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 (prevailing Lauraceae, Fagaceae, rarely Hamamelidaceae, Myricaceae, Geinitziaceae, and angiosperms (prevailingly Lauraceae, Fagaceae, rarely Hamamelidaceae, Myricaceae, Juglandaceae, Leguminosae (including *Leguminosites hradekensis* E. Knoblch 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. *Microbaptus donata* (Holý) Kvaček et Teodoridis comb. n.), Haloragaceae, Altingiaceae, Ulmaceae, Rosaceae, Ericaceae, Symlocaceae, Rutaceae, Aquifoliaceae, Staphyleaceae, Vitaceae, Sabiaceae, Caprifoliaceae, Potamogetonaceae, Arecales, 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, WMT 24.0 °C, CMT 6.2 °C, 3–WET 131.7 cm, 3–DRY 20.0 cm, GROWSEAS 20.3 cm, GROWSEAS 10.3 month, GROWSEAS 203.1 cm, MMGSP 9.9 cm, RH 54.5 %, ENTHAL 29.9 kJ/kg; LMA estimates – MAT1 is 21.1 °C (sensu Wolfe 1979) and MAT2 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.

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 (Zabystřan 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. (Grottau in German) started as a joint project involving František Holý, Čestmír 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 (Opluštil 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 Zittau (Žitava, Zitawa) Basin near the state boundary between the Czech Republic and Germany, 5 km south of Zittau 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 Kralóvě, 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. 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 (Zitava, Žitawa) 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 Graihan (in Graihan 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 particular 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 horizontal zones 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 peagravels and coarse-grained sands, (G) coarse-grained sands with clayish silts with Fagus, Ocoea, 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 19th (Poppe 1866, Engelhardt 1870, 1878) and 20th centuries (e.g., Heinke 1932, Mai 1960, 1964, Czeccott et al. 1959 and other continuations of this collectiv opus). The exploration of the mastixoid 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 Ziembińska-Tworydlo (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 8th EPPC in Budapest, 2010. This approach already created several “plexus” species accepted in the current palaeobotanical practice, e.g. Dolistoborus 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 Polydoptites stiriacus UNGER, p. 121, pl. 36, figs 1-5 (Parschlug, Schönegg, Arnfels, Trofaich).
    1852 Goniopteris stiriaca (UNGER) A. BRAUN, p. 555.
    1860 Lastraea stiriaca (UNGER) HEER, p. 31, pls 7-8 (Eritz, Rochette, St. Gallen, Ruppen, Hoher Rhonen).
    1960 Cyclosorus stiriacus (UNGER) CHING et TAKHITAJAN in FATAILEV, 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 (Murnerweiler).
    2002 Pronephrium stiriacum (UNGER) E. KNOBLOCH et KVAČEK; Kvaček, p. 221, pl. 4, fig. 7 (Kučín).

Incomplete sterile pinnae bearing several pinnules on a slender rachis (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. Anticlinal cell walls coarsely undulate, stomata polycytic, broadly elliptic, sub-parallelly arranged; guard cells 40–50 µm long and 15–25 µm wide with a narrow pore.

Discussion: 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 (Czeccott 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).


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, anticlinal 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.

Discussion: The preserved traits of the fragment are not sufficient for identification within the natural fern system.

Material: 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. 15, 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 anticinal 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 × 50 µm in size.

Discussion: Fossil needles similar to those described above from the Kristina Mine (Kvaček 1966, 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, monocylic, with lateral subsidiary cells elongate, little different from non-modified cells, and two polar subsidiary cells relatively elongate, often shared by adjacent stomata.

Discussion: Kvaček (1966) assigned these fossils to Pseudotsuga on account of the stomatal arrangement (monocylic, 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).

Material: 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 thomasiensis 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 thomasiensis (GÖPPERT) HEER; Menzel, p. 21, pl. 3, figs 1–10 (Herzogenrath).

1919 Pinus thomasiensis (GÖPPERT) REICHENBACH in KRAUSEL, p. 115, pl. 10, figs 29–30 (Weigersdorf).

1964 Pinus thomasiensis (GÖPPERT) REICHENBACH; Mai, pp. 15, 58, 86, pl. 1, fig. 3, pl. 12, fig. 1 (Wiesa, Piskowitz, Sandfürsten, Weigersdorf).

1966 Pinus thomasiensis (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 exomucronate showing a shallow transverse wrinkle (Holý 1975, p. 11, pl. 1, fig. 6, as Pinus cf. thomasiensis (GÖPPERT) REICHENBACH).

Discussion: These mostly abraded seed cones were tentatively identified by Holý (1966, 1975, 1977a) as Pinus cf. thomasiensis 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).

**Material:** Ca. 20 partly abraded seed cones, G 7708, G 8815-17, Gs 102.

**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 *Thuius salicornioides* Unger, p. 11, pl. 2, figs 1-4, pl. 20, fig. 8 (Radoboj).


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, trivedined 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.

**Discussion:** 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 *Dictaxocladus* 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 *Dictaxocladus* and widely spread in *Tetraclinis salicornioides*. More pronounced differences are in the seed cones (subglobose in racemose fertile branches in *Dictaxocladus* vs quadrivalvate solitary, rarely paired in *Tetraclinis*) and leaf anatomy (non-papillate straight-walled stomatal zones with thin Florin rings in *Dictaxocladus* 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.

**Material:** 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).


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).

**Discussion:** The variation of foliage matches the situation described by Kovar-Eder (1996) in Kőflach and Kvaček et al. (2011) in Arjuzanx. Some of cryptomerioid and cupressoid foliage types show dicyclic stomata unlike typically incompletely tricyclic amphicyclocytic stomata of
Quasisequoia couttsiae 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 (Staunton 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).


