6. COMBINED INVESTIGATIONS ON HUNGARIAN NEOGENE LIGNITES

M. KEDVES[1], M. SZÓNOKY[2] and S. GULYÁS[2]

1. Cell Biological and Evolutionary Micropaleontological Laboratory of the Department of Botany of the J.A. University, H-6701, P.O. Box 993, Szeged, Hungary, 2. Department of Geology and Paleontology of the J.A. University, H-6701, P.O. Box 658, Szeged, Hungary

Abstract

Wood anatomical and palynological investigations were carried out on the samples of the Upper Pliocene of Bátaszék. The embedding sediment of the fossilized woody remnants is rich in sporomorphs, mostly in *gymnosperm* pollen grains of *Pinus, Picea* and/or *Abies* type. The observed organic microplancton taxa are in general reworked from Mesozoic (Jurassic, and/or Cretaceous) sediments. Several xylem remnants were also observed in the embedding sediment, in different kind of preservation. *Sequoioxylon gypsaceum, Sequoioxylon/Cupressinoxylon* and a *dicotyledonous* vessel fragment was identified. Six woody remnants were anatomically investigated. All are *gymnosperms*: Cf. *Taxodiaceae, Glyptostroboxylon* sp., *Taxodioxylon distichoides* HUARD 1966, *Taxodioxylon taxodii* GOTHAN 1905, *Cupressinoxylon secretiferum* GREGUSS 1967, *Cupressinoxylon cf. secretiferum* GREGUSS 1967.

Key words: Fossil wood anatomy, Palynology, Pannonian, Bátaszék, Hungary.

Introduction

The paleontological and paleobotanical findings were the subject of several previous investigations. Wood anatomy and experimental ultrastructure studies were carried out on lignite samples from Bátaszék (KEDVES, 1999, KEDVES and PÁRDUTZ, 2000).

Previously multidisciplinary investigations were made by LENNERT, SZÓNOKY, GULYÁS, SZUROMI-KORECZ, SHATILOVA, SÜTŐ-SZENTAI, GEARY and MAGYAR (1999). Fossil woods were collected by S. GULYÁS. The LM anatomy and the palynological investigations of the xylem remnants embedding layers including the woody fragments are the subjects of this contribution.

The aim of this paper is a short review on the most important paleontological results of the Lake Pannon of Bátaszék and the description and evaluations of the new data.

These investigations constitute a part of the International Geosphere-Biosphere Programme: A Study of Global Change (IGBP); B. Techniques for Extracting Environmental Data of the Past, 16.

Materials and Methods

The material for our investigations was collected by S. GULYÁS, on the 14.08.1998 in Bátaszék, from the bluish-grey silt. Six lignite samples were the subject of wood anatomical studies. Thin sections, and thin slides were made and investigated with the LM method. One embedding sample was treated for palynological study. The sample was treated with the HCl and HF method. The organic residues were mounted in glycerine-jelly hydrated at 39.6%. The woody fragments and the spores and pollen grains were also investigated in the palynological slides. The quantitative data of the sporo-

morphs were suitable to reconstruct the environmental vegetation of the sedimentary basin and the presumed reworking from older layers.

Results

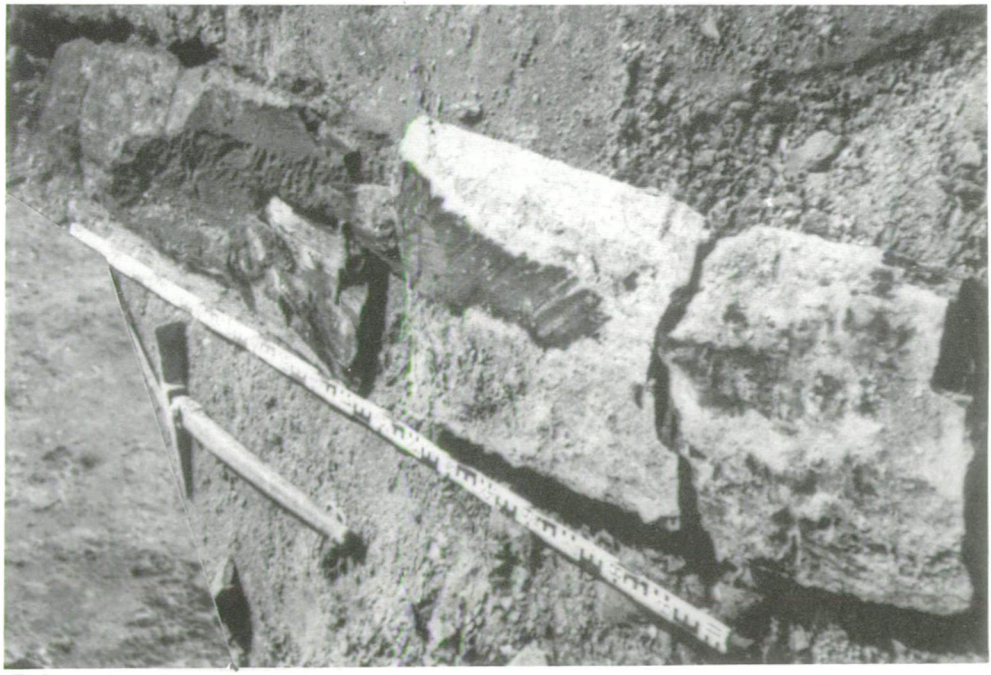
1. The most important previous paleontological data of the Lake Pannon of the Bátaszék brickyard

Based on the paper of LENNERT et al. (1999) we cite the following:

P. 69: "From the Bátaszék outcrop we identified 51 mollusk species (25 bivalve and 26 gastropod), with about 4000 individuals. Shells from the gray silt were usually in good condition, sometimes even with the nacreous layer preserved (especially in *Lymnocardium majeri*). In layer 21, *Lymnocardium* shells were articulated (closed or open), whereas *Congeria* shells were either articulated or disarticulated. We regard the shells of the clayey silt as mostly autochtonous."

P. 74: "The Bátaszék Mollusk fauna is very similar to the classic Szekszárd fauna of LŐRENTHEY (1894) and Okrugljak (Zagreb) fauna of BRUSINA (1884). The Bátaszék fauna is also very similar to the fauna of Jazovnik (Kosarlija valley), a facies stratotype of the "Lower Portaferrian" in western Serbia (STEVANOVIC 1951, 1990).

P. 75: "The Bátaszék outcrop belongs to the sublittoral *Congeria rhomboidea* Zone. A probably transported specimen of *Prosodacnomya* sp. establishes the correlation with the littoral *Prosodacnomya* Zone. *Dinoflagellates* indicate the lower part of the *Galeacysta etrusca* Zone (it corresponds to the "*Spiniferites tihanyensis* Zone" of SÜTŐ-SZENTAI 1994; see SÜTŐ-SZENTAI, 1995). The *ostracod* fauna corresponds to the "Portaferrian" fauna of KRSTIC (1990)."



Text-fig. 6.1.

2. Wood anatomy of the investigated lignite samples

One sample from a large trunk (Text-fig. 6.1.) and five further small pieces were the subjects of our wood anatomical studies. The LM results may be summarized short as follows:

Sample No. 1 : Cf. *Taxodiaceae* (Plate 6.1., figs. 1-4)

The preservation of the secondary wood of this sample is very poor. The cross section (Plate 6.1., fig. 1) well illustrates the compressed and degraded tracheids. The structure of the late wood is in some places perceptible only in some places. The ray is uniseriate and 1-4 cells high (Plate 6.1., fig. 2). The areolate pits of the radial wall of the tracheids are uniseriate (Plate 6.1., fig. 3). The cross field pits are perceptible only in the late wood of taxodioid character (Plate 6.1., fig. 4).

Remark. - Similar preservation was published by SÁRKÁNY (1943) (Plate XLV, fig. 2) from the Miocene lignite of Várpalota.

