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LM AND TEM INVESTIGATIONS ON HUNGARIAN NEOGENE LIGNITES

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ABSTRACT. The LM and the TEM structure of the secondary wood of two lignite samples and the spore-pollen data of two Upper Pliocene Formation (Tihany and Torony) are presented in this paper. The ultrastructure of the (*Sequoia*) wood remains was investigated on non-experimental and partially dissolved samples with diethylamine and merkaptoethanol. The different layers (S3, S2, S1) of the secondary wall were well perceptible on some samples after dissolution with diethylamine. The spore-pollen composition of the Tihany Formation was investigated on two localities (Szombathely and Iharosberény), and the Torony Formation from one locality. The association of vegetation was different on the investigated localities.

KEY WORDS: Upper Pliocene lignite LM, TEM structure, Palynology

INTRODUCTION

The LM anatomy of the Hungarian Tertiary lignites was investigated previously by several authors: e.g.: Hollendonner (1931), Haraszty (1933, 1953, 1957), Sárkány (1943), Maácz (1955). Simoncsics (1956). Greguss (1959), Kedves (1959). The TEM method was first used for reworked secondary wood remnants from Lake Vadkert by Kedves and Szederkényi (1988). The importance of the ultrastructure data in the reconstruction of the alteration during the fossilization processes was emphasized.

Regarding the Palynology of the Hungarian Neogene lignites there are several papers and monographies published by Maácz and Simoncsics (1956), Nagy (1958, 1969, 1985, 1992) and by Simoncsics (l956, 1959, 1960, 1969).

A great number of new fossil taxa were described, and schemes for the zonation of the vegetation surrounding the sedimentary basins were published.

During the last years several new programs started in our Laboratory. One of them is the combined investigation of the Hungarian Neogene lignites. Within this program:

1. Wood anatomy by the LM and TEM method. The TEM structure was investigated on non-experimental and partially dissolved xylem remnants with two organic solvents (diethylamine, merkaptoethanol).
2. Palynological studies including the tissue fragments also of the organic micro remnant assemblages.

All of the samples of this research program were investigated previously by geological, malacological and geochemical methods, by Prof. Dr. M. Hetényi and Dr. M. Szónoky. At the end of our research program a combined synthetical paper is projected including the most important results of all investigations.

METHOD

For LM anatomical studies thin slides and macerated lignite material were investigated.

For TEM studies the inorganic components were eliminated, post fixation with OsO4 aq dil., embedding in Araldite (Durcupan, Fluka). Partial degradation or dissolution with diethylamine and merkaptoethanol. The ultrathin sections and the TEM investigations were made in the EM Laboratory of the Institute of Biophysics of the Biological Research Centre of the Hungarian Academy of Science. Details of the method were published previously (Kedves 1997). In this contribution the following results will be presented:

1. LM and TEM structure of two lignit samples from the following localities: Mohács and Bátaszék. The preservation state of the two lignit samples is quite different. As basic literature the monographies of Greguss were used (1945, 1955, 1967).
2. Spore – pollen data from two Upper Pliocene formation from Transdanubia. Qualitative and quantitative data of the average samples, which were investigated geochemically. The woody fragments were also investigated.

RESULTS

LM AND TEM ANATOMY OF THE SECONDARY WOOD OF TWO LIGNITE SAMPLES

1. ***Sequoioxylon gypsaceum*** (Göppert) Greguss 1967

(Pl. 1, figs 1–12)

Locality: Mohács, Upper Pannonian, brick-works, lower level. (Sample: No 3).

LM anatomy: The secondary wood is carbonified. The annual rings are narrow (Pl. 1, fig. l). The rays are uniseriate and 1–6 cells high. The ray cells are full of reddish-brown resin content (Pl. 1, fig. 2). The bordered pits of the radial wall are arranged in one or in two rows (Pl. 1, fig. 3). In the cross field there are 2–4 taxodioid pits (Pl. 1, fig. 4).

TEM results.

1. Ultrastructure of the non-experimental xylem remnants. (Pl. 1, figs 5–7) The electron density of the superficial parts of the secondary wood are well illustrated. On the surfaces there are granular elements. The secondary wood is finely lamellar.

2. After partial dissolution with diethylamine (Pl. 1, figs 8–10) the different layers of the seconday wood are well shown on the TEM pictures, particularly on fig. 8 of Pl. 1.

S3, S2, are relatively well preserved, the S1 is damaged, and remains of the primary wall were observed, the middle lamella was completely destroyed.

