

## A REVIEW OF THE EARLY MIOCENE MASTIXIOID FLORA OF THE KRISTINA MINE AT HRÁDEK NAD NISOU IN NORTH BOHEMIA (THE CZECH REPUBLIC)

Dedicated in memory of the late František Holý (1935–1984), an eminent Czech palaeobotanist

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**Abstract.** A detailed survey is presented of the early Miocene flora of the abandoned Kristina Mine at Hrádek nad Nisou in the Hrádek part of the Zittau Basin, North Bohemia. It is based on leaf morphological and anatomical study of macrofossils recovered since 1963 with additional information on carpological records. The flora belongs to the Younger Mastixioid Floras *sensu* Mai (1964) and is correlated with the early Miocene floristic assemblage (“Florenkomplex”) of Eichelskopf–Wiesa (Mai 1995), i.e., the floristic zone VI in Saxony *sensu* Mai (1967). It includes in the foliage record representatives of ferns (Thelypteridaceae, Polypodiales fam. inc.), conifers (Pinaceae, Cupressaceae, Geinitziaceae) and angiosperms (prevaingly Lauraceae, Fagaceae, rarely Hamamelidaceae, Myricaceae, Juglandaceae, Leguminosae (including *Leguminosites hradekensis* (E. KNOBLOCH et KVAČEK) KVAČEK et TEODORIDIS comb. n.), Oleaceae and uncertain families). The carpological record adds, in addition to the above families, representatives of Magnoliaceae, Nymphaeaceae, Schisandraceae (incl. Illiciaceae), Menispermaceae, Cornaceae, Lythraceae (incl. *Microdiptera donata* (HOLÝ) KVAČEK et TEODORIDIS comb. n.), Haloragaceae, Altingiaceae, Ulmaceae, Rosaceae, Ericaceae, Symplocaceae, Styracaceae, Rutaceae, Aquifoliaceae, Staphyleaceae, Vitaceae, Sabiaceae, Caprifoliaceae, Potamogetonaceae, Arecaceae, Cyperaceae, Stemonaceae and Sparganiaceae. An informal term “plexus” is attached to names of fossil species whose parts have not yet been found in organic connection. Vegetation is classified as broad-leaved evergreen forest type according to the new statistical method developed for zonal forest formations (IPR vegetation analysis). Palaeoenvironmental and climatic proxy data based on angiosperm leaf record using a combination of the physiognomic (CLAMP, LMA) and Nearest Living Relatives (CA) techniques are, according to CLAMP estimates – MAT 14.2 °C, WMMT 24.0 °C, CMMT 6.2 °C, 3–WET 131.7 cm, 3–DRY 20.0 cm, GROWSEAS 10.3 month, GSP 203.1 cm, MMGSP 9.9 cm, RH 54.5 %, SH 5.5 g/kg, and ENTHAL 29.9 kJ/kg; LMA estimates – MAT<sub>1</sub> is 21.1 °C (*sensu* Wolfe 1979) and MAT<sub>2</sub> is 18.7 °C (*sensu* Su et al. 2010), and value of the sampling error *sensu* Miller et al. (2006) is 3.1 °C; CA proxy data intervals: MAT 17–18 °C, WMT 26.5–26.9 °C, CMT 9.6–12.6 °C, and MAP 1146–1146 mm. The obtained climate proxy datasets correspond more or less with those of stratigraphically analogous sites from Wackersdorf, Wiesa and Berzdorf in Germany as well as the summarised proxy datasets of the Mydlovary Fm. in South Bohemia.

■ Early Miocene, plant macrofossils, north Bohemia, IPR–vegetation analysis, palaeoclimate

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### Introduction

The present paper is focused on leaf and carpological remains from the abandoned lignite open cast mine Kristina near Hrádek nad Nisou (Neisse) in North Bohemia, which were excavated in the 1960s before the mine was flooded, re-cultivated and converted into a recreation zone. The results connected with foliage were included in the Ph.D. thesis of the second author written in the Czech language (Kvaček 1966) and only partly published (Kvaček and Bůžek 1966, Kvaček 1971, 1972, 1989, Kvaček and Walther 1984b, 1988). The carpological data were included in the Ph.D. thesis of the first author (Holý 1975), who initiated the study but was

unable to publish all the results of the explorations before his untimely death (Holý 1977 a, b, 1978a, b).

In order to make the text of both manuscript theses available to the wider scientific community, we have re-worked the text dealing with foliage according to the latest taxonomical studies and translated it into English. The data on carpology which adds information on the fossil fruits and seeds of the Kristina Mine are based on the Czech manuscript by Holý (1975) and the published data (Holý 1977a, b, 1978a) updated according to new publications (e.g., Gregor 1989, Mai 1999a, b, 2000, Mai and Martinetto 2000, Czaja 2003). Our account complements the paper on

carpological record obtained from the drill cores in the Hrádek part of the Zittau Basin (Teodoridis 2003) from the periphery of the mine (Zabysřtan et al. 1967).

The concluding chapters are focused on the complex evaluation of the macroflora and its palaeoenvironmental characteristics. Due to a long gap between the recovery of the Hrádek flora in the field and the present paper, various previously published tentative comparisons and views on its character have been taken into consideration (e.g. Mai 1995, Kovar-Eder et al. 2001, Kvaček and Teodoridis 2007).

## Material and methods

Field work carried out in the now abandoned Kristina Mine NW of the town of Hrádek/N. (Grottaw in German) started as a joint project involving František Holý, Āestmír Bůžek and Zlatko Kvaček in the 1960s, at the time when the open cast mine was still easily accessible (text-figs 1, 2). The mining activity ceased there in 1972 (Opluřtil et al. 2010) after the pit was flooded and transformed into a recreation area and camp site called “Kristýna”. Our recent

visits to the site have confirmed that no fossiliferous deposits are now accessible there.

The site is situated in the southernmost part of the Zittaw (Žitawa, Žitawa) Basin near the state boundary between the Czech Republic and Germany, 5 km south of Zittaw and 20 km northwest of Liberec (Reichenberg in German) – 50°51'33.694"N, 14°49'28.198"E (text-fig. 1). [Günther and Gregor (1989, p. 74) erroneously called this site “Hradek Kralove”, i.e. Hradec Králové, and misplaced it geographically.] A detailed description of the fossiliferous layers and their macropalaeobotanical content was given by Holý (1975, 1977a, 1978a, b) – see also text-fig. 3.

Only a few impressions of macrofossils were collected from the ironstone in the roof of the lignite seam. Most rock samples, containing compressions of foliage, fruits and seeds were collected directly in the mine in the sand, and sandy clay as well as clay lignite deposits. The richest fossil content was obtained by washing sandy deposits for fruits and seeds and silty lenses, intercalated in sandy layers for leaf compressions later prepared in the laboratory.



**Text-fig. 1. Geographical position of the studied locality of Hrádek/N. (Kristina Mine) and other floras compared in detail. Symbols: 1. Hrádek/N. (Kristina Mine), 2. Bogatynia (Turów Mine), 3. Hartau, 4. Berzdorf, 5. Wiesa, 6. Libkovic Mb. of the Most Fm. (Most Basin), 7. Cypris Shale (Sokolov Basin), 8. Cypris Shale (Cheb Basin), 9. České Budějovice and Třeboň basins, 10. Wackersdorf, 11. Köflach (Oberdorf Mine).**



**Text-fig. 2.** Čestmír Bůžek and Zlatko Kvaček during the field work in the Kristina Mine in 1964 (photo by František Holý).

The extracted leaf remains were oxidized in diluted hydrogen peroxide to reveal venation and transferred, after rinsing in water, into glycerol on glass preparations of sub-macerated leaves in a similar method as in the Wackersdorf flora case (Knobloch and Kvaček 1976). Most samples were fragmentary but suitable for preparation of cuticles. Routine maceration with Schultze solution used for cuticle analysis (see e.g., Kunzmann et al. 2009) was successfully employed in most cases. For permanent preparations, leaf macrofossils were embedded into glycerol jelly on slides and covered by plastic film. Cuticle preparations were partly stained with safranin. Fossil fruits and seeds worked out by F. Holý and Č. Bůžek were partly sieved directly in the mine or later separated in the laboratories on sieves (meshes diameter 5.0, 2.5, 1.0, 0.5 and 0.2 mm). They were kept in a dried state in tubes, Franke microslides or boxes without any additional conservation treatment.

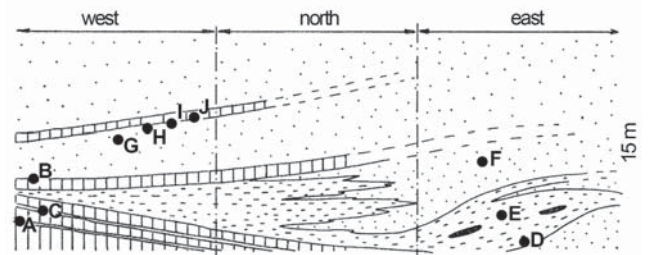
All specimens treated in this paper, with a few exceptions, have survived till now and are housed in the collections of the National Museum in Prague (NM). Leaf compressions were documented with a Nikon Coolpix 4500 camera and Olympus SZX12 light microscope in transmitted light for details of venation, cuticle structures were documented using an Olympus microscope in interference and phase contrast light. Carpological material was documented by the Nikon Coolpix 4500 camera and Olympus SZX12 light microscope with Olympus DP72 camera.

For synecological evaluation of the leaf assemblage and estimations of palaeoclimatic signals we applied four different palaeoenvironmental methods, i.e. Integrated Plant Record vegetation analysis (IPR–vegetation analysis), Climate Leaf Analysis Multivariate Program (CLAMP), Leaf Margin Analysis (LMA) and Coexistence Approach (CA) – for details see Mosbrugger and Utescher (1997), Kvaček et al. (2011) and Teodoridis et al. (2011a, b, c).

## Geology

The Zittau (Žitava, Żitawa) Basin is shared by Germany, Poland and the Czech Republic extending across the Southern Poland – Upper Lusatia – North Bohemia borders. The part within the Czech Republic is its southernmost

extension, called the Hrádek part. It was considered by Grahman (in Grahman and Ebert 1937) as a prolongation of the Ohře (Eger) Rift that starts in Bohemia (Ulrych 2010) and enters the lignite-bearing deposits of the NW German – Polish Basin (Mai 1995, text–figs 26, 29). The basin fill of the Hrádek part of the Zittau Basin is divided into two sedimentary cycles (Václ and Čadek 1962), namely into the Loučné and Hrádek Formations, the former with volcanic bodies and the basal seam complex of Oligocene age, the latter with three lignite seam complexes within delta deposits of early Miocene age (Opluštil et al. 2010). The lower, middle and upper coal seams always grade upwards into the clastic deposits. The character and structure of the lignite and adjacent delta deposits were described in detail several times (Václ and Čadek 1962, Teodoridis 2003, Kvaček et al. 2006, Opluštil et al. 2010). According to the systematic study of the carpological material (Teodoridis 2003, text-fig. 2), four stratigraphical levels were recognized, i.e. the roof of the basal coal seam in the Loučné Fm. and the Lower, Middle and Upper Coal Seam complexes within the Hrádek Fm. The delimitation of these levels is approximate because the levels always contain coal seams together with the closest underlying and overlying clastic deposits. The deposits in which the Kristina Mine operated belong to the Upper Lignite Seam complex, where the roof of the seam is split into several seamlets entering the overlying clastic sediments (for details see text-fig. 3 and Holý 1977a, 1978a). Exact correlation of the fill in the Czech Republic with other parts of the basin, in particularly with the sites in Germany (Hartau) and Poland (Turów Mine) has not been finally settled due to the complicated tectonic situation (Václ and Čadek 1962).



**Text-fig. 3.** Schematic geological section of the Kristina Mine near Hrádek/N. (state in 1963–1964) – height/length ratio 3:1. Explanations: vertical hatching – lignite seam, seamlet; dotted – coarse-grained sand, pea-gravel; short lines – sandy clay; white – clay; black lines – clay ironstone concretions; black dots – individual fossiliferous horizons designated as (A) plastic clay from the upper part of the main xylitic seam (about 5 m under t of the seam), (B) clay and “Blätterkohle” from the uppermost part of the first seamlet (split off the Main Coal Seam), (C) slightly sandy brown clay under the uppermost part of the Main Coal Seam, (D) base of the sandy clay with large concretions of the clay ironstone above the Main Coal Seam, (E) sandy clay (incl. clay ironstone) supplying most of leaf material with cuticles (F) 1–2 cm thin silty lenticles or thin beds of the sandy clay with xylites and *Eomastixia* within pea-gravels and coarse-grained sands, (G) coarse-grained sands with clayish silts with *Fagus*, *Ocotea*, *Pterocarya*, *Tectocarya*, (H) brown sandy clay underlying the uppermost seamlet, (I) lignite clay, base of the uppermost seamlet (J) *Glyptostrobus* – “Blätterkohle”, base of the uppermost seamlet (according to Holý 1975, modified).

## Research history

The first palaeobotanical data from the Zittau Basin were recorded in 19<sup>th</sup> (Poppe 1866, Engelhardt 1870, 1878) and 20<sup>th</sup> centuries (e.g., Heinke 1932, Mai 1960, 1964, Czecczot et al. 1959 and other continuations of this collectiv opus). The exploration of the mastixioid flora of the Kristina Mine started in the 1960s, when Holý (1964) published a preliminary survey of his research in this area and Č. Bůžek, F. Holý and Z. Kvaček (Bůžek et al. 1966) announced the first results of their joint collecting activity. Carpological records were included in an unpublished Ph.D. thesis by Holý (1975) and fossil leaves with cuticles were treated in detail by Kvaček (1966) also in the unpublished Ph.D. thesis. Teodoridis (2003) evaluated additional carpological material from several drill cores in the vicinity of Hrádek/N. and Uhelná, which had been collected by F. Holý and deposited in the National Museum, Prague.

Along with macrofossils information on palynology became available in an unpublished report by Bořková (1959) and new data on palynology of the basal seam were published by Konzalová and Ziemińska-Tworzydło (1999, 2008). In the latter study the occurrence of *Boehlensipollis hohli* KRUTZSCH in the basal coal seam at Rybaszewice suggested a possible correlation with the Oligocene floras in Central Europe and enlarged the pollen spectra of the first sedimentary cycle of the basin.

Plant macrofossils from the Kristina Mine were later worked out separately (e.g., Kvaček 1971, Holý 1977a, b, 1978a), but never in a complete monograph. Preliminary floral lists and evaluation are available in several more general surveys (e.g., Günther and Gregor 1989, Kvaček and Teodoridis 2007, Opluštil et al. 2010) and must be considered as tentative only, requiring reassessment.

## Systematic Palaeobotany

The system follows the newly suggested arrangements, in particular with respect to angiosperms, according to the results of molecular phylogeny (Judd et al. 2002, Soltis et al. 2005). The synonymy lists are limited to references to the first validly published names and main synonyms with addition of a few mainly concerning the material from the Zittau Basin or adjacent sites in North Bohemia, Germany and Poland. The description of the material is accompanied by lists of precise recently given inventory numbers if the specimens are indeed still available and, in parentheses, a preliminary numbering given by Kvaček (1966) for foliage. In a few cases a new informal nomenclatural term “species plexus” (instead of the previously used vague terms “complex” or “plant”) is introduced for the fossil species, of which more complete specimens showing organic connection of individual parts have not been recovered so far, following the approach for treating fossil “whole plant species” as suggested by Kvaček (2010) and discussed at the 8<sup>th</sup> EPPC in Budapest, 2010. This approach already created several “plexus” species accepted in the current palaeobotanical practice, e.g. *Doliosrobis taxiformis*, *Taxodium dubium*, *Platanus neptuni* and many others, uniting detached fossil organs into one fossil species.

## Pteridophytes

### Thelypteridaceae CHING

#### *Pronephrium* C. PRESL

#### *Pronephrium stiriacum* (UNGER) E. KNOBLOCH et KVAČEK

Pl. 1, figs 1-2, pl. 10, fig. 1

- 1847 *Polypodites stiriacus* UNGER, p. 121, pl. 36, figs 1-5 (Parschlug, Schönegg, Arnfels, Trofaiach).  
1852 *Goniopteris stiriaca* (UNGER) A. BRAUN, p. 555.  
1855 *Lastraea stiriaca* (UNGER) HEER, p. 31, pls 7-8 (Eritz, Rochette, St. Gallen, Ruppen, Hoher Rhonen).  
1960 *Cyclosorus stiriacus* (UNGER) CHING et TAKHTAJAN in FATALIEV, p. 1217, pl. 2, figs 1-1a, text-fig. 3 (Katar).  
1962 *Cyclosorus stiriacus* (UNGER) GRAMBAST, nom. illegit, p. 24, text-fig. 4 (Vauboyen).  
1963 *Abacopteris stiriaca* (UNGER) CHING, p. 298.  
1976 *Pronephrium stiriacum* (UNGER) E. KNOBLOCH et KVAČEK, p. 12, pl. 1, fig. 1 (Murnerweiher).  
2002 *Pronephrium stiriacum* (UNGER) E. KNOBLOCH et KVAČEK; Kvaček, p. 221, pl. 4, fig. 7 (Kučlín).

Incomplete sterile pinnae bearing several pinnules on a slender rhachis (incomplete length of up to 40 mm), crenate on margins according to almost fused pinnules, incisions between pinnules 2 mm, pinnules max. 9 mm long, at angles of 55–60°, at the apex rounded and slightly turned upwards, midrib of pinnules almost the same thickness as secondaries, straight to slightly bent on very end, secondaries in 6 pairs on each side, opposite to alternate, the basal pairs interconnected between adjacent pinnules (goniopterid), higher slightly bent and looping with the margin. Leaf anatomy is partly visible on compressions in transmitted light. Anticlinical cell walls coarsely undulate, stomata polocytic, broadly elliptic, sub-parallelly arranged; guard cells 40–50 µm long and 15–25 µm wide with a narrow pore.

**D i s c u s s i o n :** Incomplete fragments of the recovered fern foliage correspond to other records of *Pronephrium stiriacum*, a common swamp fern of the European Cenozoic, also at Turów (Czecczot 1961a, as *Goniopteris stiriaca* (UNG.) A. BRAUN). The material from the Kristina Mine is preserved as isolated leaf compressions and exhibits in transmitted light the goniopterid venation and epidermal anatomy. *Pronephrium penangianum* (HOOK.) HOLTUM (syn. *Abacopteris penangiana* (HOOK.) CHING) from the Himalayas is considered as the nearest living relative according to several authors (e.g., Ching 1963). For further taxonomical details see Kvaček et al. (2011).

**M a t e r i a l :** Fragmentary pinnae, G 8863a-c, 8864a-c, 8865-66 (KR 58, 67, 171, 180, 240).

### Polypodiaceae gen. et sp. indet.

Pl. 1, fig. 3, pl. 10, fig. 2

A fragmentary sterile pinnule 10 mm long and 5 mm wide, toothed on margin, venation open, secondaries steep, entering the marginal teeth, epidermal cells 100–130 µm in size, anticlinical walls coarsely wavy, stomata on the abaxial epidermis widely spaced, oval-quadrangular 34–50 µm long and 30–35 µm wide, perpendicular with veins, double lines seen on outlines of guard cells, groups of uniserial tri-

chomes 170–900 µm long abaxially, consisting of (3–) 4–5 cylindrical cells.

**D i s c u s s i o n :** The preserved traits of the fragment are not sufficient for identification within the natural fern system.

**M a t e r i a l :** A detached pinnule, G 8867a-b (KR 77).

## Conifers

### Pinaceae LINDL.

#### *Tsuga* (ENDLICHER) CARRIÈRE sect. *Tsuga*

##### *Tsuga schneideriana* KUNZMANN et MAI

Pl. 1, fig. 4, pl. 10, figs 3-4

- 1976 *Tsuga* sp.; Knobloch and Kvaček, p. 13, pl. 2, figs 6-9, pl. 12, fig. 21, pl. 15, fig. 12, pl. 20, fig. 9, text-fig. 3 (Wackersdorf).  
2005 *Tsuga schneideriana* KUNZMANN et MAI, p. 106, pl. 12, figs 1-9, pl. 13, figs 1-3 (Wiesa).

Leaves linear, needle-like, flat, 1 mm wide, one complete 17 mm long, blunt at apex, shortly petiolate at base, with obliquely attached petiole 0.7 mm long, entire on margin, adaxially slightly grooved along the strong and straight midrib, hypostomatic, epidermis thinly cutinized, non-modified cells straight-walled, very long, with smooth anticlinal walls, two abaxial stomatal bands containing 3–5 rows of stomata with sparsely distributed incompletely amphicyclic stomata arranged longitudinally. Stomatal apparatus composed of two lateral short halfmoon-shaped and two polar elongate subsidiary cells bordering the stomatal pit  $25 \times 50 \mu\text{m}$  in size.

**D i s c u s s i o n :** Fossil needles similar to those described above from the Kristina Mine (Kvaček 1966, p. 19, pl. 3, figs 6a, b, pl. 4, fig. 3, text-figs 8-9) were assigned to *Tsuga* from Wackersdorf by Kvaček and Knobloch (1976) and later from Wiesa by Kunzmann and Mai (2005), who more thoroughly studied modern living counterparts. Kvaček (1966) recognized the erroneous identification of such fossils assigned to *Keteleeria* (Mai 1964) and suggested as the most similar living species *T. jeffreyi* HENRY and *T. mertensiana* (BONG.) SARG. from North America while Kunzmann and Mai (2005), based on more complex comparative material argued for *Tsuga dumosa* (D. DON) EICHLER from southern China, NE India and Burma as the nearest living relative.

**M a t e r i a l :** Isolated needles on slides, G 8868a-b, 8869a-c, 8870, 8871 (KR 104A, B, 346).

#### *Cathaya* CHUN et KUANG

##### *Cathaya roseltii* SCHNEIDER

Pl. 1, fig. 5, pl. 10, fig. 5

- 1981 *Cathaya roseltii* SCHNEIDER, p. 889, pls 1-2, text-fig.1 a-e (Bluno at Spremberg).  
2005 *Cathaya roseltii* SCHNEIDER; Kunzmann and Mai, p. 82, pl. 3, figs 1-7 (Wiesa).

Needle fragments 1.5–1.9 mm wide, up to 19 mm long, incompletely preserved in length, margins entire, slightly

revolute, midrib straight, strong, adaxially with a shallow groove, abaxially with a prominent keel, epidermis only slightly cutinized, exhibiting very narrow and elongate non-modified cells with straight anticlines, leaves hypostomatic, stomata in two bands containing 5–7 very regularly disposed 55–60 µm wide rows of densely set stomata without rows of non-modified cells. Stomata longitudinally oriented, monocyclic, with lateral subsidiary cells elongate, little different from non-modified cells, and two polar subsidiary cells relatively elongate, often shared by adjacent stomata.

**D i s c u s s i o n :** Kvaček (1966) assigned these fossils to *Pseudotsuga* on account of the stomatal arrangement (monocyclic, densely set stomata in longitudinal rows). At that time, he was unaware of the relict conifer genus *Cathaya* living in China whose foliage matches with fossils as correctly recognized by Schneider (1981) and differs from *Pseudotsuga* by homogenous stomatal bands without rows of non-modified cells (Kunzmann and Mai 2005). The fossil needles from the Kristina Mine perfectly match similar fossils from Wiesa, which were assigned to *Cathaya* by Kunzmann and Mai (2005) and compared with the living *Cathaya argyrophylla* CHUN et KUANG from Central China. *C. schneideriana* was also recorded in the mastixioid flora of Arjuzanx in western France (Kvaček et al. 2011).

**M a t e r i a l :** Fragmentary isolated needles on slides, G 8872a-c, 8873a-d (KR 103A, B).

## *Pinus* L.

### *Pinus hampeana* (UNGER) HEER

Pl. 4, figs 10-11

- ? 1845 *Pinites thomasianus* GÖPPERT in GÖPPERT et BERENDT, p. 92, pl. 3, figs 1-10 (Svetlogorsk).  
1847 *Pitys hampeana* UNGER, p. 76, pl. 20, figs 1-3 (Hauenstein).  
1855 *Pinus hampeana* (UNGER) HEER, p. 56, pl. 20, fig. 4 (Monod).  
1913 *Pinus laricio thomasiana* (GÖPPERT) HEER; Menzel, p. 21, pl. 3, figs 1-10 (Herzogenrath).  
1919 *Pinus thomasiana* (GÖPPERT) REICHENBACH in KRÄUSEL, p.115, pl. 10, figs 29-30 (Weigersdorf).  
1964 *Pinus thomasiana* (GÖPPERT) REICHENBACH; Mai, pp. 15, 58, 86, pl. 1, fig. 3, pl. 12, fig. 1 (Wiesa, Piskowitz, Sandförsstgen, Weigersdorf).  
1966 *Pinus thomasiana* (GÖPPERT) REICHENBACH; Holý, p. 42, text-fig. 2 (Hrádek/N., Kristina Mine).

Seed cones 40–50 mm long and ca. 20 mm wide, obliquely ovoid, cone scales with rarely preserved rhombic flat umbo, 6–7 mm wide, indistinctly sharply short extramucronate showing a shallow transverse wrinkle (Holý 1975, p. 11, pl. 1, fig. 6, as *Pinus* cf. *thomasiana* (GÖPPERT) REICHENBACH).

**D i s c u s s i o n :** These mostly abraded seed cones were tentatively identified by Holý (1966, 1975, 1977a) as *Pinus* cf. *thomasiana* and compared with the Miocene pines related to sect. *Sylvestres* (i.e., sect. *Pinus* subsect. *Sylvestres* LOUND.) – see e.g., Kilpper 1968a, b, Mai 1999a. Mai (1986, p. 589) corrected the taxonomy of this pine, often distributed in the Younger Mastixioid floras of Europe, introducing a proper species name *Pinus hampeana* (UNGER) HEER. At least some better preserved specimens from the Kristina Mine (Holý 1966) fit with the concept of

*Pinus hampeana* introduced by Mai (1986, 1999a) and confirm *P. thunbergiana* FRANCO (= *P. massoniana* SIEBOLD et ZUCC.) from Japan as the closest living species (Mai 1999a).

**M a t e r i a l :** Ca. 20 partly abraded seed cones, G 7708, G 8815-17, Gs102.

**Cupressaceae L. C. RICHARD ex BARTLING  
sensu GADEK et al. 2000**

***Tetraclinis* MASTERS**

***Tetraclinis salicornioides* (UNGER) KVAČEK**

Pl. 1, fig. 6, pl. 4, fig. 12, pl. 10, fig. 6

- 1847 *Thuites salicornioides* UNGER, p. 11, pl. 2, figs 1-4, pl. 20, fig. 8 (Radoboj).  
1977a *Tetraclinis* sp.; Holý, p. 111 (Hrádek/N., Kristina Mine).  
1989 *Tetraclinis salicornioides* (UNGER) KVAČEK, p. 48, pl. 1, fig. 11, pl. 2, figs 2-14, pl. 3, figs 1-4, text-fig. 1 (Hrádek/N., Kristina Mine and many other sites, full synonymy).

Isolated cladode-like branch segments, up to 10 mm long, 2–5 mm wide, corresponding to pseudo-whorls, composed of pairs of dimorphic facial and lateral leaves with rounded to bluntly mucronate apices and rounded base, in each pseudo-whorl fused along most of their length to form a dorsoventrally flattened phylloclade-like segment, simple pseudo-whorls oval, triveined in surface view, wider pseudo-whorls at nodes of branching, expanded apically, showing five prominent longitudinal lines on either surface. Facial leaves adpressed, ob-triangular, with obvious central midvein, lateral leaves lanceolate to falcate, each folded along its midvein in the plane of compression, shorter than the facial, closely imbricate, more commonly fused to the margins of the facial leaves. Segments showing thickly cutinized epidermis with heavily papillate outer surface, non-modified cells irregularly disposed and stomata in irregular short rows, monocyclic to incompletely amphicyclic. A single incomplete seed cone with only three cone scales preserved was recovered in the Kristina Mine (Holý 1975, pl. 2, fig. 1, recorded as *Tetraclinis* sp. and Kvaček 1989, pl. II(6), fig. 4, assigned to *Tetraclinis salicornioides*). The probably unripen cone is 8-10 mm large, with decussately arranged cone scales of subtriangular outline, abaxially bearing a short mucro slightly below the middle of the scale length on radially striated bract area.

**D i s c u s s i o n :** The record does not deviate from the other of this species from Europe (see, e.g., Knobloch and Kvaček 1976, Walther and Kvaček 2007) and stresses the difference in seed cones between *T. salicornioides* with the subcentral mucro and *T. brachyodon* with the subapical mucro (Kvaček et al. 2000). Impressions of sterile foliage of *Tetraclinis salicornioides* are almost indistinguishable from an unrelated extinct cupressoid conifer *Ditaxocladus* S.X. GUO et Z.H. SUN occurring in the Late Cretaceous and the Palaeocene in the Northern Hemisphere (Guo et al. 2012). The sprays of both conifers differ in the general form, which is slender elongate in *Ditaxocladus* and widely spread in *Tetraclinis salicornioides*. More pronounced differences are in the seed cones (subglobose in racemose fertile branches in *Ditaxocladus* vs quadrivalvate solitary, rarely

paired in *Tetraclinis*) and leaf anatomy (non-papillate straight-walled stomatal zones with thin Florin rings in *Ditaxocladus* vs thick and papillate cuticles with undulate anticlines and strong Florin rings around the stomatal pits in *Tetraclinis salicornioides*- see Guo et al. 2012). According to Kvaček et al. (2011), *T. salicornioides* may be better compared ecologically to *Calocedrus macrolepis* KURZ distributed in SE China, Myanmar (Burma), Thailand and Vietnam based on its foliage physiognomy.

**M a t e r i a l :** Fragmentary branches isolated on slides, G 8874a-b, 8875a-b, 8876-78 (KR 238, 272, 323, 344, 345), a seed cone, G 4590.

***Glyptostrobus* ENDLICHER**

***Glyptostrobus europaeus* (BRONGNIART) UNGER**

Pl. 1, fig 7-8, pl. 4, figs 13-15, pl. 10, fig. 7

- 1833 *Taxodium europaeum* BRONGNIART, p. 168 (Island of Icos, former Illiodroma).  
1850b *Glyptostrobus europaeus* (BRONGNIART) UNGER, p. 434 (Island of Icos, former Illiodroma).  
1977a *Glyptostrobus europaeus* (BRONGNIART) UNGER; Holý, p. 111 (Hrádek/N., Kristina Mine).  
1978a *Glyptostrobus europaeus* (BRONGNIART) UNGER; Holý, p. 2 (Hrádek/N., Kristina Mine).  
2003 *Glyptostrobus europaeus* (BRONGNIART) UNGER; Teodoridis, pp. 12-13, pl. 1, figs 3, 4, 11-14, pl. 2, figs 2, 3, 7 (Hrádek/N., drill cores).

Fragments of foliage shoots of two sorts, cryptomerioid shoots with shorter scale leaves, partly adpressed and cupressoid with fully adpressed short leaves, both helically arranged, bluntly pointed and amphistomatic; non-modified cells elongate, usually quadrangular and narrow, quite elongate (15 times longer than wide) on margins and over the veins, almost straight-walled, stomata irregularly disposed, bicyclic, subsidiary cells 4–6, on the outer periphery thickened, forming dense areas both abaxially and adaxially, obliquely orientated.

Incomplete to complete seed cones 14–19 mm long and 9–12 mm wide, obovate to globular, obtuse at apex, cuneate at base, consisting of 15 to 25 scales, scale complexes rhombic to deltoid, formed by connate bract scale (lower part) and seed scale (upper part), bract scales wedge-shaped, base narrowed, apical part mucronate, small umbo, abaxial side wrinkled, seed scale rounded or triangular with notched margin, sculptured by radial furrows, seed scales overgrowing by 2 to 4 mm beyond the bract scale. Seeds 3–6 mm long and 1.5–2 mm wide, apically winged, oblong, distinctly bent, flat, seed bodies oval, situated in the lower third, finely longitudinally sculptured, seed wings bent, starting at basal parts, forming basal rims, bordering seeds towards obtuse apices, distinct concave sides crest-shaped, descending to convex sides, upper surface distinctly perforated (Holý, 1975, pl. 1, figs 1-5).

**D i s c u s s i o n :** The variation of foliage matches the situation described by Kovar-Eder (1996) in Köflach and Kvaček et al. (2011) in Arjuzanx. Some of cryptomerioid and cupressoid foliage types show dicyclic stomata unlike typically incompletely tricyclic amphicyclic stomata of

*Sequoia abietina* with a very narrow (sunken) inner ring of subsidiary cells (see e.g., Kunzmann and Mai 2005, pl. 15). The nearest living relative is *Glyptostrobus pensilis* (STAUTON ex D. DON) K. KOCH from SE Asia.

**Material:** Compressions of sterile leafy twigs, isolated seed cones, cone scales and seeds, G 8879-84 (KR 271, 300, 303, 336, 337), G 4598, 4614, 8828-30, Gs 96.

### *Sequoia* ENDLICHER

#### *Sequoia abietina* (BRONGNIART in CUVIER) E. KNOBLOCH

Pl. 1, fig. 3, pl. 4, figs 16-17, pl. 10, fig. 8

- 1822 *Phyllites abietina* BRONGNIART in CUVIER, p. 362, pl. 11, fig. 13 (Habichtswald).  
 1964 *Sequoia abietina* (BRONGNIART in CUVIER) E. KNOBLOCH, p. 601 (Habichtswald).  
 1977a *Sequoia couttsiae* HEER; Holý, p. 111 (Hrádek/N., Kristina Mine).  
 1978a *Sequoia couttsiae* HEER; Holý, p. 2 (Hrádek/N., Kristina Mine).  
 2003 *Sequoia abietina* (BRONGNIART in CUVIER) E. KNOBLOCH; Teodoridis, p. 12, pl. 1, figs 1, 2, 5-10, pl. 2, figs 1, 4-6, 10 (Hrádek/N., drill cores).

Twigs cupressoid and cryptomerioid besides taxodioid, bearing needle-like univeined helically and distichously arranged needles 1.5 mm wide and ca. 6 mm long, blunt at apex, hypostomatic, with amphicyclic stomata, mostly longitudinally orientated, in two abaxial bands per 4–5 rows, cupressoid particularly on twigs bearing seed cones, with shortly decurrent, helically arranged adpressed scale leaves. Stomata bicyclic to incompletely tricyclic, closely set and irregularly arranged, with narrow ca. 5 subsidiary cells, stomatal pit widely quadrangular. Seed cones globular to broadly ovoid, immature specimens 8–12 mm in size, bearing less than 20 helically arranged, peltate cone scales, bract scale area transversally narrow rhomboidal, irregularly radially wrinkled, with deeper cross ridge and a minute central mucro. Seeds flat, obliquely oval to sub-triangular, 2.5–3.4 mm long and 1.8–2.4 mm wide, rounded to truncate or shallowly subcordate at base, hilar scar sub-basal, transversal, slightly elongate, embryo straight to slightly curved (Kvaček 1966, p. 25, pl. 3, figs 11-12, pl. 5, fig. 6, as *Sequoia* sp., Holý, 1975, p. 12, pl. 1, figs 7-15, as *Sequoia couttsiae*).

**Discussion:** The cones of *Sequoia abietina* recovered from the Kristina Mine correspond clearly with those described from Upper Lusatia (Mai 1964, as *Sequoia langsdorfii*, Czaja 2003) and differ significantly, contrary to the view of Holý (1975), from the records of *Quasisequoia couttsiae* (HEER) KUNZMANN from the Most Basin and other localities of this conifer (Bůžek and Holý 1964, Kunzmann 1999) in its much narrower transversally elongated bract-scale area and mostly straight to indistinctly curved embryo contrary to mostly curved embryos in *Quasisequoia couttsiae*. However, seeds with straight and curved embryos occur together in one seed cone in both *Sequoia abietina* and *Quasisequoia couttsiae* (Kunzmann 1999) as well as the modern representatives of *Sequoia* and *Sequoiadendron* (Teodoridis personal observation). Hence the generic differentiation on the basis of seeds is equivoal. Associated

foliage with typically incompletely tricyclic amphicyclic stomata showing epidermal structure known from other sites of *Sequoia abietina* (see Kunzmann and Mai 2005) is also assignable to this conifer. We encountered similar problems when identifying all the twig fragments at hand due to the absence of leaf anatomy details as Kovar-Eder also in the case of the material from the Oberdorf Mine (Kovar-Eder and Meller 2001).

Kunzmann (1999) in an extensive comparative study confirmed the affinity of this conifer distributed in the Cenozoic in Europe to the living *S. sempervirens* (D. DON) ENDLICHER distributed on the Pacific coast of North America. The carpological material described as *Sequoia abietina* (BRONGNIART in CUVIER) E. KNOBLOCH from drill cores Hr 39 and Hr 44 near Hrádek/N., belonging to the lower, middle and upper coal seams s. l. of the Zittau Basin (Teodoridis 2003), can be assigned either to *Sequoia* ENDLICHER or *Quasisequoia* SHRINIVASAN et FRIIS. The morphological differences between seeds and cones of both taxa are well defined by Pinggen (1994) and Kunzmann (1999).

**Material:** Compressions of leafy twigs, partly with attached seed cones, isolated seed cones and seeds, G 4593a, b, 4597, 8831-33, 8885a-b, 8886a.b, 8887-89 (KR 8, 269, 270), Gs 90-92.

### Geinitziaceae KUNZMANN

#### *Cupressospermum* MAI emend. KUNZMANN

##### *Cupressospermum saxonicum* MAI emend. KUNZMANN

Pl. 4, figs 19-21, pl. 10, fig. 5

- 1960 *Cupressospermum saxonicum* MAI, p. 75, pl. 3, figs 1-5 (Olbersdorf Mine at Zittau).  
 1977a *Cupressospermum saxonicum* MAI; Holý, p. 111 (Hrádek/N., Kristina Mine).  
 1978a *Cupressospermum saxonicum* MAI; Holý, p. 2 (Hrádek/N., Kristina Mine).  
 1999 *Cupressospermum saxonicum* MAI; Kunzmann, p. 92, pls 21-23, text-figs 18, 21.5 (several sites in Saxony, Bohemia, Rhineland – for details see Mai and Schneider 1988).

Leafy shoots cupressoid, leaves helically arranged, triangular, adpressed, with distinct resin channels, amphistomatic, stomata bicyclic, obliquely arranged corresponding to the structures from the German sites described by Kunzmann (1999). Seed cones (Holý 1975, p. 15, pl. 2, figs 2-10) globular to slightly ellipsoidal, 15–20 mm long, composed of 25 to 30 helically arranged cone scales, umbo irregularly quadrangular, up to 6 mm wide with radial mounds, wavy on the margin, depression across in the centre or slightly below and a short sharp adpressed mucro slightly above. According to new observations by V. Teodoridis cone scales with irregularly quadrangular bract-scale area, ca. 6 mm wide, rarely transversally rhomboid to polygonal, with a transversal depression and a short sharp mucro. Seeds in situ rounded to transversally oval, 2.6–3.5 mm wide, 1.5–2.5 mm tall, dorsally convex, ventrally concave, embryo horseshoe-like curved to sub-circular, testa with a thick rim on the seed margin but lacking on the seed base.

**Discussion:** Seeds in situ recovered at the Kristina Mine correspond exactly with the dispersed seeds from the type locality Olbersdorf (Mai 1960, p. 75, pl. 3, figs 1-5, text-figs 1-2). Holý (1975) was the first who recognized all macroscopic remains belonging to *Cupressospermum saxonicum*, originally based on dispersed seeds, and recognized this conifer at Herzogenrath among fossils described as *Sequoia couttsiae* by Menzel (1913, p. 26, pl. 3, figs 22-27). He also suggested its relationship to *Geinitzia* ENDLICHER, a notion confirmed by more recent detailed studies by Kunzmann (1999). The conifer occurs in Europe only, mainly in the Miocene (see Mai and Schneider 1988).

