cambriense* (Slaviková) Vanguestaine; M. Vanguestaine, P.M. Brück, pp. 75, 77, 86–90, 92, figs. 4–7, pls. 1:10; 2:1.
2008 *Cristallinium cambriense* (Slaviková) Vanguestaine; M. Vecoli *et al*., pp. 59, 60, fig. 3, pl. 1:3, 4, 7.
2009 *Cristallinium cambriense*; Z. Szczepanik, p. 27, fig. 2.
2009 *Cristallinium cambriense*; A. Żylińska, Z. Szczepanik, p. 426, text-fig. 9.
2011 *Cristallinium cambriense* (Slaviková) Vanguestaine; M. Jachowicz-Zdanowska, figs. 5, 8:I, J.

Material. – Over 150 well preserved specimens.

Dimensions. – Diameter of vesicle 30–50 µm, diameter of polygonal fields from 10 to 15 µm, height of granules 0.5–1.0 µm.

Remarks. – This species was described for the first time as *Dictyotidium cambriense* from the Barrandian, Czech Republic from the Cambrian Jince Formation (Slavíková, 1968). Later, those forms were moved to the new genus *Cristallinum* indicated as the type species (Vanguestaine, 1978). This taxon has been broadly discussed in numerous publications (Martin, Dean, 1981, 1988; Moczydłowska, 1998; Vanguestaine, 2002). It is one of the characteristic species first appearing in basal sediments of the Cambrian Series 3 (Young *et al*., 1994). However, the author's investigations have not confirmed the occurrence of *Cristrallinium cambriense* in the Goczałkowice Formation, as was suggested earlier by (Moczydłowska, 1998) who studied samples from the same section.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA VII *Ammonidium bellulum–Ammonidium notatum*, BAMA VIII *Turrisphaeridium semireticulatum* and BAMA IX *Adara alea–Multiplicisphaeridium llynense* zones.

Stratigraphic range. – *Acadoparadoxides oelandicus*, *Paradoxides paradoxissimus* zones.

Cristallinium compactum n.sp.

Pl. XXIX, Figs. 3, 4

Derivation of name. – From Latin *compactus* – compact, the name refers to the compact shape of the vesicle construction.
Holotype. – Pl. XXIX, Fig. 3; coll. OG 546/2013/prep. 1.
Locus typicus – Poland, Upper Silesian Block, Sosnowiec Formation, Sosnowiec G 1 borehole, depth 3184.0 m.

Material. – Over 30 specimens.

Diagnosis. – Tiny acritarchs of cubical vesicle whose surface is covered with tiny grains. Frequently the large opening is observed.

Dimensions. – Diameter of vesicle 15–25 µm.

Remarks. – It differs clearly from *Cristallinium cambriense* species by general vesicle's shape.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA IX *Adara alea–Multiplicisphaeridium llynense* Zone.

Stratigraphic range. – Cambrian Series 3 – *Paradoxides paradoxissiumus* Zone.

Genus Eklundia n.gen.

Type species: *Eklundia campanula* (Eklund, 1990) n.comb.

Derivation of name. – In honour of Christer Eklund, who first described forms presently accepted as the type species of *Eklundia* n.gen.

Diagnosis. – Acritarchs with bilayered wall, consisting of distinct circular or oval, thicker, darker central vesicle, surrounded by external, transparent, thin layer bearing hollow processes of inequal length and variable shape. The processes are straight, thin, often wider at the base, with more or less divided distal terminations. It seems that processes are mostly confined to the vesicle equatorial zone. The surface of the internal vesicle is smooth or granular; processes surface is smooth. There is no communication between the vesicle cavity and that of the processes. No opening structure observed.

Remarks. – The new genus includes acritarchs occurring often in Cambrian System Series 2. They were earlier classified as species of such genera as: *Baltisphaeridium* (Volkova, 1969b), *Goniosphaeridium* (Downie, 1982), *Multiplicisphaeridium* (Eklund, 1990) or *Polygonium* (Moczydłowska, 1998). The proposed new taxonomic approach for morphologically similar forms is the first attempt to set in order that characteristic acritarch group. Designated new species forms differ, first of all, by degree of the processes ramification. The author's decision to define new species is based on the fact that they appear within the analysed Cambrian profiles in specific sequence. In addition, some of them are characterised by relatively short extends.

Eklundia campanula (Eklund, 1990) n.comb.

Pl. XIX, Figs. 5–10

Basionym: 1990 *Multiplicisphaeridium campanulum* sp.nov.; K. Eklund, pp. 38, 39, fig. 9:M.

1996 *Multiplicisphaeridium* sp.; M. Jachowicz *in* Z. Buła, M. Jachowicz, pl. II: 8.

2010b *Multiplicisphaeridium campanulum* sp. nov.; M. Jachowicz-Zdanowska, fig. 4, tabl. VII: 5, 6.

Material. – Over 300 well preserved specimens.

Dimensions. – Diameter of vesicle 11–20 µm, length of processes 5–15 µm.

Description. – Acritarchs with distinctly outlined, thick, darker and opaque, circular or oval central vesicle surrounded by thin, transparent external one bearing heterogeneous processes of inequal length and variable shape. The processes are hollow, mostly widened at the base, have irregularly, usually bifurcate tips. The particular branches may be divided into smaller ones. Simple processes are straight, narrow or slightly widened at the base, and narrowing toward acute tips. Several neighbouring processes are often fused at the base that may be high, developed in the form of a distinct, membrane-like appendix. The length of the processes varies between one-fourth to full length of the vesicle diameter. The processes are best developed in the equatorial zone of the vesicle. The internal vesicle surface is smooth or granular, the processes surface is smooth. There is no communication of the vesicle cavity with the process interior. No opening structure observed.

Remarks. – The species differs from other forms of this genus by strongly developed, fused together, broad, and high bases, common for several neighbouring processes.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Piotrowice 1, Sułoszowa boreholes, Goczałkowice Formation, Pszczyna Member; BAMA IV *Skiagia–Eklundia campanula* Zone.

Stratigraphic range. – Cambrian Series 2 – *Holmia* Zone, ?Cambrian Series 3 – *Acadoparadoxides oelandicus* Zone.

Eklundia florentinata n.sp.

Pl. XX, Figs. 10, 11

Derivation of name. – Latin *florens* – "flowery" referring to highly developed distal portions of the processes.
Holotype. – Pl. XX, Fig. 10; coll. OG 546/2013/prep. 1.
Locus typicus. – Poland, Upper Silesian Block, Goczałkowice IG 1 borehole, depth 2771.5 m.

Material. – Over 50 well preserved specimens.

Diagnosis. – Acritarchs with distinctly outlined, darker, opaque, circular or oval vesicle surrounded by thin, transparent external one bearing hollow, heteromorphic, diaphanous, transparent processes of inequal length. The processes are straight, thin, and long, widened at the base, gradually narrowing towards the apex. Most processes display multi-ordered terminal branching. Their length varies, from one-quarter to one-half of the internal vesicle diameter. It rarely exceeds one-half length of the diameter. The processes are best developed in the equatorial zone of the vesicle. The vesicle surface is smooth or granular, the process surface is smooth. There is no communication of the vesicle cavity with that of the processes. No opening structure observed.

Dimensions. – Diameter of vesicle 15–25 µm, length of processes 8–15 µm.

Remarks. – It strongly differs from the rest of the species by irregularly ramified tips of the processes.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1 borehole, Goczałkowice Formation: Pszczyna Member; BAMA V *Skiagia–Eklundia varia* Zone.

Stratigraphic range. – Cambrian Series 2 – *Holmia* Zone.

Eklundia pusilla n.sp.

Pl. XIX, Figs. 1–4

Derivation of name. – Latin *pusillus* – "very small", because of specimens size and weakly developed processes.
Holotype. – Pl. XIX, Fig. 1.
Locus typicus. – Poland, Upper Silesian Block, Goczałkowice Formation, Pszczyna Siltstones with Trilobites Member, Goczałkowice IG 1 borehole, depth 2893.0 m.

Material. – Over 100 well preserved specimens.

Diagnosis. – Acritarchs with distinctly outlined, darker, opaque, circular or oval central vesicle surrounded by thin, transparent external one bearing hollow, sparse heteromorphic, diaphanous, transparent processes of various lengths and shapes. The processes are straight, thin or in the shape of elongated spines. Their length vary between one-quarter to one-half of the vesicle diameter, slightly longer ones are rare. The processes are fused at widened bases and probably confined mostly to the vesicle's equatorial zone. The distal ends of processes are usually sharp but single processes may bear slight bifurcations. The vesicle surface is smooth or slightly granular, that of the processes is smooth. There is no communication between the vesicle cavity and that of the processes. No opening structure observed.

Dimensions. – Diameter of vesicle 10–20 µm, length of processes 4–15 µm.

Remarks. – *Eklundia pusilla* n.sp. differs from *Eklundia florentinata* n.sp. and *Eklundia varia* n.comb. by poorly developed processes, and by distinctly smaller size.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Piotrowice 1, Sułoszowa boreholes, Goczałkowice Formation: Pszczyna Member; BAMA IV *Skiagia–Eklundia campanula* Zone.

Stratigraphic range. – Cambrian Series 2 – *Holmia* Zone.

Eklundia varia (Volkova, 1969) n.comb.

Pl. XIX, Figs. 11, 12; Pl. XX, Figs. 1–9

Basionym: 1969b *Baltisphaeridium varium* Volkova sp.nov.; N.A. Volkova, pp. 225, 226, pl. L:5.

1969b *Baltisphaeridium varium* sp.nov.; N.A. Volkova, pp. 225, 226, pl. L:48, pl. 51:13, 14.
1971 *Baltisphaeridium varium* Volkova; A.I. Fridrichsone, p. 10, pl. 2:1–5.
1974 *Baltisphaeridium varium* Volkova; N.A. Volkova, pl. 27:15.
1979 *Baltisphaeridium varium* Volkova; N.A. Volkova *et al.*, p. 13, pl. VI:1–5.
1982 *Goniosphaeidium varium* (Volkova 1969) comb. nov.; C. Downie, p. 278, fig. 11:a, b, g.
1983 *Baltisphaeridium varium* Volkova; N.A. Volkova *et al.*, p. 13, pl. VI:1–5.
1986 *Goniosphaeridium varium* (Vol.) Dow.; M. Moczydłowska, C. Vidal, p. 218, figs. 5, 7:26.
1989a *Baltisphaeridium varium* Volkova; S.E. Hagenfeldt, p. 26, pl. 1:8.
1991 *Goniosphaeridium varium* (Volkova) Downie, 1982; M. Moczydłowska, pp. 15, 39, 41, 43, 55, 56, fig. 5, pl. 10:B.
1992 *Goniosphaeridium* cf. *varium* (Volkova) sensu Downie 1982; W. Zang, p. 101, pl. 3:E–J.
1994 *Polygonium varium*; W.A.S. Sarjeant, R.P.W. Stancliffe, p. 44.
1998 *Polygonium varium* (Volkova) n. comb.; M. Moczydłowska, pp. 33, 90, 91, figs. 14, 16, 38:A–D.
1999 *Polygonium varium* (Volkova) Moczydłowska, 1998; M. Moczydłowska, p. 213, text-fig. 3, pl. 2: figs. 1–6.
2001 *Polygonium ?varium* (Volkova) Sarjeant et Stancliffe, 1994; M. Vavrdová, J. Bek, tab. 1, pl. I:3.
2009 *Polygonium varium*; Z. Szczepanik, fig. 2.
2010 *Polygonium varium*; T. Palacios, fig. 1.
2010b *Polygonium varium*; M. Jachowicz-Zdanowska, fig. 4.

Material. – Over 300 well preserved specimens

Description. – Acritarchs with distinctly outlined, darker, opaque, circular or oval vesicle surrounded by thin, transparent external one bearing hollow densely set heteromorphic, diaphanous, transparent processes. These are straight, thin and long, conical, and short, widened at the base, and gradually narrowing towards the distal terminations. Some processes are slightly, bifurcate or more rarely, irregularly branched. The processes are mostly confined to the vesicle equatorial zone. The length of the processes varies, from one-quarter to one-half of the vesicle diameter, only rarely exceeding one-half of the diameter. The vesicle surface is smooth or granular, that of the processes is smooth. There is no communication between the vesicle cavity with that of the processes. No opening structure observed.

Dimensions. – Diameter of vesicle 15–30 µm, length of processes 5–20 µm.

Remarks. – The morphological characteristics of the *varia* species specimens caused classify it to the new created the *Eklundia* genus.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Jarząbkowice 1, Klucze 1, Piotrowice 1, Sułoszowa boreholes, Goczałkowice Formation: Pszczyna and Jarząbkowice member; BAMA IV *Skiagia–Eklundia campanula*, BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones; Czech Republic, Brno Block, Měnín 1, Němčičky 3, Němčičky 6, BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones.

Stratigraphic range. – Cambrian Series 2 – *Holmia*, *Protolenus* zones, Cambrian Series 3 – *Acadoparadoxides oelandicus* Zone.

Genus *Eliasum* Fombella, 1977

Type species. – *Eliasum llaniscum* Fombella, 1977

Eliasum asturicum Fombella, 1977

Pl. XXVIII, Fig. 16

1977 *Eliasum asturicum* n.sp; M.A. Fombella, p. 118, pl. 1:1, fig. 1:2a.
1978 *Eliasum asturicum* Fombella, 1977; M.A. Fombella, pl. 3:21.
1981 *Eliasum* cf. *E. asturicum* Fombella, 1977; F. Martin, W.T. Dean, p. 19, pl. 2:6.
1993 *Eliasum asturicum* Fombella, 1977; M.A. Fombella Blanco *et al*., pl. 1:2, tabl. 1.
2006 *Eliasum asturicum*; T. Palacios *et al*., p. 41.
2008 *Eliasum asturicum*; T. Palacios, p. 291, figs. 2, 3:C.
2010 *Eliasum asturicum*; T. Palacios, fig. 1.

Dimensions. – Diameter of vesicle length 120–160 μm, width 40–50 μm.

Material. – 30 well preserved specimens.

Remarks. – *Eliasum* asturicum is similar to *E. llaniscum* but differs by having delicate ornament visible along specimen edges. The specimens documented from the Upper Silesian Block differ additionally by distinctly larger sizes.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA IX *Adara alea–Multiplicisphaeridium llynense* Zone.

Stratigraphic range. – Cambrian Series 3, *Paradoxides paradoxissimus* Zone.

Eliasum llaniscum Fombella, 1977

Pl. XXVIII, Figs. 10–12, 15

Synonymy. – See M. Moczydłowska, 1998, p. 66.

Additionally:
1983 *Cymatiosphaera* sp. 1; N.A. Volkova *et al*., p. 33, pl. XVI:6–8.
1993 *Eliasum llaniscum* Fombella; F. Martn *in*: M.A. Fombella Blanco *et al*., p. 49, fig. 8:i, j.
1996 *Eliasum llanisum* Fombella; M. Jachowicz *in* Z. Buła, M. Jachowicz, p. 315, pl. IV:7, 8.
1998 ?*Eliasum llaniscum* Fombella; O. Fatka, M. Vavrdová, p. 55.
1998 *Eliasum llaniscum*; T. Palacios, M. Moczydłowska, pp. 65, 72, 73, figs. 3, 5, 8:L.
1999 *Eliasum llaniscum* Fombella; M. Moczydłowska, pp. 210, 211, 213, 214, 216, 220, text-fig. 3, pl. 3:5.
2000 *Eliasum llaniscum* Fombella; Z. Szczepanik, tabl. 2.
2002 *Eliasum llanisum* Fombella; M. Vanguestaine *et al*., pp. 53, 63, 65, 67, 69, 70, fig. 5.
2001 *Eliasum llaniscum* Fombella; Z. Szczepanik, p.122, pl. II:10, 11.
2004 *Eliasum llaniscum* Fombella; P.M. Brück, M. Vanguestaine, p. 207, 217, figs. 6:12, 13; 11.
2005 *Eliasum llaniscum* Fombella; P.M. Brück, Vanguestaine, p. 529, fig. 5: 11–13.
? 2005 *Eliasum llaniscum* Fombella; M. Vanguestaine, R. Léonard, p. 134, pl. 3:F.
2006 *Eliasum llaniscum* Fombella; E. Raevskaya, E. Golubkova, pp. 59, 61, fig. 5, pl. I:1–3.
2006 *Eliasum llaniscum*(kreator); T. Palacios *et al*., p. 41.
2008 *Eliasum llaniscum* Fombella; T. Palacios, p. 289, figs. 2, 3:F.
2008 *Eliasum llaniscum* Fombella; M. Vanguestaine, P.M. Brück, pp. 79, 80, 86–92, figs. 4–7, pl. 2:3, 5.
2008 *Eliasum llaniscum* Fombella; M. Vecoli *at al.,* p. 60, fig. 3, pl. 1:6.
2009 *Eliasum llaniscum* Fombella; T. Palacios *et al*., pp. 127–129, figs. 2–4, 5:B.
2009 *Eliasum llaniscum*; Szczepanik; fig. 2.
2009 *Eliasum llaniscum* Fombella; A. Żylińska, Z. Szczepanik, p. 444, text-fig. 9, pl. 10:31, 33.
2010 *Eliasum llaniscum*; T. Palacios, fig. 1.
2011 *Eliasum llaniscum* Fombella; M. Jachowicz-Zdanowska, figs. 5, 8:K.

Material. – Over 300 variously preserved specimens

Dimensions. – Diameter of the vesicle length 50–110 μm, width 15–30 μm.

Remarks. – The occurrence of *Eliasum llanisum* in Brunovistulicum is limited to the Sosnowiec Formation. It was found within the entire thickness of the unit. In the assemblages of the – BAMA VIII *Turrisphaeridium semireticulatum* Zone the representatives of the species are abundant, over 40 specimens in a single microscope slide. In the two other acritarch zones, recognised within Sosnowiec Formation, the discussed species is less abundant – from few to dozen or so specimens in a single microscope slide. The specimens of *Eliasum llaniscum* foud in the higher zones are distinctly smaller, and have less strongly developed folds on the wall deffering in that way from those found in the basal part of the Sosnowiec IG 1 borehole section. This, however, does not provide the sufficient basis for distinction of new species. Generally, the stratigraphic range of that distinctive taxon embraces the higher part of the Cambrian Series 2 and Series 3 (Molyneux *et al*., 1996). The upper range limit of that taxon was discussed in many publications (Fombella, 1978, 1986; Moczydłowska, 1998; Brück, Vanguestaine, 2004; Moczydłowska, Stockfors, 2004). In the present paper, the interpretation by Palacios *et al*., (2009, pp.127–129) has been accepted. According to that interpretation, the highest extent of *Eliasum llaniscum* is to the youngest Cambrian Series – Furongian.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation; BAMA VII *Ammonidium bellulum–Ammonidium notatum*, BAMA VIII *Turrisphaeridium semireticulatum* and BAMA IX *Adara alea–Multiplicisphaeridium llynense* zones.

Stratigraphic range. – Cambrian Series 2 – *Protolenus* Zone, Cambrian Series 3, Furongian – *Olenus* Zone.

Genus *Globosphaeridium* Moczydłowska, 1991

Type species: *Globosphaeridium cerinum* (Volkova,1968) Moczydłowska, 1991.

Globosphaeridium arenulum n.sp.

Pl. IV, Fig. 13

Derivation of name. – Latin *arenula*, *arenulae* – “fine sand”, with reference to the surface ornament.
Holotype. – Pl. IV, Fig. 13; coll. OG 546/2013/prep. 2.
Locus typicus. – Poland, Upper Silesian Block, Goczałkowice Formation, Głogoczów Member, Kozy Mt 3 borehole, depth 1492.8 m.

Material. – Over 150 well preserved specimens.

Diagnosis. – Acritarchs with unilayered, oval, more rarely circular vesicle. The vesicle surface is covered by minute, short, acute, solid processes. The specimens often occur in groups of 5–6 specimens. No opening structure observed.

Dimensions. – Diameter of vesicle 25–30 µm, length of processes 2–3 µm.

Remarks. – The new species approximates *Lophosphaeridium latviense*. It differs by having less numerous, scattered processes on the vesicle surface, and by their sharp tips.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Sułoszowa, Kozy Mt 3, boreholes, Goczałkowice Formation: Głogoczów Member; BAMA III *Ichnosphaera flexuosa–Comaspheridium molliculum* Zone.

Stratigraphic range. – Cambrian Series 2 – *Schmidtiellus*, *Holmia* Zone.

Genus *Goniosphaeridium* (Eisenack, 1969) Kjellström, 1971

Type species: *Goniosphaeridium polygonale* (Eisenack, 1931) Eisenack, 1959.

Goniosphaeridium volkovae Hagenfeldt, 1989

Pl. XVIII, Fig. 4

1979 *Baltisphaeridium* sp. 2.; N.A. Volkova *et al*., p.13, pl. 6:10–12.
1983 *Baltisphaeridium* sp. 2.; N.A. Volkova *et al*., p.18, pl. 6: 10–12.
1989a *Goniosphaeridium volkovae* Hagenfeldt n.sp.; S. Hagenfeldt, pp. 54–56, pl. 3:1.
1990 *Solisphaeridium baltoscandium* sp.nov.; K. Eklund, p. 41, fig. 8:I.
1994 *Polygonium ?baltoscandium* (Eklund) comb.nov.; W.A.S. Sarjeant, R.P.W. Stancliffe, p. 43.
1997 *Micrhystridium* sp.; M. Jachowicz, A. Přichystal, pl.1:3.
1997 *Multiplicisphaeridium* sp.; M. Jachowicz, A. Přichystal, pl.1:6.
1998 *Solisphaeridium baltoscandium* (Eklund) emended; M. Moczydłowska, pp. 25, 30, 99, 100, figs. 14, 15, 41:A.
2010b *Polygonium baltoscandium*; M. Jachowicz-Zdanowska, fig. 4.

Material. – 35 well preserved specimens.

Dimensions. – Diameter of vesicle 20–30 µm, length of processes 10–15 µm.

Remarks. – These acritarchs were first described as *Baltisphaeridium* sp. 2 from the Early Cambrian sediments in Lithuania (Volkova *et al*., 1979). They were defined later in detail, and classified as *Goniosphaeridium volkovae* (Hagenfeldt, 1989a). During the subsequent years, similar specimens, including *Baltisphaeridium* sp. 2. (Volkova *et al*., 1979), were classified as *Solisphaeridium baltoscandium* (Eklund, 1990; Moczydłowska, 1998). In the present paper, the earlier interpretation by Hagenfeldt (1989a) has been accepted.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1 borehole, Goczałkowice Formation: Pszczyna Member; BAMA V *Skiagia–Eklundia varia* Zone; Czech Republic, Brno Block, Měnín 1, Němčičky 3, Němčičky 6 boreholes; BAMA VI *Volkovia dentifera–Liepaina plana* Zone.

Stratigraphic range. – Cambrian Series 2 – *Holmia*, *Protolenus* zones; Cambrian Series 3 – *Acadoparadoxides oelandicus* Zone.

Genus *Granomarginata* Naumova,1960

Type species – *Granomarginata prima* Naumova, 1960 (Pl. XVII, Fig. 2).

Granomarginata parva n.sp.

Pl. XVII, Fig. 1

Derivation of name. – Latin *parvus, -a, -um* – „small", in reference to small size of specimens.
Holoptype. – Pl. XVII, Fig. 1; coll. OG 546/2013/prep. 1.
Locus typicus. – Poland, Upper Silesian Block, Sosnowiec Formation, Sosnowiec IG 1, depth 3412.5 m.

Material. – Over 100 fairly well preserved specimens.

Diagnosis. – Minute acritarchs with circular or more rarely oval vesicle. The internal vesicle enclosed in an irregular envelope – zone constructed similarly to the internal one.

Dimensions. – Diameter of the external vesicle 15–25 µm, diameter of the internal vesicle 8–10 µm,

Remarks. – This species differs from *Granomarginata prima* Naumova, 1960 by the construction of the external zone that is of spongy character. Specimens of *G. parva* n.sp. have been encountered in the Upper Silesian Block only. They constitute a characteristic component of the acritarch assemblages within the basal sediments of the Sosnowiec Formation.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA VII *Ammonidium bellulum–Ammonidium notatum* Zone.

Stratigraphic range. – Cambrian Series 3 – *Acadoparadoxides oelandicus* Zone.

Granomarginata squamacea Volkova, 1968

Pl. XVII, Figs. 3, 4, 14

Synonymy. – See M. Moczydłowska, 1991, p. 57.

Additionally:
1983 *Granomarginata squamacea* Volkova; N.A. Volkova *et al*., pl. XVIII:5–9.
1992 *Granomarginata squamacea* Volkova; M. Moczydłowska, G. Vidal, p. 27, figs 4:f, g; 7.
1992 *Granomarginata squamacea* Volkova; T. Palacios, G. Vidal, pp. 425, 432.
1994 *Annulum squamaceum* (Volkova) Martin *in* Martin et Dean, 1983; F. Martin *in* T. Young *et al*., p. 339.
1995 *Granomarginata squamacea* Volkova; G. Vidal *et al*., fig. 6:1.
1996 *Granomarginata squamacea* Volkova; M. Jachowicz *in* Z. Buła, M. Jachowicz, pl. II:5, 7.

1997 *Annulum squamaceum* (Volkova) Martin; M. Jachowicz, A. Přichystal, p. 330, pl.:1.
1997 *Annulum squamaceum* (Volkova) Martin 1983; F. Martin *in* W.T. Dean *et al*., p. 49, fig. 8:o.
1998 *Annulum squamaceum* (Volkova 1968) Martin 1983; O. Fatka, M. Vavrdová, p. 55.
1998 *Granomarginata squamacea* Volkova; M. Moczydłowska, pp. 29–31, 70, figs. 14–16, 29:A–D.
1998 *Granomarginata squamacea* Volkova; T. Palacios, M. Moczydłowska, figs. 3, 9:G.
2000 *Granomarginata squamacea* Volkova; Z. Szczepanik, tabl. 1.
2001 *Granomarginata squamacea*; M. Moczydłowska *et al*., pp. 439–441.
2001 *Granomarginata squamacea* Volkova; M. Vavrdová, J. Bek, p. 119, tab. 1.
2002 ?*Granomarginata squamacea* Volkova; M. Vanguestaine *et al*., pp. 57, 63, 68, 69, figs. 3–5, pl. III:4.
2002 *Granomarginata squamacea* Volkova; M. Moczydłowska, pp. 201, 204, figs. 4, 9:2, 4.
2004 *Granomarginata squamacea* Volkova; P.M. Brück, M. Vanguestaine, p. 207, figs. 4:1; 3, 9.
2008 *Granomarginata squamacea* Volkova; M. Vanguestaine, P.M. Brück, pp. 80, 86, 87, figs. 4–6, pl. 2:9.
2008 *Annulum squamaceum* (Volkova) emend. Martin *in* Martin and Dean; M. Vecoli *et al*., pp. 59, 60, fig. 3, pl. 1:11.
2009 *Granomarginata squamacea*; A. Żylińska, Z. Szczepanik, text-fig. 9.
2010b *Granomarginata squamacea* Volkova; M. Jachowicz-Zdanowska, fig. 4, tabl. VIII:3.
2011 *Granomarginata squamacea* Volkova; M. Moczydłowska, pp. 127–129, pl. 7:1–4.
2011 *Granomarginata squamacea* Volkova; M. Jachowicz-Zdanowska, figs. 5, 6:I, J; 7:B.

Material. – Over 300 variously preserved specimens.

Dimensions. – Diameter of the external vesicle 10–150 µm, diameter of the internal vesicle 10–50 µm.

Remarks. – The species is commonly encountered in Cambrian sediments. In the Brunovistulicum, it appears in all acritarch zones recognised. The specimens of this species, from the Brunovistulicum demonstrate some morphologic differentiation, first of all in the construction of the zone enclosing the internal vesicle. Some forms have distinctly spongy zone (Pl. XVII, Figs. 3, 4) others have an envelope structured similarly as the internal vesicle (Pl. XVII, Fig. 14). The discussed taxon has a long stratigraphic range, therefore, it has been decided that, at the moment, there is no need for any subdivision of this taxon.

Present record. – Poland, Upper Silesian Block, Borzęta IG 1, Chrząstowice, WB 137, WB 141, Rajbrot 1, Rajbrot 2, Wiśniowa 3, Wiśniowa 6, Wiśniowa IG 1, Trojanowice, Kęty 8, Kęty 9, Klucze 1, Kozy Mt 3, Andrychów 3, Głogoczów IG 1, Goczałkowice IG 1, Sułoszowa, Piotrowice 1 boreholes, Borzęta Formation: Myślenice, Osieczany and Rajbrot members; BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites* Zone; Goczałkowice Formation: Głogoczów, Pszczyna members; BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum*, BAMA IV *Skiagia–Eklundia campanula*, BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones; Sosnowiec Formation: BAMA VII *Ammonidium bellulum–Ammonidium notatum*, BAMA VIII *Turrisphaeridium semireticulatum semireticulatum* and BAMA IX *Adara alea–Multiplicisphaeridium llynense* zones; Czech Republic, Brno Block, Měnín 1, Němčičky 3, Němčičky 6 boreholes; BAMA II *Asteridium tornatum–Comasphaeridium velvetum*, BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum*, BAMA IV *Skiagia–Eklundia campanula*, BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera –Liepaina plana* zones.

Stratigraphic range. – Terreneuvian – *Platysolenites* Zone, Cambrian Series 2 – *Schmidtiellus*, Holmia, *Protolenus* zones, Cambrian Series 3 – *Acadoparadoxides oelandicus*, *Paradoxides paradoxissimus* zones.

Genus *Ichnosphaera* n.gen.

Type species. – *Ichnosphaera flexuosa* (Eklund, 1990) n.comb.

Derivation of name. – Greek *ichno* – trace, track, ichnofossils – trace fossils – the name refers to the trace fossils that are characteristic feature of the Głogoczów Member sediments in the Upper Silesian Block.

Diagnosis. – Acritarchs with circular or oval vesicle of unilayered, smooth wall. The vesicle surface bears occasionally densely set, slender processes usually of equal length. The processes are slightly widened at the base, and narrowing gradually toward their tips along the whole length. The distal process terminations are simple, very thin, capillary. The surface of the processes is smooth or covered with thin hairs. The processes appear to be hollow; the dark solid knob-like swelling are visible at the processes bases. The vesicle cavity does not communicate with the process interior. The opening structure of the „median split" type has been observed.

Remarks. – Observation in the transmitted light revealed dark and solid bases of the processes that gave an impression of the knob-like, round swellings within their proximal part. On the other hand, studies in the scanning microscope did not reveal the presence of any distinct swellings at the process bases that are only very slightly widened. To conclude, those knob-like swellings are located inside the vesicle wall, and not on its surface. Such fastening of the processes within the vesicle's wall reminds "hair bulb".

The new genus differs from *Skiagia* by thin, sharp, simple process terminations, whereas from *Elektoriskos* – by the fastening mode of the processes, and by their ornamentation of tiny hairs. Several species of *Ichnosphaera* n.gen., characterised by delicate, flexible processes, that occur in the study area, were earlier included in *Elektoriskos*, *Skiagia*, *Comasphaeridium,* or *Baltisphaeridium*.

In the Brunovistulicum, all species of *Ichnosphaera* occur exclusively in the bioturbated sandstones of the Goczałkowice Formation.

Ichnosphaera aranea n.sp.

