Studia bot. hung. 30–31, pp. 27–55, 1999–2000

UPPER CRETACEOUS FLORA FROM AJKA (W HUNGARY). I. THALLOPHYTA

L. RÁKOSI[1] and M. BARBACKA[2]

[1]*Hungarian Geological Survey, H-1143 Budapest, Stefánia út 14, Hungary*
[2]*Department of Botany, Hungarian Natural History Museum H-1476 Budapest, Pf. 222, Hungary*

Rich fossilised plant material was collected from eleven boreholes (Upper Cretaceous) near Ajka (W Hungary). A review of megaspores, representing 30 taxa is discussed in this paper. This is the first report of megaspores of this age from Hungary. Two new species are described: *Bacutriletes ajkaënsis*, *Spermatites kaptalanfaënsis*.

Key words: Upper Cretaceous, Hungary, megaspores

INTRODUCTION

The locality is found in the western part of Hungary, in the Bakony Mts, in the vicinity of the town of Ajka. It is one of the four Senonian deposits in Hungary and belongs to the Ajka Coal Formation, the Bakony part of the Transdanubian Central Range (GÓCZÁN *et al.* 1986, CSÁSZÁR and GÓCZÁN 1988). The stratigraphical and geological study was made in earlier times parallel with the coal production of the brown coal deposits in this area (the coal production has been continuous from the middle of 19th century).

Based on palynological investigations, the flora of the Upper Cretaceous brown coal deposits in Hungary is rather rich and varied. However, the megaspores and other macrofossils collected from near Ajka have not been studied thoroughly.

In connection with the coal exploration in the Transdanubian Central Range the planned work was extended to analise the borehole samples on macrofloral and palaeocarpological material, on phytoplankton above the 200 μm size, on megaspores, fossil leaves, fruits and seeds, as well as fossil wood (preserved mainly as fusain). However, the investigation was never complete yet the material contained valuable samples that needed thorough investigation.

Occasional data were published with long intervals. VADÁSZ (1940, pp. 39 and 48) mentioned that Hollendonner identified some fusain remains as belonging to *Taxodium*. GREGUSS (1949) also examined some samples of fusain and established a new species, *Podocarpoxylon ajkaënse*. PAÁL-SOLT (1962) mentioned some conifer fusains as well as showed that frondous woods were also present there.

Part of the fruit and seed material was examined by KNOBLOCH (1981, 1985, 1986) and KNOBLOCH and MAI (1986). They were the first who provided a detailed account of the palaeocarpological investigations in the region, but the material used for their studies came from boreholes different from those recently examined by us.

GELLAI and TÓTH (1982) examined the genus *Munieria* from Sümeg-Gyepükaján, while CSÁSZÁR and BODROGI (1985) completed a detailed study of the distribution and ecology of this genus in Hungary.

As the material from the region of Ajka originates from boreholes (excluding fusain remains), and the opening of new bores are not prospected in the near future, the collected remains seem to be the only palaeobotanical representatives of the Upper Cretaceous in Hungary. The authors have resumed the interrupted examinations within the following groups: 1 – Thallophyta megaspores, 2 – seeds and fruits, 3 – leaves, 4 – fusained woods. The present paper deals with material from the first group.

MATERIAL AND METHODS

The investigated material consists of 378 samples collected from 11 boreholes in the region of Ajka (Fig. 1):

1 – Gyepükaján – borehole No 9; 24 samples from 590.4–455.0 m (Gy-9)
2 – Gyepükaján – borehole No 12; 30 samples from 545,9–452.0 m (Gy-12)
3 – Gyepükaján – borehole No 15; 1 sample from 496.6 m (Gy-15)
4 – Csabrendek – borehole No 2; 39 samples from 672.5–551.8 m (Cr-2)
5 – Káptalanfa – borehole No 1; 48 samples from 728.2–618.6 m (Kf-1)
6 – Káptalanfa – borehole No. 2; 29 samples from 811.0–696.0 m (Kf-2)
7 – Káptalanfa – borehole No. 6; 23 samples from 655.4–550.8 m (Kf-6)
8 – Nemeshany – borehole No 1; 64 samples from 683.8–634.4 m (Nh-1)
9 – Ajka – Ármin shaft, 164 samples (A-181)
10 – Magyarpolány – borehole No 42; 15 samples from 723.9–645,7 m (Mp-42)
11 – Somlóvásárhely – borehole No 1, 61 samples from 1437.3–1292.0 m (Sv-1)

Plant remains larger than 200 μm were used for examination. Material was obtained in the usual way by desintegration of matrix in HCl and washing, followed by treatment with H_2O_2 and selection. The cleaned specimens were then stored in water containing phenol. The preservation of the material allowed examination in SEM (a SEM of JEOL-35 type was used). Unfortunately, in many cases the material was polluted by small pyrite crystals which were very difficult to remove.

The entire material is stored as slides for examination in light microscope or SEM (in this case they were covered by gold) in the palaeontological collections of the Hungarian Geological Survey, Budapest. The two holotypes (*Bacutriletes ajkaënsis* n. sp. (No BP 2000.2.1) and *Spermatites kaptalanfaënsis* n. sp. No BP 2000.1.1) have been preserved in the Hungarian Natural History Museum, Budapest.

SYSTEMATICAL DESCRIPTION

The artificial classification (Potonié 1970)
Anteturma: Proximegerminantes
Turma: Triletes
Subturma: Azonotriletes
Infraturma: Apiculati
Subinfraturma: Verrucati
Genus: *Cabochonicus* Batten et Ferguson 1987

Cabochonicus carbunculus Batten et Ferguson 1987

Description: Trilete, rounded triangular megaspore, 400–500 μm in diameter. The surface is ornamented by 10–20 μm large verrucae and gemmae. At the proximal side the surface is smooth around the trilete mark.

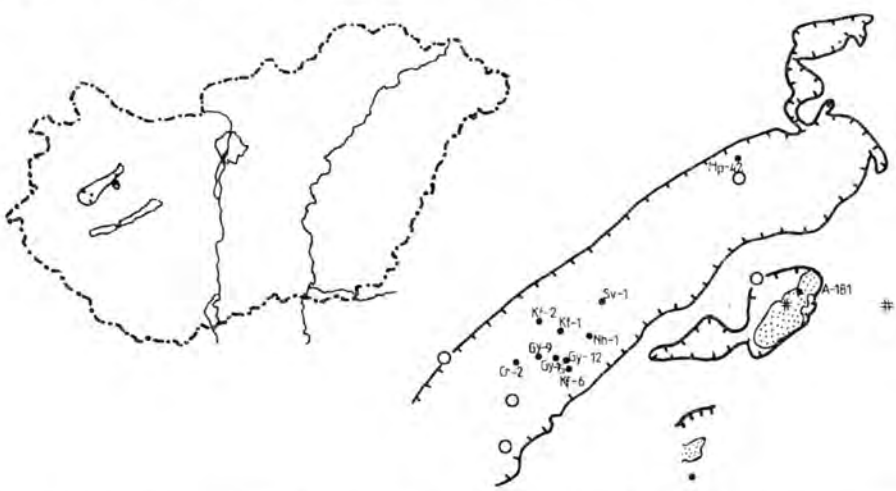


Fig. 1. The Upper Cretaceous coal areas near Ajka. (1) = extension of the Ajka Coal Formation, (2) = Ajka mine area, (3) = boreholes.

Remark: KNOBLOCH (1984) mentioned some samples of *C. carbunculus* from Alsópere borehole No Ot 84.

Genus: *Verrutriletes* (van der Hammen 1954) Potonié 1956
Generotype: *Verrutriletes* (al. *Triletes*) *compostipunctatus* (Dijkstra 1949) Potonié 1956

Verrutriletes compostipunctatus (Dijkstra 1949) Potonié 1956

Description: Trilete, rounded megaspore, 200–300 μm in diameter, the surface with scattered verrucae 5–10 μm large.

Remark: This species was found in the boreholes Kf-1 from 628.3 m, Kf-6 from 569.0 m, and Nh-1 from 641.7 m and 635.2 m, as well as bench sample No 100.

Subinfraturma: Baculati
Genus: *Bacutriletes* (van der Hammen 1954) Potonié 1956
Generotype: *Bacutriletes* (al. *Triletes*) *tylosus* (Harris 1935) Potonié 1956

Bacutriletes ajkaënsis n. sp.
Figs 2–8

Holotype: No BP 2000.2.1, Figs 2–3.