**Material:** Leafy shoots attached to seed cones, isolated seed cones and seeds, G 4591, 4593, 4594, 4595a, b, 4596, 8823, 8824, Gs 93-95.

## Angiosperms

### Nymphaeaceae SALISB.

#### *Pseudoeryale* DOROFEEV

##### *Pseudoeryale* sp.

Pl. 4, fig. 22

1977a *Pseudoeryale* sp.; Holý, p. 111 (Hrádek/N., Kristina Mine).

Fragmentary seed very wrinkled and compressed, 4.8 mm long, with a rounded operculum on the apex surrounded by an indistinct area with hilum outside (Holý 1975, p. 21, pl. 3, fig. 4).

**Discussion:** According to Holý (1975), the single specimen corresponds to the diagnosis of the extinct genus *Pseudoeryale* DOROFEEV (1972) based on the material from the Miocene of Isakovka, western Siberia. This ancient element closely related to the living *Euryale* was according to Dorofeev (1974) widely distributed from the Netherland to Japan, and also in Central Europe in the late Cenozoic.

**Material:** A single seed, G 3050.

### Schisandraceae BLUME (incl. Illiciaceae A.C. SM.)

#### *Illicium* L.

##### *Illicium germanicum* MAI

Pl. 4, fig. 23

1970b *Illicium germanicum* MAI, p. 449, pl. 99, fig. 22 (Wiesa).

1977a *Illicium germanicum* MAI; Holý, p. 112 (Hrádek/N., Kristina Mine).

The seed is elongate-elliptic, narrowed towards the base, 8.5 mm long and 3.2 mm wide, hilum 1.1 mm wide forming entrance into oblique space within the base, on its thin margin divided into fine teeth, four wide and flat longitudinal ridges radiate from hilum on the inner side of sclerotesta, outer surface densely and finely striate, diverging obliquely apically, perpendicular in the middle and obliquely basally above the base, sclerotesta showing prismatic sclereids, micropyle not observed (Holý 1975, p. 22, pl. 3, fig. 4).

**Discussion:** According to Holý (1975) the described specimen is specifically identical with *Illicium germanicum* MAI (1970b) described from Wiesa. The single specimen is too incomplete preventing us from verifying this statement. *Illicium verum* HOOK. (Himalayas to Fujian) was indicated as the nearest living relative.

**Material:** One seed, G 4603.

## Lauraceae JUSS.

### *Laurus* L.

#### *Laurus abchasica* (KOLAKOVSKII et SHAKRYL) FERGUSON

Pl. 1, fig. 9, pl. 10, figs 10-11

1958 *Laurophyllum abchasicum* KOLAKOVSKII et SHAKRYL in KOLAKOVSKII, p. 346, pl. 7, figs 1-3, pl. 10, figs 4-8 (Duab).

1966 *Laurophyllum abchasicum* KOLAKOVSKII et SHAKRYL; Kvaček and Bůžek, p. 201 (“*abchasiacum*”), pl. 1, figs 1-2, pl. 4, fig. 7 (lectotypification) (Hrádek/N., Kristina Mine).

1974 *Laurus abchasica* (KOLAKOVSKII et SHAKRYL) FERGUSON, p. 64, text-figs 7A-H, 8A-D, 9A-D, 10 (Kreuzau).

1975 *Litsaeophyllum miocenicum* JUCHNIEWICZ, p. 81, pl. 10, figs 1-2 (Turów).

Two fragments of leaf lamina up to 10 mm long, 7 mm wide, apex and base not preserved, margin entire, venation probably brochidodromous, midrib strong, moderate, secondaries alternate, originating at an angle of 40–50°, venation of higher orders poorly preserved. Adaxial epidermis smooth, cell outlines polygonal, only slightly elongate over veins, anticlinal walls fine undulate, abaxial epidermis medium cutinized, smooth, non-modified cells polygonal, 20–30 µm in diameter, anticlinal walls very fine and regularly Ω-like undulate, stomata brachyparacytic, rounded to rhomboidal, (15–) 20–25 µm long and 15–20 µm wide, with submerged subsidiary cells leaving very narrow traces on the cuticle surface, solitary simple trichome bases on veins, mesophyllous oil cells lens-shaped, 30–35 µm in diameter, abundant.

**Discussion:** Kvaček (1966) first assigned this fossil species to *Laurus* in his unpublished thesis, which confirmed the view of Kolakovskii and Shakryl (in Kolakovskii 1958) who suspected affinities of *Laurophyllum abchasicum* to *Laurus*. Kvaček and Bůžek (1966) corrected the measurements of the epidermal structure and the omission of the typification but did not form the necessary nomenclatural changes. Ferguson (1974) correctly introduced a legitimate combination based on a detailed comparative study of the living representatives. The relationship to the fossil *Laurus pliocaenica* (SAPORTA et MARION) KOLAKOVSKII (1964) still remains unresolved. Ferguson (1974) stated that *Laurus azorica* (SEUB.) FRANCO (= *Laurus canariensis* WEBB et BERTH. non WILLD.) of the Canary Islands must be considered as the nearest living relative rather than *L. nobilis* L. of the Mediterranean. Worobiec (2007) summarized the so far published records of *Laurus abchasica* and added new occurrences from Turów (Juchniewicz 1975, as a dispersed cuticle taxon *Litsaeophyllum miocenicum*) and Bełchatów. Kürschner (in Kürschner et al. 2008, Kürschner and Kvaček 2009) followed stomatal density of individual populations of this lineage and stated that variation was



dependent on climatic trends during the Oligocene till present.

**M a t e r i a l :** Fragmentary leaf compressions, G 8890a-b, 8891 (KR 46, 176).

### ***Ocotea* AUBL.**

#### ***Ocotea hradekensis* (KVAČEK et BŮŽEK) KVAČEK**

Pl. 1, fig. 11, pl. 10, fig. 12, pl. 11, fig. 1

- 1966 *Laurophyllum hradekense* KVAČEK et BŮŽEK, p. 292, pl. 2, figs 2-3, pl. 4, figs 5-6 (Hrádek/N., Kristina Mine).  
1971 *Laurophyllum hradekense* KVAČEK et BŮŽEK; Kvaček, p. 60, pl. 2, fig. 14, pl. 8, fig. text-fig. 8 (Hrádek/N., Kristina Mine).  
1996 *Ocotea hradekensis* (KVAČEK et BŮŽEK) KVAČEK in BŮŽEK et al., p. 25, pl. 16, figs 1-2, pl. 18, fig. 3 (Cheb Basin).

Incomplete simple leaves and leaf fragments, petiolate, lamina elliptic to obovate, 19 mm long, 11 mm wide, base cuneate, narrowed into petiole (up to 9 mm long), apex blunt to emarginated, margin entire, venation brochidromous, midrib strong, straight or slightly (?secondarily) curved, secondary veins distinct, originating at an angle of 30–40°, looping by margin, alternate, ovoid glands in axils of lower pair of secondaries preserved, tertiary veins perpendicular, straight to sinuous, rarely forked, venation of higher orders regular polygonal reticulate, areolation well developed, 3- to 4-sided, veinlets dichotomous to dendritic branched. Adaxial epidermis moderately cutinized, smooth, non-modified cells polygonal 25 and more µm in diameter, anticlinal walls coarsely wavy to almost straight, abaxial epidermis in general similar to the adaxial, bearing brachyparacytic stomata 25–30 (36) µm long, guard cells deeply sunken, leaving broad ledges not reaching the stomatal poles. Hydathodes present on the abaxial leaf side. Lens-shaped mesophyllous oil cells common.

**D i s c u s s i o n :** Because of similar stomatal patterns and regular occurrence of axillar glands attached to the base of the lower secondaries, Kvaček (in Bůžek et al. 1996) suggested a recombination of *Laurophyllum hradekense* with *Ocotea* and listed *O. foetens* (AIT.) BAILL. from the Canary Islands as the nearest living relative. The relationship to *Ocotea heerii* (GAUDIN) MAI is still open because of the lack of epidermal characteristics of the latter Pliocene species.

**M a t e r i a l :** Fragmentary leaf compressions, G 8892-8893, 8894a-b, 8895a-HOLO, 8895b, 8896, 8962 (KR 56, 186, 190, 246, 247, 300, 415).

### ***Ocotea rhenana* MENZEL**

Pl. 4, figs 24-25

- 1913 *Ocotea rhenana* MENZEL, p. 30, pl. 4, figs 2-5 (Herzogenrath).  
1913 *Carpolithus complanatus* MENZEL (non ENGELHARDT 1898), p. 72, pl. 6, figs 15-16 (Herzogenrath).  
1938 *Laurocalyx rhenanus* (MENZEL) KIRCHHEIMER, p. 333, pl. 4, figs 8-11 (Wiesa).  
1942 *Laurocarpum rhenanum* (MENZEL) KIRCHHEIMER, p. 434, text-figs 10-12 (Wiesa).  
1977a *Ocotea rhenana* MENZEL; Holý, p. 112 (Hrádek/N., Kristina Mine).

Globular to ovate fruits embedded in wide cupules, broadly rounded at base, well compressed due to fossilisation, 8–20 mm in diameter. Upper margin of cupules smooth, straight, outer as well inner surface smooth, wrinkled only due to compression. Cupules reaching towards one third or one half of the length of fruits, on the base abruptly narrowing into a short, stout stalk.

**D i s c u s s i o n :** According to Holý (1975) the material from the Kristina Mine fully corresponds with the type specimens from Herzogenrath (Menzel 1913) and other sites in Upper Lusatia (Kirchheimer 1938, 1942, Mai 1964, 1971). We hesitate to combine this carpological material with co-occurring foliage because it is uncertain to which fossil species it should be assigned. *Laurophyllum pseudoprinceps* described below is one candidate, because it is sometimes closely associated with *Ocotea rhenana* in Rhineland (Z. Kvaček, own observation).

**M a t e r i a l :** More than 50 more or less mature fruits in cupules or empty cupules and fragments, G 4607, 8825, 8826, 8827.

### ***Ocotea dorofeevii* HOLÝ**

Pl. 4, figs 26-27

- 1977a *Ocotea dorofeevii* HOLÝ, p. 116, pl. 3, figs 1-7 (Hrádek/N., Kristina Mine).

For the description and discussion see Holý (1975, 1977a).

**M a t e r i a l :** Eight fruits and cupules, G 4318, 4321-22, 4324-25.

### ***Sassafras* TREW.**

#### ***Sassafras* cf. *lusaticum* MAI**

Pl. 4, figs 28-29

- ? 1971 *Sassafras lusaticum* MAI, p. 324, pl. 34, fig. 16 (Schlabendorf).  
1977a *Sassafras* cf. *lusaticum* MAI; Holý, p. 112 (Hrádek/N., Kristina Mine).

Cupules narrow funnel-shaped, 5.5–6.8 mm long and 4.0–5.3 mm wide, narrowing into long, thin and longitudinally striate stalk, upper edge of cupules straight to wavy, bent inside, outer surface wrinkled, occasionally with six distinct keels (Holý 1975, p. 44, pl. 7, fig. 2).

**D i s c u s s i o n :** As stated by Holý (1975), the identification is equivocal due to poor preservation and scarcity of the material.

**M a t e r i a l :** Empty cupules, G 3063, 8966.

### ***Phoebe* NEES**

#### ***Phoebe bohemica* MAI**

Pl. 4, fig. 30

- 1971 *Phoebe bohemica* MAI, p. 318, pl. 33, fig. 5 (Zittau Basin).  
1977a *Phoebe bohemica* MAI; Holý, p. 112 (Hrádek/N., Kristina Mine).

Cupules thin-walled, empty 3.7–5 mm long, with fruits 6–8.7 mm long, 3.0–4.2 mm wide, perianth penta- to hexameric,

tips elliptic, free, starting from the stalk, in immature specimens very thin, smooth, in mature tough and slightly thickened, irregularly wrinkled, cupules to the base abruptly narrowed into woody wrinkled stalk. Fruits rounded ovoid to ellipsoidal, finely granulate on the surface or very finely striate longitudinally, with a short point on the apex, at maturity reaching high above the cupules (Holý 1975, p. 45, pl. 7, fig. 3).

**D i s c u s s i o n :** Holý (1975) confirmed the identification of the recovered fossils by matching them with the type material of this element known only from the Zittau Basin.

**M a t e r i a l :** Cupules, some with fruits inside, G 3051, 8967, 8968.

### *Laurophyllum* GÖPPERT

#### *Laurophyllum pseudoprinceps* WEYLAND et KILPPER

Pl. 1, figs 10, 12-14, pl. 11, figs 2-3

- 1963 *Laurophyllum pseudoprinceps* WEYLAND et KILPPER, p. 100, pl. 23, figs 14-19, text-fig. 6 (Frimmersdorf Mine, Ville).  
 1963 *Laurophyllum verrucosum* WEYLAND et KILPPER, p. 102, pl. 24, figs 24-25, pl. 25, figs 26-27 (Frimmersdorf Mine, Ville).  
 1963 *Laurophyllum undulatum* WEYLAND et KILPPER, p. 101, pl. 24, figs 20-21, text-fig. 7-8 (Frimmersdorf Mine, Ville).  
 1971 *Laurophyllum pseudoprinceps* WEYLAND et KILPPER; Kvaček, p. 50, pl. 1, figs 4-6, pl. 3, figs 3-5, pl. 4, figs 1-4, text-fig. 1 (Hrádek/N., Kristina Mine, many other sites in North Bohemian Oligocene and Miocene).

Incomplete and fragmentary simple leaves, lamina elliptic to ovate, 37–67 mm long, 12–27 mm wide, base cuneate, decurrent into an up to 13 mm long and 2 mm wide petiole, apex acuminate and blunt, margin entire, venation brochidodromous, midrib strong, straight or slightly curved in apical part, secondary veins thinner, straight, looping by margin, alternate, originating at an angle of 30–50°, tertiary veins perpendicular, straight to sinuous, venation of the higher orders regular polygonal reticulate, areolation well developed, 4-sided, veinlets dichotomous to dendritic branching. Adaxial epidermis thickly cutinized, partly granulate or smooth, non-modified cells polygonal, anticlinal walls varying from almost straight to strongly undulate, mostly exhibiting bead-like thickening. Abaxial cuticle usually also strongly cutinized, non-modified cells showing polygonal to strongly lobately wavy outlines, stomata amphibrachyparacytic, usually 17–25 µm long and 15–20 µm wide, outer subsidiary cells partly unequally developed. Trichome bases simple, sporadic. Lens-shaped oil cells common.

**D i s c u s s i o n :** This element is very common in the Miocene and Oligocene of Europe but seems to be endemic to Europe. Due to autecological variation (sun vs shade leaves) extreme forms have usually been assigned to independent fossil species (Weyland and Kilpper 1963) or even genera (Juchniewicz 1975). We support the previous interpretations by Kvaček (1971) and others and consider them as ecotypes of the same species. The stomatal type suggests an affinity to *Ocotea* (hence not generally accepted *Ocoteophyllum* JUCHNIEWICZ 1975 or the direct transfer to

*Ocotea* by Uzunova and Stojanova 1999) but no exact living counterpart in today's natural world has been suggested so far to match in all respects. Therefore we hesitate to accept the direct transfer into this living genus (see also Kvaček et al. 2011).

**M a t e r i a l s t u d i e d :** Isolated leaf compressions on slides, G 8894-8961 (KR 31, 32, 36, 51, 53, 61, 62, 63, 85, 124, 125, 127, 131, 144, 146, 149, 150, 161, 163, 174, 189, 191, 227, 228, 230, 231, 263, 296, 297, 298, 317, 321, 322, 408, 409, 528, sine num.).

#### *Laurophyllum rugatum* KVAČEK et BŮŽEK

Pl. 1, figs 15-17, pl. 11, figs 4-5

- 1966 *Laurophyllum rugatum* KVAČEK et BŮŽEK, p. 292, pl. 3, figs 3-5, pl. 4, fig. 4 (Hrádek/N., Kristina Mine).  
 1971 *Laurophyllum rugatum* KVAČEK et BŮŽEK; Kvaček, p. 61, pl. 8, figs 5-6, text-fig. 6 (Hrádek/N., Kristina Mine).

Fragmentary leaves simple, lamina elliptic, 21–23 mm long, 10–18 mm wide, base cuneate, decurrent into an up to 7 mm long petiole, apex not preserved, margin entire, venation brochidodromous, midrib strong, straight, secondary veins thinner, straight, looping by margin, alternate, originating at an angle of 30–40°, tertiary veins perpendicular, straight to sinuous, venation of the higher orders regular polygonal reticulate, areolation well developed, 4-sided, veinlets unbranched to rarely once branched. Adaxial epidermis strongly cutinized, smooth except for radial striation around sparsely distributed simple trichome bases, showing polygonal outlines of non-modified cells ca. 12–25 µm in diameter, anticlinal walls thick, straight. Abaxial epidermis thinly cutinized, densely covered by rounded simple trichome bases, non-modified cells with slightly finely wavy anticlinal walls, stomata brachyparacytic, rounded to broadly rhombic oval, (10–) 15–20 µm in diameter showing broad stomatal ledges reaching mostly to the stomatal poles. Trichome bases rounded, very dense over the abaxial leaf side.

**D i s c u s s i o n :** *Laurophyllum rugatum* is a rare, easily recognizable species without clarified affinities to modern genera. Besides the Zittau Basin, it was also recovered from the Cheb Basin, in Saxony and Wackersdorf (see Knobloch and Kvaček 1976).

**M a t e r i a l :** Isolated leaf compressions on slides, G 8963a -b, 8964a-b, 8965a-b (KR 3, 7, 34).

#### *Laurophyllum pseudovillense* KVAČEK

Pl. 1, figs 18-20, pl. 11, figs 6-7

- 1966 *Laurophyllum villense* KVAČEK et BŮŽEK, p. 209, pl. 1, fig. 6, pl. 2, fig. 1, pl. 4, figs 1-2, nom. illegit. (non *Laurophyllites villensis* WEYLAND et KILPPER) (Hrádek/N., Kristina Mine).  
 1971 *Laurophyllum pseudovillense* KVAČEK, p. 62, pl. 1, figs 1-3, pl. 11, figs 1-3, text-fig. 10 (Hrádek/N., Kristina Mine).

Incomplete and fragmentary simple leaves, petiolate, lamina elliptic to ovate, 21–26 mm long, 12–19 mm wide, base cuneate, decurrent into fragmentary petiole (2 mm long), apex not preserved probably acuminate and blunt, margin

entire, venation brochidodromous, midrib strong, straight, secondary veins thinner straight, looping by margin, opposite to alternate, originating at an angle of 40–50°, tertiary veins perpendicular, straight or sinuous to curved, often forked, venation of the higher orders regular polygonal reticulate, areolation well developed, 4-sided, veinlets unbranched to one branched. Adaxial epidermis moderately cutinized, smooth, on veins faintly striate, outline of non-modified cells polygonal, 10–20 µm in diameter, anticlinal walls smooth and straight or slightly curved, abaxial epidermis very thinly cutinized, smooth, non-modified cells hardly discernible, stomata brachyparacytic, oval, (10–)15–20 µm long, delicately reflected in the cuticle, trichome bases simple, conspicuous, thickened, with a circle of subsidiary cells, sparsely scattered among stomata, more often on veins. Mesophyllous lens-shaped oil cells common.

**Discussion:** Kvaček and Bůžek (1966) wrongly assigned this species to *Laurophyllites villensis* WEYLAND et KILPPER and only later Kvaček (1971) corrected this mistake. *Laurophyllum pseudovillense* has been rarely recognized in the European Miocene (Knobloch and Kvaček 1976) and is aberrant from most other fossil Lauraceae by its very delicate thinly cutinized abaxial epidermis which corresponds with several modern genera, e.g., *Persea* MILL., *Litsea* LAM.

**Material:** Isolated leaf compressions on slides, G 8986-9004, 9171b (KR 102, 128, 129, 136, 179, 198, 200, 209, 264, 265, 325/2, 476, 477, 478, 486).

### *Laurophyllum* sp.

Pl. 1, figs 21-23, pl. 11, figs 8-9

Incomplete and fragmentary simple leaves, petiolate, lamina elliptic to ovate 20–27 mm long, 10–14 mm wide, base cuneate with fragmentary petiole (5 mm long), apex not preserved, margin entire, venation brochidodromous, midrib strong, straight, secondary veins thinner, straight, looping by margin, alternate, originating at an angle of 30–50°, tertiary veins perpendicular, straight, venation of higher orders regular polygonal reticulate, areolation well developed, 4-sided, free ending veinlets absent. Adaxial epidermis medium cutinized, non-modified cells polygonal, ca. 25 µm in diameter with slightly to strongly wavy anticlinal walls, abaxial epidermis thinly cutinized, non-modified cells with straight to wavy anticlines, stomata brachyparacytic, guard cells deeply sunken, with inner subsidiary cells often asymmetrically developed, 12–15 (–20) µm long and additional outer subsidiary cells, less modified, simple small trichome bases on veins, lens-shaped oil cells in mesophyll.

**Discussion:** Kvaček (1966) believed that this material should be conspecific with *Litsea edwardsii* BANDULSKA (1926), which it matches well in the structure of the abaxial cuticle. At present we hesitate to accept this view considering the very different age (middle Eocene) and associated flora at the type locality Bournemouth.

**Material:** Leaf compressions on slides G 9005-9008 (KR 2, 19, 193, 234).

## *Cinnamomum* L. sect. *Camphora* NEES

### *Cinnamomum polymorphum* (A. BRAUN) HEER plexus

Pl. 2, figs 1-7, pl. 5, figs 1-2, pl. 11, figs 10-12

- 1845 *Ceanothus polymorphus* A. BRAUN, p. 171 (Öhningen).  
 1847 *Ceanothus bilinicus* UNGER, p. 145, pl. 49, fig. 9 (Bilina).  
 1851 *Daphnogene polymorpha* (A. BRAUN) ETTINGSHAUSEN, p. 16, pl. 2, figs 23-25 (Hernals).  
 1855 *Camphora polymorpha* (A. BRAUN) HEER, p. 112, pl. 1, fig. 11 (Öhningen).  
 1856 *Cinnamomum polymorphum* (A. BRAUN) HEER, p. 88, pl. 91, figs 11 c-d, pl. 93, figs 25-28, pl. 94, figs 1-16 (Öhningen).  
 1960 *Homalanthus costatus* MAI, p. 18, pl. 4, figs 25-28, pl. 5, fig. 3 (Wiesa).  
 1977a *Cinnamomum zlatkoi* HOLÝ, p. 115, pl. 3, figs 14-16 (Hrádek/N., Kristina Mine).  
 1994 *Cinnamomum costatum* (MAI) PINGEN, FERGUSON et COLLINSON, p. 164, pls 1-3, pl. 4, figs 1-2, pl. 5, fig. 1 (Wiesa, Kreuzau and many other sites).

Leaves simple, petiolate, lamina lanceolate, elliptic to ovate, rarely obovate, 22–89 mm long, 5–34 mm wide, base rarely slightly asymmetric, widely cuneate to cuneate, petiole up to 8 mm long, apex acuminate to shortly acuminate and blunt, margin entire, venation suprabaasal acrodromous, midrib strong, straight or slightly curved in apical part, lateral veins thinner, alternate or rarely opposite, at an angle of 20–35°, running along margin, usually connecting secondaries at 2/3 of the blade length, secondary veins thinner, alternate or opposite, at an angle of 40–55°, curved and looping near margin or straight to forked between midrib and lateral veins, tertiary veins alternate, perpendicular, straight to sinuous, often forked, venation of higher orders regular polygonal reticulate, areolation well-developed, 3- to 4-sided, veinlets lacking. Adaxial epidermis strongly cutinized, smooth and hairless, with thin hypodermis underneath showing polygonal non-modified cells with variable anticlinal walls from straight to minutely undulate, partly with slight lens-shaped thickenings (exceptional in wider forms in the present material), abaxial epidermis medium cutinized, non-modified cells polygonal, variable in outline, anticlinal walls straight to curved to small undulate, stomata brachyparacytic with narrow subsidiary cells producing a roundish stoma, ca. 15 µm in diameter, rarely with asymmetrically disposed one or two outer subsidiary cells, trichome bases simple, round, in variable density, lens-shaped mesophyllous oil cells common. Associated fruits small, ovoid, partly embedded in thin-walled cupules with smooth margins (for details on carpological record see Holý 1977a, p. 115, as *Cinnamomum zlatkoi*).

**Discussion:** Since the study by Kvaček and Walther (1974), various leaf forms of this species varying from narrow lanceolate (*bilinica* or *scheuchzeri* forms) to broadly oval (*polymorphum*, *buchii* and *spectabile* forms) have been considered as ecotypical variation of a single species producing fruits of the *Cinnamomum* sect. *Camphora* type. We merge the detached cupules and fruits described under different species names (Mai 1960, Holý 1977a, Pingen et al. 1994) with leaves identified as *Daphnogene polymorpha* and confirm the view of Heer (1856) and Ferguson (1971) that these Neogene fossil taxa form a single

plexus, which is closely related to *Cinnamomum camphora* L. (Holý 1977a, Pinggen et al. 1994, Mai 1999b). It is a typical member of many Miocene floras in Europe, namely of the mastixioid type. Kvaček and Walther (1974) hesitated to merge all triveined leaf forms of the European Cenozoic into a single entity and distinguished *Daphnogene cinnamomifolia* (BRONGN.) UNGER to designate ancestral records from the Palaeogene, whose affinities to *Cinnamomum camphora* are so far uncertain. For the time being we refrain from formally recognizing intraspecific taxa within both *Daphnogene cinnamomifolia* and *Cinnamomum polymorphum*.

**M a t e r i a l:** Numerous leaf compressions on slides, G 7696-7697, 9009-9155 (KR 1, 4, 50, 52, 59, 66, 73, 74, 82, 83, 84, 100, 101, 115, 116, 117, 118, 119, 120, 132, 135, 141, 142, 155, 157, 150a, 162, 166, 169, 201, 203, 205, 206, 216, 226, 236, 237, 242, 243, 244, 254, 255, 256, 257, 258, 259, 260, 261, 262, 266, 267, 258, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284), fruits and cupules, G 4305, 4306.

### *Cinnamomum* L. sect. *Malabathrum* MEISSN.

#### *Cinnamomum lusaticum* MAI

Pl. 5, figs 3-4

- 1971 *Cinnamomum lusaticum* MAI, p. 322, pls 14-15 (Reichwalde).  
1977a *Cinnamomum lusaticum* MAI; Holý, p. 112 (Hrádek/N., Kristina Mine).

Cupules broadly obconical, funnel-shaped, 5.5–7.8 mm long, 4.5–5.0 mm wide, blunt at base, irregularly wrinkled, abruptly narrowing into a stout wrinkled stalk, upper margin uneven and wavy, indistinctly 6-lobed, perianth slightly closed, inner surface of cupules smooth, fruit elongate ellipsoidal (Holý 1975, pp. 41-42, pl. 7, fig. 1).

**D i s c u s s i o n:** Cinnamomoid fruits in the Hrádek flora occur in two forms assigned by Holý (1975, 1977a) to *Cinnamomum lusaticum* MAI and *C. zlatkoi* HOLÝ. The latter is now merged with *Cinnamomum polymorphum* (sect. *Camphora* MEISSN.). Holý (1975, p. 42) maintained that the material he collected and assigned to *Cinnamomum lusaticum* was larger than the type of *Cinnamomum lusaticum* from Reichwalde (Lusatia, Germany – Mai 1971, 1999b) and the margin of the cupules less distinctly wavy. The wavy margin of cupules excludes the affinity to *Cinnamomum* sect. *Camphora* (Mai 1999b, p. 7). It will be necessary to compare the fruits of *Cinnamomum lusaticum* in more detail and follow in broader context its relationship to foliage.

**M a t e r i a l:** 11 fruits in cupules, G 4608, 4610, 8969-8970.

## Magnoliaceae

### *Magnolia* L.

#### *Magnolia burseracea* (MENZEL) MAI

Pl. 5, figs 5-6

- 1913 *Carpolithes burseraceus* MENZEL, p. 84, pl. 7, figs 10-12 (Herzogenrath).

- 1975 *Magnolia burseracea* (MENZEL) MAI, p. 567, pl. 25, figs 24-26 (Nirm).  
1977a *Magnolia burseracea* (MENZEL) MAI; Holý, p. 111 (Hrádek/N., Kristina Mine).  
2003 *Magnolia burseracea* (MENZEL) MAI; Teodoridis, pp. 12-13, pl. 1, figs 15, 18, 19, 22, pl. 2, figs 8-9 (Hrádek/N., drill cores).

Seeds ovoid, broadly ellipsoidal to broadly trigonal in outline, 5.3–8.4 mm long, 3.7–6.5 mm wide, rarely slightly asymmetrical, sinus of raphe visible only in the lower half of seeds, testa thin, smooth, composed of radially disposed prismatic sclereids, on sides of the base thinner (0.2 mm), on the top thicker (0.4 mm), apex obtuse, micropyle subterminal, heteropyle distinctly concave, rounded or blunt with wedge-shaped condylus, exceptionally cordate at base (Holý, 1975, pl. 3, figs 1-2).

**D i s c u s s i o n:** As stated by Holý (1975, pp. 19-20), the specimens described by Menzel (1913) have sclerotesta thinner than 0.5 mm and their form is slightly roundish to ovoid. The same applies to the material from Sandförsstgen (Holý, own observation). The other specimens of the sites Salzhausen, Konzendorf, Düren, Wiesa and Merka differ in their often cordate base and thicker testa (ca. 1 mm). *Magnolia schiedeana* SCHLECHTER from the Mexican uplands is cited as the nearest living relative (Tiffney 1977, Mai 1999b).

**M a t e r i a l:** Ca. 20 seeds and more fragments, G 3605, 4605, 4620, 8971-72, Gs 3072.

### *Liriodendron* L.

#### *Liriodendron* sp.

Pl. 5, fig. 7

- 1977a *Liriodendron* sp.; Holý, p. 111 (Hrádek/N., Kristina Mine).

One half of seed obliquely drop-like, 5.75 mm long and 2.8 mm wide, granulate on the surface.

**D i s c u s s i o n:** Fruitlets and seeds of *Liriodendron* have been frequently recorded in Europe, beginning in the Oligocene (Bůžek et al. 1976, at Markvartice) and continuing into the Pliocene. The presented material is too fragmentary for a precise identification (Holý 1975, p. 20, pl. 3, fig. 3).

**M a t e r i a l:** Fragment of seed, G 3064.

## Araceae JUSS.

### *Epipremnites* GREGOR et BOGNER

#### *Epipremnites ornatus* (E. M. REID et CHANDLER) GREGOR et BOGNER

Pl. 5, fig. 8

- 1926 *Epipremnum ornatum* E. M. REID et CHANDLER, p. 83, pl. 4, figs 24-25 (Bembridge).  
1978 *Epipremnum* (?) *ornatum* E. M. REID et CHANDLER; Holý, p. 2 (Hrádek/N., Kristina Mine).  
1984 *Epipremnites ornatus* (E. M. REID et CHANDLER) GREGOR et BOGNER, p. 6, text-fig. 1, 2/6 (Bembridge).

Seed asymmetrical, reniform, 2.5 mm long, 1.5 mm high, slightly compressed, both ends slightly taller than the saddle, asymmetrically curved, chalaza area rounded, micropyle area obliquely truncate, tiny hilum on the saddle scar, rows of pits on sides (Holý 1975, p. 17, pl. 21, fig. 1).

**D i s c u s s i o n :** Holý (1975) doubted the systematic position of these seeds relative to *Epipremnum*. Also according to Gregor and Bogner (1984, 1989) the affinity of such fossils to *Epipremnum* is equivocal and they were correct in establishing a fossil genus.

**M a t e r i a l :** One seed, G 3033.

### Potamogetonaceae RCHB.

#### Potamogeton L.

##### Potamogeton heinkei MAI

Pl. 5, figs 9-10

- 1964 *Potamogeton heinkei* MAI, p. 78, pl. 4, figs 1-6 (Hartau).  
1978a *Potamogeton heinkei* MAI; Holý, p. 2 (Hrádek/N., Kristina Mine).

Endocarps widely ovoid, 1.2–1.9 mm long, 0.9–1.5 mm wide (L/W index 1.1–1.6), smooth on surface, walls thick, base rounded, apex more or less rounded with a tiny point on ventral margin, sides flat, weakly convex to slightly concave, germination valve roundish, without keel (Holý 1975, p. 99, pl. 21, figs 9-12.).

**D i s c u s s i o n :** According to Holý (1975) this type of endocarps co-occurs with the next species and to distinguish between them is often difficult. A diagnostic feature of *Potamogeton heinkei* is the lack of the style base and a very short connection between the apex and the top of the germination valve. Very similar endocarps produce the nearest living relatives *P. pauciflorus* PURSH., *P. foliosus* RAF. and *P. heterophyllus* SCHREB. (Holý 1978a, p. 100). Teodoridis (2003) reported morphologically similar endocarps identified as *Potamogeton wiesiensis* KRICHHEIMER from the Hr 51 drill core near Hrádek /N. However, *P. wiesiensis* shows a distinctly well-developed keel of germination valve, which is lacking in *P. heinkei* and also *P. noctensis* MAI ex HOLÝ (see Teodoridis 2007). On the other hand, Teodoridis (2003) considered a possible affinity of *P. wiesiensis* with both the latter mentioned species because of smaller size of endocarps with a relatively indistinct keel and shallow central depressions.

**M a t e r i a l :** 60 endocarps, G 3040, 8973-74, Gs 110.

##### Potamogeton noctensis MAI ex HOLÝ

Pl. 5, figs 11-12

- 1978a *Potamogeton noctensis* MAI ex HOLÝ, pp. 2, 10, pl. 3, figs 1-10 (Hrádek/N., Kristina Mine).

For the description and discussion see Holý (1978a).

**M a t e r i a l :** About 100 endocarps, G 3041, 4289-99, Gs 83, 107, 110.

### Arecaceae SCHULTZ SCH.

#### Spinophyllum HUARD

##### Spinophyllum daemonorops (UNGER) HUARD

Pl. 5, fig. 13

- 1860 *Palaeospathe daemonorops* UNGER, pp. 9-10, pl. 2, figs 9-12 (Laubach).  
1863 *Palmacites daemonorops* (UNGER) HEER, p. 36, pl. 4, figs 7-15 (Bovey Tracey).  
1937 *Palmoxylon daemonorops* (UNGER) KIRCHHEIMER, p. 46, fig. 43 (Laubach).  
1957 *Calamus daemonorops* (UNGER) CHANDLER, p. 88, pl. 12, figs 24-42 (Bovey Tracey).  
1967 *Spinophyllum daemonorops* (UNGER) HUARD, p. 332 (Arjuzanx).  
1975 *Daemonorops* cf. *geniculatus* (GRIFF.) MART.; Czezcott and Juchniewicz, pp. 57, 62, pl. 12, fig. 3 (Turów).  
1978 *Calamus daemonorops* (UNGER) CHANDLER; Holý, p. 2 (Hrádek/N., Kristina Mine).  
1980 *Spinophyllum daemonorops* (UNGER) HUARD; Czezcott and Juchniewicz, p. 26, pls 4-5, 7 (Turów).  
2003 *Calamus daemonorops* (UNGER) CHANDLER; Teodoridis, p. 26, pl. 7, figs 17-18 (Hrádek/N., drill cores).

Spines narrowly pointed, 5–18 mm long, 0.5–1.4 mm thick, solitary or fused at base to form groups of 3–4 (max. 5), lustrous to dull on surface, free or rarely attached to fragments of wood (Holý 1975, pp. 97-98, pl. 21, fig. 2).

**D i s c u s s i o n :** Chandler (1957) believed, on account of fruits and flowers co-occurring with spines at Bovey Tracey, in the affinity of such fossils to *Calamus* L. while Huard (1967) transferred *Calamus daemonorops* (UNGER) CHANDLER to an artificial fossil genus doubting this straight-forward relationship. In a detailed anatomical study he defined *Spinophyllum* HUARD typified by *S. daemonorops* (UNGER) HUARD adding another species *S. lepidocaryoides* HUARD. According to Czezcott and Juchniewicz (1975) the same type of spines occurs also at Turów and seems to belong to *Daemonorops*, while later (Czezcott and Juchniewicz 1980) they returned to the non-committal name *Spinophyllum*. According to Mai and Walther (1978, p. 147), the likely living analogue of this fossil palm represented by a single species *Calamus daemonorops* is the East Asiatic calamoid *Calamus draco* WILLD. The material at hand does not suit to a verification of this view.

**M a t e r i a l :** Ca. 50 fragments of spines, G 3075, 4606.

### Cyperaceae JUSS.

#### Dulichium PERSOON

##### Dulichium marginatum (C. et E.M. REID) DOROFEEV

Pl. 5, figs 14-15

- 1915 *Dulichium spathaceum* var. *marginatum* C. et E.M. REID, p. 66, pl. 3, figs 3-6 (Reuver).  
1963a *Dulichium marginatum* (C. et E.M. REID) DOROFEEV, p. 117, pl. 13, figs 17-23 (Kozjulino).  
2003 *Dulichium marginatum* (C. et E.M. REID) DOROFEEV; Teodoridis, p. 25, pl. 7, figs 7-8, 11, pl. 8, figs 11-12 (Hrádek/N., drill cores).

Fruits 1.8–2.6 mm long, 0.7–0.9 mm wide, elliptic elongate, on the base narrowed into a short neck, apex narrowed, shortly pointed, remains of bristles arising from the basal collar, walls coriaceous, rows of small cells visible on the surface (Holý 1975, p. 95, pl. 20, figs 11–12).

**D i s c u s s i o n :** According to Holý (1975), this record is very close to that from western Siberia (Dorofeev 1963a) while similar fruits from the Netherland are bigger. *Dulichium* is a monotypic genus containing the single aquatic to semi-aquatic species *D. arundinaceum* (L.) BRITT. native to North America.

**M a t e r i a l :** 5 fruits, G 3035, 3087.

## Stemonaceae CARUEL

### ? *Stemona* LOUR.

#### cf. *Stemona germanica* (MAI) MAI

Pl. 5, fig. 16

? 2008 *Stemona germanica* (MAI) MAI, p. 197, pl. 4, figs 1–18 (Gonna, Walbeck, Hartau, Nochten).

For more detailed synonymy see Mai (2008).

Seeds obliquely ovoid to rounded rhomboidal, 1.3–1.4 mm long, 0.9–1.3 wide, hilum seen as a large oval scar above the base, micropyle on opposite end, surface covered by ca. 20 sharp distinct ribs with small tubercles on edges, running continuously from hilum to micropyle (Holý 1975, p. 100, pl. 21, fig. 13, as *Carpolithus* sp.).

**D i s c u s s i o n :** Holý (1975) did not recognize the affinity of the two specimens available and called them *Carpolithus*. According to Martinetto (in sched. i.e. a note on the label) they may represent a new species of *Spirellea* E. KNOBLOCH et MAI. Mai (2008) suggested for such fossil seeds affinity to the Stemonaceae. They were also recorded from the Miocene of nearby Hartau, Germany (Mai 1964, as *Carpolithus* sp.) and many more sites of the European Maastrichtian to Upper Miocene (for more details see Mai 2008). Similar ribbed seeds of a broader form and coarser ribbing were assigned to *Lemnospermum* NIKITIN associated with an aquatic plant called *Limnobiophyllum expansum* (HEER) KVAČEK (Araceae) in the Early Miocene deposits of the North Bohemian Basin in the Bílina Mine (Kvaček 1995, 1998).

**M a t e r i a l :** 2 seeds, G 3067 a, b.

## Typhaceae JUSS. (incl. Sparganiaceae JUSS.)

### *Sparganium* L.

#### *Sparganium camenzianum* KIRCHHEIMER

Pl. 5, figs 17–18

1941a *Sparganium camenzianum* KIRCHHEIMER, p. 226, fig. 18 (Wiesa).