3. Interesting effect happened after partial dissolution with merkaptoethanol (Pl. 1, figs 11, 12). The electron dense stries in the secondary wood may be the remnants of the resinous material.

2. ***Sequoioxylon gypsaceum*** (Göppert) Greguss 1967

(Pl. 2, figs 1–10)

Locality: Bátaszék, Upper Pannonian, layer D-1/B (sample No 10).

LM anatomy: The structure of the secondary wood is altered during the fossilization and compressed. In general the late wood is in more or less in a well preservation state (Pl. 2, fig. 1). The annual ring was definite, in the late wood there are about 4–6-10 seriate thick walled tracheids with narrow lumina. The ray cells are uniseriate and 1–11 cells high (Pl. 2, fig. 2). The bordered pits of the late wood are arranged in one row. In the cross field there are generally two taxodioid pits (Pl. 2, fig. 3).

TEM results

1. Ultrastructure of the non-experimental xylem remnants (Pl. 2, fig. 4) Granular substance with electron dense stries were observed.

2. The ultrastructure of the damaged xylem remnant after partial dissolution with diethylamine (Pl. 2, figs 5, 6) is lamellar. There are very fine and more electron dense lamellae. The electron dense lamellae may be the remnants of the resin content of the longitudinal parenchym.

3. After partial dissolution with merkaptoethanol the TEM structure is in this case similar to the previous one. Interesting is the cross-section of a compressed and degraded tracheid (Pl. 2, fig. 7). The ultrastructure of the longitudinal sections is similar to the previous (Pl. 2, figs 8, 9). Worth of mentioning is a relatively well preserved resin content (Pl. 2, fig. 10).

PALYNOLOGY OF SOME LIGNITE SAMPLES

Tihany Formation

(Pl. 3, figs 1–39, Pl. 4, figs 1–5)

The results of the qualitative data are illustrated on the plates and all of the data of the different taxa and tissue fragments are in the explanation of the plates.

This formation was investigated from two localities:

1. Szombathely, bore hole No II, 712.0–712.7 m.

1.1. Abundant or common sporomorphs (over 10%)

Taxodiaceae-Cupressaceae 10.2
Salix 10.62
Alnus 25.5
Myricaceae 31.4

A mixed swamp forest with Myricaceae shrubs may be presumed.

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*.

2. Iharosberény, sample No 78, 130.1–130.3 m.

2.1. Abundant or common sporomorphs (over 10%)

Taxodiaceae-Cupressaceae 50.8
Myricaceae 16.8

A Taxodiaceae-Cupressaceae swamp forest may be presumed, which followed by Myricaceae shrubs.

2.2. Pollen grains over 5%

Alnus 9.4
Carya 5.1

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

In this sample more or less preserved secondary wood fragments were observed: spirally thickened tracheid (Taxaceae, Cephalotaxaceae, etc., Pl. 4, fig. 1), bordered pitting of degraded tracheids (Pl. 4, fig. 2), cross-fields with pinoide pitting (Pl. 4, fig. 3), Angiosperm, probably Betulaceae vessel (Pl. 4, fig. 4), Salicaceae woody fragment (Pl. 4, fig. 5).

Torony Formation

(Pl. 4, figs 6–16)

Some selected spore-pollen taxa are represented in Pl. 4.

This formation was investigated from one locality (Szombathely, bore hole II, 189.5–189.7 m).

Quantitative data:

Abundant or common forms (over 10%)
Castaneoid types 10.5
Salix 10.5
Alnus 13.8

Sporomorphs, over 5%
Polypodiaceae (*Levigatosporites haardti*) 6.0
Pinus 6.6.
Larix 6.0
Taxodiaceae-Cupressaceae 8.4
Monogemmites pseudosetarius 5.1
Ulmus/*Zelkova* 7.8

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

This association of sporomorphs refer to an open swamp near a mixed forest zone.

CONCLUSIONS

The results presented in this contribution represent part of a multidisciplinary research program. The palaeobotanical part contains the wood anatomy, by the classical and the experimental transmission electronmicroscopical methods of the Neogene lignit samples of Hungary. In this case the degradation process during fossilization is also an important point of view, and the lignit samples of different preservation are partially dissolved with two organic solvents.

On the basis of our up-to-date knowledges the different layers of the secondary wall may be discovered and well represented after partial dissolution with diethylamine. But we have data that in other cases the merkaptoethanol was more succesful in this case.