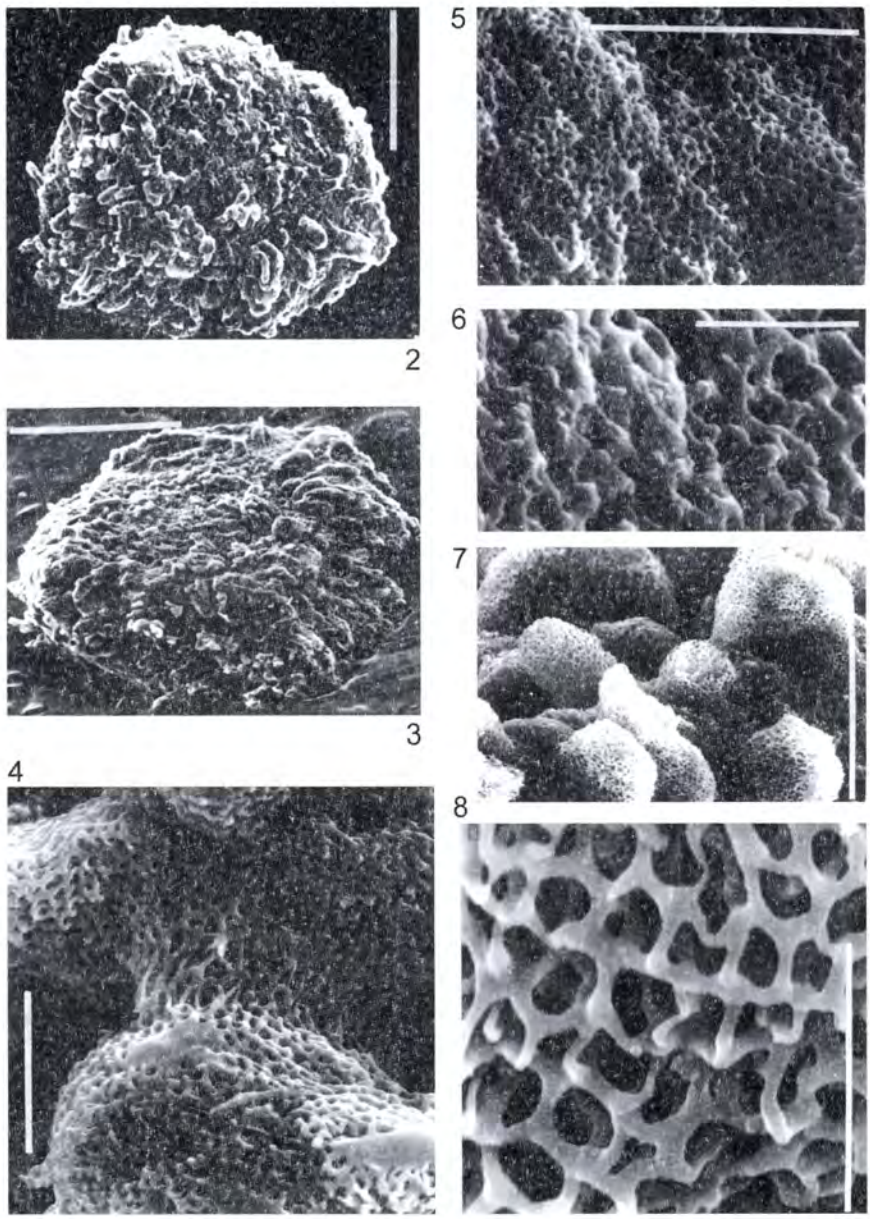
Type locality: Ajka, Ármin shaft, Gyula field, gallery 112, IV bench sample No 84.

Stratigraphical position: yellow marl Ajka Coal Formation, Late Santonian.

Etymology: The locality in Ajka.

Diagnosis: Rounded, triangle shaped megaspore 510 × 523 μm in size, both at the proximal and distal side ornamented by bacula. The Y mark slightly visible, because of the presence of bacula. The exosporium among the bacula shows reticulated surface (Figs 4–5), the surface of the baculum is also reticulated (Fig. 6). The ectexosporium has spongy-like structure (Figs 7–8).

Discussion: The megaspore differs from *B. volfarticensis* Knobloch (1984) in the size of the bacula, which here in *B. ajkaënsis* are considerably thinner. It is also different from *B. nanus* (Dijkstra 1949) Potonié 1956 because of its smaller size.



Figs 2–8. – **2–3** = *Bacutriletes ajkaënsis* n. sp. (holotype), Ajka, Ármin shaft, Gyula field, gallery 112, bench IV, sample 84; SEM, bar = 200 μm. – **4–5** = The surface of the megaspore; SEM, bars = 10 μm (Fig. 4), 5 μm (Fig. 5). – **6** = The surface of the bacula, SEM; bar = 30 μm. – **7–8** = Spongy structure of bacules; SEM, bars = 10 μm (Fig. 7), 5 μm (Fig. 8).

Infraturma: Murornati
Genus: *Horstisporites* Potonié 1956
Generotype: *Horstisporites* (al. *Triletes*) *reticuliferus* (Dijkstra 1951) Potonié 1956

Horstisporites harrisii (Murray 1939) Potonié 1956
Figs 9–15

Description: Trilete megaspore, circular to subcircular, 500–600 μm in diameter. The surface is muricate (Figs 10–11).

Remarks: The surface is well comparable to *H. harrisii* illustrated by BERGAD (1978, Pl. 3, Fig. 5). In SEM the differentiation into perine and exosporium is well visible. In the examined material from Ajka only few samples of *H. harrisii* were found in borehole Kf-2, from 805.0 and 800.7 m.

Genus: *Erlansonisporites* Potonié 1956
Generotype: *Erlansonisporites* (al. *Selaginellites*) *erlansonii* (Miner 1932) Potonié 1956

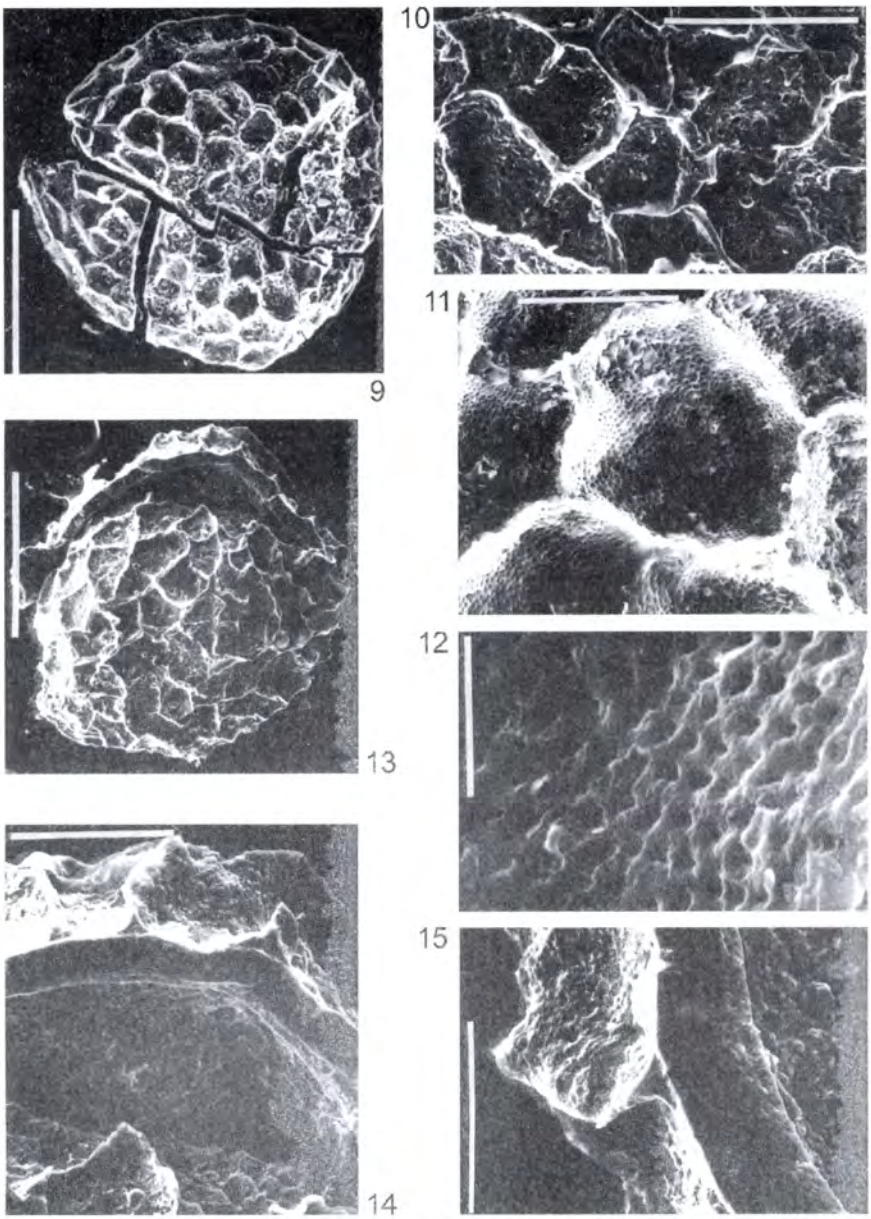
Erlansonisporites spinosus Bergad 1978
Figs 16–18

Description: Trilete megaspore, outline circular, trilete mark often completely covered by strong reticulations thus being partially visible or invisible. Diameter 350–500 μm.

Remark: Up to now only few samples were found in Maastrichtian levels.

Turma: Vestitriletes
Subturma: Perinotriletes
Genus: *Dictyothylakos* Horst 1954
Generotype: *Dictyothylakos pesslarae* Horst 1954
Dictyothylakos sp.

Description: Brown in colour, fibre-shaped, reticulated fragments of different size. The lumen of a reticulum is about 4–15 μm, the meshes of anastomosis 2–6 μm wide.



Figs 9–15. – **9–12** = *Horstisporites harrisii*, borehole Kf-2, 805.0 m. – **9** = The distal side of the spora, SEM, bar = 400 μm. – **10** = Reticules, bar = 200 μm. – **11** = The structure of the reticules, bar = 30 μm. – **12** = Surface of exosporium; SEM, bar = 5 μm. – **13–15** = *Horstisporites harrisii*. – **13** = The distal side of the spora; SEM, bar = 400 μm. – **14** = The structure of the perine and exosporium; SEM, bar = 100 μm. – **15** = The same, bar = 60 μm.

Remarks: This species was described from English Wealden by HORST (1954, p. 610). Later HUGHES (1955), who interpreted it as perisporium of megaspore, described it under the name *Triletes retiarius*. However, his illustrated sample differs from the typical *Dictyothylakos*.

POTONIÉ (1956) created a new genus, *Thylakosporites*, and placed the Huges species into this genus. The *Dictyothylakos* fragments of perisporium have never been mentioned as found together with the body of spore and their taxonomic appurtenance was kept on discussing. In HUEBER's opinion (1982, pp. 15–17) *Thylakosporites* and *Dictyothylakos* should be regarded as different genera. This way the genus *Dictyothylakos* was described from the Lower Cretaceous of the Netherlands and Egypt (DIJKSTRA 1961), from Alberta: Albian (SINGH 1964) and Upper Cretaceous (GUNTHER and HILLS 1972), from Hettangian of Poland (MARCINKIEWICZ 1971) as well as from North Dakota from the Paleocene (MELCHIOR and HALL 1983). The latter authors supposed that the perisporium may belong to Trichoptera. La Pasha and MILLER (1985) also described the *Dictyothylakos* and noted that it was composed of very resistant materials.

