

## FLORA AND VEGETATION OF THE ROOF OF THE MAIN LIGNITE SEAM IN THE BÍLINA MINE (MOST BASIN, LOWER MIOCENE)

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**Abstract.** In the roof of the main lignite seam in the locality Důl Bílina (Bílina Mine) of northern Bohemia, a fossil flora with 51 different taxa has been described. Unique state of preservation has allowed application of the cuticular analysis and the analysis of the pollen in situ. The assemblage is parautochthonous and reflects azonal vegetation, typical of the area of the so-called “back swamp”. Its main part was formed of the *Nyssa-Taxodium* association. The flora is attributable to the floristic complex Bílina-Brandis of the Atlantic-Boreal bioprovince, Early Miocene in age.

■ flora, vegetation, Lower Miocene, Bílina, Czech Republic

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### Introduction

This work represents a slightly modified English version of the master's thesis of the author (Sakala 1997). The aim of the study was to characterise the fossil flora and vegetation of the roof of the main lignite seam in the locality Bílina Mine (the former Maxim Gorkij Mine), more precisely of the so-called Horizon n° 30 (or its lateral equivalent n° 13), situated in the upper part of the Clayey Superseam Horizon in sense of the local stratigraphy.

For the purpose of the master's thesis, the author had at his disposal both the fossil material coming from his own collections in the studied locality, and the material borrowed mainly from the collections of the Bílina Mine, gathered by Mr. Z. Dvořák. To describe fossil remains, the standard scientific methods have been applied. Results of the research are summarised partially at the end of every chapter devoted to the flora and vegetation of the described horizon, as well as generally in the conclusions at the end of the present work.

### Geological setting

Since the geology of the Most Basin is relatively well known thanks to numerous works (Havlena 1964, Malkovský et al. 1987, Bůžek et al. 1992, etc.), this part of the present paper, i.e. geological setting, is noticeably reduced in comparison with the original master's thesis, using the references to previous works.

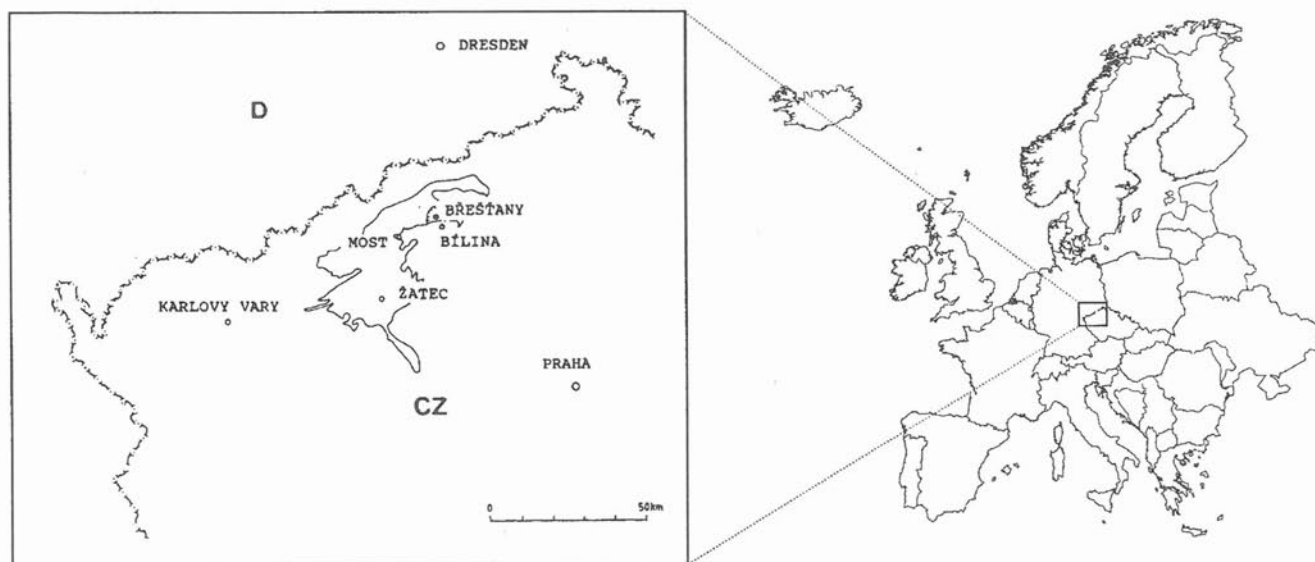
#### Most Basin

The described Horizon n° 30 is located in the roof of the main lignite seam exposed in the Bílina Mine at the SE border

of the Most Basin (see text-fig. 1). Therefore the geology of the basin will be briefly summarised first in this chapter.

The Most Basin (the former North Bohemia Lignite Basin) belongs to the Krušné hory Piedmont Basins, and due to its area of 1400 km<sup>2</sup>, is the most important of them. It is limited tectonically in the NW and SE, and in NE and SW by neovolcanites of the Doupov and České středohoří Mts. There are several hypotheses regarding mechanisms of the origin of the basin, (Havlena 1983). They interpret the basin as a synclinal part of a megafold, a simple tectonic graben or a rift structure in terms of the plate tectonics (Kopecký 1976). One of the possible explanations is also vulcanotectonic subsidence (Malkovský 1980). According this theory, the upper part of the Earth's crust sinks through the “emptied” places in the upper mantle, which produces the volcanic material. In the case of the Most Basin, the source of volcanic material of the western České středohoří Mts. was predominately in the central (Most) part of the Most Basin, i.e. in the part where the locality studied is situated.

In whole area of the present Tertiary Krušné hory Piedmont Basins, which were developing at that time as one complex, the sedimentation had probably already started in the Middle Eocene. It continued in the Late Eocene with deposition of basal fluvial-lacustrine, predominately sandy layers in isolated depressions at many localities of western Bohemia, from the Sokolov and Cheb areas, over Karlovy Vary to the North Bohemia Basin and České středohoří Mts. (e.g. near the town of Litoměřice). In the area of the Most Basin, this so-called “Basal Member” is deposited on the basement. It is correlated, even in the absence of direct palaeontological evidence, with the **Staré Sedlo Formation**. Over most of the region, the basement is formed of metamorphic and eruptive rocks of the Krušné



Text-fig. 1. Geographic position of the Most Basin and the locality Bílina Mine after Kvaček (1998) modified by Prokop

hory crystalline complex, partly covered also by younger sediments of the Permian-Carboniferous or Upper Cretaceous.

In the Early Oligocene, the Paleogene peneplane rifted when pyroclastic rocks and effusive neovolcanites of the first volcanic phase had been ejected. Accumulated deposits of the stratovolcanos of the Doupov Mts. and western České středohoří Mts. produced the Cheb Basin together with the Sokolov Basin and the Most Basin as dammed lakes in a flat relief. The Krušné hory Mts. did not yet exist in their present form - their main uplift took place in the Quaternary. The **Střezov Formation** (Early Oligocene - Oligocene-Miocene boundary), composed mostly of volcanic bodies, tuffites and reworked pyroclastic rocks, were deposited.

In the next volcanotectonic subsidence phase, if we accept this hypothesis, after a longer hiatus the main, very rich facies of the fill of the Most Basin, the Most (productive) Formation (Late Egerian - Eggenburgian) was deposited over the Střezov Formation. Within the sedimentation of the Most Formation, the main lignite seam, up to 60 m thick, originated. The basement and the base of this seam are in the Prunéřov area dated by a mollusc and a mammal fauna (Fejfar 1974, Čtyroký and Elznic 1977) to the MN 3a zone. The sedimentation in the basin was during this phase highly influenced by the presence of the so-called deltas, near Žatec and Bílina on the southern edge of the basin. These "delta" areas were places with the most intense subsidence and therefore were predestined as the places where the rivers emptied into the basin and formed alluvial fans. The so-called "Overlying Member", Early Miocene in age, within the Most Formation, is the youngest preserved part of the sedimentary fill of the Most Basin (excluding the Quaternary).

#### Bílina Mine (the former Maxim Gorkij Mine)

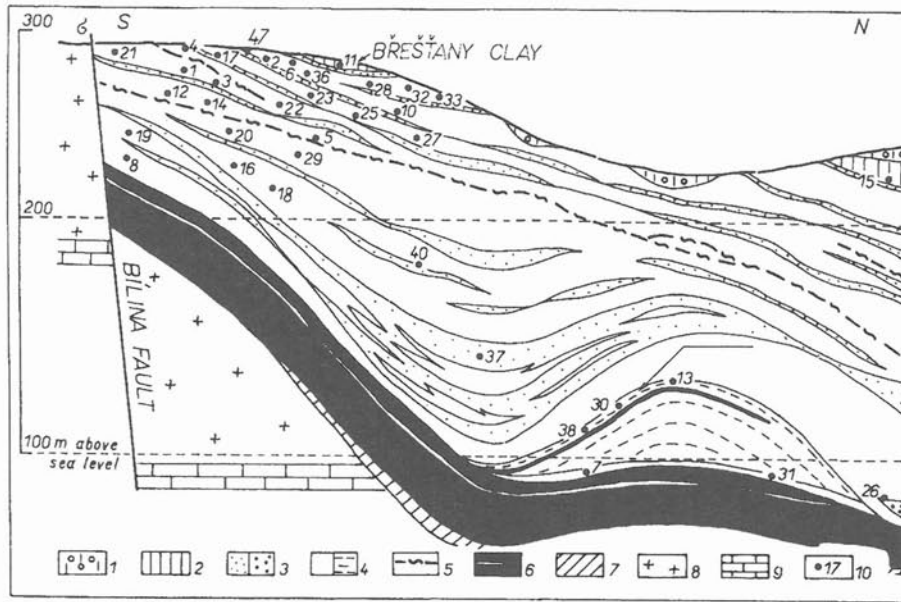
The Bílina Mine (the former Maxim Gorkij) is a lignite open-cast mine, situated in the Most part of the Most (North Bohemia) Basin in the area of the so-called Bílina delta in the proximity of the town of Bílina.

The geological setting of the Bílina Mine is similar to that of the Most Basin (see text-fig. 2). It has recently been described in detail by Bůžek et al. (1992, 1993), and also by Kvaček (1998). A detailed description is therefore not required but a general idea of the position and extent of the Horizon 30 within the sedimentary fill of the Bílina Mine is given below.

A layer of firm laminated claystone about 40 m thick can be found in the roof of the Main Lignite Seam in normal development (Bůžek et al. 1992). The lower part of this Clayey Superseam Horizon usually contains pelocarbonate lens-shaped concretions up to 1 m across, and also very often tree trunks (Bůžek et al. 1992). In the upper part of the Clayey Superseam Horizon a seamlet up to 8 m thick of high quality coal occurs (Bůžek et al. 1992). Finally, in the roof of this seamlet, a dark black-brown claystone is exposed – this is the rock of the described Horizon n° 30.

#### Horizon n° 30

Horizon n° 30 (or Horizon 30) is formed of dark black-brown claystone, rich in fossils. In addition to numerous fossil plants, there are remains of fish, bird feathers, amphibians, and reptiles. Particularly interesting finds of fossil insects (Prokop 1997, Prokop and Bílý 1999, Prokop and Nel 1999, Prokop and Nel in press) also occur there. The horizon is situated in the roof of the main lignite seam worked in the Bílina Mine, i.e. in the upper part of the Clayey Superseam Horizon, which is itself a component of the Upper Sandy-Clayey Member. Horizon 30 encompasses the previously defined Horizon 13, which, as was shown during the mining activities (Z. Dvořák pers. comm.), is a lateral equivalent of Horizon 30. The term "horizon" means in this case a fossiliferous level rather than a lithostratigraphical unit – from the hierarchic point of view, Horizon 30 cannot be a "horizon", since it constitutes another unit, denominated as the Clayey Superseam Horizon. Stratigraphically, Horizon 30, as per the whole Most Formation, belongs to the Lower Miocene (Eggenburgian), specifically to the mammal zone MN 3a (Fejfar and Kvaček 1993).



Text-fig. 2. Geological section of the Bílina Mine 1 – Quaternary; 2 – Lake Clayey Horizon; 3 – Delta Sandy Horizon (sand, sandstone); 4 – clay, claystone; 5 – coal clay, 6 – lignite seam; 7 – clayey coal; 8 – neovolcanite bodies of the Střezov formation; 9 – Upper Cretaceous; 10 – fossiliferous layers (position of the studied Horizon n° 30 (or 13) shown by the arrow) after Bůžek et al. (1992)

The fossil bearing rock of Horizon 30 is a flat-bedded pelite, which is situated in the roof of the main lignite seam and another smaller seamlet. These indications point to sedimentation in the relatively calm environment of a smaller, shallow lake or another type of water reservoir placed within the Bílina alluvial fan (“delta”). Chronologically, the sedimentation follows the main coal-forming phase, when the coal-forming swamps were no longer in maximum development and they no longer covered the majority of the basin. During the deposition of the Horizon 30, the majority of peat-bogs were disturbed by accumulation of clastic inorganic sediments in an alluvial fan. Between fans, as described by Elznic (1970), smaller peat-bogs were created by infilling some swamps, bays and smaller lakes. On the basis of the character of the studied vegetation (see the summary in the chapter devoted to the vegetation), accumulation of plant remains, i.e. sedimentation of Horizon 30, probably immediately followed the back-swamp. The clastic sediments, together with remains of back-swamp vegetation, were laid down from suspension just before entering the proper (inner) peat-forming swamp, which was rather local during this period. As a result of vegetation cover arising in the peat-forming swamp, only relatively pure water with little clastic material penetrated into the interior of the peat, and the clastics were deposited in the direction of the water inflow in the form of a tongue (Mach 1997).

## Material and methods

A binocular magnifying glass was used for observations and studies of fossil macro-remains, vegetative, or reproductive organs. For description of macroscopic plant parts, currently accepted terminology was applied, from the works of

Dilcher (1974) and Hickey (1973) for leaf characters, and from Slavíková (1990) and Stearn (1998) for other organs.

In the studied locality, the plant fossils are found predominantly in a form of carbonized compressions. This type of preservation permits use of cuticular analysis for the identification of the leaf fossils as an aid to the description of external leaf morphology. The chosen fragments of the fossil lamina were macerated in a drop of Schulze solution directly on the slide. Unfortunately, the original continuous carbonized plant substance was cracked owing to shrinkage while drying, and the macerated pieces were small, generally of several mm<sup>2</sup>. Hydrofluoric acid was not applied to clean impurities – needles were used to remove clay particles mechanically from the specimens. After reaching the required oxidation, the Schulze solution was removed by filter paper and the samples were rinsed with several water drops, before adding 5% KOH. The carbonized mesophyll tissue dissolved in this solution, and the adaxial and abaxial cuticles were separated with needles. The resulting cuticles and other acid-resistant remains (e.g. pollen in situ) were placed on the slide in a drop of glycerine. A drop of water was used for fragile cuticles. There were covered with glass and sealed with Canada balsam. This type of methodology and terminology, used in subsequent descriptions of isolated cuticles, were taken from Kvaček (1985). The cuticles were studied with an optical microscope in normal transmitted light and, if required, in phase-contrast.

## Characteristic of the flora

### History of the research

The palaeobotanical research of the Tertiary of North Bohemia has a rich history, documented by a series of both small



and extensive studies. The first study of this flora was done by Sternberg (1820-1838). This research reached its peak in the second half of the last century, when several monographs were published (Ettingshausen 1866-1869, Engelhardt 1891, Velenovský 1881). At the beginning of the 20<sup>th</sup> century there was a general decline in palaeobotanical activities of the Krušné hory Piedmont Tertiary. This decline peaked during World War I, with the exception of work by Brabenec (1904, 1909). This long gap in palaeobotanical research was interrupted only in 1934 by a study on alder foliage from the Břešřany clay by Czecczot. The decline terminated in 1950, when M. Procházka started extensive palaeobotanical collections from the Českém středohoří Mts. and the Chomutov-Žatec area. Procházka's doctoral thesis from 1952, posthumously published (Procházka and Bůžek 1975) was an important work dealing with maples from the North Bohemian Tertiary. From the beginning of the 1960s to the present day, the research in the Most Bohemia Basin has progressed mainly due to Č. Bůžek(†) - F. Holý(†) - Z. Kvaček, who either individually (Bůžek 1971, Kvaček 1966, 1971, 1995 etc.), or jointly (Bůžek, Holý and Kvaček 1967, Bůžek and Holý 1964, Kvaček and Bůžek 1972 etc.), or in collaboration with other authors (Bůžek, Konzalová and Kvaček 1971, Bůžek, Dvořák, Kvaček and Prokš 1992 etc.) contributed enormously to the understanding of Tertiary plant composition in the Most Basin area. The most recent work, including a good overview of plant composition in the Bílina locality, is by Kvaček (1998).

### Systematic descriptions

The studied taxa are arranged according the botanical system, the families of the classes Pteridopsida and Pinopsida according to Dostál (1989), the families of the classes Magnoliopsida and Liliopsida according to Tachtadžan (1987), in an increasing order, i.e. from primitive to more derived.

Every specimen has its preliminary catalogue number. When there are few specimens or specimens of particular interest, its(their) number(s) is(are) given in the paragraph Material: after the description of state and number of preserved specimens. All specimens studied (except for *Decodon gibbosus* n° NĚM G 7682-7691) are housed in the palaeobotanical collections of the Bílina Mine (Doly Bílina).

The synonym list is limited to the type records and those coming from the area of the North Bohemia Basin.

In the discussion, where possible, a probable living analogue of each taxon and its brief autecological characteristic are mentioned.

## PTERIDOPSIDA

### Osmundaceae

#### *Osmunda* L.

#### *Osmunda pardschlugiana* (UNGER 1847) ANDREÁNSZKY 1959

Pl. 1, fig. 4

1847 *Pteris pardschlugiana* UNGER; Unger, p. 122, pl. 36, fig. 6

1866 *Asplenium neogenicum* ETTINGSHAUSEN; Ettingshausen, p. 15, pl. 3, figs 16, 17

1881 *Pteris bilinica* ETTINGSHAUSEN; Engelhardt, p. 77 partim, pl. 1, fig. 1 (right)

1891 *Pteris pardschlugiana* UNGER; Engelhardt, p. 143, pl. 1, fig. 17  
1959 *Osmunda pardschlugiana* (UNGER) ANDREÁNSZKY; Andreánszky, p. 45, pl. 7, fig. 4; text-fig. 2

Material: A single carbonised fragment of frond - incomplete pinnate pinna (MG(30)272).

Description: Pinnulae sterile, 30-35 mm long and 10-14 mm wide (smaller, hardly measurable pinnulae cumulated in the upper part of the pinna), lanceolate to elliptic, very shortly petiolate and alternately attached on a conspicuous rhachis (lateral rhachis) of the pinna. Margin crenate. Apex blunt, base truncate. Venation of pinnulae pinnate, not anastomosing; secondaries abaxially curved, splitting off a conspicuous midvein. These veins nearly regularly twice forked: first, just after splitting off the main vein, second, at about one-third of the distance between the midvein and the pinnula margin. These forked veins terminate in the margin of the pinnula in the sinuses between the teeth.

Discussion: The described pinna is incomplete, with several attached pinnulae. Bůžek (1971) doubted the attribution of *Pteris bilinica* ETTINGSHAUSEN (described by Ettingshausen (1866) from the Břešřany Clay of the Břešřany locality) to *Osmunda*. Yet, a part of the described material (isolated pinnulae) from the same species, described by Engelhardt (1881) from Libědice, still remains in *Osmunda pardschlugiana* (UNGER) ANDREÁNSZKY in Bůžek's (1971) conception. The author fully agrees with Bůžek (1971) that the original Ettingshausen's species *Pteris bilinica* ETTINGSHAUSEN belongs to the species *Woodwardia muensteriana* (C. PRESL in STERNBERG) KRÄUSEL. This idea can be supported by the fact that the representatives of the species *Osmunda pardschlugiana* have crenate pinnulae, which are mutually separated on the rhachis. On the other hand, the foliage of *Woodwardia muensteriana* is characterised by entire-margined (or very finely dentate) pinnulae not separated from each other, more precisely, the pinna is simple, pinnately parted, and entire-margined, exactly as Ettingshausen (1866) described it. The original Ettingshausen's species *Pteris bilinica* is attributed here to the species *Woodwardia muensteriana*, and characterised hereafter (see the description of this species).

The genus *Osmunda* (comprising 14 species) lives today in tropical, subtropical and temperate zones of the both hemispheres (Novák 1972). The fossil species *Osmunda pardschlugiana* is compared by Bůžek (1971) to the extant species *Osmunda regalis*, that once lived even in Bohemia in the Labe Sand Mts. and in the Lužické hory Mts. as a relict from the humid period of the Post-glacial Atlantic (Novák 1972). In spite of this morphological resemblance, Bůžek (1971) stresses the absence of lateral lobes in the lateral pinnulae of the fossil representative. This fact can be supported by our own observations on the present fossil material. Kvaček and Bůžek (1983) note that the fossil *Osmunda pardschlugiana* is close to the extant *O. palustris*.



## Aspleniaceae

### ? *Asplenium* L.

#### cf. *Asplenium* sp.

Pl. 1, fig. 5

Material: A single carbonised frond (MG(30)403).

Description: Fern frond sterile, 30 mm long, simple to bipinnate in the lower part, with long petiole (10 mm), triangular, narrowing towards the top. Four pinnae alternately attached on each side of the frond rachis and one terminal pinna at the apex. Pinnae alternately pinnate with pinnately parted (almost divided) pinnulae in the lower part, toward the apex of the frond, pinnae simple, markedly pinnately divided, and on the top of the frond, pinnae just lobed. Pinnulae fan-shaped broaden, decurrent along the petiolule, with rounded lobes. Venation seen as a plastic, very fine and dense net, present on the pinnae surface, formed by veins longitudinally oriented (in directions of the pinnae dividing), and mutually anastomosing. Sporangia not observed.

Discussion: The specimen is compared to the genus *Asplenium* L. on the basis of external morphological resemblance: small pinnate frond with blunt, shapely broaden pinnulae, anastomosing veins. No analogous record is known, at least to the author's knowledge, in the palaeontologic literature. It is evident that more material, particularly fertile, is needed to get an exact and unambiguous attribution.

The *Aspleniaceae* family contains at present 9 genera with 700 species. Most of them belong just to the genus *Asplenium* (spleenwort). This genus has a world-wide distribution (spleenwort grows under different types of climate, e.g. tropical, north temperate regions, but also on different types of substrates, e.g. limestone, non-calcareous rocks, serpentines). Because of this wide range of distribution and uncertain systematic affinities, a more precise autecological characteristic remains problematic.

## Blechnaceae

### *Blechnum* L.

#### *Blechnum dentatum* (GOEPPERT 1836)

HEER 1872

Pl. 1, fig. 3

- 1836 *Aspidites dentatus* GOEPPERT; Goepfert, p. 355, pl. 21, figs 7,8  
1852 *Taeniopteris dentata* STERNBERG; A. Braun, p. 558  
1866 *Blechnum goepperti* ETTINGSHAUSEN; Ettingshausen, p. 14, pl. 3, figs 1-4  
1866 *Blechnum braunii* ETTINGSHAUSEN; Ettingshausen, p. 15, pl. 3, figs 5-8  
1872 *Blechnum dentatum* STERNBERG sp.; Heer, p. 11, pl. 1, fig. 1, 1b

Material: A single carbonised pinna (MG(30)264).

Description: Isolated, long lanceolate sterile pinna, 80 mm long and 10 mm wide, with the crenate margin, rounded, slightly asymmetrical base and acuminate apex, rounded on the top.

Venation formed by a conspicuous midvein, from which hardly visible straight secondaries split off, and terminate in the leaf margin. Veins forking before entering the margin not seen on the specimen.

Discussion: Sterile pinnae are attributed here to the species *Blechnum dentatum* on the basis of characteristic shape of pinnula and straight course of secondaries without looping, (in regard of the present state of preservation, this would point to the species *Salix haidingeri*.) Another feature characteristic of the species *Blechnum dentatum* is the presence of a long trichome on the upper cuticle, exactly as figured by Barthel (1976; p. 461, text-fig. 7d).

The genus *Blechnum* contains today about 200 species growing especially in the Tropics and Subtropics of both hemispheres (Novák 1972). The species *B. spicant* occurs in temperate regions of the Northern Hemisphere, and also in the Czech Republic (Dostál 1989). Barthel (1976) indicated *Blechnum serrulatum* occurring in the areas of Central and South America as the nearest living species to the fossil *Blechnum dentatum*.

## *Woodwardia* SMITH

### *Woodwardia muensteriana* (C. PRESL in STERNBERG 1838) KRÄUSEL 1921

Pl. 1, figs 1, 2

- 1838 *Pecopteris münsteriana* C. PRESL; Presl in Sternberg, p. 154, pl. 36, fig. 2  
1866 *Pteris bilinica* ETTINGSHAUSEN; Ettingshausen, p. 14, pl. 3, figs 14, 15  
1881 *Pteris bilinica* ETTINGSHAUSEN; Engelhardt, p. 77, pl. 1, fig. 1 (left)  
1881 *Woodwardia roessneriana* HEER; Velenovský, p. 11, pl. 1, figs 1-8  
1921 *Woodwardia münsteriana* (C. PRESL in STERNBERG) KRÄUSEL; Kräusel, p. 366, pl. 11, figs 2, 6-8, pl. 12, fig. 4

Material: A single carbonised fragment of leaf frond – pinnately divided pinna (MG(30)300).

Description: Sterile part of a fern frond, a pinna, 95 mm long, and 20 mm wide at the base (frond widest at base, narrowing toward the top). Pinna formed by a conspicuous rachis with attached pinnulae, alternately arranged and mutually connected at the base. Pinnulae about 10 mm long and 5 mm wide, entire-margined, narrower at the rounded apex, adaxially bent in the upper part. At the base, about 1/3 from the main rachis to the apex, adjacent pinnulae mutually connected; these “sinuses” on the pinna margin rounded, at angles of 10-30° (the pinna is in fact simple, not really pinnate, only pinnately divided and its so-called “pinnulae” represent in reality rounded teeth). Secondary veins (main veins of pinnulae) entering from the conspicuous main pinna vein to the pinnulae at an angle of about 60°. These veins bordered from both sides by elongated polygonal areolae, disposed characteristically in line, and limited, besides the secondary veins (or the main veins of pinnulae), by several times forked “tertiary” veins ending in the pinnula margin. Areolae present on both sides of the main pinna vein. Areolae long elongated, and rectangular, limited transversally by the two subsequent secondaries, and abaxially by a vein, parallel to the main vein and connecting the secondaries.

Discussion: As stated above (see the description of the species *Osmunda pardschlugiana*), the original Ettingshausen species *Pteris bilinica* is attributed here to the species *Woodwardia muensteriana* above all on the basis of the entire-margined pinnulae and the simple pinnately divided leaf. Regarding the venation of our specimen, it is attributed to the species *Woodwardia muensteriana* as well. Besides the features already described, this attribution is based on the presence of the characteristic polygonal areolae along the main vein of pinnulae, as well as the areolae on the both sides of the main pinna vein (secondary from the point of view of the whole frond). These features suggest a safe species determination, in spite of the absence of fertile fronds, which were previously described even from the area of the Most Basin (Luft 1956a, Bůžek 1971, Humík 1978).

The genus *Woodwardia* is represented today by 12 species (Novák 1972). Luft (1956a) compared the fossil species *Woodwardia muensteriana* (C. PRESL in STERNBERG) KRÄUSEL to the extant species *Woodwardia virginica* (L.) SM. and suggested that the fossil species, a robust swamp fern (Kvaček and Bůžek 1983), was bigger than its probable extant equivalent, living in Atlantic North America.

## Salviniaceae

### *Salvinia* ADANSON

#### *Salvinia reussii* ETTINGSHAUSEN 1866 sensu BŮŽEK, KONZALOVÁ et Z. KVAČEK 1971

Pl. 1, fig. 6, Pl. 2, fig. 1

- 1866 *Salvinia mildeana* GOEPPERT; Ettingshausen, p. 18, pl. 2, fig. 23  
 1866 *Salvinia cordata* ETTINGSHAUSEN; Ettingshausen, p. 18, pl. 2, figs 19, 20  
 1866 *Salvinia reussii* ETTINGSHAUSEN; Ettingshausen, p. 18, pl. 2, figs 21, 22  
 1881 *Salvinia formosa* HEER; Velenovský, p. 12, pl. 1, figs 14-17  
 1891 *Salvinia mildeana* GOEPPERT; Engelhardt, p. 16 (144), pl. 1 (4), figs 26, 27  
 1904 *Salvinia formosa* HEER; Brabenec, p. 12, pl. 1, fig. 2a-d  
 1951 *Salvinia formosa* HEER; Procházka, p. 99  
 1954 *Salvinia formosa* HEER; Procházka, pp. 170, 172, 173  
 1955 *Salvinia formosa* HEER; Procházka, p. 144  
 1956 *Salvinia formosa* HEER; Procházka, p. 181  
 1956b *Salvinia formosa* HEER; Luft, pp. 106, 107  
 1957 *Salvinia formosa* HEER; Luft-Hurník, p. 106  
 1960 *Salvinia formosa* HEER; Bůžek, pp. 12, 13  
 1961 *Salvinia formosa* HEER; Bůžek, pp. 82, 83  
 1962 *Salvinia formosa* HEER; Holý, p. 142  
 1963 *Salvinia mildeana* GOEPPERT; Hurník, p. 171  
 1963 *Salvinia mildeana* GOEPPERT; Němejc, p. 462, pl. 56, figs 4-6  
 1971 *Salvinia reussii* ETTINGSHAUSEN; Bůžek, Konzalová et Kvaček, p. 202, pls. 1-8, text-figs 1-9, 11

Material: Numerous carbonised leaves, rarely together with floats.