Pl. VIII, Figs. 1–6; Pl. IX, Figs. 4, 6, 9, 10; Pl. X, Figs. 5, 10

2010b *Ichnosphaera* sp.; M. Jachowicz-Zdanowska, tabl. V:7, 13.

Derivation of name. – From Latin *aranea* – "cobweb", with reference to delicate processes.

Holotype. – Pl. VIII, Fig. 2; coll. OG 546/2013/prep. 3.
Locus typicus. – Poland, Upper Silesian Block, Kozy MT 3 borehole depth 1497.7 m.

Material. – Over 500 very well preserved specimens.

Diagnosis. – Acritarchs with circular or oval vesicle of unilayered wall. The vesicle surface is densely covered with very delicate processes of more or less equal length. The process length varies from 50–100% of the vesicle diameter. The vesicle surface is smooth or slightly wrinkled. The process surface is occasionally smooth but usually it is covered by delicate hairs. The processes are delicate, bent, slightly widened at the base. They are gradually narrowing towards the tips to form a capillary thinning. The processes appear to be hollow; the dark solid knob-like swelling are visible at the processes bases. There is no communication between the vesicle cavity and that of the processes. The opening structure is "median split".

Dimensions. – Diameter of vesicle 15–30 µm, length of processes 10–20 µm.

Remarks. – *Ichnosphaera aranea* differs from *Ichnosphaera flexuosa* by having much more delicate processes usually covered with tiny hairs that often catch small fragments of the organic matter.

Present record. – Poland, Upper Silesian Block, Andrychów 3, Głogoczów IG 1, Goczałkowice IG 1, Kęty 8, Kęty 9, Klucze 1, Kozy Mt 3, boreholes, Goczałkowice Formation: Głogoczów Member; BAMA III *Ichnosphaera flexuosa* –*Comasphaeridium molliculum* Zone.

Stratigraphic range. – Cambrian Series 2 – *Schmidtiellus*, ?*Holmia* zones.

Ichnosphaera delicata n.sp.

Pl. VI, 1–11

Derivation of name. – From Latin *delicatus* – delicate, gentle, soft, the name refers to the shape of the processes.
Holotype. – Pl. VI, Fig. 10; coll. OG 546/2013/prep. 1.
Locus typicus. – Poland, Upper Silesian Block, Kozy Mt 3 borehole, depth 1492.6 m.

non 1974 *Baltisphaeridium brachyspinosum* sp. nov.; V.V. Kirjanov, p. 120, 121, pl. 7:1.
1979 *Baltisphaeridium brachyspinosum* Kirjanov; N.A. Volkova *et al*., p. 8, pl. X:15.
1983 *Baltisphaeridium brachyspinosum* Kirjanov; N.A. Volkova *et al*., p.12, Pl. X:15.
1986 *Comasphaerdium* (= *Baltisphaeridium*) *brachyspinosum* (Kirj.); M. Moczydłowska, G. Vidal, p. 214, figs. 5, 7:8; 9:A, B.
1988 *Comasphaeridium brachyspinosum* (Kirjanov, 1974) comb.nov.; M. Moczydłowska, G. Vidal, p. 3, pl. 1:4.
1990 *Comasphaeridium brachyspinosum* (Kirjanov) Moczydłowska et Vidal; G. Vidal, J.S. Nystuen, p. 204, fig. 12:A.
1991 *Comasphaeridium brachyspinosum* (Kirjanov) Moczydłowska et Vidal; M. Moczydłowska, pp. 13, 33, 37–41, 43, 50, fig. 5, pl. 2:E.
1992 *Comasphaeridium brachyspinosum* (Kirjanov) Moczydłowska et Vidal; M. Moczydłowska, G. Vidal, p. 25, figs. 7; 8:c, d.
1994 *Comasphaeridium brachyspinosum* (Kirjanov) Moczydłowska et Vidal; M. Jachowicz, ryc. 2:15.
1994 *Filisphaeridium brachyspinosum* (Kirjanov, 1974) comb. nov.; W.A.S. Sarjeant, R.P.W. Stancliffe, p. 29.
2000 *Comasphaeridium brachyspinosum* (Kirjanov) Moczydłowska et Vidal; N.M. Talyzina, M. Moczydłowska, pp. 3, 5, 7, 9, 13, 15, fig. 16, 18, 19, pl. 2:5–7.
2001 *Comasphaerdium brachyspinosum*; M. Moczydłowska *et al*., p. 439.
2001 *Comasphaeridium brachyspinosum* (Kirjanov) Moczydłowska et Vidal; M. Vavrdová, J. Bek, tab.1.
2002 *Comasphaeridium brachyspinosum* (Kirjanov) Moczydłowska et Vidal; M. Moczydłowska, p. 196, fig. 4.
2009 *Comasphaeridium brachyspinosum* (Kirjanov) Moczydłowska et Vidal; M. Moczydłowska, S. Willman, p. 31, fig. 1.
2009 *Comasphaeridium brachyspinosum*; Z. Szczepanik, fig. 2.
2010b *Comasphaeridium brachyspinosum* (Kirjanov) Moczydłowska et Vidal; M. Jachowicz-Zdanowska, fig. 4, tabl. V1, 2, 8–10, 12.
2011 *Comasphaeridium brachyspinosum* (Kirjanov) Moczydłowska et Vidal; M. Moczydłowska, pl. 3:6.
? 2011 *Comasphaeridium molliculum* Moczydłowska, 1988; M. Moczydłowska, p. 122, 123, pl. 3:1, 2.
2011 *Comasphaeridium brachyspinosum* (Kirjanov) Moczydłowska et Vidal; M. Jachowicz-Zdanowska, figs. 5, 6:K.

Material. – Over 500 well preserved specimens.

Description. – Acritarchs with circular or oval vesicle of unilayered wall. The vesicle surface is quite densely covered with short, delicate, hairy processes of more or less equal length not exceeding 30% of the vesicle diameter. The processes are narrowing gradually toward the tips, and sharply ended. The processes appear to be hollow; the dark solid knob-like swelling are visible at the processes bases. There is no communication of the vesicle cavity with that of the processes. The opening structure is made by "median split".

Dimensions. – Diameter of vesicle 20–30 µm, length of processes 5–10 µm.

Remarks. –The species name *brachyspinosum* was first used by Kirjanov (1974) for *Baltisphaeridium brachyspinosum*, described from the Lower Cambrian sediments of Ukraine (Kirjanov, 1974). The specimens of that species presented subsequently by Volkova *et al*. (1979, 1983) differ, however, distinctly from the holotype. Moczydłowska and Vidal (1988) proposed a new combination assignig *B. brachyspinosum* to *Comasphaeridium* – The new taxon diagnosis and presented holotype differed from the *B. brachyspinosum* sensu Kirjanov, 1974 holotype because the characteristic features of the latter were the clubby, drawing-pin-like processes, which are lacking in *Comasphaeridium brachyspinosum* sensu Moczydłowska et Vidal, 1988. The widened, funnel-shaped processes of *B. brachyspinosum* sensu Kirjanov, 1974 are typical of *Skiagia*. According to the author of the present paper, the specimen representing *B. brachyspinosum* Kirjanov (1974) is an earlier synonym of *Skiagia brevispinosa* Downie (1982). Therefore, the new combination *Skiagia brachyspinosa* (Kirjanov, 1974) n. comb. has been suggested in the present paper. However, for acritarchs described as *Comasphaeridium brachyspinosum* (Moczydłowska, Vidal, 1988) new species name "*delicata*" is proposed. The morphological characteristics of this species justifies inclusion in the new genus *Ichnosphaera* n.gen.

Present record. – Poland, Upper Silesian Block, Andrychów 3, Głogoczów IG 1, Goczałkowice IG 1, Kęty 8, Kęty 9, Klucze 1, Kozy Mt 3, Piotrowice 1, Sułoszowa, boreholes, Goczałkowice Formation: Głogoczów and Pszczyna members; BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* and BAMA IV *Skiagia–Eklundia campanula* zones; Czech Republic, Brno Block, Měnín 1, Němčičky 3, boreholes: BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* Zone.

Stratigraphic range. – Cambrian Series 2 – *Schmidtiellus*, *Holmia, Protolenus* zones.

Ichnosphaera flexuosa (Eklund, 1990) n.comb.

Pl. VII, Figs. 1, 3; Pl. IX, Figs. 5, 11; Pl. X, Figs. 1–4, 6–9

Basionym: 1990 *Elektroriskos flexuosus* sp. nov.; C. Eklund, p. 36, fig. 10:C.

1986 *Skiagia ornata* type 1; M. Moczydłowska, Vidal, figs. 7, 11:C, D.
1996 *Elektoriscos flexuosus* sp. nov.; G. Vidal, M. Moczydłowska, p. 163.
non 2004 *Elektoriskos flexuosus* Eklund, 1990; P.M. Brück, M. Vanguestaine, p. 207, figs. 3:15, 18: 8.
2010b *Ichnosphaera* n. sp.; M. Jachowicz-Zdanowska, fig. 4, tabl. V:3, 11.
2011 *Ichnosphaera* n. sp.; M. Jachowicz-Zdanowska, figs. 5, 6:M.

Material. – Over 100 well preserved specimens.

Description. – Acritarchs with circular or oval vesicle of unilayered wall. The vesicle surface is densely covered with processes of more or less equal length. The process length is equal to or exceeding the vesicle diameter. The vesicle surface is smooth, occasionally slightly wrinkled. The process surface is smooth or covered with delicate hairs. The processes are delicate, bent, more massive at the base, narrowing gradually toward the tips, up to a capillary thinning. The process bases are solid and distinctly darker with visible knob-like swelling. There is no communication between the vesicle cavity and that of the processes. The opening structure consists of "median split."

Dimensions. – Diameter of vesicle 20–45 µm, length of processes 10–25 µm.

Remarks. – This species was first described as *Skiagia* type 1 (Moczydłowska, Vidal, 1986), and later as *Electoriscos flexuosus* (Eklund, 1990). The character of the processes justifies their inclusion to *Ichnosphaera* n.gen.

Present record. – Poland, Upper Silesian Block, Głogoczów IG 1, Goczałkowice IG 1, Klucze 1, Sułoszowa boreholes, Goczałkowice Formation: Głogoczów Member; BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* Zone.

Stratigraphic range. – Cambrian Series 2 – *Schmidtiellus*, ?*Holmia,* ?*Protolenus* zones.

Ichnosphaera robusta n.sp.

Pl. VII, Figs. 2, 4; Pl. IX, Figs. 7, 8

Derivation of name. – From Latin *robustus* – robust, the name refers to the shape of the robust shape of the vesicle.
Holotype. – Pl. VII, Fig. 2; coll. OG 546/2013/prep. 3.
Locus typicus. – Poland, Upper Silesian Block, Goczałkowice IG 1 borehole, depth 2984.0 m.

2004 *Elektoriskos flexuosus* Eklund, 1990; P.M. Brück, M. Vanguestaine, p. 207, figs. 3:15, 18; 8.

Material. – Over 40 variously preserved specimens.

Diagnosis. – Acritarchs with circular or oval vesicle of unilayered wall. The vesicle surface bears quite massive, flexible, discrete processes. The distance between processes often exceeds 10 µm. The processes length equals 80–100% of the vesicle diameter. The vesicle surface is smooth or slightly wrinkled, that of the processes is smooth. The processes are more massive at the base, narrowing gradually towards the tips, up to capillary thinning. The process bases are solid and distinctly darker with visible knob-like swelling. There is no communication between the vesicle cavity and that of the processes. The opening structure is a "median split."

Dimensions. – Diameter of vesicle 15–25 µm, length of processes 10–25 µm.

Remarks. – *Ichnosphaera robusta* differs from other species of *Ichnosphaera* by being smaller and by the number, distribution, and character of the processes. The diameter of the encountered specimens of this species, without processes, rarely exceeds 20 µm.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Sułoszowa boreholes, Goczałkowice Formation: Głogoczów Member; BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* Zone.

Stratigraphic range. – Cambrian Series 2 – *Schmidtiellus*, *Holmia* Zone.

Ichnosphaera stipatica (Hagenfeldt, 1989) n.comb.

Pl. VII, Figs. 5, 6

Basionym: 1989a *Baltisphaeridium stipaticum* Hagenfeldt; S.E. Hagenfeldt, pp. 24–26, pl. 1:7.

? 2011 *Comasphaeridium molliculum* Moczydłowska, 1988; M. Moczydłowska, pl. 4:1–6.

Material. – Over 300 well preserved specimens.

Description. – Acritarchs with circular or oval vesicle of unilayered wall. The vesicle surface is quite densely covered with hairy processes of more or less equal length not exceeding one-half of the vesicle diameter. The processes are narrowing gradually toward the tips, and sharply ended. The processes appear to be hollow; the dark solid knob-like swelling are visible at the processes bases. There is no communication of the vesicle cavity with that of the processes. The excystment structure not observed.

Dimensions. – Diameter of vesicle 20–44 µm, length of processes 5–12 µm.

Remarks. – Morphology of the processes and the manner of their attachment to the vesicle wall justifies the transfer of the species to *Ichnosphaera*. *I. aranea*, *I. flexuosa*, and *I. robusta* possess distinctly longer processes, whereas processes *I. delicata* are thinner, more delicate, and usually shorter.

Present record. – Upper Silesian Block, Andrychów 3, Głogoczów IG 1, Goczałkowice IG 1, Kęty 8, Kęty 9, Kozy Mt 3, Piotrowice 1, Sułoszowa boreholes, Goczałkowice Formation: Głogoczów Member; BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* Zone.

Stratigraphic range. – Cambrian Series 2 – *Schmidtiellus*, ?*Holmia* zones.

Genus *Lechistania* n.gen.

Type species: *Lechistania magna* n.sp.

Derivation of name. – *Lechistan* = Poland, country at the Vistula river, an older name of Poland, still being used in several languages of Eastern Europe and in the Near East countries.

Lechistania magna n.sp.

Pl. XI, Figs. 1–7

Derivation of name. – From Latin *magnus* – big, great, with reference to the size of specimens.
Holotype. – Pl. XI, Fig. 4; coll. OG 546/2013/prep. 1.
Locus typicus. – Poland, Upper Silesian Block, Kozy Mt 3 borehole, depth 1497.9 m.

Material. – Over 60 well preserved specimens.

Diagnosis. – Acritarchs with vesicle of circular, rarely oval outline, with unilayered wall. Central part of the vesicle is distinctly thicker. In the equatorial zone, it continues as irregular, thinner, membrane-like, frayed zone. The vesicle surface is smooth or covered with swellings. The surface of the membrane-like zone is smooth. No opening structure observed.

Dimensions. – Diameter of the internal vesicle 20–40 µm, diameter of the external zone 10–20 µm.

Remarks. – Those characteristic acritarchs representing the new genus have been encountered exclusively in samples from Kozy Mt 3 borehole where they occurred at the depth of 1497.9 m. They are quite abundant from several to a dozen or so specimens in a standard microscope slide.

Present record. – Poland, Upper Silesian Block, Kozy Mt 3 borehole, Goczałkowice Formation: Głogoczów Member; BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* Zone.

Stratigraphic range. – Cambrian Series 2 – *Schmidtiellus* Zone.

Genus *Leiovalia* Eisenack, 1965

Type species: *Leiofusa* (=*Leiovalia*) *ovalis*, Eisenack, 1938

Leiovalia sp.

Pl. II, Fig. 10

Material. – Over 50 variously preserved specimens.

Description. – Large acritarchs with vesicle of fairly broad ellipse shape.

Dimensions. – The length of vesicle 100–200 µm, and its width 50–80 µm

Present record. – Poland, Upper Silesian Block, Borzęta IG 1, Chrząstowice, Rajbrot 1, Rajbrot 2, Trojanowice, WB 137, WB 147 boreholes, Borzęta Formation: Myślenice, Osieczany, Rajbrot members; BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites* Zone.

Stratigraphic range. – Cambrian – Terreneuvian – *Platysolenites* Zone.

Genus *Multiplicisphaeridium* (Staplin, 1961) Lister, 1970

Type species: *Multiplicisphaeridium ramispinosum* Staplin, 1961

Multiplicisphaeridium llynense (Martin, 1994) n.comb.

Pl. XXXIII, Figs. 9, 11–16

Basionym: 1994 *Heliosphaeridium* ?*llynense* Martin sp.nov.; M. Martin *in* T. Young *et al*., pp. 355, 356, fig. 11:b, g, h, j, k, o, q.

Material. – Over 100 well preserved specimens.

Description. – Acritarchs with oval or circular vesicle, with unilayered, smooth wall bearing slender, flexible, heteromorphic processes. The length of the processes varies from one-half to one and half of the vesicle diameter. Length of majority of the processes equals or slightly exceeds the vesicle diameter. The process bases are variable: poorly outlined, only slightly widened, or distinct, wide, and conical. That feature depends probably on preservation. The process terminations are also variable: straight and sharp or bifurcate. The arms of bifurcations are short, from 3 to 4 µm. The processes are hollow and connected freely with the inner cavity of the vesicle.

Dimensions. – Diameter of vesicle 9–25 µm, length of processes 4–11 µm.

Remarks. – Originally, the processes have been described as possessing multi-ordered modes (up to four) of terminal branching (Martin *in*:Young *et al*., 1994). However, there exists a clear discrepancy between the taxon description and illustrations where that feature is not presented. All the observed specimens possess straight and weekly branched process terminations.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA IX *Adara alea–Multiplicisphaeridium llynense* Zone.

Stratigraphic range. – Cambrian 3 – *Paradoxides paradoxissimus* Zone.

Multiplicisphaeridium xianum Fombella, 1977

Pl. XVIII, Figs. 9–13

Synonymy. – See M. Moczydłowska, 1998, pp. 88, 89.

Additionally:
1996 *Multiplicisphaeridium dendroideum* (Jankauskas) Jankauskas et Kirjanov; M. Jachowicz *in* Z. Buła, M. Jachowicz, Pl. II:10, 11.
1997 *Multiplicisphaeridium dendroideum* (Jankauskas) Jankauskas et Kirjanov, 1983; M. Jachowicz, A. Přichystal, p. 330, pl. 1:7.
1998 *Multiplicisphaeridium xianum* Fombella; M. Moczydłowska, pp. 25, 29, 30, 88–90, Figs. 14–16, 34:D–F.
2000 *Multiplicisphaeridium dendroideum* (Jankauskas); Z. Szczepanik, tabl. 1.
2001 *Multiplicisphaeridium dendroideum* = *M. xianum*; M. Moczydłowska *et al*., p. 441.
2009 *Multiplicisphaeridium dendroideum*; Z. Szczepanik, fig. 2.
2009 *Multiplicisphaeridium xianum*; A. Żylińska, Z. Szczepanik, text-fig. 9.
2010b *Multiplicisphaeridium xianum* Fombella; M. Jachowicz-Zdanowska, fig. 4, tabl. IV:8.

Material. – Over 100 variously preserved specimens.

Dimensions. – Diameter of vesicle 15–20 µm, length of processes 7–15 µm.

Remarks. – In the material studied, specimens with the clear round, oval polygonal vesicle were observed. Individual specimens also differ in the degree of branching of the processes, but are in this work classified as one species. This highly morphologically differentiated acritarch group certainly requires further detailed taxonomic studies.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Klucze 1, Piotrowice 1, Sułoszowa boreholes, Goczałkowice Formation: Pszczyna Member; BAMA IV *Skiagia–Eklundia campanula* and BAMA V *Skiagia–Eklundia varia* zones; Czech Republic, Brno Block, Měnín 1, Němčičky 3, boreholes; BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones.

Stratigraphic range. – Cambrian Series 2 and Series 3 – *Eccadoparadoxides paradoxissimus* Zone.

Genus *Navifusa* (Combaz, Lange et Pansart, 1967) Eisenack *et al*., 1976

Type species: *Bion navis* Eisenack, 1938

Navifusa sp.

Pl. II, Figs. 3–7

Material. – 25 fairly well preserved specimens.

Description. – Large acritarchs with thin wall and a characteristic shape of a strongly elongated ellipse.

Dimensions. – Diameter of vesicle 50–150 µm, vesicle width 5–15 µm.

Remarks. – Only single specimens have been encountered within the investigated area.

Present record. – Poland, Upper Silesian Block, Borzęta IG 1, Chrząstowice, Rajbrot 1, Rajbrot 2, Trojanowice, Wiśniowa IG 1 boreholes, Borzęta Formation: Myślenice, Osieczany, Rajbrot members; BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites* Zone.

Stratigraphic range. – Cambrian – Terreneuvian – *Platysolenites* Zone.

Genus *Parmasphaeridium* n.gen.

Type species. – *Parmasphaeridium implicatum* n.sp.

Derivation of name. – Latin *parma* – small round shield, *parmatus* means – armed with small round shields.

Diagnosis. – Acritarchs with distinctly outlined, darker, opaque, circular or oval vesicle. The vesicle is densely covered by heteromorphic, membranous, transparent processes of various length. The processes are straight, thin, short or long. They are mostly confined to the vesicle equatorial zone. The vesicle surface is smooth or granular, the process surface is smooth. There is no communication of the vesicle cavity with that of the processes. No opening structure observed.

Remarks. – The type species of this genus was earlier classified as *Baltisphaeridium implicatum* (Fridrichsone, 1971), *Goniosphaeridium implicatum* (Downie, 1982), *Polygonium implicatum* (Sarjeant, Stancliffe, 1994), or recently as *Solisphaeridium implicatum* (Moczydłowska, 1998). According to the present author, the characteristic morphological features of this taxon and related forms justify the creation of the new genus to include these disputable forms that display no similarities to other acritarch taxa known so far.

Parmasphaeridium implicatum (Fridrichsone, 1971) n.comb.

Pl. XXI, Figs. 7–10, 12

Basionym: 1971 *Baltisphaeridium implicatum* Fridrichsone sp.nov.; A.I. Fridrichsone, pp. 11, 12, pl. III:7.

1969b *Baltisphaeridium* sp. 1; N.A. Volkova, p. 226, pl. XLIX:20.
1971 *Baltisphaeridium implicatum* Fridrichsone sp. nov.; A.I. Fridrichsone, pp. 11, 12, pl. III: 8–14.
nomen nudum 1979 *Comasphaeridium piliferum* n. sp.; M.A. Fombella pls. 4:66; 5:80.
non 1982 *Goniosphaeridium implicatum* (Fridrichsone) comb. nov.; C. Downie, p. 278, fig. 10:v–x.
1983 *Baltisphaeridium implicatum* Fridrichsone; N.A. Volkova *et al*., p. 14, pl. IV:5, 6.
1986 *Goniosphaeridium implicatum* (Frid.); M. Moczydłowska, G. Vidal, fig. 5.
1987 *Baltisphaeridium implicatum* Fridrichsone; A.H. Knoll, K. Swett, p. 915, fig. 7.7.
? 1989a *Baltisphaeridium implicatum* Fridrichsone; S.E. Hagenfeldt, pp. 21–24, pl. 1:5.
1991 *Goniosphaeridium implicatum* (Fridrichsone) Downie; M. Moczydłowska, pp. 15, 41, 55, fig. 5, pl. 10: A.
non 1992 *Goniosphaeridium* cf. *implicatum* (Fridrichsone) *sensu* Downie, 1982; W. Zang, p. 101, Pl. 3:C, D (note misprint on p. 101, as pl. 2:C, D).
1994 *Polygonium implicatum* (Fridrichsone, p. 11, 12, pl. 3, figs. 7–14) comb.nov.; W.A.S. Sarjeant, R.P.W. Stancliffe, p. 43.
1994 *Polygonium implicatum* (Fridrichsone, p. 11, 12, pl. 3, figs 7–14) comb.nov.; W.A.S. Sarjeant, R.P.W. Stancliffe, p. 43.
1998 *Solisphaeridium implicatum* (Fridrichsone) n.comb.; M. Moczydłowska, pp. 25, 30, 31, 104, 105, figs. 14–16; 44:A–D.

2001 *Goniosphaeridium* (= *Solisphaeridium*) *implicatum*; M. Moczydłowska *et al*., p. 441.
2001 *Goniosphaeridium implicatum* (Fridrichsone) Downie 1982; M. Vavrdová, J. Bek, p. 118, tab. 1.
2010b *Solisphaeridium implicatum* (Fridrichsone) Moczydłowska; M. Jachowicz-Zdanowska, fig. 4, tabl. VIII: 4.
2011 *Solisphaeridium implicatum* (Fridrichsone) Moczydłowska; M. Jachowicz-Zdanowska, fig. 7:D, E.

Material. – Over 100 variously preserved specimens.

Description. – Acritarchs with circular or oval bilayered vesicle. The internal wall is distinctly outlined, thick, dark, and opaque, the external one is thin and transparent. Numerous processes project from that wall. Majority of them are shaped as thicker or thinner needles. The processes tips are uneven, cut aslant, bluntly or sharply ended. The process length varies, from one-fourth to three quarters of the vesicle diameter, processes of a given specimen are of uneven length. The vesicle surface is smooth or slightly granular, the processes are smooth. There is no communications between the internal vesicle cavity and that of the processes.

Dimensions. – Diameter of vesicle 10–20 µm, length of processes 7–20 µm.

Remarks. – The processes are hardly visible on the vesicle surface, they are mostly confined to the equatorial zone, possibly they are developed on one hemisphaere only.

Present record. – Poland, Upper Silesian Block, Poland, Goczałkowice IG 1, Klucze 1, Sułoszowa, Jarząbkowice 1, Sosnowiec IG 1 boreholes, Goczałkowice Formation: Pszczyna and Jarząbkowice members, BAMA V *Skiagia–Eklundia varia* and *Volkovia dentifera–Liepaina* plana zones; Sosnowiec Formation: BAMA VII *Ammonidium bellulum–Ammonidium notatum*, BAMA VIII *Turrisphaeridium semireticulatum* and BAMA IX *Adara alea–Multiplicisphaeridium llynense* zones; Czech Republic, Brno Block, Měnín 1, Němčičky 3, Němčičky 6 boreholes; BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones.

Stratigraphic range. – Cambrian Series 2 – *Holmia*, *Protolenus* Zones, Cambrian Series 3 – *Acadoparadoxides oelandicus*, *Paradoxides paradoxissimus* zones.

Parmasphaeridium robustispinosum n.sp.

Pl. XXI, Figs. 1–6

Derivation of name. – Latin *robustum* (= robust) in reference to massive and short processes shapes.
Holotype. – Pl. XXI, Fig. 6; coll. OG 546/2013/prep. 3.
Locus typicus. – Poland, Upper Silesian Block, Goczałkowice Formation, Sułoszowa borehole, depth 199.1 m.

Material. – Over 200 variously preserved specimens.

Diagnosis. – Acritarchs with circular or oval vesicle, with bilayered wall. The inner wall is distinctly outlined, dark, and opaqueI, the external one is thin and transparent. Sharply or bluntly ended processes project from the vesicle surface. The processes rary in length, from one-fourth to one-half of the internal vesicle diameter, processes of a given specimen are of inequal length. The surface of the internal wall is smooth or slightly granular, and that of the processes is smooth. The processes are hollow and there is no communications between vesicle internal cavity and that of the processes.

Dimensions. – Diameter of vesicle 10–20 µm, length of processes 5–10 µm.

Remarks. – The *Parmasphaeridium robustispinosum* differs from the *Parmaspheridium implicatum* by much shorter processes. The author of the present paper decided to create the new species because in the study area it has a very short extent within the Cambrian.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Sułoszowa boreholes, Goczałkowice Formation: Pszczyna Member; BAMA IV *Skiagia–Eklundia campanula* Zone.

Stratigraphic range. – Cambrian Series 2 – *Holmia* Zone.

Parmasphaeridium sp.

Pl. XXI, figs. 11, 13, 14

Material. – Over 50 well preserved specimens.

Diagnosis. – Acritarchs with circular or oval bilayered vesicle. with the internal wall is distinctly outlined, thick, dark, and opaqueI, the external one is thin and transparent. Very thin, needle-like, straight, sharply or bluntly ended processesproject from vesicle wall. The processes rary in length from very short – about one-fourth of the internal vesicle diameter, up to the long ones, much exceeding the length of that diameter. Processes of inequal length appear on a given specimen. The internal vesicle surface is smooth or slightly granular; that of the processes is smooth. There is no communication between the vesicle cavity and that of the processes.

Dimensions. – Diameter of vesicle 15–30 µm, length of processes 7–18 µm.

Remarks. – In this paper, they have been classified to the genus level only, because they are slightly similar to the *P. implicatum* forms.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA VIII *Turrisphaeridium semireticulatum* and BAMA IX *Adara alea–Multiplicisphaeridium llynense* zones.

Stratigraphic range. – Cambrian Series 3 – *Paradoxides paradoxissimus* Zone.

Genus *Pseudotasmanites* Kirjanov, 1974

Type species: *Pseudotasmanites parvus* Kirjanov, 1974

Pseudotasmanites sp.

Pl. III, Figs. 3, 5–8

2010b *Tasmanites* sp. – M. Jachowicz-Zdanowska, tabl. IV: 4, 6, 7.

Material. – Over 300 variously preserved specimens.

Description. – Acritarchs with circular or oval vesicle which is dark, thick, and perforated by irregular irregular holes.

Dimensions. – Diameter of vesicle 100–500 μm.

Remarks. – It is not quite clear at the moment whether the holes of the wall are the original or secondary feature.

Present record. – Poland, Upper Silesian Block, Borzęta IG 1, Trojanowice, Rajbrot 1, Rajbrot 2 boreholes, Borzęta Formation: Myślenice, Osieczany and Rajbrot members; BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites* Zone.

Stratigraphic range. – Terreneuvian – *Platysolenites* Zone.

Genus *Pterospermella* Eisenack, 1972

Type species: *Pterospermella aureolata* (Cookson et Eisenack) Eisenack, 1972.

Pterospermella gigantea n.sp.

Pl. IV, Figs. 16, 17

Derivation of name. – From Latin *giganteus*, *-a*, *-um* – with reference to specimens size.
Holotype. – Pl. IV, Fig. 16; coll. OG 546/2013/prep. 2.
Locus typicus. – Poland, Upper Silesian Block, Kozy Mt 3 borehole, depth 1492.8 m.

Material. – Over 40 well preserved specimens.

Diagnosis. – Acritarchs with circular or oval vesicle consisting of massive, internal part, and of external areola. The external envelope is delicate, transparent, occasionally irregularly wrinkled. No opening structure observed.

Dimensions. – Diameter of the internal vesicle 100–150 μm, diameter of the external zone 10–25 μm.

Remarks. – The species differs distinctly from *Pterospermella velata* by much bigger size.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Kozy Mt 3 boreholes, Goczałkowice Formation: Głogoczów Member; BAMA III *Ichnosphaera flexuosa –Comasphaeridium molliculum* Zone.

Stratigraphic range. – Cambrian Series 2 – *Schmidtiellus*, *Holmia* zones.

Pterospermella inordinata n.sp.

Pl. XVII, Figs. 5–10

2010b *Pterospermella* sp.; M. Jachowicz-Zdanowska, tabl. VII:4.

Derivation of name. – From Latin *inordinatus, -a, -um* – disordered.
Holotype. – Pl. XVII, Fig. 8; coll. OG 546/2013/prep. 1.
Locus typicus. – Poland, Upper Silesian Block, Sułoszowa borehole, depth 199.1 m.

Material. – Over 500 variously preserved specimens.

Diagnosis. – Acritarchs with circular or oval vesicle consisting of a central vesicle very densely covered by hairy processes, placed within membrane-like or rather in spongy areola. Hairy processes are best visible in the area beyond the vesicle. The margin of specimens is uneven, often shredded. The process length equals about one-half of the central vesicle diameter.

