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**"Die Mikroflora der untermiozänen Fundstelle Altmittweida,
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ABSTRACT

This thesis is about the microflora of the fossil plant bearing site of Altmittweida (Saxony, Germany). Altmittweida was stratigraphically dated and is of Lower Miocene age. Hitherto studies focused on the macrofossil record of this and surrounding sites. Up to now, the reconstruction of the flora of the Upper Oligocene and the Lower Miocene consists of lacustrine and marsh plant assemblages, riparian and fen woods as well as mesophytic forests. The microfossil assemblage shows much greater diversity in comparison to the macrofossil record. The results of this study lead to a comprehensive checklist of the flora, which is composed of: 57 angiosperm and three gymnosperm pollen taxa. Additionally, five spore types were found, four belonging to ferns and one moss determined on genus-level.

The macrofossil record of surrounding sites includes taxa, that were unknown from Altmittweida. Now, they could be detected in the microfossil assemblage. Further, there is evidence for taxa hitherto unknown from the macrofossil record. Surprisingly, a finding indicates the presence of Cucurbitaceae in the Lower Miocene of Europe. Early proves for the genus *Fagus* are now also known from the microflora of Altmittweida. The results confirm, that the analysis of the microfossil record of a site enriches and adds to the knowledge of the vegetation at that time.

ZUSAMMENFASSUNG

Diese Arbeit berichtet über die Mikroflora der Pflanzenfundstelle Altmittweida (Sachsen, Deutschland). Altmittweida wird stratigraphisch in das Untermiozän gestellt. Bisherige Studien haben sich mit den Makrofossilien aus dieser und umliegenden Fundstellen beschäftigt. Darauf basierend wurden Wasser- und Sumpfpflanzengesellschaften, Bruch- und Auenwälder und mesophytische Wälder als Flora des Oberoligozäns und Untermiozäns rekonstruiert.

Im Vergleich zu den bisher nachgewiesenen Makrofossilien zeigt die Mikroflora-vergesellschaftung eine wesentlich höhere Diversität. Die Ergebnisse der Untersuchung der Mikroflora von Altmittweida führte zu einer umfangreichen Florenliste bestehend aus: 57 Angiospermen und drei Gymnospermen Pollentaxa. Zusätzlich wurden fünf verschiedene Sporentypen verzeichnet, vier Farntaxa und eine Moosgattung.

Im Makrofossilrekord umliegender Fundstellen treten einige Pflanzen auf, die zuvor aus der Fundstelle Altmittweida unbekannt waren, sich nun aber im Mikrofossilbefund nachweisen lassen. Zusätzlich treten einige Taxa auf, die nur im Mikrofossilrekord nachweisbar sind. Interessant ist der Nachweis einer Cucurbitaceae aus dem Untermiozän Europas. Frühe Nachweise der Gattung *Fagus* sind nun auch im Mikrofossilrekord Altmittweidas bestätigt. Es bestätigt sich erneut, dass durch eine zusätzliche, detaillierte Analyse der Mikroflora eines Fundortes, die Kenntnis der damals vorherrschende Vegetation erweitert und vervollständigt werden kann.

INTRODUCTION

The analysis of fossil pollen grains is an important part of the reconstruction of environments in the past. The record of pollen gives additional information of occurring taxa in a site: like in the case of herbaceous plants (herbs and shrubs), which are hardly ever found as macrofossils (as leaves, stems, seeds or flowers), but are frequently found in the microfossil assemblage.

In this study, the microfossil record of Altmittweida (Saxony, Germany) was analysed for the first time. Altmittweida is a small village in the administrative district of central Saxony and located about 63 kilometres southeast of Leipzig (Figure 1). This site was described together with another one, the site Frankenau. Thus, it is presented as Altmittweida-Frankenau in Mai and Walther (1991). However, Altmittweida as macrofossil bearing site is known since Engelhardt (1870).



Fig. 1. Map of plant fossil sites of Saxony, Germany (MAI and WALTHER, 1991)

The sediment of the site is composed of xylic brown coal, paper coal and clays. The age is dated to be upper Oligocene to lower Miocene. However, the sites of Mittweida consist mainly of erosion residuals of the Cottbus- and Spremberg- Formation (ESCHER et al., 1998-2002) and of parts of the Bitterfeld Seams (EISSMANN, 2002) (Figure 2 and Figure 3). The greatest thickness of the sediment is occurring in Frankenau with a height of 45 meters (MAI and WALTHER, 1991).

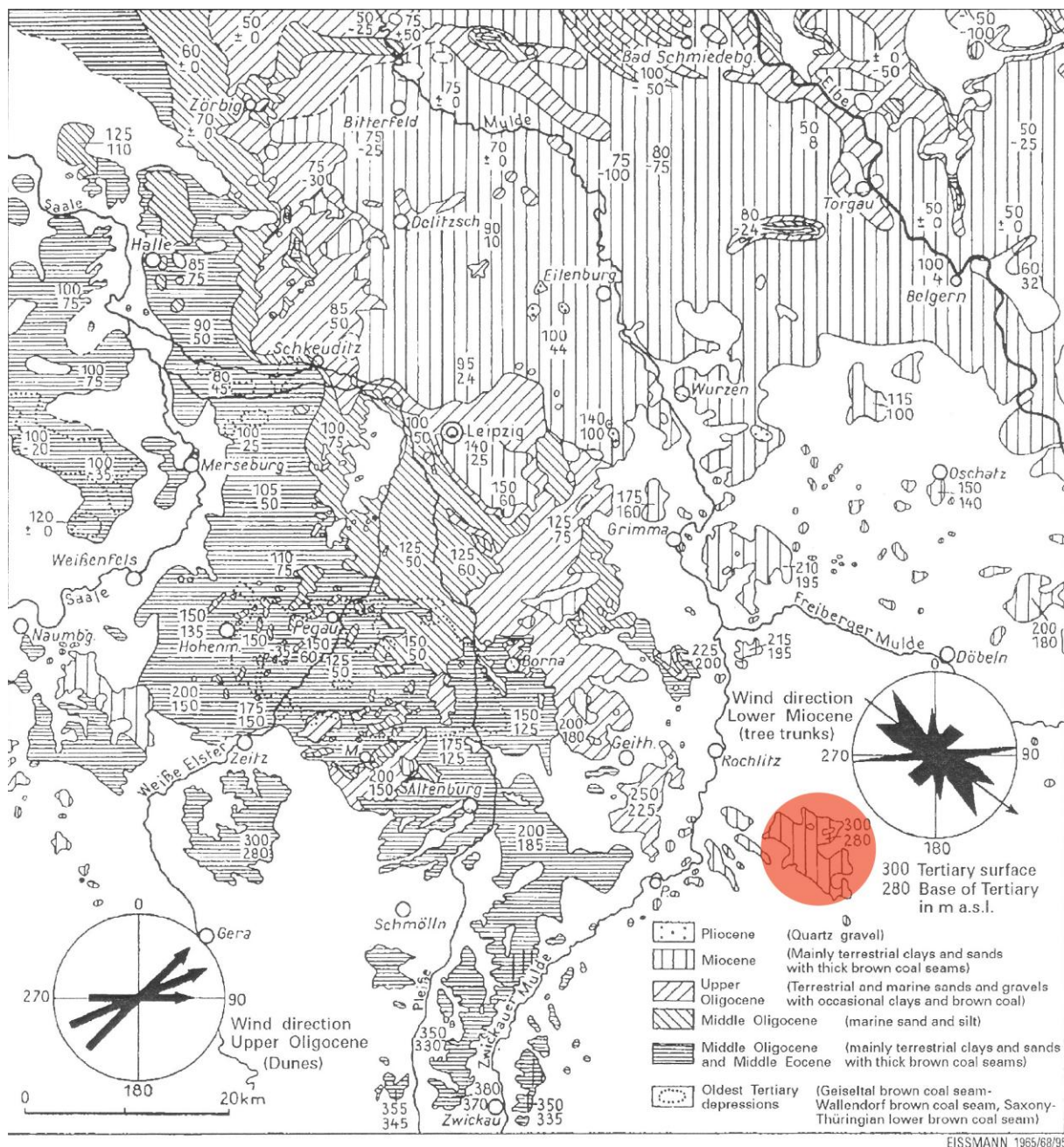
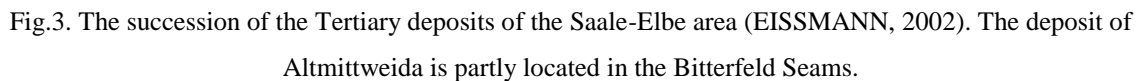


Fig.2. Map of the Tertiary deposits of the Saale-Elbe area (EISSMANN, 2002). Altmittweida is located in the red colored region.



The hitherto picture of this region at the time of the lower Miocene, based on the macrofossil record, was: 1) a flora composed of mesophile riparian and summergreen forests with laurophyll elements; 2) a similar flora as already known from northern Bohemia (Most-Chomutov-Teplice basin, Czech Republic); 3) frequent occurrence of tropical and subtropical elements like *Calamus* and *Symplocos*; 4) other main elements are: *Myrica*, *Quercus*, *Acer*, *Fraxinus*, *Alnus*, *Ulmus*, *Liquidambar*, *Laurophyllum*, *Trapa* and Juglandaceae like *Carya*, *Cyclocarya* and *Juglans*.

The microfossil record was hitherto not known from Altmittweida, but from a near site: Bockwitz. Walther and Zetter (1993) analysed macrofossils and fossil pollen grains from Bockwitz, but excluded all taxa except for Fagaceae. Some aspects of the microfossil record of another near site, the site of Cospuden (although of middle Oligocene age), are known too (DENK et al., in press).

MATERIAL AND METHODS

The material for this analysis was collected by Prof. Harald Walther during a field trip in the year 1992. The name of the locality is "Mulde Pfarrholz". It is known from macrofossils and south of the town Altmittweida.

The material was prepared for the light microscope in the first place. The preparation started with the anorganic step.

Therefore the sediment was crushed into small pieces and powdered in a mortar. Concentrated HCL was added to check if the sample contains carbonates. Due to the absence of carbonates, the sample was processed and the second step was performed: removal of the silica content. The sediment was filled in a HF- resistant plastic vessel (1000 ml) and 250-300 ml concentrated HF was added. The vessel was placed in the fume cupboard and allowed to rest for three days, stirring it periodically (FAEGRI and IVERSEN, 1989). After that the content was put in a 4-5 liter HF- resistant vessel with water to neutralize the acid.

After waiting about one hour for the sediment to settle down, the HF- water mixture was decanted and the sediment was put into a glass vessel (600 ml). Concentrated HCL was added and the sample was put above a Bunsen burner to boil it for about ten minutes to avoid fluorspar. After another twenty minutes the sample was decanted again and filled into a centrifuge tube.

The tube was filled up with water to neutralize the acid and turned in the centrifuge (Heraeus Instruments Laforfuge 400) up to 3000 rotations per minute. This procedure was repeated two times more.

At this point the organic step follows. The first procedure of the organic step is the chlorination. The centrifuge tube with the sediment was filled to one quarter with glacial acetic acid and to two quarters with a saturated sodium chlorate- water solution. Finally five drops of concentrated HCL were added and the whole sample was mixed with a glass rod.

Meanwhile a water bath was prepared over the Bunsen burner. The centrifuge tube with the sample in it was held into the boiling water for approximately five to seven minutes and was sometimes stirred with the glass rod. During this procedure the oxidation takes place and the solution usually changes its colour.

After this step the centrifuge was used three more times to wash the sample with water, and once more with glacial acetic acid. This procedure is necessary to remove the water particles to prevent an exothermic reaction in the next working step (ERDTMAN, 1954), which contains concentrated H_2SO_4 .

The following working step is called acetolysis. The acetolyse liquid contains nine parts of acetic anhydride and one part of concentrated H_2SO_4 . This procedure has to be done to colour the organic matter, especially the sporopollenin.

After the acetolyse liquid was added to the sample, the centrifuge tube was put in the water bath again and boiled for about five to ten minutes. During this process the colour of the organic matter changed to a light brown.

Afterwards the sample was put in the centrifuge again and washed out one time with glacial acetic acid and several times with water (until all the bubbles were gone).

The last step was to put the sample with the organic matter in glycerin.

The organic material in glycerin was put on several slides for the light microscope without a cover glass. For light microscope photography five to ten different elements were transferred to other slides with just a single drop of glycerin. The transfer was done with a micromanipulator composed of a human short hair on a dissecting needle. This way pictures can be taken without interfering organic material. Furthermore you can turn the pollen grains in several directions and take pictures from different perspectives.

The work on the light microscope had been done on a Nikon Eclipse 80i (magnifications 10x, 20x, 40x, 60x) . The microscopic pictures were taken with a Samsung Digimax V70 in 60x magnification.

For the SEM preparation five to ten pollen grains were collected with the micromanipulator and transferred on an aluminium stub in a single drop of ethanol absolute. The ethanol is necessary to remove the glycerin from the pollen surface. After this procedure the fixing was done (Zetter 1989). The SEM pictures were taken with a Joel JSM 6400 Scanning Electrone Microscope. For the image editing and the plate design Adobe Photoshop CS3 was used.

Terminology and pollen descriptions follow mostly HESSE et al., 2009, SONTAG, 1966 and THIELE-PFEIFFER, 1980. In addition the palynological internet database of the University of Vienna (www.palдат.org) was consulted.

TAXONOMY

Bryophyta

Sphagnaceae - peat moss family

The genus *Sphagnum* includes between 151 and 350 species of mosses commonly called peat moss, due to its prevalence in peat bogs and mires. Peat mosses occur mainly in the Northern Hemisphere. Most species in that region dominate the top layer of peat bogs and moist tundra areas. In the Southern Hemisphere, the distribution is limited to New Zealand, Tasmania, southernmost Chile and Argentina (EDDY, 1988). Within the main clade of *Sphagnum* there is relatively short phylogenetic distance. Molecular dating methods suggest, that nearly all current *Sphagnum* species are descendants from a radiation that occurred just 14 mya ago (SHAW et al., 2010).

Sphagnum sp.

Stereisporites (Stereisporites) involutus minutoides - KRUTZSCH, 1963

Plate 1, Fig. 1 - 3

Spore, monad, oblate, convex triangular in polar view (LM); equatorial diameter 21 - 25 µm in LM, 19 - 24 µm in SEM; proximal pole with trilete tetrad mark, three leasura 1/3 to 1/2 of the radius long (4 - 6 µm) (LM, SEM), leasura 4-5µm long; exospore nearly 1 µm thick, tectate, perispore absent (LM); sculpturing verrucate in LM, distal polar area verrucate in SEM, verrucate areas around proximal pole verrucae along the laesura (2 - 4 µm) (SEM).

Pteridophyta

In all of the described fern spores the perispore is absent. The perispore is important for lower level determination. Thus, the fern spores could not be attributed to a specific fern family.

Monolete Spore - gen. et sp. indet

Laevigatosporites haardti - POTONIÉ and VENITZ, 1934

Plate 1, Fig. 4 - 6

Spore, monad, oblate, elliptic in polar view (LM); equatorial diameter 36 - 40 µm in LM, 34 - 35 µm in SEM; proximal pole with monolete mark, long leasura (LM, SEM); exospore more than 1 µm thick, tectate, perispore absent (LM); sculpturing scabrate in LM, scabrate in SEM.

Trilete Spore - gen. et sp. indet

Plate 1, Fig. 7 - 9

Spore, monad, oblate, circular in polar view (LM); equatorial diameter 38 - 42 µm in LM, 33 - 37 µm in SEM; proximal pole with trilete tetrad mark, leasura 3/4 of the radius long (10 - 12 µm) (LM, SEM); exospore more than 1 µm thick, tectate, perispore absent (LM); sculpturing psilate in LM, psilate in SEM.

Trilete Spore - gen. et sp. indet

Plate 1, Fig. 10 - 12

Spore, monad, oblate, concave triangular in polar view (LM); equatorial diameter 49 - 53 μm in LM, 44 - 48 μm in SEM; proximal pole with trilete tetrad mark (LM); exospore more than 1 μm thick, tectate, perispore absent (LM); sculpturing verrucate in LM, verrucate in SEM, verrucae 1 - 4 μm wide with perforations (SEM).

Trilete Spore - gen. et sp. indet

Plate 2, Fig. 1 - 3

Spore, monad, oblate, convex triangular in polar view (LM); equatorial diameter 33 - 37 μm in LM, 28 - 32 μm in SEM; proximal pole with trilete tetrad mark, leasura more than 2/3 of the radius long (LM); exospore nearly 1 μm thick, tectate, perispore absent (LM); sculpturing rugulate in LM, rugulate, perforate in SEM, around perforations sculpture microechinate to microrugulate (SEM).

Gymnosperms

Pinaceae - pine family

Pinus is the largest genus of the pine family with about 115 species. These plants are native to most of the Northern Hemisphere. They appear in Eurasia and in the northernmost regions of Africa. In North America, they range from Canada to south to Nicaragua. The highest diversity of the genus is found in Mexico and California (FARJON, 1984).

Pinus sp. 1 (subgenus *pinus*)

Pityosporites macroinsignis - KRUTZSCH, 1971

Plate 2, Fig. 4 - 6

Pollen, monad, bisaccate in equatorial view (LM); equatorial diameter 79 - 83 μm in LM, 62 - 66 μm in SEM, polar axis 35 - 39 μm in LM, 33 - 37 μm in SEM; leptoma (LM), sacci 34 - 38 μm in diameter (LM), 28 - 32 μm in SEM, corpus 54 - 58 μm wide in LM, 42 - 46 μm in SEM; exine more than 1 μm thick (LM); tectate, sculpturing alveolate in saccus area, scabrate in corpus area (LM), rugulate, fossulate in SEM, saccus with perforations, rugulae with granulae as a suprasculpture (SEM).

Pinus sp. 2 (subgenus *strobus*)

Plate 2, Fig. 7 - 9

Pollen, monad, bisaccate in equatorial view (LM); equatorial diameter 81 - 85 μm in LM, 62 - 66 μm in SEM, polar axis 36 - 40 μm in LM, 33 - 37 μm in SEM; leptoma (LM), sacci 33 - 37 μm in diameter (LM), 25 - 29 μm in SEM, corpus 56 - 60 μm wide in LM, 39 - 43 μm in SEM; exine nearly 1 μm thick (LM); tectate, sculpturing perforate in saccus area, scabrate in corpus area (LM), rugulate, fossulate in SEM, saccus with perforations.

Cupressaceae - cypress family

Formerly, the Taxodiaceae were treated as a separate family. Now it is widely accepted that the Cupressaceae include the Taxodiaceae, because they do not differ from the Cupressaceae in any consistent characteristics. Cupressaceae is the most widely distributed conifer family, with a near-global range on all continents except for Antarctica. Most terrestrial habitats are occupied, with the exclusion of polar tundra and tropical lowland rainforest (FARJON, 2005).

Taxodiaceae - gen. et sp. indet

Inaperturopollenites sp. - THOMSON and PFLUG, 1953

Plate 2, Fig. 10 - 12

Pollen, monad, sphäroidal to oblate, circular to elliptic in equatorial view (LM); equatorial diameter 26 - 30 μm in LM, 21 - 25 μm in SEM, polar axis 23 - 27 μm in LM, 16 - 20 μm in SEM; leptoma (LM, SEM) with a papilla on distal pole, papilla 7 - 10 μm wide, exine more than 1 μm thick, nexine thinner than sexine (LM); tectate sculpturing scabrate in LM, microverrucate in SEM, orbiculae attached on pollen surface.

Angiosperms

Aceraceae (Sapindaceae) - maple family

Acer is a genus with approximately more than 120 species, most of them native to Asia. Others appear in Europe, northern Africa, and North America (WU et al., 2008) Only one species is native to the Southern Hemisphere (GIBBS and CHEN, 2009).

Acer sp. 1

Aceripollenites sp. 1 - NAGY, 1969

Plate 3, Fig. 1 - 3

Pollen, monad, prolate, elliptic in equatorial view (LM); equatorial diameter 18 - 22 μm in LM, 13 - 17 μm in SEM, polar axis 33 - 37 μm in LM, 34 - 38 μm in SEM; tricolpate, colpi long (LM, SEM); exine more than 1 μm thick, nexine thinner than sexine (LM); tectate,

sculpturing striate in LM, striate in SEM, striae cross each other and are slightly wrinkled, striae 0,2 - 0,5 μm wide (SEM).

Acer sp. 2

Aceripollenites sp. 2 - NAGY, 1969

Plate 3, Fig. 4 - 6

Pollen, monad, subprolate, elliptic in equatorial view (LM); equatorial diameter 19 - 23 μm in LM, 19 - 23 μm in SEM, polar axis 23 - 27 μm in LM, 28 - 32 μm in SEM; tricolpate, colpi long (LM, SEM); exine more than 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM, striate in SEM, striae cross each other and are strong wrinkled, striae 0,5 - 0,8 μm wide (SEM).

Altingiaceae - sweet gum family

Liquidambar is a genus comprised of four species affiliated to the family Altingiaceae. Today the species are localized in Asia and eastern North America. The genus was much more widespread in the Tertiary, but has disappeared from Europe in course of the extensive glaciation in the high northern latitudes and the Alps (SVENNING, 2003).

Liquidambar sp.

Periporopollenites stigmosus - THOMSON and PFLUG, 1953

Plate 3, Fig. 7 - 9

Pollen, monad, sphaeroidal, circular in equatorial and polar view (LM); diameter 33 - 37 μm in LM, 28 - 32 μm in SEM; pantoporate (LM, SEM); pori 2 - 5 μm in diameter (SEM); exine more than 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM,

microechinate and perforate in SEM, porus membrane recessed, rugulate with microechinae but without perforations (SEM).

Aquifoliaceae - holly family

Ilex is a genus of approximately 600 species of flowering plants attributed to the family Aquifoliaceae, and the only recent genus. The distribution of the genus extends from tropical and subtropical to temperate regions of both the northern and southern hemisphere. Most of the species can be found in the tropical regions of Central and South America and Asia (WU et al., 2008).

***Ilex* sp. 1**

Ilexpollenites sp. - THIERGART, 1937

Plate 3, Fig 10 - 12

Pollen, monad, elliptic in equatorial view (LM); equatorial diameter 25 - 29 μm in LM, 14 - 18 μm in SEM, polar axis 34 - 38 μm in LM, 27 - 31 μm in SEM; tricolporate, endopori circular, as wide as colpi (LM); exine nearly 1 μm thick, nexine thinner than sexine (LM); intectate, sculpturing clavate in LM and SEM, clavae 1,4 - 1,8 μm wide, ribs as a suprasculpture, smaller clavae in between (SEM).

***Ilex* sp. 2**

Ilexpollenites sp. - THIERGART, 1937

Plate 4, Fig 1 - 3

Pollen, monad, elliptic in equatorial view (LM); equatorial diameter 21 - 25 μm in LM,

16 - 20 μm in SEM, polar axis 24 - 28 μm in LM, 21 - 25 μm in SEM; tricolporate, endopori circular, wider as colpi (LM); exine more than 1 μm thick, nexine thinner than sexine (LM); intectate, sculpturing clavate in LM and in SEM, clavae 1,2 - 1,6 μm wide, indistinct ribs as a suprasculpture, smaller clavae in between (SEM).

Araliaceae - aralia family

The family of the Araliaceae includes about 50 genera and 1350 species. The distribution is extensive, ranging from tropical to subtropical regions of both hemispheres. They can also be found in temperate areas, where they are less diverse than in the tropical and subtropical regions (WU et al., 2007).

Araliaceae - gen. et sp. indet

Plate 4, Fig. 4 - 9

Pollen, monad, prolate, rhombic truncate in equatorial view, triangular in polar view (LM); equatorial diameter 10 - 14 μm in LM, 6 - 10 μm in SEM, polar axis 11 - 15 μm in LM, 10 - 14 μm in SEM; tricolporate, colpi long (LM, SEM), endopori circular, wider as colpi (LM); exine less than 1 μm thick, nexine thinner than sexine (LM); semitectate, sculpturing scabrate in LM, heterobrochate, microreticulate in SEM, in colpus area lumina get smaller, muri without a suprasculpture (psilate), muri 0,3 - 0,6 μm wide, margo with perforations, sexine protruding at the area of endopori (SEM).