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 univeneed helically and distichously arranged needles 1.5 mm wide and ca. 6 mm long, blunt at apex, hypostomatic, with amphiycycloic 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. Stomatata biciclic to incompletely tricyclic, obliquely arranged corresponding to the view of Holý (1975), from the records of Hródek/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 SHIRINVASAN et FRIIS. The morphological differences between seeds and cones of both taxa are well defined by Pingen (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).


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 biciclic, 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 macro 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 macro. 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 locality exclusively 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 Cupressospernum saxonicum, originally based on dispersed seeds, and recognized this conifer at Herzogenrath among fossils described as Sequoia couthtiae 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.

Pseudoeyryale Dorofeev

Pseudoeyryale sp.

Pl. 4, fig. 22

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 Pseudoeyryale 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 Netherlands 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 (Hradék/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 Shkryl) Ferguson

Pl. 1, fig. 9, pl. 10, figs 10-11
1958 Laurphyllum abhasicum Kolakovskii et Shkryl in Kolakovskii, p. 346, pl. 7, figs 1-3, pl. 10, figs 4-8 (Duab).
1966 Laurphyllum abhasicum Kolakovskii et Shkryl; Kvaček and Bůžek, p. 201 ("abhasiaca"), pl. 1, figs 1-2, pl. 4, fig. 7 (lectotypification) (Hradék/N., Kristina Mine).
1974 Laurus abchasica (Kolakovskii et Shkryl) 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 Shkryl (1958) who suspected affinities of Laurphyllum abhasicum 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 pliciocenica (Saporta et Marion) Kolakovskii (1964) still remains unresolved. Ferguson (1974) stated that Laurus azorica (Steud.) Franco (= Laurus canariensis Webb et Berth. non Willd.) of the Canary Islands must be considered as the nearest living relative rather than Laurus 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 Belchatów. 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.

**Material:** 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 brochidodromous, 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 parallel, straight to sinuous, rarely forked, veination 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 25–30 µm long, guard cells 6–8.7 long, 3.0–4.2 mm wide, perianth penta- to hexameric, 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.

**Discussion:** 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 pseudoprinces* described below is one candidate, because it is sometimes closely associated with *Ocotea rhenana* in Rhineland (Z. Kvaček, own observation).

**Material:** 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).

**Material:** Eight fruits and cupules, G 4318, 4321-22, 4324-25.

**Sassafras TREW.**

**Sassafras cf. lusaticum MAI**

Pl. 4, figs 28-29


1977a *Sassafras cf. lusaticum* MAI; Holý, p. 112 (Hrádek/N., Kristina Mine).

Cupules narrow funnel-shaped, 5.5–6.8 mm wide 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).

**Discussion:** As stated by Holý (1975), the identification is equivocal due to poor preservation and scarcity of the material.

**Material:** Empty cupules, G 3063, 8966.

**Phoebe NEES**

**Phoebe bohemica MAI**

Pl. 4, fig. 30

1971 *Phoebe bohemica* MAI; Holý, p. 112 (Hrádek/N., Kristina Mine).

Cupules thin-walled, empty 3.7–5 mm long, with fruits 6–8.7 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).

Discussion: 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.

Material: Cupules, some with fruits inside, G 3051, 8967, 8968.

Laurophyllum GÖPPERT

Laurophyllum pseudoprinceps WEYLAND et KILPPER

Pl. 1, figs 10-12, 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 4-4, 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, 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 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.

Discussion: 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).

Material: 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, anticinal 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.


*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.


*Cinnamomum* L. sect. *Camphora* NEES

*Cinnamomum* polymorphum (A. BRAUN) HEER plexus

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

1845 *Ceanothus polymorphus* A. BRAUN, p. 171 (Öhningen).
1847 *Ceanothus bilicinum* UNGER, p. 145, pl. 49, fig. 9 (Bilina).
1851 *Daphnogene polymorpha* (A. BRAUN) ETTINGHAUSEN, 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, 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, pl. 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 suprabasal 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 anticinal 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, anticinal 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 (*bilicinica* or *scheuchzeri* forms) to broadly oval (*polyphorum, buchii* and *spectabile* forms) have been considered as ecotypic 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, Pingen et al. 1994, Mai 1999b). It is a typical member of many Miocene floras in Europe, namely of the mastixioid type. Kváček and Walther (1974) hesitated to merge all triveined leaf forms of the European Cenozoic into a single entity and distinguished *Daphnogene cinnamonifolia* (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 cinnamonifolia* and *Cinnamomum polymorphum*.


*Cinnamomum L. sect. Malabathrum MEISSN.*

*Cinnamomum lusatium MAI*

Pl. 5, figs 3-4


1977a *Cinnamomum lusatium 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).

**Discussion:** Cinnamomoid fruits in the Hrádek flora occur in two forms assigned 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 Sandförstgen (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).

**Material:** Ca. 20 seeds and more fragments, G 3605, 4605, 4620, 8971-72, Gs 3072.

*Liriodendron L.*

*Liriodendron sp.*

Pl. 5, fig. 7


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

**Discussion:** 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).

**Material:** 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 *Epipremnium ornatum* E. M. Reid et Chandler, p. 83, pl. 4, figs 24-25 (Bembridge).


1984 *Epipremnites ornatus* (E. M. Reid et Chandler) GREGOR et BOGNER, p. 6, text-fig. 1, 2/6 (Bembridge).


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).

**Discussion:** 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 Sandförstgen (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).

**Material:** Fragment of seed, G 3064.
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).

Discussion: 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.

Material: 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).

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.).

Discussion: 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* Purs., *P. foliosus* RAF. and *P. heterophyllus* Schreb. (Holý 1978a, p. 100).