In Hungary it is relatively common in the vicinity of Ajka.

Incertae sedis
Genus: *Costatheca* (Miner 1935) Hall 1967
Generotype: *Costatheca* (al. *Chrysotheca*) *discoënsis* (Miner 1935) Hall 1967

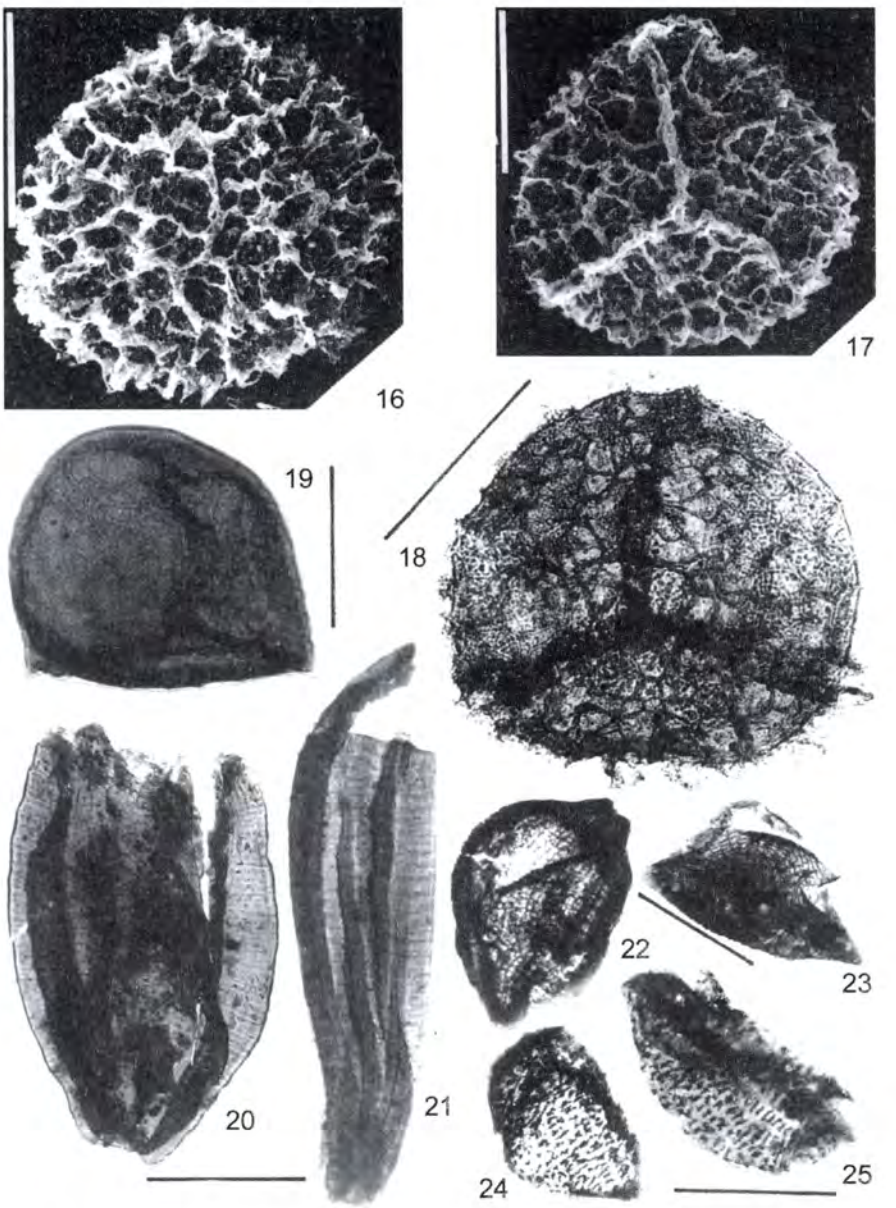
Costatheca discoënsis (Miner 1935) Hall 1967
Figs 20–21, 30–31

Description: Seed cuticles variable in shape, oblong, ovate, lanceolate or elliptic. Dimensions: 600–1800 μm long and 150–600 μm wide. Seed anatropous with a micropyle around the short funicle. Often with striations.

Remarks: This species was emended by BINDA and NYAMBUDIRI (1983), and by KNOBLOCH (1986).

A number of species is known from Albian deposits (BATTEN and ZAVATTIERI 1996).

In the examined material *C. discoënsis* is frequent, in the borehole Gy-9 dominant in the level of 590.4 m. There are two unusual forms in the material, with numerous, different shaped one-cell spores of fungi inside (Fig. 34). It appears questionable that those specimens really belong to genus *Costatheca*; they are either perithecia of fossil Mycophyta or zoosporangia (Saprolegniaceae). This question may be justified because JANSONIUS *et al.* (1981) proved that *Geleenites fascinus*

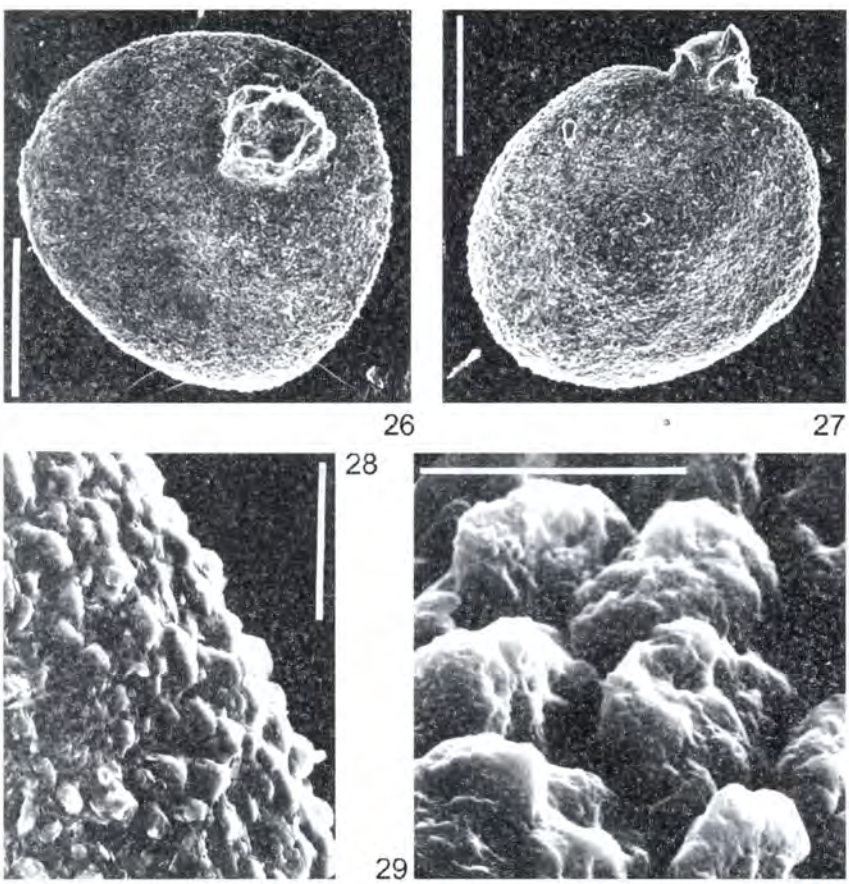


Figs 16–25. – **16–18** = *Erlansonisporites spinosus*, borehole Kf-2, from 800.7 m; SEM. – **16** = Distal view, bar = 200 μm. – **17** = Proximal view, bar = 200 μm. – **18** = Proximal view, bar = 200 μm. – **19** = *Minerisporites borealis*, borehole Gy-12, from 540 m, bar = 300 μm. – **20–21** = *Costatheca discoënsis*, borehole Gy-9, from 590.4 m, bar = 300 μm. – **22–23** = *Spermatites ellipticus* subsp. *minor*, borehole Gy-12 from 528.6 m, bar = 50 μm. – **24–25** = *Costatheca verrucata*, borehole Gy-9, 474.4 m, bar = 1 mm.

Dijkstra 1949 showed Mycophyta characteristics and it was probably a fossil conidiophore.

An important sample was found in the borehole Kf-2, from 789.6 m. The large number of *Costatheca discoënsis* was arranged massula-like in four rows around a central body (Figs 30–31). At the circumference of this structure the coalified envelope remains were observed. The relationship of the genus *Costatheca* is not clear up to now. MINER (1935) classified it to Jungermanniales and considered it as a remain of a perianth. KNOBLOCH (1981, 1986) suggested its relationship with Angiospermae.

It appears that no reference to this type of structure was made to date. In our opinion, on the basis of the observations available so far, the *Costatheca* may be a reproductive organ of an unknown and undescribed fossil Algae.

