

5. PALYNOLOGICAL INVESTIGATIONS ON HUNGARIAN NEOGENE LIGNITES

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Abstract

Palynological data and tissue fragments were investigated from Miocene and Upper Pannonian lignite samples from Hungary. The qualitative and quantitative results are presented in this contribution. Peculiar attention was paid to the reconstruction of the brown coal forming vegetation and for its zonation.

Key words: Palynology, fossil, Neogene, Hungary.

Introduction

There are a great number of publications of the spore-pollen assemblages of the Hungarian Neogene layers: Monographs on the Neogene sporomorphs in Hungary were published by E. NAGY (1958, 1969, 1985, 1992a). Based on the geological ages and the character of the publications the following will be emphasized:

Miocene sporomorphs: MAÁ CZ and SIMONCSICS (1956), SIMONCSICS (1959a,b, 1960, 1963, 1964, 1969), KEDVÉS (1959, 1960), E. NAGY (1962a, 1963b, 1968a, 1979a,b), BÓNA and RUMLI-SZENTAI (1966).

Organic planctonic microfossils: E. NAGY and BODOR (1982), FUCHS and SÜTŐ-SZENTAI (1991, 1994), JÁMBOR et al. (1985, 1987), JUHÁSZ et al. (1996).

Reconstruction of the zonation of the vegetation around the sedimentary basin: SIMONCSICS (1960), E. NAGY (1962b, 1976b). Paleofloristic and climatic changes, E. NAGY (1991, 1993), E. NAGY and Ó. KOVÁCS (1997). Description of the fossil mangrove from the Lower Badenian (E. NAGY and KÓKAY, 1990).

Pliocene sporomorphs: E. NAGY (1957b, 1959, 1988, 1989), E. NAGY and PLANDEROVÁ (1987), RÁKOSI (1963), MIHÁLTZ-FARAGÓ (1976), BODOR (1983).

Organic planctonic microfossils: E. NAGY (1976a), SÜTŐ-SZENTAI (1981, 1982a,b, 1983b,c, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994a, 1995a,b, 1999a,b in preparation).

Vegetation zonation in the Upper Pannonian: KEDVES (1962).

Neogene sporomorphs: E. NAGY (1963a,c,d, 1965c, 1968b, 1973).

Organic planctonic microfossils: E. NAGY (1965a,b, 1966), SÜTŐ-SZENTAI (1983a, 1994b, 1998).

Vegetation reconstruction: E. NAGY (1967, 1980).

Combined paleobotanical results from the Hungarian Neogene: E. NAGY and PÁLFALVY (1961), PÁLFALVY and RÁKOSI (1979).

Methodical papers: E. NAGY (1957a, 1961).

This contribution is within the combined investigations of the Hungarian Neogene lignites and included into the IGBP Global Change research program, B. Techniques for Extracting Environmental Data of the Past, 16. This paper presents in the first place the palynological results of the samples investigated previously geochemically by Prof. Dr. M. HETÉNYI.

Materials and Methods

Miocene

Bükkábrány mine: H/20-6, H/17-5, H/16-4, H/28-3. Horizontal sampling by 5 m.

Upper Pannonian: Torony Formation: Szombathely II, 189.5-189.7 m.

Tihany Formation: Szombathely II, 712.0-712.7 m.

Iharosberény sample No: 78, 130.1-130.3 m.

Tiszapalkonya bore-hole I: TK-I-10, 401.9-402.3 m, TK-I-19, 519.7-519.9 m, TK-I-8, 1217.8-1218.3 m.

The lignite samples were treated with HCl, HNO₃, KOH. The slides were mounted in glycerine jelly hydrated of 39.6%.

In the determination of the secondary xylem remnants monographs of GREGUSS (1945, 1955, 1967, 1969) were used. Concerning the organic planctonic remnant several monographies were investigated.

Results

Tissue fragments

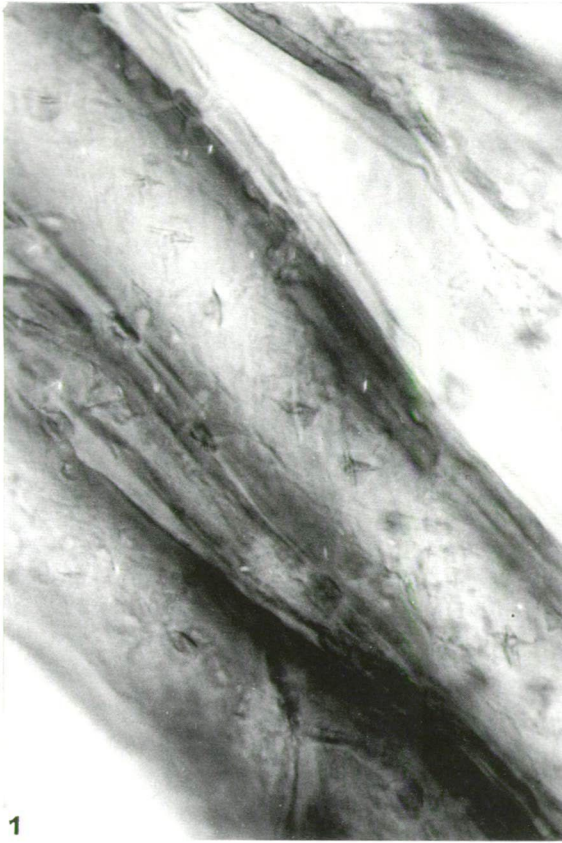
Gymnosperm (Plate 5.1., figs. 1-4) and *angiosperm* (Plate 5.1., figs. 5,6) secondary woody fragments were observed in the macerated material. *Taxodiaceae-Cupressaceae*, *Taxaceae* or *Cephalotaxaceae*, *Abietaceae* may be presumed based on the xylotomical data. Fungal remnant within the tracheids (Plate 5.1., fig. 2) was also observed. The *angiosperm* vessel fragments refer to *Betulaceae* (*Alnus*, *Betula*) (Plate 5.1., fig. 5), and in all probability *Salicaceae* (Plate 5.1., fig. 6).

Palynological data

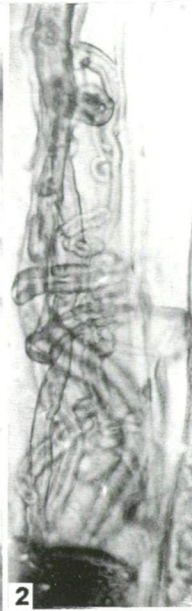
Taxonomy

Plate 5.1.

1. *Gymnosperm* tracheid; slide: H-9-2, cross-table number: 15.8/127.7.
2. *Gymnosperm* tracheid transversed by hyphae; slide: H-9-5, cross-table number: 18.4/139.4.
3. *Gymnosperm* tracheid. The areolate pitting is well preserved; slide: H-8-5, cross-table number: 21.4/132.2.
4. *Gymnosperm* tracheid, similar to *Taxaceae* or *Cephalotaxaceae* thickening; slide: H-1-1, cross-table number: 20.2/144.9.
5. *Angiosperm* vessel of *Betulaceae*, origin (*Alnus*, *Betula*); slide: H-9-2, cross-table number: 10.4/141.6.
6. *Angiosperm* vessel probably of *Salicaceae* origin; slide: H-9-2, cross-table number: 20.4/141.6.