Dimensions. – Diameter of vesicle 15–30 μm, length of processes 7–15 μm.

Remarks. – The species does not resemble, other acritarch taxa described so far. It differs from *Pterospermella vitalis* Jankauskas by larger number of the hairy processes, and by their length.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Sułoszowa, boreholes, Goczałkowice Formation: Pszczyna Member; BAMA IV *Skiagia–Eklundia campanula* Zone.

Stratigraphic range. – Cambrian Series 2 – *Holmia* Zone.

Genus *Pterospermopsimorpha* Timoffeev, 1966

Type species: *Pterospermopsimorpha pileiformis* Timoffeev, 1966

Pterospermopsimorpha rugulosa n.sp.

Pl. XVII, figs. 11–13

2010b *Pterospermopsimorpha* sp.; M. Jachowicz-Zdanowska, tabl. VIII:1, 2.

Derivation of name. – From Latin – *rugosus* – wrinkled
Holotype. – Pl. XVII, Fig. 13; coll. OG 546/2013/prep. 3.
Locus typicus. – Poland, Upper Silesian Block, Goczałkowice Formation, Klucze 1 borehole, depth 1680.0–1690.0 m.

Material. – Over 500 variously preserved specimens.

Diagnosis. – Acritarchs of circular or oval outline, with double wall. The internal vesicle is distinctly outlined, thicker and darker. It is enveloped by a thinner, membrane-like, transparent external wall, on which massive and irregular wrinkles are visible. The internal vesicle surface is smooth, the external vesicle is often rugged. No opening structure observed.

Dimensions. – Diameter of the external vesicle 40–70 μm, of the internal vesicle 20–50 μm.

Remarks. – The new species differs from *Pterospermopsimorpha wolynica* (Kirjanov, 1974) described from the Lower Cambrian by more massive construction and stronger folding of the external coat. That folding is rather an original feature, and not caused by poor preservation. That species occurs very abundantly in samples from the Pszczyna Member – over 50 specimens in a standard microscope slide.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Klucze 1, Piotrowice 1, Sułoszowa, Jarząbkowice 1, boreholes, Goczałkowice Formation: Pszczyna and Jarząbkowice members; BAMA IV *Skiagia–Eklundia campanula*, BAMA V *Skiagia–Eklundia varia* nad BAMA VI

Volkovia dentifera–Liepaina plana zones; Czech Republic, Brno Block, Měnín 1, Němčičky 3, Němčičky 6 boreholes: BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones.

Stratigraphic range. – Cambrian Series 2 – *Holmia*, *Protolenus* zones.

Pterospermopsimorpha sp.

Pl. I, Figs. 1, 2, 4–6, 8–11

2010b *Granomarginata* sp.; M.Jachowicz-Zdanowska, tabl. I:1, 2, 4
2010b *Disphaeromorphitae* Downie, Evitt, Sarjeant, 1963; M. Jachowicz-Zdanowska, tabl. I: 8.
2010b *Pterospermopsimorpha* sp.; M. Jachowicz-Zdanowska, tabl. I: 5, 6, 9–11.

Materiał. – Over 100 variously preserved specimens.

Description. – Acritarchs with circular or oval outline, bilayered. Distinctly outlined, thicker and darker internal vesicle is encircled by a thinner, membrane-like, transparent external one.

Dimensions. – Diameter of the external vesicle 30–60 μm, of the internal one 20–50 μm.

Remarks. – It differs from *P. rugulosa* by simpler construction, and smaller size. The stratigraphic extent is also different – the described form has been encountered in the Borzęta Formation only.

Present record. – Poland, Upper Silesian Block, Wiśniowa IG 1, 3, 6, Trojanowice boreholes, Borzęta Formation: Myślenice and Osieczany members; BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites* Zone.

Stratigraphic range. – Terreneuvian – *Platysolenites* Zone.

Genus *Pulvinosphaeridium* (Eisenack, 1954) Deunff, 1954

Type species: *Pulvinosphaeridium pulvinellum* Eisenack, 1954

Pulvinosphaeridium antiquum Paškevičiene, 1979

Pl. II, Figs 1, 2

1980 *Pulvinosphaeridium antiquum*, sp.nov.; L.T. Paškevičiene, p. 32, figs. 1, 8:1–8.
2010b *Pulvinosphaeridium antiquum*; M. Jachowicz-Zdanowska, fig. 4.

Material. – 20 fairly well preserved specimens.

Dimensions. – Diameter of vesicle 100–250 μm.

Remarks. – In the study area, only single specimens of that species have been encountered.

Present record. – Poland, Upper Silesian Block, Borzęta IG 1, Trojanowice, Rajbrot 1, Rajbrot 2 boreholes, Borzęta Formation: Myślenice, Osieczany and Rajbrot members; BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites* Zone.

Stratigraphic range. – Terreneuvian – *Platysolenites* Zone.

Pulvinosphaeridium sp.

Pl. II, Fig. 8

Material. – 10 fairly well preserved specimens.

Description. – Acritarchs with rectangular outline, with slightly darker and more massive internal part, and with distinctly thinner, tight outer wall repeating the outline of the central vesicle.

Dimensions. – Diameter of the internal vesicle 100–150 μm, of the external zone 10–25 μm.

Remarks. – Within the study area, only single specimens of that species have been documented.

Present record. – Poland, Upper Silesian Block, Borzęta IG 1 borehole, Borzęta Formation: Osieczany and Rajbrot members, BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites* Zone.

Stratigraphic range. – Terreneuvian – *Platysolenites* Zone.

Genus *Retisphaeridium* (Staplin *et al*., 1965) Vanguestaine *in* Brück and Vanguestaine, 2005

Type species: *Retisphaeridium dichamerum* (Staplin, Jansonius et Pocock, 1965)

Retisphaeridium lechistanium n.sp.

Pl. XXXIV, Figs. 1–6

1968 *Retisphaeridium* n. sp.; K. Slavíková, pl. II:8.

Derivation of name. – *Lechistan* – „Poland", country at the Vistula river, an older denomination of Poland, still being used in several languages of Eastern Europe and in the Near East countries.
Holotype. – Pl. XXXIV, Fig. 5; coll. OG 546/2013/prep. 1.
Locus typicus. – Poland, Upper Silesian Block, Sosnowiec Formation, Sosnowiec IG 1 borehole, depth 3204.5 m.

Material. – Over 50 well preserved specimens.

Diagnosis. – Large acritarchs with vesicle of polygonal, usually pentagonal, outline. The wall is unilayered. Smooth, regular, broad folds of the wall subdivide the vesicle into large, rectangular or pentagonal fields. The opening structure is located on one of the fields, it has a form of regular fractures running along the internal sides of the folds.

Dimensions. – Diameter of vesicle 40–60 μm.

Remarks. – *Retisphaeridium lechistanium* differs from other species of the genus by its shape and size. The acritarchs were first encountered in the Těně Sš III borehole, located in the Brda Mts. of the Czech Barrandian region where thay occur in the *Ellipsocephalus hoffi* Zone (Slavíková, 1968). At that time, the forms were illustrated, and determined to the genus level only. Neither definition nor description had been given.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA VIII *Turrisphaeridium semireticulatum* and BAMA IX *Adara alea –Multiplicisphaeridium llynense* zones.

Stratigraphic range. – Cambrian Series 3 – *Paradoxides paradoxissimus* Zone.

Genus *Sagatum* Vavrdová et Bek, 2001

Type species: *Sagatum priscum* (Kirjanov et Volkova 1979) Vavrdová et Bek, 2001

Sagatum priscum (Kirjanov et Volkova 1979) Vavrdová et Bek, 2001

Pl.XVIII, Figs. 14, 16, 17

Synonymy – See M. Vavrdová, J. Bek, 2001, p. 116.

Additionally:

2003 *Sagatum priscum* (Kirjanov et Volkova) Vavrdová et Bek, 2001; M. Vavrdová *et al*., p. 72, fig. 7:1, 2.

2004 *Sagatum priscum* (Kirjanov et Volkova) nov. Vavrdová et Bek, 2001; M. Vavrdová, p.6, pl.1:4.

2006 *Sagatum priscum* (Kirjanov et Volkova) Vavrdová et Bek, 2001; M. Vavrdová, p. 118, 120.

2010b *Sagatum* priscum; M. Jachowicz-Zdanowska, fig. 4.

Material. – Over 20 fairly well preserved specimens.

Dimensions. – Diameter of the internal vesicle 40–85 µm, of the external one 45–95 µm.

Remarks. – Only single specimens of that species have been documented within the Brunovistulicum area.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Sułoszowa boreholes, Goczałkowice Formation: Pszczyna Member; BAMA IV *Skiagia–Eklundia campanula* and BAMA V *Skiagia–Eklundia varia* zones; Czech Republic, Brno Block, Měnín 1, Němčičky 3 boreholes; BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones.

Stratigraphic range. – Cambrian Series 2 – *Schmidtiellus*, *Holmia*, *Protolenus* zones.

Genus *Skiagia* Downie, 1982

Type species: *Skiagia scottica* Downie, 1982

Skiagia brachyspinosa (Kirjanov, 1974) n.comb.

Pl. XVI, Fig. 12

Basionym: 1974 *Baltisphaeridium brachyspinosum* Kirjanov, sp. nov.; V.V. Kirjanov, pp. 120, 121, tab. 7: 1.

1982 *Skiagia brevispinosa* sp. nov.; C. Downie, p. 263, figs. 5, 7:m–o.

1997 *Skiagia brevispinosa* Downie; M. Jachowicz, A. Přichystal, p. 330, pl. 8.

2002 *Skiagia* sp. cf. *S. brevispinosa* Downie; M. Vanguestaine *et al*., pp. 59, 69, 70, figs. 3–5, 6:1–3, pl. I:1–3.

2010b *Skiagia brevispinosa*; M. Jachowicz-Zdanowska, fig. 4.

Material. – Over 30 variously preserved specimens.

Dimensions. – Diameter of vesicle 15–20 µm, length of processes 7–15 µm.

Description. – Acritarchs with oval or circular vesicle covered by short, slender processes which taper to small funnel-tips. The processes bases are widened and solid, not communicating with the vesicle interior. The ornamentation of the vesicle wall, and that of the processes, psilate.

Remarks. – Acritarchs were originally described as *Baltisphaeridium brachyspinosum* Kirjanov, sp. nov. (Kirjanov, 1974) and successively as *Skiagia brevispinosa* Downie 1982. Therefore the specific epithet *brachyspinosa* has priority. See also discussion on *Ichnosphaera delicata* n.sp.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Kozy Mt 3, Sułoszowa boreholes, Goczałkowice Formation: Głogoczów and Pszczyna members; BAMA III *Ichnosphaera flexuosa–Comasphaeridium molliculum* and BAMA IV *Skiagia–Eklundia campanula* zones;Czech Republic, Brno Block, Měnín 1, Němčičky 3, boreholes; BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones.

Stratigraphic range. – Cambrian Series 2 – *Holmia*, *Protolenus* zones.

Skiagia pilosiuscula (Jankauskas, 1983) n.comb.

Pl. XV, Figs. 3, 5, 6

Basionym: 1983 *Baltisphaeridium pilosiusculum* Jankauskas sp.nov.; N.A. Volkova *et al*., p. 16, pl. VI: 7.

1983 *Baltisphaeridium pilosiusculum* Jankauskas sp.nov.; N.A. Volkova *et al.* , p. 16, pl. VI: 8.

1996 *Baltisphaeridium pilosiusculum* Jankauskas, 1983; P. Dziadzio, M. Jachowicz, ryc. 2:9

Material. – Over 150 well preserved specimens.

Dimensions. – Diameter of vesicle 30–55 µm, length of processes 10–20 µm.

Description. – Acritarchs with oval or circular vesicle covered by rare slender and tubular processes, which are hollow but separated from the vesicle cavity by the solid basis. The processes are slightly wider in the basal portion and their tips are funnel-like. The ornamentation of the vesicle wall is shagrinate to granulate, and that of the processes, psilate. The excystment structure is by median split.

Remarks. – Similar specimens have been described as *Baltisphaeridium pilosiusculum* (Jankauskas *in* Volkova *et al*., 1983) from Cambrian sediments recognised in the Prabuty borehole located in south-eastern Poland. According to the original diagnosis, the processes are narrowing toward the tips, and are sharply cut. Specimens described by Jankauskas are similar to those encountered in the Brunovistulicum, the process tips are usually slightly funnel-shaped. That feature is characteristic of *Skiagia*. In the investigated area, those forms appear in the Goczałkowice IG 1 borehole, within the interval documented by trilobite fauna of the *Holmia* Zone.

Present record. – Poland, Upper Silesian Block, Goczałkowice IG 1, Klucze 1, Jarząbkowice 1 boreholes, Goczałkowice Formation: Pszczyna and Jarząbkowice members; BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones; Czech Republic, Brno Block, Měnín 1, Němčičky 3, boreholes; BAMA V *Skiagia–Eklundia varia* and BAMA VI *Volkovia dentifera–Liepaina plana* zones.

Stratigraphic range. – Cambrian Series 2 – *Holmia*, *Protolenus* zones.

Genus *Tawuia* Hofmann, 1979

Type species: *Tawuia dalensis* Hofmann, 1979.

Tawuia sp.

Pl. III, Fig. 10

Material. – 10 variously preserved specimens.

Description. – Specimens with alongated elliptical outline, thick walled. No opening structure observed.

Dimensions. – Diameter of vesicle 100–500 µm.

Remarks. – Specimens of *Tawuia* sp. are large and quite different from other Cambrian acritarchs. Single specimens have been encountered the Brunovistulicum area.

Present record – Poland, Upper Silesian Block, Borzęta IG 1, Trojanowice, Rajbrot 1, Rajbrot 2 boreholes, Borzęta Formation: Myślenice, Osieczany and Rajbrot members; BAMA I *Pulvinosphaeridium antiquum–Pseudotasmanites* Zone.

Stratigraphic range. – Terreneuvian – *Platysolenites* Zone.

Genus *Turrisphaeridium* n.gen.

Type species: *Turrisphaeridium semireticulatum* (Timofeev, 1959) n. comb.

Derivation of name. – From Latin *turris* – tower, with reference to the processes shape.

Diagnosis. – Acritarchs with circular or oval, unilayered vesicle. Cylindrical processes of more or less the same length, and similarly wide along the whole length project from the vesicle surface. The processes are slightly widened at the tips that are usually truncated or occasionally slightly rounded. The vesicle and process surfaces are smooth or slightly granular. Distinct jagged irregularities occur at the tips. Fairly thick membrane may be seen between the processes. The processes are hollow, communicating with the vesicle interior.

Turrisphaeridium semireticulatum (Timofeev, 1959) n.comb.

Pl. XXIV, Figs. 1–17; Pl. XXV, Figs. 1–11; Pl. XXVI, Figs. 1, 2, 7, 10, 12, 13, 15, 17; Pl. XXVII, Figs. 1–6, 10–12

Basionym: 1959 *Archaeohystrichosphaeridium semireticulatum* sp. n.; B.V. Timofeev, p. 45, 46, tabl. III:65.

1981 *Celtiberium* cf. *geminum* Fombella; U. Erkmen, N. Bozdoğan, pp. 49, 50, pl. 1:4.
1981 *Liepaina* ? n. sp.; G. Vidal, figs. 1, 3:A, B.
1983 *Celtiberium* cf. *clarum* Fombella 1978; M. Vanguestaine, J. Van Looy, p. 71, fig. 3, pl. 1:1.
1983 *Celtiberium* cf. *geminum* Fombella 1977; M. Vanguestaine, J. Van Looy, p. 71, fig. 3, pl. 1:5, 6.
1996 *Adara alea* Martin; M. Jachowicz *in* Z. Buła, M. Jachowicz, p. 315, 321, pl. IV:2, 6.
1998 *Adara alea* Martin; M. Moczydłowska, pp. 26, 27, 31, 46–49, figs. 14, 15, 21:A–C.
2005 *Adara alea* Martin *in* Martin et Dean; M. Vanguestaine, R. Léonard, pp. 134, 138, 139, fig. 7, pl. III:A, B.

Material. – Over 500 well preserved specimens.

Diagnosis. – Acritarchs with circular or oval, unilayered vesicle. Cylindrical processes of more or less the same length, and similarly wide along the whole length project from the vesicle surface. The processes are slightly widened at the tips. The tips are usually truncated, occasionally slightly rounded, jagged. The processes are connected with a fairly thick membrane that is attached to them close to the base, in the middle, or at the tip itself. The membrane has uneven jagged edges. It hampers observations of the processes bases. The vesicle and process surfaces are smooth or slightly granular. The membrane stretched between the processes forms a network on the vesicle surface. The processes are hollow, communicating with the vesicle interior. A broad opening structure was often observed on one side of the vesicle.

Dimensions. – Diameter of vesicle 15–50 µm, length of processes 4–8 µm.

Remarks. – That species is characterised by strong variability of size, from 15 up to 40–50 µm. The process length is 4–8 µm, irrespective of the length of vesicle diameter. Therefore, processes of smaller specimens seem to be longer. That genus differs from *Adara*, *Celtiberium* and *Tubulosphaera* by the shape of the processes. The processes of *Adara* are conical, distinctly widened at the base, and narrowing toward the tips. The process height does not exceed their basal width (Martin, Dean, 1981). The genus *Celtiberium* has processes with broad bases and gently rounded tips (Fombella, 1977). Tube-like processes of *Tubulosphaera* are short, massive, and smooth (Palacios, Moczydłowska, 1998).

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1, Sosnowiec Formation: BAMA VIII *Turrisphaeridium semireticulatum* Zone.

Stratigraphic range. – Cambrian Series 3 – *Paradoxides paradoxissimus* Zone.

Turrisphaeridium turgidum n.sp.

Pl. XXV, Figs. 12, 13, Pl. XXVI, Fig. 18

Derivation of name. – From Latin *turgidus*– swollen, buldging, pompous, in reference to the vesicle's shape.

Holotype. – Pl. XXV, Fig. 13; coll. OG 546/2013/prep. 11.

Locus typicus. – Poland, Upper Silesian Block, Sosnowiec Formation, Sosnowiec IG 1 borehole, depth 3204.5 m.

Material. – Over 100 well preserved specimens.

Diagnosis. – Acritarchs with circular or oval, unilayered vesicle. The vesicle is covered with short, cylindrical processes with very broad, conical bases that gently merge with the vesicle outline. The process tips are truncated, and covered with very tiny jagged irregularities. The processes are hollow, communicating with the vesicle interior. The vesicle and process surfaces are smooth, occasionally small radial wrinkles are visible at the process bases.

Dimensions. – Diameter of vesicle 20–60 µm, length of processes 3–5 µm.

Remarks. – This species is similar to *Adara undulata*. It differs from other ones by the shape of processes, which in the latter have character of the flat, rounded cones merged with the vesicle outline.

Present record. – Poland, Upper Silesian Block, Sosnowiec IG 1 borehole, Sosnowiec Formation: BAMA VIII *Turrisphaeridium semireticulatum* Zone.

Stratigraphic range. – Cambrian Series 3 – *Paradoxides paradoxissimus* Zone.

SUMMARY OF THE RESULTS

The present study is so far the most comprehensive palynological analysis of the Cambrian from Brunovistulicum, based on a largest numer of studied borehole sections situated both in the USB area of Poland and in the Brno Block of Moravia in Czech Republic. Investigated samples cover almost all lithostratigraphic units, except for a few palynologically barren intervals. The samples yielded rich collection of usually well preserved organic microfossils that allowed many important taxonomic, biostratigraphic and regional geological conclusions.

1. The systematic study of the collected palynological material allowed to make taxonomic revisions of previously analysed acritarch associations. Five new genera and nineteen new species and eleven species new combinations are described. The new and revised taxa include mainly those that appear in the Cambrian Series 2 and the forms characteristic for the Cambrian Series 3.

2. The most important new taxa of Series 2 include in particular *Ichnosphaera* n.gen., with the typical *Ichnosphaera flexuosa* (Eklund, 1990) n.comb. species, and other new and revised species: *Ichnosphaera robusta* n.sp, *I. aranea* n.sp., *I. delicata* n.sp. and *I. stipatica* (Hagenfeldt, 1989) n.comb. *Ichnosphaera* n.gen. is a characteristic dominant component of the acritarch associations from the Głogoczów Member of the Goczałkowice Formation in the USB area. It is accompanied by specimens of *Lechistania* n.gen., with the type species *Lechistania magna* n.sp.

3. Another characteristic acritarch group, common in the Cambrian Series 2, comprises forms attributed to *Eklundia* n.gen. with the type species *Eklundia campanula* (Eklund, 1990) n.comb. This genus includes acritarch specimens earlier ascribed to various species of the genera *Baltisphaeridium*, *Multiplicisphaeridium*, *Goniosphaeridium* or *Polygonium*. Newly erected *Eklundia* n.gen. species, *E. pussilla* n.sp., *E. varia* (Volkova, 1969) n.comb. and *E. florentinata* n.sp. appear in a clear chronological succession in the Goczałkowice Formation deposits which supports their definition as separate taxa.

4. Several forms have their first appearances in the Cambrian Series 2 deposits of the studied area, including *Baltisphaeridium implicatum* (Fridrichsone, 1971), *Goniosphaeridium implicatum* (Fridrichsone) comb. nov. Downie 1982, *Polygonium implicatum* Sarjeant, Stancliffe, 1994 or *Solisphaeridium implicatum* (Fridrichsone) comb. nov. Moczydłowska, 1998. These forms are included by the present author into *Parmasphaeridium* n.gen. Two species are distinguished within this genus: the typical *P. implicatum* (Fridrichsone, 1971) n.comb. and *P. robustispinosum* n.sp. The latter appears in the Cambrian Series 2 as the earliest representative of the discussed genus.

5. A new acritarch assemblage has been recognised in the Series 3 of the Sosnowiec Formation with the index genus *Turrisphaeridium* n.gen., represented by *T. semireticulatum* (Timofeev, 1959) n.comb. and *T. turgidum* n.sp. Other new taxa from these strata include *Retisphaeridum lechistanium* n.sp., *A. oligum* (Jankauskas, 1976) n.comb., *Ammonidium notatum* (Volkova, 1969) n.comb. and *Multiplicisphaeridium llynense* (Martin, 1994) n.comb. species.

6. Analysis of a vertical distribution of studied microfossils allowed to establish a succession of nine acritarch assemblage zones, BAMA I to BAMA IX, correlated with the Lower to Middle Cambrian series: Terreneuvian, Series 2, and Series 3. The zones are partly separated by palynologically barren intervals.

7. The palynological subdivision proposed in this paper is more detailed then previous one and the identified acritarch assemblages are easily recognisable. Three assemblage zones are characteristic acme zones based on the dominant index forms of genus *Ichnosphaera* n.gen. (BAMA III, Series 2), *Turrisphaeridium* n.gen. (BAMA VII, Series 3) and *Adara* (BAMA IX, Series 3), respectively.

8. BAMA I and II acritarch associations, distinguished in the oldest Cambrian deposits of the Brunovistulicum, differing distinctly in terms of the genus and species content of their microfossil assemblages, are to be correlated with the *Platysolenites* Zone, in the basal part of the Cambrian system. The obtained results require distinguishing at least two microfloristic assemblages in the Cambrian deposits of this horizon in the Brunovistulicum. The older one occurs in the Borzęta Formation in the eastern margin of the USB (Buła, Jachowicz, 1996; Buła, 2000). The BAMA II Zone was encountered so far only in the Měnín 1 borehole in the Brno Block (Vavrdová *et al*., 2003). The zone was originally established as the *Asteridium tornatum–Comasphaeridium velvetum* Zone by Moczydłowska (1991) and was redefined for the purposes of the present study.

9. The BAMA III–VI zones, correlated here with the Series 2 are recognised in the Goczałkowice Formation of both the Upper Silesian and Brno blocks. The BAMA VI Zone is known so far only from fragmentary Cambrian sections and its boundaries with under- and overlying zones are not known.

10. The BAMA III assemblages, characterised by a dominance of weakly sculptured taxa *Comasphaeridium*, *Asteridium* and *Ichnosphaera* n.gen. are here correlated with the *Schmidtiellus* Zone, and the lower part of the *Holmia* Zone. Similar assemblages are documented from comparable lithology and facies in the Moravian Měnín 1 borehole.

11. The BAMA IV and BAMA V zones, correlated with the upper part of the *Holmia* Zone of the Series 2 assemblages, were distinguished in the Pszczyna Member of the Goczałkowice Formation and are traced in other sections of the USB and in the Měnín 1 borehole (Brno Block).

12. The BAMA VI Zone is the equivalent of the *Protolenus* Zone of the uppermost part of the Series 2 and is established in fragmentary Cambrian sections of the Brno Block (Mikulaš *et al*., 2008). These are correlated with the Jarząbkowice 1 section (USB) comprising the uppermost member of the Goczałkowice Formation (Buła, Żaba, 2005).

13. The BAMA VII to BAMA IX zones are correlated with the Series 3 of the Cambrian System, and were established in the Sosnowiec Formation known only from the Sosnowiec IG 1 borehole in the USB area (Buła, Jachowicz, 1996; Buła, 2000). The BAMA VII Zone is here correlated with the trilobite *Acadoparadoxides oelandicus* Zone, while BAMA VIII and BAMA IX Zones are regarded as equivalents of the *Paradoxides paradoxissimus* Zone. The key to above interpretations is the occurrence of the index species *Adara alea*, whose well-documented stratigraphic range is limited to the upper part of the *P. paradoxissimus* Zone (Martin, Dean, 1988). Thus, the Furongian to Ordovician age of the uppermost Lower Palaeozoic strata in the Sosnowiec IG 1, suggested earlier by Moczydłowska (1998), is not confirmed by the present study.

14. Stratigraphic distribution of the acritarch assemblages from the Cambrian of the Brunovistulicum well reflects the evolution of this group. The investigated material clearly demonstrates gradual changes in a generic composition of the assemblages, which are dominated in the Early Cambrian by *Asteridium* (*Platysolenites* Zone), *Comasphaeridium* (*Schmidtiellus* Zone), and *Skiagia* (*Holmia* Zone), and subsequently, in Series 3, by *Ammonidium bellulum*, *A. notatum* (Volkova, 1969) n.comb., *Turrisphaeridium* n.gen. and *Adara*.

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Appendix

List of taxa

Genus *Alliumela* Vanderflit, 1971
Alliumella baltica Vanderflit, 1971
Genus Adara (Fombella, 1977) Martin, 1981
Adara alea Martin, 1981
Adara undulata Moczydłowska, 1998
Genus *Ammonidium* (Lister, 1970) Sarjeant, Vavrdová, 1997
Ammonidium belullum (Moczydłowska, 1998) Sarjeant, Stanclift, 2000
Ammonidium notatum (Volkova, 1969) n.comb.
Ammonidium oligum (Jankauskas, 1976) n.comb.
Genus *Archeodiscina* (Naumova, 1960) Volkova, 1968
Archeodiscina multipunctata n.sp.
Archeodiscina umbonulata Volkova, 1968
Genus *Asteridium* Moczydłowska, 1991
Asteridium lanatum (Volkova, 1969) Moczydłowska, 1991
Asteridium pallidum (Volkova, 1968) Moczydłowska, 1991
Asteridium spinosum (Volkova, 1969) Moczydłowska, 1991
Asteridium tornatum (Volkova, 1968) Moczydłowska, 1991
Genus *Ceratophyton* Kirjanov, 1979
Ceratophyton vernicosum Kirjanov, 1974
Genus *Chuaria* Walcott, 1899
Chuaria circularis (Walcott, 1899) Vidal, Ford, 1985
Genus Comasphaeridium Staplin, Jansonius, Pocock, 1965
Comasphaeridium agglutinatum Moczydłowska, 1988
Comasphaeridium francinae n.sp.
Comasphaeridium longispinosum Hagenfeldt, 1989 emend.
Comasphaeridium molliculum Moczydłowska, Vidal, 1988
Comasphaeridium silesiense Moczydłowska, 1998 emend
Comasphaeridium soniae n.sp.
Comasphaeridium spinosum n.sp.
Comasphaeridium strigosum (Jankauskas, 1976) Downie, 1982
Comasphaeridium velvetum Moczydłowska, 1988
Comasphaeridium vozmedianum (Fombella, 1979) emend.
Genus *Cristallinium* Vanguestaine, 1978
Cristallinium cambriense (Slaviková, 1968) Vanguestaine, 1978
Cristallinium compactum n.sp.
Cristallinium randomense (Martin, 1981) Martin, 1988
Genus *Cymatiosphaera* Wetzel, 1933
Cymatiosphaera cramerii Slaviková, 1968
Cymatiosphaera postae (Jankauskas, 1976) Jankauskas, 1979
Genus *Eklundia* n.gen.
Eklundia campanula (Eklund, 1990) n.comb.
Eklundia florentinata n.sp.
Eklundia pusilla n.sp.
Eklundia varia (Volkova, 1969) n.comb.
Genus *Eliasum* Fombella, 1977
Eliasum asturicum Fombella, 1977
Eliasum jennessii Martin, 1984
Eliasum llaniscum Fombella, 1977
Genus *Estiastra*
Estiastra minima Volkova, 1969
Genus *Fimbriaglomerella* Loeblich, Drugg, 1968
Fimbriaglomerella membranacea (Kirjanov, 1974) Moczydłowska, 1991
Fimbriaglomerella minuta (Jankauskas, 1979) Moczydłowska, 1991
Genus *Globosphaeridium* Moczydłowska, 1991
Globosphaeridium arenulum n.sp.
Globosphaeridium cerinum (Volkova, 1968) Moczydłowska, 1991
Genus *Globus* Vidal in Moczydłowska, Vidal, 1988
Globus gossipinus Vidal in Moczydłowska, Vidal, 1988
Genus *Goniosphaeridium* (Eisenack, 1969) Kjellström, 1971
Goniosphaeridium volkovae Hagenfeldt, 1989
Genus *Granomarginata* Naumova, 1960
Granomarginata parva n.sp.
Granomarginata prima Naumova, 1960
Granomarginata squamacea Volkova, 1968
Genus *Heliosphaeridium* Moczydłowska, 1991
Heliosphaeridium coniferum (Downie, 1982) Moczydłowska, 1991
Heliosphaeridium dissimilare (Volkova, 1969) Moczydłowska, 1991
Heliosphaeridium lanceolatum (Vanguestaine, 1974) Moczydłowska, 1998
Heliosphaeridium longum (Moczydłowska, 1988) Moczydłowska, 1991
Heliosphaeridium lubomlense (Kirjanov, 1974)
Heliosphaeridium obscurum (Volkova, 1969) Moczydłowska, 1991
Heliosphaeridium oligum (Jankauskas, 1976) Moczydłowska, 1998
Heliosphaeridium radzynicum (Volkova, 1974)
Genus *Ichnosphaera* n.gen.
Ichnosphaera aranea n.sp.
Ichnosphaera delicata n. sp.
Ichnosphaera flexuosa (Eklund, 1990) n.comb.
Ichnosphaera robusta n. sp.
Ichnosphaera stipatica (Hagenfeldt, 1089) n.comb.
Genus *Lechistania* n.gen.
Lechistania magna n.sp.
Genus *Leiosphaeridia* Eisenack, 1958
Leiosphaeridia tenuissima Eisenack, 1958
Genus *Leiovalia* Eisenack, 1965
Leiovalia tenera Kirjanov, 1974
Leiovalia sp.
Genus *Liepaina* Jankauskas, Volkova, 1979 in Volkova, Kirjanov, Piskun, Paškevičiene, Jankauskas, 1974
Liepaina plana Jankauskas, Volkova, 1979 in Volkova, Kirjanov, Piskun, Paškevičiene, Jankauskas, 1974
Genus *Lophosphaeridium* Timofeev, 1959
Lophosphaeridium dubium Volkova, 1968
Lophosphaeridium varabile Volkova, 1974
Genus *Multiplicisphaeridium* (Staplin, 1961) Lister, 1970
Multiplicisphaeridium llynense (Martin, 1994) n.comb.
Multiplicisphaeridium martae Cramer, Diez, 1972
Multiplicisphaeridium ramosum Moczydłowska, 1998