The aim of the palynological investigations in this case is the establishment of the type of the vegetation which formed the brown coal basin. These results will be evaluated with the geochemical and further geological data at the end of this program.

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P L A T E S

Plate 1

1–12.	*Sequoioxylon gypsaceum* (Göppert) Greguss 1967
1–4.	LM Pictures
1.	Cross section, × 250
2.	Tangential section, × 250
3.	Bordered pits of the radial wall of the tracheids, × 1.000
4.	Cross fields of the radial section, × 1.000
5–12.	TEM pictures
5–7.	Ultrastructure of the non-dissoluted material
5.	Experiment No: T-9-7, negative No: 6800, × 5.000
6.	Experiment No: T-9-7, negative No: 6787, × 5.000
7.	Experiment No: T-9-7, negative No: 6798, × 5.000
8–10.	Partial dissolution with diethylamine
8.	Experiment No: T-9-8, negative No: 6832, × 5.000
9.	Experiment No: T-9-8, negative No: 6886, × 5.000
10.	Experiment No: T-9-8, negative No: 6837, × 15.000
11, 12.	Partial dissolution with merkaptoethanol
11.	Experiment No: T-9-9, negative No: 6809, × 15.000
12.	Experiment No: T-9-9, negative No: 6810, × 50.000

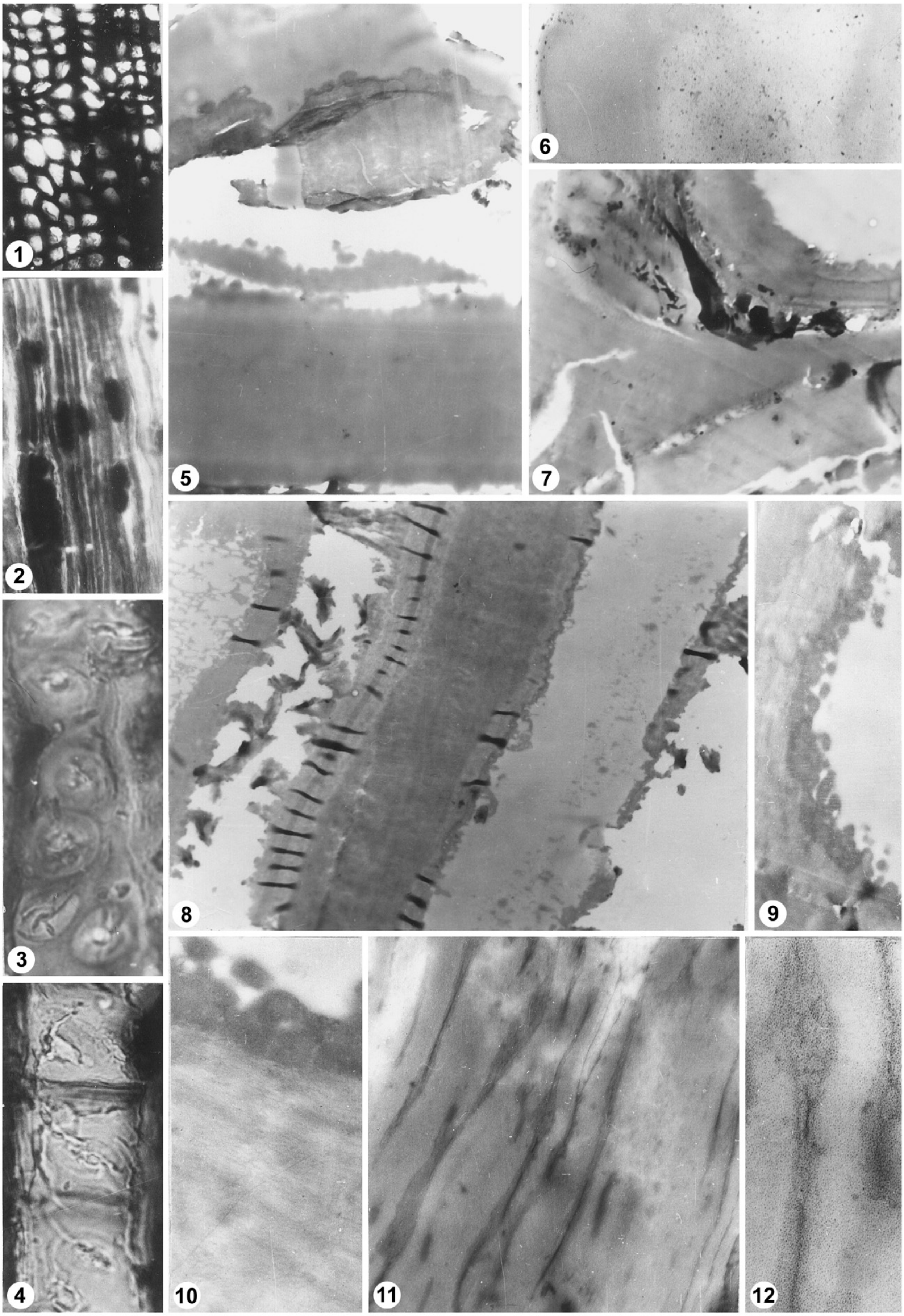
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Plate 2