1



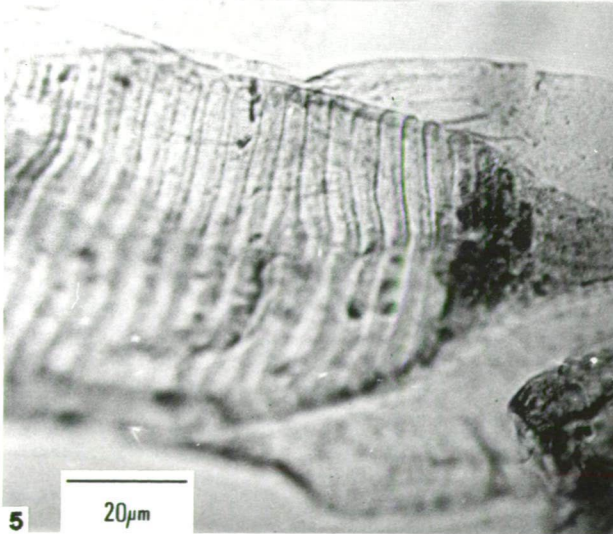
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3

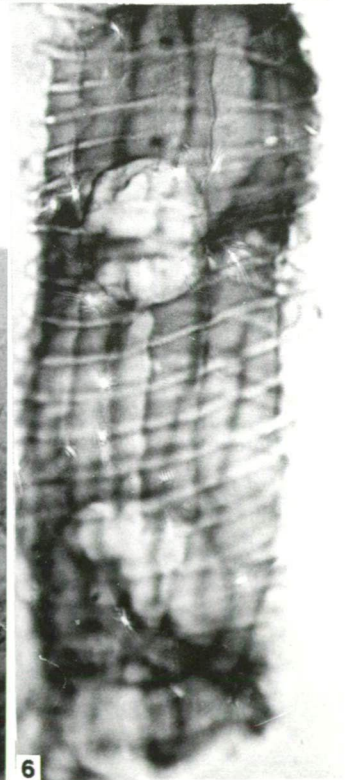


4



5

20 μ m



6

Plate 5.1.

PHYLUM: BRYOPHYTA
CLASSIS: MUSCI
SUBCLASSIS: SPHAGNIDAE

Ordo: *Sphagnales*

Familia: *Sphagnaceae*, *Sphagnum*; *Stereisporites* (*Stereisporites*) *involutus* (DOKT.-HREBN. 1960) KRUTZSCH 1963b.

PHYLUM: PTERIDOPHYTA
CLASSIS: LYCOPSIDA

Ordo: *Lycopodiales*

Familia: *Lycopodiaceae*, *Lycopodium*; *Retitriletes punctoides* KRUTZSCH 1963a.

CLASSIS: PTEROPSIDA
SUBCLASSIS: LEPTOSPORANGIATAE

Ordo: *Osmundales*

Familia: *Osmundaceae*, *Osmunda*; *Baculatisporites primarius* (WOLFF 1934) THOMSON et PFLUG 1953 subfsp. *primarius* (Plate 5.2., fig. 2).

Ordo: *Filicales*

Familia: *Polypodiaceae*; *Laevigatosporites haardti* (POTONIÉ et VENITZ 1934) THOMSON et PFLUG 1953 subfsp. *haardti* (Plate 5.2., fig. 3), *Verrucatosporites tenellis* (KRUTZSCH 1959) KRUTZSCH 1967 (Plate 5.2., fig. 4).

Familia: *Pteridaceae*, *Pteris*; *Polypodiaceoisporites gracillimus* E. NAGY 1963b subfsp. *granoverrucatus* KRUTZSCH 1967.

SUBCLASSIS: HYDROPTERIDES

Ordo: *Salvinales*

Familia: *Salviniaceae*; *Azolla bohémica* PAČLTOVÁ 1960 (Plate 5.2., fig. 1), *Azolla* v. *Salvinia*; *Hydrosporites levis* KRUTZSCH 1962.

PHYLUM: GYMNOSPERMATOPHYTA
SUBPHYLUM: PTERIDOSPERMOPHYTINA
CLASSIS: CYCADOPSIDA

Ordo: *Cycadales*

Familia: *Cycadaceae*; *Cycadopites gracilis* KRUTZSCH 1970a.

SUBPHYLUM: CONIFEROPHYTINA
CLASSIS: CONIFEROPSIDA

Ordo: *Pinales*

Familia: *Abietaceae*, *Pinus*; *Pityosporites microalatus* (POTONIÉ 1931b) THOMSON et PFLUG 1953 (Plate 5.2., figs. 5,7), cf. *Cedrus*; *Cedripites dacrydioides* KRUTZSCH 1971 (Plate 5.2., fig. 6), *Cedripites miocaenicus* KRUTZSCH 1971 (Plate 5.2., fig. 8), *Abies*; *Abiespollenites absolutus* THIERGART 1938 (Plate 5.2., fig. 9), *Keteleeria* v. *Abies*; *Abiespollenites maximus* KRUTZSCH 1971 (Plate 5.2., fig. 10), *Abies*; *Abiespollenites microsaccoides* KRUTZSCH 1971 (Plate 5.2., figs. 11,12), *Picea*; cf. *Piceapollis praemarinus* KRUTZSCH 1971 (Plate 5.3., fig. 1), *Pseudotsuga* v. *Larix*; *Psophosphaera pseudotsugoides* KRUTZSCH 1971, *Tsuga*; *Zonalapollenites rueterbergensis* KRUTZSCH 1971 (Plate 5.3., figs. 2,3).

Familia: *Taxodiaceae*, *Sequoia*; *Sequoiapollenites polyformosus* THIERGART 1938 (Plate 5.3., fig. 5), *Sequoiapollenites sculpturius* KRUTZSCH 1971 (Plate 5.3., figs. 8-

11), cf. *Glyptostrobus*; *Inaperturopollenites concedipites* (WODEHOUSE 1933) KRUTZSCH 1971 (Plate 5.3., figs. 6,7).

Familia: *Cupressaceae*, *Juniperus* type; *Cupressacites* cf. *insulipapillatus* (TREVISAN 1967) KRUTZSCH 1971 (Plate 5.3., fig. 12).

PHYLUM: ANGIOSPERMATOPHYTA
CLASSIS: DICOTYLEDONOPSIDA

Ordo: *Magnoliales*

Familia: *Magnoliaceae*; *Magnolipollis* cf. *micropunctatus* KRUTZSCH 1970a (Plate 5.3., fig. 4).

Ordo: *Dilleniales*

Familia: *Dipterocarpaceae*; *Dipterocarpacearumpollenites spinosus* E. NAGY 1969.