Multiplicisphaeridium xianum Fombella, 1977
Genus *Navifusa* Combaz, Lange, Pansart, 1967
Navifusa sp.
Genus *Parmasphaeridium* n.gen.
Parmasphaeridium implicatum (Fridrichsone, 1971) n.comb.
Parmasphaeridium robustispinosum n.sp.
Parmasphaeridium sp.
Genus *Polygonium* Vavrdová, 1966
Polygonium baltoscandium(Eklund) Sarjeant, Stancliffe, 1994
Genus *Pseudotasmanites* Kirjanov, 1974
Pseudotasmanites sp.
Genus *Pterospermella* Eisenack, 1972
Pterospermella inordinata n.sp.
Pterospermella gigantea n.sp.
Pterospermella solida (Volkova, 1969) Volkova, 1979
Pterospermella velata Moczydłowska, 1988
Genus *Pterospermopsimorpha* Timoffeev, 1966
Pterospermopsimorpha rugulosa n.sp.
Pterospermopsimorpha sp.
Genus *Pulvinosphaeridium* (Eisenack, 1954) Deunff, 1954
Pulvinosphaeridium antiquum Paškevičiene, 1979
Pulvinosphaeridium sp.
Genus *Retisphaeridium* Staplin, Jansonius, Pocock, 1965
Retisphaeridium brayense (Gardiner, Vanguestaine, 1971) Moczydłowska, Crimes, 1995
Retisphaeridium capsulatum Vanguestaine in Brück, Vanguestaine, 2005
Retisphaeridium dichamerum Staplin, Jansonius, Pocock, 1965
Retisphaeridium howelii Martin in Martin, Dean, 1983
Retisphaeridium lechistanium n.sp.
Retisphaeridium postae (Jankauskas, 1976) Vanguestaine *in* Brück, Vanguestaine, 2004
Retisphaeridium pusillum (Moczydłowska, 1998) Vanguestaine *in* Brück, Vanguestaine, 2005
Genus *Revinotesta* Vanguestaine, 1974
Revinotesta sp.
Genus *Rugashaera* Martin, 1988
Rugasphaera terranovana Martin, 1988
Genus *Sagatum* Vavrdová, Bek, 2001
Sagatum priscum (Kirjanov, Volkova, 1979) Vavrdová, Bek, 2001
Genus *Skiagia* Downie, 1982
Skiagia brachyspinosa (Kirjanov, 1974) n.comb.
Skiagia ciliosa (Volkova, 1969) Downie, 1982
Skiagia compressa (Volkova, 1968) Downie, 1982
Skiagia orbiculare (Volkova, 1968) Downie, 1982
Skiagia ornata (Volkova, 1968) Downie, 1982
Skiagia pura Moczydłowska, 1988
Skiagia scottica Downie, 1982
Skiagia pilosiuscula (Jankauskas, 1983) n.comb.
Genus *Solisphaeridium* Staplin, Jansonius, Pocock, 1965
Solisphaeridium elegans Moczydłowska, 1998
Solisphaeridium flexipilosum Slaviková, 1968
Solisphaeridium multiflexipilosum Slaviková, 1968
Genus *Tasmanites* Newton, 1875
Tasmanites bobrowskae Ważyńska, 1967
Tasmanites tenellus Volkova, 1968
Genus *Tawuia* Hofmann, 1979
Tawuia sp.
Genus *Teophipolia* Kirjanov, 1979
Teophipolia lancerata Kirjanov, 1979
Genus *Timofeevia* Vanguestaine, 1978
Timofeevia lancarae (Cramer et Diez, 1972) Vanguestaine, 1978
Timofeevia phosphoritica Vanguestaine, 1978
Timofeevia pentagonalis (Vanguestaine, 1974) Vanguestaine, 1978
Genus *Tubulosphaera* Palacios *in* Palacios, Moczydłowska, 1998
Genus *Turrisphaeridium* n.gen.
Turrisphaeridium semireticulatum (Timofeev, 1959) n.comb.
Turrisphaeridium turgidum n.sp.
Genus *Volkovia* Downie, 1982
Volkovia dentifera (Volkova, 1969) Downie, 1982
Genus *Vulcavnisphaera* Deunff, 1961
Vulcavnisphaera lanugo Martin, 1988
Vulcavnisphaera turbata Martin, 1981

PLATES

PLATE I

Figs. 1, 2, 4–6, 8–11. *Pterospermopsimorpha* sp.; Wiśniowa IG 1 borehole, depth 2758.8–2761.4 m

Figs. 3, 7. *Leiosphaeridia* sp.; Wiśniowa IG 1 borehole, depth 2758.8–2761.4 m

Figs. 12–14, 16. *Cyanobacteria* Stanier,1977; Wiśniowa 6 borehole, depth 2226.5–2227.5 m

Fig. 15. *Cyanobacteria* Stanier,1977; Borzęta IG 1 borehole, depth 3355.2 m

Scale bar equals 20 μm for Figs. 1–11; 100 μm for Figs. 12–16

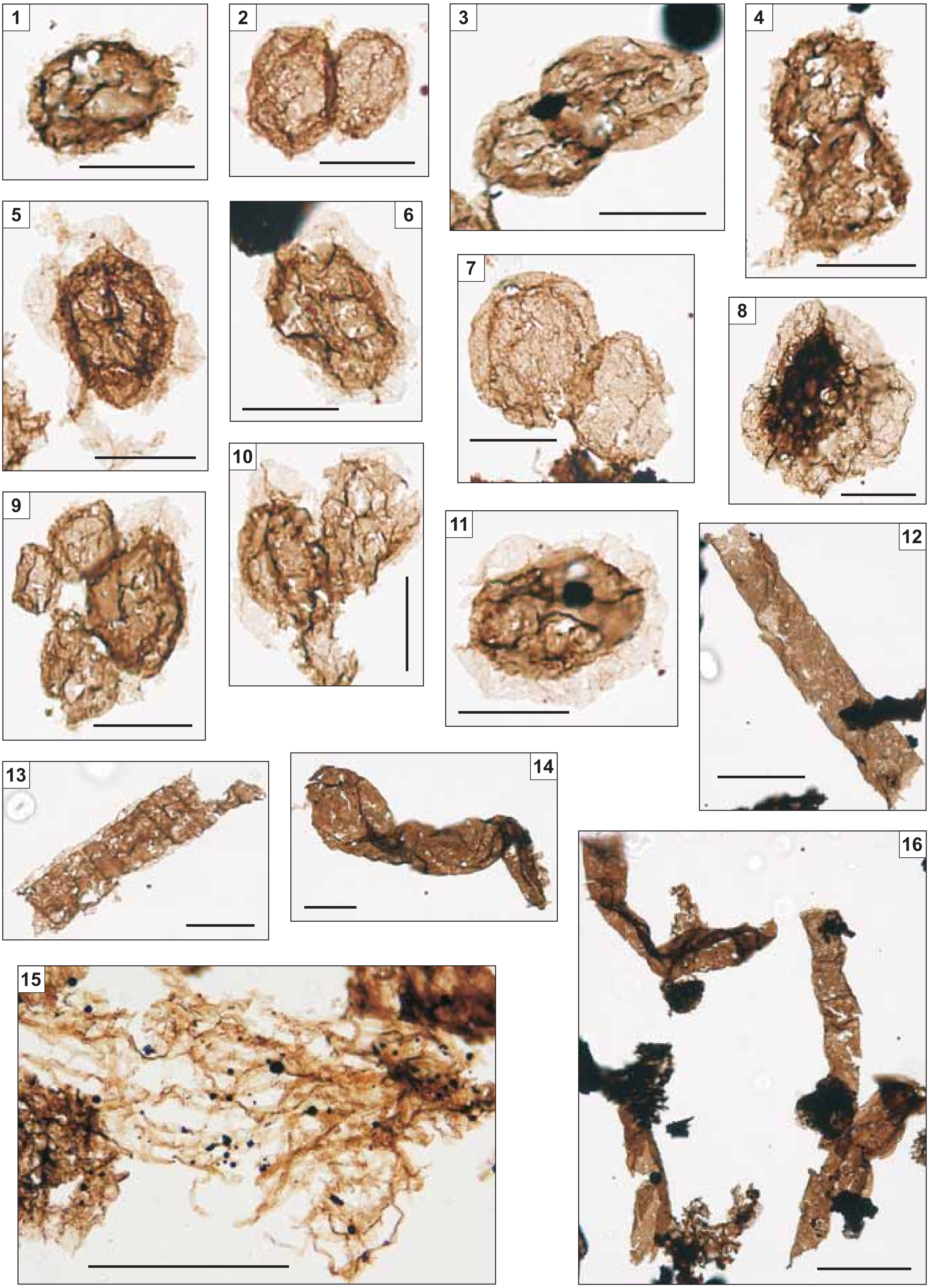
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PLATE II

Figs. 1, 2. *Pulvinosphaeridium antiquum* Paškevičiene, 1980

Figs. 3–7. *Navifusa* sp.

Fig. 8. *Pulvinosphaeridium* sp.

Fig. 9. *Leiosphaeridia* sp.

Fig. 10. *Leiovalia* sp.

Figs. 1–4, 7–10. Wiśniowa IG 1 borehole, depth 2761.4–2765.8 m;
Figs. 5, 6. Borzęta IG 1 borehole, depth 3355.2 m

Scale bar equals 100 µm for Figs. 1, 2, 9; 50 µm for Figs. 3–7, 10

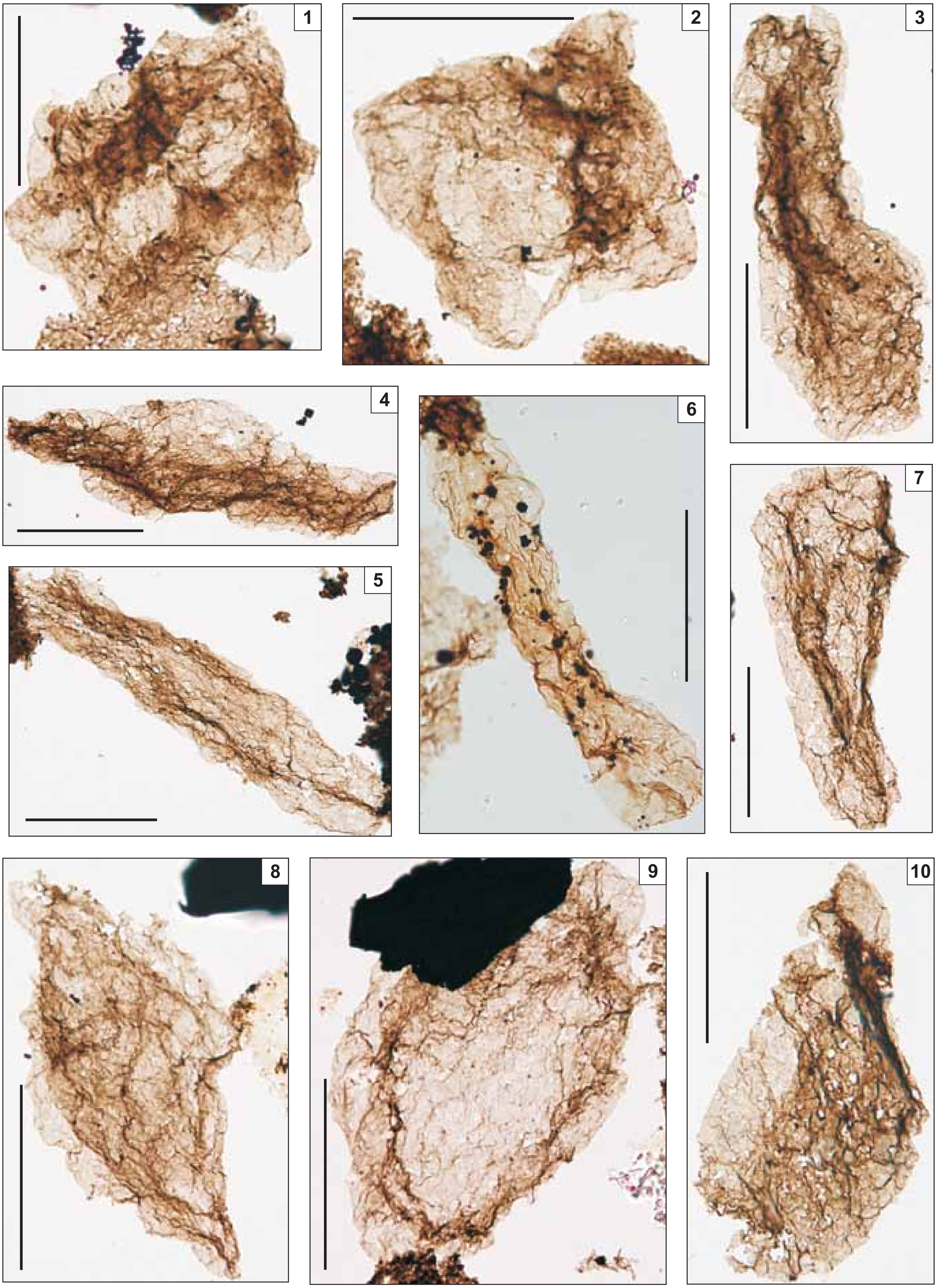
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PLATE III

Borzęta IG 1 borehole, depth 3355.2 m

Figs. 1, 2, 4. *Leiosphaeridia tenuissima* Eisenack,1958

Figs. 3, 5–8. *Pseudotasmanites* sp.

Figs. 9, 11, 12. *Chuaria circularis* Walcott,1899

Fig. 10. *Tawuia* sp.

Scale bar equals 200 μm

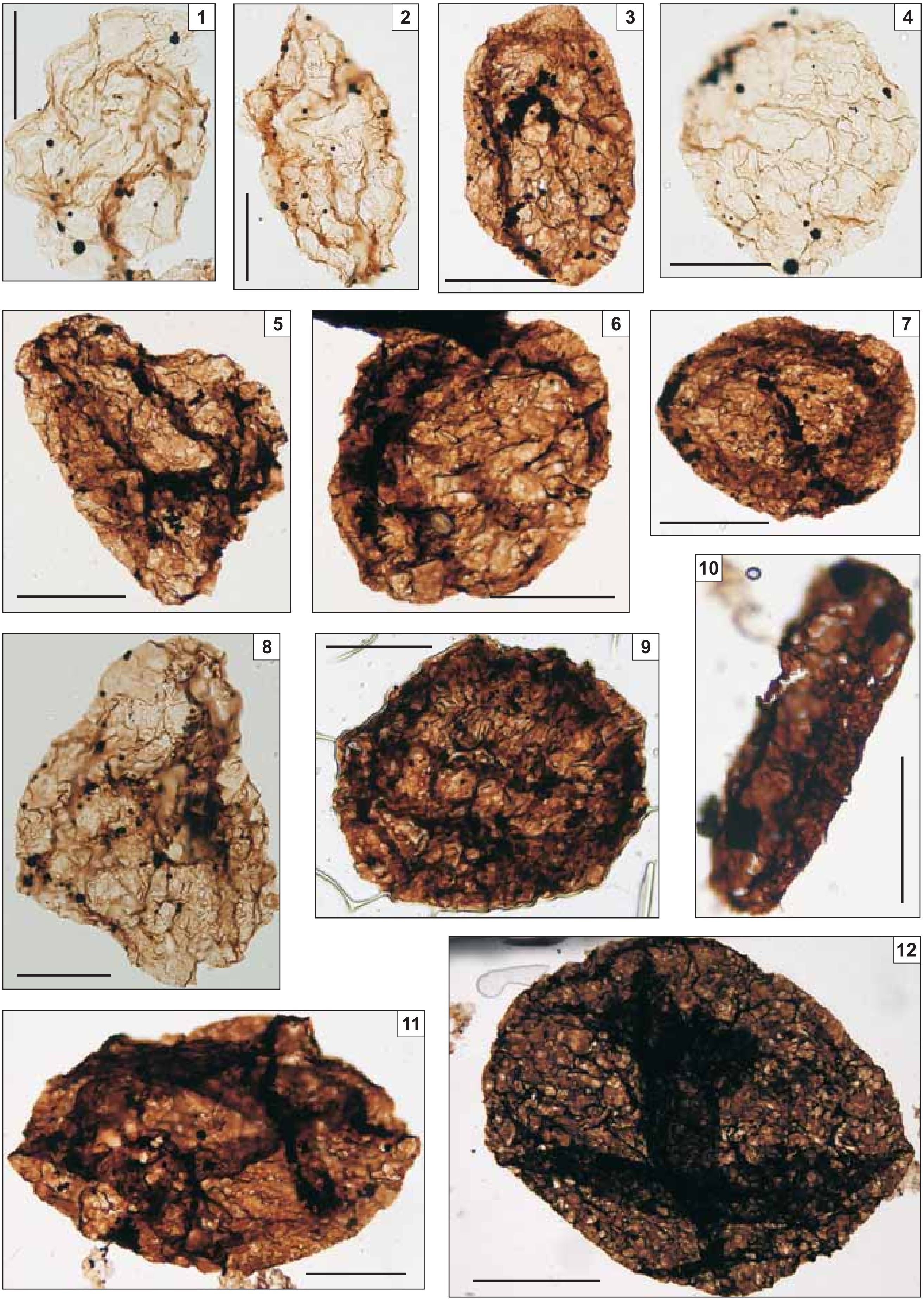
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PLATE IV

Figs. 1, 2. *Archeodiscina umbonulata* Volkova, 1968; Měnín 1 borehole; depth 473.0–477.5 m

Figs. 3, 8. *Archeodiscina umbonulata* Volkova, 1968; Goczałkowice IG 1 borehole; depth 2893.0 m

Figs. 4, 5, 9. *Archeodiscina umbonulata* Volkova, 1968; Sułoszowa borehole; depth 199.1 m

Fig. 6. *Asteridium pallidum* (Volkova, 1968) Moczydłowska, 1991; Sułoszowa borehole, depth 321.0 m

Fig. 7. *Archeodiscina multipunctata* n.sp; Sułoszowa borehole; depth 199.1 m

Fig. 10. *Asteridium lanatum* (Volkova, 1969) Moczydłowska, 1991; Kozy Mt 3 borehole, depth 1492.6 m

Figs. 11, 14. *Pterospermella velata* Moczydłowska, 1988; Kozy Mt 3 borehole depth 1494.1 m

Fig. 12. *Archeodiscina multipunctata* n.sp; Sułoszowa borehole; holotype; depth 199.1 m

Fig. 13. *Globosphaeridium arenulum* n.sp.; holotype; Kozy Mt 3 borehole, depth 1492.8 m

Fig. 15. *Pterospermella* sp.; Kozy Mt 3 borehole depth 1494.1 m

Figs. 16, 17. *Pterospermella gigantea* n.sp.; Kozy MT 3 borehole, depth 1492.8 m; Fig. 16 – holotype

Fig. 18. *Tasmanites bobrowskae* Ważyńska, 1967; Sułoszowa borehole, borehole, depth 321.0 m

Scale bar 20 µm for Figs. 1–15, 17; 50 µm for Fig. 18; 100 µm for Fig. 16

PLATE IV

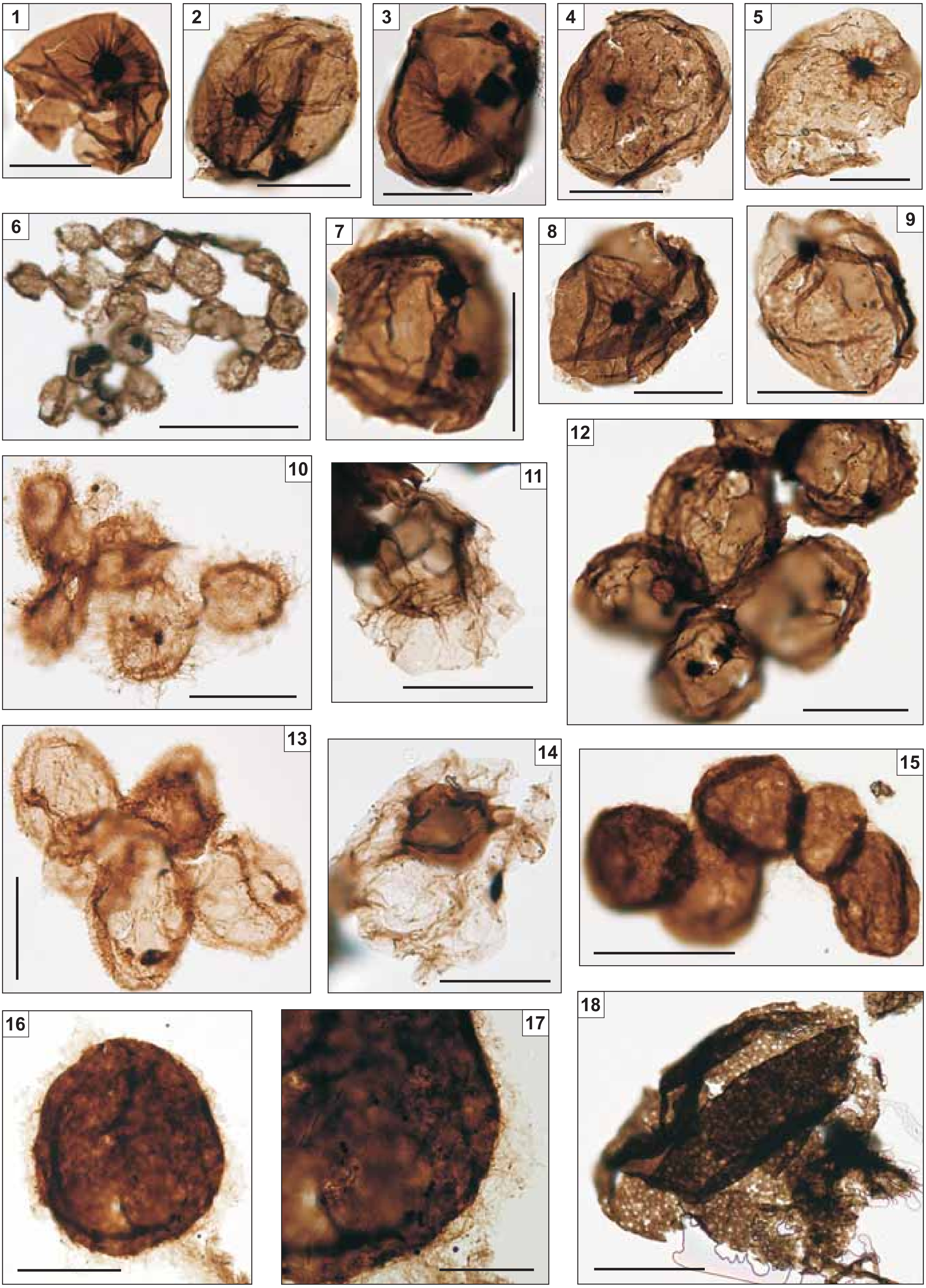

PLATE V

Fig. 1. *Comasphaeridium agglutinatum* Moczydłowska, 1988; Kozy Mt 3 borehole, depth 1492.6 m

Figs. 2, 5. *Comasphaeridium velvetum* Moczydłowska, 1988; Kozy Mt 3 borehole, depth 1492.6 m

Figs. 3, 6, 9. ?*Comasphaeridium strigosum* (Jankauskas, 1976) Downie, 1982; Kozy Mt 3 borehole, depth 1492.6 m

Figs. 4, 10. *Comasphaeridium strigosum* (Jankauskas, 1976) Downie, 1982; Goczałkowice IG 1 borehole, depth 2771.5 m

Fig. 7. *Comasphaeridium spinosum* n.sp.; holotype; Sułoszowa borehole; depth 199.1 m

Fig. 8. *Comasphaeridium spinosum* n.sp.; Goczałkowice IG 1 borehole, depth 2768.0 m

Fig. 11. ?*Comasphaeridium strigosum* (Jankauskas, 1976) Downie, 1982; Němčičky 6 borehole, depth 5157.8 m

Scale bar equals 20 µm

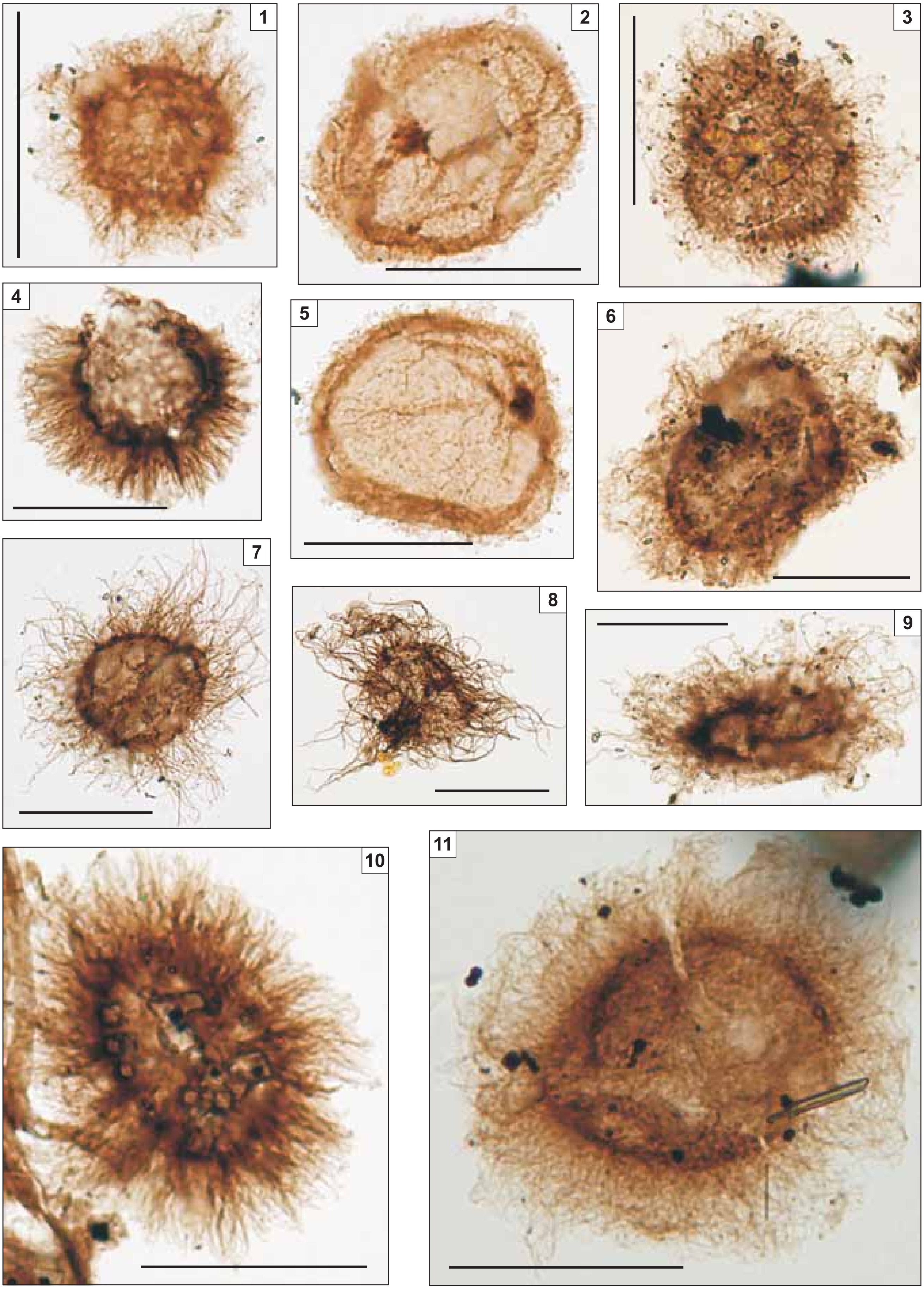
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PLATE VI

Ichnosphaera delicata n.sp., Kozy Mt 3 borehole

Figs. 1, 3, 4, 7–9, 11.	Depth 1492.6 m
Fig. 2.	Depth 1497.7 m
Figs. 5, 6.	Depth 1497.9 m
Fig. 10.	Holotype, depth 1492.6 m

Scale bar equals 20 μm

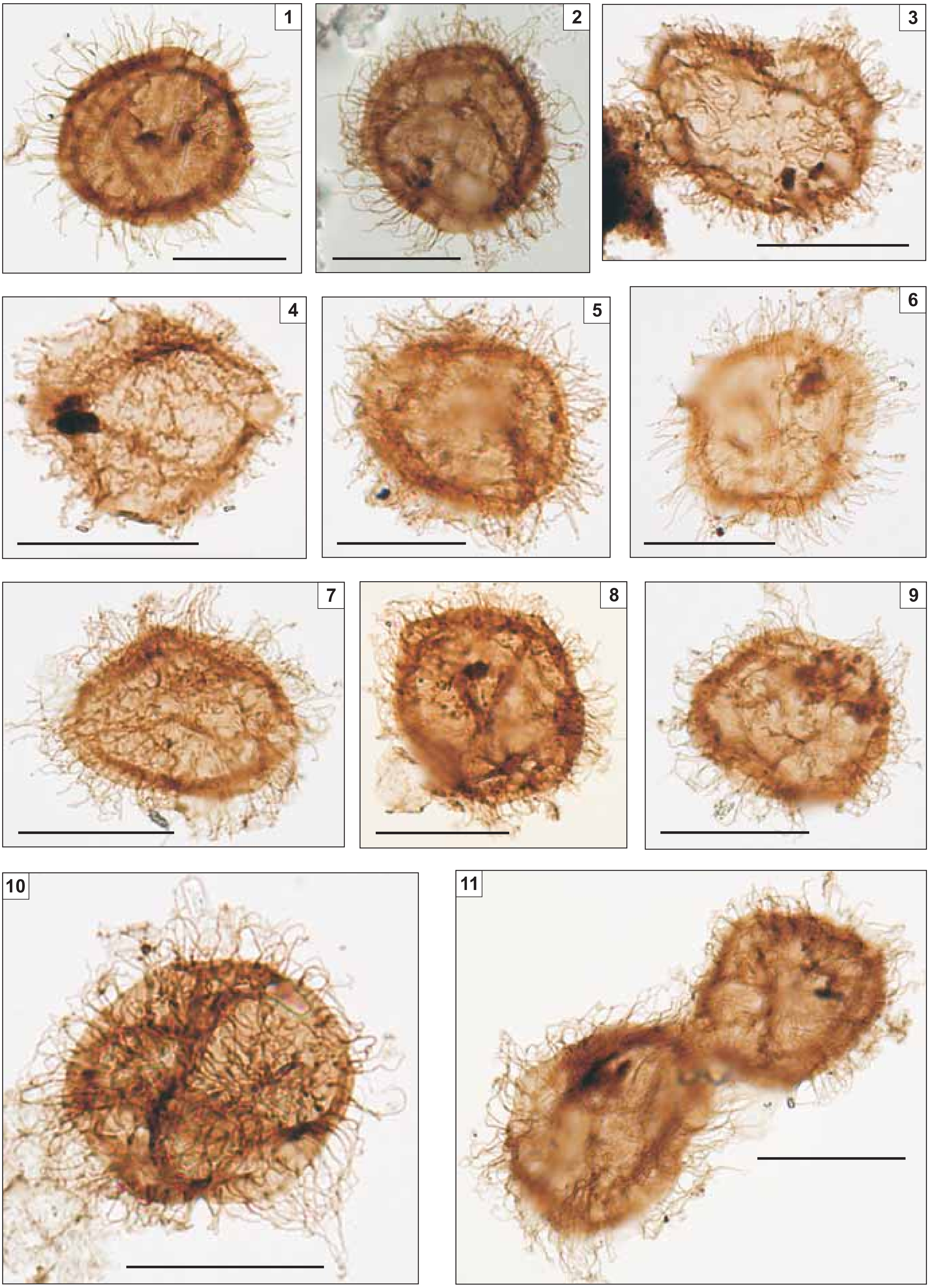
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PLATE VII

