Acta Biologica Szeged. 25 (3—4), pp. 55—69 (1979)

In honour of Prof. PÁL GREGUSS
on the occasion of his ninetieth birthday

AZOLLA AND SALVINIA FROM THE PLEISTOCENE OF VÉSZTŐ (GREAT HUNGARIAN PLAIN)

P. SIMONCSICS and MARGIT SZÉLES

Attila József University, Szeged;
Industrial Research Laboratory of Oil and Natural Gas, Budapest
(Received February, 20 1979)

Abstract

From the Pleistocene deep-boring No. 1 at Vésztő, in the course of Ostracoda investigations, some Salviniaceae fossils came to light, namely

Salvinia sp. 1 megaspore (? S. natans foss.),
Salvinia sp. 2 megaspore,
Salvinia sp. microsporangium,
Azolla filiculoides LAM. foss. megaspore and massula,
Azolla tegeliensis FLORSCH. em. BERTELSEN, megaspore,
Azolla danica BERTELSEN, massula.

The sensitivity to the cold climate and facies-marking role of these species of the communities of plants floating on the water surface is indisputable. The determined *Azolla* megaspores and massulae mainly occur in the lower part of Pleistocene and indicate a climate corresponding to that of the interglacial periods.

In our material, they help us to divide the lower stage of Pleistocene in a greater detail, what could not be achieved on the basis of ostracods.

Introduction

In the course of the investigation of the microfaunistical samples of the deep-boring at Vésztő (in the Great Hungarian Plain: MARGIT SZÉLES), several Salvinia and *Azolla* megaspores, massulae, resp. microsporangia were found. The determination and evaluation of these induce the belief that — together with the existing Ostracoda and the future palynological examinations — the single stages of Pleistocene can be divided better stratigraphically and investigated facies-ecologically and climatically than at present.

In Hungary, but a few fossils of Salviniaceae could so far be found. From the old literature of the Carpathian basin, *Salvinia* leaves were demonstrated by STAUB (1881 and 1887) from the Aquitanian stages of Fruska-Gora and the Zsil-valley. *Salvinia* leaf fossils were similarly found in the Oligocene at Érd, as a result of the investigations by RÁSKY (1949). And from the middle Miocene macroflora in the environment of Eger-Tihamér, *Salvinia* leaves were demonstrated by IGALI ZELLER (1955).

In the recent palynological literature mainly Salviniaceae microspore fossils are reflected. E. NAGY described (1969) a microspore connected with *Azolla* from the Torton stage of Hídas (Mecsek mountains). The palynologist author of this paper has found *Hydrosporis* sp. microspores in more than one boring sample from the Miocene through the Pannonian till the Pleistocene, referring to *Azolla* or *Salvinia*.

MIHÁLTZ FARAGÓ (1973) found *Azolla* — having a part, according to him, "together with both microsporangium and glochidium" — in the Egyek-1 boring, at the limit of Plio- and Pleistocene, and interglacial stages of the Pleistocene.

We have no knowledge about that the Hungarian special literature rendered an account of any description of the *Azolla* or *Salvinia* megaspore and massula. It is worth, anyway, calling the attention to these because — in spite of the rich Pleistocene occurrences — the territory of Hungary is one of the missing links in Europe in this respect and because their macroscopical light- and electron-microscopical morphology is well-known and, at the same time, the research workers dealing with the washed material, can easily expose and determine these, too, apart from the shells of molluscs, ostracods, *Chara* oogonia and diatoms.

Materials and Methods

The material of our investigation originates from the deep-boring at Vésztő-1 which passed througt the Pleistocene from 22 till 520 m with core-boring. In the course of ostracod investigations, shell fragments of molluscs, embrional snail shells and, in addition to *Bythinia* opercula, oogonia of *Chara, Salvinia* and *Azolla* megaspores and massulae, as well as carbonized tiny wood fossils were found.

The *Salvinia* and *Azolla* examinations have only comprised the fossils of six samples from the depths 340–370 m and 430–450 m where these occurred in large masses and the ostracod fauna was poor (Table 2).

Knowing the varied methodics of isolation and exposure from Schwarzenholz's (1961) method of the separation with $H_2O_2-NH_4OH$ till Bertelsen's method with bromoform-alcohol (1972), we have applied the following method: From the washed material we have picked out the megaspores one by one and in unnumbered amount, as well as (owing to their limited number) 25 massulae, resp. microsporangia, under a "Cytoplast" (Zeiss) binocular stereomicroscope, with a sharp-pointed splinter of wood. The untreated fossils were examined and photographed with a Zeiss microscope illuminated from above. For examining and photographing certain details (massula, glochidium, microsporangium, microspore, megaspore-perine and exine), some preparations washed and cleared with Na-hypochlorite were used. If necessary, we have also investigated and photographed megaspores, microsporangia and massulae macerated with dissecting needles.

In this paper, the *Azolla* megaspore means — according to POTONIÉ (1956) and KEMPF (1969b) — the fossil that comprises the megaspore in the strict sense of the word, the gula originating from the megaspore perine, the floats connected with the gula, the parts of the sporangiodermis covering the point of the gula.

By *Salvinia* megaspore the megaspore body and the conical triple lamella covering the not visible gula are meant, without any other constituent (stalk, sporangiodermis) which don't—or only exceptionally do — occur in fossils.