Ordo: *Myrtales*

Familia: *Thymelaeaceae*; *Thymelipollis retisculpturius* KRUTZSCH 1966.

Familia: *Onagraceae*; *Corsinipollenites oculus-noctis* (THIERGART 1940) NAKOMAN 1965.

Ordo: *Terebinthales*

Familia: *Aceraceae*, *Acer*; *Aceripollenites reticulatus* E. NAGY 1969.

Ordo: *Celastrales*

Familia: *Aquifoliaceae*, *Ilex*; *Ilexpollenites margaritatus* (POTONIÉ 1931a) THIERGART 1938 f. *medius* PFLUG et THOMSON 1953 (Plate 5.3., fig. 33).

Ordo: *Cornales*

Familia: *Araliaceae* v. *Cornaceae*; *Araliaceoipollenites euphorii* (POTONIÉ 1931a) POTONIÉ 1960.

Familia: *Umbelliferae*; *Umbelliferoipollenites* fssp.

Familia: *Nyssaceae*; *Nyssapollenites* fsp.

Ordo: *Rubiales*

Familia: *Adoxaceae*; *Retitricolporites nagyae* KEDVES 1978.

Ordo: *Malvales*

Familia: *Tiliaceae*, *Tilia*; *Intratriporopollenites insculptus* MAI 1961.

Ordo: *Ligustrales*

Familia: *Oleaceae*, *Fraxinus* type.

Ordo: *Asterales*

Familia: *Compositae*, *Tubuliflorae*; *Tubulifloridites* fsp., *Liguliflorae*, *Cichoreacidites gracilis* (E. NAGY 1969) n. comb. syn.: *Cichoriaearumpollenites gracilis* n.g. n.sp.

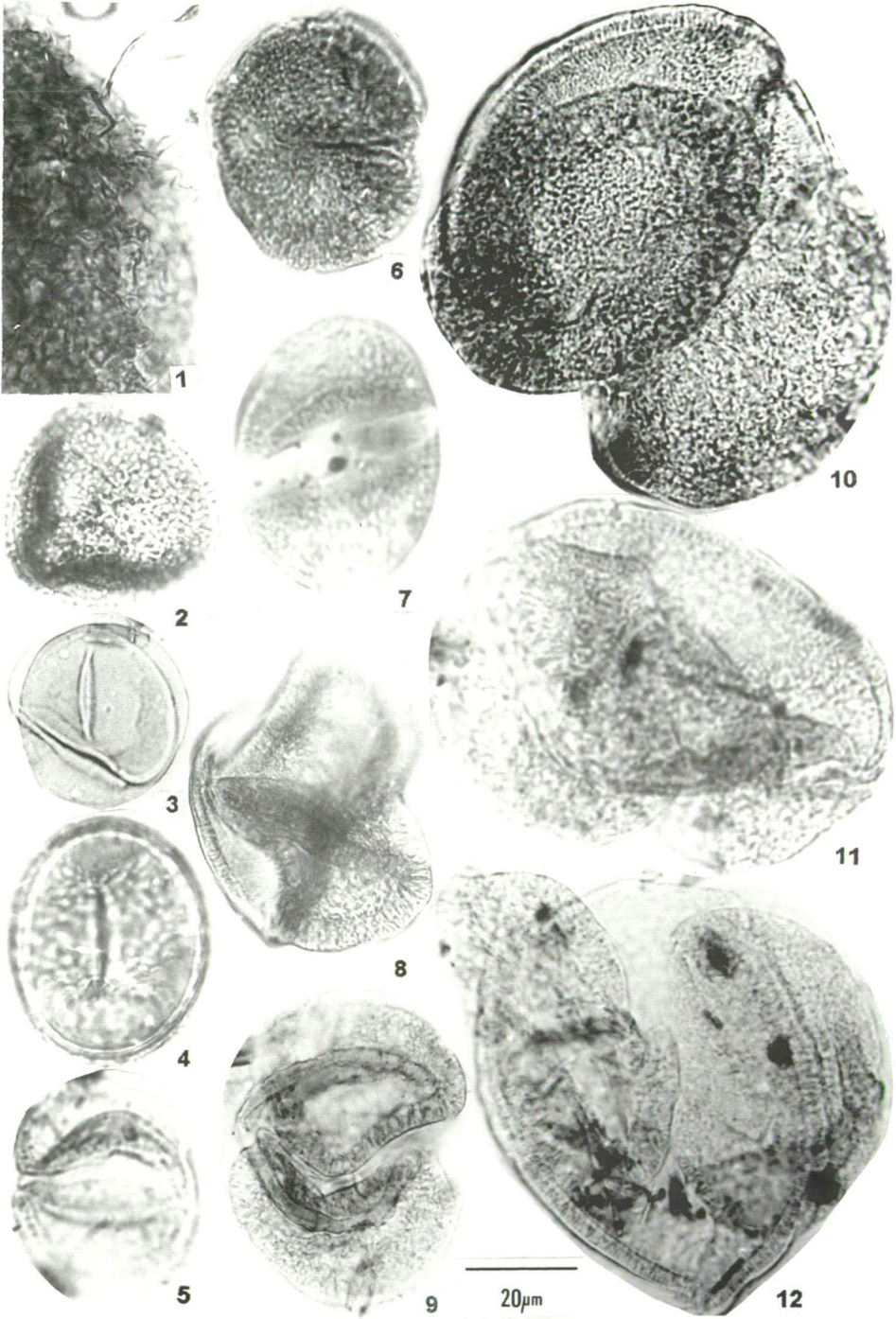


Plate 5.2.