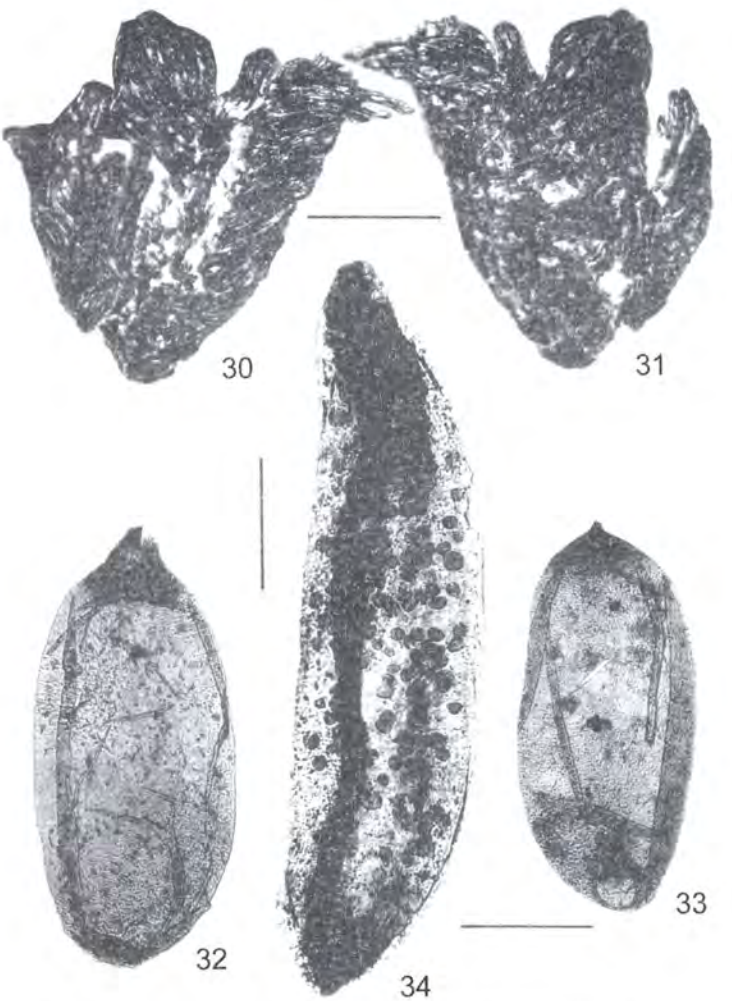


Figs 26–29. *Lobasporites lobatus*, borehole Kf-2, bars = 200 µm (Figs 26–27), 30 µm (Fig. 28), 5 µm (Fig. 29).

Costatheca verrucata Gunther et Hills 1972
Figs 24–25

Description: Ovate to bean-shaped, 300–400 μm in diameter and 200–300 μm long. The size of verrucae 2–10 μm.

Remark: This species is known only from the Upper Maastrichtian, in Ajka only a small number of specimens were found.



Figs 30–34. – **30–31** = *Costateca discoënsis*, massulae; borehole Kf-2, 789.6 m, bar = 1 mm. – **32–33** = *Spermatites pylophorus*, bar = 300 μm. – **34** = *Costatheca discoënsis*, borehole Gy-9, 590.4 m, bar = 300 μm.

Costatheca striata (Dijkstra 1949) Hall 1967
emend. Binda and Nambudiri 1982

Description: Seed cuticles oblong, ovate, 800–1300 μm long and 300–600 μm wide, often with striations. Cells of testa are rectangular to hexagonal.

Remark: In Ajka this species occurs in numbers higher than *C. verrucata*.

Costatheca friisae Knobloch 1986

Description: Seed cuticles ovate, 300–350 μm wide. The plicae on the surface form anastomosis towards the acute apex.

Remark: Only a few samples were found in the boreholes of Gyepükaján and Káptalanfa.

Genus: *Spermatites* Miner 1935
Generotype: *Spermatites elongatus* Miner 1935

Remark: The taxonomic position and affinity of this genus is still unknown.

Spermatites elongatus Miner 1935

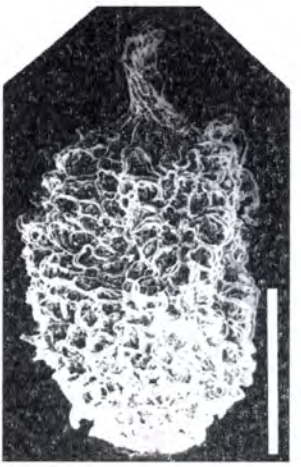
Description: Cuticular seed coat, oblong to elliptical in shape with narrow end at the top in lateral view. Length 800–1000 μm, width 300–500 μm.

Remarks: This species is very common in Ajka. The cuticular structure of the specimens is well visible. Sometimes minor differences are noticed if compared with data from the literature (BATTEN and ZAVATTIERI 1996).

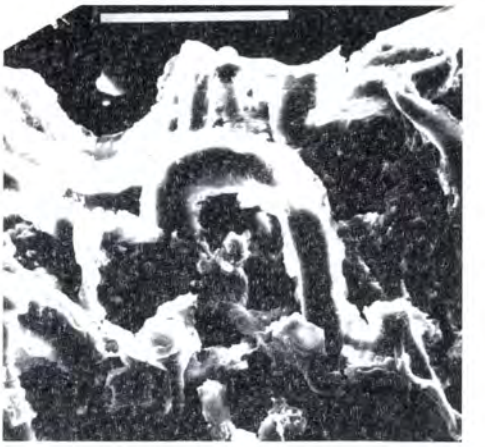
Similar structures were described as Diptera (Insecta) by WEYLAND *et al.* (1960).

Spermatites ellipticus Miner 1935 subsp. *minor* Binda 1968
Figs 22–23

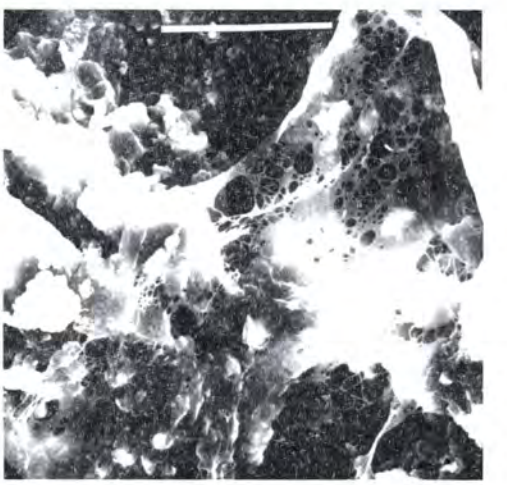
Description: Elliptical to oblong in shape, with convex sides, about 400–500 μm long and 250–350 μm wide. Surface reticulated, the meshes become narrower towards the tip.



35



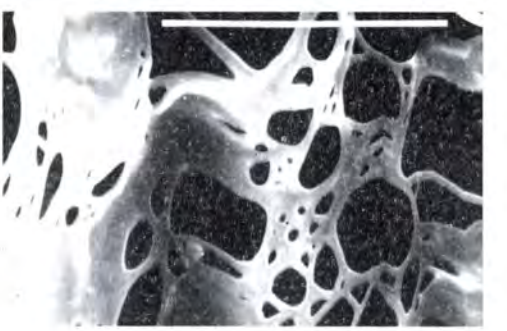
37



38



36



39

Figs 35–39. *Spermatites kaptalanfaënsis*, SEM. – **35** = Holotype, borehole Gy-12, 526.6 m, bar = 400 μm. – **36** = Holotype, detail, bar = 100 μm. – **37** = Loops on the surface, bar = 50 μm. – **38** = The net-shaped structure among loops, bar = 30 μm. – **39** = Detail from the Fig. 38, bar = 5 μm.

Remark: Some samples were found in the boreholes Kf-1, Kf-6 and Gy-12, from 528.6 m.

Spermatites pylophorus Miner 1935
Figs 32–33

Description: Cuticular seed coat obovate to oblong-elliptical in shape, 800–1000 μm long and 300–600 μm wide. The micropyle is reticulated.

Remark: This species occurs in big numbers in the borehole Gy-12 in between 543.2 and 513.0 m in the *Munieria* bearing clay-marl.

Spermatites kaptalanfaënsis n.sp.
Figs 35–41

Holotype: No BP 2000.1.1, Fig. 35.

Type locality: Gyepükaján, borehole No 12, from 528.6 m.

Stratigraphical position: yellow marl Ajka Coal Formation, Senonian.

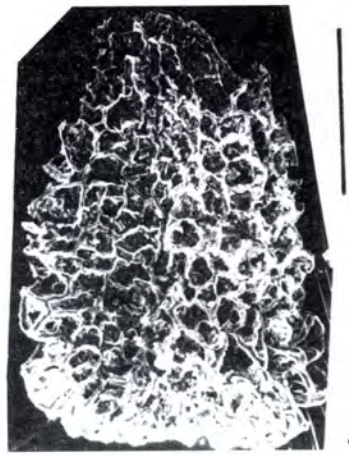
Etymology: From the name of the village near the borehole.

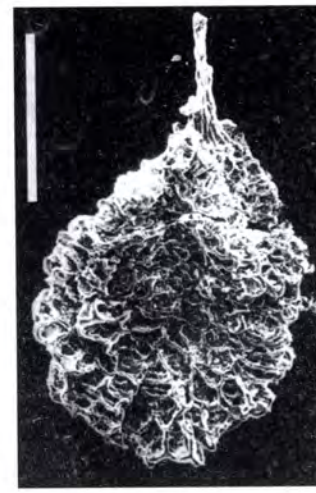
Diagnosis: The oval-shaped cuticular seed with an extended end. The whole body is covered by reticulated ornament that forms numerous loops. At the extension, the loops somewhat straighten and become wound.

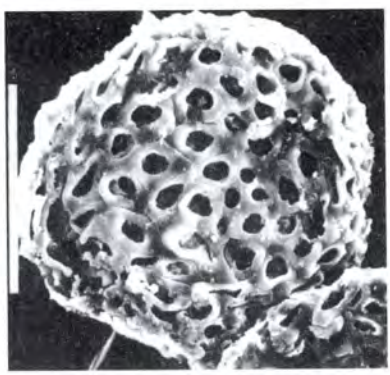
Description: The specimen is a cuticular seed 833 μm long and 555 μm wide, with one end elongated into a beak-shaped, 200–250 μm long extension. The whole body appears to have a fiber-like and reticulated, almost ornamented cover with numerous loops. Their size is about 10–15 μm. Between the meshes a net-like structure is observed (Figs 38–39). At the beak the loops (Figs 37, 40–41) become straightened and, upon reaching the end, form a loose spiral (Fig. 36).

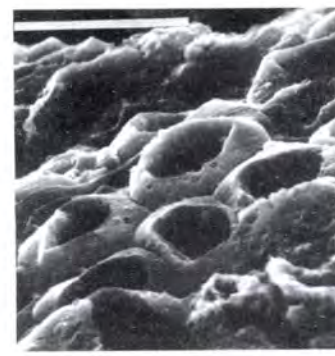
Remark: The presence of ornament is the main difference between the new species and those known so far.