Description: Leaves, often in pairs, oval, max. 20 x 15 mm, and entire-margined. Venation formed by a conspicuous midvein, bordered on both sides by polygonal, elongate, and undivided medial areolae, separated from each other by alternate secondary veins. Secondaries together with parallel intersecondary veins forming parallel bands of nearly equal width, which, separated by transverse connecting veins, give rise to a regular net composed of small quadrangular or polygonal

areolae. Areolae with characteristic tubercles, their exact number per areola not discernible due to the state of preservation. Secondaries, together with intersecondary veins, not entering the leaf margin – forming loops, which resemble an intramarginal vein. Stem with conspicuous medial vascular bundle seen on one specimen (MG(30)303). On this stem, two leaves branching off from a characteristic node, recognisable as a small circle. These two leaves having a petiole, broad-keeled towards the lower side of the blade, slightly longer than 10 mm, and containing several vascular bundles. 3 + 3 floats branching off from the same node. This branching corresponds with that figured by Bůžek et al. (1971; p. 191, text-fig. 7), except for the 4<sup>th</sup> float, which is missing in our case. Floats 13-15 mm long and 3-5 mm wide, elongated to oval, rough, membranous, with visible midvein and acuminate apex. Trichomes of the “Borstenhaare” type not seen. No absorption system preserved, perhaps except for a ?wider “whorled” branching segment.

Discussion: Records of the genus *Salvinia* in the Most Basin were described in a detailed monograph by Bůžek et al. (1971). Besides the morphological description, there was anatomic analysis and a description of sporangia and spores. The authors (Bůžek, Konzalová and Kvaček 1971) joined several types under a single specific name *Salvinia reussii* and gave an emended diagnosis of this newly defined species. They described bizarre, probably floating organs, which have no analogue among extant taxa. Together with Bonnet (1955) and in contradiction with the today common interpretations, the authors (Bůžek et al. 1971) suggest, such a complicated complex, as the floating apparatus, segments of absorbing system and sporophylls, must be of stem origin rather than leaf origin, created by metamorphosis of a single (the 3<sup>rd</sup> ventral) leaf.

Regarding all facts, Bůžek et al. (1971) noticed that none of the today living representatives of the genus *Salvinia* could be proposed as a direct descendant of this fossil floating fern *Salvinia reussii*. Hence, the fossil representative could not be attributed to a particular phytogeographical element.

## PINOPSIDA

### Taxodiaceae

#### *Taxodium* RICH.

#### *Taxodium dubium* (STERNBERG 1823) HEER 1853 Pl. 2, figs 2-5

- 1823 *Phyllites dubius* STERNBERG; Sternberg, p. 37, pl. 36, fig. 3  
 1853 *Taxodium dubium* (STERNBERG) HEER; Heer, p. 136

Material: Carbonised brachyblasts, whole twig, several male reproductive complexes and one seed.

Description: Brachyblasts arranged alternately on the twigs. Brachyblast leaves flat, linear to lanceolate, with acute apex, rounded base, conspicuous midrib, and sometimes dense parallel venation. Leaves on the brachyblast in two ranks, alternately, unequally spaced. Additional to the brachyblasts and in two ranks (alternately) arranged flat leaves, the foliage of the 2<sup>nd</sup> type - scale, spirally arranged leaves, characteristic of

longer shoots (macroblasts) is recognisable on the twig (specimen MG(30)240). Male cones arranged in spike, microsporangia appressed to the axis. Pollen globular, smooth, characteristically V-shaped split open. Seed very small, only about 4 mm long and 2 mm wide, oval, bent. Seed cavity, centrally disposed with a distinct longitudinal furrow, occupying almost the whole length of the seed, on both sides with a narrowly winged edge. Seed base rounded, apex narrower acute. Sculptation of seed cavity indistinct. Wing densely, finely, and longitudinally furrowed.

Adaxial cuticle without stomata. Ordinary cells (10-17.5 x 10-27.5  $\mu\text{m}$ ) quadratic to polygonal, isometric to slightly elongated (more elongated near the leaf margin), often wider than longer, with straight to slightly undulate anticlines, arranged in straight to slightly undulate rows. Abaxial cuticle containing stomata - a single stomatal band of 2 rows observed. Stomata amphicyclic, orientated obliquely or perpendicularly to the cell length (never longitudinally). Subsidiary cells in two circles. The inner, widely oval to circular, formed by 4-5 wider subsidiary cells, never touching the inner circle of the subsidiary cells of neighbouring stoma. Stomatal pit 30-37.5  $\mu\text{m}$  long, oval to rhomboidal, with a distinctive stomatal aperture in the middle. Ordinary cells of the abaxial cuticle similar to those from the adaxial side; those, lying within the stomatal bands, irregularly orientated and more isometric.

Discussion: Morphology of the needles (typically flat, disposed in two ranks on the brachyblasts) together with the character of the cuticle, allows a reliable attribution to the genus *Taxodium*. Similar foliage can be observed among the genera *Metasequoia* and *Sequoia*. The genus *Metasequoia* is easily distinguished from the genus *Taxodium* by opposite needles. The genus *Sequoia* (needle-like foliage) is distinct from *Taxodium* owing to the epidermal architecture, precisely owing to dark-colour subsidiary cells and strongly elongated ordinary epidermal cells of *Sequoia* (Kvaček 1985).

Within the genus *Taxodium*, 3 species growing in the areas of southeastern USA and Mexico, are recognized (Novák 1972). *T. distichum*, a characteristic component of swampy regularly flooded forest of the Southern states of the eastern part of USA around the Gulf of Mexico, is traditionally suggested as an extant analogue of the fossil species. This environmental characteristic matches very well the supposed environment, occupied by the fossil bald-cypress in the Tertiary of the Most Basin. Bůžek (1971) points out (according to Němejc's personal communication) that the fossil representative is rather closer to the extant Mexican *T. mucronatum* - however, this bald-cypress is a mountainous swamp species.

### *Glyptostrobus* ENDL.

#### *Glyptostrobus europaeus* (BRONGNIART 1833) UNGER 1850

Pl. 2, fig. 8, Pl. 3, figs 1, 2

1833 *Taxodium europaeum* BRONGNIART; Brongniart, p. 168  
1850b *Glyptostrobus europaeus* (BRONGNIART) UNGER; Unger, p. 434

Material: Carbonised twigs, seed cones, isolated seeds and male reproductive structures.

Description: Twigs covered by scale-like, spirally arranged leaves, closely appressed to the axis or slightly protruding. Awl-like cryptomeroid leaves characteristic of brachyblasts recognisable on one specimen (MG(30)366). Male reproductive structures recognisable as very small, hardly visible cones on tops of some scale leafy twigs. Seed cones about 20 mm long, and 15 mm wide, rhomboidal in shape, with rounded apex and cup-like narrowing rounded base. Cone scales longitudinally elongated, mutually overlapping, composed of narrower lower supporting scale and upper, triangularly widening seed scale with crenate margin. Scales, essentially their lower elongated part, distinctly longitudinally sculptured, scale number per cone uncertain due to the state of preservation. Seeds winged, 7 to 12 mm big. Seed cavity oval, distinctly bent, finely longitudinally sculptured, occupying the lower half of the seed (i.e. seed cavity + wing). Seed wing markedly bilobate, straight symmetric, but most often bent in opposite direction to the seed cavity. Wing starting at seed base and coating seed cavity on both sides and in the upper part, outside the seed cavity, becoming narrower into a rounded tip. Venation of the wing hardly visible, formed by long elongated, very small, polygonal areolae.

Scale leaves with two adaxial, densely covered, thin (about 70  $\mu\text{m}$ ) stomatal bands, composed of mainly obliquely and perpendicularly orientated amphicyclic stomata. Stomata surrounded by 2-3 circles of subsidiary cells. Inner circle oval, equably wide, composed on the average of 6 cells. This circle surrounding oval, 12.5-15  $\mu\text{m}$  long stomatal pit with distinctive middle aperture. Ordinary cells (7.5-15 x 7.5-30  $\mu\text{m}$ ) elongated, quadrangular to polygonal, with straight to slightly undulate anticlines, disposed in rows. Ordinary cells shorter and wider within the stomatal band. Periclinal walls of the ordinary cells densely covered by conspicuous scars after crystals. Abaxial leaf side rarely covered with stomatal bands. Stomata of same character like on the adaxial side, however, rather longitudinally or obliquely orientated. Ordinary cells, contrary to the adaxial side, rather more quadratic and wider, with less conspicuous scars after crystals and densely disposed.

Discussion: The genus *Glyptostrobus* is unequivocally proven by seed cones, isolated cone scales and isolated seeds in the North Bohemian Tertiary (Bůžek and Holý 1964). Sterile scale-like twigs are morphologically indistinguishable from the representative of the bald-cypress family *Quasisequoia couttsiae* described below. A comparative attempt was undertaken on the basis of observations of the cuticles, taken from the leaves of fertile twigs of these two representatives, in order to make unequivocal distinction between them in sterile state. In spite of the fact that on microscopic level they are both similar in epidermal structure, as already noticed by Kvaček (1985), some differences have been found. The species *Glyptostrobus europaeus* has contrary to *Quasisequoia couttsiae*: a) on the average smaller (about 15  $\mu\text{m}$ ), more oval stomatal pits surrounded by more equably wide and more regular inner circles of subsidiary cells, b) stomata orientated often perpendicularly to the leaf length essentially on the adaxial side, and c) rather more distinctive (bigger) scars after crystals on the periclinal cell walls. Although these differences present a useful aid at distinguishing sterile twigs, they were studied on few specimens only, and so require further more detailed studies before being generalised.



The genus *Glyptostrobus* is monotypic today - a single living species *G. pensilis* lives in south-eastern China (Novák 1972). The fossil representative does not practically differ from the extant one on the basis of the epidermal structure (Kvaček 1960, 1966), although the fossil could be a cumulative taxon (Kvaček 1985). *Glyptostrobus europaeus* is a typical coal-forming Tertiary tree of swamp forests. It presents a case where autecology of the extant representative has changed - *G. pensilis* does not grow today directly in swamps, although it occurs in humid biotopes on the river banks and near the sea coast (Svešnikova 1963).

***Quasisequoia* SHRINIVASAN et FRIIS  
emend. KUNZMANN**

***Quasisequoia couttsiae* (HEER 1862)  
KUNZMANN 1999**

Pl. 2, figs 6, 7, Pl. 3, figs 3, 4

- 1862 *Sequoia couttsiae* HEER; Heer, p. 1051-1055, pl. 59 - 61  
 1884 *Athrotaxis couttsiae* (HEER) GARDNER; Gardner, p. 90-91, pl. 6, fig. 1-9, pl. 10, figs 6-9  
 1964 *Sequoiadendron* cf. *couttsiae* (HEER) GRAMBAST; Bůžek et Holý, p. 112, pl. 3, figs 1-11  
 1999 *Quasisequoia couttsiae* (HEER) KUNZMANN; Kunzmann, p. 57, pl. 10, figs 5-6, pls. 11-13, text-figs 13-14

Material: Carbonised twigs, seed cones and several seeds.

Description: Twigs covered by scale-like, spirally arranged leaves, closely fitting to the axis or just slightly protruding. Cones 15-30 mm long and 10-15 mm wide, spherical to oval, with rounded apex and slightly cuneate base, scales rhomboidal in cross-section. Their number per cone - 10 - measurable on the well-preserved specimens (e.g. MG(30)366). In mature open cones there are two main parts of the scale recognisable (i.e., peltate apophysis and stalk). Small immature cones frequent. Isolated seeds 5 x 3 mm in size, elliptical, except for the apex, perfectly symmetrical. Seed cavity narrowly elongate, oval, occupying the whole length of the seed, situated in the middle part, surrounded on both sides by a narrow wing. Seed cavity and winged board distinctly longitudinally sculptured. Base of the seed slightly cordate with a trace of a hilum. Apex of the seed rounded, distinctly asymmetrical, bent, terminating in a characteristic small bump-like protuberance. Seeds often very cracked due to drying with detached pieces of carbonised matter.

Adaxial cuticle composed of isometric (12.5-17 µm in diameter) to longitudinally elongated (5-10 x 20-40 µm) epidermal cells with straight to slightly undulate anticlines, distinct scars after crystals on the outer periclinal walls. Stomata amphicyclic, in 2 rows, orientated essentially longitudinally, parallel to the stomatal band, but some stomata orientated obliquely or perpendicularly. Stomatal pits 25-45 µm long, stoma surrounded by two circles of cells. Inner circle formed by (4)-5 subsidiary cells, outer circle often incomplete. On the abaxial cuticle, ordinary cells about 15 µm wide and up to 110 µm long, distinctly elongated in the direction of the longitudinal axis, with more or less straight anticlines. On the periclinal walls distinct scars left by crystals. Amphicyclic stomata, contrary to the adaxial cuticle, in groups rather than in continuous bands. Orientation of stomata mostly parallel to the cell length, but also oblique.

Stomatal pits 32.5-50 µm long, stoma surrounded by two circles of cells. Inner circle very narrow (narrower than on the adaxial side), often interrupted, formed by 5 subsidiary cells, outer circle, same as on the adaxial side, commonly incomplete.

Discussion: The systematic position of the extinct conifer, known as "*Athrotaxis*" *couttsiae* within the family Taxodiaceae was not completely clear until the revision by Kunzmann (1999). Macroscopically, sterile twigs appeared as those in the genera *Athrotaxis*, *Glyptostrobus*, or in the genera *Sequoia* and *Sequoiadendron*. The accompanied cones and seeds unequivocally rule out species *Glyptostrobus europaeus*, otherwise in sterile state very similar with and easily mistaken for the species *Quasisequoia couttsiae*; however, certain differences in the epidermal structure can be observed (see the previous description). Regarding the cones, *Q. couttsiae* was compared to the extant species *Sequoia sempervirens*, with which it shares similar seeds, cones, and the arrangement of seeds on the scale in a single row only; contrary to the similar living species *Sequoiadendron giganteum*, which has seeds in two rows on the scale (Chandler 1964). Mai and Walther (1978) attributed the remains of seeds and cones accompanying the twigs to the genus *Athrotaxis*. From the epidermal point of view, "*Athrotaxis*" *couttsiae* differs both from representatives of the genus *Sequoia* that have narrowly elongated epidermal cells, and from representatives of the genus *Athrotaxis* with monocyclic stomata - there is probably an extinct genus (Kvaček 1985). After a thorough comparative study, Kunzmann (1999) attributed this Conifer to the extinct genus *Quasisequoia*, occurring also in the Cretaceous.

*Quasisequoia couttsiae* does not have any exact living relative. During the Tertiary, it represented, with *Glyptostrobus europaeus*, the main coal-forming element, common in the lignite seams. This swampy conifer could reach over 2 m in the trunk diameter (Kvaček and Bůžek 1983).

## MAGNOLIOPSIDA

### Lauraceae

***Laurocarpum* E. M. REID et CHANDLER**

***Laurocarpum* sp.**

Pl. 3, fig. 5

- 1856 *Cinnamomum polymorphum* HEER partim; Heer, p. 88, pl. 94, figs 12-16 (non fig. 17)

Material: A single carbonised stalked drupe (MG(30)290).

Description: Drupe, 6 mm long and 5 mm wide, roundish, at the apex slightly narrowing. Fruit on a stalk, about 15 mm long, incomplete. Stalk widened into a blunt, bell-like cupule at the point of the fruit attachment, the. Fruit and stalk slightly densely longitudinally striated.

Discussion: Fruit is attributable to the family Lauraceae on the basis of its oval shape and the typical cupule. The distinct cupule points to a drupe of the genus *Cinnamomum* rather than to a berry with a less conspicuous cupule, typical of the genus *Laurus*.

*Laurocarpum* fossils are connected mostly to the coal facies in the Most Basin and may represent fruits belonging to the leaves of the species *Laurophyllum saxonicum* LITKE. This plant is an evergreen component of the swamp vegetation, analogous to the extant lauraceous *Persea borbonia* or *P. pubescens* from southeastern USA (Kvaček and Bůžek 1983).

### Berberidaceae

#### ? *Mahonia* NUTTAL

cf. *Mahonia* sp.

Pl. 3, fig. 6

Material: Three carbonised leaf remains (MG(30)298, 431, 432).

Description: Leaves very narrow (8-18 mm) elongate. Base, preserved in one case only, narrowing, cuneate, convex from one side and concave from the other. Leaf apex not preserved on any specimen. Margin ? irregularly simple toothed. Teeth perpendicular to the leaf margin, in one case (MG(30)431) tooth slightly spiny. Sinuses between teeth rounded. Venation indistinct except for the straight middle vein. Secondaries alternate, diverging at unequal angles, often on the same side, two very close to each other. Secondaries terminating in the tooth, often forked before entering the tooth. Secondary venation indistinct, probably semicraspedodromous to craspedodromous. Neither palmate venation, formed by 3 and more main veins, nor intersecondary, tertiary nor higher-order veins seen on the specimens.

Discussion: These problematic leaf remains are compared to isolated leaflets of the originally compound leaf of the genus *Mahonia*, mainly on the basis of the distinctly simple toothed margin. The shape of the leaves is comparable to that described by Arnold (1936) as a new species *Mahonia malheurensis*. The leaves of *Mahonia* are characterised by thorny teeth and features of the venation (Kvaček and Bůžek 1994, Arnold 1936, Meyer and Manchester 1997): palmate venation with 3-6 basal (primary) veins, lateral ones are less conspicuous and steeper than secondary veins that split off alternately above them from the middle main veins forming craspedodromous, or semicraspedodromous to brochidodromous secondary venation. These features are either absent (palmate venation), or just very poorly perceptible on the studied specimens (craspedodromous to semicraspedodromous secondary venation, spiny teeth of the leaf margin). For these reasons, the fossil leaves are not assigned for sure to *Mahonia*.

The extant genus *Mahonia* contains about 70 species of evergreen shrubs, native to eastern Asia and North and Central America (Meyer and Manchester 1997). It is possible to separate 2 groups within this genus on the basis of the inflorescences (Ahrendt 1961); this distinction is also supported by the difference in venation type between the groups (Schorn 1966). The first group Orientales with palmate venation inhabits eastern Asia, with a single exception of North-American species (*M. nervosa*). The second group Occidentales, with pinnate or modified pinnate venation, is characteristic of Pacific North America and Central America (Schorn 1966). So mere absence of palmate venation (as in the present case) may

not preclude attribution of a foliage to the genus *Mahonia*. *Mahonia* generally presents an evergreen element of the undergrowth, often in the Mixed Mesophytic Forest, on the banks of river coming into the basin (compare Kvaček and Bůžek 1994).

### Cercidiphyllaceae

#### *Cercidiphyllum* SIEB. et ZUCC.

*Cercidiphyllum crenatum* (UNGER 1850) R. BROWN  
1935 emend. Z. KVAČEK et KONZALOVÁ 1996

Pl. 4, figs 1-5

1850a *Dombeyopsis crenata* UNGER; Unger, p. 448

1866 *Ficus asarifolia* ETTINGSHAUSEN; Ettingshausen, p. 80, pl. 25, figs 2, 3, 6

1869 *Grewia crenata* (UNGER) HEER; Ettingshausen, p. 15, pl. 42, fig. 7

1881 *Grewia crenata* UNGER (HEER); Velenovský, p. 36, pl. 9, figs 10-14

1935 *Cercidiphyllum crenatum* (UNGER) R. BROWN; Brown, p. 575, pl. 68, figs 1, 6, 8-10

1980 *Cercidiphyllum helveticum* (HEER) JÄHNICHEN, MAI et WALTHER; Jähnichen, Mai et Walther, p. 371, pl. 7, figs 1-15, pl. 8, fig. 1

1996 *Cercidiphyllum crenatum* (UNGER) R. BROWN; Kvaček et Konzalová, p. 149, pl. 1, figs 1-4, pl. 2, figs 2-8, pl. 3, figs 3-7, pl. 4, figs 1-14

Material: Several carbonised leaves, male inflorescences, isolated fruit follicles and seeds.

Description: Leaves long petiolate (petiole rarely preserved), rounded, deeply cordate. Margin crenate, glandular, with chlorantoid teeth. Venation palmate, with 5-7 primary veins. Lateral veins diverging from primary veins, and terminate in the leaf margin after a second branching. Male inflorescences composed of 4-6 flowers. Flowers with long stalk, terminated by a pentamerous cup-like perianth (calyx) and a group of stamens; if poorly preserved, recognisable just as clusters of oval anthers, from both sides rounded. Inflorescence subtended by conspicuous elongate prophylls; on some specimens 2-3 pairs of thin flower bracts (perhaps opposite). Follicles found mainly isolated, only rarely in pairs or more, forming infructescences, smooth (without specific sculptation), long oval with short acute or rounded apex. Seeds winged, asymmetrical, about 10 mm long, with a single proximal wing.

Discussion: The species *Cercidiphyllum crenatum* has been studied in detail by Kvaček and Konzalová (1996). Besides the detailed description (e.g. twigs, epidermal structure) of the organ parts known earlier, the authors gave here for the first time characteristics of the staminate inflorescences and pollen in situ. The above descriptions are based on new specimens coming also from the locality Důl Bílina, right from the Horizon n° 30.

Considering the living relatives of *Cercidiphyllum*, all our fossil leaves represent leaves growing on brachyblasts. Nevertheless, the analogies can be precarious. The presence of the perianth (pentamerous in addition) and subtending prophyll of whole inflorescence, clearly individualised flowers of the male inflorescence (compare Heel 1987) and anthers without a distal tip are the characters which differentiate the fossil *Cer-*

*cidiphyllum* from its extant analogue. These characteristics (especially presence of the perianth and absence of the distal tip of anthers) would point rather to the proximity of the family Trochodendraceae (genus *Tetracentron*) and the possible entomophily of the fossil representative. While showing some similarities within the order Trochodendrales (Endress 1986), the genus *Cercidiphyllum* (and the whole family Cercidiphyllaceae), presents a clearly distinguishable group (reliably from the Early Miocene) in view of its diclinic flowers (Kvaček and Konzalová 1996).

*Cercidiphyllum crenatum* is known from the Oligocene to Pliocene over the whole Northern Hemisphere (Asia, North America, Europe) within the analogue assemblages of the Mixed Mesophytic and temperate Broad-leaved Deciduous Forest (Kvaček and Konzalová 1996). It grew best on lowland moist soils and survived even swampy conditions (Kvaček and Konzalová 1996), contrary to the extant *C. japonicum* that inhabits moist mountainous valleys rather than swamps (Nunata 1974).

## Fagaceae

### *Quercus* L.

#### *Quercus rhenana* (KRÄUSEL et WEYLAND 1950) KNOBLOCH et Z. KVAČEK 1976

Pl. 4, figs 6, 7, text-fig. 3

1950 *Illicium rhenanum* KRÄUSEL et WEYLAND; Kräusel et Weyland, p. 50, pl. 9, figs 5-7, pl. 10, figs 1-2, pl. 11, fig. 6, text-fig. 14

1966 *Quercus lusatica* JÄHNICHEN; Jähnichen, p. 478, pl. 1-4, 8, pl. 9, figs 21, 22, text-figs 1, 3, 4

1976 *Quercus rhenana* (KRÄUSEL et WEYLAND) KNOBLOCH et Z. KVAČEK; Knobloch et Kvaček, p. 41, pl. 17, figs 6, 8, 14, pl. 21, figs 5-6, pl. 24, fig. 10

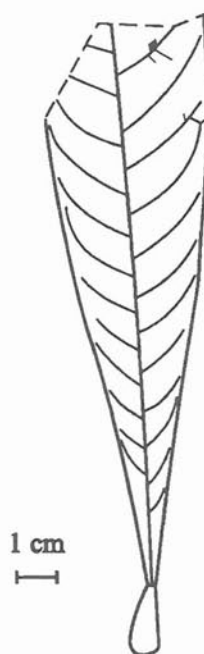
**Material:** A single incomplete impression of the leaf with only fragmentary remains of very thin carbonised substance (MG(30)244).

**Description:** Leaf elongate, considerably large (only fragment 150 mm long), entire-margined with cuneate (widened in the lower part) decurrent base. Leaf apex not preserved. From pronounced main vein, less conspicuous, mutually parallel secondaries alternately splitting off, curved, running just along the leaf margin. Looping, typical of brochidodromous venation, not clear. Tertiaries, perceptible especially in the uppermost part of the leaf fragment as imprints, originating from the secondaries at an angle of about 70°. Very poorly recognisable higher order venation (only as imprints) forming a dense areolation.

Adaxial cuticle not observed. Abaxial cuticle characterised by distinctly lobate ordinary epidermal cells, averaging 25-30 µm across. Stomata cyclocytic, widely oval, 30 µm long and about 25 µm wide with an elliptical front cavity, 12.5 µm wide, almost reaching the poles. A circle of subsidiary cells, about 5 µm wide and without perceptible transverse cell walls around the stoma. Typical wax ring around the stoma (Kvaček 1985) not developed. Trichome bases not recognisable.

**Discussion:** The taxonomic affinity of foliage of the *Quercus rhenana* type is not entirely clear so far. Jähnichen (1966) examined the remains and concluded, on the basis of accom-

panying fruits and other characters, that *Q. rhenana* (*Q. lusatica* in his sense) belongs to the subgenus *Quercus*. Its closest relatives should inhabit southeastern Atlantic North America. Knobloch and Kvaček (1976), established a new combination *Quercus rhenana*, showing that Jähnichen (1966) had neglected a comparison with other representatives of the family Fagaceae, e.g. with the genera *Lithocarpus* and *Castanopsis*. It is very difficult to distinguish these genera from the oaks s.s. based just on fruit characteristics. The nut, coming from the Horizon n° 30, can be regarded as a fruit, accompanying the leaves of *Quercus rhenana*. Here it is attributed to the genus *Castanopsis* (see next description). Finally, a very interesting absence of the characteristic wax ring, coating the guard cells of the stoma, was observed (Kvaček 1985). This could be explained by relatively high air humidity in the studied locality, when an apparatus, restraining the undesirable evaporation from the leaf surface (wax ring in our case) is no more needed.



Text-fig. 3. *Quercus rhenana* (KRÄUSEL et WEYLAND) KNOBLOCH et Z. KVAČEK, leaf; MG(30) 244.

Independently from its possible systematic affinity, *Quercus rhenana* can be considered as a swampy evergreen oak (Kvaček and Bůžek 1983). Jähnichen (1966) considered it an integral component of the Centro-European mastixioid floras from the Late Oligocene to Middle Miocene.

### *Castanopsis* (D. DON) SPACH

#### *Castanopsis* cf. *schmidtiana* (GEINITZ 1879) KRÄUSEL 1920

Pl. 4, fig. 8

1879 *Cycadospermum schmidtianum* GEINITZ; Geinitz, p. 113, pl. 4, fig. 2

1920 *Castanopsis schmidtiana* KRÄUSEL; Kräusel, pp. 368-372

**Material:** A single fruit impression (MG(30)335).



Description: Lateral impression of nut, 25 x 20 mm big, oval, slightly longitudinally elongate. Neither cupule nor scar after cupule preserved. About 5 conspicuous longitudinal ribs recognisable on the impression; between ribs dense, longitudinal grooving - furrowing of the pericarp surface. Fruit narrowing apically and projecting into a poorly preserved, small, ? rounded tip.

Discussion: The fossil fruits and wood of the genus *Castanopsis* from the European Tertiary oak-laurel forest were investigated in detail by Mai (1989). Within the European Tertiary fruit remains of *Castanopsis*, Mai (1989) recognizes 3 species: *Castanopsis salinarum*, *C. schmidtiana* and *C. pyramidata*. On the basis of the available features, the described specimen can be attributed to the species *Castanopsis schmidtiana*. As preservation is in impression only, with incomplete diagnostic features available (above all shape, scar after cupule and clearly defined apical ending), the specimen is left in open nomenclature. Its possible attribution to the species *Castanopsis salinarum*, which is characterised by a more oval shape without typical acuminate apical ending and smaller cupule, is not completely excluded. The samara described here presents a characteristic fruit, accompanying the foliage of the *Quercus rhenana* type. It is uncertain whether foliage really corresponds to the fossil oak, or rather to another representative, for instance to the genus *Castanopsis*, of the Fagaceae family.

The genus *Castanopsis*, containing 100-110 species, inhabits today essentially tropical and subtropical areas of south(eastern) Asia and North America. The species *C. chrysophylla* (DOUGL.) A. DC. can be distributed in colder areas of Pacific North America (46° N) (Mai 1989). The fossil species *Castanopsis schmidtiana* fits best, after Mai (1989), the recent *C. platyacantha*, growing in the Mixed Deciduous-evergreen Forest of South China at altitudes of 1300-1600 metres above sea-level.

## Betulaceae

### *Betula* L.

#### *Betula* sp. (folium)

Pl. 5, fig. 1

Material: One carbonised leaf (MG(30)430).