Sample No. 2 : *Glyptostroboxylon* sp. (Plate 6.2., figs. 1-4)

The degradation of the compressed secondary wood structure is well illustrated in the picture of Plate 6.2., fig. 1. The late wood is about 5-7 tracheids broad. The fossil resin containing parenchym cells is well shown in the early and the late wood alike. The uniseriate rays in the tangential sections are about 1-6 cells high (Plate 6.2., fig. 2). The horizontal wall of the resin containing longitudinal parenchym cells is knottedly thickened (Plate 6.2., fig. 3). There are generaly two or three thickenings. The pitting of the cross fields is glyptostroboide type (cf. GREGUSS, 1968), the number of the pits are 2-3 (Plate 6.2., fig. 4).

Remark. - This tissue structure is very similar to or more or less identical with the *Glyptostroboxylon tenerum* CONVENTZ published by HARASZTY (1957) from Hidas (Mecsek, Miocene) and HARASZTY (1960) from Rudabánya. The preservation of the cross-sectional picture is similar to those published by SÁRKÁNY (1943), (Plate XLVII, figs. 7-9), from the Miocene lignites of Várpalota.

Sample No. 3: *Taxodioxylon distichoides* HUARD 1966 (Plate 6.3., figs. 1-4)

The preservation of this sample is peculiar. The greatest part of the woody remnant was in a bad preservation, but in some small parts the most important characteristic features are well preserved. The horizontal wall of the longitudinal parenchym cells are thickened. There are resin drops in these cells (Plate 6.3., fig. 1). The observed rays are of 2-8 cells high (Plate 6.3., fig. 2). The wall of the tracheids following HUARD (1966); p. 19: "ne possèdent pas d'épaississements spiralés vrais, mais la plupart ont un aspect strié en hélice provoqué par la dissociation des fibrilles de cellulose de la paroi secondaire."

The bordered pits of the radial wall of the tracheids are in general uniseriate.

(Plate 6.3., fig. 4). In the cross fields two taxodioid pits were observed (Plate 6.3., fig. 3).

Sample No. 4: *Taxodioxylon taxodii* GOTHAN 1905 (Plate 6.4., figs. 1-4)

A relatively well preserved sample was investigated. The annual ring boundary is definite. The late wood is broad (Plate 6.4., fig. 1). The uniseriate rays are relatively 2-18 cells high (Plate 6.4., fig. 2). There are dark resin drops in the longitudinal parenchym cells (Plate 6.4., fig. 3). The horizontal wall of the longitudinal parenchym cell is thickened. The number of the thickenings is about 4-5. The number of the tiny pits in the cross fields are 2-3. This number is in several cases not well perceptible in consequence of the preservation state (Plate 6.4., fig. 4).

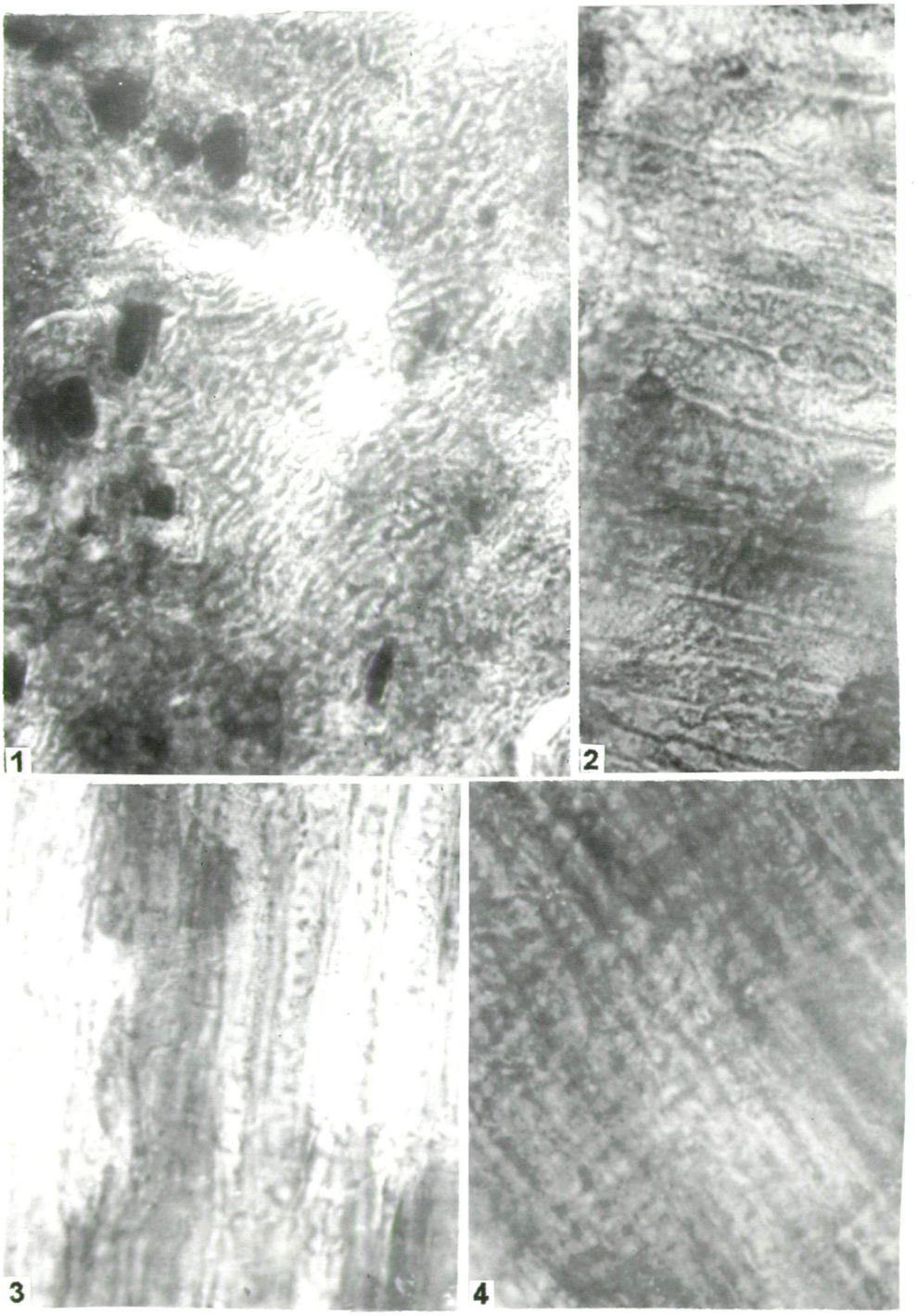


Plate 6.1.

