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OLIGOCENE FLORA OF BECHLEJOVICE AT DĚČÍN FROM THE NEOVOLCANIC AREA OF THE ČESKÉ STŘEDOHOŘÍ MOUNTAINS, CZECH REPUBLIC

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Abstract: The laminated diatomite of Bechlejovice in the suburbs of Děčín from the area of the České středohoří Mountains, northern Bohemia, has become a world-known palaeontological site of Tertiary frogs. It is now evaluated in respect of the flora and vegetation based on plant macrofossils. Also the so far accomplished explorations in palaeontological, geological and geochemical research are reviewed. The plant macrofossil record includes a bryophyte, two ferns (*Polypodium*, *Rumohra*), a cycad (?), a single conifer (*Torreya*) and over 70 angiosperms, of which *Mahonia pseudosimplex* sp. nov., *Tilia brassicoides* (SAPORTA) comb. nov., *Zelkova zelkovifolia* (UNG.) BŮŽEK et KOTLABA forma *bechlejovicensis* forma nov., *Rosa milosii* sp. nov., *Leguminosites cladrastioides* sp. nov. and *Ziziphus ziziphoides* (UNG.) WEYL. forma *bilinica* (ETTINGSH.) stat. nov. have been newly established. Noteworthy elements, such as *Platanus schimperi* (HEER) SAP. et MAR., *Sterculia crassinervia* (ETTINGSH.) PROCHÁZKA et BŮŽEK, cf. *Matudaea menzelii* WALTHER, *Haemanthophyllum* sp., *Diospyros brachysepala* A. BR., cf. *Pyracantha kraeuselii* WALTHER, *Ailanthus prescheri* WALTHER, *Dicotylophyllum deichmuelleri* Z. KVAČEK et WALTHER, *D. heerii* (ENGELH.) Z. KVAČEK et WALTHER, and Arecaceae gen. et sp. have been newly recorded at this site. Vegetation reconstruction of this local macrofossil assemblage presumes only a narrow belt of aquatic herbs ("*Typha*", *Haemanthophyllum*) rimming the lake. A mixed mesophytic broad-leaved forest with a small proportion of thermophilic elements (Lauraceae, *Platanus neptuni* (ETTINGSH.) Z. KVAČEK et al., cf. *Quercus bavarica* (KNOBLOCH et Z. KVAČEK) Z. KVAČEK, ? *Sloanea artocarpites* (ETTINGSH.) Z. KVAČEK et HABLY, Arecaceae gen. et sp.), well developed shrubs (? Zamiaceae gen. et sp., *Rosa*, *Mahonia, Ziziphus*, *Ampelopsis*) and herb undergrowth (*Rumohra recentior* (UNG.) BARTHEL, *Polypodium radonii* Z. KVAČEK, Monocotyledonae gen. et sp.) vegetated on the raised habitats around the lake on the fertile volcanogenic soils. Judging from the frequency of leaf impressions, the canopy and smaller tree storeys of the forest were dominated in close proximity of the lake by various hamamelids, such as *Cercidiphyllum,* Juglandaceae (*Carya*, *Cyclocarya*), Betulaceae (*Alnus*, *Ostrya*, *Carpinus*) and other woody elements, such as *Craigia*, *Tilia*, *Ulmus, Zelkova* and various species of *Acer.* The legumes, *Populus*, Rosaceae, *Toxicodendron, Ampelopsis, Smilax* and some more, partly enigmatic angiosperms represented minor accessory admixtures nearby the site. Palynological data inform us that this characteristic covers only a narrow section of the landscape, while additional conifers (including Pinaceae and Cupressaceae) and broad-leaved woody plants (including *Engelhardia*) were represented in wider environs. The Early Oligocene age of Bechlejovice is estimated in view of the presence of ancient Palaeogene elements (*Boehlensipollis hohlii*, *Platanus schimperi*, *Sterculia crassinervia*, *Haemanthophyllum*) and the correlation with the radiometrically dated level at Roudníky near Ústí nad Labem with umbrid fish and a similar flora. Both sites belong to the lower part of the volcanic complex characterised by older olivine-rich basalts (Ústí Formation sensu Cajz).

■ Flora and vegetation, Early Oligocene, northern Bohemia, volcanic setting.

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Introduction

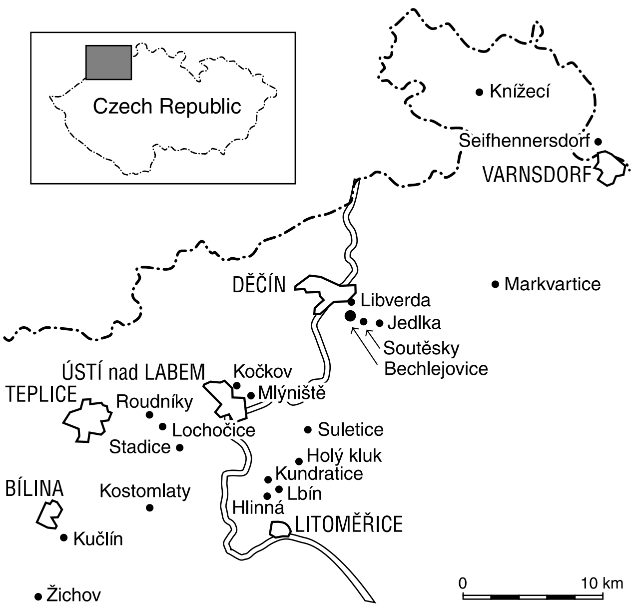
The České středohoří Mountains in northern Bohemia has been a traditional area of the geological and palaeontological research since the 19th century (Špinar 1972a). Just after the end of the Second World War, new activities and intensive geological survey of the Tertiary was initiated by late Miloš Procházka, a member of the State (Central) Geological Survey in Prague. He worked there during his university studies and announced the discovery of a new very promising palaeontological site of Bechlejovice near Děčín - now administratively belonging to the town of Děčín (Procházka 1951, 1953). In his report given at the Academy of Sciences on April 6, 1952 he stated that Bechlejovice would become one of the most important Czech sites of the Tertiary fauna and flora. He did not live long enough to see any more detailed published evaluation of the fossils he and his co-workers and successors – Z. Špinar, Č. Bůžek, B. Novotný and the others gathered in large quantities. The diatomite of Bechlejovice is noteworthy by its laminated structure, which Procházka (1953) tried to elucidate by a changing production of diatoms due to the seasonality of the climate / environment. He got the first hand information of the site from late Bohuslav Fott, a well-known algologist and professor at the Charles University. In the field he was guided by Mr. J. Štrof from Děčín. While faunal remains attracted attention of several zoopalaeontologists, who described in detail remains of frogs, fish and other fauna, plant remains, although quantitatively overwhelming, and maybe just for this reason, were massively collected, but not systematically evaluated. Only partial studies on maples and some rarities have been produced so far besides the very limited short summaries of the flora (Bůžek et al. 1990, Knobloch 1994). The material gathered up to now surely outnumbers thousands of specimens and has been dispersed, partly in exchange and by selling to various organisations and private collections. A most interesting suite of the material, selected by our late colleagues Čestmír Bůžek and Erwin Knobloch, who both intended to write a monograph of the Bechlejovice flora, forms the basis of the present study. The text does not certainly cover all vascular plants occurring in the assemblage. Nonetheless, we have tried our best to check all important available specimens housed at the National Museum and the selected parts of the collections at the Czech Geological Survey, mostly gathered by M. Procházka and Č. Bůžek (sold parts housed at the Dresden Museum of Mineralogy and Geology and elsewhere) and the Faculty of Sciences, Charles University accumulated by Z. Špinar and his students between 1950s and 1970s.

In the absence of large quantities of fruits and seeds, it is difficult to interpret such a flora taxonomically. *In situ* pollen and poorly preserved cuticles have helped in some cases, but we have taken a cautious approach to naming the fossils. The present account is similar in its style to the monographs on the Suletice-Berand and Kundratice floras previously published in the present journal (Kvaček and Walther 1995, 1998). Many of the established taxa from the latter site helped to determine the material from Bechlejovice, based mostly on leaf impressions.

Geological setting

The volcanic mountain range of the České středohoří Mountains forms a part of the Ohře (Eger) Rift structure (Kopecký 1978) in northern Bohemia and stretches from the town of Most northeast-eastwards to the towns of Ústí nad Labem, Děčín and Česká Lípa (Text-fig. 1). Until recently it was interpreted as a denudation remnant of the neovolcanic complex consisting of channels, intrusions and lava flows intercalated by pyroclastics, volcaniclastics and sediments including diatomite and coal. Cajz (2000) suggested a new concept and considered this unit as consisting of three formations, the lowest Ústí Formation (older olivine-rich basalts), the middle Děčín Formation (mostly tephritic and basanite (trachybasaltoid) rocks, a composite volcano) and the upper Dobrná Formation (lava flows of olivine-rich younger basalts), relying on the succession and differentiation of magma. The model of magma differentiation envisaged already by Hibsch (1926) is not very suitable for such a lithostratigraphic subdivision (I. Chlupáč, personal communication 2002), where the time succession of layers and intrusions within a particular section is difficult to trace on the mere superposition principle. This is also the case of the locality Bechlejovice situated in the central part of the České středohoří Mountains.

The diatomite and other fossiliferous layers at the settlement of Bechlejovice (former Bachelsdorf) are today included administratively within the southeastern suburbs of the town of Děčín (Teschen in German). They are situated south of the Březiny (Birkigt) village, on the foot of the Bechlejovice Wall (former Steinwand), a large massif consisting of several lava flows of pycritic basalts and tephrites with intercalated volcaniclastics and pyroclastics. The diatomite layer crops out in its lowest position within the volcanic rocks at 165–200 m a.s.l. (co-ordinates 14° 14' 59" N and 50° 45' 31" E). Today, the diatomite is only accessible on the western part of the Bechlejovice Wall in the ravine of the creek, while on all other places, it is covered by basalt stony debris. According to the detailed description of the geological section (Procházka 1953, Holý 1958, Valečka et al. 1970, Špinar 1972a) the thickness of the main layer of the diatomite is ca. 5 m. The deposit is inclined under the angle of 5–10° to the northeast. The Bechlejovice lake was probably more than 2 km^2 large (Novotný 1974). The diatomite was worked in the years 1932–1935 in a quarry, which is not visible today. This was the place, where Procházka and Špinar initiated large-scale excavations for collecting fossils. The deep pit, which was later enlarged by expeditions of the Charles University and other collectors collapsed in 1980s. Later attempts to uncover the diatomite in a larger scale have all failed.



Text-fig. 1. Geographic position of the locality Bechlejovice among the others within the České středohoří Mountains and adjacent Saxony.

During the geological mapping, Procházka (1953) compiled a general geological section of the region, consisting of the following layers (from below):

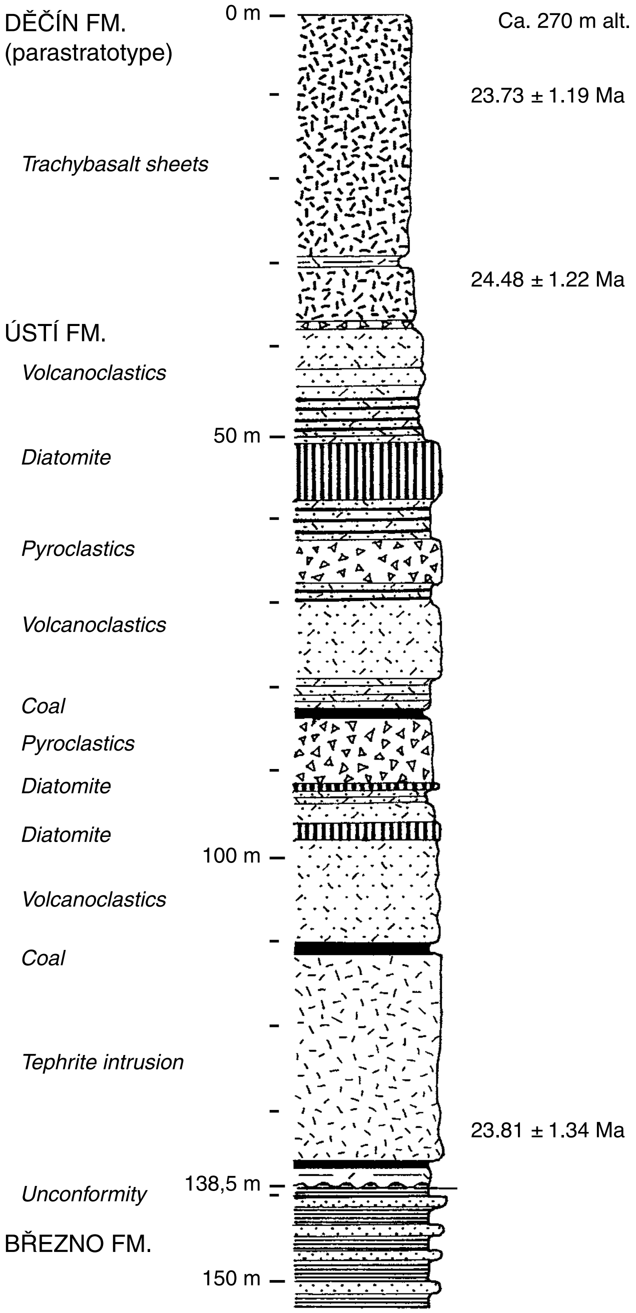
Rusty yellow fine-grained sandstone – sand (? reworked Cretaceous), diatomite (2.2–3.8 m), greenish grey tuff – tuffite (12 m), lowest basalt sheet (15 m), tuff (3 m), basalt sheet (3 m), dark red ash tuffite (5 m), basalt sheets of the Bechlejovice Wall with tuff intercalations (55 m), tephritic tuff (ca. 20 m), nepheline tephrite sheet (locally 6 m), tephritic tuff (ca. 70 m), leucite tephrite sheet (up to 10 m). (The names of the rocks are cited according to Procházka, although they may not correspond to the currently accepted terminology.)

In 1955, the borehole S-3 was executed on the foot of the Bechlejovice Wall (see Valečka et al. 1970, Špinar 1972a, Bellon et al. 1998), in which a more precise geological section below the basaltoid massif was obtained (Text-fig. 2). The basement of the Tertiary rocks is made by the Late Cretaceous sandstone of the Březno Formation, as evidenced by forams. The Tertiary starts at the depth of 138.5 m with sandy basaltoid volcaniclastics and thin layers of coal deposits, which were intruded by a thick tephrite body, as evidenced by contact metamorphosis. The intrusion was dated by K-Ar method to 26.81 ± 1.34 Ma (Bellon et al. 1998). The basaltoid volcaniclastics, partly intercalated with coarse pyroclastic material and diatomite layers (up to 1.5 m in thickness) continue upwards to a depth of 56.7 m, where the main fossiliferous diatomite in thickness of more than 5 m was struck. The volcaniclastics continue some other 12 m above the diatomite. The upper part of the core contains two thick lava flows of the picritic trachybasalt dated by two samples to 24.5 ± 1.2 Ma and 23.7 ± 1.2 Ma respectively (Bellon et al. 1998).

Material and Methods

The richest fossiliferous deposit of Bechlejovice is the laminated diatomite. The plant remains preserved in this sediment are impressions without carbonised substance, typically showing in various degree details of venation. The epidermal anatomical structure is in most cases not preserved, although the cuticle membrane can be removed from the impression with the aid of the collodion transfer-film-technique. The cell structure is entirely damaged by impressions of diatom shells in most cases and even thicker cuticles of coriaceous leaves reflect only exceptionally recognisable cell patterns (*Torreya*, *Laurophyllum acutimontanum*). Catkins in some cases yielded pollen *in situ*. This research has been undertaken separately (J. Dašková, in prep.) and only briefly noted in the systematic part. Plant remains in volcaniclastic layers adjacent to the diatomite are preserved as dark compressions not showing details of the venation. Their cuticles are better preserved, but such fossils were only exceptionally collected.

The preparation of macrofossils has been done with the aid of preparation needles, by careful removing diatomite layers covering the leaf margins and stalk areas. The cuticles have been obtained in a similar way as described by Kvaček and Walther (1998). Fragments of plant fossils were mechanically removed from the slab and put for a few minutes into 30 % HF to soften the adhering matrix. In the cases of carbonised fossils, the samples after rinsing in distilled water were oxidised in the Schulze solution for a few minutes, then transferred into water and 5 % water solution of KOH, then rinsed in water and mounted in glycerol. In cases of naturally oxidised samples, the maceration in the Schulze solution was omitted.



Text-fig. 2 Geological section of the core S-3 (adapted from Valečka et al. 1970).

The collections from Bechlejovice are dispersed in various institutions. The basic material for this study is housed in the Czech Geological Survey (UUG) and gathered by M. Procházka and Č. Bůžek. The second major collection transferred to the National Museum, Prague (NM) was partly made by B. Novotný, V. Zázvorka and F. Holý. Some important specimens are at present housed at the Natural History Faculty of the Charles University (PRC) and in part originate from the fieldwork organised by Z. Špinar. Duplicate collections were sold by the Czech Geological Survey to the Natural History Museum, Vienna, the Humboldt University, Museum für Naturkunde, Berlin and Staatliches Museum für Mineralogie und Geologie zu Dresden (MMG) in 1995 to obtain funding for publication activities. The numbers of the specimens actually studied are pre-fixed by Be (PRC), Ba (MMG), G (NM) and MP (UUG). The present exact location of the specimens reproduced on photo-prints, which were at our disposal (numbers without prefix), is uncertain. The material indicated in the systematic part forms only a negligible portion of the total plant macrofossils collected at Bechlejovice and does not express the proportion of the frequency. Hence, no attempt has been made to evaluate abundance of the described taxa more precisely.

Age

Until new radiometric data of the volcanic complex of the České středohoří Mountains were obtained (Kopecký 1978, etc.), most of the fossiliferous sediments intercalated between magmatic rocks were considered, after Hibsch, of Aquitanian age, based on the faunal remains and micropalaeobotany (Procházka 1953, Holý 1958, Řeháková 1958). Špinar (1972b) assigned the diatomite of Bechlejovice to the Middle Aquitanian and this dating was taken over by other palaeontologists and geologists working in this area (e.g. Obrhelová 1979). The Chatt – Aquitanian age was supported for most diatomite layers by the correlation based on diatoms (Řeháková in Malkovský 1985). After the above-mentioned radiometric ages had been obtained, the main volcanic phase was assigned to the Oligocene. Obrhelová and Obrhel (1987) established the succession of the fish faunas from the Tertiary of the former Czechoslovak Republic and included the one from Bechlejovice into their type B of Oligocene age. Konzalová (1981) recorded the Early and early Late Oligocene index sporomorph *Boehlensipollis hohlii* in the Bechlejovice pollen spectra. The unusually "cold" character of the vegetation reconstructed from this site on the basis of megafossils presented a problem. This anomaly was previously explained due to the environmental factors (e.g. slope exposition) and the stratigraphical position of the Bechlejovice flora was usually estimated higher in the Oligocene (Bůžek et al. 1990, Kvaček and Walther 2001). In addition, the radiometric ages from the rocks intercalated in the geological section (core S-3) corroborated Late Oligocene age of the deposit, i.e. less than 26.8 Ma (see Bellon et al. 1998, fig. 1). Only recently, this view changed radically (Kvaček and Walther 2003).

The advanced evaluation of the site of Roudníky near Ústí nad Labem (Kvaček et al. in progress), which was dated radiometrically on the Eocene-Oligocene boundary (Bellon et al. 1998), revealed many common links and the same aspects of "cold" broad-leaved deciduous vegetation corresponding to that of Bechlejovice. At Roudníky, also the lower vertebrate fauna with an umbrid and alligators corresponds to that of Bechlejovice. The geological re-assessment of the Bechlejovice section (Cajz 2000, p. 13) revealed that the radiometric dating came from the tephritic intrusion and trachybasalt lava flows (Děčín Formation), which arose much later than the diatomite-volcaniclastic complex connected with the older olivine-rich basalts of the Ústí Formation originated. According to this new interpretation (Kvaček and Walther 2003) the site of Bechlejovice including the laminated diatomite must be situated in a very low position within the Lower Oligocene. Typically Early Palaeogene elements newly recognised in this assemblage, such as *Sterculia crassinervia*, *Platanus schimperi* and *Haemanthophyllum,* stress the ancient character of the flora of Bechlejovice and confirm this surprising solution of the long disputed age of Bechlejovice. The flora should now be assigned to the Floral Assemblage Haselbach – Valeč (in sense of Kvaček and Walther 2001) together with Roudníky and reflects, in contrary to the basinal type of vegetation of Haselbach, the vegetation in volcanic environment. The "cold" character of Roudníky and Bechlejovice may correspond to the drop of the mean annual temperature on the Eocene-Oligocene boundary. In view of the medium proportion of the thermophilic (33.3 %) and intermediate (27.3 %) elements vs. deciduous (39.4 %) in the pollen spectra of Bechlejovice (Konzalová 2003) and the presence of palms and alligators, this deterioration was surely not very drastic (see also the conclusions on climate, p. 44).

History of research

A detailed review of the research of the Bechlejovice site till the year 2000 was given in a comprehensive unpublished report on the palaeontology of the České středohoří Mountains and the periphery by Radoň (2001). This text has served as the main source of information for this chapter. The first palaeontological object published from this site is a leaf impression from the collection of E. Hibsch, identified as *Acer trilobatum* by Engelhardt (1895). Hibsch (1896) knew the Bechlejovice diatomite, which he described at the alt. of 180 m a.s.l. at the base of the Bechlejovice Wall, called by him "Steinwand". Reichelt (1900) received samples of the Bechlejovice diatomite and described a suite of diatoms. Reports of fossil plants from Bechlejovice are included in the review of the Tertiary flora in northern Bohemia by Brabenec (1909), who noted about 30 species from "tuffites" of Birkigt (today Březiny) and a single record – *Acer trilobatum* from the diatomite of Bachelsdorf (i.e. Bechlejovice) excerpting mostly Engelhardt's works. According to Rehnelt (1961) the diatomite was recovered by Karl Prinz in 1930 and yielded plentiful plant fossils and bones. As stated in the introduction, the main initiator of the extensive fieldwork was Miloš Procházka, who visited as a student this place together with Blanka Pacltová, presently professor emeritus of palynology at the Charles University, and recovered besides very beautiful plant impressions also the noteworthy faunal remains, namely skeletons of frogs. B. Pacltová found the first specimen of a frog with preserved traces of muscles (B. Pacltová, personal communication). Immediately after their trip, Z. Špinar overtook the animal fossils for further research (Procházka 1951, Špinar 1972a). In 1951, the department of palaeontology of the Charles University organised extensive collections at Bechlejovice in summer 1951. The group headed by Z. Špinar and M. Procházka included also other students of the faculty, O. Fejfar, J. Jaroš, B. Pacltová and E. Štenglová (Procházka 1951, Procházka and Špinar 1952, Špinar 1952). Besides the palaeontological content, these two leaders studied also the details of stratigraphical and geological position of the site. The regular summer fieldwork continued regularly every summer till 1964. Z. Špinar overtook most of the organising after 1956, when Procházka was killed tragically in a fatal accident when mountaineering in the Suché Rocks at Železný Brod at an age of 33 years. The group around Z. Špinar increased of Č. Bůžek and Z. Řeháková from the Central Geological Survey, F. Holý and Z. Záruba from the National Museum and Z. Kvaček and N. Obrhelová from the Geological Institute of the Czechoslovak Academy of Sciences. Along with the staff of the university, also private persons were engaged in the large-scale collecting at Bechlejovice. A group of scholars guided by B. Novotný, teacher of the secondary school in Děčín, gathered valuable material in 1951–1957. Novotný himself rescued valuable fossils from private collectors and offered them for scientific examination. His activities are documented in a number of short reports (Novotný 1956, 1962, 1966, 1967a, b, 1968, 1974). His collections that included also a part of the specimens found by Procházka (Novotný 1967b) were transferred to the National Museum, Prague.

The excavations took place at two places in Bechlejovice (see Novotný 1967b, Špinar 1972a). The first place, where the diatomite outcropped, was damaged by landslide in the spring 1956 during the thawing and was covered by basalt boulders. This place yielded most complete and rare material collected from three pits by Procházka personally, as we have noticed in his handwriting notes on the labels attached to some specimens with tentative identifications. In this year, the stream (Bechlejovice or Chlum Creek) uncovered the second place of collecting on the western side of the Bechlejovice Wall at the creek. Excavations at this place took place mainly from 1961 onwards (Bůžek 1970, Bůžek, Holý and Kvaček 1966, Řeháková 1970, Špinar 1972a). The samples for the diatomology came from both places in 1956 and 1961 respectively (Bůžek 1970, Řeháková 1970). The second place was open by a long and deeper trench during the geological mapping (see Nepraš 1961, Růžičková et al. 1970) to obtain a more complete geological section. The section was ca. 7 m thick across the overlying volcaniclastics and diatomite to the underlying sandy “tuffites” at the level of the Bechlejovice Creek. Several metres apart, a test pit uncovered softer and light diatomite layers rich in fossils, which corresponded to the first place (Bůžek 1970, Řeháková 1970). The review of the palaeontological collections and activities at that time can be excerpted also from the reports by Špinar (1972a) and by Novotný (1974).

Besides plant macrofossil remains treated in this monograph, also diatoms, pollen and animal fossils have been described from various levels and places at Bechlejovice. Frogs are the most famous and typical for this locality thanks to several studies and monographs by Špinar (1972b etc.). Frogs have been preserved as mature individuals and also in various ontogenetic stages. The best preserved specimens showed remains of soft parts, such as mussels, veins and entrails (Špinar 1954, 1972a). One of the rare taxa of frogs was described as *Eopelobates bayeri* of the family Pelobatideae (Špinar 1952, 1954). The mature individuals are extremely rare. After the first complete specimen recovered in summer 1952, only a few others have been known so far. The terrestrial frogs were mostly preserved as tadpoles. The layer bearing frogs was only some centimetres thick and only experts, like Mr. Havlata, technician of the university, were able to fix its position at the beginning of the new season. For a few first days, students had to work hard to remove slush accumulated during the winter. Of hundreds of frog fossils, most specimens belonged to the extinct family Palaeobatrachidae (Špinar 1953, 1954, 1962, 1963, 1966, 1967a, b, 1972a, b). Up to now five species have been described from Bechlejovice: *Palaeobatrachus grandipes, P. dilluvianus, P. luedeckii, P. novotnyi*, and *P. rostae* (Špinar 1972b). The rarity of the frog fauna is the group Discoglossidae (Bombinidae), represented by a single species *Opisthocoelellus hessi* (Špinar 1976) based on a single specimen of a mature individual and a single poorly preserved tadpole. In 1952, the first fossils of fish, amphibians (probably *Palaeotriton* or *Chelotriton* according to Bellon et al. 1998) and insects were recorded (Špinar 1953). The ichthyofauna was treated in several papers by Obrhelová (1979), Obrhelová and Obrhel (1987) and Gaudant (in Bellon et al. 1998). Up to now only *Umbra prochazkai* has been verified (teste Gaudant in Bellon et al. 1998), although Obrhelová (1979) mentioned also dispersed bones of *Pirskenius* sp. Fejfar (1966) announced the presence of *Peratherium* sp., Marsupialia. Common occurrences of crayfish were at the beginning ascribed to *Micropsalis papyracea*, Palaemonidae (Zázvorka 1956), a species known from other places of the České středohoří Mountains. According to the revision by Houša (1956, 1957), the record from Bechlejovice differs in various diagnostic characters allowing establishing a new genus *Bechleja* with a single species *B. inopinata*. Štamberg (1970) studied large coprolites and suggested that they might belong to alligators of the *Diplocynodon* type, in smaller extent to large snakes of the family Boidae. Of various kinds of insects, only a few groups have been so far described in detail. A unique material of the insect fauna reviewed by Prokop (2003) is represented by several isolated records of aquatic and terrestrial species (Dermaptera, Heteroptera, Hymenoptera). These rather well preserved fossils were evaluated in taxonomic papers. *Lethocerus sulcifemoralis* ŘÍHA et KUKALOVÁ (1967) belongs to aquatic groups. A new ant species *Camptonotus novotnyi* was described by Samšiňák (1967) and a record of earwig of the Dermatoptera was noted by Říha (1973). Novotný (1974) announced further groups of insects, like beetles, dragon-flies and water bed-bugs, which are at present under the investigation by Prokop. In addition, two new specimens of mayfly larvae (Ephemeroptera: ?Heptageniidae) indicate possible stream water environment (Prokop, personal communication

2004). Impressions of earthworms were noted by Ziegler (1994). General remarks on animal fossils are included in Fejfar and Kvaček (1993) and Glöckner (1995).