Description: Leaf widely ovate, 35 x 28 mm large, with relatively long petiole (>10 mm). Leaf apex acute, at angle of about 90°. Base widely cordate. Leaf margin distinctly double toothed, i.e. every main tooth bearing again one or two teeth. Venation craspedodromous. 5 pairs of secondaries subparallelly splitting off the conspicuous midvein, at an angle of about 50°. Completely at the base, a pair of veins, originating practically from the petiole at angle of about 60°, curving very soon distinctly abaxially and continuing more or less parallel to the lower leaf margin. Secondaries terminating in the apices of the rounded main teeth. Sometimes recognisable veins, splitting off the secondaries abaxially, and entering the teeth of the 2<sup>nd</sup> order. No more venation details discernible.

Discussion: A leaf birch of this type has not been described so far from the area of the Most Basin. The leaf margin is quite unusual in combination with obtuse teeth with acute tooting.

The foliage of the recent birch *Betula papyrifera* var. *cordifolia* (REGEL) FERN. (= *B. cordifolia* REGEL), inhabiting northern areas of North America, from Labrador to Minnesota (Krüssmann 1960), seems to be morphologically closest to the fossil. Another birch, very similar in its leaf shape, venation and partially in its margin is *B. platyphylla* var. *szechuanica* (SCHNEID.) REHD., growing in western China (Krüssmann 1960). Similar foliage can be observed among the representatives of the series *Excelsae*, unlike the isolated fruit scale described below, attributed also to a birch.

#### *Betula* sp. (bractea)

Pl. 5, fig. 2

Material: One supporting bract (MG(30)293).

Description: Supporting fruit bract trilobate, 10 x 3 mm large, rounded at the base, slightly widening toward the apex with two lateral cup-like projecting lobes. Third middle lobe highest and slightly wider, at the apex indistinctly bilobate.

Discussion: This type of bract, with distinctly acuminate middle lobe, is not typical of the Most Basin (Bůžek and Holý 1964), but it has been noticed elsewhere (e.g. Meyer and Manchester 1997; pl. 30, fig. 7).

Supporting scales found in the fossil specimen are similar to the living representatives (Krüssmann 1960) which are essentially in the birches from the series *Costatae*, above all in the species *Betula nigra* L., *B. corylifolia* GUNNARSSON, *B. grossa* SIEB. et ZUCC. and *B. globispica* SHIRAS. In the light of this comparison, the attribution of a single birch leaf to this fossil bract remains questionable. The birches of the series *Costatae* have 7 or more pairs of secondary veins. In contrast, the studied leaf only shows 5 pairs (max. 6, when the 6<sup>th</sup> pair is in the very apex of the leaf, in the poorly seen part of the specimen). It is possible that the 2 isolated fossil specimens of *Betula* do not represent the same species. A comparison of the possible autecology of the fossil species with that of *Betula nigra* is worth noticing - this extant species grows today on alluvial sediments of swamps of the pacific part of USA, from New Hampshire to Florida (Gleason 1963).

### *Alnus* MILL.

#### *Alnus julianiformis* (STERNBERG 1823) Z. KVAČEK et HOLY 1974

Pl. 5, figs 3-5, text-fig. 4

- 1823 *Phyllites julianaeformis* STERNBERG; Sternberg, p. 37, 39, pl. 36, fig. 2  
 1845 *Fagus feroniae* UNGER; Unger, p. 106, pl. 28, figs 3, 4  
 1866 *Fagus feroniae* UNGER; Ettingshausen, p. 126, pl. 1, fig. 18, pl. 2, figs 7, 8, pl. 15, figs 12-20, 22, p.16, fig. 1  
 1866 *Quercus furcinervis* ROSSMÄSSLER sp.; Ettingshausen, p. 58, pl. 16, figs 11, 12  
 1866 *Quercus hoernesi* ETTINGSHAUSEN; Ettingshausen, p. 55, pl. 16, fig. 4(?)  
 1866 *Quercus Pseudo-Alnus* ETTINGSHAUSEN; Ettingshausen, p. 59, pl. 17, fig. 3  
 1881 *Fagus feroniae* UNGER; Velenovský, p. 23, pl. 3, figs 7, 8  
 1891 *Fagus feroniae* UNGER; Engelhardt, p. 158, pl. 7, figs 32-34, pl. 8, figs 4-8, 10  
 1934 *Fagus feroniae* UNGER; Czeczott, pp. 109-116, text-figs 29, 30  
 1971 *Alnus attenuata* (GOEPPERT) KNOBLOCH; Knobloch, p. 264  
 1974 *Alnus julianaeformis* (STERNBERG) Z. KVAČEK et HOLY; Kvaček et Holý, pp. 367, pl. 1, 2, 3, pl. 4, fig. 1, text-fig. 1

Material: Great quantity of carbonised leaves and several catkins.

Description: Leaves long petiolate, up to 100 mm long, oval-lanceolate to widely oval. Base rounded, roundly truncate to widely cuneate. Apex acuminate. Leaf margin densely simple serrate. Venation craspedodromous. A distinct midvein giving rise to secondary veins originating alternately, at angles of  $40^\circ$  (in the upper part) to  $50^\circ$  (in the lower part) straight, or at the base curved abaxially toward the leaf margin. Secondaries terminating in the margin, entering the sinuses. Side veins, abaxially splitting off the secondaries, curved and terminating also in sinuses, particularly in the lower part of the leaf. Tertiaries often forked, perpendicular to the secondaries, forming, together with veins of higher orders, dense polygonal areolation. The tertiary vein nearest to the margin often splitting a vein, parallel to two adjacent secondaries. This vein terminating in the tooth (sinus) between the teeth (sinuses), the termination points of the secondaries – just as described by Czezzott (1934) - see text-fig. 4. Male composed inflorescences (catkins) found in association with the leaves. Catkins 60 mm long, with 15 mm long stalk. No more details (e.g. prophylls of partial flowers) visible due to the state of preservation.

On the abaxial cuticle long elongate anomocytic stomata ( $27.5 \times 12.5 \mu\text{m}$ ) with clutched, relatively darker guard cells with a thin aperture, reaching the poles. Unicellular trichomes, up to  $60 \mu\text{m}$  long, and multicellular trichome bases present.

From one catkin, characteristic 4-5 porate pollen of the alder type, ornamented on the borders by folds of exina, and abaxial cuticle of a subtending bract of flower dichasiums obtained. Ordinary cells,  $15\text{-}20 \mu\text{m}$  in diameter, with undulate to lobate anticlinal walls. Stomata anomocytic, rounded to almost circular ( $25\text{-}30 \mu\text{m}$  wide and  $22.5\text{-}30 \mu\text{m}$  long) with close or just in the middle slightly open aperture.

Discussion: The leaf morphology was essential to attributing the described specimens to the species *Alnus julianiformis* (STERNBERG) Z. KVAČEK et HOLÝ – wider, oval leaves point to this species rather than to the species *Alnus gaudinii* (HEER) KNOBLOCH et Z. KVAČEK. The catkins were attributed to the species *Alnus julianiformis*, because they display alder male inflorescences accompanying the abundant, and in the Horizon 30, exclusively spread alder leaves. Nevertheless, the leaf epidermis taken from the bract of catkin would suggest the species *Alnus gaudinii* by its relatively big stomata.

Leaves, attributed today to this alder, were for long time considered to be beech or oak. Czezzott (1934) studied these problematic remains that had been know as *Fagus feroniae* UNGER. She gives the basic features distinguishing this type of leaf from those of extant and extinct beeches: long petiole, often with symmetrical base, abruptly acute apex of the leaf; characteristic splitting of the 3<sup>rd</sup> order vein closest to the margin; absence of beech fruits in the Bílina locality, while hundreds of specimens of *Fagus feroniae* are present; double toothed margin (this type of margin was not observed, so the distinction of orders can not be hold). On the basis of these features, supported among others even by the doubts of Saporita (1891-92), Czezzot concluded that *Fagus feroniae* UNGER presents an alder due to external morphology close to that of extant *Alnus japonica* SIEB. et ZUCC. The attribution of the fossils to the genus alder is supported by Kvaček and Holý (1974) in a new combination *Alnus julianiformis* (STERNBERG) Z. KVAČEK et HOLÝ. The species is characterised on



Text-fig. 4. *Alnus julianiformis* (STERNBERG) Z. KVAČEK et HOLÝ, characteristic branching of the tertiary vein near the leaf margin after Czezzott (1934)

the basis on epidermal structure, indicating a closer systematic affinity of the fossil with the representatives of the subgenus *Alnaster*, or with the species *Alnus trabeculosa* HAND.-MAZZ. of the subgenus *Alnus* rather than with the species *Alnus japonica* SIEB. et ZUCC (Kvaček and Holý 1974).

In the area of the Most Basin, *Alnus julianiformis* is a member of the characteristic assemblage of swampy plants. During the Miocene to Early Pliocene, this species is regarded as being a representative of the Arcto-Tertiary Broad-leaved Deciduous element in subtropical mastixioid floras (Kvaček and Holý 1974). On the basis of the palaeoecological analysis of the fossil floras, Kvaček and Holý (1974) consider *Alnus julianiformis* as a typical representative of Mixed Mesophytic Forest, in climatic conditions comparable to those from the uplands of the Yang-tse valley in the middle China.

#### *Alnus* sp. (amentum)

Pl. 5, fig. 6

Material: A single carbonised female catkin (MG(30)294).

Description: Female catkin 25 mm long and about 7 mm wide. Relatively thick and up to 4 mm long, densely innervated supporting bracts of partial male inflorescences reposing very densely on both sides. Structure of these inflorescences not clear.

Discussion: Catkins of this sort, morphologically transitional between birch and alder, are found in the Důl Bílina locality in other horizons with the foliage of *Alnus menzelii* (Z. Kvaček pers. comm.), so they can be logically linked to this species. *Alnus menzelii* is described by Raniecka-Bobrowska (1954) as a new species on the basis of the foliage and 26 male catkins; female catkins are not described. On the basis of the comparison with living and fossil representatives, Raniecka-Bobrowska (1954) considers the species *Alnus subcordata* C. A. MEY, growing today on the river bank of Caucasus and Iran, and *A. serrulata* WILLD., growing on the bank of water reservoirs, moderately flooded, in Pacific North America, from Canada to Kentucky, the closest to the fossil alder *Alnus menzelii*. Within the described horizon, no leaves of *Alnus menzelii* have been found, thus, the catkin should be regarded as an external element in the association studied.

## Juglandaceae

### *Engelhardia* LESCH. ex BL.

#### *Engelhardia macroptera* (BRONGNIART 1828) UNGER 1866

Pl. 6, fig. 1

- 1828 *Carpinus macroptera* BRONGNIART; Brongniart, p. 48, pl. 3, fig. 6  
1866 *Engelhardia macroptera* (BRONGNIART) UNGER; Unger, p. 52, pl. 16, figs 9-11  
1869 *Engelhardia bilinica* ETTINGSHAUSEN; Ettingshausen, p. 49, pl. 52, fig. 5

Material: Two carbonised remains fruits: one complete, the second incomplete (MG(30)288, 355).

Description: Fruit, nut, about 5 mm big, oval, rounded to acute at the base, acuminate at the apex. Cross-section of the nut with visible middle secondary septum, or poorly perceptible hook-like protuberances in the middle of the seed cavity recognisable, as well as longitudinally sculptured fruit surface. Nut surrounded by a typical trilobate, entire-margined bract. Bract formed by one larger lobe (20 x 6 mm) rounded and slightly broader at the apex and two smaller (15 x 5 mm), rounded, roughly equally wide lateral lobes. So-called "basal lobe" not present. Venation of all lobes, especially of the middle one, characterised by 3 veins. Veins, with the most distinct in the middle, more or less parallel, originating from the base of the lobes. In the upper part of the lobes, secondaries, alternately split off the midvein, several times splitting and looping mutually. Two lateral primary veins joining on these veins. Lobes also innervated by numerous veins of higher orders.

Discussion: Jähnichen et al. (1977) conducted a detailed study of the fossil leaves and fruits of *Engelhardia* in the Tertiary of Europe. They noted that the foliage of the type *Engelhardia orsbergensis* (WESS. et WEB.) JÄHNICHEN, MAI et WALTHER and fruits of *Engelhardia macroptera* (BRONGNIART) UNGER belong probably to a single member of the family Juglandaceae, representing the section *Paleocarya*, a section defined by Knobloch and Kvaček (1976) on the basis of leaves, and partially modified and completed by Jähnichen et al. (1977) describing the fruits.

In the Horizon n° 30, the foliage of the extinct *Engelhardia* (stratigraphic range for Europe: from the middle Eocene to Pliocene) has not been documented so far. From the taxonomic point of view, the fossil stands between the species *Engelhardia roxburghiana* LINDL. ex WALL. from eastern Asia and the species *Oreomunnea mexicana* STANDL. from Central America (Jähnichen et al. 1977). From the ecological point of view, the fossil *Engelhardia* had a great environmental variety: subtropical-paratropical rain forest, subtropical rain forest and lauraceous forest, mesophytic forest and deciduous forest of warm climate. Generally, the fossil can be regarded as a thermophile, probably evergreen element (Kvaček and Bůžek 1983).

#### *Juglandaceae* gen. et sp. indet. (fructus)

Pl. 6, fig. 2

Material: A single fossilised fruit (MG(30)421).

Description: Endocarp ("nut"), three-dimensionally preserved, 9 mm long and 7 mm wide, oval, at the apex narrowing and slightly acuminate. A longitudinal open line, probably of dehiscence, running in the middle of the endocarp. On both sides, perpendicular to the dehiscence line, a slightly narrowing and acuminate zone perceptible, probably a fusing line of two carpels composing the endocarp. Endocarp surface distinctly bumped and furrowed. Seed visible through the open line of dehiscence.

Discussion: This unusual fruit probably presents a "nut" (precisely a hard endocarp of a drupe) of some representative of Juglandaceae. The endocarps of *Carya* seem to be morphologically closest to the fossil, but they are markedly bigger and rather smoother. The possibility cannot be completely ruled out that the fossilized endocarp might belong to *Engelhardia macroptera* (BRONGNIART) UNGER. The exact taxonomic position of the fossil remains open, and it is pointed just to its probable affinity to the Juglandaceae family.

## Ebenaceae

### *Diospyros* L.

#### *Diospyros brachysepala* A. BRAUN 1845 sensu HANTKE 1954

Pl. 6, fig. 3

- 1845 *Diospyros brachysepala* A. BRAUN; Braun, p. 170  
1954 *Diospyros brachysepala* A. BRAUN sensu HANTKE; Hantke, p. 80, pl. 14, figs 4-6

Material: Several carbonised leaves.

Description: Leaves 35-55 mm long, 20-25 mm wide, oblong to oval entire-margined shortly petiolate. Leaf apex acuminate, terminated partly in a small rounded tip. Base rounded to cuneate, often slightly decurrent along the petiole, sometimes slightly asymmetrical. Venation brochidodromous, composed of a distinct midvein. Secondary veins splitting alternately to subopposite, at angles of 40-70°, at first straight to slightly undulate, later curved upward, and looped along the margin. Secondaries often at the margin forming abaxial branches. Progressively smaller "loops", formed by joining of perpendicular tertiaries to the following secondary vein, recognisable in the lower part of the leaf. Tertiaries perpendicular, inconspicuous and irregularly distributed. Venation of higher orders forming a dense areolation between the secondaries.

Discussion: The leaves are attributed to the genus *Diospyros* because of their smaller size, characteristic venation and wider oval entire-margined shape with very typical, acuminate rounded tip (though this is not always present).

Living relatives (persimmons) are spread throughout the tropics, especially in Indo-Malaysia (Novák 1972). The possible living analogue, *D. kaki*, currently mentioned by Bůžek (1971), represents a common tree of the zone of the Mixed Mesophytic Forest of eastern Asia (Kvaček and Bůžek 1983).



## Salicaceae

### *Salix* L.

#### *Salix haidingeri* ETTINGSHAUSEN 1866 sensu BŮŽEK 1971

Pl. 6, fig. 4

- 1850a *Salix angustissima* A. BRAUN partim; Unger, p. 418 (locality Bilina only)  
1866 *Salix haidingeri* ETTINGSHAUSEN partim; Ettingshausen, p. 88, pl. 29, figs 9-13, 15, 16, non fig. 8  
1866 *Salix angusta* A. BRAUN; Unger, p. 71, pl. 22, fig. 17 (illustration described as *Salix angustifolia* A. BRAUN)  
1881 *Salix angusta* A. BRAUN; Engelhardt, p. 81, pl. 1, fig. 17  
1891 *Salix angusta* A. BRAUN; Engelhardt, p. 164, pl. 10, figs 15  
1971 *Salix haidingeri* ETTINGSHAUSEN sensu BŮŽEK; Bůžek, p. 66, pl. 35, figs 1-10, pl. 36, figs 1-12, text-fig. 8

Material: A single incomplete leaf compression (MG(30)217).

Description: Leaf fragmentary, narrowly lanceolate. Fragment 80 mm long, 12 mm wide, with rounded base, and 5 mm long petiole. Leaf apex not preserved. Leaf margin crenulate in places, but often serrate. Tooth axes distinctly inclined toward the midvein. Venation brochidodromous-semicraspedodromous. Midvein distinct. Dense secondary veins originating alternately at angles of 50-65°. Intersecondaries often present. Secondaries straight at the base, curved upward along the margin and looped to the succeeding secondary vein. Small branches originating in the loops, terminated in sinuses, probably, like in the case of the living representatives, into marginal glands (not present on the fossil). Tertiaries approximately perpendicular to the secondaries; forming, together with intersecondary veins, areolae divided by veins of higher orders.

Discussion: Bůžek (1971) delimits *Salix haidingeri*, the species defined originally by Ettingshausen (1866), in a new sense: he merged finely toothed forms, mostly known as *Salix lavateri* A. BRAUN (described originally by Ettingshausen (1866) as a new species *Salix haidingeri* ETTINGSHAUSEN), and the entire-margined forms known as *Salix angusta* A. BRAUN into one species - *Salix haidingeri* ETTINGSHAUSEN 1866 sensu BŮŽEK 1971. Bůžek (1971) supports this diagnosis by stating that there is a continuous transition between two extreme forms (finely toothed vs. entire-margined). The different types do not differ in basic features (petiole, blade character and course secondary veins); and, in addition, the extreme forms consistently occur together (Bůžek 1971). The features of our studied material match very well those of the Bůžek's (1971) new delimitation of this species. At the end of the description, Bůžek (1971) revised the specimens described by Engelhardt (1891) from the locality Ledvice, namely pl. 10, fig. 16; pl. 15, fig. 6, as *Salix angusta* A. BRAUN. He supposes that it is in fact a representative of the species "*Ficus*" *multinervis* because of the presence of an intramarginal vein in the first specimen. We are unable to give an opinion on the second specimen (Engelhardt 1891; pl. 15, fig. 6), but the first specimen (Engelhardt 1891; pl. 10, fig. 16) undoubtedly represents the so-called "*Ficus*" *multinervis*, newly recognized as a representative of the family Lythraceae *Decodon gibbosus* (E. M. REID) E. M. REID in NIKITIN by Kvaček and Sakala (1999).

The leaves, very long, entire-margined or toothed in the upper part, of the fossil species *Salix haidingeri*, are compared by Bůžek (1971) to the foliage of extant *S. purpurea* L. and *S. caspica* PALL., growing in Caucasus and Iran. Generally, it can be observed that the species *Salix haidingeri* was a component of riparian forests, growing along the stream, flowing into the basin (Kvaček and Bůžek 1983).

## ? Sterculiaceae

### *Dombeyopsis* UNG.

#### *Dombeyopsis lobata* UNGER 1850

Pl. 6, fig. 5

- 1850a *Dombeyopsis lobata* UNGER; Unger, p. 447  
1850a *Dombeyopsis sidaefolia* UNGER; Unger, p. 448  
1860 *Ficus dombeyopsis* UNGER; Unger, p. 13, pl. 6, fig. 1  
1860 *Ficus tiliaefolia* HEER; Unger, p. 14, pl. 6, fig. 2  
1866 *Cecropia heerii* ETTINGSHAUSEN; Ettingshausen, p. 82, pl. 27, pl. 28, fig. 7  
1866 *Cecropia europaea* ETTINGSHAUSEN; Ettingshausen, p. 82, pl. 28, figs 1, 2  
1881 *Ficus tiliaefolia* A. BRAUN; Velenovský, p. 28, pl. 6, figs 1-4  
1891 *Ficus tiliaefolia* A. BRAUN; Engelhardt, p. 162, pl. 6 (IX), fig. 25(?), pl. 7(X), fig. 9

Material: Several carbonised leaves.

Description: Leaves considerably large (up to 210 mm long and 160 mm wide), trilobate, entire-margined to slightly crenate. Leaf lobes tapering at acute angles (two lateral at an angle of 60°, middle one at an angle of 30°), rounded. Leaf base deeply cordate with long petiole. Venation palmate, brochidodromous, with 5 primary veins (1 medial and 2+2 lateral). Three primary middle veins (1 medial and 1+1 lateral) terminating each in one lobe. Secondary veins, branched abaxially from 4 lateral primary veins, splitting off another abaxial branch before the margin, and looping with the previously split secondary vein. Secondaries also diverging and mutually looping on both sides of the medial primary vein. Tertiaries perpendicular to the secondary veins. Areolae between the tertiaries very poorly recognisable.

Adaxial cuticle thin, grained. Ordinary cells (diameter 20 µm) polygonal with straight anticlines, somewhere elongated in one direction. Neither stomata, nor trichomes (nor their bases), typical of this type foliage observed (Knobloch and Kvaček 1976). Abaxial cuticle not seen.

Discussion: The systematic affinity of the formal genus *Dombeyopsis* has been largely discussed since the time of its description (see Knobloch and Kvaček 1976). The results of the cuticular analysis can elucidate this problem (see Kvaček 1985). This author rules out its systematic attribution to the families Moraceae, Scrophulariaceae, Menispermaceae and Alangiaceae considering the indumentum of leaves. On the other hand, he points to its relations to Sterculiaceae. Nevertheless, Kvaček (1985) opposes to attributing them directly to a particular genus of this family because of the absence of co-occurring fruit remains. Co-occurring fossil fruit remains are those attributed today to the genus *Craigia* from the family Tiliaceae. Despite the differences in foliage of extant *Craigia* and the fossil taxon (simple entire lanceolate

leaves with serrate margin) and the absence of direct connection of fruit remains and leaves on one twig, it is very probable that a Tertiary tree existed with foliage of the *Dombeyopsis* type and fruits, belonging to the genus *Craigia* (Kvaček 1993). According to Z. Kvaček (personal communication) the foliage occurring in the Bílina Mine has yielded epidermal structure matching that described by Knobloch and Kvaček (1976) and will be treated in a separate study (Kvaček, Manchester, Akhmetiev, in prep.).

## Tiliaceae

### *Craigia* SMITH et EVANS

#### *Craigia brononii* (UNGER 1845) Z. KVAČEK, BŮŽEK et MANCHESTER 1991

Pl. 6, fig. 6

- 1845 *Ulmus brononii* UNGER; Unger pl. 25, figs 2-4  
 1866 *Ulmus brononii* UNGER; Ettingshausen, p. 62, partim, pl. 18, figs 1-5 (fructus) (non pl. 17, figs 9,10, pl. 18, fig. 6)  
 1866 *Ulmus longifolia* UNGER; Ettingshausen, p. 62, pl. 18, fig. 8 (fructus)  
 1881 *Ulmus longifolia* UNGER; Velenovský, p. 25, pl. 3, figs 24, 25 (fructus)  
 1948 *Pteleaearpum brononii* (UNGER) WEYLAND; Weyland, p. 130, pl. 21, fig. 5, text figs 5-9  
 1991 *Craigia brononii* (UNGER) Z. KVAČEK, BŮŽEK et MANCHESTER; Kvaček, Bůžek et Manchester, p. 78, figs 3, 4

Material: Great number of carbonised fruit remains.

Description: Isolated oval (obovate) capsule valves, 10 to 23 mm long and 7 to 15 mm wide, with central locular area surrounded by a winged board. Characteristic middle septum with serially arranged, diagonal oriented ovules on both sides in cases of suitable preservation. Mostly a single mature ovule (seed) from each side of the septum. Distinct reticulate venation originating in the central body, reaching the marginal vein of the wing. Valve base generally narrowing, slightly cordate, without recognisable stalk. Apex widely oval, sometimes with apically notched wing. Incomplete (halved) valves often found, due to folding and/or splitting along the septum (suture).

Discussion: The fruit remains attributed to the genus *Craigia*, have been interpreted in different ways since their discovery in the last century. Originally, they were described as one-seeded winged samaras of a fossil elm, but the opinions on their nature have varied considerably through time (see Bůžek, Kvaček and Manchester 1989). They were treated and accepted by several authors under a formal name *Pteleaearpum*, established by Weyland (1948) that highlighted the similarity between these dehiscent fruit remains and the indehiscent fruits of the extant genus *Ptelea* of Rutaceae. Bůžek, Kvaček and Manchester (1989) interpret these fossils as isolated valves of 3-carpelate dehiscent capsules with three wings. This character together with others (capsule with loculicidal dehiscence, reticulate venation of valves, terminating in marginal veins, upper ovary, axile placentation with serial arrangement of ovules, fasciculate trichomes) have led these authors to systematic attribution to Sapindaceae, namely to the tribes Harpullieae and Koelreuterieae. Yet the characteristics of the

fossil genus (fruit remains) of the so-called *Pteleaearpum* did not correspond completely to any extant representative of Sapindaceae. The same authors solved this problem. Kvaček, Bůžek and Manchester (1991) pointed out that the characteristics of the fruit of the extant genus *Craigia* of the family Tiliaceae, rather than any genus in Sapindaceae, matched perfectly those of the fossil. These authors proposed for the fossil remains, spread in Eurasia, and interpreted as isolated valves of 5-carpelate, 5-winged dehiscent capsules, a new recombination - *Craigia brononii*.

The genus *Craigia* is represented by two species in the modern flora, growing in South China and North Vietnam. These medium trees grow on calcareous basements (pH 6-7.5) in the Broad-leaved Evergreen and Deciduous Mixed Forest and in the forest partly humid, at altitudes from 1400 to 1700 m (above sea level). However, fossil representatives of the genus, which existed in Europe during the Lower Pliocene in association with deciduous woody plants with dominant representatives of Fagaceae (Mädler 1939, Givulescu and Ghiurca 1969, Geisert et al. 1979), were probably less sensitive, at least regarding the temperature.

## Ulmaceae

### *Ulmus* L.

#### *Ulmus pyramidalis* GOEPPERT 1855

Pl. 7, figs 1-3

- 1855 *Ulmus pyramidalis* GOEPPERT; Goepfert, p. 28, pl. 13, figs 10-12  
 1866 *Carpinus pyramidalis* GAUDIN; Ettingshausen, p. 49, pl. 15, figs 5-9, 21  
 1866 *Ulmus bronni* UNGER; Ettingshausen, p. 62, pl. 17, figs 9, 10  
 1866 *Ulmus longifolia* UNGER; Ettingshausen, p. 62, partim, pl. 18, figs 7, 9-10, non fig. 8 (fructus)  
 1866 *Ulmus plurinervia* UNGER; Ettingshausen, p. 63, pl. 18, figs 12, 13  
 1866 *Ulmus minuta* GOEPPERT; Ettingshausen, p. 64, pl. 18, figs 21, 22  
 1866 *Ulmus brauni* HEER; Ettingshausen, p. 64, pl. 18, figs 23, 25(?), 26, 27(?)  
 1866 *Planera ungeri* ETTINGSHAUSEN; Ettingshausen, p. 65, partim, pl. 18, figs 14-16 18(?) 19(?), non figs 17, 20  
 1881 *Carpinus grandis* UNGER; Velenovský, p. 23, partim, pl. 2, fig. 25(?), pl. 3, figs 1-5, non fig. 6  
 1881 *Ulmus longifolia* UNGER; Velenovský, p. 25, partim, pl. 4, figs 3-13, non pl. 3, figs 24, 25 (fructi)  
 1881 *Planera ungeri* ETTINGSHAUSEN; Velenovský, p. 26, partim, pl. 3, figs 19-21, 22(?), non figs 18, 16-23, pl. 4, fig. 14 (?)  
 1881 *Betula brongniartii* ETTINGSHAUSEN; Engelhardt, p. 78, partim, pl. 1, fig. 13 (non fig. 12)  
 1881 *Carpinus grandis* UNGER; Engelhardt, p. 81, pl. 1, figs 9, 10  
 1891 *Ulmus longifolia* UNGER; Engelhardt, p. 160, pl. 9, figs 14, 16-20, 24(?)

Material: Several carbonised leaves and two fruits.

Description: Leaves variable in size (40-70 mm long, 13-35 mm wide, often very small, immature) narrow to widely lanceolate, often with asymmetric blade, petiolate. Leaf apex acute to acuminate-acute, base rounded to indistinctly cordate, often slightly asymmetrical. Margin double (even triple in places) serrate. Main teeth relatively short, but conspicuous perpendicular straight, or convex, and often acuminate. Wider forms

having very conspicuous 2<sup>nd</sup> order teeth, so their leaf margin seemed simple serrate. Venation craspedodromous. Midvein straight. Secondary veins, mutually parallel originating densely, alternate to opposite, at angles of 30-60°, mostly in the lower part of the leaf domed at the base, curved slightly adaxially (toward the midvein) after that, and terminating in the margin in the main tooth. Abaxial branches occasionally split off from secondary veins near the leaf margin. These branches terminating in small teeth of higher orders. Forking of the secondaries not observed. Fine, dense, polygonal areolation between secondary veins formed by veins of higher orders. Fruit, winged samara about 10 mm long, oval. Wing surrounding the seed cavity entire-margined, seen as a dark wide border (almost as dark as the seed region), apically with a deep V-shaped notch. Fruit stalked, with relatively elongate calyx situated just below the fruit base, ? pentamerous, with sepals joined together at the base, and free apically.