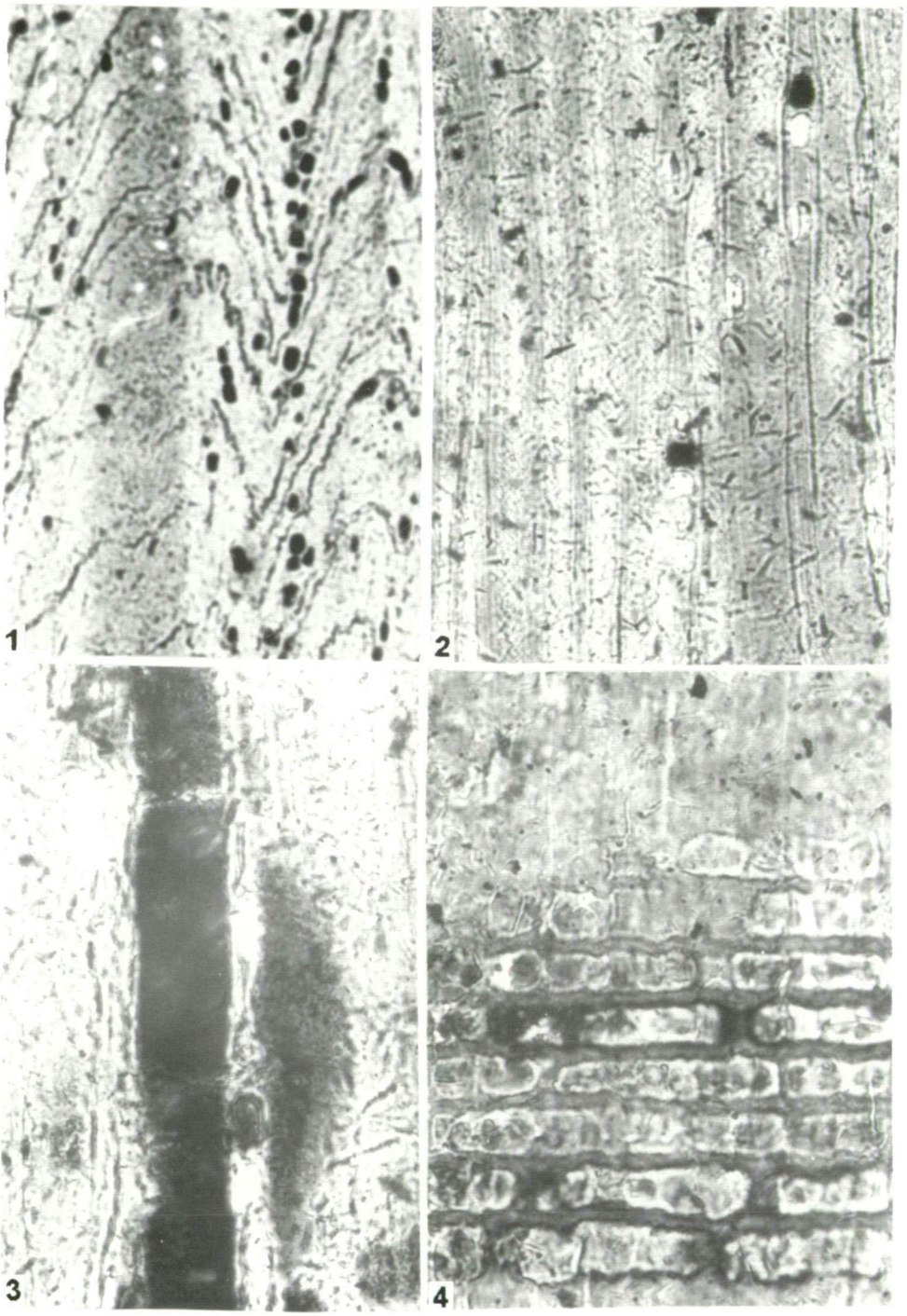


Plate 6.2.

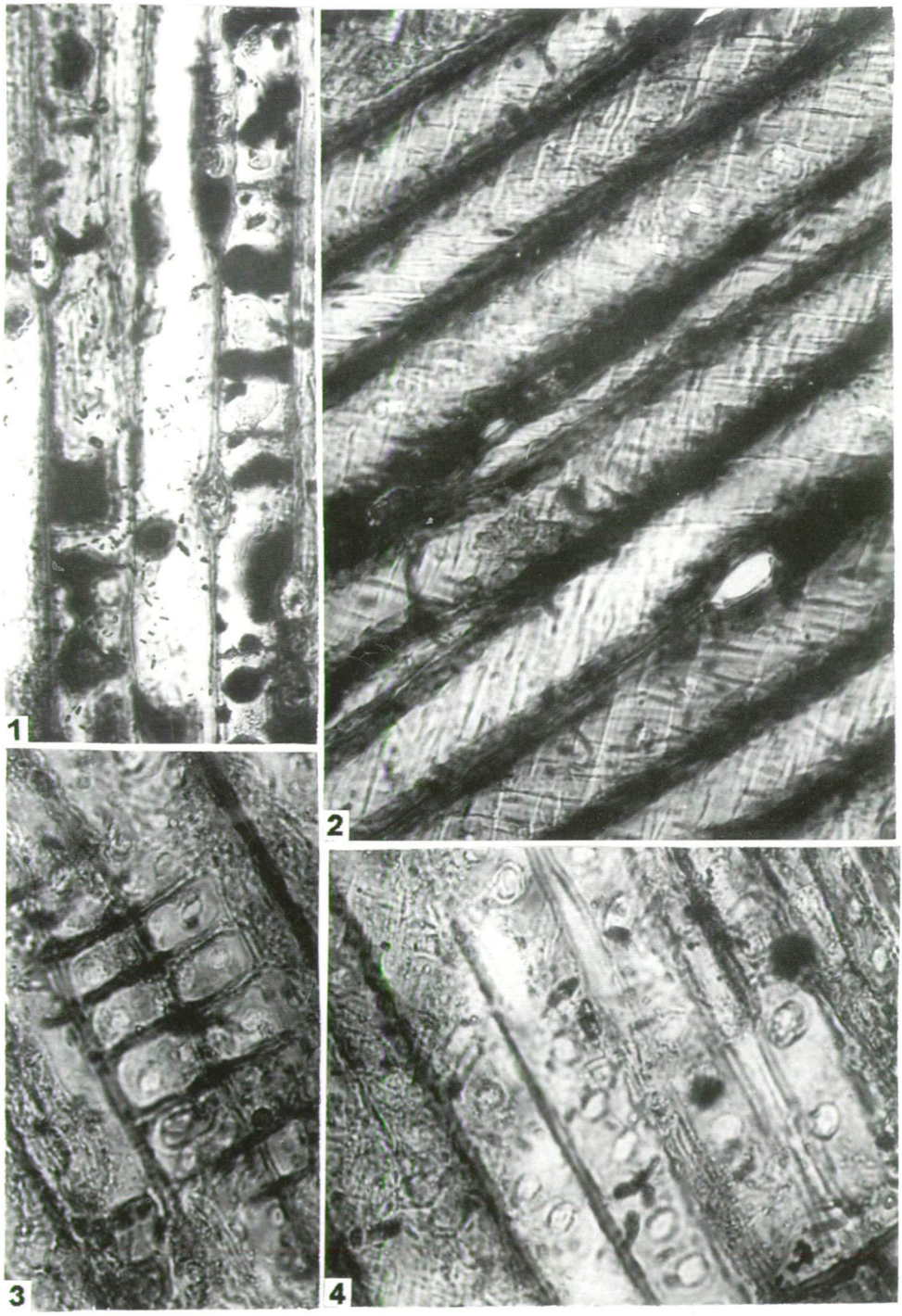


Plate 6.3.