Clethraceae - white-alder family

The Clethraceae is a small family of flowering plants. The family is native to the warm temperate and tropical regions of Asia and America, with one species present on Madeira (WATSON and DALLWITZ, 1992).

Clethraceae - gen- et sp. indet

Plate 4, Fig. 10 - 12

Pollen, monad, prolate, elliptic in equatorial view, circular in polar view (LM); equatorial diameter 10 - 14 μm in LM, 9 - 13 μm in SEM, polar axis 11 - 15 μm in LM, 9 - 13 μm in SEM; tricolporate, colpi long (LM, SEM), endopori circular, wider as colpi (LM); exine less than 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM, psilate to slightly microrugulate in SEM, rare perforations, in area of endopori sexine is arching, forming a bridge (SEM).

Cornaceae - dogwood family

Nyssa is a small genus of about 9 to 11 species of trees. Most species are highly tolerant of wet soils and flooding, and some depend on such environments as habitat. Five species are native to eastern North America. Other species are found in eastern and southeastern Asia (WU et al., 2007).

Nyssa sp.

Nyssapollenites sp. - THIERGART, 1937

Plate 4, Fig. 1 - 6

Pollen, monad, sphäroidal to subprolate, circular to elliptic in equatorial view, convex triangular to triangular in polar view (LM); equatorial diameter 35 - 39 μm in LM, 28 - 32 μm in SEM, polar axis 36 - 40 μm in LM, 34 - 38 μm in SEM; tricolporate, colpi long, endopori circular with a costa, endopori wider as colpi (LM); exine nearly 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM, microrugulate, perforate in SEM, perforations increase in polar area, margo around colpi without perforations, colpus membrane microrugulate to microverrucate (SEM).

The genus *Cornus* is a group of about 30 - 60 species of woody plants assigned to the family Cornaceae, commonly known as dogwoods. Various species of dogwood can be found in temperate and boreal Eurasia and North America. China, Japan and the southeastern United States are particularly rich in native species (WU et al., 2005).

Cornus sp.

Plate 5, Fig. 7 - 12

Pollen, monad, prolate, elliptic in equatorial view (LM); equatorial diameter 31 - 35 μm in LM, 24 - 28 μm in SEM, polar axis 41 - 45 μm in LM, 32 - 36 μm in SEM; tricolporate, area around the colpi thickened, endopori rectangular, endopori wider as colpi (LM); exine less than 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM, perforate with microechinae in SEM (in mesocolpi), along colpi and at polar areas perforate, colpus ends rounded, in area of endopori sexine is arching, forming a bridge (SEM).

Cucurbitaceae - gourd family

Cucurbitaceae is a plant family, also known as gourd family, including about 125 extant genera and 960 species. Most of the plants in this family are annual vines, but there are also woody lianas, thorny shrubs, and trees. The family is predominantly distributed around the tropics, where those with edible fruits were amongst the earliest cultivated plants in both the Old and New World (BATES et al., 1990).

Cucurbitaceae - gen. et sp. indet - BARTH et al., 2005

Plate 5, Fig. 1 - 3

Pollen, monad, oblate, circular in polar view (LM); equatorial diameter 32 - 36 μm in LM, 26 - 30 μm in SEM; stephanobrevicolpate, colpi short (LM, SEM); exine less than 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing echinate in LM, echinate with microclavae in SEM, around colpi a higher concentration of echinae (SEM).

Cyperaceae - sedge family

Cyperaceae is a family of monocotyledonous flowering plants known as sedges, which superficially resemble grasses or rushes. The family is large, with some 5,500 species described in about 109 genera. These species are widely distributed. The centers of diversity for the group occur in tropical Asia and South America. While sedges may be found growing in all kinds of situations, many are associated with wetlands or with poor soils (GOVAERTS et al., 2007).

Cyperaceae - gen. et sp. indet

Plate 5, Fig. 4 - 6

Pollen, pseudomonad, prolate, elliptic in equatorial view (LM); equatorial diameter 26 - 30 μm in LM, 22 - 26 μm in SEM, polar axis 34 - 38 μm in LM, 26 - 30 μm in SEM; apertures with indistinct margin (poroid); exine nearly 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM, microrugulate, microverrucate, microechinate, perforate in SEM.

Ericaceae - heath family

Ericaceae, the heath family, is a plant family, comprising mostly calcifuge (lime-hating) plants that thrive in acidic soils. Many well-known plants of the Ericaceae live in temperate climates. However, the family also contains many tropical species (KATHLEEN et al., 2002). In eastern North America, members of this family often grow in association with an oak canopy, in a so called oak-heath forest (SCHAFALÉ and WEAKLEY, 1990).

Ericaceae - gen. et sp. indet 1

Ericipites sp. - WODEHOUSE, 1933

Plate 5, Fig. 7 - 9

Pollen, tetrad tetrahedral, spheroidal, heteropolar in equatorial view (LM); equatorial diameter 29 - 33 μm in LM, 22 - 26 μm in SEM; tricolporate, colpi long (LM, SEM), endopori circular, as wide as colpi (LM); exine nearly 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing psilate in LM, rugulate, fossulate in SEM, rugulae with a low relief, rugulae 0,2 - 0,5 μm wide, microverrucae as a suprasculpture (SEM).

Ericaceae - gen. et sp. indet 2

Ericipites sp. - WODEHOUSE, 1933

Plate 5, Fig. 10 - 12

Pollen, tetrad tetrahedral, spheroidal, circular in polar view (LM); equatorial diameter 32 - 36 μm in LM, 26 - 30 μm in SEM; tricolporate, endopori circular, endopori wider as colpi (LM); exine nearly 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM, rugulate, fossulate in SEM, rugulae 0,4 - 0,7 μm wide, rugulae with a high relief, around the colpi rugulae become bigger and wider, microverrucae as a suprasculpture (SEM).

Eucommiaceae - eucommia family

Eucommia is a small tree native to China. It is the only genus in the family Eucommiaceae, containing a single species *Eucommia ulmoides*. In the fossil record, the genus *Eucommia* appears frequently in brown coals of the tertiary (10 - 35 Ma) in central Europa and North America (WANG et al., 2003). However, in Europe the evidence of pollen grains can be followed back into the late Paleocene or early Eocene.

Eucommia sp.

Plate 6, Fig. 1 - 3

Pollen, monad, prolate, elliptic in equatorial view (LM); equatorial diameter 14 - 18 μm in LM, 9 - 13 μm in SEM, polar axis 18 - 22 μm in LM, 12 - 16 μm in SEM; tricolporate to tricolporoidate, colpi long; exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, microechinate, perforate in SEM, number of perforations increase around colpi (SEM).

Fagaceae - beech family

Lithocarpus is a genus of the beech family Fagaceae, differing from *Quercus* in the presence of erect male spikes. There are approximately more than 100 different species. All but one are native to east and southeast Asia; the only exception native to western North America is found in southwest Oregon and California. Although normally included in *Lithocarpus*, recent genetic evidence suggests that the North American species is only distantly related to the Asian species; it rather should be transferred to a genus of its own (MANOS et al., 2001).

Lithocarpus sp.

Castaneoideapollis oviformis - POTONIÉ, 1931

Plate 6, Fig. 4 - 6

Pollen, monad, prolate, elliptic in equatorial view (LM); equatorial diameter 8 - 12 μm in LM, 6 - 10 μm in SEM, polar axis 13 - 17 μm in LM, 11 - 15 μm in SEM; tricolporate, endopori circular, as wide as colpi (LM); exine nearly 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing psilate in LM, rugulate, fossulate in SEM, higher concentration of fossulae in equatorial area (SEM).

The genus *Quercus* is comprised of about 600 species. Most of them are trees or shrubs. The genus is native to the northern hemisphere, and includes deciduous and evergreen species. *Quercus* extends from cold latitudes to tropical Asia and America (PHILIPS, 1979).

Quercus sp. 1 (cerris type)

Quercoidites sp. - THOMSON and PFLUG, 1953

Plate 6, Fig. 7 - 12

Pollen, monad, prolate, circular to trilobate in polar view, elliptic in equatorial view (LM); equatorial diameter 19 - 23 μm in LM, 17 - 21 μm in SEM, polar axis 24 - 28 μm in LM, 21 - 25 μm in SEM; tricolporoidate, endopori circular, as wide as colpi (LM); exine more than 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM, verrucate to microverrucate in SEM, verrucae 0,4 - 0,7 μm wide, with microstriae as a suprasculpture (SEM).

Quercus sp. 2 (ilex type)

Quercoidites sp. - THOMSON and PFLUG, 1953

Plate 7, Fig. 1 - 3

Pollen, monad, prolate, trilobate in polar view, elliptic in equatorial view (LM); equatorial diameter 17 - 21 μm in LM, 15 - 19 μm in SEM, polar axis 23 - 27 μm in LM, 20 - 24 μm in SEM; tricolporoidate, colpi long (LM, SEM); exine nearly 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM, microrugulate in SEM.

Quercus sp. 3 (subgenus cyclobalanopsis)

Plate 7, Fig. 4 - 6

Pollen, monad, prolate, convex triangular in polar view, elliptic in equatorial view (LM); equatorial diameter 19 - 23 μm in LM, 15 - 19 μm in SEM, polar axis 18 - 22 μm in LM, 13 - 17 μm in SEM; tricolporate, endopori elliptic with a costa, as wide as colpi (LM); exine nearly 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM, microrugulate to microverrucate, microechinate, perforate (SEM), colpus membrane microrugulate to microverrucate (SEM).

Fagus is a genus of ten species of deciduous trees in the family Fagaceae. It is native to temperate regions of Europe, Asia and North America (WU et al., 1999).

Fagus sp.

Faguspollenites sp. - RAATZ, 1937

Plate 7, Fig. 7 - 9

Pollen, monad, spheroidal, circular in polar and equatorial view (LM); equatorial diameter 33 - 37 μm in LM, 28 - 32 μm in SEM, polar axis 32 - 36 μm in LM, 30 - 34 μm in SEM; tricolporate, colpi long (LM), endopori elliptic, wider as colpi (LM); exine more than 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM, rugulate in SEM, rugulae cross each other, rugulae 0,3 - 0,6 μm wide (SEM).

Trigonobalanopsis is an extinct genus of evergreen trees in the family of Fagaceae. In Europe the genus can be found in tertiary floras and appears the first time in the Eocene. In western Asia *Trigonobalanopsis* is limited to the Eocene. The most recent evidence of occurrence is known from the Pliocene of Europe (MAI, 1995).

Trigonobalanopsis sp.

Tricolporopollenites cingulum - POTONIÉ, 1931

Plate 7, Fig. 10 - 12

Pollen, monad, prolate, elliptic in equatorial view (LM); equatorial diameter 18 - 22 μm in LM, 12 - 16 μm in SEM, polar axis 18 - 22 μm in LM, 14 - 18 μm in SEM; tricolporate, endopori elliptic, wider as colpi (LM); exine nearly 1 μm thick, nexine thinner than sexine (LM); tectate, sculpturing scabrate in LM, rugulate in SEM, rugulae cross each other, rugulae 0,1 - 0,3 μm wide, rugulae with distinct ribs as a suprasculpture, in area of endopori sexine is arching, forming a bridge, colpus membrane granulate (SEM).

Juglandaceae - walnut family

Trees in the genus *Carya* are commonly known as hickory. The genus includes 17–19 species of deciduous trees. Between five and six species are native to Asia, whereas the others are native to North America (PHILIPS, 1979).

Carya sp.

Carya - pollenites fsp1. - SONTAG, 1966

Plate 8, Fig. 1 - 6

Pollen, monad, oblate, circular in polar view (LM); equatorial diameter 38 - 42 μm in LM, 30 - 34 μm in SEM; triporate, pori circular with an indistinct annulus (LM); exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, microechinate in SEM, uniformly spaced microechinae, +/- 8 microechinae per 2 μm , characteristic thinning of exine in distal polar area (SEM).

Cyclocarya is a genus of flowering plants in the family Juglandaceae, comprising a single species *Cyclocarya paliurus* (Wheel Wingnut). It was formerly treated in the genus *Pterocarya* as *Pterocarya paliurus*. *Cyclocarya* is native to eastern and central China (WU et al., 1999).

Cyclocarya sp.

Plate 8, Fig. 7 - 12

Pollen, monad, oblate, circular in polar view, elliptic in equatorial view (LM); equatorial diameter 36 - 40 μm in LM, 30 - 34 μm in SEM, polar axis 30 - 34 μm in LM;

tri - tetraporate, pori circular with an annulus (LM); exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, microechinate in SEM, uniformly spaced microechinae, +/- 12 microechinae per 2 μm , perforations between the microechinae, membrane of the pori granulate (SEM).

Engelhardia is a genus of seven species of trees in the family Juglandaceae. It is native to southeast Asia, ranging from northern India east to Taiwan, Indonesia and the Philippines (WU et al., 1999).

Engelhardia sp. 1

"Engelhardtia" - Formen 8b - SONTAG, 1966

Plate 9, Fig. 1 - 3

Pollen, monad, oblate, circular in polar view (LM); equatorial diameter 22 - 26 μm in LM, 16 - 20 μm in SEM; triporate, pori circular without an annulus (LM); exine nearly 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, microechinate in SEM, uniformly spaced microechinae, +/- 11 microechinae per 2 μm (SEM).

Engelhardia sp. 2

Pollenites punctatus gracilis - POTONIÉ, 1931 b

Plate 9, Fig. 4 - 6

Pollen, monad, oblate, convex triangular in polar view (LM); equatorial diameter 25 - 29 μm in LM, 17 - 21 μm in SEM; triporate, pori circular without an annulus (LM); exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, microechinate in SEM, uniformly spaced microechinae, +/- 9 microechinae per 2 μm (SEM).

Engelhardia sp. 3

Pollenites quietus - POTONIÉ, 1931 c

Plate 9, Fig. 7 - 9

Pollen, monad, oblate, straight triangular in polar view (LM); equatorial diameter 18 - 22 μm in LM, 14 - 18 μm in SEM; triporate, pori circular without an annulus (LM); exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, microechinate in SEM, uniformly spaced microechinae, +/- 13 microechinae per 2 μm (SEM).

Platycarya is a genus of flowering plants assigned to the family Juglandaceae. Usually treated as comprised of a single species - *Platycarya strobilacea* – some authors accept one to two additional species. It is native to eastern Asia in China, Korea, and Japan (WU et al. 1999).

Platycarya sp.

Platycaryapollenites sp. - NAGY, 1969

Plate 9, Fig. 10 - 12

Pollen, monad, oblate, convex triangular in polar view (LM); equatorial diameter 18 - 22 μm in LM, 13 - 17 μm in SEM; triporate, pori circular without an annulus, two characteristic channel-like thinnings cross each other (LM); exine nearly 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, microechinate in SEM, uniformly spaced microechinae, +/- 12 microechinae per 2 μm , thinnings of different pattern (mostly channel like) on each pole, microechinae also in the thinnings (SEM).

Loranthaceae - mistletoe family

Loranthaceae is a family of flowering plants, that consists of about 75 genera and 1,000 species. Usually they are woody plants, many are hemi-parasites, and all of them except for three thrive in the mistletoe habit. The distribution is ranging from temperate to tropical climates (WATSON and DALLWITZ, 1992)

Loranthaceae - gen. et sp. indet

Gothanipollis sp. - KRUTZSCH, 1959

Plate 10, Fig. 1 - 3

Pollen, monad, oblate, concave triangular in polar view (LM); equatorial diameter 21 - 25 μm in LM, 16 - 20 μm in SEM; trisyncolporate; exine nearly 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, mesocolpium area microverrucate in SEM, microverrucae 0,3 - 0,6 μm in diameter, microverrucae with a granulate suprasculpture, psilate margo around colpi, colpus membrane granulate (SEM).

Lythraceae - loosestrife family

Decodon is a monotypic genus in the family Lythraceae, with one species in the warm - temperate, eastern North America. The shrubs with woody stems usually grow near riversides of swamps or small lakes (JÄGER et al., 2008).

Decodon sp. 1

Lythraceaeapollenites - THIELE - PFEIFFER, 1980

Plate 10, Fig. 4 - 6

Pollen, monad, prolate, elliptic in equatorial view (LM), with three meridional ridges (SEM); equatorial diameter 17 - 21 μm wide in LM, 14 - 18 μm in SEM, polar axis 20 - 24 μm in LM, 18 - 22 μm in SEM; tricolporate, endopori small and circular (LM); exine more than 1 μm thick, nexine thinner than sexine, sexine slightly thickened in polar areas; tectate, sculpturing scabrate in LM, rugulate in SEM, at meridional ridges rugulae become wider in equatorial area, around colpi rugulae are thinner, rugulae 0,4 - 0,7 μm wide (SEM).

Decodon sp. 2

Lythraceaeapollenites - THIELE - PFEIFFER, 1980

Plate 10, Fig.7 - 9

Pollen, monad, prolate, straight triangular in polar view, elliptic in equatorial view (LM), with three meridional ridges (SEM); equatorial diameter 18 - 22 μm in LM, 16 - 20 μm in SEM, polar axis 27 - 31 μm in LM, 25 - 29 μm in SEM; tricolporate, colpi long, endopori circular, as wide as colpi (LM); exine nearly 1 μm thick, nexine thinner than sexine, sexine slightly thickened in polar areas; tectate, sculpturing scabrate in LM, rugulate in SEM, around apertures rugulae short, running along the polar axis, at meridional ridges rugulae elongated, running perpendicular to the polar axis in equatorial area, rugulae 0,2 - 0,5 μm wide (SEM).

Mastixiaceae

The family Mastixiaceae consists of two genera: *Mastixia* and *Diplopanax* (FAN and XIANG, 2003). Usually the plants are resinous evergreen trees. Today the Mastixiaceae are

placed in the family Cornaceae. Its range extends from India through Southeast Asia and New Guinea to the Solomon Islands (KUBITZKI, 2004).

Mastixiaceae - gen. et sp. indet

Plate 10, Fig. 10 - 12

Pollen, monad, oblate, convex triangular in polar view (LM); equatorial diameter 47 - 51 μm in LM, 37 - 41 μm in SEM; tricolporate, colpi get wider in equatorial area, endopori elliptic (SEM); exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, perforate- fossulate in SEM, perforations uniformly spaced, different diameter of perforations, surface of the colpus membrane granulate (SEM).

Myricaceae - wax-myrtle family

Myrica is a genus of about 50 species of small trees and shrubs in the family Myricaceae (Order Fagales). Its distribution is nearly worldwide, except for some warm temperate parts of the Old World and Australia (WU et al. 1999).

Myrica sp.

Triatriopollenites rurensis - THOMSON and PFLUG, 1953

Plate 11, Fig. 1 - 3

Pollen, monad, oblate, convex triangular in polar view (LM); equatorial diameter 28 - 32 μm in LM, 23 - 27 μm in SEM; triporate, pori circular; exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing psilate in LM, microechinate in SEM, small perforations between the microechinae (SEM).

Oleaceae - olive family

The Oleaceae, or olive family, is a plant family containing 24 extant genera and around 600 species. They are mesophytic shrubs, trees and occasionally vines occurring worldwide (JOHNSON, 1957).

Oleaceae - gen. et sp. indet 1

Tricolporopollenites microreticulatus 1 - THOMSON and PFLUG, 1953

Plate 11, Fig. 7 - 9

Pollen, monad, sphäroidal, circular in polar and equatorial view (LM); diameter 24 - 28 µm in LM, 20 - 24 µm in SEM; tricolporate, endopori small (LM); exine +/- 1 µm thick, nexine thinner than sexine; semitectate, reticulate in LM, reticulate, heterobrochate in SEM, lumina 0,5 - 0,9 µm in diameter, muri 0,5 - 0,8 µm wide, muri with irregularly shaped and loose spaced ribs as a suprasculpture (SEM).

Oleaceae - gen. et sp. indet 2

Tricolporopollenites microreticulatus 2 - THOMSON and PFLUG, 1953

Plate 12, Fig. 1 - 3

Pollen, monad, sphäroidal, circular in equatorial and in polar view (LM); diameter 18 - 22 µm in LM, 12 - 16 µm in SEM; tricolporate, endopori circular; exine +/- 1 µm thick, nexine thinner than sexine; semitectate, reticulate in LM, reticulate, heterobrochate in SEM, lumina 0,5 - 0,8 µm in diameter, muri 0,3 - 0,6 µm wide, with irregularly distributed microverrucae as a suprasculpture (SEM).

Oleaceae - gen. et sp. indet 3

Tricolporopollenites microreticulatus 3 - THOMSON and PFLUG, 1953

Plate 12, Fig 4 - 6

Pollen, monad, sphäroidal, circular in equatorial view (LM); diameter 14 - 18 μm in LM, 11 - 15 μm in SEM; tricolporate, colpi short (SEM); exine +/- 1 μm thick, nexine thinner than sexine; semitectate, reticulate in LM, reticulate, heterobrochate in SEM, lumina 1,0 - 1,5 μm in diameter, columellae high, muri 0,3 - 0,6 μm wide, with microverrucae and microechinae as a suprasculpture, colpus membrane granulate (SEM).

Fraxinus is a genus of flowering plants attributed to the olive and lilac family Oleaceae. It contains about 60 species of usually medium to large trees. In large part the taxa are deciduous though a few subtropical species are evergreen. The distribution is mainly ranging from temperate to subtropical regions of the northern hemisphere (WU et al., 1996).

***Fraxinus* sp. 1**

Tricolporopollenites microreticulatus 4 - THOMSON and PFLUG, 1953

Plate 11, Fig. 4 - 6

Pollen, monad, sphäroidal, circular in polar and equatorial view (LM); diameter 20 - 24 μm in LM, 14 - 18 μm in SEM; tetracolporate, colpi short (LM, SEM), endopori small and circular, as wide as colpi (LM); exine +/- 1 μm thick, nexine thinner than sexine; semitectate, scabrate in LM, perforate to microreticulate in SEM, muri angular shaped with irregularly shaped ribs as a suprasculpture, muri 0,3 - 0,6 μm wide (SEM).

Fraxinus sp. 2

Tricolporopollenites microreticulatus 5 - THOMSON and PFLUG, 1953

Plate 11, Fig. 10 - 12

Pollen, monad, sphäroidal, circular in polar and equatorial view (LM); diameter 19 - 23 µm in LM, 16 - 20 µm in SEM; tricolporate, colpi short, endopori small and circular; exine +/- 1 µm thick, nexine as thick as sexine; semitectate, reticulate in LM, reticulate, heterobrochate in SEM, lumina 0,5 - 0,9 µm in diameter, muri 0,4 - 0,7 µm wide, muri with regular densely spaced ribs as a suprasculpture (SEM).

Platanaceae - plane-tree family

Platanus is a genus of about 6 - 10 species of trees, native to the Northern Hemisphere. They are the sole living members of the family Platanaceae and are frequently found in riparian or other wetland habitats. All are deciduous and most of them are distributed in the temperate regions. Only one species is evergreen and can be found in the tropics of Indochina (BEAN, 1987).

Platanus sp.

Plate 12, Fig. 7 - 9

Pollen, monad, oblate, trilobate in polar view (LM); equatorial diameter 18 - 22 µm in LM, 10 - 14 µm in SEM; tricolpate, colpi broad (LM); exine +/- 1 µm thick, nexine as thick as sexine, semitectate, sculpturing scabrate in LM, microreticulate, homobrochate in SEM, lumina 0,2 - 0,4 µm in diameter, muri 0,3 - 0,6 µm wide, muri surface psilate, colpus membrane microechinate (SEM).

Rhamnaceae - buckthorn family

Rhamnaceae is a large family of flowering plants, mostly trees, shrubs and some vines. The family contains 50 genera and approximately more than 900 species. The Rhamnaceae occur worldwide, but are more common in the tropical and subtropical regions. The earliest fossil evidence of Rhamnaceae is from the Eocene (WU et al., 2007).