Discussion: The leaves, attributed to this species, are variable: from narrow or widely lanceolate forms with double margin (or even triple) serrate to wider forms (sensu Bůžek 1971 - e.g., pl. 20, fig. 17), less distinctly double serrate, even seen as simple serrate. The distinctly toothed margin presents the essential feature allowing attribution of the fossils to *U. pyramidalis*. The type of accompanying samaras, deeply notched with calyx remains should not be confused with other characteristic fruits from the Most Basin, previously attributed by Ettingshausen (1866) or Velenovský (1881) to *U. bronni*, or *U. longifolia*, and are recognised today as belonging to the genus *Craigia* of *Tiliaceae* (see description of *Craigia*).

*Ulmus pyramidalis* belongs to the riparian forest, in the Most Basin characteristic essentially of uplifted terrains along rivers or levées. The possible nearest living relative *U. americana* L. from the riparian forest of the eastern and south-eastern USA is most frequently listed (Kvaček and Bůžek 1983). However, neither in this species, nor in *U. alata* MICHX., another elm that is compared to the fossil, is the calyx shifted on a fruit stalk (Bůžek 1971), which is a typical feature of the samaras of *Ulmus pyramidalis*.

### *Zelkova* SPACH

#### *Zelkova zelkovifolia* (UNGER 1843) BŮŽEK et KOTLABA in KOTLABA 1963

Pl. 7, fig. 4

- 1843 *Ulmus zelkovaefolia* UNGER; Unger, pl. 24., figs 9-13, non fig. 7 (fructus)  
 1866 *Planera ungeri* ETTINGSHAUSEN; Ettingshausen, p. 65, partim, pl. 18, figs 17, 20, non figs 14-16 18 19  
 1881 *Planera ungeri* ETTINGSHAUSEN; Velenovský, p. 26, pl. 3, fig. 23 sub fig. 16 (right), non figs 18-22, non pl. 4, fig. 14  
 1963 *Zelkova zelkovaefolia* (UNGER) BŮŽEK et KOTLABA; Bůžek et Kotlaba in Kotlaba, p. 59, pl. 3, figs 7, 8

Material: A single carbonised leaf (MG(30)320).

Description: Leaf small (25 x 10 mm), lanceolate, with 5 mm long petiole. Base rounded, slightly asymmetrical, cordate. Apex tapering into a rounded, slightly curved tip. Leaf margin distinctly coarsely simple serrate. Teeth straight on apical side, and concave on basal side. Venation (craspedodromous) hardly seen. From conspicuous straight midvein less distinct secondary veins alternately splitting off, each terminating in one

tooth of the margin; in one case forking of the secondary vein seen. Veins of higher orders, or other details of venation not perceptible.

Discussion: This single small carbonised, poorly preserved specimen is attributed to the species *Zelkova zelkovifolia* (UNGER) BŮŽEK et KOTLABA mainly on the basis of the coarsely simple serrate leaf margin and the course of the secondaries, terminating each in one tooth. The fossil leaf could also represent an immature specimen of elm with teeth of higher orders not yet distinctly developed.

The extant genus *Zelkova* is represented by 5 species, growing in Sicily, Crete, and in the areas from eastern Caucasus to Iran, China and Japan (Novák 1972). The fossil representative, *Zelkova zelkovifolia*, corresponds to the extant *Z. carpinifolia* from the relict forests of Colchis (Kvaček and Bůžek 1983).

### Rosaceae

#### *Rosa* L.

#### *Rosa* sp. (apocarpium)

Pl. 7, fig. 5

Material: A single carbonised apocarpium on a stalk (MG(30)399).

Description: Apocarpium (hip) hypanthium-like, 10 mm long, elongated, narrowly barrel shaped, terminated in the upper narrowing part by three clearly recognisable erect sepals about 2 mm long, seen as a wide "trident" at the apex of the receptacle. Fourth sepal, less perceptible, arising behind the first range of three sepals, between right and middle sepal (in specimen MG(30)399A). Fifth and last sepal not perceptible - either not present, or very probably hidden behind the other sepals. Sepals relatively wide at the base, narrowing at the apex, terminating acutely at an angle of about 90°. Sepal margin, as well as other details of the venation, not recognisable. Sepals very indistinctly longitudinally sculptured. Apocarpium resting by a cuneately narrowing base on a fruit stalk, about 20 mm long and 2 mm wide. About 5 (4 in the upper and 1 in the lower part) thorns on the stalk, about 1 mm long, with apex slightly rounded, at angle of 90°; at the base about 1.5 mm wide, long oval in cross-section. Stalk slightly widening at the very base.

Discussion: The fruit remain is attributed to the rose family on the basis of external resemblance to a hip (hypanthium-like apocarpium of the genus *Rosa*). This attribution can be supported by the presence of the characteristic thorns on the fruit stalk. The pentamerous symmetry of the calyx (characteristic of roses) is supposed. Thus, the absence of one sepal is viewed as secondary. The relatively small size of the sepals could be explained by the immaturity of the apocarpium. The interesting presence of a fossil bird feather lying across the apocarpium stalk must also be noticed.

The apocarpium is most logically attributable to the species *Rosa europaea* (ETT.) Z. KVAČEK et HURNÍK (Kvaček and Hurník 2000, this volume), the only described representative of the roses in the Most Basin so far. This rose, having still unclear relations to extant species, has probably formed a shrubby understory of riparian forests (Kvaček and Bůžek 1983).



## *Rubus* L.

### *Rubus merianii* (HEER 1859) KOLAKOVSKIJ 1964

Pl. 7, figs 6, 7

1859 *Rhus meriani* HEER; Heer, p. 82, pl. 126, figs 5-11  
1964 *Rubus meriani* (HEER) KOLAKOVSKIJ; Kolakovskij, p. 131

Material: Three specimens with compound leaves and one incomplete isolated leaflet (MG(30)258, 334, 427).

Description: Leaves palmately compound, with remains of petiole in the lower part covered with rhomboidal scars of thorns. Completely preserved leaves pentafoliolate - the first leaf merged with lateral leaflets, the second one with all leaflets free. Incomplete leaf consisting of only 2 preserved ? lower lateral leaflets of a originally ? palmately compound, probably ternate leaf, regarding the mutual position of the preserved leaflets. Leaflets up to ?60 mm long and 10-30 mm wide, with short petiolules, or sessile, narrowly to widely lanceolate, with rounded to slightly cordate base, and acute to acuminate apex. Leaf margin shallowly (specimen with two leaflets preserved) to distinctly (specimens with 5 leaflets) doubly serrate, in the lower part of leaflets simple. Venation craspedodromous with a distinct midvein. Secondary veins alternate to sub-parallel in the lower part, at angles of 40-60°. These veins bent, curving upwards along the margin, entering the main teeth, exceptionally into the sinuses between the teeth. Secondaries often branching off abaxial (or even adaxial) veins near the leaf margin, terminating in the main teeth. Tertiaries indistinct, forming more or less perpendicular connections between secondary veins. Venation of higher orders not recognisable on the specimens.

Cuticle covered by a very clean cutin layer, no conspicuous structures seen. Anticlinal lines not clearly visible, on the cuticle surface a lot of problematic impurities (attached allochthonous pollen, small crystals), could be misinterpreted as morphological structures. Unicellular trichomes (3.5 x 25 µm) sometimes perceptible. Structures oval to round, about 25 µm in diameter, relatively often visible - probably trichome bases.

Discussion: Heer (1859) first assigned such leaf remains to the genus *Rhus* (family Anacardiaceae). Kolakovskij (1964) attributes them to the family Rosaceae on the basis of their leaf forms, type of the venation and presence of thorns on the petioles and more precisely, regarding the compound leaves and characteristic venation of leaflets, into the genus *Rubus*. In the studied locality, one problematic carbonised calyx (see below) was found additional to relatively safely attributable compound leaves.

Kolakovskij (1964) placed the nearest possible extant analogues of this fossil species in the group of East Asiatic species with small elongated leaves. Regarding the ecological requirements, *Rubus merianii* represents probably a moisture-loving black-berry, which formed a shrubby understory in swamps (Kvaček and Bůžek 1983). According to Kolakovskij (1964), this species probably inhabited areas of humid warm temperate climate.

### *Rubus* sp. 1 (foliolum)

Pl. 8, figs 1, 2

Material: A single carbonised leaflet (MG(30)257).

Description: Leaflet 110 mm long, 50 mm wide, widely lanceolate, petiole missing. Base narrowing cordate, apex long, tapering into a rounded tip. Margin poorly preserved, simple (? double) serrate, teeth widely spaced. Venation craspedodromous. Secondary veins alternate, splitting off the conspicuous straight midvein at angles of about 50°. These veins, at first straight, then curved along the leaf margin, entering the tooth margin. Secondaries often forking before entering the margin. 3<sup>rd</sup> order veins forming perpendicular connections between secondary veins, often branched and mutually connected. Higher order venation not recognisable.

Abaxial cuticle with conspicuous anomocytic stomata, widely oval to nearly rounded, 15 µm long, and 12.5-15 µm wide with about 5 µm wide, oval-rounded outer cavities with distinct linear aperture in the middle. Serial trichomes about 25 µm long, elongated and one bicellular, 22.5 µm long, barrel-like trichome. Outlines of ordinary cells not perceptible.

Discussion: The leaf is attributed here on the basis of the comparison with extant representatives, to the genus *Rubus*. This leaf remain may represent a leaflet, perhaps the medial one, of a palmately compound leaf. The main features, supporting this attribution, are: toothed margin, craspedodromous venation with forking of the secondary veins, elongated apex, and, above all, a distinctly cordate base. The epidermal structure is not in contradiction to the assigning (wide anomocytic stomata).

The specimen can be seen as another possible type (perhaps species) of the genus *Rubus* in the studied locality (see *Rubus vrsovicensis* Z. KVAČEK et HURNÍK 2000, this volume). Contrary to the previously described, small (narrow)-leaved species *Rubus meriani*, this representative was rather large-leaved, yet probably having the same requirements and inhabiting the same type of habitat as a shrubby understory in the swamps. It is possible that the calyx, relatively big (see below), compared to *Rubus*, belongs right to this type with more robust leaves.

### *Rubus* sp. 2 (folium compositum)

Pl. 8, fig. 3

Material: One carbonised compound leaf (MG(30)276).

Description: Leaf palmately compound, pentafoliolate. Leaflets up to 80 mm large and 30 mm wide, narrowly lanceolate, shortly petiolate, except for the middle leaflet with long (25 mm), in the lower part distinctly thorny petiolule. Base rounded cordate, apex of leaflets? acute (in one case only not preserved). Leaf margin distinctly double serrate, teeth somewhat widely spaced and widely rounded, simple and rather narrower and sharper in the lower part of the leaflets. Venation craspedodromous with distinct midvein. Secondary veins regularly, alternate, branching off at angles 40-60°. These veins curved, running along leaf margin, entering the main teeth. Secondaries often near the leaf margin branching off abaxially veins, also terminating in the main teeth. Tertiaries indistinct, forming more or less perpendicular connections between secondary veins. Venation of higher orders not recognisable.

Discussion: This fossil *Rubus* can be viewed as a longly elongated, large-leaved transitional form situated between the typically small-leaved species *Rubus meriani* and the large-leaved, relatively wide form, which is attributed also to *Rubus*

(see the previous description). A possible independent status of these types as 3 different species in the studied locality is not ruled out. On the other hand, the variability within a single species could also offer an explanation. The blackberries are markedly apomictic plants, which make the distinction on the specific level equivocal. In spite of this fact, in Czech Republic only, there are over 110 species of this genus estimated today (Holub 1999).

***Rubus* sp. (calyx)**

Pl. 8, fig. 4

Material: One carbonised calyx (MG(30)289).

Description: Calyx pentamerous, 25 mm in diameter, formed by a circular centre, 5 mm in diameter, sculptured by oval depressions, about 1.5 mm long, and near the margin covered by filamentous aggregates, orientated towards the middle. Five free sepals projecting regularly from the circular centre of the calyx. Sepals entire-margined, 10 mm long, sessile, at the base (in the lower half) widest, gradually narrowing and at the apex tapering into a very thin ? spine. Venation of leaflets recognisable just as a midvein with remains of two alternate secondaries at the apex of one of the leaflets.

Discussion: At first the calyx had been provisionally assigned to the species *Diospyros brachysepala*, but taking a closer look at the specimen, the attribution of the calyx to *Rubus* was preferred. The main argument, leading to this attribution was the pentamerous symmetry, so characteristic of Rosaceae, and absent in the calyx remains of the species *Diospyros brachysepala* (e.g. Bůžek 1971), which is traditionally compared to the recent *D. kaki* with notoriously quadrimorous calyx. The calyx of the species *Diospyros brachysepala* has in addition a different leaflet characters - sepals are short and wide. Within the family Rosaceae, two genera are present as leaves in the Most Basin, were considered: *Rosa* and *Rubus*. The fossil specimen was compared to the calyces of both. Both genera share these features, which are seen in the studied fossil: sepals widest in the lower half, narrowing towards the apex and terminating by a spine (sharp distinct tip) + filamentous structures, which could be explained as remains of stamen filaments, persistent together with the calyx even after shedding the corolla. However, the genus *Rosa* often has pinnately divided sepals and its fruits, close in the receptacle, do not exhibit characteristic sculpture, which was observed on the surface of the circular centre. On the other hand, *Rubus* has entire sepals. The sculpture (ovals are not sculptured themselves what would have corresponded to imprints of seeds - see Bůžek and Holý 1964) in the middle is interpreted here as traces of individual fruitlets of an apocarpium on an originally slightly domed receptacle. This points rather to a raspberry (*Rubus ideus* L.), where fruitlets are fused together, and in complete maturity fall off from the receptacle without the central cone-like part. In the blackberry (subgenus *Rubus*), on the other hand, the fruitlets are also mutually connected, but in addition, even fused to the central cone-like receptacle, and they separate together with it from the flat stalk basement (Novák 1972; p. 497). Hence, the blackberries would not leave the observed traces.

? *Crataegus* L.

cf. *Crataegus* sp.

Pl. 8, fig. 5

Material: A single carbonised leaf (MG(30)391).

Description: Leaf 15 mm long, petiolate. Leaf margin double toothed with conspicuous 1<sup>st</sup> order teeth. Lateral lobe perceptible in the lower part. Base rounded, symmetrical. Apex not preserved. Venation craspedodromous, with distinct midvein. Secondary veins splitting off sparsely, alternately, at angles of 45-50°, curving upwards and terminating in the teeth or in the lower part of the lateral lobe. Abaxial branching of secondaries recognisable near the margin as well as after diverging from the midvein. No more details of venation seen.

Discussion: This lobed leaf is compared to the foliage of *Crataegus*, yet its attribution even to some other genera, e.g. *Pyrus*, cannot be completely ruled out.

Bůžek (1971) compares a similar specimen of a *Crataegus* leaf to forms of the species *C. calpodendron* (EHRH.) MED., which grows today in North America.

**Lythraceae**

***Decodon* GMELIN**

***Decodon gibbosus* (E.M. REID 1920)**

E.M. REID in NIKITIN 1929

emend. Z. KVAČEK et SAKALA 1999

Pl. 9, figs 1-3

Material: A great number of carbonised leaves, in one case a twig with leaves and fruits and seeds attached, isolated fruits with seeds (NMG 7682a, b to 7691, several unnumbered specimens).

Description & Discussion of the studied material as well as the synonymy list have been recently included in a detailed separate study by Kvaček and Sakala (1999).

**Leguminosae**

? *Leguminosites* BOWERBANK

cf. *Leguminosites* sp.

Pl. 9, fig. 4

Material Three carbonised leaflets (MG(30)395, 396, 398).

Description: Leaflets 14-20 mm long, 8-11 mm wide, oval to widely obovate, entire-margined, shortly petiolate. Apex rounded, base cuneately narrowing, asymmetrical. Venation brochidodromous, very poorly recognisable. Secondary veins mutually parallel, about 4 in number from each side, splitting off alternately from conspicuous midvein at acute angles of 30-40°, looping near the margin. Areolation between secondary veins formed by veins of higher orders, very poorly seen. No more venation details recognisable.

Discussion: The leaflets are compared with the foliage of Fabales, mostly on the basis of oval, entire-margined, relative-

ly smaller forms of leaves with short petiolule (however, without perceptible transversal hatching, which is typical of the fabaceous foliage) and brochidodromous venation. A similar type of leaves, relatively small, oval and shortly petiolulate, occurs e.g. among the representatives of Loranthaceae. However, the latter differ from the studied specimens by their rather acrodromous venation (compare Knobloch and Kvaček 1976).

The ecological requirements of the representatives with this sort of foliage cannot be estimated without its attribution to a particular natural genus - Leguminosae (Fabales) are spread today from tropic to cold zones and they grow in very different habitats from lowlands to high mountains (Novák 1972).

## Aceraceae

### *Acer* L.

#### *Acer tricuspidatum* BRONN 1838 sensu PROCHÁZKA et BŮŽEK 1975

Pl. 9, figs 5-8, text-figs 5, 6

- 1823 *Phyllites lobatus* STERNBERG; Sternberg, p. 37, pl. 35, fig. 2  
 1825 *Phyllites trilobatus* STERNBERG; Sternberg, p. 42, pl. 50, fig. 2  
 1838 *Acer tricuspidatum* BRONN; Bronn, pl. 35, fig. 10a,b  
 1845 *Acer trilobatum* A. BRAUN; Braun, p. 172  
 1869 *Acer bilanicum* ETTIGSHAUSEN; Ettigshausen, p. 21, pl. 44, figs 13, 14  
 1869 *Acer bruckmanni* A. BRAUN; Ettigshausen, p. 20, pl. 44, figs 6  
 1881 *Acer sturi* ENGELHARDT; Engelhardt, p. 83, pl. 1, fig. 21  
 1881 *Acer magnum* VELENOVSKÝ; Velenovský, p. 38, pl. 7, figs 7-9  
 1891 *Acer brachyphyllum* HEER; Engelhardt, p. 181, pl. 14, figs 8  
 1891 *Acer bruckmanni* A. BRAUN; Engelhardt, p. 181, pl. 14, figs 5  
 1891 *Acer grosse-dentatum* HEER; Engelhardt, p. 181, pl. 14, figs 12, pl. 15, fig. 14  
 1968 *Acer tricuspidatum* BRONN; Walther, pp. 636, 637, pl. 2, figs 1-3 (neotype)  
 1975 *Acer tricuspidatum* BRONN sensu PROCHÁZKA et BŮŽEK; Procházka et Bůžek, pls. 22-24, text-figs 2, 3, 4d, 5-13

Material: Carbonised leaf remains and fruits - bi-samaras, mostly disintegrated into partial samaras.

Description: Leaves palmately lobed, split in three or with poorly developed 4<sup>th</sup> and 5<sup>th</sup> lobe on external sides of two lateral lobes. Base rounded. Lobes either acute, equally narrowing, or with the middle lobe pentagonal in shape, i.e. with one pair of bigger teeth in the middle, then markedly narrowed. Lobes terminating at acute angles (25-60°), roundly at the apex. Leaf margin between conspicuous teeth in the lobes finely toothed, widely spaced to practically entire-margined. Angles between lobes of about 90°. Venation palmate, craspedodromous. Secondary veins splitting off the three main veins, alternate or almost opposite, at angles of 40-50°, straight or slightly curved adaxially. Higher order venation not recognizable.

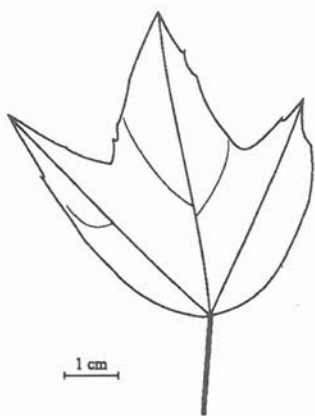
Adaxial cuticle without stomata or any trichomes, showing polygonal cells with straight to slightly wavy anticlines, 17.5-37 µm large, more elongated above the veins. Abaxial cuticle formed by polygonal cells, 15 µm in diameter. Stomata (17.5 x 12.5 µm) anomocytic, with prominent ledges forming roundly rectangular, narrow outer cavity almost reaching the poles. Very conspicuous appressed unicellular trichomes, long up to 125 µm, their bases oval and about 12.5 µm long.

Fruit remains found either as isolated samaras, or very rarely complete, in form of bi-samaras. Samara about 25 mm long and in the widest place, i.e. in about half wing length, up to 10 mm wide. Seed cavity oval and about 8 mm across, wing base connecting on the seed without any sulcus. Dorsal wing margin conspicuous, straight, ventral margin slightly convex. Veins originating from the dorsal margin and from the area of connection of the wing on the seed, curved abaxially toward the ventral side, branched several times, terminating in the margin. Within the complete fruits (bi-samaras) samaras mutually orientated normally (i.e. by the ventral sides together), grown by the lower third of the seed cavity, at angle of 80°.

Discussion: The fossil maples from the North Bohemian Tertiary were studied in detail by Procházka (1952) in his Doctoral thesis and by Procházka and Bůžek (1975), which present an abbreviated version of the thesis by M. Procházka, who had already died at that time. All specimens of fossil maples in the studied locality are attributed to the species *Acer tricuspidatum* BRONN sensu PROCHÁZKA et BŮŽEK on the basis of leaf forms split in three acute to pentagonal lobes, not narrowing at the base, and thanks to the character of the taken cuticle (anomocytic stomata with prominent outer ledges, which form a roundly rectangular outer cavity, conspicuous appressed unicellular trichomes - see Walther 1972, Kvaček 1985). Among the forms, as discerned within the species by Procházka (1952), and Procházka and Bůžek (1975), there are *A. tricuspidatum* BRONN forma *tricuspidatum* (see text-fig. 5) with trilobate leaves, with rounded base and acute lobes. This form, considered as evolutionarily primitive, is the most abundant within the species *A. tricuspidatum* (Procházka 1952). One of the recovered specimens (see text-fig. 6) is attributable to the form *A. tricuspidatum* BRONN f. *productum* (HEER) PROCHÁZKA et BŮŽEK on the basis of the distinctly robust middle lobe and relatively less prominent lateral lobes. This form is, after the form *tricuspidatum*, the most abundant (Procházka 1952).

The fossil representative of the maple, at present designated as *Acer tricuspidatum*, has been known for a long time - the oldest designation of this species, however illegitimate for nomenclatorial reasons (Kvaček 1965), appeared already in the Sternberg's (1823) work. The fossils of this species are the most abundant within the maples. In addition, in the Miocene of Central Europe, this species is in maximal development (whole range: Lower Oligocene to Upper Pliocene of Europe; outside Europe known only from the Paleogene of Greenland - see Procházka 1952). As a living relative of *Acer tricuspidatum*, the extant *A. rubrum* L. from Atlantic North America is generally noted. All samaras, found in the studied locality, are attributed here to the species *A. tricuspidatum* because of absence of any other maple species. However, they prove this comparison independently by their characteristics, especially by a relatively big seed, without any sulcus on the wing at the base and practically right angle in the line of union of individual samaras in a bi-samara. Besides a similar external morphology, this comparison is supported by ecological requirements of the species - *A. rubrum* L. is a typical swampy species of south-eastern part of USA, *Acer tricuspidatum*, regarding its occurrence, can be considered as a typical swampy maple (Procházka 1952). By its cuticular structure, *Acer tricuspidatum* is close to the modern *A. saccharinum* L. (Walther 1972, Kvaček 1985).





Text-fig. 5. *Acer tricuspidatum* BRONN forma *tricuspidatum*, leaf; MG(30) 249.



Text-fig. 6. *Acer tricuspidatum* BRONN forma *productum* (HEER) PROCHÁZKA et BŮŽEK, leaf; MG(30) 253.

*Acer* sp. (flos)  
Pl. 10, figs 1, 2

Material: Group of 3 carbonised flowers (MG(30)295).

Description: Group of 3 monoclinic flowers (the left one 25 mm long, other two flowers 20 mm long). Flowers separate but, regarding their mutual position, originally joined in an inflorescence. Receptacle, blunt, bell-like widening, slightly rounded, at the end of a narrow stalk. Perianth in a single circle, joined together in the upper part, crenate, without recognisable structure. Androecium formed by 5 stamens, represented by distinct anthers, 3 x 1 mm big, oval, rounded on both sides, with conspicuous spindle-like connectives. Filaments only very poorly preserved in the right flower, attachment of anthers on filaments hardly seen. Styles two in number, slightly curved filamentous projecting about 3 mm from the flowers (upper parts of the stamens), having slightly widening ends – stigmas. Styles perhaps joined together in the lower part, as appearing in the middle and the right flower. Pollen taken from the upper left part of the anther of the middle flower, located just beside the right style. Pollen oval to round, 30-45 µm big, tricolpate, colpi reaching the poles. Exine distinctly microreticulate, clavately sculptured. Pollen found in groups of several grains, having no well recognisable colpi - evidently not completely mature.

Discussion: This unusual specimen of three well preserved flowers is attributed here to the maple. The representatives,

documented in the locality by leaves were considered first. Two conspicuous styles, projecting from the flower and indicating a bi-carpellate ovary, were the main guide. The genus *Acer* satisfies this condition (Novák 1972, Krüssmann 1960, Dostál 1989): additional to similar long stalked flowers with only a single circle of perianth (calyx), distinctly projecting anthers (yet 5 stamens in the fossil flowers, contrary to generally 8 in the extant maples) and flowers grouped in inflorescences (the recovered specimen interpreted as 3 neighbouring flowers of a simple inflorescence). The character of the pollen in situ, taken from the flower, must also be considered as one of the essential arguments. The pollen is tricolpate and its general character corresponds to that of the maple (B. Pacltová, personal communication).

If that is so, the flowers belong most probably to the representative, characterised by the foliage of *Acer tricuspidatum*. Therefore comparison of the fossil *Acer tricuspidatum* with the extant *A. rubrum* L., which is polygamous, would remain possible.

## Meliaceae

### ? *Cedrela* P. BROWNE

cf. *Cedrela* sp.  
Pl. 10, figs 3, 4

Material: Several isolated carbonised leaflets (MG(30)267, 381, 382).

Description: Leaflets 60-90 mm long, 12-27 mm wide, elongated, entire-margined, shortly petiolulate. Blade curved and imperceptibly to very distinctly asymmetrical. One margin always straight (less convex), reposing relatively lower at the base. Second margin decurrent relatively higher on the petiole, connecting as a bow-like dome in the direction of the leaf curvature. Base more or less asymmetrical, cuneate, partly decurrent along the petiole. Some leaf forms without different course of two margins and conspicuous asymmetry of the base, but the one of the margins always straight to convex, the other decurrent and concave. Apex narrowing, tapering into a curved rounded tip. Venation brochidodromous. Secondary veins straight, mutually parallel, originating at angles of 65-70°, relatively densely and regularly in the conspicuous, curved midvein. Secondaries near the margin forming a series of regular, mutually connected loops. Secondaries often looping with abaxial veins, branching near the margin by upper adjacent secondary veins. Tertiaries together with higher order veins forming dense polygonal areolation between the secondary veins.

Adaxial cuticle without stomata, slightly grained, formed by polygonal cells, on average 25 µm across. Anticlinal straight to slightly undulate, thickened in the corners. Trichome bases oval (7.5 µm in diameter), with conspicuous cutin rim recognisable on the surface. On the abaxial side, stomata (about 3 per 3.14 x 10<sup>4</sup> µm<sup>2</sup>) very numerous. Stomata anomocytic, 17.5-22.5 x 12.5-17.5 µm with conspicuous narrow spindle-like outer cavity with thickened outer ledges. Guard cells indistinct, relatively lighter. Trichome base oval to round, 12.5-22.5 µm across, light. Ordinary cells indistinct, 17.5-30 µm across, with

undulate to slightly sinuous anticlines. Characteristic striation present on the cuticle.

Discussion: The leaf remains are compared to the foliage of the genus *Cedrela*. It is supposed that the studied leaf fossils (leaflets) had originally formed compound ? even pinnate leaves. In spite of the fact that the leaflets are relatively variable, essentially in size and curving of the leaf margin, they show constantly some characteristic features: asymmetrical base, short petiolule, acuminate apex, entire-margined margin, conspicuous midrib and characteristic loops just near the margin, brochidodromous venation, seen in places as eucamp-todromous. Meyer and Manchester (1997) describe a very similar type of leaf as the species *Cedrela merrillii* (CHANEY) BROWN. They match the studied material very well by the character of the venation, and even by other features (perhaps except for shallowly crenate margin sometimes present in their specimens). On the basis of the described features, Meyer and Manchester (1997) compare their material, besides *Cedrela*, to the very similar Asiatic genus *Toona*.

There are 6-8 species of the genus *Cedrela* estimated today, growing in Mexico and tropical South America and 6-15 species of the genus *Toona* (sometimes included into the genus *Cedrela*) in south-eastern Asia and Australia (Meyer and Manchester 1997). These deciduous or evergreen trees and shrubs essentially inhabit the tropics. The species *Cedrela* (*Toona*) *sinensis* extends into temperate Mixed Mesophytic and Broad-leaved Deciduous Forest of China (Wang 1961).

## Anacardiaceae

### ? *Rhus* L.

cf. *Rhus* sp.