1977a *Sparganium camenzianum* KIRCHHEIMER; Holý, p. 113 (Hrádek/N., Kristina Mine).

2003 *Sparganium camenzianum* KIRCHHEIMER; Teodoridis, pp. 25–26, pl. 7, figs 12–16, pl. 8, fig. 6 (Hrádek/N., drill cores).

Endocarps obovoid to elongate obovoid, in two forms, smaller 0.9–1.2 mm long, 0.75–1.25 mm wide, slender

2.4–2.9 mm long, 1.3–1.6 mm wide, acute at base, suddenly narrowed, in slender forms base wedge-shaped, apex abruptly narrowing into 0.94 mm long and 0.2–0.3 mm wide neck with slightly oblique apical pore, upper surface smooth, with a rarely visible longitudinal rib and 5–6 fine traces of vascular bundles (Holý 1975, p. 96, pl. 20, figs 13–16).

**D i s c u s s i o n :** According to Holý (1975) the record is identical with *Sparganium camenzianum* from Wiesa and Hartau, from where two forms were also indicated (see Mai 1964). Holý (1975) does not rule out a mixture of two species. Mai (1999a) compared fossil endocarps of *S. camenzianum* with the extant *S. emersum* REHM. and *S. glomeratum* LAEST from Japan.

**M a t e r i a l :** 4 endocarps, G 3070, 8975–76.

## Sabiaceae BLUME

### *Meliosma* BLUME

#### *Meliosma miessleri* MAI

Pl. 5, fig. 19–20

1964 *Meliosma miessleri* MAI, p. 109, pl. 14, figs 19–24 (Hartau).  
1977a *Meliosma miessleri* MAI; Holý, p. 112 (Hrádek/N., Kristina Mine).

Endocarps bisymmetrical, widely ovoid to globular (to obliquely slightly reniform), disc-shaped compressed from sides to inflated, 3.8–4.5 mm long, 3.4–4.0 mm wide, walls ca. 0.3 mm thick, keel on the base blunt forming an eccentrically shifted knob towards ventral side, with 0.8–1.2 mm wide chalaza showing oblique rapidly narrowing funicular canal, 3–5 weak or indistinct little combs radiating from chalaza, partly anastomosing, partly mixed with isolated tubercles, more distinct near chalaza, surface partly fully smooth, near apex reticulate with shallow lacunae, below chalaza mostly tiny micropyle showing the position of the dehiscence line (Holý 1975, pp. 81–2).

**D i s c u s s i o n :** According to Holý (1975) the material is identical with the type specimens from Upper Lusatia (Hartau). The nearest fossil species appears to be *M. reticulata* (C. et E.M. REID) CHANDLER (1957) from Bovey Tracy, which differs in thicker walls and distinct dense surface reticulum with sharp ribs. Mai (2000) indicated that *M. pendens* REHD. et WILS. and *M. myriantha* SIEBOLD et ZUCC. from East Asia be living species producing comparative fruits but stated that no exact closely related living relative can be suggested. Teodoridis (2003) described about 20 *Meliosma wetteraviensis* (LUDWIG) MAI endocarps from the Hr 42, Hr 44 and Hr 51 drill cores from the environs of Hrádek/N. These endocarps differ from *Meliosma miessleri* in their form and size, the form and size of chalaza, and thickness of the endocarp's wall.

**M a t e r i a l :** Over 50 seeds and free valves, G 3071, 8859–60.

## Menispermaceae JUSS.

### *Parabaena* MIERS

#### *Parabaena europaea* CZECZOTT et SKIRGIELLO

Pl. 5, fig. 21

1967 *Parabaena europaea* CZECZOTT et SKIRGIELLO, p. 109, pl. 5, figs 13–14 (Turów).

1977a *Parabaena europaea* CZECZOTT et SKIRGIELLO; Holý, p. 112 (Hrádek/N., Kristina Mine).

Endocarps broadly ovate, 6.7–7.4 mm long, 5.3 mm wide, 3.9 mm thick, apically pointed into the rest of style, at base slightly cordate, with short and thin ventrally orientated stalk, bisymmetrical along the dorso-ventral plane of dehiscence, in side view boat-shaped, on sides vaulted and decorated, apex flatly beak-shaped, dorsally sub-hemispherical, divided by a thin medial ridge, on sides with two or three meridionally orientated appendices converting towards medial ridge and reaching almost to the margin of the ventral side, on the surface finely striate, ventral side deeply concave, cavity broadly ovoid, undivided, on margin a thin border with four blunt lobes, locule biconvex, in dorsal view broadly oval, cross section of the locule in the dehiscence plane asymmetrically horn-shaped, narrower at the base, widen at the apex, with the opening of raphe obliquely orientated from the ventral hilum, micropylar channel entering the rest of style (Holý 1975, p. 22-3, pl. 3, figs 6-10).

**Discussion:** Holý (1975) did not complete any emendation of *Parabaena europaea* CZECZOTT et SKIRGIELLO (1967) based on a single poorly preserved specimen because of insufficient comparative living material. He suggested a broader revision of similar remains of the Menispermaceae from the Eocene and Pliocene of England (Chandler 1964, Reid C. and E.M. 1915, as *Jongmansia cypreaeformis*).

**Material:** Two endocarps, one valve, G 4604, G 4850, 8850.

## Santalaceae R. BR. (incl. Viscaceae MŮ.)

### *Viscum* L.

#### *Viscum morlotii* (UNGER) E. KNOBLOCH et KVAČEK

Pl. 2, figs 8-9, pl. 12, fig. 1

- 1852 *Potamogeton morlotii* UNGER, p. 88, pl. 29, figs 6-8 (Kainberg).  
1904 *Viscophyllum morlotii* (UNGER) KNOLL, p. 17, pl. 4, figs 1-9, 13-18, text-figs A, B (Hochwald).  
1961b *Viscum lusaticum* CZECZOTT, pp. 74, 113, pl. 22, figs 3-7, pl. 23, figs 1-5, text-figs 12g-h (Turów).  
1976 *Viscum morlotii* (UNGER) E. KNOBLOCH et KVAČEK, p. 67, pl. 12, fig. 17, pl. 17, figs 5, 13, pl. 33, figs 4-11 (Wackersdorf).

Complete leaves and fragments, short petiolate, lamina obovate, 11–25 mm long and 4–9 mm wide, L/W index 2.4–3.1, base cuneate to decurrent, apex obtuse, margin entire, venation acrodromous, looping near the margin, thicker midrib and 2 or 3 lateral veins on either side, poorly preserved, venation of higher orders alternate percurrent, consisting of sinuous veins, areolation lacking. Adaxial and abaxial epidermis of the same structure, thickly cutinized, outlines of non-modified cells ca. 30 µm in diameter, anticlinal wall straight, pitted, outer periclinal wall with very indistinct lens-shaped medial papilla in the cell centre, stomata brachyparacytic, 60–70 µm long, with two broad subsidiary cells attached by thinner cuticular zone to two deeply sunken guard cells, stomatal ledges reaching both stomatal poles, pore narrow slit-like.

**Discussion:** Knobloch and Kvaček (1976) after detailed comparative study of the epidermal anatomy of the Loranthaceae and Viscaceae confirmed the view of Czezcott (1961b) and used the genus *Viscum* L. instead of *Viscophyllum* KNOLL for the leaf remains with narrow forms from various populations in Europe. They also corrected the priority of using the epithet “*morlotii*” instead of “*lusaticum*”, contrary to Czezcott (1961b). For more information on affinities and synonymy see Knobloch and Kvaček (1976). *Viscum morlotii* occurs mostly in the European mastixoid floras, recently also in Arjuzanx (Kvaček et al. 2011), while Pliocene records of *Viscum* belong prevalingly to the broader-leaved *Viscum miquelii* (GEYLER et KINKELIN) CZECZOTT. Due to uniform foliage morphology and anatomy, the nearest living relatives have not yet been established.

**Material:** Isolated leaf compressions on slides, G 9156-9165 (KR 20, 33, 65, 68, 183, 188, 426, 327).

## Altingiaceae HORAN.

### *Liquidambar* L.

#### *Liquidambar europaea* A. BRAUN plexus

Pl. 5, fig. 22

- 1836 *Liquidambar europaea* A. BRAUN in BUCKLAND, p. 513 (Öhningen).  
1847 *Liquidambar europaea* A. BRAUN; Unger, p. 120, pl. 35, figs 1-5 (Parschlug).  
1959 *Liquidambar magniloculata* CZECZOTT et SKIRGIELLO in CZECZOTT et al., p. 121, pl. 15, figs 1-4 (Turów).  
1977a *Liquidambar europaea* A. BRAUN; Holý, p. 112 (Hrádek/N., Kristina Mine).

Rounded compressed infructescences 9–14 mm in diameter, showing roundish polygonal locules 2–3 mm across on surface, interocular septa smooth, inner septa partly preserved showing septicidal fruitlet dehiscence (Holý 1975, p. 38, pl. 6, figs 5-6).

**Discussion:** According to Holý (1975) the living relative appears to be *L. styraciflua* L. from the Atlantic part of North America. Later Holý (in sched.) identified the material as “*L. magniloculata* CZECZOTT et SKIRGIELLO”. Mai (1999b) treated the two fossil species *L. europaea* and *L. magniloculata* as synonymous.

**Material:** 5 compressed abraded infructescences, G 4588-89.

## Haloragaceae R. BR.

### *Proserpinaca* L.

#### *Proserpinaca ervinii* HOLÝ

Pl. 5, fig. 23, Pl. 6, fig. 1

- 1978a *Proserpinaca ervinii* HOLÝ, p. 8, pl. 2, figs 10-18, text-figs 2 A-C (Hrádek/N., Kristina Mine).

For the description and discussion see Holý (1978a).

**Material:** 15 fruits, G 3066, 4263-69, 4370-77.

## Hamamelidaceae R. BR.

### *Corylopsis* SIEBOLD et ZUCC.

#### *Corylopsis* sp.

Pl. 6, fig. 2

1977a *Corylopsis* sp.; Holý, p. 112 (Hrádek/N., Kristina Mine).

Isolated seeds 4.1–5.5 mm long, 2.8–3.7 mm wide, broadly ovate to oval, rounded on top, base oblique with large roundish scar reaching to the lower third or half of the seed length, surface smooth, lustrous (Holý 1975, pp. 36–7, pl. 6, figs 1–2).

**D i s c u s s i o n :** According to Holý (1975) the material seems to represent a new species similar in form to *C. urse-lensis* MÄDLER from Niederursel (Mädler 1939) and Krościenko (Szafer 1947) but the specimens are bigger and stouter. *C. uralensis* DOROFEEV (1970, pp. 50–51) looks to be very similar but also bigger, pointed at the apex.

**M a t e r i a l :** 4 seeds, G 4586, 4588, 8846.

### *Distylium* SIEBOLD et ZUCC.

#### *Distylium fergusonii* E. KNOBLOCH et KVAČEK plexus

Pl. 2, figs 10–13, pl. 6, fig. 3, pl. 12, fig. 2

1976 *Distylium fergusonii* E. KNOBLOCH et KVAČEK, p. 45, pl. 17, figs 1, 3, 20, pl. 20, figs 1, 7, 13–14, text-fig. 18 (Wackersdorf).

1977a *Distylium* cf. *uralense* KOLESNIKOVA; Holý, p. 112 (Hrádek/N., Kristina Mine).

2003 *Distylium* cf. *uralense* KOLESNIKOVA; Teodoridis, p. 14, pl. 1, figs 20, 23–25 (Hrádek/N., drill cores).

Leaf fragments without preserved petiole, lamina incomplete, probably narrow elliptic to elliptic, 4–10 mm long and 2–7 mm wide, base widely cuneate, apex attenuate and blunt, margin entire, venation brochidodromous, midrib thick, secondary veins thinner, alternate, at angles of 50–80°, curved and looping at margin, intersecondaries thinner, obvious, tertiary veins alternate perpendicular, sinuous, venation of higher orders regular polygonal reticulate, areolation well developed, 4-sided, veinlets dichotomous branching. Adaxial epidermis strongly cutinized, smooth to partly faintly striate, non-modified cells polygonal to lobate, 25–40 µm in diameter, anticlinal walls regularly undulate, trichome bases star-like, mostly 30 µm in diameter, thickly cutinized, sparse, adaxial epidermis heavily striate, thickly cutinized, anticlinal walls of non-modified cells undulate, but mostly not discernible due to striation, stomata brachyparacytic, subsidiary cells wide, without clear distinct limits, guard cells pairs oval, 18–20 µm long and 12–18 µm wide, ledges thickened, bordering broadly oval pore. Trichome bases of the same kind as adaxially, but denser. Seeds narrow elongate, obovate, 6.9–7.4 mm long, 3.2 mm wide, with an elliptic oblique scar on base, smooth and a little lustrous on outer surface (Holý 1975, p. 37, pl. 6, figs 3–4).

**D i s c u s s i o n :** Kvaček (1966) wrongly assigned these leaves from the Kristina Mine to *Symplociphyllum* sp. The abaxial epidermis clearly refers the material to *Distylium fergusonii*, which is, as elsewhere in Europe, also

associated there with seeds assignable to *Distylium uralense* KOLESNIKOVA (Holý 1975, 1977a, p. 112). Such seeds occurred, e.g., in Hartau, Wiesa, Sandförstgen (Mai 1964, 1999b), in the drill cores from Hrádek/N. (Teodoridis 2003) and at Köflach (Meller et al. 1999). According to Mai and Walther (1991), *D. uralense* is correlated with the recent *D. racemosum* SIEBOLD et ZUCC. native to SE China.

**M a t e r i a l :** Isolated leaf compressions on slides, G 9166–9170 (KR 46, 70, 79, 331, 332, 464), three isolated seeds, G 4585–86, 4589.

## Vitaceae JUSS.

### *Vitis* L.

#### *Vitis lusatica* CZECZOTT et SKIRGIELLO

Pl. 6, figs 4–5

1959 *Vitis lusatica* CZECZOTT et SKIRGIELLO in CZECZOTT et al., p. 193, pl. 17, figs 4–12 (Turów).

1977a *Vitis lusatica* CZECZOTT et SKIRGIELLO; Holý, p. 112 (Hrádek/N., Kristina Mine).

Seeds ovoid to obovoid, 4.6–6 mm long, 3.2–3.7 mm wide, deeply incised on top, often obliquely cut, dorsal side with radial furrows, ventral side slightly convex, bearing a narrow keel (with fine raphe) and deep lateral parallel furrows, often with side tubercles, base rounded narrowing into cylindrical micropylar process (Holý 1975, pp. 76–77, pl. 16, figs 3–6).

**D i s c u s s i o n :** According to Holý (1975) living relatives of *Vitis lusatica* are unknown. Seeds of *V. glabra* CHANDLER (1963, p. 103) from the Lower Eocene of England are very similar and it is also sometime difficult to distinguish *Vitis lusatica* from marginal forms of *Tetrastigma chandlerae* KIRCHHEIMER. The small seeds described by Teodoridis (2003, p. 23, pl. 5, fig. 22, pl. 6, fig. 12) as *Vitis* cf. *teutonica* AL. BR. from the drill cores near Hrádek/N. show morphological affinity to small specimens of *V. lusatica* known from the Zittau Basin in Poland (Czeczott et al. 1959) and elsewhere in Saxony (e.g., Mai 1964, Czaja 2003).

**M a t e r i a l :** 25 seeds, several fragments, G 3052, 8838–39.

### *Vitis parasilvestris* KIRCHHEIMER

Pl. 6, figs 6–7

1941b *Vitis parasilvestris* KIRCHHEIMER, p. 650, fig. 9 (Klettwitz).

1964 *Vitis parasilvestris* KIRCHHEIMER; Mai, p. 37, pl. 3, fig. 27 (Wiesa).

1977a *Vitis parasilvestris* KIRCHHEIMER; Holý, p. 112 (Hrádek/N., Kristina Mine).

Seeds elongate obovoid, 4.1–5.5 mm long, 2.3–3.3 mm wide, deeply incised on top, often asymmetrical, base narrowing into a stout, elongated cylindrical micropylar process, dorsal side convex with small oval chalaza, ventral side keeled, raphe with lateral parallel deep narrow furrows (Holý 1975, pp. 76–7, pl. 16, figs 3–6).

**D i s c u s s i o n :** According to Holý (1975) this fossil species is close to the living *V. silvestris* GMEL. and is often



named *V. silvestris* GMEL. foss. A fossil species closely related to *Vitis parasilvestris* was described from the Oligocene and Miocene of western Siberia as *V. tomskiana* DOROFEEV (1963a, p. 214).

**M a t e r i a l:** 6 seeds, several fragments, G 3055, 8837.

### *Ampelopsis* MCHX.

#### *Ampelopsis malvaeformis* (SCHLOTHEIM) MAI

Pl. 6, figs 8-9

- 1822 *Carpolithus malvaeformis* SCHLOTHEIM, p. 98, pl. 21, fig. 9a-c (Penkhof).  
1857 *Vitis ludwigii* A. BRAUN, p. 184 (Dorheim).  
1957 *Ampelopsis ludwigii* (A. BRAUN) DOROFEEV, p. 644, pl. 1, figs 1-2 (Orlovka).  
1977a *Ampelopsis ludwigii* (A. BRAUN) DOROFEEV; Holý, p. 112 (Hrádek/N., Kristina Mine).  
1982 *Ampelopsis malvaeformis* (SCHLOTHEIM) MAI in Mai and Gregor, p. 418, pl. 21, figs 1-3 (Salzhausen).  
2003 *Ampelopsis ludwigii* (A. BRAUN) DOROFEEV; Teodoridis, p. 23, pl. 6, fig. 13, pl. 7, figs 1-2 (Hrádek/N., drill cores).

Seeds triangular-cordate, 3.3–4.1 mm long, 2.3–3.5 mm wide, apex rounded to truncate to emarginate, base often long cuneate narrowing into stalk, dorsal side distinctly radially striate with oval chalaza, ventral side with a long trigonal keel of raphe reaching to the basal micropyle, raphe deeply cut into the apex, both lateral furrows diverging from the base obliquely below the apex (Holý 1975, pp. 77-78, pl. 16, figs 7-12).

**D i s c u s s i o n:** According to Holý (1975) the seeds perfectly matched those found at Krościenko (Szafer 1947) and in Upper Lusatia (Mai 1964). Similar in form but of different size are those from Turów (Czeczott et al. 1959). The specimens kept at the Naturkunde Museum, Berlin (orig. Mai 1964) are also slightly bigger. As suggested by Mai (2000) the living species matching the above fossils in seed morphology are *A. orientalis* (BOISS.) PLANCH. (Near East) and *A. leeooides* PLANCH. (Japan).

**M a t e r i a l:** 24 seeds, G 3039, 8840-41.

#### *Ampelopsis rotundata* CHANDLER

Pl. 6, figs 10-11

- 1926 *Ampelopsis rotundata* CHANDLER, p. 31, pl. 5, figs 5a-c (Hordle).  
1977a *Ampelopsis rotundata* CHANDLER; Holý, p. 112 (Hrádek/N., Kristina Mine).  
2003 *Ampelopsis rotundata* CHANDLER; Teodoridis, pp. 23-24, pl. 7, figs 5-6 (Hrádek/N., drill cores).

Seeds shortly broadly obovoid, 2.8–3.7 mm long and 2.3–3.2 mm wide, apex broadly rounded, often slightly flattened from above and from the ventral side, only with a slight incision, base continuously cuneate, pointed, dorsal side with strong oval chalaza connected with raphe, ventral side strongly convex, lateral furrows deep, strongly diverging (Holý 1975, p. 78, pl. 17, figs 1-4).

**D i s c u s s i o n:** According to Holý (1975) the seeds are identical with those from the Eocene of England (Chandler 1926). Similar but bigger are those of *A. monas-*

*teriensis* KIRCHHEIMER. An identical species appears to be *A. heeri* DOROFEEV (1963b) and very close two other Siberian species *A. rotundatoides* DOROFEEV (1957, p. 645, Kozjulino) and *A. tertiaris* DOROFEEV (1963a, pp. 217-8). Czeczott et al. (1959) described very similar material as *Vitis teutonica* A. BRAUN from Turów. Mai (1997) discussed in detail the taxonomical status and suggested the living *A. heterophylla* SIEBOLD et ZUCC., *A. fargesii* GAGNEP. and *A. megaphylla* DIELS et GILG from East Asia as plants producing similar seeds.

**M a t e r i a l:** 35 seeds, G 3042, 8842-43.

### *Tetrastigma* PLANCHON

#### *Tetrastigma lobata* CHANDLER

Pl. 6, figs 12-13

- 1926 *Tetrastigma lobata* CHANDLER, p. 32, pl. 5, figs 3a-c (Hordle).  
1977a *Tetrastigma lobata* CHANDLER; Holý, p. 112 (Hrádek/N., Kristina Mine).

Seeds rounded obovoid, 3.5–5.4 mm long, 3.1–4.9 mm wide, apex rounded, with only a narrow raphe, base rounded, with a short micropylar knob, dorsal side with oval chalaza and deep radiating furrows that divide the surface into lobes, ventral side with narrow parallel-sided keel and shallow indistinct raphe, the surface perpendicularly divided on both side of keel by furrows in several distinct lobes (Holý 1975, pp. 79-80, pl. 17, figs 5-7).

**D i s c u s s i o n:** According to Holý (1975) these seeds deviate from the variation within *Tetrastigma chandlerae* KIRCHHEIMER and match the record of *Tetrastigma lobata* from the Upper Lusatia, a single record of this species from the continental Europe, where it is associated with *A. chandlerae*. Czeczott et al. (1959) assigned similar material from Turów to the latter and stated that it is connected with transitional forms. They did not publish the quantitative variation within their specimens, thus not allowing exact assessment of the relationship.

**M a t e r i a l:** 10 seeds and fragments, G 3054, 8844.

#### *Tetrastigma chandlerae* KIRCHHEIMER

Pl. 6, figs 14-15

- 1938b *Tetrastigma chandlerae* KIRCHHEIMER, p. 337 (“*chandleri*”), pl. 4, figs 16-20, text-fig. 4 (Wiesa).  
1959 *Tetrastigma chandleri* KIRCHHEIMER; Czeczott et al., p. 125, pl. 18, fig. 4, ?2 (non 3) (Turów).  
1964 *Tetrastigma chandleri* KIRCHHEIMER; Mai, pp. 35, 78, 111, pl. 9, fig. 13, pl. 14, figs 33-34 (Wiesa, Merka).  
1977a *Tetrastigma chandleri* KIRCHHEIMER; Holý, p. 112 (Hrádek/N., Kristina Mine).

Seeds ovoid to ellipsoid, often with flat sides, 4.6–6.1 mm long, 2.6–4.1 mm wide, apex rounded with a deeply cut furrow of raphe, base abruptly narrowed into short conical micropylar tubercle, dorsal side with elliptic chalaza and short furrows radiating from there dividing the margin into radial lobes, ventral side with a narrow keel running from the apical incision to the base bearing a narrow line of

raphe, 3–4 cross furrows running from the keel dividing the surface into transversal lobes (Holý 1975, pp. 80–81, pl. 17, figs 8–11).

**D i s c u s s i o n :** According to Holý (1975) the material corresponds to the records common in Upper Lusatia, particularly from Wiesa near Kamenz. Specimens from Turów are distinctly bigger. Kirchheimer (1938) indicated *T. lanceolarium* (ROXB.) PLANCH. as a comparable living species, distributed mostly in lowland evergreen forests of Thailand, Indonesia, Myanmar, Vietnam and India.

**M a t e r i a l :** Ca. 25 seeds and several fragments, G 3046, 4623, 8845, Gs 108, 109, 236.

#### **Vitaceae gen. et sp. indet.**

Pl. 12, fig. 3

Dispersed cuticles striate to papillate, not reflecting anticlinal cell walls except widely scattered stomata of variable size, 20–30 µm long and 10–20 µm wide. Stomatal ledges double, bordering a boat-like widely open outer cavity, stomatal pore slit-like.

**D i s c u s s i o n :** This very incompletely documented dispersed fragment is referred to the Vitaceae because similar epidermal patterns have been documented in Vitaceae-like foliage of the European Miocene several times (e.g., Ferguson 1971 – taxon No. LIX, Knobloch and Kvaček 1976 – as “*Rhus*” *pyrrhae* UNGER).

**M a t e r i a l :** Dispersed cuticle, G 9171a (KR 325/1).

#### **Staphyleaceae MARTYNOV**

##### ***Turpinia* VENT.**

##### ***Turpinia ettingshausenii* (ENGELHARDT) MAI**

Pl. 6, fig. 16

- 1870 *Leguminosites ettingshausenii* ENGELHARDT, p. 42, pl. 11, figs 8–9 (Zittau).  
1964 *Turpinia ettingshausenii* (ENGELHARDT) MAI, pp. 95, 108, pl. 12, figs 14–15, pl. 14, figs 6–14 (Kummersberg, Hartau).  
1977a *Turpinia ettingshausenii* (ENGELHARDT) MAI; Holý, p. 112 (Hrádek/N., Kristina Mine).  
2003 *Turpinia ettingshausenii* (ENGELHARDT) MAI, Teodoridis, pp. 20–21, pl. 5, fig. 7, pl. 6, fig. 14 (Hrádek/N., drill cores).

Seeds irregular in outline, mostly ovoid to elongate ovoid, 4.5–7.8 mm long, 2.8–5.3 mm wide, at base obliquely cut, blunt, on sides irregularly flattened, hence looking conical or oblong prismatic, hilum deeply sunken subapical, up to 2.3 mm long on base, with a funnel-shaped hole for the vascular bundle of raphe on the bottom, along with further ca. 5 vascular bundles (usually in two rows) entering the testa tissue within hilum, tiny perforation of micropyllar canal in opposite position., dehiscence along the peripheral suture in the widest part of seed, testa irregularly thick (0.5–1.0 mm), consisting of a thick layer of isodiametric thick-walled sclereids, embryonal cavity variable in shape, ellipsoidal, ovoid or irregularly globular, outer surface of seeds lustrous, densely punctate.

**D i s c u s s i o n :** According to Holý (1975, pp. 68–69, pl. 13, figs 1–6) the above described seeds are identical with

those from Hartau and Kummersberg near Zittau recorded by Mai (1964, p. 97) who compared the fossil seeds with those produced by *Turpinia montana* KOHD. and *T. formosana* NAKAI from eastern Asia.

**M a t e r i a l :** Ca. 100 seeds and fragments, G 770, 3045, 3074, 3075, 4619, Gs78.

#### **Lythraceae J. ST.-HILL.**

##### ***Microdiptera* CHANDLER**

##### ***Microdiptera parva* CHANDLER**

Pl. 6, fig. 17

- 1957 *Microdiptera parva* CHANDLER, p. 107, pl. 15, figs 133–149 (Hordle).  
1977a *Microdiptera parva* CHANDLER; Holý, p. 112 (Hrádek/N., Kristina Mine).

Seeds irregularly sub-circular, ovoid to broadly triangular, 1.2–1.6 mm long, 1.4–1.8 mm wide, anatomic, dorsoventrally compressed, seed body elongate quadrangular, hilar end slightly narrower than the apical, micropyle basal, hilum basiventral, very thin, irregularly trigonal to rounded wings on seed sides, each wider than the seed width, ventral side flat, raphe on a medial rib running from apex to hilum, wings separated from the body by longitudinal striae, dorsal side very slightly vaulted, germination operculum oval to broadly oval, reaching half or more the seed length.

**D i s c u s s i o n :** According to Holý (1975, pp. 70, pl. 13, figs 7–11), the seeds correspond in size variation to *Mneme sibirica* (NIKITIN) EYDE as emended by Dorofeev (1963a) who noticed transitions towards *Mneme menzelii* (E. M. REID) EYDE. *Mneme tavdensis* DOROFEEV (1968, pp. 117–119) differs in its deltoid to quadrangular form. The record from Hartau (Mai 1964, pp. 112–113) falls within the form variation of *Microdiptera donata* (HOLÝ) KVAČEK et TEODORIDIS comb. n. (see below).

**M a t e r i a l :** 50 seeds, G 3052, 3082.

##### ***Microdiptera elongata* (DOROFEEV) DOROFEEV**

Pl. 6, fig. 18

- 1963a *Diclidocarya elongata* DOROFEEV, p. 232, pl. 40, figs 31–35 (Kompasski Bor on Tym River).  
1968 *Microdiptera elongata* (DOROFEEV) DOROFEEV, p. 119 (Kompasski Bor on Tym River).  
1977a *Microdiptera elongata* (DOROFEEV) DOROFEEV; Holý, p. 112 (Hrádek/N., Kristina Mine).

Seed rounded ellipsoidal, 1.14 mm long, 0.5 mm wide, base rounded, lateral walls in the upper half very thin, ventral side damaged, wings lacking, dorsal side slightly convex, with elliptic germination operculum 0.75×0.4 mm in size showing ca. 8 longitudinal rows of isodiametric meshes ca. 450 µm mm in diameter, operculum fused in the upper part, dehiscence from the base to the lower third of seed length.

**D i s c u s s i o n :** According to Holý (1975, p. 71, pl. 14, fig. 12) the single recovered specimen available matches the records from the Oligocene of western Siberia (Dorofeev 1963a, 1968).

**M a t e r i a l :** One incomplete seed, G 3036.

***Microdiptera donata* (HOLÝ) KVAČEK et TEODORIDIS,  
comb. n.**

Pl. 6, fig. 19

1978a *Mneme donata* HOLÝ, p. 6, pl. 1, figs 17-22, pl. 2, figs 1-9, text-fig. 1 (basionym) (Hrádek/N., Kristina Mine).

? 2003 *Microdiptera uralensis* (DOROFEEV) MAI; Teodoridis, p. 22, pl. 5, figs 17, 18, 21, pl. 6, figs 9-11 (Hrádek/N., drill cores).

For the description and relationships see Holý (1978a, as *Mneme donata*).

**Discussion:** According to Mai (in Mai and Walther 1978) the fossil genus *Mneme* EYDE is synonymous with *Microdiptera* CHANDLER; hence a newly proposed combination is required. The seeds described from the drill cores Hr 42 and Hr 44 at Hrádek/N. by Teodoridis (2003) show a transitional character in their size (L/W index 1.15-1.71). This allows the assigning of this material to *M. donata* (L/W index 1.1-1.5) and *M. uralensis* (1.55-1.92). However, the number of longitudinal rows of polygonal cells on the germination operculum is more numerous (8-12) than in the type material from the Kristina Mine (Holý 1978a).

**Material:** Ca. 75 seeds, G 3080, 3081, 4289-97, 4351, 4367-78, 4599.

**Fabaceae LINDL.**

***Leguminosites* BOWERBANK emend. SCHIMPER**

***Leguminosites hradekensis* (E. KNOBLOCH et KVAČEK)  
KVAČEK et TEODORIDIS, comb. n.**

Pl. 2, figs 14-19, pl. 12, figs 4-6

1976 *Magnolia hradekensis* E. KNOBLOCH et KVAČEK, p. 18, pl. 4, figs 15-19, pl. 5, figs 1-7, pl. 9, figs 1, 9, pl. 15, fig. 14, text-fig. 5 (basionym) (Wackersdorf).

Detached fragmentary leaflets, lamina probably ovate to elliptic, 8-20 mm long and 5-13 mm wide, base and apex not preserved, margin entire, venation brochidodromous, midrib strong, moderate, straight, secondary veins numerous, thinner, straight to slightly curved, looping, alternate to opposite, originating at almost acute angles, intersecondaries obvious, thinner, parallel, tertiary veins alternate percurrent, curved to sinuous, venation of higher orders regular polygonal reticulate, areolation well developed, areoles 3- or 4-sided, veinlets one branched to dichotomous branching. Adaxial epidermis medium cutinized, smooth, non-modified cells polygonal to lobate, 20-25 or up to 35 µm in diameter, anticlinal walls almost straight to strongly wavy, cells narrow elongate over veins, with cylindrical basal cells of serial trichomes 15 µm in diameter, abaxial epidermis delicately cutinized reflecting polygonal to lobate non-modified cells with curved to strongly wavy anticlinal walls, stomata amphicycloparacytic, subsidiary cells sometimes repeatedly subdivided radially, outer circle of subsidiary cells composed of larger cells not much different from the non-modified cells, pairs of slender guard cells 13-16 µm wide and 23-26 µm long, mother cells of undeveloped stomata often present. Cylindrical bases of

uniserial trichomes 15-20 µm in diameter scattered among stomata, more densely in some leaf forms, complete trichomes up to 180 µm long rarely preserved with thin-walled apical cell.

**Discussion:** The record from the Wackersdorf locality is much more completely documented than the first specimens recovered in the Kristina Mine (Kvaček 1966). Therefore the material from Wackersdorf was preferably published (Knobloch and Kvaček 1976) and the most complete specimens chosen as the type of this foliage species, although in the manuscript (Kvaček 1966) the Kristina Mine was intended to be the type locality. The affinity to the Magnoliaceae is now rejected because of the lack of mesophyllous oil cells and the peculiar stomatal type (see Kvaček et al. 2011). More similar in respect of leaf morphology (short petiolule) as well as anatomy are certainly legume leaflets (for comparison see legume foliage described from the Eocene of North America by Herendeen 1992, p. 137, figs 270-276).

**Material:** Leaflet compressions isolated on slides, G 9172-9175 (KR 21, 43a, b, 410).

**Betulaceae GRAY**

***Alnus julianiformis* (STERNBERG) KVAČEK et HOLÝ**

Pl. 2, figs 20-21, pl. 12, figs 7-8

1823 *Phyllites julianiformis* STERNBERG, p. 37, 39, pl. 36, fig. 2 (Bílina).

1845 *Fagus feroniae* UNGER, p. 106, pl. 28, figs 3-4 (Bílina).

1974 *Alnus julianiformis* (STERNBERG) KVAČEK et HOLÝ, p. 368, pls 1-3, pl. 4, fig. 1, text-fig. 1 (Bílina, Břeštany).

Incomplete leaves and fragments, lamina widely elliptic to obovate, 6-32 mm long and 12-25 mm wide, apex not preserved, probably obtuse or acute, base cuneate with fragmentary petiole, margin irregularly simple serrate, teeth acute, sinus angular, venation craspedodromous/semi-craspedodromous, midrib straight, strong, secondaries alternate, thinner, regularly spaced, originating at an angle of 30-40°, curved, looping, tertiary veins alternate percurrent, straight or curved, venation of higher orders regular polygonal reticulate, areolation well developed, 4-sided. Adaxial epidermis medium cutinized, smooth, showing outlines of non-modified cells 12-20 µm in diameter with almost straight anticlines, abaxial epidermis thinly cutinized, showing non-modified cells with shallowly wavy anticlines, stomata anomocytic, elliptic, guard cells ca. 25 µm long and 20 µm wide, scattered four-celled trichome bases ca. 28 µm in diameter.

**Discussion:** In gross morphology and epidermal anatomy the leaf remains described above correspond to *A. julianiformis* from the Bílina area (Kvaček and Holý 1974) and Wackersdorf (Knobloch and Kvaček 1976). *A. trabeculosa* HAND.-MAZZ. of East Asia has been suggested as the living relative (Kvaček and Holý 1974).

**Material:** Leaf compressions on slides, G 9176-9183 (KR 143, 144, 147, 151, 194a, b, 224, 225, 248).

## Fagaceae DUMORT.

### *Fagus* L.

#### *Fagus deucalionis* UNGER plexus

Pl. 2, figs 22-27, pl. 3, figs 6-7, pl. 6, fig. 20, pl. 7, fig. 1, pl. 12, figs 9-10

- 1847 *Fagus deucalionis* UNGER, p. 101, pl. 27, figs 1-6 (Počerny, in German Putschirn).  
1906 *Fagus ferruginea* AIT. forma *miocenica* MENZEL, p. 48, pl. 3, figs 4-5, 10-12 (Rauno).  
1933 *Fagus* cf. *ferruginea* AIT.; Menzel in Gothan and Sapper, p. 15, pl. 3, fig. 8 (Klettwitz).  
1989 *Fagus attenuata* GÖPPERT; Kvaček and Walther, p. 214, text-fig. 1f (Hrádek/N., Kristina Mine).  
1989 *Fagus decurrens* C. et E.M. REID; Kvaček and Walther, p. 214, text-fig. 1b-c (Hrádek/N., Kristina Mine).  
1991 *Fagus menzelii* KVAČEK et WALTHER, p. 485, pls 7-8, text-figs 9-10 (Kausche).

Incomplete leaves and fragments, lamina elliptic to widely elliptic to ovate, 12–28 mm long and 8–25 mm wide, apex not preserved, probably acute to shortly attenuate, base cuneate with petiole up to 8 mm long, margin partly entire, at places regularly widely simple serrate, teeth acute, rarely blunt, sinus angular, venation simply pseudocraspedodromous, midrib straight, strong, secondaries alternate to opposite, thinner, regularly spaced, straight, originating at an angle of 30 to 40°, curved just before entering the marginal tooth, tertiary veins alternate percurrent, straight or curved, often forked, venation of higher orders regular polygonal reticulate, areolation well developed, 4-sided. Adaxial and abaxial cuticles hardly discernible on macerated samples, more visible directly on the sub-macerated leaf compressions. Cupules broadly ovate to broadly acute, 8–21 mm long, 6–13.3 mm wide, on apices often broken, (probable original length 8–21 mm), valves ovoid to broadly lanceolate, on base rounded, concentrically striate, on surface dense decurrent bases of spines present, stalk conical, short. Fruits elongate ovoid, 9–11 mm long, 4.5–5 mm wide, triangular, apically narrowing into pointed apex, edges sharp to winged, bluntly rounded on base (Holý 1975, pp. 32-34, pl. 5, figs 15-17, as *Fagus decurrens*).

**D i s c u s s i o n :** *Fagus* leaf fossils of the European Early-Middle Miocene were usually assigned to *F. attenuata* GÖPPERT (Kvaček and Walther 1989) but the revision by Walther and Zastawniak (1991) corrected the affinity of the type specimen to *Alnus* (see Walther in Kvaček and Walther 1991, p. 488). Later the leaf fossils of this form have been assigned either to *Fagus silesiaca* WALTHER et ZASTAWNIAK (1991) based on the Late Miocene material of Sošnica or *F. menzelii* KVAČEK et WALTHER (1991) based on the Middle Miocene material from Germany (Kausche and other sites). Walther (in Kvaček and Walther 1991, p. 488) confirmed that differences between the two entities are negligible. Associated cupules are also very similar, usually assigned to a single fossil species (Holý 1975, Kvaček and Walther 1989 as *Fagus decurrens* C. et E. M. REID, Denk and Meller 2001, Teodoridis 2003). We include the two fossil species based on foliage, which were thriving under quite different environmental conditions into a single species plexus and, contrary to the recent treatment of fossil beech foliage

(Denk 2004), we consider them and other fossil morphotypes of beech in Europe as infraspecific variation. As shown by Denk and Meller (2001) the morphology of fossil cupules of beech conforms to a single species throughout Europe and therefore we suggest assigning the populations of the Kristina Mine and others connected with mastixioid floras (including the Late Oligocene site Počerny) into an informal species plexus *Fagus deucalionis*.

**M a t e r i a l :** Leaf compressions on slides, G 9184-9194, partly missing (KR 5, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 23, 25, 26, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 121, 122, 123a, b), numerous cupules, several fruits, G 8821, 8822, Gs 232.