1–10. *Sequoioxylon gypsaceum* (Göppert) Greguss 1967

1–3. LM pictures. The degradation of the wall structure is well illustrated

1. Cross section × 250

2. Tangential section × 1.000

3. Cross fields of the radial section, × 1.000

4–10. TEM pictures

4. Cross section of the tracheids without dissolution. Experiment No: T-9-10, negative No: 6816, × 50.000

5, 6. Partially degraded lignit remnants dissolved with diethylamine. The electron dense longitudinal lines are in all probability the remnants of the resinous content of the longitudinal parenchym

5. Experiment No: T-9-11, negative No: 6822, × 15.000

6. Experiment No: T-9-11, negative No: 6819, × 15.000

7–10. Partially dissolved xylem remnants with merkaptoethanol

7. Cross section of a compressed and degraded tracheid during the fossilization. Expreiment No: T-9-12, negative No: 6828, × 5.000

8–9. Degraded and more or less homogenised xylem remnants, with resin remnants

8. Experiment No: T-9-12, negative No: 6833, × 5.000

9. Experiment No: T-9-12, negative No: 6834, × 15.000

10. Longitudinal section of the resin remnant, Experiment No: T-9-12, negative No: 6835, × 50.000

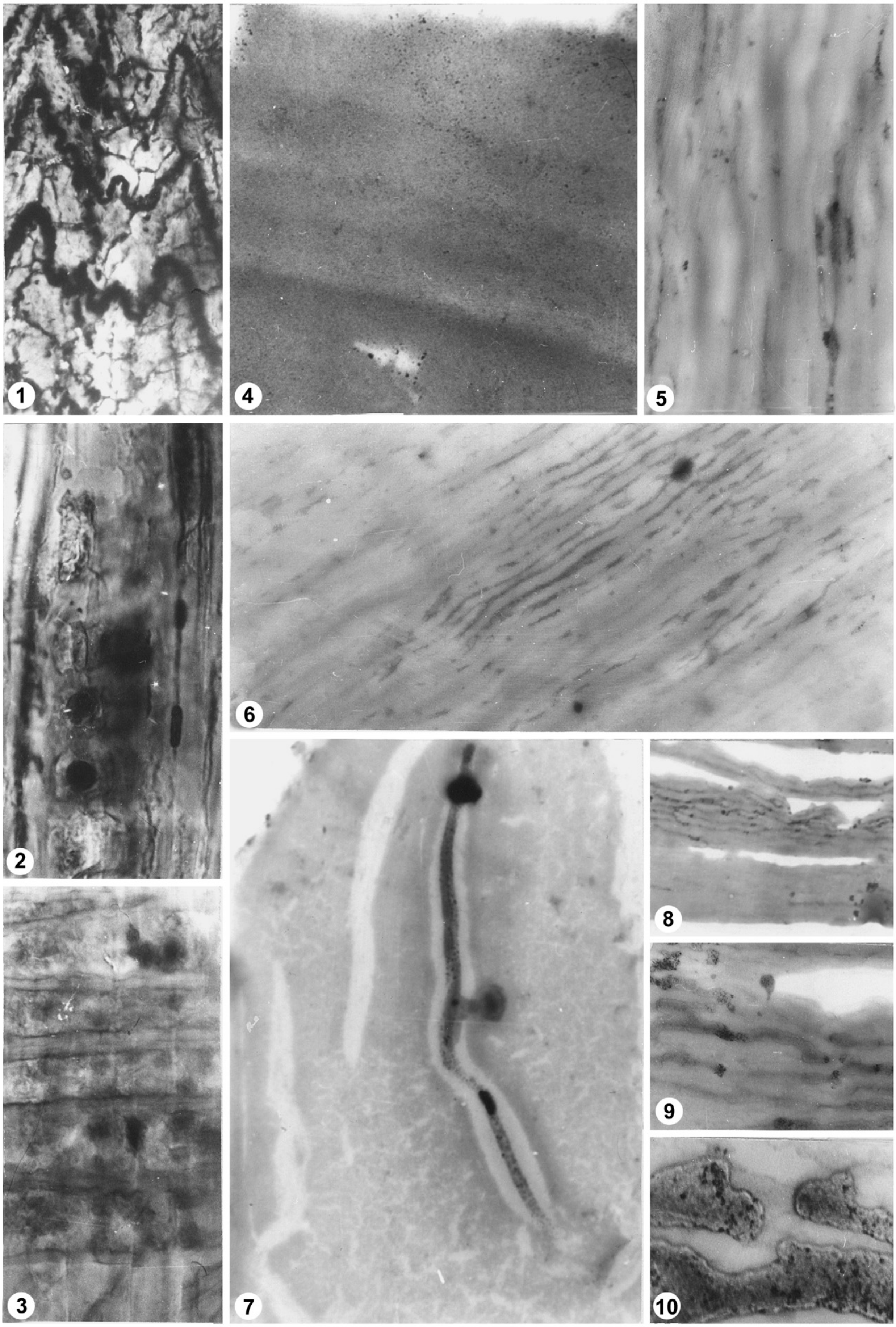
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Plate 3