Rhamnaceae - gen. et sp. indet

Plate 12, Fig. 10 - 12

Pollen, monad, oblate, elliptic in equatorial view, triangular in polar view (LM); equatorial diameter 18 - 22 μm in LM, 12 - 16 μm in SEM, polar axis 14 - 18 μm in LM; tricolporate, colpi long, endopori circular, endopori wider as colpi; exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing psilate in LM, rugulate, fossulate, perforate in SEM, rugulate in mesocolpi, rugulae 0,3 - 0,6 μm wide, in polar area and around colpi perforate, colpus membrane granulate (SEM).

Rosaceae - rose family

The Rosaceae or rose family is a large family of flowering plants, with about 2830 species placed in 95 genera. The plants can be herbs, shrubs or trees. Most species are deciduous, but some are evergreen. The Rosaceae show a cosmopolitan distribution (found nearly everywhere except for Antarctica), but there are many more species endemic to the temperate northern hemisphere than anywhere else (STEVENS, 2001).

Rosaceae - gen. et sp. indet

Plate 13, Fig. 1 - 3

Pollen, monad, prolate, elliptic in equatorial view (LM); equatorial diameter 18 - 22 μm in LM, 15 - 19 μm in SEM, polar axis 27 - 31 μm in LM, 22 - 26 μm in SEM; tricolporate, endopori circular without annulus, endopori wider as colpi, in the area of endopori sexine typically swelled (bridge) (LM); exine more than 1 μm thick, sexine thinner than nexine; tectate, sculpturing scabrate in LM, striate in SEM, striae do not cross each other, striae running in different directions (along polar axis and perpendicular), striae 0,2 - 0,5 μm wide, striae psilate. (SEM).

Rutaceae - citrus family

Zanthoxylum is a genus of about 250 species of deciduous and evergreen trees and shrubs in the citrus family. The plants are native to the warm temperate regions of Asia and North America and subtropical areas around the world. (WU et al., 2008).

Zanthoxylum sp.

Plate 13, Fig. 4 - 6

Pollen, monad, prolate, elliptic in equatorial view, circular in polar view (LM); equatorial diameter 18 - 19 μm in LM, 15 - 16 μm in SEM, polar axis 23 - 24 μm in LM, 20 - 21 μm in SEM; tricolporate, colpi long, endopori rectangular and broad, endopori wider as colpi; exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, striate in SEM, striae in polar regions forming a striato - reticulate pattern, striae running parallel along the polar axis, striae 0,3 - 0,6 μm wide, colpus membrane microrugulate to microverrucate, colpi with small bridge in the area of endopori (SEM).

Salicaceae - willow family

Salix is a species rich genus of about 400 species of deciduous trees and shrubs, found primarily on moist soils in cold and temperate regions of the Northern Hemisphere. Only few species can be found in the tropics and subtropics (NEWSHOLME, 1992).

Salix sp. 1

Tricolpopollenites retiformis 1 - THOMSON and PFLUG, 1953

Plate 13, Fig. 7 - 12

Pollen, monad, prolate, elliptic in equatorial view, circular in polar view (LM); equatorial diameter 11 - 15 μm in LM, 10 - 14 μm in SEM, polar axis 22 - 26 μm in LM, 19 - 23 μm in SEM; tricolporate, colpi long, endopori circular; exine less than 1 μm thick, nexine thinner than sexine; semitectate, reticulate in LM, reticulate, heterobrochate in SEM, towards apertures reticulum becomes microreticulate, margo with perforations, lumina 0,9 - 1,3 μm in diameter, muri 0,3 - 0,7 μm wide, profile of the muri triangular shaped, muri without a suprasculpture (psilate), muri of different thickness, broader muri with perforations, short columellae, free standing columellae clearly visible below the lumina of the reticulum (SEM).

Salix sp. 2

Tricolpopollenites retiformis 2 - THOMSON and PFLUG, 1953

Plate 14, Fig. 1 - 3

Pollen, monad, prolate, circular in polar view (LM); equatorial view 18 - 22 μm in LM, 12 - 16 μm in SEM; tricolporate, colpi broad; exine less than 1 μm thick, nexine thinner than sexine; semitectate, reticulate in LM, reticulate, heterobrochate in SEM, towards apertures reticulum becomes microreticulate, broad margo without reticulum around colpi, lumina

0,4 - 0,7 μm in diameter, muri 0,3 - 0,6 μm wide, profile of the muri triangular shaped, muri without a suprasculpture (psilate), muri strong angular shaped, muri of different thickness, broader muri with perforations, colpus membrane granulate (SEM).

Sapotaceae - sapodilla family

The Sapotaceae is a family of flowering plants, assigned to the order of Ericales. The family includes approximately 1100 species of evergreen trees and shrubs in approximately 53 genera. The distribution of the family is pantropical (WU et al., 1996).

Sapotaceae - gen. et sp. indet 1

Tetracolporopollenites sapotoides - THOMSON and PFLUG, 1953

Plate 14, Fig. 4 - 6

Pollen, monad, prolate, triangular to circular in polar view, elliptic in equatorial view (LM); equatorial diameter 29 - 33 μm in LM, 23 - 27 μm in SEM, polar axis 35 - 39 μm in LM, 28 - 32 μm in SEM; tricolporate, colpi narrow, endopori elliptic with a costa, endopori wider as colpi; exine +/- 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, microverrucate, fossulate in SEM, occasionally perforations (SEM).

Sapotaceae - gen. et sp. indet 2

Tetracolporopollenites sp. - THIELE - PFEIFFER, 1980

Plate 14, Fig. 7 - 9

Pollen, monad, prolate, elliptic in equatorial view (LM); equatorial diameter 21 - 25 μm in LM, 15 - 19 μm in SEM, polar axis 28 - 32 μm in LM, 22 - 26 μm in SEM; tetracolporate, colpi narrow and long with sometimes broader rounded ends, endopori slit like and

rectangular, endopori wider as colpi; exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, microverrucate, fossulate in SEM, irregularly distributed perforations, area around colpi strikingly thickened (LM, SEM).

Sapotaceae - gen. et sp. indet 3

Tetracolporopollenites sp. 2 - THIELE - PFEIFFER, 1980

Plate 14, Fig. 10 - 12

Pollen, monad, prolate, elliptic in equatorial view (LM); equatorial diameter 23 - 27 μm in LM, 18 - 22 μm in SEM, polar axis 38 - 42 μm in LM, 30 - 34 μm in SEM; tetracolporate, colpi wide and long, endopori elliptic with a costa, endopori wider as colpi; exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, microverrucate, fossulate in SEM, irregularly distributed perforations, area around colpi strikingly thickened (SEM).

Styracaceae - styrax family

The Styracaceae is a small family of flowering plants placed in the order of Ericales, containing 11 genera and about 160 species of trees and shrubs. The family occurs in warm temperate and subtropical regions of the Northern Hemisphere (FRITSCH et al., 2001).

Styracaceae - gen. et sp. indet

Plate 15, Fig. 1 - 3

Pollen, monad, prolate, elliptic in equatorial view (LM); equatorial diameter 29 - 33 μm in LM, 21 - 25 μm in SEM, polar axis 36 - 40 μm in LM, 30 - 34 μm in SEM; tricolporate, colpi long, endopori rectangular; exine more than 1 μm thick, nexine thicker than sexine; tectate,

sculpturing rugulate in LM, rugulate, perforate in SEM, rugulae cross each other and are wrinkled, rugulae 1,2 - 1,6 µm wide, surface of the rugulae covered with ribs (SEM).

Symplocaceae - sweetleaf family

Symplocos is a genus of flowering plants in the family Symplocaceae, containing about 200 species. Most of the species are evergreen shrubs or trees, that can be found in the tropics and subtropics of Asia, Australia and America (WU et al., 1996).

Symplocos sp. 1

Porocolpopollenites vestibulum (forma a) - POTONIE, 1931

Plate 15, Fig. 4 - 6

Pollen, monad, oblate, convex triangular in polar view (LM); equatorial diameter 31 - 35 µm in LM, 26 - 30 µm in SEM; tricolporate, colpi short, endopori circular; exine +/- 1 µm thick, nexine thinner than sexine; tectate, sculpturing rugulate, fossulate in LM, rugulate, fossulate, perforate in SEM, rugulae are connected and form a kind of reticulum, irregularly distributed perforations, rugulae 1,0 - 1,4 µm wide, surface of the rugulae psilate, colpus membrane granulate (SEM).

Symplocos sp. 2

Porocolpopollenites vestibulum (forma b) - POTONIE, 1931

Plate 15, Fig. 7 - 9

Pollen, monad, oblate, straight triangular in polar view (LM); equatorial diameter 38 - 42 µm in LM, 30 - 34 µm in SEM; tricolporate, colpi short; exine +/- 1 µm thick, sexine as thick as nexine; tectate, sculpturing rugulate, fossulate in LM, rugulate, fossulate, perforate in SEM,

rugulae are connected and form a kind of reticulum, irregularly distributed perforations, rugulae 0,8 - 1,2 μm wide, microverrucae on the surface of the rugulae, colpus membrane granulate (SEM).

Symplocos sp. 3

Porocolpopollenites vestibulum (forma d) - POTONIÉ, 1931

Plate 15, Fig. 10 - 12

Pollen, monad, oblate, concave triangular in polar view (LM); equatorial diameter 28 - 32 μm in LM, 22 - 26 μm in SEM; tricolporate, colpi short; exine +/- 1 μm thick, sexine as thick as nexine; tectate, sculpturing scabrate in LM, rugulate to granulate in SEM, rugulae are not connected with each other, rugulae 0,3 - 0,6 μm wide, surface of the rugulae psilate, rare perforations, margo less sculptured, colpus membrane granulate (SEM).

Typhaceae - cattail family

Sparganium is a genus of flowering plants, containing about 14 species distributed in temperate regions of both, the Northern and Southern Hemisphere. It was previously placed in its own family, the Sparganiaceae (KAUL, 1997).

Sparganium sp.

Plate 16, Fig. 1 - 3

Pollen, monad, sphaeroidal (infolded), circular in equatorial and polar view (LM); diameter 22 - 26 μm in LM, 18 - 22 μm in SEM, polar axis 36 - 40 μm in LM, 30 - 34 μm in SEM; ulcus on distal side, ulcus circular with an indistinct annulus; exine +/- 1 μm thick, nexine

thinner than sexine; semitectate, sculpturing heterobrochate to microreticulate in LM and SEM, lumina narrow, muri 0,3 – 0,6 µm wide, with microechinae as a suprasculpture (SEM).

Ulmaceae - elm family

Ulmus is a genus of flowering plants, containing about 40 species. It is placed in the family Ulmaceae. The plants are deciduous and semi-deciduous trees. The genus first appeared in the Miocene period about 40 million years ago in central Asia and dispersed over most of the Northern Hemisphere (WU et al., 2003).

Ulmus sp.

Polyporopollenites undulosus - WOLFF, 1934

Plate 16, Fig. 4 - 6

Pollen, monad, oblate, circular in polar view (LM); equatorial diameter 28 – 32 µm in LM, 23 – 27 µm in SEM; stephanoporate with five pori, pori circular with an indistinct annulus; exine +/- 1 µm thick, nexine thinner than sexine; tectate, sculpturing rugulate in LM, rugulate, microechinate in SEM.

Zelkova is a genus comprised of six species placed in the family Ulmaceae. The plants are deciduous trees. *Zelkova* is native to southern Europe, and southwest and eastern Asia (ANDREWS, 1994)

Zelkova sp.

Polyporopollenites verrucatus - THIELE - PFEIFFER, 1980

Plate 16, Fig. 7 - 9

Pollen, monad, oblate, circular in polar view (LM); equatorial diameter 36 - 40 μm in LM, 28 - 32 μm in SEM; stephanoporate with five pori, pori elliptic with an annulus; exine more than 1 μm thick, nexine thinner than sexine; tectate, sculpturing rugulate in LM, rugulate, microechinate in SEM, microechinae very high in number (SEM).

Vitaceae - grapevine family

Parthenocissus is a genus of climbing plants assigned to the family Vitaceae. It contains about 12 species, distributed in Asia and North America (NIE et al., 2010).

Parthenocissus sp.

Tricolporopollenites marcodurensis - THOMSON and PFLUG, 1953

Plate 16, Fig. 10 - 12

Pollen, monad, prolate, elliptic in equatorial view (LM); equatorial diameter 31 - 35 μm in LM, 24 - 28 μm in SEM, polar axis 41 - 45 μm in LM, 33 - 37 μm in SEM; tricolporate, colpi long, endopori elliptic, as wide as colpi, with thickenings in the corners of crossing colpi; exine more than 1 μm thick, nexine thinner than sexine; semitectate, sculpturing reticulate to microreticulate in LM, heterobrochate, microreticulate in SEM, lumina narrow, in mesocolpi lumina are elongated, at polar areas lumina are more open (circular), muri without a suprasculpture (psilate), muri 0,4 - 0,7 μm wide, colpus membrane microrugulate to microverrucat, in area of endopori sexine is arching, forming a bridge (SEM).

Zingiberaceae - ginger family

The Zingiberaceae, or the Ginger family, is a family of flowering plants, containing 52 genera and more than 1200 species. Its distribution is throughout limited to tropical Africa, Asia, and America (KRESS et al., 2002). The genus *Spirematospermum* is extinct. It is only known from the macrofossil record. Its seed structure is similar to seeds found in the family Zingiberaceae (CHANDLER, 1925).

***Spirematospermum* sp.**

Plate 17, Fig. 1 - 3

Pollen, monad, sphäroidal, circular in equatorial and polar view (LM); diameter 17 - 21 µm in LM, 13 - 17 µm in SEM; inaperturate; exine more than 1 µm thick, sexine thinner than nexine; tectate, sculpturing echinate in LM, echinate in SEM, echinae nearly 1 µm in diameter (SEM).

Indeterminate

Indet. 1

Plate 17, Fig. 4 - 6

Pollen, monad, prolate, elliptic in equatorial view (LM); equatorial diameter 36 - 40 µm in LM, 26 - 30 µm in SEM, polar axis 42 - 46 µm in LM, 30 - 34 µm in SEM; tricolporate, endopori circular, colpi wider as endopori; exine more than 1 µm thick, nexine thinner than sexine; tectate, sculpturing scabrate in LM, rugulate, fossulate in SEM, rugulae 0,4 - 0,7 µm wide, microperforations between the rugulae, in colpus area number of the microperforations increase (SEM).

Indet. 2

Plate 17, Fig. 7 - 9

Pollen, monad, sphäroidal, convex triangular in polar view, circular in equatorial view (LM); equatorial diameter 13 - 17 μm in LM, 11 - 15 μm in SEM, polar axis 13 - 17 μm in LM, 11 - 15 μm in SEM; tricolporate, colpi long, endopori circular with an indistinct annulus, as wide as colpi; exine +/- 1 μm thick, nexine thinner than sexine; semitectate, sculpturing scabrate in LM, microreticulate, heterobrochate in SEM, muri 0,2 - 0,4 μm wide, margo with perforations, colpus membrane microverrucate to psilate (SEM).

Indet. 3

Plate 17, Fig. 10 - 12

Pollen, monad, sphäroidal, circular in equatorial and polar view (LM); diameter 26 - 30 μm in LM, 22 - 26 μm in SEM; tetracolporate, colpi long, endopori elliptic with an indistinct annulus, endopori wider as colpi; exine +/- 1 μm thick, sexine as thick as nexine; tectate, sculpturing microreticulate in LM, microreticulate, heterobrochate to perforate in SEM, in mesocolpium microreticulate, around colpi microreticulum becomes disorganized and perforate, lumina circular, muri 0,2 - 0,4 μm wide, colpus membrane microrugulate to microverrucate (SEM).

RESULTS

The investigated sample from the Altmittweida outcrop provides a rich and diverse assemblage of pollen taxa. Up to now, 65 different taxa were identified altogether, including five spore taxa from ferns and mosses, three gymnosperm and 57 angiosperm pollen taxa. Moreover several hyphae and spores of fungi were observed but not included.

40 taxa were identified on genus level. None of them were determined on species level. All could be assigned to a family, except for three angiosperm pollen taxa and four fern spore taxa.

Spores and bisaccate gymnosperms are very rare in the sample, whereas pollen grains of Cupressaceae (Taxodiaceae) are highly abundant. Among the angiosperms, anemophilous taxa like the Juglandaceae (*Carya*, *Cyclocarya*, *Engelhardtia* and *Platycarya*) and the Myricaceae (*Myrica*) appear in significant high numbers. Angiosperms like the Aquifoliaceae (*Ilex*) and the Fagaceae (*Quercus*), as well as elements of lacustrine vegetation like the Lythraceae (*Decodon*) and the Salicaceae (*Salix*) are frequently found too.

In comparison with the macrofossils of the area Altmittweida and Frankenau (MAI and WALTHER, 1991), several genera like *Acer*, *Ilex*, *Nyssa*, *Carya*, *Decodon*, *Myrica*, *Platanus* and *Salix* can now be confirmed in the microfossil assemblage.

Others like the Pteridophyta, the Cupressaceae, the Cyperaceae, the Rhamnaceae and the Rosaceae appear in both, the microfossil and the macrofossil assemblage. However, they could be identified on genus and species level in the macrofossil record only.

Families like the Araceae, the Arecaceae, the Betulaceae, the Hydrocharitaceae, the Malvaceae, the Ranunculaceae, the Rubiaceae and the Sapindaceae are up to now exclusively known from the macrofossil record.

Most of the families preserved in the microflora like the Pinaceae (*Pinus*), the Altingiaceae (*Liquidambar*), the Araliaceae, the Ericaceae, the Fagaceae (*Lithocarpus*, *Quercus*, *Fagus*, *Trigonobalanopsis*), the Juglandaceae (*Cyclocarya*), the Loranthaceae, the Mastixiaceae, the Rutaceae (*Zanthoxylum*), the Styracaceae, the Symplocaceae (*Symplocos*), the Typhaceae (*Sparganium*), the Ulmaceae (*Ulmus*, *Zelkova*), the Vitaceae (*Parthenocissus*) and the

Zingiberaceae (*Spirematospermum*) could not be found in the macrofossil record of Altmittweida or Frankenau. However, they appear as macrofossils in other lower Miocene locations of the surrounding region in the sites Brandis, Altenbach, Leipnitz, Gröbern, Liebertwolknitz and Delitzsch-Nordwest (MAI and WALTHER, 1991).

In contrast there are families and genera like the Clethraceae, the Cucurbitaceae, the Oleaceae, the Sapotaceae, *Eucommia*, *Engelhardia*, *Fraxinus*, *Lithocarpus*, *Platycarya* and *Sphagnum* which could only be found in the microflora of Altmittweida.

There are some special findings in the microflora of Altmittweida:

Interesting is a possible evidence of a Cucurbitaceae (BARTH et al., 2005) in the lower Miocene of Europe, which has not been documented before. Taxonomic characteristics like the echinate sculpture and the stephanobrevicolpate apertures confirm this assumption. On the other hand, the identification is based on a South American type. It is uncertain if these plants were also part of the Eurasian flora or if they are related.

Eucommia seems to be unique in the microfossil record since it is not described in literature. However, the microechinate, perforate sculpture is an obvious proof for this plant in the microfossil assemblage.

An early evidence of *Fagus* could also be found in the microflora of Altmittweida.

For a complete list of the identified taxa see Table, which includes the known macrofossil taxa too.

Family	Macrofossils	Microfossils
Bryophyta:		<i>Sphagnum sp.</i>
Pteridophyta:	<i>Osmunda lignitum (Blechnum goeppertii)</i>	
	<i>Salvinia cerebrata</i>	
	<i>Salvinia sp.</i>	
	<i>Selaginella lusatica</i>	
	<i>Woodwardia minor</i>	
		Trilete Spore gen. et sp. indet 1
		Trilete Spore gen. et sp. indet 2
		Trilete Spore gen. et sp. indet 3

		Monolete Spore gen. et sp. indet
Gymnosperma:		
Pinaceae:		<i>Pinus sp. 1</i> (subgenus pinus)
		<i>Pinus sp. 2</i> (subgenus strobus)
Cupressaceae:	<i>Athrotaxis couttsiae</i>	Taxodiaceae gen. et sp. indet
	<i>Glyptostrobus europaea</i>	
	<i>Glyptostrobus brevisiliquata</i>	
	<i>Taxodioxydon gypsaceum</i> (<i>Cupressinoxylon protolarix</i> , <i>Betulanium sp.</i>)	
Angiosperma:		
Aceraceae:	<i>Acer tricuspidatum</i> (<i>Acer</i> <i>trilobatum</i>)	<i>Acer sp. 1</i>
		<i>Acer sp. 2</i>
Altingiaceae:		<i>Liquidambar sp.</i>
Aquifoliaceae:	<i>Ilex saxonica</i>	<i>Ilex sp. 1</i>
		<i>Ilex sp. 2</i>
Araceae:	<i>Pistia sibirica</i>	
Araliaceae:		Araliaceae gen. et sp. indet
Arecaceae:	<i>Calamus daemnorops</i> (<i>Palmacites daemnorops</i>)	
Betulaceae:	<i>Alnus julianaeformis</i> (<i>Fagus</i> <i>feroniae</i>)	
	<i>Alnus lusatica</i>	
Clethraceae:		Clethraceae gen. et sp. indet
Cornaceae:	<i>Nyssa disseminata</i>	<i>Nyssa sp.</i>
	<i>Nyssa ornithobroma</i> (<i>Anona</i> <i>altenburgensis</i>)	
	<i>Swida gorbunovii</i>	<i>Cornus sp.</i>
Cucurbitaceae:		Cucurbitaceae gen. et sp. indet
Cyperaceae:	<i>Caricoidea jugata</i>	Cyperaceae gen. et sp. indet
Ericaceae:		Ericaceae gen. et sp. indet 1
		Ericaceae gen. et sp. indet 2
Eucommiaceae:		<i>Eucommia sp.</i>
Fagaceae:		<i>Lithocarpus sp.</i>
		<i>Quercus sp. (cerris type)</i>
		<i>Quercus sp. (ilex type)</i>
		<i>Quercus sp.</i> (<i>cyclobalanopsis type</i>)

		<i>Fagus sp.</i>
		<i>Trigonobalanopsis sp.</i>
Hydrocharitaceae:	<i>Stratiotes kaltennordheimensis</i>	
Juglandaceae:	<i>Carya ventricosa</i>	<i>Carya sp.</i>
		<i>Cyclocarya sp.</i>
		<i>Engelhardtia sp. 1</i>
		<i>Engelhardtia sp. 2</i>
		<i>Engelhardtia sp. 3</i>
		<i>Platycarya sp.</i>
Loranthaceae:		Loranthaceae gen. et sp. indet
Lythraceae:	<i>Decodon gibbosus</i>	<i>Decodon sp. 1</i>
	<i>Decodon tetraedrifomis</i>	<i>Decodon sp. 2</i>
	<i>"Trapa" credneri</i>	
Malvaceae:	<i>Burretia insculpta (Tilia)</i>	
Mastixiaceae:		Mastixiaceae gen. et sp. indet
Myricaceae:	<i>Myrica boveyana</i>	<i>Myrica sp.</i>
	<i>Myrica ceriferiformis</i>	
	<i>Myrica integerrima (M. salicina, Quercus haidingeri)</i>	
Oleaceae:		<i>Fraxinus sp. 1</i>
		<i>Fraxinus sp. 2</i>
		Oleaceae gen. et sp. indet 1
		Oleaceae gen. et sp. indet 2
		Oleaceae gen. et sp. indet 3
Platanaceae:	<i>Aracistrobus dravertii</i>	
	<i>Platanus leucophylla (P. aceroides)</i>	<i>Platanus sp.</i>
Ranunculaceae:	<i>Ranunculus marginalis</i>	
Rhamnaceae:	<i>Paliurus favonii</i>	Rhamnaceae gen. et sp. indet
Rosaceae:	<i>Rubus microspermus</i>	Rosaceae gen. et sp. indet
Rubiaceae:	<i>Cephalanthus kireevskianus</i>	
Rutaceae:		<i>Zanthoxylum</i>
Salicaceae:	<i>Populus populina</i>	
	<i>Salix varians</i>	<i>Salix sp. 1</i>
		<i>Salix sp. 2</i>
Sapindaceae:	<i>Koelreuteria margaritifera (Carpolithus nitens)</i>	
Sapotaceae:		Sapotaceae gen. et sp. indet 1
		Sapotaceae gen. et sp. indet 2
		Sapotaceae gen. et sp. indet 3
Styracaceae:		Styracaceae gen. et sp. indet

Symplocaceae:		<i>Symplocos sp. 1</i>
		<i>Symplocos sp. 2</i>
		<i>Symplocos sp. 3</i>
Typhaceae:		<i>Sparganium sp.</i>
Ulmaceae:		<i>Ulmus sp.</i>
		<i>Zelkova sp.</i>
Vitaceae:		<i>Parthenocissus sp.</i>
Zingiberaceae:		<i>Spirematospermum sp.</i>
Indeterminate:	<i>Vaccinioides sativa</i>	
		Indet. gen. et sp. indet 1
		Indet. gen. et sp. indet 2
		Indet. gen. et sp. indet 3

Table: Identified taxa in the macrofossil record (MAI and WALTHER, 1991) and the here described microfossil record of Altmittweida.