### *Trigonobalanopsis* KVAČEK et WALTHER

#### *Trigonobalanopsis rhamnoides* (ROSSMÄSSLER) KVAČEK et WALTHER plexus

Pl. 3, figs 1-4, pl. 7, figs 2-3, pl. 12, figs 11-12

- 1844 *Phyllites rhamnoides* ROSSMÄSSLER, p. 35, pl. 8, figs 30-31 (Altsattel, i.e. Staré Sedlo).  
1970a *Trigonobalanus exacantha* MAI, p. 385, pl. 1, figs 19-26, pl. 2, 1-15, pl. 3, figs 3-6, 15-19 (Wiesa).  
1988 *Trigonobalanopsis rhamnoides* (ROSSMÄSSLER) KVAČEK et WALTHER, p. 405, pl. 2, figs 1-8, pls 50-54, pl. 55, figs 2-7, pl. 56, figs 1-4, pl. 57, text-figs 2-4 (Staré Sedlo, Wackersdorf Hrádek/N., Kristina Mine, Wiesa, Kleinsaubernitz, Plesná, drill core V 146).  
1988 *Trigonobalanopsis exacantha* (MAI) KVAČEK et WALTHER, pp. 404, 413, pls 47-48, pl. 49, fig.8, pl. 55, fig.1 (Hrádek/N. Kristina Mine, Wiesa, Cheb Basin, drill core V 14).  
1989 *Trigonobalanopsis rhamnoides* (ROSSMÄSSLER) KVAČEK et WALTHER; Kvaček and Walther, p. 224, figs 4g-j, l (Jehličná, Wiesa, Hrádek/N., Kristina Mine, Adendorf).  
1989 *Trigonobalanopsis exacantha* (MAI) KVAČEK et WALTHER; Kvaček and Walther, p. 222, figs 4a-f, k (Hrádek/N., Kristina Mine, Wiesa).

Leaves petiolate, mostly incompletely and fragmentarily preserved, lamina elliptic to ovate, 35–50 mm long and 10–20 mm wide, base cuneate to rounded with short petiole (up to 7 mm long), apex attenuate and obtuse, margin entire, venation brochidodromous, midrib strong, straight, secondary veins thinner, distinct, straight or curved, looping at margin, alternate, regularly spaced, originating at an angle of 25–40°, tertiary veins alternate to opposite percurrent, straight to sinuous, rarely forked, venation of higher orders regular polygonal reticulate, areolation well developed, areoles 4-sided, veinlets one branched. Adaxial epidermis thinly cutinized, reflecting outline of polygonal cells 10–15 µm in size, anticlinal walls straight (in sun leaves) or minutely undulate (in shade leaves). Trichome bases sparsely distributed. Abaxial epidermis medium cutinized, showing non-modified polygonal cells 10–15 µm in size, rounded cyclocytic stomata 20–25 µm in diameter with 3–4 narrow and thickened subsidiary cells, variously dense simple bases of glandular serial trichomes and on the thick veins solitary broader thickly cutinized bases left by unicellular trichomes. Differences of shade and sun leaves are expressed in the intensity of sinuous anticlinal cell walls and density of stomata and glandular trichome bases (see

Kvaček and Walther 1978). Cupules mostly with 3, rarely 2, 4 or 5 valves, narrow pyramidal to broadly ovoid, 9–15 mm long, 5–10 mm wide, at base cuneate, often with an oblique stalk, valves keeled, fused only in the lower third to half, outer surface coarsely striate, fruits pyramidal, trigonal, 4–7 mm long, 3–4.5 mm wide, widest in the lower third or half, often strongly compressed, edges sharp to slightly winged, sides convex, base rounded, apex with three widely open styles (Holý 1975, p. 35, pl. 5, figs 11-14, as *Trigonobalanus exacantha*).

**D i s c u s s i o n :** Foliage of this extinct member of the Fagaceae has usually been recognized mainly according to the rhamnoid venation (*Phyllites rhamnoides* ROSSM.) and a very typical abaxial cuticle. First Kräusel and Weyland (1954) recognized its affinity to the Fagaceae and assigned it to *Castanopsis*. Ecotypical variation of sun and shade leaves led them to recognize two species, *Castanopsis dechenii* (WEBER) KRÄUSEL et WEYLAND and *C. toscana* (BANDULSKA) KRÄUSEL et WEYLAND. Kvaček (1966) suggested a similar interpretation for the material from the Kristina Mine. However a parallel comparative study of fruits and leaves from several occurrences in the European Tertiary led Kvaček and Walther (1988, 1989) to establish an independent fossil genus *Trigonobalanopsis* for this kind of foliage as well as for fruits originally interpreted as *Trigonobalanus* by Mai (1970a) and regularly associated together. The fruits assigned to *Trigonobalanopsis exacantha* (MAI) KVAČEK et WALTHER are very common in the Hrádek flora (Holý 1977a, p. 112, as *Trigonobalanus exacantha* MAI, Kvaček and Walther 1988, p. 41, pl. 60, figs 2-7, 1989, text-figs 4 a-b, Teodoridis 2003, pp. 14-15, pl. 3, figs 5-8).

The taxonomically nearest living relative is certainly *Trigonobalanus doichangensis* (A. CAMUS) FORMAN from SE Asia (Laos, southern China, etc.), recently removed from this genus to *Formanodendron* NIXON et CREPET (1989). However, Kvaček (2007) rather saw the nearest ecological analogue of *Trigonobalanopsis* in several living species of *Castanopsis* from southern Asia.

**M a t e r i a l :** Leaf compressions on slides, G 7698, 9195-9265 (KR 6, 37, 42, 54, 55, 72, 78, 81, 87, 88, 92, 96, 98, 99, 133, 134, 137, 138, 145, 154, 158, 165, 195, 196, 214, 301, 302, 304, 305, 306, 307, 308, 309, 310, 311, 312, 314, 315, 316, 383, 500), numerous cupules and fruits, G 3010, 4622, 5403, 8818-20, Gs 100, 102, 233-235.

### *Quercus* L.

#### *Quercus bavarica* (E. KNOBLOCH et KVAČEK) KVAČEK

Pl. 3, fig. 5, pl. 13, fig. 1

- 1976 *Castanopsis bavarica* E. KNOBLOCH et KVAČEK, p. 40, pl. 4, figs 2-3, 9-10, pl. 15, fig. 6, pl. 21, figs 1-4, text-fig. 15 (Wackersdorf).  
2004 *Quercus bavarica* (E. KNOBLOCH et KVAČEK) KVAČEK, p. 12, pl. 10, figs 1-5, 12-13 (Flörsheim).

Leaf incomplete, elliptic, 23 mm long, 11 mm wide, base cuneate, apex not preserved, margin entire, venation eucamptodromous, midrib strong, straight, secondary veins thinner, distinct, curved towards the margin, alternate, relatively widely spaced, originating at an angle of 30–40°, tertiary veins poorly preserved, alternate percurrent, straight

to sinuous or forked, venation of higher orders regular polygonal reticulate, areolation well developed, areoles 4-sided. Adaxial epidermis thinly cutinized, smooth to granulate outside, non-modified cells polygonal, ca. 12 µm in diameter, anticlinal walls straight, abaxial epidermis medium cutinized, smooth except for occasional granulate periphery of stomata, non-modified cells straight-walled, 10–12 µm in diameter, stomata cyclocytic, subsidiary cells 5–6, very little different from the non-modified cells, guard cell pairs elliptical, 20–22 µm long and 12–15 µm wide, with polar very thin T pieces, stomatal ledges broad, moderately thickened around small elliptical pore, trichome bases quite sparse, rounded, 15 µm in diameter, with subsidiary cells reaching under the base and leaving small polygonal scar of terminal trichome part 8 µm in diameter, often asymmetrically positioned. Terminal parts of trichomes not preserved.

**D i s c u s s i o n :** Kvaček (2004) in agreement with others (Kvaček and Walther 1988, Walther 1999, Meller et al. 1999) was in favour of transferring this rare element of the mastixioid floras from *Castanopsis* to *Quercus* L. More comparative studies are required to fix the systematic position of *Quercus bavarica* within this genus.

**M a t e r i a l :** Incomplete leaf compressions on slide, G 9266-9267 (KR 23, 496).

#### *Quercus rhenana* (KRÄUSEL et WEYLAND)

##### E. KNOBLOCH et KVAČEK plexus

Pl. 3, figs 8-10, pl. 7, figs 3-4, pl. 13, figs 3-4

- 1950 *Illicium rhenanum* KRÄUSEL et WEYLAND, p. 50, pl. 9, figs 5-7, pl. 10, figs 1-2, pl. 11, fig. 5 (Brühl).  
1966 *Quercus lusatica* JÄHNICHEN, p. 478, pls 1-4, pl. 9, figs 21-22, text-figs 1, 3-4 (Hartau, Wiesa).  
1976 *Quercus rhenana* (KRÄUSEL et WEYLAND) E. KNOBLOCH et KVAČEK, p. 41, pl. 17, figs 6, 8, 14, pl. 21, figs 5-6, pl. 34, fig. 10 (Wackersdorf, Oder 2a Mine).  
1999b *Quercus* sp. ? Sect. *Phellos* LOUD.; Mai, p. 34, pl. 11, fig. 3 (Wiesa).  
1999b *Quercus sapperi* (MENZEL) MAI; Mai, p. 33, pl. 11, fig. 6 (Hartau).

For more synonyms and discussion see Jähnicen (1966, as *Quercus lusatica*).

Incomplete leaves and fragments, lamina elliptic to ovate, 14–78 mm long and 7–29 mm wide, apex shortly attenuate and blunt, base cuneate to widely cuneate, margin entire, venation brochidodromous to eucamptodromous, midrib strong, straight, secondary veins thinner, regularly spaced, alternate to subopposite, straight, curved towards the margin, originating at an angle of 40–60°, tertiary veins alternate percurrent, straight to sinuous or often forked, venation of higher orders regular polygonal reticulate, areolation well developed, areoles 4-sided, veinlets lacking. Adaxial epidermis medium thick, cuticle fine punctate on surface showing polygonal non-modified cells with seemingly straight, but in detail fine undulate anticlines, rare solitary simple trichome bases with a ring of small subsidiary cells, abaxial epidermis medium cutinized, showing polygonal outlines of non-modified cells and large rounded cyclocytic stomata with a pair of guard cells 28–30 µm in diameter surrounded by a ring of massively cutinized subsidiary cells with strong striation, which may partly be shared by two

adjacent stomata. Simple rounded trichome bases ca. 15 µm in diameter. Acorns ovoid, partly compressed, 23–43 mm long and 17–29 mm wide, without cupule, base rounded, apex shortly attenuated and blunt, apical surface with fine parallel striation.

**D i s c u s s i o n :** Foliage of this oak commonly occurs in coaly facies in several sites in the Miocene of Europe. Because the gross morphology is not very characteristic and can be easily mistaken for Lauraceae, it is difficult to decide on the correct name (see e.g., Palamarev and Mai 1998, p. 250-251, *Quercus lyellii* group). Even the epidermal characteristics vary among similar leaf forms and may be useful in dividing various fossil populations over Europe (cf. Kovar-Eder 1996). The occurrence from the Kristina Mine matches the records from the neighbouring sites of Turów in Poland (as *Magnolia* sp. sensu Czezcott et al. 1959) and Saxony (as *Castanopsis* sp. sensu Mai 1964). The leaves are regularly accompanied at Hartau, Turów (Jähnichen 1966, p. 507), Hrádek/N., and Medard Mine by fruits and cupules more recently assigned to *Quercus* sp. (? Sect. *Phellos* LOUD.) by Mai (1999b, p. 34, pl. 11, fig. 3) and the *Quercus sapperi* (MENZEL) MAI type (Mai 1999b, p. 33, pl. 11, fig. 6).

Because of quite unusual epidermal pattern, Kvaček (1966) hesitated to use a modern genus and called the foliage of this element *Quercophyllum* sp. Indeed we could speculate that *Quercus rhenana* may represent an extinct entity within the Fagaceae subfam. Quercoideae but the complete characteristics, including in particular male inflorescences and pollen in situ are needed to resolve its relationship.

**M a t e r i a l :** Fragmentary leaf compressions on slides, G 9268-9285 (KR 57, 75, 93, 94, 95, 152, 156, 167, 184, 215, 467-473), compression of fruit, G 9286 (KR 175), impressions of leaves, G 8814a, b, and a fruit, G 8813, in ironstone.

### **Juglandaceae DC ex PERLEB.**

#### ***Engelhardia* LESCHEN. ex BLUME**

#### ***Engelhardia orsbergensis* (WESSEL et WEBER) JÄHNICHEN, MAI et WALTHER**

Pl. 3, figs 10-14, pl. 13, fig. 5

- 1856 *Banksia orsbergensis* WESSEL et WEBER, p. 146, pl. 25, figs 9a-d (Orsberg).  
1977 *Engelhardia orsbergensis* (WESSEL et WEBER) JÄHNICHEN, MAI et WALTHER, pp. 326-346, pls 38-49, text-figs 1-3 (localities and stratigraphy see Jähnichen et al. 1977, pp. 336-337).

Complete leaves not preserved, leaflets sessile, shortly petiolulate, lamina elongate to narrow elliptic, 20–60 mm long, 10–20 mm wide, apex acute, base asymmetric, rounded to widely cuneate, margin simple coarsely to minutely serrate, teeth acute, sinus angular, in the lower leaflet part entire, venation semicraspedodromous, midrib strong, straight to slightly curved, secondary veins numerous, distinctly thinner, mostly straight, alternate, originating at an angle of 50–80°, looping at the margin, intersecodaries parallel, thinner, tertiary veins percurrent, straight to sinuous,

venation of higher orders regular polygonal reticulate, areolation well developed, 3- to 4-sided, veinlets lacking. Abaxial epidermis thinly cutinized, composed of non-modified polygonal rounded cells, poorly preserved, stomata anomocytic, widely elliptic, 20–26 µm long and 15–18 µm wide, sunken and usually seen only as traces of outer ledges surrounded by a circle of low papillae, peltate trichomes rarely preserved with large lens-shaped head 130–150 µm and more in diameter, crenulate on margin, composed of numerous narrow segments, trichome bases of uniform size, rounded, typically with double outline, 19–24 µm in diameter.

**D i s c u s s i o n :** The leaf records of this typical extinct representative of the Juglandaceae, tribe Engelhardiae (Manchester 1987) have been variously assigned to *Engelhardia* (Saporta 1865, Kvaček 1972 as *Engelhardia detecta* SAPORTA, Jähnichen et al. 1977 as *Engelhardia orsbergensis*), *Palaeocarya* SAPORTA (Jähnichen et al. 1984, Manchester 1987) and *Oreoroa* DILCHER et MANCHESTER (1986). The obtained leaflets, although incomplete, match in all respects the other occurrences of this sort in Europe, e.g., from Wackersdorf (Knobloch and Kvaček 1976) and elsewhere (Jähnichen et al. 1977). The currently employed epithet is, however, illegitimate (a later synonym – see Winterscheid and Kvaček, personal communication) and requires conservation.

**M a t e r i a l :** Leaflet compressions on slides, G 9287-9306 (KR 97, 168, 202, 212, 213, 217, 218, 219, 253, 479, 525).

#### ***Pterocarya* KUNTH.**

#### ***Pterocarya limburgensis* C. et E.M. REID**

Pl. 7, figs 6-7

- 1915 *Pterocarya limburgensis* C. et E.M. REID, p. 73, pl. 4, figs 15-21 (Reuver).  
1961 *Pterocarya* cf. *stenoptera* DC; Czezcott and Skirgiełło, pp. 54, 104, pl. 16, figs 1-6 (Turów).  
1964 *Pterocarya* cf. *raciborskii* ZABLOCKI; Mai, p. 103-104, pl. 13, fig. 7 (Hartau).  
1977a *Pterocarya raciborskii* ZABLOCKI; Holý, p. 112 (Hrádek/N., Kristina Mine).  
2003 *Pterocarya limburgensis*. C. et E.M. REID; Teodoridis, p. 16, pl. 3, figs 11-12 (Hrádek/N., drill cores).

Nuts obliquely ovoid to broadly ovoid, transversally elongate, variable in form, strongly compressed, 3.2–5.3 mm tall, 3.0–5.3 mm wide, base obliquely bent, usually rounded, apex shortly pyramidal, pointed, rarely long elongate, bent, with remnants of style, 10 (9–12) strong wing ribs often anastomosing or forked running from the base, more distinct at the base and the lower third or half, disappearing towards but never entering the apex, dehiscence line on a meridional rib running over the apex, inner structures not known (Holý 1975, pp. 31-32, pl. 5, figs 8-10).

**D i s c u s s i o n :** Holý (1975, 1977a) maintained the morphological identity of the material from the Kristina Mine with the poorly illustrated type material of *Pterocarya raciborskii* ZABLOCKI from Wieliczka in Poland (Zablocki 1928, p. 189, pl. 10, figs 21-34 – see Łancucka-Środoniowa and Zastawniak 1997) based only on the similar size variation.

Nevertheless the above-described material corresponds to *Pterocarya* remains indicated from the Zittau Basin and Saxony (Czeczott and Skirgiełło 1961, Mai 1964, 1999b, Czaja 2003, Teodoridis 2003). The nearest living relative appears to be *Pterocarya hupehensis* SKAN. Mai (1999b, p. 46) includes *Pterocarya raciborskii* into the genus *Cyclocarya* ILJINSKAYA.

**M a t e r i a l:** More than 50 fruits, G 3065, 8977-78, Gs 84.

***Cyclocarya* ILJINSKAYA**  
***Cyclocarya nemejcii* HOLÝ**

Pl. 7, figs 8-9

1977a *Cyclocarya nemejcii* HOLÝ, p. 114, pl. 2, figs 1-14 (Hrádek/N., Kristina Mine).

For the description and discussion see Holý (1977a, p. 114). Mai (1999b, p. 46) stresses a great similarity with *Cyclocarya nucifera* (LUDWIG) MAI and suggests undertaking statistical morphometrical studies for discrimination of the two species.

**M a t e r i a l:** More than 20 endocarps, G 3049, 4307-09.

**Myricaceae A. RICH. ex KUNTH**

***Myrica* L.**

***Myrica ceriferiformis* KOWNAS**

Pl. 7, figs 10-11

1955 *Myrica ceriferiformis* KOWNAS, p. 459, figs 8 a-b (Dobrzyn).  
2003 *Myrica ceriferiformis* KOWNAS; Teodoridis, p. 16, pl. 3, figs 13-21, pl. 4, figs 1, 4 (Hrádek/N., drill cores).

Endocarps secondarily compressed, medium thin-walled, roundish to ovoid, 3–4.3 mm long, 2.6–3.7 mm wide, dehiscence sutures wide, without leaving a rib on the endocarp surface, apex with a tiny point (remain of the style), exocarp composed of ca. 12–14 tightly packed tiny verrucae (Holý 1975, p. 25, pl. 4, figs 1-2).

**D i s c u s s i o n:** According to Holý (1975) the material matches the type specimens from the Polish locality Dobrzyn (Kownas 1955) except for finer verrucae. Fruits from Klettwitz and Piskowitz (Mai 1964) are usually ovoid, with fewer verrucae on the surface than is seen in the type illustrated in Kownas (1955). Similar fruits are produced by *Myrica cerifera* L. and *M. pensylvanica* LOIS. living in the Atlantic North America. Similar endocarps and exocarps have been described from the drill cores near Hrádek/N. as *Myrica ceriferiformoides* BŮŽEK et HOLÝ (Teodoridis 2003). In the case that the exocarp is preserved, both taxa are clearly distinguished, however the endocarps of *M. ceriferiformis*, *M. ceriferiformoides* as well as *M. suppanii* KIRCHH. and *M. boveyana* (HEER) CHANDLER show very similar morphological characteristics allowing mistakes to be made in their specific determinations (e.g., Bůžek and Holý 1966, Gregor 1975b, Teodoridis 2003). We are sure that the same also applies to endocarps of the two next species of *Myrica* defined by Holý (1977a, 1978a).

**M a t e r i a l:** 10 endocarps, G 8861-62.

***Myrica cestmiri* HOLÝ**

Pl. 7, figs 12-13

1977a *Myrica cestmiri* HOLÝ, pp.113-114, pl. 1, figs 1-19 (Hrádek/N., Kristina Mine).

For the description and discussion see Holý 1977a, pp. 113-114.

**M a t e r i a l:** Ca. 65 endocarps, G 2483, 3043, 4270-88.

***Myrica hudibra* HOLÝ**

Pl. 7, figs 14-15

1978a *Myrica hudibra* HOLÝ, p. 4, pl. 1, figs 1-16 (Hrádek/N., Kristina Mine).

For the description and discussion see Holý 1978a, p. 4.

**M a t e r i a l:** Over 100 endocarps, G 4350-66.

***Myrica lignitum* (UNGER) SAPORTA**

Pl. 3, figs 15-16, pl. 13, figs 6-7

1847 *Quercus lignitum* UNGER, p. 113, pl. 31, figs 5-7 (Parschlug).  
1865 *Myrica lignitum* (UNGER) SAPORTA, p. 102 (? non pl. 5, fig. 10) (Parschlug).

Deattached fragments of leaf lamina, up to 11 mm long and 6 mm wide, midrib strong, venation not preserved. Abaxial cuticle bearing fully preserved peltate trichomes with resin content on biserial stalks.

**D i s c u s s i o n:** Such peltate trichomes are typical of this widely spread species (Kovar 1982), but inadequately preserved material without other details of epidermal structure prevents us from discussing this record in more details. For more information see Kovar-Eder et al. (2004).

**M a t e r i a l:** Leaf fragments on slides, G 9307-9319 (KR 139, 140).

***Myrica pseudointegerrima* WEYLAND et KILPPER**

Pl. 3, figs 17-18, pl. 13, fig. 8

1963 *Myrica pseudointegerrima* WEYLAND et KILPPER, p. 95, pl. 21, figs 1-6, pl. 22, fig. 7, text-figs 7-8 (Frimmersdorf Mine, Ville, Herman Mine, Heerlen).

Dispersed leaf fragments. Adaxial epidermis medium cutinized, outline of non-modified cells polygonal, 15–20 µm in diameter, anticlinal walls straight to slightly curved, widely dispersed biserial trichome bases 10 × 20 µm in size, without preserved distal parts, surrounded by smaller subsidiary cells, abaxial epidermis similar in preservation to adaxial, anticlinal cell walls more wavy, stomata anomocytic, 20 µm long and 30 µm wide with widely open thickened stomatal ledges, polar T pieces, biserial trichome bases less dense than adaxially.

**D i s c u s s i o n:** Weyland and Kilpper (1963) misinterpreted the stomatal type of this rare species as paracytic due to its thicker stomatal ledges. This is a typical feature distinguishing it from other fossil species of *Myrica* in Europe.

**Material:** Dispersed leaf fragments and cuticles, missing (KR 338, 339, 340, 341).

## **Euphorbiaceae JUSS.**

### ***Sapium* BROWNE**

#### ***Sapium germanicum* KIRCHHEIMER**

Pl. 7, fig. 16

- 1941a *Sapium germanicum* KIRCHHEIMER, p. 206, fig. 8 (Wiesa).  
1964 *Sapium germanicum* KIRCHHEIMER; Mai, p. 33, 78, pl. 9, fig. 10 (Wiesa, Merka).  
1977a *Sapium germanicum* KIRCHHEIMER, Holý p. 112 (Hrádek/N., Kristina Mine).

Seeds secondarily compressed, ca. 2.3–5.1 mm in diameter, only slightly elongate, hilum tiny, not perforated, exceptionally seen on the secondary keel due deformation, sclerotesta thin, composed of prismatic radial sclereids (Holý 1975, p. 62, pl. 12, figs 1-2).

**Discussion:** Kirchheimer (1957) suggested *Sapium sebiferum* (L.) ROXB. from China as a living relative producing similar seeds. Martinetto (in schedae) notes that this material from the Hrádek flora may belong partly to lauroid fruits.

**Material:** 26 seeds and fragments, G 3031, 3083, 4603, 4604, 7776, 8852, Gs 79, Gs 83.

## **Hypericaceae JUSS.**

### ***Hypericum* L.**

#### ***Hypericum septestum* NIKITIN ex ARBUZOVA**

Pl. 7, fig. 17

- 1948 *Hypericum septestum* NIKITIN, p. 1104 (nomen nudum) (Kievskoe).  
1957 *Hypericum septestum* NIKITIN, nom. illegit. (without typification); Dorofeev, p. 307, pl. 4, fig. 18 (Lagernyi Sad).  
1977c *Hypericum septestum* NIKITIN; Holý, p. 2 (Hrádek/N., Kristina Mine).  
2003 *Hypericum septestum* NIKITIN; Teodoridis, p. 20, pl. 6, figs 4-6 (Hrádek/N., drill cores).  
2005 *Hypericum septestum* NIKITIN ex ARBUZOVA, p. 43, pl. 110, figs 1-12, pl. 111, figs 1-5 (typification) (Lagernyi Sad, Ekaterinskoe, Kievskoe, western Siberia).

Seeds cylindrical, 1.0 mm long, 0.4–0.5 mm wide, secondarily slightly compressed, straight along long axis, sides very slightly convex, base and apex rounded, lateral vascular bundle running longitudinally from dotted chalaza on apex (anatropic seed), surface lustrous, covered by ca. 20–24 longitudinal rows of roundish polygonal cells (one cell 38 µm in diameter) forming a reticulum (Holý 1975, p. 50, pl. 8, fig. 5).

**Discussion:** *H. septestum* was described from the Late Oligocene to Early Miocene deposits of western Siberia (Dorofeev 1957, 1963a, Arbuzova 2005) and reported from the Late Oligocene to Late Miocene deposits of Europe (e.g., Palamarev and Petkova 1987, Mai 2001, Czaja 2003).

Teodoridis (2003) described an incomplete seed from the same stratigraphically level as the Kristina Mine from the drill core Hr 42 near Hrádek/N. *H. septestum* shows close morphological affinity to *Hypericum miocenicum* DOROFEEV emend. MAI (1997), however, the latter differs from *H. septestum* in the structure of the upper surface (lower number of longitudinal rows of polygonal cells – Teodoridis 2003). Recently, Meseguer and Sanmartín (2012) produced a complete summary of *Hypericum* palaeobiological datasets. According to Gümbel and Mai (2002) and Arbuzova (2005), *H. septestum* is comparable with the modern *Triadenum virginicum* (L.) RAF. (= *H. virginicum* L.).

**Material:** 2 seeds, G 3069.

## **Salicaceae LINDL.**

### ***Salix* L.**

#### ***Salix varians* GÖPPERT**

Pl. 3, figs 19-20, pl. 13, figs 9-10

- 1855 *Salix varians* GÖPPERT, p. 26, pl. 20, figs 1-2 (Sošnica = Schossnitz in German).  
1954 *Rhus liblarensis* KRÄUSEL et WEYLAND, p. 148, pl. 31, figs 7-10, pl. 32, figs 1-2, text-fig. 1 (Liblar).

Leaf fragments, probably lanceolate to slightly ovate, 9–36 mm long and 6–28 mm wide, base cuneate, apex short attenuate and blunt, margin crenulate to serrate with fine glandular teeth, venation eucamptodromous to brochidodromous, midrib strong, straight, secondary veins alternate, numerous, curved towards the apex and margin, originating at an angle of 45–65°, rare very thin intersecondary veins, parallel with secondary veins, tertiary veins opposite to alternate percurrent, curved to sinuous, venation of higher orders regular polygonal reticulate, areolation well-developed, 3- to 4-sided. Adaxial cuticle medium thick showing outlines of non-modified polygonal cells 8–10 µm in diameter, anticlines straight to slightly bent, single-celled trichome bases sporadically distributed, round, heavily cutinised, 5–8 µm in diameter, directly on the margin small rare paracytic stomata visible, abaxial cuticle reflecting outlines of non-modified cells in form and size similar to those of adaxial leaf side, but more delicate, stomata paracytic, irregularly arranged, sometimes in dense groups, 15–25 µm long, 10–20 µm wide, stomata ledges strongly cutinised, lateral subsidiary cells difficult to see, simple trichome bases irregularly distributed.

**Discussion:** Foliage of *Salix* is clearly recognizable morphologically as well as anatomically (Ghahremaninejad et al. 2012). However, individual species vary considerably in morphology of leaf lamina and the identification of fossils based on fragmentary leaf compressions may be equivocal, which applies also for our record. The obtained leaf epidermal structure corresponds to that of the material from the type locality Sošnica (Z. Kvaček, own observation, H. Walther, personal communication).

**Material:** Leaf compressions on slides, G 9307-9319 (KR 177, 178, 221, 386, 423, 424, 427).



## Moraceae LINK.

### *Ficus* L.

#### *Ficus potentilloides* MAI

Pl. 7, figs 18-19

1964 *Ficus potentilloides* MAI, pp. 23, 104, pl. 2, fig. 17, pl. 13, figs 19-22 (Wiesa, Hartau).

1978a *Ficus potentilloides* MAI; Holý, p. 2 (Hrádek/N., Kristina Mine).

Endocarps rounded-ovoid to ellipsoidal, variously deformed, 1–1.3 mm in diameter, fine punctate on surface, bisymmetrical dehiscence into two valves visible on some specimens, distinct placental area under small apical knob, with the mouth of short funicular canal and subapical micropyle above (Holý 1975, p. 39, pl. 6, figs 9-10).

**D i s c u s s i o n :** The material undoubtedly matches that from the type locality Hartau. *F. europaea* NEGRU (1972) is closely related, but differs in the form (roundish to sub-circular to half circular, apex sharp, ventral side at least a little convex). *Ficus potentilloides* is an ancient species accompanying Neogene mastixioid floras. Its fruitlets match those produced by the living *F. carica* L. widely cultivated in Europe.

**M a t e r i a l :** 10 deformed endocarps, G 3060, 3084, 8979-80.

## Rosaceae JUSS.

### *Rubus* L.

#### *Rubus* spp.

Pl. 7, figs 20-21

1977a *Rubus* sp. div.; Holý, p. 112 (Hrádek/N., Kristina Mine).

Two forms recognized: A) endocarps asymmetrically ovoid, 1.4–1.7 mm long, 0.8–1.1 mm wide, ventral side straight, apex roundish, bent towards ventral side and pointed in that direction, base rounded, dorsal side convex, surface reticulum regular, rather fine, with meshes slightly elongate in the direction of dorsal arch, reticulum sometimes disappears near central area. B) endocarps quite symmetrical, slightly obliquely ovoid to elongate ovoid, 1.5–2.4 mm long, 0.9–1.3 mm wide, ventral side always slightly convex, surface reticulum forming regular isometric meshes over the whole side.

**D i s c u s s i o n :** According to Holý (1975, p. 46, pl. 7, fig. 11) the two recognized forms are partly comparable with *Rubus laticostatus* KIRCHHEIMER and some others from Siberia. *R. microspermus* CHANDLER (1957) is also similar. The carpology of the whole genus has not been fully worked out and our material is too scanty for a more precise identification.

**M a t e r i a l :** 20 fruitlet endocarps, G 3011, 3034, 8857-58.

## Ulmaceae MIRB.

### *Trema* LOUR.

#### *Trema lusatica* MAI

Pl. 7, fig. 22

1964 *Trema lusatica* MAI, pp. 22, 105, pl. 4, figs 21-22, pl. 13, figs 23-25 (Wiesa, Hartau).

1977a *Trema lusatica* MAI; Holý, p. 112 (Hrádek/N., Kristina Mine).

2003 *Trema lusatica* MAI; Teodoridis, p. 20, pl. 5, figs 15-16, pl. 6, fig. 7 (Hrádek/N., drill cores).

Endocarps thin-walled, slightly convex to flattened, broadly ovoid, 1.5–1.8 (–2.25) mm long, 1.2–1.6 (–1.95) mm wide, dehiscence along the periphery of endocarps, innervation of the funicle indicated by a small sub-apical trace, margin roundish thickened sending out short small rounded combs, at places with cross anastomoses, forming a net of shallow lacunae, walls on cross section with fine radial striation suggesting orientation of elongate prismatic sclereids, locule fine punctate.

**D i s c u s s i o n :** According to Holý (1975, p. 40, pl. 6, figs 7-8) the material is specifically identical with the records from Hartau and Wiesa (Mai 1964). Teodoridis (2003) reported similar endocarps from the drill core Hr 42 at Hrádek/N. Mai (1999b) compared the fossil *Trema lusatica* with various extant paratropical species of the Northern Hemisphere, e.g. *T. velutina* PLANCH (Hong Kong), *T. lamarckiana* BENTH. (Bermudas, West Indies) and *T. micrantha* DECAISNE (Mexico).

**M a t e r i a l :** 25 endocarps, G 3032, 3037, 3073.

## Rutaceae JUSS.

### *Zanthoxylum* L.

#### *Zanthoxylum kristinae* (HOLÝ) GREGOR

Pl. 8, figs 1-2

1977a *Rutaspermum kristinae* HOLÝ, p. 119, pl. 5, figs 1-12 (Hrádek/N., Kristina Mine).

1987 *Zanthoxylum kristinae* (HOLÝ) GREGOR, pp. 118-119, pl. 6, figs 1-3 (Hrádek/N., Kristina Mine).

Description and discussion see Holý (1975, 1977a) and Gregor (1987). New records were published from Wieliczka (Łancucka-Środoniowa and Zastawniak 1997) and Berzdorf (Czaja 2003). According to Gregor (1987), comparable seeds are produced by *Zanthoxylum clava-herculis* L. (Caribbean) and *Z. stipitatum* ENGL. (Bolivia).

**M a t e r i a l :** 28 seeds, some fragments, G 3085, 4312-13, 4316-17, 4319.

## *Toddalia* BLUME

#### *Toddalia latisiliquata* (LUDWIG) GREGOR

Pl. 8, fig. 3

1860 *Cytisus latisiliquatus* LUDWIG, p. 145, pl. 58, figs 14, 17 (Hessenbrücken).

1964 *Carpolithus latisiliquatus* (LUDWIG) MAI, p. 118, pl. 16, fig. 12 (Hartau).

1975a *Toddalia latisiliquata* (LUDWIG) GREGOR, p.126, fig. 4c (Hessenbrücken).

1977a *Toddalia latisiliquata* (LUDWIG) GREGOR; Holý, p. 112 (Hrádek/N., Kristina Mine)

Seeds anatropic, 5.6 mm long, 2.9 mm wide, 2.4 mm thick, in lateral view obliquely reniform to boat-shaped, dorsal side rounded, ventral side concave, bent saddle-like, with

deep, long triangular hilar scar, 2.1 mm long, 1 mm wide, sides flat, near the scar slightly concave, forming an angle of 35°, funicular canal entering the hilum from the lower part of ventral edge, micropyle probably above the upper sharp end of hilum, testa very thick, on surface with fine rounded pits (Holý 1975, pp. 64-65, pl. 12, figs 8-9, as *Toddalia latisiliquata* (LUDWIG) HOLÝ comb. nov.)

**D i s c u s s i o n :** Holý (1975) recognized the systematic position of these long enigmatic seeds at the same time as Gregor (1975a, b), who produced a detailed study of the fossil representatives of *Toddalia* BLUME. For further details we refer to this account that includes also the material from the Kristina Mine.

**M a t e r i a l :** A large quantity of seeds, G 3034, 3054.

## **Sapindaceae JUSS. (incl. Aceraceae JUSS.)**

### ***Acer* L.**

#### ***Acer tricuspdatum* BRONN emend. WALTHER**

Pl. 3, figs 21-23, pl. 13, figs 11-12

- 1838 *Acer tricuspdatum* BRONN, p. 865, pl. 35, figs 10 a-b (Salzhausen).  
1845 *Acer trilobatum* A. BRAUN, p. 172 (Öhningen).  
1972 *Acer tricuspdatum* BRONN; Walther, p. 56, pls 7-18, pl. 24, figs 5-7, pls 39-51, text-figs 13-18 (review of several occurrences in Europe).

Incomplete leaves and lamina fragments, ovate, palmately sub-trilobed, 12–46 mm long and 6–19 mm wide, medial lobe widely triangular, lateral lobes triangular, apices acute, base widely cuneate to rounded, margin irregularly simple bluntly serrate, to entire, tooth apices obtuse, venation basal actinodromous, 3 primary veins, lateral veins originating at an angle of 30–40°, straight, strong, secondary veins thinner, alternate, straight, at angles of 30–50°, tertiary veins opposite to alternate percurrent, curved to sinuous, venation of higher orders regular, polygonal reticulate, areolation well-developed, 3- to 4-sided, freely ending veinlets dichotomous branching. Adaxial epidermis thinly cutinized, faintly striate, composed of polygonal cells 15–25 µm in diameter with straight to slightly curved anticlinal walls. Abaxial epidermis medium cutinized, hairy, faintly granulate, non-modified cells polygonal, ca. 10 µm in diameter with slightly sinuous anticlinal walls, stomata anomocytic, sub-circular no elliptic, 10–20 µm long and 8–10 µm wide, outer stomatal ledges sub-parallel, thick, unicellular trichomes 70–100 µm long, dense on veins and among stomata.

**D i s c u s s i o n :** The above described epidermis structure corresponds to the standard hairy leaf forms, as described, e.g., by Walther (1972). *Acer tricuspdatum* belongs to Arctotertiary elements and occurs infrequently in mastixioid floras of Europe (Kvaček et al. 2011). The nearest living relatives belong to sect. *Rubra* PAX (*A. rubrum* L., *A. saccharinum* L.) and grow in the eastern part of North America.

**M a t e r i a l :** Fragments of leaf compressions on slides G 9320-26 (KR 45, 148, 164, 187, 208, 209, 428).

## **? *Sapindus* L.**

### **? *Sapindus* sp.**

Pl. 3, figs 24-25, pl. 14, figs 1-2

Fragment of leaflet base, lamina probably oblong to elliptic ovate, 29 mm long and 21 mm wide, base asymmetric cuneate, margin entire, venation brochidodromous, primary vein distinct, straight, secondary veins thinner, opposite to alternate, curved, numerous, at angles of 55–70°, inter-secondaries thinner and parallel, tertiary veins alternate perpendicular, sinuous, venation of higher orders regular polygonal reticulate, areolation well-developed, 3- to 4-sided, veinlets with dendritic branching. Adaxial epidermis thinly cutinized, faintly striate, reflecting non-modified polygonal cells ca. 32–38 µm in diameter, abaxial epidermis less cutinized, smooth, outlines of non-modified cells polygonal, of variable size, 12–30 µm in diameter, stomata anomocytic, elliptic, simple bases of serial trichomes scattered, 15–17 µm in diameter, remains of trichomes up to 38 µm long, without preserved apical parts.

**D i s c u s s i o n :** Although fragmentary, the strongly asymmetric base of the present fossil suggests that it was a leaflet. Such remains are referred usually to *Sapindus* L. (cf. Bůžek 1971). We present the first epidermal structure of such foliage, which indeed matches some species of *Sapindus* with deciduous foliage from warmer parts of North America and Asia in the overall structure of its abaxial cuticle (anomocytic small stomata, serial trichomes – Pl. 14, fig. 3 in this study). Some confusion exists in the taxonomy of *Sapindus* preventing us from suggesting a living relative species more exactly.

**M a t e r i a l :** One compression of a leaflet fragment on a slide G 9327 (KR 22).

## **Cornaceae DUMORT. (incl. Nyssaceae JUSS. ex DUMORT.)**

### **Subfam. Cornoideae**

#### ***Swida* OPIZ**

#### ***Swida gorbunovii* (DOROFEEV) NEGRU**

Pl. 8, fig. 4

- 1955 *Cornus gorbunovii* DOROFEEV, p. 137, pl. 6, figs 13-16 (Odesa).  
1964 *Cornus gorbunovii* DOROFEEV; Mai, p. 113, pl. 15, figs 1-3 (Hartau).  
1972 *Swida gorbunovii* (DOROFEEV) NEGRU, p. 146 (Odesa).  
1977a *Swida gorbunovii* (DOROFEEV) NEGRU; Holý, p. 113 (Hrádek/N., Kristina Mine).