As noted above, the studies of Bechlejovice diatoms were undertaken from the very beginning of the discovery of the site (Reichelt 1900). Řeháková (1970) offered a more detailed analysis of the diatom assemblages within the České středohoří Mountains including Bechlejovice.

Vascular plants were most common at the site and attracted attention of several people. First of all, Procházka, who had recovered the site, intended a large-scale study of the flora. His tentative identifications are still noted on labels attached to the specimens he collected. Unfortunately, he was able to work out only maples before his untimely death (Procházka 1952, Procházka and Bůžek 1975). Later on, the macropalaeobotanical studies were undertaken by his successor in the geological survey, Č. Bůžek, who organised collections and selected most valuable plant fossils from the material gathered from studies of frogs by Špinar. He summarised several times the general characteristics of the flora (Bůžek et al. 1990, Bůžek in Bellon et al. 1998) and also took part in the systematic studies (Bůžek et al. 1981). Before the present study was completed, several other accounts dealing with selected plant elements treated also the material of Bechlejovice (*Quercus cruciata* – Kvaček and Walther 1981, *Cercidiphyllum crenatum* – Kvaček and Konzalová 1996, *Polypodium radonii* – Kvaček 2001). Bůžek intended to fulfil Procházka's idea of a monograph dealing with the Bechlejovice flora, selected most interesting specimens and had them photographically documented. Unfortunately, the fate repeated again and Bůžek died in 1992 before finishing his intention. Then E. Knobloch, who was for a long time engaged at the former Central Geological Institute (the present Czech Geological Survey), took over the whole collection, studied also collections of the National Museum and made tentative selections of interesting and rare elements, such as *Platanus neptuni*, *Comptonia*, *Populus zaddachii* etc. (Knobloch 1994). At about that time, he offered to co-operate with us in order to finish the monograph together. However, due to his progressive illness he gave up the participation and transferred the material to our hands before his death in 2004. Due to these circumstances some important specimens from the collections disappeared.

The palynological studies were initiated at Bechlejovice by our late friend František Holý (1958), who graduated at the Charles University in palynology. His results are still very valuable. Later on Konzalová (1981) succeeded him in the study of pollen spectra from the České středohoří Mountains including Bechlejovice. In her review focused on the distribution of the index fossil *Boehlensipollis hohlii* she found it also occurring at Bechlejovice and she added from this site several sporomorphs and pollen assigned to natural genera. It is obvious from her data (Konzalová 2003, fig. 8) that the spore and pollen spectra of Bechlejovice do not deviate much from the other post-Grand Coupure sites (in sense of Stehlin – see Bůžek et al. 1990), such as Javory-Stará Bohyně, Žichov and Lochočice.

Studies of various groups of fossils from Bechlejovice have been in progress till now. A new palaeontological project is being submitted to undertake more complex studies of the Palaeogene within the České středohoří Mountains. If it is accepted, it will concentrate on four groups – diatoms, vascular plants, and insect and fish faunas with the aim to explore the development of environment in volcanic settings. And the diatomite of Bechlejovice has been proposed as one of the sites considered as well.

Systematic descriptions

The descriptions of the entities follow the alphabetical order for practical reasons, as it was introduced in the monograph of the flora of Kundratice (Kvaček and Walther 1998). In table 1 the arrangement expresses their general systematic position. Some taxa indicated by previous authors (e.g. *Engelhardia* and *Nyssa* fruits by Holý 1958, *Trapa* and Nymphaeaceae by Obrhelová 1979) have not been recovered in the collections studied. As stated in the chapter on the material, some taxa are documented only by photo-prints and the location of the reproduced specimens is partly uncertain.

Acer L.

Acer angustilobum HEER

Pl. 1, figs 2–4, text-figs 3.1–9, 12.7, 13.18

1859 *Acer angustilobum* HEER, p. 57, pl. 117, fig. 25a, pl. 118, figs 4–9 (Hoher Rhonen, St. Gallen, Wangen, etc.).

1972 *Acer angustilobum* HEER; Walther, p. 40, pls 3–5, pl. 6, figs 1–5, pls 31–35 text-figs 9, 10a, b (Kundratice, Seihennersdorf, Schrotzburg, Münzenberg, Čermníky).

1975 *Acer dasycarpoides* HEER forma *angustilobum* PROCHÁZKA et BŮŽEK, p. 37, pl. 21, figs 6–10, text-figs 14–15 (Bechlejovice, Kundratice).

Description: Leaves long petiolate, petiole up to 25 mm long, blade trilobate, 53 and more mm long and max. 61 mm wide, with narrow lobes, medial lobe slightly narrowing towards the base with low irregular blunt teeth.

Remarks: This maple species, which is rare at Bechlejovice, is connected with *Acer palaeosaccharinum* STUR by transition forms with more prominently dentate margin (see discussion about *A. palaeosaccharinum* below). Without the characteristic abaxial cuticle (stomata deeply sunken, surrounded by papillate cells – see Walther 1972) it is uncertain, whether all specimens included here from Bechlejovice do belong to this species.

Material: NM G 7181, UUG MP 41, MP 44, 3735; G6837b; MMG Ba 137, Ba 251, Ba 322, Ba 435, Ba 505.

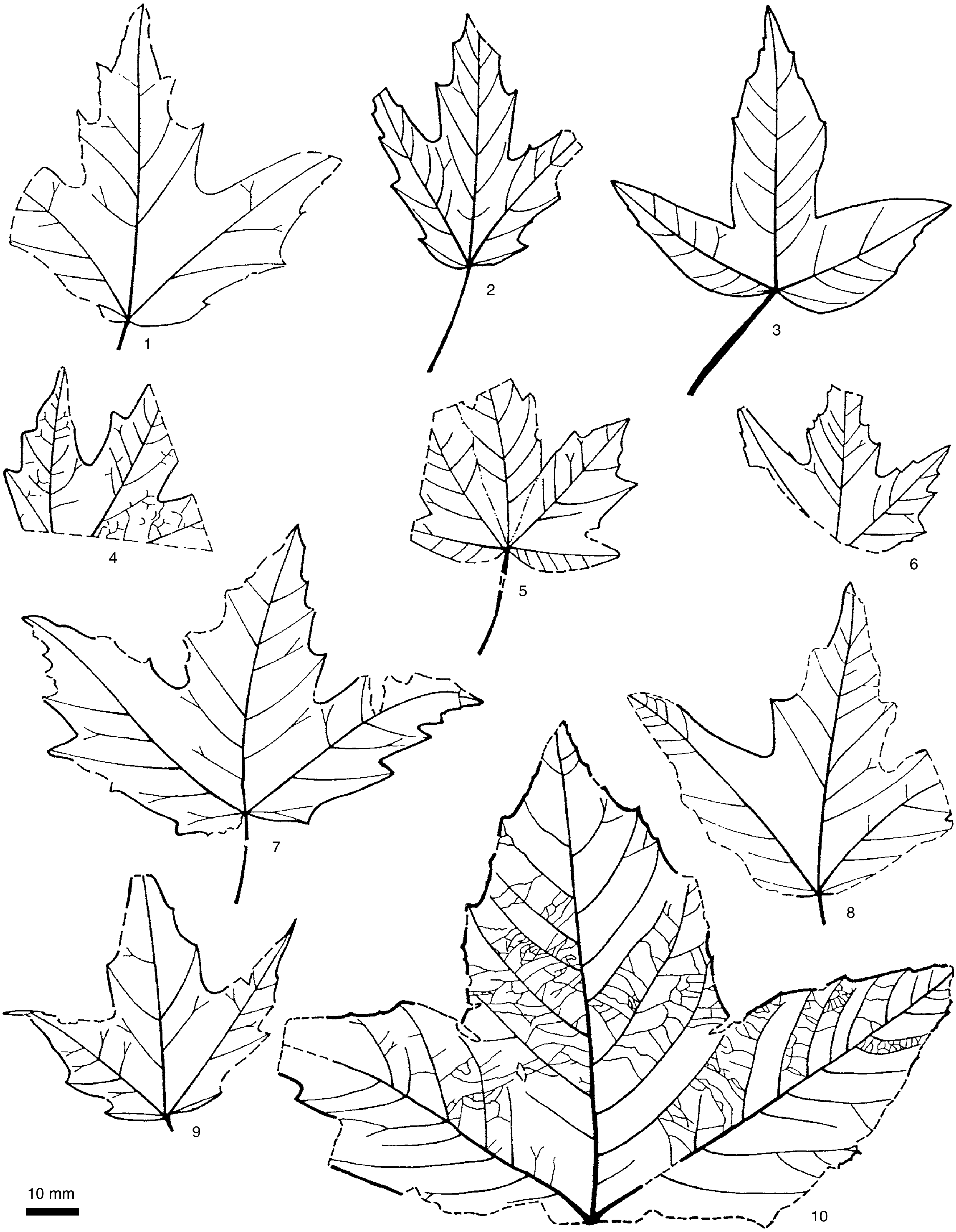
Acer integrilobum WEBER emend. WALTHER

Pl. 1, fig. 5, text-figs 4.1–7, 13.17

1852 *Acer integrilobum* WEBER, p. 196, pl. 22, figs 22a–c (Stösschen, Rott, Quegstein).

1967 *Acer loclense* HANTKE; Walther, p. 266, pl. 5, figs 1–2 (Seifhennersdorf).

1972 *Acer integrilobum* WEBER; Walther, p. 101, pl. 25, figs 1, 3 (Rott), 2, 4, 6 (Kreuzau), 5, 7–10 (Břešťany), pl. 26, figs



Text-fig. 3. **1–9 *Acer angustilobum* HEER (partly transitional forms to *Acer palaeosaccharinum* STUR), 1 MMG Ba 148, 2 UUG MP 41a, 3 NM G 7181, 4 MMG Ba 435, 5 MMG Ba 137, 6 MMG Ba 154, 7 MMG Ba 322, 8 MMG Ba 505, 9 MMG Ba 251, 10 *Acer tricuspidatum* BRONN, UUG MP 40.**

1–3, 5 (Lerch), 4 (Kreuzau), 6 (Kokoschütz = Kokoszyce), pl. 55, figs 1, 3 (Břešťany), 2, 10 (Lerch), 4, 5 (Kreuzau), 6 (Kokoschütz = Kokoszyce), 7–9 (Břešťany), pl. 56, figs 6–7 (Kreuzau).

1975 *Acer pseudomonspessulanum* UNGER; Procházka and Bůžek, p. 61, pro parte, text-fig. 21 (Suletice).

1994 *Acer pseudomonspessulanum* UNGER; Knobloch, p. 67, pl. 1, fig. 3 (Bechlejovice).

1995 *Acer* cf. *decipiens* A. BRAUN; Kvaček and Walther, p. 29, pl. 10, fig. 2 (Suletice-Berand).

Description: Leaves petiolate, petiole up to 34 mm long, blade trilobate, ca. 55 mm long and 65 mm wide, entire-margined or with only small irregular teeth occasionally on the medial lobe as well as on the side lobes, base rounded to sub-cordate.

Remarks: Such nearly entire-margined trilobate maple leaves are typical accessory elements in the volcanic floras, e.g. at Seifhennersdorf (Walther 1967 – as *A. loclense*, Walther 1996), Suletice-Berand (Kvaček and Walther 1995 – as *A.* cf. *decipiens*) and Kundratice (Kvaček and Walther 1998). These maples are also elements of mesophytic forests. We apply the currently accepted species concept given by Walther (1972). Some specimens may form a transition to the *A. monspessulanum* complex (as suggested by Stroebitzer – Hermann, personal communication).

Material: UUG MP 45, 28511; PRC Be 263–265; MMG Ba 318, Ba 434, Ba 452, Ba 485, Ba 490.

Acer palaeosaccharinum STUR

Pl. 1, fig. 1, text-figs. 4.8–11, 5.1–7, 13.23

1867 *Acer palaeosaccharinum* STUR, p. 177, pl. 5, fig. 8 (Tállya).

1953 *Acer palaeosaccharinum* STUR; Procházka, p. 24, pl. 5, fig. 2a (holotype of forma *subdasycarpoides* PROCHÁZKA et BŮŽEK), pl. 6, fig. 1 (Bechlejovice).

1972 *Acer palaeosaccharinum* STUR; Walther, p. 97, pl. 52, figs 1, 4 (Kundratice), 2–3 (Suletice-Berand), 5–7 (Bechlejovice), pl. 53 (Kundratice).

1975 *Acer palaeosaccharinum* STUR; Procházka and Bůžek, p. 48, pl. 20, figs 1–6 (?) 7, ? pl. 21, fig. 2, text-figs 16–17 (Bechlejovice, Suletice).

1975 *Acer palaeosaccharinum* STUR forma *subdasycarpoides* PROCHÁZKA et BŮŽEK, p. 51, pl. 21, figs 1, 3–5, text-fig. 20 (Bechlejovice, Suletice).

Description: Leaves tri- to quinquelobate, 49–90 mm long, 42–79 mm wide, coarsely and sharply dentate, medial lobe narrowing towards the base, leaf size and form rather variable (see Walther 1972, Procházka and Bůžek 1975).

Remarks: Leaves of *Acer palaeosaccharinum* show similarities in gross morphological architecture with *Acer haselbachense* WALTHER (1972). Both species differ in the epidermis structure. While *A. palaeosaccharinum* STUR sensu WALTHER (1972) shows a smooth abaxial cuticle with non-papillate cells around anomocytic stomata, *A. haselbachense* exhibits a papillate leaf underside with distinctly doomed cells around anomocytic stomata. In the material of Kleinsaubernitz (Walther 1999) maple leaves of similar gross morphology are also papillate and hence assigned to *Acer haselbachense*. The latter material is the first record of *A. haselbachense* in volcanic floras. *A. haselbachense* and *A. palaeosaccharinum* grew obviously in different habitats – in riparian forests and mesophytic vegetation, respectively.

Stur (1867) described a fragment of maple foliage as *Acer palaeosaccharinum* from the Middle Miocene of Tállya (Hungary), which is the type locality of this species. Pax (1885, 1902) placed this leaf fragment to section *Palaeosaccharina* PAX. This form from the Neogene should be, in view of Schenk (1890), related to members of section *Platanoidea* PAX. In his opinion, the separation of the members of sections *Palaesaccharina* and *Platanoidea* took place during the Miocene. Kvaček et al. (1994) named maple specimens from the Pliocene of Gérce (Hungary) as *Acer* cf. *palaeosaccharinum* STUR showing a similar gross morphology, which Hably and Kvaček (1997) later compared with *A. subcampestre* GOEPP. and this opinion was also confirmed by Stroebitzer-Herman (personal communication). Engelhardt (1885) described this kind of maple leaves as a new species *Acer subplatanoides* ENGELH. from the Oligocene of Kundratice, followed later by Menzel (1896–1897) for Suletice. First Procházka (1952, 1953) used the name *Acer palaeosaccharinum* for coarsely toothed maple leaves from the volcanic floras of the České středohoří Mts. All later authors dealing with this and adjacent areas, e.g. Knobloch (1961), Mai (1963), Walther (1964, 1972, 1996), Procházka and Bůžek (1975), Kvaček and Walther (1995, 1998, 2001) followed this philosophy and used the same name in the same sense.

In our opinion, it seems likely that *Acer haselbachense* and *Acer palaeosaccharinum* may present a case of parallel evolution in the history of the genus *Acer* L. and require further studies. Some leaf forms with less developed teeth on the lobes (*Acer palaeosaccharinum* forma *subdasycarpoides* PROCHÁZKA et BŮŽEK 1975) are transitional to *A. angustilobum* HEER sensu WALTHER (1972).

Material: UUG MP 42, MP 43, 3735; MMG Ba 140, Ba 142, Ba 149, Ba 311, Ba 332, Ba 514, Ba 516.

Acer tricuspidatum BRONN

Pl. 1, figs 8 (?)–9, text-fig. 3.10

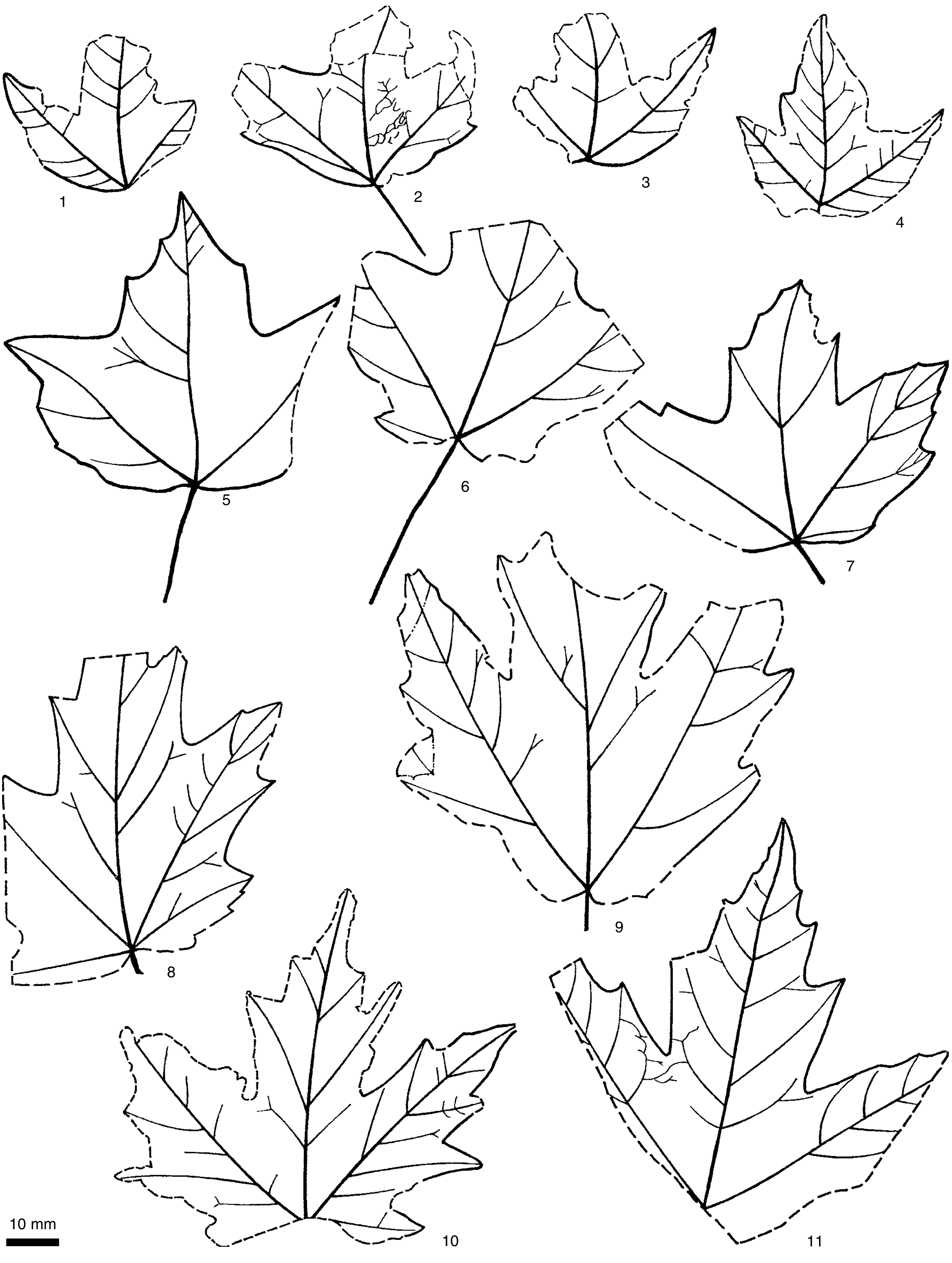
1838 *Acer tricuspidatum* BRONN, p. 865, pl. 25, figs 10a, b (Salzhausen).

1968 *Acer tricuspidatum* BRONN; Walther, p. 636, pl. 1, figs 1–2, pl. 2, figs 1–3 (neotype) (Salzhausen).

1972 *Acer tricuspidatum* BRONN; Walther, p. 57, pls 7–18, pl. 24, figs 5–7, pls 39–51 (Suletice-Berand, Kundratice, Seifhennersdorf, Rott, Münzenberg, Břešťany, Salzhausen, etc.).

1975 *Acer tricuspidatum* BRONN; Procházka and Bůžek, p. 24, pls 22–24, text-figs 2, 3, 4d, 5–13 (Kundratice, Žichov, Suletice, Vršovice, Želénky, Břešťany, Březno etc.).

Description: Leaves petiolate, petiole up to 13 mm long, blade mostly trilobate, rarely sub-quinquelobate, up to 94 mm long, and 125 mm wide, gross morphology and marginal dentation corresponding to the characteristics giv-



Text-fig. 4. 1–7 *Acer integrilobum* WEBER, 1 MMG Ba 434, 2 MMG Ba 485, 3 MMG Ba 430, 4 MMG Ba 452, 5 UUG MP 45, 6 MMG Ba 318, 7 UUG 28 511, 8–11 *Acer palaeosaccharinum* STUR, 8 MMG Ba 149, 9 MMG Ba 321, 10 MMG Ba 392, 11 MMG Ba 514.

en by Walther (1972); one leaf differing in gross-morphology from the main forms, 45 mm long, 42 mm wide, with a broad main lobe and tooth-like lateral lobes.

Remarks: According to the gross morphology, these specimens are of the same type of maple leaves that have been known from other volcanic floras, such as Seifhennersdorf (Mai 1963, Walther 1972), Suletice-Berand (e.g. Kvaček and Walther 1995), Kundratice (e.g. Kvaček and Walther 1998). The characteristic of these above-mentioned remains with cuticular structure preserved differs from the type specimen and other material from the Miocene in the absence of trichomes (see Walther 1972, Stroebitzer-Hermann – personal communication). They may belong most likely to an independent subspecies of *A. tricuspidatum* or even to another species (e.g. *A. dasycarpoides* – personal communication by M. Ströbitzer-Hermann). These Oligocene populations are surely closely related to the typical *A. tricuspidatum* widely distributed in the Neogene, but of different autecology being prevailingly attached to non-swampy habitats. One aberrant specimen reproduced on pl. 1, fig. 8 matches in general the "*productum*" form but differs in the fine regular dentation of the margin similar to the Rosaceae type of foliage.

Material: UUG MP 40; NM ?G 8359; MMG Ba 137, Ba 184, Ba 321.

Acer sp. 1 (fruits)

Pl. 1, fig. 7

1994 *Acer* sp.; Knobloch, p. 67, pl. 1, fig. 4 (Bechlejovice).

Description: A partial samara, seed part compressed, rounded, 5 mm across, attachment scar at angle of about 45° with the curved wing, attachment area between the seed part and the wing wide, wing ovate, 18 mm long and 7 mm wide, the dorsal line strongly curved.

Remarks: This fruit remain seems to be an aberrant specimen, not matching any of the so far described species based on fruits (cf. Mai 1995).

Material: Missing.

Acer sp. 2 (fruits)

Pl. 1, fig. 6

Description: Complete and partial samaras, seed part compressed, rounded, 7–9 mm across, attachment scar as well as both partial fruits at angle of about 30° with the wing, attachment area between the seed part and the wing slightly narrowed, wing elliptic, 21–25 mm long and 9–10 mm wide, the dorsal line slightly curved.

Remarks: Similar fruits can be found in *A. heldreichii* ORPH. from the Balkan Peninsula. It belongs to sect. *Spicata* PAX, which also can be compared with foliage of *A. angustilobum – A. haselbachense* group. On the other hand, there are also similarities with a partial samara of the fossil *Acer schornii* WOLFE et TANAI (1987) from western North America, which was compared with extant *A. saccharum* MARSH.

Material: NM G 8360; PRC Be 253–255.

Ailanthus DESF.

Ailanthus prescheri WALTHER

Pl. 2, figs 1–2

1961 *Myrica lignitum* (UNGER) SAPORTA; Knobloch, p. 256, pro parte, pl. 3, figs 1–2, 8 (Hrazený (= Pirskenberg) at Knížecí).

1995 *Ailanthus* sp. sensu Kvaček and Walther, p. 29, pl. 8, fig. 2 (Suletice-Berand).

1998 *Ailanthus* sp. sensu Kvaček and Walther, p. 6, pl. 4, fig. 4, text-fig. 13.28 (Kundratice).

1999 *Ailanthus prescheri* WALTHER, p. 125, pl. 15, figs 1–4, text-figs 10.1, 16.40 (Kleinsaubernitz).

Description: Fragmentary apex of an elongate leaflet ca. 15 mm wide, narrow acute, widely simple dentate, teeth directed admedially, slightly retroflexed and patent, acute to blunt, sinuses sharp, venation semicraspedodromous, midrib straight, secondaries widely spaced according to the marginal teeth, arch-like, sending abmedial veinlet into the tooth and then touching the margin on sinuses and looping with the intersecondary vein, tertiaries and higher-order veins reticulate.

Remarks: This element of the České středohoří Mts. was assigned to various old species, like *Carya elaenoides* UNGER, *Myrica hakeaefolia* UNGER (Engelhardt 1885, Kvaček and Walther 1998, as *Ailanthus* sp.) and was presently established as a new species of *Ailanthus* (Walther 1999). Its peculiar marginal venation recalls the Juglandaceae rather than the Simaroubaceae and the epidermal structure obtained from the core of Kleinsaubernitz does not give a straight-forward answer as to the affinities. At Bechlejovice only a single fragment was recovered.

Material: NM G 8361a, b.

Alnus MILL.

Alnus gaudinii (HEER) KNOBLOCH et Z. KVAČEK

Pl. 2, figs 5–7, text-fig. 11.6

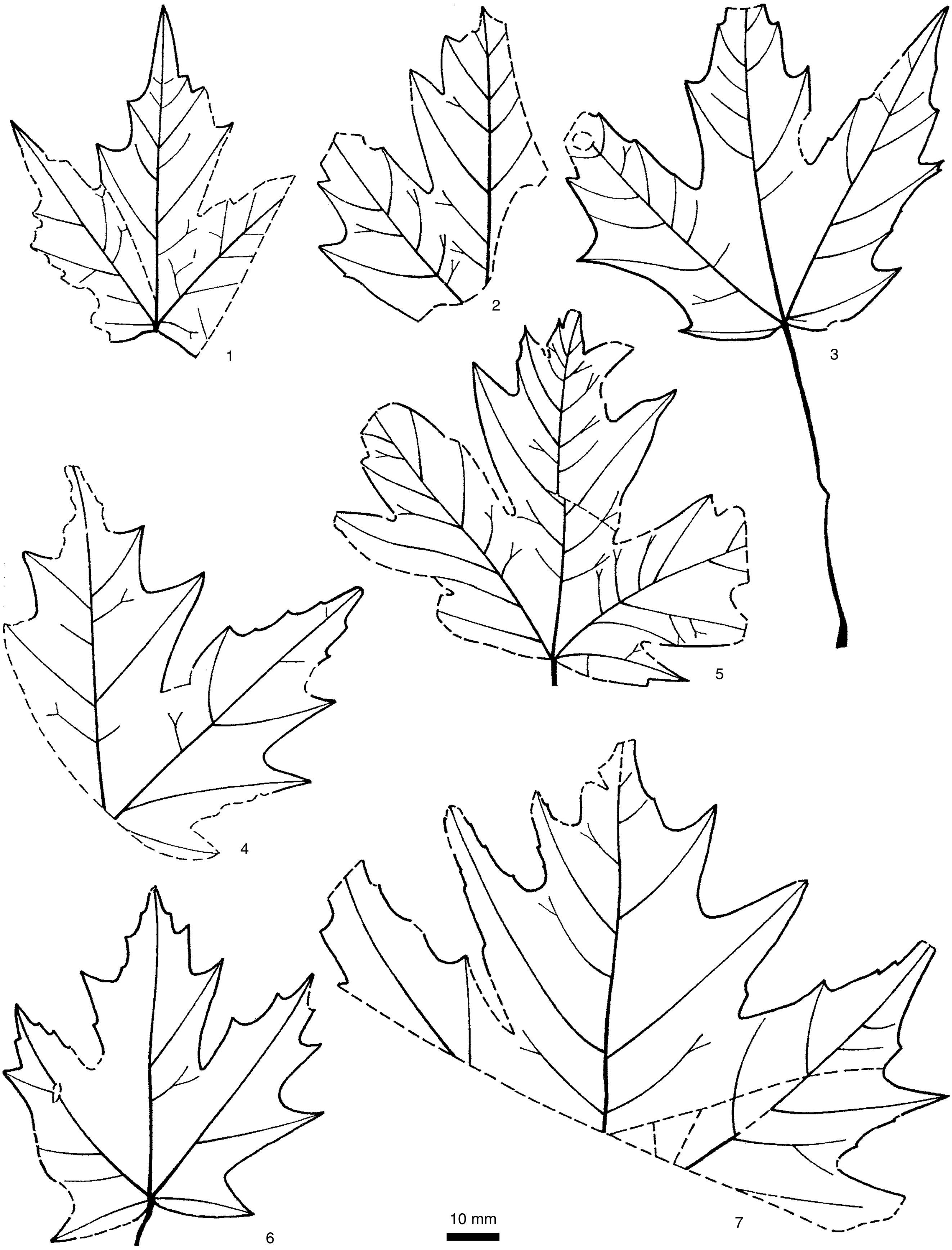
1859 *Rhamnus gaudinii* HEER, p. 79, pl. 124, figs 4–15, pl. 125, figs 1, 7, 13 (Lausanne and other localities).