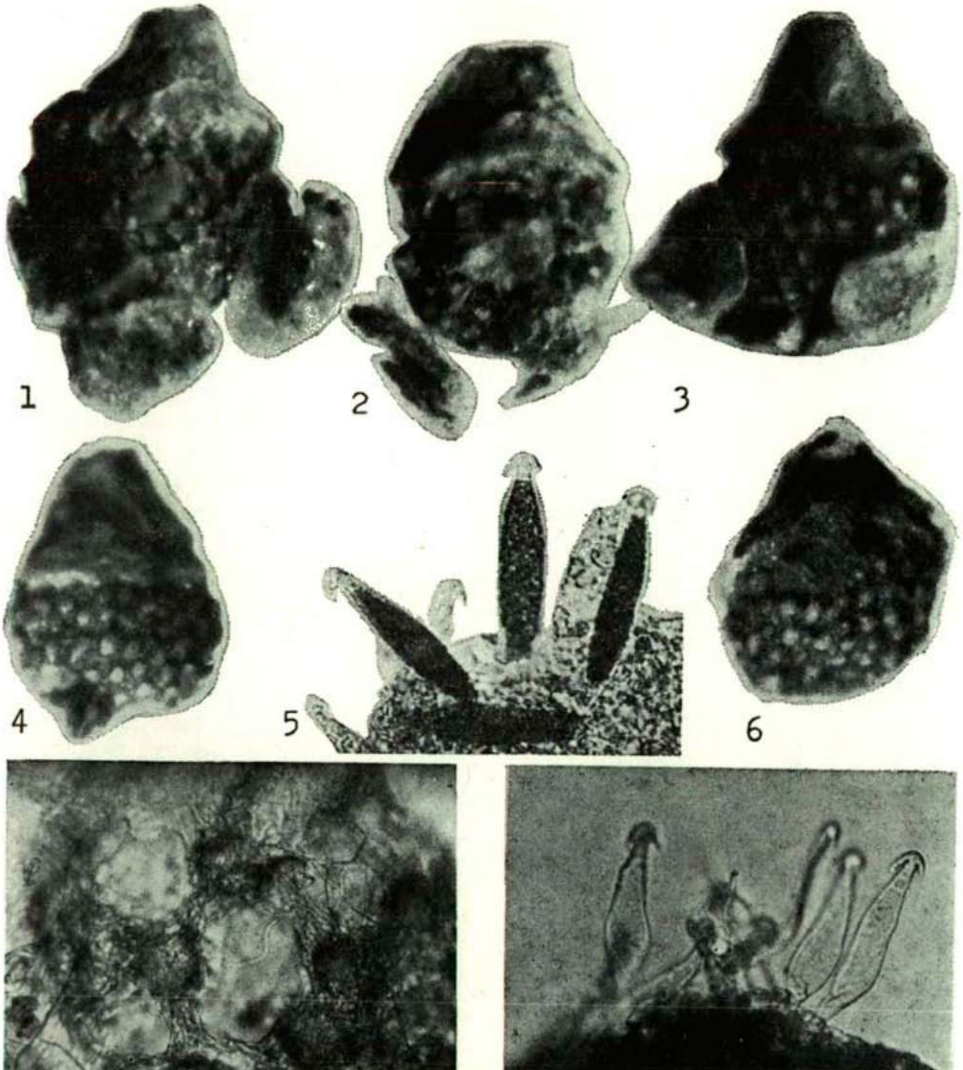
Microsporangium means the (stalked) organ of the *Salvinia* genus containing a single massula and that of the *Azolla* genus containing more massulae, surrounded with a sporangiodermis (SADEBECK in ENGLER-PRANTL, 1902). The microspongium of the Salvinia genus occurs isolated as a fossil. The *Salvinia* microsporangia contain microspore exines surrounded with a vacuolar wall. Massula means a formation of approximately spherical form, of tapetum origin and vacuolar structure, enclosing microspore exines. The hooked or hookless glochidia of the surface are formed from the material of the massula. The massula of the *Azolla* species occurs as a fossil, isolated or sticking to the megaspores.

Results

Azolla filiculoides LAM. foss. megaspore
(Plate I, photographs 1–4 and 6–7)

The megaspore is a ball with a conical apical part. As a matter of fact, the megaspore is formed by the ball. The conical apical part is formed by the elongated

Plate I



Figs. 1–4, 6: *Azolla filiculoides* LAM. foss. megapores and massulae, x100.
Figs. 5, 8: *A. filiculoides* massulae with anchor-shaped glochidia, x500.
Fig. 7: *A. filiculoides* perine with capilli, x500.

gula, the three floats connected with that, and by the sporangiodermis covering the apex of the gula.

The perine, the external wall of the ball, is verrucated. The verrucae are large, of 15–20 μm diameter and height. If illuminated from above, they are clear (e.g. Fig. I/4), at transillumination they are dark (Fig. I/7). The surface of the megaspore perine is woven with hairs, capilli.

The structure of the megaspore body is connected with different functions. The perine verrucae which consist of tiny vesicles, full of air and having very thin walls, play a part in keeping the megaspore at the surface of the water. Owing to their thin, membranous wall, they — and possibly the verrucae damaged by glochidia — mean gates for the penetration of spermatozoids. The perine seems, namely, at another place to be impenetrably compact. And owing to the perine capilli, the massulae can get entangled in it by their glochidia.

The polar axis of the megaspore (apparatus) is 350–490 μm, the maximum diameter of the megaspore body is 280–380 μm. These measurements agree with those given by HILTERMANN (1954), MÄDLER (1954), BERTELSEN (1972), and others. The 160–180 μm height of the conical apical part seems to be a more stable datum than that of the diameter of the megaspore.

At the contact of the megaspore body and the conical apical part the perine has no verrucae. Here the lower and upper parts are often separated from each other or may easily be separated. In this case, the perineless megapore exine falls out of it. The surface of the exine is granulated densely and finely. The laesurae of the trilete-mark are straight, 45–60 μm long. The diameter of the megaspore exine in preparations changed between 280–400 μm.

In the material, there occurred isolated exines, megaspore bodies consisting only of perine, and the fragments of the conical part comprizing floats, as well.

The massulae also occur, as a rule, stuck to the megaspores.

Azolla filiculoides megaspores and massulae occurred in samples taken from 361.76–362.22 m, 354.20–354.73 m, 344.48–345.31 m depth.