Teodoridis (2003) reported morphologically similar endocarps identified as *Potamogeton wiesaensis* Kirchheimer from the Hr 51 drill core near Hrádek /N. However, *P. wiesaensis* 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. wiesaensis* with both the latter mentioned species because of smaller size of endocarps with a relatively indistinct keel and shallow central depressions.

Material: 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).

Material: About 100 endocarps, G 3041, 4289-99, Gs 83, 107, 110.

**Arecales 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 *Palmacies daemonorops* (UNGER) Heer, p. 36, pl. 4, figs 7-15 (Bovey Tracey).
1937 *Palmoxylen daemonorops* (UNGER) Kirchheimer, p. 46, fig. 43 (Laubach).
1957 *Calamus daemonorops* (UNGER) Chandler, p. 88, pl. 12, figs 24-42 (Bovey Tracey).
1975 *Daenomerps* cf. *geniculatus* (GRIFF.) MART.; Czeczott and Juchniewicz, pp. 57, 62, pl. 12, fig. 3 (Turów).
1980 *Spinophyllum daemonorops* (UNGER) HuARD; Czeczott and Juchniewicz, p. 26, pl. 4-5, 7 (Turów).

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).

Discussion: Chandler (1957) believed, on account of fruits and flowers co-occurring with spines at Bovey Tracey, in the affinity of such fossils to Calamus while Huard (1967) transferred *Calamus daemonorops* (UNGER) CHANDLER to an artificial fossil genus doubting this straightforward relationship. In a detailed anatomical study he defined Spinophyllum HuARD typified by *S. daemonorops* (UNGER) HuARD adding another species *S. lepidocaryoides* HuARD. According to Czeczott and Juchniewicz (1975) the same type of spines occurs also at Turów and seems to belong to Daenomerps, while later (Czeczott and Juchniewicz 1980) they returned to the non-committal name Spinophyllum. According to Mai and Waller (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.

Material: Ca. 50 fragments of spines, G 3075, 4606.

**Cyperaceae JUSS.**

**Dulichium Persson**

**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).

**Discussion:** 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.

**Material:** 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, Nichten).

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.).

**Discussion:** Holý (1975) did not recognize the affinity of the two specimens available and called them *Carpolithus*. According to Martinetto (in scheda, i.e. a note on the label) they may represent a new species of *Spirella* 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 *Limnobophyllum expansum* (Heer) Kvaček (Araceae) in the Early Miocene deposits of the North Bohemian Basin in the Bílina Mine (Kvaček 1995, 1998).

**Material:** 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 (Hrάdek/N., Kristina Mine).

2003 *Sparganium camenzianum* Kirchheimer; Teodoridis, pp. 25-26, pl. 7, figs 12-16, pl. 8, fig. 6 (Hrάdek/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).

**Discussion:** 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.

**Material:** 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 micropyyle showing the position of the dehiscence line (Holý 1975, pp. 81-2).

**Discussion:** 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* Reid. et Wils. and *M. myriantha* Siebold et Zucc. from East Asia be living species producing comparative fruits but stated that no exactly 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.

**Material:** Over 50 seeds and free valves, G 3071, 8859-60.

**Menispermaceae Juss.**

*Parabaena Miers*

*Parabaena europaea* Czečzott et Skirgiello

Pl. 5, fig. 21

1967 *Parabaena europaea* Czečzott 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 medionerally 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 Menispermaeae from the Eocene and Pliocene of England (Chandler 1964, Reid C. and E.M. 1915, as Jongmansia cypraeaformis).

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

Santalaceae R. Br. (incl. Viscaceae Miq.)

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 Viscohylum 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 (Wackendorf).

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, anticlinial wall straight, pitted, outer periclinal wall with very indistinct lens-shaped medial papilla in the cell centre, stomata brachypanicritic, 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 Czeczott (1961b) and used the genus Viscum L. instead of Viscohylum 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 Czeczott (1961b). For more information on affinities and synonymy see Knobloch and Kvaček (1976). Viscum morlotii occurs mostly in the European mastixioid floras, recently also in Arjuzanx (Kvaček et al. 2011), while Pliocene records of Viscum belong prevailingly to the broader-leaved Viscum miguelii (Geylek et Kinkel in Czeczott. Due to uniform foliage morphology and anatomy, the nearest living relatives have not yet been established.


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 infructescenses 9–14 mm in diameter, showing roundish polygonal locules 2–3 mm across on surface, interlocular 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.

Halaragaceae 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 ovated, 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).

Discussion: According to Holý (1975) the material seems to represent a new species similar in form to C. urселensis Mădler from Niederursel (Mădler 1939) and Krościenko (Szafer 1947) but the specimens are bigger and stouter. C. urселensis Dorofeev (1970, pp. 50-51) looks to be very similar but also bigger, pointed at the apex.

Material: 4 seeds, G 4586, 4588, 8486.

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, antitinal 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).

Discussion: Kvaček (1966) wrongly assigned these leaves from the Kristina Mine to Sympliociphyllum 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.


Vitaceae Juss.

Vitis L.

Vitis lusatica Czeczott et Skirgelio

Pl. 6, figs 4-5

1959 Vitis lusatica Czeczott et Skirgelio in Czeczott et al., p. 193, pl. 17, figs 4-12 (Turów).


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).

Discussion: 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).

Material: 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).


Seeds elongate obovate, 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).

Discussion: 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 DOROFFEEV* (1963a, pp. 214).