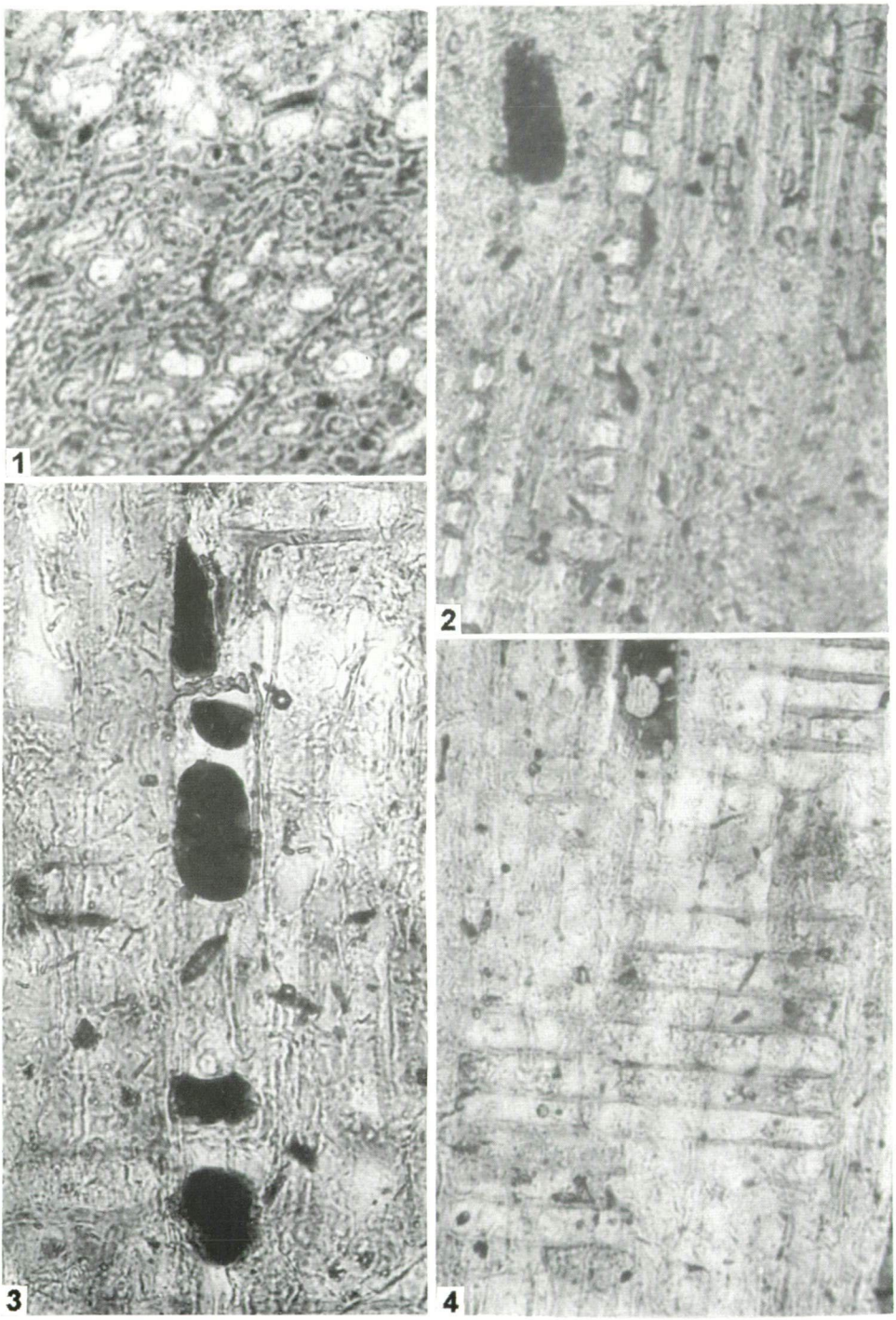


Plate 6.4.

Sample No. 5: *Cupressinoxylon secretiferum* GREGUSS 1967 (Plate 6.5., figs. 1-5)

The annual rings are distinct, the late wood is broad (Plate 6.5., fig. 1). Striations on the wall of the tracheids are not in a good preservation (Plate 6.5., fig. 2). The longitudinal parenchym and the cells of the rays are full of dark resinous content (Plate 6.5., figs. 2-5). The rays are uniseriate and in general 1-4-8 cells high (Plate 6.5., figs. 2,4). The horizontal wall of the longitudinal parenchym cell is generally not thickened (Plate 6.5., fig. 3). The areolate pits of the radial wall of the tracheids are uniseriate, but in several places not well perceptible. In the cross fields there are in general one or two cupressoid pits (Plate 6.5., fig. 5).

Sample No. 6: *Cupressinoxylon* cf. *secretiferum* GREGUSS 1967 (Plate 6.6., figs. 1-4)

The preservation state of this sample is extremely interesting. The greatest part is amorphous lignite, there are uniseriate thick walled tracheids "embedded" in this homogeneous substance (Plate 6.6., fig. 1). The uniseriate ray cells are not always filled with dark resinous content probably in consequence of the fossilization process (Plate 6.6., figs. 2,3). In our thin slides the cupressoid pittings of the cross fields are relatively well preserved, their number is 1-3 (Plate 6.6., fig. 4).

Plate 6.1.

1-4. Cf. *Taxodiaceae*
1. Cross section, 500x.
2. Tangential section, 500x.
3. Radial section, bordered pits of the tracheids, 500x.
4. Radial section, cross fields, 500x.

Plate 6.2.

1-4. *Glyptostroboxylon* sp.
1. Cross section, 250x.
2. Tangential section, 500x.
3. Tangential section, 750x.
4. Radial section, cross fields, 750x.

Plate 6.3.

1-4. *Taxodioxylon distichoides* HUARD 1966
1. Tangential section, 500x.
2. Tangential section, 750x.
3. Radial section, cross fields, 750x.
4. Radial section, areolate pitting on the radial wall of the tracheids, 750x.

Plate 6.4.

1-4. *Taxodioxylon taxodii* GOTHAN 1905
1. Cross section, 500x.
2. Tangential section, 500x.
3. Tangential section, 750x.
4. Radial section, cross fields, 500x.

3. Tissue fragments within the spore-pollen assemblage

The tissue fragments observed in the slides for palynological studies are in different state of preservation. Dark nearly black fragments and light brownish tissue occurred in the same samples. The greatest part of the observed secondary xylem remnants is of *gymnospermous* origin. The bordered pits of the radial wall of the tracheids (Plate 6.7., figs. 1,3,4,5) may be of *Taxodiaceae* origin. Based on the book of GREGUSS (1967) similar pitting was described from the following genuses: *Cupressinoxylon, Sequoioxylon, Metasequoioxylon, Glyptostroboxylon* and *Taxodioxylon*. In picture 1 of Plate 6.7., a very coalified tissue fragment is illustrated, the other one is not so carbonified. The cross field pitting illustrated in fig. 2 (Plate 6.7.) is very similar to the well preserved *Sequoioxylon gypsaceum* (GOEPPERT) GREGUSS 1967 from the Helvetian of Sajószentpéter (Plate LXIV, figs. 7-9, in the book of GREGUSS, 1967). Regarding the recent taxa this is comparable with *Sequoia sempervirens* (LAMBERT) ENDL. (GREGUSS, 1955, Plate 189, fig. 3). Similar but poorly preserved cross field is illustrated in fig. 6 (Plate 6.7.). Radial pitting of the autumn tracheids is illustrated in picture 7 (Plate 6.7.). This also may be of *Taxodiaceae* origin, but very similar structure was published by GREGUSS (1967) from *Cupressinoxylon secretiferum* GREGUSS 1967 in Plate LI., figs. 8,9. A poorly preserved vessel of *angiospermous* origin was observed (Plate 6.7., fig. 8). The perforation of the trachea is unknown in this way the nearer taxonomic position is only a *dicotyledonous* woody fragment. GREGUSS (1969) in his monograph on the Hungarian Tertiary *angiosperm* woods published in several fossil taxa the observed pitting of trachea.

4. Palynological data

PHYLUM: PTERIDOPHYTA
CLASSIS: PTEROPSIDA
SUBCLASSIS: LEPTOSPORANGIATAE

Ordo: *Osmundales*

Familia: *Osmundaceae, Osmunda; Baculatisporites nanus* (WOLFF 1934) KRUTZSCH 1959 subfsp. nanus (Plate 6.8., figs. 1,2).

PHYLUM: GYMNOSPERMATOPHYTA
SUBPHYLUM: PTERIDOSPERMOPHYTINA
CLASSIS: CYCADOPSIDA

Ordo: *Cycadales*

Familia: *Cycadaceae* v. *Spadiciflorae*; *Cycadopites minor* (KEDVES 1961) KEDVES 1968 (Plate 6.8., fig. 12).

SUBPHYLUM: CONIFEROPHYTINA
CLASSIS: CONIFEROPSIDA

Ordo: *Pinales*

Familia: *Abietaceae, Pinus; Pityosporites peuceformis* (ZAKLINSKAYA 1957) KRUTZSCH 1971 (Plate 6.8., fig. 3), *Pityosporites minutus* (ZAKLINSKAYA 1957) KRUTZSCH 1971 (Plate 6.8., figs. 4,5), *Pityosporites microalatus* (POTONIÉ 1931b) THOMSON et PFLUG 1953 (Plate 6.8., fig. 6), *Cedrus; Abiespollenites cedroides* (THOMSON 1953) KRUTZSCH 1971 (Plate 6.8., fig. 7), *Keteleeria* v. *Abies; Abiespollenites dubius* (KHLONOVA 1960) KRUTZSCH 1971 (Plate 6.8., figs. 8,9), *Tsuga; Zonalapollenites helenensis* KRUTZSCH 1971 (Plate 6.8., fig. 10), cf. *Zonalapollenites azonalis* KRUTZSCH 1971 (Plate 6.8., fig. 11).