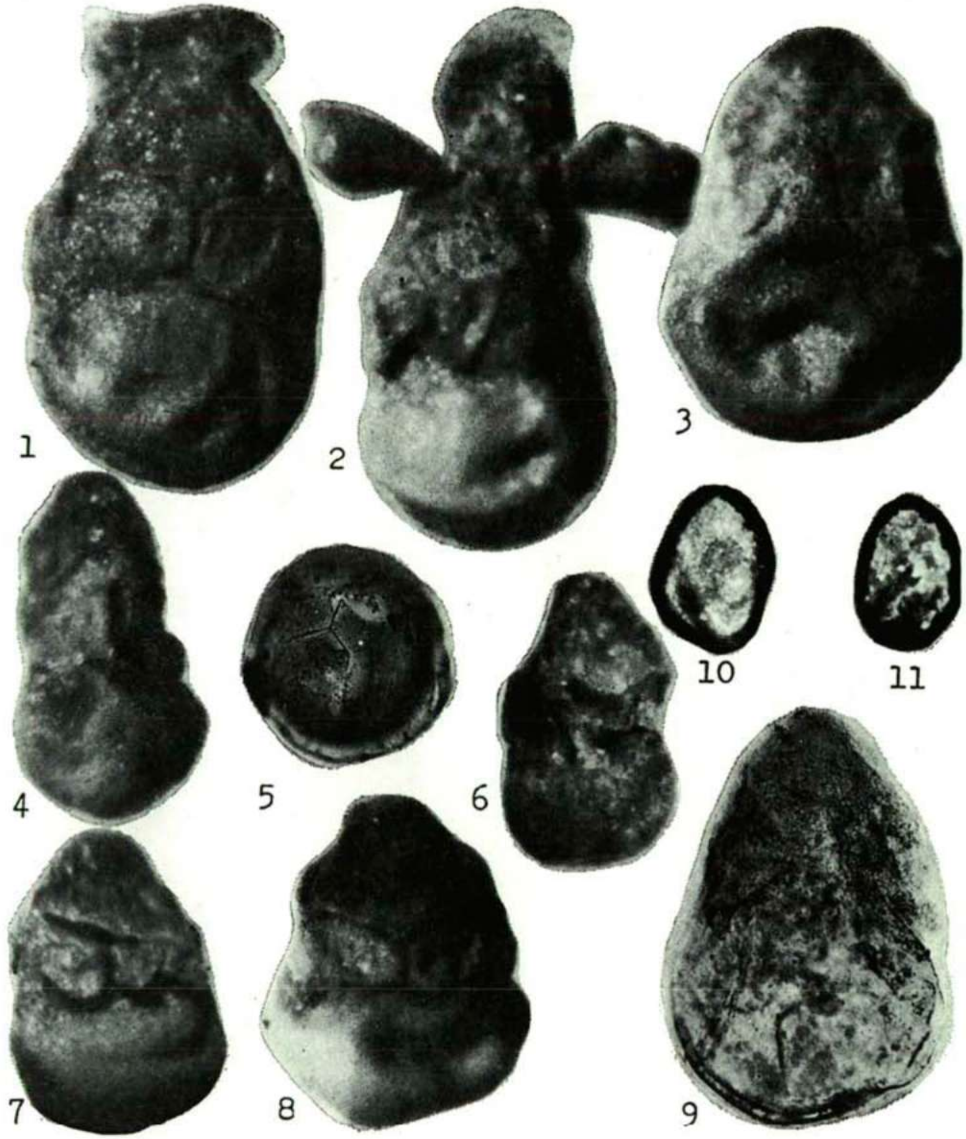
Azolla filiculoides LAM. foss. massula
(Plate I, photographs 5 and 8)

They are disk-shaped fossil bodies of a 135–190 μm diameter (without glochidium). Their substance is a vacuolar cell wall which corresponds to the perine of the microspore exines and originates from the tapetum of the microspongium. At their surface, there are anchor glochidia which are 56–80 μm long and their stalk has a maximum breadth of 8–10 μm. Under the about 10 μm wide hooked head, in the stalk, generally one septum, but rarely two septa, are to be found. The not septate glochidia are rare. Inside the massulae several microspores can be found with an about 18 μm diameter and with an about 1 μm thick, smooth exine. We did not succeed in observing the trilete-mark on the microspore. In Plate I, photographs 5 and 8 glochidia are demonstrated.

The *A. filiculoides* massulae generally occur connected with the megaspores (Plate I, photographs 1–3 and 6). It is rare if they are found isolated.

The perine-like material of massulae is extremely resistant. It endures even the rude pollen-exploring methods and materials. In pollen preparations, PACLTOVÁ (1960) and KRUTZSCH (1962) demonstrated fine glochidia and massula-pieces which probably don't belong to the *A. filiculoides* species.

Plate II



Figs. 1–4, 6–9: *Azolla tegeliensis* FLORSCHÜTZ em. BERTELSEN megaspores, x100.
Figs. 5: *A. tegeliensis* megaspore exine, x100.
Figs. 10—11: *Azolla danica* BERTELSEN massulae, x100.

According to the diagnosis of the recent *A. filiculoides* LAM (STRASBURGER 1873 in BERTELSEN 1972), "die Glochidien an den Massulae unseptiert", and at the var. *rubra*: "Die Glochidien der Massulae am Scheitel septiert". The distribution area of the former includes, according to SADEBECK (1902), the subtropic areas of the American Continent from California till the tropical, subtropical areas of Patagonia. And as the area of the septate variety of glochidia, Australia, New Zealand, and Tasmania are given.

The area of *A. filiculoides* foss. and of *A. interglacialica* NIKITIN, synonymous with it, extends from Northern Europe till Greece, from the Atlantic till about the Ural. Here is to be mentioned an occurrence from the Southern Banat, published by MÄDLER (1954) and touching Hungary, as well.

A. filiculoides foss. was considered by the old literature as an interglacial guide fossil of Mindel-Riss. The data collected from about 1928 till now were summarized by BERTELSEN (1972). According to these, the species occurs from Tiglian (Tiglian C substage) in the Waalian, "Cromerian", and Holsteinian interglacial periods and is the guide fossil of Holsteinian. And Holstein corresponds to the Mindel-Riss interglacial period. At evaluating the fossils stratigraphically, it is remarkable that it was found in the brown coal of Megapolis in Greece, as well, and — according to MÄDLER (1971) — the period of this is "die erste Wärmezeit des Pleistozäns". It was published similarly by BERTELSEN, that *A. filiculoides* must have become extinct in Europe, probably with the Saalian, as connected probably with the Saalian glaciation.

Azolla tegeliensis FLORSCHÜTZ emend. BERTELSEN megaspore (Plate II, photographs 1–9, Plate III, photographs 1–2)