1976 *Alnus gaudinii* (HEER) KNOBLOCH et Z. KVAČEK, p. 33, pl. 6, figs 1, 3, pl. 7, figs 1, 5, pl. 13, fig. 4, pl. 15, figs 1–4, 7–8, 10–11, 13, 15, 17, pl. 16, figs 1–5, pl. 19, fig. 15, pl. 20, fig. 10, text-figs 11–12 (Wackersdorf).

1998 *Alnus gaudinii* (HEER) KNOBLOCH et Z. KVAČEK; Kvaček and Walther, p. 7, pl. 3, figs 1–3, text-figs 13/4–5 (Kundratice).

For full synonymy see Knobloch and Kvaček (1976, p. 33), Mai and Walther (1988, p. 133), Kvaček and Walther (1998, p. 65).

Description: Leaves oval, long oval to narrow elongate, variable in size, long petiolate, petiole 12–20 mm long, lamina varying in size of 65–110 mm in length and 15–50 mm in width, base cuneate to rounded, apex tapered, margin very fine and almost regularly dentate, teeth small, sometimes with swollen tips, abmedial side concave to straight. Aberrant leaves with emarginate apex due to damage; venation distinctly impressed, craspedodromous to semicraspedodromous, midrib thick, secondaries in up to 10 pairs, sub-opposite, widely spaced, bent, running toward the



Text-fig. 5. **1–7** ***Acer palaeosaccharinum*** **STUR, 1 MMG Ba 516, 2 MMG Ba 311, 3 UUG 3735, 4 MMG Ba 140, 5 MMG Ba 142, 6 UUG MP 42, 7 missing.**

margin, entering the teeth mostly by side veinlets, higher-order venation poorly visible; texture thick, impressions bearing usually coal substance.

Remarks: *Alnus gaudinii* represents an important ± riparian element in the Tertiary floras (Knobloch and Kvaček 1976, Mai and Walther 1988, Belz and Mosbrugger 1994). In the volcanic floras this alder is more abundant only at the locality of Kundratice up to now (Kvaček and Walther 1998). *Alnus gaudinii* is a persistent species with a long stratigraphical span from Early Oligocene to Late Pliocene in Central Europe.

Material: UUG MP 196a, b, 3628, 3669, 3670, 3683, 3688, 3696, 3698; PRC Be 11, Be 13, Be 15–17.

Alnus kefersteinii (GOEPPERT) UNGER (fruits, catkins)

Pl. 2, figs 3–4, text-fig. 11.8

1838 *Alnites kefersteinii* GOEPPERT, p. 564, pl. 41, figs 1–5 (Salzhausen).

1847 *Alnus kefersteinii* (GOEPPERT) UNGER, p. 113, pro parte, pl. 33, fig. 2 (non pl. 33, figs 1, 3–4) (Bílina).

1998 *Alnus kefersteinii* (GOEPPERT) UNGER; Kvaček and Walther, p. 8, pl. 3, figs 5, 6, text-fig. 13.6 (Kundratice).

Description: Cone-like infructescences cylindrical, flattened, 11–15 mm in length, 8 mm in width, long stalked. Male catkins more than 10 mm long and about 8 mm wide with pentaporate pollen *in situ* of the *Alnipollenites verus* – type (J. Dašková, personal communication).

Remarks: These big infructescences of alder must be identified with *Alnus kefersteinii* and belong obviously to the leaves of *Alnus gaudinii* (Kvaček and Walther 1998). Goeppert (1838, as *Alnites kefersteinii*) included into the same taxon also associated male catkins and we follow him in this respect. Unfortunately, the type material of this taxon from Salzhausen has not been critically re-studied.

Material: NM G 8345a, b, G 8362; UUG MP 145, 9149, 9157, 9166; PRC Be 12.

Ampelopsis MICHX.

Ampelopsis hibschii BŮŽEK, Z. KVAČEK et WALTHER

Pl. 3, figs 1–2, text-fig. 11.9

1981 *Ampelopsis hibschii* BŮŽEK, Z. KVAČEK et WALTHER, p. 127, pls 1–6, text-figs 1–7 (Kundratice, Bechlejovice, Suletice-Berand, Haselbach etc.).

Description: Leaves simple, petiolate, petiole up to 20 mm long, blade roundish, ovate, wide-ovate to cordate, base widely cuneate, truncate to obliquely-cordate, mostly asymmetric, 52–100 mm long and 60–70 wide, irregularly and coarsely dentate to lobed or incompletely divided, leaf apex often almost separated from the rest of the lamina (transition to compound leaf type).

Remarks: Leaf impressions have been treated in detail separately together with the material from Kundratice and Haselbach (Bůžek et al. 1981). In comparison with other volcanic localities (Proboštov, Kundratice, Suletice, Seifhennersdorf – e.g. Kvaček and Walther 1998, Walther 1996) all varieties of the leaves in size and form have been found. *Ampelopsis hibschii* is a typical accessory element of the Early Oligocene near-shore and/or basinal lowland vegetation, e.g. in the Weisselster Basin, and also of the volcanic sites of Central Europe with more mesic vegetation (Kvaček and Walther 2001). These characteristic leaf remains are mainly known from the Floral Assemblage Haselbach (Mai and Walther 1978, Walther 1990) while the remains of this sort from the Early Miocene Most Formation (e.g. Kvaček et al. 2004) are fragmentary and equivocal. *Ampelopsis hibschii* was most probably a typical liana in the assemblage of Bechlejovice.

Material: UUG Be 1001A, Be 1001B, Be 1002, Be 1003A, Be 1003B, Be 1004, Be 1005, Be 1006, Be 1007, Be 1008, Be 1009, Be 1010, Be 1011, Be 1012, Be 1013, Be 1015, Be 1018; PRC Be 318a, b.

Ampelopsis sp.

Pl. 3, fig. 3

Description: Leaflet symmetrical, petiolulate, petiolule 10 mm long, thin, lamina broadly obovate, incompletely preserved, ca. 50 mm long and 50 mm wide, base rounded, apex missing, margin coarsely bluntly simple (to double) dentate, lowermost tooth bearing additional much smaller teeth on the abmedial side, otherwise tooth sides straight, sinus angular, venation craspedodromous sub-triveined, midrib slightly bent, lateral primaries opposite, arising well above the blade base under an angle of 40–50°, almost straight, sending widely spaced abmedial side veinlets into secondary teeth, a single pair of preserved secondaries slightly alternate, bent, sub-parallel with the primaries, the lowermost pair of tertiaries very thin, bent, following the course of the margin, the other arising from the midrib irregularly spaced above the lateral primaries, sub-parallel with the secondaries, partly forked, venation of higher orders not preserved.

Remarks: This unique fossil matches in its gross-morphology particularly the leaflets of bipinnate leaves in *Ampelopsis arborea* (L.) KOEHNE from the southern USA. It is true that some other Vitaceae genera, particularly *Cissus* L. and *Rhoicissus* PLANCH. with composed leaves may produce leaflets with a similar venation, but the lateral leaflets are usually strongly asymmetrical and the terminal narrow cuneate at the base. In view of the rarity of this leaf form at Bechlejovice, a more detailed treatment together with Tertiary foliage of the Vitaceae from other sites is planned for the future.

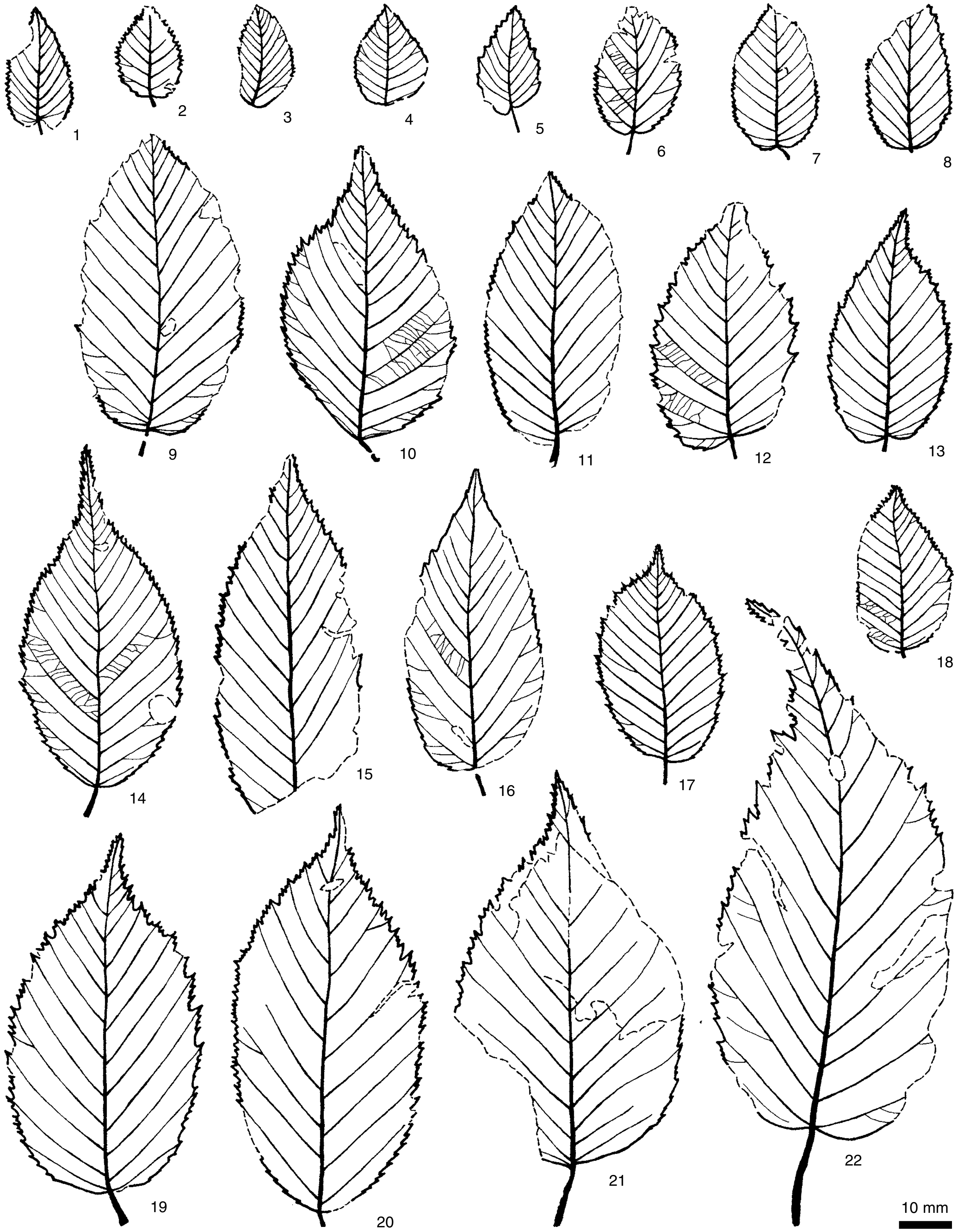
Material: NM G 7176.

gen. inc.

Arecaceae gen. et sp.

Pl. 3, figs 4–5

Description: Large fragments up to 62 mm long and 25 mm wide of monocotyledonous leaves consisting of plicately composed ca. 10 mm wide segments demarcated by slightly raised edges, showing dense parallel venation, par-



Text-fig. 6. 1–22 *Carpinus grandis* UNG. 1 UUG 3525, 2 UUG 3521, 3 UUG MP 53, 4 MMG Ba 414, 5 MMG Ba 513, 6 UUG MP 54, 7 UUG 3523, 8 UUG 3516, 9 UUG 3529, 10 UUG 3538, 11 UUG 3514, 12 UUG 3515, 13 UUG 3520, 14 UUG 3542, 15 UUG 3495, 16 UUG MP 55, 17 UUG MP 7, 18 UUG 3517, 19 UUG 3492, 20 UUG 3578, 21 UUG 3491, 22 UUG 3528.

allel veins almost of the same thickness, 4 per 1 mm, crossveins wavy, widely spaced, oblique, partly forked.

Remarks: Gross morphology of these fragments refers clearly to the Arecaceae foliage. It is difficult to judge the whole architecture of the leaves and therefore we cannot use any of the mopho-taxa of palms, such as *Sabalites, Palmacites* etc. (see Reed and Hickey 1972). Similar remains occur, e.g. at the Early Oligocene flora of Flörsheim (Kvaček 2004, as Monocotyledonae sp. 2). Well-characterised leaves of sabaloid palms (cf. *Sabal major*) were reported from Seifhennersdorf (Walther 1996) and a fan-like leaf of *Sabal* sp. from Hammerunterwiesenthal (Walther 1998).

Material: NM G 8363; UUG MP 131–132 (tuffite).

Betula L.

Betula buzekii Z. KVAČEK et WALTHER

Pl. 4, fig. 1, text-fig. 12.8

1998 *Betula buzekii* Z. KVAČEK et WALTHER, p. 9, pl. 3, figs 8–10 (Kundratice).

Description: Leaves simple, petiolate, petiole 8 mm long, blade ovate, 41–51 mm long, 22–38 mm wide, base widely rounded to slightly subcordate, apex acute, margin double serrate, teeth small, triangular, biconvex with extended tips; venation craspedodromous, midrib straight, secondaries straight, sub-opposite, in 10 pairs, starting from the very base.

Remarks: These leaves match in the gross morphology the type specimens of *Betula buzekii* (Kvaček and Walther 1998). Birch leaf fossils of this kind occur also but rarely at other volcanic sites, e.g. Seifhennersdorf (Mai 1963 as *Betula dryadum*, Walther 1964, 1996 as *B. subpubescens*), Kundratice (Kvaček and Walther 1998), Kleinsaubernitz (Walther 1999 as *Betula kleinsaubernitzensis*).

Material: NM G 3490, G 7191a, b; UUG MP 178, 3490.

fam. inc.

Bryophyta gen. et sp.

Pl. 4, fig. 2

Description: A tuft of sterile stems of a leafy moss with dense, helically disposed phylloids about 1 mm long and 0.4 mm wide, without an apparent structure.

Remarks: Similar remains are extremely rare in the Palaeogene in Europe. More abundant records have been announced from the Middle Eocene of Eckfeld being similar to the specimen described above (Wilde and Frankenhäuser 1998, pl. 1, fig. 2).

Material: NM G 8364.

Carpinus L.

Carpinus grandis UNGER emend. HEER

Pl. 4, figs 3–5, text-figs 6.1–21, 13.2

1852 *Carpinus grandis* UNGER, p. 11, pl. 10, figs 4–5 (non figs 2–3) (Trbovlje, Radoboj).

1953 *Carpinus grandis* UNGER; Procházka, p. 24, pl. 4, fig. 2a (Bechlejovice).

1978 *Carpinus grandis* UNGER; Mai and Walther, p. 69, pl. 7, figs 5–11, pl. 11, fig. 5, pl. 29, figs 1–12 (Haselbach and adjacent sites).

For further synonyms see Mai and Walther (1978).

Description: Twigs with alternate leaves, leaves simple, typically shortly petiolate, petiole 2–11 mm long, blade narrow oblong, oblong-ovate to ovate, 17–110 (typically 34) mm long, 12–45 (typically 33) mm wide, apex acute to shortly acuminate, rarely attenuate, base rarely cuneate, mostly rounded, subcordate to cordate, margin indistinctly double serrate, main teeth slightly longer, rarely more prominent, secondary teeth fine; venation craspedodromous, midrib thick, secondaries dense, in 8–17 (typically 14) pairs, sub-alternate to alternate, straight, at low angles running into the main teeth, sending to margin abmedial veinlets into secondary teeth, intersecondaries lacking, tertiaries percurrent, rarely forked, perpendicular to slightly oblique to the secondaries.

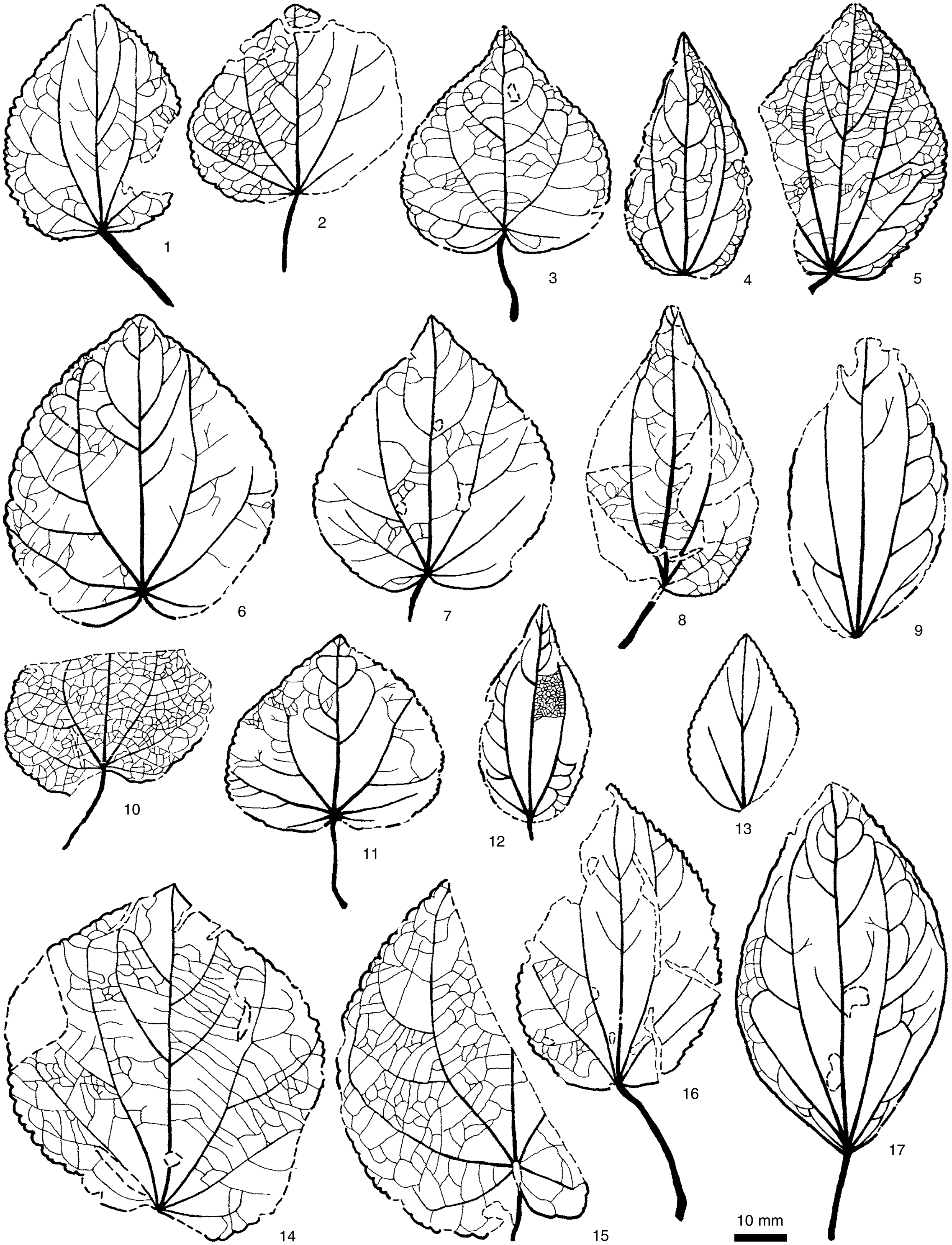
Remarks: According to the gross morphology of leaves this suite of impressions belongs to the formal aggregate unit (morpho-species) *Carpinus grandis* UNGER occurring in Central Europe from the Early Oligocene onwards (e.g. Mai and Walther 1978, 1991, Kvaček and Walther 2001). The variation of the leaves is quite the same as in the population known from the Oligocene flora of Seifhennersdorf (e.g. Mai 1963, Walther 1964, 1996). Some of the leaves are characterized by a cordate base and prominent main teeth of the margin. This type of leaves may represent another species of *Carpinus*. Mai in Mai and Walther (1978) defined two co-occurring natural species of *Carpinus* on the basis of fruit remains: *C. cordataeformis* and *C. mediomontana* from the basinal flora of Haselbach and also from the volcanic flora of Seifhennersdorf. Fruits of *C. mediomontana* occur also at Suletice-Berand and Kundratice (e.g. Kvaček and Walther 1998, 2001). The anatomical structure of the abaxial leaf side may allow the distinction between the natural species in cases when it is available (Walther in Mai and Walther 1991). Due to uniform leaf morphology among species of *Carpinus*, the differentiation according to gross morphology is difficult. A small branch of 60 mm length with three attached leaves and buds is an important specimen coming from Bechlejovice. The branch demonstrates again the autochthony of this leaf assemblage. The hornbeam foliage is more frequent at Bechlejovice than at Kundratice (see Kvaček and Walther 1998). At Seihennersdorf, the *Carpinus* foliage is absolutely dominant. The distinction from *Ostrya* is sometimes equivocal, mostly expressed in the character of the shorter and more delicate teeth in *Carpinus* vs. more distinctly double serrate margin with long mucronate teeth in *Ostrya*.

Material: UUG MP 7–8, MP 53–54, MP 191–192, MP 143, MP 195, MP 197a–c, 3491, 3492, 3493, 3495, 3514, 3515, 3516, 3517, 3520, 3521, 3522, 3523, 3524, 3525, 3527, 3528, 3529, 3538, 3542, 3578, 3734; MMG Ba 33, Ba 239, Ba 414, Ba 513.

Carpinus cordataeformis MAI (fruits)

Pl. 4, figs 6–7

1963 *Carpinus cordataeformis* MAi sensu stricto, p. 55, pro parte, pl. 4, figs 1–2, text-figs 6a, b (non c–d) (Seifhennersdorf).



Text-fig. 7. 1–17 *Cercidiphyllum crenatum* (UNG.) R. BROWN, 1 UUG 3663, 2 UUG 3659, 3 UUG 3486, 4 UUG MP 58, 5 UUG 3482, 6 UUG 3709, 7 UUG 3655, 8 UUG MP 56, 9 UUG 104, 10 UUG 3657, 11 UUG 3487, 12 UUG MP 58, 13 UUG 9142, 14 UUG 3478, 15 UUG 3479, 16 UUG 3662, 17 UUG MP 57.

1978 *Carpinus cordataeformis* MAI in MAI et WALTHER, p. 67, pl. 28, figs 13–15 (Haselbach).

Description: Involucres oval to ovate, 12–23 mm long, 4–12 mm wide, almost entire, only in the apex region some small teeth present, primary veins 4 to 7, sometimes in the upper part forked, straight to slightly curved in the apex region, fruit about 2.5 mm long.

Remarks: The available specimens match the type material from Seifhennersdorf (Mai 1963). This rare species is only known from Seifhennersdorf and Bechlejovice.

Material: NM G 8382; UUG MP 146, MP 149, MP 180a.

Carpinus mediomontana MAI (fruits)

Pl. 4, fig. 8, text-figs 12.12, 13.13, 13.19

1963 *Carpinus cordataeformis* MAI, p. 55, pro parte, pl. 4, figs 3–4, text-figs 6c–d (Seifhennersdorf).

1978 *Carpinus mediomontana* MAI in MAI et WALTHER, p. 68, pl. 6, figs 6a–c, d (holotype), e–g, pl. 28, figs 21–27 (Haselbach).

1994 *Carpinus cordataeformis* MAI; Knobloch, p. 65, pl. 1, fig. 6 (Bechlejovice).

1998 *Carpinus mediomontana* MAI; Kvaček and Walther, p. 10, pl. 4, fig. 15 (Kundratice).

Description: Fragmentary infructescence with alternate, patent fruits, detached involucres 17–24 (typically 21) mm long, 7–11 (typically 9) mm wide, narrow ovate, coarsely serrate and asymmetrical, often with a side lobe, about 5 basal veins radiating from the base, craspedodromous, entering the teeth, fruits ovoid, strongly compressed, about 3.5 mm long and 5 mm wide.

Remarks: The involucres are rare in the flora of Bechlejovice and most of them match *C. mediomontana* MAI in MAI et WALTHER (1978) from the Lower Oligocene of the Weisselster Depression (Floral Assemblage Haselbach).

Material: UUG MP 147–148, 3518, 9145, 9161; Teplice Mus. s.n.; PRC Be 317a, b.

Carpinus (vel *Ostrya*) sp. (male catkins)

Pl. 4, fig. 9

Description: Narrow male catkins ca. 40 mm long, with pollen *in situ* of the *Carpinus – Ostrya* type.

Remarks: J. Dašková (personal communication) was able to identify this kind of catkins according to the pollen type found *in situ*. The impressions/compressions do not show gross morphological features diagnostic for each genus, but in view of much higher frequency of *Ostrya* at Bechlejovice, the affinity to this genus is more probable.

Material: NM G 8365.

Carya NUTT.

Carya cf. ***serrifolia*** (GOEPPERT) KRÄUSEL

Pl. 5, figs 1–4

? 1855 *Quercus serrifolia* GOEPPERT, p. 17, pl. 5, fig. 14 (Sośnica).

? 1921 *Carya serrifolia* (GOEPPERT) KRÄUSEL, p. 389, pl. 5, fig. 2 (Sośnica, Ruppersdorf = Wyszonowice).

1963 *Carya serrifolia* (GOEPPERT) KRÄUSEL; Mai, p. 53, pl. 3, figs 6–11 (Seifhennersdorf).

1964 *Carya serrifolia* (GOEPPERT) KRÄUSEL; Walther, p. 32, pl. 9, 10, figs 1–3 (Seifhennersdorf).

1974 *Carya* cf. *serrifolia* (GOEPPERT) KRÄUSEL; Walther, p. 143, pls 1–3, pl. 4, figs 1–4, text-figs 1–3 (Seifhennersdorf).

1995 *Carya serrifolia* (GOEPPERT) KRÄUSEL; Kvaček and Walther, p. 31, pl. 4, fig. 3, pl. 6, figs 2–3, text-fig. 4.9 (Suletice-Berand).

1998 *Carya serrifolia* (GOEPPERT) KRÄUSEL; Kvaček and Walther, p. 11, pl. 4, fig. 5, text-fig. 13.40 (Kundratice).

Description: Leaves incomplete, detached lateral leaflets more or less asymmetrical or rare terminal symmetrical, sessile or sub-sessile, narrow oval to lanceolate, 35–120 mm long, 14–37 mm wide, maximum width in the lower third, apex acute, sometimes acuminate, rarely rounded, base mostly distinctly asymmetrical, cuneate to almost rounded, margin irregularly finely toothed, density of teeth 5 per 10 mm, teeth sharp, slightly flexuous, sinus angular; venation craspedodromous to mixed semicraspedodromous, midrib medium strong, almost straight or slightly curved, secondaries opposite or subopposite to alternate, at an angle of almost 90° to ca. 30°, depending of the position in the lamina and the width of the leaflet, in 14–18 pairs, in larger leaves straight, often forked and ending in the teeth, or also looping close to the margin, sending side veinlets, in narrower leaves slightly bent, intersecondaries one between two secondaries reaching maximum one third of the distance to margin, tertiaries very thin, mostly poorly visible, slightly oblique to secondaries, mostly percurrent, higher-order venation areolate.