DISCUSSION

Based on the findings the following contribution can be made to the paleobiogeography: Since *Eucommia* is native to China it suggests immigration to Europe during the tertiary, probably in the Oligocene.

Fagus first appears in middle Oligocene in Europe (DENK et al., in press) and is hitherto only known as a macrofossil from the upper Oligocene site Borna and the lower Miocene site Gröbern in Saxony (MAI and WALTHER, 1991). In the upper Oligocene site Bockwitz (MAI and WALTHER, 1991), the genus *Fagus* is found in both, macrofossil and microfossil record (WALTHER and ZETTER, 1993). Since *Fagus* dislikes moister habitats, pollen and macrofossils are difficult to find. However, there are wooded areas with a slightly higher elevation (less than two meters) near marshes or swamps, called hummocks, where *Fagus* is able to thrive in spite of moist conditions. Nevertheless the evidence of *Fagus* shows that its distribution is wider than originally assumed.

Sphagnum mosses are common in most wetland environments, thriving in and around swamps, fens, bogs, ponds and lakes (RYDIN et al., 2006a). The fern spores grow mostly in moist environments and are absent in dry regions. They often occur in relatively shady places

as part of the undergrowth and in various forest types. Ferns are often growing in open patches within woodland and at the forest borderland (KRAMER and GREEN, 1990; TRYON and LUGARDON, 1991).

The Cyperaceae, *Sparganium* and *Decodon* are typical elements of a lacustrine vegetation. The Cyperaceae are common in wetland environments like swamps, peats or banks of lacustrine waters. *Sparganium* is part of the reed bed and is therefore also growing on the waterfront of lakes or abandoned river channels. *Decodon* thrives near sluggish water bodies like ponds or oxbow lakes with slow moving or standing water conditions. Around this body of standing water different types of forests probably merged into each other.

First of all *Nyssa* and the Taxodiaceae are typical elements of a wetland forest due to their adaptation in colonizing unstable and dysaerobe substrate (FERGUSON et al., 1998).

The area around the wetland forest certainly consisted of a well-drained broad-leaved forest. The trees of this forest have superficial roots and are able to survive a short period of flooding. Others grow on natural levées, hummocks and on the higher ground of the surrounding slopes (FERGUSON et al., 1998). It is conceivable that *Acer*, *Liquidambar*, *Platanus*, *Symplocos*, *Fraxinus*, *Ulmus*, *Zelkova*, the Juglandaceae, the Fagaceae and the Salicaceae were part of this forest.

Next to the well-drained broad-leaved forest it is possible that there was a well-drained coniferous forest. This type of forest is implied by the rare occurrence of *Pinus* in the microfossil record. Usually these trees can be found at high altitudes but as long as the air humidity was high enough these plants could have survived on lower grounds as well. However, the conifers were probably restricted to some sites where the angiosperms were unable to gain a foothold (FERGUSON et al., 1998).

Many warm temperate taxa are abundant. Plants such as *Engelhardia*, *Liquidambar*, *Symplocos*, *Zanthoxylum*, *Spirematospermum*, the Araliaceae, the Clethraceae, the Cucurbitaceae, the Mastixiaceae, the Sapotaceae and the Styracaceae point to a warm-temperate to subtropical climate. Other taxa like *Ilex* and the Oleaceae are representatives of a warm-temperate climate too, but can reach to the temperate regions. Typical temperate elements of the Northern Hemisphere like *Acer*, *Quercus*, *Fagus*, *Platanus*, *Salix* and *Ulmus* could also be identified and are part of the microfossil assemblage.

Concluding from these results, the microfossil record confirms the reconstruction of the vegetation based on macrofossils. The vegetation consists mainly of mesophil alluvial forest and warm-temperate summer forest elements. In addition, laurophyll forest plants can be found in the macrofossil record and are part of the flora (MMF in KNOBLOCH and KVACEK, 1976).

The microfossil assemblage is frequently not included in palaeobotanical investigations. If there are palynological investigations, they are usually based on light microscopy. The use of the scanning electron microscope is necessary to get detailed information about the taxa. With additional taxonomic information, pollen grains can be assigned to a family, a genus or even a species.

In this study, the microflora of Altmittweida was investigated and shows a more detailed picture of the lower Miocene vegetation of Saxony (Germany). For a proper reconstruction of the vegetation in the past, all information possible must be gathered and combined.

Although there is agreement between the macrofossil and the microfossil record of Altmittweida, new information contributes to hitherto knowledge and results in:

- 1) a more complete reconstruction of the local flora;
- 2) detection of new elements not found before in the macrofossil record of Altmittweida, but known from surrounding sites;
- 3) an estimate about the composition of the vegetation (not quantitatively as the strong preservation bias has to be taken into account);
- 4) new research topics due to special findings (confirmation of *Fagus*, the enigmatic Curcubitaceae pollen grain, *Eucommia*);

Finally, the first description of the micro fossil record of Altmittweida contributes to climatic reconstructions based on preserved taxa.

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PLATES

Plate 1:

Fig. 1: *Sphagnum sp.* LM; polar view

Fig. 2: *Sphagnum sp.* SEM; polar view

Fig. 3: *Sphagnum sp.* SEM; detail picture of the surface

Fig. 4: **Monolete Spore, gen. et sp. indet 1.** LM; polar view

Fig. 5: **Monolete Spore, gen. et sp. indet 1.** SEM; polar view

Fig. 6: **Monolete Spore, gen. et sp. indet 1.** SEM; detail picture of the surface

Fig. 7: **Trilete Spore, gen. et sp. indet 1.** LM; polar view

Fig. 8: **Trilete Spore, gen. et sp. indet 1.** SEM; polar view

Fig. 9: **Trilete Spore, gen. et sp. indet 1.** SEM; detail picture of the surface

Fig. 10: **Trilete Spore, gen. et sp. indet 2.** LM; polar view

Fig. 11: **Trilete Spore, gen. et sp. indet 2.** SEM; polar view

Fig. 12: **Trilete Spore, gen. et sp. indet 2.** SEM; detail picture of the surface

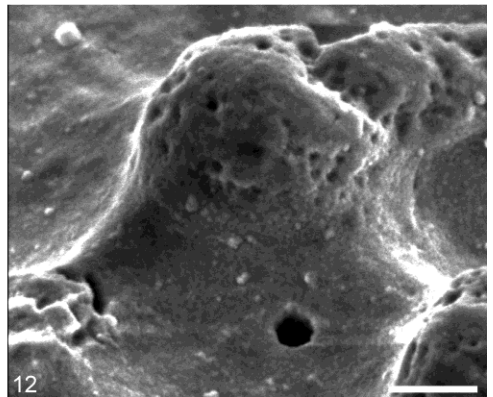
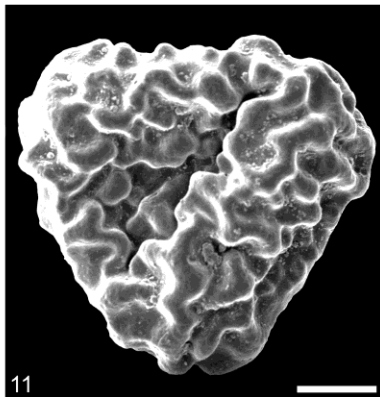
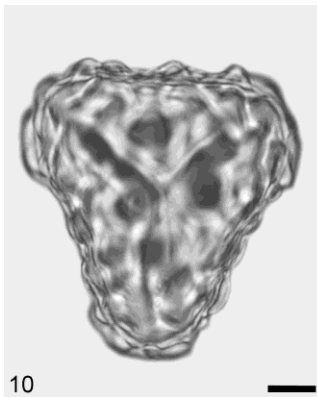
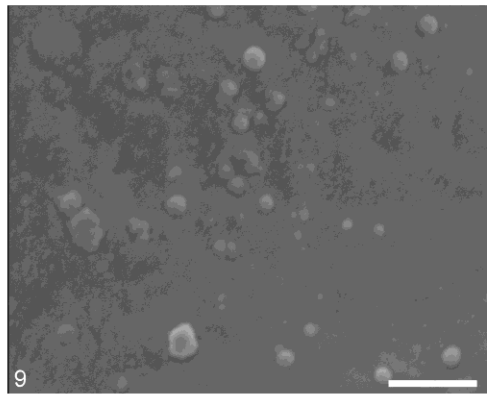
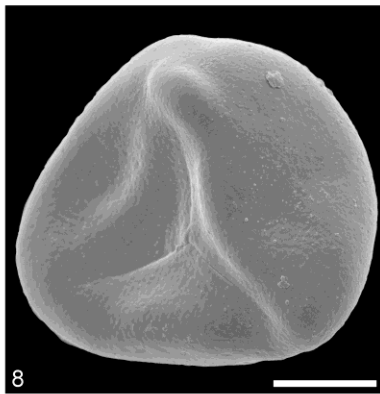
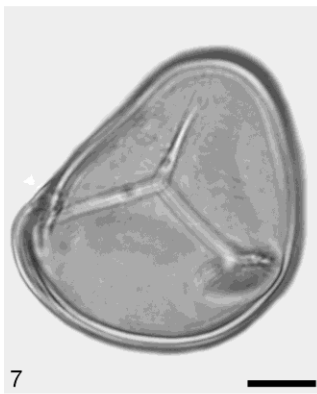
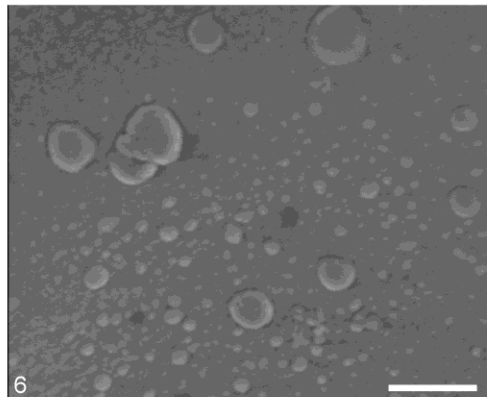
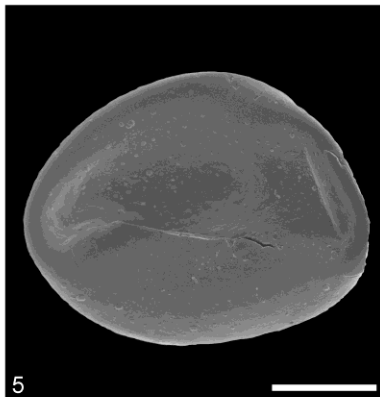
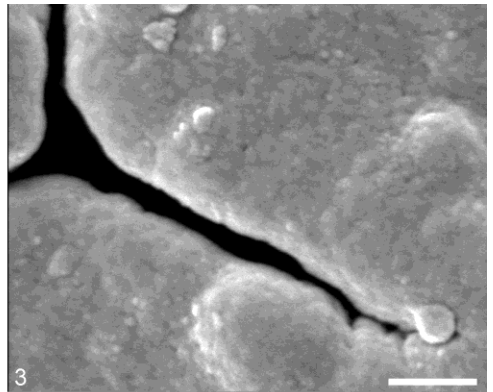
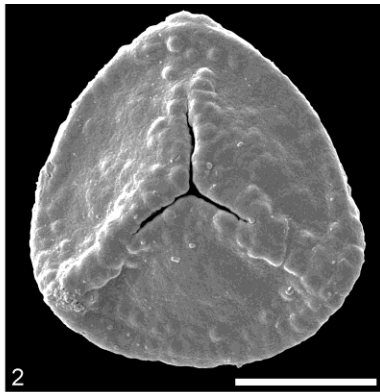
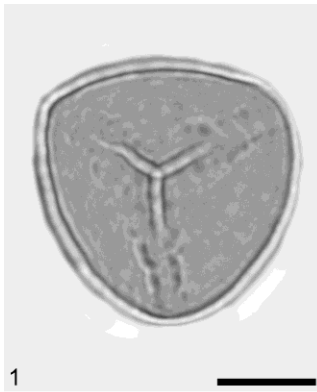


Plate 2:

Fig. 1: **Trilete Spore, gen. et sp. indet 3.** LM; polar view

Fig. 2: **Trilete Spore, gen. et sp. indet 3.** SEM; polar view

Fig. 3: **Trilete Spore, gen. et sp. indet 3.** SEM; detail picture of the surface

Fig. 4: ***Pinus sp. 1.* (subgenus *pinus*).** LM; equatorial view

Fig. 5: ***Pinus sp. 1.* (subgenus *pinus*).** SEM; equatorial view

Fig. 6: ***Pinus sp. 1.* (subgenus *pinus*).** SEM; detail picture of the corpus surface

Fig. 7: ***Pinus sp. 2.* (subgenus *strobis*).** LM; equatorial view

Fig. 8: ***Pinus sp. 2.* (subgenus *strobis*).** SEM; equatorial view

Fig. 9: ***Pinus sp. 2.* (subgenus *strobis*).** SEM; detail picture of the saccus surface

Fig. 10: **Taxodiaceae - gen. et sp. indet.** LM; equatorial view

Fig. 11: **Taxodiaceae - gen. et sp. indet.** SEM; equatorial view

Fig. 12: **Taxodiaceae - gen. et sp. indet.** SEM; detail picture of the surface

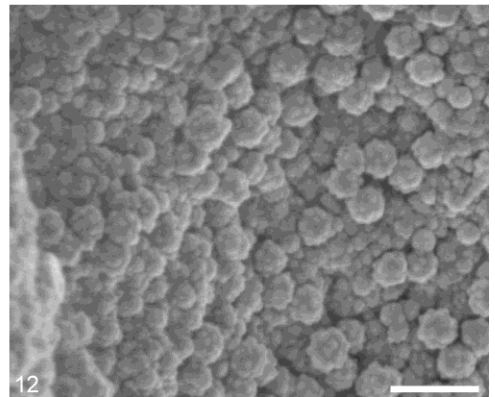
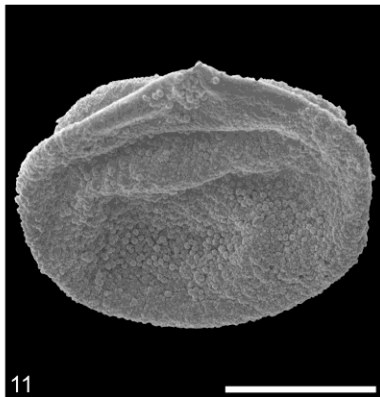
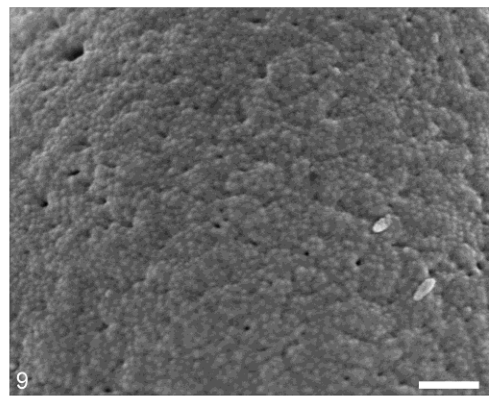
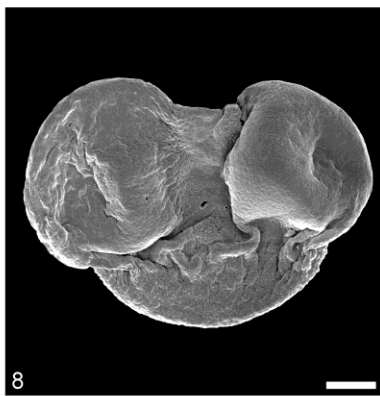
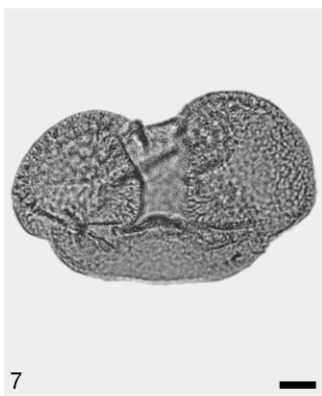
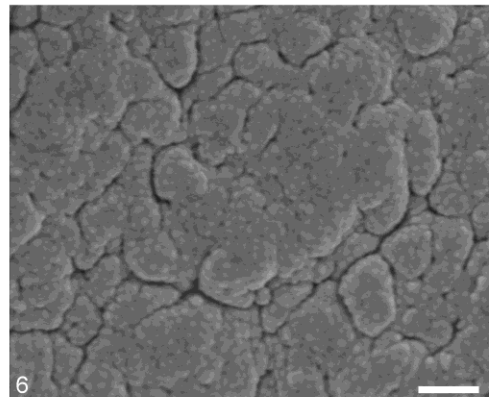
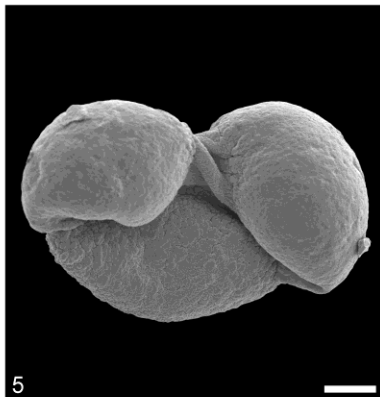
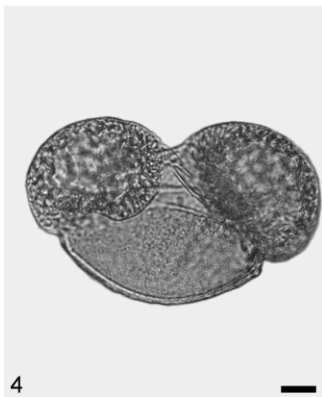
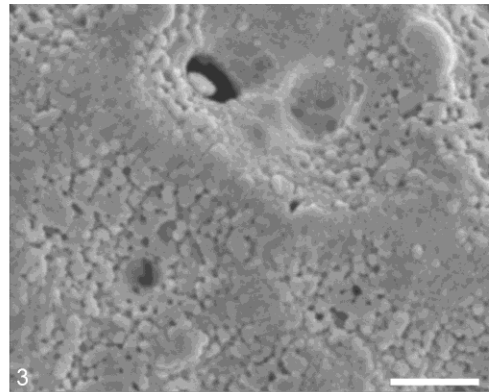
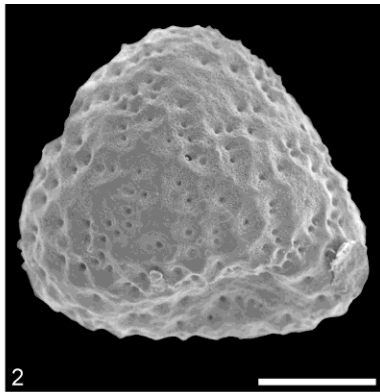
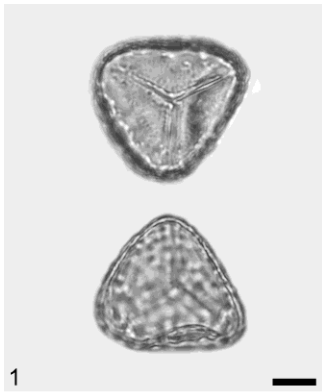


Plate 3:

Fig. 1: *Acer sp. 1*. LM; equatorial view

Fig. 2: *Acer sp. 1*. SEM; equatorial view

Fig. 3: *Acer sp. 1*. SEM; detail picture of the surface

Fig. 4: *Acer sp. 2*. LM; equatorial view

Fig. 5: *Acer sp. 2*. SEM; equatorial view

Fig. 6: *Acer sp. 2*. SEM; detail picture of the surface

Fig. 7: *Liquidambar sp.* LM;

Fig. 8: *Liquidambar sp.* SEM;

Fig. 9: *Liquidambar sp.* SEM; detail picture of the surface

Fig. 10: *Ilex sp. 1*. LM; equatorial view

Fig. 11: *Ilex sp. 1*. SEM; equatorial view

Fig. 12: *Ilex sp. 1*. SEM; detail picture of the surface

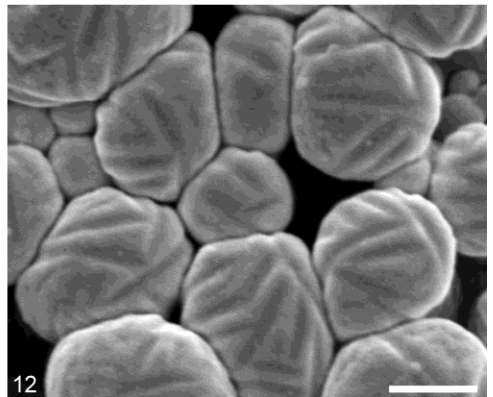
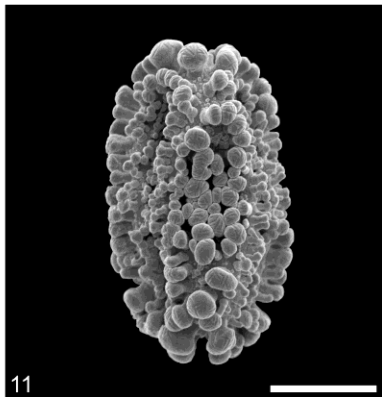
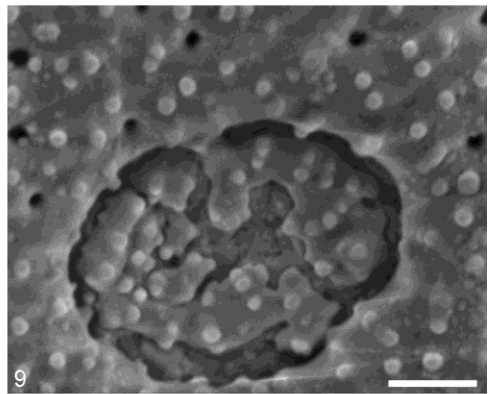
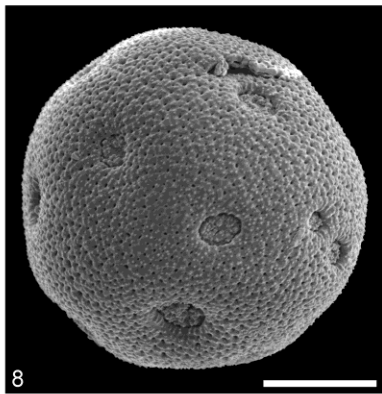
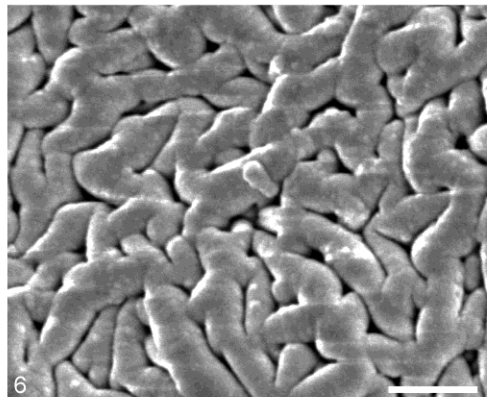
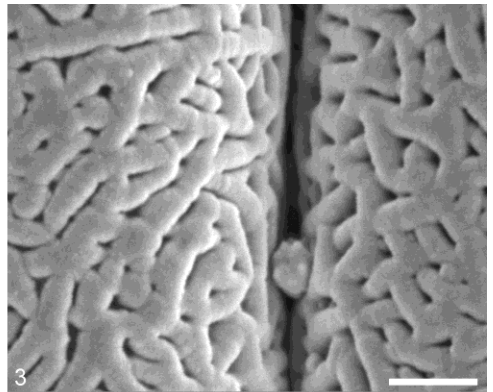
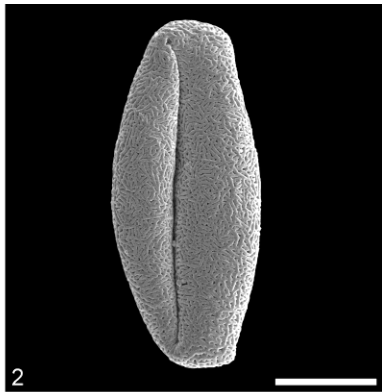