Palynology of the Tihany Formation

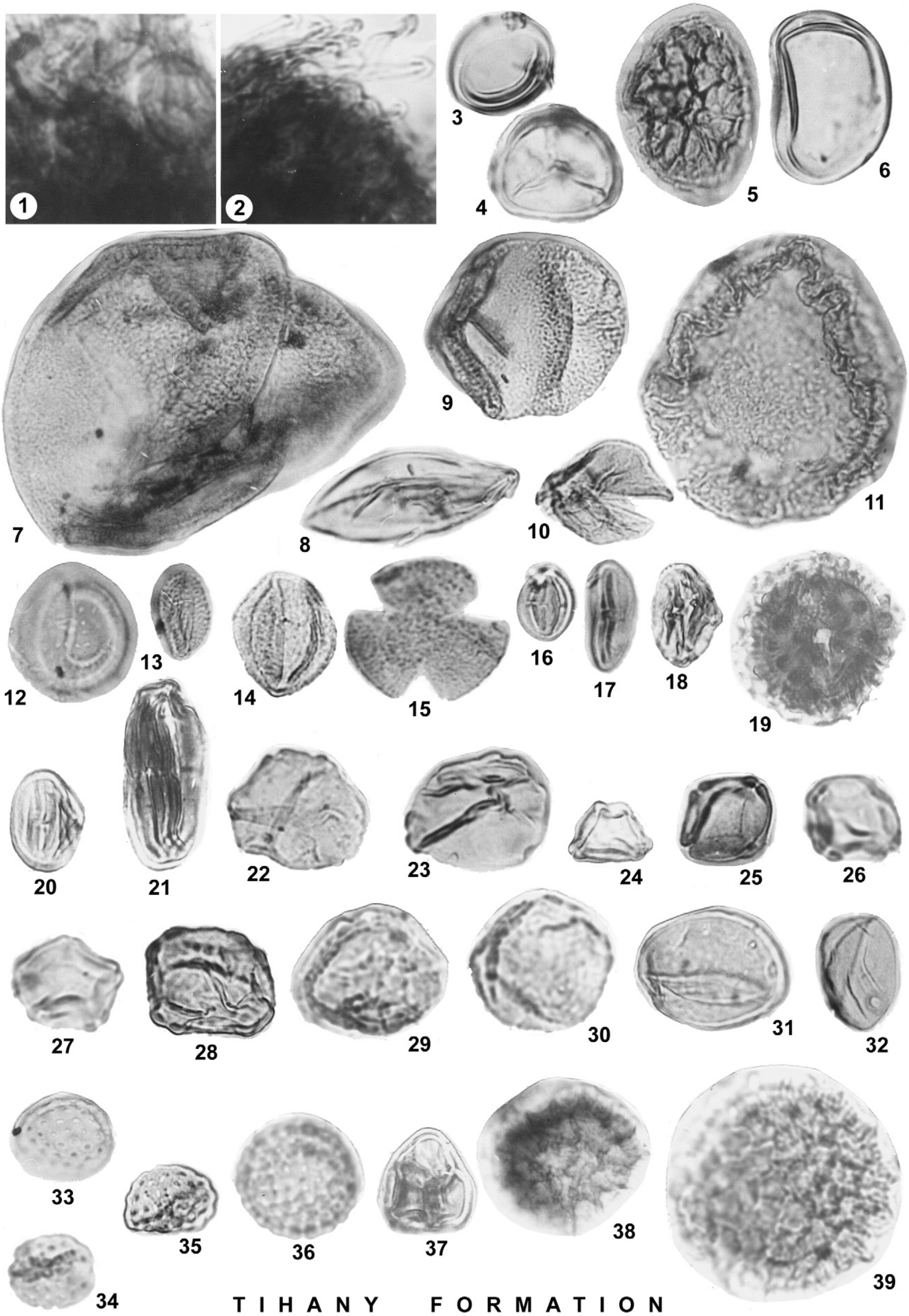
1, 2. *Azolla bohemica* Pacltová 1960
1. Slide: H-1-2, cross-table number: 11.1/151.3
2. Slide: H-1-2, cross-table number: 21.5/141.4
3. *Hydrosporis levis* Krutzsch 1962, *Azolla*, *Salvinia*, slide: H-1-1, cross-table number. 13.1/141.6
4. *Stereisporites* (*Stereisporites*) involutus (Dokt.-Hrebn. 1960) Krutzsch 1963b, Sphagnaceae, slide: H-1-5, cross-table number: 17.3/142.2
5. *Retitriletes punctoides* Krutzsch 1963a, Lycopodiaceae, slide: H-1-1, cross-table number: 21.3/143.8
6. *Laevigatosporites haardti* (R. Potonié et Venitz 1934) Thomson et Pflug 1953 subfsp. haardti, Polypodiaceae, slide: H-1-1, cross-table number: 21.3/143.8
7. *Abiespollenites microsaccoides* Krutzsch 1971, Abietaceae, slide: H-1-1, cross-table number: 14.5/151.9
8. *Cycadopites gracilis* Krutzsch 1970, Cycadaceae, slide: H-1-1, cross-table number: 10.8/147.8
9. *Pityosporites microalatus* (R. Potonié 1931b) Thomson et Pflug 1953, Abietaceae, *Pinus haploxylon* type, slide: H-1-1, cross-table number: 11.6/117.2
10. *Inaperturopollenites hiatus* (R. Potonié 1931b) Thomson et Pflug 1953, Taxodiaceae v. Cupressaceae, slide: H-1-1, cross-table number: 20.2/149.3
11. *Zonalapollenites rueterbergensis* Krutzsch 1971, Tsuga, slide: H-1-5, cross-table number. 7.3/128.1
12. *Monogemmites pseudosetarius* (Weyland et Pflug 1957) Krutzsch 1970, slide: H-1-1, cross-table number: 7.5/146.6
