4. LM AND TEM INVESTIGATIONS ON THE UPPER CRETACEOUS AJKAITE OF HUNGARY II.

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Abstract

This paper presents the LM morphology of the woody remnants of the amber containing brown coal samples and the ultrastructure of a peculiar fossil *angiosperm* pollen grain. Based on the xylem remnants *Pteridophyta, Cycadophyta, Coniferophytina*, ancient *dicotyledonous* taxa and *Palmae* may be presumed. Among the *Coniferophytina* it is worth mentioning the lack of the *Araucariaceae* tracheids, because of the presence of the *Araucariaceae* pollen grains in the samples. The amber in the *dicotyledonous* vessel is evidence of the *angiosperm* origin of the Ajkaite. The perforation type of the vessel is printed in the fossil resin remnant. This kind of vessel occurs in the Cretaceous and at the *Magnoliaceae*, and particularly in the *Amentiflorae*. The new TEM data, which are concerning the genus *Complexiopollis* KRUTZSCH 1959 em. TSCHUDY 1973, are different from the previously published ones. In the investigated specimen the protoplasm was not preserved.

Key words: Plant microfossils, LM, TEM, Upper Cretaceous, Ajkaite.

Introduction

In our previous paper the aim of our investigations was published (KEDVES, SZÓNOKY, MADARÁSZ and KOVÁCS, 2000). In this paper the program of this kind of research is just shortly summarized. The importance of the LM structure of the secondary xylem elements in the Ajkaite containing brown coal such as in the reconstruction of the "amber tree" was emphasized. The aim of this part of investigation is to get some information for the origin of the Ajkaite producing tree. The "partial xylotomy" namely the presence of the woody fragments in the palynological assemblage was used previously in several papers, e.g.: ZANDER (1923), WILSON (1971), SCHRANK (1984), DUTTA, BHUYAN and KUMAR (1998), KHANDEVAL ASGA and GUPTA (1994), etc. The TEM data of *Complexiopollenites* pollen grain is included in the program of our studies on the protoplasm of the fossil spore and pollen taxa, but till this time has not been succesful. But the ultrastructure of the exine is a peculiar type within the *Complexiopollis* genus.

Materials and Methods

The data of the two Ajkaite containing coal samples were published in the previously mentioned paper. For the present LM investigations 25 slides were investigated from each sample. Different kinds of xylem remnants were investigated statistically. The epidermis fragments were noticed without nearer determination.

For ultrastructure investigations the amber was ultrathin sectioned in this way without any fixation, in natur of condition. The pictures were taken in the EM Laboratory of the Department of Biophysics of the Biological Research Center of the Hungarian Academy of Sciences on a Tesla BS-540 instrument (resolution 6-7 Å).

Results

1. LM results

Sample	KG-99	SZM-99
Number of the observed plant tissue remnants:	1543	1933
Number of the secondary xylem and resinous remnants:	208	152
Number of the epidermis remnants:	1335	1781

Types of the different secondary xylem remnants

Cycadopsida, Pteridophyta or *Palmales* remnants

Type A. Scalariform thickenings of tracheids (Plate 4.1., figs. 1-3).

Fig. 1. - The lumen of the tracheids are 11-38 μm. GREGUSS (1968) in his monograph on the Xylotomy of the living *Cycads* compared this type with the vessel of palms and the branched scalariform thickenings of *Sigillaria*. Among the recent *Cycadales* the genus of *Microcycas* was pointed out. Similar structures were published in this monographs at the following species: *Cycas circinalis* L., *Stangeria paradoxa* TH. MOORE, *Macrozamia macdonnelli* (F. MUELL.) A.DC., *Microcycas calocoma* (MIQ.) A.DC., *Ceratozamia mexicana* BRONGN., *Zamia angustifolia* (JACQ.) SCHUSTER, *Z. floridana* A.DC., *Z. gutierrezi* SAUVALLE, *Z. obidensis* DUCKE, *Z. portoricensis* URBAN, *Z. pumila* L., *Z. silicea* BRITTON. GREGUSS (1969) described the *Palmoxylon dorogense* with similar tracheid thickenings. Figs. 2,3. - Similar to the previous one, but the elements are narrower; *Encephalartos barteri* CARRUTHERS, *E. septentrionalis* SCHWEINF., *E. villosus* (GAERTN.) LEMAIRE, *Dioon edule* LINDL., *D. spinulosum* DYER. Similar tracheids were published by STROTHER and TRAVERSE (1979) from Silurian rocks from Pennsylvania, U.S.A.