Remarks: This suite of *Carya* foliage matches perfectly that from Seifhennersdorf, which was also characterised in respect of epidermal anatomy (Walther 1974). At this occasion Walther (1974) demonstrated that none of the representatives from North America fully corresponds with the fossil remains. It is also true for co-occurring fruits (Mai 1963, as *Carya* cf. *costata*, Mai 1981, as *C. quadrangula*), which belong to the East Asiatic *C. poilanei* group. Because the type and topotypical specimens from Sośnica have not been newly revised and their leaf anatomy is up to now unknown, the open nomenclature is applied following the approach of Walther (1974).

Material: NM G 7190, G 7189, G 7179a, b, G 7182; UUG MP 50–52, MP 66, MP 151a, MP 155–158, MP 160–161, MP 162b, MP 163–168, MP 170, MP 180b, 3704.

Carya sp.

Pl. 5, fig. 5

Description: Leaflets slightly asymmetrical, subsessile, lamina obovate to elliptic, 57–65 mm wide, 95 to ca. 140 mm long, base rounded to cuneate, asymmetrical, apex fragmentary, acute, margin serrate – dentate, teeth irregular, sharp, often mucronate, sinuses sharp or slightly rounded, venation semicraspedodromous, midrib strong at the base, much slender towards the apex, secondaries in 10 pairs (the basal pair very short, thin), at a wide angle, on one side slightly steeper, irregularly spaced, curved towards the margin, forked, looping and sending outer veinlets into teeth, tertiaries admedially oblique, arch-like, percurrent, widely spaced, higher-order veins poorly visible.

Remarks: Such large leaflets of the *Carya* type are rare in the volcanic floras (? at Seifhennersdorf). Without remains of the cuticle we hesitate to identify it with any species. Surprisingly similar foliage has been known from the Early Palaeogene of Far East as *Carya grandidentata* ILJINSKAJA et BUDANTSEV (in Budantsev 1994).

Material: NM G 6837a; UUG MP 130.

Cercidiphyllum SIEB. et ZUCC.

Cercidiphyllum crenatum (UNGER) R. BROWN

Pl. 6, figs 1–4, text-figs 7.1–17, 12.11, 12.15, 13.3

1850a *Dombeyopsis crenata* UNGER, p. 448, basionym (Hoher Rhonen).
1935 *Cercidiphyllum crenatum* (UNGER) R. BROWN, p. 575, pl. 68, figs 1, 9, 10 (Bridge Creek, Republic).
1953 *Cercidiphyllum crenatum* (UNGER) R. BROWN; Procházka, p. 24, pl. 5, fig. 1a (Bechlejovice).
1953 *Philadelphus* sp. sensu Procházka, p. 14 (Bechlejovice).
1996 *Cercidiphyllum crenatum* (UNGER) R. BROWN; Kvaček and Konzalová, p. 149, pl. 1, figs 1–2 (Bílina Mine), 3 (Hoher Rhonen), 4 (Bechlejovice), pl. 2, figs 2–3 (Bechlejovice), 4–8 (Bílina Mine), pl. 3, figs 3–7 (Bílina Mine), pl. 4 (Bílina Mine).
2000 *Cercidiphyllum crenatum* (UNGER) R. BROWN; Hably et al., p. 63, pl. 2, figs 1–3 (Bechlejovice).
For further synonyms see Jähnichen et al. (1980).

Description: Fertile branch with alternate brachyblasts and attached fruits, leaves long petiolate, with petiole up to 17 mm long, dimorphous, blade 72–31 mm long, 15–50 mm wide, mostly rounded, cordate with rounded to widely acute, blunt apex, rarely widely ovate to lanceolate, only 12 mm wide with acute apex and rounded base; transitions between both extreme forms rare, margin crenulate to glandular crenulate; venations actinodrome to brochidodromous, 3–5 (–7) basal primaries starting from the very leaf base, secondaries rare, forming loops along the margin, tertiaries oblique. Fruits in cluster of 2–4, spindle-like bluntly pointed follicles.

Remarks: C*ercidiphyllum crenatum* is known from most volcanic floras, e.g. Markvartice (Bůžek et al. 1976), Seifhennersdorf (Jähnichen et al. 1980, Walther 1996), Kundratice (Kvaček and Walther 1998) and Bechlejovice (Kvaček and Konzalová 1996). The populations from the České středohoří Mts. match well with the other records from the Northern Hemisphere, but the one from Bechlejovice is extreme in the leaf dimorphy, unlike modern *Cercidiphyllum* SIEBOLD et ZUCCARINI (see Jähnichen et al. 1980, Kvaček and Konzalová 1996). Some of the extremely narrow forms are difficult to differentiate from *Ziziphus ziziphoides* and have not been encountered elsewhere. Procházka (1953) believed to assign them to *Philadelphus.* Some others have been assigned to *Cinnamomum polymorphum* (Procházka, in sched.). Principally similar but much larger leaf fossils were described from the Lower Oligocene of Kazakhstan as *Populus arnaudii* (SAPORTA) ILJINSKAJA (1963), partly associated with typical rounded leaves of *Cercidiphyllum* (Iljinskaja 1986). *C. crenatum* occurs more frequently at Kundratice and also at Bechlejovice in contrast to the coal-bearing localities Seifhennersdorf and Markvartice. The fertile twig from Bechlejovice (Kvaček and Konzalová 1996) corroborates the connection of foliage and fruits. The alternate arrangement of brachyblasts is not unusual for the extant species (Z. K. personal observation) and has been found in another rich fossil occurrence at Köflach (Kovar-Eder et al. 1998).

Material: NM G 8366; UUG 104, MP 33, MP 35, MP 56, MP 69–73, MP 80–86, MP 139–142, 3467, 3476, 3475, 3478, 3481, 3482, 3484, 3485, 3486, 3488, 3655, 3656, 3660, 3662, 3663, 9139, 9140, 9142, 9144, 9145, 9174, 9142, 9145, 9150, 9167, 9168, 9177, 9181; MMG Ba 96, Ba 366.

Comptonia L'HÉRIT.

Comptonia cf. *difformis* (STERNBERG) BERRY

Pl. 7, fig. 1, text-fig. 12.2

1994 aff. *Comptonia* cf. *latiloba* (HEER) KNOBLOCH, p. 65 (Bechlejovice).

Description: Apical parts of pinnatifid leaves, incompletely preserved, 30 mm long, 20 mm wide, segments rhombic triangulate, almost entire-margined, with indistinct solitary teeth on the tip of lobes, obliquely orientated to the midrib, venation rarely visible, semicraspedodromous, midrib stout, strong, secondaries in number of the lobes, under an angle of 40–35°, forked near the lobe tip, abmedial veinlet ending in the lobe tip, the admedial veinlet looping with an adjacent intersecondary vein.

Remarks: *Comptonia* leaves are very rare in volcanic floras (e.g. Knobloch 1961 – Hrazený at Knížecí). The fragments studied are comparable with the specimen described by Walther (1999) from Kleinsaubernitz as *Comptonia difformis* (STERNB.) BERRY.

Material: UUG MP 10, MP 128.

Cornus L.

Cornus studeri HEER

Pl. 6, figs 5–7, text-fig. 12.5

1859 *Cornus studeri* HEER, p. 27, pl. 105, figs 18–21 (Monod, Eriz etc.).
1995 *Cornus studeri* HEER; Kvaček and Walther, p. 31, pl. 8, fig. 7, text-fig. 4.8 (Suletice-Berand).
1998 *Cornus studeri* HEER; Kvaček and Walther, p. 12, pl. 4, fig. 9, text-figs 6, 13/31 (Kundratice).

Description: Leaves simple, shortly petiolate, petiole 7–13 mm long, lamina ovate to oval, 32–80 and more mm long, 15–65 mm wide, entire-margined, apex acuminate, base cuneate, sometimes shortly decurrent, venation eucamptodromous, midrib straight, anomaly forked, in one branch reaching the apex, secondaries bent, closely spaced, in 5–7 sub-opposite pairs, at a narrow angle, sometimes steeply forked, the basal pair sometimes reaching over the two thirds of the lamina sub-parallel to the margin, the uppermost two pairs sub-parallel with the midrib, tertiaries not visible, lamina probably firm.

Remarks: This is a rare element typical of the České středohoří Mountains (Kundratice, Suletice-Berand, Hrazený hill at Knížecí). The exact affinities within the Cornaceae remain equivocal, even if the epidermal anatomy is available (Kvaček and Walther 1998).

Material: NM G 7163, G 7169 G 7167, G 8358; UUG MP 179, MP 194b, MP 202a, b, 3629, 3622, 3668, 3671, 3684, 3687, 9178.

Craigia W. W. SMITH et EVANS

Craigia bronnii (UNGER) Z. KVAČEK, BŮŽEK et MANCHESTER (fruits)

Pl. 9, figs 5–7, text-fig. 13.10

1845 *Ulmus bronnii* UNGER, p. 79, pro parte, pl. 25, figs 2–4 (non fig. 1) (Bílina).

1848 *Pteleaeocarpum bronnii* (UNGER) WEYLAND, p. 130, pl. 21, fig. 5, text-figs 5–9 (Rott).

1991 *Craigia bronnii* (UNGER) Z. KVAČEK, BŮŽEK et MANCHESTER, p. 522 (Bílina).

Description: Detached capsule valves elliptic, obovate to rounded, 7–19 (mean 12.4) mm long and 6–20 (mean 9.5) mm wide, sometimes emarginate at the apex, with a fusiform central locule and peripheral wing, exceptional one bead-like seed or two undeveloped very small seeds attached to the central side of septum. Wing venation radially disposed, reticulate, rows of areoles perpendicular from the septum to the wing periphery in the lower half of the fruit, steeper oblique along the margin of the wing in the apical part. No remains of the stalk seen.

Remarks: The fruit remains of *Craigia*, widely spread in the Northern Hemisphere Tertiary (Bůžek et al. 1989, as *Pteleaecarpum*), are quite uniform in the morphology of the detached valves, which originally formed 5-winged capsules (Kvaček et al. 2002). The species differences are better expressed in the associated foliage, which are in the case of *C. bronnii* obviously the leaves of *Dombeyopsis lobata* (Kvaček 1993). The type population from the localities at Bílina (Břešťany Clay) produced in general larger fruits than that encountered at Bechlejovice. As the capsules studied are obviously mature, i.e. disintegrated, the size difference might not be due to stages of maturity. Such ontogenic variation was found at Hambach, where very small immature carpels to bigger fruits were preserved as complete capsules (Kvaček et al. 2002). In the case of the Bechlejovice population, we may deal with an ancestor taxon to the Early Miocene population from Bílina. A closer relationship can be expected to that from the Early Oligocene site Kiin-Kerish in Kazakhstan, called *Rutaceites zaisanicus* ILJINSKAJA (1963), which matches perfectly both in the form and the size. Unfortunately, no information about foliage belonging to this plant is available in the latter case.

Material: NM G 8367a, b, G 8368–8369; PRC more than 40 specimens s. n.

Crataegus L.

Crataegus pirskenbergensis KNOBLOCH

Pl. 7, figs 2–5

1961 *Crataegus pirskenbergensis* KNOBLOCH, p. 279, pl. 8, figs 7–8 (Hrazený hill at Knížecí).

1994 *Crataegus* cf. *pirskenbergensis* KNOBLOCH; Knobloch, p. 75, pl. 1, fig. 9 (*Crataegus* sp. in figure captions) (Bechlejovice).

2000 *Crataegus pirskenbergensis* KNOBLOCH; Hably et al., p. 63, pl. 2, fig. 11 (Bechlejovice).

Description: Leaves simple, slightly asymmetrical, petiolate, petiole (9–) 12 to 44 mm long, lamina pinnatifid to pinnatilobed, widely ovate, 25–55 (–75) mm wide and 45–70 (–90) mm long, with three lobes on each side and sharp to narrow rounded sinuses, apex bluntly acute, base rounded to truncate, sometimes slightly decurrent on the petiole, margin entire on the base, higher above widely coarsely double dentate-lobed, venation craspedodromous, midrib almost straight, 2 to 5 pairs of secondaries widely spaced, sometimes with thin intersecondaries, lower pair stronger, reaching the lobes, secondaries within lobes at a wide angle, details of venation not visible, texture thin.

Remarks: *Crataegus* leaves are very rare in the volcanic floras in North Bohemia (Hrazený, Kundratice). The specimens studied vary as to the depth of dissected marginal lobes and sometimes even their directions and the number. According to Knobloch (manuscript notes), *C. pirskenbergensis* is identical with *C. praemonogyna* KRYSHT. from the Middle Miocene.

Material: NM G 7215; UUG MP 1–3, MP 62, MP 64–65, MP 150.

Cyclocarya ILJINSKAJA

Cyclocarya sp.

Pl. 8, figs 1–4, text-fig. 12.14

1991 *Cyclocarya cyclocarpa* (SCHLECHTENDAL) ILJINSKAJA corr. Knobloch; Mai and Walther, p. 72, pro parte (foliage only), pl. 36, figs 2–4, pl. 37, figs 1–8, text-figs 6.4–8 (Bockwitz).

Description: Leaves composed, imparipinnate, incomplete, about 130 and more mm long and 135 mm wide, with three pairs of opposite leaflets at an angle of 90 to 37°, lateral leaflets very shortly petiolulate, petiolules 1–1.5 mm long, terminal leaflet with 10 mm long petiolule, lamina oblong to ovate, rarely lanceolate, 40–120 mm long and 25–45 mm wide, apex acuminate, base rounded (to cuneate in terminal leaflets), only partly slightly asymmetrical, margin finely toothed, slightly irregular, teeth shortly mucronate, slightly flexuous to retroflexed, ca. 6 per 10 mm, venation semicraspedodromous, midrib strong, mostly straight, secondaries delicate, in up to 18 mostly opposite or sub-opposite pairs, at an angle of 60° or rarely to 30°, almost straight or slightly bent, looping along the margin and sending series of side veinlets into teeth, intersecondaries occasionally present one per two adjacent secondaries, tertiaries poorly preserved, slightly oblique, anastomosing, sometimes forked, ca. 12–14 per 10 mm, higher-order venation reticulate.

Remarks: We do not share the opinion of the previous authors (Schlechtendal 1897, Iljinskaja 1953, Mai and Walther 1991) to combine the fruits and foliage under the same species name (*Pterocarya cyclocarpa*, *Cyclocarya cycloptera* or *C. cyclocarpa*). Our specimens of leaves are more similar to those that accompany the fruits in the Weisselster Depression than the leaf fossils assigned to this genus from Knížecí (Knobloch 1961) and Seifhennersdorf (Mai 1963) with craspedodromous venation. In connection with this discrepancy we can refer to the leaves accompanying *Cyclocarya* fruits in the North American Paleocene (Manchester 1987, as "*Pterocarya*" *hispida*) showing the same kind of marginal venation as in our case.

Material: UUG MP 46–49, MP 169, MP 175, MP 193a, b; MMG Ba 472.

Dicotylophyllum SAPORTA

Dicotylophyllum deichmuelleri Z. KVAČEK et WALTHER

Pl. 10, figs 1–3

1998 *Dicotylophyllum deichmuelleri* Z. KVAČEK et WALTHER, p. 14, pl. 6, figs 7–12, text-fig. 13/7 (Kundratice).

Description: Leaves elongate, shortly petiolate, petiole 3.5–4.0 mm long, lamina ca. 14–20 mm wide and 32–42 mm long, widely inconspicuously crenate, teeth very low, probably glandular, blunt, base cuneate, apex blunt acute, venation semicraspedodromous, midrib stout, straight, secondaries regularly widely spaced, in 5–6 opposite pairs, at an angle of ca. 60°, bent, at first straight, further slightly curved angular in the course, sending admedial veinlets into the teeth, tertiaries admedially oblique to the secondaries, faintly preserved.

Remarks: These leaf impressions of variable size match the type material mainly in the kind of the margin. They vary in the form; one leaf belongs to the slender leaf forms of *D. deichmuelleri,* the other to wider forms characterised on the basis of several specimens from Kundratice (Kvaček and Walther 1998). Similar impressions from the Neogene were described as *Evonymus latoniae* UNG. and *Quercus gmelinii* UNG. from Parschlug, Styria (see Unger 1850a, 1852, Kovar-Eder et al. 2004). In spite of the preserved cuticle structure of the type material the affinity of this very characteristic element of the Palaeogene floras of the České středohoří Mountains is still vague. Although the leaves vary from slender to wider forms, they are always inconspicuously bluntly and widely toothed and shortly petiolate. Besides the specimens from the type locality of Kundratice and those described above, similar leaf forms occur also in the Suletice-Berand flora (see Engelhardt 1898, pl. 2, figs. 12, 22 – as *Euonymus latoniae*; Kvaček and Walther 1995, pl. 8, fig. 4, as "*Elaeodendron*" sp.) and elsewhere in the České středohoří Mountains. The paracytic stomata with not sunken guard cells suggest that the leaves may belong to the Symplocaceae (see also Z. Kvaček 2004).

Material: NM G 8370, G 8371; UUG MP 29.

Dicotylophyllum heerii (ENGELHARDT) Z. KVAČEK et WALTHER

Pl. 10, figs 4–5

1885 *Euonymus heeri* ENGELHARDT, p. 48, pl. 15, fig. 3, basionym (Kundratice).

1998 *Dicotylophyllum heeri* (ENGELHARDT) Z. KVAČEK et WALTHER, p. 14, pl. 6, figs 3–6, text-figs 7–8, 13/28 (Kundratice).

Description: Leaves petiolate, petiole thin, slightly oblique to the course of the midrib, 7–11 mm of the preserved length, lamina elongate, 52–92 mm long and 20–35 mm wide, rounded at base, apex acuminate, margin shallowly crenulate to sub-entire, teeth rounded on the top, admedially appressed, venation semicraspedodromous, midrib thin, straight, secondaries regularly spaced, at an angle of 65–70°, looping along the margin and sending abmedial veinlets towards the teeth, interseconaries present one between two adjacent secondaries, tertiary and higher-order venation seen at places as polygonal areoles.

Remarks: This type of leaves has commonly been collected at the site of Kundratice. We are unaware of its occurrence outside the area of the České středohoří Mountains. A wider comparative study is needed to elucidate its affinities. The lamina tissue is sometimes in dark colour and may suggest at least a firm texture. Similar crenulate teeth can be found among various species of *Prunus* and also in the fossil morpho-genus *Pruniphyllum* WEYLAND (1948) based on the material from Rott.

Material: NM G 8372; UUG MP 125–127, MP 176a, b, MP 190.

Dicotylophyllum sp. 1

Pl. 10, fig. 7

Description: Leaf simple, subtrilobate, long petiolate, petiole 20 mm long, lamina broad ovate, ca. 80 mm long and 48 mm wide, apex acuminate, base subcordate, margin irregularly double serrate, large lateral main teeth forming short lobes, and 5 smaller main teeth, slightly biconvex, interspaced with fine secondary teeth starting from the very base, a few between higher main teeth, sinus sharp, venation craspedodromous, midrib strong, straight, secondaries subopposite to opposite, in 6 pairs, at an angle of 30–50°, after the first short bending straight, ending in the main teeth, the lowermost secondaries giving off abmedial side veinlets into secondary teeth or even sinuses, tertiary ca. 5 per 10 mm, oblique to the secondaries, partly forked, higher-order veins not preserved.

Remarks: We are uncertain, to which family this unique leaf impression belongs; the main teeth recall Ulmaceae. According to E. Knobloch (in scheda), an affinity to Vitaceae can also be suspected.

Material: UUG 9079.

Dicotylophyllum sp. 2

Pl. 10, fig. 8, text-fig. 11.4

Description: Leaf (? leaflet) fragment, lamina slightly asymmetric, probably broadly ovate, ca. 67 mm long, reconstructed width ca. 53 mm, apex acuminate rounded, slightly emarginate, base missing, margin finely lobed, lobes slightly emarginate, entire, admedially oriented, 3 preserved, venation semicraspedodromous, midrib thinly tapered, secondaries bent, alternate, in 6 preserved pairs, at an angle of 35–60°, looping at margin, partly two adjacent secodaries terminally fused, tertiaries coarsely areolate.

Remarks: At first sight the leaf fragment recalls an aberrant specimen of *Ampelopsis hibschii* described above. Against this determination there are several venation characters and the form of the margin.

Material: NM G 8349.

Dicotylophyllum sp. 3

Pl. 11, fig. 1

Description: Leaf simple, shortly petiolate, petiole 5 mm, lamina ovate lanceolate, ca. 33 mm long, 13 mm wide, apex acuminate, incompletely preserved, base cuneate, slightly asymmetrical, margin irregularly crenulate, teeth very shortly mucronate, glandular near the sinus, sinuses sharp angular, venation semicraspedodromous, midrib straight and strong, secondaries subopposite, in about 10 pairs, forked before the margin and sending one branch into sinuses, sometimes into the teeth, tertiary and higher-order venation reticulate.

Remarks: No suggestions. Probably not related to Ulmaceae, although the leaf recalls *Cedrelospermum* in the marginal teeth.

Material: UUG MP 37.

Dicotylophyllum sp. 4

Pl. 11, fig. 2

Description: Leaflet (?) probably sessile, lamina asymmetrical, narrow ovate, ca. 83 mm long and 32 mm wide, apex missing (? acute), base rounded to subcordate, margin almost entire, with widely spaced tiny sharp (? glandular) spreading teeth, venation camptodromous – semicraspedodromous, midrib straight, strong, secondaries opposite to alternate, in 8 pairs, at an angle of 30–40°, gently curved towards margin forming two series of loops very close to the margin, sending solitary side veinlets into teeth, intesecondaries solitary, looping with secondaries, tertiaries and higher order venation reticulate.

Remarks: Affinities uncertain on the basis of the characteristics available (? possibly Juglandaceae).

Material: NM G 7193.

Dicotylophyllum sp. 5

Pl. 11, figs 3–4

Description: Leaf lanceolate, incomplete, ca. 73 mm long, 18 mm wide, base narrow cuneate, apex acuminate, with elongate “drip-tip”, teeth narrow sharp mucronate, with admedially hooked mucro, irregularly spaced, slightly double size, venation craspedodromous, midrib straight, secondaries widely spaced, alternate, curved upwards, in ca. 5 pairs, at an angle of 17–30°, abmedially forked, side veinlets entering the teeth, no interscondaries, tertiartiary veins poorly visible, anastomosing between the secondaries, sometimes forked.

Remarks: Such a combination of the leaf apex, the form of the margin and the secondaries is quite characteristic. Similar forms used to be assigned to *Quercus*. Still we are reluctant to assign this single specimen to a plant family suitable for matching. The material at hand is certainly not sufficient to show the variation of this interesting plant.

Material: NM G 8374.

Dicotylophyllum sp. 6

Pl. 10, fig. 6

Description: Leaf simple, shortly petiolate, petiole 2 mm long, lamina incomplete ? ovate, ca. 30 mm wide, length and apex not preserved, base subcordate, margin widely coarsely toothed, only two straight teeth preserved, venation triveined, craspedodromous, midrib straight, thin, lateral primaries slightly bent, S-like abmedially curved at the end before entering the tooth, secondaries alternate.

Remarks: No suggestions as to the affinities.

Material: NM G 8373.

Dicotylophyllum sp. 7

Pl. 11, fig. 5

Description: Leaves subsessile (?), elliptic, 25–30 mm wide, ca. 80 mm long, entire-margined, base cuneate, apex rounded, venation brochidodromous, midrib somewhat wavy, at the end very thin, secondaries arch-like, mostly irregularly widely spaced, alternate, thin, in 4 pairs, at an angle of 35–45°, looping in a series of thin loops along the margin, intersecondaries present sometimes more between two secondaries, tertiaries irregularly oriented, forked and widely spaced, forming with higher-order veins hardly visible irregular network.

Remarks: Similar leaves are produced by some oaks, e.g. *Quercus inopina* ASHE, a single-stemmed evergreen shrub to small tree of Florida, but also by a number of other woody plants (*Guettarda elliptica* SW., Rubiaceae or some legumes, etc.).

Material: NM G 8375a.

Diospyros L.

Diospyros sp.

Pl. 11, figs 7–9, text-fig. 11.10

Description: Leaves simple, petiolate, petiole ca. 5 mm long, lamina ovate to elliptic, 25–45 mm wide, 50 to more than 100 mm long, entire-margined, margin not thickened, apex acute, base cuneate, shortly decurrent, venation camptodromous, midrib strong, straight, secondaries in ca. 5–7 pairs, lowermost thin, arising from the base, higher alternate to sub-opposite, regularly widely spaced, slightly curved and looping along the margin, lower secondaries with outer loops, intersecondaries up to three, tertiaries slightly oblique, alternate, partly forked, widely spaced, curved, texture thin.

Remarks: With this characteristic of gross-morphology we are unable to decide unequivocally the systematic position, although the leaves most probably belong to calyces of the *Diospyros* type described below. We are against the method to combine two organs without any further proves besides the association, as Braun (1845), Heer (1859), Hantke (1954) and Bůžek (1971) applied for this kind of the remains. In spite of a very critical approach by Bůžek (1971), the leaf forms assigned by him to *Diospyros brachysepala* from Čermníky are rather variable and differ from those occurring at Bechlejovice and Öhningen (see Heer 1859, pl. 102, figs 1–9, 16–18) in a broader and shorter form and smaller size. We anticipate that the calyces may not be so characteristic to allow differentiation at the species level, being quite uniform throughout the genus.

Material: UUG MP 6, MP 38, MP 74–77, MP 153, 3706, 3641.

Diospyros brachysepala A. BRAUN (calyces)

Pl. 11, fig. 6

1845 *Diospyros brachysepala* A. BRAUN, p. 170, pro parte, calyces only (Öhningen).

1859 *Diospyros brachysepala* A. BR.; Heer, p. 11, 191, pro parte, pl. 102, figs 10–12 (non 1–9 = *Diospyros anceps* HEER) (Öhningen).

1971 *Diospyros brachysepala* A. BR.; Bůžek, p. 65, pro parte, pl. 26, figs 9–12 (Čermníky).

Description: Calyx quadrisepalous, deeply cleft, sepals short, 7 mm wide, 12 mm long, broadly triangular, shortly fused, central attachment scar of fruit rounded, 4 mm across.

Remarks: The specimens are most similar to the remains described by Heer (1859) as belonging to *Diospyros.* Contrary to our concept, Hantke (1954) combined these calyx remains of *D. brachysepala* A. BR. with the leaves originally added by Al. Braun to the same species and also those separated later by Heer (1859) as *D. anceps*. *D. lotus* L. (eastern Asia) was suggested as a Recent analogue. These calyces are extraordinarily rare in the North Bohemian Tertiary floras (e.g. Bůžek 1971). They obviously belong to the same plant as foliage remains described above as *Diospyros* sp. and match those from Öhningen.

Material: NM G 8376, G 8377.

Dombeyopsis UNGER

Dombeyopsis lobata UNGER

Pl. 9, figs 1–4, text-fig. 12.16

1850a *Dombeyopsis lobata* UNGER, p. 447 (Bílina-Břežánky).

1850a *Dombeyopsis sideaefolia* UNGER, p. 447 (Bílina-Břežánky).

1852 *Dombeyopsis dechenii* WEBER, p. 193, pl. 21, fig. 10 (Rott etc.).

1852 *Dombeyopsis pentagonalis* WEBER, p. 194, pl. 21, fig. 11 (Orsberg).

1859–1861 *Dombeyopsis tridens* LUDWIG, p. 127, pl. 49, figs 2–3 (Salzhausen).

1860 *Ficus dombeyopsis* UNGER, p. 13, pl. 5, figs 1–7, pl. 6, fig. 1, nom. illegit. superfl. (Salzhausen, Břežánky).

1883 *Bombax dechenii* (WEBER) FRIEDRICH, p. 142, pro parte (only the basionym, non pl. 17, figs 1–4, pl. 18, fig. 7) (only Rott).

1969 *Firmiana lobata* (UNGER) KNOBLOCH, p. 111, pl. 57, figs 3–4, pl. 62, figs 4–5, pl. 75, fig. 3, text-fig. 247.9 (Moravská Nová Ves).