Endocarps secondarily compressed, 2.6–3.8 mm long, 2.7–4.2 mm wide, broadly elongate, rarely elongate or transversally ovoid, bilocular, both locules interconnected, slightly oblique, asymmetrically developed, base sometimes narrowed into a short conical stalk, apex narrowed, sharply pointed, a thin shallow groove on medial septum between locules, seen mainly on laterally compressed specimens, surface smooth, at most with thin ribs reaching from the

base to half the endocarp length, 6 meridional vascular bundles (sometimes with thinner bundles between them) on fine ribs (grooves) (Holý 1975, p. 92, pl. 20, figs 4-7).

**D i s c u s s i o n :** According to Holý (1975), the material perfectly matches the records from western Siberia, Upper Lusatia and Poland (Raniecka-Bobrowska 1959 as *Cornus* aff. *stolonifera*, Szafer 1961, as *Cornus alba* L. foss.).

**M a t e r i a l :** Over 100 endocarps, G 3012, 3047, 8851, Gs 101.

### Subfam. Nyssioideae ARNOTT

#### *Nyssa* L.

##### *Nyssa ornithobroma* UNGER

Pl. 8, figs 5-7

1860 *Nyssa ornithobroma* UNGER, p. 16, pl. 8, figs 15-18 (Salzhausen).

1977a *Nyssa ornithobroma* UNGER; Holý, p. 112 (Hrádek/N., Kristina Mine).

2003 *Nyssa ornithobroma* UNGER; Teodoridis, p. 17, pl. 5, figs 2-4 (Hrádek/N., drill cores).

Endocarps secondarily compressed, broadly to long obovoid to ellipsoid, widest usually above half of the length, 6–14 mm long, 3.5–7 mm wide, bi- to trilobular, with 10–14 longitudinal vascular bundles on surface between low ribs, apex usually pointed, base more rounded, germination operculum sub-apical, trigonal to slightly elongate trigonal, thin rugulose coriaceous exocarp rarely preserved.

**D i s c u s s i o n :** According to Holý (1975) this species differs from endocarps of *Nyssa disseminata* (LUDWIG) KIRCHHEIMER, which are 5–14 mm long, ovoid, with broadly triangular operculum and always unilocular. The material from the Kristina Mine deviates from the standard populations of *Nyssa ornithobroma* by the lack of typically winged large fruits with long triangular operculum. In addition, it includes broadly ovoid rounded forms recalling *N. macrocarpa* DOROFFEV. Endocarps of the living species *N. aquatica* L. are in many ways similar but are strictly unilocular, with 8–10 vascular bundles on distinct ribs and twice as large. Those of *N. sinensis* OLIVER correspond in size (8–14 mm long) and form and are partly bilobular. This extant taxon occupies mixed wet forests along streams in SE China. However, autecological habitats of the modern *N. biflora* WALT. and *N. aquatica* L. (significant elements of swamp forests in the southeastern part of the USA) correspond more closely to a supposed niche of *Nyssa ornithobroma*.

**M a t e r i a l :** Numerous endocarps, G 3013, 4618, 8847, 8848, 8849, Gs 82.

### Subfam. Mastixioideae HARMS

Holý (1977b) made a detailed revision of the fossil representatives of the Mastixioideae from the Kristina Mine and elsewhere within the Bohemian Massive, which requires only slight corrections.

### *Mastixia* BLUME

#### *Mastixia lusatica* MAI

Pl. 8, figs 8-9

1964 *Mastixia amygdalaeformis* (SCHLOTHEIM) KIRCHHEIMER sensu MAI, pp. 42, 63, 81, 90, 97, 114, pl. 7, fig. 3, pl. 8, fig. 12, pl. 11, fig. 6-7, pl. 12, figs 16-17, pl. 15, figs 15-16 (Wiesa, Schmekwitz-Piskowitz, Merka-Quatitz, Kummersberg, Hartau).

1970b *Mastixia lusatica* MAI, p. 466, pl. 64, figs 1-10 (Wiesa, Sandförsstgen).

1977b *Mastixia lusatica* MAI; Holý, p. 131, pl. 1, figs 20-39 (Hrádek/N., Kristina Mine).

2003 *Mastixia lusatica* MAI; Teodoridis, p. 17, pl. 5, fig. 5 (Hrádek/N., drill cores).

For the description and discussion see Holý (1977b, p. 131). After the revision in 1977 some larger specimens from the Kristina Mine were identified by Holý (in schedae) as *M. venosa* (C. PRESL in STERNBERG) HOLÝ (1984). A definite solution of this problem would require a detailed study of the material from Podlesí and Počerny (the latter site being the type locality of *M. venosa*).

**M a t e r i a l :** Numerous endocarps, G 236, 2298-2312, 2313-2327, 2328-2343, 2344-2358, 2359-2373, 2374-2388, 2389-2403, 2404-2418, 2419-2431, 4183, 4226, 4617, 8834, 8835, Gs 98, 10 endocarps sine num. identified as *M. venosa*.

### *Diplopanax* HANDEL-MAZZETTI

#### *Diplopanax limnophilus* (UNGER) CZAJA

Pl. 8, fig. 10

1850b *Quercus limnophila* UNGER, p. 319, p.p., pl. 35, figs 1-2 (Wieliczka).

1938a *Xylomastixia lusatica* KIRCHHEIMER, p. 348, pl. 7, figs 1-6 (Wiesa).

1941c *Mastixicarpum limnophilum* (UNGER) KIRCHHEIMER, p. 613, figs 7-8 (Wieliczka).

1964 *Mastixicarpum lusaticum* MAI, pp. 44, 81, 90, 115, pl. 8, fig. 12, pl. 15, fig. 17 (Wiesa, Merka, Sandförsstgen, Hartau).

1977b *Mastixicarpum limnophilum* (UNGER) KIRCHHEIMER; Holý, p. 134, pl. 2, figs 1-16 (Hrádek/N., Kristina Mine).

2003 *Diplopanax limnophilus* (UNGER) CZAJA, p. 75, pl. 13, figs 12-13 (Berzdorf).

For the description and discussion of the material from the Kristina Mine see Holý (1977b, as *Mastixicarpum limnophilum*) and for more general information Czaja (2003) and Ševčík et al. (2007). Recently, a very similar type of fruits has been recognized in the modern species *D. stachyanthus* HANDEL-MAZZETTI from SE China and N Vietnam and *D. vietnamensis* AVERYANOV et T.H. NGUYEN from Vietnam, Kontum Province (Averyanov and Nguye 2002).

**M a t e r i a l :** Ca. 30 endocarps, G 4228-37, Gs 111.

### *Eomastixia* CHANDLER

#### *Eomastixia saxonica* (MENZEL) HOLÝ

Pl. 8, figs 11-12

1933 *Elaeocarpus saxonicus* MENZEL in GOTHAN et SAPPER, p. 26, pl. 6, fig. 9 (Gohra).

1977b *Eomastixia saxonica* (MENZEL) HOLÝ, p. 142, pl. 3, figs 1-19 (Hrádek/N., Kristina Mine).  
For further synonyms see Holý (1977b).

For the description and discussion see Holý (1977b).

**M a t e r i a l:** Numerous fruits and endocarps, G 3007, 4148, 4178, Gs 50, 99.

### ***Tectocarya* KIRCHHEIMER**

#### ***Tectocarya elliptica* (UNGER) HOLÝ**

Pl. 8, fig. 13

1850a *Annona elliptica* UNGER, p. 442 (Salzhausen).  
1866 *Annona elliptica* UNGER, p. 43, pl. 14, fig. 2 (Salzhausen).  
1934 *Tectocarya lusatica* KIRCHHEIMER, p. 774, figs 15-16 (Merka).  
1977b *Tectocarya elliptica* (UNGER) HOLÝ, p. 136, pl. 2, figs 17-31 (Hrádek/N., Kristina Mine).  
For further synonyms see Holý (1977b).

Stone fruits secondarily compressed flat, 21–35 mm long, 11–20 mm wide, oval to elliptic in outline, rounded at base, slightly narrowed at apex, unilocular, apical disc broad, exceptionally well preserved, exocarp thick, consisting of loose parenchymous tissue fused to endocarp, endocarp ellipsoidal, medium thick-walled, with many short longitudinal ribs on surface, sunken germination valve elongate, indicated as a dorsal groove.

For the discussion see Holý (1977b).

**M a t e r i a l:** Over 20 fruits, G 4154, 4196, 4201, 4238-41.

#### **cf. *Tectocarya robusta* KIRCHHEIMER**

Pl. 9, fig. 1

?1935b *Tectocarya robusta* KIRCHHEIMER, p. 67, pl. 8, fig. 24a, f (Merka).  
1977b cf. *Tectocarya robusta* KIRCHHEIMER; Holý, p. 138, pl. 4, figs 20-28 (Hrádek/N., Kristina Mine).

For the description and discussion see Holý (1977b).

**M a t e r i a l:** 10 endocarps, G 4186-91.

### ***Retinomastixia* KIRCHHEIMER**

#### ***Retinomastixia oertelii* GREGOR**

Pl. 8, figs 14-15

1977b *Retinomastixia schultei* KIRCHHEIMER; Holý, p. 134, pl. 4, figs 27-32 (Hrádek/N., Kristina Mine).  
1978b *Retinomastixia oertelii* GREGOR, p. 64, pl. 14, figs 1-4 (Wackersdorf).  
1999c *Retinomastixia oertelii* GREGOR; Mai, p. 61, pl. 16, figs 14-16 (Sandförstgen, Hartau).  
For further synonyms see Gregor (1978b)

For the description see Holý (1977b, as *Retinomastixia schultei*), for the discussion Gregor (1975, 1978a) and Mai (1999c).

**M a t e r i a l:** Ca. 30 fruits, numerous fragments, G 3009, 4257-62.

## **Ericaceae JUSS.**

### ***Leucothoë* D. DON**

#### ***Leucothoë narbonnensis* (SAPORTA) WEYLAND plexus**

Pl. 9, figs 2-3

1865 *Andromeda (Leucothoë) narbonnensis* SAPORTA, p. 142, pl. 8, fig. 1 (Armissan).  
1943 *Leucothoë narbonnensis* (SAPORTA) WEYLAND, p. 118 (Armissan) (? non pl. 21, figs 3-6 – Rott).  
1960 *Leucothoë narbonnensis* (SAPORTA) MAI, p. 85, pl. 6, figs 5-16 (Wiesa).  
1977a *Leucothoë* sp.; Holý, p. 112 (Hrádek/N., Kristina Mine).

Pentamerous capsules 2.1–3.5 mm long, 1.4–2.9 mm wide, ellipsoid pear-shaped, short stalked at base, apex 5-sided, with a pit in the middle, fruits septicial, smooth, dehiscence starting at the apex separating individual endocarps from the central styler column, seeds bent elongate ovoid, 0.7–1.2 mm long, 0.5–0.8 mm wide, flattened on sides, with distinct meshes of prosenchymatous tissue of testa on surface (Holý 1975, p. 51, pl. 8, figs 6-11).

**D i s c u s s i o n:** Holý (1975, p. 52) intended to separate fruits usually treated as *Leucothoë narbonnensis* under an independent fossil species, because Weyland (1943) allegedly pre-occupied the epithet “*narbonnensis*” for vegetative remains. We disagree with this view (see also Mai 2000) and treat *Leucothoë narbonnensis* in sense of combined fossil species as “plexus”.

**M a t e r i a l:** Numerous fruits, G 3061, 8853-54, Gs 81.

## **Pentaphylacaceae ENGL.**

### **(incl. Ternstroemiaceae MIRB. ex DC)**

#### ***Ternstroemia* NUTIS ex L.**

##### ***Ternstroemia chandlerae* HOLÝ**

Pl. 9, figs 4-5

1977a *Ternstroemia chandlerae* HOLÝ (“*chandleri*”), p. 117, pl. 3, figs 8-13 (Hrádek/N., Kristina Mine).

For the description and discussion see Holý (1977a). According to Mai (1999b, p. 35), this species is most probably synonymous with variable *Ternstroemia sequoioides* (ENGELHARDT) BŮŽEK et HOLÝ in BŮŽEK et al. (1996).

**M a t e r i a l:** Seeds, G 4300-04, 4612.

### ***Eurya* THUNB.**

#### ***Eurya stigmosa* (LUDWIG) MAI**

Pl. 9, fig. 6

1860 *Potamogeton stigmossus* LUDWIG, p. 60, pl. 8, fig. 13 (Salzhausen).  
1957 *Myrtospermum variabile* CHANDLER, p. 112 (Bovey Tracey).  
1960 *Eurya stigmosa* (LUDWIG) MAI, p. 79, pl. 4, figs 8-17 (Wiesa).  
1960 ?*Cleyera* ? *variabilis* (CHANDLER) CHANDLER, pp. 213, 225, pl. 31, figs 48-56, pl. 34, fig. 145 (Bournemouth).  
1961 *Myrtospermum warrenii* CHANDLER, p. 81, pl. 8, figs 10-19 (Reading beds).

- 1971 *Eurya stigmosa* (LUDWIG) MAI; Mai, p. 329, pl. 34, figs 27-28 (Salzhausen and further references).  
 1977a *Eurya stigmosa* (LUDWIG) MAI; Holý, p. 112 (Hrádek/N., Kristina Mine).  
 2003 *Eurya stigmosa* (LUDWIG) MAI; Teodoridis, p. 19, pl. 4, figs 5, 7, 8 (Hrádek/N., drill cores).

Seeds thick, discoid, horseshoe-shaped, roundish reniform, variously obliquely asymmetric, very variable in shape, 1.3–2.0 mm in size, sides variously vaulted, flattened or concave, surface ornamented by ca. 10 concentric rows of radially elongate cells, 0.05–0.06 mm wide in honeycomb-like structure, base straight or slightly cordate, shorter than half of the seed length, dehiscence in the plane of symmetry, condylus elliptic, high above the seed centre, seen as transversal, differently structured elevation, funicular canal as triangular cavity between embryonal pit and hilum, testa double layered, outer thicker layer composed of horseshoe-shaped radially disposed sclereids, inner layer composed of small isodiametric sclereids.

**Discussion:** According to Holý (1975, pl. 8, figs 1-4) *Eurya stigmosa* is certainly an aggregate species because of the wide variation in seeds. *Eurya japonica* THUNB. used to be indicated as the nearest living relative.

**Material:** Ca. 50 seeds, G 3059, 4611, 4613, Gs 98.

## Styracaceae DC et SPRENG.

### *Rehderodendron* HU

#### *Rehderodendron custodum* HOLÝ

Pl. 9, figs 7-8

- 1977a *Rehderodendron custodum* HOLÝ, p. 118, pl. 4, figs 1-20 (Hrádek/N., Kristina Mine).

For the description and discussion see Holý (1977a). The species has been accepted, although transitions to *R. ehrenbergii* (KIRCHHEIMER) MAI with larger fruits exist (see also Mai 2000, p. 47).

**Material:** Ca. 40 endocarps, G 4228, 4326-4344, Gs 80; and G 3006, 8835 identified as *R. ehrenbergii*.

## Symplocaceae DESF.

### *Symplocos* JACQUIN

European Tertiary representatives were revised by Mai and Martinetto (2006) and their treatment is followed here, although Holý (1975, pp. 52-59, 1977a, p. 112) originally recognized more species.

#### *Symplocos schereri* KIRCHHEIMER

Pl. 9, fig. 9

- 1935a *Symplocos schereri* KIRCHHEIMER, p. 291, fig. 8 (Konzen-dorf).  
 1940 *Symplocos wiesaensis* KIRCHHEIMER, p. 288, fig. 5 (Wiesa).  
 1977a *Symplocos schereri* KIRCHHEIMER; Holý, p. 112 (Hrádek/N., Kristina Mine).  
 2006 *Symplocos schereri* KIRCHHEIMER; Mai and Martinetto, p. 21, pl.2, fig. 9, pl. 8, figs 2-7 (review of sites).

Endocarps 5–10 mm long, 3.5–6.5 wide, elongate ovoid, 2–3 locular, apex blunt, base narrowed, usually with three points, apical pit deep, wider than the half of the endocarp width, distinct longitudinal winged ribs irregularly wavy and irregularly thick, often radially dichotomizing on the surface (Holý 1975, pp. 52-53, pl. 9, figs 1-8, partly identified as *Symplocos wiesaensis*).

**Discussion:** In the Hrádek flora Holý (1975) recognized in addition to *S. schereri* also *S. wiesaensis*, admitting that the two morphotypes were connected with transitional forms. His view was confirmed by the treatment by Mai and Martinetto (2006) in merging the two and suggesting *S. tanakae* MATSUMURA from Japan as the nearest living relative.

**Material:** More than 20 endocarps, G 4582, 8981, Gs 37.

#### *Symplocos casparyi* LUDWIG

Pl. 9, figs 10-11

- 1857 *Symplocos casparyi* LUDWIG, p. 99, pl. 20, figs 6a-f (Dorheim).  
 1860 *Carpinus salzhausensis* LUDWIG, p. 100, pl. 33, fig. 8 (Salzhausen).  
 1867 *Carpolithus lignitarum* QUENSTEDT, p. 914, pl. 86, fig. 35 (Salzhausen).  
 1935c *Symplocos salzhausensis* (LUDWIG) KIRCHHEIMER, pp. 718, 737, fig. 19 (Salzhausen).  
 1935c *Symplocos lignitarum* (QUENSTEDT) KIRCHHEIMER, p. 718, figs 17-18 (Salzhausen).  
 1977a *Symplocos lignitarum* (QUENSTEDT) KIRCHHEIMER; Holý, p. 112 (Hrádek/N., Kristina Mine).  
 1977a *Symplocos salzhausensis* (LUDWIG) KIRCHHEIMER; Holý, p. 112 (Hrádek/N., Kristina Mine).  
 2003 *Symplocos lignitarum* (QUENSTEDT) KIRCHHEIMER; Teodoridis, p. 21, pl. 5, figs 8-10 (Hrádek/N., drill cores).  
 2003 *Symplocos salzhausensis* (LUDWIG) KIRCHHEIMER; Teodoridis, pp. 21-22, pl. 5, figs 11, 13, 14 (Hrádek/N., drill cores).  
 2003 *Symplocos lusatica* MAI; Teodoridis, p. 21, pl. 5, fig. 12 (Hrádek/N., drill cores).  
 For further synonyms see Mai and Martinetto (2006).

Endocarps variable in form, two forms are recognizable in the Kristina flora: “*lignitarum*” – endocarps 4.1–9 mm long, 3.3–4.8 mm wide, mostly short cylindrical to elongate ovoid, rarely bent, mostly trilocular (exceptionally with 2 or 4 locules) with convex sides, base rounded, often with a small central pit, apex straight, truncate, apical pit shallow reaching half of the width of endocarps, surface with longitudinal shallow blunt ribs running throughout the length of the endocarps, rarely smooth, “*salzhausensis*” – endocarps 2.5–5 mm high, 3.6–4.8 mm wide, widely ovoid to transversally ovoid, base rounded or blunt, often with a central pit, apex rounded, blunt, apical pit shallow, rounded to triangular, reaching to one third of the complete width of endocarps, mostly trilocular with evenly developed locules, on surface often smooth or with indistinct low rounded widely spaced ribs or elongate protuberances (Holý 1975, pp. 54-57, pl. 9, figs 9-12, pl. 10, figs 1-7, as *Symplocos lignitarum* and *S. salzhausensis*).

**Discussion:** According to Holý (1975) the “*lignitarum*” morphotype is most common in central Europe (Hartau, Turów) and also in the Hrádek flora. Mai and Martinetto (2006) recognized still more morphotypes and indicated other living species (e.g., *S. glandulifera* BRAND) matching in fruit morphology.

**Material:** Numerous endocarps (G 4583, 4631, 6493, 8982-83, Gs 85, Gs 86).

### *Symplocos pseudogregaria* KIRCHHEIMER

Pl. 9, fig. 12

1938a *Symplocos pseudogregaria* KIRCHHEIMER, p. 354, pl. 7, figs 17-20, pl. 8, figs 1-2 (Niederpleis).

1941a *Symplocos poppeana* KIRCHHEIMER, p. 217, figs 12-13 (Wiesa).

1977a *Symplocos poppeana* KIRCHHEIMER; Holý, p. 11 (Hrádek/N., Kristina Mine).

Endocarps 5.4–9 mm long, 3–4.1 mm wide, trilobular, mostly cylindrical, base rounded, apex truncate, with a wide, shallow apical pit, surface cover by fine longitudinal striae and rows of protuberances or furrows; 3 of them following the sutures of carpels from the base to about half of the endocarp length (Holý 1975, pp. 57-58, pl.10, fig. 8, as *Symplocos poppeana*).

**Discussion:** Mai and Martinetto (2006) reinterpreted *Symplocos pseudogregaria* as a polymorphic species and merged with it several morphotypes, including *Symplocos poppeana*, which was indicated for the Hrádek flora by Holý (1975, 1977a). They listed several living species having similar endocarps, e.g., *S. anomala* BRAND, *S. tingifera* CHEN and *S. kuroki* NAGAMASU, distributed in E Asia (southern Japan, Yunnan, Indonesia).

**Material:** 5 poorly preserved endocarps, G 8984, Gs 89.

### *Symplocos minutula* (STERNBERG) KIRCHHEIMER

Pl. 9, fig. 13

1825 *Carpolithes minutulus* STERNBERG, p. 41, pl. 53, fig. 8 (“*Carpolites*”) (Salzhausen).

1949 *Symplocos minutula* (STERNBERG) KIRCHHEIMER, p. 16, pl. 1, fig. 6, pl. 2, fig. 16 (Salzhausen).

1977a *Symplocos minutula* (STERNBERG) KIRCHHEIMER; Holý, p. 112 (Hrádek/N., Kristina Mine).

Endocarps 5.5–7.7 mm long, 3.0–4.7 mm wide, slightly bent, elongate ovoid, (?) trilobular, base rounded, sides towards apex narrowed, apical pit deep, enclosed by the margin, on the neck often corroded and split, surface smooth, at most very thinly striate-wrinkled (Holý 1975, pp. 68-69, pl. 11, figs 1-3).

**Discussion:** The Sternberg’s collection at NM includes syntypes of *Carpolithes minutulus* (Holý 1975, Kvaček and Straková 1997), contrary to the statement of Kirchheimer (1957). However, the lectotypification has not been done. Mai and Martinetto (2006) listed *S. tinctoria* L’HÉRITIER (SE USA) and *S. ramosissima* WALL. (Himalayas) and *S. glauca* (THUNBERG) KOIDZUMI (Japan) as living species with similar endocarps.

**Material:** 6 compressed endocarps, G 8985, Gs 88.

### *Sphenotheca* KIRCHHEIMER

#### *Sphenotheca incurva* KIRCHHEIMER

Pl. 9, fig. 14

1934 *Sphenotheca incurva* KIRCHHEIMER, p. 789, fig. 19 (Kausche).

1977a *Sphenotheca incurva* KIRCHHEIMER; Holý, p. 112 (Hrádek/N., Kristina Mine).

Fruits sack-shaped, elongate, slightly asymmetrical 14.3–15.5 mm long, 7.2–9 mm in diameter, neck-like narrowed below slightly oblique truncate apex with a broad collar and wide central pit with canal openings from three locules, base rounded, on one specimen mesocarp abraded to the surface of longitudinal pectinate wings of endocarp (Holý 1975, p. 59, pl. 11, fig. 4).

**Discussion:** This extinct member of the Symplocaceae is a marker of the Younger Mastixioid Floras of Europe (Mai 2000).

**Material:** 2 fruits, G 4584, 5409.

### Theaceae MIRB. ex KER GAWL.

#### *Gordonia* ELLIS

#### *Gordonia hradekensis* (KVAČEK et BŮŽEK) BOZUKOV et PALAMAREV

Pl. 3, figs 26-30, pl. 14, figs 4-5

1966 *Symplociphyllum hradekense* KVAČEK et BŮŽEK, p. 293, pl. 2, figs 5-6, pl. 3, fig. 1, pl. 4, figs 8-9 (Hrádek/N., Kristina Mine).

1984b *Polyspora hradekensis* (KVAČEK et BŮŽEK) KVAČEK et WALTHER, p. 335, pls 57-59 (Hrádek/N., Kristina Mine, Wackersdorf).

1995 *Gordonia hradekensis* (KVAČEK et BŮŽEK) BOZUKOV et PALAMAREV, p. 182, text-fig. 7 (Satovcha).

Leaves simple, lamina oblong to elliptic or slightly ovate, up to 33–62 mm long and 9–14 mm wide, base cuneate with petiole, up to 10 mm long, apex attenuate to acute, rarely emarginate, margin entire in basal part, upper margin regularly simply serrate, teeth blunt to acute, glandular, sinus angular to rounded, venation semicraspedodromous, midrib strong, straight, secondary veins thinner, curved, alternate, rarely opposite, originating at an angle of 30–50°, tertiary veins alternate to opposite percurrent, straight to sinuou or forked, venation of higher orders regular polygonal reticulate, areolation well developed, areoles 3- to 4-sided, veinlets unbranched. Adaxial epidermis thickly cutinized, smooth, reflecting outlines of non-modified cells 30 µm or more in diameter, anticlinal walls curved to undulate with lens-shaped thickenings in sinuses, solitary star-like simple trichome bases 20–25 µm in diameter and with thickened outer wall, abaxial epidermis medium cutinized, strongly striate around the stomata, non-modified cells similar to those of the adaxial epidermis, stomata anisocytic to cyclocytic, guard cell pairs rounded to broadly oval, 25–35 µm wide and 30–40 µm long, trichome bases of the same type as in the adaxial epidermis, scattered over the whole surface.

**Discussion:** Kvaček and Walther (1984b) corrected the previous view of Kvaček (1966, in Kvaček and Bůžek

1966) who erroneously interpreted the stomatal type of *Symplociphyllum hradekense* KVAČEK et BŮŽEK as paracytic suggesting affinities with Symplocaceae, and recognized *Polyspora* SWEET as the nearest living relative based on wide comparative study (Kvaček and Walther 1984a). This genus is generally, but not always (Judd et al. 2002) considered a later synonym of *Gordonia* ELLIS. Bozukov and Palamarev (1995) supplied the resulting combination. A transfer to *Styrax* (Styracaceae) (Schweigert 1992) is not supported by the epidermal anatomy and hence not acceptable. The fossil genus *Symplociphyllum* KVAČEK et BŮŽEK must be re-typified, because its original type falls into the genus *Polyspora* or *Gordonia* (see below).

**M a t e r i a l :** Several mostly incomplete leaf compressions on slides, G 9328-9389 (KR 28, 29, 30, 35, 38, 44, 47, 48, 49, 64, 69, 70, 71, 86, 96, 153, 160, 170, 172, 173, 185, 192, 207, 210, 211, 220, 222, 223, 229, 232, 239, 249, 250, 251, 252, 299, 429, 435, 524).

## Oleaceae HOFFMANS et LINK

### *Fraxinus* L.

#### *Fraxinus bilinica* (ETTINGSHAUSEN) KVAČEK et HURNÍK

Pl. 4, figs 1-4, pl. 14, figs 6-7

- 1849 *Juglans bilinica* UNGER, p. 126 pro parte (non pl. 14, fig. 20) (Bílina).  
 1860 *Carya bilinica* (UNGER) ETTINGSHAUSEN; Unger, p. 39, pro parte, pl. 17, figs 1-8 (Bílina).  
 2000 *Fraxinus bilinica* (UNGER) KVAČEK et HURNÍK, p. 19, pl. 8, figs 7(-?8), text-figs 4.2, 4.7 (Zabrušany, Louny-Vršovice).

Leaflets elliptic, 12–33 mm long, 9–35 mm wide, apex not preserved, probably short acuminate, base cuneate, margin bluntly serrate, teeth small, blunt, sinus angular, venation semicraspedodromous, midrib strong, straight, secondary veins thinner, almost straight to slightly curved, alternate, rarely subopposite, originating at an angle of 40–60°, looping near margin, occasional intersecondaries thin, short, parallel and sinuous, tertiary veins alternate percurrent, straight to sinuous, often forked, innervating mostly teeth sinuses on margin, venation of higher orders regular polygonal reticulate, areolation well developed, areoles 3- to 4-sided, veinlets lacking. Leaf lamina tough, but epidermis thinly cutinized thus the cuticle structure hardly observable, clearest in sub-macerated compressions. Adaxial cuticle indistinctly striate to punctate, reflecting outlines of polygonal cells 20–25 µm in diameter with straight or very little wavy anticlinal walls, on veins slightly elongate, with rounded simple bases 6–8 µm in diameter formed after small peltate glandular trichomes. Abaxial cuticle still thinner, smooth, showing only scattered pairs of guard cells 20–30 µm long and 10–20 µm wide with slightly thickened boat-like stomatal ledges and trichome bases of the same type as adaxially, but denser, occasionally with a rarely preserved rounded polycellular shield 25–50 µm in diameter.

**D i s c u s s i o n :** Kvaček (1966) separated the Hrádek ash foliage with almost straight adaxial epidermal anticlines (as *Fraxinus* sp.) from a younger population from the Pannonian of South Moravia at Poštorná, which differs in its much more undulate adaxial anticlines. This difference

was also confirmed by Kovar-Eder (in Kovar-Eder and Krainer 1991) who assigned the material of Poštorná to *F. angusta* HUMMEL. Kvaček and Hurník (2000) suggested uniting the Early Miocene occurrences of ash foliage from Bílina and elsewhere under the binomen *Fraxinus bilinica* (UNGER) KVAČEK et HURNÍK leaving aside the previously used name of *F. ungeri* (GAUDIN) E. KNOBLOCH et KVAČEK for priority reasons. According to Kovar-Eder (1996) the ash foliage from Hrádek identified here as *F. bilinica* clearly corresponds in leaf epidermal anatomy with the record from the Oberdorf Mine at Köflach. No living analogous species has been suggested so far.

**M a t e r i a l :** Isolated incomplete leaflet compressions on slides, G 9381-9397, partly missing (KR 39, 40, 41, 60, 80, 91, 191, 411, 414, 415).

## Araliaceae JUSS.

### Araliaceae gen. et sp. indet.

Pl. 9, figs 15-16

Endocarps (?) quite flat, almost half-moon to asymmetrically elongate to broadly ovoid, base and apex broadly rounded, the latter partly narrowed, ventral side straight to slightly convex, dorsal side almost semicircular, surface of lateral sides smooth, lustrous, sometimes with bent transversal striation (Holý 1975, p. 93, pl. 80, figs 8-9).

**D i s c u s s i o n :** According to Holý (1975), similar but smaller endocarps are produced by *Aralia* L., while in *Schefflera* J.R. FORST. et G. FORST. or *Eleutherococcus* MAXIM. (syn. *Acanthopanax* (DECNE. et PLANCH.) MIQ.) they are similar in size, but with different sculptures. The lack of comparative living material prevented even the generic identification. The specimens are not available for further studies.

**M a t e r i a l :** 8 endocarps, missing.

## Aquifoliaceae DC ex A. RICH.

### *Ilex* L.

#### *Ilex* cf. *protogaea* MAI

Pl. 9, fig. 17

?1970b *Ilex protogaea* MAI, p. 459, pl. 62, figs 9-15 (Schlabendorf).

Stone slender, 4 mm long, 1.2 mm wide, in lateral view long boat-like, ventral edge straight, sharp, sides joining under a sharp angle, bearing two very thin longitudinal ribs, dorsal side narrow, with two longitudinal anastomosing ribs (Holý 1975, p. 66, pl. 12, figs 13-14).

**D i s c u s s i o n :** According to Holý (1975), the relationship to the similar *Ilex cantalensis* E.M. REID and *I. lusatica* MENZEL are discussed in Mai (1970b, p. 459). A living species with similar endocarps appears to be *I. dahoon* WALT.

**M a t e r i a l :** One stone, G 3062.

#### *Ilex saxonica* MAI

Pl. 9, fig. 18

- 1964 *Ilex saxonica* MAI, p. 33, pl. 2, figs 19-21, pl. 6, figs 7-8 (Wiesa).  
 1977a *Ilex saxonica* MAI; Holý, p. 112 (Hrádek/N., Kristina Mine).

Stones 4.8–5.8 mm long, 2.2–2.7 mm wide, in side view elongate half-moon shaped, ventral edge straight to slightly concave, dorsal side rounded, sides joining at very sharp angle, apex rounded, base narrowed, high (to wing-like) thick ribs on dorsal and lateral sides, often anastomosing, forming deep lacunae, 1–2 wing ribs on sides (Holý 1975, pp. 66–67, pl. 12, fig. 10).

**Discussion:** According to Holý (1975) the endocarps best match those of *Ilex perado* DC living on Madeira.

**Material:** 4 stones, G 3056.

### *Ilex wiesaensis* MAI

Pl. 9, fig. 19

1970b *Ilex wiesaensis* MAI, p. 458, pl. 60, figs 14–18 (Wiesa).

Stone asymmetrically ellipsoidal, 4.3 mm long, 1.6 mm wide, ventral edge straight, dorsal side slightly convex, with 6 very thin ribs running throughout the whole side and rarely anastomosing, lateral sides with 2 or more distinct ribs (Holý 1975, p. 67, pl. 12, fig. 11).

**Discussion:** According to Holý (1975) similar endocarps are produced by *I. ambigua* CHAPM. living in North America.

**Material:** One stone, G 3061.

## Adoxaceae TRAUTV.

### *Sambucus* L.

#### *Sambucus pulchella* C. et E.M. REID

Pl. 9, figs 20–21

1915 *Sambucus pulchella* C. et E.M. REID, p. 135, pl. 17, figs 7–10 (Reuver).

1977a *Sambucus pulchella* C. et E.M. REID; Holý, p. 113 (Hrádek/N., Kristina Mine).

Seeds anatropic, elongate ovoid, 1.9–2.4 mm long, 1.1–1.5 mm wide, apex slightly acute, with a tiny hilum shifted sideward, base rounded, surface granulate due to transverse densely spaced rows (Holý 1975, p. 94, pl. 20, fig. 10).

**Discussion:** According to Holý (1975) seeds of *Sambucus parvula* and *S. colwellensis* (Chandler 1963b, Upper Headon) are smaller, with more distinct transversal striae, those of *S. muddensis* (Chandler 1963a, Mudford) are similar in size, but the surface is coarsely rugulate with deep furrows. The material from Hrádek best matches the records from the Pliocene of Reuver, Swalmen and Brunssum. Similar populations were described from Krościenko (Szafer 1947, as *S. cf. ebulus* L.) and western Siberia (Dorofeev 1963a), the latter differing in its coarse sculpture (Holý 1975). According to Czaja (2003) similar seeds to this species were later published from Köflach (Meller 1998, as *Sambucus* sp.) and Berzdorf matching those produced by *S. nigra* L. and *S. racemosa* L. native in Europe (Czaja 2003).

**Material:** 4 seeds, G 3032, 8855–56.

## Angiosperms fam. inc.

### ? Monocotyledonae gen. et sp. indet.

Pl. 14, fig. 8

Leaf (?) fragment with parallel venation. Epidermis on both sides thickly cutinized, finely granulate and in thicker zones striate, reflecting trigonal to polygonal cell outlines 15–35 µm in diameter, partly parallel, straight-walled, some cells thickened, stomata widely scattered, perpendicularly arranged to cell length, amphicyclic, guard cell pairs thinly cutinized, 30 µm long and 40 µm wide, with thickened ledges bordering boat-shaped pore, subsidiary cells narrow, half-moon shaped, in 2–3 circles per 8 cells, thickly cutinized. Strong trichome bases simple, 20–25 µm in diameter, solitary, irregularly disposed.

**Discussion:** Dispersed cuticles with similar structure were described as *Freycinetia rhenana* WEYLAND (1957) from Rhineland and *Monocotylphyllum lusaticum* JUCHNIEWICZ (1975) from Turów showing less cutinized stomata and less complicated stomatal complexes. According to Kvaček and Wilde (2006) the tissue fragment in the former case belongs to the stalk of a dicot leaf. The affinity of the above described structure remains dubious.

**Material:** Dispersed cuticle, G 9398 (KR 324).

### *Symplociphyllum* KVAČEK et BŮŽEK

#### *Symplociphyllum weylandii* KVAČEK et BŮŽEK

Pl. 4, figs 1–4, pl. 14, figs 9–10

1959 *Illicium lusaticum* (JÄHNICHEN) KRÄUSEL et WEYLAND sensu KRÄUSEL et WEYLAND, p. 106, pl. 20, figs 12–15, text-fig. 6–7 (non *Kadsura lusatica* JÄHNICHEN nec *Illicium lusaticum* (JÄHNICHEN) KRÄUSEL et WEYLAND pro nomen) (Düren).

1966 *Symplociphyllum weylandii* KVAČEK et BŮŽEK, p. 293, pl. 3, figs 4–5, pl. 4, fig. 3 (Hrádek/N., Kristina Mine).

Incomplete leaf, probably elliptic to ovate, 35 mm long, 17 mm wide, apex and base not preserved, margin entire, venation brochidodromous, midrib strong and straight, secondary veins very thin, straight, alternate to subopposite, originating at an angle of 40–60°, looping at the margin, tertiary veins perpendicular, straight to sinuous, venation of higher orders poorly preserved. Adaxial epidermis medium cutinized, smooth, non-modified cells polygonal, irregularly disposed, anticlinal walls coarsely wavy and sinuous with indistinct lens-shaped thickenings, scattered solitary simple rounded trichome bases, abaxial cuticle thinly cutinized, almost smooth, only faintly radially striate around some stomata, non-modified cells of the same form and size as adaxially, but without thickenings in sinuses, stomata incompletely cyclocytic, subsidiary cells 3–4 in one circle, slightly darker, guard cell pairs broadly oval to circular, 25–27 µm long and 20–25 µm wide, stomatal ledges short and not thickened, bordering oval pore.

**Discussion:** The stomatal type in the original diagnosis (Kvaček and Bůžek 1966) was wrongly interpreted as paracytic. The same type of dispersed cuticles with stomata was described as *Coronicutis hartauensis* ROSELT et SCHNEIDER (1969) from the nearby locality of Hartau in Germany (abaxial leaf side only) and *Myrsine*



*miocenica* JUCHNIEWICZ (1975) from Turów. So far the affinity has not been resolved. The Symplocaceae family is ruled out by the stomatal type. The affinity to Myrsinaceae R. BR. requires more detailed comparisons. A fragment with similar cuticle structure from the mastixioid flora of the Oberdorf Mine (Kovar-Eder et al. 2001) differing mainly in the striate adaxial cuticle was assigned to *Ternstroemites* (*T. waltheri* KOVAR-EDER).

**Material:** Leaf compression on slide, G 9399 (KR 182).

**cf. "*Illicium*" *limburgense* KRÄUSEL et WEYLAND  
sensu LITKE**

Pl. 4, figs 8-10, pl. 14, figs 12

?1950 *Illicium limburgense* KRÄUSEL et WEYLAND, p. 52, pl. 11, figs 1-5, text-figs 16-17 (Heerlen, Herman Mine).

?1966 *Illicium limburgense* KRÄUSEL et WEYLAND; Litke, p. 304, pl. 22, figs 7-8, pl. 23, fig. 1, text-figs 9c, d (Lower Lusatia).

Dispersed leaf fragments 5 mm and 10 mm long, 6 mm and 11 mm wide, apex and base not preserved, margin simple regularly serrate, teeth blunt, sinus rounded, venation semicraspedodromous, primary veins not preserved, secondaries looping, tertiary veins alternate percurrent, sinuous, innervating teeth apices on margin, venation of higher orders regular polygonal reticulate, areolation well developed, areoles 4-sided, free endig veinlets lacking. Adaxial epidermis medium cutinized, smooth, reflecting polygonal non-modified cells 20–30 µm in diameter, with almost straight and (by focusing) shallow undulate anticlinal walls, scattered trichome bases massively cutinized, 50–60 µm in diameter, with a central star-like rounded cell 28–32 µm in diameter, surrounded by 3–4 circles of small subsidiary cells, abaxial epidermis as abaxially, non-modified cells polygonal lobate, 20–30 µm in diameter, on thicker veins with low central papillae, stomata cyclocytic, guard-cell pairs rounded, 30–32 µm in diameter with granulate outer surface, surrounded by a narrow ring composed of a small number of subsidiary cells (cross walls between cells not well discernible). Polar T-pieces occasionally preserved, stomatal ledges not reaching to the stomatal poles, pore slit-like. Trichome bases of the same form as adaxially, but denser.