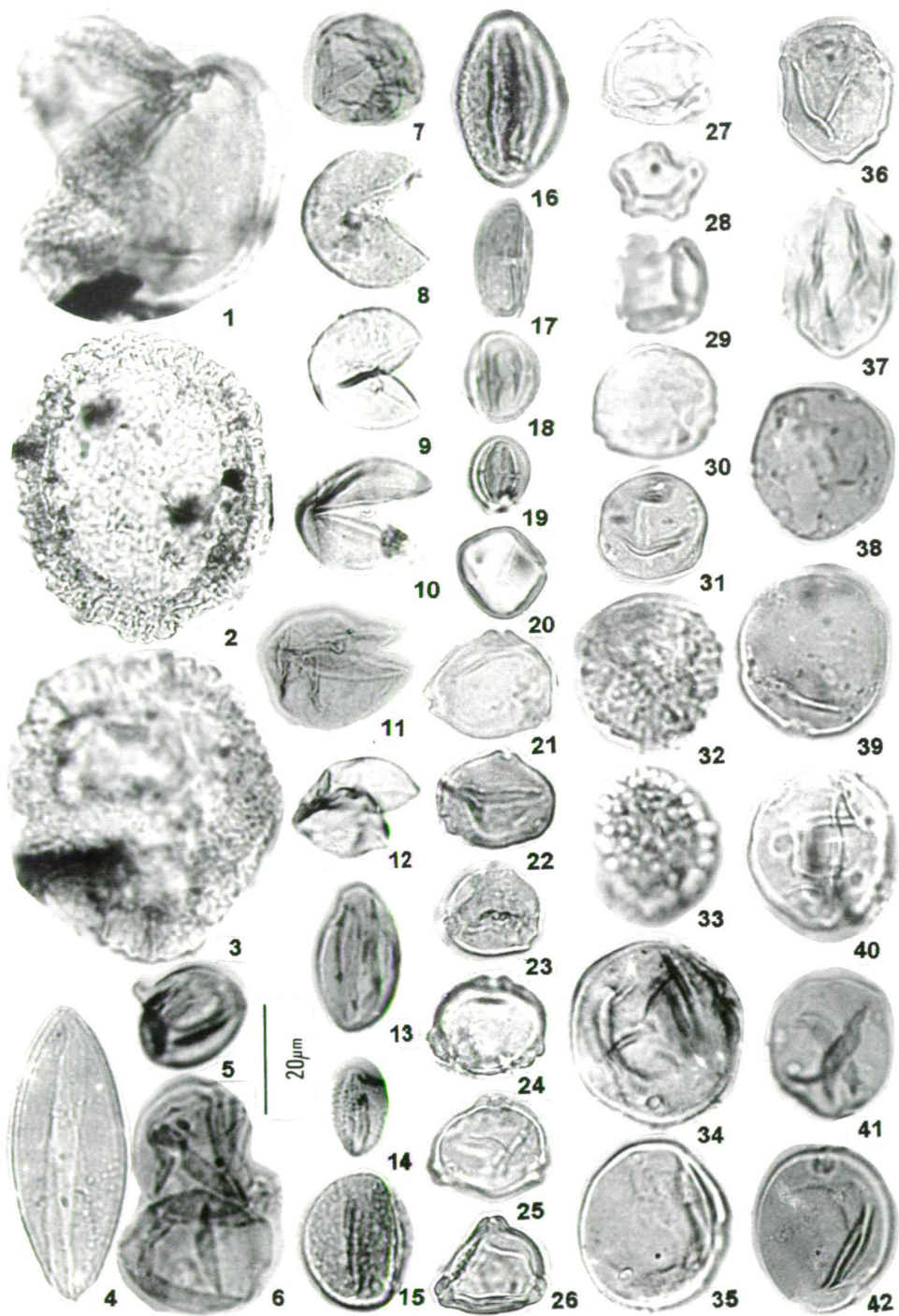


Plate 5.3.

Ordo: *Ericales*

Familia: *Ericaceae*; *Ericipites callidus* (POTONIÉ 1931a) KRUTZSCH 1970b.

Familia: *Cyrillaceae*; cf. *Cyrillaceapollenites* fsp. (Plate 5.3., fig. 20).

Ordo: *Caryophyllales*

Familia: *Chenopodiaceae*; *Chenopodiipollis psilatoides* (TREVISAN 1967) KEDVES 1981, *Ch. microforaminatus* (TREVISAN 1967) KEDVES 1981.

Ordo: *Ebenales*

Familia: *Sapotaceae*; *Tetracolporopollenites biconus* PFLUG 1953.

Ordo: *Polygonales*

Familia: *Polygonaceae*, *Polygonum persicaria* type; *Persicarioipollis minor* KRUTZSCH 1962, *Persicarioipollis crassicus* KRUTZSCH 1962.

Plate 5.2.

1. *Azolla bohemica* PACLTOVÁ 1960, *Azolla* v. *Salvinia*; slide: H-1-5, cross-table number: 19.4/126.3.
2. *Baculatisporites primarius* (WOLFF 1934) THOMSON et PFLUG 1953 subfsp. *primarius*, *Osmundaceae*, *Osmunda*; slide: H-1-5, cross-table number: 12.4/153.7.
3. *Laevigatosporites haardti* (POTONIÉ et VENITZ 1934), THOMSON et PFLUG 1953 subfsp. *haardti* *Polypodiaceae*; slide: H-9-2, cross-table number: 12.6/135.3.
4. *Verrucatosporites tenellis* (KRUTZSCH 1959) KRUTZSCH 1967c, *Polypodiaceae*; slide: H-10-1, cross-table number: 26.2/144.2.
5. *Pityosporites microalatus* (POTONIÉ 1931b) THOMSON et PFLUG 1953 *Abietaceae*, *Pinus*; slide: H-1-2, cross-table number: 19.3/147.2.
6. *Cedripites dacrydioides* KRUTZSCH 1971, cf. *Cedrus*; slide: H-10-2, cross-table number: 22.9/135.5.
7. *Pityosporites microalatus* (POTONIÉ 1931b) THOMSON et PFLUG 1953, *Abietaceae*, *Pinus*; slide: H-1-4, cross-table number: 23.5/119.6.
8. *Cedripites miocaeuicis* KRUTZSCH 1971, cf. *Cedrus*; slide: H-1-5, cross-table number: 7.6/137.6.
9. *Abiespollenites absolutus* THIERGART 1938, *Abietaceae*, *Abies*; slide: H-1-5, cross-table number: 24.2/135.2.
10. *Abiespollenites maximus* KRUTZSCH 1971, *Abietaceae*, *Keteleeria* v. *Abies*; slide: H-10-4, cross-table number: 15.3/139.8.
11. *Abiespollenites microsaccoides* KRUTZSCH 1971, *Abietaceae*, *Abies*; slide: H-1-2, cross-table number: 8.4/142.2.
12. *Abiespollenites microsaccoides* KRUTZSCH 1971, *Abietaceae*, *Abies*; slide: H-1-1, cross-table number: 23.3/150.4.

Plate 5.3.

1. Cf. *Piceapollis praemarinus* KRUTZSCH 1971, *Abietaceae*, *Picea*; slide: H-1-2, cross-table number: 6.3/148.1.
2. *Zonalapollenites rueterbergensis* KRUTZSCH 1971, *Abietaceae*, *Tsuga*; slide: H-1-5, cross-table number: 8.2/145.5.
3. *Zonalapollenites rueterbergensis* KRUTZSCH 1971, *Abietaceae*, *Tsuga*; slide: H-1-4, cross-table number: 20.8/120.7.
4. *Magnoliipollis* cf. *micropunctatus* KRUTZSCH 1970, *Magnoliaceae*; slide: H-3-1, cross-table number: 17.2/142.4.
5. *Sequoiapollenites polyformosus* THIERGART 1938, *Taxodiaceae*, *Sequoia*; slide: H-3-4, cross-table number: 17.4/138.8.
6. *Inaperturopollenites concedipites* (WODEHOUSE 1933) KRUTZSCH 1971, *Taxodiaceae*, cf. *Glyptostrobus*; slide: H-7-3, cross-table number: 13.8/130.7.
7. *Inaperturopollenites concedipites* (WODEHOUSE 1933) KRUTZSCH 1971, *Taxodiaceae*, cf. *Glyptostrobus*; slide: H-1-1, cross-table number: 22.6/154.2.