Plate 4

Fig. 1: *Ilex sp. 2*. LM; equatorial view

Fig. 2: *Ilex sp. 2*. SEM; equatorial view

Fig. 3: *Ilex sp. 2*. SEM; detail picture of the surface

Fig. 4: **Araliaceae - gen. et sp. indet.** LM; polar and equatorial view

Fig. 5: **Araliaceae - gen. et sp. indet.** SEM; equatorial view

Fig. 6: **Araliaceae - gen. et sp. indet.** SEM; detail picture of the surface

Fig. 7: **Araliaceae - gen. et sp. indet.** LM; equatorial view

Fig. 8: **Araliaceae - gen. et sp. indet.** SEM; equatorial view

Fig. 9: **Araliaceae - gen. et sp. indet.** SEM; detail picture of the surface

Fig. 10: **Clethraceae - gen. et sp. indet.** LM; polar and equatorial view

Fig. 11: **Clethraceae - gen. et sp. indet.** SEM; equatorial view

Fig. 12: **Clethraceae - gen. et sp. indet.** SEM; detail picture of the surface

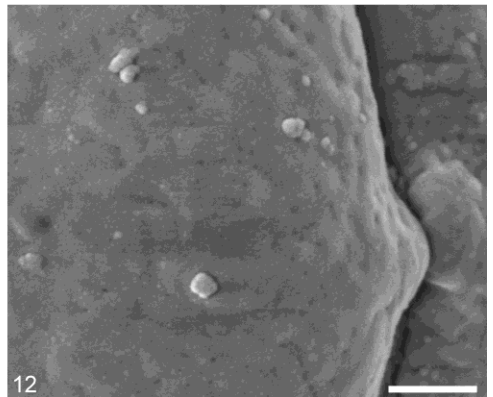
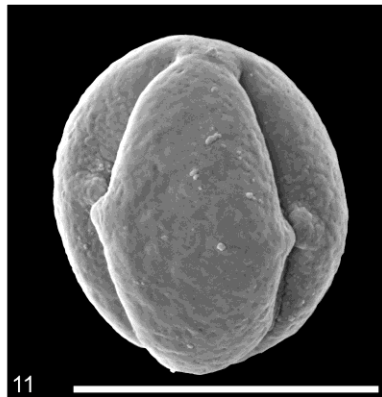
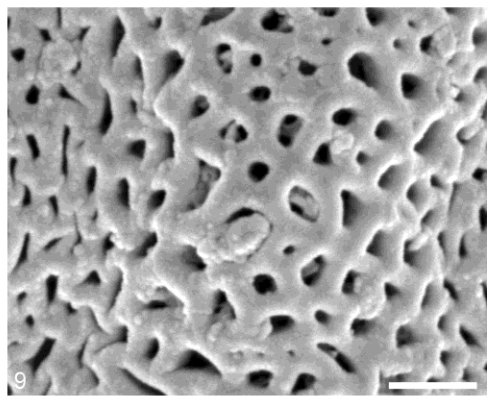
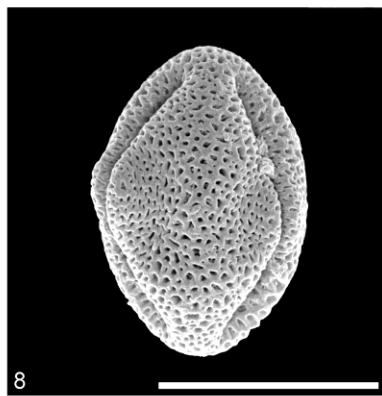
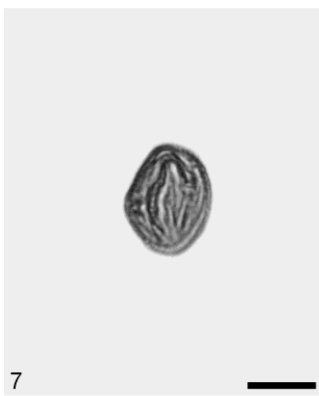
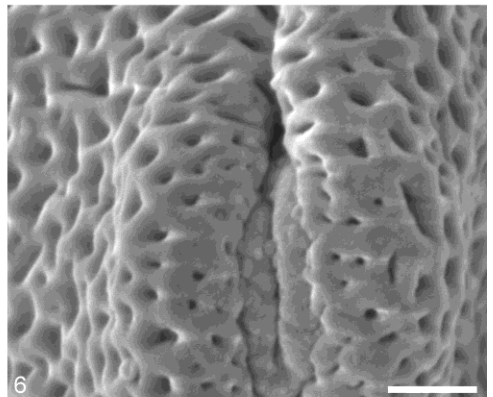
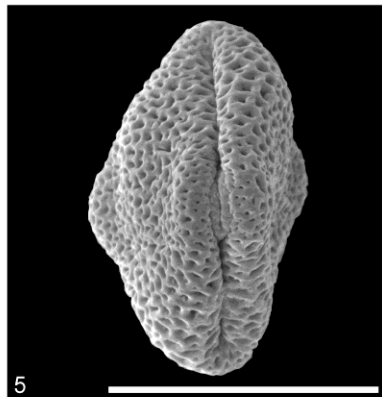
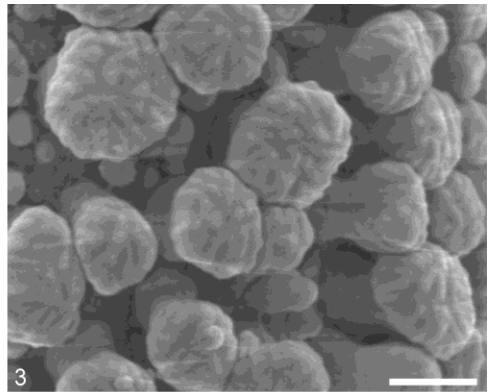
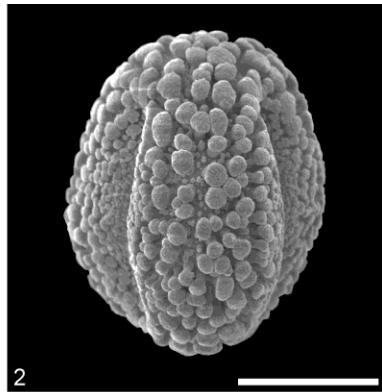


Plate 5

Fig. 1: *Nyssa sp.* LM; equatorial and polar view

Fig. 2: *Nyssa sp.* SEM; equatorial view

Fig. 3: *Nyssa sp.* SEM; detail picture of the surface

Fig. 4: *Nyssa sp.* LM; equatorial and polar view

Fig. 5: *Nyssa sp.* SEM; equatorial view

Fig. 6: *Nyssa sp.* SEM; detail picture of the surface

Fig. 7: *Cornus sp.* LM; equatorial view

Fig. 8: *Cornus sp.* SEM; equatorial view

Fig. 9: *Cornus sp.* SEM; detail picture of the surface

Fig. 10: *Cornus sp.* LM; equatorial view

Fig. 11: *Cornus sp.* SEM; equatorial view

Fig. 12: *Cornus sp.* SEM; detail picture of the surface

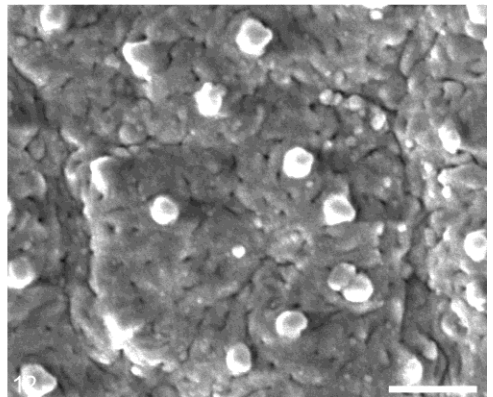
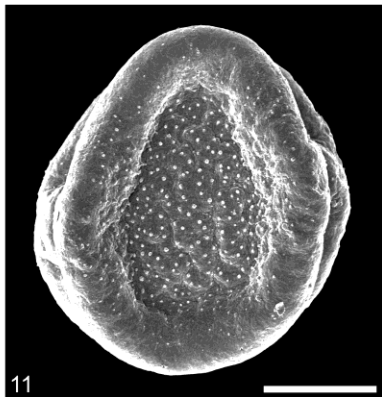
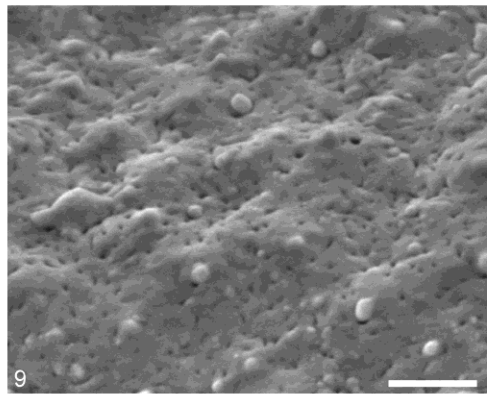
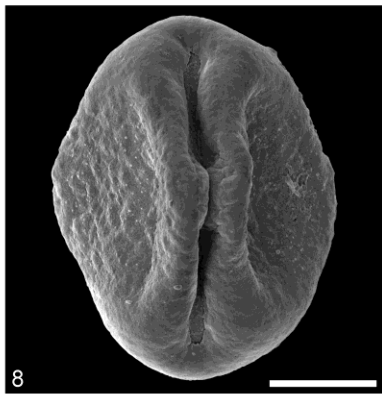
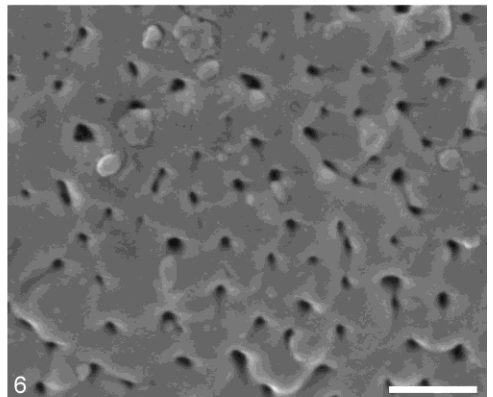
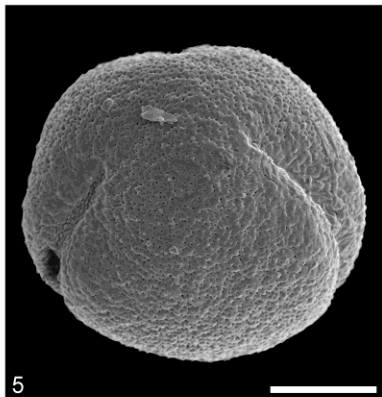
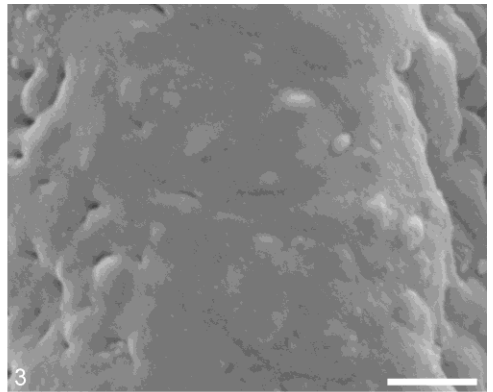
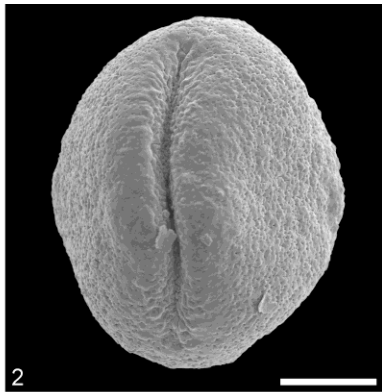
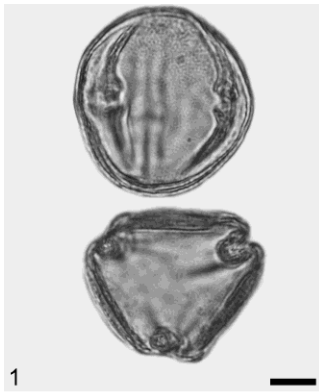


Plate 6

Fig. 1: **Cucurbitaceae - gen. et sp. indet.** LM; polar view

Fig. 2: **Cucurbitaceae - gen. et sp. indet.** SEM; polar view

Fig. 3: **Cucurbitaceae - gen. et sp. indet.** SEM; detail picture of the surface

Fig. 4: **Cyperaceae - gen. et sp. indet.** LM; equatorial view

Fig. 5: **Cyperaceae - gen. et sp. indet.** SEM; equatorial view

Fig. 6: **Cyperaceae - gen. et sp. indet.** SEM; detail picture of the surface

Fig. 7: **Ericaceae - gen. et sp. indet. 1.** LM;

Fig. 8: **Ericaceae - gen. et sp. indet. 1.** SEM;

Fig. 9: **Ericaceae - gen. et sp. indet. 1.** SEM; detail picture of the surface

Fig. 10: **Ericaceae - gen. et sp. indet. 2.** LM;

Fig. 11: **Ericaceae - gen. et sp. indet. 2.** SEM;

Fig. 12: **Ericaceae - gen. et sp. indet. 2.** SEM; detail picture of the surface

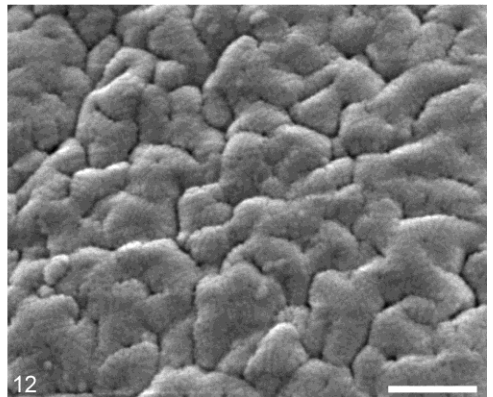
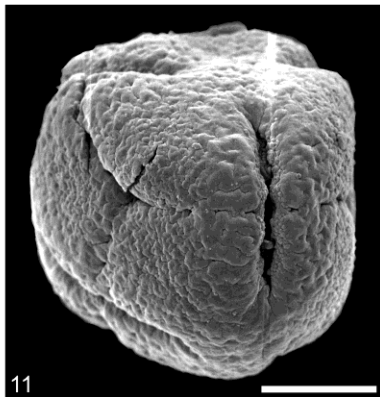
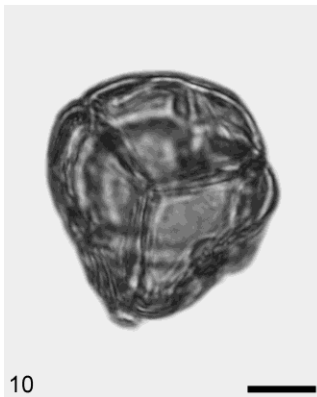
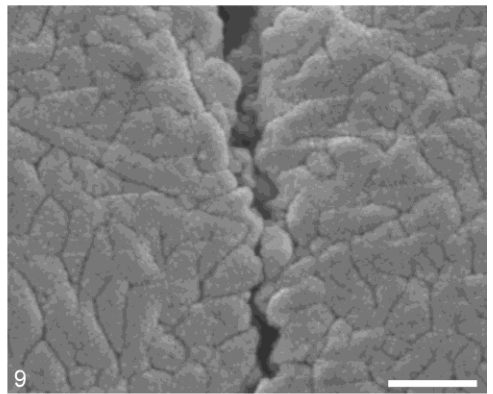
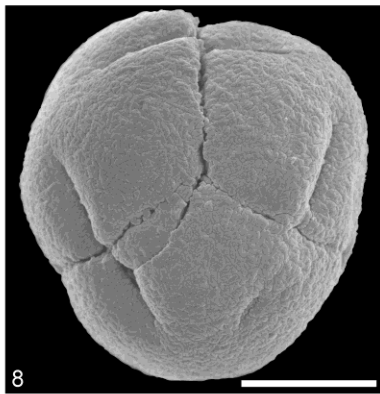
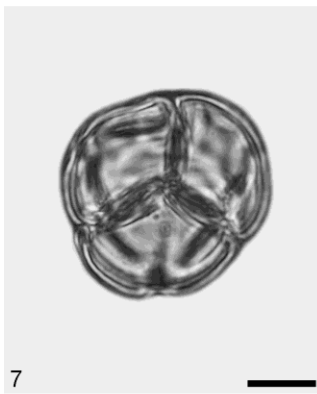
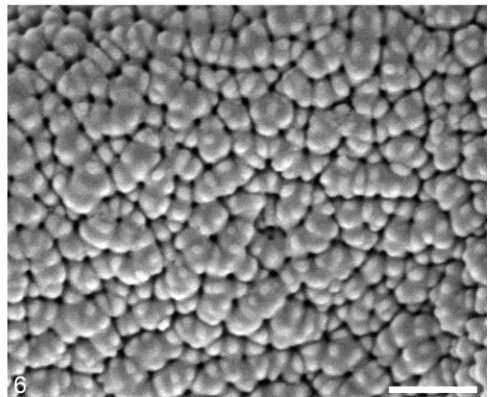
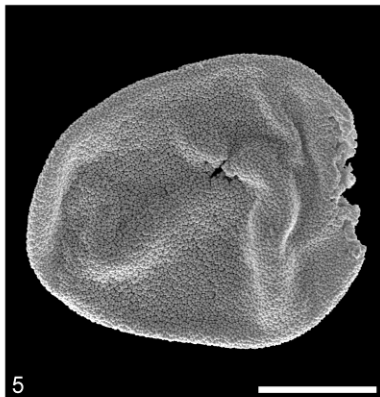
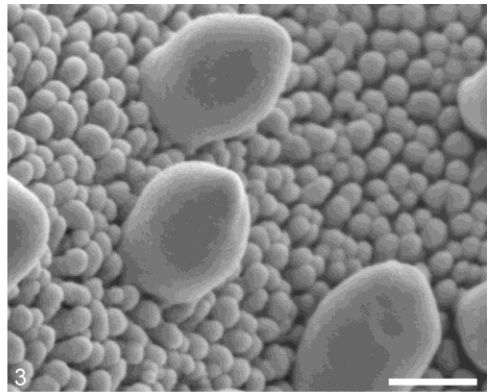
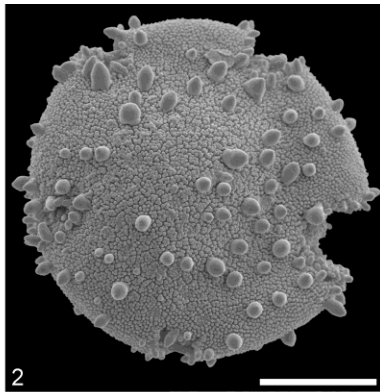
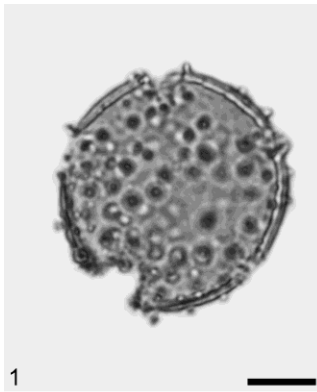


Plate 7

Fig. 1: *Eucommia sp.* LM; equatorial view

Fig. 2: *Eucommia sp.* SEM; equatorial view

Fig. 3: *Eucommia sp.* SEM; detail picture of the surface

Fig. 4: *Lithocarpus sp.* LM; equatorial view

Fig. 5: *Lithocarpus sp.* SEM; equatorial view

Fig. 6: *Lithocarpus sp.* SEM; detail picture of the surface

Fig. 7: *Quercus sp.* 1 (cerris type). LM; equatorial and polar view

Fig. 8: *Quercus sp.* 1 (cerris type). SEM; equatorial view

Fig. 9: *Quercus sp.* 1 (cerris type). SEM; detail picture of the surface

Fig. 10: *Quercus sp.* 1 (cerris type). LM; equatorial and polar view

Fig. 11: *Quercus sp.* 1 (cerris type). SEM; equatorial view

Fig. 12: *Quercus sp.* 1 (cerris type). SEM; detail picture of the surface

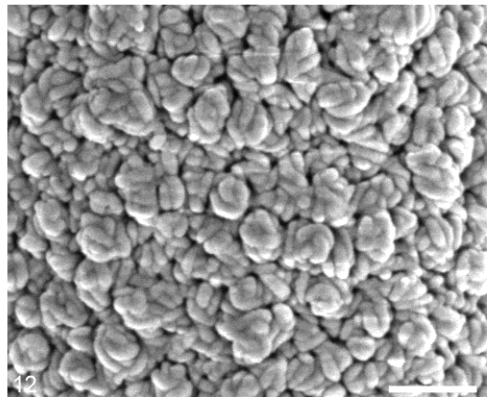
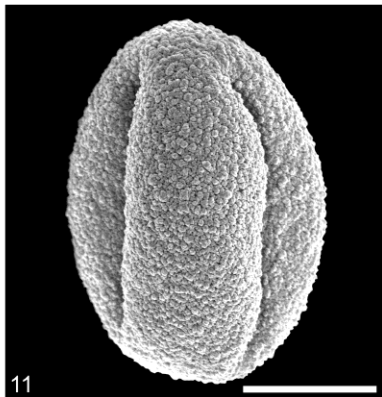
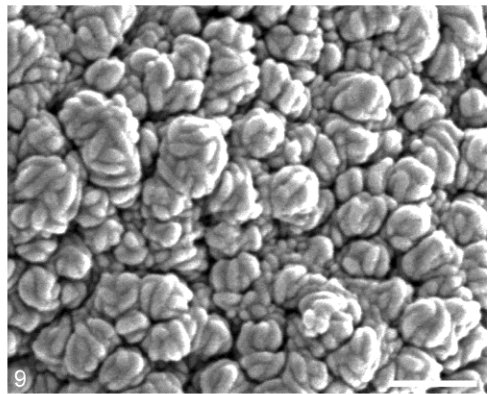
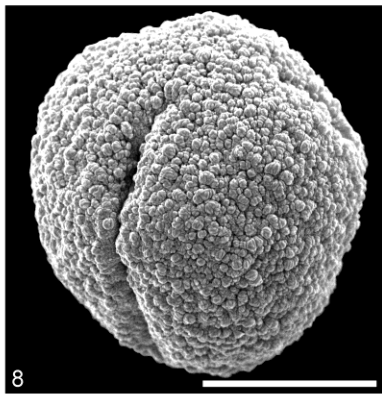
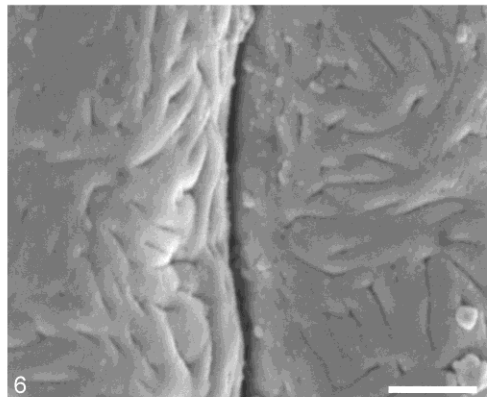
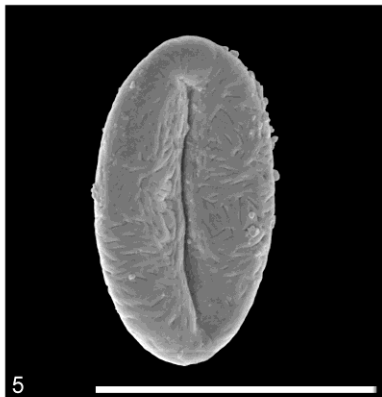
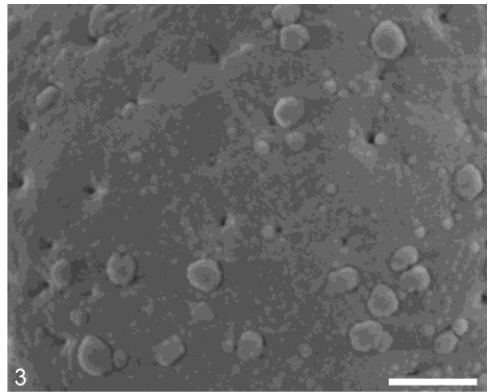
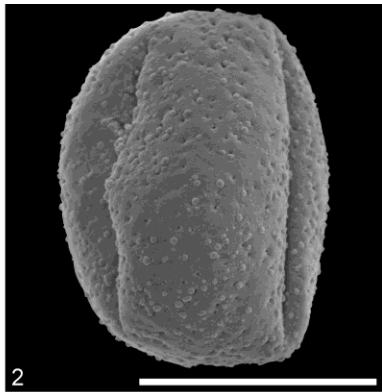