Description: Leaves simple, long petiolate, petiole incompletely preserved, broadly attached from below to the blade, oblique to the course of the midrib, blade trilobate, roundish, 50–160 and more mm across, deeply cordate, symmetrical, apices blunt and broad, rarely more prominent, sinuses round, margin sub-entire to crenulate (in smaller forms), venation palmate, camptodromous – craspedodromous, 9 primaries radiating from the base, the outer lateral thinner, midrib the same thickness as inner laterals, outer admedial side veins widely spaced, looping along margin, subparallel, those of the inner laterals widely spaced, in the lobes also a few admedial side veins, secondaries arising high above the blade base, at an angle of ca. 40°, as a rule in 5 sub-opposite pairs, tertiaries perpendicular to the primaries, widely spaced, percurrent or forked in the middle, convex, in the basal part of the blade in the spider net pattern, slightly oblique to the secondaries, higher-order veins in rectangular network. One aberrant specimen with lamina broadly ovate, slightly trilobate, 102 mm long, ca. 110 mm wide, sub-cordate at the base, apex blunt, narrow acuminate and glandular, margin sub-entire, with solitary glandular tiny teeth mostly on the apical part, palinactinodromous – slightly pedate, midrib straight, upwards slightly curved in the apex, two inner lateral primaries at an angle of 30–40° thick, forked near the lobe sinus, very close to the lamina base giving off three thinner primaries in subsequent manner, the basal running parallel with the margin, the inner one leading to the lobe, looping partly with the side veinlet of the inner primaries, by an abmedial branch leading to the glandular tooth of the apex, secondaries in 4 pairs, slightly alternate, looping along the margin, sending a few side veinlets into teeth.

Remarks: Besides large and entire or sub-entire-margined leaf forms identical with the type material from the Early Miocene Břešťany Clay, also smaller and crenulate leaf forms co-occur. It is tempting to separate them into another taxon. However, in view of the variation in size known among other arboreal elements, we interpret them as a consequence of environmental factors or ontogenetical development of foliage. As at many other sites of the European Tertiary, *Dombeyopsis lobata* is accompanied at Bechlejovice with the fruit remains of *Craigia bronnii*, which obviously belong to the same plant. The record at Bechlejovice solves the inclusion of shallow dentate leaves of *D. dechenii* into *D. lobata* because both entire and dentate leaf forms co-occur here. A complete treatment including full synonymy will be given in the prepared monograph of fossil *Craigia* (Akhmetiev, Kvaček and Manchester in prep.). An anomalous leaf from Bechlejovice was considered for Nymphaeaceae by Procházka (in sched.).

Material: NM G 7171a, b, G 7175, G 7177a, b, G 7183a, b, G 7184a, b G 8356; UUG MP 9, MP 14–15, MP 23, MP 93–97.

Haemanthophyllum BUDANTSEV

Haemanthophyllum sp.

Pl. 12, figs 1–2

Description: Leaf incomplete, without petiole and medial part, entire-margined, deeply cordate, sub-orbicular, ca. 35 mm wide, full length and apex not preserved, venation campylodromous, midrib area not preserved, lateral primaries 3–4 on each side of the 1.5 mm wide midrib area, forming strongly recurved arches the outermost (intramarginal) vein thinner than the others, running very close (max. 0.5 mm) to and sub-parallel with the margin and merging the margin close to the very base and in the upper part of the lamina, cross-veins percurrent and straight, very rarely forked, densely spaced, typically at a distance of 0.5 (–1) mm, admedially oblique, at an angel of ca. 60° to almost perpendicular in the upper part of the leaf, irregular small areoles along the margin and between more widely spaced cross-veins visible at places. Texture apparently very thin.

Remarks: This is a very unusual type of foliage belonging clearly to the monocots. At first sight it recalls leaves of *Caldesia* PARLAT., an aquatic plant of the Alismataceae documented by fruits from the Oligocene and Neogene of Eurasia as well as the Lower Miocene of eastern USA (Haggard and Tiffney 1997). In its size and venation the leaf fragment at hand generally corresponds to the rare and not yet described specimens of the same sort from the Miocene Clarkia flora in western North America rightly assigned to *Caldesia* by Smiley and Rember (1985, personal observation Z.K. in 1999). The Clarkia fossils match the venation of *Caldesia* in the simple midrib, oblique, percurrent, partly dichomizing dense cross-veins and lateral primaries in number of 5 on each side joining successively the fimbrial vein on the margin before reaching the apex. Due to poor and incomplete preservation of the unique specimen from Bechlejovice, a closer characteristic of this taxon is not warranted. Our record decidedly differs from the extant species of *Caldesia* by the intramarginal vein and the ascending character of the other lateral primaries that do not join the margin. However, it matches in this respect *Haemanthophyllum cordatum* GOLOVNEVA (1987) from the high latitude Late Cretaceous to Early Palaeogene, which is similar but differs in more numerous primaries. Golovneva (1987, 1997) believed the best match for *Haemanthophyllum* to be the genus *Aponogeton* and not the representatives of Alismataceae. The leaf fragment from Bechlejovice is too incomplete and without the midrib area to bring more information to this problem.

Material: NM G 8378.

Laurophyllum GOEPP.

Laurophyllum acutimontanum MAI

Pl. 12, figs 8–10, text-fig. 13.22

1963 *Laurophyllum (Tetradenia) acutimontanum* MAI, p. 72, pl. 8, figs 7–9, 12 (non 10), pl. 9, figs 1–4, text-figs 11f–h (Seifhennersdorf).

1971 *Laurophyllum acutimontanum* MAI; Kvaček, p. 53, pl. 2, fig. 5, pl. 6, figs 4–6, pl. 7, figs 1–2, text-figs 3–4 (Plesná, Markvartice, Bechlejovice).

Description: Leaves fragmentary, narrow lanceolate, about 28–30 mm wide, and more than 90–100 mm long, entire-margined, texture coriaceous, venation brochiododromous, midrib straight, medium thick, secodaries irregularly and alternately arising from the midrib in variable angles, teriaries and higher-order veins reticulate, abaxial cuticle poorly preserved except one carbonised compression, showing typical amphicyclobrachyparacytic stomata with swollen papillate subsidiary cells.

Remarks: This lauroid is very typical in its lower epidermis, which was obtained also from the Bechlejovice material. It commonly occurred in the Oligocene of the České středohoří Mountains and elsewhere in Central Europe and started to appear in the Late Eocene (Kvaček 1988).

Material: NM G 8379a, b G 8380a, b; PRC Be 1, Be 3, Be 6, cuticle preparations Be 1/1,2, Be 3/1, Be 4/1, Be 6/1, 2; MMG Ba 337:2.

Laurophyllum cf. *pseudoprinceps* WEYLAND et KILPPER

Pl. 12, figs 6–7, text-fig. 13.12

? 1963 *Laurophyllum pseudoprinceps* WEYLAND et KILPPER, p. 100, pl. 23, figs 14–19, text-fig. 6 (Frimmersdorf).

Description: Leaves simple, petiolate, petiole 4 mm long, lamina lanceolate to oval, 27–63 mm long and 18–32 mm wide, entire-margined, venation transitional between brochidodrome and acrodrome, midrib straight, thick, secondaries widely spaced, in 5–6 pairs, subopposite to slightly alternate, the lowermost pair much thicker, curved, arising well above the lamina base and looping with the much thinner pairs above, intersecondaries common, tertiary not visible.

Remarks: Such lauroid leaves with a more distinct lower pair of secondaries but not directly triveined are common in the morphospecies *L. pseudoprinceps.* We use the open nomenlature because the epidermal structure is not preserved. This element is proved by epidermal anatomy only at Markvartice (Bůžek et al. 1976), while the other occurrences (e.g. Kundratice – Kvaček and Walther 1998) are equivocal like in the present case.

Material: NM G 7165; UUG 3667, 3702, 3703.

Laurophyllum sp.

Pl. 12, figs 3–5, text-figs 12.6, 12.13, 13.4

Description: Leaves narrow lanceolate to linear, ca. 45–120 mm long and 5–20 mm wide, entire-margined, texture thin, venation brochidodromous.

Remarks: Such leaf impressions have been sometimes compared with the species established on the basis of epidermal anatomy (Kvaček and Walther 1995, 1998). In the case of Bechlejovice we refrain from such comparisons, which can be misleading. This narrow leaf form is similar to various species of this morpho-genus, notably to *L. medimontanum* with extremely thin leaf laminas. *Laurophyllum* cf. *villense* from the Lower Oligocene of Floersheim in Hesse is also similar in the variation of its form (Kvaček 2004).

Material: UUG ?MP 172, 3606, 3617, 3627, 3630, 3631, 3633, 3634, 3635, 3636, 3637, 3638, 3642, 3640, 3644, 3645, 3646, 3647, 3648, 3651, 3652, 3654, 3658, 3666, 3673, 3674, 3675, 3676, 3682, 3705; MMG Ba 241, Ba 256.

Leguminosites BOWERBANK emend. SCHIMPER

Leguminosites cladrastioides sp. n.

Pl. 13, figs 1–3, text-fig. 12.10

Holotype designated here: NM G 5504, figured in pl. 13, fig. 3.

Etymology: referring to the similarity to the leaves of *Cladrastis.*

Stratum typicum: Volcanic complex of the České středohoří Mountains, lower part, Early Oligocene.

Locus typicus: Bechlejovice, suburbs of the town Děčín, North Bohemia, Czech Republic.

Description: Leaves compound, with more than 7 pairs of sub-opposite to slightly alternate leaflets, incomplete in length, petiole enlarged on the base, 25 mm and more long, continuing into almost straight rachis, leaflets attached at an angle of 90–40° (the lowermost pair to 130°), sessile to very shortly petiolulate, narrow ovate to slightly falcate, 8–20 mm wide and 20–60 mm long, slightly asymmetric and rounded at base, apex narrow acute, venation brochidodromous, midrib gently bent, secondaries in 7 or more subopposite pairs, widely and irregularly spaced, at an angle of 50–65°, thinning towards the loops near margin, short intersecondaries occasionally present, tertiaries and higher-order veins reticulate forming ± isometric meshes.

Remarks: This is a peculiar legume foliage occurring in fragments of not disitegrated leaves. Both slightly alternate arrangement of leaflets and their form refer to the genus *Cladrastis* (cf. Herendeen 1992, figs 158–161), although there are surely other alternatives among extant representatives of this large group with similar foliage. Such complete fossils are rare in the fossil record, although the lack of epidermal anatomy diminishes the value of the described material. Leaf and leaflet remains referred to *Cladrastis* from East Asia (see e.g. Ozaki 1991) are usually broader then the fossils, those from the Eocene of North America (Herendeen 1992) are more similar, but usually longer petiolulate.

Material: NM G 5504; UUG MP 16–17, MP 173.

Leguminosites sp. 1

Pl. 13, figs 5–7, text-fig. 13.20

1998 Leguminosae gen. et sp. forma 1, Kvaček and Walther, p. 20, pl. 10, fig. 9, pl. 11, fig. 1 (Kundratice).
1998 Leguminosae gen. et sp. forma 2, Kvaček and Walther, p. 20, pl. 10, fig. 10, text-fig. 13.23 (Kundratice).

Description: Leaflets shortly petiolulate, petiolule 2 mm long, lamina slightly ovate, 17–23 mm long, 8–19 mm wide, entire-margined, apex rounded, base rounded, venation camptodromous, midrib medium strong, straight, secondaries poorly visible.

Remarks: We compare these isolated leaflets with similar forms from Kundratice without being convinced that they represent the same natural species.

Material: UUG MP 19–20, MP 144, MP 215.

Leguminosites sp. 2 (fruit)

Pl. 13, fig. 4

Description: Pod stalked, stalk 3 mm long, body narrow elongate, about 50 mm long and 6 mm high, without any traces of seeds on the surface, margins almost parallel, straight, ends acute.

Remarks: Such a slender but shorter pod without traces of seeds from the Middle Miocene of Parschlug was assigned to *Cytisus* by Unger (1850a, 1864) and transferred to *Leguminosites* by Kovar-Eder et al. (2004, as *Leguminosites dionysi*). A similar and still shorter pod was described from Suletice-Berand (Kvaček and Walther 1995, pl. 7, fig. 7, as Leguminosae gen. et sp. indet.). No exact analogue is suggested. Fruits of legumes occur extremely rarely in the Oligocene of the České středohoří Mountains.

Material: NM G 8381.

gen. inc.

Magnoliaceae gen. et sp.

Pl. 14, figs 1–2

Description: Leaves incomplete, broadly ovate to elongate-elliptical, ca. 70–100 mm long and 27–44 mm wide, apex acuminate, base cuneate to widely cuneate, entire-margined, margin thickened, venation brochidodromous, midrib strong and straight, secondaries irregularly spaced, alternate, in ca. 8 pairs, at an acute angle, looping inside the lamina, intersecondaries present, tertiaries perpendicular to secondaries, about 5–7 per 10 mm, partly forked, higher-order venation distinct, areolate, texture coriaceous.

Remarks: The larger size and wider outline distinguishes this leaf form from the previously characterised lauroids. The affinities with magnoliids are obvious, particularly to broad-leaved Magnoliaceae (e.g. Walther 2003). Other alternatives (Lauraceae, Nyssaceae) are less probable.

Material: UUG MP 13, MP 203, 3658.

Mahonia NUTT.

Mahonia pseudosimplex sp. nov.

Pl. 14, figs 5–6, text-fig. 12.4

1990 *Ilex* sp.; Bůžek et al., p. 175, fig. 6.18 (Bechlejovice).
2000 *Mahonia* sp., Hably, Kvaček and Manchester, p. 64, pl. 3, fig. 21 (Bechlejovice).

Holotype designated here: NM G 8384a, b figured in Pl. 14, fig. 5.

Etymology: Referring to the similarity to the leaves of *Mahonia simplex* AXELROD.

Stratum typicum: Volcanic complex of the České středohoří Mountains, lower part, Early Oligocene.

Locus typicus: Bechlejovice, suburbs of the town Děčín, North Bohemia, Czech Republic.

Description: Leaf incomplete, pinnately compound, preserved in length of 75 mm, rachis stout, strong, leaflets opposite, sessile, oblong, strongly asymmetrical, with the midrib at an angle of 45–50° to the rachis, base slightly subcordate, apex missing, margin widely toothed, teeth 3 per side, spiny, sinuses shallow rounded, venation palmate (?), not well visible except a strong midrib.

Remarks: This single fragmentary specimen has smaller and much shallower lobed leaflets than the Miocene *M. bilinica* from the Most Basin (Kvaček and Bůžek 1994). The lobes of the latter are often long more than half of the lamina. *Mahonia* is rare also in the whole Tertiary of Europe. Our specimen is similar to aberrant forms of *M. simplex* with shallow teeth from the Palaeogene of North America (Hably et al. 2000). Knobloch (1994) mentioned *Mahonia* as a member of the Bechlejovice flora without any illustration.

Material studied: NM G 8384a, b.

? *Matudaea* LUNDELL

cf. *Matudaea menzelii* WALTHER

Pl. 14, figs 7–8, text-figs 11.5, 11.7, 13.6

?1978 *Matudaea menzelii* WALTHER in MAI et WALTHER, p. 51, pl. 3, figs 1–4, pl. 11, figs 2–3, pl. 24, figs 1–3, 4 (holotype), 5–9 (Haselbach, Regis mines).

Description: Leaves petiolate, petiole 15 mm in length, blade ovate, fragmentary, entire margined and, 35 to 50 mm long and 35 mm wide, venation acrodromous, two basal veins starting from the very base of lamina, in one sample directly from the slender petiole, secondaries extremely thin.

Remarks: These samples match perfectly the type material of *Matudaea menzelii* WALTHER from the Lower Oligocene of Haselbach, although they recall large forms of *Daphnogene* (Mai and Walther 1978, Walther 1980a). In view of the lack of the characteristic leaf epidermal evidence, the identification must remain tentative. Similar fragments, also without cuticle structure, were described from Suletice – Berand (Kvaček and Walther 1995), Kundratice (Kvaček and Walther 1998), Holý Kluk (Radoň et al. in press), and also with cuticle remains from the Upper Oligocene of Kleinsaubernitz, Saxony (Walther 1999). This representative of Hamamelidaceae is a characteristic accessory element in the Early to Late Oligocene lowland and volcanic vegetation of Central Europe. Extant species are *Matudaea trinervia* and *M. hirsuta* and both occur in small relict areas in Central America (Lundell 1940, Walther 1980).

Material: UUG MP 36a, b, 3677, 3678.

Mimosites BOWERBANK emend. ETTINGSHAUSEN

Mimosites haeringianus ETTINGSHAUSEN

Pl. 13, figs 8–10, text-fig. 13.16

1853 *Mimosites haeringianus* ETTINGSHAUSEN, p. 92, pl. 30, figs 23–37 ("*haeringiana*") (Häring).

1998 *Mimosites haeringianus* ETTINGSHAUSEN; Kvaček and Walther, p. 22, pl. 11, figs 8–9, text-fig. 13/26 (Kundratice).

Description: Leaves paripinnate, leaflets opposite, in more than 12 pairs, entire-margined, densely spaced, partly touching each other, sessile, sub-opposite, narrow elongate, typically 2.5 mm wide and up to 25 mm long, apex acute, base asymmetrical, almost subcordate, venation brochidodromous, at the base partly actinodromous, midrib straight, thin, secondaries steep, at an angle of ca. 20–30°, ± widely spaced, basal long ascending along the margin, and densely interspersed with intersecondaries, forming with delicate tertiaries elongate meshes sub-parallel with the midrib.

Remarks: This typical member of the Early Oligocene leaf assemblages of Central Europe is represented at Bechlejovice only by a few incomplete leaves, which show a remarkable venation of the leaflets. The material matches in all respects the specimens from Kundratice, Suletice-Berand and other localities of the České středohoří Mts. (see Kvaček and Walther 1995, 1998). This type of mimosoid foliage is more robust and differs from that known as *Acacia parschlugiana* UNGER from the Early–Middle Miocene deposits of Styria (Kovar-Eder et al. 2004) and the Randecker Maar (Rüffle 1963, as "Leguminosaenartiges Blattrest", pl. 9, figs 23–25). On the other hand, heterogenous *Acacia sotzkiana* UNGER includes forms (Unger 1850b, pl. 46 (67), fig. 2) reminiscent of *Mimosites haeringianus*. The type assemblage from Häring includes many similar leaflet forms, which obviously belong to microphyllic legumes, but they are not identifiable to a natural genus (see also Butzmann and Gregor 2002). Among them *Mimosites haeringianus* represents a characteristic and common element, which connects the Häring flora with that of Bechlejovice at least at the species level. While at Häring only detached leaflets occur, the Oligocene sites of the České středohoří Mts. have yielded leaf fragments with attached leaflets.

Material: NM G 7186; UUG MP 4, MP 5a, b.

fam. et gen. inc.

Monocotyledonae gen. et sp.

Pl. 14, figs 3–4

Description: Fragments of strap-like leaves with parallel venation, veins very thin, vaguely differentiated in two orders of thickness, thicker veins ca. 1 mm apart, thinner 3–4 per 1 mm, without cross veins visible.

Remarks: Not identifiable monocots.

Material: NM G 8383.

Ostrya SCOP.

Ostrya atlantidis UNGER

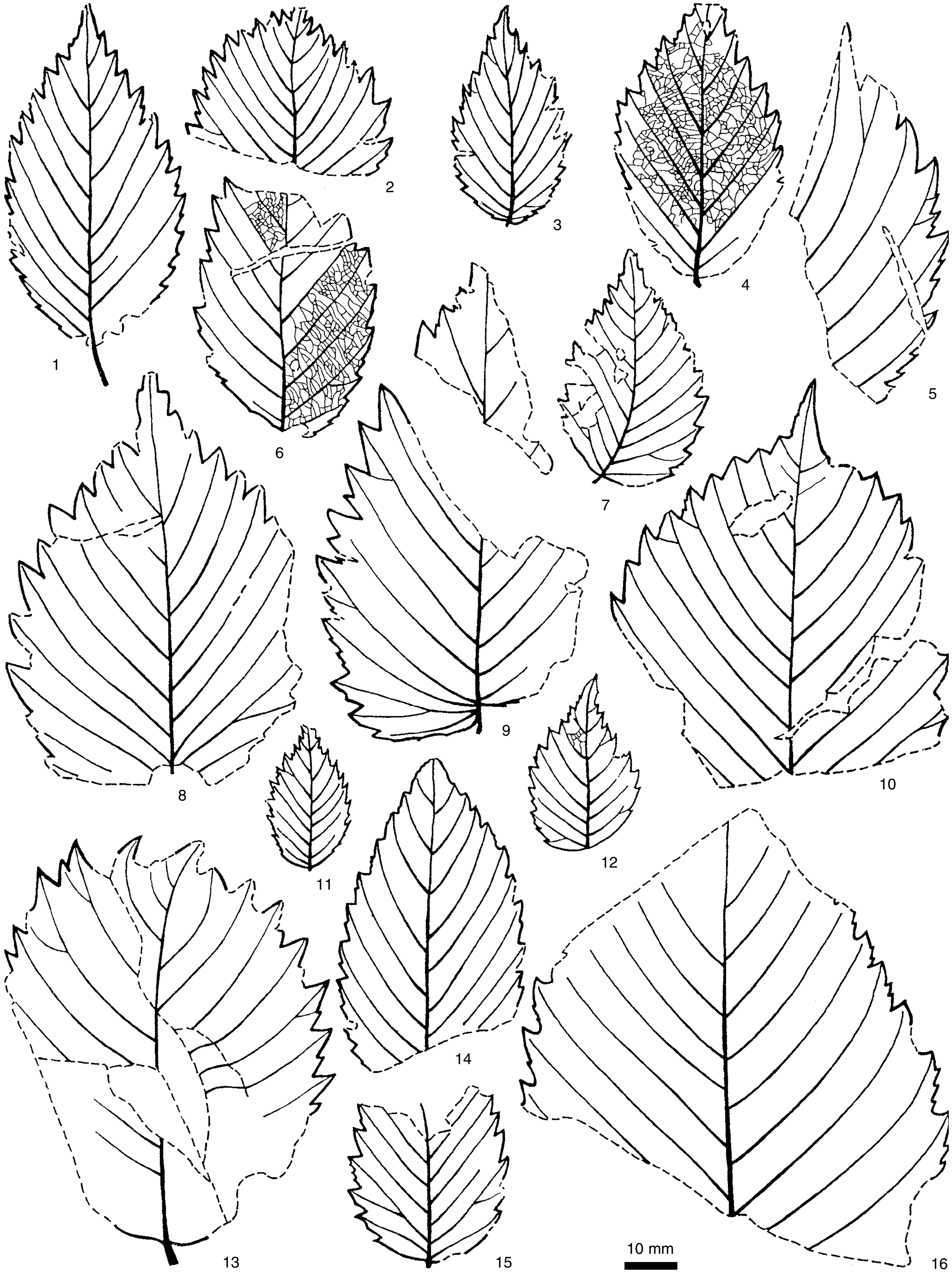
Pl. 15, figs 1–5, text-fig. 12.9

1850a *Ostrya atlantidis* UNGER, p. 408 (Radoboj).

1852 *Ostrya atlantidis* UNGER; Unger, p. 41, pl. 20, figs 9–11 (Radoboj).

1953 *Carpinus grandis* UNGER; Procházka, p. 24, pl. 4, fig. 1a (Bechlejovice).

1998 *Ostrya atlantidis* UNGER; Kvaček and Walther, p. 23, pl. 12, figs 4–7, text-figs 13/34–35 (Kundratice).



Text-fig. 8. 1–16 *Ulmus fischeri* HEER, 1 UUG 3594, 2 UUG 3714, 3 UUG 3471, 4 UUG 3717, 5 UUG 8152, 6 UUG 3563, 7 UUG 3722, 8 UUG 8165, 9 UUG 3466, 10 UUG 8167, 11 UUG 8170, 13 UUG 8166, 14 UUG 3565, 15 UUG 3718, 16 UUG 3468 .

2000 *Ostrya atlantidis* UNGER; Hably et al., p. 63, pl. 2, figs 8–9 (Bechlejovice).

Description: Leaves simple, petiolate, preserved petiole 11–16 mm long, blade ovate, oblong ovate, oblong to narrow ovate, 43–90 mm long, 17–35 mm wide, apex acute, acuminate, rarely attenuate, base sometimes asymmetric, subcordate, rounded or cuneate, margin indistinctly double serrate, teeth long mucronate, main teeth _more prominent; venation craspedodromous, midrib thinner, secondaries in 11–17 pairs, sub-opposite to alternate, straight, entering the main teeth, sending side veinlets into the secondary teeth, tertiaries percurrent, rarely forked, nearly perpendicular to secondaries; involucres wide elliptical, 10–20 mm long and 7–14 mm wide with several longitudinal veins, occasional with a fruit impression inside.

Remarks: This deciduous tree was abundant in Bechlejovice, being represented by about 68 specimens of leaves. After the present study it can be stated that it is surely a predominate element in this flora (see Kvaček and Walther 1998). The morphological transition to the foliage of *Carpinus grandis* (without mucronate teeth) makes a sure delimitation of both taxa difficult. But there seem some other characteristics: the attenuate apex and the asymmetrical bases, which help to differentiate *Ostrya* from *Carpinus* leaves. Knobloch (manuscript notes) suggested to separate the leaves into an independent morpho-species, but a more thorough study is needed to solve this problem in our opinion.

Material studied: UUG MP 205, 28512, 3494, 3532, 3533, 3536, 3537, 3538. 3539, 3540, 3541, 3545, 3568, 3573, 3574, 3575, 3576, 3577, 3579, 3580, 3582, 3585, 3590, 3612, 3614, 3615, 9152 (fructus), 9153 (fructus); MMG Ba 11, Ba 14, Ba 30, Ba 35, Ba 49, ?Ba 74, Ba 85, Ba 86, Ba 158, Ba 166, Ba 170, Ba 181, Ba 207, Ba 217, Ba 218, Ba 225, Ba 238, Ba 272, Ba 297, Ba 312, Ba 313, Ba 314, Ba 317, Ba 369, Ba 399, Ba 403, Ba 408, Ba 412, Ba 226, Ba 428, Ba 431.

Platanus L.

Platanus neptuni (ETTINGSHAUSEN) BŮŽEK, HOLÝ et Z. KVAČEK forma *reussii* (ETTINGSHAUSEN) Z. KVAČEK et MANCHESTER

Pl. 15, figs 6–8

1866 *Sparganium neptuni* ETTINGSHAUSEN, p. 31, pro parte, pl. 7. figs 10–16 (non figs 9, 17–18) (Kučlín).

1866 *Myrica reussii* ETTINGHAUSEN, p. 44, pl. 14, fig. 4 (Kučlín).

1967 *Platanus neptuni* (ETTINGSHAUSEN) BŮŽEK, HOLÝ et Z. KVAČEK, p. 205, pl. 1, figs 1–4, 6 (non 5 = *Sloanea artocarpites*), pls 2–4 (Kučlín etc.).

1994 *Platanus neptuni* (ETTINGSHAUSEN) BŮŽEK, HOLÝ et Z. KVAČEK; Knobloch, p. 65, pl. 1, fig. 1 (Bechlejovice).

2004 *Platanus neptuni* (ETTINGSHAUSEN) BŮŽEK, HOLÝ et Z. KVAČEK forma *reussii* (ETTINGSHAUSEN) Z. KVAČEK et MANCHESTER, p. 19 (Kučlín etc.).

Description: Leaf simple, incomplete, elongate, ca. 30 mm wide and more than 110 mm long, indistinctly toothed-crenulate, apex acute, base missing, venation semicraspedodromous, midrib prominent, straight, secondaries regularly widely spaced, at a wide angle of ca. 60°, looping well inside the lamina, with intersecondaries, tertiaries and higher-order veins reticulate forming isometric irregularly disposed meshes. Abaxial cuticle poorly preserved, showing a single stoma of the characteristic appearance, broadly oval, 25 µm long and 23 µm wide with double outline, showing widely open spindle-shaped outer cavity and medial linear slit.

Remarks: This plane tree, which belongs to an extinct subgenus *Glandulosa* Z. KVAČEK, MANCHESTER et GUO (2001), was widely spread in the Palaeogene floras of the České středohoří Mountains starting with the Late Eocene (Kučlín, type locality). At Bechlejovice it is extremely rare but the identification of the only specimen (Knobloch 1994) was corroborated by the cuticle structure. The *Platanus neptuni* complex has recently been monographically treated by Kvaček and Manchester (2004). The co-occurrence of *P. neptuni* and *P. schimperi* is extremely rare in the European Tertiary, namely in the Tard Clay flora in Hungary and probably also at Menat (Z. K., personal observation 2004).