13. *Salixipollenites helveticus* E. Nagy 1969, Salicaceae, *Salix*, slide: H-1-1, cross-table number: 14.5/142.9
14. *Quercopollenites granulatus* E. Nagy 1969, Fagaceae, *Quercus*, slide: H-1-1, cross-table number: 20.6/112.6
15. *Aceripollenites reticulatus* E. Nagy 1969, Aceraceae, *Acer*, slide: H-1-1, cross-table number: 9.5/113.9
16. *Cupuliferoipollenites oviformis* (R. Potonié 1931b) R. Potonié 1960, Fagaceae slide: H-1-1, cross-table number: 15.3/146.9
17. *Cupuliferoipollenites pusillus* (R. Potonié 1934) R. Potonié 1960, Fagaceae, slide: H-1-1, cross-table number: 9.9/110.4
18. *Fususpollenites fusus* (R. Potonié 1934) Kedves 1978, Fagaceae, slide: H-1-1, cross-table number: 7.4/138.3
19. *Tubulifloridites* fsp., Asteraceae, Tubuliflorae, slide: H-1-5, cross-table number: 24.6/130.8
20. *Tetracolporopollenites biconus* Pflug 1953, Sapotaceae, slide: H-1-1, cross-table number: 18.9/121.9
21. *Sapotaceoidaepollenites turgidus* E. Nagy 1964, Sapotaceae, slide: H-1-5, cross-table number: 8.6/120.3
22. cf. *Pterocaryapollenites stellatus* (R. Potonié et Venitz 1934) Thiergart 1937, Juglandaceae, *Pterocarya*, slide: H-1-1, cross-table number: 9.9/110.4
23. *Alabroidaepollenites myricoides* (Kremp 1949) Kedves et Russell 1982, Myricaceae, slide. H-1-1, cross-table number: 14.6/116.8
24. *Betulaepollenites betuloides* (Pflug 1953) E. Nagy 1964, Betulaceae, *Betula*, slide: H-1-5, cross-table number: 13.9/142.6