**Material:** 6 seeds, several fragments, G 3035, 8837.

**Ampelopsis MCHX.**

**Ampelopsis malvaeformis (SCHLOTHEIM) MAI**

1822 *Carpolithus malvaeformis* SCHLOTHEIM, p. 98, pl. 21, fig. 9a-c (Pemkho).
1857 *Vitis ludwigii* A. BRAUN, p. 184 (Dorheim).
1957 *Ampelopsis ludwigii* (A. BRAUN) DOROFFEEV; p. 644, pl. 1, figs 1-2 (Orlovka).
1978 *Ampelopsis malvaeformis* (SCHLOTHEIM) MAI in Mai and Gregor, p. 418, pl. 21, figs 1-3 (Salzhausen).
2003 *Ampelopsis ludwigii* (A. BRAUN) DOROFFEEV; 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, ventral side distinctively radially striate with oval chalaza, ventral side with a long trigonal keel of raphe reaching to the basal micropyyle, 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).

**Discussion:** 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 (Czeckott 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. leeoides* PLANCH. (Japan).

**Material:** 24 seeds, G 3039, 8840-41.

**Ampelopsis rotundata CHANDLER**

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).

**Discussion:** 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-

**Material:** 35 seeds, G 3042, 8842-43.

**Tetrastigma PlANCHON**

**Tetrastigma lobata CHANDLER**

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 micropyllar 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).

**Discussion:** 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. fargesii* GAGNEP. and *A. heterophylla* in detail the taxonomical status and suggested the living *A. heeri* DOROFEEV (1963b) and very close two other Siberian species *A. rotundatoides* DOROFEEV (1957, p. 645, KOZJULINO) and *A. tertiaria* DOROFEEV (1963a, pp. 217-8). Czeckott 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.

**Material:** 10 seeds and fragments, G 3054, 8844.

**Tetrastigma chandlerae KIRCHHEIMER**

1938b *Tetrastigma chandlerae* KIRCHHEIMER, p. 337 (“chandleri”), pl. 4, figs 16-20, text-fig. 4 (Wiesa).
1959 *Tetrastigma chandleri* KIRCHHEIMER; Czeckott 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 micropyllar tube, 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).

Discussion: 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 particularly from Wiesa near Kamenz. Specimens from material corresponds to the records common in Upper Lusatia, especially from Zittau (Mai 1964, p. 97) who compared the fossil seeds with those produced by Turpinia montana KOHD. and T. formosana NAKAI from eastern Asia.

Material: 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, anatropic, 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.

Discussion: 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 tavdendsis 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).

Material: 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.

Discussion: 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).

Material: One incomplete seed, G 3036.

Vitaceae gen. et sp. indet.

Pl. 12, fig. 3

Dispersed cuticles striate to papillate, not reflecting anticinal 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.

Discussion: 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).

Material: 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 micropylar 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.

Discussion: According to Holy (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.

Material: Ca. 25 seeds and several fragments, G 3046, 4623, 8845, Gs 108, 109, 236.

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, anatropic, 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.

Discussion: 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 tavdendsis 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).

Material: 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.

Discussion: 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).

Material: 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, fis 17, 18, 21, pl. 6, figs 9-11 (Hrádek N., drill cores).

Discussion: According to Mai (in Mai and Walther 1978) the fossil genus Mneme Evde 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, intersecondary obvious, thinner, parallel, tertiary veins alternate percurrent, curved to sinusuous, 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 µm or up to 35 µm in diameter, anticinal 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 anticinal walls, stomata amphicycloparyct, 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, Brčšany).

Incomplete leaves and fragments, lamina widely elliptic to oblanceolate, 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 Bilina 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: Leaflet compressions on slides, G 9176-9183 (KR 143, 144, 147, 151, 194a, b, 224, 225, 248).
In complete 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, apicually 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).

Discussion: Fagus leaf fossils of the European Early-Middle Miocene were usually assigned to F. attenualata Göppert (Kváček and Walther 1989) but the revision by Walther and Zastawniak (1991) corrected the affinity of the type specimen to Alnus (see Walther in Kváček 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 Kváček et Walther (1991) based on the Middle Miocene material from Germany (Kausche and other sites). Walther (in Kváček 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, Kváček 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 beach 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 decurrens.

Material: 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.

Trigonobalanus exacantha (ROSSMÄSSLER) Kváček et Walther

Trigonobalanus exacantha (ROSSMÄSSLER) Kváček et Walther

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).

1906 Fagus ferruginea AIT. forma miocenica MENZEL, p. 48, pl. 3, figs 4-5, 10-12 (Rauno).

1910 Fagus cf. ferruginea AIT.; Menzel in Gothan and Sapper, pl. 15, pl. 3, fig. 8 (Klettwitz).

1933 Fagus attenuata Göppert; Kvaček and Walther, p. 214, text-fig. 1f (Hrádek/N., Kristina Mine).

1939 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).

Triquetra ferruginea AIT. forma miocenica MENZEL

Pl. 2, 114, 121, 122, 123a, b), numerous cupules, several fruits, G 8821, 8822, Gs 232.

Trigonobalanopsis exacantha (ROSSMÄSSLER) Kváček et Walther

Trigonobalanopsis ferruginea (ROSSMÄSSLER) Kváček et Walther

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

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*).

**Discussion:** 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) Krausel 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 Háride 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 *Trigonobalanus* in several living species of *Castanopsis* from southern Asia.


**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 (Flörshaim).

Leaf incomplete, elliptic, 23 mm long, 11 mm wide, base cuneate, apex not preserved, margin entire, venation eucaempodromous, 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.

**Discussion:** 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 mastixoid floras from *Castanopsis* to *Quercus*. More comparative studies are required to fix the systematic position of *Quercus bavarica* within this genus.

**Material:** Incomplete leaf compressions on slide, G 9266-9267 (KR 23, 496).

*Quercus rhena**na (Kräusel et Weyland)

E. KNOBLOCH et Kvaček plexus

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

1950 *Ilicium rhenanum* Kräusel et Weyland, p. 50, pl. 9, figs 5-7, pl. 10, figs 1-2, pl. 11, fig. 5 (Brühl).