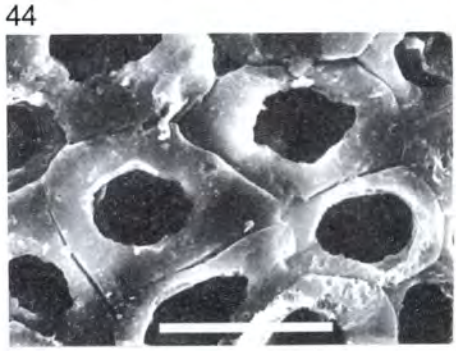
This form is common in certain levels of the Nh-1, Kf-1, Kf-6, and Gy-2 boreholes.

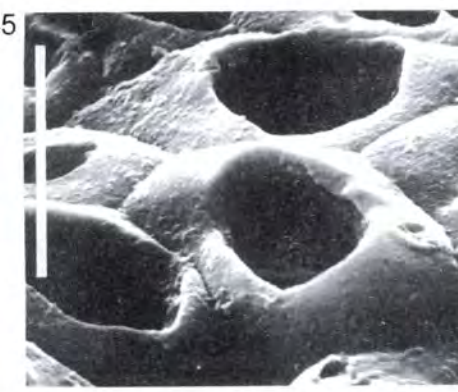












Figs 40–45. – **40–41** = *Spermatites kaptalanfaënsis*, borehole Kf-6, 630.4 m; SEM, bar = 400 μm. – **42–45** = *Schizosporis reticulatus*, borehole Gy-12, 528.6 m; SEM, bars = 60 μm (Fig. 42), 15 μm (Figs 43–44), 10 μm (Fig. 45).

The natural system

Division: Prasinophyta
Order: Pterospermales
Family: Cymatiosphaeraceae
Genus: *Schizosporis* Cookson et Dettman 1959
Generotype: *Schizosporis reticulatus* Cookson et Dettman 1959

Schizosporis reticulatus Cookson et Dettman 1959
Figs 42–45

Description: A rounded pseudoreticular capsula, 900–1100 μm in diameter, with elevated polygonal to rounded meshes and relatively large pits in the centre of each mesh.

Remarks: This taxon was described by several authors, most of whom considered it to be a planktonic organism of unknown origin. BRENNER (1963) published high quality light microscope pictures of it. PIERCE (1976) rejected it as belonging to algae and mentioned "unknown relation". VAN GEEL (1979) assigned the genus to the family of Zygnemataceae and TAPPAN (1980) to Prasinophyta.

Found in the boreholes Kf-1, from 686.4 m, 622.9 m, Kf-2 from 805.0 m, 800.7 m, Gy-12 from 528.6 m (dominant) and 500.8 m as well as from comparing sample from Ajka, No 21. Age: Upper Cretaceous, Ajka Coal Formation.

Division: Chlorophyta
Class: Bryopsidophyceae
Order: Dasycladales
Family: Dasycladaceae
Tribus: Diploporae
Genus: *Munieria* Deecke 1883
Generotype: *Munieria baconica* Deecke 1883

Munieria grambasti Bystricki 1976 subsp. *sarda* Cherchi, Gašic, Schmidt et Schroeder 1981

Description: Calcareous Chlorophyta. The axis of thallus is divided into segments, ornamented by radially distributed pores. The calcareous skeleton is rounded, with longitudinal grooves on the surface.

Remark: This species occurs in great numbers in all examined samples.

Division: Charophyta
Class: Charophyceae
Order: Charales
Family: Characeae
Subfamily: Charoideae
Genus: *Amblyochara* Grambast 1962

Amblyochara begudiana Grambast 1962

Remark: This species was described from the locality near Ajka (RÁKOSI 1989, p. 24, Pl. V, Figs 1, 4).

Genus: *Mesochara* Grambast 1962

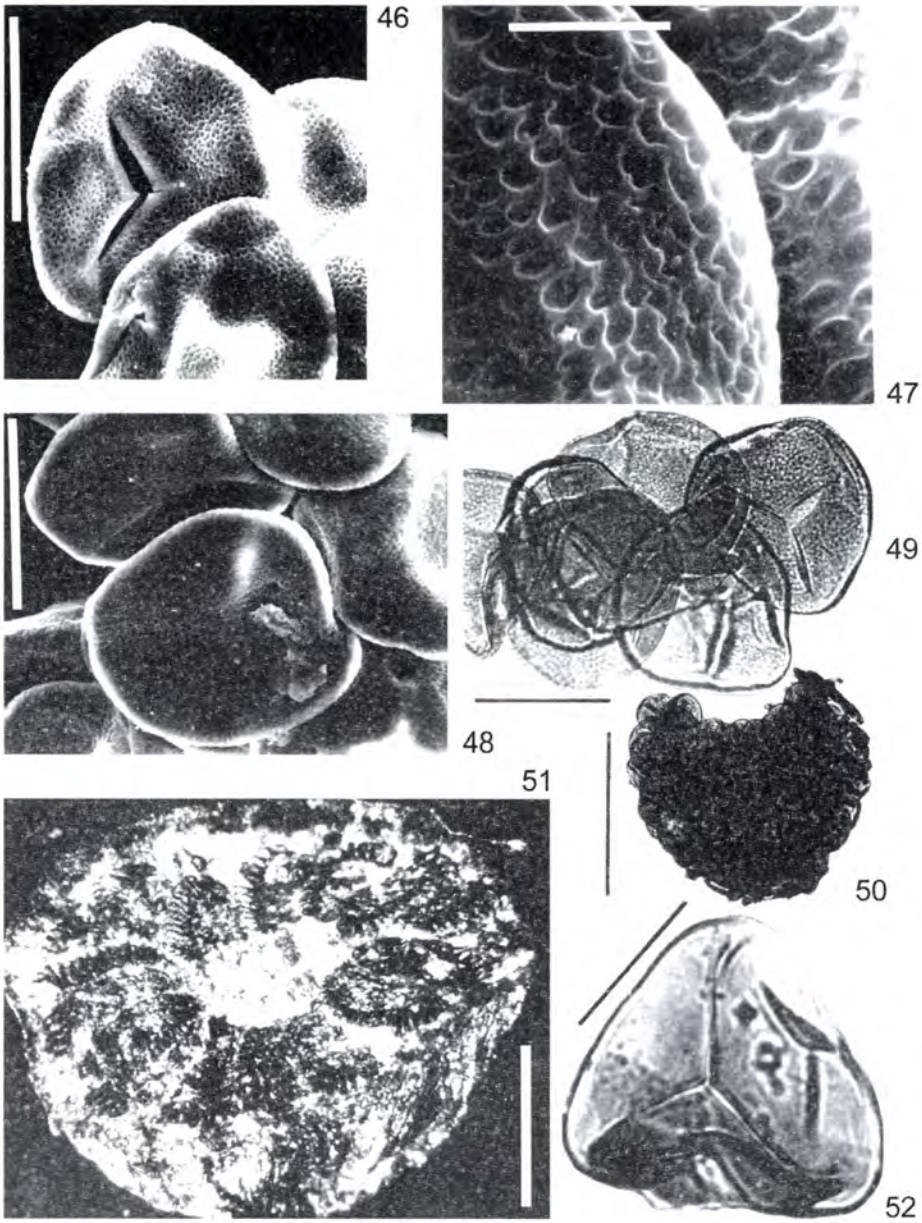
Mesochara symmetrica (Peck) Grambast 1962

Remark: This species was described from the locality near Ajka (RÁKOSI 1989, p. 24).

Genus: *Microchara* Grambast 1959
Microchara laevigata Grambast et Gutierrez 1977

Remarks: This species has already been described from this locality by Rákosi (1989, p. 23, Pl. V, Figs 2–3, 5). The samples are found mainly in marl or clay layers. In the material they are often found as compressed gyrogonites.

This species is dominant in the borehole No 1 in Somlóvásárhely, from 1368.2 and 1380.5 m, and also common in the borehole No 1 in Nemeshany, from 675.5–675.6 m. Age: Upper Cretaceous, Ajka Coal Formation.



Figs 46–52. – **46–50** = *Vadaszisporites minutireticulatus*, borehole Kf-2, 788.0 m. – **46** = SEM, bar = 40 µm. – **47** = Spore wall perforation, SEM, bar = 5 µm. – **48** = SEM, bar = 40 µm. – **49** = Bar = 50 µm. – **50** = Massula of spores, bar = 300 µm. – **51** = Cyatheaceae, borehole Gy-12, 493.1 m, bar = 300 µm. – **52** = *Cyathidites australis*, the spore prepared from sporangium from Fig. 51, bar = 30 µm.

Division: Tracheophyta
Class: Lycopsida
Order: Isoëtales
Family: Isoëtaceae
Genus: *Minerisporites* Potonié 1956
Generotype: *Minerisporites* (al. *Selaginellites*) *mirabilis* (Miner 1935) Potonié 1956

Minerisporites borealis (Miner 1935) Potonié 1956
Fig. 19

Description: Trilete megaspore with cingulum and reticulated surface, 300–400 μm large. The dehiscence line reaches beyond the perine.

Remark: It was found in the boreholes Cr-2, from 655.3 m, 631.4 m, Kf-2, from 702.65–702.85 m, 701.65–701.9 m and 700.8 m, Kf-6 from 630.4 m, Gy-9 from 590.4 m, 583.0 m, Gy-12 from 540.0 m (dominant), 531.6, Gy-15 from 496.6 and Nh-1, from 664.25 m.

Order: Lycopodiales
Family: Lycopodiaceae
Genus: *Vadaszisporites* Deák et Combaz 1967
Generotype: *Vadaszisporites (Microreticulatisporites) urkutikus* (Deák 1964) Deák et Combaz 1967

Vadaszisporites minutireticulatus Juhász 1975
Figs 46–49

Description: The trilete microspore with reticulated lumen. The size of particular microspores is about 40–50 μm, lumina of reticulum 0.3–0.5 μm.

Remark: Only a small number of spore massulae were found in the borehole Kf-2.