Pl. 10, fig. 5

Material: One incomplete compound leaf and isolated carbonised leaflets (MG(30)243, 275).

Description: Leaf compound, odd-pinnate, about 220 mm long with opposite leaflets. Leaflets about ? 70 mm long, 20-25 mm wide, elongate, entire-margined, shortly petiolulate. Leaf apex not preserved. Base of leaflets rounded to cuneate, often very distinctly asymmetrical. Venation brochidodromous. Mid-vein conspicuous. Secondary veins straight, mutually parallel, unequally spaced, originating at angles of about 60°. These veins mutually looping near the margin. Tertiaries and higher order veins forming dense areolation between the secondary veins. Fine barley-like sculpture recognisable on the areolae surface.

Discussion: The most complete specimen (MG(30)275) is interpreted as a compound, odd pinnate, entire-margined leaf with opposite phyllotaxy of leaflets. It is compared to the genus *Rhus*, which typically has odd pinnate and often entire-margined leaves (Krüssmann 1960). In addition, the pollen, assigned to Anacardiaceae is very abundant in the Most Basin, while simultaneously corresponding macroremains are not known so far. So, this attribution could fill the gap in the macrofossil record. However, morphotypes closer to extant representatives of *Rhus* are rare (Konzalová 1976). This attribution must be viewed as preliminary, because an exact assignment

of these problematic remains call for further works, including more detailed comparative studies of the genus *Rhus*.

## Rhamnaceae

### *Paliurus* MILL.

#### *Paliurus tiliaefolius* (UNGER 1847) BŮŽEK 1971

Pl. 10, fig. 6

- 1847 *Ceanothus tiliaefolius* UNGER; Unger, p. 143, pl. 49, figs 1-6  
1847 *Paliurus favonii* UNGER; Unger, p. 147, pl. 50, figs 7, 8  
1869 *Zizyphus tiliaefolius* (UNGER) HEER; Ettihgshausen, p. 39, pl. 50, figs 8, 14, 15, 17 18  
1869 *Zizyphus ovatus* WEBER; Ettihgshausen, p. 40, pl. 50, fig. 16(?)  
1869 *Zizyphus bilineatus* ETTIHGSHAUSEN; Ettihgshausen, p. 40, pl. 51, fig. 1(?)  
1881 *Ficus tiliaefolia* A. BRAUN; Engelhardt, p. 81, pl. 1, fig. 14  
1881 *Paliurus geinitzi* ENGELHARDT; Engelhardt, p. 84, pl. 2, fig. 3(?)  
1881 *Zizyphus tiliaefolius* (UNGER) HEER; Velenovský, p. 41, pl. 8, figs 22, 23  
1904 *Paliurus friči* BRABENEC; Brabeneč, p. 18, pl. 1, fig. 11a  
1971 *Paliurus tiliaefolius* (UNGER) BŮŽEK; Bůžek, p. 74, pl. 33, figs 1-3, 5, 8, 14, pl. 34, figs 1-17

Material: Several carbonised leaves.

Description: Leaves broadly ovate, variable in size (50 x 45 mm to 25 x 20 mm), petiolate. Leaf margin irregularly finely crenate to serrate. Apex narrowing, rounded, at angle of about 90°. Base slightly cordate to rounded, with a characteristic small cuneate basal projection, delimited on both sides by two lateral primary veins. Venation basal acrodromous with three main veins - one conspicuous midrib and two lateral, less conspicuous, primary veins. Two lateral main veins originating slightly asymmetrically at angles of 50-60° from the medial main vein from the area out of the leaf blade, forming a characteristic cuneate triangular area. Lateral main veins after curving slightly adaxially, continue more or less parallel to the midrib, and terminate near the margin, in the last third of the distance from the base to the apex. Lateral primary veins branching off abaxial lateral veins, forming regular mutually connected loops. Several secondary veins, alternate to almost opposite, originating from the midvein in the upper half of the leaf, curving adaxially along the margin and terminating blindly like the lateral primary veins. Small veins originating from these secondary veins, as well as from the lateral loops of lateral primary veins, and entering the leaf margin. The 3<sup>rd</sup> and higher order veins forming a dense polygonal areolation between the primary and the secondary veins. Epidermal structure not studied. Typical fruit remains not found in association.

Discussion: In the work devoted to the Tertiary flora of the Pětipsy Area of the Most Basin, Bůžek (1971) attributed such leaf remains to the genus *Paliurus*, in spite of a relatively significant morphological resemblance between the fossils and the two genera of Rhamnaceae, the genus *Zizyphus* and, above all, with some species of the genus *Ceanothus*. As the main reason of the new combination, besides certain morphological differences (*Paliurus* develops symmetric and cordate leaves more often than *Zizyphus*, and the leaf margin is rather very finely serrate to almost entire-margined, contrary to coarsely crenate margin of *Zizyphus*), Bůžek (1971) stresses an abundant, and of the Most Basin typical occurrence of the

characteristic fruits of *Paliurus* (trilocular winged nuts), described from the area of the Most Basin already by Ettingshausen (1869), which are found in association with the leaves. Furthermore, neither fruits, nor stones of the genera *Ceanothus* and *Ziziphus* have been recognised in this area.

The genus *Paliurus* includes 6 species, inhabiting today the Mediterranean and East Asia (Novák 1972). The subtropical climate typical of the range of *Paliurus* corresponds rather to the climate during the deposition of the Lower Miocene of the Most Basin than that characteristic of the modern distribution area of *Ziziphus*, i.e. tropical and subtropical. Bůžek (1971), among others, sees in this fact an indirect support for his new combination.

### *Berchemia* NECKER

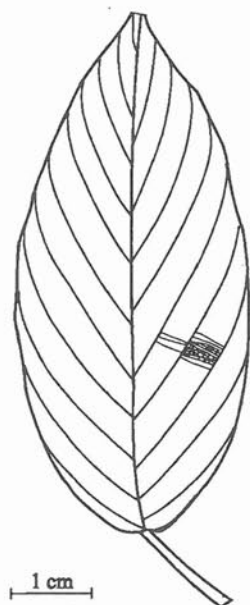
#### *Berchemia multinervis* (A. BRAUN 1836) HEER 1859

Pl. 10, fig. 7, text-figs 7, 8

- 1836 *Rhamnus multinervis* A. BRAUN; Braun in Buckland, p. 513  
 1859 *Berchemia multinervis* (A. BRAUN) HEER; Heer, p. 77, pl. 128, figs 9-18  
 1869 *Berchemia multinervis* (A. BRAUN) HEER; Ettingshausen, p. 41, pl. 49, figs 15-17(?)  
 1881 *Berchemia multinervis* (A. BRAUN) HEER; Velenovský, p. 42, pl. 4, figs 26, 27  
 1891 *Berchemia multinervis* (A. BRAUN) HEER; Engelhardt, p. 188, pl. 12, fig. 2, 19-28, pl. 13, figs 4, 5(?)

Material: Several carbonised leaves.

Description: Leaves long ovate, but may even be elliptic to almost circular, entire-margined, sometimes with very slightly undulate margin, especially near the apex. Petiole up to 15 mm long (maybe more). Leaf apex rounded, at angle of just under 90°, only rarely distinctly more acute. Base rounded, or very slightly cordate. Venation typically eucamptodromous with a distinct midrib. Secondary veins parallel, curved along, but

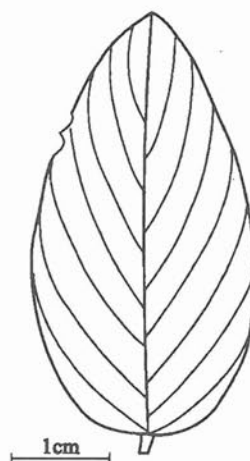


Text-fig. 7. *Berchemia multinervis* (A. BRAUN) HEER, leaf; MG(30)247.

not entering the margin. Secondaries in the lower part of the leaf practically opposite, higher up towards the leaf apex alternate, originating from the main vein at more acute angles. Tertiaries poorly preserved, connected to the secondaries at right angles. Higher order veins of (if recognisable) forming a dense areolation between the tertiaries (see text-figs 7,8).

Discussion: Heer (1859) was the first to place these leaves to the genus *Berchemia*, and compared them to almost morphologically identical foliage of the extant North American liana *B. scandens* (HILL.) K. KOCH. A similar foliage can be observed in the East Asian *B. lineata* DC., as well as in other genera, especially in the genus *Cornus* (Bůžek 1971). Concerning *Cornus studeri* HEER, Bůžek (1971), in his replay to Weyland's (1934) doubts about the independence of *Berchemia multinervis* in connection with this species, notes that *Cornus studeri* HEER has a steeper acrodromous venation and its leaf shape more slender and elongated.

The representatives of the family Rhamnaceae have recently been studied by Jones and Dilcher (1980) in connection with revision of leaf remains from the Eocene of North America, described as *Rhamnus marginatus* LESQUEREUX. They described a new genus *Berhamniphyllum* with the type species *Berhamniphyllum clairbornense*. This genus has been newly assigned to tribe Zizyphaeae (leaves matching closer the representatives of this tribe than the genus *Rhamnus* or any other member of the tribe Rhamneae). As already apparent from the designation, the closet living genera are *Rhamnidium* and *Berchemia*. In this context, the authors do not rule out the attribution of their fossils to either genus, or to other extant or extinct representatives of the tribe Zizyphaeae. Regarding their species, it is considered by Jones and Dilcher (1980) as a distinctly aggregate species. They note also that *Berchemia multinervis* probably fits the diagnosis of their new species. Due to the fact that a good sample of cuticle (only upper epidermis showing just the anticlines of ordinary cells) has not been obtained from the North Bohemian material, this question cannot be discussed in detail. Using macroscopic characteristics, the studied specimens are less acute at the base and at the apex than those that Jones and Dilcher (1980) present and characterise as a new species. However, it must be said that the studied specimens assigned to *Berchemia*



Text-fig. 8. *Berchemia multinervis* (A. BRAUN) HEER, leaf; MG(30)250.



*multinervis*, several in number, are variable in morphology. So it is not excluded that the leaves of *Berchemia multinervis*, at least some of them, will be assigned in the future to the fossil genus *Rhamniphyllum*.

The genus *Berchemia* with its 22 species occurs today in southern and eastern Asia, eastern North America, northern Central America and eastern Africa.

## Nyssaceae

### *Nyssa* GRONOV ex L.

#### *Nyssa haidingeri* (ETTINGSHAUSEN 1866) Z. KVAČEK et BŮŽEK 1972

Pl. 11, figs 1, 2

- 1866 *Laurus haidingeri* ETTINGSHAUSEN; Ettingshausen, p. 174, pl. 30, figs 5, 8, 9  
 ?1866 *Coccoloba bilinica* ETTINGSHAUSEN; Ettingshausen, p. 164, pl. 30, fig. 1  
 ?1866 *Coccoloba acutangula* ETTINGSHAUSEN; Ettingshausen, p. 164, pl. 30, fig. 2  
 1868 *Laurus nectandroides* ETTINGSHAUSEN; Ettingshausen, partim, p. 194, pl. 31, fig. 1 (v) (non figs 2a, b, 6, 7, 10)  
 ?1868 *Laurus agathophyllum* ETTINGSHAUSEN; Ettingshausen, p. 194, pl. 31, fig. 3 (v)  
 1868 *Persea speciosa* HEER; Ettingshausen, p. 197, pl. 32, fig. 15, 16 (v)  
 1868 *Laurus heliadum* UNGER; Ettingshausen, p. 194, pl. 32, fig. 1  
 ?1868 *Protea bilinica* ETTINGSHAUSEN; Ettingshausen, p. 202, pl. 35, fig. 1  
 1868 *Cinchonidium bilinicum* ETTINGSHAUSEN; Ettingshausen, p. 207, pl. 35, fig. 31 (v) (non figs 28-30)  
 1869 *Bombax oblongifolium* ETTINGSHAUSEN; Ettingshausen, p. 12, pl. 42, fig. 8 (v), 9  
 ?1869 *Bombax salmaliaefolium* ETTINGSHAUSEN; Ettingshausen, p. 12, pl. 42, fig. 10, 11  
 ?1869 *Rhamnus heerii* ETTINGSHAUSEN; Ettingshausen, p. 43, pl. 50, fig. 20, pl. 51, fig. 2  
 1891 *Bombax oblongifolium* ETTINGSHAUSEN; Engelhardt, p. 178, pl. 13, figs 14-16  
 1972 *Nyssa haidingeri* (ETTINGSHAUSEN) Z. KVAČEK et BŮŽEK; Kvaček et Bůžek, p. 373, pl. 1, pl. 2, figs 1, 2, pl. 3, figs 1-3, pl. 4, figs 1-5, text-figs 1, 2

Material: Great number of carbonised leaves.

Description: Leaves entire-margined (sometimes with one or few characteristic coarse teeth), elliptic or oblong to obovate, long petiolate, about 100 mm long and 45-70 mm wide; one smaller (40 x 20 mm), probably young specimen found. Base acute cuneate, often asymmetrical. Leaf apex acute, slightly acuminate, but even very often at angle of around 90°. Venation camptodromous - brochidodromous with distinct, narrowing midvein. Secondary veins alternate or even opposite, branching off, curving up along the margin, curving abaxially often at the base, immediately after branching from the main vein. Secondaries often forked, sometimes at their base, terminating in form of mutually connected loops, often formed by connection between the secondary vein and an abaxial branch of the upper adjacent secondary vein. Venation of higher orders not recognisable on the specimens.

Discussion: Kvaček and Bůžek (1972) attributed these characteristic entire-margined leaf remains, assigned previously to various families (*Lauraceae*, *Bombacaceae*, *Rutaceae* etc.),

into the extant genus *Nyssa* on the basis of the epidermal structure, namely of the presence of spatulate glandular trichomes.

The species *Nyssa haidingeri* with its characteristic features does not correspond exactly to any living representative of *Nyssa*. From the point of view of leaf morphology, the fossil leaves correspond to the entire-margined leaves from the complex *Nyssa sylvatica*, or to the species *Nyssa ogeche* by some epidermal similarities. On the other hand, the accompanying fruit remains (see the description below) point rather to a relationship with the species *Nyssa aquatica*. Hence the fossil species *Nyssa haidingeri* does not match any living representative of this genus, neither in eastern Asia, nor in North America (Kvaček and Bůžek 1972).

The fossil remains of the species *Nyssa haidingeri* very often occur together with characteristic elements of the lignite swamp, e.g., *Glyptostrobus europaeus*, *Taxodium dubium*, *Dombeyopsis lobata*, *Woodwardia muensteriana* and others (e.g., localities Čermníky, Břežanky, Mine Bílina etc.). It is just like the living *Nyssa biflora*, *N. aquatica* and *N. ogeche*, which inhabit the area of the Atlantic coast of North America, in conditions of warm temperate to subtropical swamp forest together with typical representatives of the genus *Taxodium*. *Nyssa haidingeri* can be so considered as a characteristic indicator of swampy conditions of rather warm climate.

#### *Nyssa* cf. *haidingeri* (ETTINGSHAUSEN 1866) Z. KVAČEK et BŮŽEK 1972

Pl. 11, fig. 3

Material: Three highly carbonised leaves (MG(30)236, 379, 280).

Description: Leaves entire-margined, 60-80 x 16-20 mm big, oblong, petiolate, highly carbonized. Blade widest in about the middle of the leaf. Toward the base leaf distinctly cuneately narrowing, symmetrically decurrent along the petiole. Toward the apex leaf narrowing more gently, terminating by an indistinct rounded tip. Venation very indistinct, formed by a straight midvein and relatively dense secondary veins, originating at very small angles (30-35°). Secondaries curved up at the margin and perhaps (not clearly seen) mutually looped. No venation details recognisable on the specimens.

Adaxial cuticle formed by square to polygonal, 12.5-30 μm big cells, arranged in more or less regular rows. Abaxial epidermis formed by similar cells, however with less conspicuous anticlines. Spathulate trichome, about 30 μm long, unicellular observed. Stomata not seen.

Discussion: The leaves are interpreted here as badly preserved narrow-leaved forms of the previous species. This comparison is even supported by the presence of a spatulate trichome on the upper cuticle, very characteristic of *Nyssa haidingeri*.

#### *Nyssa disseminata* (LUDWIG 1857) KIRCHHEIMER 1937

Pl. 11, fig. 4

- 1857 *Pinus disseminata* LUDWIG; Ludwig, p. 89, pl. 20, figs 2a-g  
 1881 *Nyssa vertumni* UNGER; Velenovský, p. 37, pl. 6, figs 20-24  
 1937 *Nyssa disseminata* (LUDWIG) KIRCHHEIMER; Kirchheimer, p. 916, fig. 11

Material: Several impressions-compressions of endocarps, two of them complete.

Description: Endocarps oval, 15-20 mm long and 8-11 mm wide (among them one very small, perhaps immature), on the apical end rounded, on the other basal end narrowing and transversally cut. Surface typically sculpted in form of conspicuous longitudinal 4-10 ribs.

Discussion: Kvaček and Bůžek (1972) compare the fossil endocarps to those of extant *Nyssa*. On the basis of the number of ribs, the fossil remains are closer to the species *Nyssa aquatica* rather than to the *Nyssa sylvatica* complex. By their size, they are situated between both groups. On the basis of the surface character, the fossils differ from the species *Nyssa javanica* and *N. ogeche*. These facts just demonstrate that this fossil *Nyssa* has no exact living analogue. Kvaček and Bůžek (1972) criticise the attribution of the fossil endocarps from the Most Basin to the species *Nyssa disseminata* (LUDWIG) KIRCHHEIMER by Bůžek and Holý (1964), and furthermore, they call attention to a too wide concept of this species by Kirchheimer (1957) including probably more natural species.

It is very probable that the endocarps together with the foliage of the *Nyssa haidingeri* type belong to a single species of the genus *Nyssa*.

#### *Nyssa* sp.

Pl. 11, figs 5, 6

Material: Several carbonised capitulum-like inflorescences (MG(30)354, 422-426).

Description: Inflorescences globous, capitulum-like (7-10 mm in diameter), resting on a stalk, 25 mm long, 2 mm wide, and in the upper part bluntly widening. Inflorescences either globous, i.e. stalk apex surrounded entirely by the capitulum, or forming rather semi-globular capitulum. Inner structure of the inflorescences not completely evident due to decay processes. Widely roundish, about 2 mm long anthers clearly recognisable. Pollen taken from the anthers tricolporate, chagrinata, oval.

Discussion: Such remains have been compared most often to the male inflorescences of the genus *Sparganium* (Bur Reed). The tricolporate pollen *in situ* demonstrates evidently the incorrectness of such an interpretation (*Sparganium*, family Sparganiaceae as a whole, have monoporate to monosulcate pollen - see Konzalová 1976). In spite of the fact that the detailed pollen analysis was not yet undertaken (detailed study of *Nyssa* is in preparation with Z. Kvaček and J. Dašková), the pollen corresponds in general to *Nyssa*. Macroscopically, the studied specimens match quite well the male capitulum-like inflorescences of the extant *Nyssa*.

One of the arguments supporting this attribution is the fact that the fossils of the genus *Nyssa* are very abundant in the studied horizon.

### Apocynaceae

#### *Apocynospermum* E. M. REID et CHANDLER

#### *Apocynospermum striatum* E. M. REID et CHANDLER 1926

Pl. 12, fig. 1

1898 *Cypselites quadricostatus* ENGELHARDT; Engelhardt, p. 22, pl. 1, figs 42, 44-45, 51

1926 *Apocynospermum striatum* E. M. REID et CHANDLER; Reid et Chandler, p. 118, pl. 8, fig. 3

Material: Several carbonised seeds with pappus (MG(30)285, 299, 387-390).

Description: Seeds very thin and up to 40 mm long. Frontal beak-like part thin, about 10 mm long, finely longitudinally sculptured, tipping into a thin, elongated, compact, serried pappus, slightly diverging at the end.

Discussion: These remains, according to Reid and Chandler (1926), are generally accepted as seeds with a pappus, belonging to the family Apocynaceae. From the nomenclatorial point of view, as already mentioned by Kvaček and Walther (1995), the priority should have been given to the designation *Cypselites quadricostatus* of Engelhardt (1898) or some other *Cypselites* species. Furthermore, similar remains had been described still earlier by Heer (1859, p. 2) and interpreted as one-seeded samaras with a pappus from Asteraceae, belonging to the formal genus *Cypselites*.

Apocynaceae grow today essentially in the Tropics, only 7 species reaching the extratropical zones and only one of them the northern limit of the temperate zone (Novák 1972).

### Oleaceae

#### *Fraxinus* L.

#### *Fraxinus bilinica* (UNGER 1849) Z. KVAČEK et HURNÍK 2000

Pl. 11, figs 7, 8

1849 *Juglans bilinica* UNGER; Unger, p. 126. pro parte (specimens from Bilina, non pl. 14, fig. 20) (Basionym)

1850a *Juglans (Carya) bilinica* UNGER; Unger, p. 469. pro parte (specimens from Bilina)

?1859 *Pavia ungeri* GAUDIN; Gaudin et Strozzi, p. 17, pl. 4

1868 *Carya bilinica* UNGER; Ettingshausen, pl. 51, figs 14, 15

1881 *Carya bilinica* UNGER; Velenovský, p. 44, pl. 8, figs 1, 3, pl. 9, 16

1971 *Juglans juglandiformis* (STERNBERG) GIEBEL; Bůžek, p. 44, pl. 11, figs 4-7, pl. 23, fig. 1 (typo excl.)

1976 *Fraxinus ungeri* (GAUDIN in GAUDIN et STROZZI 1859) KNOBLOCH et KVAČEK; Knobloch et Kvaček, p. 63, pro parte pl. 7, fig. 7, pl. 11, fig. 10, pl. 13, figs 2, 5, pl. 14, fig. 13, pl. 28, figs 1-3, 5-8, pl. 29, figs 1, 4, 7-9, pl. 30, figs 1, 2, 6, pl. 31, figs 14, 15, pl. 33, figs 1-3 (? typo excl.)

2000 *Fraxinus bilinica* (UNGER) Z. KVAČEK et HURNÍK; Kvaček et Hurník, p. 19, pl. 8, figs 7-(?)8, text-figs 4.2, 4.7

Material: Several carbonised leaf remains (MG(30)241, 260, 400-402).

Description: Leaflets narrowly lanceolate, variable in size, up to 120 mm long and 30 mm wide with short, about 5 mm long petiolule. Base rounded to cuneate, asymmetrical, and slightly decurrent along the petiole. Apex narrowing, tapering into an elongated tip. Leaf margin distinctly widely-spaced simple to double serrate. Teeth relatively wide, tapering, rounded, with axes more or less parallel to the margin, sometimes con-

vex domed in the lower part of the basal tooth side. Margin in one case entire in the lower part. Venation semicraspedodromous to brochidodromous. Secondary veins regularly branching from a midvein at angles of 60–80°, slightly bent, curving distinctly up near the margin and branching. One branch, often absent, entering the sinus. Second branch looping to the upper adjacent secondary vein. Abaxial veins very numerous, less conspicuous, complicatedly branched running from the loops toward the leaf margin. Secondaries often branched and looped already before the margin. Tertiaries seen between the secondary veins as transversal branched connections, together with veins of higher orders forming a distinct polygonal areolation.

Adaxial cuticle granulate, fragmental to relatively entirely preserved, without stomata. Ordinary cells polygonal, up to 37.5 µm long (on average about 25 µm) with anticlines straight to wavy. One roundish, 20 µm long trichome base observed. Abaxial cuticle striate with similar ordinary cells. Characteristic roundish trichome bases (12.5 µm in diameter) with strongly cutinized periphery, strongly cutinized anticlines radially running out and very indistinct shapes of rounded peltate trichomes of larger diameter. Stomata anomocytic, about 25 µm long, narrowly elongate with thickened outer ledges.

Discussion: Kvaček and Hurník (2000, this volume) delimit *F. bilinica* as a new combination to replace the illegitimate and geologically much younger *Fraxinus ungeri*. Thanks to external morphology, and above all to the cuticle features, these leaves can be distinguished from other similar forms, essentially from the representatives of the family Juglandaceae. The main diagnostic feature is undoubtedly the character of peltate trichomes. The representatives of Juglandaceae present generally larger glandular trichome heads with a very poorly seen segmentation in the fossils. Concerning little smaller glandular trichomes of the genera *Carya* and *Juglans*, their head is very thin-walled, so incapable of being preserved in the fossils. In the genus *Juglans* (except for *J. regia* L.), uniserial glandular trichomes are also present (Kvaček and Knobloch 1976). Besides the external leaf morphology, the attribution of relatively variable leaf forms to *Fraxinus bilinica* was above all made thanks to the presence of typical roundish, more strongly cutinized and radially projecting (star-like) bases of peltate trichomes. Regarding the trichomes themselves, they were not preserved in the specimens: at their best they had the form of practically imperceptible impressions of circular heads.

The living ash relatives of the fossil *Fraxinus bilinica* inhabit humid habitats. They represent an important element of the riparian forests of SE USA and the vegetation of montane subtropical zones of Assam (Kvaček et Bůžek 1983).

### *Fraxinus macroptera* ETTINGSHAUSEN 1868

Pl. 12, fig. 2

1868 *Fraxinus macroptera* ETTINGSHAUSEN; Ettingshausen, p. 213, pl. 36, figs. 10

1868 *Fraxinus lonchoptera* ETTINGSHAUSEN; Ettingshausen, p. 213, pl. 36, figs 11, 12

Material: Two carbonised samaras (MG(30)261, 375).

Description: Samara winged, 35–40 mm long. Wing long obovate to narrowly long elongated, entire-margined, reposing

on upper side of a longitudinally elongated seed cavity. Seed cavity in one samara indistinguishable from the wing, in another seen as a lower, dark part of the fruit. Lowest part missing in one samara, the second fruit attached to a stalk. Venation of the fruit characterised by a middle straight vein and mutually parallel lateral veins, originating densely on both sides at very steep angles. Veins of the same order as the lateral veins, parallel to them, coming already from the base, running longitudinally. Very fine, longitudinally orientated venation recognisable between all veins, forming probably anastomoses between them. All veins terminating in the fruit margin.

Discussion: The fruits, almost indistinguishable from the samaras of the extant ash *F. excelsior* L., native also to Czech Republic, prove undoubtedly the presence of the genus *Fraxinus* in the studied horizon. The fruits very probably belong to the fossil ash with the foliage of the *Fraxinus bilinica* type (see the above description).

### Dicotyledonae inc. fam.

cf. "*Ficus*" *truncata* HEER 1859 sensu BŮŽEK 1971  
Pl. 12, fig. 3

?1859 *Ficus truncata* HEER; Heer, p. 183, pl. 152, fig. 15.

?1881 *Ficus truncata* HEER; Velenovský, p. 29, pl. 6, fig. 5.

?1891 *Ficus titanum* ETTINGSHAUSEN; Engelhardt, p. 163, pl. 10, fig. 17.

?1971 "*Ficus*" *truncata* HEER sensu BŮŽEK; Bůžek, p. 92, pl. 46, figs 1–9, pl. 47, figs 3–8, pl. 48, figs 1,2, text-fig. 15 d, e.

Material: A single impression of the leaf (MG(30)374).

Description: Leaf 11 mm long and 70 mm wide (in the widest place), ? shortly petiolate, entire-margined, widely ovate in shape. Base shallowly cordate, apex narrowing, acuminate. Venation palmate brochidodromous with three main veins. Main veins originating from the petiole already under the leaf blade – forming so characteristic v-shaped part of lamina at the base of the leaf. Middle main vein straight, conspicuous. Lateral main veins as distinct as the middle one originating from the petiole at angle of 45°, first straight than slightly curved, and at the leaf margin looped to the secondary vein, branched from the middle main vein. Lateral main veins jointing off abaxially up to 8 parallel and mutually looped branches. First branches jointed off from the lateral main veins just at the base running along basal margin. Secondary mutually parallel veins originating from the middle vein at angle of about 40° and looping together near the margin. Tertiaries forming perpendicular connections between primary, secondary veins and abaxial branches. Venation of higher orders forming a dense, very well recognisable polygonal areolation between the tertiaries.

Discussion: The leaf impression is compared to some of the forms of the species "*Ficus*" *truncata*, as newly defined by Bůžek (1971). On the basis of features such as e.g., asymmetrical blade or character of the venation of the 3<sup>rd</sup> order, this author notes that a representative of the genus *Ficus* cannot be considered. The forms, comparable with the described impression, are mentioned in the synonym list. Those figured by Bůžek (1971; tab. 46, figs 5–7, tab. 47, figs 3–7) are most similar. On the other hand, the typical form of the species *Ficus titanum* ETTINGSHAUSEN (1866), newly included by Bůžek (1971) under the concept of "*Ficus*" *truncata*, is completely



dissimilar to the studied specimen, because of its cuneate base and straighter lateral main veins.

The systematic affinity of the leaves attributed to the species "*Ficus truncata*" is in doubt. (Kvaček and Bůžek 1983).

### *Dicotylophyllum* sp. 1

Pl. 12, figs 4, 5

Material: A single incomplete carbonised leaf (MG(30)385).