Figs. 1, 3. *Ichnosphaera flexuosa* (Eklund, 1990) n.comb.; Goczałkowice IG 1 borehole, depth 2975.0 m

Fig. 2. *Ichnosphaera robusta* n.sp.; holotype; Goczałkowice IG 1 borehole, depth 2984.0 m

Fig. 4. *Ichnosphaera robusta* n.sp.; Goczałkowice IG 1 borehole, depth 2975.0 m

Fig. 5. *Ichnosphaera stipatica* (Hagenfeldt, 1989) n.comb.; Goczałkowice IG 1 borehole, depth 3032.0 m

Fig. 6. *Ichnosphaera stipatica* (Hagenfeldt, 1989) n.comb.; Goczałkowice IG 1 borehole, depth 2975.0 m

Scale bar equals 20 μm

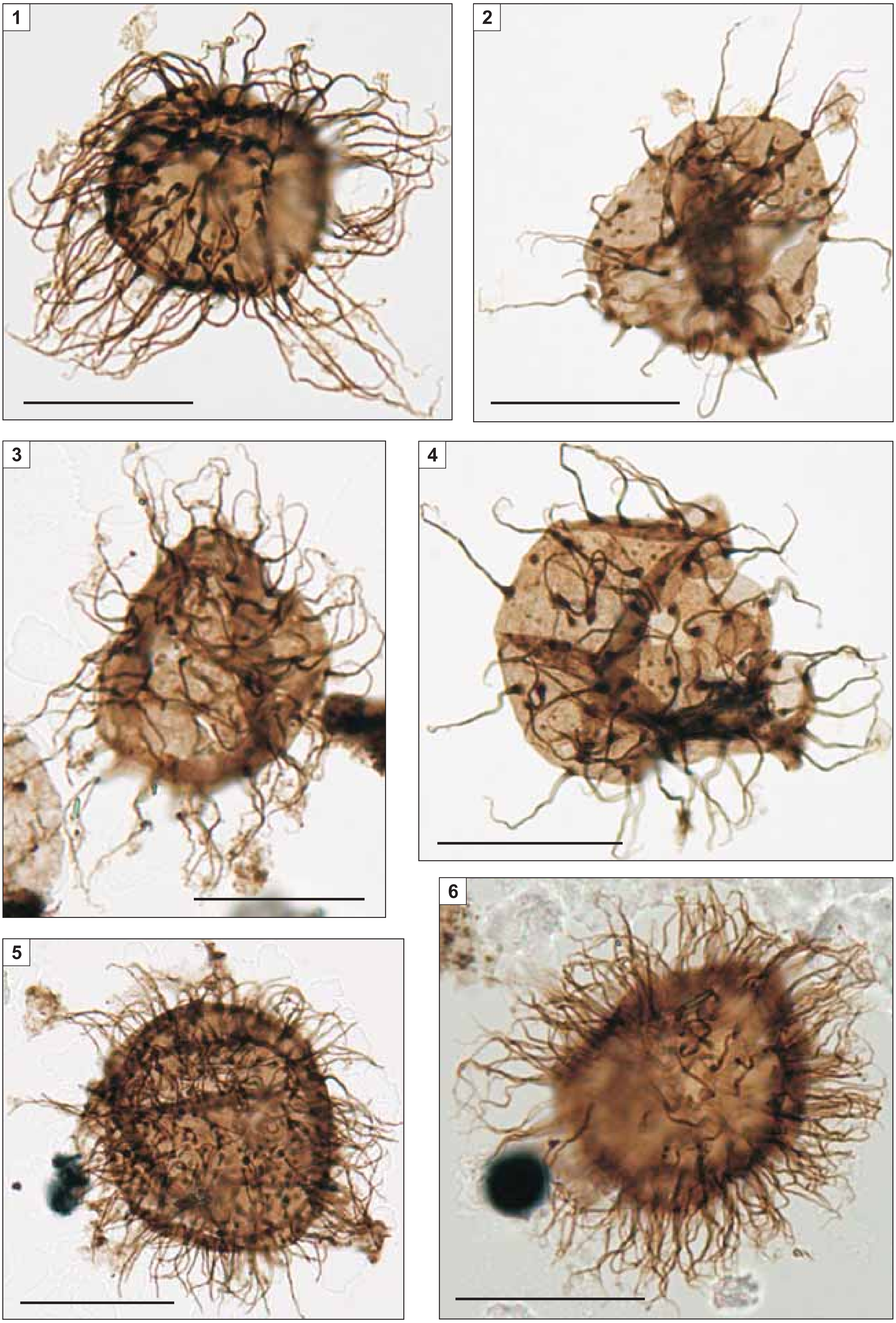
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PLATE VIII

Ichnosphaera aranea n.sp.; Kozy Mt 3 borehole

Figs. 1, 3. Depth 1492.6 m

Fig. 2. Holotype, depth 1497.7 m

Figs. 4–6. Depth 1497.7 m

Scale bar equals 20 µm

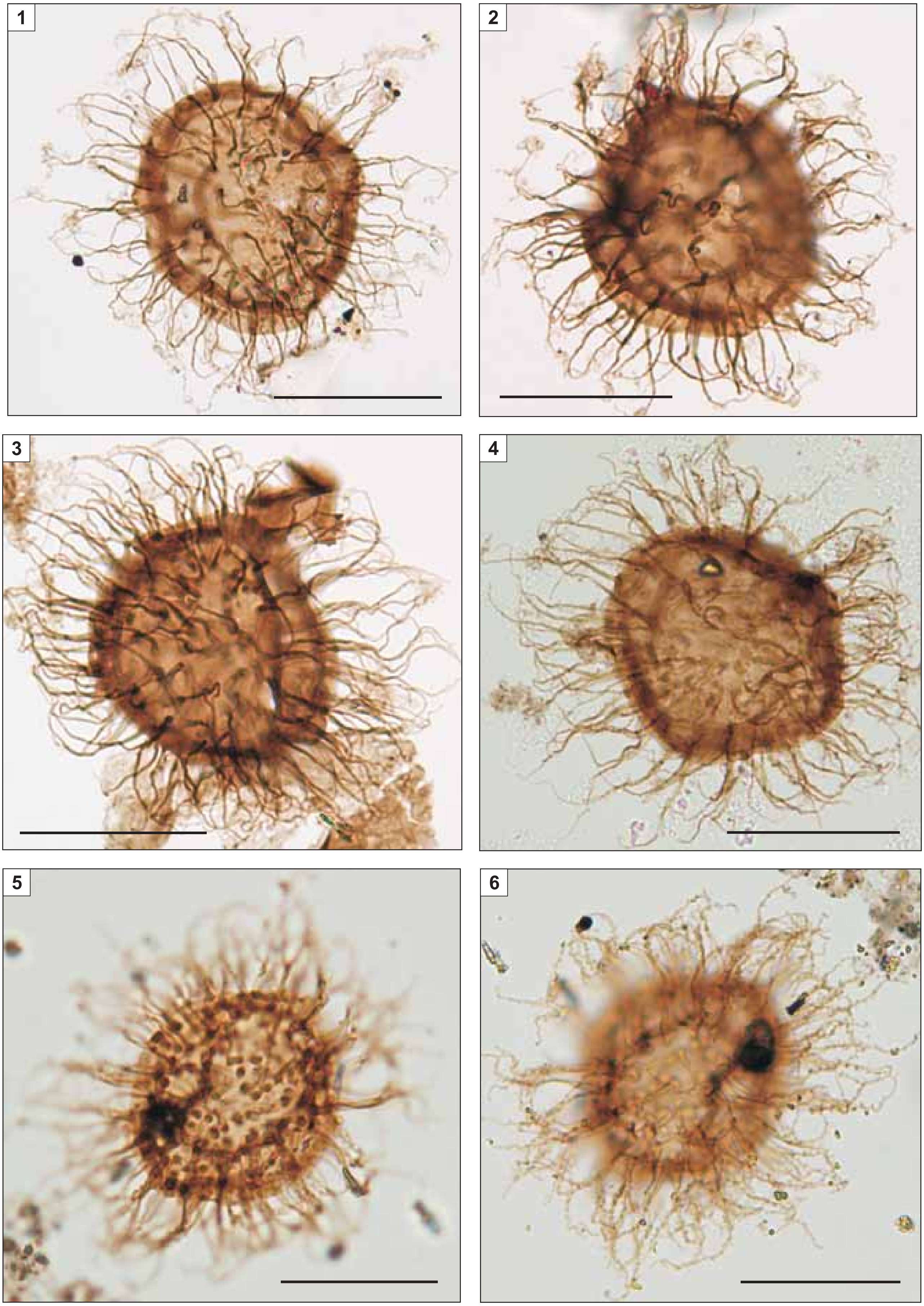
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PLATE IX

Figs. 1–3. *Globosphaeridium cerinum* (Volkova, 1968) Moczydłowska, 1991; Goczałkowice IG 1 borehole, depth 2894.5 m

Figs. 4, 6, 9, 10. *Ichnosphaera aranea* n.sp.; Kozy Mt 3 borehole, depth 1497.0 m

Figs. 5, 11. *Ichnosphaera flexuosa* (Eklund, 1990) n.comb.; Kozy Mt 3 borehole, depth 1497.0 m

Figs. 7, 8. *Ichnosphaera robusta* n.sp.; Kozy Mt 3 borehole, depth 1497.0 m

Scale bar equals 20 µm

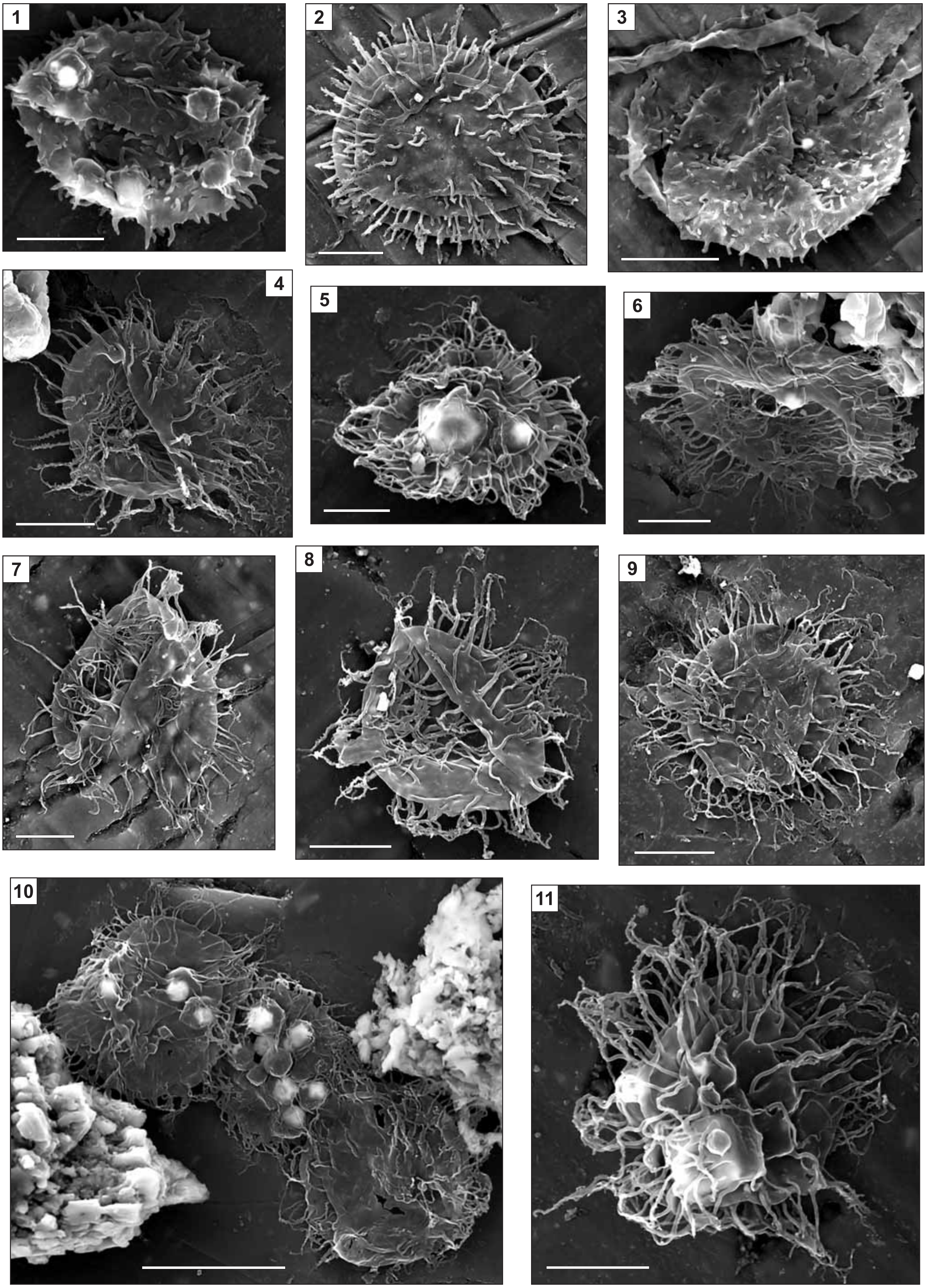
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PLATE X

Kozy Mt 3 borehole, depth 1497.0 m

Figs. 1–4, 6–9. *Ichnosphaera flexuosa* (Eklund, 1990) n.comb.

Figs. 5, 10. *Ichnosphaera aranea* n.sp.

Scale bar equals 20 µm

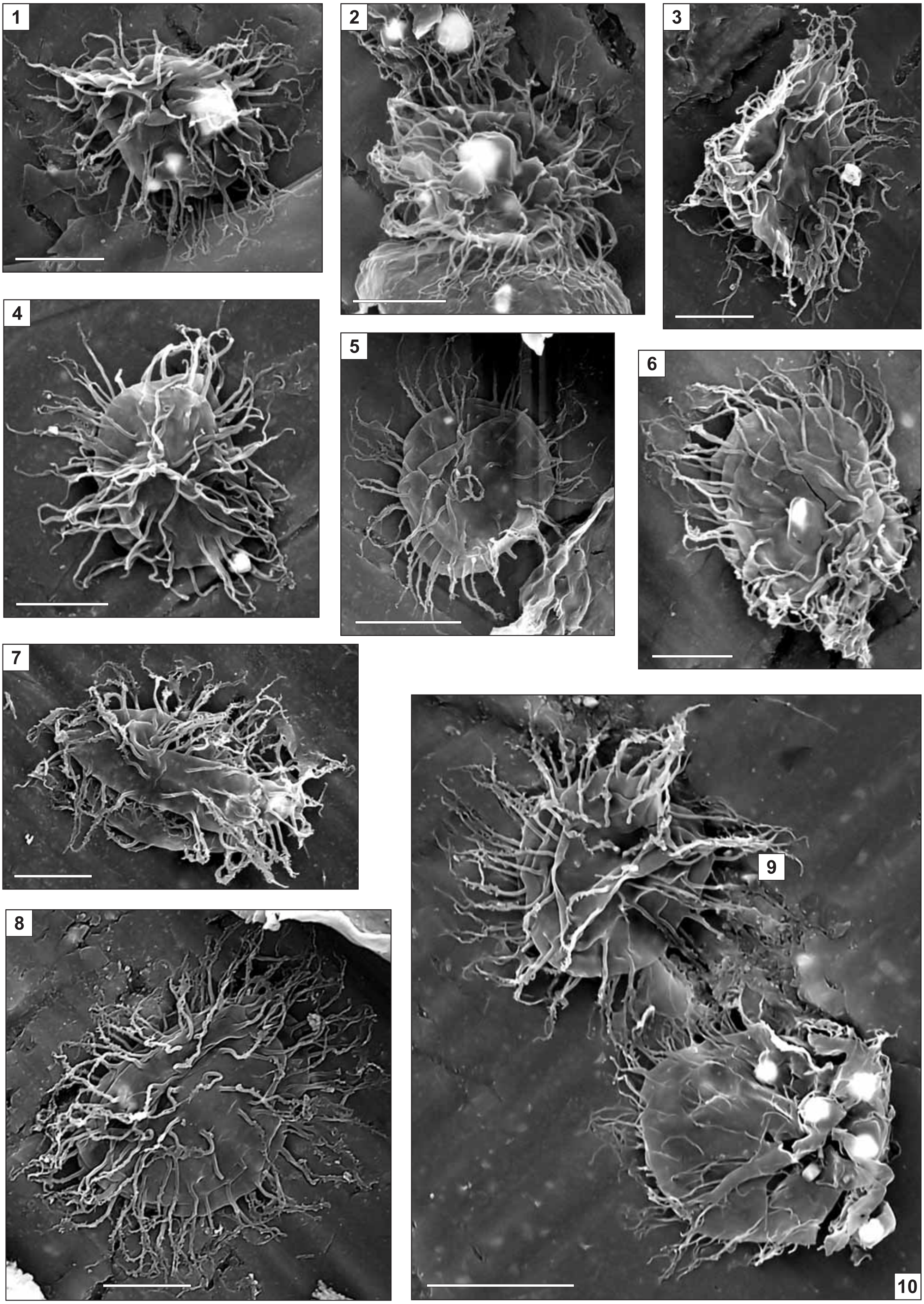
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PLATE XI

Kozy Mt 3 borehole, depth 1497.9 m

Figs. 1–7. *Lechistania magna* n.sp.; Fig. 4 – holotype

Scale bar equals 20 µm

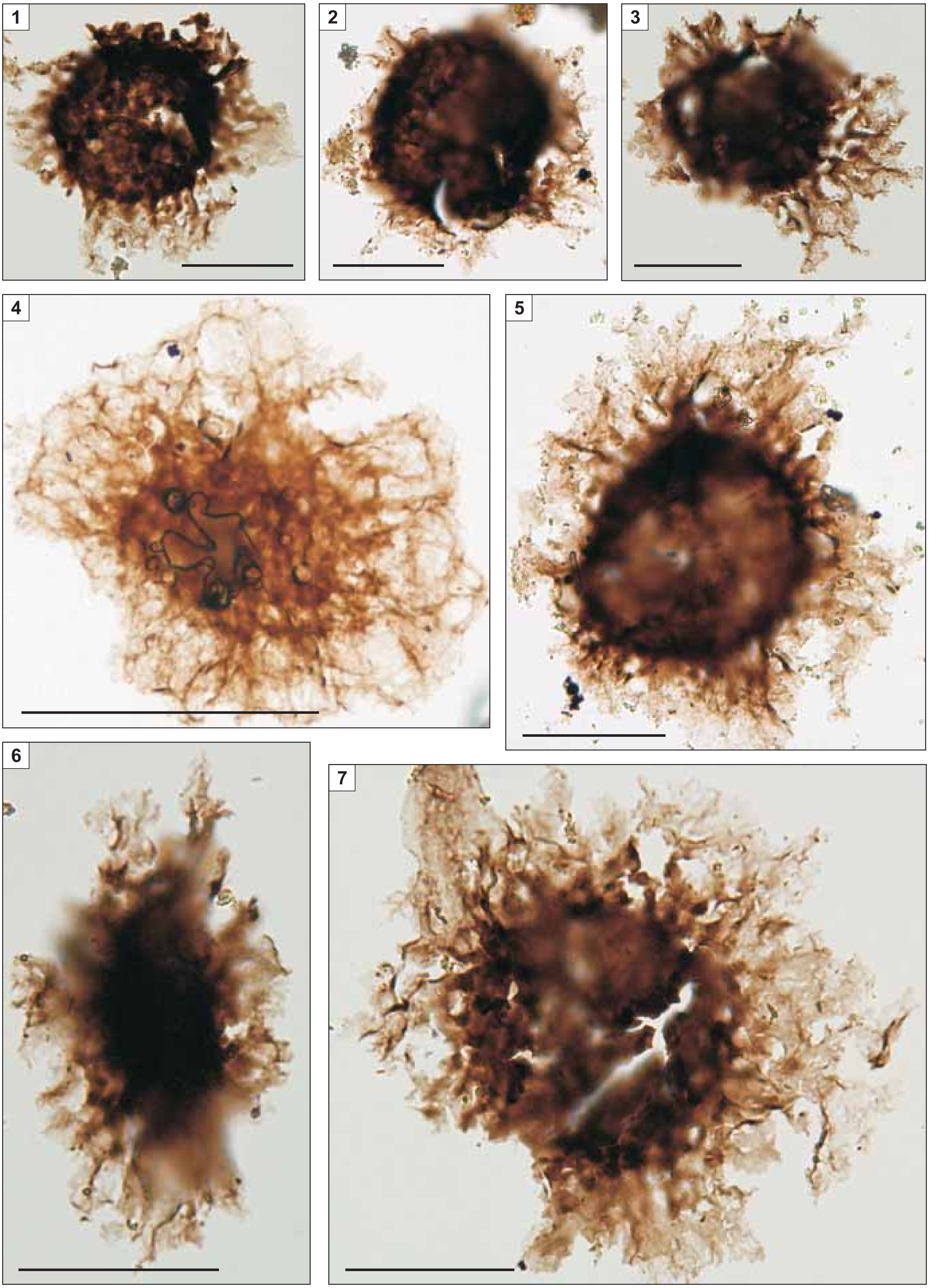
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PLATE XII

Figs. 1–3. *Skiagia scottica* Downie, 1982; Sułoszowa borehole, depth 199.1 m

Figs. 4, 6, 9–12. *Skiagia orbiculare* (Volkova, 1968) Downie, 1982; Sułoszowa borehole, depth 199.1 m

Fig. 5. *Skiagia pura* Moczydłowska, 1988; Sułoszowa borehole, depth 321.0 m

Figs. 7, 8. *Skiagia ciliosa* (Volkova, 1969) Downie, 1982; Sułoszowa borehole, depth 199.1 m

Scale bar equals 20 µm

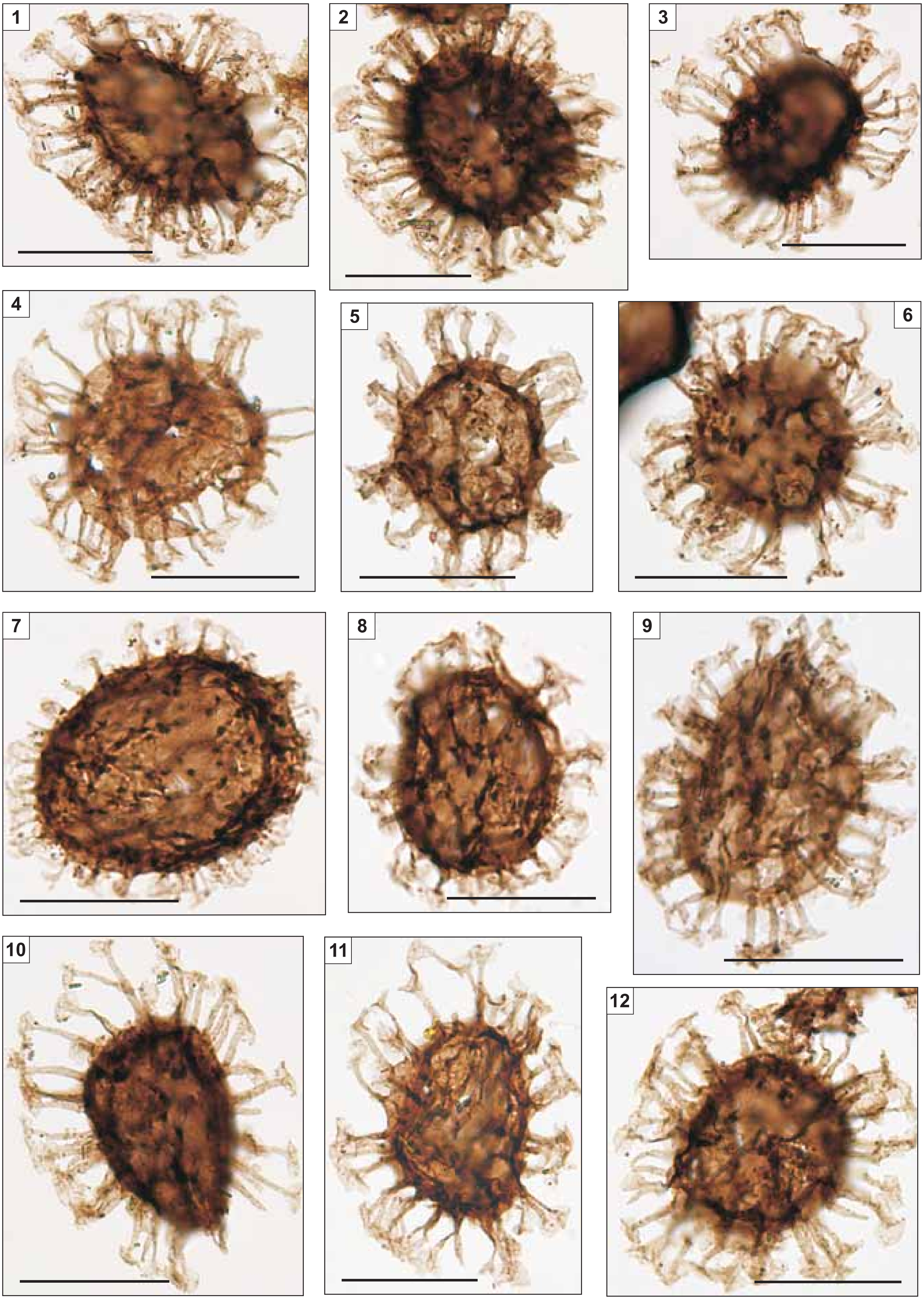
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PLATE XIII

Figs. 1–3.	*Skiagia pura* Moczydłowska, 1988; Sułoszowa borehole, depth 321.0 m
Fig. 4.	*Skiagia orbiculare* (Volkova, 1968) Downie, 1982; Goczałkowice IG 1 borehole, depth 3032.0 m
Figs. 5, 6, 10.	*Skiagia compressa* (Volkova, 1968) Downie, 1982; Němčičky 3 borehole, depth 5400.5 m
Figs. 7, 9, 11, 12.	*Skiagia ciliosa* (Volkova, 1969) Downie, 1982; Goczałkowice IG 1 borehole, depth 2850.45 m
Fig. 8.	*Skiagia scottica* (Volkova, 1968) Downie, 1982; Goczałkowice IG 1 borehole, depth 2781.3 m

Scale bar equals 20 µm

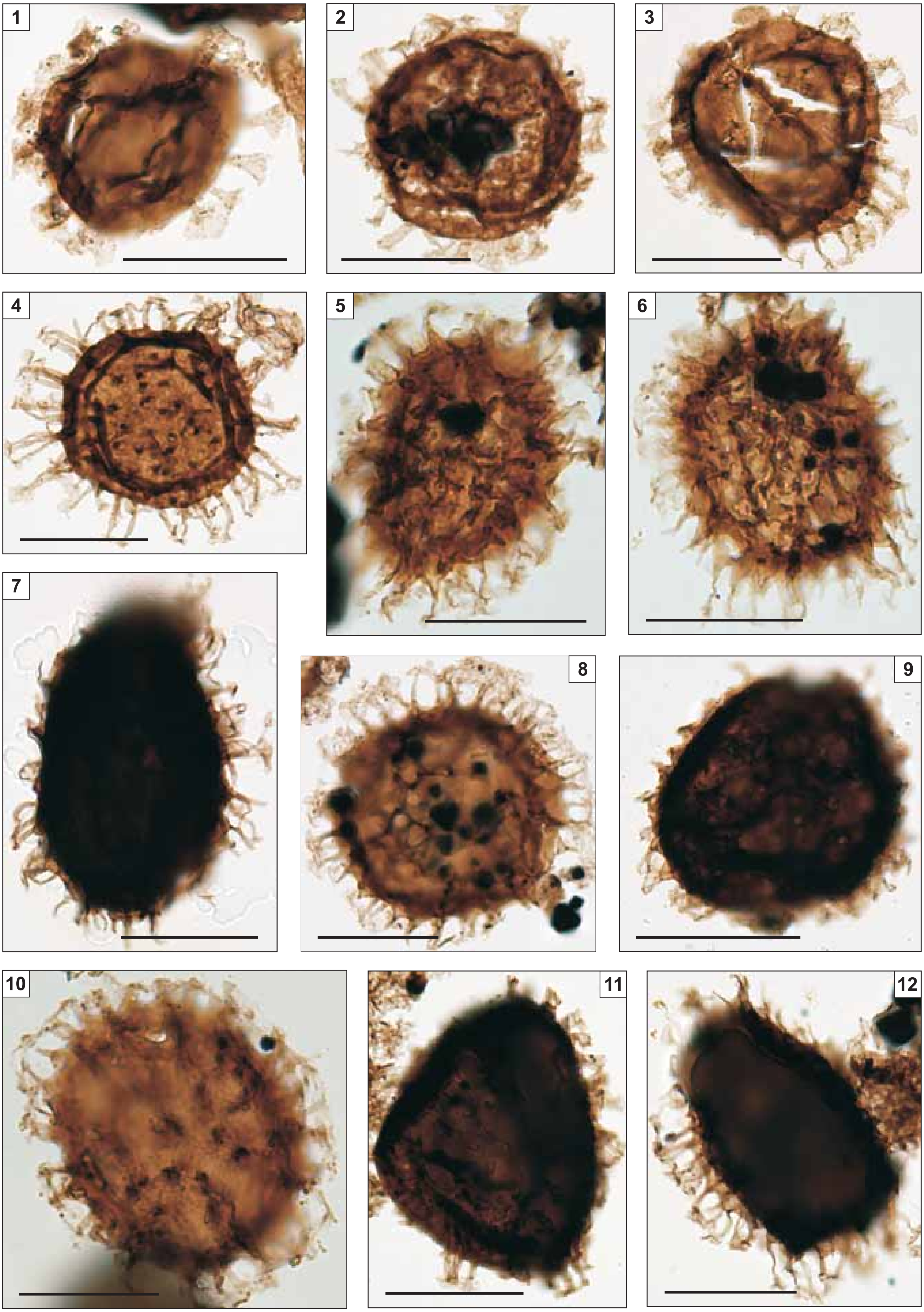
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PLATE XIV

Fig. 1. *Skiagia ornata* (Volkova, 1968) Downie, 1982; Kozy Mt 3 borehole, depth 1492.8 m

Fig. 2. *Skiagia ornata* (Volkova, 1968) Downie, 1982; Kozy Mt 3 borehole, depth 1470.0 m