Plate 8

Fig. 1: *Quercus sp. 2* (ilex type). LM; equatorial and polar view

Fig. 2: *Quercus sp. 2* (ilex type). SEM; equatorial view

Fig. 3: *Quercus sp. 2* (ilex type). SEM; detail picture of the surface

Fig. 4: *Quercus sp. 3* (subgenus *cyclobalanopsis*). LM; equatorial and polar view

Fig. 5: *Quercus sp. 3* (subgenus *cyclobalanopsis*). SEM; equatorial view

Fig. 6: *Quercus sp. 3* (subgenus *cyclobalanopsis*). SEM; detail picture of the surface

Fig. 7: *Fagus sp.* LM; equatorial and polar view

Fig. 8: *Fagus sp.* SEM; equatorial view

Fig. 9: *Fagus sp.* SEM; detail picture of the surface

Fig. 10: *Trigonobalanopsis sp.* LM; equatorial view

Fig. 11: *Trigonobalanopsis sp.* SEM; equatorial view

Fig. 12: *Trigonobalanopsis sp.* SEM; detail picture of the surface

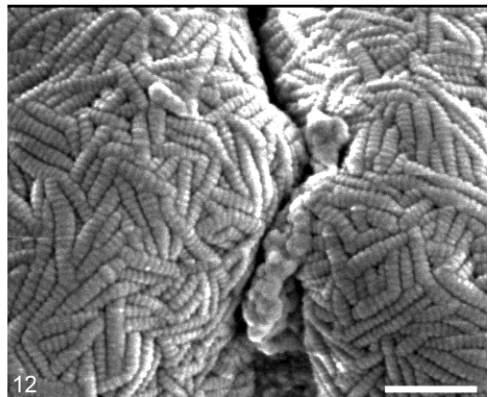
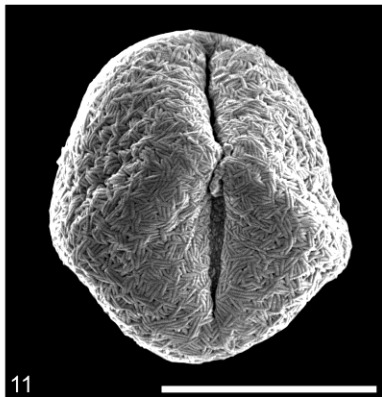
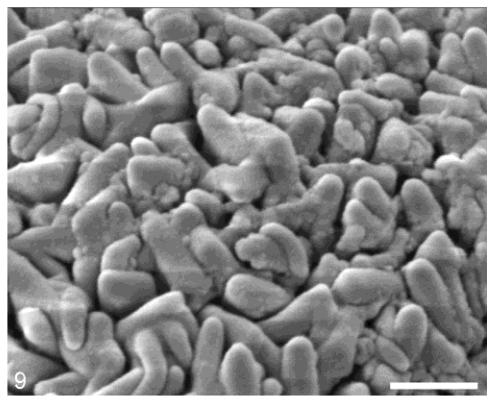
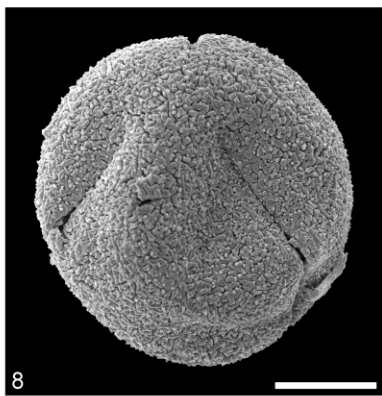
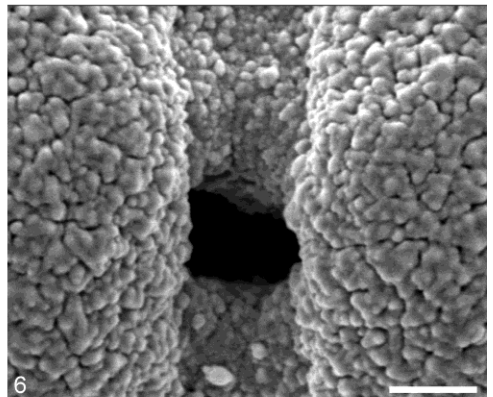
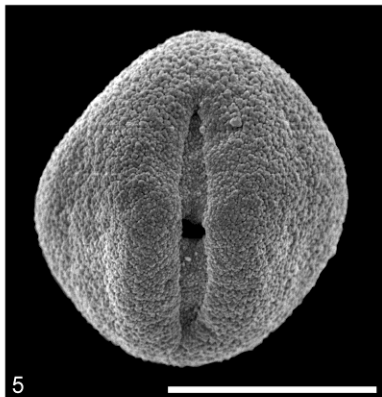
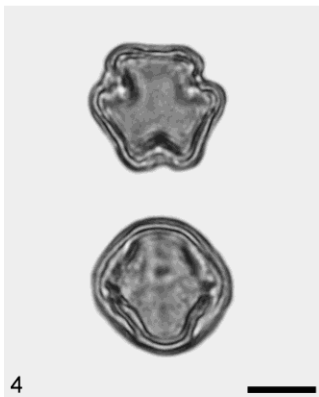
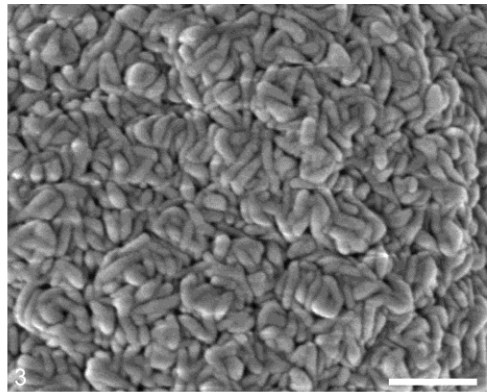
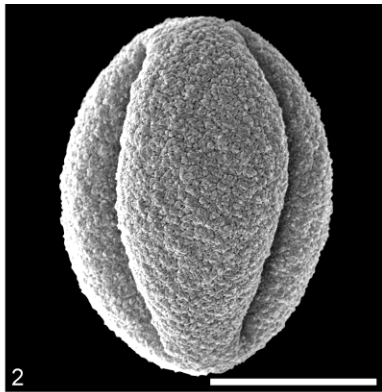


Plate 9

Fig. 1: *Carya sp.* LM; polar view

Fig. 2: *Carya sp.* SEM; polar view

Fig. 3: *Carya sp.* SEM; detail picture of the surface

Fig. 4: *Carya sp.* LM; polar view

Fig. 5: *Carya sp.* SEM; polar view

Fig. 6: *Carya sp.* SEM; detail picture of the surface

Fig. 7: *Cyclocarya sp.* LM; equatorial and polar view

Fig. 8: *Cyclocarya sp.* SEM; polar view

Fig. 9: *Cyclocarya sp.* SEM; detail picture of the surface

Fig. 10: *Cyclocarya sp.* LM; equatorial and polar view

Fig. 11: *Cyclocarya sp.* SEM; equatorial view

Fig. 12: *Cyclocarya sp.* SEM; detail picture of the surface

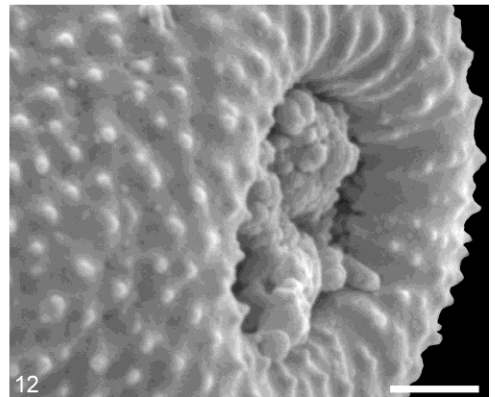
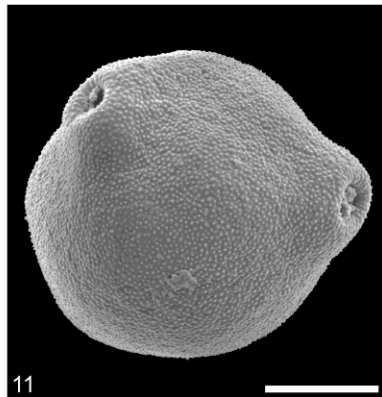
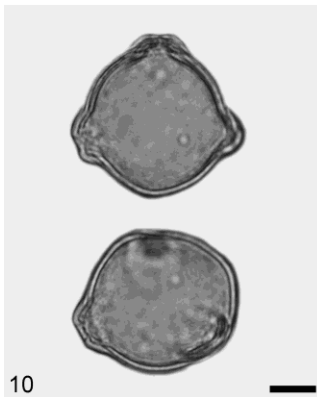
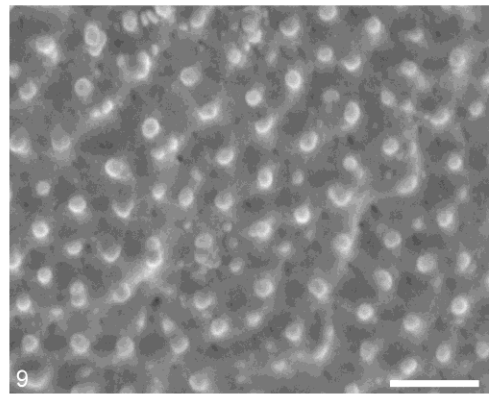
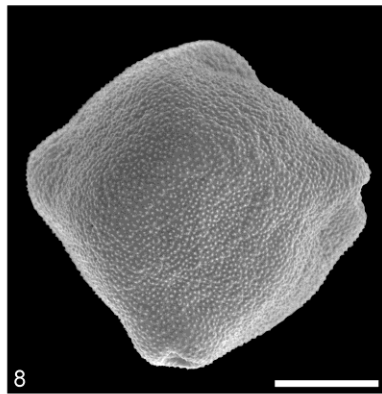
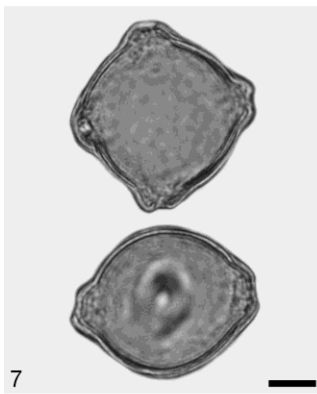
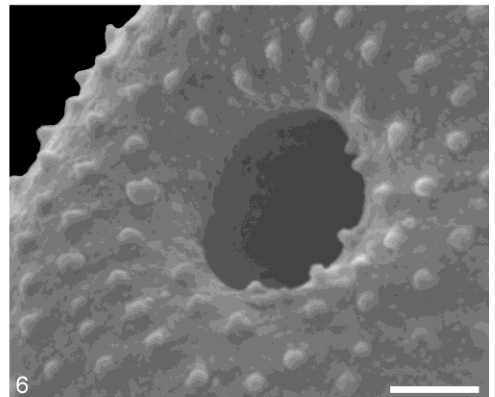
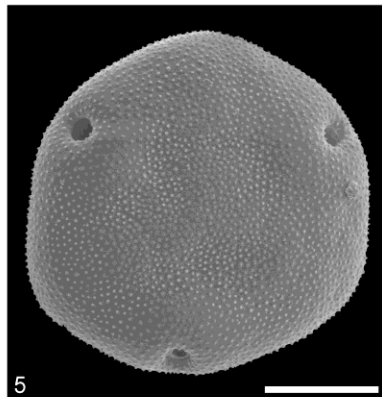
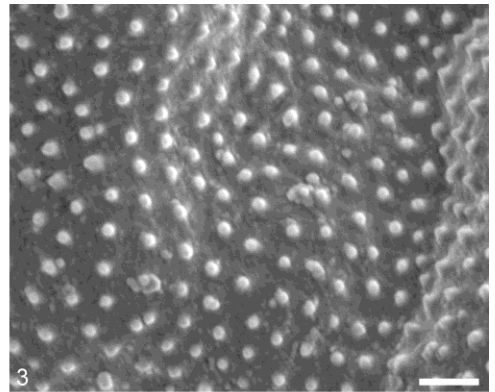
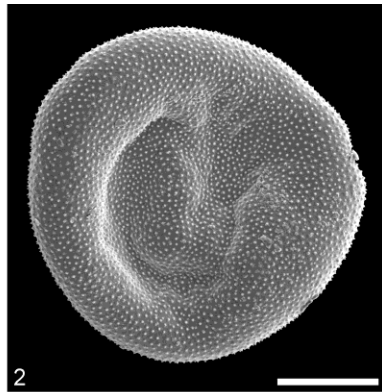
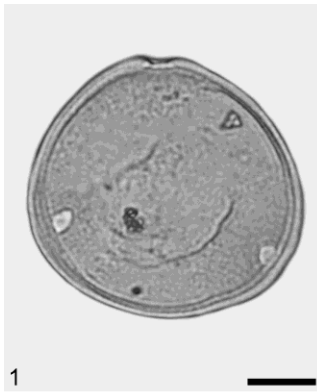


Plate 10

Fig. 1: *Engelhardia sp. 1*. LM; polar view

Fig. 2: *Engelhardia sp. 1*. SEM; polar view

Fig. 3: *Engelhardia sp. 1*. SEM; detail picture of the surface

Fig. 4: *Engelhardia sp. 2*. LM; polar view

Fig. 5: *Engelhardia sp. 2*. SEM; polar view

Fig. 6: *Engelhardia sp. 2*. SEM; detail picture of the surface

Fig. 7: *Engelhardia sp. 3*. LM; polar view

Fig. 8: *Engelhardia sp. 3*. SEM; polar view

Fig. 9: *Engelhardia sp. 3*. SEM; detail picture of the surface

Fig. 10: *Platycarya sp.* LM; polar view

Fig. 11: *Platycarya sp.* SEM; polar view

Fig. 12: *Platycarya sp.* SEM; detail picture of the surface

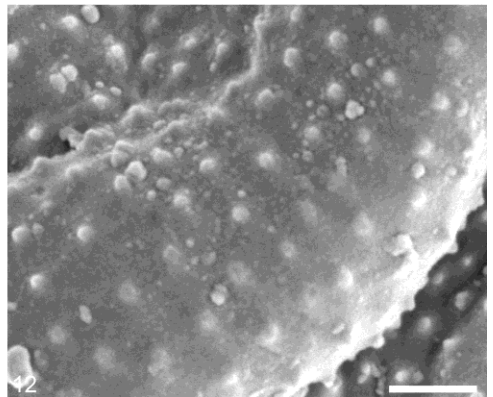
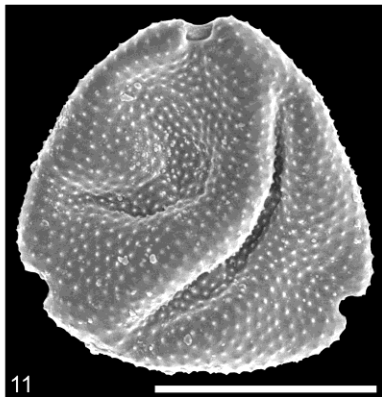
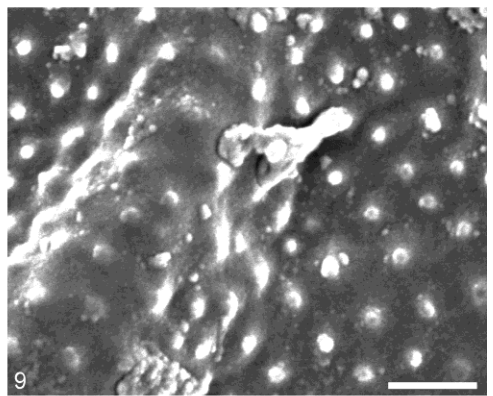
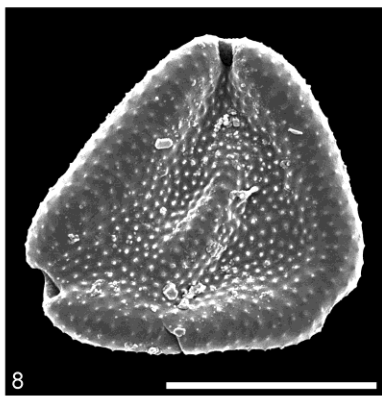
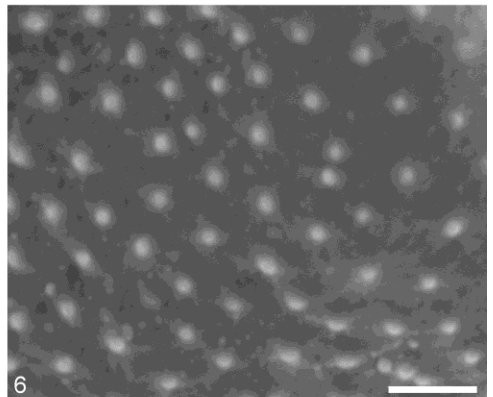
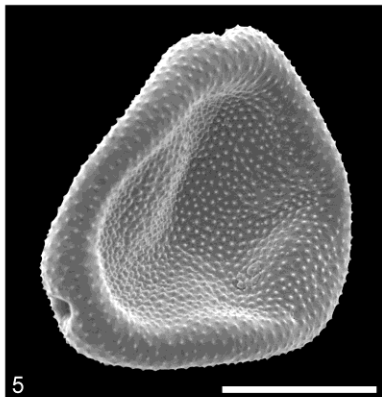
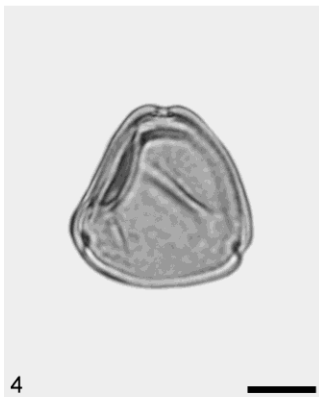
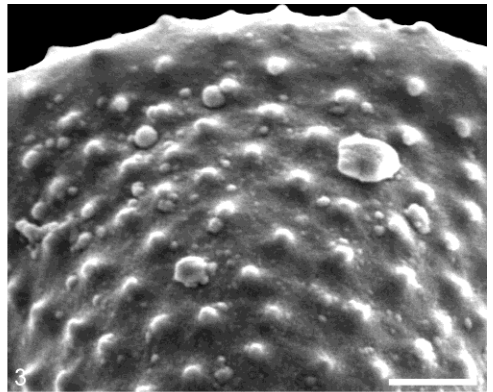
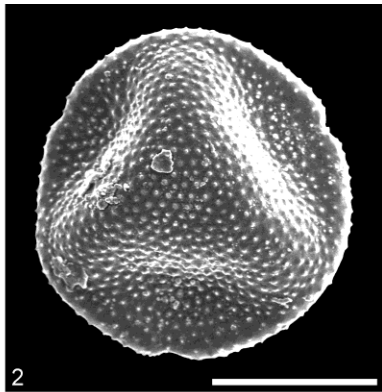


Plate 11

Fig. 1: **Loranthaceae - gen. et sp. indet.** LM; polar view

Fig. 2: **Loranthaceae - gen. et sp. indet.** SEM; polar view

Fig. 3: **Loranthaceae - gen. et sp. indet.** SEM; detail picture of the surface

Fig. 4: ***Decodon sp. 1.*** LM; equatorial view

Fig. 5: ***Decodon sp. 1.*** SEM; equatorial view

Fig. 6: ***Decodon sp. 1.*** SEM; detail picture of the surface

Fig. 7: ***Decodon sp. 2.*** LM; equatorial and polar view

Fig. 8: ***Decodon sp. 2.*** SEM; equatorial view

Fig. 9: ***Decodon sp. 2.*** SEM; detail picture of the surface

Fig. 10: **Mastixiaceae - gen. et sp. indet.** LM; polar view

Fig. 11: **Mastixiaceae - gen. et sp. indet.** SEM; polar view

Fig. 12: **Mastixiaceae - gen. et sp. indet.** SEM; detail picture of the surface