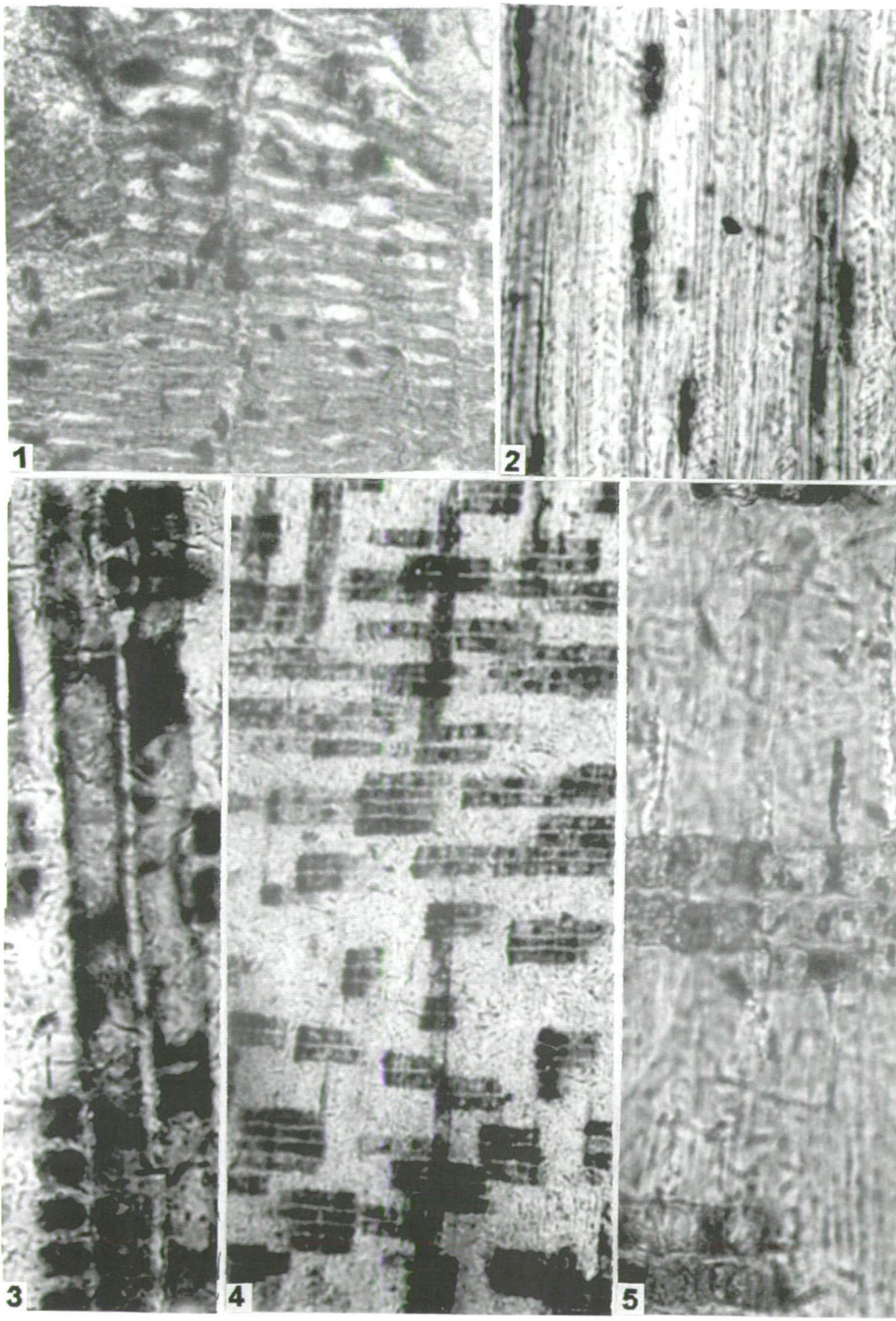


Plate 6.5.

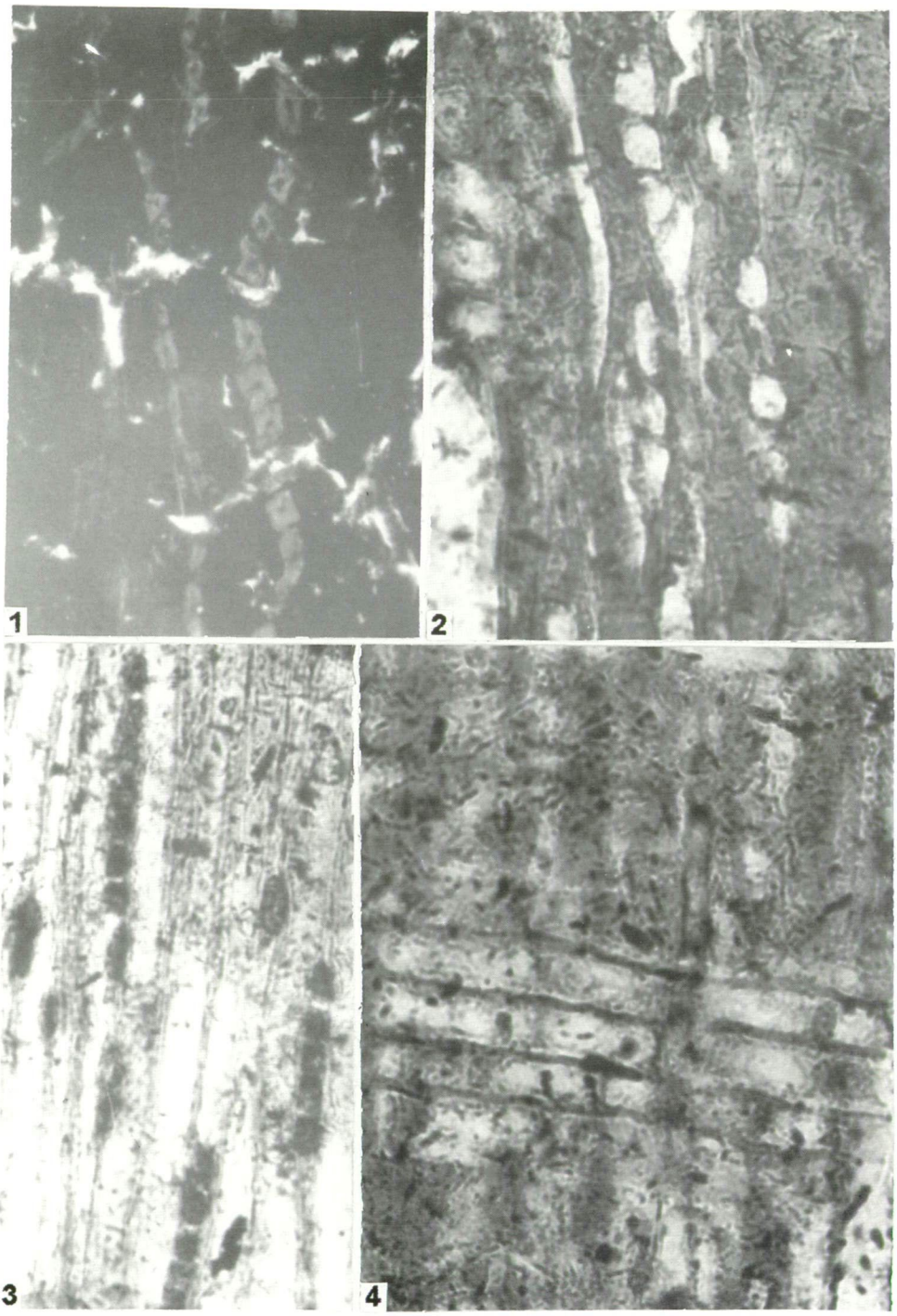


Plate 6.6.