Figs. 3, 4. *Skiagia ornata* (Volkova, 1968) Downie, 1982; Goczałkowice IG 1 borehole, depth 2771.5 m

Figs. 5, 6. *Skiagia compressa* (Volkova, 1968) Downie, 1982; Goczałkowice IG 1 borehole, depth 2771.5 m

Scale bar equals 20 µm

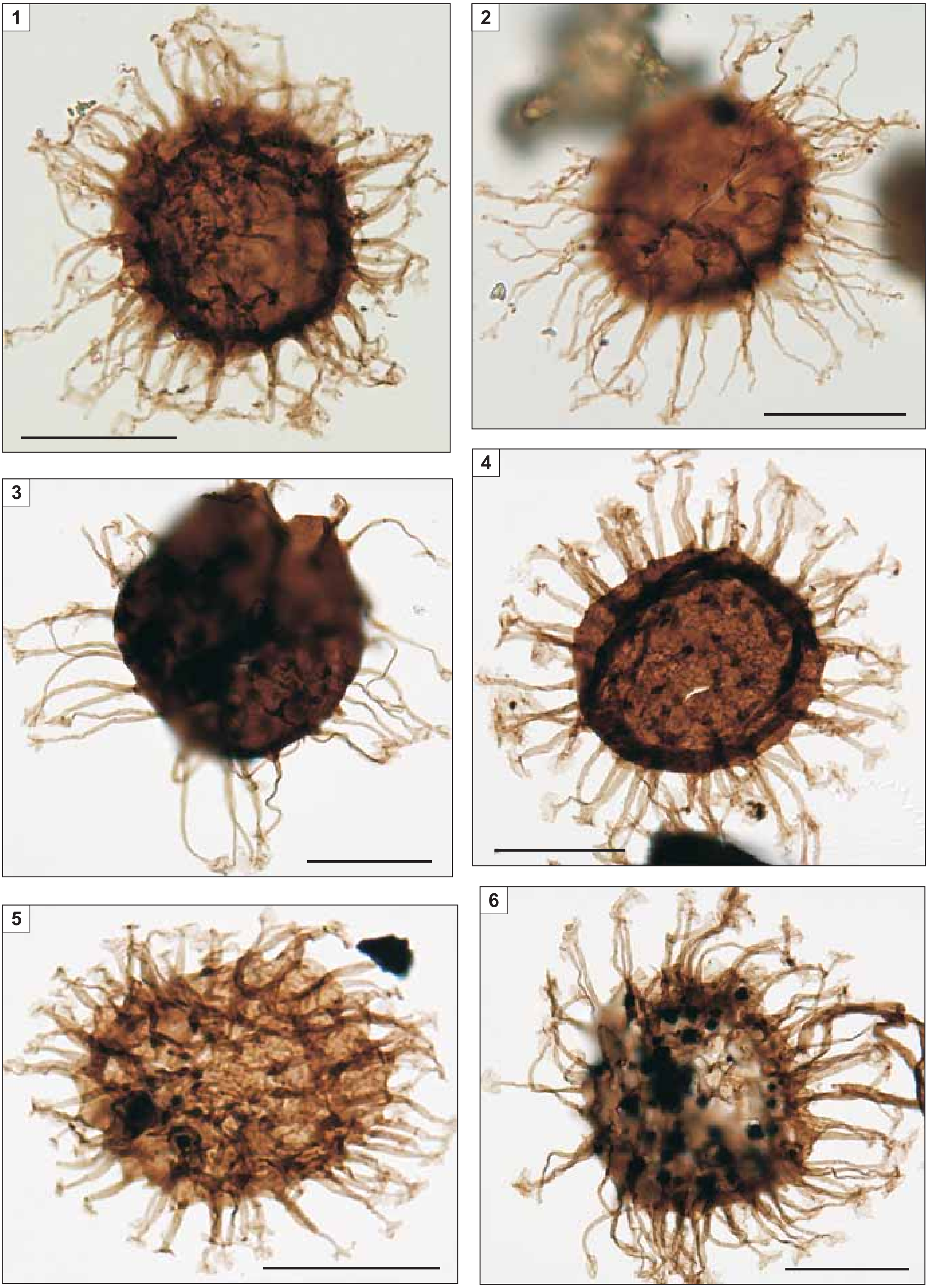
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PLATE XV

Fig. 1. *Skiagia compressa* (Volkova, 1968) Downie, 1982; Goczałkowice IG1 borehole, depth 2771.5 m

Figs. 2, 4. *Skiagia orbiculare* (Volkova, 1968) Downie, 1982; Goczałkowice IG 1 borehole, depth 2771.5 m

Fig. 3. *Skiagia pilosiuscula* (Jankauskas, 1983) n.comb.; Goczałkowice IG 1 borehole, depth 2771.5 m

Figs. 5, 6. *Skiagia pilosiuscula* (Jankauskas, 1983) n.comb.; Goczałkowice IG 1 borehole, depth 2792.0 m

Scale bar equals 20 μm

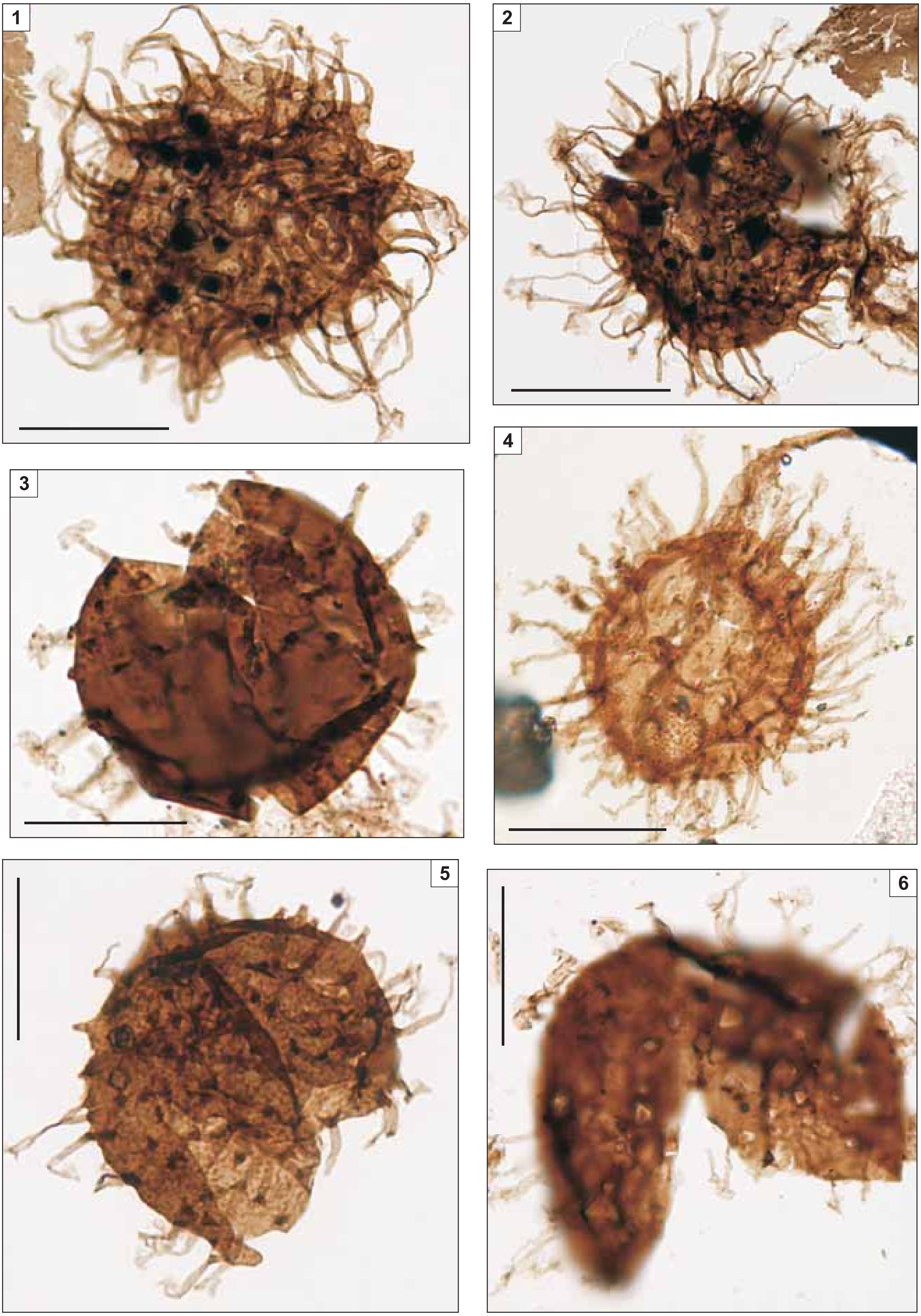
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PLATE XVI

Figs. 1–3. *Asteridium spinosum* (Volkova, 1969) Moczydłowska, 1991; Sosnowiec IG 1 borehole, depth 3217.2 m

Figs. 4, 5, 8. *Heliosphaeridium longum* (Moczydłowska, 1988) Moczydłowska, 1991; Sosnowiec IG 1 borehole, depth 3212.0 m

Figs. 6, 10. *Asteridium* sp.; Sosnowiec IG 1 borehole, 3163.5 m

Fig. 7. *Heliosphaeridium dissimilare* (Volkova, 1969) Moczydłowska, 1991; Sułoszowa borehole, depth 199.1 m

Fig. 9. *Heliosphaeridium coniferum* (Downie, 1982) Moczydłowska, 1991; Goczałkowice IG 1 borehole, depth 2771.0 m

Figs. 11, 15. *Globus gossipinus* Vidal, 1988; Měnín 1 borehole, depth 473.0–477.5 m

Fig. 12. *Skiagia brachyspinosa* (Kirjanov, 1974) n.comb.; Němčičky 6, depth 5157.8 m

Figs. 13, 14. *Heliosphaeridium obscurum* (Volkova, 1969) Moczydłowska, 1991; Goczałkowice IG 1 borehole, depth 2771.0 m

Fig. 16. *Globosphaeridium cerinum* (Volkova, 1968) Moczydłowska, 1991; Kozy Mt 3 borehole, depth 1492.5 m

Figs. 17, 18. *Lophospheridium dubium* (Volkova, 1968) Moczydłowska, 1991; Sułoszowa borehole, depth 199.1 m

Figs. 19–22. *Ceratophyton vernicosum* Kirjanov, 1979; Borzęta IG 1 borehole depth 3353.3 m

Fig. 23. *Comasphaeridium molliculum* (Moczydłowska et Vidal, 1988); Sułoszowa borehole depth 321.0 m

Figs. 24–28. *Ceratophyton vernicosum* Kirjanov, 1979; Borzęta IG 1 borehole depth 3368.0 m

Scale bar equals 20 µm for Figs. 1–19; 100 µm for Figs. 20–28

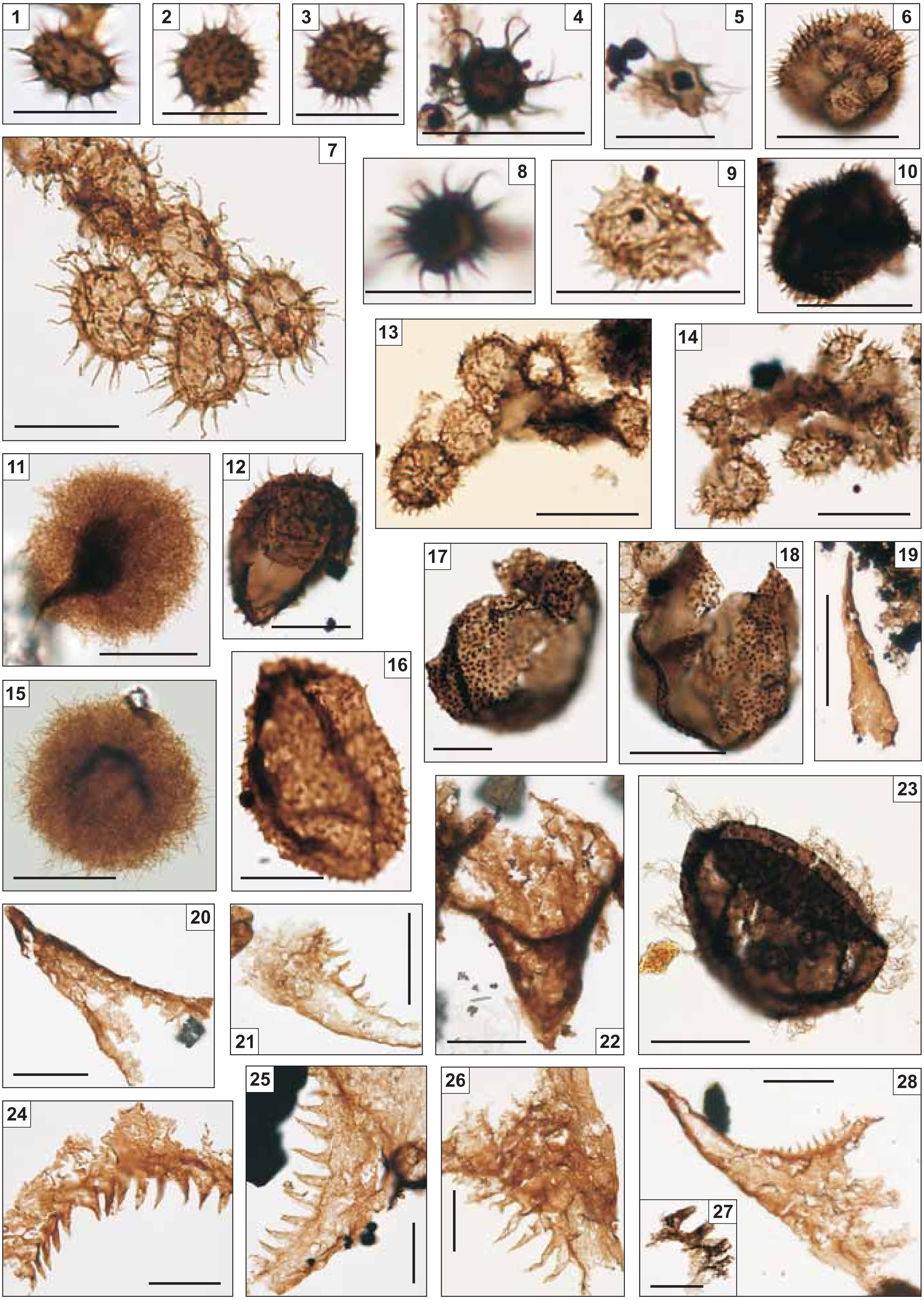
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PLATE XVII

Fig. 1. *Granomarginata parva* n. sp.; holotype, Sosnowiec borehole, depth 3412.5 m

Fig. 2. *Granomarginata prima* Naumova, 1961; Sułoszowa borehole, depth 199.1 m

Figs. 3, 4. *Granomarginata squamacea* Volkova, 1968; Klucze 1 borehole, depth 1680.0–1690.0 m

Figs. 5–10. *Pterospermella inordinata* n.sp.; Sułoszowa borehole, depth 199.1 m; Fig. 8 – holotype

Figs. 11, 12. *Pterospermopsimorpha rugulosa* n.sp.; Sułoszowa borehole, depth 199.1 m

Fig. 13. *Pterospermopsimorpha rugulosa* n.sp.; holotype; Klucze 1 borehole, depth 1680.0–1690.0 m

Fig. 14. *Granomarginata squamacea* Volkova, 1968; Goczałkowice IG 1 borehole, depth 2843.5 m

Scale bar equals 20 µm

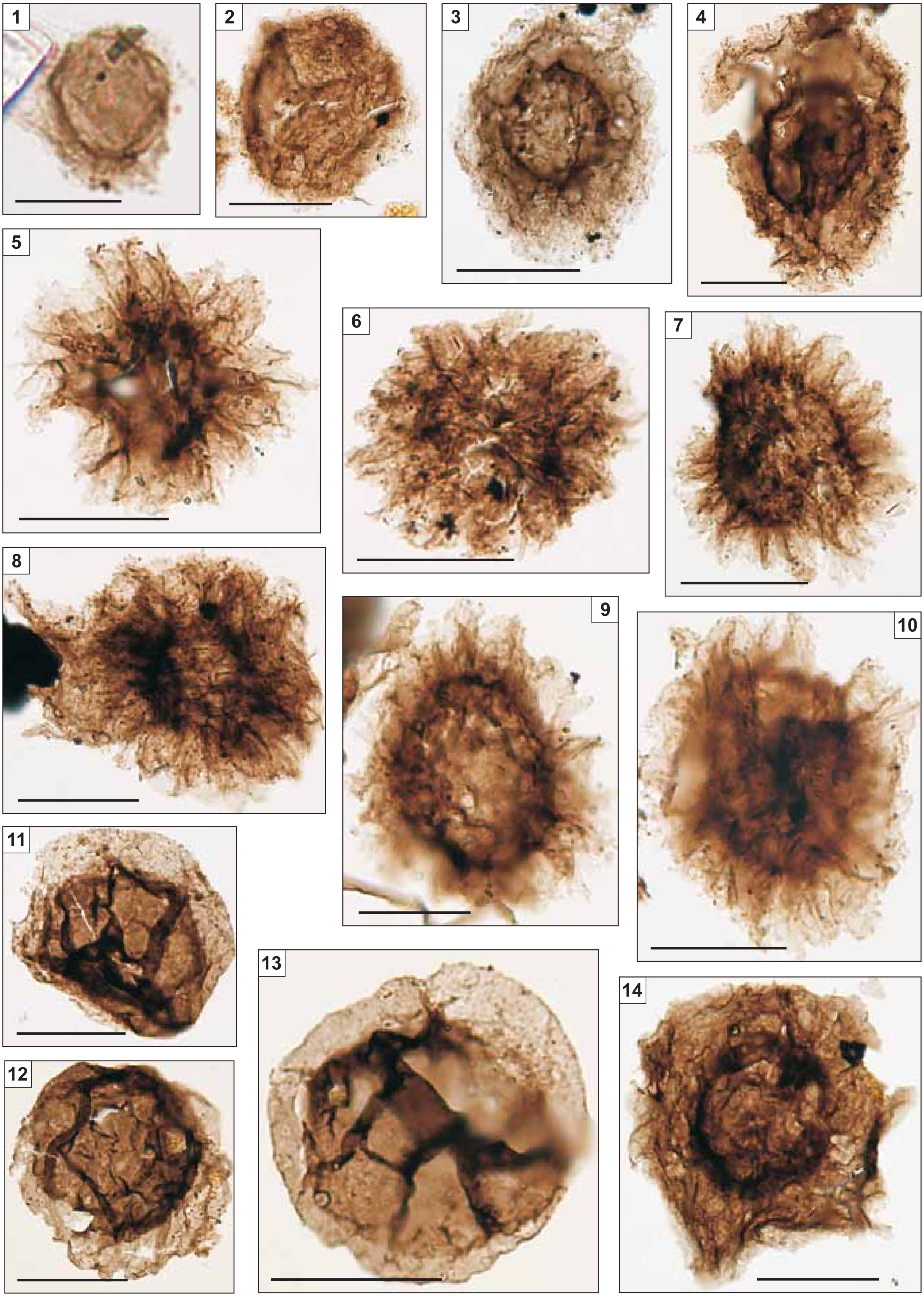
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PLATE XVIII

Figs. 1–3, 7. *Estiastra minima* Volkova, 1969; Sułoszowa borehole, depth 199.1 m

Fig. 4. *Goniosphaeridium volkovae* Hagenfeldt 1989; Goczałkowice IG 1 borehole, depth 2768.0 m

Fig. 5. *Solisphaeridium elegans* Moczydłowska, 1998; Sułoszowa borehole, depth 199.1 m

Fig. 6. *Revinotesta* sp.; Sułoszowa borehole, depth 199.1 m

Fig. 8. *Estiastra minima* Volkova, 1969; Goczałkowice IG 1 borehole, depth 2768.0 m

Figs. 9, 10. *Multiplicisphaeridium xianum* Fombella, 1977; Goczałkowice IG 1 borehole, depth 2792.0 m

Figs. 11–13. *Multiplicisphaeridium xianum* Fombella, 1977; Sułoszowa borehole, depth 199.1 m

Fig. 14. *Sagatum priscum* (Kirjanov et Volkova, 1983) Vavrdová and Bek, 2001; Goczałkowice IG 1 borehole, depth 2768.0 m

Fig. 15. *Leiovalia tenera* Kirjanov, 1974; Němčičky 6 borehole, depth 5157.8 m

Figs. 16, 17. *Sagatum priscum* (Kirjanov et Volkova, 1983) Vavrdová and Bek, 2001; Sułoszowa borehole, depth 199.1 m

Scale bar equals 20 µm

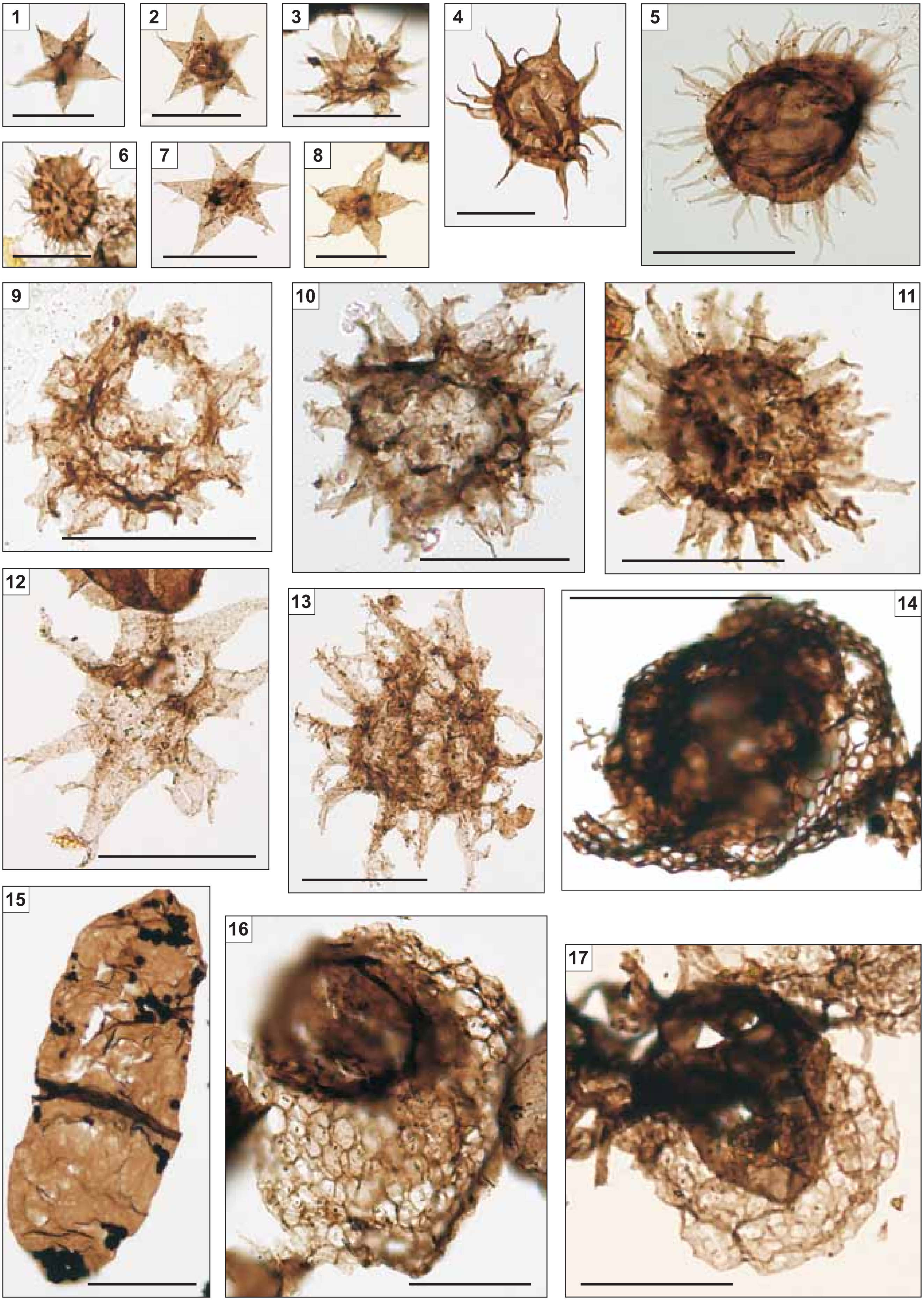
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PLATE XIX

Figs. 1–4. *Eklundia pusilla* n.sp.; Goczałkowice IG 1 borehole, depth 2893.0 m; Fig. 1 – holotype

Fig. 5. *Eklundia campanula* (Eklund, 1990) n.comb.; Goczałkowice IG 1 borehole, depth 2872.5 m

Figs. 6–10. *Eklundia campanula* (Eklund, 1990) n.comb.; Sułoszowa borehole, depth 199.1 m

Figs. 11, 12. *Eklundia varia* (Volkova, 1969) n.comb.; Goczałkowice IG 1 borehole, depth 2842.3 m

Scale bar equals 20 µm

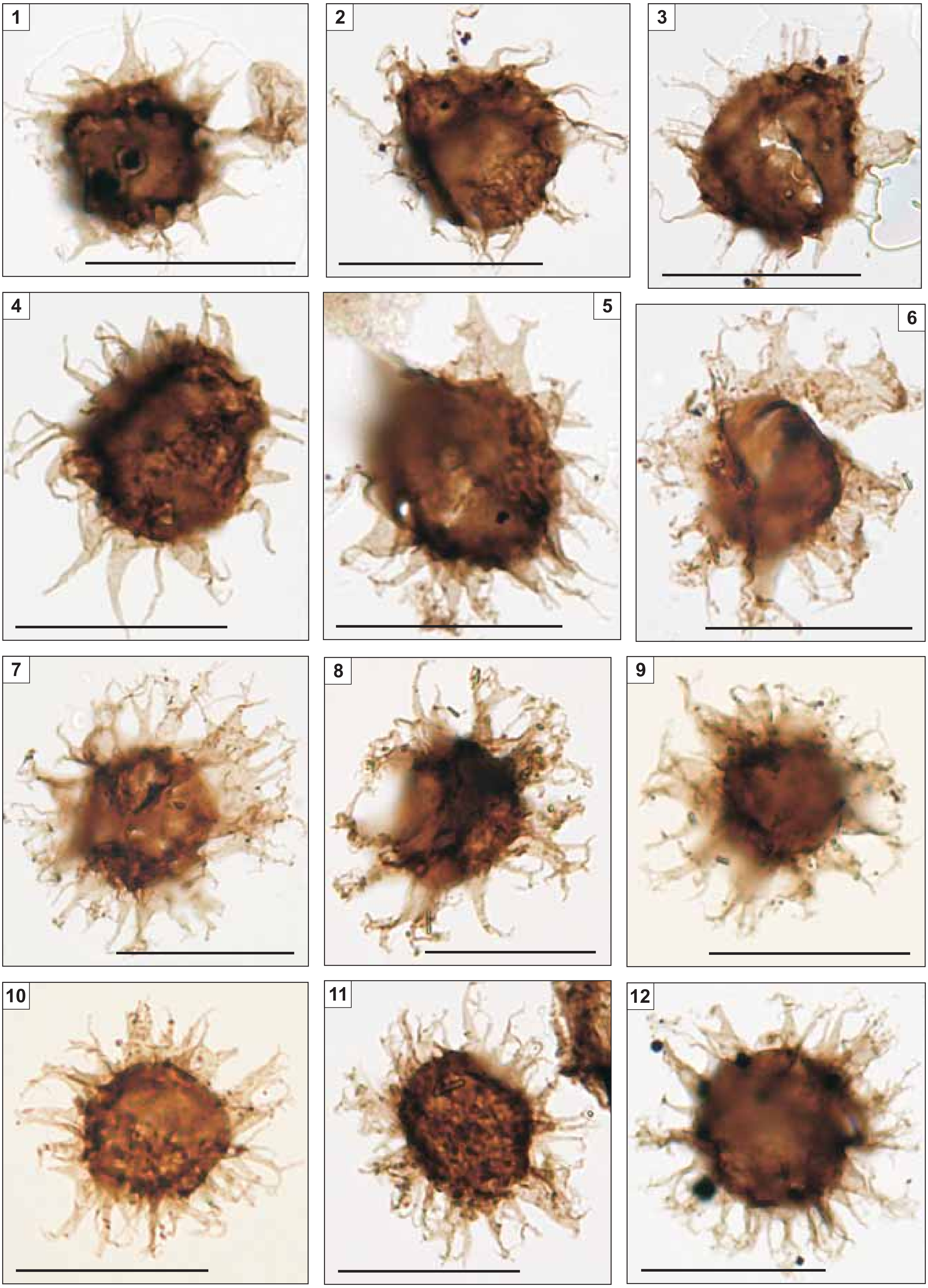
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PLATE XX

Figs. 1, 2. *Eklundia varia* (Volkova, 1969) n.comb.; Sułoszowa borehole, depth 199.1 m

Figs. 3, 4. *Eklundia varia* (Volkova, 1969) n.comb.; Goczałkowice IG1 borehole, depth 2842.7 m

Figs. 5–9. *Eklundia varia* (Volkova, 1969) n.comb.; Goczałkowice IG1 borehole, depth 2771.5 m

Figs. 10, 11. *Eklundia florentinata* n.sp.; Goczałkowice IG1 borehole, depth 2771.5 m; Fig. 10 – holotype

Scale bar equals 20 µm

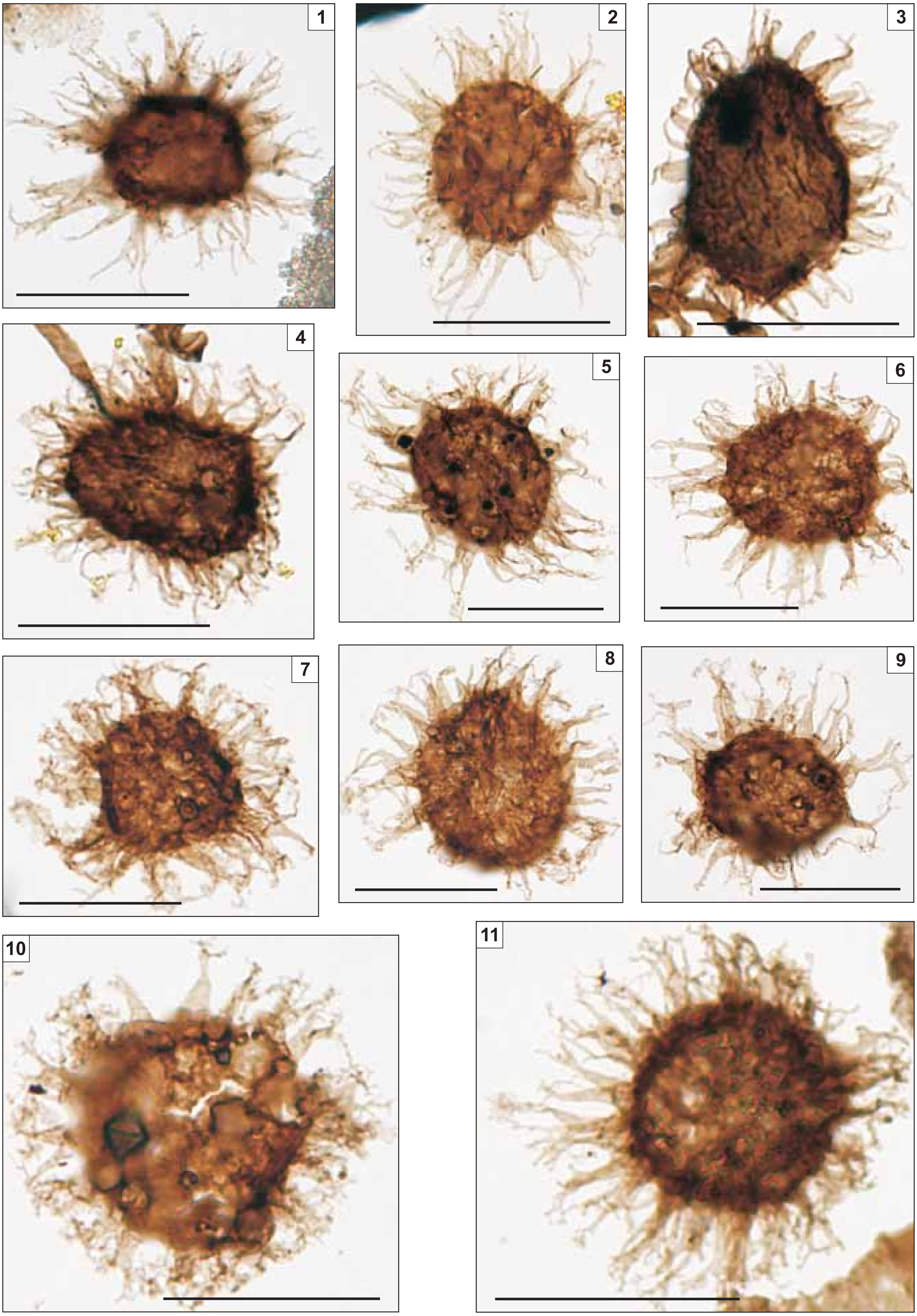
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PLATE XXI