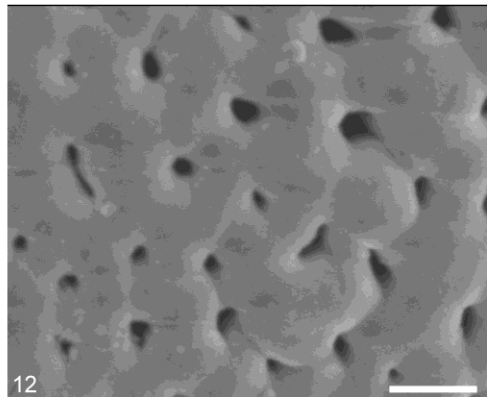
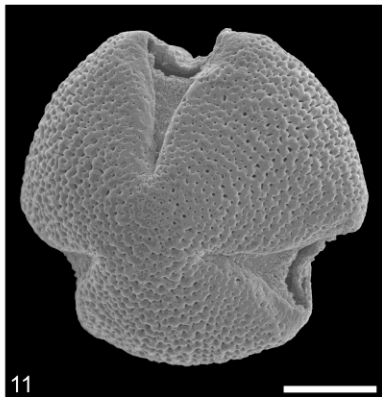
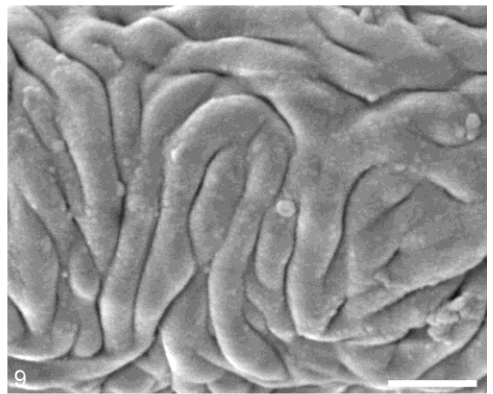
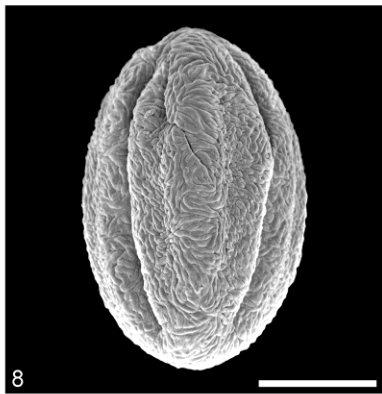
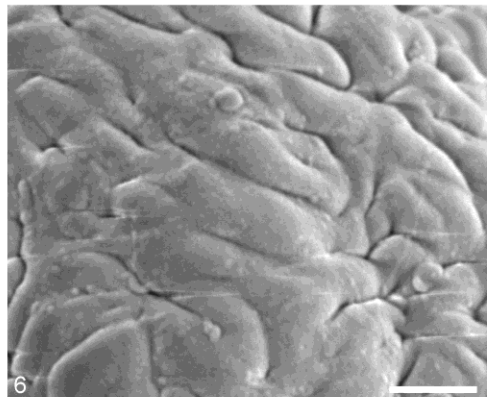
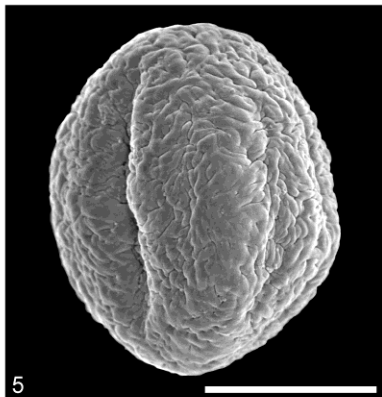
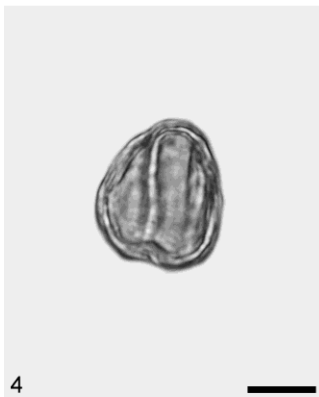
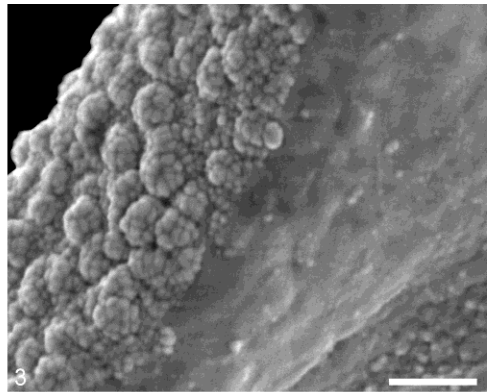
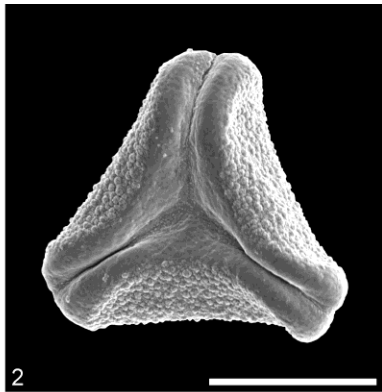


Plate 12

Fig. 1: *Myrica sp.* LM; polar view

Fig. 2: *Myrica sp.* SEM; polar view

Fig. 3: *Myrica sp.* SEM; detail picture of the surface

Fig. 4: **Oleaceae - gen. et sp. indet. 1.** LM;

Fig. 5: **Oleaceae - gen. et sp. indet. 1.** SEM;

Fig. 6: **Oleaceae - gen. et sp. indet. 1.** SEM; detail picture of the surface

Fig. 7: **Oleaceae - gen. et sp. indet. 2.** LM;

Fig. 8: **Oleaceae - gen. et sp. indet. 2.** SEM;

Fig. 9: **Oleaceae - gen. et sp. indet. 2.** SEM; detail picture of the surface

Fig. 10: **Oleaceae - gen. et sp. indet. 3.** LM;

Fig. 11: **Oleaceae - gen. et sp. indet. 3.** SEM;

Fig. 12: **Oleaceae - gen. et sp. indet. 3.** SEM; detail picture of the surface

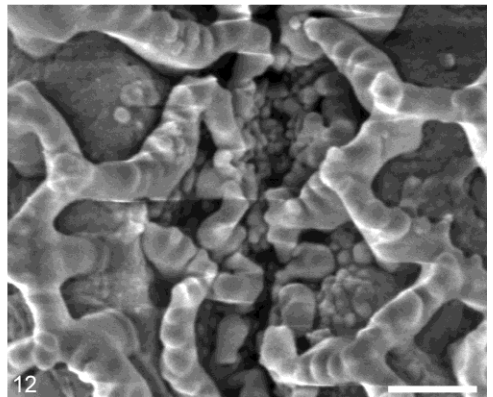
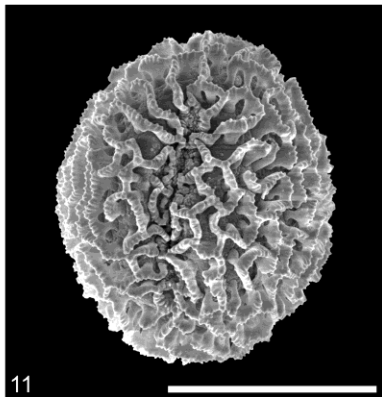
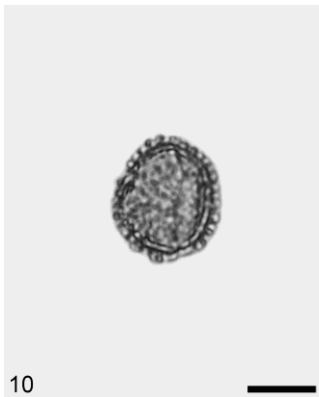
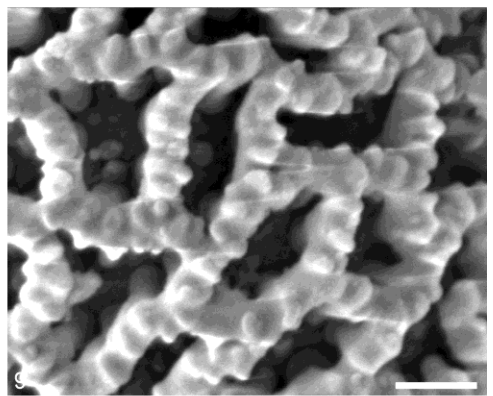
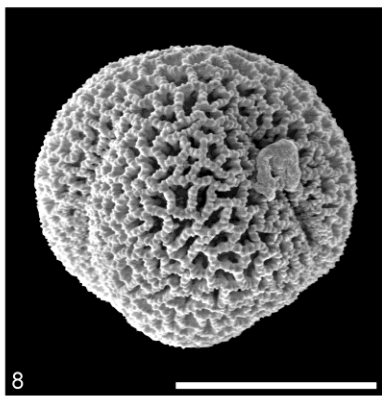
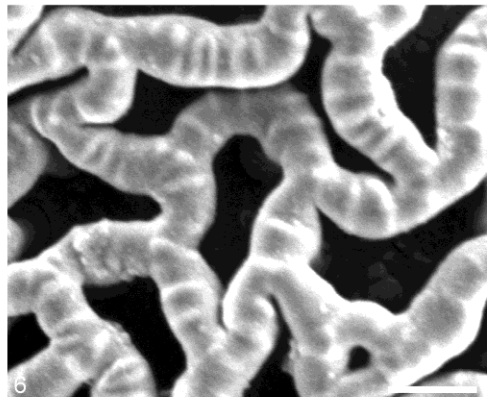
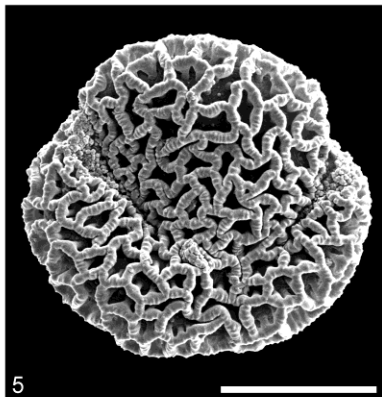
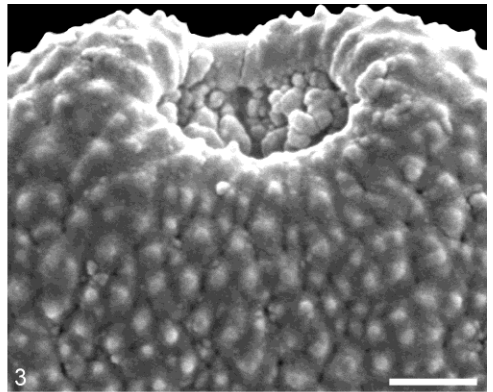
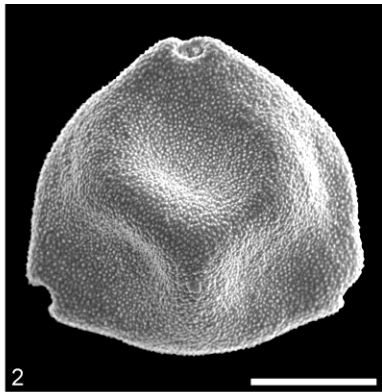


Plate 13

Fig. 1: *Fraxinus sp. 1*. LM;

Fig. 2: *Fraxinus sp. 1*. SEM;

Fig. 3: *Fraxinus sp. 1*. SEM; detail picture of the surface

Fig. 4: *Fraxinus sp. 2*. LM;

Fig. 5: *Fraxinus sp. 2*. SEM;

Fig. 6: *Fraxinus sp. 2*. SEM; detail picture of the surface

Fig. 7: *Platanus sp.* LM; polar view

Fig. 8: *Platanus sp.* SEM; polar view

Fig. 9: *Platanus sp.* SEM; detail picture of the surface

Fig. 10: **Rhamnaceae - gen. et sp. indet.** LM; polar and equatorial view

Fig. 11: **Rhamnaceae - gen. et sp. indet.** SEM; polar view

Fig. 12: **Rhamnaceae - gen. et sp. indet.** SEM; detail picture of the surface

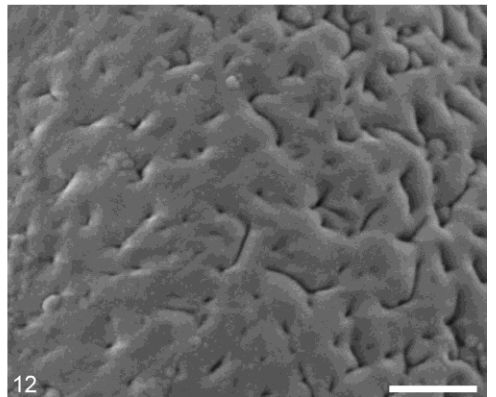
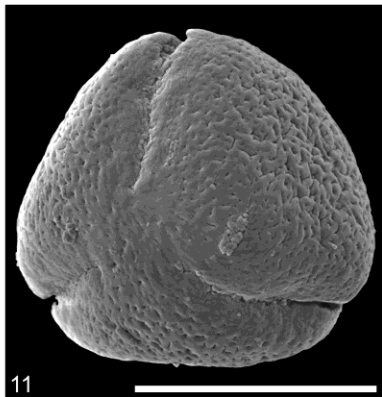
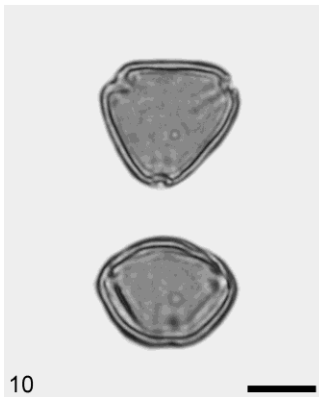
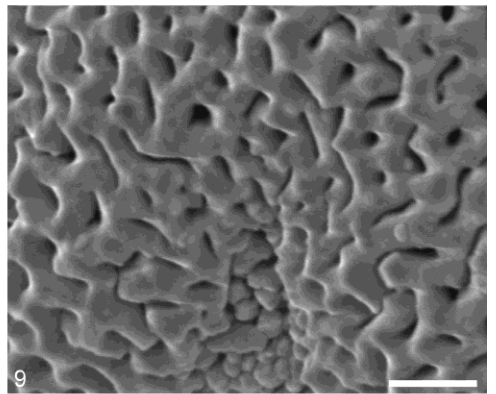
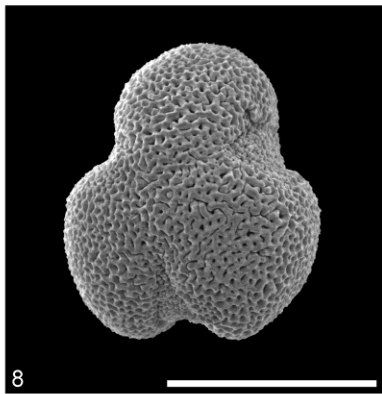
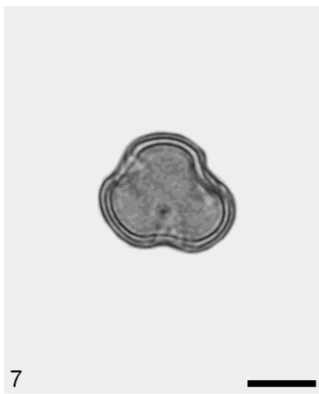
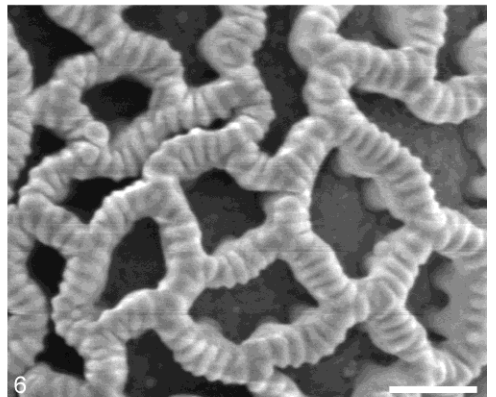
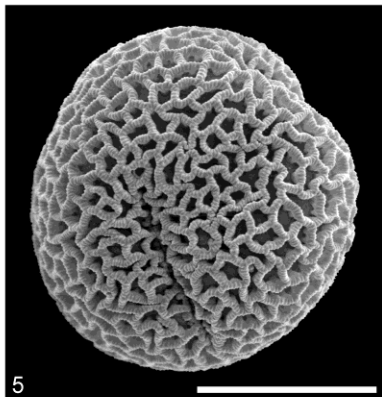
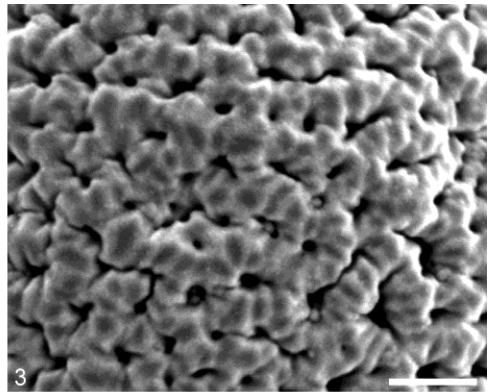
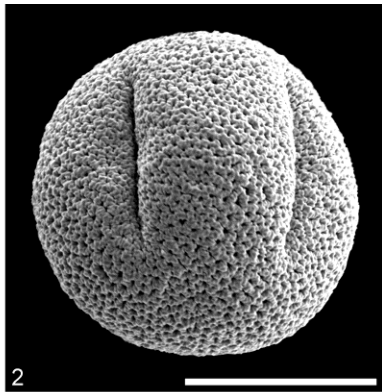


Plate 14

Fig. 1: **Rosaceae - gen. et sp. indet.** LM; equatorial view

Fig. 2: **Rosaceae - gen. et sp. indet.** SEM; equatorial view

Fig. 3: **Rosaceae - gen. et sp. indet.** SEM; detail picture of the surface

Fig. 4: *Zanthoxylum sp.* LM; polar and equatorial view

Fig. 5: *Zanthoxylum sp.* SEM; equatorial view

Fig. 6: *Zanthoxylum sp.* SEM; detail picture of the surface

Fig. 7: *Salix sp. 1.* LM; equatorial view

Fig. 8: *Salix sp. 1.* SEM; equatorial view

Fig. 9: *Salix sp. 1.* SEM; detail picture of the surface

Fig. 10: *Salix sp. 1.* LM; polar view

Fig. 11: *Salix sp. 1.* SEM; polar view

Fig. 12: *Salix sp. 1.* SEM; detail picture of the surface

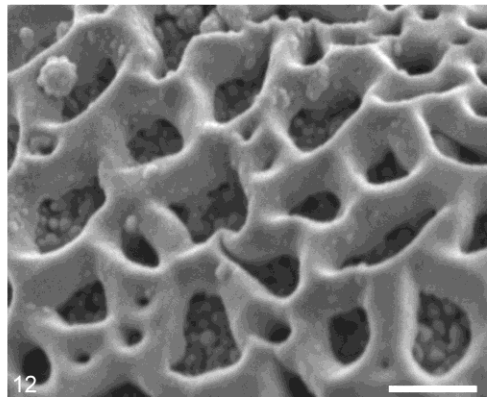
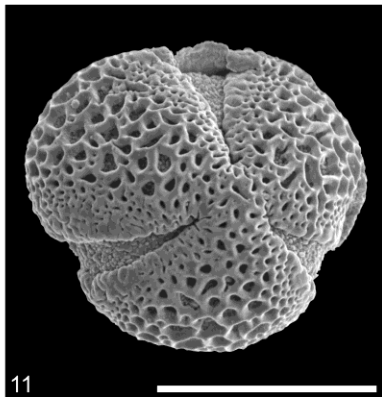
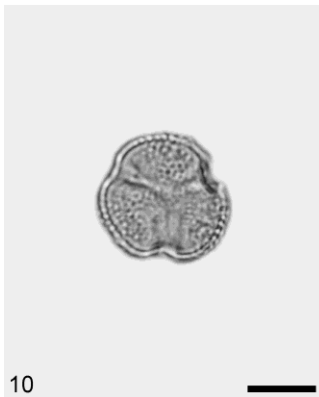
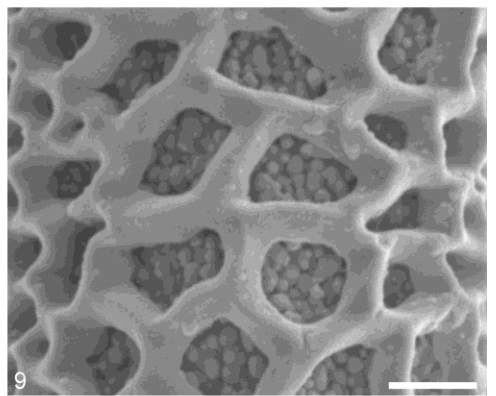
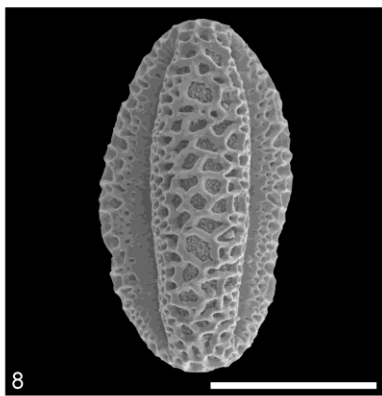
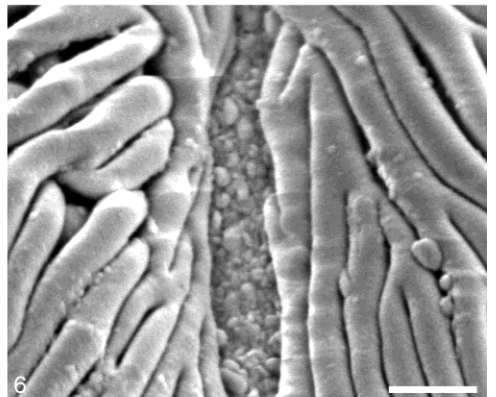
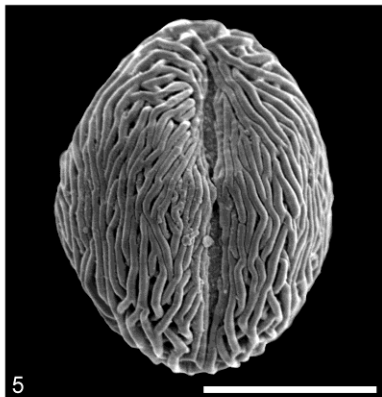
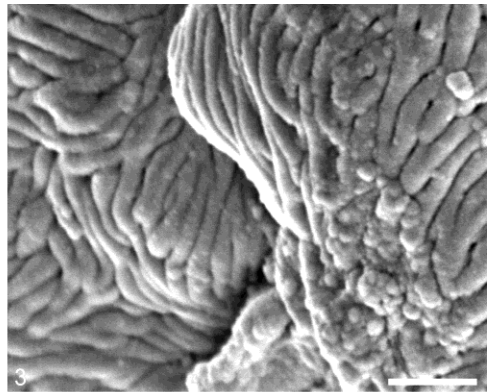
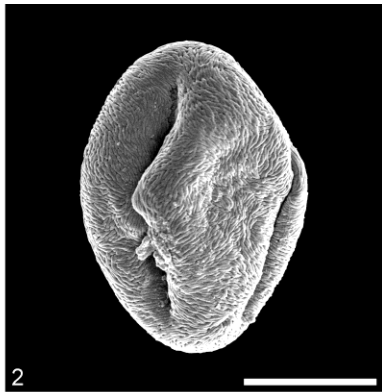


Plate 15

Fig. 1: *Salix sp. 2.* LM; polar view

Fig. 2: *Salix sp. 2.* SEM; polar view

Fig. 3: *Salix sp. 2.* SEM; detail picture of the surface

Fig. 4: **Sapotaceae - gen. et sp. indet. 1.** LM; polar and equatorial view

Fig. 5: **Sapotaceae - gen. et sp. indet. 1.** SEM; equatorial view

Fig. 6: **Sapotaceae - gen. et sp. indet. 1.** SEM; detail picture of the surface

Fig. 7: **Sapotaceae - gen. et sp. indet. 2.** LM; equatorial view

Fig. 8: **Sapotaceae - gen. et sp. indet. 2.** SEM; equatorial view

Fig. 9: **Sapotaceae - gen. et sp. indet. 2.** SEM; detail picture of the surface

Fig. 10: **Sapotaceae - gen. et sp. indet. 3.** LM; equatorial view

Fig. 11: **Sapotaceae - gen. et sp. indet. 3.** SEM; equatorial view

Fig. 12: **Sapotaceae - gen. et sp. indet. 3.** SEM; detail picture of the surface