**Discussion:** The above described dispersed fragments do not show many of the important morphological characters of leaves. This element of the Hrádek flora is very incompletely documented but according to its thick cuticles, it may belong to the evergreen components. The leaves were probably thickly covered by stellate trichomes, of which only polycellular trichome bases are recognizable. Leaves with similar epidermal structures were described from Heerlen (Kräusel and Weyland 1950, Weyland et al. 1967), but in this case trichome bases (interpreted as openings by Kräusel and Weyland) are almost lacking. Litke (1966, pl. 22, fig. 8) illustrated dispersed cuticles from Lower Lusatia similar in the type of stomata and also with rare polycellular trichome bases corresponding more closely to our material. *Rhododendron ponticoides* JUCHNIEWICZ (1975) from Turów, similar to our material, differs in much larger stomata. We interpret darker

thickened spots in the latter species as trichome bases resembling those we found in our material. Although affinities to the Ericaceae seem probable, more comparative studies are required to unequivocally settle the systematic position of these quite distinct elements. The leaf anatomical structure of *Illicium* differs in many respects, mainly in the type of paracytic stomata and mesophyllous oil cells, and cannot be considered for comparative purposes.

**Material:** Dispersed leaf fragments on slides, G 9400-9401 (KR 347, 465).

**General characteristics of the flora of Hrádek/N.**

The Miocene flora of the Kristina Mine (table 1) belongs to the "Younger Mastixioid Floras" as defined by Mai (1964) and its development falls into the Early-Middle Miocene Optimum. The most characteristic and specific elements can be listed as follows: *Cupressospermum*, *Mastixia lusatica*, *Eomastixia saxonica*, *Retinomastixia*, *Diplopanax*, *Trema*, *Rehderodendron*, *Symplocos schereri*, and *Sphenotheca incurva* with respect to carpology, *Tsuga schneideriana*, *Laurus abchasica*, *Ocotea hradekensis*, *Laurophyllum rugatum*, *L. pseudovillense*, *Leguminosites hradekensis*, *Gordonia hradekensis* as to foliage, and the combined elements of *Distylium* and *Trigonobalanopsis*. Most of the elements belong to the "palaeotropical" group, while the "arctotertiary" elements are in the minority. Apparent lack of large fruits, such as those of *Carya*, seems to be due taphonomic processes. In addition, the foliage size must have been heavily biased by preparation technique and selective collections. Nearest floras with respect to diversity and species content were combined into the Floristic Assemblage ("Florenkomplex") Eichelskopf–Wiesa by Mai (1995).

**Palaeoenvironmental analysis and vegetation**

Plant megafossils recovered within this section of the Kristina Mine have been differentiated into several palaeo-associations or taphocoenoses mainly due to the depositional characters of macrofossil-bearing deposits (Holý 1975, 1978b). The section is mostly built up of delta sedimentation, which is characteristic of regular interchanging and merging layers of lignite, lignite clay, sandy clay and sand. Their sequence was described in great detail by Holý (1975, updated) as follows (see text-fig. 3):

Layer A (clay within the upper part of the main lignite seam)

*Glyptostrobus europaeus*.

Layers C, D, E (silty clay with ironstone nodules in the lignite seam roof)

*Diplopanax limnophilus*, *Dulichium marginatum*, *Eurya stigmatica*, *Ilex wiesaensis*, *Magnolia burseracea*, *Mastixia lusatica*, *Meliosma miesleri*, *Microdiptera donata*, *Myrica hudibra*, *Nyssa ornithobroma*, *Pinus hampeana*, *Quercus rhenana* plexus, *Rubus* spp., *Sapium germanicum*, *Sequoia abietina*, *Swida gorbunovii*, *Symplocos casparyi*, *Trigonobalanopsis rhamnoides* plexus, *Turpinia ettingshausenii*.

Layer F (sand with thin clayey-silty interbeds, a lateral equivalent of C)

*Acer tricuspidatum*, *Alnus julianiformis*, *Ampelopsis ludwigii*, *A. rotundata*, Araliaceae gen., *Cathaya roselitii*,

**Table 1. List of plant taxa occurring in the Hrádek/N. flora and their scoring according to the IPR-vegetation analysis (see Kovar – Eder et al. 2008, and Teodoridis et al. 2011a, 2012 for details).**

Taxa	IPR-vegetation analysis scoring												Problematic taxa		
	ZONAL									AZONAL					
	CONIFER	BLD	BLE	SCL	LEG	ZONPALM	ARBFERN	DRY HERB	MESO HERB	AZONAL WOODY	AZONAL NON-WOODY	AQUATIC			
<i>Acer tricuspidatum</i>		0.25								0.75					1.00
<i>Alnus julianiformis</i>		0.50								0.50					1.00
<i>Ampelopsis malvaeformis</i>		0.50								0.50					1.00
<i>Ampelopsis rotundata</i>		0.50								0.50					1.00
<i>Araliaceae</i> gen. et sp. indet.		0.33	0.33							0.34					1.00
<i>Cathaya roseltii</i>	1.00														1.00
<i>Cinnamomum lusaticum</i>			1.00												1.00
<i>Cinnamomum polymorphum plexus</i>			1.00												1.00
<i>Corylopsis</i> sp.		1.00													1.00
<i>Cupressospermum saxonicum</i>	1.00														1.00
<i>Cyclocarya nemejci</i>		1.00													1.00
<i>Diplopanax limnophilus</i>			1.00												1.00
<i>Distylium fergusonii plexus</i>			1.00												1.00
<i>Dulichium marginatum</i>											1.00				1.00
<i>Engelhardia orsbergensis</i>		0.50	0.50												1.00
<i>Eomastixia saxonica</i>			1.00												1.00
<i>Epipremnites ornatus</i>									1.00						1.00
<i>Eurya stigmosa</i>			1.00												1.00
<i>Fagus menzelii plexus</i>		1.00													1.00
<i>Ficus potentilloides</i>		0.50	0.50												1.00
<i>Fraxinus bilinica</i>		0.50								0.50					1.00
<i>Glyptostrobus europaeus</i>										1.00					1.00
<i>Gordonia hradekensis</i>			1.00												1.00
<i>Hypericum septestum</i>								0.30	0.30		0.34				1.00
<i>Ilex</i> cf. <i>protogaea</i>			1.00												1.00
<i>Ilex saxonica</i>			1.00												1.00
<i>Ilex wiesaensis</i>			1.00												1.00
<i>Illicium germanicum</i>			1.00												1.00
cf. " <i>Illicium</i> " <i>limburgense</i>			1.00												1.00
<i>Laurophyllum pseudoprinceps</i>			1.00												1.00
<i>Laurophyllum pseudovillense</i>			1.00												1.00
<i>Laurophyllum rugatum</i>			1.00												1.00
<i>Laurophyllum</i> sp.			1.00												1.00
<i>Laurus abchasica</i>			1.00												1.00
<i>Leguminosites hradekensis</i>			0.50	0.50											1.00
<i>Leucothoë narbonnensis plexus</i>		0.50	0.50												1.00
<i>Liquidambar europaea plexus</i>		0.50								0.50					1.00
<i>Liriodendron</i> sp.		1.00													1.00
<i>Magnolia burseracea</i>										1.00					1.00
<i>Mastixia lusatica</i>			1.00												1.00
<i>Meliosma miessleri</i>		0.50	0.50												1.00
<i>Microdiptera donata</i>												1.00			1.00
<i>Microdiptera elongata</i>												1.00			1.00
<i>Microdiptera parva</i>												1.00			1.00
? <i>Monocotyledonae</i> gen. et sp.														1.00	1.00
<i>Myrica ceriferiformis</i>										1.00					1.00
<i>Myrica cestmiri</i>			0.33	0.33						0.34					1.00
<i>Myrica hudibra</i>			0.33	0.33						0.34					1.00
<i>Myrica lignitum</i>										1.00					1.00
<i>Myrica pseudointegerima</i>			0.33	0.33						0.34					1.00
<i>Nyssa ornithobroma</i>										1.00					1.00
<i>Ocotea dorofeevii</i>			1.00												1.00
<i>Ocotea hradekensis</i>			1.00												1.00
<i>Ocotea rhenana</i>			1.00												1.00
<i>Parabaena europaea</i>									1.00						1.00
<i>Phoebe bohemica</i>			1.00												1.00
<i>Pinus hampeana</i>	1.00														1.00

Polypodiaceae gen. et sp. indet.									0.50		0.50			1.00
<i>Potamogeton heinkei</i>												1.00		1.00
<i>Potamogeton nochtensis</i>												1.00		1.00
<i>Pronephrium stiriacum</i>											1.00			1.00
<i>Proserpinaca ervinii</i>												1.00		1.00
<i>Pseudoeueryale</i> sp.												1.00		1.00
<i>Pterocarya raciborskii</i>	0.50									0.50				1.00
<i>Quercus bavarica</i>	1.00													1.00
<i>Quercus rhenana plexus</i>										1.00				1.00
<i>Rehderodendron custodum</i>	1.00													1.00
<i>Retinomastixia oertelii</i>			1.00											1.00
<i>Rubus</i> spp.	0.25	0.25	0.25							0.25				1.00
<i>Salix varians</i>										1.00				1.00
<i>Sambucus pulchella</i>	1.00													1.00
? <i>Sapindus</i> sp.	1.00													1.00
<i>Sapium germanicum</i>	1.00													1.00
<i>Sassafras</i> cf. <i>lusaticum</i>	1.00													1.00
<i>Sequoia abietina</i>										1.00				1.00
<i>Sparganium camenzianum</i>											1.00			1.00
<i>Sphenotheca incurva</i>			1.00											1.00
<i>Spinophyllum daemonorops</i>										1.00				1.00
cf. <i>Stemona germanica</i>								0.33	0.33		0.34			1.00
<i>Swida gorbunovii</i>	1.00													1.00
<i>Symplociphyllum weylandii</i>			1.00											1.00
<i>Symplocos casparyi</i>			1.00											1.00
<i>Symplocos minutula</i>			1.00											1.00
<i>Symplocos pseudogregaria</i>			1.00											1.00
<i>Symplocos schererii</i>			1.00											1.00
<i>Tectocarya elliptica</i>			1.00											1.00
cf. <i>Tectocarya robusta</i>			1.00											1.00
<i>Temstroemia chandlerae</i>			1.00											1.00
<i>Tetraclinis salicornioides</i>	1.00													1.00
<i>Tetrastigma chandlerae</i>		0.50								0.50				1.00
<i>Tetrastigma lobata</i>		0.50								0.50				1.00
<i>Toddalia latisiliquata</i>			1.00											1.00
<i>Trema lusatica</i>			1.00											1.00
<i>Trigonobalanopsis rhamnoides plexus</i>			1.00											1.00
<i>Tsuga schneideriana</i>	1.00													1.00
<i>Turpinia ettingshausenii</i>			1.00											1.00
<i>Viscum morlotii</i>													1.00	1.00
Vitaceae gen. et sp. indet.	0.50									0.50				1.00
<i>Vitis lusatica</i>	0.50									0.50				1.00
<i>Vitis parasilvestris</i>	0.50									0.50				1.00
<i>Zanthoxylum kristinae</i>		0.34	0.33	0.33										1.00
Sum of taxa	5.00	19.67	40.40	2.07	0.00	0.00	0.00	0.66	3.16	16.86	4.18	7.00	2.00	101.00
Sum zonal taxa														70.96
Percentage of zonal taxa	7.05	27.72	56.93	2.92	0.00	0.00	0.00	0.93	4.45	-	-	-	-	100.00
Sum zonal woody angiosperms														62.14
Percentage of zonal woody angiosperms	-	31.65	65.01	3.33	0.00	0.00	-	-	-	-	-	-	-	100.00
Sum of % SCL+ LEG														3.33
Sum of % D-HERB + H-HERB (ZONAL HERB)														5.38

*Cinnamomum polymorphum plexus*, *Cinnamomum lusaticum*, *Corylopsis* sp., *Cupressospermum saxonicum*, *Distylium fergusonii plexus*, *Dulichium marginatum*, *Engelhardia orsbergensis*, *Eomastixia saxonia*, *Eurya stigmosa*, *Fraxinus bilinica*, *Glyptostrobus europaeus*, *ordonia hradekensis*, *Ilex saxonica*, *Illicium germanicum*, *Laurophyllum pseudo-princeps*, *L. pseudovillense*, *L. rugatum*, *Laurophyllum* sp., *Laurus abchasica*, *Leguminosites hradekensis*, *Leucothoë*

*narbonnensis*, *Liquidambar europaea*, *Liriodendron* sp., *Magnolia burseracea*, *Mastixia lusatica*, *Meliosma miesleri*, *Microdiptera parva*, *M. elongata*, *Myrica ceriferiformis*, *M. hudibra*, *M. lignitum*, *Nyssa ornithobroma*, *Ocotea dorofeevii*, *O. hradekensis*, *O. rhenana*, *Parabaena europaea*, *Phoebe bohemica*, *Pinus hampeana*, *Pronephrium stiriacum*, *Pseudoeueryale* sp., *Pterocarya limburgensis*, *Quercus rhenana plexus*, *Q. bavarica*, *Rehderodendron custodum*, *Retinomastixia*

*oertelii*, *Rubus* spp., *Salix varians*, *Sambucus pulchella*, *Sapium germanicum*, *Sassafras lusaticum*, *Sparganium camenzianum*, *Sphenotheca incurva*, *Swida gorbunovii*, *Symplocos casparyi*, *S. minutula*, *S. schererii*, *Symplociphyllum weylandii*, *Tectocarya lusatica*, *Ternstroemia chandlerae*, *Tetraclinis salicornioides*, *Tetrastigma chandlerae*, *T. lobata*, *Toddalia latisiliquata*, *Trema lusatica*, *Trigonobalanopsis rhamnoides* plexus, *Tsuga schneideriana*, *Turpinia ettingshausenii*, *Viscum morlotii*, *Vitis lusatica*, *Vitis parasilvestris*, *Zanthoxylum kristinae*.

Layer B (lowermost clayey lignite seamlet).

*Cupressospermum saxonicum*, *Epipremnites ornatus*, *Ficus potentilloides*, *Glyptostrobus europaeus*, *Microdiptera donata*, *Microdiptera parva*, *Sequoia abietina*, *Spinophyllum demonorops*.

Layer G (coarse-grained sand below the higher lignite seamlet).

*Cyclocarya nemejcii*, *Fagus deucalionis* plexus, *Glyptostrobus europaeus*, *Ilex cf. protogaea*, *Magnolia burseracea*, *Nyssa ornithobroma*, *Ocotea rhenana*, *Pterocarya limburgensis*, *Sequoia abietina*, *Symplocos casparyi*, *Tectocarya lusatica*, *Trigonobalanopsis rhamnoides* plexus.

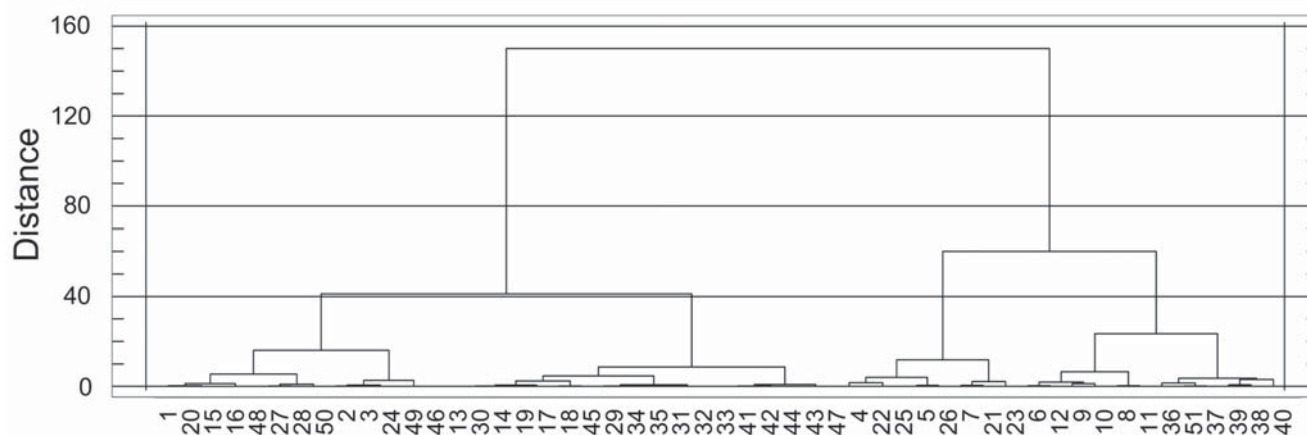
Layers H–J (lignite clay in the floor of the highest seamlet).

*Cupressospermum saxonicum*, *Dulichium marginatum*, *Glyptostrobus europaeus*, *Hypericum septestum*, *Magnolia burseracea*, *Microdiptera donata*, *Myrica cestmirii*, *M. pseudolignitum*, *Nyssa ornithobroma*, *Potamogeton heinkei*, *Proserpinaca ervinii*, *P. nochtensis*, *Sequoia abietina*, *Symplocos casparyi*, *Tetrastigma chandlerae*.

Holý (1978b) called the richest obviously zonal association of the layer F “Mastixiaceae – Lauraceae – Symplocaceae taphocoenosis” while most of the others are in his opinion autochthonous to semiautochthonous, i.e., azonal, dominated by coal-forming, swampy and aquatic elements, except for the layer G containing *Fagus*, *Pterocarya* and evergreen Fagaceae. In our opinion, the appearance of *Fagus deucalionis* plexus indicates a transition from the typical evergreen forest of the Miocene optimum to the beginning of the climatic decline towards the mixed mesophytic forest enriched by deciduous elements. A very similar succession was described in the Berzdorf Basin north of Hrádek/N. (Czaja 2003).

## Palaeovegetation signals from IPR-vegetation analysis

The above described fossil plant assemblage of the Kristina Mine, Hrádek/N. was evaluated using IPR-vegetation analysis (e.g., Kovar-Eder et al. 2008, Teodoridis et al. 2011a) of the following characteristic of key components, i.e., broad-leaved deciduous (BLD) – 31.7 %, broad-leaved evergreen (BLE) – 65.0 %, sclerophyllous + legume-like (SCL+LEG) – 3.3 %, dry herbaceous + mesophytic herbaceous /zonal herbaceous/ (D-HERB + M-HERB /ZONAL HERB/) – 5.4 % (for a detailed taxa scoring see Table 1). According to the thresholds for the key components detailed above for defining vegetation types (modified by Teodoridis et al. 2011a, table 8), the flora of Hrádek/N belongs to the broad-leaved evergreen forest (BLEF) vegetation type. Results of IPR-vegetation analysis from the stratigraphically comparable floras of Wackersdorf (Germany – Gregor 1978, Günther and Gregor 1993, Knobloch and Kvaček 1976), Berzdorf and Wiesa (Czaja 2003, Jechorek, pers. comm.) and the Mydlovary Formation of the České Budějovice and Třeboň Basins, Czech Republic, i.e., localities: Mydlovary, Ledenice, Hluboká and Kamenný Újezd (Knobloch 1986, Knobloch and Kvaček 1996), i.e., BLD 53%, 45.6 %, and 45.8 %; BLE 42.6 %, 48.6 %, and 43.2 %; SCL+LEG 4%, 5.8 % and 11.1 %; and ZONAL HERB 2.6 %, 13.8 % and 5.2 % (Kovar-Eder et al. 2008, Teodoridis et al. 2011c, see Appendix), also indicate the Broad-leaved Evergreen forest vegetation type as a possible zonal vegetation cover for upland environments (for details see Appendix). A dendrogram (text-fig. 4) derived from cluster analysis (Ward’s method, Euclidean square distance – Teodoridis et al. 2011a, 2012) show the relationship between the mentioned fossil floras, i.e., Hrádek/N (48), Wackersdorf (49), Berzdorf and Wiesa (50) and the Mydlovary Fm. (51), and modern tropical, subtropical and temperate vegetation assemblages from SE China and Japan (sensu Teodoridis et al. 2011a, 2012, Appendix – this volume) based on the mutual combination of their BLD, BLE, SCL+LEG values. Based on the dendrogram (text-fig. 4), there is a close relationship among the fossil floras of Kristina Mine, Wackersdorf and



Text-fig. 4. Dendrogram (Ward’s method, squared Euclidean distance) showing the relationship between the studied fossil vegetation assemblages of Hrádek/N. (48), Wackersdorf (49), Berzdorf and Wiesa (50) and the Mydlovary Fm. (51) and the studied modern vegetation units from SE China and Japan (Teodoridis et al. 2011a, 2012, Appendix – this volume).

Berzdorf included in a one subcluster. The vegetation assemblage of Kristina Mine (48) shows the closest affinity to the BLEF vegetation assemblage of *Castanopsis eyrei* comm. from Mt. Longqi, Fujian, China (16). The three modern assemblages of BLEF from China, i.e. Mt. Emei (1), summarizing the results of BLEF from Mt. Longqi (20) and *Castanopsis fargesii* comm. from Mt. Longqi (15), form a relatively isolated cluster with a close affinity to that of the Kristina Mine. Similarly, the flora of Berzdorf (50) shows the closest affinity to BLEF vegetation associations of *Podocarpus nagi* from Nara and the Precincts of Kasuga Shrine, Japan (27, 28). The fossil vegetation of Wackersdorf (49) is included in the cluster with a specific “cooler” BLEF association of *Camellia japonica* from Mt. Fuji, Japan (24), and the monsoon forest vegetation assemblage from Xishuangbanna, Yunnan, China (46), and MMF vegetation from Mt. Emei, China (2, 3). Finally, vegetation assemblages of the Mydlovary Fm. (51) are isolated from the other mentioned fossil sites and show the closest affinities to modern MMF vegetation associations of *Eurya-Cryptomeria japonica* from the Yakushima Island, Japan only (38, 40, 36, 37, 39).

### Palaeoclimatic signals using CLAMP, LMA and CA techniques

The plant assemblage of the Kristina Mine was evaluated using a combination of the physiognomic (CLAMP, LMA) and Nearest Living Relatives (CA) techniques. The CLAMP method uses the physiognomic characteristics of the Kristina Mine assemblage presented in Table 2 and 144 physiognomic and meteorological reference datasets (Physg3brcAZ, GRIDMet3brAZ) selected by a new statistical tool published by Teodoridis et al. (2012). The palaeoclimatic estimates for the Kristina Mine are as follows: CLAMP estimates – MAT 14.2 °C, WMMT 24.0 °C, CMMT 6.2 °C, 3–WET 131.7 cm, 3–DRY 20.0 cm, GROWSEAS 10.3 month, GSP 203.1 cm, MMGSP 9.9 cm, RH 54.5 %, SH 5.5 g/kg, and ENTHAL 29.9 kJ/kg; LMA estimates – MAT<sub>1</sub> is 21.1 °C (sensu Wolfe 1979) and MAT<sub>2</sub> is 18.7 °C (sensu Su et al. 2010), and value of the sampling error sensu Miller et al. (2006) is 3.1 °C; CA proxy data intervals: MAT 17–18°C, WMMT 26.5–26.9 °C, CMMT 9.6–12.6 °C, and MAP 1146–1146 mm (Utescher personal communication). The obtained climate proxy datasets correspond more or less with those of stratigraphical analogous sites from Wackersdorf and Wiesa (Berzdorf) as well as the summarised proxy datasets of the Mydlovary Fm., i.e., Wackersdorf: MAT 15.7–16.6 °C, WMMT 24.9–26.0°C, CMMT 5.6–10.9 °C, MAP 1096–1187 mm (CA), MAT 18 °C, WMMT 26 °C, CMMT 12.1 °C, 3–WET 88.3 cm, 3–DRY 23.4 cm (CLAMP), Wiesa and Berzdorf: MAT 17.7–18 °C, WMMT 26.5–26.5 °C, CMMT 9.6–9.6 °C, MAP 1146–1355 mm (CA), and Mydlovary Fm.: MAT 15.7–16.6 °C, WMMT 24.9–26.0°C, CMMT 5.6–10.9 °C, MAP 1096–1187 mm (CA), MAT 13.9 °C, WMMT 25.3 °C, CMMT 4.1 °C, 3–WET 88.1 cm, 3–DRY 17.9 cm (CLAMP) – for details see Mosbrugger et al. (2005) and Teodoridis et al. (2011b). The presented palaeoclimatic proxy datasets of the Kristina Mine are comparable with the estimates formerly published by Holý (1975), i.e., WMMT over 22 °C, and

**Table 2. Percentages of foliar physiognomic characters of the studied fossil flora of the Kristina Mine at Hrádek/N.**

Foliar Physiognomic Characters [%]		Hrádek/N (Kristina Mine)
Margin Character States	Lobed	9.52
	No Teeth	64.29
	Tth Regular	28.57
	Teeth Close	28.57
	Teeth Round	19.05
	Teeth Acute	19.05
	Tth Compound	0.00
Size Character States	Nanophyll	0.00
	Leptophyll I	0.00
	Leptophyll II	0.00
	Microphyll I	24.19
	Microphyll II	49.19
	Microphyll III	26.57
	Mesophyll I	0.00
	Mesophyll II	0.00
	Mesophyll III	0.00
Apex Character States	Apex Emarginate	3.95
	Apex Round	26.24
	Apex Acute	35.14
	Apex Attenuate	31.35
Base Character States	Base Cordate	7.90
	Base Round	22.19
	Base Acute	69.81
Length to Width Character States	L:W < 1:1	4.76
	L:W 1-2:1	4.76
	L:W 2-3:1	30.14
	L:W 3-4:1	43.24
	L:W > 4:1	17.05
Shape Character States	Obovate	0.00
	Elliptic	45.24
	Ovate	54.76
Total number of taxa		21

CMMT over 5 °C. The presented palaeoclimatic estimates for Hrádek/N. correspond to the late Early Miocene Climatic optimum indicated by Teodoridis and Kvaček (2006). This optimum is also supported by stomatal density indicating an increase of atmospheric CO<sub>2</sub> concentration during the deposition of the Libkovice Member of the Most Formation in the Most Basin (Kürschner et al. 2005, Kürschner and Kvaček 2006).

### Phytostratigraphical correlation

The flora of the Kristina Mine is characterized by a mass occurrence of thermophilous elements mainly of the Mastixioideae (i.e., *Mastixia lusatica*, *Tectocarya elliptica*, *Diplopanax limnophilus*, *Eomastixia saxonica*, *Retinomastixia oertelii*) associated with *Gordonia hradekensis*, *Laurophyllum rugatum*, *Laurus abchasica*, and *Zanthoxylum kristinae*. A similar floristic composition is also known from the drill core floras from the Upper Coal Seam s. l. of the Hrádek Formation (Teodoridis 2003), but leaf elements and some Mastixioideae, such as *Diplopanax*, *Eomastixia*, *Retinomastixia*, are lacking. Generally, these floras are correlated, based on the phytostratigraphical markers mentioned, to the floristic assemblage of Eichelskopf–Wiesa (Mai 1995, 2000), i.e., the floristic zone VI in Saxony sensu Mai (1967). However, the flora from the uppermost level of

the Kristina Mine (level G sensu Holý 1975, see also above) appears less thermophilous containing additional deciduous elements, as *Fagus* and *Pterocarya* (Holý 1978b) and may correspond to the floristic assemblage of Františkovy Lázně–Kleinleipisch (Mai 1995, Czaja 2003). The studied flora of the Kristina Mine as well as the mentioned drill core floras from the vicinity of Hrádek /N. and Chotyně

(Teodoridis 2003) are stratigraphically comparable with the floras from the German and Polish parts of the Zittau Basin, i.e., Hartau 1/69 (flora C – Mai 1964, 2000) and Turów (Czeczott et al. 1959, Czeczott 1961a, b, Czeczott and Skirgiełło 1961, 1967, 1975, 1980, Czeczott and Juchniewicz 1980, Juchniewicz 1975). The exact correlation within the floras of the Bohemian Massif (Kvaček and Teodoridis

## Appendix

**DATA sources for the percentage values of BLD, BLE and SCL+LEG components of the studied fossil vegetation assemblages of Hrádek/N. (48), Wackersdorf (49), Berzdorf and Wiesa (50) and the Mydlovary Fm. (51), and of forty-seven modern vegetation units from SE China and Japan (1-47) used in cluster analysis. – Abbreviations: BLDF (broad-leaved deciduous forests), MMF (mixed mesophytic forests), BLEF (broad-leaved evergreen forests), ShSF (subhumid sclerophyllous forests), BLDF/MMF (ecotone, transitional vegetation between broad-leaved deciduous forests and mixed mesophytic forests) BLEF/MMF (ecotone, transitional vegetation between broad-leaved evergreen forests and mixed mesophytic forests) – see Teodoridis et al. (2011a, 2012) for details.**

Time/Zone	Country	Area	Vegetation type - empirical classification	Studied modern vegetation units [region, (sub)community, (sub)association] and fossil floras / studied fossil floras sensu Teodoridis et al. (2011a, b, c, 2012)	Site numbers - Cluster analysis	IPR - vegetation analysis								
						% of BLD	% of BLE	% of SCL + LEG	% of zonal herb (DRY + MESO herbs) of zonal taxa	number of zonal taxa	number of zonal woody angiosperms	total number of taxa	problematic taxa	Classification sensu Teodoridis et al. (2011a)
RECENT SUBTROPICAL and TEMPERATE ZONE	China	Mt. Emei	BLEF	plots (Tang and Ohsawa 1997, Tang et al. 2007)	1	34	66	0	-	62	64	64	0	BLEF
			MMF	1 plot (Tang and Ohsawa 1997)	2	65	36	0	-	23	23	24	0	BLEF/MMF
				vegetation description (Li and Shi 2007)	3	67	31	1	51	637	313	735	0	BLEF/MMF
			BLDF	2 plots (Tang and Ohsawa 1997)	4	80	17	4	-	46	43	47	0	BLDF
		Meili Snow Mts	BLDF	<i>Betula</i> spp., <i>Acer</i> spp., <i>Sorbus</i> spp. comm.	5	100	0	0	63	52	19	53	0	BLDF
				summarized communities of <i>Hippophae rhamnoides</i> , <i>Prunus mira</i> , <i>Salix luctuosa</i> and <i>Zanthoxylum simulans</i> , and <i>Populus haoana</i> var. <i>haoana</i>	6	68	6	26	58	37	16	41	0	ShSF
				Summary for BLDF	7	84	3	13	56	79	35	83	0	BLDF
			ShSF	<i>Quercus guyavifolia</i> comm.	8	56	12	33	40	39	24	41	0	ShSF
				<i>Quercus aquifolioides</i> comm., <i>Q. aquifolioides</i> and <i>Pinus armandii</i> subcomm.	9	55	21	24	50	37	19	39	0	ShSF
				<i>Quercus aquifolioides</i> comm., <i>Q. aquifolioides</i> subcomm.	10	64	14	22	53	72	34	77	0	ShSF
				<i>Quercus aquifolioides</i> comm., <i>Q. aquifolioides</i> and <i>Populus davidiana</i> subcomm.	11	54	15	31	47	30	16	32	0	ShSF
				Summary for ShSF	12	62	12	26	49	118	55	124	0	ShSF
		Mt. Longqi	BLEF	<i>Phoebe bournei</i> comm.	13	17	80	3	30	46	32	47	0	BLEF
				<i>Altingia chinensis</i> comm.	14	14	82	3	19	35	31	41	0	BLEF
				<i>Castanopsis fargesii</i> comm.	15	38	60	1	30	150	104	160	0	BLEF
				<i>Castanopsis eyrei</i> comm.	16	29	69	3	9	44	40	48	0	BLEF
				<i>Castanopsis carlesii</i> comm.	17	17	83	0	10	42	36	43	0	BLEF
				<i>Lithocarpus polystachys</i> comm.	18	23	77	0	14	42	35	43	0	BLEF
				plots (He et al. 1998)	19	14	84	2	-	59	56	61	0	BLEF
				Summary for BLEF	20	35	64	1	26	234	171	249	0	BLEF

Time/Zone	Country	Area	Vegetation type - empirical classification	Studied modern vegetation units [region, (sub)community, (sub)association] and fossil floras / studied fossil floras sensu Teodoridis et al. (2011a, b, c, 2012)	Site numbers - Cluster analysis	IPR - vegetation analysis							Classification sensu Teodoridis et al. (2011a)		
						% of BLD	% of BLE	% of SCL + LEG	% of zonal herb (DRY + MESO herbs) of zonal taxa	number of zonal taxa	number of zonal woody angiosperms	total number of taxa		problematic taxa	
RECENT	SUBTROPICAL and TEMPERATE ZONE	Japan	Shirakami Sanchi	BLDF	<i>Lindera membranacea-Fagus crenata</i> comm.	22	78	9	13	53	178	82	205	2	BLDF / MMF
					<i>Quercus mongolica</i> var. <i>grosseserrata-Lindera umbellata</i> var. <i>membranacea</i> comm.	22	87	6	6	47	106	55	122	2	BLDF
					<i>Ilex-Thuja standishii</i> comm.	23	77	5	18	39	67	38	72	0	BLDF / MMF
			Mt. Fuji	BLEF	<i>Camellia japonica</i> region	24	55	42	3	-	38	36	39	0	BLEF
					<i>Fagus crenata</i> region	25	89	5	6	-	104	93	113	0	BLDF
				BLDF	<i>Vaccinium-Picea</i> region	26	95	2	3	-	107	97	122	2	BLDF
			Nara	BLEF	<i>Podocarpus nagi</i> assoc., typical subassoc.	27	33	57	6	44	50	25	60	0	BLEF
					<i>Podocarpus nagi</i> assoc.	28	38	53	6	41	65	33	78	1	BLEF
			Shiroyama	BLEF	<i>Elaeocarpus sylvestris</i> var. <i>ellipticus</i> assoc.	29	17	73	6	25	44	32	52	3	BLEF
			Yakushima Island	BLEF	<i>Ficus superba</i> var. <i>japonica-Persea thunbergii</i> assoc.	30	17	81	2	30	87	61	99	1	BLEF
					<i>Tarennia-Castanopsis sieboldii</i> assoc.	31	16	80	5	30	108	75	122	0	BLEF
					<i>Hydrangea-Castanopsis sieboldii</i> assoc.	32	14	80	6	31	119	81	134	1	BLEF
		<i>Distylium-Quercus salicina</i> assoc., typical subassoc.			33	14	81	6	39	62	36	67	0	BLEF	
		<i>Distylium-Quercus salicina</i> assoc., <i>Maesa japonica</i> subassoc.			34	19	76	5	45	148	76	172	4	BLEF	
		Summary for <i>Distylium-Quercus salicina</i> assoc.			35	20	75	5	44	149	77	172	4	BLEF	
		MMF		<i>Eurya-Cryptomeria japonica</i> assoc., <i>Dryopteris nipponensis</i> subassoc.	36	56	32	12	52	73	33	87	1	BLEF / MMF	
				<i>Eurya-Cryptomeria japonica</i> assoc., typical subassoc.	37	56	27	17	42	54	29	62	0	MMF	
				<i>Eurya-Cryptomeria japonica</i> assoc., <i>Tsuga sieboldii</i> subassoc.	38	43	42	15	49	88	41	105	2	BLEF	
				<i>Eurya-Cryptomeria japonica</i> assoc., <i>Carex morrowii</i> var. <i>laxa</i> subassoc.	39	53	31	16	43	37	19	45	2	BLEF / MMF	
		Summary for <i>Eurya-Cryptomeria japonica</i> assoc.	40	43	38	19	52	103	48	122	2	BLEF / MMF			
		TROPICAL ZONE	China	Jianfengling	Tropical lowland rain forest	41	5	95	1	1	148	146	152	0	BLEF
					Tropical montane rain forest	42	1	98	0	1	245	242	254	0	BLEF
				Xishuangbanna	Tropical seasonal rain forest	43	9	89	0	1	98	97	99	0	BLEF
Tropical montane rain forest	44				3	97	0	0	59	58	59	0	BLEF		
Tropical seasonal moist forest	45				26	73	1	2	74	74	74	0	BLEF		
Monsoon forest	46				59	40	1	39	60	37	69	0	BLEF		
Tropical montane broad-leaved evergreen forest	47				9	91	0	0	54	54	54	0	BLEF		
FOSSIL	Czech Republic	Germany	Hrádek/N. (Kristina Mine)	48	32	65	3	6	70	62	101	2	BLEF		
			Wackersdorf (Gregor 1978b, Günther and Gregor 1993, Knobloch and Kvaček 1976)	49	53	43	4	3	138	124	203	13	BLEF		
			Berzdorf and Wiesa (Czaja 2003, Jechorek pers. comm.)	50	46	49	6	14	106	87	191	6	BLEF		
			Mydlovary Fm. (Knobloch 1986, Knobloch and Kvaček 1996)	51	46	43	11	5	58	48	78	3	BLEF		

2007) is equivocal based on the plant macrofossils available. However, floristic affinities (mainly based on the mastixioid elements) between the floras of Hrádek/N. (Kristina Mine and the drill cores) with those of the Cypris Formation in the Cheb and Sokolov Basins (Bůžek et al. 1996) and the Libkovice Member of the Most Formation, Most Basin (Teodoridis and Kvaček 2006) are also anticipated as being the Early Miocene, i.e., Ottnagian to Karpatian age. New “younger” Badenian elements recovered from the Mydlovary Formation in the České Budějovice and Třeboň basins, i.e. *Magnolia liblarensis*, *Smilax sagittifera* and *Illipophyllum thomsonii* (Knobloch and Kvaček 1996), appear for the first time in the Bohemian Tertiary there and stress the Middle Miocene age of the Mydlovary Formation.

The flora of Hrádek/N. can be correlated with similar Early Miocene floras situated outside the Czech Republic (Kovar-Eder et al. 2001), e.g., Wackersdorf (Gregor 1975b, Knobloch and Kvaček 1976), Oberdorf Mine (Kovar-Eder and Meller 2001) and partly also with the so far incompletely described flora of Turów, Poland (in several papers by Czaczkott et al.).

Many various elements in common connect now, after the revision done by Łańcucka-Środoniowa and Zastawniak (1997), the Hrádek carpoﬂoral record with the famous Middle Miocene flora of Wieliczka. Yet the scarcity of the genus *Mastixia* and the occurrence of new elements (e.g., *Eucommia*) stress the age difference between these two Miocene floristic levels (Mai 1995).

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## Explanations of the plates

### PLATE 1

#### *Pronephrium stiriacum* (UNGER) E. KNOBLOCH et KVAČEK

1. Fragmentary pinna, G 8863a (KR 58) (scale bar 5 mm).
2. Detail of a pinnulae from fig. 1 (scale bar 3 mm).

#### Polypodiaceae gen. et sp. indet.

3. Fragmentary pinnule, G 8867a (KR 77) (scale bar 5 mm).

#### *Tsuga schneideriana* KUNZMANN et MAI

4. Complete needle, G 8868a (KR 104A) (scale bar 3 mm).

#### *Cathaya roselii* SCHNEIDER

5. Fragment of a needle, G 8872a (KR 103A) (scale bar 5 mm).

#### *Tetraclinis salicornioides* (UNGER) KVAČEK

6. Isolated cladode-like branch segment, G 8874a (KR 238) (scale bar 3 mm).

#### *Glyptostrobus europaeus* (BRONGNIART) UNGER

7. Fragment of foliage shoot, G 8884a (KR 488A) (scale bar 5 mm).

#### *Sequoia abietina* (BRONGNIART) E. KNOBLOCH

8. Fragment of taxodioid foliage shoot, G 8886a (KR 269) (scale bar 5 mm).

#### *Laurus abchasica* (KOLAKOVSKII et SHAKRYL) FERGUSON

9. Leaf fragment, G 8890a (KR 46) (scale bar 3 mm).

#### *Ocotea hradekensis* (KVAČEK et BŮŽEK) KVAČEK

11. Incomplete leaf, holotype, G 8895a (KR 300) (scale bar 5 mm).

#### *Laurophyllum pseudoprinceps* WEYLAND et KILPPER

10. Leaf without right-hand half, G 8918a (KR 186) (scale bar 5 mm).
12. Petiolate leaf base, G 8945a (KR 408) (scale bar 10 mm).
13. Leaf apex, G 8910a (KR 146) (scale bar 10 mm).
14. Venation detail of the leaf fragment shown in fig. 13 (scale bar 1 mm).