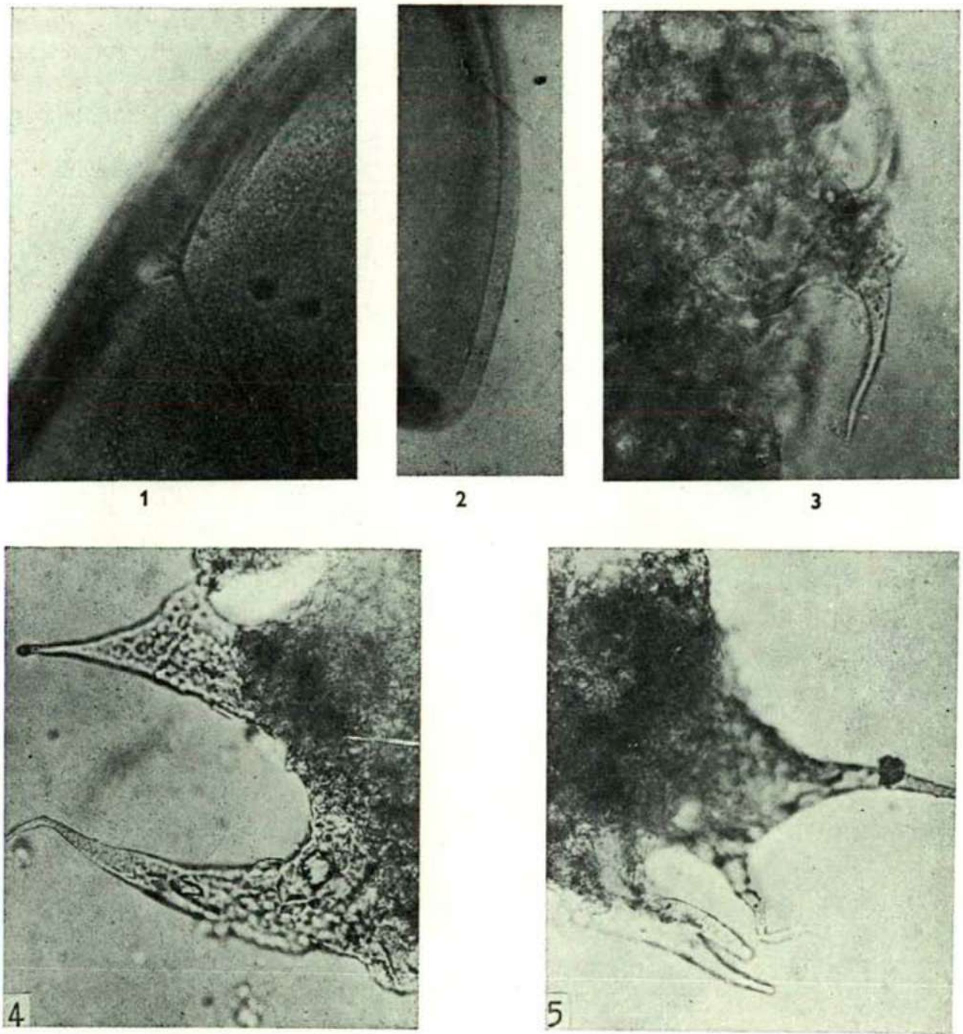
The megaspore has an ovoid shape. In its conical apical part, it has nine floats. On each concave side of the gula with triradial columella there are two diamond-shaped floats and above them and alternately a larger triangular float. The edge of the gula starts with an 8–10 μm wide basis but apically it grows narrow (Plate II, photographs 3 and 9). At the apex of the gula the so-called acrolamella is frequent with a number of capilli (Plate II, figs. 1–2).

The globular basal part, the perine of the megaspore body is comparatively smooth but in some grains the sporadically scatterred granules — which take a part in Bertelsen's emended diagnosis — can be seen even macroscopically (Plate II, photograph 3).

The perine of the basal part is elastic and can easily be broken with dissecting needles. The megaspore exine of a more solid wall can be prepared from it. The diameter of the megaspore exine is 250–300 μm (6 specimens). On it, there is a sharp-trilete-mark in a straight line. The laesurae of the trilete-mark are 40–60 μm long (Plate II, photograph 5 and Plate III, photograph 1). The exine is 3.2–4 μm thick and it seems to be of identical structure in the whole cross-section (Plate III, photograph 2). Its surface is granulate, with scatterred smooth spots (Plate III, photograph 1). The perine is 8–10 μm thick.

The sizes of megaspore vary between 380–680×240–410 μm. The height of the conical apical part is less variable (230–300 μm) than the *A. filiculoides*. The data of BERTELSEN (1972) don't move between so wide end values. Nevertheless, it is improbable that among the megaspores of nine floats one of the species described by DOROFEEV (1959, 1963b, 1968) also occurs.

Plate III



Figs. 1–2: *A. tegeliensis* megaspore exines, fig. 1: surface with tetrad mark, fig. 2: optical section, x500.
Figs. 3–5: *Azolla danica* Bertelsen massulae with simple glochidia, x500.

In our material, *A. tegeliensis* occurs in large numbers in the samples originating from 339.88–450.00 m, 449.13–449.88 m and 433.67–433.91 m depths. In each of the samples in 361.76–362.22 m and 354.20–354.73 m depths there was found one specimen.

Azolla tegeliensis is, according to the data got till now, a fossil of extremely confined area. According to Bertelsen's investigations and the literary data (1972), it occurred in the Danish territory of the North Sea, in more than one habitat of Holland, in Öbel in Germany, as well as — according to the work of GREGUSS & VANHOORNE (1961) — in Belgium (Prof. PÁL GREGUSS determined the wood fossils of the lignite, originating from Saint-Leonard in Belgium, with the reliability characterizing him). In Kempf's paper (1969b) the thought presents itself that its area must have been larger than known until now.

It is noteworthy, at any rate, that *A. tegeliensis* can be found even about 1000 km south of these habitats.

As to the stratigraphy of the fossil, it is narrow enough, too. The Tiglian is only generally given or the embeddig rock is determined as Tiglian. In the work of GREGUSS & VANHOORNE (1961), it is written about the age of lignite that it is the "first interglacial of the Quaternary period". Rather exact data can be found in Bertelsen's work, too. According to the boring samples from the sector of the North Sea belonging to Denmark *Azolla tegeliensis* occurs beginning with the sporadic Reuverian fossils, through the Pretiglian, till the Tiglian. Its occurrence in the Waalian interglacial is uncertain. These are the sure facts.

With full knowledge of these facts, it is inexplicable how becomes this fossil in Dorofeev's and Triverdi & Verma's works (1971) a Pliocene species starting from the Miocene. FRIIS (1977) likewise present it in hers Table as a Lower Pliocene species, together with the species A. pyrenaica FLORSCHÜTZ & MENÉNDEZ AMOR (1960) which was similarly found at the Pliocene-Pleistocene boundary line.

Relying upon the right literary data dealing with this species, we consider *Azolla tegeliensis* as a fossil starting from the Pliocene-Pleistocene boundary and being wide-spread till the Upper Tiglian, the scattered specimens of which can also be found in the Waalian interglacial period and occur from the Upper Tiglian together with the *Azolla filiculoides,* as well.

Azolla danica BERTELSEN massula
(Plate II, photographs 10–11, Plate III, photographs 3–5,
and Plate IV, photographs 9–11)

Massulae are irregular, ovoid formations, their surface is uneven, their thickness is changing. Glochidia without anchor, branching or not-branching off, stick to the surface in few places (it seems that at two points) (Plate III, photograph 3). Preparing the massula with needless, it turns out that the basis of glochidia agrees with the vacuolar structure of the massula body, the end of glochidia is only an inarticulate straight, reclinate or spiral hairlike formation (Plate III, photographs 4–5).

The diameter of massulae is 120–250 μm, the length of the non-vacuolated ends of glochidia is about 35–60 μm, and their surface is smooth.

The microspores in massulae (Plate IV, photographs 10–11) have a 19–22 μm diameter, their equator-contour is a circle. The laesura of the trilete-mark is 5–6 μm. On the surface of massula, where a microspore is in the massula, the wall of massula (perine) creates a reticulum (Plate IV, photograph 9), the mess sizes are 1–5 μm, on average 2 μm wide.