8. *Sequoiapollenites sculpturius* KRUTZSCH 1971, *Taxodiaceae, Sequoia*; slide: H-10-4, cross-table number: 20.7/141.2.
9. *Sequoiapollenites sculpturius* KRUTZSCH 1971, *Taxodiaceae, Sequoia*; slide: H-10-4, cross-table number: 20.5/142.3.
10. *Sequoiapollenites sculpturius* KRUTZSCH 1971, *Taxodiaceae, Sequoia*; slide: H-1-5, cross-table number: 14.2/141.3.
11. *Sequoiapollenites sculpturius* KRUTZSCH 1971, *Taxodiaceae, Sequoia*; slide: H-1-1, cross-table number: 20.9/137.4.
12. *Cupressacites* cf. *insulipapillatus* (TREVISAN 1967) KRUTZSCH 1971; *Cupressaceae Juniperus* type; slide: H-1-1, cross-table number: 12.1/139.2.
13. *Salixipollenites* fsp., *Salicaceae Salix*; slide: H-7-3, cross-table number: 10.1/138.3.
14. *Salixipollenites helveticus* E. NAGY 1969, *Salicaceae, Salix*; slide: H-1-1, cross-table number: 0.9/145.3.
15. *Quercopollenites granulatus* E. NAGY 1969, *Fagaceae, Quercus*; slide: H-10-4, cross-table number: 11.6/139.7.
16. *Tricolporopollenites microhenrici* (POTONIÉ 1931a) KRUTZSCH 1961 subfsp. *intragranulatus* PFLUG 1953a; slide: H-8-5, cross-table number: 16.4/133.9.
17. *Cupuliferoipollenites pusillus* (POTONIÉ 1934) POTONIÉ 1960, *Fagaceae, Castaneoid* type; slide: H-3-1, cross-table number: 15.2/145.4.
18. *Cupuliferoipollenites oviformis* (POTONIÉ 1931a) POTONIÉ 1960, *Fagaceae, Castaneoid* type; slide: H-7-2, cross-table number: 7.1/130.1.
19. *Cupuliferoipollenites oviformis* (POTONIÉ 1931a) POTONIÉ 1960, *Fagaceae, Castaneoid* type; slide: H-1-1, cross-table number: 15.3/146.9.
20. Cf. *Cyrillaceaeipollenites* fsp., *Cyrillaceae*; slide: H-1-1, cross-table number: 22.6/154.2.
21. *Labraferoidaeipollenites menatensis* KEDVES 1982 in KEDVES and RUSSELL, *Myricaceae*; slide: H-4-3, cross-table number: 19.3/141.5.
22. *Labraferoidaeipollenites menatensis* KEDVES 1982 in KEDVES and RUSSELL, *Myricaceae*; slide: H-8-5, cross-table number: 9.6/134.2.
23. *Plicatopollis* fsp., *Juglandaceae*; slide: H-6-1, cross-table number: 15.3/144.2.
24. *Betulaepollenites betuloides* (PFLUG 1953) E. NAGY 1969, *Betulaceae, Betula*; slide: H-6-1, cross-table number: 16.3/140.2.
25. *Betulaepollenite betuloides* (PFLUG 1953) E. NAGY 1969, *Betulaceae, Betula*; slide: H-4-2, cross-table number: 20.4/136.3.
26. *Betulaepollenites betuloides* (PFLUG 1953) E. NAGY 1969, *Betulaceae, Betula*; slide: H-6-1, cross-table number: 9.6/141.2.
27. *Betulaepollenites betuloides* (PFLUG 1953) E. NAGY 1969, *Betulaceae, Betula*; slide: H-4-5, cross-table number: 15.7/142.3.
28. *Alnipollenites verus* POTONIÉ 1934, *Betulaceae, Alnus*; slide: H-7-5, cross-table number: 7.9/137.5.
29. *Alnipollenites verus* POTONIÉ 1934, *Betulaceae, Alnus*; slide: H-1-2, cross-table number: 9.7/146.1.
30. *Ostryapollenites rhenanus* (THOMSON 1950) E. NAGY 1969, *Betulaceae, Ostrya*; slide: H-2-1, cross-table number: 8.6/138.3.
31. *Ostryapollenites rhenanus* (THOMSON 1950) E. NAGY 1969, *Betulaceae, Ostrya*; slide: H-5-1, cross-table number: 16.3/137.7.
32. *Ulmipollenites stillatus* E. NAGY 1969, *Ulmaceae, Ulmus*; slide: H-6-1, cross-table number: 20.6/141.5.
33. *Ilexpollenites margaritatus* (POTONIÉ 1931a) THIERGART 1938 f. *medius* PFLUG et THOMSON 1953, *Aquifoliaceae, Ilex*; slide: H-10-1, cross-table number: 19.3/147.6.
34. *Caryapollenites simplex* (POTONIÉ 1931b) POTONIÉ 1960, *Juglandaceae, Carya*; slide: H-10-3, cross-table number: 7.9/129.3.
35. *Caryapollenites simplex* (POTONIÉ 1931b) POTONIÉ 1960, *Juglandaceae, Carya*; slide: H-10-4, cross-table number: 9.8/135.9.
36. *Pterocaryapollenites* fsp., *Juglandaceae, Pterocarya*; slide: H-6-1, cross-table number: 10.7/146.9.
37. *Pterocaryapollenites* fsp., *Juglandaceae, Pterocarya*; slide: H-7-2, cross-table number: 10.8/141.2.
38. *Juglanspollenites verus* RAATZ 1937, *Juglandaceae, Juglans*; slide: H-10-1, cross-table number: 13.6/138.5.
39. *Celtipollenites komloensis* E. NAGY 1969, *Ulmaceae, Celtidoideae, Celtis*; slide: H-10-1, cross-table number: 19.3/146.7.
40. *Celtipollenites komloensis* E. NAGY 1969, *Ulmaceae, Celtidoideae, Celtis*; slide: H-1-2, cross-table number: 15.3/155.6.
41. *Celtipollenites komloensis* E. NAGY 1969, *Ulmaceae, Celtidoideae, Celtis*; slide: H-7-4, cross-table number: 12.3/142.5.
42. *Celtipollenites komloensis* E. NAGY 1969, *Ulmaceae, Celtidoideae, Celtis*; slide: H-10-4, cross-table number: 20.5/137.9.

Ordo: *Urticales*

Familia: *Urticaceae*; *Triporopollenites urticoides* E. NAGY 1969.

Familia: *Ulmaceae*, *Ulmoideae*, *Ulmus*; *Ulmipollenites undulosus* WOLFF 1934, *U. stillatus* E. NAGY 1969 (Plate 5.3., fig. 32), *Zelkova*, *Zelkovaepollenites thiergarti* E. NAGY 1969, Concerning the identification of the *Ulmus* and *Zelkova* pollen MORITA, FUJIKI, KATAOKA and MIYOSHI (1988) established that the pollen grains of the two genres may be distinguishable by LM method on the basis of shape and structure. Pollen grains of *Zelkova* has thicker annulus and exine, and coarser sculpture than that of *Ulmus*. *Celtidoideae*, *Celtis*, *Celtipollenites komloensis* E. NAGY 1969 (Plate 5.3., figs. 39-42).