Description: Leaf fragmentary, 50 mm long, 10 mm wide, elongate, without a preserved petiole. Base cuneate, decurrent, asymmetrical. Apex not preserved. Leaf margin simple toothed. Teeth and even sinuses straight, acute to slightly rounded. Abmedial side of teeth often inclined downward to the tangent of the leaf margin. Venation semicraspedodromous, exceptionally good preserved comparing to the specimens from the described horizon. Straight secondary veins regularly branching off from a straight midvein at angles of 55-60°, curving up near the margin and branching. The abaxial branch continuing into the leaf margin, entering the sinus, adaxial branch looping to the upper adjacent secondary vein. Besides the abaxial branches of the secondary veins, very numerous less conspicuous abaxial veins originating from the loops towards the margin. Tertiaries together with veins of higher orders forming between secondary veins a distinct dense areolation.

Discussion: The systematic affinity of this specimen is unknown.

### *Dicotylophyllum* sp. 2

Pl. 12, fig. 6

Material: A single incomplete carbonised leaf (MG(30)384).

Description: Leaf fragmentary, 100 mm long, up to 35 mm wide, elongated with about 15 mm long, wide petiole. Base cuneate, indistinctly asymmetrical. Apex not preserved. Leaf margin simple shallowly toothed. Teeth relatively different in expressiveness, perpendicular or slightly inclined upward to the tangent of the margin. Sinuses distinctly rounded. Venation composedly brochidodromous. Straight secondary veins branching off from a very conspicuous midvein at angles of 60-70°, near the midvein as well as near the margin, often forked and mutually connected. Secondaries together with their forked branches forming near the margin mutually connected loops of several orders. Numerous abaxial veins running from the loops towards the margin. Intersecondary complex branched veins often present between the secondary veins. Veins of higher orders not recognisable.

Discussion: The systematic affinity of this specimen is unknown.

### *Dicotylophyllum* sp. 3

Pl. 12, fig. 7

Material: A single carbonised leaf (MG(30)383).

Description: Leaf 85 mm long, up to 33 mm wide, entire-margined, shortly petiolate, lanceolate, with cuneate asymmetric base and equally narrowing acute apex. Venation brochidodromous. Secondary veins, relatively widely spaced, straight, mutually parallel, originating from conspicuous

straight midvein at angles of about 50°, near the margin, secondaries mutually looping. Higher order venation not recognisable on the specimen.

Discussion: The systematic affinity of this specimen is unknown.

## LILIOPSIDA

### Poaceae vel Cyperaceae div gen. et sp.

Material: Several fragments of carbonised leaves (MG(30)431).

Description: Leaves fragmentary, entire-margined, very long, more than 200 mm and thin (under 5 mm). Venation parallel, formed by conspicuous longitudinal veins, between them dense, parallel, less conspicuous veins present.

Discussion: These monocotyledonous leaves represent remains of reed and grass covers of uncertain taxonomic composition (Kvaček and Bůžek 1983).

### Flora - conclusions

- 51 different taxa including about 45 in the Tertiary really living species were described (a highly cumulative taxon *Poaceae* vel *Cyperaceae* div gen. et sp., including a great number of leaf forms is considered here as a single morphospecies because the remains cannot be assigned to natural species).

- Floristic composition covers three vascular plant divisions: Pteridophyta (class Pteridopsida), Pinophyta (class Pinopsida), and Magnoliophyta (classes Magnoliopsida and Liliopsida).

- Most of described taxa have been known either directly from the Most Basin (Bůžek 1971), or from other Miocene localities of the Bohemian Massif (Knobloch and Kvaček 1976).

- Besides those known from the previous research, the following taxa are newly described:

#### a) new to the area of the Most Basin

*Apocynospermum striatum* – known e.g. from the Volcanic Complex of the České středohoří Mts. (Kvaček and Walther 1995),

*Betula* sp. - leaf and bract – while the leaves and even the fruit bracts of birches were described from the area of the Most Basin (see e.g., Bůžek 1971, Bůžek and Holý 1964), the specimens morphologically comparable to those from the present study (i.e. leaves broadly ovate, distinctly double toothed with rounded teeth of the 1<sup>st</sup> order and distinctly longitudinally elongated bracts) are not known from the North-Bohemian Tertiary, *Castanopsis* cf. *schmidtiana* – fruits accompanying the foliage *Quercus rhenana* are already known (Kvaček and Bůžek 1983), however, they are newly compared to *Castanopsis schmidtiana*. Thus the Tertiary area of the occurrence of the *Castanopsis* fruit remains, as described by Mai (1989), is so extended to Czech Republic,

cf. *Cedrela* sp. – characteristic leaf forms without any analogues in the basin are compared to the foliage of the genus *Cedrela*, characterised by Meyer and Manchester (1997) in their description of the species *Cedrela merrillii*,

*Decodon gibbosus* – a unique specimen of a fruiting leafy twig, most recently studied in detail by Kvaček and Sakala (1999),  
**cf. *Rhus* sp.** – a compound odd-pinnate entire-margined leaf with opposite leaflets, compared here to *Rhus*, namely to its entire-margined forms; it could explain a discrepancy that the pollen attributed to the family Anacardiaceae is very abundant in the Most Basin, but the morphotypes looking like the extant representatives of the genus *Rhus* are rare (Konzalová 1976), and no corresponding foliage has been known,  
***Rubus* sp. 1, 2 – leaf remains** – one compound leaf and one leaflet distinct from the narrow-leaved *Rubus merianii*, typical of the basin; regarding the variability of extant blackberries, the specimens cannot be considered as individual species, nevertheless this possibility cannot be completely rejected.

#### b) taxa described for the first time

***Acer* sp. - flower** – nowhere any equivalent was found for these three very well preserved flowers; on the basis of the flower plan and above all of the character of the pollen in situ, the specimen is attributed to a maple, and because *Acer tricuspidatum* is the only known maple and occurs very abundantly in the studied locality, the flowers should be most probably referred to this species,

**cf. *Asplenium* sp.** – a very nice small fern frond compared on the basis of the external morphology to spleenwort; among the taxa, described in the literature, no morphologically analogue fern has been discovered,

***Rubus* sp. - calyx** – this pentamerous calyx, markedly distinct from the tetramerous calces of *Diospyros*, is by its symmetry, as well as by its shape and acuminate sepals tapering into a sharp spine attributable to the genus *Rubus*, and comparable on the basis of the sculpture of the apocarpium rather to a raspberry; even for this taxon no exact analogue has been found in the literature.

- Besides the known, well characterised taxa and the newly described but attributable ones, there also several problematic:

#### c) problematic taxa

***Nyssa* sp.** – these problematic carbonised inflorescences are compared to the genus *Nyssa* on the basis of certain morpho-

logic resemblance and pollen character; thanks to the pollen in situ (tricolporate pollen), the inflorescences were clearly distinguished from the morphologically similar inflorescences of the genus *Sparganium* (monoporate to monosulcate pollen), frequently recorded in the basin in form of endocarps (Kvaček and Bůžek 1983),

***Dicotylophyllum* sp. 1-3** – three leaves of unknown systematic affinity are placed here under the form genus *Dicotylophyllum*,  
***Juglandaceae* gen. et sp. indet. - endocarp** – a fruit remain compared to juglandaceous endocarps, but without precise specific and generic relationship,

**cf. *Mahonia* sp.** – poorly preserved leaves, which are comparable, owing to their toothed margin and elongate shape, with *Mahonia malheurensis* Arnold (1936) from the Tertiary of North America; however, the features allowing an attribution of the fossils to the genus *Mahonia* are either absent, or not evident on the specimens, and so this attribution must be viewed as preliminary.

- Cuticular analysis was demonstrated as irreplaceable during the description fossil plant remains. Two principal results of its application are:

Distinction between the sterile foliage of *Glyptostrobus europaeus* and *Quasisequoia couttsiae* on the basis of the epidermal structure (see *Glyptostrobus europaeus* in the systematic descriptions). Distinction of sterile twigs of these two representatives is practically impossible on the basis of gross morphology, so the obtained results, although preliminary, could be useful.

Absence of the otherwise characteristic wax rings surrounding the guard cells of the stoma in the species *Quercus rhennana*, as well as the absence of otherwise characteristic trichomes in the other representatives of the flora from the studied horizon. This fact can be explained by relatively high air humidity in the studied locality, i.e. environment not requiring adaptations restraining undesirable evaporation from the leaf surface.

- At the end of this chapter, a brief summary of the flora composition in the described locality is shown (taxa are ranged in alphabetic order within the corresponding divisions, frequency classes: \* - 1, \*\* - 2-5, \*\*\* - 5-10, \*\*\*\* - >10 specimens recovered)

<i>Pteridophyta</i>		
Taxon	Organ	Frequency class
cf. <i>Asplenium</i> sp.	carbonised frond	*
<i>Blechnum dentatum</i>	carbonised pinna	*
<i>Osmunda porschlugiana</i>	incomplete pinnate pinna	*
<i>Salvinia reussii</i>	leaves, floats	****
<i>Woodwardia muensteriana</i>	carbonised simple pinna	*

<i>Pinophyta</i>		
Taxon	Organ	Frequency class
<i>Glyptostrobus europaeus</i>	twigs, male & female cones and seeds	****
<i>Quasisequoia couttsiae</i>	twigs, female cones and seeds	****
<i>Taxodium dubium</i>	brachyblasts, twig, male cones, one seed	****

	<i>Magnoliophyta</i>	
Taxon	Organ	Frequency class
<i>Acer tricuspidatum</i>	carbonised leaves and fruits	****
<i>Acer</i> sp.	group of 3 carbonised flowers	*
<i>Alnus julianiformis</i>	carbonised leaves and catkins	****
<i>Alnus</i> sp.	carbonised male catkin	*
<i>Apocynospermum striatum</i>	carbonised seeds	***
<i>Berchemia multinervis</i>	carbonised leaves	***
<i>Betula</i> sp.	carbonised leaf	*
<i>Betula</i> sp.	carbonised bract	*
<i>Castanopsis</i> cf. <i>schmidtiana</i>	fruit imprint	*
<i>Cercidiphyllum crenatum</i>	leaves, flowers, fruits and seeds	****
cf. <i>Cedrela</i> sp.	carbonised leaves	***
<i>Craigia brononii</i>	carbonised fruit valves	****
cf. <i>Crataegus</i> sp.	carbonised leaf	*
<i>Decodon gibbosus</i>	carbonised leaves, fruits, seeds	****
<i>Dicotylophyllum</i> sp. 1	carbonised leaf	*
<i>Dicotylophyllum</i> sp. 2	carbonised leaf	*
<i>Dicotylophyllum</i> sp. 3	carbonised leaf	*
<i>Diospyros brachysepala</i>	carbonised leaves	***
<i>Dombeyopsis lobata</i>	carbonised leaves	***
<i>Engelhardia macroptera</i>	carbonised fruits	**
cf. " <i>Ficus</i> " <i>truncata</i>	leaf impression	*
<i>Fraxinus bilinica</i>	carbonised leaves	***
<i>Fraxinus macroptera</i>	carbonised samaras	**
<i>Juglandaceae</i> gen. et sp.	complete fossilised endocarp	*
<i>Laurocarpum</i> sp.	carbonised fruit	*
<i>Leguminosites</i> sp.	leaves	**
cf. <i>Mahonia</i> sp.	carbonised leaves	**
<i>Nyssa haidingeri</i>	carbonised leaves	****
<i>Nyssa</i> cf. <i>haidingeri</i>	highly carbonised leaves	**
<i>Nyssa disseminata</i>	endocarp impressions/compressions	***
<i>Nyssa</i> sp.	carbonised inflorescences	***
<i>Paliurus tiliaefolius</i>	carbonised leaves	***
<i>Poaceae</i> vel <i>Cyperaceae</i>	carbonised leaves	***
<i>Quercus rhenana</i>	leaf imprint	*
cf. <i>Rhus</i> sp.	compound leaf, isolated leaflets	**
<i>Rosa</i> sp.	carbonised apocarpium	*
<i>Rubus merianii</i>	compound leaves and leaflet	**
<i>Rubus</i> sp. 1	carbonised leaflet	*
<i>Rubus</i> sp. 2	carbonised compound leaf	*
<i>Rubus</i> sp.	carbonized calyx	*
<i>Salix haidingeri</i>	leaf imprint	*
<i>Ulmus pyramidalis</i>	leaves and fruits	***
<i>Zelkova zelkovifolia</i>	carbonised leaf	*



## Characteristic of the vegetation

### History of the research

#### Most Basin

Contrary to a relatively important volume of works concerning the fossil flora, studies about the character of the vegetation of the Most Basin during deposition of the Tertiary sediments are not so numerous.

The pioneering work by Hurník (1961, 1973) must be pointed out. In the basin, Hurník (1961) delimits 4 areas (Břešťany, Most-Bílina, Krušné hory-Ervěnice and other parts of the basin) and 1 horizon (with aquatic plants) characterised subsequently by their floristic composition. Regarding the geological research, this author arrives at palaeogeographical and ecological conclusions. The same author (Hurník 1973) focuses later on only the Miocene "delta" in the Most area, where he distinguishes 4 plant associations: vegetation of shallow-water reservoirs with borders covered by vegetation, swamps of the *Taxodium-Glyptostrobus* type, broad-leaved forests in the proximity of the swamp and finally a certain equivalent of the riparian forest.

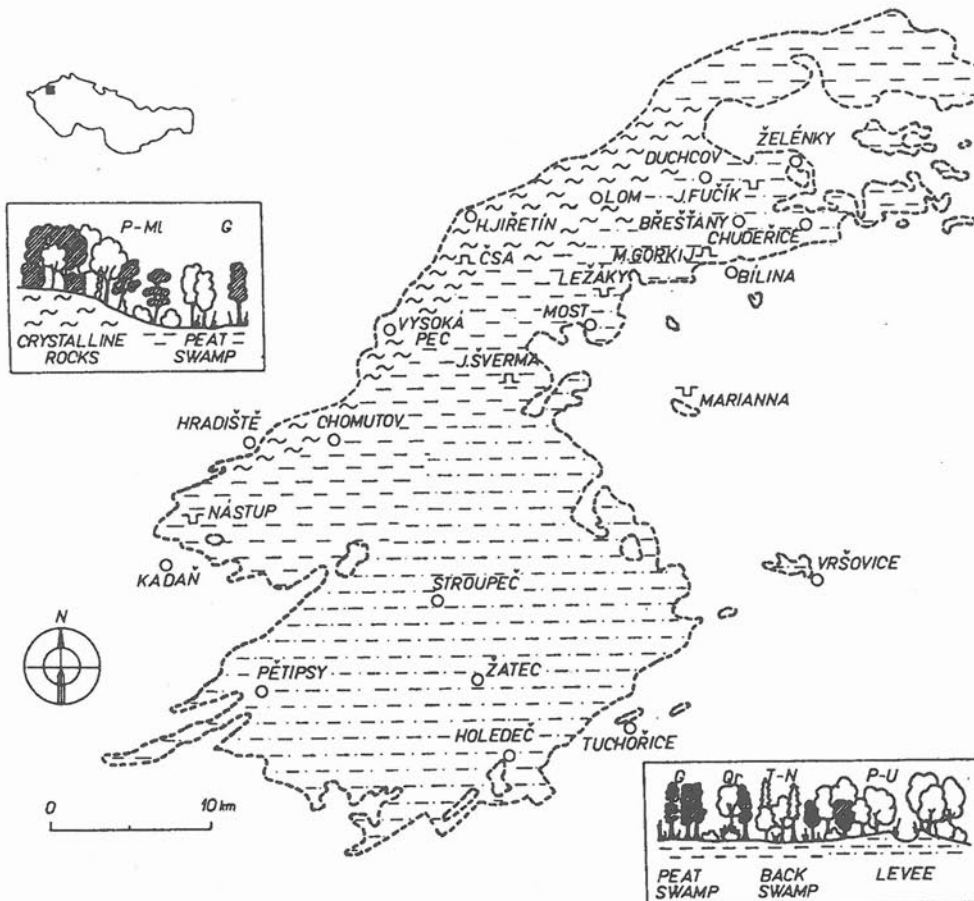
Focusing on the Most Basin, Kvaček and Bůžek (1983) define 15 principal plant associations typical of the given sedimentary environment (lithofacies), and derived habitats of the fossil plants. These plant associations are described subsequently more in detail by their characteristic and accompanying species.

This classification, using 'palaeoassociation', is taken up again by Boulter, Hubbard and Kvaček (1993). These authors apply "objective" multivariate statistical methods, namely cluster analysis and principal components analysis, to the "intuitively" defined assemblages, and they so obtained 17 groups (assemblages) instead of the 8 original.

Finally, the study by Kvaček (1998) offers a quite new and detailed vegetation overview of the whole basin focused on aquatic plant horizons n° 21 and 47 in the Bílina Mine.

#### Horizon n° 30

The character of the fossil vegetation, typical of the Horizon n° 30 within the "Clayey Superseam Horizon" is noticed by Bůžek et al. (1992). The plant assemblages are attributed there to the *Nyssa-Taxodium* association defined by Kvaček and Bůžek (1983). The occurrence of relatively flood tolerant



Text-fig. 9. The Most Basin with major types of forest vegetation in the Most Formation. The accompanying cartoons present schematic reconstructions of transects across the edges of the basin.

Legend: P-MI = *Pinus-Myrica lignitum* association; G = *Glyptostrobus* association; Qr = *Quercus rhenana* association; T-N = *Taxodium-Nyssa* association; P-U = *Parrotia-Ulmus pyradimalis* association. after Boulter, Hubbard and Kvaček (1993)

species with abundant leaf and fruit remains belonging to the genus *Nyssa* and to another, obviously swampy element *Dombeyopsis lobata* are also described.

Recently, the character of the vegetation, as well as the environment of sedimentation of the clay strata are noted by Kvaček and Konzalová (1996) in connection with new records of reproductive structures of the genus *Cercidiphyllum*, coming among others from the Horizon n° 30. They gave a list of some typical species and a characteristic of the whole assemblage as a manifestly swampy forest. They also characterised the place of formation of the fossiliferous layers as calm waters near the swamp forest on the basis of the co-occurrence of preserved leaves, flowers and fruit remains.

Kvaček and Sakala (1999) supply a short characteristic of the Horizon n° 30 in order to give some idea about the environment of *Decodon gibbosus*.

### General overview of the published results

The study made by Bůžek et al. (1993) reviews recent opinions about the Tertiary vegetation of the Most Basin:

Differences in the Tertiary vegetation of the Most Basin were evoked by local environment conditions (dampness of terrain, quality of substrate), as well as global changes of climate, causing migrations of higher amplitude.

The Upper Eocene flora of the Staré Sedlo type, proved so far in the Cheb and the Sokolov basins (Bůžek et al. 1982), in the Doupovské hory Mts. and in neighbourhood of Litoměřice, is not known from the Most Basin.

Two vegetation types (more thermophile and less thermophile) recognised in the Střezov Formation reflect a general cooling trend during the Oligocene.

Within the Miocene fill, the Most Formation, three phytostratigraphic levels corresponding to the development of the floras in the neighbouring part of Germany can be discerned (from the oldest to the youngest):

a) less thermophile riparian vegetation of the so-called "Hlavačov gravel-sands" with a high percentage of deciduous woody plants, beeches above all

b) very diversified vegetation of warm temperate zone of highly humid type with tendency to warming, which occupies the majority of the main seam strata and the lower part of its overlying beds (including the flora of the studied Horizon n° 30 and the world-famous flora of the Břešťany Clay)

c) subtropical assemblage starting just under the Lom Seam within "Lake Clayey Horizon", corresponding to the Early Miocene climatic optimum.

Within these three phytostratigraphical levels, Kvaček and Bůžek (1983) established several vegetation types (associations) depending on development of the environment of sedimentation (e.g., the *Glyptostrobus* association characteristic of peat-forming swamps, or the *Parrotia-Ulmus pyramidalis* association typical of the so-called levées along the water streams). These main types of vegetation of the Most Basin are presented in a short review - see p. 121-122 in Bůžek et al. (1992) as well as in a detailed description (Boulter, Hubbard and Kvaček 1993). Major types of forest vegetation in the Most Basin are presented in the text-fig. 9.

### Vegetation – conclusions

1) Neither trunks, nor tree stumps in life position were found in the locality studied (Z. Dvořák personal communication) as is common elsewhere in the other horizons of the locality Důl Bílina. The result is that the vegetation is not unequivocally autochthonous. On the other hand, as already maintained by Konzalová and Kvaček (1996), leaf and reproductive organs (inflorescences, sexual complexes, seeds, fruits, cones) belonging to a single plant are found together. All this points to the fact that the plants must have lived in the direct proximity of the place of deposition of the fossiliferous sediment. Regarding these two main facts, the vegetation (plant assemblage) can be called **paraautochthonous** sensu Behrensmeyer and Hook (1992), i.e. even though the plants were transported from the place of their growth (and shedding in the cases of isolated organs), they have always stayed within their original environment. So in this case the plants (plant fragments in form of fossils) safely indicate the climatic conditions in the place of their deposition.

2) Vegetation in place and time of the deposition of the Horizon n° 30 was **azonal** (sensu Hendrych 1984), unequivocally contingent on high level of groundwater as well as surface water if the vegetation cover was flooded. Because of the fact that the azonal vegetation is not very specific of climatic zone and has highly local character, any reconstruction of climatic conditions of wider range, based on this vegetation is imprecise and can be misleading. The ratio entire-margined/toothed leaves (45%) cannot give firm evidence about the character of climate.

3) Main part of the original vegetation has been formed, as already noticed (Bůžek et al. 1992, Kvaček and Konzalová 1996), by the ***Nyssa-Taxodium* association** (sensu Kvaček and Bůžek 1983), formed in the studied horizon essentially by the species: *Acer tricuspidatum*, *Alnus julianiformis*, *Quasisequoia couttsiae*, *Cercidiphyllum crenatum*, *Glyptostrobus europaeus*, *Rubus meriani* (and sp.) and above all by *Taxodium dubium* and *Nyssa haidingeri/disseminata*. The *Nyssa-Taxodium* association is typical of the area of the so-called "back swamp", situated on the periphery of the inner peat-forming swamp, rather toward the riparian habitats of clayey and sandy facies near the place where the river emptied into the basin (Kvaček and Bůžek 1983). Supposedly, the plant remains, together with the clastics, were deposited just beyond the back swamp area, before the river entered the inner peat-forming swamp (see Mach 1997). Besides this main association, the *Quercus rhenana*, *Decodon*-*Poaceae* vel *Cyperaceae* associations and the typically aquatic *Savinia reussii* association occur. The representatives of these associations are just added to the principal *Nyssa-Taxodium* association and complement so the azonal character of the vegetation, highly influenced by the water level. Rare occurrence of birch, willow, *Osmunda*, and problematic species cf. "*Ficus*" *truncata* can be seen as allochthonous elements, inhabiting originally upstream habitats along the rivers, and belonging to the *Parrotia-Ulmus pyramidalis* association (Kvaček and Bůžek 1983).

4) Regarding the ranking of wider range, the described vegetation is attributable into the **floristic complex Bílina-Brandis** of the Atlantic-Boreal Bioprovince (after Mai 1995). The laurophyllous element, contrary to the definition of this complex, is significantly impoverished in the studied locality.

On the other hand, the Arcto-Tertiary elements absolutely prevail. This fact can be linked again to the specific conditions of the locality when the more thermophile elements, which have grown in the same time, but in other place, just could not be present in the Horizon 30.

## General conclusions

A fossil flora has been described from the locality Důl Bílina (Mine Bílina), the Most Basin in the northern Bohemia (Czech Republic). It occurs in the roof of the main lignite seam, in the so-called Horizon n° 30, within the Most Formation, Early Miocene in age (Eggenburgian, mammal zone MN 3a). The flora includes 51 different taxa including about 45 species previously described in Tertiary, 3 taxa are described for the first time, 10 described newly for the area of the Most Basin and 8 taxa are recorded as problematic.

The state of preservation allowed an application of the cuticular analysis. The cuticular analysis permitted, besides a more safe attribution of leaf forms, often very variable (e.g. in the species *Fraxinus bilinica*), the distinction between sterile foliage of *Glyptostrobus europaeus* and *Quasisequoia coultisae*. Thanks to the cuticular analysis, the absence of the otherwise characteristic wax rings surrounding the stomatal guard cells in *Quercus rhenana*, as well as the absence of otherwise characteristic trichomes in the other representatives of the flora from the studied horizon could be noticed. This fact can be explained by a relatively high air humidity in the studied locality (e.g. higher than in the locality Wackersdorf from where these representatives have been described, see Knobloch and Kvaček 1976), minimizing adaptations to restrain undesirable evaporation from the leaf surface.

Regarding microscopic techniques, besides the cuticular analysis, analysis of the pollen in situ has been carried out. The pollen investigation has allowed to attribute unusual monoclinic flowers to the genus *Acer* and to distinguish problematic carbonized inflorescences, referred here as *Nyssa* sp.

The vegetation of the studied horizon is characterized as parautochthonous, azonal, typical of the area of the so-called "back swamp", attributable to the Atlantic-Boreal Bioprovince, namely to the floristic complex Bílina-Brandis (after Mai 1995). Its main part is formed of the *Nyssa-Taxodium* association (sensu Kvaček and Bůžek 1983). Besides this principal association, there are some others, such as *Quercus rhenana* association, *Decodon-Poaceae* vel *Cyperaceae* association and the typically aquatic *Salvinia reussii* association. As allochthonous, inhabiting originally the habitats upstream along the rivers emptying into the basin, some elements from the accompanying *Parrotia-Ulmus pyramidalis* association (sensu Kvaček and Bůžek 1983) must also be noticed. As the extant analogue of the described vegetation, the swamp forests (*Nyssa-Taxodium*-swamps) of the SE of USA can be considered. Some East Asiatic elements, e.g. *Craigia*, *Cercidiphyllum* and *Glyptostrobus* are associated to this principal assemblage.

Because of the azonal character of vegetation, not indication of climatic zones and of distinctly local character, no reconstruction of climatic conditions of wider (more regional) range has been attempted. The ratio of entire-margined to toothed leaves (45%) is only a rough indication and cannot give evidence about the character of the climate. In spite of

similarity in composition of the described assemblage with some other sites, the vegetation cannot be directly compared to the zonal vegetation of the localities at Čermníky (Mixed Mesophytic Forest; Bůžek 1971) and Wackersdorf (Mixed Mesophytic Forest to Subtropical Evergreen virgin forest; Knobloch and Kvaček 1976).

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Finally, I would like to thank all my family, especially my grandmother, for a peaceful and easy-going family background, thanks to which I could untroubled concentrate on the preparation of the present master's thesis.

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## Flóra a vegetace těsného nadloží hlavní uhelné sloje na dole Bílina (mostecká pánev, spodní miocén)

Jakub Sakala

Na lokalitě Důl Bílina v mostecké (severočeské hnědouhelné) pánvi byla popsána fosilní flóra v těsném nadloží hlavní uhelné sloje (mosteckého souvrství spodnomiocenního stáří, eggenburg, savčí zóna MN 3a). Bylo zjištěno 51 rozdílných taxonů zahrnujících asi 45 v terciéru skutečně existujících druhů. Z těchto 51 taxonů jsou 3 popsány zcela poprvé, 9 popsáno nově na území severočeské pánve a 6 taxonů lze označit za problematické.

Stav zachování dovozoval užití kutikulární analýzy. Kutikulární analýza umožnila, vedle spolehlivějšího přiřazení lis-



ových forem, často velmi variabilních (např. u druhu *Fraxinus bilinica*), odlišení sterilních větviček druhu *Glyptostrobus europaeus* od druhu *Quasisequoia couttsiae*, jejichž vzájemné odlišení na základě morfologie není možné. Dále byla díky kutikulární analýze zjištěna nepřítomnost jinak charakteristického voskového prstence obklopujícího svěrací buňky průduchu u druhu *Quercus rhenana*, jakož i absence jinak charakteristických trichomů u ostatních zástupců flóry popisovaného horizontu. Tento fakt je možné vysvětlit relativně vysokou vzdušnou vlhkostí na mnou zkoumané lokalitě (vyšší než např. na lokalitě Wackersdorf, odkud jsou tito zástupci popsáni), a tudíž potlačením adaptací sloužících k zabraňování nežádoucího odparu z povrchu listů.

Z mikroskopických technik bylo vedle kutikulární analýzy použito analýzy pylu in situ. Zkoumaní pylu umožnilo přiřazení neobvyklých nálezů oboupohlavných květů k rodu *Acer* a jasné vydělení problematických zuhelnatělých květenství, zde označených jako *Nyssa* sp.

Vegetace zkoumaného horizontu je charakterizována jako parautochtonní, azonální, typická pro oblast tzv. zadního močálu (back swamp), přiřaditelná k atlantsko-boreální bioprovincii do floristického komplexu Bílina-Brandis (ve smyslu Maie 1995). Její základ tvoří asociace *Nyssa-Taxodium*. Vedle této základní asociace se přidávají asociace *Quercus rhenana*, *Decodon-Poaceae* vel *Cyperaceae* a typicky vodní asociace *Salvinia reussii*. Coby alochtonní, obývající původně bitopy výše proti proudu přínosu podél vodních toků, přistupují k těmto asociacím některé prvky z asociace *Parrotia-Ulmus pyramidalis*. Za dnešní dobu popisované vegetace mohou být považovány mokřadní porosty (*Nyssa-Taxodium* swamps) z oblasti jv. USA. K tomuto základnímu společenstvu na lokalitě přistupují některé východoasijské prvky, jako např. *Craigaia*, *Cercidiphyllum* a *Glyptostrobus*.