The massulae occur isolated in samples containing several specimens of the *Azolla tegeliensis*. From among these, 12 specimens were prepared. In two cases, we succeeded in detaching from the acrolamella of *A. tegeliensis* some granules that proved to be *A. danica* massulae. This verifies the supposition (BERTELSEN, 1972) that *Azolla danica* is the massula of *A. tegeliensis*.

In our material, they occurred but in a low number in the samples originating from the depths 449.88–450.00 m, 449.13–449.88 m, and 433.67–433.91 m.

A. danica massulae have so far been found only in the Danish area of the North Sea in a depth of about 280 m below sea level, from a sample of *A. tegeliensis* above "maximum", from the upper Tiglian interglacial period where already *A. filiculoides* appeared, too. Their occurrence in Hungary is an important evidence in proof of the wide area.

Salvinia sp. 1 megaspore
(Plate IV, photograph 12)

The megaspore, having but few determinative marks, is approximately spindle-shaped. Its lower part, the megaspore body, is smooth, somewhat rugose. Between the conical apical part and the body of the megaspore the transition is gradual, both parts are delimited from each other only with a weak lacing. The conical apical part consists of three lobes, opened at the apex. These are named by KEMPF (1971) "Keimöffnungslappen", covering the gula which is smaller-sized than that of Azollae and is here invisible. The megaspores have no floats.

The length of the polar axis is 550–650 μm, that of the transverse axis is 350–400 μm. The height of the conical apical part is 230 μm, the diameter of its basis being 290–300 μm.

There occurred only two specimens in the samples originating from the depth 433.67–433.91 m.

It will have been the megaspore of *Salvinia natans* (L.) ALL.

Salvinia sp. 2 megaspore
(Plate IV, photographs 1–3 and 7)

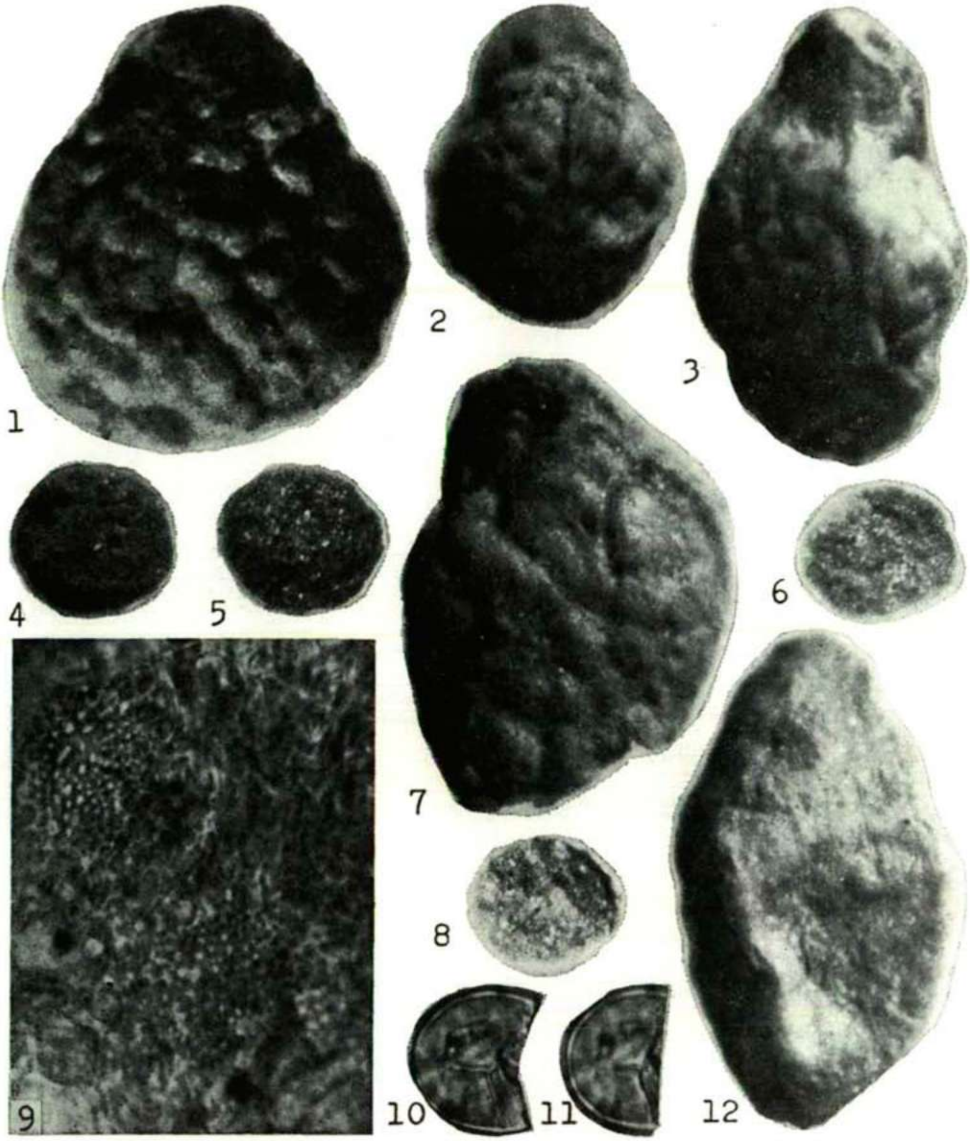
The megaspore is approximately ovoid-shaped, with a body of approximately spherical form to which the conical apical part is attached with a strong lacing.

The spherical or ovoid megaspora body is covered with flat, blurred verrucae. The flat verrucae sometimes resemble to the ornamental elements of *Salvinia cerebrata* NIKITIN ex DOROFEEV (FRIIS, 1977) but they never lie in a polar angle of sight because their longitudinal axis is longer than the transverse axis.

The semicircles of the conical apical part (Keimöffnungslappen) are only a little open, two lobes are generally larger than the third one. The surface ornamentation of these consists of irregular, creased and smaller, verruca-like elements.

The sizes of megaspores are various. The polar axis varies at the measured specimens between 400–650 μm, and the body diameter between 350–550 μm. The verrucae on the body surface have a 50–70 μm basis and are about 10, maximum 20 μm high.

Plate IV



Figs. 1–3, 7: *Salvinia* sp. 2 megapores, x100.
Figs. 4–6, 8: *Salvinia* sp. microsporangia, x100.
Fig. 9: *Azolla danica* surface of the massula, x1000.
Figs. 10–11: *A. danica* microspores, x1000.
Fig. 12: *Salvinia* sp. 1 megaspore, x100.

DOROFEEV (1963a) divides the megaspores into two sections: i.e., the ovoid- and spindle-shaped ones into the *Eusalvinia,* the spherical ones into the Cerebrata section.