Type B. Scalariform thickenings of tracheids sometimes with areolate pits (Plate 4.1., figs. 4-6).

Type C. Similar to Type B, but the elements of the scalariform thickenings are rare (Plate 4.1., figs. 7-9).

Gymnospermatophyta, Coniferophytina remnants

Type D. Fibre tracheid (Plate 4.1., fig. 10).

Type E Areolate, bordered pits of slit-like type (Plate 4.1., figs. 11,12). - In the book of GREGUSS (1955) this kind of bordered pit occurs at the following recent taxa: *Austrotaxus spicarus* COMPT., *Phyllocladus trichomanoides* D. DON., *Podocarpus macrophyllus* D. DON., *Callitropsis araucarioides* COMPT. Further data were published by GREGUSS (1972): *Dacrydium falciforme* PILGER, *D. intermedium* T. KIRK, *D. westlandicum* T. KIRK, *Podocarpus nubigenus* LINDLEY, *P. pilgeri* FOXW., *P. sellowii* KLOTZSCH, *P. ustus* BRONGN. and GRIS.

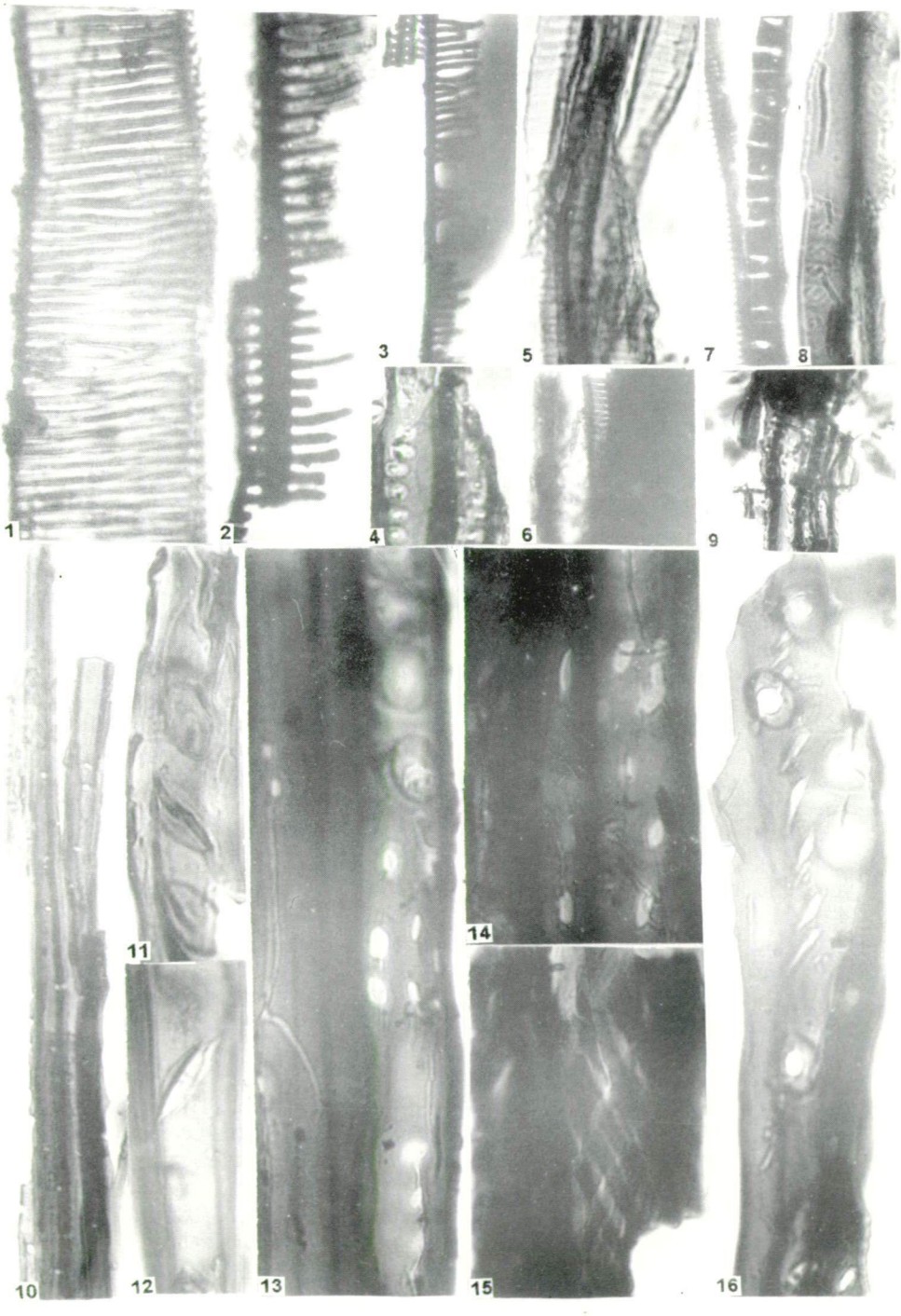

Plate 4.1.