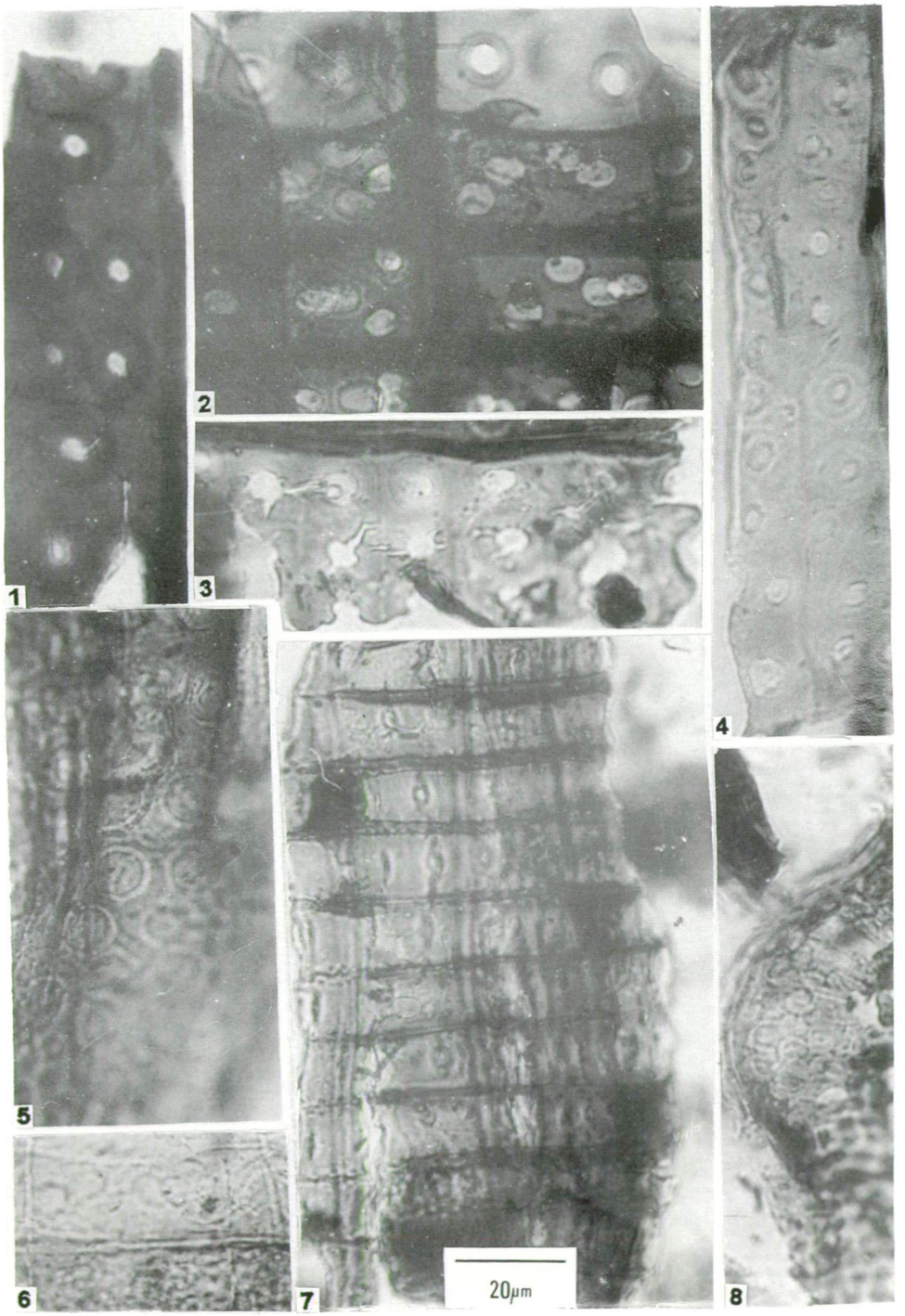


Plate 6.7.

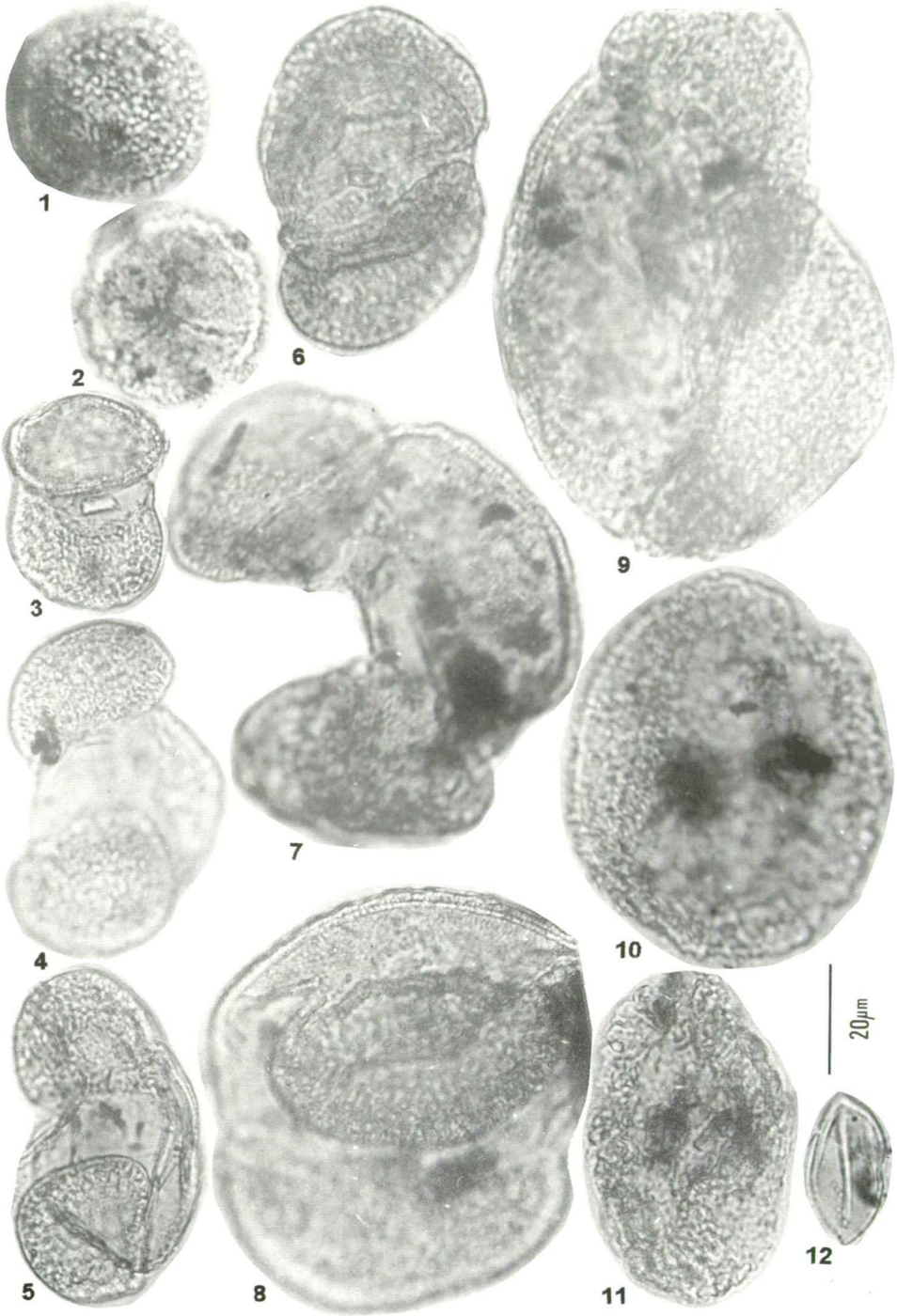


Plate 6.8.

Plate 6.5.