Material: NM G 8387a, b.

Platanus schimperi (HEER) SAPORTA et MARION

Pl. 15, fig. 9

1859 *Acer schimperi* HEER, p. 313 (Menat).

1878 *Aralia looziana* SAPORTA et MARION, p. 77, pl. 13, figs 1–3 (Gelinden).

1885 *Platanus schimperi* (HEER) SAPORTA et MARION, p. 207 (Menat).

1883 *Aralia weissii* FRIEDRICH, p. 131, pl. 18, figs 1–6 (Bornstedt).

1912 *Platanus schimperi* (HEER) SAPORTA et MARION; Laurent, p. 102, pl. 11, fig. 5, pl. 12, fig. 1 (Ménat).

1959 *Acer atavissimum* ANDREÁNSZKY, p. 14, pl. 3, fig. 12, text-fig. 7 (Kiseged).

Description: Leaves petiolate, petiole 15 mm long, cup-like enlarged at the base, trilobate, lamina ca. 80–100 mm long and 70 mm wide, base rounded, lobes acute, about 25 mm long, sinuses rounded, margin coarsely widely dentate mainly on outer margins of the lobes and the apex, in the lower part of the lamina entire, venation triveined, lateral primaries starting above the lamina base at an angle of 25°, reaching the lobes, secondaries still steeper, one pair approaching the sinuses, the others ending in the teeth, like the outer abmedial veinlets from the lateral primaries and a parallel pair of thin veinlets starting from the very base of the lamina, higher-order venation not preserved.

Remarks: This very ancient element of the European Tertiary floras started to appear in the Palaeocene strata (Gelinden, Menat) and survived in Central Europe till the Early Oligocene (Tard Clay, Kiscellian – Andreánszky 1965, Hably et al. 2000). While *P. schimperi* is well documented by several specimens from the site of the Kiseged Hill at Eger (the collections in Budapest, own observation), the record from the Late Eocene Staré Sedlo Formation (Knobloch et al. 1996) is equivocal and unique. The specimens from Bechlejovice prove the occurrence without doubt and present the first documentation of *P. schimperi* for the Oligocene of the České středohoří Mountains.

Material: NM G 8385, G 8386a, b.

Polypodium L.

Polypodium radonii Z. KVAČEK

Pl. 19, fig. 1, text-fig. 13.7

1994 cf. *Woodwardia* sp., Knobloch, p. 65, pl. 1, fig. 10 (Bechlejovice).
2001 *Polypodium radonii* Z. KVAČEK, p. 165, pls 1–3 (Holý Kluk, Bechlejovice).

Description: One fertile frond and another more complete frond including grooved stipes more than 25 mm long, blade more than 80 mm long and 45 mm wide, simple deeply pinnatifid, partly fertile, bearing about seven pairs of alternate pinnae attached at an angle of 55 to 70°, the lowermost at 120° to the rachis, pinnae falcate to elongate, acute to narrow rounded at apex, 5–8 mm wide and 14–30 mm long, entire-margined, sinuses rounded; secondaries 2–3 times forked, not reaching the margin, almost invisible, lowermost tertiary veins acroscopic, short, in the fertile specimen bearing solitary broadly elliptic sori 0.8 × 1 mm, spores *in situ* verrucate, monolete, 50–65 µm long and 45–60 µm high, laesura straight, simple, ca. 35 µm long.

Remarks: This fern was treated in detail in a separate study (Kvaček 2001). It belongs to the *Polypodium vulgare* complex and the spores *in situ* are most similar to the *favus* complex (e.g. *Polypodiisporites bockwitzensis* (KRUTZSCH) NAGY, described from the Upper Oligocene of the Weisselster Basin – see Krutzsch 1967, as *Verrucatisporites bockwitzensis*). Similar but more coarsely verrucate spores have been obtained from *Polypodium fertile* MACGINITIE from the Miocene Weawerville Formation of California (Kvaček et al. 2004). At Bechlejovice it is extremely rare, probably due to closed canopy forests surrounding the Bechlejovice lake, and its growth habit was probably epiphytic or epilithic, like today in the case of *Polypodium macaronesicum* from Canary Islands (Kvaček 2001).

Material: NM G 7765a–c; UUG 9150.

Populus L.

Populus zaddachii HEER

Pl. 16, figs 6–7

1859 *Populus zaddachii* HEER, p. 307 (Svetlogorsk).
1978 *Populus zaddachii* HEER; Mai and Walther, p. 88, pl. 5, fig. 10, pl. 35, figs 1–6, pl. 40, fig. 12 (Haselbach, Schleenhain, Regis II and III, Waltersdorf, etc.).
1994 *Populus zaddachii* HEER; Knobloch, p. 65, pl. 1, fig. 2 (Bechlejovice).

Description: Leaves simple, long petiolate, petiole flat, 16 mm long, lamina ovate, 41–48 mm wide, 71–94 mm long, finely glandular crenulate, apex acuminate, base rounded to subcordate, venation actinodromous, midrib tick, running directly into the apex, outer lateral basal veins very fine, running directly from the base up to the first third of the lamina, inner lateral basal veins much thicker, shortly decurrent along the midrib then in acute angles slightly curved up to the upper third of the lamina, about 7 secondaries alternate or sub-opposite, curved in wider angles, semi-craspedodromous, intersecondaries 1 to 2, short, higher-order venation not preserved. Lamina possibly firm – dark colour of the impressions.

Remarks: This species was originally described from the Lower Oligocene of the Baltic region and then firstly recorded in the Oligocene of Central Europe at Haselbach (Mai and Walther 1978) and later much more often at Thierbach (Mai and Walther 1991). It is also present as an important accessory element in the volcanic floras of Kundratice, Hrazený, Suletice-Berand and Seihennersdorf (Walther 1996, Kvaček and Walther 1998, 1995). Walther (in Mai and Walther 1991) recognised this poplar as a mesophytic rather than riparian element. According to the epidermal anatomy and gross morphology, *Populus zaddachii* belongs to sect. *Leucoides* SPACH.

Material: NM G 8389; UUG MP 22a, b, MP 91–92, MP 154, .

Pungiphyllum FRANKENHÄUSER et WILDE

Pungiphyllum cruciatum (A. BRAUN) FRANKENHÄUSER et WILDE

Pl. 16, fig. 8, text-fig. 12.1

1851 *Quercus cruciata* A. BRAUN in STITZENBERGER, p. 76 (Öhningen).
1856 *Quercus cruciata* A. BRAUN; Heer, p. 55, pl. 77, figs 10–12 (Hoher Rhonen, Öhningen)
1981 “*Quercus*” *cruciata* A. BR.; Kvaček and Walther, p. 85, pls 7–10, pl. 11, figs 2–5, ? pl. 12, figs 1–3, text-figs 6–7 (Kundratice, Ipolytarnóc, Bechlejovice, Flörsheim etc.).
1990 “*Quercus*” *cruciata* A. BR.; Bůžek et al., p. 175, fig. 6.16 (Bechlejovice).
1995 *Pungiphyllum cruciatum* (A. BRAUN) FRANKENHÄUSER et WILDE, p. 101 (Öhningen).

Description: Leaves (or leaflets) incomplete, preserved in length of 40 mm, deeply lobate, with about three major spiny lobes on one side (? not in one level), 17 mm in length, lower pairs smaller, also spiny, at a right angle, the upper in a narrower angels, margin thickened, venation craspedodromous, lamina seems extremely thin, only the midrib and secondaries are thickened, intersecondaries forked, directed into sinuses, dense, tending to camptodromous patterns, tertiary not well visible, irregular.

Remarks: This species is very rare in the Oligocene of North Bohemia (Kundratice, Suletice-Berand, Bechlejovice). Similar forms occur also at Kučlín (Kvaček 2002a, as *Pungiphyllum* cf. *waltheri* FRANKENHÄUSER et WILDE). The systematic position of these leaves (leaflets) is up to now ambiguous (see Frankenhäuser and Wilde 1995).

Material studied: NM G 8390; UUG MP 34, MP 78, MP 136.

? *Pyracantha* M. ROEM.

cf. *Pyracantha kraeuselii* WALTHER

Pl. 16, figs 4–5

? 1978 *Pyracantha kraeuselii* WALTHER in MAI et WALTHER, p. 98, pl. 7, fig. 11, pl. 11, fig. 4, pl. 35, figs 7–9, pl. 39, figs 1–7 (Haselbach).
1998 “*Palaeolobium*” sp. 1; Z. Kvaček and Walther, p. 23, pl. 13, figs 1–3, text-fig. 13.24 (Kundratice)

Description: Leaves simple, petiolate, petiole 5 mm long, blade elongate to oblanceolate, 14–49 mm wide, 33–96 mm long, apex rounded and mostly apiculate, base narrow cuneate, margin entire to sub-entire, venation eucamptodromous, midrib straight, thin, secondaries very thin, arising alternately and densely at an angle of 45–50°, rarely forked, from the base, more often at margin steeply forked abmedially, tertiaries very dense and strongly oblique.

Remarks: This is a typical element of the flora of Kundratice (Engelhardt 1895, as *Palaeolobium haeringianum, P. sotzkianum, P. sturi* etc.) also treated by Kvaček and Walther (1998, as "*Palaeolobium*" sp. 1), who were unable to solve its taxonomical position. E. Knobloch (in sched.) suggested an affinity to *Pyracantha.* In the venation pattern, particularly steeply forked secondaries, this leaf form is very similar to the compressions with the preserved epidermal structure described as *Pyracantha kraeuselii* WALTHER (in Mai and Walther 1978, Walther 1980b) from the Haselbach Oligocene. Like in the type specimen we have noticed only poor traces of the teeth, which may be due to the slightly revolute margin (like in some willow foliage). This taxon would add another member of the family Rosaceae, which was well diversified in the Bechlejovice assemblage. Walther (in Mai and Walther 1978) found extant *Pyracantha coccinea* ROEM. (Southern Europe, widely cultivated), *P. crenulata* (ROXB.) ROEMER (western Himalaya to Bhutan), *P. crenato-serrata* (HANCE) REHDER (SW and Central China) similar in most respects.

Material: NM G 8347; UUG MP 26, MP 87a, b, MP 151b.

? *Quercus* L.

cf. *Quercus bavarica* (KNOBLOCH et Z. KVAČEK) Z. KVAČEK

Pl. 16, fig. 1, pl. 23, fig. 1

? 1976 *Castanopsis bavarica* KNOBLOCH et Z. KVAČEK, p. 40, pl. 4, figs 2, 3, 9, 10, pl. 15, fig. 6, pl. 21, figs 1–4, pl. 24, fig. 7, text-fig. 15 (Wackersdorf).

? 2004 *Quercus bavarica* (KNOBLOCH et Z. KVAČEK) Z. KVAČEK, p. 000, pl. 10, figs 1–5, 12–13 (Flörsheim).

Description: Leaves shortly petiolate, petiole thin, 3 mm long, lamina oval, 36–55 mm long, 15–20 mm wide, entire-margined, base cuneate, apex acute, venation brochidodromous, midrib straight, strong, secondaries regularly disposed, in 5–8 pairs, looping along the margin, tertiaries not visible.

Remarks: Having not obtained any epidermal structure from the material of Bechlejovice, we are not quite sure about the determination of these two impressions, which morphologically match both *Quercus bavarica* and *Trigonobalanopsis rhamnoides,* common thermophilic members of many European Tertiary floras (see Kvaček and Walther 1988, Kvaček 2004). In the Bohemian Palaeogene *T. rhamnoides* was recorded only in the Staré Sedlo Formation so far (Knobloch et al. 1996), but not in the České středohoří Mts. floras. The leaf impressions studied are more similar in a sledner leaf form and steeper secondaries with *Quercus bavarica*, which often co-occurs, e.g. at the Early Oligocene site Flörsheim (Kvaček 2004). The cupule described below may belong to the same taxon.

Material: NM G 8388; UUG 3639.

? *Quercus* sp. (fruit)

Pl. 16, figs 2–3

Description: Cupule well flattened, rounded, ca. 20 mm across, with short spines ca. 1.5–2 mm long stretching out of the outline.

Discussion: This unique fruit fossil is poorly preserved and recalls an oak cupule without stalk. Less probable is an affinity with a valve of *Sloanea*, which should show a septum.

Material: NM G 8344a, b.

Rosa L.

Rosa lignitum HEER

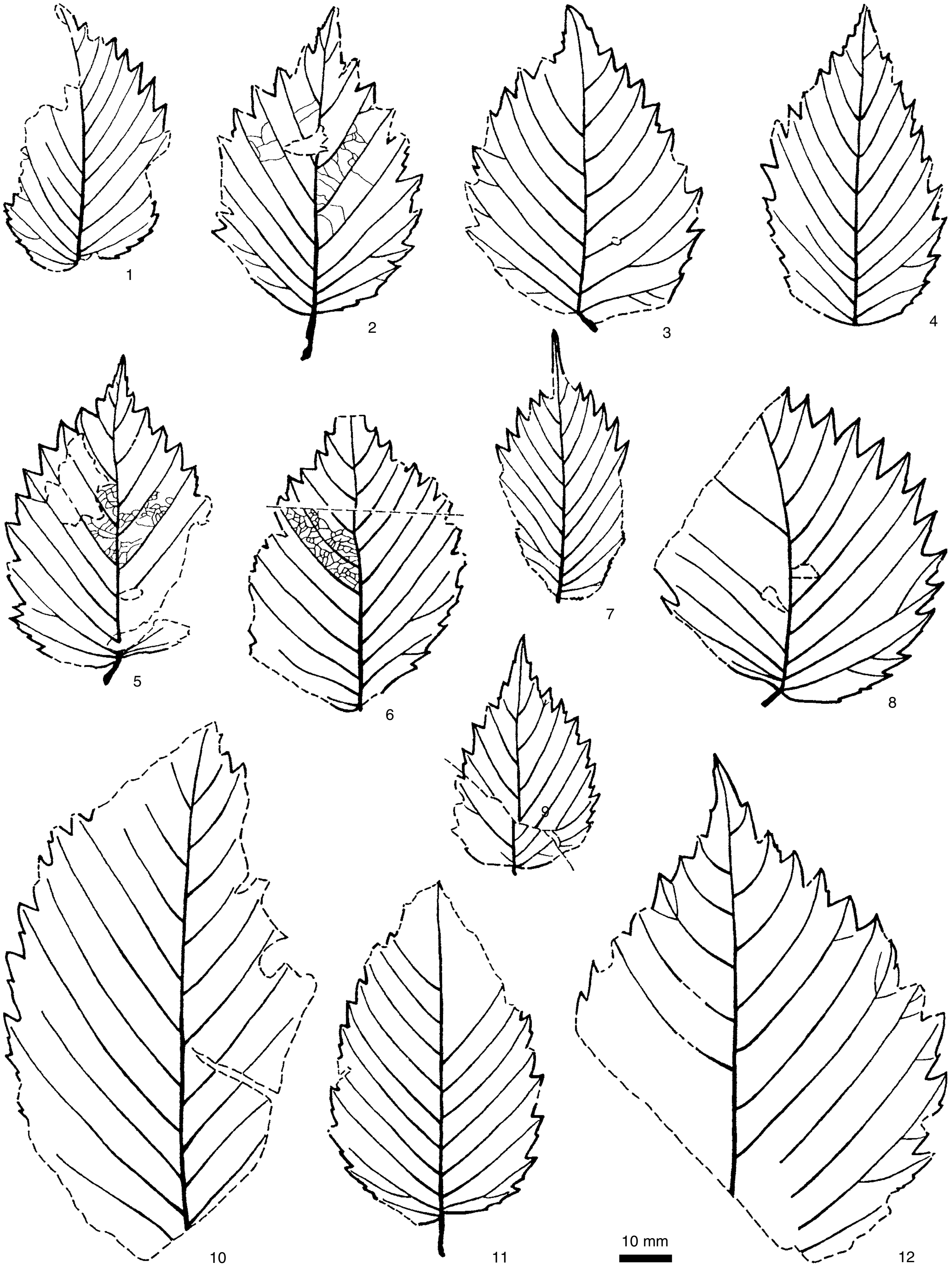
Pl. 17, figs 1–3, text-figs 11.3, 13.9, 13.14

1869 *Rosa lignitum* HEER, p. 99, pl. 30, fig. 33 (Chlapovo).

1953 *Rosa* sensu Procházka, p. 22 (Bechlejovice).

Description: Twigs covered of fine direct prickles 1.5–4 mm long, with attached leaves imparipinnately compound, long petiolate, 50 (–80) mm long (including 4 to 33 mm long and at the base 2 mm thick petiole with shortly fused narrow 2–5 mm long stipules) with two pairs of lateral opposite – sub-opposite, to leaflets and a terminal leaflet, very rarely only, often incomplete, mostly with basal leaflets. Lateral leaflets sessile, opposite, oblong to oblong lanceolate, rarely obovate, cuneate, almost symmetrical, apex acute, 4 to 7 mm wide, 11 to 24 mm long, the terminal leaflet petiolulate (petiolule 2.5 mm long), elliptic, at the apex slightly acuminate, at the base cuneate, otherwise similar in its size of the lamina to the lateral leaflets. Margin finely simple serrate to crenulate, teeth irregular, small, triangular to widely triangular, acute to blunt at the apex, incisions sharp, teeth partly lacking on the very base of the leaflets. Venation semi-craspedodromous, midrib strong, straight, secondaries fine, almost alternate to sub-opposite, under narrow angles, in about 7–9 pairs, and near the margin fine loops with side veinlets directed into the teeth. Higher-order venation fine, areolate. Texture relatively firm, leaflets mostly attached to the rachis (? not deciduous).

Remarks: The leaflets and fragmentary leaves of *R. lignitum* from Kundratice (Kvaček and Walther 1998) and other Oligocene localities, like Haselbach (Mai and Walther 1978, Kvaček and Walther 2001) are indistinguishable from our more complete material. The attached twigs bring more details for identification (stipules, prickles). The Early Miocene *Rosa europaea* Z. KVAČEK et HURNÍK (syn. *R. bohemica* sensu Bůžek 1971, non Engelhardt, nec H. Braun) differs in a more obovate shape of leaflets and finely crenulate margin. For the latter also complete leaves are available. The identity with *R. lignitum* was only anticipated by Walther (in Mai and Walther 1978), the view, which is to be revised. Similar middle Miocene leaves of a rose



Text-fig. 9. 1–12 *Ulmus fischeri* HEER, 1 UUG 8178, 2 UUG 3719, 4 UUG 3469, 5 UUG 8102, 6 UUG 3712, 7 UUG 8154, 8 UUG 3721, 9 UUG 3564, 10 UUG 8171, 11 UUG 3475, 12 UUG MP 60.

from Kreuzau (Ferguson 1971 – *Rosa* No. XXXI) differ from our material in dimorphic thorns. The Oligocene remains published as leaflets of *Rosa* from Rott are in the opinion of Weyland (1948) not attributable to this genus without doubt (i.e. *Pruniphyllum nausicaes* (WESSEL et WEBER) WEYLAND, *P. dubium* (WEBER) WEYLAND), although they match quite well our fossils. No complete leaves and fruits have been found in the association.

Material: NM G 7166, G 7174, G 8398a; UUG MP 152, MP 181–189, 9148, 9198, 22881; PRC Be 277, Be 278, Be 279; MMG Ba 269.

Rosa milosii sp. nov. (fruits)

Pl. 17, figs 4–8

Holotype designated here: NM G 8391a illustrated in Pl. 17, fig. 8.

Derivation nominis: In memory of the most active student of the flora of Bechlejovice, RNDr. Miloš Procházka (1923–1956).

Description: Fruits – hips pedicellate, urn-shaped, well-flattened, body 5–7 mm wide (stalk 5 to 7 mm long, with slender, slightly bent prickles up to 3 mm long), at the base also slightly spiny, the apex with a narrow disk and five persistent sepals 5 to 7 mm wide and 10 to 22 mm long, narrow ovate slender, entire-margined (rarely with single appendages) narrowed into tips at the end slightly expanded; of the venation only the midrib visible; whole impressions with sepals up to 40 mm. (Differently sized fruits possibly due to the various stages of maturity.) Details of inner structures of the fruit hidden in the thick coal matter except impressions of elliptic achenes, about 2 mm long (exact number unknown, more than 20) within filliform mass of trichomes.

Remarks: The fruits obviously belong to the above-described leaves. In one case, the fruit was partly covered by a single leaflet. In order to asses the systematic position of our rose the following features of both organs are in our opinion important: almost entire-margined persistent sepals, the kind of fine straight prickles, in combination with foliage, which certainly belongs to the fruits – 5 leaflets and narrow, fused stipules. The series *Chinenses* (SER.) REHDER (*R. chinensis* JACQ., China, not known in wild state) or *Pimpinellifoliae* (SER.) REHD. (e.g. *R. foetida* HERRM., Central Asia) and also the series *Cinnamomeae* (SER.) REHD. (e.g. *R. setipoda* HEMSL. et WILS., Central China or *R. webbiana* ROYLE, W. Himalaya) seem to be possibly the closest in this respect. However, the identification of roses is up to now highly sophisticated matter (see also Kirchheimer 1941, 1942, Meyer and Manchester 1997).

Material: NM G 8392–8397; UUG 194a.

gen. inc.

Rosaceae gen. et sp. 1

Pl. 18, figs 1–2, text-fig. 13.5

Description: Leaves, partly fragmentary, petiolate, petiole up to 4 mm long, lamina deeply pinnatifid, ovate, 13–25 mm long, 8–19 and more mm wide, segments toothed, at least 4 on each side, max. 14 mm long and 6 mm wide, on apex of some segments crenulate to toothed, venation pinnate, craspedodromous, midrib straight, secondaries subopposite to alternate, at an angle of 45–30°, several intersecondaries parallel to the margin of the segment up to the segment apex and sending side veinlets into teeth, in lower part looping along the margin, teeth very sharp, sparsely distributed, tertiary venation in narrow oblique meshes.

Remarks: Such a type of leaves occurs to our mind mainly among the Rosaceae (e.g., *Sorbus*, *Physocarpus* etc.).

Material: UUG MP 67a, b, 2961, 9169; PRC Be 298a, b; NM G 7168, G 7185.

Rosaceae gen. et sp. 2

Pl. 18, figs 7–8

Description: Leaves simple, petiole 5 mm, lamina lanceolate to ovate, 50–60 and more mm long, 19–30 mm wide, apex acute, base cuneate, margin sharply finely irregularly toothed, teeth straight flexuous, ca. 10 teeth per 10 mm, venation semicraspedodromous, midrib straight, strong, secondaries in up to 13 pairs, opposite to alternate, at an angle of 27–44°, steeply forked very near the margin, looping with side veins of the secondaries, sending admedial outer veinlets into teeth, intersecondaries occasionally present, short, tertiaries medium dense, forked, slightly oblique, higher-order venation poorly preserved.

Remarks: The marginal venation refers to affinities with the Rosaceae.

Material: NM G 8401.

Rosaceae gen. et sp. 3

Pl. 18, figs 5–6

Description: Leaf simple (?), without base, lamina broadly ovate, more than 75 mm long, 36 mm wide, apex probably acute, margin irregularly crenulate, probably glandular, venation mostly semicraspedodromous, midrib strong, straight, secondaries in ca. 9 pairs, subopposite to alternate, under an angle of 30–52°, in the lower part straight, curved near the margin, in upper half curved, looping with the adjacent secondaries, occasionally craspedodromous, intersecondaries solitary, short, tertiaries about 8 per 10 mm, perpendicular, rarely forked, higher-order venation forming polygonal meshes.

Remarks: This leaf is probably referable to the Rosaceae, matching very large leaflets of *Rosa lignitum*.

Material: NM G 8399.

Rosaceae gen. et sp. 4

Pl. 18, figs 3–4, text-fig. 11.2

Description: Detached leaflets, one terminal, long petiolulate, petiolule 12 mm long, lateral sessile, lamina broadly lanceolate to elongate, ca. 80–155 mm long, 25–43 mm wide, apex acute to acuminate, base cuneate, in lateral leaflet asymmetrical, margin crenulate to flexuous toothed, teeth slightly irregular, ? angular, partly mucronate, ca. 5 per 10 mm, sinuses angular or narrow rounded, venation semicraspedodromous, midrib strong, straight, secondaries in 10–12 and more pairs, under an angle of 40–52°, at first straight, near margin curved, looping mutually, sending side veinlets into teeth and into the sinuses, intersecondaries sometimes present, short, tertiaries in coarse polygonal network.

Remarks: The marginal venation refers to the Rosaceae, mainly *Sorbus.*

Material: NM G 8400; UUG MP 159.

Rumohra RADDI

Rumohra recentior (UNGER) BARTHEL

Pl. 19, figs 2–3

1847 *Sphenopteris recentior* UNGER, p. 123, pl. 37, fig. 4 (Radoboj).

1976 *Rumohra recentior* (UNGER) BARTHEL, p. 457, pls 80–81, text-figs 6a–d (Geiseltal, Kayna-Süd).

Description: Incomplete sterile fern fronds, apex with a lateral pinna and a detached pinna, preserved length 30 mm, rhachis strong, without any structure, pinna almost perpendicular, pinnules ovate, slightly asymmetrical, deeply dentate, up to 11 mm long and 3 mm wide, segments broadly attached, admedially oriented, shallowly dissected, secondary veins alternate, 3 times forked, reaching the margin, the lowermost admedial.

Remarks: These fragments are up to now the first records of this fern in the Oligocene of the České středohoří Mountains and Saxony. From Palaeogene of North Bohemia it is only known from the Doupov Mountains, the locality Valeč (Bůžek et al. 1980) and from Kučlín (pers. observ.).

Material: Missing.

Saportaspermum MEYER et MANCHESTER

Saportaspermum sp. (seeds)

Pl. 19, figs 4–5, text-fig. 11.13

Description: Winged seeds, ca. 20 mm long, wing 6–7 mm wide, seed body slightly obliquely attached, oval, 6–7 mm long, venation of wing not visible.

Remarks: Such seeds are spread in the European Cenozoic but differ in size and shape from site to site. The affinities are so far unknown. Meyer and Manchester (1997) separated this morpho-genus of enigmatic seeds from *Cedrelospermum* SAPORTA emend. MANCHESTER typified by the fruits of an extinct representative of the Ulmaceae. Similar seeds are produces by various Sterculiaceae (e.g. *Reevesia* LINDL.).

Material: Missing.

? *Sassafras* NEES

Sassafras (vel *Lindera*) sp.

Pl. 19, fig. 6

Description: Leaf fragmentary, simple, ? petiolate, lamina trilobate (?), base concave-cuneate, side lobe narrow, more than 80 mm long, max. 20 mm wide, entire-margined, sinus rounded, venation acrodrome suprabasal, midrib incompletely preserved, straight, lateral primaries arising 20 mm above the base, sub-opposite, straight, at an angle of 42°, abmedial side veins very thin steeply curved along the margin, secondaries not preserved, tertiaries perpendicular, very thin and dense, poorly visible.

Remarks: Such leaf forms occurring in the Palaeogene of Eurasia have been attributed to *Lindera* (e.g. *Lindera stenoloba* (SAPORTA) LAURENT 1912, Menat, France; Iljinskaja 1963, as *Lindera vassilenkoi*, Kiin-Kerish, Kazakhstan) and *Sassafras* (e.g. *Sassafras tenuilobatum* ANDREÁNSZKY 1959, Kiseged, Hungary). The absence of secondaries below the pair of subbasal lateral primaries in *Lindera* was suggested as a distinguishing character from *Sassafras,* e.g., by Laurent (1912, p. 122) and Imchanickaja (1967, pp. 797–798). The preservation of the specimen studied is not sufficient to show this diagnostic character. The distance of the subbasal lateral primaries from the lamina base is in our case longer than one would expect in *Lindera.*

Material: Missing.

? *Sloanea* L.

cf. *Sloanea artocarpites* (ETTINGSHAUSEN) Z. KVAČEK et HABLY

Pl. 20, fig. 1, pl. 23, fig. 2, text-fig. 13.1

Description: Leaves incomplete, simple, slightly asymmetric, broadly elliptic, ca. 90 to over 137 mm long, 28–92 mm wide, apex and base missing, margin sub-entire, with minute teeth on the upper part of blade, lower part entire, venation eucamptodromous to semicraspedodromous, midrib stout, straight, secondaries arising at distances of ca. 6–20 mm from each other, at an angle of 28–40°, looping along the margin and sending short admedial outer veinlets into teeth, intersecondaries in larger forms occasionally present, short, perpendicular to the midrib, tertiaries slightly oblique, usually percurrent, rarely forked.