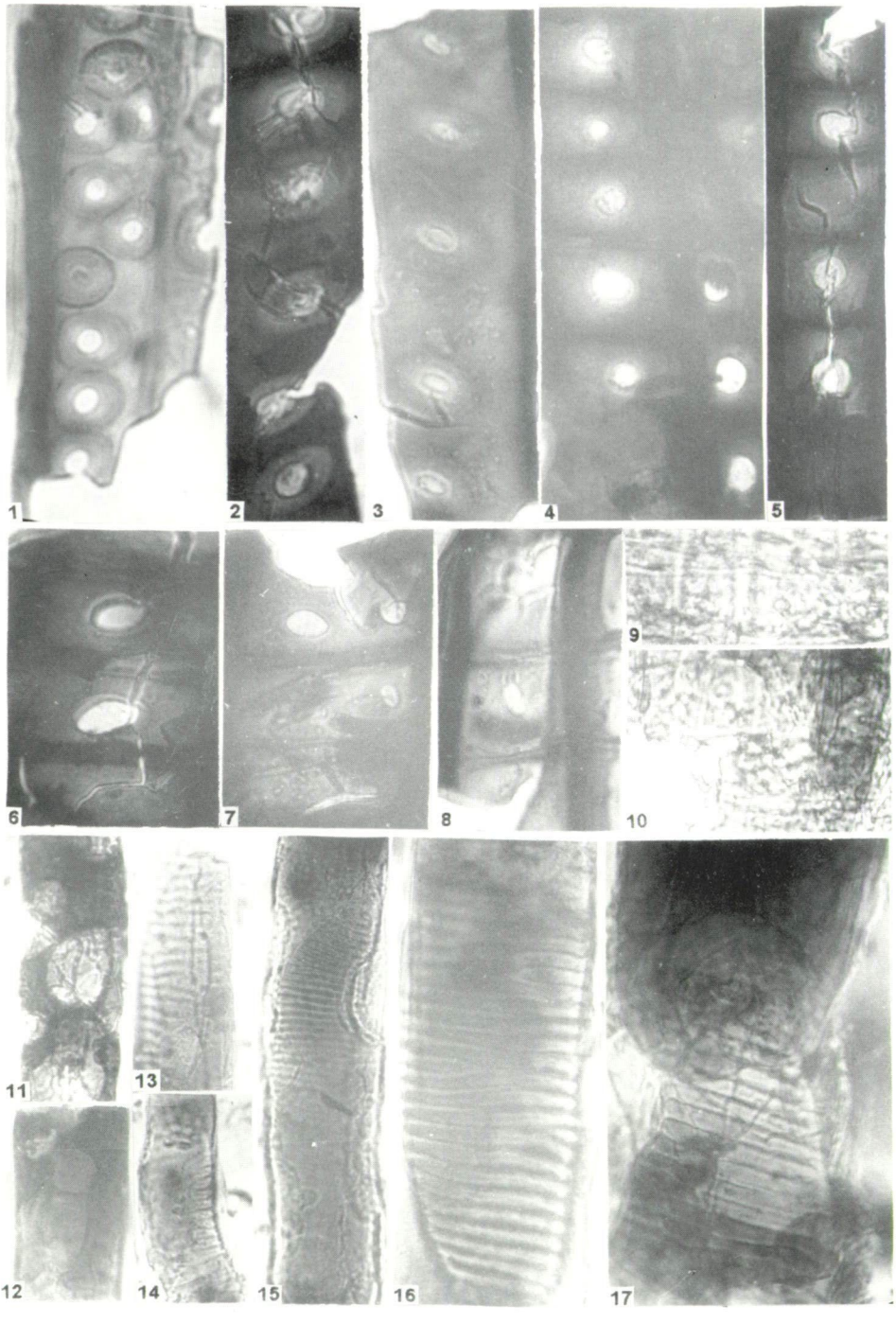

Plate 4.2.

Plate 4.1.

1 - 3. Type A; 1. slide: KG-99-11, cross-table number: 13.8/138.2 670x, 2. slide: KG-99-18, cross-table number: 24.0/127.7 670x, 3. slide: KG-99-18, cross-table number: 24.0/127.7 335x.
4 - 6. Type B; 4. slide: KG-99-11, cross-table number: 22.2/137.3 670x, 5. slide: KG-99-14, cross-table number: 18.4/129.8 670x, 6. slide: KG-99-11, cross-table number: 10.1/142.2 335x.
7 - 9. Type C; 7. slide: KG-99-15, cross-table number: 13.3/140.1 335x, 8. slide: KG-99-21, cross-table number: 19.6/140.0 670x, 9. slide: KG-99-10, cross-table number: 14.2/126.8 335x.
10. Type D; slide: KG-99-15, cross-table number: 12.3/130.6 670x.
11,12. Type E; 11. slide: SzM-99-8, cross-table number: 22.9/138.1 670x, 12. slide: SzM-99-12, cross-table number: 15.3/133.4 670x.
13,14. Type F; 13. slide: KG-99-14, cross-table number: 24.7/139.5 670x, 14. slide: KG-99-9, cross-table number: 8.4/126.7 670x.
15. Type G; slide: SzM-99-12, cross-table number: 11.5/140.2 670x.
16. Type H; slide: KG-99-12, cross-table number: 17.1/125.1 670x.

Plate 4.2.

1 - 5. Type H; 1. slide: KG-99-17, cross-table number: 22.2/135.8, 670x, 2. slide: KG-99-14, cross-table number: 14.4/133.8, 670x, 3. slide: KG-99-7, cross-table number: 25.8/145.4, 670x, 4. slide: KG-99-7, cross-table number: 11.3/139.3, 670x, 5. slide: KG-99-13, cross-table number: 19.7/136.5, 670x.