1966 *Quercus lasatica* Jähnicke, p. 478, pls 1-4, pl. 9, figs 21-22, text-figs 1, 3-4 (Hartau, Wiesa).

1976 *Quercus rhena**na* (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 Jähnicke (1966, as *Quercus lasatica*).

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.

**Discussion**: 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 Laraceous, 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 Czeczott et al. 1959) and Saxony (as Castanopsis sp. sensu Mai 1964). The leaves are regularly accompanied at Hartau, Turów in Poland (as Magnolia sp. sensu Czeczott 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. (cf. 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.

**Material**: Fragmentary leaf compressions on slides, G 9286-9285 (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).


Complete leaves not preserved, leaflets sessile, shortly petiolute, 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 semiarcapedromous, 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.

**Discussion**: 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.


**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; Czeczott and Skirgiello, 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).

**Discussion**: 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 Luncucka-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 (Czechott 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* ILLJINSKAYA.

**Material**: More than 50 fruits, G 3065, 8977-78, Gs 84.

### *Cyclocarya* ILLJINSKAYA

**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.

**Material**: 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).

**Discussion**: According to Holý (1975) the material matches the type specimens from the Polish locality Dobrzyn (Kownas 1955) except for finer verrucae. Fruits from Klettewitz 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 ceriferiformes* 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).

**Material**: 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.

**Material**: 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.

**Material**: 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, figs 5-7 (Parschlug).

1865 *Myrica lignitum* (UNGER) SAPORTA, p. 102 (non pl. 5, fig. 10) (Parschlug).

Detached 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.

**Discussion**: 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).

**Material**: 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 cutinated, 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.

**Discussion**: Weyland and Kilpper (1963) mis-interpreted 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.

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).

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 scheda) 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 Arbusova

Pl. 7, fig. 17

1948 Hypericum septestum Nikitin, p. 1104 (nomen nudum) (Kierevskoe).
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 Arbusova, p. 43, pl. 110, figs 1-12, pl. 111, figs 1-5 (typification) (Lagernyi Sad, Ekaterinsko, Kierevskoe, 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, Arbusova 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 Sanmartin (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 Kraśel 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, abaxiale 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, bissymmetrical 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).

**Discussion:** 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 a young species accompanying Neogene mastixoid floras. Its fruitlets match those produced by the living *F. carica* L. widely cultivated in Europe.

**Material:** 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.

**Discussion:** According to Holý (1975, p. 46, pl. 7, fig. 11) the two recognized forms are partly comparable with *Rubus laticosatus* 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.

**Material:** 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).


1987 *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.

**Discussion:** 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).

**Material:** 25 endocarps, G 3032, 3037, 3073.

Rutaceae JUSS.

**Zanthoxylum L.**

**Zanthoxylum kristinae (HOLY) GREGOR**

Pl. 8, figs 1-2

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

1987 *Zanthoxylum kristinae* (HOLY) 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 (Lancucka-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).

**Material:** 28 seeds, some fragments, G 3085, 4312-13, 4316-17, 4319.

Toddalia BLUME

**Toddalia latissilique *LUDWIG* GREGOR**

Pl. 8, fig. 3

1860 *Cyttisus latissiliquatus* LUDWIG, p. 145, pl. 58, figs 14, 17 (Hessenbrücken).

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

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

1977a *Toddalia latissiliquata* (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 latissiliquata (LUDWIG) HOLÝ comb. nov.)

Discussion: 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.

Material: A large quantity of seeds, G 3034, 3054.

Sapindaceae Juss. (incl. Aceraceae Juss.)

Acer L.

Acer tricuspidatum BRONN emend. WALther

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

1838 Acer tricuspidatum BRONN, p. 865, pl. 35, figs 10 a-b (Salzhausen).

1845 Acer trilobatum A. BRAUN, p. 172 (Öhningen).

1972 Acer tricuspidatum BRON; 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, 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.

Discussion: 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.

Material: 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).

Discussion: 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.).

Material: Over 100 endocarps, G 3012, 3047, 8851, Gs 101.

Subfam. Nyssoideae 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 trilocular, 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.

Discussion: 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_ Dorofeev. 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 partially bilocular. 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._

Material: 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_ (Schloth.) 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, Sandförstgen).


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 scheda) as _M. venosa_ (C. PRESL in STERNBERG) HOLÝ (1984). A definite solution of this problem would require a detailed study of the material from Podlesi and Počerny (the latter site being the type locality of _M. venosa_.

Material: 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


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, Sandförstgen, Hartau).


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 Nguyê 2002).

Material: Ca. 30 endocarps, G 4228-37, Gs 111.

_Eomastixia Chandler_

_Eomastixia saxonica (Menzel) Holý_

Pl. 8, figs 11-12

1933 _Elaecarpus saxonicus_ Menzel in Gothan et Sapper, p. 26, pl. 6, fig. 9 (Gohra).
80

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).

**Material:** 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).
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 discus 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).

**Material:** Over 20 fruits, G 4154, 4196, 4201, 4238-41.

*Retinomastixia Kirchheimer*

*Retinomastixia oertelii* GREGOR

Pl. 8, figs 14-15

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).

**Material:** 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).

Pentamericous capsules 2.1–3.5 mm long, 1.4–2.9 mm wide, ellipsoid pear-shaped, short stalked at base, with a pit in the middle, fruits sepctidal, smooth, dehiscence starting at the apex separating individual endocarps from the central stylar 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).

**Discussion:** 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”.

**Material:** 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).

**Material:** Seeds, G 4300-04, 4612.

Eurya Thunb.