Remarks: Such large sub-entire to coarsely dentate leaves have been recognized according to the leaf anatomy and co-occurring fruits as representing fossil species of *Sloanea* L. (Kvaček et al. 2001). *Sloanea artocarpites* is a common element at several sites of the Oligocene in North Bohemia (Suletice-Berand, Kundratice, Holý Kluk, Žichov).

Material: UUG MP 21, MP 31, 3643.

Smilax L.

Smilax weberi WESSEL in WESSEL et WEBER

Pl. 19, fig. 7, text-fig. 13.21

1847 *Smilacites grandifolius* UNGER, p. 218, pl. 40, fig, 3 (Radoboj).

1855 *Smilax grandifolia* (UNGER) HEER (non Buckland), p. 82, pl. 30, fig. 8 (Croisette).

1856 *Smilax weberi* WESSEL in WESSEL et WEBER, p. 127, pl. 21, fig.1 (Rott).

Description: Leaves subtriangular, hastate to subcordate, 50–90 mm long, 27–80 (typically 50) mm wide, entire-margined, apex acuminate; venation actinodromous – acrodromous, primary veins 5 to rarely 7, the medial one thicker, lateral veins originating at low angles, curving upwards, the outer pair more slender than the inner pair, looping marginally. Higher-order venation not visible.

Remarks: The several specimens at hand match in gross morphology *Smilax weberi* WESSEL from the type locality Rott (Wessel and Weber 1856, pl. 21, fig.1) and also the specimens described by Bůžek (1971, pl. 46, fig. 59) from the Lower Miocene of North Bohemia. Leaves of *Smilax* occur in the Oligocene as rare accessory elements, e.g. at Seifhennersdorf (Walther 1964), Suletice-Berand (Kvaček and Walther 1995), Kundratice (Kvaček and Walther 1998) and Kleinsaubernitz (Walther 1999). The Bechlejovice record is probably the oldest in Central Europe.

Material: NM G 7180a, b; UUG MP 18, MP 30, MP 129.

Sterculia L.

Sterculia crassinervia (ETTINGSHAUSEN) PROCHÁZKA et BŮŽEK

Pl. 20, figs 2–5

1869 *Acer crassinervium* ETTINSGHAUSEN, p. 22, pl. 45, figs 8–16 (Kučlín).

1975 *Sterculia crassinervia* (ETTINGSHAUSEN) PROCHÁZKA et BŮŽEK, p. 59 (Kučlín).

Description: Leaves simple, petiole not preserved, lamina subtrilobate – trilobate, 60–100 and more mm long, 32–110 and more mm wide, entire-margined, apex acute rounded, slightly retuse, base rounded, sometimes shortly decurrent, lobes short, often very low, not fully developed, rounded at apices, sinuses rounded, venation actinodrome – brochidodromous, three primaries arising from the very base of lamina, lateral at an angle of 35°, directed into lobes but looping before arriving to the margin region, secondaries arising not far from the base, regularly disposed, opposite to sub-opposite, in four pairs parallel to lateral primaries and looping along the margin, intersecondaries very thin, short, similar to tertiaries, tertiaries percurrent, slightly broken in the middle, higher-order venation in fine areoles.

Remarks: This species is so far known only from the Late Eocene diatomite from Kučlín (Ettingshausen 1869, as *Acer crassinervium*). We share the opinion of Procházka (in Procházka and Bůžek 1975) that it does not belong to maple foliage (also confirmed by Stroebitzer-Hermann, personal communication). The affinities with the Sterculiaceae are probable but it is difficult to indicate any genus fully agreeing with the fossils. One of the probabilities suggested also by co-occurring pollen is *Reevesia*. This genus produces winged seeds recalling those described above as *Saportaspemum* sp.

Material: NM G 7173a, b, G 8351, G 8402; UUG MP 11a, b, MP 12a, b, ?MP 68.

Tilia L.

Tilia gigantea ETTINGSHAUSEN

Pl. 21, figs 1–3, text-figs 11.12, 13.8

1869 *Tilia gigantea* ETTINGSHAUSEN, p. 16, pl. 43, fig.12, holotype (Žichov)

1869 *Tilia lignitum* ETTINSGHAUSEN, p. 15, pro parte, pl. 42, fig. 3 (Žichov) (non fig. 6, Parschlug).

1964 *Tilia* cf. *irtyschensis* (SHAPARENKO) GRUBOV; Walther, p. 65, pl. 24, fig. 1, pl. 25, figs 1–3 (Seifhennersdorf).

2000 *Tilia gigantea* ETTINGSHAUSEN; Hably et al., p. 61, pro parte (only foliage, non pl. 1, fig. 12 = *Tilia brassicoides*).

Description: Leaves simple to slightly trilobate, long petiolate, petiole 25 mm long, blade sub-circular to broadly oval, deeply cordate, rarely shallowly cordate to truncate, 60–128 mm long, 40–115 mm wide, apex acuminate, obtuse, base cordate, asymmetric, margin coarsely simple serrate, partly shortly mucronate, denser than the secondaries, venation palmate, craspedodromous, about five (to seven) primaries, midrib stout, usually oblique to the course of the petiole, lateral primaries with dense sub-parallel abmedial side-veins, secondaries regularly and densely disposed, sub-parallel with the inner lateral primaries, almost straight to gently bent, often abmedially forked near the margin forming short fields parallel with the margin, tertiaries principally convex, percurrent, rarely forked, in the basal part disposed in the spider-net pattern, higher-order veins very delicate, almost invisible, reticulate.

Remarks: Remains of *Tilia* L. rarely occur in volcanic floras of the České středohoří Mountains (e.g. Seifhennersdorf, Suletice, Kundratice). The characteristics of these leaves are typical of *Tilia gigantea* ETTINGSHAUSEN based on the type from Žichov (see Hably et al. 2001). The same type of foliage from Seifhennersdorf (Walther 1964) has previously been assigned according to the gross morphology and cuticular remains (typical stellate trichomes) to the closely allied *Tilia* cf. *irtyschensis*.

Material: NM G 7178a, b, G 7680, G 7689; UUG MP 27–28, MP 98–117, MP 174, MP 177, 3658.

Tilia brassicoides (SAPORTA) Z. KVAČEK et WALTHER, comb. nov. (bracts)

Pl. 21, figs 4–7, text-fig. 11.11

1890 *Rumex brassicoides* SAPORTA, Rev. Gén. Botan. 2, pp. 225, 238, pl. 13, fig. 2, holotype and basionym (Manosque).

2000 *Tilia gigantea* ETTINGSHAUSEN; Hably, Kvaček and Manchester, p. 61, pro parte (only bracts), pl. 1, fig. 12 (Bechlejovice).

Holotype: Collections of the Natural History Museum, Paris (coll. Saporta), figured by Saporta, 1890, pl. 13, fig. 2 and re-figured in Pl. 21, fig. 7.

Locus typicus: Manosque, France.

Stratum typicum: Oligocene.

Description: Bracts broadly oval, 27–35 mm wide and 30–50 mm long, rounded at the apex, deeply cordate to truncate at the base, pedunculate, venation brochidodromous – sub-actinodromous, midrib stout, steeply forked several times in a short distance above the bract base, secondaries steep, partly forked, looping well within the bract blade and forming additional smaller loops towards the periphery, thin sedondaries, rarely together with 2 steep lateral primaries arising fan-like from the base, tertiaries and higher-order veins reticulate, peduncle strong, attached at one point to the bract base, continuing upwards very slightly inclined from the midrib of the bract, soon branched several times, fruits missing.

Text-fig. 10. 1–3, 6, 8–17 *Zelkova zelkovifolia* (UNGER) BŮŽEK et KOTLABA, 1 UUG 8157, 2 UUG 8150, 3 UUG MP 61, 6 UUG 3710, 8 UUG 8176, 9 MMG Ba 301, 10 UUG 8164, 10 UUG 8164, 11 UUG 9151, 12 UUG 3562, 13 UUG 8186, 14 UUG 3489, 15 UUG 8189, 16 UUG 8156, 17 UUG 8186; 7, 18 *Zelkova zelkovifolia* (UNGER) BŮŽEK et KOTLABA forma *bechlejovicensis* forma nov., 7 G 8410 holotype, 18 UUG 9155.

Remarks: This type of bracts co-occurs with the leaves of *Tilia gigantea* at Bechlejovice and belongs obviously to the same plant. This primitive form of bracts attached at one point to the peduncle is similar to *Tilia circularis* from the Oligocene of North America, which has circular to broadly oval bracts (Manchester 1994). However, in the bract venation, which is not purely actinodromous, *T. brassicoides* stands between *T. circularis* (type A) and *T. pedunculata* (type B in sense of Manchester 1994). We do not follow the view of Hably et al. (2000) to assign both foliage and bracts to a single species and, according to the current practice, we assign the bracts to a separate morpho-species. The holotype from Manosque represented in the collection of the Natural History Museum in Paris matches in most features our material. However, we are unaware of any *Tilia*-like foliage co-occurring with the unique type specimen at Manosque.

Material: NM G 7169, G 7172a, b, G 8903, G 8904; UUG MP 118–124.

Torreya ARN.

Torreya bilinica SAPORTA et MARION

Pl. 22, figs 5–8

1866 *Sequoia langsdorfii* (BRONGN.) HEER; Ettingshausen, p. 39, pro parte, pl. 13, fig. 9 (non fig. 10) (Žichov).
1876 *Torreya bilinica* SAPORTA et MARION, p. 221 (Žichov).
1984 *Torreya bilinica* SAPORTA et MARION; Kvaček, p. 478, figs 5–6 (Žichov, Kundratice).

Description: Leaves lineal, flat, univeined, 25 mm long, 2.0–2.5 mm wide, cuneate , shortly obliquely petiolate and asymmetric at the base, bluntly triangular at the apex, entire-margined. Coal substance thick, referring possibly to the coriaceous texture. Abaxial cuticle with narrow prosenchymous cells and strongly papillate stomatal bands showing faint outlines of stomata.

Remarks: Morphologically similar remains recall *Cephalotaxus parvifolia*, known from Seifhennersdorf and Kundratice (Walther 1964, 1996, Kvaček and Walther 1998). However, the structure of the epidermis is different and characterizes typical epidermal structure of *Torreya* (Kvaček 1984). The fossils from Bechlejovice do not differ in any respect from the needles of *T. bilinica* from Seifhennersdorf, Kundratice, Žichov and Kleinsaubernitz.

Material: NM G 8406a, b, G 8407.

Toxicodendron MILL.

Toxicodendron herthae (UNGER)
Z. KVAČEK et WALTHER

Pl. 22, figs 1–4, text-fig. 12.3

1849 *Rhus herthae* UNGER, p. 6 (non pl. 14, fig. 21) (Parschlug).
1998 *Toxicodendron herthae* (UNGER) Z. KVAČEK et WALTHER, p. 27, pl. 15, figs 3–8, text-fig. 13.16 (Kundratice).

Description: Leaflets shortly petiolulate, slightly asymmetric to symmetric at the base, elongate, 20–30 mm wide and over 70 mm long, widely coarsely simple serrate, teeth rounded, apex acuminate, entire, venation craspedodromous, midrib thin, straight, secondaries densely spaced according to the number of teeth, at an angle of ca. 50–60°, entering the teeth or bent along the entire margin, often forked at the margin forming a transitional semicraspedodromous venation type, secretory strands adhering the secondaries in most cases, intersecondaries regularly present, higher-order venation very delicate, poorly preserved.

Remarks: This noteworthy type of leaflets belongs unequivocally to the *Rhus – Toxicodendron* complex. There are various extant species similar in the form of leaflets and teeth in both taxa (either genera or subgenera) so that the generic affinity suggested by Kvaček and Walther (1998) is more or less arbitrary. The type population from Parschlug (Kovar-Eder et al. 2004) varies in higher degree and includes also shorter leaflets, which do not occur at Bechlejovice.

Material: NM G 8405a, b; UUG MP 24–25, MP 137–138, 9147, 9172, 9175, 9176, 9178.

? *Typha* L.

"*Typha*" *latissima* A. BRAUN

Pl. 23, fig. 3

1855 *Typha latissima* A. BRAUN; Heer, p. 98, pls 43–44 (Öhningen).

Description: Strap-like leaf fragments up to 20 mm wide, incomplete, venation parallel, parallel veins in two orders, thicker about 1.5 mm apart, thinner almost of the same thickness, as far as observed on fragmentary material, ca. 6 per 1 mm, cross-veins only at places visible, almost perpendicular between two adjacent primaries, irregularly disposed at distances of ca. 2–3 mm between each other.

Remarks: Such leaf fragments have usually been assigned to the Typhaceae as a morpho-taxon of foliage matching both *Sparganium* L. and *Typha* L. (e.g. Kvaček and Hurník 2000). Because of the lack of anatomical traits we hesitate to use another taxon *Typhaeloipum* UNG. (*T. lacustre* UNG.), probably more appropriate for such a sort of monocot foliage.

Material: UUG MP 39, MP 133–135.

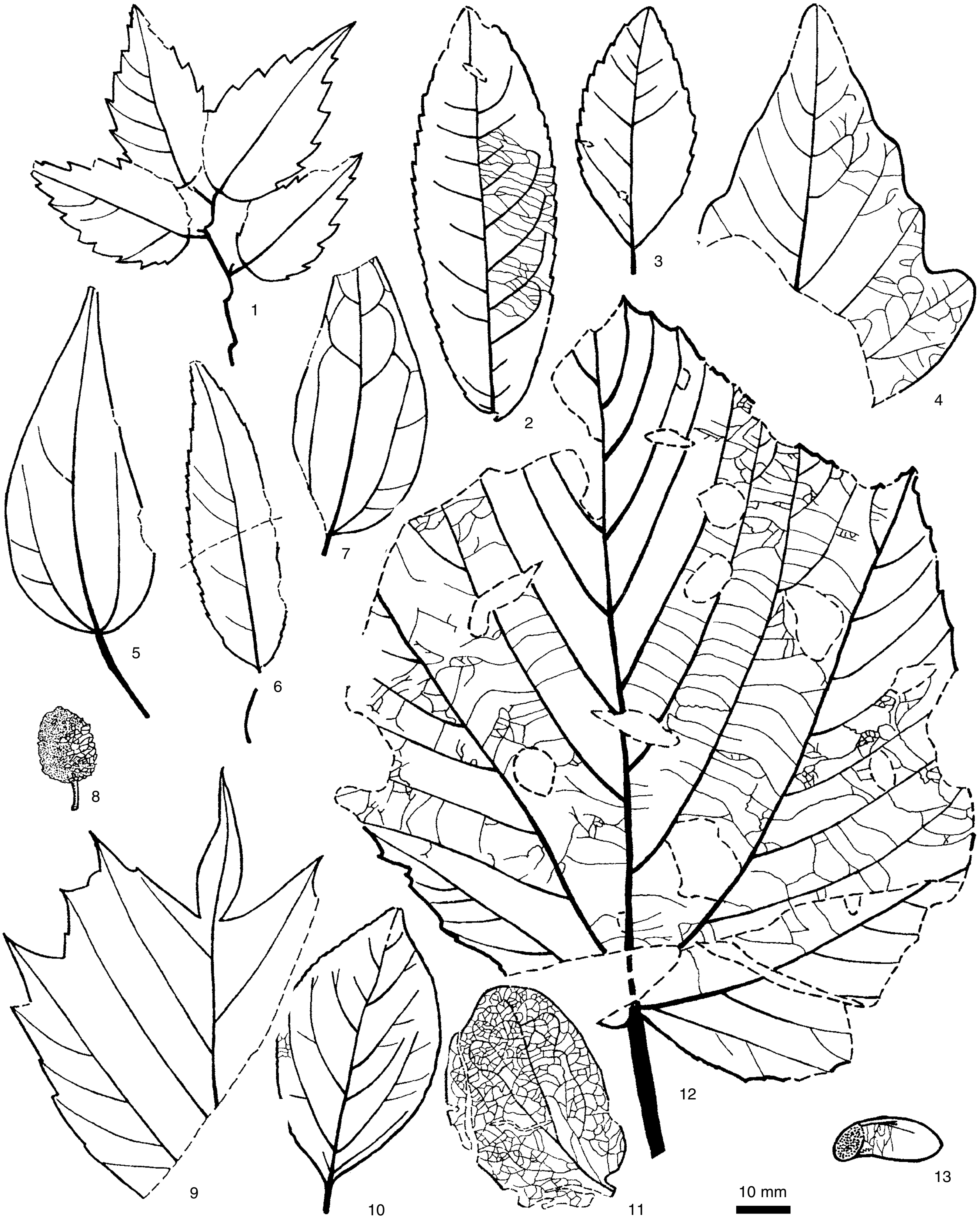
Ulmus L.

Ulmus fischeri HEER

Pl. 24, figs 5–8, text-figs 8.1–16, 9.1–12, 13.11

1856 *Ulmus fischeri* HEER, p. 57, pl. 57, figs 1–3 (Eriz-Losenegg near Bern).
1963 *Ulmus braunii* HEER; Mai, p. 66, pl. 4, fig. 4 (Seifhennersdorf).
1964 *Ulmus* sp.; Walther p. 40, pl. 14, figs 2, 4 (Seifhennersdorf).
1991 *Ulmus drepanodonta* GRUBOV; Mai and Walther, p. 50, pl. 27, figs 1–10 (former mines Borna-Ost, Bockwitz).
1998 *Ulmus fischeri* HEER; Kvaček and Walther, p. 27, pl. 16, figs 1–9, text-fig. 13/39 (Kundratice).

For further synonyms see Walther (1999).



Text-fig. 11. Floral picture (cont. 1). 1 *Zelkova zelkovifolia* (UNGER) BŮŽEK et KOTLABA, UUG 3643; 2 Rosaceae gen. et sp. 4, NM G 8400, 3 *Rosa lignitum* HEER, missing; 4 *Dicotylophyllum* sp. 2, NM G 8349; 5 cf. *Matudaea menzelii* WALTHER, UUG 3677; 6 *Alnus gaudinii* (HEER) KNOBLOCH et Z. KVAČEK, UUG 3670; 7 cf. *Matudaea menzelii* WALTHER, UUG 3678; 8 *Alnus kefersteinii* (GOEPP.) UNG., UUG 9157; 9 *Ampelopsis hibschii* BŮŽEK, Z. KVAČEK et WALTHER, UUG Be 1008; 10 *Diospyros* sp., UUG MP 6; 11 *Tilia brassicoides* (SAPORTA) comb. nov., NM G 8404; 12 *Tilia gigantea* ETTINGSH., NM G 7680; 13 *Saportaspermum* sp., missing.

Description: Leaves shortly petiolate, petiole up to 16 mm long, lamina oval to ovate, variable in size, typically medium-sized, 26–111 (typically 60) mm long and 19–62 mm wide, margin simple to double serrate, teeth triangular to oblong triangular, rarely with extremely long tooth apices, slightly biconvex, base slightly to distinctly asymmetrical, apex short to long acuminate, venation craspedodromous, midrib thick, secondaries slightly bent, densely spaced, in more than 10 pairs in larger leaves, sometimes forked at one third of their length, entering the main teeth. A single poorly preserved fruit associated, elliptic, 9 mm long and 7 mm broad, emarginate on the apex, with two short remains of stigmas, wing narrow, 2 mm wide, seed body spindle-like, 5 mm long and 2.5 mm wide.

Remarks: This species has previously been assigned to the closely allied *Ulmus drepanodonta* GRUBOV (= *U. fischeri* in sense of Mai and Walther 1991) from the Kazachstan Oligocene (Grubov in Kryshtofovich 1956). It occurs in almost all volcanic floras of the studied area (except the sites of Žichov and Matrý) and also in the Oligocene floras of the Weisselster Basin near Leipzig, Germany (Mai and Walther 1978, 1991). Small leaves are difficult to differentiate from the *Zelkova* foliage (Walther 1964, Kvaček and Walther 1995, 1998). Helpful traits to distinguish both genera are mainly in the form of teeth and density of the secondaries, which is much lower in *Zelkova*. The fruit is similar to *Ulmus* sp. sensu Kvaček and Walther (1998) from Kundratice and *Ulmus* sp. B sensu Meyer and Manchester (1997) from the Oligocene of Oregon except for the persistent stigmas.

Material studied: UUG MP 60, MP 89, MP 171, MP 198–201, MP 204 (fruit), 3363, 3460, 3466, 3468, 3471, 3474, 3475, 3480, 3563, 3564, 3565, 3591, 3594, 3595, 3712, 3714, 3715, 3717, 3718, 3719, 3722, 8102, 8153, 8159, 8165, 8166, 8169, 8167, 8170, 8171, 8174, 8179, 8184, 8190, 8191.

gen. inc.

? **Zamiaceae** gen. et sp.

Pl. 23, fig. 6

Description: Fragment of a leaf frond, 22 mm long and 126 mm wide, with 6 incomplete segments, rachis straight, ca. 2 mm wide, segments 3.4–3.5 mm wide and max. 14 mm long, slightly abmedially bent, margins parallel, apex rounded, venation parallel, veins of the same thickness, hardly visible.

Remarks: This poorly preserved fragment recalls a cycadalean leaf fossil. The attachment of segments is most similar to the genus *Dioon* LINDL. but also some of the representatives of *Encephalartos* LEHM. Such fossil remains have been encountered in the Lower Miocene of southern Europe (Kvaček and Velitzelos 2000), but usually much larger. Cycads have not been recorded so far in the Oligocene of Central Europe.

Material: Missing.

Zelkova SPACH

Zelkova zelkovifolia (UNGER) BŮŽEK et KOTLABA

Pl. 24, figs 1–2, text-figs 10.1–3, 6, 8–17, 11.1

1843 *Ulmus zelkovifolia* UNGER, pro parte, pl. 24, figs 9–13 (non fig. 7 – fructus) (Parschlug).

1845 *Ulmus zelkovifolia* UNGER, pro parte, pl. 26, fig. 7 (non fig. 8 – fructus) (Parschlug).

1847 *Ulmus zelkovifolia* UNGER, pro parte, p. 94 (non fructus) (Parschlug).

1963 *Zelkova zelkovifolia* (UNGER) BŮŽEK et KOTLABA in KOTLABA, p. 59, pl. 3, figs 7–8 (?).

1998 *Zelkova zelkovifolia* (UNGER) BŮŽEK et KOTLABA; Kvaček and Walther, p. 28, pl. 15, figs 9–12, text-fig. 13/27 (Kundratice).

Description: Twigs with alternate leaves. Leaves ovate, shortly petiolate, 27–70 mm long and 15–4.8 mm wide, base subcordate to wide cuneate, sometimes slightly to strongly asymmetrical, apex acute, partly extremely long, when teeth extreme coarse, margin simple coarsely serrate, teeth slightly convex or straight on admedial side, convex on abmedial side, in rare cases teeth extremely convex/concave or slightly convex to straight with more or less long acute apices. Venation craspedodromous, midrib thick, secondaries typically in 6–9 pairs, thin, slightly bent, entering marginal teeth. In subcordate leaves the first basal secondary vein bifurcates into two branches which turn into the teeth. Tertiaries mostly not observable.

Remarks: The variation in the development of teeth is an important hint of the intermediate position of *Zelkova zelkovifolia* between the extant *Z. carpinifolia*, *Z. abeliacea* and *Z. sicula* (Near East, Mediterranean) on one side and *Z. serrata* (eastern Asia) on the other side (see Kvaček and Walther 1995). The oldest record with fruits in the European Tertiary is known from Kundratice (Kvaček and Walther 1998). *Zelkova* is lacking in the Palaeogene of the Weisselster Basin near Leipzig, Germany (Floristic Assemblage Haselbach and Thierbach). Burnham (1986) described putative leaves of *Zelkova* from the Eocene and Oligocene of North America and earlier Tanai and Wolfe (1977) summarised the record of *Zelkova* from western North America. It seems likely that true *Zelkova* is not well proven in the New World Tertiary, as no fruit remains are available, although beautifully preserved leaf compressions resembling *Zelkova* do occur in the Miocene Succor Creek flora (see Manchester 1989). Leaves assigned to the "*Zelkova*" morphotype A in Burnham (1986, pl. 1, fig. 1) and C (pl. 1, figs 6, 7) can be compared with medium sized leaves of *Zelkova zelkovifolia* from Bechlejovice (Pl. 24, fig. 2).

Material: UUG MP 61, MP 90, 3470, 3543, 3572, 3772, 8150, 8156, 8157, 8161, 8163, 8175, 8176, 8181, 8186, 8187.

Zelkova zelkovifolia (UNGER) BŮŽEK et KOTLABA forma ***bechlejovicensis*** forma nova

Pl. 24, figs 3–4, text-figs 10.7, 18

Diagnose: Foliage differing from the type form in teeth narrow oblong, triangular, partly curved, with extreme long, partly mucronate tooth apices.

Text-fig. 12. Floral picture (cont. 2). 1 *Pungiphyllum cruciatum* (AL. BR.) FRANKENHÄUSER et WILDE, UUG MP 34; 2 *Comptonia* cf. *difformis* (STERNB.) BERRY, UUG MP 10; 3 *Toxicodendron herthae* (UNG.) Z. KVAČEK et WALTHER, UUG 9176; 4 *Mahonia pseudosimplex* sp. nov., NM G 8384a holotype; 5 *Cornus studeri* HEER, UUG 3687; 6 *Laurophyllum* sp., MMG Ba 256; 7 *Acer angustilobum* HEER, NM G 7181; 8 *Betula buzekii* Z. KVAČEK et WALTHER, NM G 7191a; 9 *Ostrya atlantidis* UNG., MMG Ba 49; 10 *Leguminosites cladrastioides* sp. nov., UUG MP 16; 11 *Cercidiphyllum crenatum* (UNG.) R. BROWN, UUG 9144; 12 *Carpinus mediomontana* MAI, UUG 9143; 13 *Laurophyllum* sp., MMG Ba 180; 14 *Cyclocarya* sp., MMG Ba 472; 15 *Cercidiphyllum crenatum* (UNG.) R. BROWN, UUG MP 35; 16 *Dombeyopsis lobata* UNG., UUG MP 23.

Holotype designated here: NM G 8410 – figured in Pl. 24, fig. 3 and text-fig. 10.7.

Etymology: Named after the type locality Bechlejovice.

Stratum typicum: Volcanic complex of the České středohoří Mountains, lower part, Early Oligocene.

Locus typicus: Bechlejovice, suburbs of the town Děčín, North Bohemia, Czech Republic.

Description: Leaves simple, shortly petiolate, petiole up to 11 mm long, lamina ovate to round-ovate, 62–81 mm long, 34–55 mm wide, apex long acute, base widely cuneate, rarely subcordate, margin simple coarsely serrate, with teeth up to 15 mm long, slightly convex to straight on abmedial site, often mucronate and slightly curved towards the leaf apex; venation craspedodromous, midrib thick, secondaries in 6–12 (typically 8) pairs, straight to slightly bent, entering the marginal teeth, the first basal secondaries rarely bifurcating either directly on the midrib or in the first third of their course in two branches which turn into the teeth, tertiaries not observable.

Remarks: Coarsely serrate leaves of *Zelkova* from Bechlejovice show partly similarities with smaller leaves of *Ulmus fischeri* in prolonged teeth (cf. Mai and Walther 1991, pl. 27, fig. 9). Different from all so far known records of *Zelkova* are extremely long and slender curved teeth with acute and mucronate apices. Such teeth are normally unknown in *Ulmus*. Similar extreme forms exist in the cultivated form called *Zelkova verschaffeltii* (DIPPEL) NICHOLSON, a problematic species with unknown origin, which may represent a juvenile form of *Z. carpinifolia* (Dippel 1893, Krüssmann 1962). The new form described above shows common morphological characteristics of the leaves, which fall outside the typical variation of leaves of both *Zelkova zelkovifolia* and *Ulmus fischeri*. Wang et al. (2001, fig. 7.257) illustrate a cleared leaf of *Z. carpinifolia* (coll. T. Denk 89650), which shows the same type of teeth as it is characteristic of these fossils. The population from Bechlejovice is now suspected to be the oldest of the *Zelkova* records of Europe and may include extreme forms ancestral to more advanced populations occurring in the later Cenozoic. Therefore, we separate this foliage type to a new form.