The Salvinia sibirica DOROFEEV, published in Kristofovich's book (1957), the *S. intermedia* NIKITIN, published by LAŃCUCKA—ŚRODONIOWA (1958), as well as the S. DOROFEEV megaspores have traits to the *Salvinia* sp. 2 megaspores. Some authors describe, unfortunately, the fossils only with macroscopic methods, without following the precise and manysided elaboration, description and presentation as BUŽEK, KONZALOVÁ & KVAČEK (1971) who have worked also with light microscope, to say nothing of the electron-microscopic *Salvinia* megaspore studies of KEMPF (1971) and FRIIS (1977).

The following stratigraphical Table would give verification and reason for that an unambiguous description and elaboration of *Salvinia* megaspores would be very important.

Table 1: Stratigraphical values of some *Salvinia* megaspores

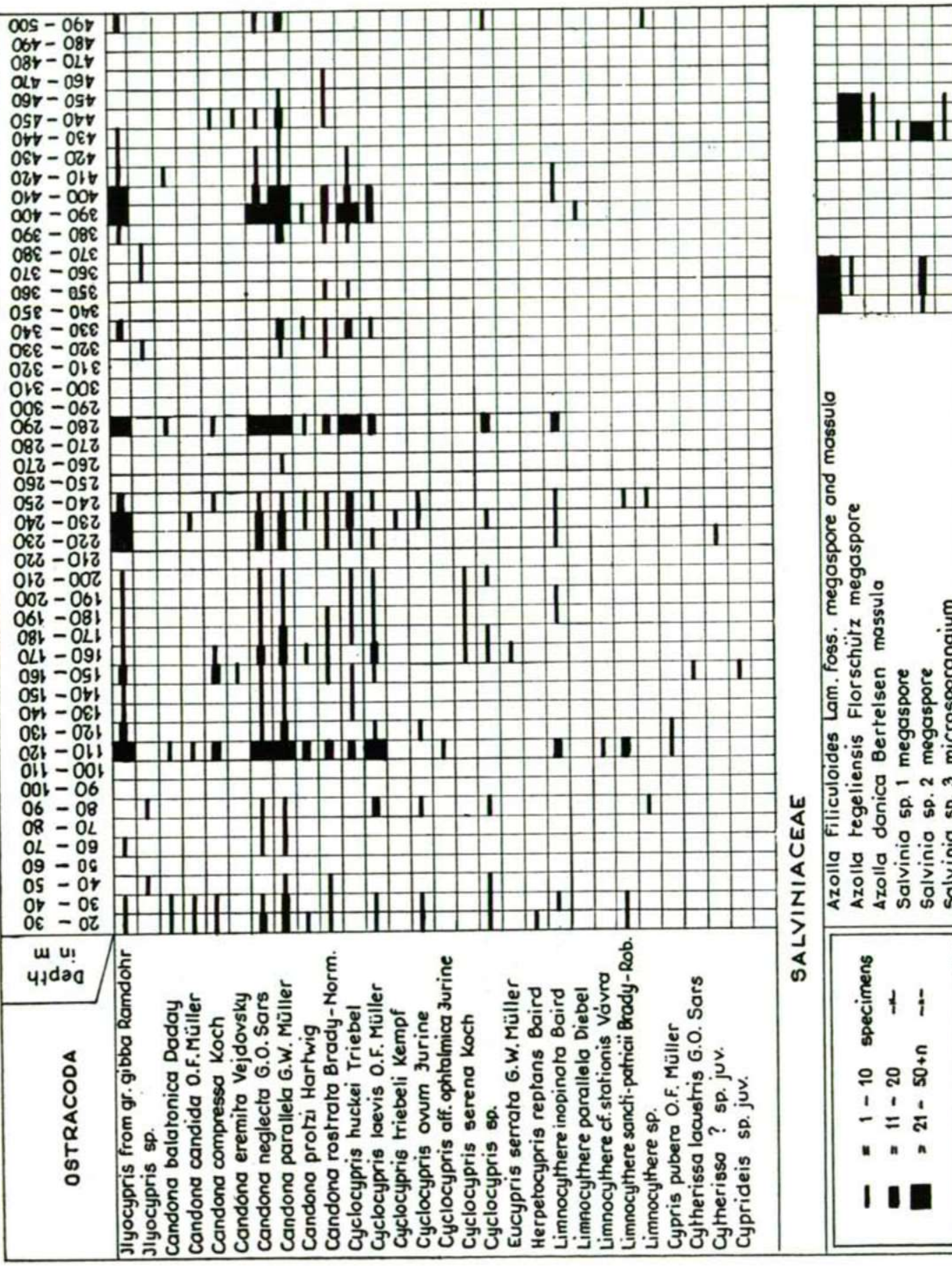
Sectio *EUSALVINIA*	Oligocene	Miocene	Pliocene	Pleistocene
Salvinia sibirica DOROFEEV		+		
Salvinia miocenica DOROFEEV		+		
Salvinia intermedia NIKITIN		+		
Salvinia rhenana KEMPF			+	
Salvinia natans (L.) ALL. foss.				+
Salvinia sp. 1 (SICS. — SZÉLES)				+
Salvinia sp. 2 (SICS. — SZÉLES)				+
Sectio *CEREBRATA*				
Salvinia turgaica DOROFEEV	+			
Salvinia cerebrata NIKITIN ex DOROFEEV	+	+		
Salvinia sp. (FRIIS)		+		
Salvinia glabra NIKITIN			+	
Salvinia maeotica DOROFEEV			+	

Salvinia sp. microsporangium
(Plate IV, photographs 4–6 and 8)

The *Salvinia* microsporangia occur in our preparations in the form of flat disks. Their edge is here and there dentate (Plate IV, photographs 5, 8) what relates to the existence of a sporodermis. In unprepared state, the surface of sporangia is granular. The sporangia, cleared with Na-hypochlorite javellization and examined with light microscope show a vacuolar structure similar to the *Azolla* massulae. In them, the microspores are of 18 μm diameter, with smooth exine and short laesurae of the trilete-mark. Having macerated the micosporangia, we did not find any glochidia.

As samples, we have preparated 2–8, together 13 microspongia from among samples, originating from 449.88–450.00 m, 449.13–449.88 m, and 433.67–433.91 m depths.