Figs. 1–3, 5, 6. *Parmasphaeridium robustispinosum* n.sp.; Sułoszowa borehole, depth 199.1 m; Fig. 6 – holotype

Fig. 4. *Parmasphaeridium robustispinosum* n.sp.; Goczałkowice IG 1 borehole, depth 2897.0 m

Figs. 7–10. *Parmasphaeridium implicatum* (Fridrichsone, 1971) n.comb.; Goczałkowice IG 1 borehole, depth 2771.5 m

Figs. 11, 13, 14. *Parmasphaeridium* sp.; Sosnowiec IG 1 borehole, depth 3204.5 m

Fig. 12. *Parmasphaeridium implicatum* (Fridrichsone, 1971) n.comb.; Klucze 1, depth 1680.0–1690.0 m

Scale bar equals 20 µm

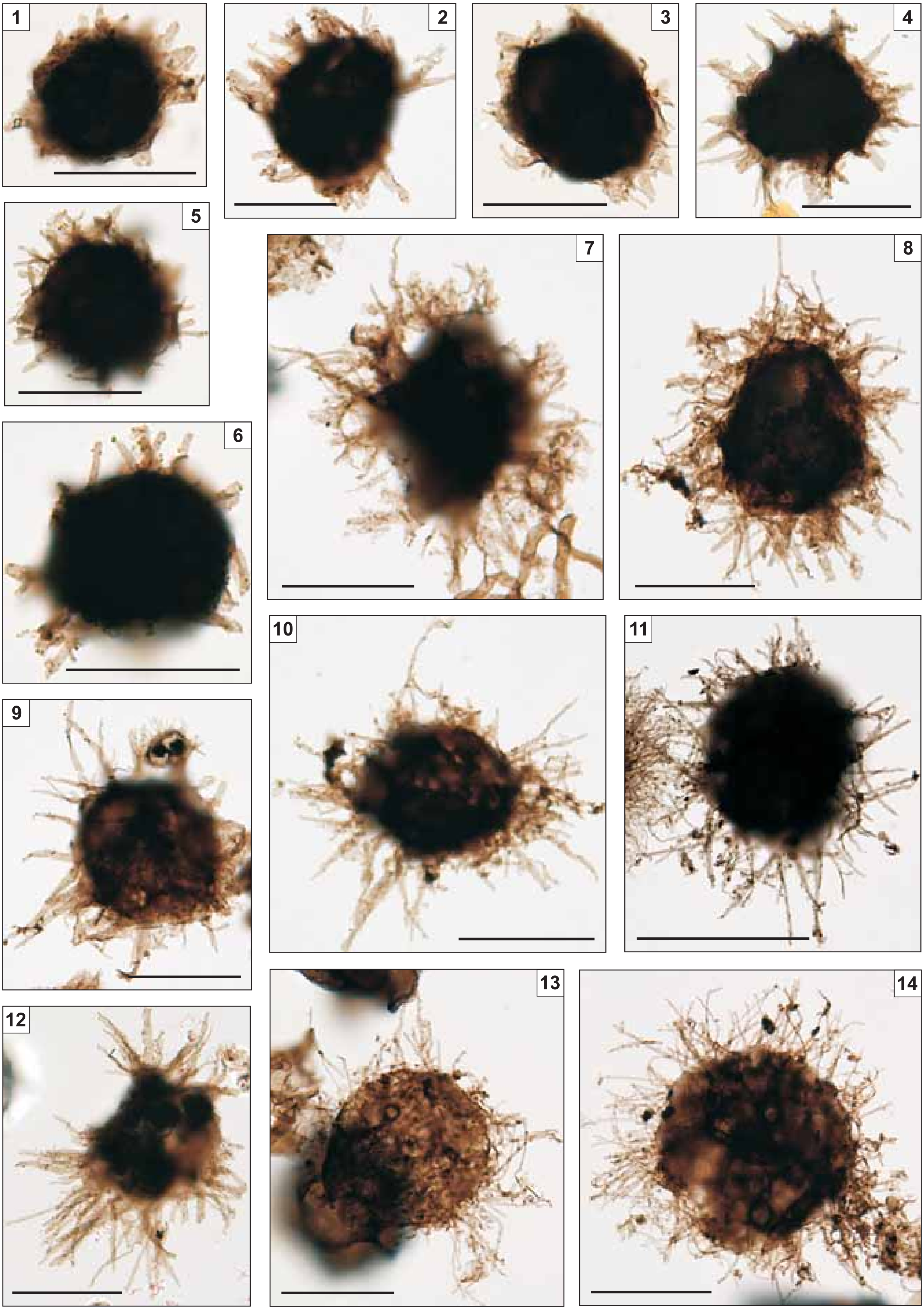
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PLATE XXII

Sosnowiec IG 1 borehole

Figs. 1–3, 6, 8, 12, 16.	*Ammonidium bellulum* (Moczydłowska, 1998) Sarjeant et Stancliffe, 2000; depth 3423.8 m
Fig. 4.	*Ammonidium oligum* (Jankauskas, 1976) n.comb.; depth 3423.8 m
Figs. 5, 7, 9–11.	*Ammonidium bellulum* (Moczydłowska, 1998) Sarjeant et Stancliffe, 2000; depth 3412.5 m
Figs. 13, 15.	*Ammonidium notatum* (Volkova, 1969) n.comb.; depth 3363.0 m
Figs. 14, 18.	*Ammonidium notatum* (Volkova, 1969) n.comb.; depth 3423.8 m
Figs. 17, 19, 21, 24.	*Ammonidium notatum* (Volkova, 1969) n.comb.; depth 3360.0 m
Figs. 20, 23.	*Ammonidium notatum* (Volkova, 1969) n.comb.; depth 3357.0 m
Fig. 22.	*Ammonidium notatum* (Volkova, 1969) n.comb.; depth 3369.4 m

Scale bar equals 20 µm

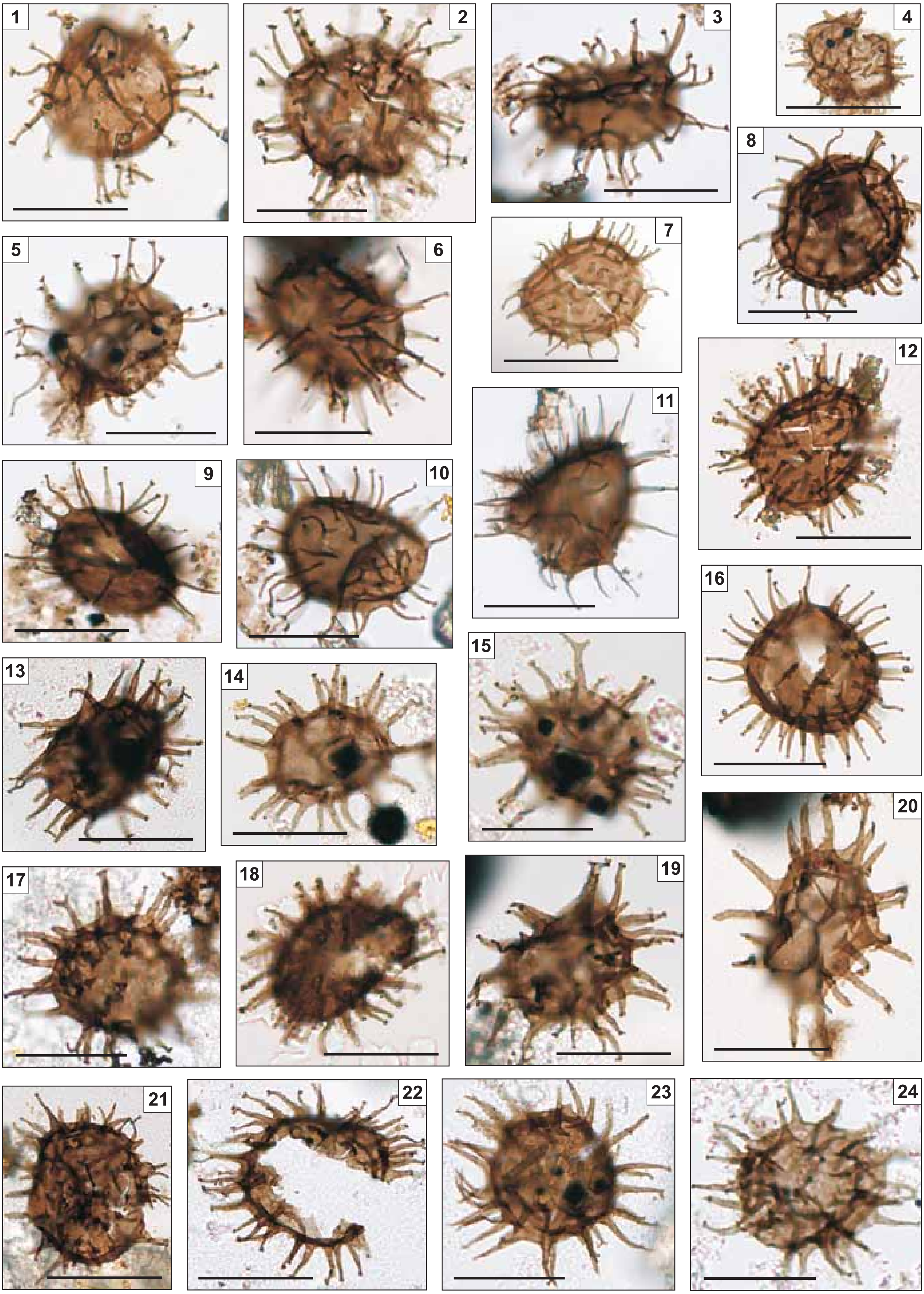
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PLATE XXIII

Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 1–8. *Multiplicisphaeridium martae* Cramer et Diez, 1972

Figs. 9–14. *Comasphaeridium longispinosum* Hagenfeldt, 1989 emend.

Scale bar equals 20 µm for Figs. 1–8; 50 µm for Figs. 9–14

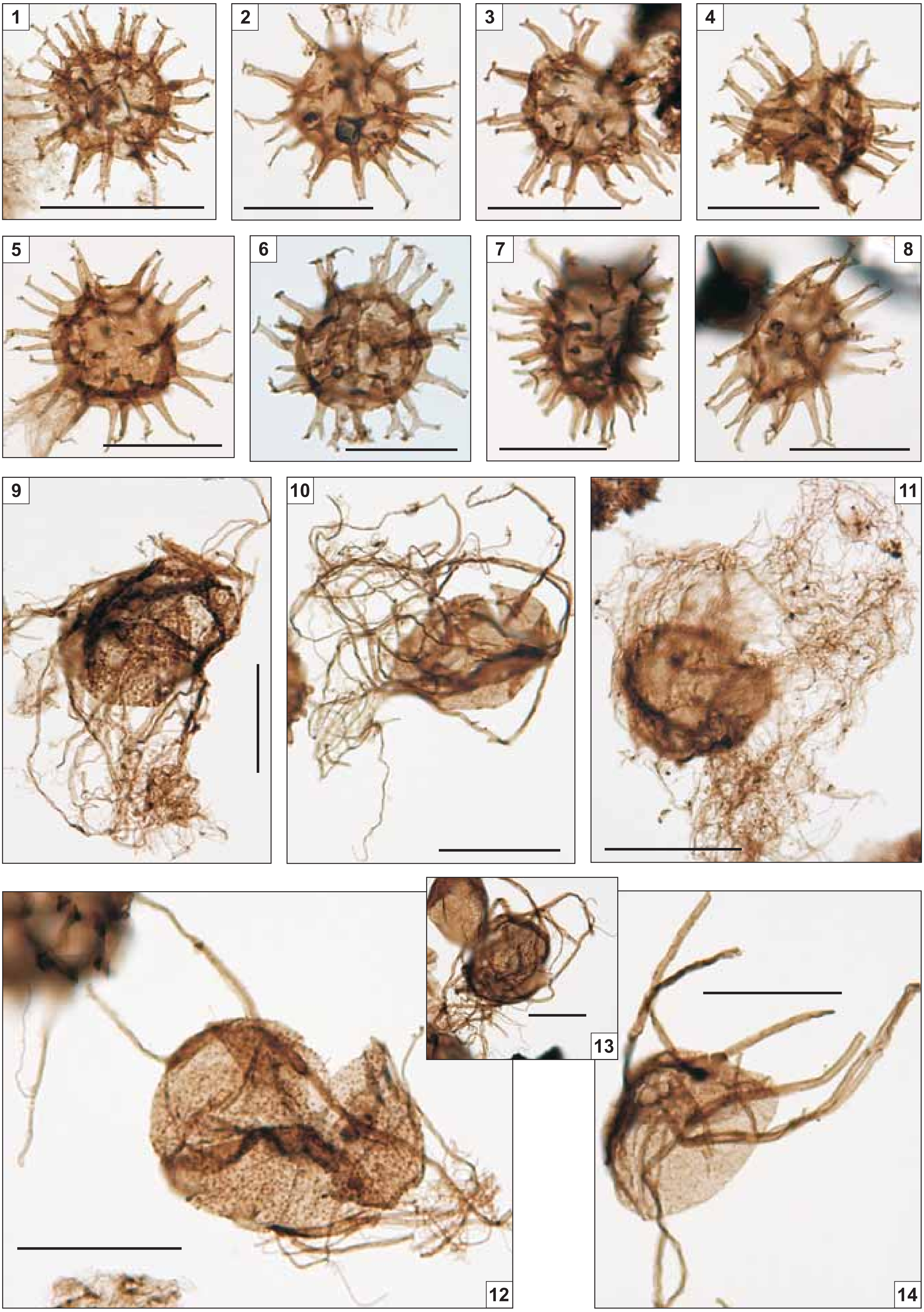
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PLATE XXIV

Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 1–17. *Turrisphaeridium semireticulatum* (Timofeev, 1959) n.comb.

Scale bar equals 20 μm

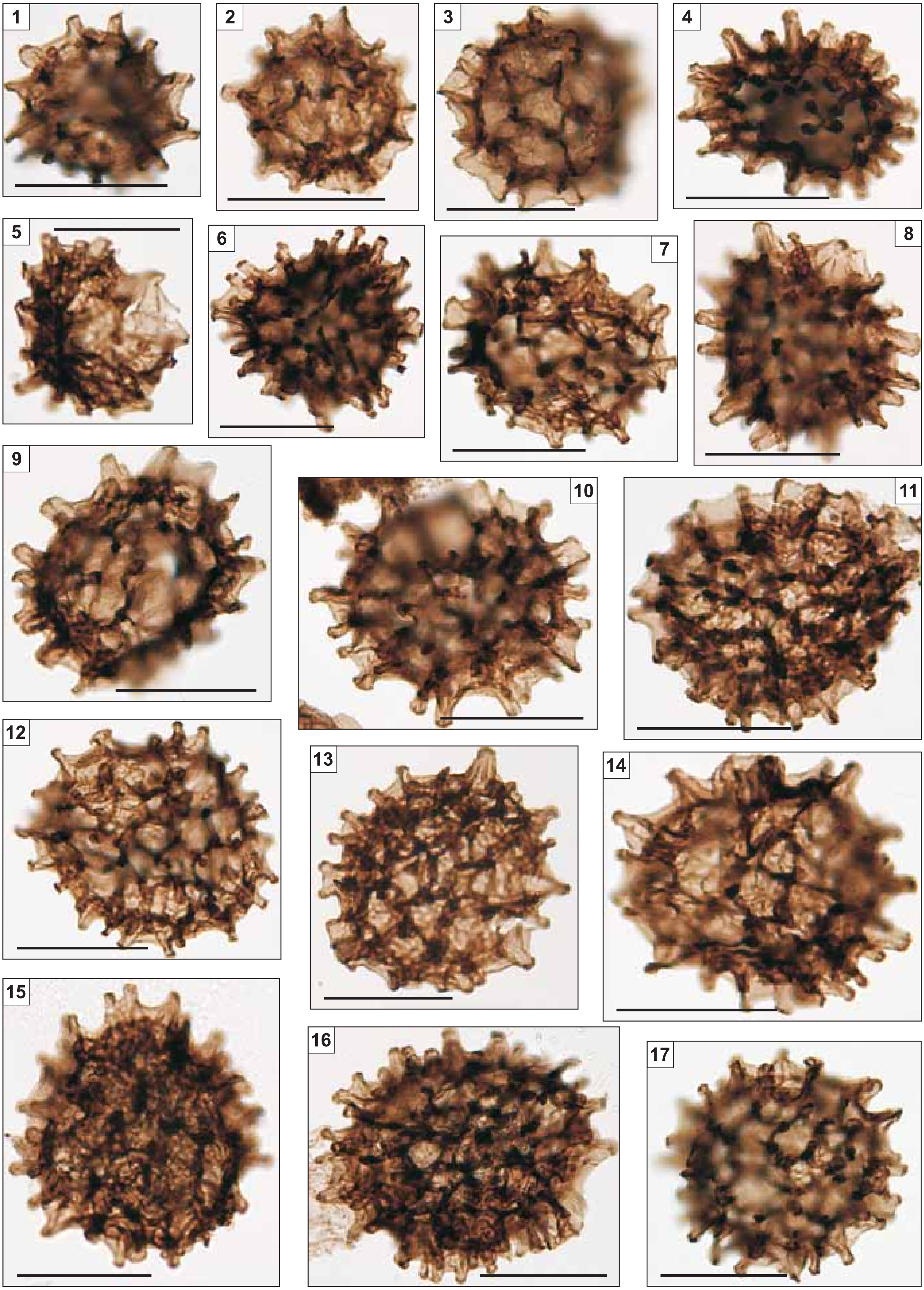
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PLATE XXV

Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 1–11. *Turrisphaeridium semireticulatum* (Timofeev, 1959) n.comb.

Figs. 12, 13. *Turrisphaeridium turgidum* n.sp.; Fig. 13 – holotype

Scale bar equals 20 µm

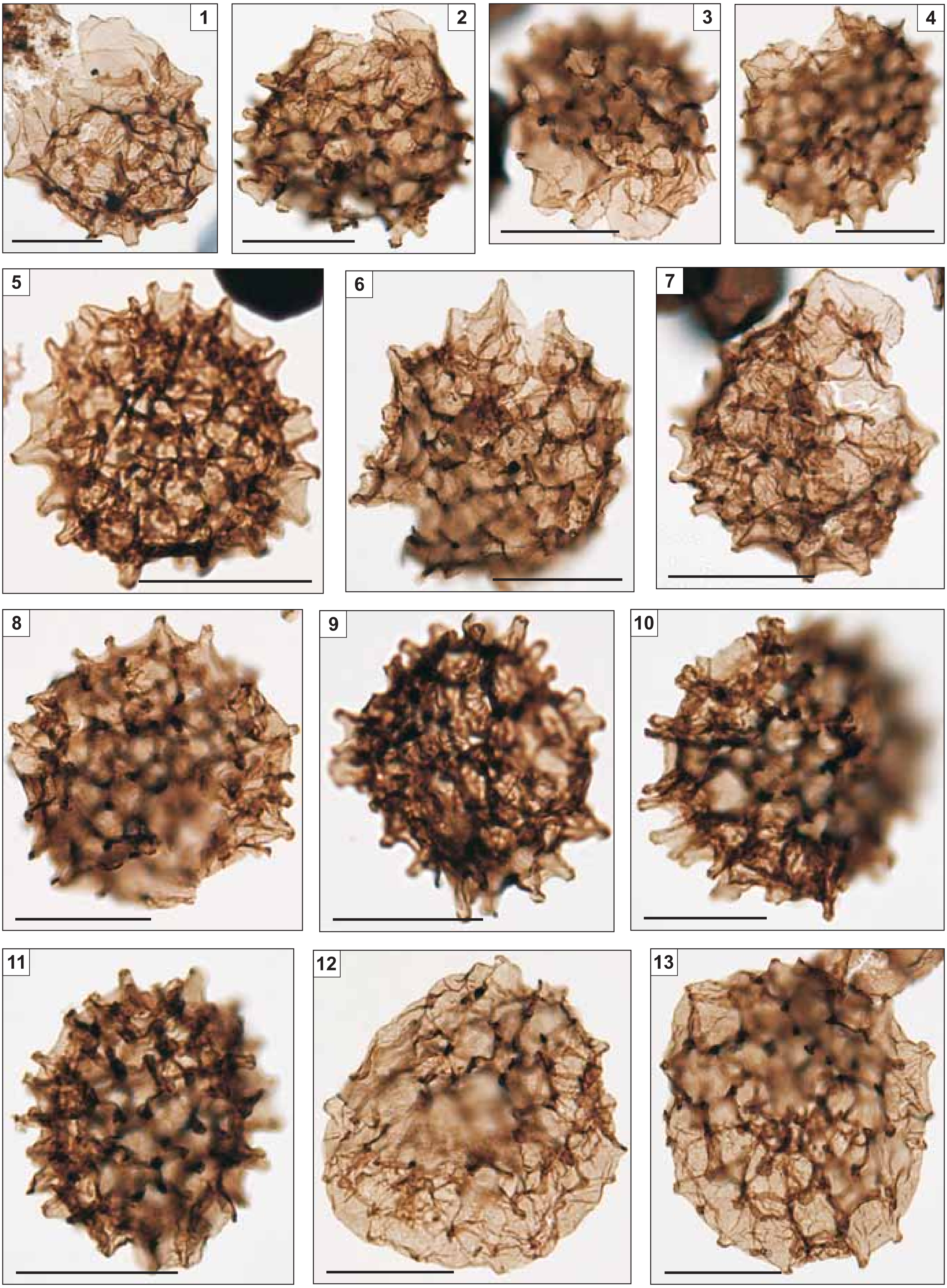
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PLATE XXVI

Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 1, 2, 7, 10, 12, 13, 15, 17.
Turrisphaeridium semireticulatum (Timofeev, 1959) n. comb.

Fig. 3. *Comasphaeridium silesiense* Moczydłowska, 1998 emended.

Figs. 4–6, 14. *Retisphaeridium postae* (Jankauskas in Jankauskas, Posti, 1976) Vanguestaine, Brück 2004

Fig. 8. *Solisphaeridium multiflexipilosum* (Slaviková, 1968) Moczydłowska, 1998

Figs. 9, 11. *Asteridium* sp.

Fig. 16. *Solisphaeridium flexipilosum* (Slaviková, 1968) Moczydłowska, 1998

Fig. 18. *Turrisphaeridium turgidum* n.sp.

Scale bar equals 20 µm

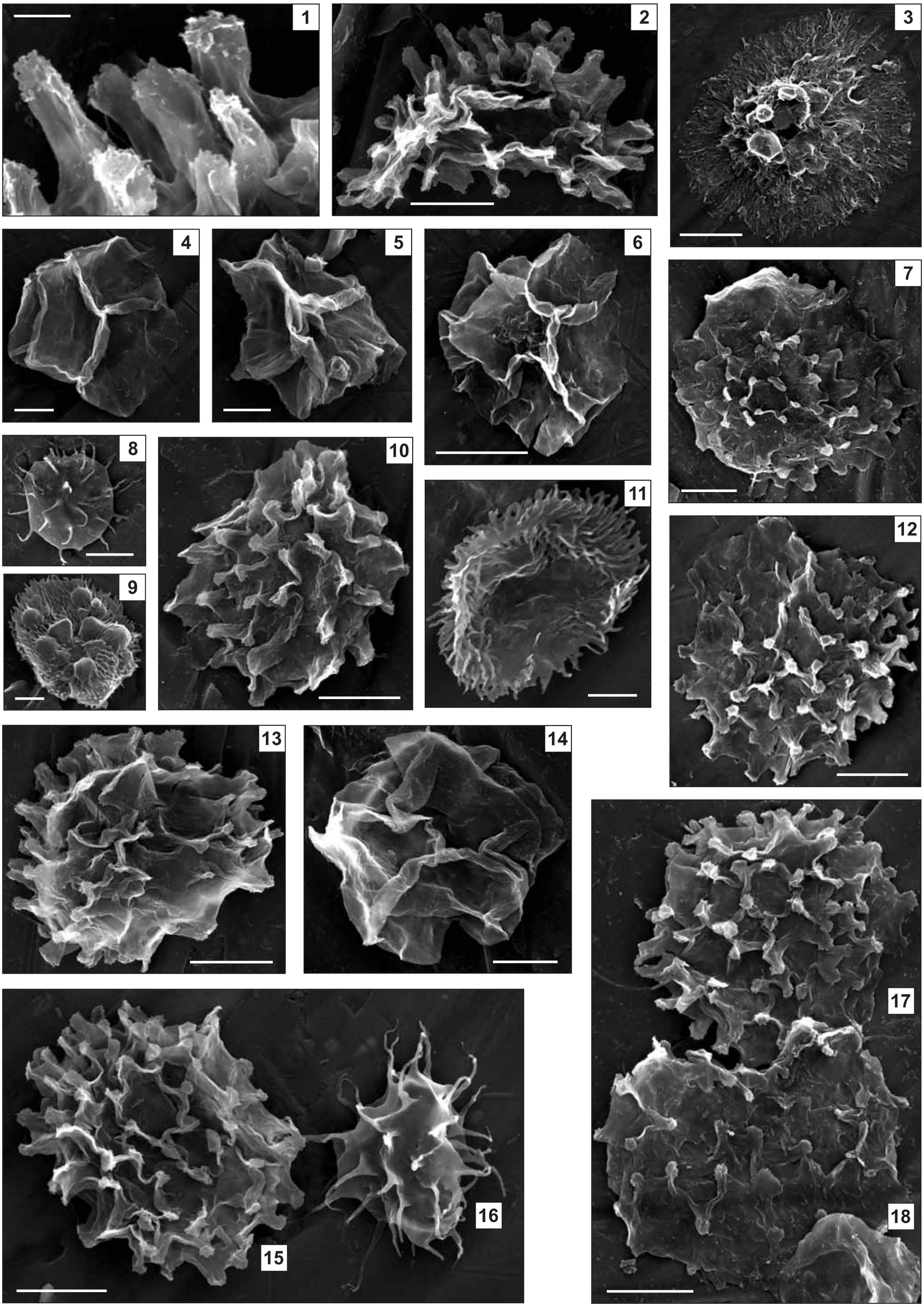
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PLATE XXVII

Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 1– 6, 10–12. *Turrisphaeridium semireticulatum* (Timofeev, 1959) n.comb.

Fig. 7. *Turrisphaeridium turgidum* n.sp.

Fig. 8. *Asteridium tornatum* (Volkova, 1969) Moczydłowska, 1991

Fig. 9. *Asteridium* sp.