Class: Filicopsida

Remarks: Among the examined specimens, remains of sporangia were often found. In the literature, fertile fern leaves are usually described with sporangia as

well as spores *in situ*. This makes it possible to establish affinities of certain samples. In case of dispersed sporangia their affinities may have been established to family level only.

Order: Filicales
Family: Cyatheaceae

cf. *Cyathidites australis*
Figs 50–52, 59–60, 62

Description: In the isolated sorus 14 sporangia and one remain of placenta are found. Indusium is lacking. Sporangia are situated in pairs. The sporangium consists of rounded annuli, that are placed obliquely to the longitudinal axis of the sporangium faced each other, around the central place (Fig. 51). The thick walls of the annuli are well visible. Mass of the spores was prepared from the sporangium; they may be identified as *Cyathidites australis* Couper 1956 (Figs 50, 52).

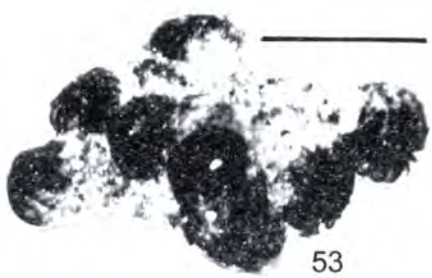
Remarks: According to palynological examinations, this type of sporangium is common in the Hungarian Senonian deposits. From the area of Ajka we know only one specimen of sorus remain that was found in the borehole Gy-12 from 493 m.

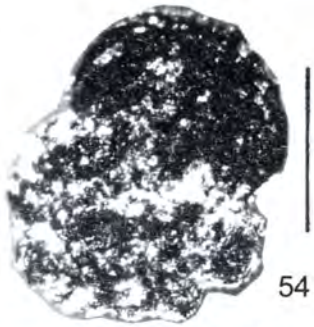
Family: Schizaeaceae

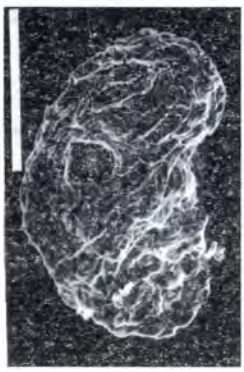
cf. *Anemia* sp.
Figs 53–58

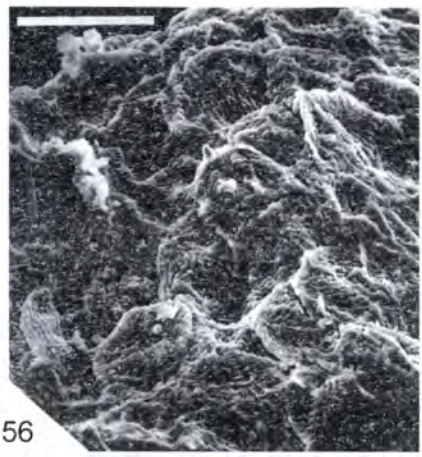
Description: The sporangia are egg-shaped, in compressed state they are 400–500 μm large. They consist of two parts; the upper one (annulus) and the lower, thin walled part, that consists of spores (50–80 μm large) with visible dehiscencia pore. The annulus consists of 14–18 thickenings. The isolated spores belong to *Appendicisporites tricuspidatus* Weyland et Greifeld 1953 (Figs 56–58).

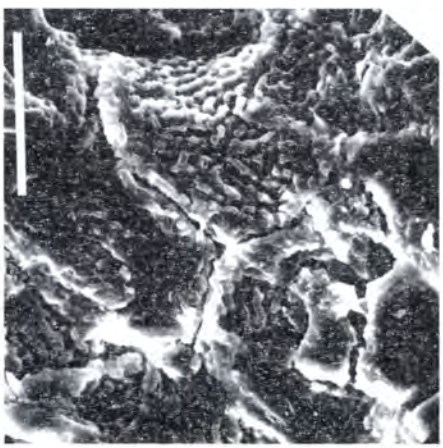
Remarks: The material originates from the borehole Kf-2 from 761.5 m. It is common in Hungarian Senonian deposits. The affinities of these sporangia are close to the family Schizaeaceae.

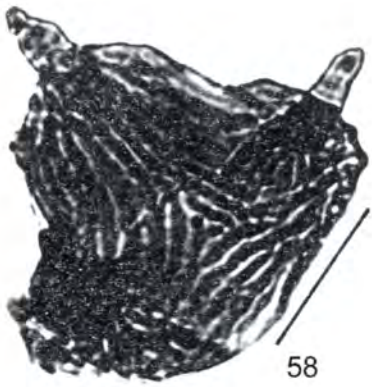












Figs 53–58. – **53–57** = Schizaeaceae, cf. *Anemia sp.*, sporangium, borehole Kf-2, 761.75 m, bars = 600 µm (Fig. 53), 200 µm (Fig. 54). – **55** = SEM, bar = 200 µm. – **56** = The spore wall with attached spores *Appendicisporites tricuspidatus*, SEM, bar = 50 µm. – **57** = Detail from Fig. 54, SEM, bar = 30 µm. – **58** = *Appendicisporites tricuspidatus*, bar = 30 µm.

Family: Polypodiaceae

Polypodiaceae gen. et sp.

Description: Sporangium surrounded by the annulus with thick walls, but not forming a complete ring. The isolated spores are in two types, trilete and monolete, thus making a more exact determination impossible.

Remark: Very common type of sporangium in Hungarian deposits.

Family: Adiantaceae
Genus: *Acrostichum* Linné 1753

Acrostichum sp.
Figs 61, 63

The genus is represented by the opened sporangium with annulus spores. Its size is about 500 μm. The spores are trilete, ornamented with granules. The material is very close to the spores *A. anglicum* described by Collinson from the Great Britain (COLLINSON 1978, p. 243, Pl. 2, Fig. H).

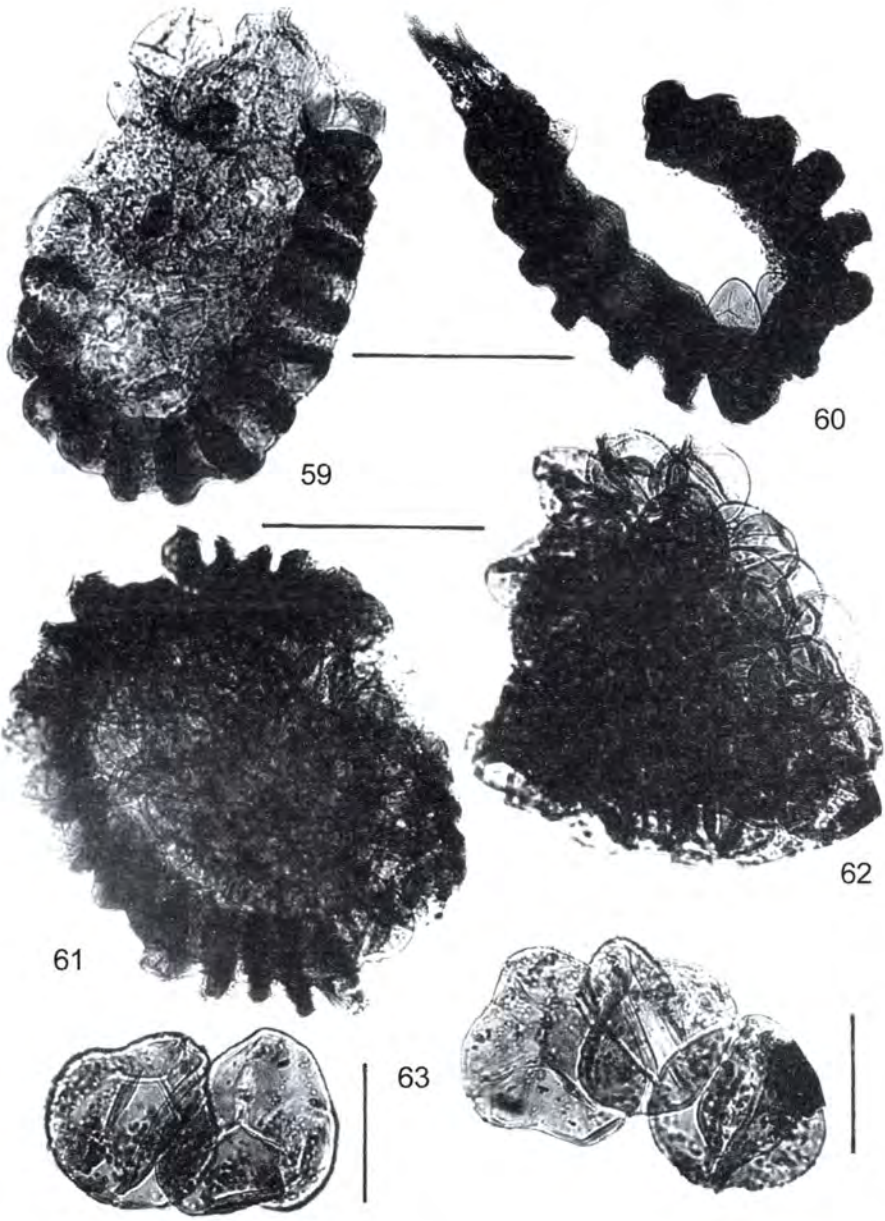
Remark: One specimen vas collected in the borehole Gy-12, from 535.6 m.

Order: Marsileales
Family: Marsileaceae

Genus: *Lobasporites* Floquet et Lachkar 1979
Generotype: *Lobasporites lobatus* (Dijkstra 1949) Floquet et Lachkar1979
Lobasporites lobatus (Dijkstra 1949) Floquet et Lachkar 1979
Figs 26–29

Description: Spheroidal megaspore, 200–600 μm in diameter. The exine is granulose, in high magnification 1–2 μm large gemmae are visible (Figs 27–28).