6 - 8. Type I; 6. slide: KG-99-14, cross-table number: 7.8/140.8, 670x, 7. slide: KG-99-24, cross-table number: 24.5/134.5, 670x, 8. slide: KG-99-13, cross-table number: 15.8/138.8, 670x.
9, 10. Type J; slide: SzM-99-12, cross-table number: 24,8/124.4, 670x.
11, 12. Type K; 11. slide: SzM-99-9, cross-table number: 17.9/140.8, 335x, 12. slide: SzM-99-13, cross-table number: 18.6/137.8, 335x.
13 - 17. Type L; 13. slide: SzM-99-18, cross-table number: 11.9/125.7, 335x, 14. slide: SzM-99-6, cross-table number: 15.2/136.3, 335x, 15. slide: SzM-99-5, cross-table number: 24.3/126.4, 335x, 16. slide: SzM-99-14, cross-table number: 11.7/128.7 670x, 17. slide: SzM-99-14, cross-table number: 19.7/139.9, 335x.

Type F. Areolate, bordered pits of modern type with cross fields pits (Plate 4.1., figs. 13,14). Probably *Podocarpaceae* (GREGUSS,1955, 1958), it is some similarity with the fusit remnants published by GREGUSS (1948) from the Upper Cretaceous brown-coal layers of Ajka and with *Podocarpoxylon svanidzei* BARALE, JACOBIDZE, LEBANIDZE and PHILLIPPE (1991), from the Bathonian coal formation of West Georgia.