*Eurya stigmosa* (LUDWIG) MAI

Pl. 9, fig. 6

1860 *Potamogeton stigmosus* 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).
1961 *?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).

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 *Symlocos 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.

**Symlocos casparyi** LUDWIG

Pl. 9, figs 10-11

1857 *Symlocos 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 *Symlocos salzhausensis* (LUDWIG) KIRCHHEIMER, pp. 718, 737, fig. 19 (Salzhausen).
1935c *Symlocos lignitarum* (QUENSTEDT) KIRCHHEIMER, p. 718, figs 17-18 (Salzhausen).
1977a *Symlocos lignitarum* (QUENSTEDT) KIRCHHEIMER; Holý, p. 112 (Hrádek/N., Kristina Mine).
1977a *Symlocos salzhausensis* (LUDWIG) KIRCHHEIMER; Holý, p. 112 (Hrádek/N., Kristina Mine).
2003 *Symlocos lignitarum* (QUENSTEDT) KIRCHHEIMER; Teodoridis, p. 21, pl. 5, figs 8-10 (Hrádek/N., drill cores).
2003 *Symlocos salzhausensis* (LUDWIG) KIRCHHEIMER; Teodoridis, pp. 21-22, pl. 5, figs 11, 13, 14 (Hrádek/N., drill cores).
2003 *Symlocos 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 *Symlocos lignitarum* and *S. salzhausensis*).

**Symlocos schereri** KIRCHHEIMER

Pl. 9, fig. 9

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

**Styracaceae DC et Spreng.**

**Rehderodendron Hu**

**Rehderodendron custodium Holý**

Pl. 9, figs 7-8

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*.

**Symlocos jacquin**

**Symlocos 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.

**Symlocos schereri** KIRCHHEIMER

Pl. 9, fig. 9

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

**Symlocos pseudogregaria** Kirchheimer
Pl. 9, fig. 12
1938a *Symlocos pseudogregaria* Kirchheimer, p. 354, pl. 7, figs 17-20, pl. 8, figs 1-2 (Niederpleis).
1941a *Symlocos poppeana* Kirchheimer, p. 217, figs 12-13 (Wiesa).
1977a *Symlocos poppeana* Kirchheimer; Holý, p. 11 (Hrádek/N., Kristina Mine).

Endocarps 5.4–9 mm long, 3–4.1 mm wide, trilocular, mostly cylindrical, base rounded, apex truncate, with a wide, shallow apical pit, surface cover by fine longitudinal striate-wrinkled (Holý 1975, p. 59, pl. 11, fig. 8, as *Symlocos poppeana*).

**Discussion:** Mai and Martinetto (2006) reinterpreted *Symlocos pseudogregaria* as a polymorphic species and merged with it several morphotypes, including *Symlocos 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.

**Symlocos minutula** (Sternberg) Kirchheimer
Pl. 9, fig. 13
1825 *Carpolithes minutulus* Sternberg, p. 41, pl. 53, fig. 8 (“Carpolites”) (Salzhausen).
1849 *Symlocos minutula* (Sternberg) Kirchheimer, p. 16, pl. 1, fig. 6, pl. 2, fig. 16 (Salzhausen).
1977a *Symlocos 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, (?) trilocular, base rounded, sides towards apex narrow, 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. ramossissima* WALL. (Himalayas) and *S. glauca* (THUNBERG) KOIDZUMI (Japan) as living species with similar endocarps.

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

**Sphenothece Kirchheimer**

**Sphenothece incurva** Kirchheimer
Pl. 9, fig. 14
1934 *Sphenothece incurva* Kirchheimer, p. 789, fig. 19 (Kausche).
1977a *Sphenothece 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 *Symlociphyllum 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 (Satovča).

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 30–50º, tertiary veins alternate to opposite percurrent, straight to sinuous 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 Walthier (1984b) corrected the previous view of Kvaček (1966, in Kvaček and Bůžek...
1966) who erroneously interpreted the stomatal type of Sympl cyniphllum hradense Kvaček and Bůžek as paracytic suggesting affinities with Sympl cocaeeae, 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 (Styraceae) (Schweigert 1992) is not supported by the epidermal anatomy and hence not acceptable. The fossil genus Sympl cyniphllum Kvaček et Bůžek must be re-typified, because its original type falls into the genus Polyspora or Gordonia. 


**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 Ungr. p. 126 pro parte (non pl. 14, fig. 20) (Bílina).

1860 Carya bilinica (Ungr.) Ettingshausen; Ungr. p. 39, pro parte, pl. 17, figs 1-8 (Bílina).

2000 Fraxinus bilinica (Ungr.) Kvaček et Hurník, p. 19, pl. 8, figs 7(-78), 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 intersecondarys 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 polygonal shield 25–50 µm in diameter.

**Discussion:** 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 Kainer 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 Bilina and elsewhere under the binomen *Fraxinus bilinica* (Ungr) 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 Kőflach. No living analogous species has been suggested so far.

**Material:** 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).

**Discussion:** According to Holý (1975), similar but smaller endocarps are produced by *Aralia* L., while in Scheflera 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.

**Aquifoliaceae DC ex A. Rich.**

*Ilex* L.

*Ilex cf. protogaea* Mai

Pl. 9, fig. 17


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).

**Discussion:** According to Holý (1975), the relationship to the similar *Ilex cantalensis* E.M. Reid and I. luzatica Menzel are discussed in Mai (1970b, p. 459). A living species with similar endocarps appears to be *I. daahoon* Walt.