Ordo: *Fagales*

Familia: *Betulaceae*, *Corylus*; *Triporopollenites coryloides* PFLUG 1953, *Betula*; *Betulaepollenites betuloides* (PFLUG 1953) E. NAGY 1969 (Plate 5.3., figs. 24-27), *Alnus*; *Alnipollenites verus* POTONIÉ 1934 (Plate 5.3., figs. 28,29), *Carpinus*; *Carpinuspollenites carpinoides* (PFLUG 1953) E. NAGY 1969, *Ostrya*; *Ostryapollenites rhenanus* (THOMSON 1950) E. NAGY 1969 (Plate 5.3., figs. 30, 31).

Familia: *Fagaceae*, *Quercus*; *Quercopollenites granulatus* E. NAGY 1969 (Plate 5.3., fig. 15), *Tricolporopollenites microhenrici* (POTONIÉ 1931a) KRUTZSCH 1961 subfsp. *intragranulatus* (Plate 5.3., fig. 16), *Castaneoid* type; *Cupuliferoipollenites oviformis* (POTONIÉ 1931a) POTONIÉ 1960 (Plate 5.3., figs. 18,19), *C. pusillus* (POTONIÉ 1934) POTONIÉ 1960 (Plate 5.3., fig. 17), cf. *Castanopsis*; *Fususpollenites fusus* (POTONIÉ 1934) KEDVES 1978.

Ordo: *Juglandales*

Familia: *Juglandaceae*, *Carya*; *Caryapollenites simplex* (POTONIÉ 1931b) POTONIÉ 1960 (Plate 5.3., figs. 34,35), *Pterocarya*; *Pterocaryapollenites* fsp. (Plate 5.3., figs. 36, 37), *Juglans*; *Juglanspollenites verus* RAATZ 1937 (Plate 5.3., fig. 38), *Engelhardtia* type; *Plicatopollis* fsp. (Plate 5.3., fig. 23).

Ordo: *Myricales*

Familia: *Myricaceae*, *Labraferoidaepollenites rurensis* (PFLUG et THOMSON 1953) KEDVES et RUSSELL 1982, *L. menatensis* KEDVES 1982, in KEDVES and RUSSELL (Plate 5.3., figs. 21,22), *Alabroidaepollenites myricoides* (KREMP 1949) KEDVES 1982, in KEDVES and RUSSELL.

Ordo: *Salicales*

Familia: *Salicaceae*, *Salix*; *Salixipollenites helveticus* E. NAGY 1969 (Plate 5.3., fig. 14), *Salixipollenites* fsp. (Plate 5.3., fig. 13).

Classis: MONOCOTYLEDONOPSIDA

Ordo: *Cyperales*

Familia: *Cyperaceae*; *Cyperaceaepollis neogenicus* KRUTZSCH 1970a.

Ordo: *Poales*

Familia: *Poaceae*; *Graminidites laevigatus* KRUTZSCH 1970a.

Ordo: *Spadiciflorae*
Familia: *Palmae*; *Monocolpopollenites* cf. *tranquillus* (POTONIÉ 1934) THOMSON et PFLUG 1953.

Ordo: *Dioscoreales* v. *Hydrocharitales*, *Smilax* v. *Hydrocharis*; *Monogemmites pseudosetarius* (WEYLAND et PFLUG 1957) KRUTZSCH 1970a. PLANDEROVÁ (1990) published this form-species as *Nymphaeapollenites pseudosetarius* (W. KR. 1970a)-n. comb., with the *Nymphaeaceae* botanical affinity.

Mycophyta and microplankton remnants

Mycophyta

Fungal cell indet. (Plate 5.4., fig. 2). This remnant is identical with those published by RÜFFLE (1963), as "Unbestimmte Hyphenstücke RM 014", Plate XVI, fig. 6.

Pyrrhophyta

Dinoflagellatae

Rhombodinium cf. *draco* GOCHT 1955 (Plate 5.4., fig. 1).

Catillopsis abdita DRUGG 1970 (Plate 5.4., figs. 3-6). Great morphological variation within this species was observed. Some are illustrated.

Quantitative data

Miocene

Bükkábrány, lignite mine

1. Sample No: H-16

Abundant or common sporomorphs (10%, or over)

Taxodiaceae-Cupressaceae (33.9%)

Pinus (15.5%)

Betula (16.3%)

Additional elements: *Osmunda*, *Polypodiaceae* (*L. haardti*), *Pinus*, *Picea*, *Abies*, *Keteleeria*, *Castaneoid* group, *Salix*, *Celtis*, *Myricaceae*, *Carya*, *Chenopodiaceae*, *Gramineae*, *Tilia*, *Cyrillaceae*, *Engelhardtia*.

Taxodiaceae-Cupressaceae swamp, followed by *Betulaceae* (*Alnus*, *Betula*) zone on the basis of the palynological data: The relatively high quantity of *Pinus* pollen grains indicate the nearness of the open swamp.

2. Sample No: H-17

Abundant or common elements (10%, or over)

Polypodiaceae (*L. haardti*) (30.8%)

Taxodiaceae-Cupressaceae (23.0%)

Alnus (13.0%)

Pollen grains of 5%, or over

Pinus (7.3%)

Salix (5.4%)

Celtis (5.0%)

Additional elements: *Osmunda*, *Cycadopites*, *Cedrus*, *Palmae*, *Monogemmites pseudosetarius*, *Castaneoid* group, *Ulmus/Zelkova*, *Acer*, *Betula*, *Myricaceae*, *Carya*, *Engelhardtia*, *Urtica*, *Cyperaceae*, *Ostrya*.