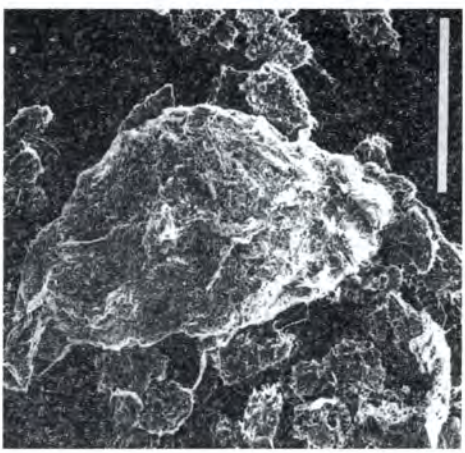
Remarks: According to HALL (1967, 1974) and ELLIS and TSCHUDY (1964) this genus belongs to the family Marsileaceae. Many authors have not accepted the genus *Lobasporites*. Up to now, the following taxa belong to the genus *Molaspora*: *M. fibrosa, M. hallii, M. reticulata, M. salium* (KOVACK and BATTEN 1989).



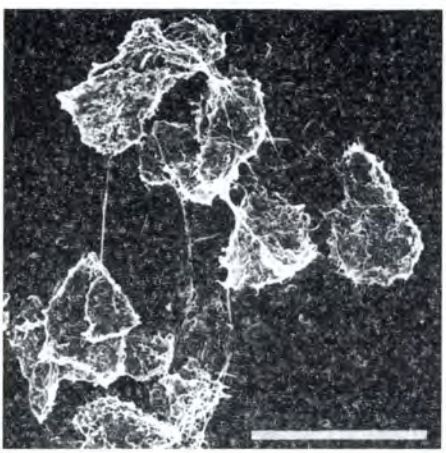
Figs 59–63. – **59–60** = Cyatheaceae, sporangium. – **59** = Borehole Nh-1, 666.9 m, bar = 200 µm. – **60** = Borehole Kf-1, 672.1 m, bar = 200 µm. – **61** = Adiantaceae, cf. *Acrostichum sp.*, borehole Gy-12, 535.6 m, bar = 200 µm. – **62** = *Leiotriletes sp.*, massulae, borehole Gy-12, 493.1, bar = 200 µm. – **63** = Spores prepared from massulae from Fig. 62.

Common species, sometimes found in great numbers in the deposits of the Ajka Coal Formation.

Occurrence: Boreholes Gy-9, from 590.4 m, 559.8 m, 484.9 m, Gy-12 from 540.0 m, 533.5 m, 528.6 m, 456.0 m, Cr-2 from 594.5 m, 594.2 m, Kf-1 from 725.7 m, 713.9 m, 619.5 m, Kf-2 from 732.7 m, between 702.85–703.25 m, Nh-1 from 664.3 m, 649.2 m, 640.4 m. Dominant in Ármin shaft, bench II (23–21 samples).

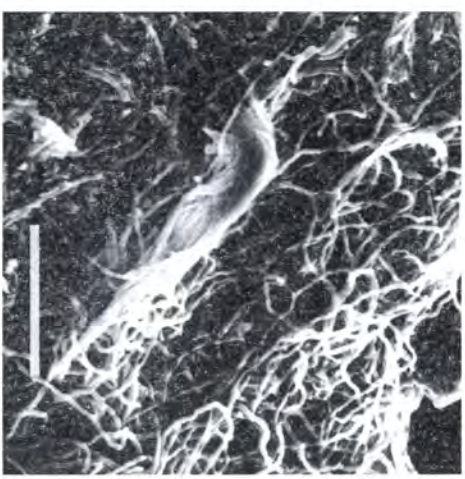


64

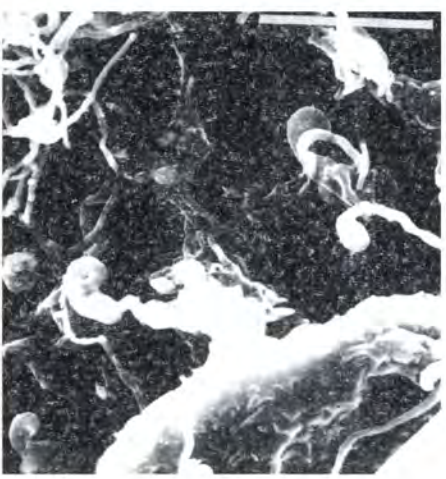


65

66



67



Figs 64–67. *Azollopsis* (*Spiralopsis*) *pusilla*, SEM. – **64** = Megaspore surrounded by microspores, borehole Kf-2, 697.15 m, bar = 450 μm. – **65** = Microspores, borehole Kf-2, 697.15, bar = 300 μm. – **66** = The surface of the megaspore with golhidia, bar = 30 μm. – **67** = Circinate golchidia, bar = 30 μm.

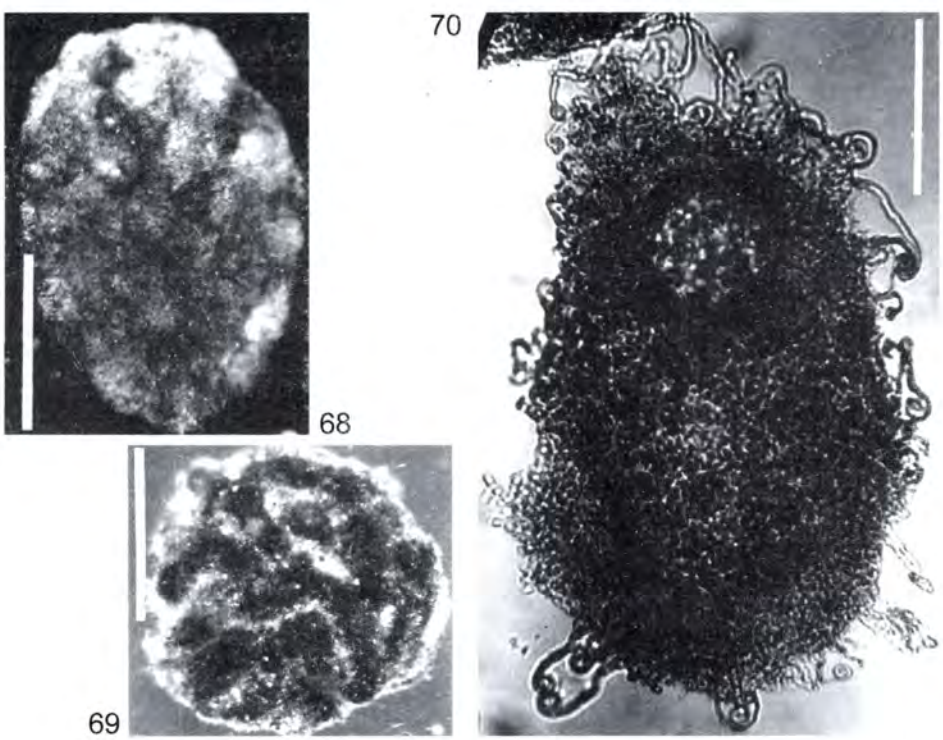
Order: Salviniales
Family: Salviniaceae

Genus: *Glomerisporites* Potonié 1956
Generotype: *Glomerisporites pupus* (Dijkstra 1949) Potonié 1956

Glomerisporites pupus (Dijkstra 1949) Potonié 1956

Description: Micro- and megaspores. In well preserved and complete remains, floats, as well as microspore massulae and golchidia were well observed.

Remarks: This species represents the heterosporous Salviniaceae, micro- and megaspores. In the well preserved set floats, microspore-mass and golchidia are found. This species is described from Hungary for the first time. In the locality it is



Figs 68–70. – **68–69** = *Azollopsis* (*Spiralopsis*) *intermedia*; borehole Kf-1, 628.3 m, bar = 300 μm. – **70** = *Azollopsis* (*Spiralopsis*) *pusilla*, megaspore with circinate golchidia, bar = 30 μm.

a common species; it was found mainly in boreholes Kf-1 from 628.3 m, 622.9 m, 619.5 m, Kf-6 from 588.7 m and Nh-1 from 649.2, 646.5, 641.4 m.

Family: Azollaceae
Genus: *Azollopsis* (Hall 1968) Sweet et Hills 1974
Generotype: *Azollopsis coccoides* Hall 1968

Azollopsis (Azollopsis) tometosa Hall 1968

Description: Megaspore complex, subcircular to ovate, 500–600 μm wide, having 100–200 floats per complex.

Remark: The material from the genus *Azollopsis* has been found maily in the borehole Kf-1, from 628.3, 622.9, 619.6 m.

Subgenus: *Spiralopsis* Sweet et Hills 1974
Generotype: *Azollopsis (Spiralopsis) intermedia* Sweet et Hills 1974
Azollopsis (Spiralopsis) intermedia Sweet et Hills 1974
Figs 68–69

Description: Megaspore complex, ovate to fusiform in shape, usually 300–500 μm long and 200–400 μm wide. It has more than 100–200 floats per megaspore complex.

Remark: This species is common in the boreholes Cr-2 and Kf-1.

Azollopsis (Spiralopsis) pusilla Sweet et Hills 1974
Figs 64–67, 70

Description: Megaspore complexes ovate to fusiform with proximal end usually more elongated than distal end, about 500 μm long and 300 μm wide. It usually shows more than 128 floats per megaspore complex. The golchidia are circinate.

Remark: The stratigraphical widespreading of heterosporous ferns belonging to the orders Marsileales and Salviniales was published recently by KOVACK and BATTEN (1989).

ECOLOGICAL RELATIONS

Found in between coal layers with marl, common among phytoplankton, *Schizosporis reticulatus* probably belongs to taxa living in freshwater. Similarly, green alga *Munieria grambasti* as well as *Amblyochara begudiana* and *Mesochara symmetrica* (Characeae) were found in these layers. These species occurred usually in the sublittoral zone of lakes.

The order Lycopodiales is represented by *Minerisporites* (Isoëtaceae). They grew in humid soil conditions or under water, mainly in oligotrophic-dystrophic marsh-lakes.