**Material:** 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 TROUTV.**

*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, Mudeford) 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 (Szafir 1947, as *S. cf. ebula* 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 trinodal 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 cuticle with similar structure were described as *Freycinetia rhenana* WEYLAND (1957) from Rhineland and *Monocotylotyllum 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 weilandii* KVAČEK et BŮŽEK

Pl. 4, figs 1-4, pl. 14, figs 9-10

1959 *Illicium lusaticum* (JAHNICHEK) KRAUSEL et WEYLAND sensu KRAUSEL et WEYLAND, p. 106, pl. 20, figs 12-15, text-fig. 6-7 (non Kadsura lusatica JAHNICHEK nec ILICILUS LUSATICUM (JAHNICHEK) KRAUSEL et WELAND pro nomen) (Düren).

1966 *Symplociphyllum weilandii* 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 sinuses with indistinct lens-shaped thickening, scattered solitary simple rounded trichome bases, abaxial cuticle thin cutinized, almost smooth, only faintly radially striate around some stomata, non-modified cells of the same form and size as adaxially, but without thickening 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 ledge 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 *Coronocitus hartewensis* ROELERT 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 Symlocaceae 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, secondary laminae, tending 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, with a central star-like rounded cell 28–32 µm in diameter, 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.


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: Cupressospernum, Mastixia lusatica, Eomastixia saxonica, Retinomastixia, Diplopanax, Trema, Rehderodendron, Symposcio schereri, and Sphenothea incava with respect to carpology, Tsuga schneideriana, Laurus abchasica, Ocoeta hradekensis, Laurophyllum 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 to taphonomic processes. In addition, the foliage size must have been heavily biased by preparation technique and selective collections. Nearest florals 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 palaeoassociations or taphocones 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, Dalichium marginatum, Eurya stigmosa, Ilex wiesensis, Magnolia burseracea, Mastixia lusatica, Meliosma miesleri, Microdiptera donata, Myrica hindiba, Nyssa ornithobroma, Pinus hampeana, Quercus rhenana plexus, Rubus spp., Sapinum germanicum, Sequoia abietina, Swida gorbunovii, Symposcio casparyi, Trigonobalanopsis rhamnoides plexus, Turpinia ettingshausenii.

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

Acer tricuspidatum, Alnus julianiformis, Ampelopsis ludwigi, A. rotundata, Araliaceae gen., Cathaya roseltii,
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).

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| Potamogeton nochtensis | 1.00 | 1.00 |
| Pronophium stiriacum | 1.00 | 1.00 |
| Proserpinaca ervii | 1.00 | 1.00 |
| Pseudoeuryale sp. | 1.00 | 1.00 |
| Pterocarya raciborskii | 0.50 | 0.50 | 1.00 |
| Quercus bavarica | 1.00 | 1.00 |
| Quercus rhenana plexus | 1.00 | 1.00 |
| Rehderodendron custodium | 1.00 | 1.00 |
| Retinomastixia celeti | 1.00 | 1.00 |
| Rubus spp. | 0.25 | 0.25 | 0.25 | 0.25 | 1.00 |
| Salix varians | 1.00 | 1.00 |
| Sambucus pulchella | 1.00 | 1.00 |
| P. Saphridus sp. | 1.00 | 1.00 |
| Sapilum germanicum | 1.00 | 1.00 |
| Sassafraea cf. lusaticum | 1.00 | 1.00 |
| Sequoia abietina | 1.00 | 1.00 |
| Sparganium camenzianum | 1.00 | 1.00 |
| Sphenotheca incureva | 1.00 | 1.00 |
| Spinothlymus daenonomops | 1.00 | 1.00 |
| cf. Stemona germanica | 0.33 | 0.33 | 0.34 | 1.00 |
| Swida gortunovi | 1.00 | 1.00 |
| Sympticophyllum waylandii | 1.00 | 1.00 |
| Symptococcas caspanyi | 1.00 | 1.00 |
| Symptococcas minuta | 1.00 | 1.00 |
| Symptococcas pseudogregaria | 1.00 | 1.00 |
| Symptococcas scharenii | 1.00 | 1.00 |
| Tectocarya elliptica | 1.00 | 1.00 |
| cf. Tectocarya robusta | 1.00 | 1.00 |
| Ternstroemia chandleriae | 1.00 | 1.00 |
| Tetracnitis salicornioides | 1.00 | 1.00 |
| Tetrasigma chandleriae | 0.50 | 0.50 | 1.00 |
| Tetrasigma lobata | 0.50 | 0.50 | 1.00 |
| Toddaia ilialitiqua | 1.00 | 1.00 |
| Trapa lusatica | 1.00 | 1.00 |
| Trigonobalanops rhamnoides plexus | 1.00 | 1.00 |
| Tsuga schneideriana | 1.00 | 1.00 |
| Turpinia ettinghausanii | 1.00 | 1.00 |
| Viscum montanum | 1.00 | 1.00 |
| Vilacicca gen, et sp, ldst | 0.50 | 0.50 | 1.00 |
| Vitis lusatica | 0.50 | 0.50 | 1.00 |
| Vitis parvissustrin | 0.50 | 0.50 | 1.00 |
| Zanthoxylum krisinae | 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 | 0.68 | 16.86 | 4.16 | 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 | - | 31.85 | 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 |

Layer B (lowermost clayey lignite seamlet).

Cupressospermum saxonicum, Epipremnites ornatus, Ficus potentilloides, Glyptostrobus europaeus, Microdiptera donata, Microdiptera parva, Sequoia abietina, Spirea pulchella.

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. noctensis, 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, Huboká and Kamenny 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
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 (Physg3brAZ, 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, is 21.1 °C (sensu Wolfe 1979) and MAT, 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 1146–1135 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 CMMT over 5 °C. The presented palaeoclimatic estimates for Hradék/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 CO2 concentration during the deposition of the Libkovicke 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 kürschneri. A similar floristic composition is also known from the drill core floras from the Upper Coal Seam s. l. of the Hradék 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–Kleinleipsch (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 Skirgiello 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.