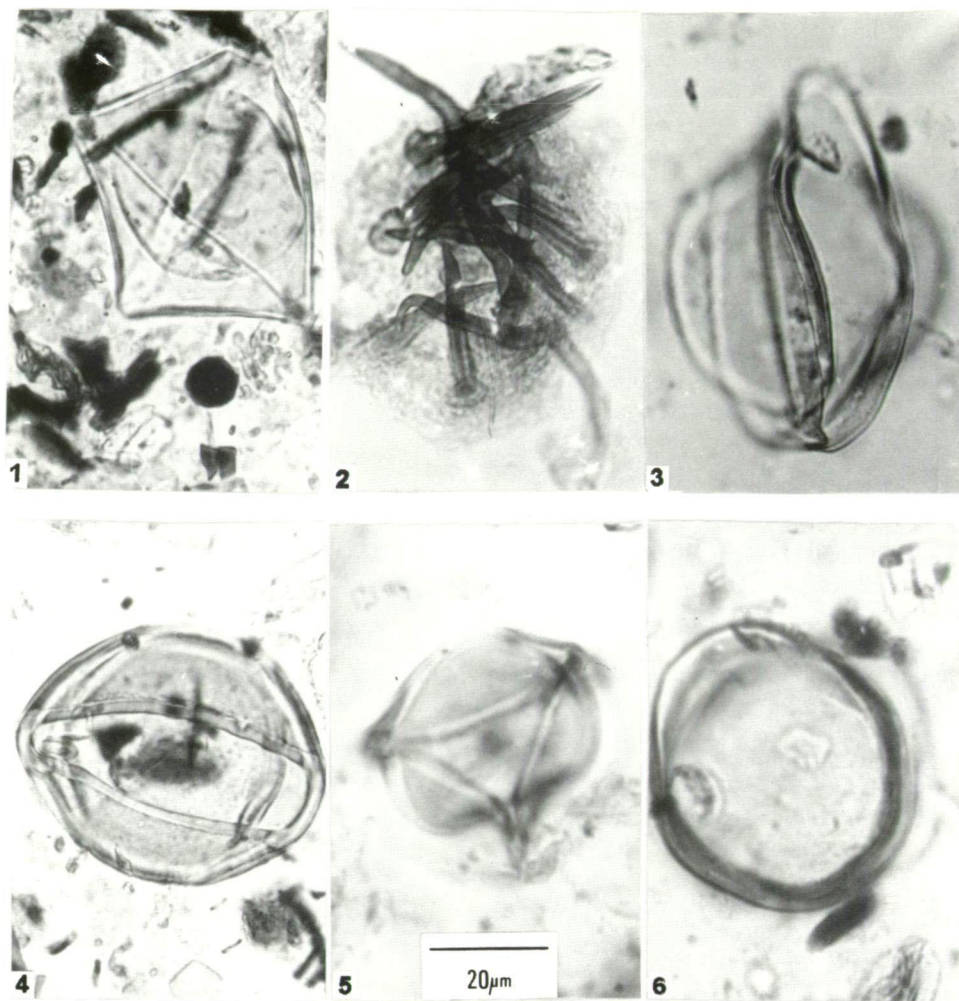


Plate 5.4.

1. *Rhombodinium* cf. *draco* GOCHT 1955; slide: H-1-5, cross-table number: 6.9/123.7.
2. Fungal cell indet.; slide: H-2-3, cross-table number: 5.6/135.8.
3. *Catillopsis abdita* DRUGG 1970; slide: H-1-1, cross-table number: 20.7/143.9.
4. *Catillopsis abdita* DRUGG 1970; slide: H-1-2, cross-table number: 17.3/147.6.
5. *Catillopsis abdita* DRUGG 1970; slide: H-1-4, cross-table number: 9.4/114.1.
6. *Catillopsis abdita* DRUGG 1970; slide: H-1-5, cross-table number: 13.5/155.9.

The high quantity of *Polypodiaceae* spores may be emphasized. *Pteridophyta* - *Taxodiaceae-Cupressaceae*, and mixed deciduous forest (*Alnus*, *Salix*, *Celtis*) zones may be reconstructed.

3. Sample No: H-20

Abundant or common elements (10%, or over)

Pinus (22.5%)
Taxodiaceae-Cupressaceae (38.7%)
Pollen grains over 5%
Castaneoid group (7.7%)
Salix (5.5%)
Alnus (6.3%)

Additional elements: *Osmunda*, *Cycadopites*, *Ulmus/Zelkova*, *Celtis*, *Thymelipollis*, *Betula*, *Myricaceae*, *Pterocarya*, *Carya*, *Engelhardtia*, *Urtica*.

Open swamp - *Taxodiaceae-Cupressaceae*, and mixed deciduous zones may be reconstructed on the basis of the palynological data.

4. Sample No: H-28

Abundant or common elements (10%, or over)
Taxodiaceae-Cupressaceae (67.6%)
Pollen grains of 5%, or over
Pinus (5.4%)
Castaneoid group (5.0%)
Salix (5.0%)

Additional elements: *Osmunda*, *Polypodiaceae* (*L. haardti*), *Cycadopites*, *Picea*, *Abies*, *Keteleeria*, *Palmae*, *Ulmus/Zelkova*, *Celtis*, *Tubulifloridites*, *Alnus*, *Myricaceae*, *Umbelliferae*.

Very characteristic *Taxodiaceae-Cupressaceae* swamp forest may be presumed based on this palynological composition.

Upper Pliocene

Tihany Formation

This formation was investigated from two localities:

1. Szombathely, bore-hole II, 712.0-712.7 m

1.1. Abundant or common sporomorphs (10%, or over)

Taxodiaceae-Cupressaceae (10.0%)
Salix (10.62%)
Alnus (25.5%)

1.2. Pollen grains over 5%

Ulmus/Zelkova (5.5%)

1.3. Additional elements: *Osmunda*, *Pteridaceae*, *Polypodiaceae*, *Pinus*, *Picea*, *Abies*, *Keteleeria*, *Monogemmites pseudosetarius*, *Castaneoid* group, *Thymelipollis*, *Cichoreacidites*, *Betula*, *Carpinus*, *Ostrya*, *Carya*, *Onagraceae*, *Polygonum*, *Adoxaceae*, *Dipterocarpaceae*, *Corylus*, *Plicatopollis*.

A mixed swamp forest may be presumed. *Taxodiaceae-Cupressaceae* swamp, *Myricaceae*, *Alnus*, *Salix* zone. The quantity of *Ulmus* and *Zelkova* pollen grains is also worth of mentioning.

2. Iharosberény, sample No: 78 (130.1-130.3 m)

2.1. Abundant or common sporomorphs (10%, or over)

Taxodiaceae-Cupressaceae (50.8%)
Myricaceae (16.8%)

Based on the abundant pollen grains a *Taxodiaceae-Cupressaceae* swamp forest and a *Myricaceae* shrub vegetation formed the lignite layers.

2.2. Pollen grains over 5%

Alnus (9.4%)

Carya (5.1%)

2.3. Additional elements: *Osmunda*, *Polypodiaceae*, *Pinus*, *Picea*, *Abies*, *Keteleeria*, *Palmae*, *Quercus*, *Castaneoid* group, *Nyssaceae*, *Ilex*, *Sapotaceae*, *Ulmus/Zelkova*, *Celtis*, *Betula*, *Ericaceae*, *Pterocarya*, *Juglans*, *Gramineae*.

2.4. In this sample more or less well preserved secondary wood fragments were observed: spirally thickened tracheids (*Taxaceae*, *Cephalotaxaceae*, etc.), bordered pitting of degraded tracheids, cross fields with pinoide pitting. *Angiosperm*, probably *Betulaceae* vessel, *Salicaceae* woody fragment.

Taxodiaceae-Cupressaceae swamp forest, followed by *Myricaceae* shrubs. Mixed zone with *Alnus*, *Carya*, and other deciduous elements may also be presumed.