1-5. *Cupressinoxylon secretiferum* GREGUSS 1967
1. Cross section, 500x.
2. Tangential section, 500x.
3. Tangential section, 750x.
4. Radial section, 250x.
5. Radial section, 750x.

Plate 6.6.

1-4. *Cupressinoxylon* cf. *secretiferum* GREGUSS 1967
1. Cross section, 500x.
2,3. Tangential section, 500x.
4. Radial section, 500x.

Plate 6.7.

1. *Gymnosperm* tracheid fragment with areolate pits. Slide: GS-1-5, cross-table number: 8.0/143.9.
2. Bordered and cross field pits of probably *Sequoioxylon gypsaceum* (GOEPPERT) GREGUSS 1967 origin. Slide: GS-1-5, cross-table number: 17.3/138.9.
3-5. Fragment of *gymnosperm* tracheid with areolate pits.
3. Slide: GS-1-6, cross-table number: 9.3/142.8.
4. Slide: GS-1, cross-table number: 15.4/138.1.
5. Slide: GS-1, cross-table number: 20.4/138.4.
6,7. Cross field pits.
6. Slide: GS-1-7, cross-table number: 14.6/130.4.
7. Slide: GS-1-6, cross-table number: 22.2/145.8.
8. *Angiosperm* vessel fragment. Slide: GS-1-7, cross-table number: 23.1/140.8.

Plate 6.8.

1. *Baculatisporites nanus* (WOLFF 1934) KRUTZSCH 1959 subfsp. *nanus*, *Osmundaceae*, *Osmunda*, slide: GS-1-7, cross-table number: 19.4/139.9.
2. *Baculatisporites nanus* (WOLFF 1934) KRUTZSCH 1959 subfsp. *nanus*, *Osmundaceae*, slide: GS-1-7, cross-table number: 18.6/129.3.
3. *Pityosporites peuceformis* (ZAKLINSKAYA 1957) KRUTZSCH 1971, *Abietaceae*, *Pinus*, slide: GS-3, cross-table number: 9.4/138.2.
4. *Pityosporites minutus* (ZAKLINSKAYA 1957) KRUTZSCH 1971, *Abietaceae*, *Pinus*, slide: GS-4, cross-table number: 23.3/138.4.
5. *Pityosporites minutus* (ZAKLINSKAYA 1957) KRUTZSCH 1971, *Abietaceae*, *Pinus*, slide: GS-1, cross-table number: 15.4/138.9.
6. *Pityosporites microalatus* (POTONIÉ 1931b) THOMSON et PFLUG 1953, *Abietaceae*, *Pinus*, slide: GS-3, cross-table number: 18.1/129.9.
7. *Abiespollenites cedroides* (THOMSON 1953) KRUTZSCH 1971, *Abietaceae*, *Cedrus*, slide: GS-4, cross-table number: 18.6/143.7.
8. *Abiespollenites dubius* (KHLONOVA 1960) KRUTZSCH 1971, *Abietaceae*, *Keteleeria* v. *Abies*, slide: GS-3, cross-table number: 13.6/134.8.
9. *Abiespollenites dubius* (KHLONOVA 1960) KRUTZSCH 1971, *Abietaceae*, *Keteleeria* v. *Abies*, slide: GS-4, cross-table number: 14.2/137.4.
10. *Zonalapollenites helenensis* KRUTZSCH 1971, *Abietaceae*, *Tsuga*, slide: GS-1, cross-table number: 14.3/143.2.
11. *Cf. Zonalapollenites azonalis* KRUTZSCH 1971, *Abietaceae*, *Tsuga*, slide: GS-1, cross-table number: 26.6/137.2.
12. *Cycadopites minor* (KEDVES 1961) KEDVES 1968, *Cycadaceae* v. *Spadiciflorae*, slide: GS-1-7, cross-table number: 10.6/129.7.

PHYLUM: ANGIOSPERMATOPHYTA
CLASSIS: DICOTYLEDONOPSIDA

Ordo: *Myrtales*
Familia: *Elaeagnaceae; Elaeagnacites huanghuaensis* KE et SHI 1978 (Plate 6.9., fig. 11).

Ordo: *Campanulales*
Familia: *Lobeliaceae; Lobeliapollenites erdtmani* E. NAGY 1969 (Plate 6.9., fig. 3).

Ordo: *Urticales*
Familia: *Ulmaceae, Celtidoideae, Zelkova; Zelkovaepollenites thiergarti* E. NAGY 1969, (Plate 6.9., fig. 8), *Celtis; Celtipollenites komloensis* E. NAGY 1969 (Plate 6.9., fig. 10).

Ordo: *Fagales*
Familia: *Betulaceae, Alnus; Alnipollenites verus* POTONIÉ 1934 (Plate 6.9., fig. 7), *Ostrya; Ostryapollenites rhenanus* (THOMSON 1950), E. NAGY 1969 (Plate 6.9., fig. 6).
Familia: *Fagaceae, Quercus; Quercopollenites granulatus* E. NAGY 1969 (Plate 6.9., fig. 2), *Quercopollenites* fsp. *petraea* type (Plate 6.9., fig. 5), cf. *Castanea; Cupuliferoipollenites oviformis* (POTONIÉ 1931a) POTONIÉ 1960 (Plate 6.9., fig. 4).
Fagaceae v. *Leguminosae; Cupuliferoidaepollenites quisqualis* (POTONIÉ 1934) POTONIÉ 1960 (Plate 6.9., fig. 1).

CLASSIS: MONOCOTYLEDONOPSIDA

Ordo: *Pandanales*
Familia: *Sparganiaceae; Sparganiaceaepollenites polygonalis* THIERGART 1938 (Plate 6.9., fig. 9).

Microplancton remnants

The observed organic microplancton remnants are reworked from older sediments.

Jurassic reworked taxa: Cf. *Acanthaulax* sp.$_1$ (Plate 6.9., figs. 15,16), cf. *Acanthaulax* sp.$_2$ (Plate 6.9., fig. 17, plate 6.10., fig. 1), *Leptodinium ambiguum* (DEFLANDRE 1939) HELENES 1984 (Plate 6.10., figs. 2,3), *Occisucysta balia* GITMEZ 1970 (Plate 6.10., figs. 4,5), *Neuffenia willei* BRENNER et DÜRR 1986 (Plate 6.10., fig. 6).

Cretaceous reworked taxa: *Hystrichosphaera ramosa* (EHRENBERG 1838) O. WETZEL 1933 var. ramosa DAVEY et WILLIAMS 1966 (Plate 6.9., figs. 12,13), *Dinogynium* sp. (Plate 6.9., fig. 14).

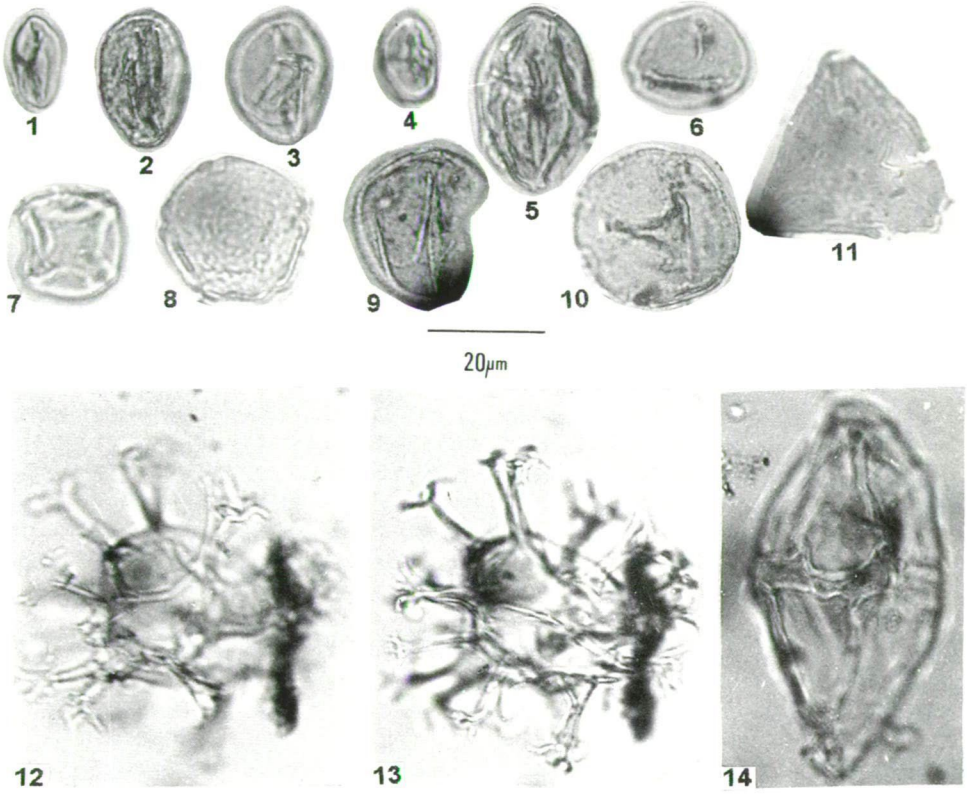


Plate 6.9.