Type G. Tracheid fragment of spiral thickenings (Plate 4.1., fig. 15). - An early type, probably reworked or their spiral thickenings are secondary characters during the fossilization processes. From the Permian layers GREGUSS (1961) described the *Platyspiroxylon heteroparenchymatosum* with similar or identical thickenings.

Type H. Tracheids with areolate, bordered pits of modern type (Plate 4.1., fig. 16, plate 4.2., figs. 1-5). From the Upper Cretaceous layers of Egypt this kind of areolate thickening was published by SCHRANK (1984). Based on the monograph of GREGUSS (1955) a great number species from the following family has similar anatomical characteristics: *Podocarpaceae, Cupressaceae, Taxodiaceae, Pinaceae.*

Type I. Cross fields of *taxodioid* or *podocarpoid* pitting (Plate 4.2., figs 6-8).

Type J. Cross fields of *cupressoid* pitting (Plate 4.2., fig. 9,10).

Type K. Resinous remnants with bubbles, probably of *taxodioid* origin (Plate 4.2., figs. 11,12).

Type L. Resinous remnant with the pattern of scalariform vessel perforation (Plate 4.2., figs. 13-17). - Based on the book of GREGUSS (1945) on the wood anatomy Cen-

tral European *Dicotyledonous* trees and shrubs, this kind of xylem remnant occurs at the following recent taxa: *Betula humilis* SCHRANK., *B. nana* L., *B. pendula* ROTH., *B. pubescens* EHRH., *Alnus incana* (L.) MOENCH., *A. glutinosa* (L.) GAERTN., *A. viridis* (CHAIX) LAM. et D.C., *Corylus avellana* L., *C. maxima* MILL., *Myrica gale* L., *Buxus sempervirens* L., *Hamamelis virginiana* L., *Cercidiphyllum japonicum* S. et Z., *Platanus orientalis* L., *Magnolia acuminata* L., *Liriodendron tulipifera* L., *Philadelphus coronarius* L., *Ribes uva-crispa* L., *R. alpinum* L., *R. silvestre* MEST. et KOCH., *Tilia platyphyllos* SCOP., *T. americana* L., *Acer platanoides* L., *Ilex aquifolium* L.,*Vitis vinifera* L., *Cornus mas* L., *C. sanquinea* L., *Rhododendron kotschyi* SIMK., *R. hirsutum* L., *Rhodothamnus chamaecistus* (L.) RCHB., *Loiseleuria procumbens* (L.) DESV., *Ledum palustre* L., *Andromeda polifolia* L., *Erica tetralix* L., *Vaccinium myrtillus* L., *V. uliginosum* L., *V. oxycoccus* L., *Chamaedaphne calyculata* (L.) MOENCH., *Empetrum nigrum* L., *Viburnum opulus* L., *V. lantana* L., *Linnaea borealis* L. In the monograph of the Tertiary *angiosperm* woods in Hungary similar or identical vessel perforations were published by GREGUSS (1969): *Palmoxylon sabaloides* GREGUSS 1954, *Liquidambaroxylon weylandii* GREGUSS 1969, *L. horváthi* GREGUSS 1969, *L. mägdefraui* GREGUSS 1969, *L.* cf. *speciosum* FÉLIX 1884, *L. cf. styraciflua*, *Ilioxylon theresiae* GREGUSS 1969, *I.* cf. *aquifolium* (HOFMANN 1939) GREGUSS 1943a, *Citronella* cf. *mucronata* D. DON., *Icacinoxylon citronelloides* SHILK. 1958, *I.* cf. *citronelloides* SHILK. 1958), *I. cf. goderdzicum* SHILK. 1958, *I. hortobágyii* GREGUSS 1969, *I. laticiphorum* GREGUSS 1969, *I. crystallophorum* GREGUSS 1969, *I. shilkinae* GREGUSS 1969, *I. sylvaticum* (TUZSON 1906) GREGUSS 1969, *Alnus* sp., *Euphorbioxylon secretiphorum* GREGUSS 1969, *Fraxinoxylon* cf. *Fraxinus excelsior* L. ANDREÁNSZKY (1955).

The quantitative data of the different xylem remnants are summarized as follows.