Jelikož se jedná o azonální vegetaci, která není vlastní žádnému určitému klimatickému pásu a má silně lokální charakter, je jakákoliv rekonstrukce klimatických podmínek panujících v širším okolí, stanovená na základě této vegetace nepřesná a může být zavádějící. Poměr celokrajných listů k listům zubatým (45%) je tak pouze orientační a rozhodně nemůže vypovídat o charakteru klimatu. Přes jistou shodu ve společenstvu popisovaných druhů tak nemůže být dost dobře srovnávána se zonální vegetací na lokalitách Čermníky (smíšený mesofytní les) a Wackersdorf (smíšený mesofytní les až subtropický vždyzelený prales).

## References

- Ahrendt, L. W. A. (1961): *Berberis* and *Mahonia*. A taxonomic revision. - Bull. Linn. Soc. Lond., 57: 369.
- Andreánszky, C. (1959): Die Flora der Sarmatischen Stufe in Ungarn. - 360 pp. Akadémiai Kiadó, Budapest.
- Arnold, Ch. A. (1936): Some Fossil species of *Mahonia* from the Tertiary of eastern and southeastern Oregon. - Contr. Mus. Paleont. Univ. Michigan, 5(4): 57-66.
- Barthel, M. (1976): Farne und Cycadeen In: Eozäne Floren des Geiseltales. - Abh. zentr. geol. Inst., 26: 440-496.
- Behrensmeyer, A. K., Hook, R. W. (1992): Paleoenvironmental context and taphonomic modes in the terrestrial fossil record. - In: Behrensmeyer, A. K., Damuth, J. D., DiMichele, W. A., Potts, R., Sues, H.-D. and Wing, S. L. (eds.): Terrestrial Ecosystems Through Time. - Univ. Chicago Press, IL, Ch. 2, Chicago.
- Bonnet, A.L.M. (1955): Contribution à l'étude des Hydropteridées: Recherches sur *Salvinia auriculata* Aubl. - Ann. Sci. Nat., Bot.-biol. végét., sér. XI, 16: 529-600.
- Boulter, M. C., Hubbard, R. N. L. B., Kvaček, Z. (1993): A comparison of intuitive and objective interpretations of Miocene plants assemblage from north Bohemia. - Palaeogeogr. Palaeoclim. Palaeoecol., 101: 81-96.
- Brabenec, B. (1904): O novém nalezišti třetihorních rostlin ve spodním pásmu vrstev žateckých. - Rozpr. Čes. Akad. Věd Umění, Tř. II, 13: 1-25.
- Brabenec, B. (1909): Souborná květena českého útvaru třetihorního. - Arch. přírodověd. Prozk. Čech 19(3): 7-144.
- Braun, A. (1845): Die Tertiär-Flora von Öhningen. - Neues Jb. Mineral. Geol. Pal., 164-173.
- Braun, A. (1852): Über fossile *Goniopteris*-Arten. - Z. deutsch. geol. Ges., 4: 545-564.
- Brongniart, A. (1828): Notice sur les plantes d'Armissan près Narbonne. - Ann. sci. nat., sér. I, 15: 43-51.
- Brongniart, A. (1833): Notice sur une Conifère fossile du terrain d'eau douce de l'île d'Iliodroma. - Ann. sci. nat., sér. I, 30: 168-175.
- Bronn, H. G. (1838): Lethaea geognostica, II. - pp. 545-1346, E. Scheitzerbarts's Verlagshandlung, Stuttgart.
- Brown, R. W. (1935): Miocene leaves, fruits and seeds of *Cercidiphyllum*. - J. Paleont., 9: 572-587.
- Buckland W. (1836): Geology and mineralogy considered with reference to natural theology, I. - 599 pp. William Pickering, London.
- Bůžek, Č. (1960): Zpráva o orientačním o paleobotanickém výzkumu pětipeské oblasti Chomutovsko-mostecko-teplické pánve. - Zpr. geol. výzk. v r. 1958: 11-13.
- Bůžek, Č. (1961): Zpráva o výzkumu flóry mostecké a teplické části Severočeské hnědouhelné pánve. - Zpr. geol. výzk. v r. 1959: 81-83.
- Bůžek, Č. (1971): Tertiary flora of the northern part of Pětipsy area (North-Bohemian Basin). - Rozpr. Ústř. Úst. geol., 36: 1-118.
- Bůžek, Č., Dvořák, Z., Kvaček, Z., Prokůš, M. (1992): Tertiary vegetation and depositional environments of the "Bílina delta" in the North-Bohemian brown-coal basin. - Čas. Mineral. Geol., 37: 117-134.
- Bůžek, Č., Holý, F. (1964): Small-sized Plants Remains from Coal Formation of the Chomutov-Most-Teplice Basin. - Sbor. geol. Věd, Ř. P, 4: 105-138.
- Bůžek, Č., Holý, F., Konzalová, M., Kvaček, Z., Stuchlík, L. (1982): Paleobotanická data k biostratigrafii a korelaci uloženin chebské pánve. - Acta montana, 60: 49-82.
- Bůžek, Č., Holý, F., Kvaček, Z. (1967): Eine bemerkenswerte Art der Familie Platanaceae Lindl. (1836) im nordböhmisches Tertiär. - Monatsber. Dtsch. Akad. Wiss., 9(3): 203-215.
- Bůžek, Č., Konzalová, M., Kvaček, Z. (1971): The genus *Salvinia* from the North-Bohemian Tertiary. - Sbor. geol. Věd, Ř. P, 13: 179-222.
- Bůžek, Č., Kvaček, Z., Dvořák, Z., Prokůš, M. (1993): Terciární vegetace severočeské hnědouhelné pánve v pohledu nových dokladů. - Zpravodaj SHD, II/93: 38-51.
- Bůžek, Č., Kvaček, Z., Manchester, S. R. (1989): Sapindaceous affinities of the *Pteleaearpum* fruits from the tertiary of Eurasia and North America. - Bot. Gaz., 150(4): 477-489.
- Chandler, M. E. J. (1964): The Lower Tertiary floras of Southern England IV: A Summary and Survey of Findings in the Light of recent botanical Observations. -151 pp. Brit. Mus. (Nat. Hist.), London.
- Czeczott, H. (1934): Co to jest *Fagus Feroniae* Unger. (Doniesenie tymczasowe). - Acta Soc. bot. Pol. Suppl., II: 109-116.
- Čtyroký, P., Elznic, A. (1977): Nový nález měkkýšů v podložním hnědouhelném souvrstí (spodní miocén) na Chomutovsku. - Čas. Mineral. Geol., 22(2): 193-198.
- Dilcher, D. L. (1974): Approaches to the identification of angiosperm leaf remains. - Bot. Rev., 40(1): 1-158.
- Dostál, J. (1989): Nová květena ČSSR I. - 758 pp. Academia, Praha.
- Elznic, A. (1970): Mostecká část neogénní severočeské hnědouhelné pánve. - MS přírodověd. fak. Karl. univ. Praha.
- Endress, P. K. (1986): Floral structure, systematics, and phylogeny in Trochodendrales. - Ann. Missouri Bot. Gard., 73: 297-324.
- Engelhardt, H. (1881): Ueber Pflanzenreste aus den Tertiärlagerungen von Liebotitz und Putschirn. - Sitz. - Ber. Isis Dresden, 77-86.
- Engelhardt, H. (1889): Die Tertiärflora von Berand im Böhmisches Mittelgebirge. - Abh. Nat. med. Ver. Lotos, I: 75-123.
- Engelhardt, H. (1891): Über die Flora der über den Braunkohlen befindlichen Tertiärschichten von Dux. - N. Acta Leopold. Carol. Acad., 57: 129-219.
- Ettingshausen, C. v. (1866): Die fossile Flora des Tertiärbeckens von Bilin. I. - Denkschr. K. Akad. Wiss. Wien, math.-naturwiss. Cl., 26: 1-98 (separatum).

- Ettingshausen, C. v. (1868): Die fossile Flora des Tertiärbeckens von Bilin. II. - Denkschr. K. Akad. Wiss. Wien, math.-naturwiss. Cl., 28: 191-242.
- Ettingshausen, C. v. (1869): Die fossile Flora des Tertiärbeckens von Bilin. III. - Denkschr. K. Akad. Wiss. Wien, math.-naturwiss. Cl., 29: 1-110.
- Fejfar, O. (1974): Die Eomyiden und Cricetiden (Rodentia, Mammalia) des Miozäns der Tschechoslowakei. - Palaeontographica, Abt. A, 146: 100-180.
- Fejfar, O., Kvaček, Z. (1993): Excursion Nr. 3: Tertiary basins in North-west Bohemia. - Průvodce exkurze, Paläontologische Gesellschaft, 63. Jahrestagung in Prag. Univerzita Karlova: 1-35, Praha.
- Gaudin, Ch. Th., Strozzi, C. (1859): Contribution à la flore fossile italienne. II. Val d'Arno. - Neue Denkschr. Allg. schweiz. Gesell. Naturwiss., 17: 1-59.
- Gardner, I. S. (1883-86): A monograph of the British Eocene flora. II: Gymnospermae. - Paleont. Soc., 37-39, 159 pp, London.
- Geinitz, H. B. (1879): Über zwei neue Kreidepflanzen: *Cycadosperrum schmidtianum* von Klitschdorf in Schleisen. - N. Jahrb. Mineral. Geol., 1879: 113.
- Geissert, F., Menillet, F., Farjanel, G. (1979): Neue Fossilfunde im Pliozän der Hagener Terrasse. - Mitt. Badischen Landesver. Naturkunde Naturschutz, N. F., 12: 17-27.
- Givulescu, R., Ghiurca, V. (1969): Die Pliozäne Flora von Chiuzbaia (Maramures). - Mem. Inst. Geol., 10: 1-81.
- Gleason, H. A. (1963): Illustrated Flora of the Northeastern United States and Adjacent Canada. - 655 pp. Hafner publishing company, New York, London.
- Goepfert, H. R. (1836): Die fossilen Farnkräuter. - Verh. K. Leop. Carol. Akad. Naturforscher, Suppl., 17: 1-486.
- Goepfert, H. R. (1855): Die tertiäre Flora von Schosnitz in Schlesien. - 52 pp. Heynsche Buchhandlung (E. Remer.), Görlitz, Königsberg.
- Hantke R. (1954): Die fossile Flora der obermiozänen Oehninger Fundstelle Schrotzburg (Schienenberg, Süd-Baden). - Denkschr. Schweiz. naturf. Ges., 80(2): 27-118.
- Havlena, V. (1964): Geologie uhelných ložisek. 2.- 440 pp. Nakl. ČSAV, Praha.
- Havlena, V. (1983): Platformní jednotky. - In: Misař, Z. et al. (1983): Geologie ČSSR I (Český masiv): 290-305, SPN, Praha.
- Heel, W. A. van (1987): Note on the morphology of the male inflorescences in *Cercidiphyllum* (Cercidiphyllaceae). - Blumea, 32: 303-309.
- Heer, O. (1853): Übersicht der Tertiärflora der Schweiz. - Mitt. Naturf. Ges., 3(7): 88-153.
- Heer, O. (1856): Die tertiäre Flora der Schweiz. 2. - 110 pp. J. Wurster, Winterthur.
- Heer, O. (1859): Die tertiäre Flora der Schweiz. 3. - 200 pp. J. Wurster, Winterthur.
- Heer, O. (1862): On the Fossil Flora of Bovey Tracey. - Philos. Trans. royal Soc. London, 152: 1039-1086.
- Heer, O. (1872): Über die Braunkohlenflora des Zsily-Thales in Siebernburg. - Jb. K. ung. Geol. Anst. 2 (1): 1-25.
- Hendrych, R. (1984): Fytogeografie. - 224 pp. SPN, Praha.
- Hickey, L. J. (1973): Classification of the architecture of dicotyledonous leaves. - Amer. J. Bot., 60(1): 17-33.
- Holub, J. (1999): Využití ostružiníků při sledování změn květeny. - Živa, 47(85): 252-253.
- Holý, F. (1962): Zpráva o paleontologickém a stratigrafickém výzkumu terciéru Chomutovsko-mostecko-teplické pánve. - Zpr. geol. výzk. v r. 1961: 140-143.
- Hurník, S. (1961): Paleofloristické oblasti nadložní série v severočeském terciéru a jejich vztah k lithofaciálnímu vývoji. - Čas. Mineral. Geol., 6(4): 419-428.
- Hurník, S. (1963): Zpráva o paleobotanickém výzkumu centrální části severočeské hnědouhelné pánve. - Zpr. geol. výzk. v r. 1962: 170-171.
- Hurník, S. (1973): Vegetation cover of the onshore part of the Miocene delta near Most in the North Bohemian brown-coal basin. - Čas. Mineral. Geol., 18(1): 57-62.
- Hurník, S. (1978): Die fossile Arten der Gattung *Woodwardia* Smith 1973 und ihre Vertretung im nordböhmischem Tertiär. - Sbor. Nár. Muz. B, přír. vědy, 32: 15-46.
- Jähnichen, H. (1966): Morphologisch-anatomische Studien über strukturbietende, ganzrandige Eichenblätter des Subgenus *Euquercus-Quercus lusatica* n. sp. - im Tertiär Mitteleuropas. - Monatsber. Dtsch. Akad. Wiss. Berlin, 8(6/7): 477-512.
- Jähnichen, H., Mai, D. H., Walther, H. (1977): Blätter und Früchte von *Engelhardia* Lesch. ex Bl. (Juglandaceae) aus dem europäischen Tertiär. - Fedd. Rep., 88(5/6): 323-363.
- Jähnichen, H., Mai, D. H., Walther, H. (1980): Blätter und Früchte von *Cercidiphyllum* Siebold & Zuccarini im mitteleuropäischen Tertiär. - Schriftenr. geol. Wiss., 16: 357-399.
- Jones, J. H., Dilcher, D. L. (1980): Investigations of angiosperms from the Eocene of North America: *Rhamnus marginatus* (Rhamnaceae) reexamined. - Amer. J. Bot., 67(6): 959-967.
- Kirchheimer, F. (1937): Paläobotanische Beiträge zur Kenntnis des Alters deutscher Braunkohlenschichten, II, Die braunkohlenführenden tone von Siegburg und Kamentz. - Braunkohle, 36: 893-931.
- Kirchheimer, F. (1957): Die Laubgewäse der Braunkohlenzeit. - 783 pp. Web Wilhelm Knapp Verlag, Halle.
- Knobloch, E. (1971): Nomenklatorisch-taxonomische Bemerkungen zu *Platanus aceroides* Goepfert und *Quercus attenuata* Goepfert. - Mitt. Bayer. Staatssamml. Paläont. hist. geol., 11: 263-265.
- Knobloch, E., Kvaček, Z. (1976): Miozäne Blätterflore vom Westrand der Böhmischem Masse. - Rozpr. Ústř. Úst. geol., 42: 1-129.
- Kolakovskij, A. A. (1964): Pliocenovája flora Kodora. - 209 pp. Suchum. botan. sad, monografii, 1, Suchumi.
- Konzalová, M. (1976): Micropaleobotanical (palynological) research of the Lower Miocene of northern Bohemia. - Rozpr. ČSAV, Ř. matem. přír. Věd, 86, 12: 1-75.
- Kopecký, L. (1976): Magmatismus ohareckého riftu, jeho vztah k hlubinné zlomové tektonice a geologickému vývoji a jeho rudní mineralizace. - In: Maheř, ed.: Československá geologie a globální tektonika. - MS Geol. úst. D. Štúra, Bratislava.
- Kotlaba, F. (1963): Tertiary plants from three new localities in Southern Slovakia. - Acta Mus. Nat. 19 B(2): 53-72.
- Kräusel, R. (1920): Nachträge zur Tertiärflora Schlesiens. I. Über einige Originale Göppert's und neuere Funde. - Jb. Preuß. Landesanst. f. d. J. 1919, 39: 329-417.
- Kräusel, R. (1921): Nachträge zur Tertiärflora Schlesiens. III. Über einige Originale Göppert's und neuere Funde. - Jb. Preuß. Landesanst. f. d. J. 1919, 40(3): 363-433.
- Kräusel, R., Weyland, H. (1950): Kritische Untersuchungen zur Kutikularanalyse tertiärer Blätter. I. - Palaeontographica, B, 91: 7-92.
- Krüssmann, G. (1960): Handbuch der Laubgehölze. Band I. - 495 pp. Paul Parey, Berlin, Hamburg.
- Kunzmann, L. (1999): Koniferen der Oberkreide und ihre Relikte im Tertiär Europas. - Abh. Staatl. Mus. Mineral. Geol. Dresden 45: 1-191.
- Kvaček, Z. (1960): Terciární rostlinné zbytky z dolu Julius Fučík (býv. Konkordia) Želénky u Duchcova. - MS geol.-geogr. fak. Karlovy univ. Praha.
- Kvaček, Z. (1965): Nomenklatorické poznámky k pojmenování terciárního javoru *Acer trilobatum* Al. Br. - Čas. Nár. muz., přír., 134: 137-141.
- Kvaček, Z. (1966): Vývoj květeny hnědouhelných močálů v českých zemích během mladších třetihor. Text and tabule. - MS Geol. úst. Čs. akad. věd, Praha.
- Kvaček, Z. (1971): Fossil Lauraceae in the stratigraphy of the North-Bohemian Basin. - Sb. Geol. Věd. Paleont., 13: 47-86.
- Kvaček, Z. (1985): Kutikulární analýza neogenních dřevin Střední Evropy. - MS Úst. geol. geotech. Čs. akad. věd, Praha.
- Kvaček, Z. (1993): The fossil history of *Craigia* (Tiliaceae) - a review. - Abstrakte, Paläontologische Gesellschaft, 63. Jahrestagung in Prag. Univerzita Karlova: p. 47, Praha.
- Kvaček, Z. (1995): *Limnobiophyllum* Krassilov - a fossil link between the Araceae and the Lemnaceae. - Aquatic botany, 50: 49-61.
- Kvaček, Z. (1998): Bilina: a window on Early Miocene marshland environments. - Rev. Palaeobot. Palynol., 101: 111-123.
- Kvaček, Z., Bůžek, Č. (1972): Nyssa-leaves from the Tertiary of Central Europe. - Čas. Mineral. Geol., 17(4): 373-382.
- Kvaček, Z., Bůžek, Č. (1983): Třetihorní společenstva severočeské hnědouhelné pánve ve vztahu k lithofaciálnímu vývoji. - MS Úst. geol. geotech. Čs. akad. věd, Praha.
- Kvaček, Z., Bůžek, Č. (1994): A new Early Miocene *Mahonia* Nutt. (Berberidaceae) of Europe. - Věst. Čs. geol. úst., 69(3): 59-62.
- Kvaček, Z., Bůžek, Č., Manchester, S. R. (1991): Fossil fruits of *Pteleacearpum* Weyland-Tiliaceous, not Sapindaceous. - Bot. Gaz., 152(4): 522-523.
- Kvaček, Z., Holý, F. (1974): *Alnus julianaeformis* (Sternberg 1823) comb. n., a noteworthy Neogene alder. - Čas. Mineral. Geol. 19(4): 367-372.

- Kvaček, Z., Hurník, S. (2000): Revision of Early Miocene plants preserved in bakced rocks in the North Bohemian Tertiary. - *Acta Mus. Nat. Pragae, Ser. B, Hist. Nat.* 56 (1-2): 1-48.
- Kvaček, Z., Konzalová, M. (1996): Emended characteristics of *Cercidiphyllum crenatum* (Unger) R. W. Brown based on reproductive structures and pollen in situ. - *Palaeontographica*, B, 239: 147-155.
- Kvaček, Z., Sakala, J. (1999): Twig with attached leaves, fruits and seeds of *Decodon* (Lythraceae) from the Lower Miocene of northern Bohemia, and implications for the identification of detached leaves and seeds. - *Rev. Palaeobot. Palynol.*, 107: 201-222.
- Kvaček, Z., Walther, H. (1995): The Oligocene volcanic flora of Suleitice-Berand near Ústí nad Labem, North Bohemia - a review. - *Acta Mus. Nat. Pragae, Ser. B, Hist. Nat.*, 1994: 25-54.
- Ludwig, R. (1857): Fossile Pflanzen aus der jüngeren Wetterauer Braunkohle. - *Paläontogr.*, 5: 81-110.
- Luft, S. (1956a): Příspěvek k poznání rodu *Woodwardia* a jiných kapradin v severočeském terciéru. - MS geol.-geogr. fak. Karlovy univ. Praha.
- Luft, S. (1956b): Zpráva o paleobotanickém výzkumu chomutovskomostecko-teplické hnědouhelné pánve. - *Zpr. geol. výzk. v r. 1955*: 106-107.
- Luft-Hurník, S. (1957): Zpráva o paleobotanickém výzkumu v severočeském terciéru. - *Zpr. geol. výzk. v r. 1956*: 105-107.
- Mädler, K. (1939): Die pliozäne Flora von Frankfurt am Main. - *Abh. Senckenberg. Naturforsch. Ges.*, 446: 1-202.
- Mach, K. (1997): A logging correlation scheme for the Main coal seam of the North Bohemian brown coal basin, and the implications for the palaeogeographical development of the basin. - In: Gayler, R., Pešek, J. (eds.) (1997): *European Coal Geology and Technology*. - *Geol. Soc. Spec. Pub.*, 25: 309-320.
- Mai, D. H. (1989): Fossile Funde von *Castanopsis* (D. Don) Spach (*Fagaceae*) und ihre Bedeutung für die europäischen Lorbeerwälder. - *Flora* 182: 269-286.
- Mai, D. H. (1995): Tertiäre Vegetationsgeschichte Europas. - 691 pp. Gustav Fischer Verlag, Jena.
- Mai, D. H., Walther, H. (1978): Die Floren der Haselbacher Serie im Weißelster-Becken (Bzirk Leipzig, DDR). - *Abh. Staatl. Mus. Min. Geol. Dresden*, 28: 1-200.
- Malkovský, M. (1980): Model of the origin of the Tertiary basins at the foot of Krušné hory Mts.: volcanotectonic subsidence. - *Věst. Ústř. Úst. geol.*, 55(3): 141-150.
- Malkovský, M. et al. (1987): Geologie severočeské hnědouhelné pánve a jejího okolí. - 424 pp. Ústř. Úst. geol., Praha.
- Meyer, H. W., Manchester, S. R. (1997): The Oligocene Bridge Creek Flora of the John Day Formation, Oregon. - *Univ. California Publ. Geol. Sci.* 141: 1-195.
- Němejc, F. (1963): *Paleobotanika II.* - 523 pp. Nakl. ČSAV, Praha.
- Novák, F. A. (1972): *Vyšší rostliny 1, 2.* - 988 pp. Academia, Praha.
- Numata, M. (ed.) (1974): *The flora and vegetation of Japan.* - Elsevier. Sci. Publ. Co., Amsterdam.
- Procházka, M. (1951): Zpráva o paleobotanických pracích v terciéru Č. středohoří. - *Věst. Ústř. úst. geol.*, 26(1-3): 95-101.
- Procházka, M. (1952): Javory severočeských třetihor. Text a tabule. - MS přír. fak. Karl. univ. Praha.
- Procházka, M. (1954): Paleontologický výzkum chomutovské a pětipeské pánve. - *Zpr. geol. výzk. v r. 1953*: 166-174.
- Procházka, M. (1955): Fytopaleontologický výzkum chomutovské a pětipeské pánve. - *Zpr. geol. výzk. v r. 1954*: 144-147.
- Procházka, M. (1956): Paleontologický výzkum chomutovské a pětipeské pánve. - *Zpr. geol. výzk. v r. 1955*: 179-184.
- Procházka, M., Bůžek, Č. (1975): Maple leaves from Tertiary of North Bohemia. - *Rozpr. Ústř. Úst. geol.*, 41: 1-86.
- Prokop, J. (1997): Fossilní hmyz z lokality Bilina (miocén) v severních Čechách. - 61 pp. MS Thesis, Charles Univ. Praha.
- Prokop, J., Bílý, S. (1999): *Dicerca bilinica* sp. n., a new species of Buprestid-beetle (Coleoptera: Buprestidae) from Lower Miocene of the Most formation in northern part of the Czech Republic. - *Acta Soc. Zool. Bohem.* 63: 311-314.
- Prokop, J., Nel, A. (1999): Tertiary termite from the Bilina mine in northern Bohemia (Isoptera: Hodotermitidae). - *Klapalekiana* 35: 141-144.
- Prokop, J., Nel, A. (in press): The first record of *Lethocerus hemelytra* from the Lower Miocene of the Most Formation in northern Bohemia, Czech Republic (Heteroptera: Nepomorpha: Belostomatidae). - *Bull. Soc. Entomol. Fr.*
- Raniecka-Bobrowska, J. (1954): Trzeciorzędowa flora liściova z Konina. - *Biul. Inst. Geol.*, 71: 5-40.
- Reid, E. M., Chandler, M. E. J. (1926): *Catalogue of Cainozoic plants in the department of geology. I. The Bembridge flora.* - 206 pp. Oxford Univ. Press, London.
- Sakala, J. (1997): *Flóra a vegetace těsného nadloží hlavní uhelné sloje na dole Bilina (mostecká pánev, spodní miocén).* - 78 pp. MS Thesis, Charles Univ. Praha.
- Saporta, G. de (1891-92): *Recherches sur la végétation du niveau aquitanien de Manosque.* - *Mém. Soc. géol. France, Paléont.*, 9: 1-83.
- Schorn, H. E. (1966): Revision of the fossil species of *Mahonia* from North America. - 150 pp. University of California master's thesis, Berkeley.
- Slavíková, Z. (1990): *Morfologie rostlin.* - 238 pp. SPN, Praha.
- Stearn, W. T. (1998): *Botanical Latin.* - 546 pp. Timber Press, Portland.
- Sternberg, K. v. (1820-1838): *Versuch einer geognostisch-botanischen Darstellung der Flora der Vorwelt.* - 1 (1820), 2 (1821), 3 (1823), 4 (1825), 5-6 (1833), 7-8 (1838), Regensburg, Praha.
- Svešnikova, I. N. (1963): *Opredelitel' sovremennykh i iskopaemykh predstavitelej Sciadopityaceae i Taxodiaceae po epiderme list'ev.* - *Paleobotanika*, 4: 205-229.
- Tachtadžan, A. (1987): *Systema magnoliofytov.* - 439 pp. Nauka, Leningrad.
- Unger, F. (1843): *Chloris protogaea. Beiträge zur Flora der Vorwelt.* - 4-5, 45-92, Taf. XVI-XXV, Leipzig.
- Unger, F. (1845): *Chloris protogaea. Beiträge zur Flora der Vorwelt.* - 6-7, XXV-CX, Enumeratio syst., Taf. XXVI-XXXV, Leipzig.
- Unger, F. (1847): *Chloris protogaea. Beiträge zur Flora der Vorwelt.* - 8-10, 93-149, Inhalt, Taf. XXXVI-L, Leipzig.
- Unger, F. (1849): *Blätterabdrücke aus dem Schwefelflöze von Swoszowice im Galicien.* - *Haiding. naturw. Abh.*, 3(1): 121-128 (separatum).
- Unger, F. (1850a): *Genera et species plantarum fossilium.* - 628 pp. W. Braumüller, Wien.
- Unger, F. (1850b): *Die Gattung Glyptostrobus in der Tertiär-Formation.* - *Sitz.-Ber. Akad. Wiss., mat.-naturw. Kl.*, 5: 434-435.
- Unger, F. (1860): *Sylloge plantarum fossilium, I.* - *Denkschr. K. Akad. Wiss. Wien, math.-naturwiss. Cl.*, 19: 1-48 (separatum).
- Unger, F. (1866): *Sylloge plantarum fossilium, III.* - *Denkschr. K. Akad. Wiss. Wien, math.-naturwiss. Cl.*, 25: 1-76.
- Velenovský, J. (1881): *Die Flora aus den ausgebrannten tertiären Letten von Vršovic bei Laun.* - *Abh. Böhm. Ges. Wiss.*, 6, 11: 3-56.
- Walther, H. (1968): *Zur Nomenklatur von Acer "trilobatum".* (Vorläufige Mitteilung). - *Jb. Mus. Mineral. Geol.* 19: 530-538.
- Walther, H. (1972): *Studie über tertiäre Acer Mitteleuropas.* - *Abh. Staatl. Mus. Mineral. Geol.* 19: 1-309.
- Wang, C.-W. (1961): *The forests of China.* - 313 pp. Publ. Maria Moors Cabot Found. Harvard University, Cambridge, Mass.
- Weyland, H. (1934): *Beiträge zur Kenntnis der rheinischen Tertiärfloren. I. Floren aus den Kieseloolith- und Braunkohlenschichten der niederrheinischen Bucht.* - *Abh. Preuß. Landesant.*, 161/II: 3-122.
- Weyland, H. (1948): *Beiträge zur Kenntnis der Rheinischen Tertiärfloren. VII. Fünfte Ergänzungen und Berichtigungen usw.* - *Palaeontographica*, B, 88: 113-188.

## Explanations of the plates

### PLATE I

#### *Woodwardia muensteriana* (C. PRESL in STERNBERG) KRÄUSEL

1. incomplete simple pinna; MG(30)300, x 1.4.
2. detail of venation; MG(30)300, x 2.7.

#### *Blechnum dentatum* (GOEPPERT) HEER

3. carbonized pinna; MG(30)264, x 1.5.

#### *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY

4. incomplete pinnate pinna; MG(30)272, x 0.7.

#### cf. *Asplenium* sp.

5. frond; MG(30)403, x 3.3.



*Salvinia reussii* ETTINGSHAUSEN  
6. leaf pair; MG(30)301, x 3.  
bar in all figures (1-6) indicates 10 mm.