Quantitative data

The per cent of the invesigated organic microfossils may be summarized as follows:

Spores	0.8%
Gymnospermatophyta	85.8%
Angiospermatophyta	7.7%
Organic-walled *Dinoflagellatae*	5.7%

The quantity of the inaperturate *gymnosperm* pollen grains (*Taxodiaceae-Cupressaceae*) is only 5.7%, the greatest part of the pollen grains is of saccate form (*Pinus, haploxylon* and *diploxylon* type, *Picea, Abies, Keteleeria, Cedrus*). So our data concerning the paleoenvironmental conditions are identical with the previous establishments. The woody remnants were deposited in the Pannonian lake in the region of Bátaszék. To the zonation of the vegetation of the shore of the sedimentary basin we have few data. Outside from the *Taxodiaceae-Cupressaceae*, the relatively high number of the pollen grains of the genus *Celtis* may be mentioned.

Discussion and Conclusions

1. The wood anatomical investigations resulted in several new data in contrast to the previous establishments. The relative taxonomic richness, and the peculiar preservations indicate the allochtonous origin of these samples. The reworked planctonic remnants support this assumption.

Plate 6.9.

1. *Cupuliferoidaepollenites quisqualis* (POTONIÉ 1934) POTONIÉ 1960, *Fagaceae* v. *Leguminosae*, slide: GS-1-6, cross-table number: 7.3/145.2.
2. *Quercopollenites granulatus* E. NAGY 1969, *Fagaceae, Quercus*, slide: GS-3, cross-table number: 11.0/128.0.
3. *Lobeliapollenites erdtmani* E. NAGY 1969, *Campanulales, Lobeliaceae*, slide: GS-1, cross-table number: 14.2/149.6.
4. *Cupuliferoipollenites oviformis* (POTONIÉ 1931a) POTONIÉ 1960, *Fagaceae, Castanea*, slide: GS-1-6, cross-table number: 9.8/130.7.
5. *Quercopollenites* fsp., *petraea* type, slide: GS-3, cross-table number: 22.9/134.8.
6. *Ostryapollenites rhenanus* (THOMSON 1950) E. NAGY 1969, *Fagaceae, Ostrya*, slide: GS-1-6, cross-table number: 10.2/130.7.
7. *Alnipollenites verus* POTONIÉ 1934, *Betulaceae, Alnus*, slide: GS-4, cross-table number: 25.6/133.8.
8. *Zelkovaepollenites thiergarti* E. NAGY 1969, *Ulmaceae, Zelkova*, slide: GS-1, cross-table number: 22.7/141.6.
9. *Sparganiaceaepollenites polygonalis* THIERGART 1938, *Sparganiaceae*, slide: GS-1-6, cross-table number: 22.6/134.2.
10. *Celtipollenites komloensis* E. NAGY 1969, *Ulmaceae, Celtidoidae*, slide: GS-1, cross-table number: 18.4/134.2.
11. *Elaeagnacites huanghuaensis* KE et SHI 1978, *Elaeagnaceae*, slide: GS-2, cross-table number: 24.5/122.2.

12,13. *Hystrichosphaera ramosa* (EHRENBERG 1838) O. WETZEL var. *ramosa* DAVEY et WILLIAMS 1966, slide: GS-4, cross-table number: 13.9/133.8.

14. *Dinogynium* sp., slide: GS-3, cross-table number: 19.8/140.9.

15,16. Cf. *Acanthaulax* $sp._1$, slide: GS-4, cross-table number: 20.3/141.7.

17. Cf. *Acanthaulax* $sp._2$, slide: GS-1-6, cross-table number: 9.3/144.8.

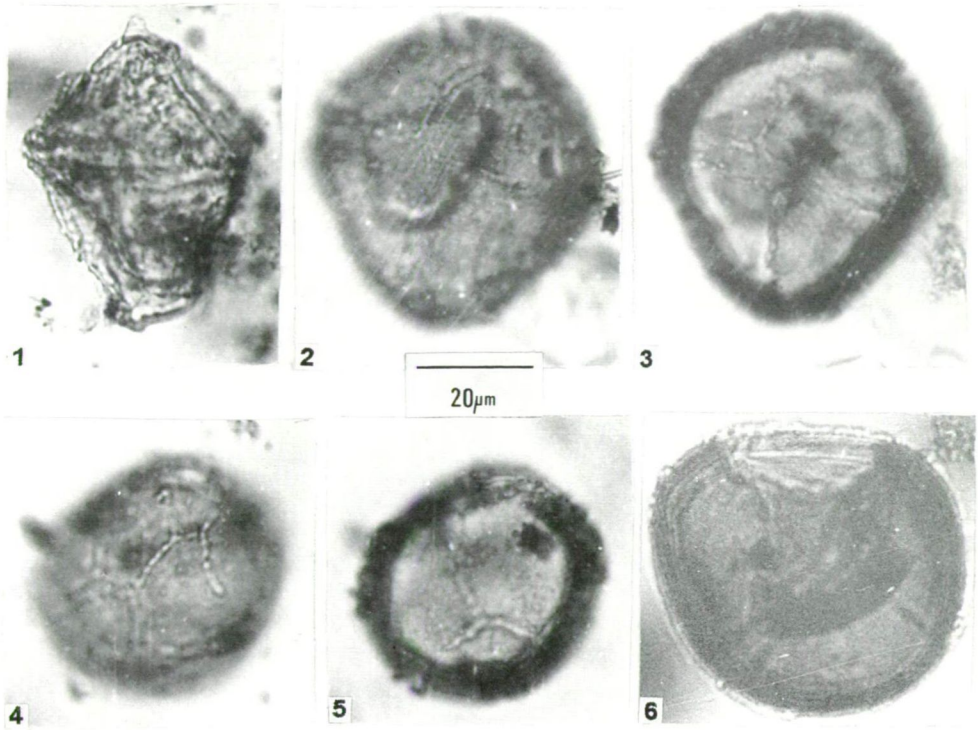


Plate 6.10.

1. Cf. *Acanthaulax* sp.$_2$, slide: GS-1-6, cross-table number: 9.3/144.8.
2,3. *Leptodinium ambiguum* (DEFLANDRE 1939) HELENES 1984, slide: GS-1-5, cross-table number: 19.8/146.2.
4,5. *Occisucysta balia* GITMEZ 1970, slide: GS-1-6, cross-table number: 24.3/128.3.
6. *Neuffenia willei* BRENNER et DÜRR 1986, slide: GS-4, cross-table number: 25.9/129.3.

2. It is worth of mentioning that reworked spores and/or pollen grains were not observed in the investigated assemblage.

3. The greatest quantity of the saccate *gymnosperm* pollen grain in the spore-pollen composition of the woody remnants embedding sediment indicate the presence of the lake during this period. The results of SHATILOVA (1999 in LENNERT et al.) are essentially identical with our observations.

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