Scale bar equals 20 µm

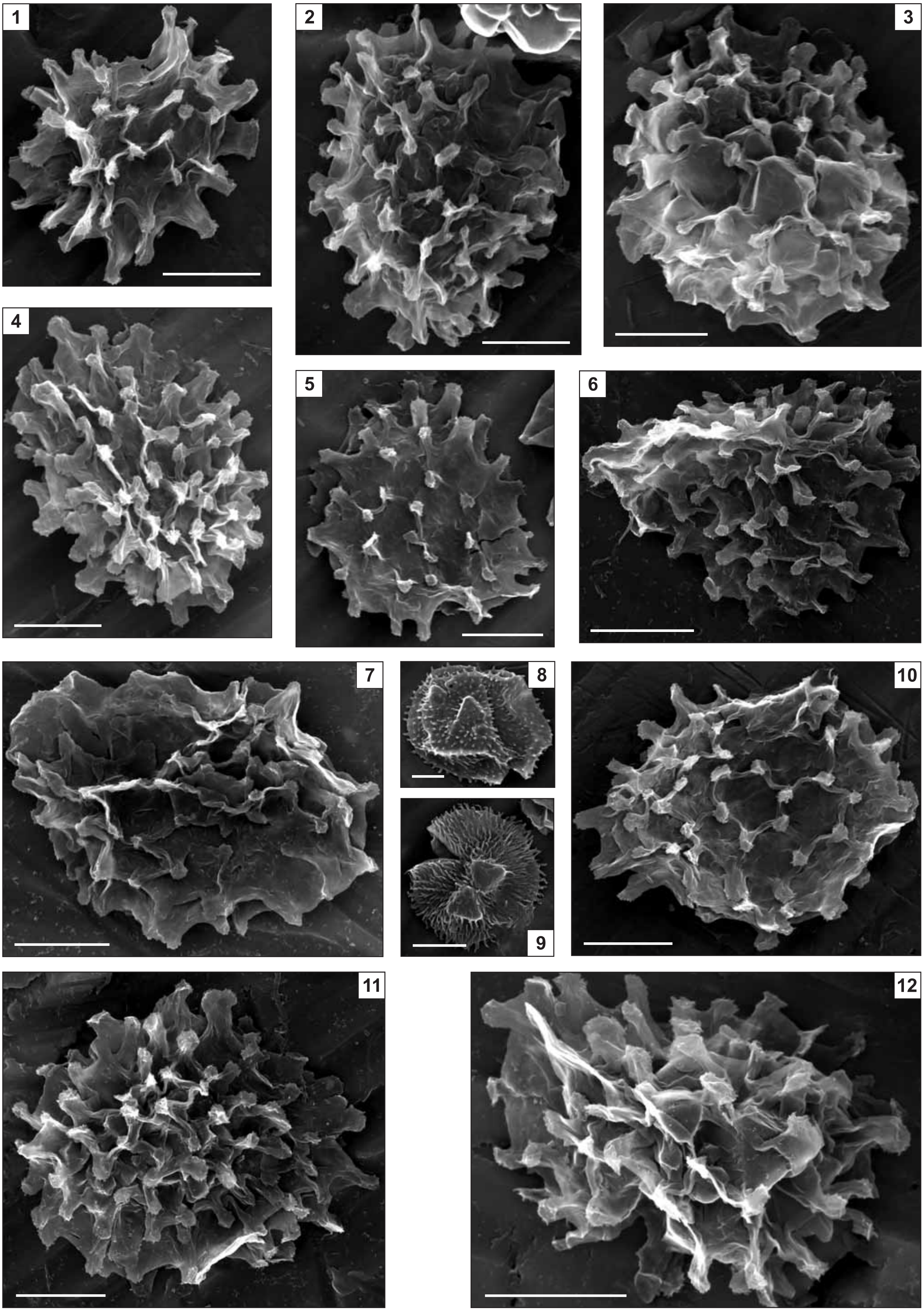
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PLATE XXVIII

Sosnowiec IG 1 borehole

Figs. 1–9, 14. *Adara alea* Martin in Martin et Dean, 1981; depth 3162.0–3163.0 m

Fig. 10. *Eliasum llaniscum* Fombella, 1977; depth 3204.5 m

Fig. 11. *Eliasum llaniscum* Fombella, 1977; depth 3211.0 m

Fig. 12. *Eliasum llaniscum* Fombella, 1977; depth 3204.5 m

Fig. 13. *Adara undulata* Moczydłowska, 1998; depth 3162.0–3163.0 m

Fig. 15. *Eliasum llaniscum* Fombella, 1977; depth 3204.5 m

Fig. 16. *Eliasum asturicum* Fombella, 1977; depth 3162.0–3163.0 m

Scale bar equals 20 µm for Figs. 1–9, 13, 14, 16; 100 µm for Figs. 10–12, 15

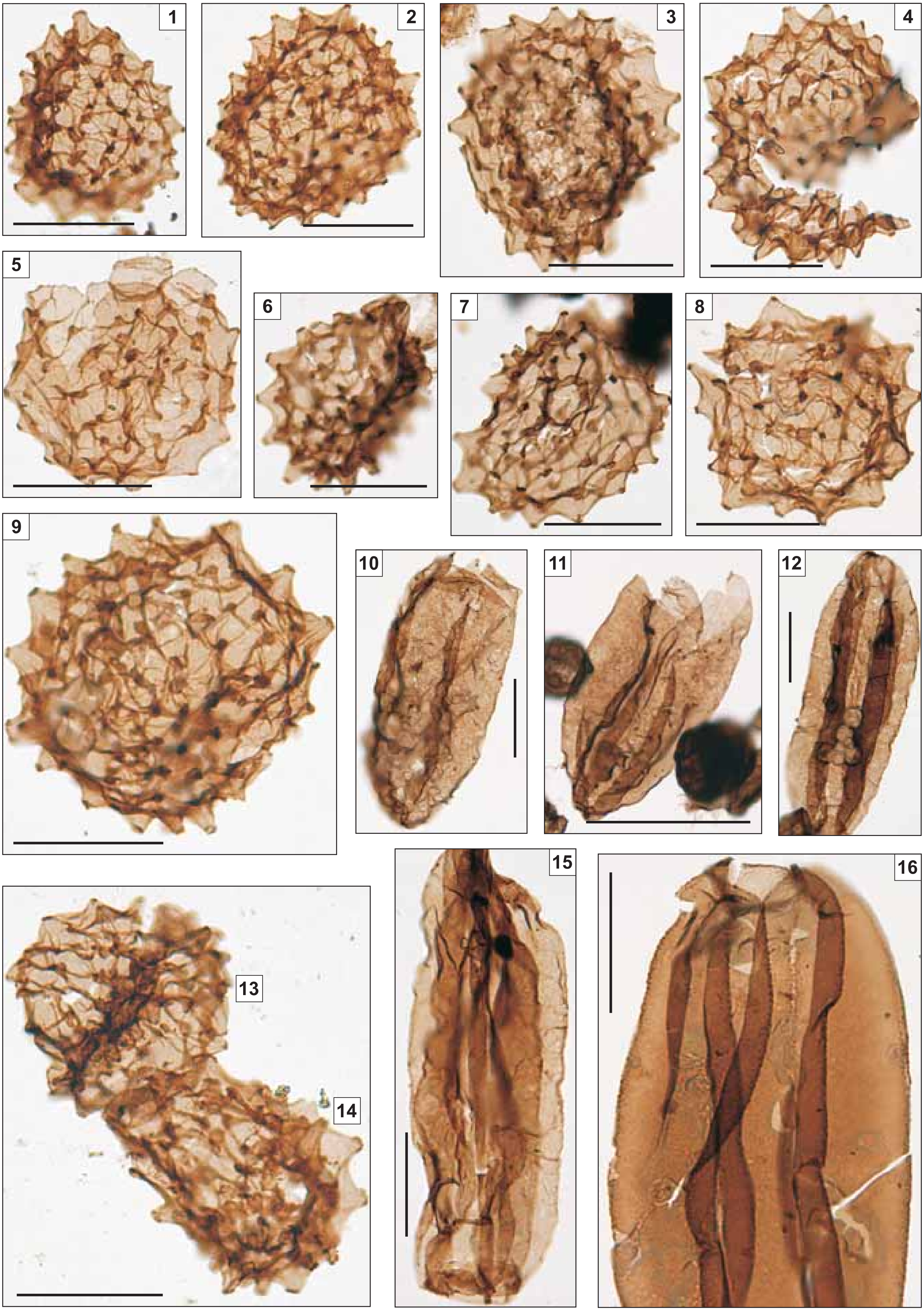
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PLATE XXIX

Fig. 1. *Retisphaeridium pusillum* (Moczydłowska, 1998) Vanguestaine in Brück, Vanguestaine, 2005; Sułoszowa borehole, depth 199.1 m

Fig. 2. *Retisphaeridium pusillum* (Moczydłowska, 1998) Vanguestaine in Brück, Vanguestaine, 2005; Sosnowiec IG 1 borehole, depth 3162.0–3163.0 m

Figs. 3, 4. *Cristallinium compactum* n.sp.; Sosnowiec IG 1 borehole, depth 3184.0 m; Fig. 3 – holotype

Figs. 5, 9. *Retisphaeridium postae* (Jankauskas 1976) Vanguestaine in Brück, Vanguestaine, 2004; Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 6, 7. *Retisphaeridium capsulatum* (Jankauskas, 1976) Vanguestaine in Brück, Vanguestaine, 2005; Sosnowiec IG 1 borehole, depth 3184.0 m

Fig. 8. *Cymatiosphaera cramerii* Slaviková, 1968; Sułoszowa borehole, depth 199.1 m

Figs. 10, 17. *Cristallinium cambriense* (Slaviková, 1968) Vanguestaine, 1978; Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 11–13. *Retisphaeridium dichamerum* Staplin, Jansonius, Pocock, 1975; Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 14, 15. ?*Retisphaeridium* sp.; Sosnowiec IG 1 borehole, depth 3204.5 m

Fig. 16. *Cymatiosphaera cramerii* Slaviková, 1968; Sosnowiec IG 1 borehole, depth 3363.0 m

Figs. 18, 19. ?*Retisphaeridium dichamerum* Staplin, Jansonius, Pocock, 1975; Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 20, 21. *Retisphaeridium brayense* (Gardiner et Vanguestaine, 1971) Moczydłowska, Crimes, 1995; Sułoszowa borehole 199.1 m

Fig. 22. *Retisphaeridium ovillense* (Cramer et Diez, 1972) Vanguestaine, 2002; Sosnowiec IG 1 borehole, depth 3204.5 m

Scale bar equals 20 µm

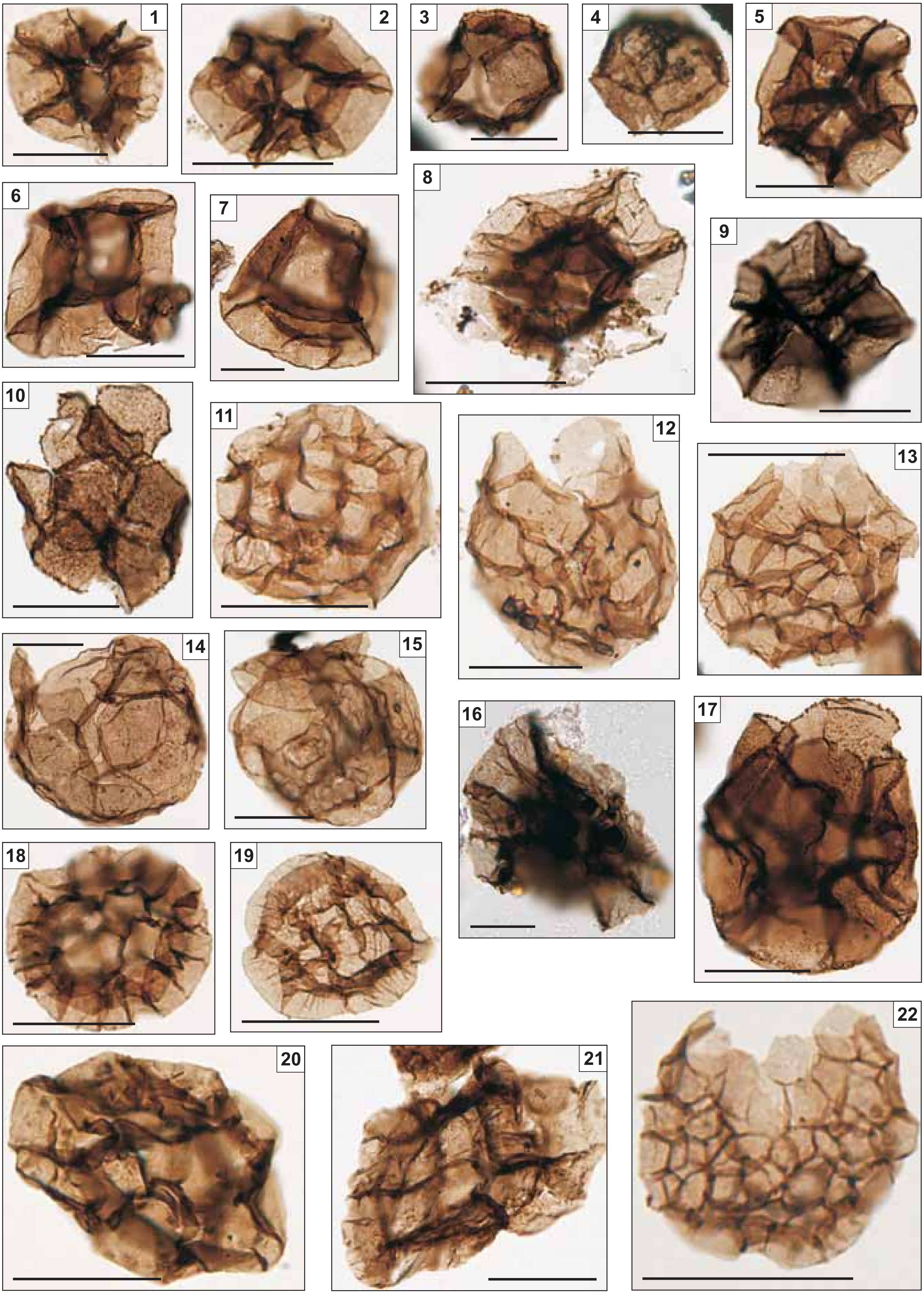
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PLATE XXX

Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 1–11. *Comasphaeridium silesiense* Moczydłowska, 1998 emend.

Scale bar equals 20 µm

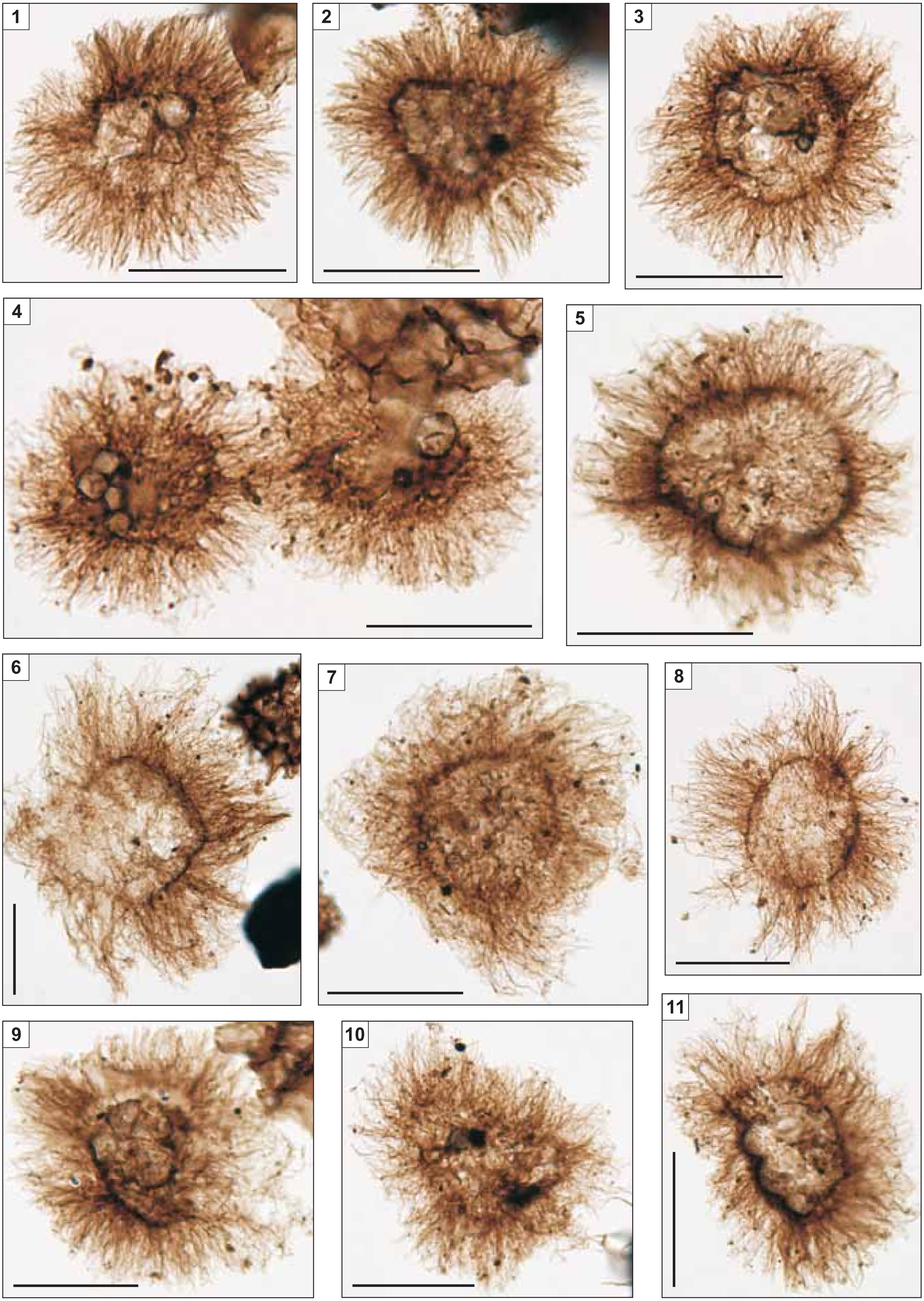
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PLATE XXXI

Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 1–8. *Comasphaeridium vozmedianum* (Fombella, 1970) emend.

Figs. 9, 12, 13, 15–18. *Comasphaeridium soniae* n.sp.; Fig. 15 – holotype

Figs. 10, 11, 14. *Comasphaeridium francinae* n.sp.; Fig. 14 – holotype

Scale bar equals 20 μm

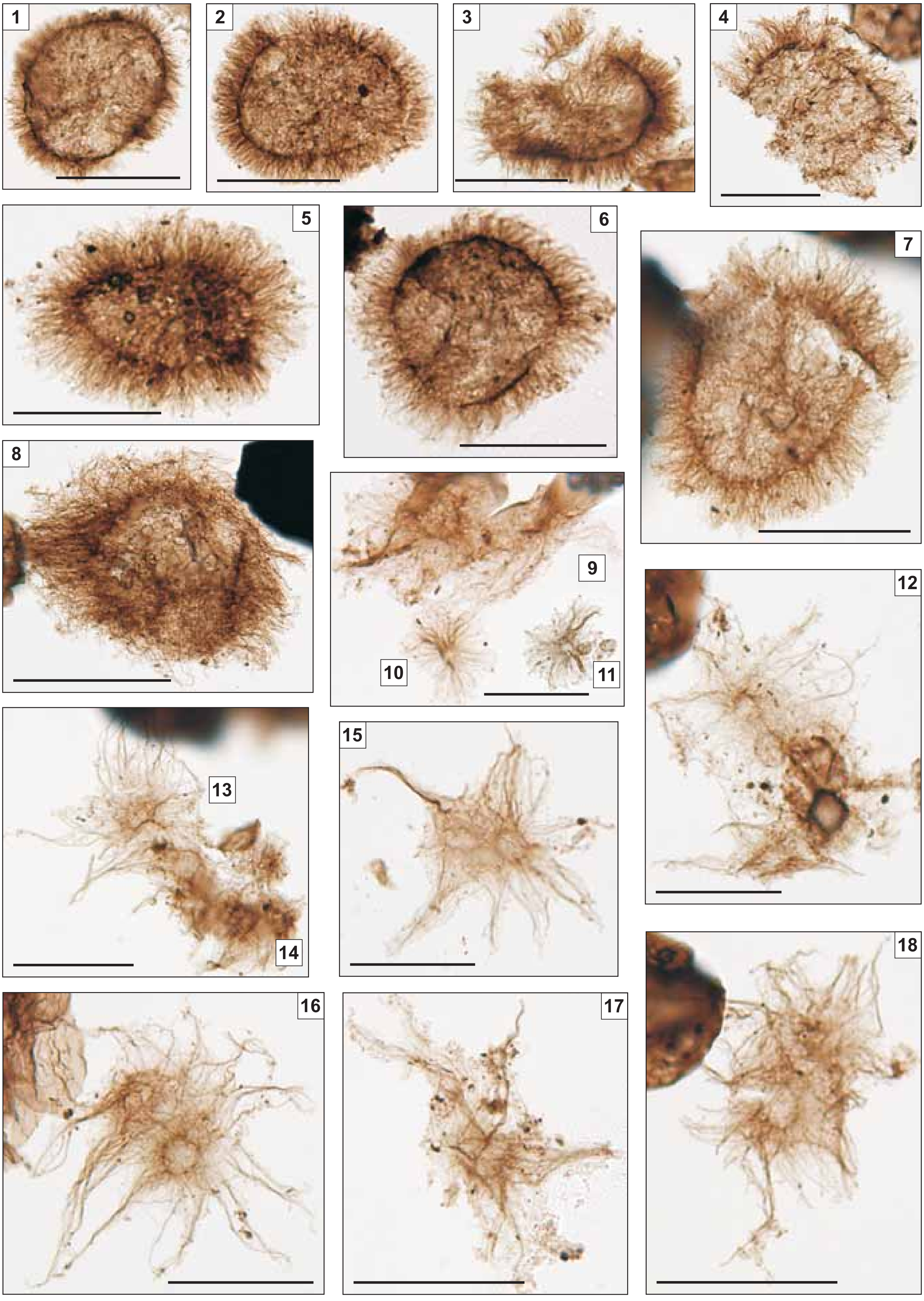
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PLATE XXXII

Sosnowiec IG 1 borehole, depth 3204.5 m

Fig. 1. *Solisphaeridium multiflexipilosum* (Slaviková, 1968) Moczydłowska, 1998

Figs. 2, 3, 5, 6. *Heliosphaeridium lanceolatum* (Vanguestaine, 1974) Moczydłowska, 1998

Figs. 4, 7–11. *Solisphaeridium flexipilosum* (Slaviková, 1968) Moczydłowska, 1998

Scale bar equals 20 µm

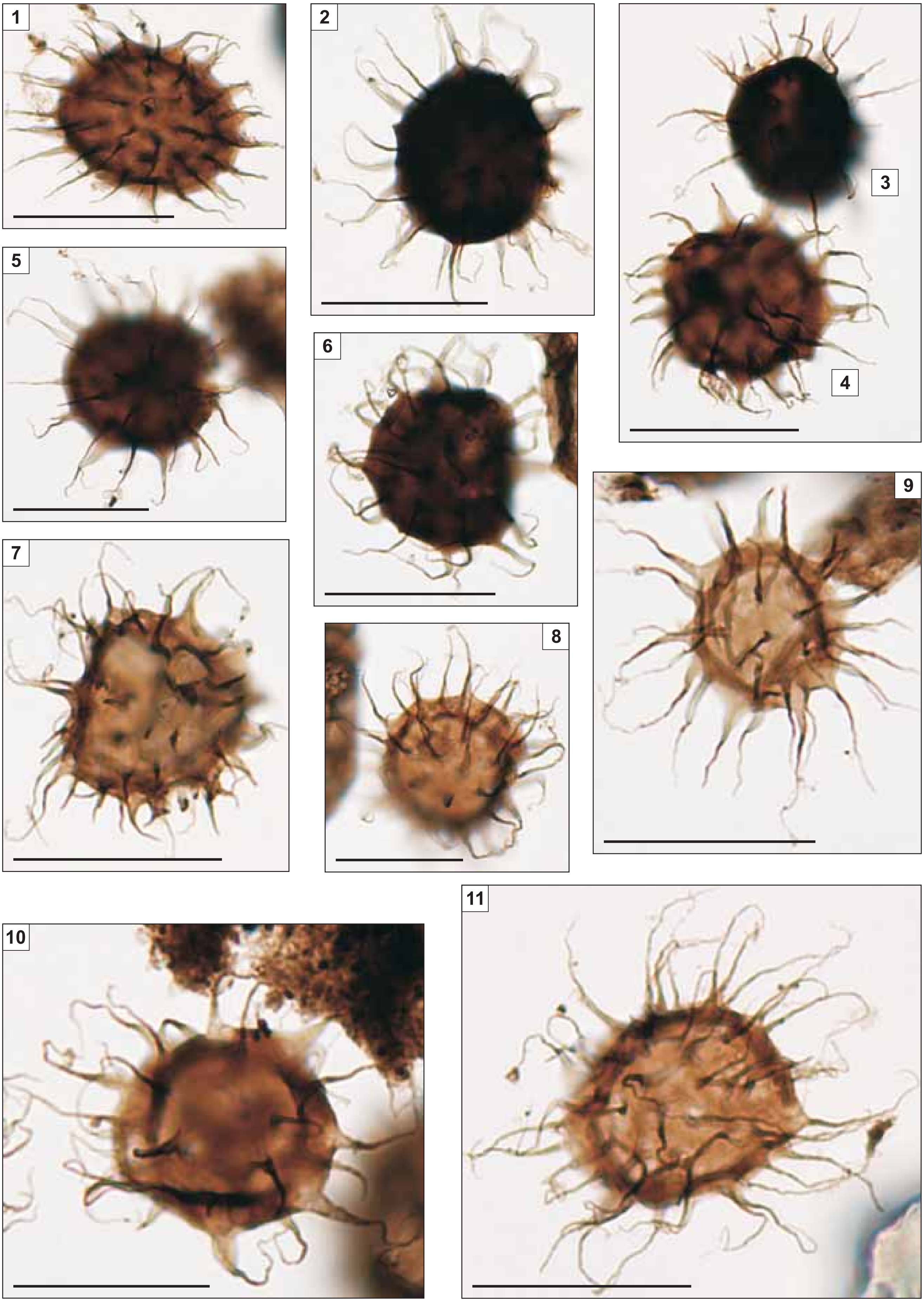
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PLATE XXXIII

Sosnowiec IG 1 borehole

Figs. 1–8, 10. *Multiplicisphaeridium ramosum* Moczydłowska, 1998; depth 3204.5 m

Figs. 9, 11–16. *Multiplicisphaeridium llynense* (Martin in Young, Martin, Dean, Rushton, 1994) n.comb.; depth 3162.0–3163.0 m

Scale bar equals 20 µm

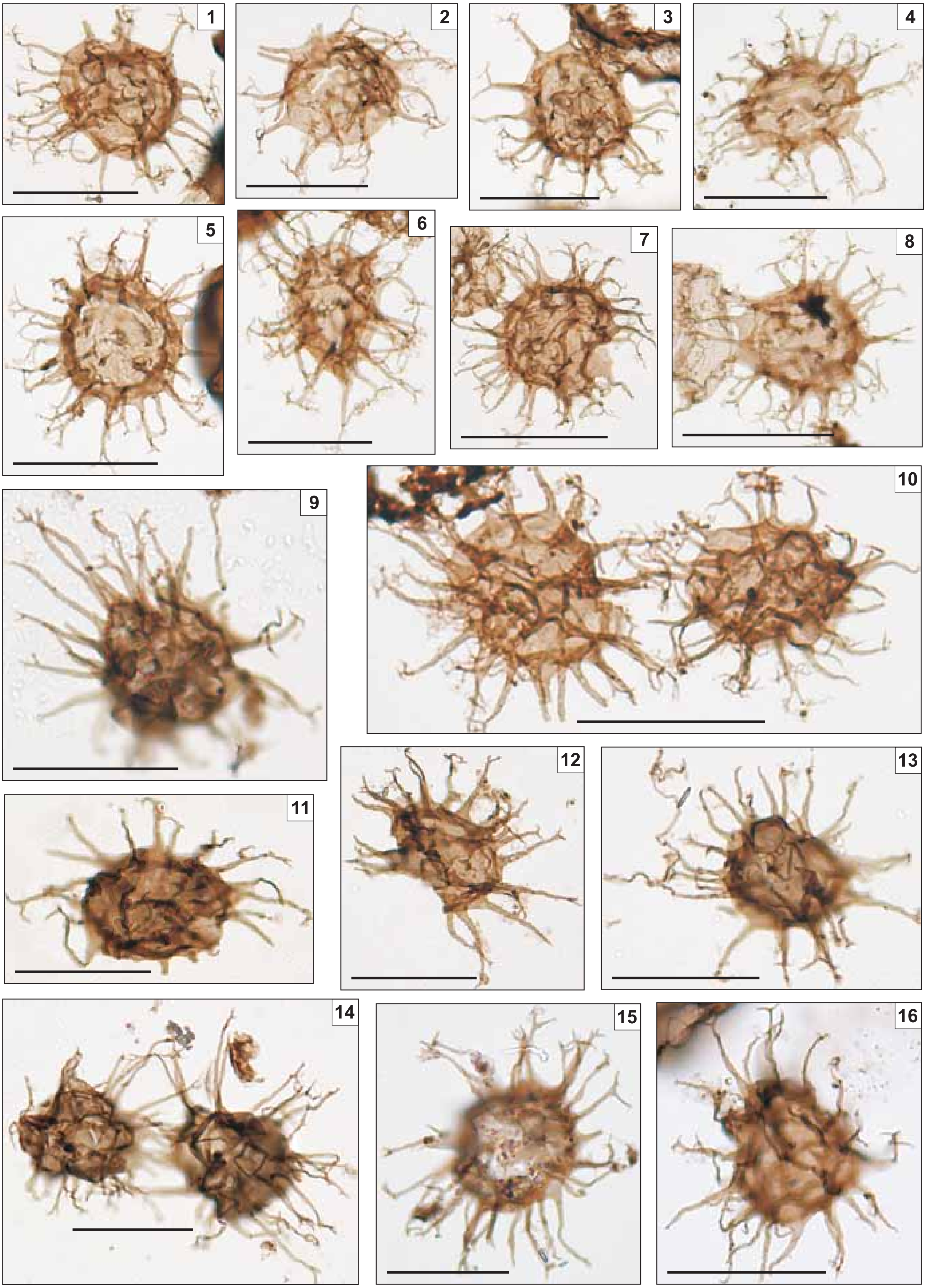
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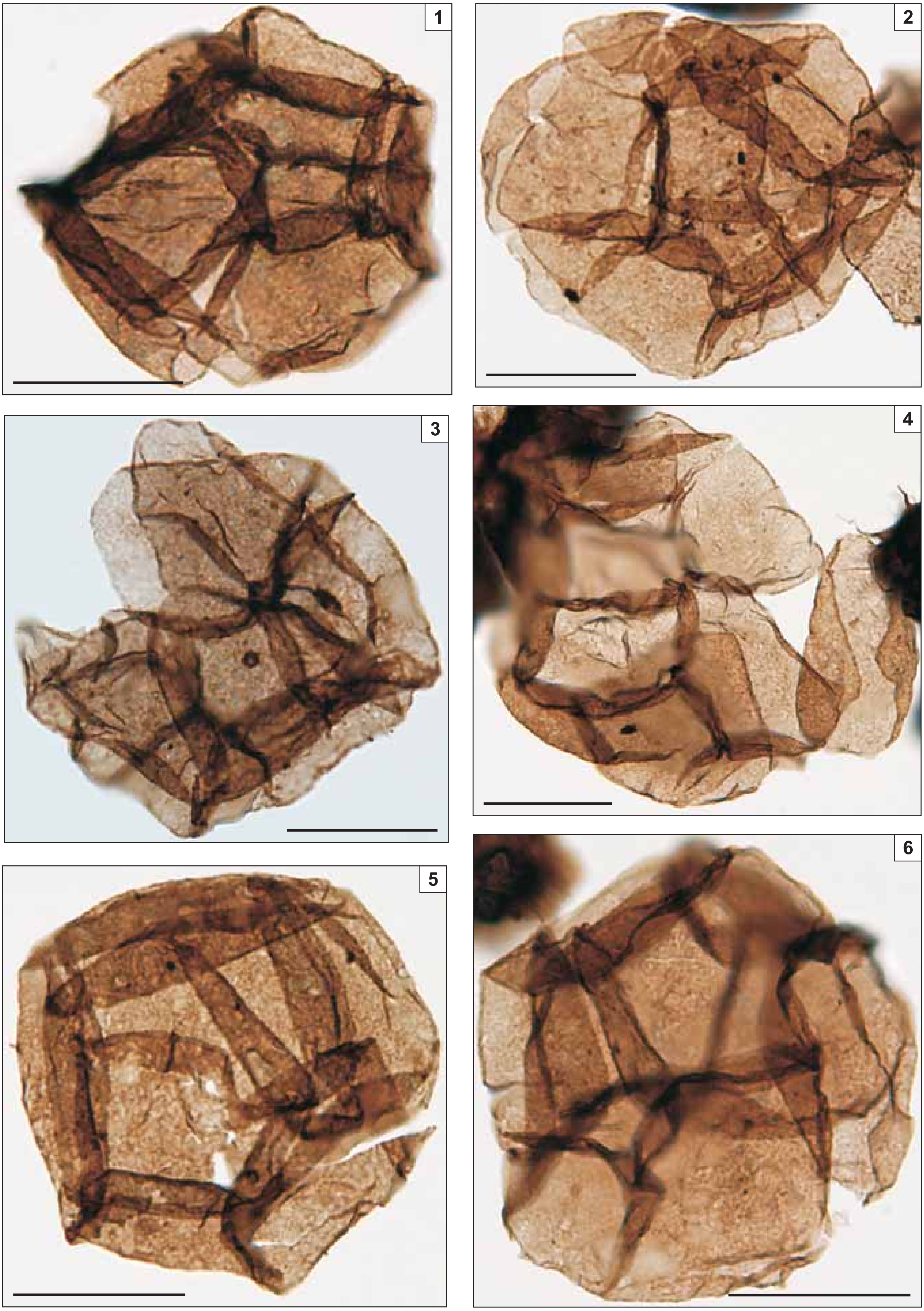
PLATE XXXIV

Sosnowiec IG 1 borehole, depth 3204.5 m

Figs. 1–6. *Retisphaeridium lechistanium* n.sp.; Fig. 5 – holotype

Scale bar equals 20 μm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