#### *Laurophyllum rugatum* KVAČEK et BŮŽEK

15. Leaf fragment, G 8964a (KR 7) (scale bar 5 mm).
16. Petiolate leaf base, G 8963a (KR 3), holotype (scale bar 5 mm).
17. Venation detail of the leaf shown in fig. 16 (scale bar 1 mm).

#### *Laurophyllum pseudovillense* KVAČEK

18. Leaf base, G 9002a (KR 478) (scale bar 5 mm).
19. Venation detail of the leaf fragment shown in fig. 18 (scale bar 2 mm).
20. Petiolate leaf base, G 8995a (KR 265), holotype (scale bar 10 mm).

#### *Laurophyllum* sp.

21. Incomplete leaf, G 9008a (KR 193) (scale bar 5 mm).
22. Leaf fragment, G 9005a (KR 2) (scale bar 5 mm).
23. Venation detail of the leaf fragment shown in fig. 22 (scale bar 1 mm).

### PLATE 2

#### *Cinnamomum polymorphum* (A. BRAUN) HEER plexus

1. Leaf, G 9013 (KR 59) (scale bar 5 mm).

2. Basal part of a leaf, G 9074a (KR 281) (scale bar 5 mm).
3. Incomplete leaf, G 978a (KR 286) (scale bar 5 mm).
4. Venation detail of the leaf shown in fig. 3 (scale bar 1 mm).
5. Unusually small leaf, G 9136a (KR SN 1) (scale bar 3 mm).
6. Leaf with blunt apex, G 9068a (KR 275) (scale bar 5 mm).
7. Untypical large leaf, G 9019a (KR 89) (scale bar 10 mm).

***Viscum morlotii* (UNGER) E. KNOBLOCH et KVAČEK**

8. Leaf, G 9156 (KR 20) (scale bar 5 mm).
9. Leaf, G 9159 (KR 68) (scale bar 5 mm).

***Distylium fergusonii* E. KNOBLOCH et KVAČEK plexus**

10. Leaf fragment, G 9166 (KR 46) (scale bar 3 mm).
11. Leaf fragment, G 9170 (KR 464) (scale bar 3 mm).
12. Venation detail of the leaf fragment shown in fig. 11 (scale bar 1 mm).
13. Leaf tip, G 9168 (KR 331) (scale bar 1 mm).

***Leguminosites hradekensis* (E. KNOBLOCH et KVAČEK) KVAČEK et TEODORIDIS comb. nov.**

14. Fragment of leaf apex, G 9172a (KR 21) (scale bar 5 mm).
15. Leaf fragment, G 9174a (KR 43A) (scale bar 3 mm).
16. Leaf fragment, G 9174b (KR 43B) (scale bar 3 mm).
17. Leaf fragment, G 9175a (KR 410) (scale bar 5 mm).
18. Venation detail of the leaf fragment shown in fig. 14 (scale bar 1 mm).
19. Venation detail of the leaf fragment shown in fig. 17 (scale bar 1 mm).

***Alnus julianiformis* (STERNBERG) KVAČEK et HOLÝ**

20. Incomplete leaf, G 9176a (KR 143) (scale bar 10 mm).
21. Fragment of leaf base, G 9181 (KR 225) (scale bar 5 mm).

***Fagus deucalionis* UNGER plexus**

22. Leaf fragment showing toothed margin, G 9194b (KR 123B) (scale bar 5 mm).
23. Venation detail of the leaf fragment shown in fig. 22 (scale bar 1 mm).
24. Entire-margined leaf base, G 9193 (KR 122) (scale bar 5 mm).
25. Leaf fragment, G 9190 (KR 112) (scale bar 5 mm).
26. Leaf fragment, G 9191 (KR 113) (scale bar 5 mm).
27. Venation detail of the leaf fragment shown in fig. 26 (scale bar 1 mm).

### PLATE 3

***Trigonobalanopsis rhamnoides* (ROSSMÄSSLER) KVAČEK et WALTHER plexus**

1. Leaf, G 9218a (KR 196) (scale bar 5 mm).
2. Leaf apex, G 9249a (KR 500) (scale bar 5 mm).
3. Incomplete leaf, G 9236a (KR 383) (scale bar 5 mm).
4. Venation detail of the leaf shown in fig. 3 (scale bar 1 mm).

***Quercus bavarica* (E. KNOBLOCH et KVAČEK) KVAČEK**

5. Basal part of leaf, G 9267a (KR 496) (scale bar 5 mm).

***Fagus deucalionis* UNGER plexus**

6. Petiolate leaf base, G 9184 (KR 23) (scale bar 5 mm).
7. Venation detail of the leaf fragment shown in fig. 6 (scale bar 1 mm).

***Quercus rhenana* (KRÄUSEL et WEYLAND) E. KNOBLOCH et KVAČEK plexus.**

8. Two incomplete leaf impressions in ironstone, G 8814a, b (scale bar 10 mm).
9. Incomplete apical part of leaf, G 9284 (KR 472) (scale bar 5 mm).
10. Fragmentary leaf lamina, G 9281a (KR 469) (scale bar 5 mm).

***Engelhardia orsbergensis* (WESSEL et WEBER) JÄHNICHEN, MAI et WALTHER**

11. Leaflet base, G 9290a (KR 202) (scale bar 1 mm).
12. Leaflet apex, G 9293 (KR 213) (scale bar 5 mm).
13. Venation detail of the leaflet fragment shown in fig. 11 (scale bar 1 mm).
14. Leaflet fragment, G 9306a (KR 525) (scale bar 5 mm).

***Salix varians* GÖPPERT**

15. Fragment of petiolate leaf base, G 9318a (KR 178) (scale bar 3 mm).
16. Fragment of leaf lamina, G 9316a (KR 424) (scale bar 5 mm).
17. Leaf apex, G 9309 (KR 177) (scale bar 5 mm).

***Myrica lignitum* (UNGER) SAPORTA**

18. Fragment of leaf lamina, G 9309a (KR 179) (scale bar 3 mm).

***Acer tricuspidatum* BRONN emend. WALTHER**

19. Leaf fragment, G 9322a (KR 164) (scale bar 5 mm).
20. Leaf base, G 9324 (KR 208) (scale bar 5 mm).
21. Venation detail of the leaf fragment shown in fig. 20 (scale bar 1 mm).

**? *Sapindus* sp.**

22. Fragmentary leaflet base, G 9327a (KR 22) (scale bar 5 mm).
23. Venation detail of the leaf fragment shown in fig. 22 (scale bar 1 mm).

***Gordonia hradekensis* (KVAČEK et BŮŽEK) BOZUKOV et PALAMAREV**

24. Leaf base, G 9328 (KR 28) (scale bar 10 mm).
25. Almost complete leaf with base, G 9332a (KR 38) (scale bar 10 mm).
26. Upper part of leaf with apex, G 9373 (KR 435) (scale bar 10 mm).
27. Almost complete petiolate leaf, G 9338a (KR 69), holotype (scale bar 10 mm).
28. Venation and margin detail of the leaf shown in fig. 27 (scale bar 1 mm).

### PLATE 4

***Fraxinus bilinica* (ETTINGSHAUSEN) KVAČEK et HURNÍK**

1. Fragment of a large leaflet, G 9387 (KR 411) (scale bar 10 mm).
2. Fragment of leaflet base, G 9389 (KR 414) (scale bar 10 mm).
3. Leaflet fragment, G 9384a (KR 60) (scale bar 5 mm).
4. Venation detail of the leaflet fragment shown in fig. 3 (scale bar 1 mm).

***Symplociphyllum weylandii* KVAČEK et BŮŽEK**

5. Leaf fragment, G 9399a (KR 182) (scale bar 5 mm).
6. Venation detail of the leaf fragment shown in fig. 5 (scale bar 1 mm).



**cf. "Illicium" limburgense KRAUSEL et Weyland sensu LITKE**

7. Leaf fragment, G 9400a (KR 465) (scale bar 3 mm).
8. Leaf fragment, G 9401a (KR 347) (scale bar 3 mm).
9. Venation detail of the leaf fragment shown in fig. 8 (scale bar 1 mm).

***Pinus hampeana* (UNGER) HEER**

10. Seed cone, G 8816 (scale bar 10 mm).
11. Seed cone, G 8817 (scale bar 10 mm).

***Tetraclinis salicornioides* (UNGER) KVAČEK**

12. Seed cone from either side, G 4590 (scale bar 3 mm).

***Glyptostrobus europaeus* (BRONGNIART) UNGER**

13. Isolated seed cone from either side, G 4598 (scale bar 5 mm).
14. Seed from either side, G 8828 (scale bar 3 mm).
15. Seed from either side, G 8829 (scale bar 3 mm).

***Sequoia abietina* (BRONGNIART in CUVIER) E. KNOBLOCH**

16. Isolated seed cone from either side, G 4593 (scale bar 5 mm).
17. Seed from either side, G 8831 (scale bar 3 mm).
18. Seed from either side, G 8833 (scale bar 3 mm).

***Cupressospermum saxonicum* MAI**

19. Isolated seed cone from either side, G 4595 (scale bar 5 mm).
20. Seed from either side, G 8823 (scale bar 3 mm).
21. Seed from either side, G 8824 (scale bar 3 mm).

***Pseudoeuryale* sp.**

22. Seed from either side, G 3050 (scale bar 1 mm).

***Illicium germanicum* MAI**

23. Germination seed valve from either side, G 4603 (scale bar 1 mm).

***Ocotea rhenana* MENZEL**

24. Almost complete cupule from either side, G 8827 (scale bar 5 mm).
25. Incomplete cupule from either side, G 8826 (scale bar 5 mm).

***Ocotea dorofeevii* HOLÝ**

26. Almost complete mature cupule from either side, G 4321, holotyp, Holý (1975, pl. 3, figs 1, 3) (scale bar 5 mm).
27. Incomplete immature cupule from either side, G 4322, Holý (1975, pl. 3, fig. 6) (scale bar 5 mm).

***Sassafras* cf. *lusaticum* MAI**

28. Empty cupule from either side, G 8966 (scale bar 1 mm).
29. Empty cupule from either side, G 3063 (scale bar 1 mm).

***Phoebe bohemica* MAI**

30. Cupule with rounded fruit from either side, G 8968 (scale bar 1 mm).

## PLATE 5

***Cinnamomum polymorphum* (A. BRAUN) HEER plexus**

1. Complete mature fruit with cupule, G 4305, holotype of *Cinnamomum zlatkoi* HOLÝ (1975, pl. 3, fig. 16) (scale bar 3 mm).
2. Empty cupule from either side, G 4306, as *C. zlatkoi* HOLÝ (1975, pl. 3, figs 14-15) (scale bar 3 mm).

***Cinnamomum lusaticum* MAI**

3. Complete mature fruit with cupule from either side, G 8969 (scale bar 3 mm).

4. Empty cupule from either side, G 8970 (scale bar 3 mm).

***Magnolia burseracea* (MENZEL) MAI**

5. Half of a seed from either side, G 8971 (scale bar 3 mm).
6. Seed from either side, G 8972 (scale bar 3 mm).

***Liriodendron* sp.**

7. Half of a seed from either side, G 3064 (scale bar 1 mm).

***Epipremnites ornatus* (E. M. REID et CHANDLER) GREGOR et BOGNER**

8. Seed from either side, G 3033 (scale bar 1 mm).

***Potamogeton heinkei* MAI**

9. Endocarp from either side, G 8973 (scale bar 1 mm).
10. Endocarp from either side, G 8974 (scale bar 1 mm).

***Potamogeton nochtensis* MAI ex HOLÝ**

11. Endocarp from either side, G 4291, syntype (scale bar 1 mm).
12. Endocarp from either side, G 4295, syntype (scale bar 1 mm).

***Spinophyllum daemonorops* (UNGER) HUARD**

13. Spines attached to a fragment of wood, G 4606, (scale bar 3 mm).

***Dulichium marginatum* (C. et E.M. REID) DOROFEEV**

14. Almost complete fruit from either side, G 3035 (scale bar 1 mm).
15. Almost complete fruit from either side, G 3087 (scale bar 1 mm).

**cf. *Stemona germanica* (MAI) MAI**

16. Seed from either side, G 3067 (scale bar 1 mm).

***Sparganium camenzianum* KIRCHHEIMER**

17. Almost complete endocarp from either side, G 8975 (scale bar 1 mm).
18. Almost complete endocarp from either side, G 8976 (scale bar 1 mm).

***Meliosma miessleri* MAI**

19. Complete globular endocarp from either side, G 8859 (scale bar 1 mm).
20. Half of incomplete globular endocarp from either side, G 8860 (scale bar 1 mm).

***Parabaena europaea* CZECZOTT et SKIRGIELLO**

21. Half of deformed endocarp, ventral and dorsal side, G 4850 (scale bar 1 mm).

***Liquidambar europaea* A. BRAUN plexus**

22. Rounded compressed infructescence from either side, G 4588 (scale bar 3 mm).

***Proserpinaca ervinii* HOLÝ**

23. Fruit from either side, G 4266, holotyp, Holý (1978a, pl. 2, figs 10) (scale bar 1 mm).

## PLATE 6

***Proserpinaca ervinii* HOLÝ**

1. Fruit from either side, G 4264 (scale bar 1 mm).

***Corylopsis* sp.**

2. Isolated seed from either side, G 4588 (scale bar 1 mm).

***Distylium fergusonii* E. KNOBLOCH et KVAČEK plexus**

3. Isolated seed from either side, G 4585 (scale bar 1 mm).

***Vitis lusatica* CZECZOTT et SKIRGIELLO**

4. Seed from either side, G 8839 (scale bar 1 mm).
5. Seed from either side, G 8838 (scale bar 1 mm).

***Vitis parasilvestris* KIRCHHEIMER**

6. Seed from either side, G 8837 (scale bar 1 mm).
7. Seed from either side, G 3050 (scale bar 1 mm).

***Ampelopsis malvaeformis* (SCHLOTHEIM) MAI**

8. Seed from either side, G 8841 (scale bar 1 mm).
9. Seed from either side, G 8840 (scale bar 1 mm).

***Ampelopsis rotundata* CHANDLER**

10. Seed from either side, G 3042, (scale bar 1 mm).
11. Seed from either side, G 8842, (scale bar 1 mm).

***Tetrastigma lobata* CHANDLER**

12. Seed from either side, G 8844 (scale bar 1 mm).
13. Seed from either side, G 3054 (scale bar 1 mm).

***Tetrastigma chandlerae* KIRCHHEIMER**

14. Seed from either side, G 8845 (scale bar 1 mm).
15. Seed from either side, G 8846 (scale bar 1 mm).

***Turpinia ettingshausenii* (ENGELHARDT) MAI**

16. Almost complete seed from either side, G 3045 (scale bar 1 mm).

***Microdiptera parva* CHANDLER**

17. Fragmentary seed from either side, G 3057 (scale bar 500 µm).

***Microdiptera elongata* (DOROFEEV) DOROFEEV**

18. Fragmentary seed from either side, G 3036 (scale bar 500 µm).

***Microdiptera donata* (HOLÝ) KVAČEK et TEODORIDIS comb. nov.**

19. Fragmentary seed from either side, G 4377 (scale bar 500 µm).

***Fagus deucalionis* UNGER plexus**

20. Cupule, G 8822 (scale bar 5mm).

**PLATE 7**

***Fagus deucalionis* UNGER plexus**

1. Cupule from either side, G 8821 (scale bar 5mm).

***Trigonobalanopsis rhamnoides* (ROSSMÄSSLER) KVAČEK et WALTHER plexus**

2. Cupule from either side, G 5403 (scale bar 3 mm).
3. Cupule from either side, G 8819 (scale bar 3 mm).

***Quercus rhenana* (KRÄUSEL et WEYLAND) E. KNOBLOCH et KVAČEK plexus**

4. Impression of an acorn in irestone, G 8813 (scale bar 10 mm).
5. Isolated exocarp of an acorn, G 9286 (KR 175) (scale bar 10 mm).

***Pterocarya limburgensis* C. et E.M. REID**

6. Fragmentary fruit from either side, G 8977 (scale bar 3 mm).
7. Fragmentary fruit from either side, G 8978 (scale bar 3 mm).

***Cyclocarya nemejcii* HOLÝ**

8. Endocarp from either side, G 4307, Holý (1978, pl. 2, figs 2, 3, 9) (scale bar 1 mm).
9. Endocarp from either side, G 4308 (scale bar 1 mm).

***Myrica ceriferiformis* KOWNAS**

10. Complete fruits with exocarp from either side, G 8861 (scale bar 1 mm).
11. Half of endocarp from either side, G 8862 (scale bar 1 mm).

***Myrica cestmiri* HOLÝ**

12. Endocarp from either side, G 4281, holotype (Holý 1977a, p. 113, pl. 1, fig. 9) (scale bar 1 mm).
13. Endocarp from either side, G 4278 (scale bar 1 mm).

***Myrica hudibra* HOLÝ**

14. Endocarp from either side, G 4350, holotype (Holý 1978a, p. 4, pl. 1, fig. 1) (scale bar 1 mm).
15. Fragmentary endocarp from either side, G 4062 (scale bar 1 mm).

***Sapium germanicum* KIRCHHEIMER**

16. Seed from either side, G 3031 (scale bar 1 mm).

***Hypericum septestum* NIKITIN**

17. Seed from either side, G 3069 (scale bar 500 µm).

***Ficus potentilloides* MAI**

18. Compressed endocarp from either side, G 8979 (scale bar 500 µm).
19. Compressed endocarp from either side, G 8980 (scale bar 500 µm).

***Rubus* spp.**

20. Compressed endocarp from either side, G 8858 (scale bar 1 mm).
21. Compressed endocarp from either side, G 8857 (scale bar 1 mm).

***Trema lusatica* MAI**

22. Compressed endocarp from either side, G 3037 (scale bar 1 mm).

**PLATE 8**

***Zanthoxylum kristinae* (HOLÝ) GREGOR**

1. Seed, G 4316 (scale bar 1 mm).
2. Seed from either side, G 4312 (scale bar 1 mm).

***Toddalia latisiliquata* (LUDWIG) GREGOR**

3. Seed from either side, G 3034 (scale bar 1 mm).

***Swida gorbunovii* (DOROFEEV) NEGRU**

4. Endocarp from either side, G 8851 (scale bar 1 mm).

***Nyssa ornithobroma* UNGER**

5. Endocarp from either side, G 8849 (scale bar 3 mm).
6. Endocarp from either side, G 8848 (scale bar 3 mm).
7. Endocarp from either side, G 8847 (scale bar 3 mm).

***Mastixia lusatica* MAI**

8. Endocarp from either side, G 236 (scale bar 5 mm).
9. Complete endocarp from either side, G 8834 (scale bar 5 mm).

***Diplopanax limnophilus* (UNGER) CZAJA**

10. Fruit from either side, G 4228 (scale bar 5 mm).

***Eomastixia saxonica* (MENZEL) HOLÝ**

11. Complete fruit from either side, G 4178 (scale bar 5 mm).
12. Endocarp from either side, G 4148 (scale bar 5 mm).

***Tectocarya elliptica* (UNGER) HOLÝ**

13. Stone fruit from either side, G 4241 (scale bar 5 mm).

***Retinomastixia oertelii* GREGOR**

14. Fruit from either side, G 4258 (scale bar 5 mm).
15. Fruit, G 4259 (scale bar 5 mm).

**PLATE 9**

**cf. *Tectocarya robusta* KIRCHHEIMER**

1. Complete endocarp from either side, G 4190 (scale bar 5 mm).

***Leucothoë narbonnensis* (SAPORTA) WEYLAND plexus**

2. Almost complete fruit from either side, G 8853 (scale bar 1 mm).
3. Fragmentary fruit from either side, G 8854 (scale bar 1 mm).

***Ternstroemia chandlerae* HOLÝ**

4. Seed from either side, G 4303 (scale bar 1 mm).
5. Seed from either side, G 4304, holotype (Holý 1978a, pl. 3, figs 8, 9) (scale bar 1 mm).

***Eurya stigmosa* (LUDWIG) MAI**

6. Almost complete seed from either side, G 3059 (scale bar 1 mm).

***Rehderodendron custodum* HOLÝ**

7. Fruit fragment, G 4328 (scale bar 5 mm).
8. Fruit fragment, G 4228 (scale bar 5 mm).

***Symplocos schererii* KIRCHHEIMER**

9. Endocarp from either side, G 8981 (scale bar 3 mm).

***Symplocos casparyi* LUDWIG**

10. Endocarp from either side, G 8982 (scale bar 1 mm).
11. Endocarp from either side, G 8983 (scale bar 1 mm).

***Symplocos pseudogregaria* KIRCHHEIMER**

12. Endocarp from either side, G 8984 (scale bar 1 mm).

***Symplocos minutula* (STERNBERG) KIRCHHEIMER**

13. Endocarp from either side, G 8985 (scale bar 5 mm).

***Sphenotheca incurva* KIRCHHEIMER**

14. Fruit from either side, G 5404 (scale bar 3 mm).

**Araliaceae gen. et sp. indet.**

15. Complete endocarp (?), missing (refigured from Holý 1975, p. 93, pl. 80, fig. 9) (scale bar 1 mm).
16. Complete endocarp (?), missing (refigured from Holý 1975, p. 93, pl. 80, fig. 8) (scale bar 1 mm).

***Ilex* cf. *protogaea* MAI**

17. Endocarp from either side, G 3062 (scale bar 1 mm).

***Ilex saxonica* MAI**

18. Endocarp, G 3056 (scale bar 1 mm).

***Ilex wiesaensis* MAI**

19. Endocarp, G 3061 (scale bar 1 mm).

***Sambucus pulchella* C. et E.M. REID**

20. Seed from either side, G 8855 (scale bar 5 mm).
21. Seed from either side, G 8856 (scale bar 5 mm).

**PLATE 10**

***Pronephrium stiriacum* (UNGER) E. KNOBLOCH et KVAČEK**

1. Abaxial epidermis, G 8866 (KR 240) (× 300).

**Polypodiaceae gen. et sp. indet.**

2. Group of trichomes on abaxial epidermis, G 8867a (KR 77) (× 250).

***Tsuga schneideriana* KUNZMANN et MAI**

3. Abaxial epidermis, G 8868b (KR 104A/1) (× 300).
4. Abaxial cuticle, G 8871 (KR 489) (× 300).

***Cathaya roseltii* SCHNEIDER**

5. Abaxial epidermis, G 8872c (KR 103A/2) (× 300).

***Tetraclinis salicornioides* (UNGER) KVAČEK**

6. Cuticle with stomata, G 8874b (KR 238/1) (× 300).

***Glyptostrobus europaeus* (BRONGNIART) UNGER**

7. Cuticle with stomata, G 8880 (KR 336) (× 300).

***Sequoia abietina* (BRONGNIART in CUVIER) E. KNOBLOCH**

8. Cuticle of a scale leaf from the stalk of a seed cone, G 4593b (× 300).

***Cupressospermum saxonicum* MAI**

5. Cuticle of a scale leaf from the stalk of a seed cone, G 4595b (× 300).

***Laurus abchasica* (KOLAKOVSKII et SHAKRYL) FERGUSON**

10. Adaxial cuticle, G 8890b (KR 176/1) (× 300).
11. Abaxial cuticle, G 8890b (KR 176/1) (× 300).

***Ocotea hradekensis* (KVAČEK et BŮŽEK) KVAČEK**

12. Adaxial cuticle, G 8895b (KR 300/1) (× 300).

**PLATE 11**

***Ocotea hradekensis* (KVAČEK et BŮŽEK) KVAČEK**

1. Abaxial cuticle, G 8895b (KR 300/1) (× 300).

***Laurophyllum pseudoprinceps* WEYLAND et KILPPER**

2. Adaxial cuticle, G 8906b (KR 125/1) (× 300).
3. Abaxial cuticle, G 8906b (KR 125/1) (× 300).

***Laurophyllum rugatum* KVAČEK et BŮŽEK**

4. Adaxial cuticle, G 8964b (KR 7/1) (× 300).
5. Abaxial cuticle, G 8964b (KR 7/1) (× 300).

***Laurophyllum pseudovillense* KVAČEK**

6. Abaxial cuticle, G 9001b (KR 477/1) (× 300).
7. Abaxial cuticle, G 9001b (KR 477/1) (× 300).

***Laurophyllum* sp.**

8. Adaxial cuticle, G 9005b (KR 2/1) (× 300).
9. Abaxial cuticle, G 9005b (KR 2/1) (× 300).

***Cinnamomum polymorphum* (A. BRAUN) HEER plexus**

10. Adaxial cuticle, G 9058b (KR 257/1) (× 300).
11. Abaxial cuticle, G 9058b (KR 257/1) (× 300).
12. Abaxial cuticle, G 9031b (KR 142/1) (× 300).

**PLATE 12**

***Viscum morlotii* (UNGER) E. KNOBLOCH et KVAČEK**

1. Abaxial cuticle, G 9157 (KR 33) (× 300).

***Distylium fergusonii* E. KNOBLOCH et KVAČEK plexus**

2. Abaxial cuticle, G 9167 (KR 70) (× 300).

**Vitaceae gen. et sp. indet.**

3. Dispersed abaxial cuticle, G 9171a (KR 325A) (× 300).

***Leguminosites hradekensis* (E. KNOBLOCH et KVAČEK) KVAČEK et TEODORIDIS, comb. n.**

4. Adaxial and abaxial cuticle, G 9175b (KR 410/1) (× 300).

5. Adaxial cuticle, G 9172b (KR 21/1) (× 300).
6. Abaxial cuticle, G 9172b (KR 21/1) (× 300).

***Alnus julianiformis* (STERNBERG) KVAČEK et HOLÝ**

7. Adaxial cuticle, G 9179c (KR 194B/2) (× 300).
8. Abaxial cuticle, G 9179c (KR 194B/2) (× 300).

***Fagus deucalionis* UNGER plexus**

9. Adaxial cuticle, G 9187 (KR 11/1) (× 300).
10. Abaxial cuticle, G 9187 (KR 11/1) (× 300).

***Trigonobalanopsis rhamnoides* (ROSSMÄSSLER) KVAČEK et WALTHER plexus**

11. Adaxial cuticle, G 9207b (KR 98/1) (× 300).
12. Abaxial cuticle, G 9207b (KR 98/1) (× 300).

## PLATE 13

***Quercus bavarica* (E. KNOBLOCH et KVAČEK) KVAČEK**

1. Abaxial cuticle, G 9267b (KR 496/1) (× 300).
2. Abaxial cuticle, G 9267b (KR 496/1) (× 300).

***Quercus rhenana* (KRÄUSEL et WEYLAND) E. KNOBLOCH et KVAČEK plexus**

3. Adaxial cuticle, G 9272 (KR 95) (× 300).
4. Abaxial cuticle, G 9272 (KR 95) (× 300).

***Engelhardia orsbergensis* (WESSEL et WEBER) JÄHNICHEN, MAI et WALTHER**

5. Abaxial cuticle, G 9299c (KR 479/3) (× 300).

***Myrica lignitum* (UNGER) SAPORTA**

6. Abaxial cuticle, G 9308b (KR 140/1) (× 300).
7. Abaxial cuticle, G 9308b (KR 140/1) (× 300).

***Myrica pseudointegerrima* WEYLAND et KILPPER**

8. Abaxial cuticle, missing (refigured from Kvaček 1966, pp. 42, 165, pl. 10, fig. 2, KR 340) (× 300).

***Salix varians* GÖPPERT**

9. Adaxial cuticle, G 9319b (KR 427/1) (× 300).
10. Abaxial cuticle, G 9319b (KR 427/1) (× 300).

***Acer tricuspidatum* BRONN emend. WALTHER**

11. Adaxial cuticle, G 9320b (KR 45/1) (× 300).
12. Abaxial cuticle, G 9320b (KR 45/1) (× 300).

## PLATE 14

**? *Sapindus* sp.**

1. Adaxial cuticle, G 9327e (KR 22/4) (× 300).
2. Abaxial cuticle, G 9327d (KR 22/3) (× 300).

***Sapindus* sp.**

3. Abaxial cuticle for comparison, as *Sapindus mukorossi* GAERTN., coll. National museum, Prague, SE China (× 300).

***Gordonia hradekensis* (KVAČEK et BŮŽEK) BOZUKOV et PALAMAREV**

4. Adaxial cuticle, G 9329b (KR 29/1) (× 300).
5. Abaxial cuticle, G 9329b (KR 29/1) (× 300).

***Fraxinus bilinica* (ETTINGSHAUSEN) KVAČEK et HURNÍK**

6. Adaxial cuticle, 9383 (KR 91) (× 300).
7. Abaxial cuticle, 9383 (KR 91) (× 300).

**? *Monocotyledonae* gen. et sp. indet.**

8. Dispersed cuticle, G 9398 (KR 324) (× 300).

***Symplociphyllum weylandii* KVAČEK et BŮŽEK**

9. Adaxial cuticle, G 9399c (KR 182/2) (× 300).
10. Abaxial cuticle, G 9399c (KR 182/2) (× 300).

**cf. "*Illicium*" *limburgense* KRÄUSEL et WEYLAND sensu LITKE**

11. Adaxial cuticle, G 9400b (KR 347/1) (× 300).
12. Abaxial cuticle, G 9400b (KR 347/1) (× 300).

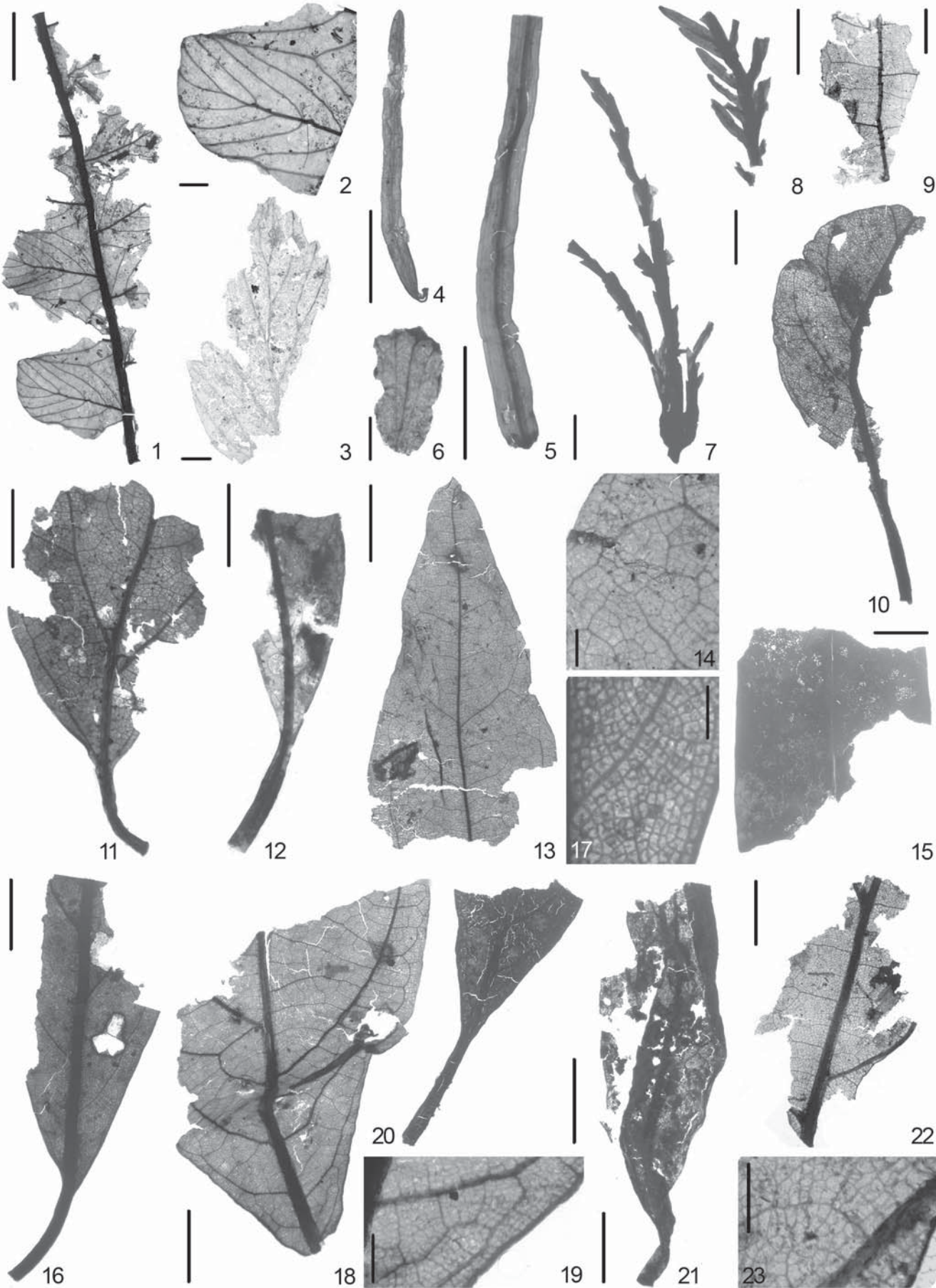


PLATE 2

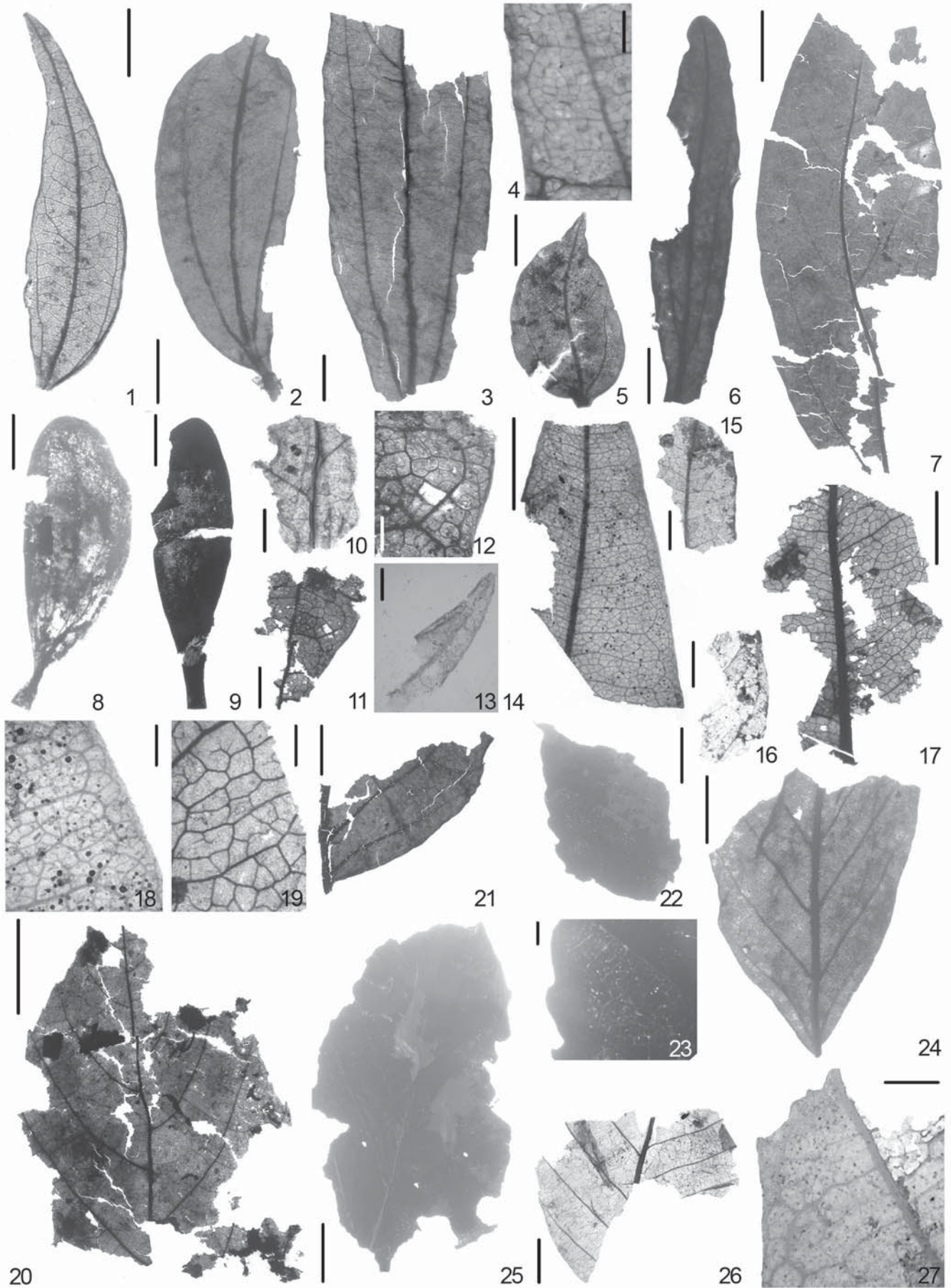
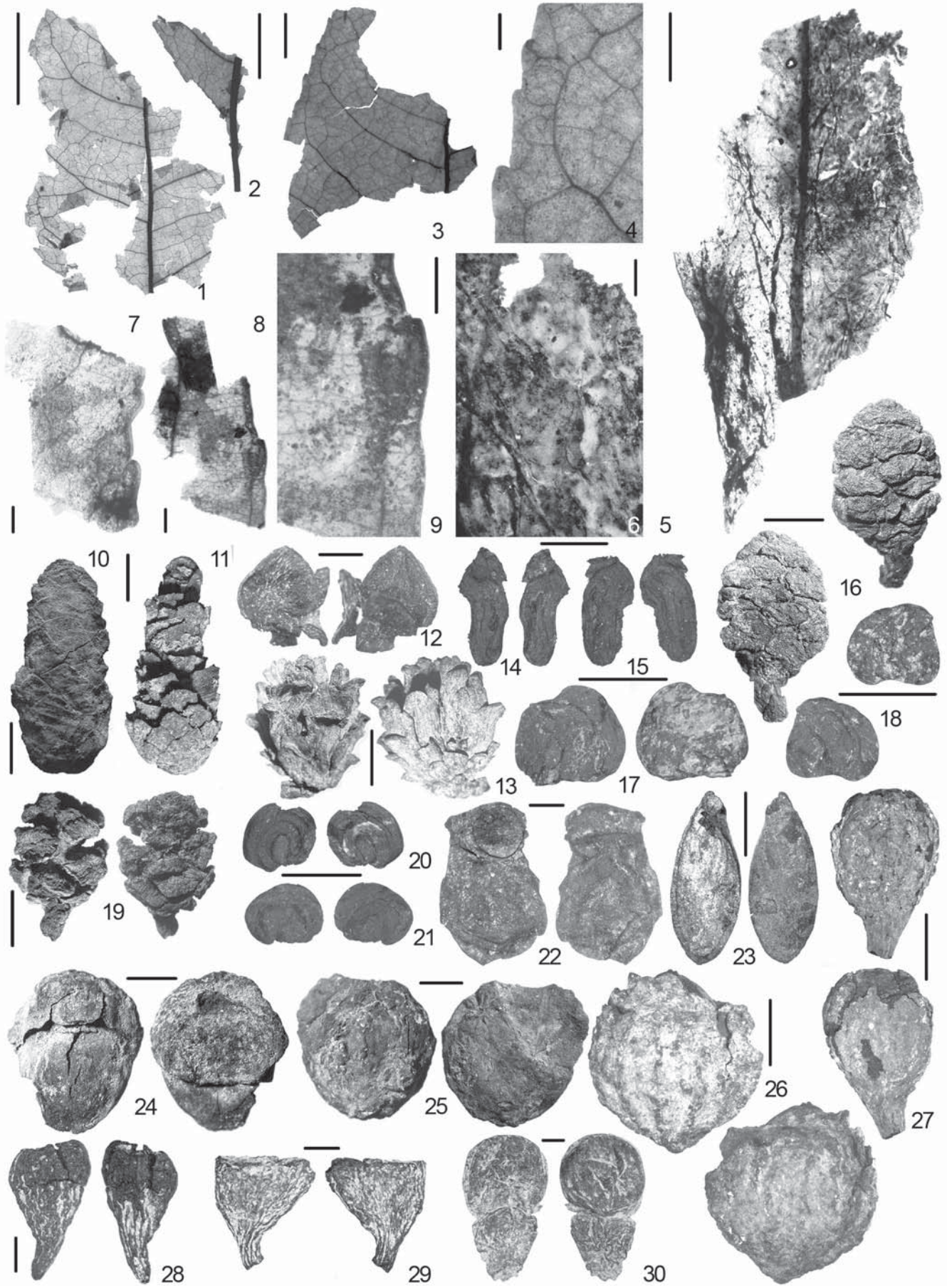