Torony Formation

Szombathely, bore-hole II, 189.5-189.7 m

Abundant or common sporomorphs (10%, or over)

Castaneoid group (10.5%)

Salix (10.5%)

Alnus (13.8%)

Sporomorphs over 5%

Polypodiaceae (*L. haardti*) (6.0%)

Pinus (6.6%)

Larix (6.0%)

Taxodiaceae-Cupressaceae (8.4%)

Monogemmites pseudosetarius (5.1%)

Ulmus/Zelkova (7.8%)

Additional elements: *Azolla*, *Hydrosporites*, *Stereisporites*, *Lycopodium*, *Pteridaceae*, *Cycadopites*, *Picea*, *Abies*, *Keteleeria*, *Cedrus*, *Tsuga*, *Araliaceae*, *Quercus*, *Sapotaceae*, *Celtis*, *Acer*, *Tubulifloridites*, *Betula*, *Myricaceae*, *Ericaceae*, *Carya*, *Chenopodiaceae*, *Polygonum*, *Gramineae*.

This spore-pollen assemblage refers to an open swamp near a mixed forest zone.

Tiszapalkonya, bore-hole I

1. Sample No: TK-I-10 (401.9-402.3 m)

1.1. Dominant or common elements (10%, or over)

Taxodiaceae-Cupressaceae (17.8%)

Celtis (36.9%)

1.2. Pollen grains of 5%, or over

Polypodiaceae (*L. haardti*) (5.0%)

Picea, *Abies*, *Keteleeria* (6.4%)

Castaneoid group (6.0%)

Alnus (8.0%)

1.3. Additional elements: *Sphagnum*, *Osmunda*, *Polypodiaceae* (*Verrucatosporites*), *Pinus*, *Cedrus*, *Tsuga*, *Monogemmites pseudosetarius*, *Quercus*, *Salix*, *Ulmus/Zelkova*, *Betula*, *Myricaceae*, *Carya*, *Polygonum*, *Tilia*, *Umbelliferae*, *Cyrillaceae*, *Cyperaceae*, *Fraxinus*.

The dominance of *Celtis* pollen grains is interesting. *Taxodiaceae-Cupressaceae* swamp forest with deciduous forest may be presumed with *Celtis*, *Alnus* and *Castaneoid* types.

2. Sample No: TK-I-9 (519.7-519.9 m)

2.1. Dominant or common elements (10%, or over)

Polypodiaceae (*L. haardti*) (11.3%)

Taxodiaceae-Cupressaceae (40.0%)

Alnus (21.0%)

2.2. Pollen grains over 5%

Picea, *Abies*, *Keteleeria* (5.3%)

2.3. Additional elements: *Sphagnum*, *Osmunda*, *Cycadopites*, *Pinus*, *Cedrus*, *Mono-gemmites pseudosetarius*, *Quercus*, *Castaneoid* group, *Salix*, *Ulmus/Zelkova*, *Celtis*, *Acer*, *Betula*, *Myricaceae*, *Carya*, *Chenopodiaceae*.

Taxodiaceae-Cupressaceae - *Alnus* swamp forest zonation is represented by the palynological data, with the high quantity of *Pteridophyta* spores.

3. Sample No: TK-I-8 (1217.8-1218.3 m)

3.1. Dominant or common elements (10%, or over)

Taxodiaceae-Cupressaceae (36.1%)

Celtis (12.5%)

Alnus (13.25%)

3.2. Pollen grains over 5%

Pinus (5.9%)

Quercus (9.6%)

Castaneoid group (8.1%)

Salix (6.6%)

3.3. Additional elements: *Osmunda*, *Cycadopites*, *Cedrus*, *Larix*, *Carya*, *Chenopodiaceae*, *Cyrillaceae*, *Engelhardtia*.

Taxodiaceae-Cupressaceae and mixed deciduous zone characterized by *Alnus*, *Celtis*, *Salix*, *Quercus* may be reconstructed.

Discussion and Conclusions

As to the paleobotanical and paleoecological interpretation of the spore-pollen data the publications of TEICHMÜLLER (1958) and the papers from the Neogene of Polish Lowlands (WAŻYŃSKA, PIWOCKI, ZIEMBIŃSKA-TWORZYDŁO, GRABOWSKA, KOHLMAN-ADAMSKA, SŁODKOWSKA and STUHLIK, 1998) apart of the establishments on the Hungarian layers were used.

Miocene

Bükkábrány lignite mine

The vegetation types of the lignite layers forming vegetation at the investigated samples are different. In this place the high quantity (22.5%) of the *Pinus*, and 38.0% of the *Taxodiaceae-Cupressaceae* pollen grains in the sample H-20 indicate a deep swamp which was followed a mixed *Salix* and *Alnus* deciduous zone. Sample H-16 is a little

similar but with a *Betula* and *Alnus* deciduous zone. The very high quantity of the *Poly-podiaceae* spores (30.8%) in the sample H-17 with 23.0% of *Taxodiaceae-Cupressaceae* pollen grains represent another type of riparian or swamp forest, with *Alnus*, *Salix* and *Celtis* mixed forest. Sample H-28 based on the spore-pollen data was formed from a typically *Taxodiaceae-Cupressaceae* swamp forest.

In comparison to the spore-pollen data isolated from Miocene sediments we can point out the relatively low quantity of the *Myricaceae* pollen grains, and in some places the important quantity of the pollen grains of *Betula*, *Alnus* and *Salix*.

Upper Pliocene

Tihany Formation

Locality: Szombathely

In the first place a deciduous forest may be reconstructed with *Salix*, *Alnus*, *Ulmus/Zelkova* woods and *Myricaceae* shrubs, on the basis of the palynological data forming the lignite layers. The quantity of the *Taxodiaceae-Cupressaceae* pollen grains is relatively low, in contrast to the following locality:

Iharosberény. At this sample a *Taxodiaceae-Cupressaceae* swamp forest followed a *Myricaceae* zone with *Alnus* and *Carya* may be reconstructed.

Finally the paleoecological conditions, and in consequence of this the lignite layers forming vegetation were different at the two localities of this formation.

Torony Formation

Locality: Szombathely

This formation was investigated from one locality only. An interesting open or deep swamp may be reconstructed on the basis of the palynological data. The vegetation around the sedimentary basin was a mixed *gymnosperm* and deciduous *angiosperm* woods.

Tiszapalkonya

At the sample TK-I-10 the high quantity (36.9%) of the pollen grains of the genus *Celtis* may be emphasized. It is interesting that in the Neogene of the Polish Lowlands the VIII climatic phase - *Celtipollenites versus* spore-pollen zone is in the Middle Miocene (ZIEMBIŃSKA-TWORZYDŁO, 1998, in: WAŻYŃSKA). *Taxodiaceae-Cupressaceae* - *Alnus* zonation may be reconstructed on the basis of the spore-pollen data of the sample TK-I-9. Similar is the zonation of the sample TK-I-8, but the deciduous forest is a mixed *Alnus/Celtis* association.

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