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<th>Time/Zone</th>
<th>Country</th>
<th>Area</th>
<th>Vegetation type – empirical classification</th>
<th>Studied modern vegetation units [region, (sub)community, (sub)association] and fossil floras / studied fossil floras sensu Teodoridis et al. (2011a, b, c, 2012)</th>
<th>Site numbers – Cluster analysis</th>
<th>IPR - vegetation analysis</th>
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<td>% of BLD % of BLE % of SCL + LEG</td>
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**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.**
Study modern vegetation units (region, (sub)community, (sub)association) and fossil floras / studied fossil floras sensu Teodoridis et al. (2011a, b, c, 2012)

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Classification sensu Teodoridis et al. (2011a)
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 Most Basin (Teodoridis and Kvaček 2006) and the Libkovice Member of the Most Formation, appearing 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 Czeczott et al.).

Many various elements in common connect now, after the revision done by Lanuucka-Šrodoniowa 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).

Acknowledgments

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References


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. Veneation 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
10. Leaf fragment, G 9166 (KR 46) (scale bar 3 mm).
11. Leaf fragment, G 9170 (KR 464) (scale bar 3 mm).
12. Veneation 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. Veneation detail of the leaf fragment shown in fig. 14 (scale bar 1 mm).
19. Veneation 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. Veneation 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. Veneation 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. Veneation 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 decaulonis** UNGER plexus
6. Petiolate leaf base, G 9184 (KR 23) (scale bar 5 mm).
7. Veneation detail of the leaf fragment shown in fig. 6 (scale bar 1 mm).

**Quercus rhenana** (KRÄUSEL et WEYLAND) E. KNOBLOCH et KVAČEK
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. Veneation 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. Veneation 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. Veneation 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. Veneation 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. Veneation 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. Veneation 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).
13. Isolated seed cone from either side, G 4593 (scale bar 5 mm).
14. Seed from either side, G 8828 (scale bar 3 mm).
15. Seed from either side, G 8831 (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 8833 (scale bar 3 mm).
21. Seed from either side, G 8823 (scale bar 3 mm).
22. 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).

Sasafras cf. lusaticum MAI
28. Empty cupule from either side, G 8966 (scale bar 1 mm).
29. Empty cupule from either side, G 8963 (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 heinkel 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 Skirgiellos
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).

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

PLATE 6

Proserpinacca 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* Czeckott 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 5 mm).

PLATE 7

*Fagus deucalionis* Unger plexus
1. Cupule from either side, G 8821 (scale bar 5 mm).

*Trigonobalanopsis rhamnoides* (Rossmassler) 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 nemejici* 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 latissiliquata* (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).
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).

*Terostroemia 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 fruit 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).

*Syringococcus schereri* **Kirchheimer**
9. Endocarp from either side, G 8981 (scale bar 3 mm).

*Symplocos scheeri* **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).

*Platycladus occidentalis* **(Engelmann) 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**

*Proserpinium stiriacum* **(Unger) E. Knobloch et Kvaček**
2. Group of trichomes on abaxial epidermis, G 8867a (KR 77) (× 250).

*Tsauga schneideriana* **Kunzmann et Mai**
3. Abaxial epidermis, G 8868b (KR 104A/1) (× 300).

*Cathaya rosettii* **Schneider**
5. Abaxial epidermis, G 8872c (KR 103A/2) (× 300).

*Tetraclinis saliciniioides* **(Engelmann) Kvaček**

*Glyptostrobus europaeus* **(Brongniart) Unger**

*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 8900b (KR 176/1) (× 300).

*Ocotea hradekensis* **(Kvaček et Bůzek) Kvaček**

**PLATE 11**

*Ocotea hradekensis* **(Kvaček et Bůzek) Kvaček**
1. Abaxial cuticle, G 8895b (KR 300/1) (× 300).

*Laurophyllum pseudoprinceps* **Weyland et Kilper**
3. Abaxial cuticle, G 8906b (KR 125/1) (× 300).

*Laurophyllum rugatum* **Kvaček et Bůzek**
5. Abaxial cuticle, G 8964b (KR 7/1) (× 300).

*Laurophyllum pseudovillense* **Kvaček**

*Laurophyllum sp.*

*Cinnamomum polymorphum* **(A. Braun) Heer plexus**
10. Adaxial cuticle, G 9058b (KR 257/1) (× 300).

**PLATE 12**

*Viscum morlotii* **(Unger) E. Knobloch et Kvaček**

*Distylium fergusonii* **E. Knobloch et Kvaček plexus**

*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.**
5. Adaxial 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

**Trigonobalanopsis rhamnoides** (Rossmässler) Kvaček et Walther plexus

**PLATE 13**

**Quercus bavarica** (E. Knobloch et Kvaček) Kvaček
1. Abaxial cuticle, G 9267b (KR 496/1) (× 300).

**Quercus rhenana** (Kräusel et Weyland) E. Knobloch et Kvaček plexus

**Engelhardia orsbergensis** (Wessel et Weber) Jähnichen, Mait et Walther
5. Abaxial cuticle, G 9299c (KR 479/3) (× 300).

**Myrica lignitum** (Unger) Saporta

**Myrica pseudointegrerrima** Weyland et Kilpper

**Salix varians** Göppert
10. Abaxial cuticle, G 9319b (KR 427/1) (× 300).

**Acer tricuspidatum** Bronn emend. Walther

**PLATE 14**

? **Sapindus** sp.

**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
5. Abaxial cuticle, G 9329b (KR 29/1) (× 300).

**Fraxinus bilinica** (Ettingshausen) Kvaček et Hurník

? **Monocotyledonae** gen. et sp. indet.
8. Dispersed cuticle, G 9398 (KR 324 (× 300).