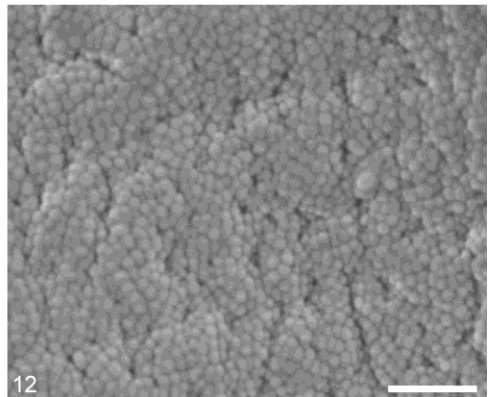
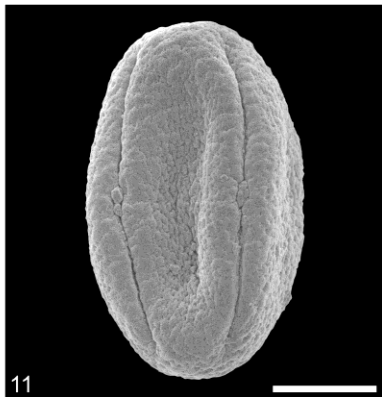
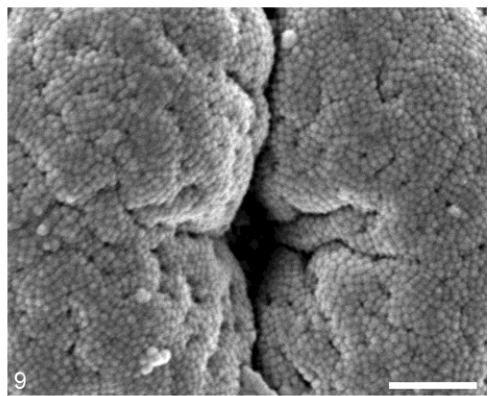
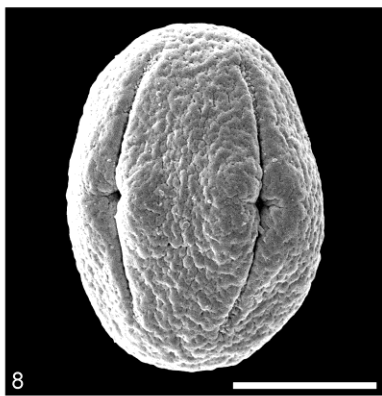
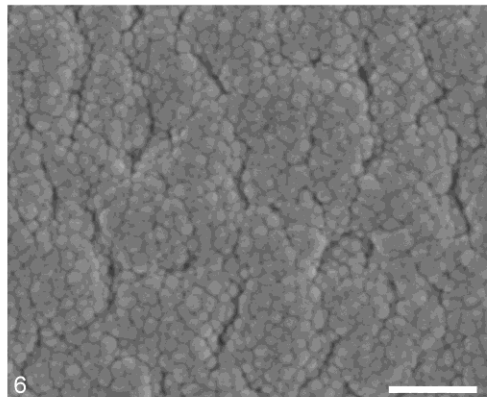
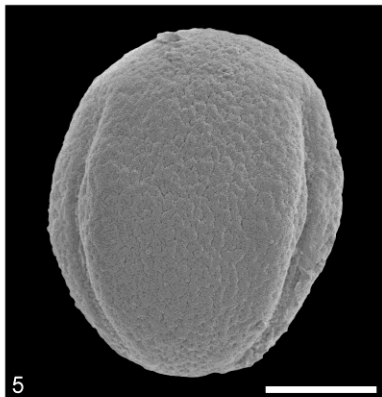
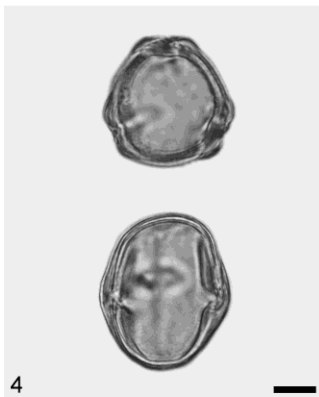
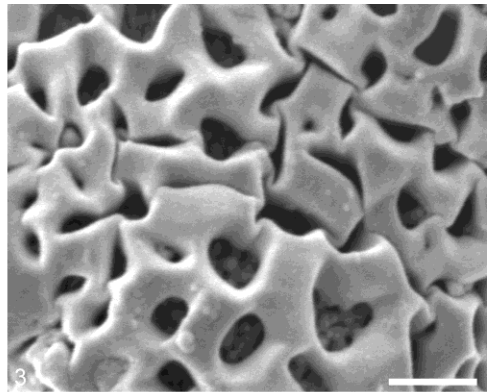
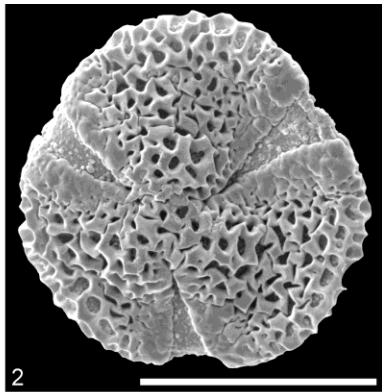


Plate 16

Fig. 1: **Styracaceae - gen. et sp. indet.** LM; equatorial view

Fig. 2: **Styracaceae - gen. et sp. indet.** SEM; equatorial view

Fig. 3: **Styracaceae - gen. et sp. indet.** SEM; detail picture of the surface

Fig. 4: *Symplocos sp. 1.* LM; polar view

Fig. 5: *Symplocos sp. 1.* SEM; polar view

Fig. 6: *Symplocos sp. 1.* SEM; detail picture of the surface

Fig. 7: *Symplocos sp. 2.* LM; polar view

Fig. 8: *Symplocos sp. 2.* SEM; polar view

Fig. 9: *Symplocos sp. 2.* SEM; detail picture of the surface

Fig. 10: *Symplocos sp. 3.* LM; polar view

Fig. 11: *Symplocos sp. 3.* SEM; polar view

Fig. 12: *Symplocos sp. 3.* SEM; detail picture of the surface

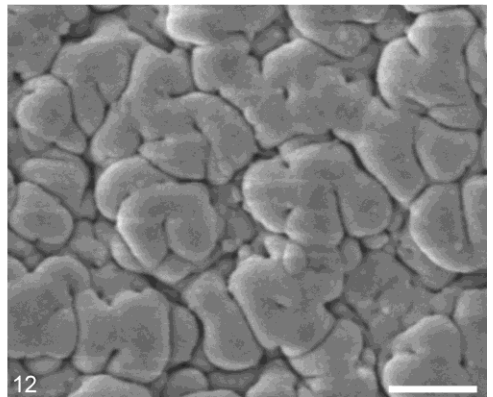
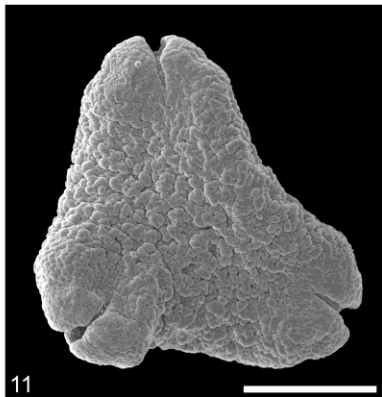
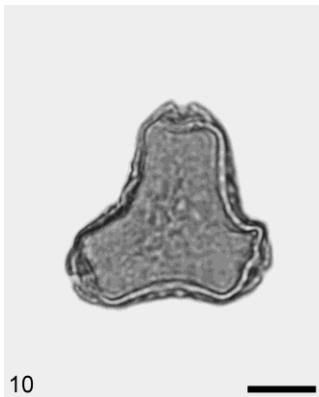
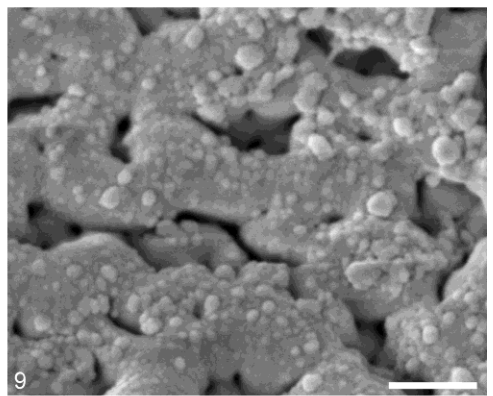
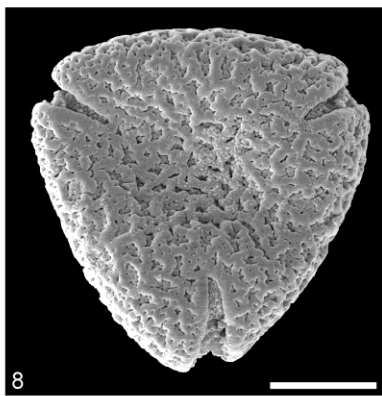
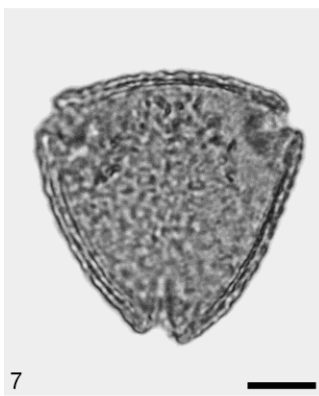
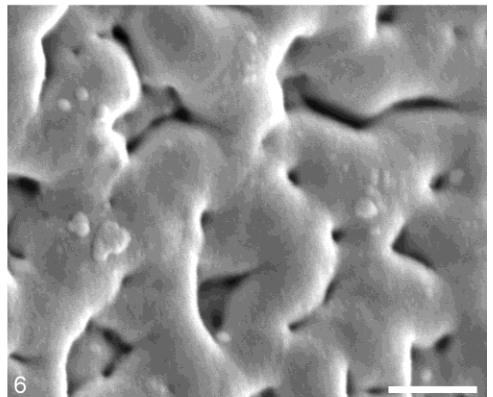
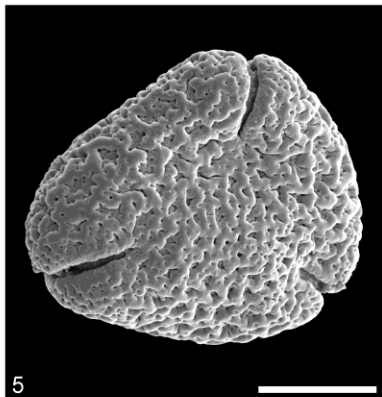
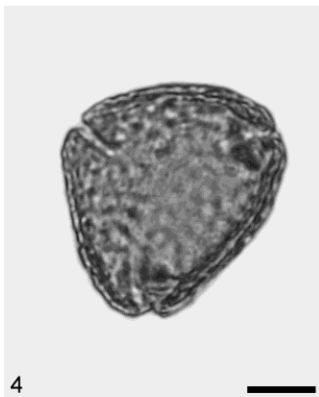
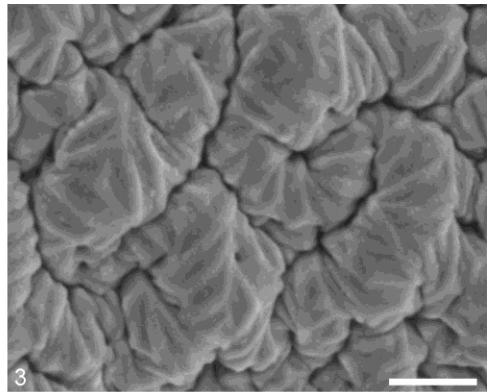
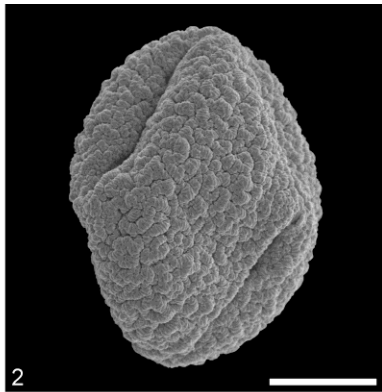
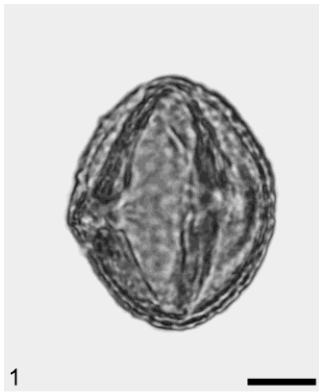


Plate 17

Fig. 1: *Sparganium sp.* LM;

Fig. 2: *Sparganium sp.* SEM;

Fig. 3: *Sparganium sp.* SEM; detail picture of the surface

Fig. 4: *Ulmus sp.* LM; polar view

Fig. 5: *Ulmus sp.* SEM; polar view

Fig. 6: *Ulmus sp.* SEM; detail picture of the surface

Fig. 7: *Zelkova sp.* LM; polar view

Fig. 8: *Zelkova sp.* SEM; polar view

Fig. 9: *Zelkova sp.* SEM; detail picture of the surface

Fig. 10: *Parthenocissus sp.* LM; equatorial view

Fig. 11: *Parthenocissus sp.* SEM; equatorial view

Fig. 12: *Parthenocissus sp.* SEM; detail picture of the surface

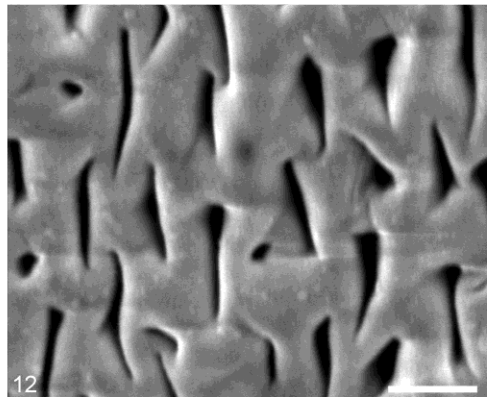
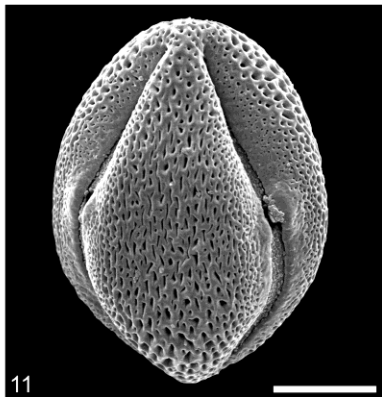
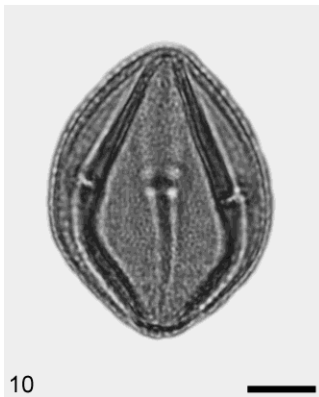
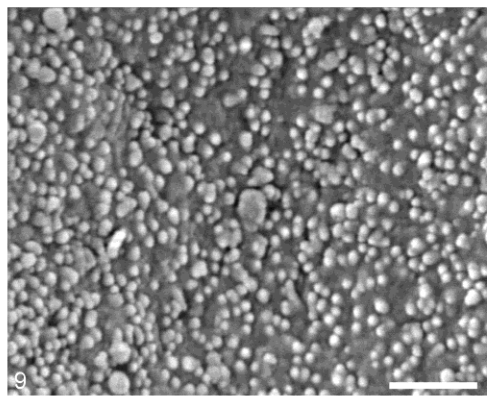
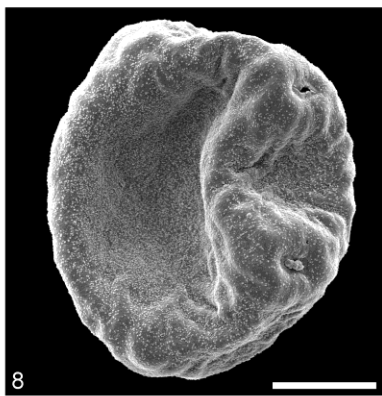
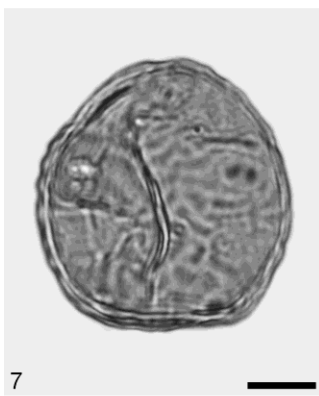
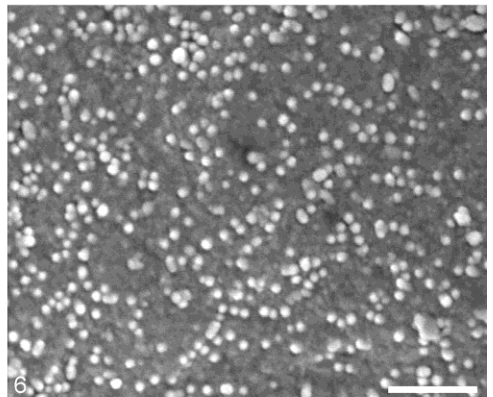
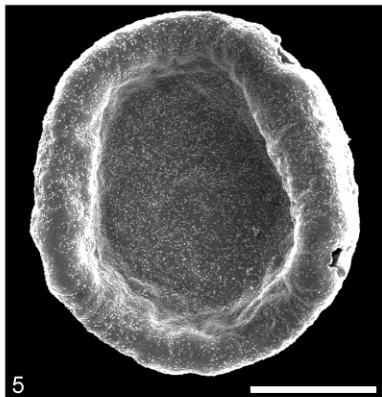
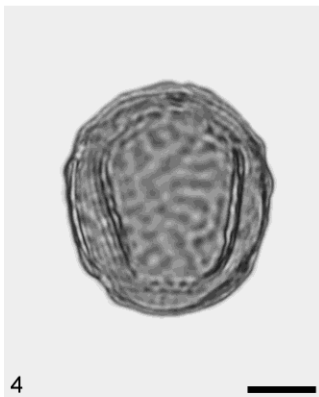
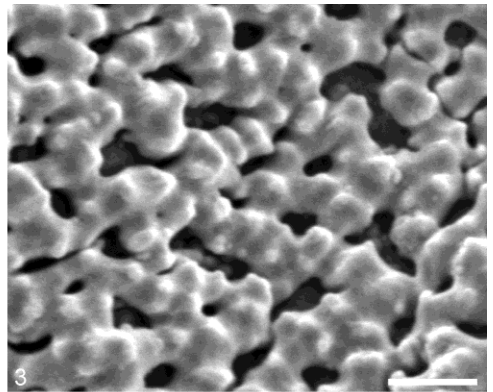
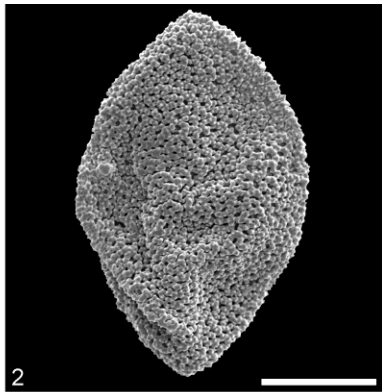


Plate 18

Fig. 1: *Spirematospermum sp.* LM;

Fig. 2: *Spirematospermum sp.* SEM;

Fig. 3: *Spirematospermum sp.* SEM; detail picture of the surface

Fig. 4: **Indet. 1.** LM; equatorial view

Fig. 5: **Indet. 1.** SEM; equatorial view

Fig. 6: **Indet. 1.** SEM; detail picture of the surface

Fig. 7: **Indet. 2.** LM; equatorial and polar view

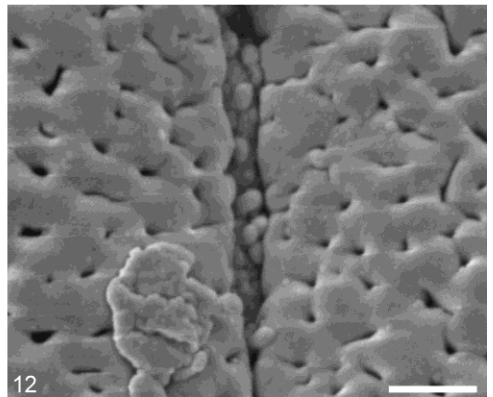
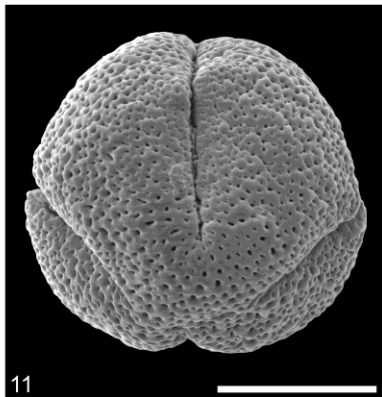
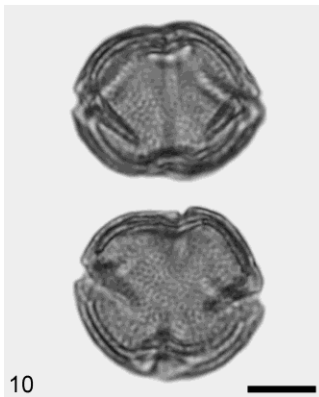
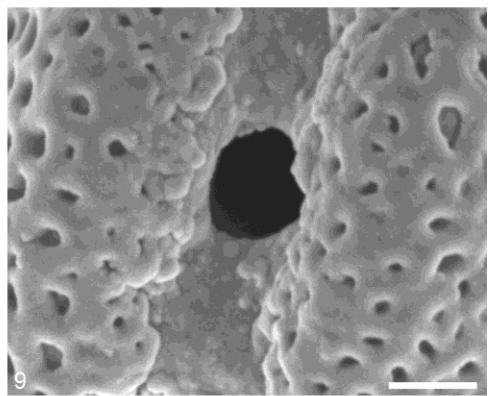
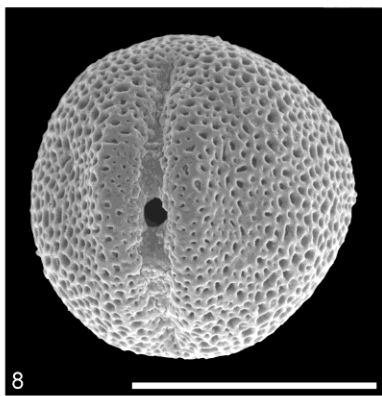
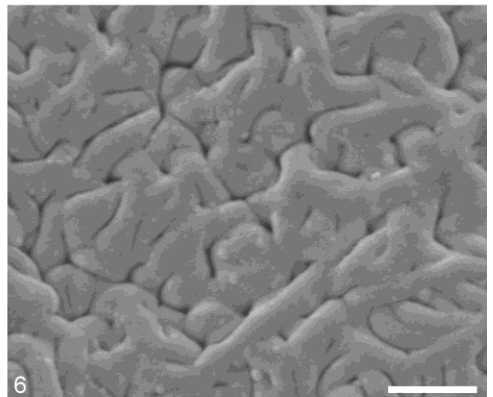
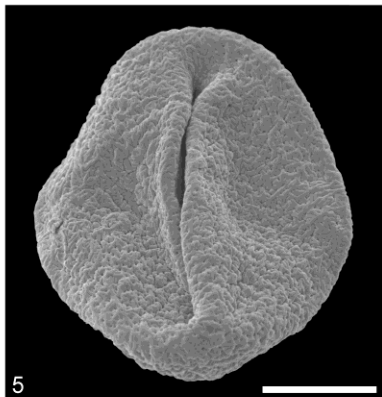
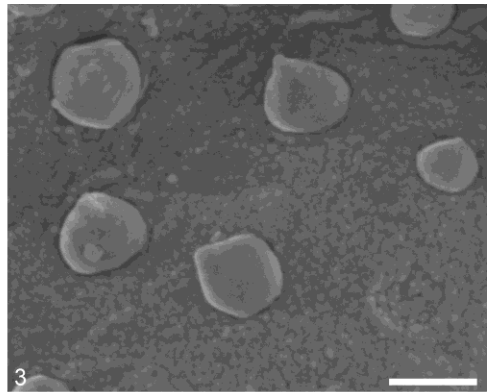
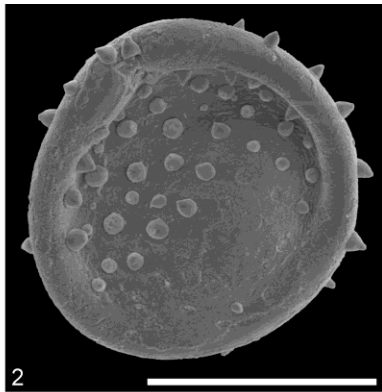
Fig. 8: **Indet. 2.** SEM; equatorial view

Fig. 9: **Indet. 2.** SEM; detail picture of the surface

Fig. 10: **Indet. 3.** LM; equatorial and polar view

Fig. 11: **Indet. 3.** SEM; equatorial view

Fig. 12: **Indet. 3.** SEM; detail picture of the surface



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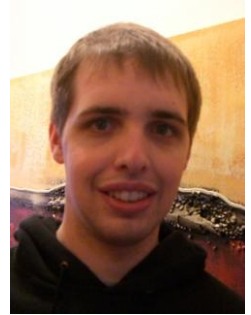
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