25–27. *Alnipollenites verus* R. Potonié 1934, Betulaceae, *Alnus*
25. slide: H-1-1, cross-table number: 8.4/151.2
26. slide: H-1-2, cross-table number: 8.6/142.1
27. slide: H-1-2, cross-table number: 20.4/146.9
28. *Zelkovapollenites thiergarti* E. Nagy 1969, Ulmaceae, *Zelkova*, slide: H-1-1, cross-table number: 22.3/15515

29, 30. *Ulmipollenites undulosus* Wolff 1934, Ulmaceae, *Ulmus*
29. slide. H-1-2, cross-table number: 12.3/139.1
30. slide: H-1-2, cross-table number: 6.6/154.6
31. *Celtipollenites komloensis* E. Nagy 1969, *Celtis*, slide: H-1-1, cross-table number: 17.7/112.1
32. *Graminidites laevigatus* Krutzsch 1970, Poaceae, slide: H-1-1, cross-table number: 17.8/141.6

33–35. *Chenopodiipollis psilatoides* (Trevisan 1967) Kedves 1981, Chenopodiaceae
33. slide: H-1-5, cross-table number: 16.4/149.3
34. slide: H-1-2, cross-table number: 11.1/132.3
35. slide: H-1-1, cross-table number: 109/151.7
36. *Chenopodiipollis multiforaminatus* (Trevisan 1967) Kedves 1981, Chenopodiaceae, H-1-2, cross-table number: 16.3/151.3
37. *Ericipites callidus* (R. Potonié 1931b) Krutzsch 1970, Ericaceae, slide: H-1-1, cross-table number: 17.9/109.7
38. *Persicarioipollenites minor* Krutzsch 1962, Polygonaceae, *Polygonum persicaria* type, slide: H-1-1, cross-table number: 9.5/113.9
39. *Persicarioipollis crassicus* Krutzsch 1962, Polygonaceae, *Polygonum persicaria* type, slide: H-1-2, cross-table number: 7.9/158.1