Types	Sample 1	Sample 2
	KG-99	*SZM-99*
A	6	2
B	10	-
C	4	-
D	6	-
E	14	4
F	2	-
G	-	1
H	152	64
I	6	2
J	-	1
K	-	2
L	7	36

The analogies and the differences are well shown in the quantitative data of the woody remnants in the two different sample. The occurrence of scalariform vessel remnants (Type L) is important in the 2nd sample.

Plate 4.3.

Plate 4.3.

1,2. Ultrastructure of the exine of a *Complexiopollis* fsp. from the Ajkaite.
1. Block number: KG-03, negative number: 8463, 10.000x.
2. Block number: KG-03, negative number: 8964, 25.000x.

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2. TEM results

During our investigations we observed an interesting exinous remnant from the genus *Complexiopollis* W. KR. 1959 em. TSCHUDY 1973 (Plate 4.3., figs. 1,2).

The plane of the sectioning was near the apertures. Tectum is thin imperforate. In the inter-apertural area the infratectum is composed of more or less globular sometimes anastomosing elements. This layer is followed by a large in all probably another infratectal layer similar to the *Cycadaceous* radially oriented alveolar structure. A thin foot layer is beneath the infratectum. As regards the apertural area our data are not complete. Some lamellar or irregular apertural elements are present. Endexine was not observed. The infratectum is in this area also two layered, but the outer layer is not granular, it is irregular or alveolar. The inner layer seems to be fragmented.

Discussion and Conclusions

1. Based on the fragmented xylotomical data the following may be emphasized:

1.1. Pollen grains of *Araucariaceae* occurred in the coal samples, but xylotomical data was not found for this family.

1.2. *Podocarpaceae* is probably by the xylotomical data but pollen grains of *Podocarpaceae* has not been found till this time.

1.3. *Taxodiaceae, Cupressaceae* and *Pinaceae* remnants are probably based on the palynological and xylotomical data.

1.4. *Pteridophyta* spores and tissue remnants are present, but the *Cycadaceae* and *Palmae* are also probably based on the xylem remnants.

1.5. In all probability the origin of the Ajkaite is a *Dicotyledonous* wood, of extinct *Amentiflorae*, which is represented by the great quantity of *Normapolles* taxa in the brown coal of Ajka. The scalariform vessel perforation is extremely frequent in the Cretaceous time based on the work of HERENDEN, WHEELER and BAAS (1999). From the recent taxa *Magnoliaceae, Degeneriaceae, Eupomatiaceae, Illiciaceae, Austrobaileyaceae, Trimeniaceae* and *Chloranthaceae* are worth mentioning.

2. The transmission electronmicroscopical results are peculiar taking into consideration the previous ultrastructural data in this subject. The first data on the *Complexiopollis praeatumescens* KRUTZSCH 1959 was published by HEGEDÜS, KEDVES and PÁRDUTZ (1971,1972, KEDVES 1990). Further TEM data of this form-genus - *C. vancampoae* DINIZ, KEDVES and SIMONCSICS 1977, *C. helmigii* (VAN AMEROM 1965) SOLÉ DE PORTA 1978 were published by KEDVES and PÁRDUTZ (1982). Endexine, lamellar foot layer were described in the apertural area, and the apertural infratectal layer is more or less granular. In the inter-apertural area the infratectal layer is columellar.

In our new TEM data we need to point out the following:

2.1. No endexine in the apertural area.

2.2. The apertural infratectal layer is irregular or alveolar. Lamellar foot layer is present.

2.3. The two kinds of infratectal layer (granular and alveolar) in the inter-apertural area was the first presented in the *Normapolles* taxa. The granular infratectum is characteristic to the *Amentiflorae*, the inner layer of *Gymnosperm, cycadaceous* affinity. In contrast to the previously mentioned taxa of the form-genus *Complexiopollis* KRUTZSCH 1959 emend TSCHUDY 1973, the granular infratectum is characteristic to the apertural area, and the inter-apertural infratectum is columellar. In this way this new TEM data is unusual and peculiar.

Finally the xylotomical and the TEM data of the *Normapolles* exines reveals to the *Amentiflorae* concerning the "amber tree" of the Upper Cretaceous Ajkaite.

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