Table 2


OSTRACODA
Depth in m
20 – 30
30 – 40
40 – 50
50 – 60
60 – 70
70 – 80
80 – 90
90 – 100
100 – 110
110 – 120
120 – 130
130 – 140
140 – 150
150 – 160
160 – 170
170 – 180
180 – 190
190 – 200
200 – 210
210 – 220
220 – 230
230 – 240
240 – 250
250 – 260
260 – 270
270 – 280
280 – 290
290 – 300
300 – 310
310 – 320
320 – 330
330 – 340
340 – 350
350 – 360
360 – 370
370 – 380
380 – 390
390 – 400
400 – 410
410 – 420
420 – 430
430 – 440
440 – 450
450 – 460
460 – 470
470 – 480
480 – 490
490 – 500
Jlyocypris from gr. gibba Ramdohr
Jlyocypris sp.
Candona balatonica Daday
Candona candida O.F. Müller
Candona compressa Koch
Candona eremita Vejdovsky
Candona neglecta G.O. Sars
Candona parallela G.W. Müller
Candona protzi Hartwig
Candona rostrata Brady-Norm.
Cyclocypris huckei Triebel
Cyclocypris laevis O.F. Müller
Cyclocypris triebeli Kempf
Cyclocypris ovum Jurine
Cyclocypris aff. ophtalmica Jurine
Cyclocypris serena Koch
Cyclocypris sp.
Eucypris serrata G.W. Müller
Herpetocypris reptans Baird
Limnocythere inopinata Baird
Limnocythere parallela Diebel
Limnocythere cf. stationis Vávra
Limnocythere sancti-patricii Brady-Rob.
Limnocythere sp.
Cypris pubera O.F. Müller
Cytherissa lacustris G.O. Sars
Cytherissa ? sp. juv.
Cyprideis sp. juv.
SALVINIACEAE
Azolla filiculoides Lam. foss. megaspore and massula
Azolla tegeliensis Florschütz megaspore
Azolla danica Bertelsen massula
Salvinia sp. 1 megaspore
Salvinia sp. 2 megaspore
Salvinia sp. 3 microsporangium
= 1 – 10 specimens
= 11 – 20
= 21 – 50+n

Discussion of results

The fossils raise several problems to be debated. Due to the limited size of this paper, the following can only be discussed in outlines.

1. The phylogeny of Salviniaceae is followed by the papers of HALL (1969, 1974), JAIN & HALL (1969), as well as of JAIN (1971) from the Lower Cretaceous. On the basis of megaspores, the *Azolla* genus appeared in the Campanian and the *Salvinia* in the Maestrichtian and diffused in the Tertiary. The genera occur both in Eurasia and in the American continent. In their diffusion, important changes were induced by the geological recent past, as well, for as much as the *Salvinia* genus died off in North America from the Miocene (MÄGDEFRAU, 1971) and the *Azolla* genus with the *A. filiculoides* in Europa owing to the Saalian glaciation (BERTELSEN, 1972).

By the disappearance of the two genera from large areas their sensitivity to the climatic factors is verified, too. By this fact their palaeographical appreciability and stratigraphical value are considerably increased.

2. The environment of the heterosporous ferns is: the standing or slowly flowing water, lake, inland waters, flood plain, the shallow water left behind after floods and the marsh with open water surface. Fresh waters like these occurred abundantly not only in the Pleistocene but also in the Tisza valley and in the region of the Triple Körös in the time before the river control in the 19th century. In these areas, *Salvinia natans* can be found even today. In this country — according to the floristic researches of VINCE BORBÁS — among the first discovered habitats takes place Vésztő and e.g. LUERSEN (1889) publishes this place of discovery with the following orthography: "Galfizug nächst Veszto im Comitate Bekes (BORBÁS, in Linnaea 45, pag. 216)". May the ducks have enjoyed already in the Lower Pleistocene the ancestor of the present-day Salviniae in the marshes of Kis-Sárrét? (The Hungarian name of *S. natans* is namely "duck-pleasure").

3. According to the results received hitherto, in our material Azollae and Salviniae occur together. They may have lived together, creating freshwater associations, so-called communities of plants floating, on the water surface or like the constituents of these (SOÓ, 1964). For the time being, the other members of the community are not known but a palynological investigation to-be may discover the autochthonous species or genera that had lived in the marshes and give a picture of the environment, the environmental vegetation of the surrounding Lower Pleistocene marshes.

4. Our fossils — as mentioned in the Introduction — came to light as by-products of the investigations of MARGIT SZÉLES into Ostracoda. The 500 m thick Pleistocene can hardly be divided on the basis of the Ostracoda fauna although it is to be supposed that very variegated events had passed off climatically during the sedimentary process. The researcher of Ostracoda nonetheless separates about three phases (Table 2):

From 520 m till ca 320 m few species occur but some of them with high enough frequency (e.g., *Cyclocypris huckei*), whereas the *Limnocythere, Cypris, Cytherissa* species are lacking therin almost entirely.

From 29 m till 110 m the fauna may perhaps be considered as the richest one. Opposite to the low level, the presence of several *Limnocythere* species and numerous *Cyclocypris* species is characteristic.

Above 100 m, many kinds of the *Candona* species, at 22 m the huge *Herpetocypris* and generally the decrease of the fauna are characteristic.

This modest division which cannot be detailed and accounted for here, is variegated by Ostracoda-free phases.

5. Our Salviniae and Azollae are given in Table 2, presenting the Ostracoda fauna. Evaluating these, the following issues can be raised:

(a) It is true in Vésztő, as well, what in the frontier zones of Denmark-Holland-Belgium-Germany proved true, namely that *Azolla tegeliensis* is older than *A. filiculoides*.

(b) It is probable that the first appearance of *A. filiculoides* at Vésztő is the 360–370 m deep Pleistocene sediment.

(c) The area of *A. tegeliensis* grew wider with the occurrence at Vésztő and, therefore, it is not limited to the above-mentioned countries.

(d) *Azolla filiculoides* and *A. tegeliensis* must have been on Hungarian territory, as well, the flora-creator and indicator of the climate, corresponding to those of the interglacial periods.

(e) The two *Azolla* species can have in Hungary, facing south, another stratigraphical value, as well, than in the countries lying along the North Sea.

(f) By means of the Ostracoda fauna, the lower section of the first boring at Vésztő (520–320 m) can be considered as undivided. But on the basis of *Azolla* megaspores, it can clearly be divided (with a 60 m gap) into a lower section with the dominance of *A. tegeliensis* (450–430 m) and into an upper section with the dominance of *A. filiculoides* (370–340 m).

6. The Pleistocene *Azolla* (and *Salvinia*) megaspores can easily be determined macroscopically with a "Cytoplast" (Zeiss) binocular stereomicroscope from the washed sample without any special treatment. Because of their facies-marking and stratigraphical importance, the research into these megaspores from the Pleistocene of the Great Hungarian Plain is justified, parallel with the Ostracoda, Mollusca, Diatoma investigations.

References

BERTELSEN, F. (1972): *Azolla* Species from the Pleistocene of the Central North Sea Area. — Grana *12*, 131–145.