× 1.000

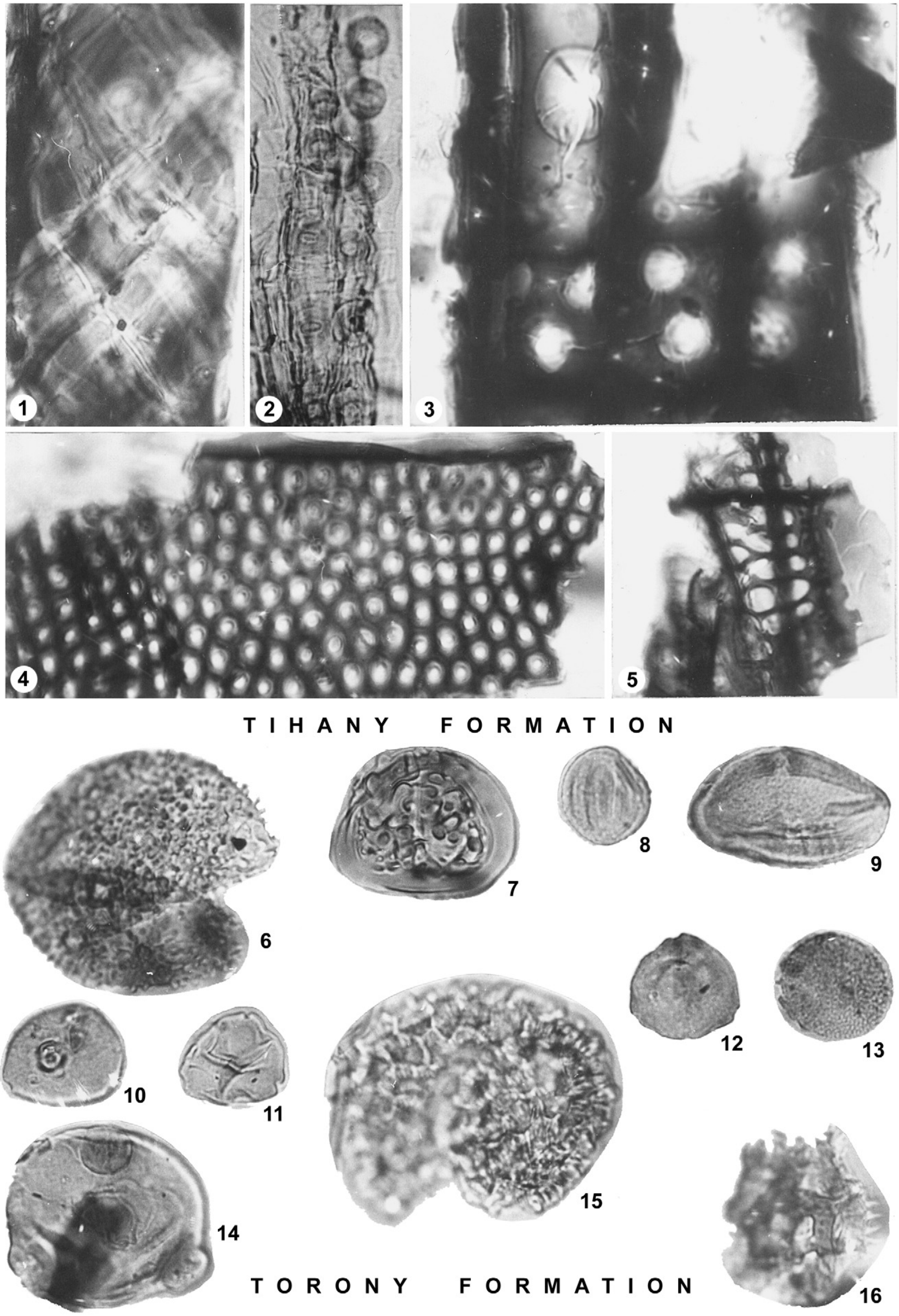


TIHANY FORMATION

Plate 4

1. Spirally thickened tracheid, slide: H-1-1, cross-table number: 20.2/144.9
2. Radial wall of degraded tracheids; the bordered pits are well shown slide: H-1-1, cross-table number: 18.2/144.9
3. *Pinuxylon* fsp., fragment of tracheids and cross fields, slide: H-1-2, cross-table number: 21.9/148.4
4. cf. *Alnus*, vessel fragment, the tiny bordered pits are closely attached to each other, slide: H-1-1, cross-table number: 11.5/154.3
5. cf. *Salix* xylem fragment, slide: H-1-1, cross-table number: 12.6/147.0
6. *Baculatisporites primarius* (Wolff 1934) Thomson & Pflug 1953 subfsp. *primarius*, Osmundaceae, slide: H-2-2, crpss-table number: 18.2/146.3
7. *Polypodiaceoisporites gracillimus* E. Bagy 1963b subfsp. *granoverrucatus* Krutzsch, Pteridaceae, slide: H-2-4, cross-table number: 14.4/151.2
8. *Retitricolporites nagyae* Kedves 1978, Adoxaceae, slide: H-2-4, cross-table number. 14,4/140.2
9. *Dipterocarpacearumpollenites spinosus* E. Nagy 1969, cf. Dipterocarpaceae, slide: H-2-5, cross-table number. 14.4/136.1
10. *Triporopollenites coryloides* Pflug 1953, Corylaceae, slide: H-2-1, cross-table number: 13.2/111.4
11. *Plicatopollis* fsp., Juglandaceae, slide: H-2-1, crpss-table number: 8.6/138.3
12. *Labraferoidaepollenites rurensis* (Pflug & Thomson 1953) Kedves & Russell 1982, Myricaceae, slide: H-2-2, cross-table number. 14.6/143.8
13. *Thymelipollis retisculpturius* Krutzsch 1966, Thymeleaceae, slide: H-2-1, cross-table number: 22.1/129.9
14. *Corsinipollenites oculus-noctis* (Thiergart 1940) Nakoman 1965 subfsp. parvus Doktorovic-Hrebnicka, Onagraceae, slide: H-2-1, cross-table number. 25.6/125.2
15. *Persicarioipolis crassicus* Krutzsch 1962, Polygonaceae, *Polygonum persicaria* type, slide. H-2-2, cross-table number. 23.4/120.3
16. *Cichoreacidites gracilis* (E. Nagy 1969) n. comb., Compositae, Liguliflorae, slide: 23,4/120.3

× 1.000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