PLATE 4





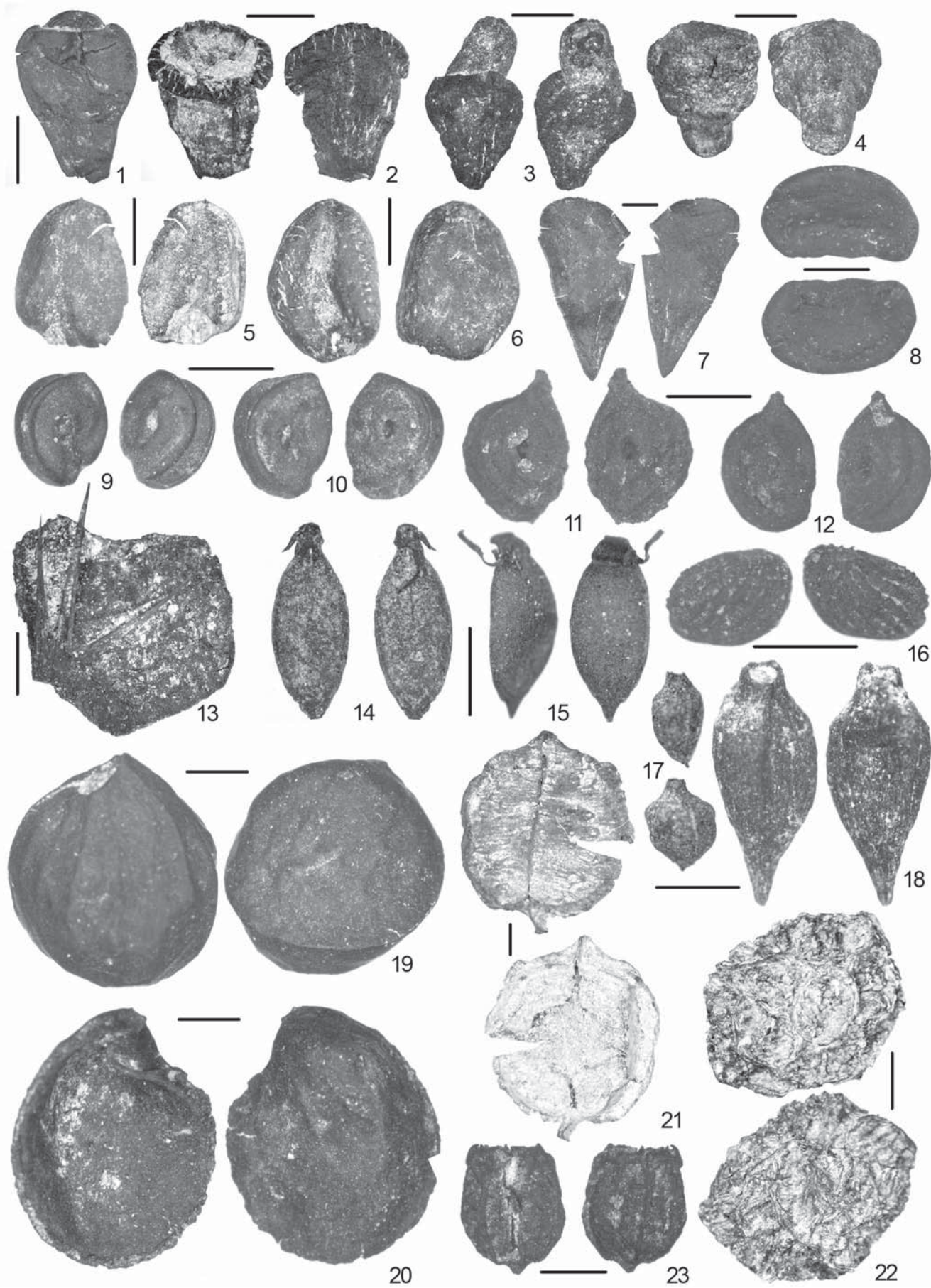


PLATE 6



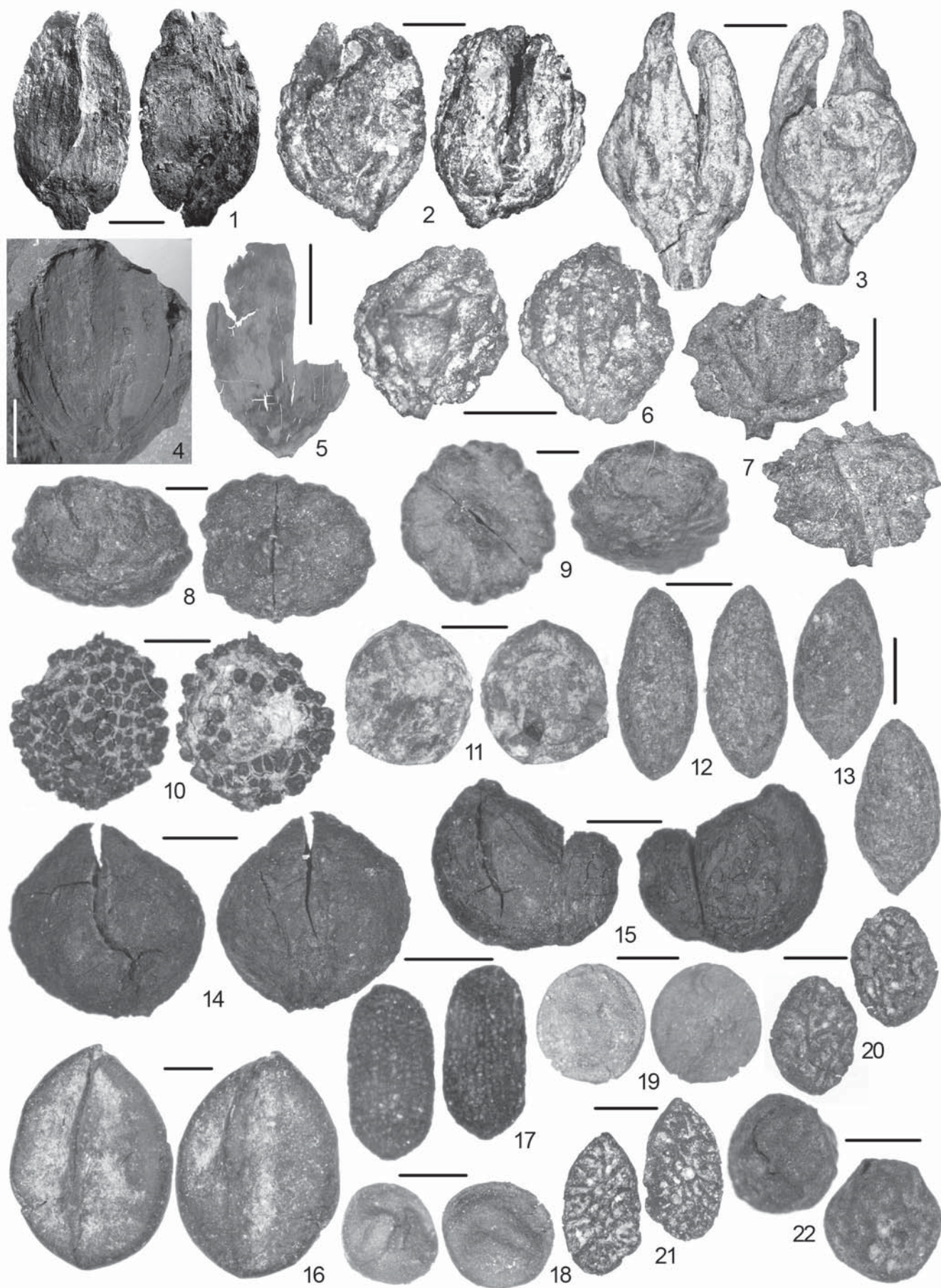
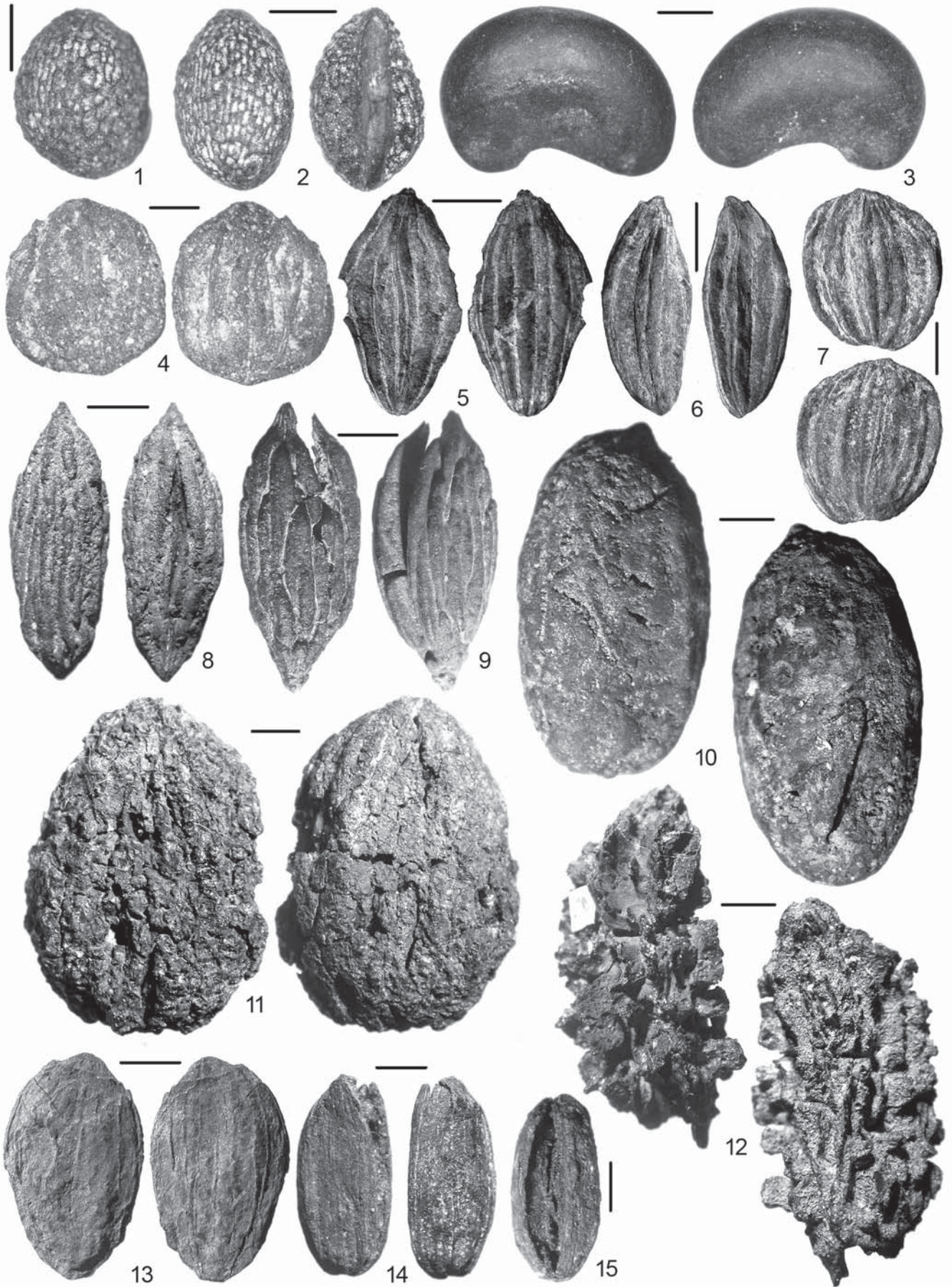


PLATE 8



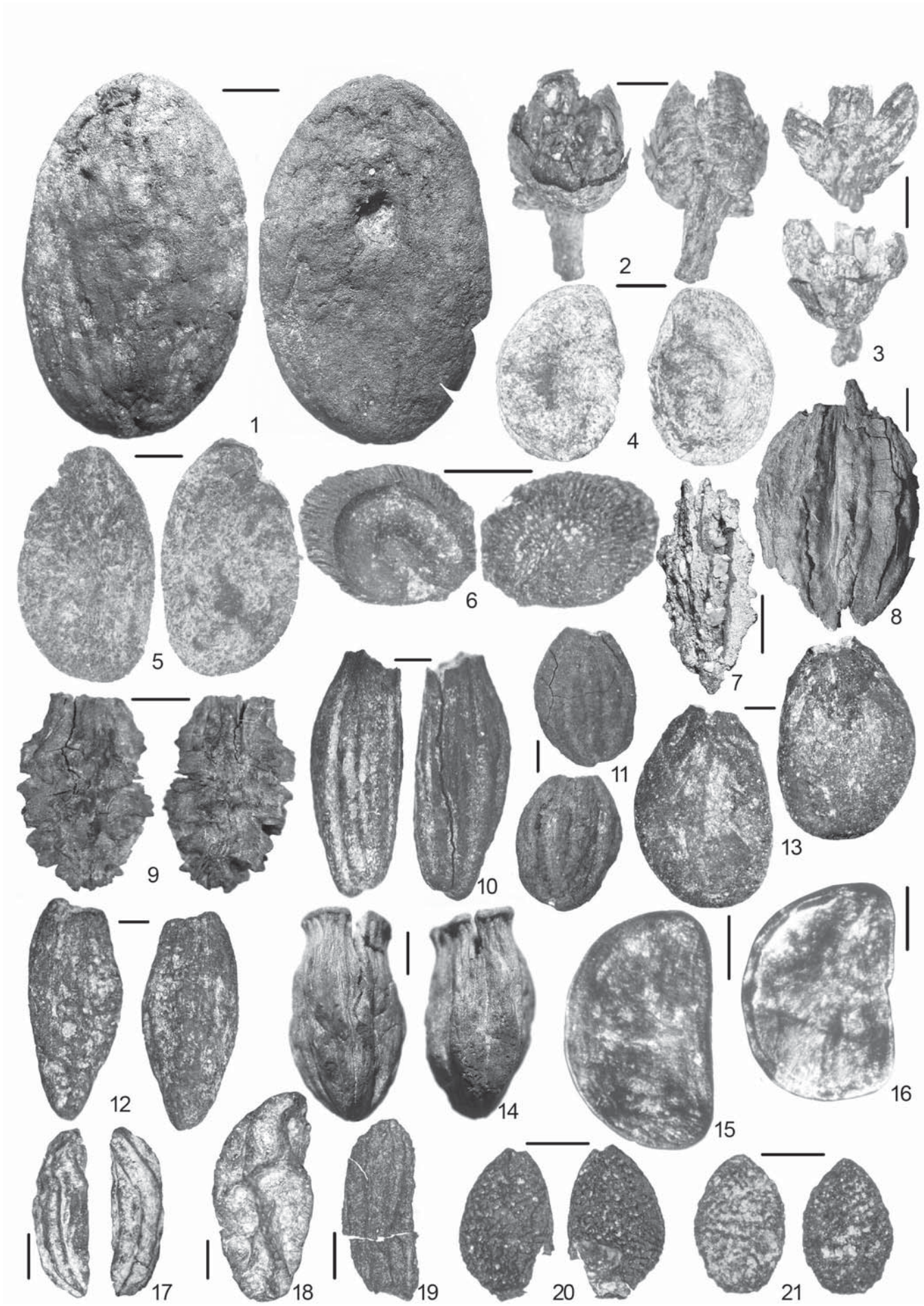
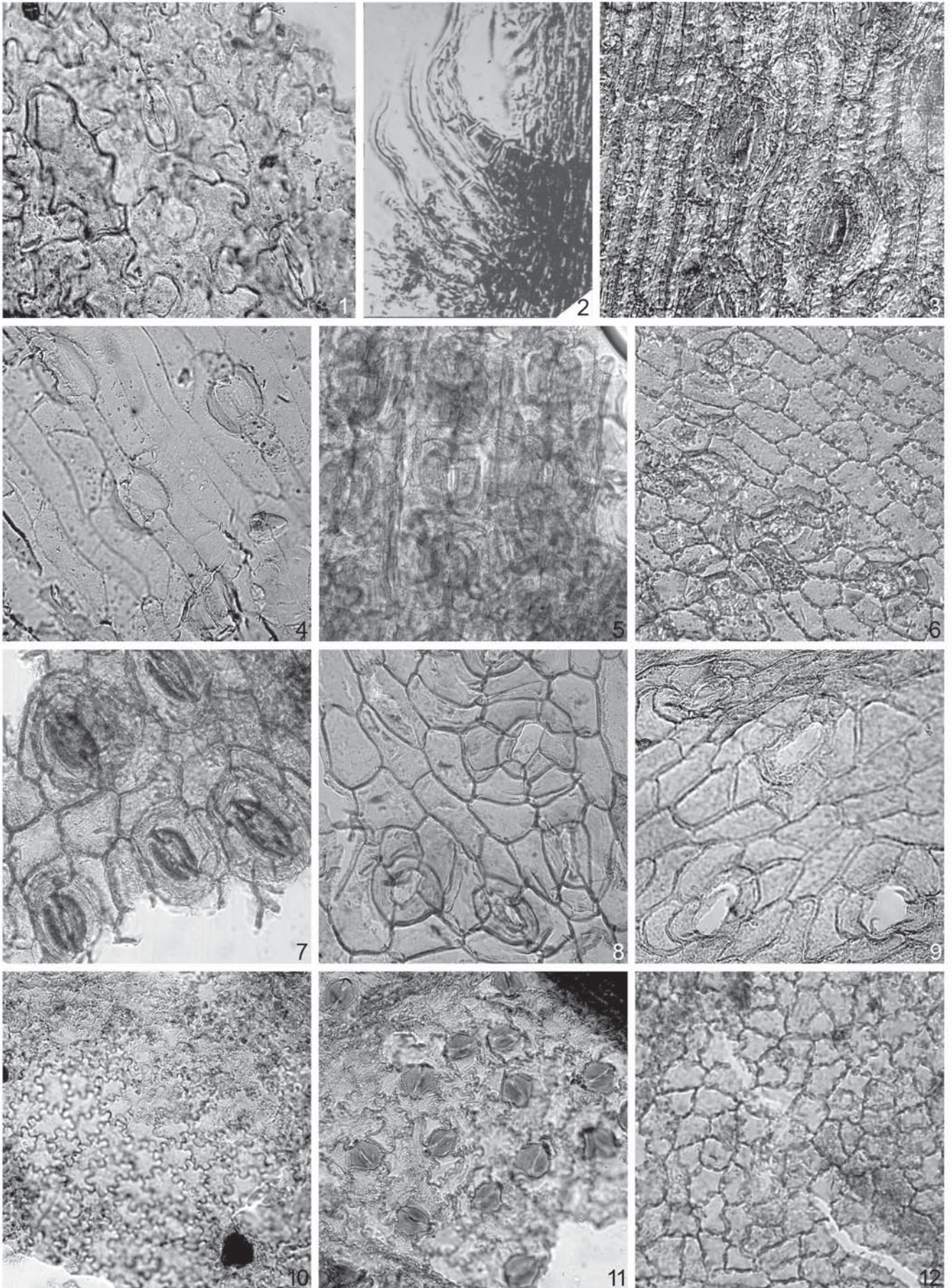


PLATE 10



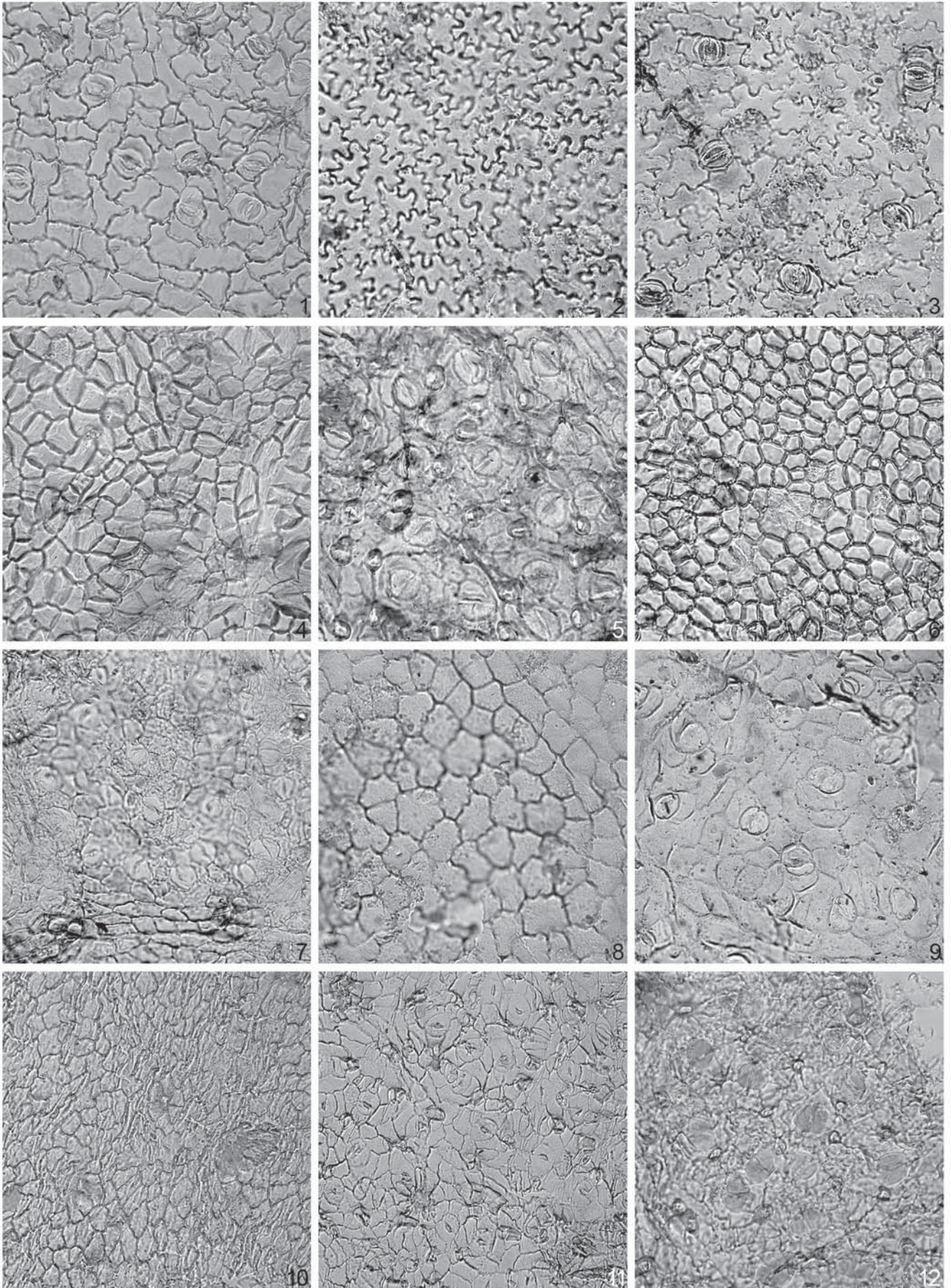
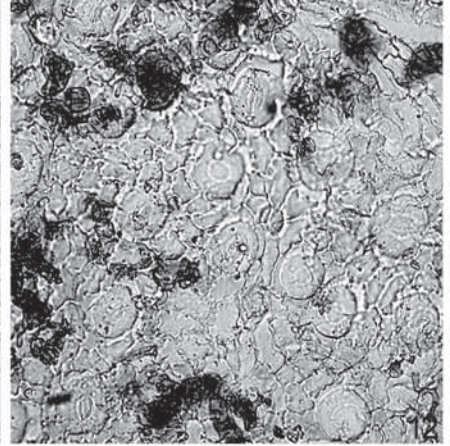
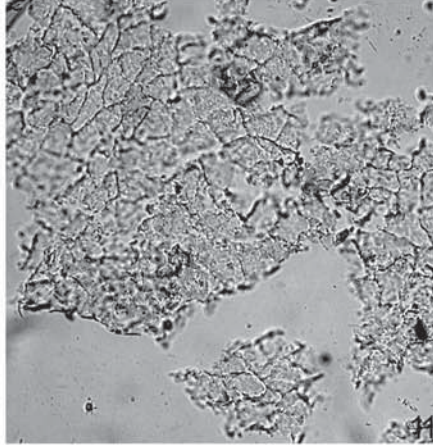
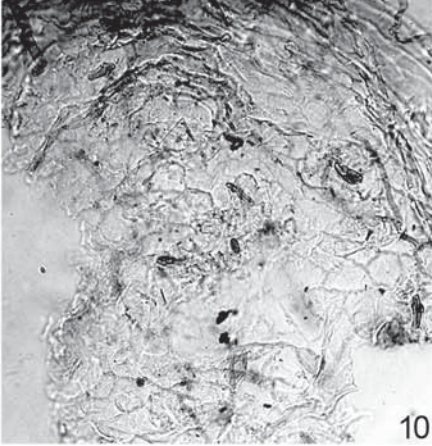
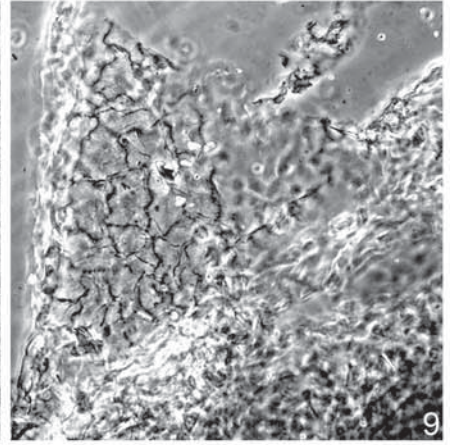
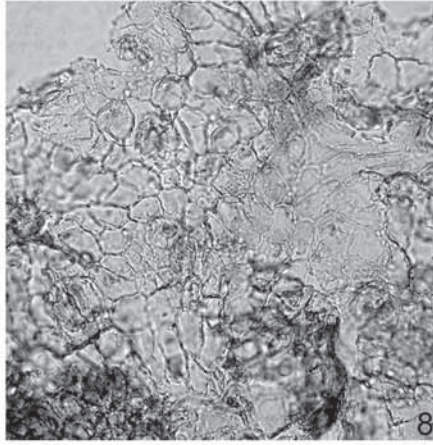
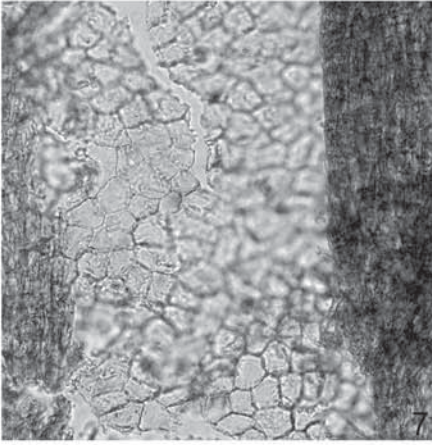
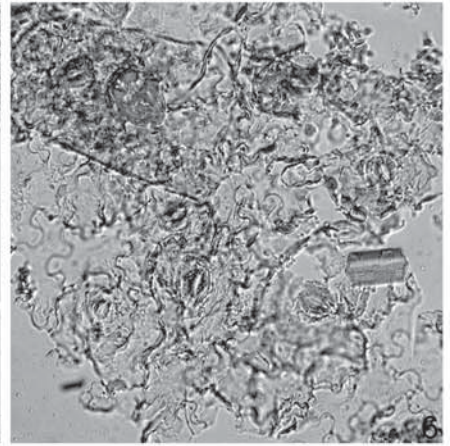
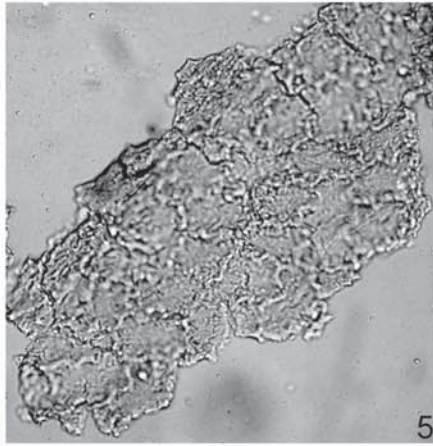
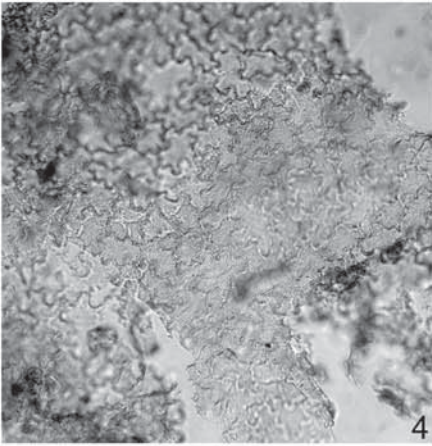
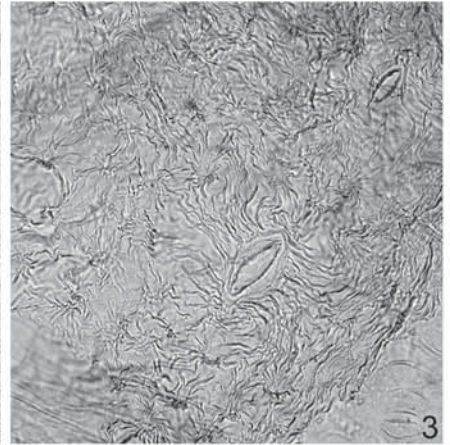
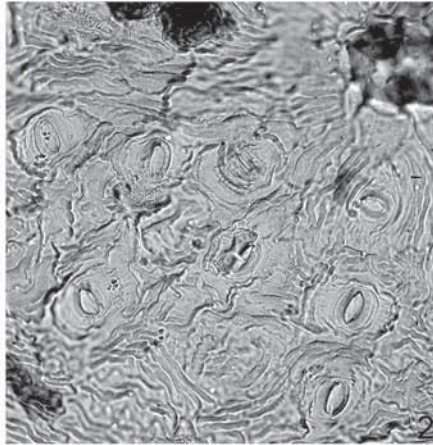
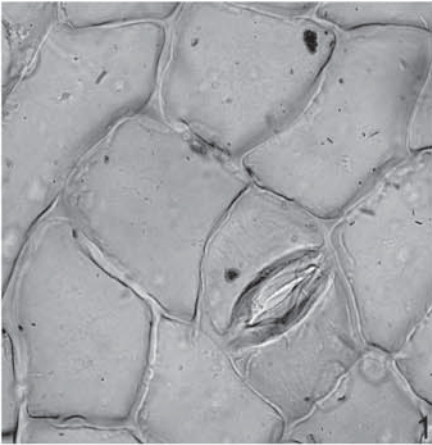


PLATE 12





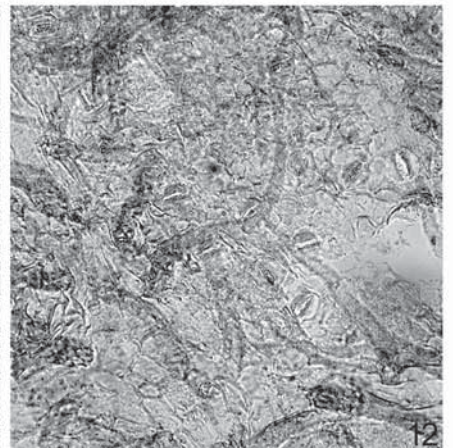
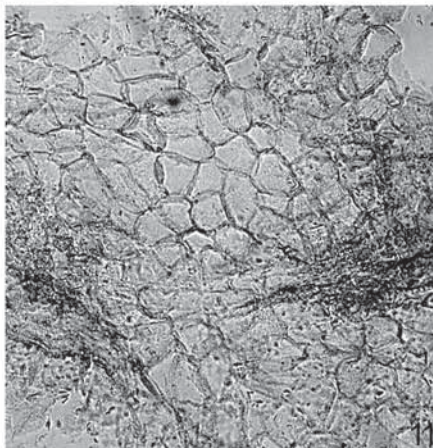
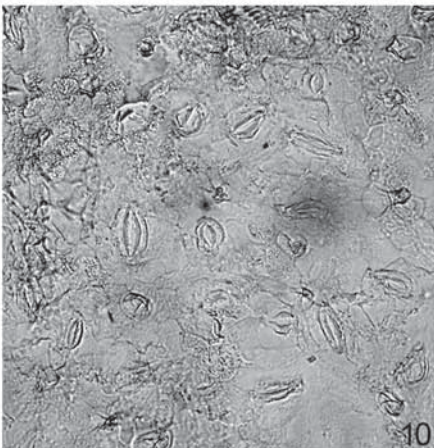
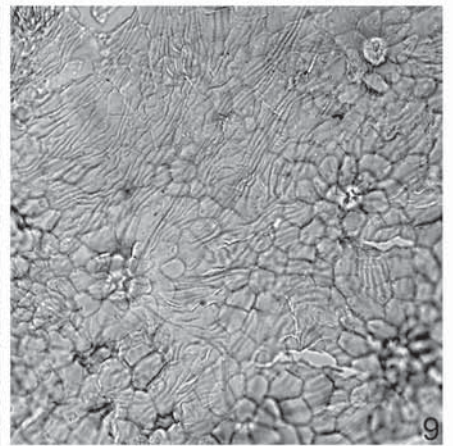
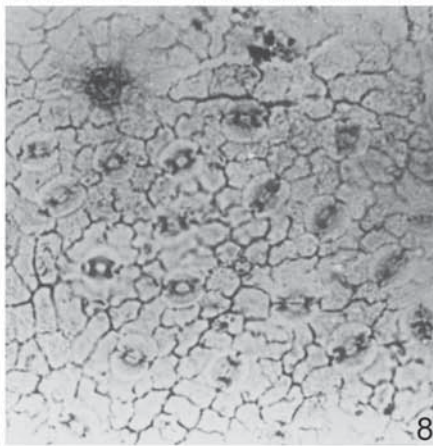
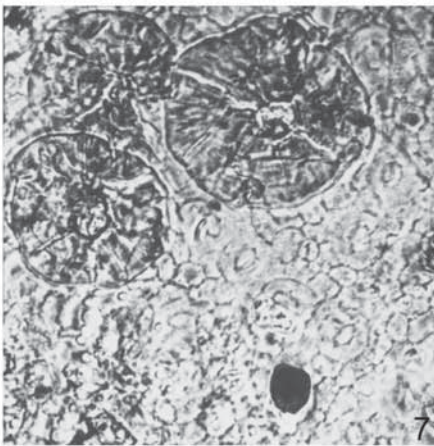
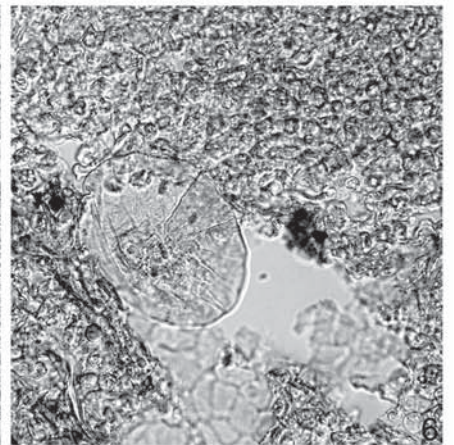
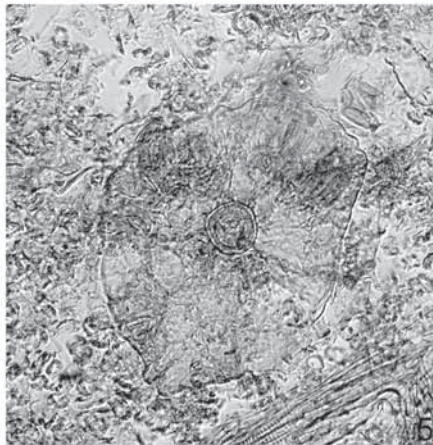
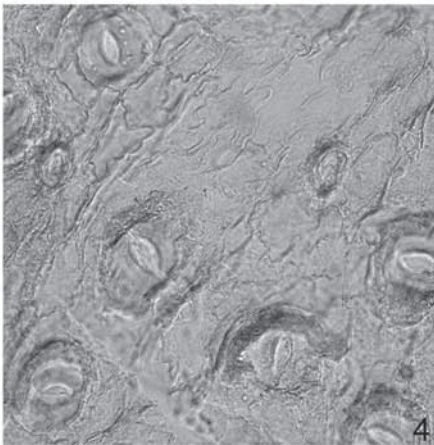
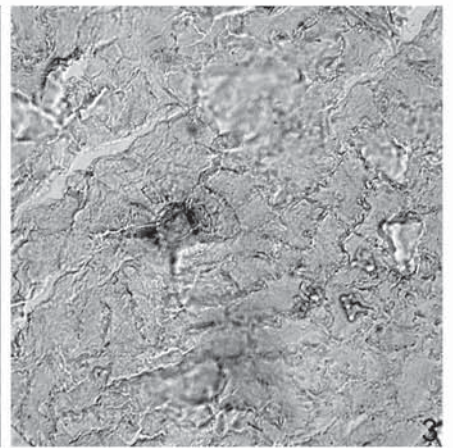
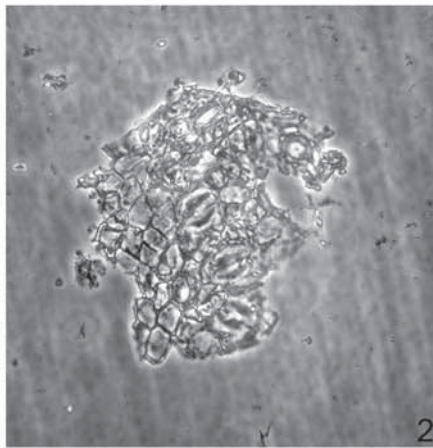
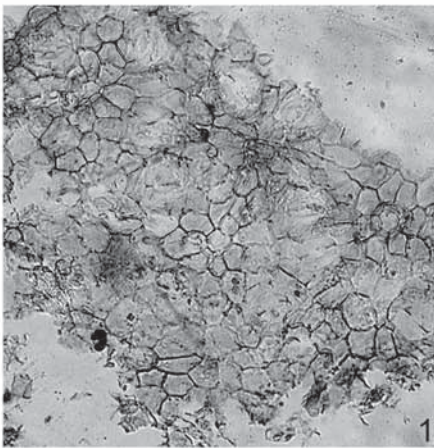


PLATE 14