BUŽEK, Č.–KONZALOVÁ, M.–KVAČEK, Z. (1971): The genus *Salvania* from the Tertiary of the North-Bohemian Basin. — Sborník Geologickych Věd Paleontologie, rada *13*, 179–222.

DOROFEEV, P. I. (1959): O novych vidach *Azolla* LAM. dlya tretičnoi flory SSSR. — Bot. Žurn. *44*, 1956–63.

DOROFEEV, P. I. (1963a): Tretičnye flory Zapadnoy Sibiri. — Izd. AN SSSR, Moscow and Leningrad.

DOROFEEV, P. I. (1963b): Tretičnye rasteniya Kazachstana. — Bot. Žurn. *48*, 171–181.

DOROFEEV, P. I. (1968): Pro megaspori *Salvinia, Azolla* ta *Pilularia* iz neogenovich vidkladiv Ukraini. — (On megaspores of *Salvinia, Azolla* and *Pilularia* from Neogen deposits of the Ukraine). — Ukrain. Bot. Žurn. *25* (6), 63–72.

FLORSCHÜTZ, F.–MENÉNDEZ AMOR, J. (1960): Une *Azolla* fossile dans les Pyrénées-orientales. — Pollen et Spores *2*, 285–292.

FRIIS, E. M. (1977): EM-studies on Salviniaceae Megaspores from the Middle Miocene Fasterholt Flora, Denmark. — Grana *16*, 113–128.

GREGUSS, P.–VANHOORNE, R. (1961): Etude paléobotanique des argiles de la Cambine à Saint-Léonard (Belgique). — Institut royal des Sciences naturelles de Belgique. *37* (33), 1–3.

HALL, J. W. (1969): Studies on fossil *Azolla*: primitive types of megaspores and massulae from the Cretaceous. — Amer. J. Bot. *56*, 1173–1180.

HALL, J. W. (1974): Cretaceous Salviniaceae. — Ann. Miss. Bot. Gard. gl *(2)*, 354–367.

HILTERMANN, H. (1954): Neue Funde von *Azolla* im Pleistozän Deutschlands. — Geol. Jb. *68*, 653–658.

IGALI ZELLER, L. (1955): Eger-Tihamér és környéke középső miocén flórája (Middle Miocene flora of Eger-Tihamér and environs). — MÁFI Évkönyve *44*, 16–20.

JAIN, R. K. (1971): Pre-Tertiary records of Salviniaceae. — Amer. J. Bot. *58*, 487–496.

JAIN, R. K.–HALL, J. W. (1969): A contribution to the early tertiary fossil record of the Salviniaceae. Amer. J. Bot. *56*, 527–33.

KEMPF, E. K. (1969a): Elektronmikroskopie der Sporodermis von känozoische Megasporen der Wasserfarn-Gattung *Azolla*. — Paläont. Z. *43*, 95–108.

KEMPF, E. K. (1969b): Elektronmikroskopie der Megasporen von *Azolla tegeliensis* aus dem Altpleistozän der Niederland. — Palaeontographica B *128*, 167–179.

KEMPF, E. K. (1971): Elektronmikroskopie der Sporodermis von Mega- und Mikrosporen der Pteridophytengattung *Salvinia* aus dem Tertiär und Quarter Deutschlands. — Palaeontographica B *136*, 47–70.

KRIŠTOFOVIČ, A. N. (1957): Paleobotanika. — Leningrad.

KRUTZSCH, W. (1962): Atlas der mittel- und jungtertiären dispersen Sporen- und Pollen-, sowie der Mikroplanktonformen des nördlichen Mitteleuropas I, 1–108.

LAŃCUCKA–ŚRODONIOWA, M. (1958): *Salvinia* and *Azolla* in the Miocene of Poland. — Acta Biol. Crakov. (Bot.), 1, 15–23.

LUERSSEN, CH. (1899): Die Farnpflanzen. Leipzig.

MÄDLER, K. (1954): *Azolla* aus dem Quarter und Tertiär, sowie ihre Bedeutung für die Taxonomie älterer Sporen. Geol. Jb. 70, 43–58.

MÄDLER, K. (1971): Die Früchte und Samen aus der frühpleistozänen Braunkohle von Megapolis in Griechenland und ihre ökologische Beduetung. — Beih. Geol. Jb. *11*, 3–59.

MÄGDEFRAU, K. (1971), in: Denffer—Schuhmacher—Mägdefrau—Ehrendorfer: Lehrbuch der Botanik. — Jena.

MIHALTZ FARAGÓ, M. (1973): Az Egyek 1. sz. fúrás palynológiai vizsgálata (Palynological investigation into the first boring of Egyek-1). — MÁFI Évi Jelentés, 219–231.

NAGY, E. (1969): Palynological elaborations into the Miocene layers of the Mecsek Mountains. — MÁFI Évkönyve 52 : 233–649.

PACLTOVÁ, BL. (1960): Plant Microfossils (mainly Sporomorphae) from the lignite Deposits near Mydlovary in the Česke Budějovice Basin. Part I. — Sborník ÚÚG. 25. Paleont. *68*, Prague.

POTONIÉ, R. (1956): Synopsis der Gattungen der Sporae dispersae I. — Beih. Geol. Jb. *23*, 1–103.

RÁSKY, K. (1949): Fossilis növények Érdről (Fossil plants from the community Érd). — Borbasia *9*, 6–10.

SADEBECK, R. (1902), in: Engler — Prantl: Die natürlichen Pflanzenfamilie I. *4*, 381–421.

SCHWARZENHOLZ, W. (1961): Isolierung von *Azolla*-Sporen aus erdigen und sandigen Sedimenten. — Geologie 10 BH *32*, 5–7.

SOÓ, R. (1964): A magyar flóra és vegetáció rendszertani növényföldrajzi kézikönyve I (Taxonomical-plant-geographical handbook of the Hungarian flora and vegetation — I). — Budapest.

STAUB, M. (1881): A Fruska-Gora aquitáni flórája (The Aquitainic flora of the Mountain Fruska-Gora). — Ért. a termtud. köréből *11*, 1–39.

STAUB, M. (1887): A Zsilvölgy aquitánkorú flórája (Aquitaine-Age flora of the Zsil valley). M. Ft. Int. Évkönyve 7, 207–424.

TRIVEDI, B. S.–VERMA, C. L. (1971): Contributions to the knowledge of *Azolla indica* sp. nov. from the Deccan Intertrappean series M.P., India. — Palaeontographica B *136*, 71–82.

Address of the authors
Dr. P. SIMONCSICS
Department of Botany, A.J.
University, H—6701 Szeged,
P.O. Box 428, Hungary
MARGIT SZÉLES
Industrial Research Laboratory
of Oil and Natural Gas,
H—1055 Budapest, Szent István körút 11,
Hungary