The species of the genus *Minerisporites* usually prefer coastal zones (either land or water).

Lobasporites lobatus belongs to Marsileaceae, the members of which live in eutrophic, swampy, seasonally flooded areas or in freshwater puddles.

Members of the family Salviniaceae prefer mainly warm climate in undisturbed, wind-protected, eutrophic fresh standing water.

Species of the recent family Azollaceae are found mainly in tropical zones. Similarly to those of the family Salviniaceae, they grow in protected areas of standing water covering the water surface.

PALAEOECOLOGICAL CONCLUSIONS

In the Ajka Coal Formation the phytoplankton is represented by *Schizosporis reticulatus* (Zygnemataceae), and green alga by *Munieria grambasti* (Dasycladaceae), and the gyrogonites of *Amblyochara begudiana*, *Mesochara symmetrica*, *Microchara laevigata* (Characeae).

All of these species require oxygen-rich, clear, oligotrophic, mainly freshwater and in certain cases oligohaline environment.

In the case of the pteridophytes, representation of aquatic and terricolous plants, the megaspores and the massulae of the heterosporous species and large-scale occurrence of microspores of the homosporous types were identified.

Systematically, the megaspores are represented by *Lobasporites lobatus* (Marsileaceae), *Glomerisporites pupus* (Salviniaceae), *Azollopsis tometosa*, *A. pusilla* (Azollaceae), *Minesporites* sp. (Isoëtaceae) and representative of Hydropteridales.

The most characteristic microspores from the fossil community of the formation belong to the families Lycopodiaceae and Cyathaceae.

The sizes of the identified spores and massulae, respectively, indicate a sedimentary process among undisturbed, near-shore conditions. The presence of megaspore species, however, refers to humid, dystrophic boggy soil, to undisturbed nutritious water surface and perhaps an environment provided by brackish water or standing water stretches of rivers.

REFERENCES

BATTEN, D. J. and ZAVATTIERI, A. M. (1996): Occurrence of dispersed seed cuticles and similar microfossils in mainly Cretaceous successions of the Northern Hemisphere. – *Cretaceous Research* **16**: 73–94.

BERGAD, R. D. (1973): North American species of the Cretaceous megaspores Balmeisporites and Monophyllosporites. – *Micropalaeontology* **19**: 53–67.

BERGAD, R. D. (1978): Ultrastructural studies of selected North American Cretaceous megaspores of Minerisporites, Erlansonisporites, Horstisporites, and Ricinospora, n. gen. – *Palynology* **2**: 39–53.

BINDA, P. j. and NAMBUDIRI, E. M. (1983): Fossil seed cuticles from the Upper Cretaceous Whitemud beds of Alberta and Saskatchewan, Canada. – *Can. J. Bot.* **61**: 2717–2728.

BRENNER, G. J. (1963): The spores and pollen of the Potomac group of Maryland. –*Maryland Dep. Geol. Mines Water Res.* **27**: 1–225.

Collinson, M. E. (1978): Dispersed fern sporangia from the British Tertiary. – *Ann. Bot.* **42**: 233–250.

CSÁSZÁR, G. h. and BODROGI, I. (1985): Munieriak a magyarországi krétában. [Munieria sp. from the Hungarian Cretaceous]. – *M. Áll. Földt. Int. Évi Jel.* **1983**: 167–212.

CSÁSZÁR, G. H. and GÓCZÁN, F. (1988): A Bakony felső-kréta kőszénkutatás és kőszén láp vizsgálat. (Upper Cretaceous coal prospecting and peat bog studies in the Bakony Mts). – *M. Áll. Földt. Int. Évi Jel.* **1986**: 155–178.

DIJKSTRA, S. J. (1961): Some Palaeocene megaspores and other small fossils. – *Meded. Geol. Stichting.*, n. s., **13**: 5–11.

ELLIS, C. H. and TSCHUDY, R. H. (1964): The Cretaceous megaspore genus Arellites Miner. – *Micropalaeontology* **10**: 73–79.

GELLAI, M. and TÓTH, K. (1982): Munieriák a Sümeg – Gyepükaján környéki szenonból (ajkai formáció). (*Munieria sp.* from the Senonian of Sümeg – Gyepükaján – Ajka Formation. – Földt. Közl. 112(3): 267–274.

GÓCZÁN, F., SIEGL-FARKAS, A., MORA-CABALAY, L., RIMANÓCZY, A., VICZIAN, J., RÁKOSI, L., CSALAGOVITS, J. and PARTÉNYI, Z. (1986): Ajka Coal Formation: biostratigraphy and geohistory. – *Acta Geol. Hung.* **29**(3–4): 221–231.

GREGUSS, P. (1949): Az ajkai felsőkrétakorú barnakőszén fuzitzárványok meghatározása (Podocarpoxylon ajkaense nov.sp.). (Bestimmung des Fusit-Einschlusses der Braunkohle von Ajka aus der oberen Kreidezeit. (Podocarpoxylon ajkaense nov. sp.)). – *Földt. Közl.* **1949**(9–12): 1–15.

GUNTHER, P. R. and HILLS, L. V. (1972): Megaspores and other palynomorps of the Brazeau Formation (Upper Cretaceous), Nordegg Area, Alberta. – *Geoscience and Man* **4**: 29–48.

HALL, J. W. (1967): Invalidity of the name Chrysotheca Miner for microfossils. – *J. Palaeontol.* **41**: 1298–1299.

HALL, J. W. (1974): Cretaceous Salviniaceae. – *Ann. Missouri Bot. Gard.* **61**: 354–367.

HORST, U. (1954): Merkwürdige Gebilde in Kohlen aus dem Wealden. – *Geologie*, Berlin, **3**: 610–612.

HUGHES, N. F. (1955): Wealden plant microfossils. – *Geol. Mag.* **92**: 201–217.
HUEBER, F. M. (1982): Megaspores and a palinomorph from the Lower Potomac Group in Virginia. – *Smithson. Contrib. Paleobiology* **49**: 1–20.
JANSONIUS, J., DIJKSTRA, S. j. and ELSIK, w. c. (1981): Geleenites Dijkstra 1949 a Cretaceous fungal fructification. – *Pollen et spores* **23**(3–4): 557–562.
KNOBLOCH, E. (1981): Die Gattung Costatheca Hall in der mitteleuropäischen Kreide. – *Sbor. Geol. Véd. Palaeontol.* **24**: 95–112.
KNOBLOCH, E. (1984): Megasporen aus der Kreide von Mitteleuropa. – *Sbor. Geol. Véd. Palaeontol.* **26**: 157–195.
KNOBLOCH, E. (1985): Costhateca Hall und Spermatites Miner – weltweit verbreitete Gattungen in der Kreide und im Paläozän. – *Documenta Naturae* **27**: 5–10.
KNOBLOCH, E. (1986): Problematische pflanzliche Mikrofossilien aus der Kreide und den Paläozän von Europa und Ägypten. – *Med. Rijks Geol. Dienst* **40**(1): 24–47.
KNOBLOCH, E. and MAI, D. H. (1986): Monographie der Früchte und Samen in der Kreide von Mitteleuropa. – *Rozpravy Úst. Ústavu Geol.* **47**: 1–217.
KOVACK, W. L. and BATTEN, D. J. (1989): Worldwide stratigraphic occurrences of Mesozoic and Tertiary megaspores. – *Palynology* **13**: 247–277.
LA PASHA, C. A. and MILLER, C. N. (1985): Flora of the Early Cretaceous Kootenai Formation in Montana, bryophytes and tracheophytes excluding conifers. – *Palaeontographica B* **196**(4–6): 115–145.
MARCINKIEWICZ, T. (1971): Stratygrafia retyku i liasu na podstawie badań megasporowych. [Stratigraphy of Rhaetian and Liassic on the grounds of megaspore examination]. – *Prace I.G.* **65**: 1–57.
MELCHIOR, H. and HALL, J. W. (1983): Some megaspores and other small fossils from the Wannagan Creek site (Paleocene) North Dakota. – *Palynology* **7**: 133–145.
MINER, E. L. (1935): Paleobotanical examinations of Cretaceous and Tertiary coals. –*Am. Mid. Nat.* **16**: 585–625.
PAÁL-SOLT, M. (1962): Kohlenpetrographische Untersuchungen aus der Kreide-Kohlenflözen von Ajka. – *M. Áll. Földtani Int. Évkönyve* **49**(4): 871–938.
PIERCE, S. T. (1976). Morphology of *Schizosporis reticulatus* Cookson and Dettman 1959. – *Geoscience and Man* **15**: 25–33.
POTONIÉ, R. (1956): Synopsis der Gattungen der Sporae Dispersae I. – *Beih. Geol. Jahrb.* **23**: 1–103.
POTONIÉ, R. (1970): Synopsis der Gattungen der Sporae Dispersae V. – *Beih. Geol. Jahrb.* **86**: 1–227.
RÁKOSI, L. (1989): Some new Thallophyta remains from the Hungarian Upper Cretaceous and Tertiary. – *M. Áll. Földt. Int. Évi Jel.* **1988**(2): 15–45.
SINGH, c. (1964): Microflora of the Lower Cretaceous Mannville Group, east central Alberta. – *Res. Coun. Alberta, Bull.* **15**: 1–239.
TAPPAN, H. (1980): *The paleobiology of plant protist.* – W. H. Freeman and Company San Francisco, 1028 pp.
VADÁSZ, E. (1940): *Kőszénföldtani tanulmányok.* – Akadémiai Kiadó, Budapest, 121 pp.
VAN GEEL, B. (1979). Fossil spores of Zygnemataceae in ditches of prehistoric settlement in Hoogkarspel (The Netherlands). – *Rev. Palaeobot. Palynol.* **22**: 337–344.
WEYLAND, H., BERENDT, W. and PETERS, i. (1960): Über einige bisher unbekannte Mikrofossilien aus der Braunkohle. – *Senckenbergiana Lethaia* **41**: 489–511.

(Received: 20 March, 2000)