#### PLATE 2

*Salvinia reussii* ETTINGSHAUSEN  
1. 3 + 3 floats; MG(30)303.. x 3.  
*Taxodium dubium* (STERNBERG) HEER  
2. brachyblast; MG(30)312, x 1.3.  
3. male cone; MG(30)239, x 1.9.  
4. twig with scale-like leaves in the upper part (their position shown by the arrow); MG(30)240, x 1.2.  
5. abaxial cuticle with amphicyclic stomata; cuticle taken from the previous specimen (MG(30)240); MG(30)240/1, x 200.  
*Quasisequoia couttsiae* (HEER) KUNZMANN  
6. immature seed cones; MG(30)406, x 3.  
7. seed; MG(30)364, x 2.8.  
*Glyptostrobus europaeus* (BRONGNIART) UNGER  
8. seed; MG(30)358, x 3.  
bar in the figures 1-4, 6 indicates 10 mm.

#### PLATE 3

*Glyptostrobus europaeus* (BRONGNIART) UNGER  
1. seed cone; MG(30)368, x 3.4.  
2. adaxial cuticle with a band of amphicyclic stomata; taken from the specimen MG(30)229; MG(30)229/2, x 200.  
*Quasisequoia couttsiae* (HEER) KUNZMANN  
3. seed cone; MG(30)281, x 1.3.  
4. amphicyclic stoma on abaxial side, taken from the specimen MG(30)230; MG(30)230/1, x 500.  
*Laurocarpum* sp.  
5. fruit; MG(30)290, x 3.2.  
cf. *Mahonia* sp.  
6. leaf; MG(30)298, x 3.1.  
bar in the figures 1, 3, 5, 6 indicates 10 mm.

#### PLATE 4

*Cercidiphyllum crenatum* (UNGER) R. BROWN  
1. leaf; MG(30)349, x 1.2.  
2. detail of the leaf venation near the margin formed by chlorantoid teeth; MG(30)351, x 3.  
3. male inflorescence; MG(30)420, x 3.  
4. infructescence of follicles; MG(30)292, x 2.8.  
5. seed; MG(30)296, x 2.9.  
*Quercus rhenana* (KRÄUSEL et WEYLAND) KNOBLOCH et Z. KVAČEK  
6. leaf; MG(30)244, x 0.7.  
7. abaxial cuticle with widely cyclocytic stomata without wax rings (position of one stoma shown by the arrow); cuticle taken from the previous leaf (MG(30)244), phase contrast; MG(30)244/1, x 500.  
*Castanopsis* cf. *schmidtiana* (GEINITZ) KRÄUSEL

8. nut impression; MG(30)335, x 3.  
bar in all figures (1-7) indicates 10 mm.

#### PLATE 5

*Betula* sp.  
1. leaf; MG(30)430, x 1.8.  
*Betula* sp.  
2. supporting fruit bract; MG(30)293, x 2.9.  
*Alnus julianiformis* (STERNBERG) Z. KVAČEK et HOLÝ  
3. leaf; MG(30)429, x 2.2.  
4. male catkin; MG(30)262, x 2.2.  
5. abaxial cuticle with anomocytic stomata, cuticle taken from the bract of the previous catkin (MG(30)262); MG(30)262/2, x 500.  
*Alnus* sp.  
6. female catkin; MG(30)294, x 3.1.  
bar in the figures 1-4, 6 indicates 10 mm.

#### PLATE 6

*Engelhardia macroptera* (BRONGNIART) UNGER  
1. nut coated by a trilobate bract; MG(30)288, x 3.2.  
*Juglandaceae* gen. et sp. indet.  
2. endocarp; MG(30)421, x 3.2.  
*Diospyros brachysepala* A. BRAUN sensu HANTKE  
3. leaf; MG(30)286, x 1.5.  
*Salix haidingeri* ETTINGSHAUSEN sensu BŮŽEK  
4. detail of the leaf venation; MG(30)217, x 6.  
*Dombeyopsis lobata* UNGER  
5. leaf; MG(30)269, x 0.6.  
*Craigia brononii* (UNGER) Z. KVAČEK, BŮŽEK et MANCHES-  
TER  
6. isolated valve of the dehiscent capsule; MG(30)302<sub>2</sub>, x 3.2.  
bar in the figures 1-3, 5, 6 indicates 10 mm.

#### PLATE 7

*Ulmus pyramidalis* GOEPPERT  
1. leaf; MG(30)318, x 2.1.  
2. samara with a remain of calyx; MG(30)312B.. x 2.8.  
3. incomplete samara; MG(30)343, x 2.8.  
*Zelkova zelkovifolia* (UNGER) BŮŽEK et KOTLABA in KO-  
TLABA  
4. leaf; MG(30)320, x 3.  
*Rosa* sp.  
5. apocarpium; MG(30)399b, x 3.  
*Rubus merianii* (HEER) KOLAKOVSKIJ  
6. incomplete compound ? ternate leaf; MG(30)258, x 1.5.  
7. compound pentamerous leaf; MG(30)334a, x 1.5.  
bar in all figures (1-7) indicates 10 mm.

## PLATE 8

### *Rubus* sp. 1.

1. isolated leaflet; MG(30)257, x 0.7.
2. abaxial cuticle with widely oval anomocytic stoma (its position shown by the arrow); cuticle taken from the previous leaflet (MG(30)257); MG(30)257/1, x 720.

### *Rubus* sp. 2.

3. compound pentamerous leaf; MG(30)276b, x 0.5.

### *Rubus* sp.

4. calyx; MG(30)289, x 3.

### cf. *Crataegus* sp.

5. leaf; MG(30)391, x 3.1.

bar in the figures 4 a 5 indicates 10 mm, bar in the lower-right part in the figures 1 a 3 indicates 50 mm.

## PLATE 9

### *Decodon gibbosus* (E.M. REID) E.M. REID in NIKITIN emend. Z. KVAČEK et SAKALA

1. leaf; MG(30)280, x 1.5.
2. leaves in direct association with fruits in the lower part; MG(30)347a, x 0.7.
3. capsule with seeds (detail from the counterpart of the previous specimen); MG(30)347c, x 6.

### *Leguminosites* sp.

4. leaf; MG(30)395, x 2.9.

### *Acer tricuspidatum* BRONN forma *tricuspidatum*

5. MG(30)249, leaf, x 1.2.
6. abaxial cuticle with distinct anomocytic stoma (arrow); cuticle taken from the previous leaf (MG(30)249), phase contrast; MG(30)249/1, x 500.

### *Acer tricuspidatum* BRONN forma *productum* (HEER) PROCHÁZKA et BŮŽEK

7. leaf; MG(30)253, x 1.9.

### *Acer tricuspidatum* BRONN sensu PROCHÁZKA et BŮŽEK

8. samara; MG(30)254, x 3.2.

bar in the figures 1, 4, 5, 7, 8 indicates 10 mm, bar in the left part in the figure 2 indicates 50 mm.

## PLATE 10

### *Acer* sp.

1. three carbonised flowers; MG(30)295, x 3.
2. group of tricolpate pollen grains taken from the middle flower of the previous specimen (MG(30)295); MG(30)295/1, x 720.

### cf. *Cedrela* sp.

3. isolated leaflet; MG(30)381, x 1.2.
4. abaxial cuticle with anomocytic stomata and characteristic striation; taken from the specimen MG(30)267, phase contrast; MG(30)267/2, x 500.

### cf. *Rhus* sp.

5. incomplete compound leaf; MG(30)275a, x 0.4.

### *Paliurus tiliaefolius* (UNGER) BŮŽEK

6. leaf; MG(30)331, x 3.2.

### *Berchemia multinervis*. (A. BRAUN) HEER

7. leaf; MG(30)347B, x 2.

bar in the figures 1, 3, 6, 7 indicates 10 mm, bar in the right part in the figure 5 indicates 50 mm.

## PLATE 11

### *Nyssa haidingeri* (ETTINGSHAUSEN) Z. KVAČEK et BŮŽEK

1. leaf; MG(30)279, x 1.8.
2. leaf with characteristic tooth; MG(30)278, x 0.7.

### *Nyssa* cf. *haidingeri* (ETTINGSHAUSEN) Z. KVAČEK et BŮŽEK

3. leaf; MG(30)236, x 1.2.

### *Nyssa disseminata* (LUDWIG) KIRCHHEIMER

4. inner wall of endocarp; MG(30)336, x 3.1.

### *Nyssa* sp.

5. carbonised inflorescence; MG(30)422, x 2.9.
6. tricolporate pollen in polar view; taken from the specimen MG(30)354; MG(30)354/1, x 720.

### *Fraxinus bilinica* (UNGER) Z. KVAČEK et HURNÍK

7. leaf; MG(30)241, x 1.3.
8. abaxial cuticle with a roundish trichome base with strongly cutinized periphery and anticlines radially running out (position of the base shown by the arrow); cuticle taken from the previous leaf (MG(30)241); MG(30)241/1, x 600.

bar in the figures 1-5 indicates 10 mm, bar in the right part in the figure 7 indicates 50 mm.

## PLATE 12

### *Apocynospermum striatum* E. M. REID et CHANDLER

1. seed with a pappus; MG(30)285, x 1,6.

### *Fraxinus macroptera* ETTINGSHAUSEN

2. samara; MG(30)261, x 3.3.

### "*Ficus*" *truncata* HEER sensu BŮŽEK

3. leaf; MG(30)374a, x 0.5.

### *Dicotylophyllum* sp. 1.

4. leaf; MG(30)385, x 2.2.

5. detail of the semicraspedodromous venation of the previous leaf; MG(30)385, x 4.5.

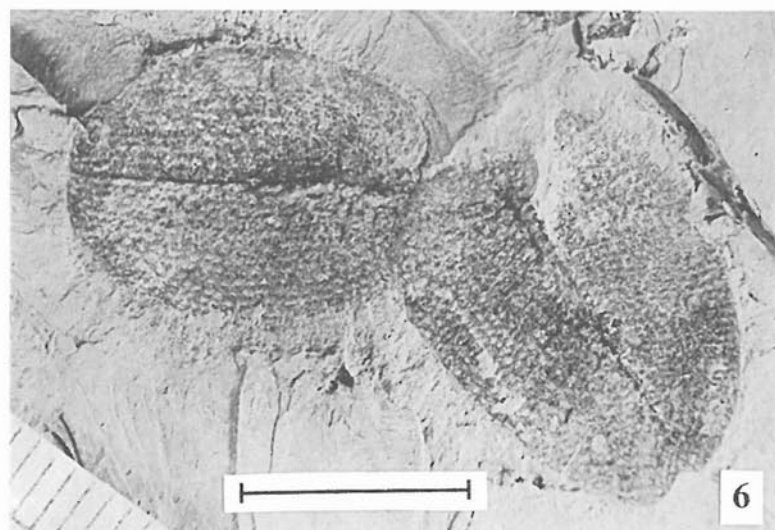
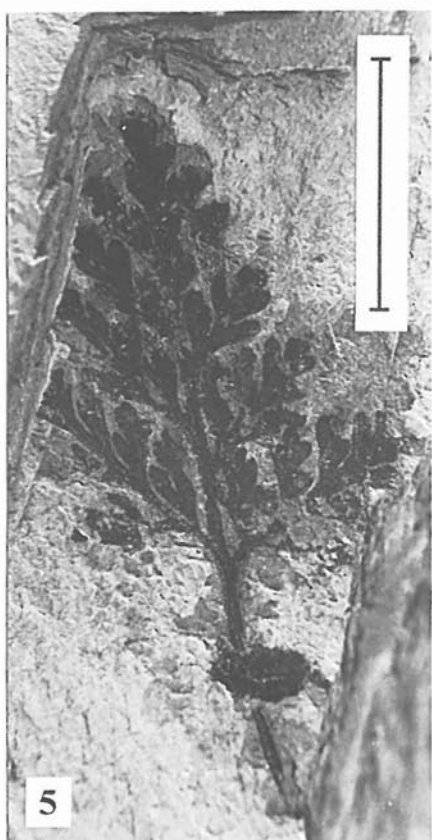
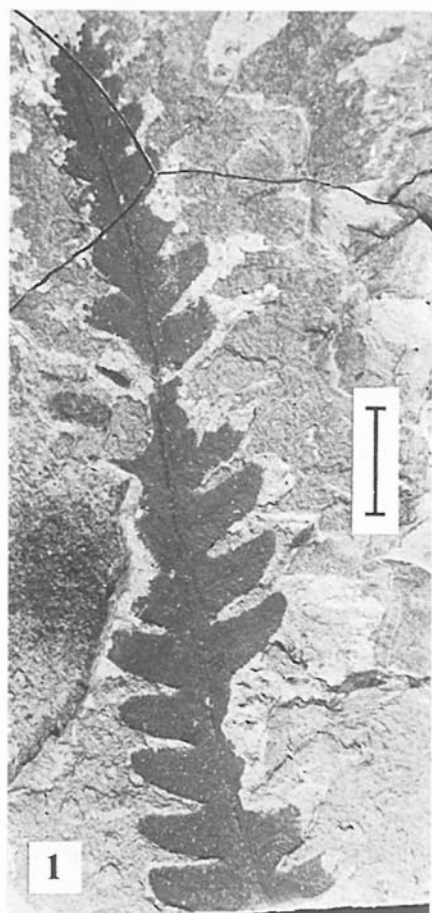
### *Dicotylophyllum* sp. 2.

6. leaf; MG(30)384, x 0.9.

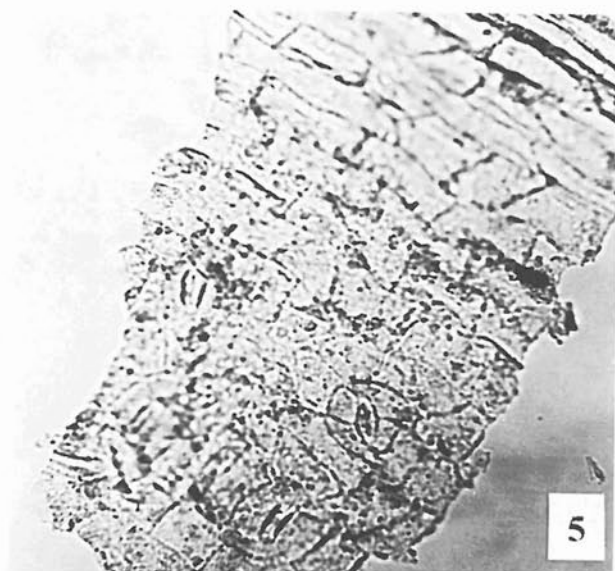
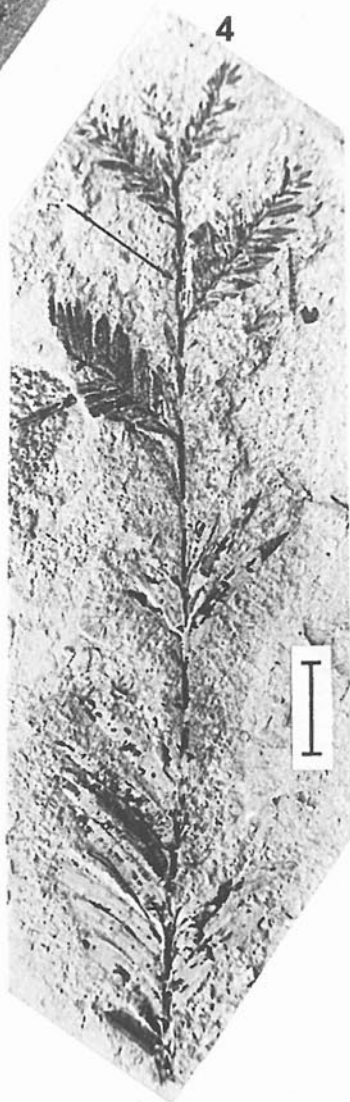
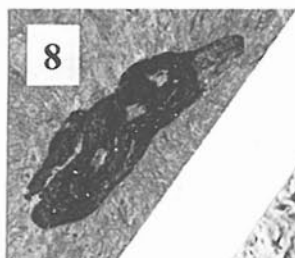
### *Dicotylophyllum* sp. 3

7. leaf; MG(30)383, x 1.3.

bar in the figures 1-4, 6, 7 1-5 indicates 10 mm.







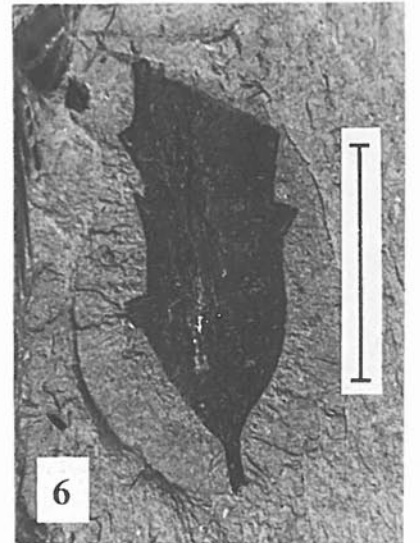
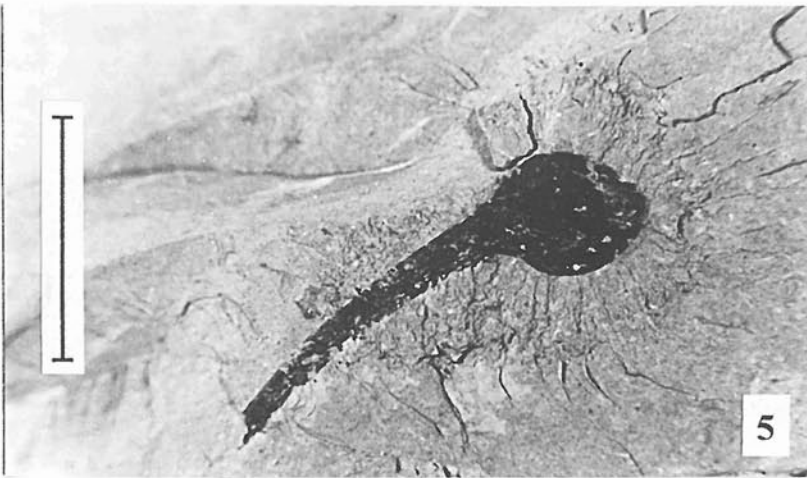
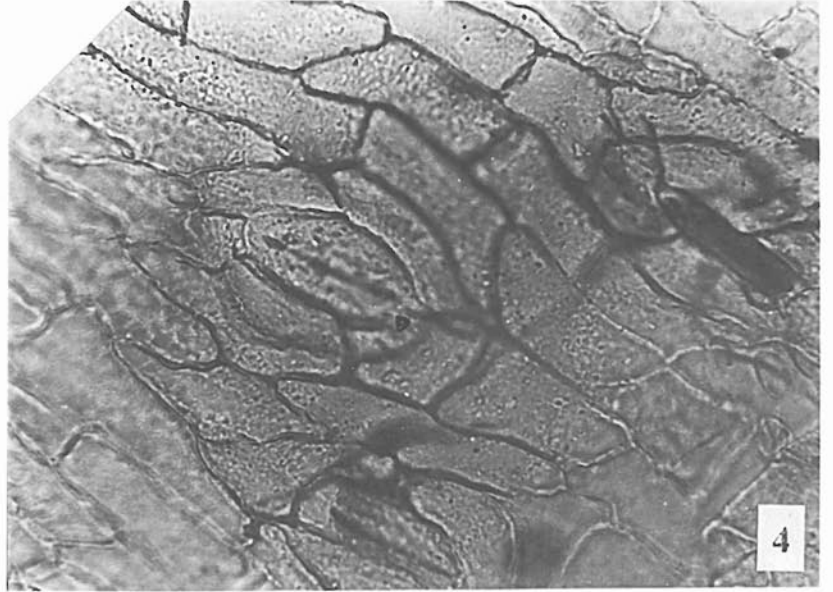
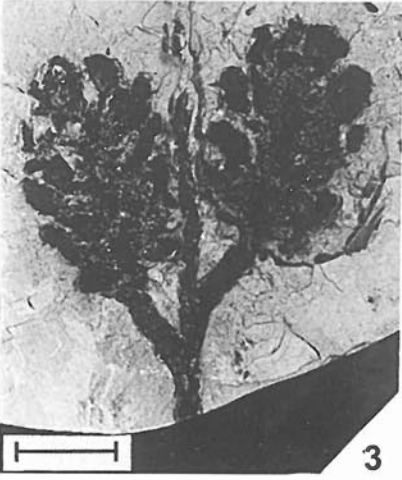
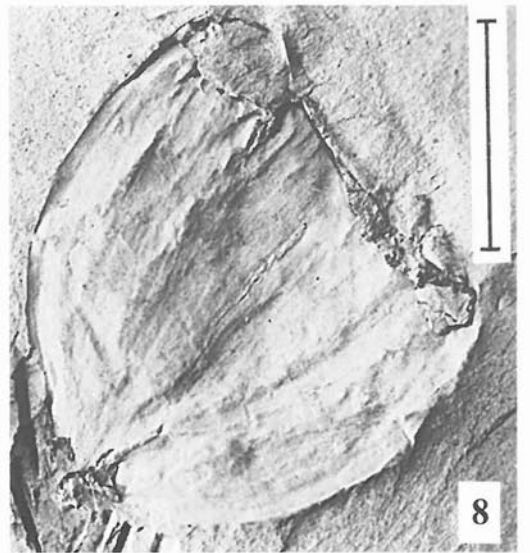
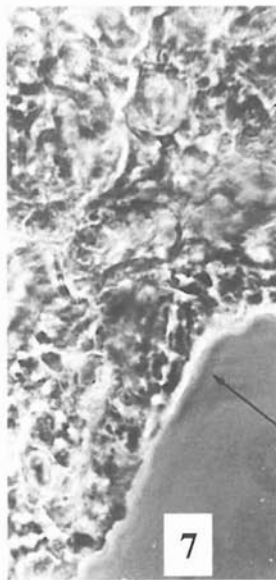
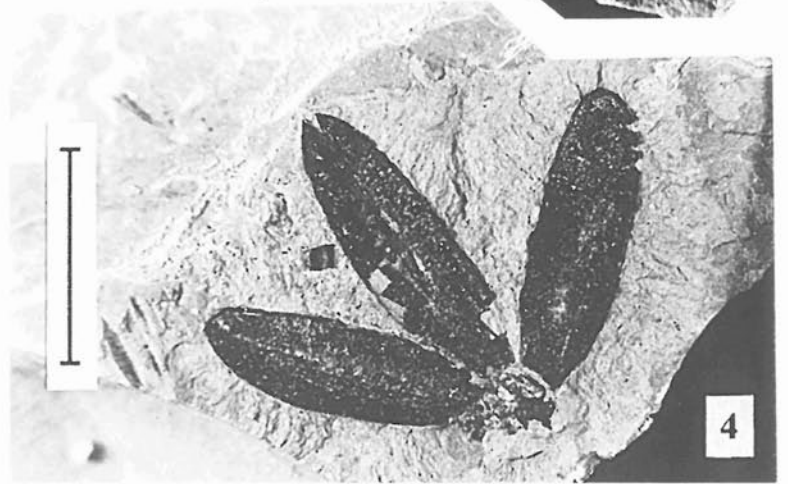
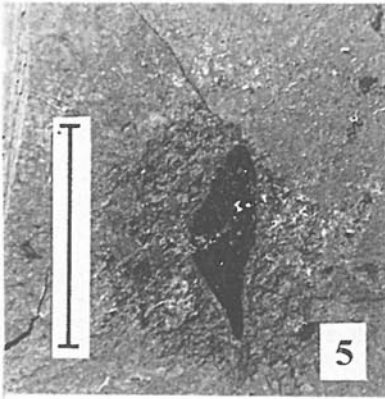
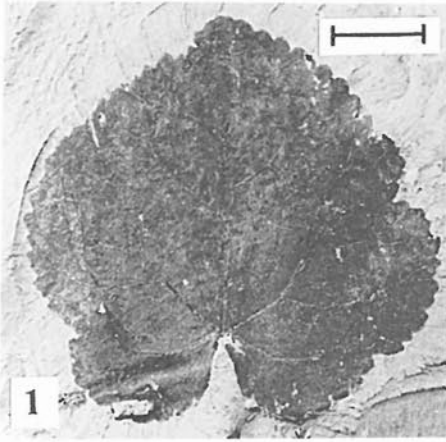


Plate 4





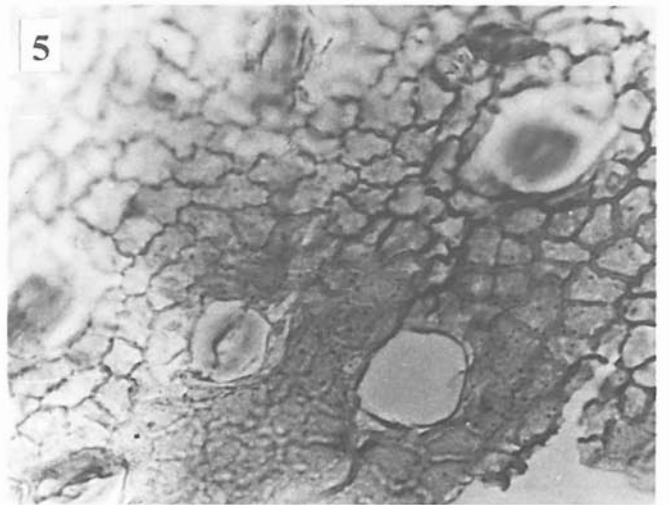
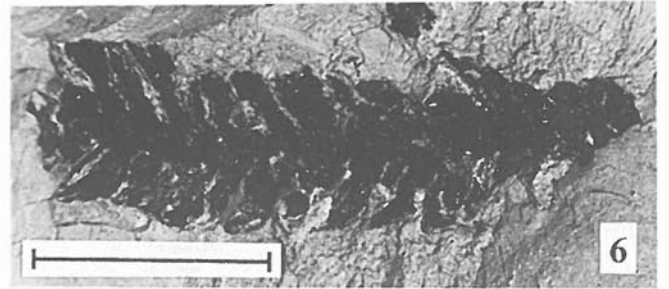
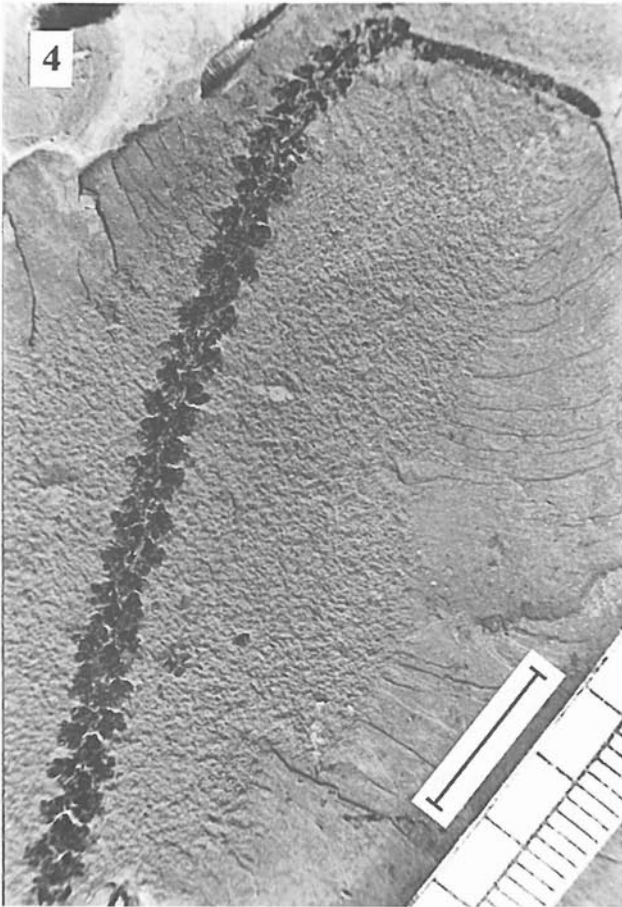
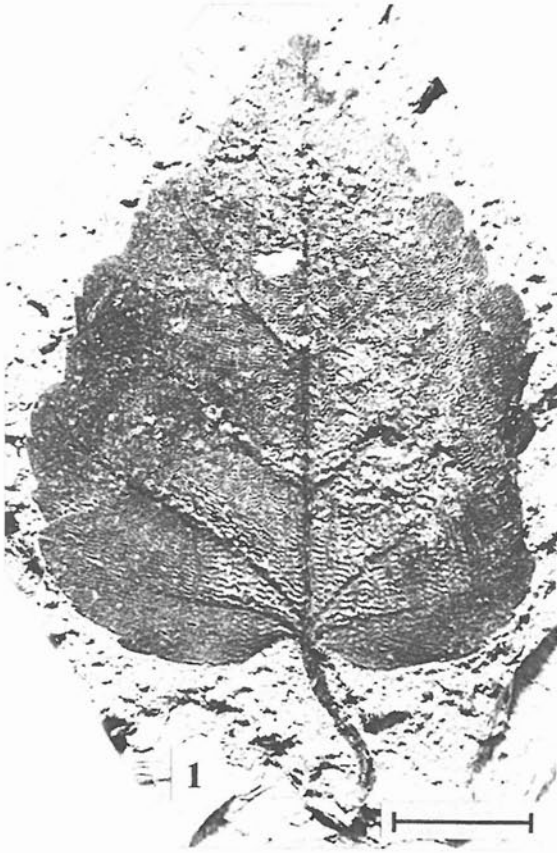


Plate 6