Material: NM G 8410; UUG MP 88, 3473, 3710, 3721, 3724, 3773, 8151, 8158, 8160, 8172, 9155.

Ziziphus MILL.

Ziziphus ziziphoides (UNGER) WEYLAND

Pl. 23, fig. 4, text-fig. 13.15

1847 *Ceanothus ziziphoides* UNGER, p. 145, pl. 49, fig. 10 (Häring).
1853 *Ceanothus ziziphoides* UNGER; Ettingshausen, p. 76, pl. 25, figs 9–39 (Häring).
1859 *Ziziphus ungeri* HEER, p. 74, pl. 122, figs 25, 26 (Ralligen Ennerhorw).
1943 *Ziziphus ziziphoides* (UNGER) WEYLAND, p. 113 (Häring).
1998 *Celtis* sp.; Kvaček and Walther, p. 11, pl. 4, fig. 8, text-fig. 13/25 (Kundratice).

Description: Leaf lanceolate, petiolate, petiole 7 mm long, lamina lanceolate, 40 mm long, 13 mm wide, finely denticulate crenate, base cuneate, apex blunt, venation triveined, acrodromous, lateral primaries diverging very steeply at an angle of ca. 20°, arising slightly above the base and reaching the apex, outer secondaries widely spaced (?) hardly visible, arch-like approaching the margin, inner secondaries very thin, oblique to the midrib.

Remarks: This type of narrow leaves prevails at the type locality Häring (Ettingshausen 1853) and is more common also elsewhere in the European Palaeogene (Petrescu et al. 1989). This typical narrow form occurs but rarely in the floras of the České středohoří Mountains, e.g. at Kučlín (Ettingshausen 1869, as *Ziziphus ungeri*) and Kundratice (Kvaček and Walther 1998, as *Celtis* sp.)

Material: NM G 8409.

Ziziphus ziziphoides (UNGER) WEYLAND forma *bilinica* (ETTINGSHAUSEN) stat. n.

Pl. 23, fig. 5

1869 *Ziziphus bilinica* ETTINGSHAUSEN, Denkschr. K. Akad. Wiss. math.-nat. Cl., 29: 40, pl. 51, fig. 1, basionym (Kučlín).

Holotype designated here: No. BP 59.1139.1, Kučlín, Late Eocene (refigured in Hably et al. 2001, pl. 37, fig. 3).

Description: Leaf fragmentary, petiolate, petiole 7 mm long, blade ca. 30 mm wide, very incomplete in length, ovate (?), inconspicuously widely denticulate-crenate, teeth rounded, glandular, blade slightly asymmetric, tri-veined, midrib straight, thin, two lateral primary veins arising at an angle of ca. 30° shortly below the lamina base, forming the edge of leaf for a very short distance, giving off arched abmedial side veinlets widely spaced and looping close to the margin, the lowermost ascending higher along the margin the others, secondaries alternate, widely spaced, at an angle of ca. 30° or less, tertiary veins ascending from the midrib at slightly wider angles, partly as intersecondaries, very thin, subparallel.

Remarks: *Ziziphus ziziphoides* is a variable species of leaves matching Rhamnaceae, in particular the genus *Ziziphus*. Although the generic assignment is equivocal in respect of parallel leaf architecture of other related genera, e.g. *Ceanothus*, *Paliurus* etc., we dwell on the currently accepted interpretation (Weyland 1943, Petrescu 1968). Broader forms are connected in most occurrences with narrow ones by transitions and obviously do not represent independent species. As pointed out by Bůžek et al. (1996), *Z. ziziphoides* differs in oblique, not horizontal course of tertiaries from *Z. paradisiaca* (UNG.) HEER that is more frequent in the Neogene (Radoboj, Cheb Basin, Magyare-

Text-fig. 13. Floral picture (cont. 3). 1 cf. *Sloanea artocarpites* (ETTINGSH.) Z. KVAČEK et HABLY, UUG MP 21; 2 *Carpinus grandis* UNG., MMG Ba 33; 3 *Cercidiphyllum crenatum* (UNG.) R. BROWN, UUG 3709; 4 *Laurophyllum* sp. MMG Ba 241; 5 Rosaceae gen. et sp. 1, UUG 9171; 6 cf. *Matudaea menzelii* WALTHER, UUG MP 36a; 7 *Polypodium radonii* Z. KVAČEK, UUG 9150; 8 *Tilia gigantea* ETTINGSH., UUG 3685; 9 *Rosa lignitum* HEER, UUG 9148; 10 *Craigia bronnii* (UNG.) Z. KVAČEK, BŮŽEK et

MANCHESTER, missing; 11 *Ulmus fischeri* HEER, UUG 8167; 12 *Laurophyllum* cf. *pseudoprinceps* WEYL. et KILPP., UUG 3702; 13 *Carpinus mediomontana* MAI, UUG 3518; 14 *Rosa lignitum* HEER, MMG Ba 269; 15 *Ziziphus ziziphoides* (UNG.) WEYL., NM G 8408, 16 *Mimosites haeringianus* ETTINGSH., NM G 7186; 17 *Acer integrilobum* WEBER, MMG Ba 452; 18 *Acer angustilobum* HEER, MMG Ba 184; 19 *Carpinus mediomontana* MAI, MMG 9161; 20 *Leguminosites* sp. 1, UUG MP 215; 21 *Smilax weberi* WESSEL, UUG MP 18; 22 *Laurophyllum acutimontanum* MAI, MMG Ba 337:2; 23 *Acer palaeosaccharinum* STUR, MMG Ba 142.

gregy). Broader forms, contrary to *Z. paradisiaca*, have a very distinct basal venation with lateral primaries stretching out of the lamina outline. This feature is well developed in the holotype from Kučlín, which represents a twig with two leaf fragments attached. The specimen from Bechlejovice matches both leaves in this respect. *Paliurus tiliaefolius* occurring mainly in the Miocene of Europe (type locality Bílina) has a similar arrangement of basal veins but decidedly differs in very fine sub-parallel, sub-horizontal tertiaries (see Bůžek 1971).

Material: NM G 8409.

Table 1. Elements of the Bechlejovice flora in comparison with other Palaeogene sites (SS - Staré Sedlo Fm., Kč - Kučlín, TC - Tard Clay, Hb - Haselbach, Ku - Kundratice, Sf - Seifhennersdorf, SB - Suletice-Berand, Ro - Roudníky, Ži - Žichov, based on data in Knobloch et al. 1996, Kvaček and Walther 1995, 1998, 2001, Kvaček 2002, Mai and Walther 1978, Radoň et al. in press, Walther 1993 etc.; system of angiosperms according to Tachhtadžan 1987 adapted).

	Bechlejovice	SS	Kč	TC	Hb	Ku	Sf	SB	Ro	Ži
Bryophyta	Bryophyta gen. et sp.					+		+		
Polypodiophyta										
Polypodiaceae	*Polypodium radonii* Z. KVAČEK									
Davalliaceae	*Rumohra recentior* (UNG.) BARTHEL									
Cycadophyta										
Zamiaceae	? Zamiaceae gen. et sp.									
Pinophyta										
Taxaceae	*Torreya bilinica* SAP. et MAR.					+	+		c	+
Magnoliophyta										
Magnoliopsida										
Magnoliaceae	Magnoliaceae gen. et sp.					+	+	+		cf
Lauraceae	*Sassafras* (vel *Lindera*) sp.			+						
	Laurophyllum acutimontanum MAI	+		+	+		+	cf	+	
	Laurophyllum cf. *pseudoprinceps* WEYL. et KILPP.	+				+		+		+
	Laurophyllum sp.	+	+	+	+	+	+	+		+
Berberidaceae	*Mahonia pseudosimplex* sp. nov.							cf		
Cercidiphyllaceae	*Cercidiphyllum crenatum* (UNG.) R. BROWN (incl. fruits)					+	+	+		+
Hamamelidaceae	cf. *Matudaea menzelii* WALTHER		+	+	+	+		+		
Platanaceae	*Platanus neptuni* (ETTINGSH.) BŮŽEK et al.	+	+	+	+	+	+	+	+	+
	Platanus schimperi (HEER) SAP. et MAR.	cf	+							
Fagaceae	cf. *Quercus bavarica* (KNOBLOCH et Z. KVAČEK) Z. KVAČEK	+								
	? *Quercus* sp. (cupule)	+								
Betulaceae	*Betula buzekii* Z. KVAČEK et WALTHER				cf.	+		cf		cf
	Alnus gaudinii (HEER) KNOBLOCH et Z. KVAČEK								+	+
	Alnus kefersteinii (GOEPP.) UNG. (fruits, catkins)			cf.	+	+				+
	Carpinus grandis UNG.				+	+	+	+	+	+
	Carpinus mediomontana MAI (fruits)				+	+	+	+	+	
	Carpinus cordataeformis MAI (fruits)				+		+			
	Ostrya atlantidis UNG. (incl. fruits)					+	cf	+	+	
	Carpinus (vel *Ostrya*) sp. (catkins)									
Myricaceae	*Comptonia* cf. *difformis* (STERNB.) BERRY			cf						
Juglandaceae	*Carya* cf. *serrifolia* (GOEPP.) KRÄUSEL							+	+	+
	Carya sp.									
	Cyclocarya sp.							+		+
Ebenaceae	*Diospyros* sp.									cf
	Diospyros brachysepala A. BR. (calyces)									
Salicaceae	*Populus zaddachii* HEER				+	+	+	+		
Elaeocarpaceae	cf. *Sloanea artocarpites* (ETT.) Z. KVAČEK et HABLY			cf		+		+		+
Malvaceae s. l.	*Tilia gigantea* ETT.					+	+			+
	Tilia brassicoides (SAP.) comb. nov. (inflorescence bracts)									
	Dombeyopsis lobata UNG.					+	+	cf		
	Craigia bronnii (UNG.) Z. KVAČEK et al. (fruits)			+		+	+	+		+
	Sterculia crassinervia (ETT.) PROCHÁZKA et BŮŽEK		+							
Ulmaceae	*Ulmus fischeri* HEER (incl. fruit)			cf	+	+	+		cf	
	Zelkova zelkovifolia (UNGER) BŮŽEK et KOTLABA					+	+	+	+	
	Zelkova zelkovifolia (UNGER) BŮŽEK et KOTLABA *f. bechlejovicensis* f. nov.									
Rosaceae s. l.	*Rosa lignitum* HEER				+	+	+	+	+	+
	Rosa milosii sp. nov. (fruits)								+	
	Crataegus pirskenbergensis KNOBLOCH								+	
	cf. *Pyracantha kraeuselii* WALTHER				+	+			+	
	Rosaceae gen. et sp. 1									
	Rosaceae gen. et sp. 2									
	Rosaceae gen. et sp. 3									
	Rosaceae gen. et sp. 4									

	Bechlejovice	SS	Kč	TC	Hb	Ku	Sf	SB	Ro	Ži
Leguminosae	*Mimosites haeringianus* ETT.			+		+		+	+	
	Leguminosites cladrastioides sp. nov.									
	Leguminosites sp. 1							+		
	Leguminosites sp. 2 (fruit)							cf		+
Sapindaceae s. l.	*Acer angustilobum* HEER					+	+	+	+	
	Acer integrilobum WEBER					+	+	+		
	Acer palaeosaccharinum STUR					+	+	+	+	+
	Acer tricuspidatum BRONN					+	+	+		cf
	Acer sp. 1 (fruits)									
	Acer sp. 2 (fruits)							+		
Simaroubaceae	*Ailanthus prescheri* WALTHER					+	+	+		
Anacardiaceae	*Toxicodendron herthae* (UNG.) Z. KVAČEK et WALTHER					+				
Rhamnaceae	*Ziziphus ziziphoides* (UNG.) WEYLAND		+	+		+				
	Ziziphus ziziphoides (UNG.) WEYLAND f. *bilinica* (ETTINGSH.) stat. nov.		+							
Vitaceae	*Ampelopsis hibschii* BŮŽEK et al.				+	+	+	+		
	Ampelopsis sp.									
Cornaceae	*Cornus studeri* Heer					+	+	+		
fam. inc.	*Pungiphyllum cruciatum* (A. BR.) FRANKENHÄUSER et WILDE		cf			+		+		
	Saportaspermum sp. (seeds)		cf							+
	Dicotylophyllum deichmuelleri Z. KVAČEK et WALTHER				+	+		+	+	
	Dicotylophyllum heerii (ENGELH.) Z. KVAČEK et WALTHER				+					
	Dicotylophyllum sp. 1									
	Dicotylophyllum sp. 2									
	Dicotylophyllum sp. 3									
	Dicotylophyllum sp. 4									
	Dicotylophyllum sp. 5									
	Dicotylophyllum sp. 6									
	Dicotylophyllum sp. 7									
Liliopsida										
? Alismataceae	*Haemanthophyllum* sp.									
Smilacaceae	*Smilax weberi* WESSEL			+				cf		+
Arecaceae	Arecaceae gen. et sp.	cf	cf	cf	cf					
Typhaceae	*"Typha" latissima* A. BR.									
	Monocotyledonae gen. et sp.									

Floristic composition with notes on palynology and comparisons with other European Palaeogene plant assemblages

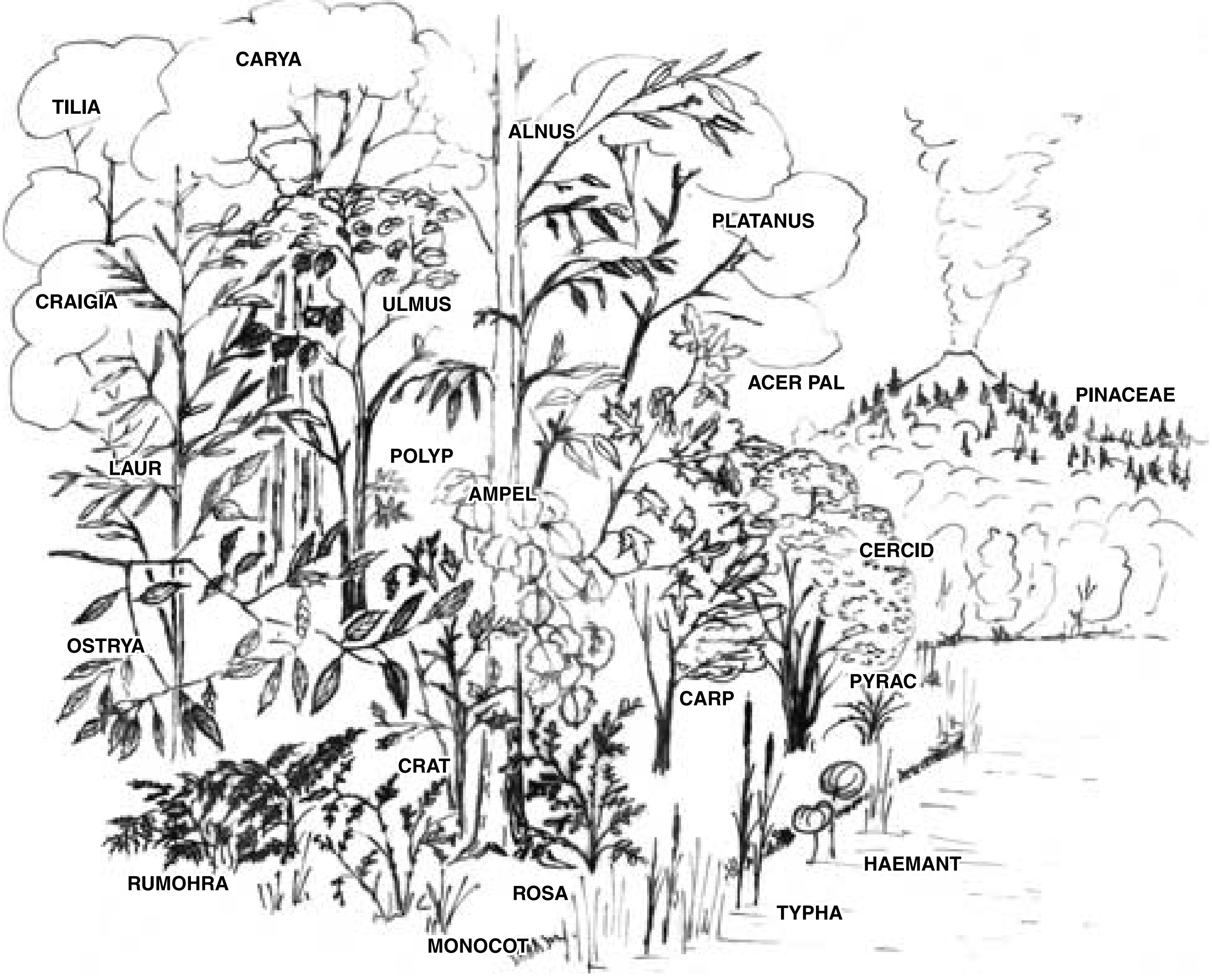
The plant assemblage obtained from Bechlejovice includes a bryophyte, a cycad (?), two ferns, one conifer and more than 70 species of angiosperms, partly based on both foliage and fruits. Due to taphonomical bias this is certainly not a complete picture of the flora. A very useful source of additional information about the floral composition can be obtained from the palynological data (Holý 1958, Konzalová 1981 etc.). According to the macrofossil plant record it seems likely that various hamamelids, such as *Cercidiphyllum,* Juglandaceae (*Carya*, *Cyclocarya*), Betulaceae (*Alnus*, *Ostrya*, *Carpinus*) and other woody broad-leaved elements of Malvaceae s.l. (*Craigia*, *Tilia*, *Reevesia* ?), Ulmaceae (*Ulmus, Zelkova*) and various species of *Acer*, Rosaceae and Leguminosae were well represented, while conifers were almost absent (Table 1). This is not quite true, if the pollen spectra are taken into account. As reflected by pollen spectra, the flora outside the depositional site was rich in conifers, belonging to the Pinaceae including *Tsuga* and Cupressaceae s.l. Another discrepancy between the pollen and leaf/fruit record is in the absence of *Engelhardia* in the latter, contrary to its abundant pollen. Otherwise there is a good agreement of wind-pollinated taxa. Holý (1958) and Konzalová (1981) listed inaperturate (Cupressaceae s.l.) and bisaccate (Pinaceae) pollen as dominating forms and regularly present *Reveesiapollis*, *Alnus*, *Pterocarya*, *Carya*, *Carpinus*, *Ulmus*, *Tilia* (*insculptus* type), *Castanea* – *oviformis* type and *Engelhardia* besides single occurrences of *Leiotriletes*, *Gleicheniidites*, *Verrucatisporites*, *Boehlensipollis*, *Tricolporopollenites marcodurensis*, *Tsuga*, *Intratripollenites instructus*, *Celtis*, *Ilex* and Onagraceae. In fact the pollen record is also incomplete in respect to the megafossils. For the palaefloristic analysis, those elements are important and may indicate palaeogeographic – stratigraphic connections to other sites. Firstly, ancient elements known from the Paleocene and Eocene, such as *Rumohra recentior* (Geiseltal), *Platanus schimperi* (Ménat), *Sterculia crassinervia* (Kučlín) and *Haemanthophyllum* (Kamčatka) stress the archaic character of the Bechlejovice assemblage. Thermophilic taxa, such as *Platanus neptuni* (Kučlín), *Laurophyllum acutimontanum* (Staré Sedlo) and *Ziziphus ziziphoides* (Kučlín) survived into the Miocene. Some others, e.g. *Matudea menzelii*, *Mimosites haeringianus*, *Ailanthus prescheri*, *Ampelopsis hibschii* and *Sloanea artocarpites* are more or less confined to the Oligocene, of them *Polypodium radonii*, *Torreya bilinica, Dicotylophyllum deichmuelleri* and *D. heerii* to the České středohoří Mountains and adjacent volcanic sites in Saxony. Several thermophilic representatives of the flora are spread also in the Lower Oligocene in Germany (e.g. *Quercus bavarica*, *Laurophyllum acutimontanum*, *Platanus neptuni,* Arecaceae gen. in the Rupelian of Flörsheim – Kvaček 2004) and Hungary (*Matudaea*, *Ziziphus*, *Platanus neptuni*, *P. schimperi* in the Kiscellian of the Tard Clay – Hably 1979, Kvaček and Hably 1998) in the near-sea facies. The broad-leaved deciduous (Turgay) elements, which form the larger part of the flora, are typical of the post-Grande Coupure sites on the Eocene-Oligocene boundary (Bůžek et al. 1990). It seems likely that at Bechlejovice the earliest records of several such elements are documented in Europe – *Cercidiphyllum*, *Zelkova*, *Craigia*, *Tilia*, *Ostrya*, *Carpinus, Rosa, Crataegus* etc. Some of them developed aberrant forms not known elsewhere, e.g. extremely narrow leaves in *Cercidiphyllum*, elongate teeth in *Zelkova zelkovifolia* f. *bechlejovicensis*, broadly ovate bracts in *Tilia brassicoides*. The pairs of shared or near-related taxa between the Oligocene of Bechlejovice and Oregon, such as *Cercidiphyllum crenatum*, *Tilia brassicoides* and *T. circularis*, *Rosa milosii* and *Rosa hiliae*, *Ostrya atlantidis* and *O. oregoniana*, *Crataegus pirskenbergensis* and *C. meriamii*, *Mahonia pseudosimplex* and *M. simplex* and others (Hably et al. 2000), stress contacts of these coeval populations between Europe and North America, most probably via Beringia. Also *Polypodium radonii* shows a close relationship both in gross morphology and spores *in situ* to *P. fertile* MACGINITIE from western North America (Kvaček et al. 2004). Most broad-leaved deciduous elements are phylogenetically connected with their East Asiatic (*Cercidiphyllum*, *Carya*, *Cyclocarya*, *Ostrya*, *Craigia* etc.) and Mediterranean descendents (*Zelkova*, *Carpinus*) rather than with those living today in North America (e.g. *Acer palaeosaccharinum, A. tricuspidatum*). Concluding this part of general floristic analysis, it can be stated that the Bechlejovice assemblage reflects the character of the European flora within the Eocene-Oligocene cooling event connected with large-scale migrations and extinctions.

The Bechlejovice plant macrofossil assemblage is most similar to those of the Early Oligocene of North Bohemia, while the others in Europe differ in the lower proportion of the broad-leaved deciduous element due to the palaeogeographical situation (Tard Clay, Flörsheim) or swampy environment (Haselbach, Seifhennersdorf, Baltic). The almost identical composition can be found at Valeč and Dvérce in the Doupov Mountains, of course, also because these sites are not yet fully explored and the number of elements is low (Bůžek et al. 1990, figs 9–10). Almost all plant elements from there are represented at Bechlejovice – *Rumohra, Platanus neptuni*, *Alnus, Zelkova*, *Ulmus fischeri*, *Mahonia*, *Carya*, *Matudaea* (Bůžek et al. 1990, fig. 9.5 – as Lauraceae), *Smilax,* but also *Pinus* (at Bechlejovice in the pollen spectrum), and additional *Tetraclinis* and *Daphnogene*, while many others are lacking. The closest similarity among the sites of the České středohoří Mountains can be found at Kundratice (Table 1). The others so far revised, e.g. Suletice-Berand, Holý Kluk, Markvartice, Žichov, besides a high number of elements in common (*Torreya*, *Laurophyllum acutimontanum*, *Cercidiphyllum*, *Craigia*, *Sloanea*, Juglandaceae, *Platanus neptuni, Rosa lignitum*, etc.), are in general more thermophilic with more diversified Lauraceae, *Oleinites* (*Dicotylophyllum maii*), *Palaeohosiea, Calocedrus suleticensis* and others. Even the Kundratice assemblage is not fully identical, differing in the endemic *Taxus engelhardtii*, almost endemic *Caphalotaxus parvifolia* (also at Seifhennersdorf), a different fern flora (*Osmunda lignitum*, *Pronephrium stiriacum*) and the lack of archaic *Platanus schimperi* and *Sterculia crassinervia*. The percentage of the plants shared between Bechlejovice and the Late Eocene Staré Sedlo and Kučlín floras is unusually high for a post-Grand Coupure type. A preliminary survey of the flora of Roudníky (Bellon et al. 1998, table 3) shows that also this assemblage is comprised of many plants in common with Bechlejovice and seems approximately coeval (Kvaček and Walther 2003), but requires further studies of recently gathered rich material from outcrops (coll. Bílina Mines, Z. Dvořák).

Taphonomy, paleoecology and vegetation

The taphonomic bias heavily distorts the picture of the Bechlejovice vegetation as reflected in the fossil assemblage. As it is a usual case for the sites of the diatomite in the volcanic environment, the crater sees were typical of calm and clear standing waters, not providing the opportunity of any mixing of plant megafossils from wider surroundings of the site. One can assume that the assemblage mostly consists of remains from the very nearby vegetation and solitary specimens arrived into the sediment from distances difficult to judge. It is now impossible to say from the frequency of the fossils, which species was most frequent, because among deciduous trees just one tree could supply the assemblage buried nearby with a lot of leaves. Therefore, a cautious approach is followed in the case of the Bechlejovice vegetation reconstruction (Text-fig. 14). So much more, if we consider palynological spectra from the fossiliferous sediment that may reflect vegetation from very far distances (e.g. Pinaceae).

The megafossil plant record from Bechlejovice can be divided into two groups. Firstly a few helophytes comprised of *Haemanthophyllum*, "*Typha*" and probably other monocots. This is a strip of vegetation surrounding the banks of the Bechlejovice Sea. The water, judging from the fauna and diatoms, was oligotrophic, very clear and not muddy and the banks were moderately steep. The second unit, the surrounding forest, was comprised of mostly non-swampy mesic humid elements, such as *Carpinus*, *Ostrya, Cercidiphyllum*, *Carya, Cyclocarya, Craigia, Tilia* and maples. These trees grew near the water because complete branches, large leaves and infructescences suggest parautochtonous depositional conditions. Also *Alnus gaudinii*, unlike other members of the genus, avoided swamps and was bound to mesophytic forests in other occurrences. A diversified representation of legumes and shrubs, such as *Rosa, Crataegus*, *Pyracantha*, *Mahonia*, *Cornus* and the like indicates open forests leaving enough light under the canopy for the undergrowth. The prevailing deciduous character of the ele-



Text-fig. 14. Reconstructed vegetation at the Bechlejovice lake (TILIA – *Tilia gigantea & brassicoides*; CARYA – *Carya* cf. *serrifolia*; CRAIGIA – *Craigia bronnii & Dombeyopsis lobata*; ULMUS – *Ulmus fischeri*, ALNUS – *Alnus gaudinii & kefersteinii*; PLATANUS – *Platanus schimperi*; LAUR – *Laurophyllum* sp.; OSTRYA – *Ostrya atlantidis*; POLYP – *Polypodium radonii*; AMPEL – *Amelopsis hibschii*; ACER PAL – *Acer palaeosaccharinum*; CERCID – *Cercidiphyllum crenatum*; CARP – *Carpinus grandis & mediomontana*; RUMOHRA – *Rumohra recentior*; CRAT – *Crataegus pirskenbergensis*; ROSA – *Rosa lignitum & milosii*; PYRAC – cf. *Pyracantha kraeuselii;* MONOCOT – Monocotyledonae gen.; TYPHA – "*Typha*" *latissima*; HAEMANT – *Haemanthophyllum* sp.; PINACEAE – Pinaceae gen.).

ments represented in the assemblage may not indicate true abundance in the forest vegetation. As noted above, the pollen spectra and individual macrofossil remains refer on other communities, probably slightly further from the depositional site. *Engelhardia*, palms, evergreen Lauraceae and *Platanus neptuni* were certainly elements requiring equable climatic conditions without very cold winters, contrary to many temperate genera. The closest recent vegetation to be compared with that of Bechlejovice is difficult to suggest, because both East Asiatic and North American (Asa-Gray) disjunctions are represented in the Bechlejovice assemblage, besides clearly extinct elements. The combination of *Torreya*, *Ostrya, Carpinus*, palms, but without *Engelhardia*, *Cercidiphyllum, Pyracantha*, *Zelkova*, *Ziziphus* etc. can be found in the Panhandle area of Florida in the Appalachicola Natural Reserve. Maybe, there was also such an area in East Asia before the man disturbed lowlands and transferred most natural forests into rice fields. And also the Mediterranean would allow surviving and accommodating such forests before man unless the anticyclone above Sahara that originated much later in the Cenozoic caused a rise of the sclerophyllous vegetation type to cover this area. The reconstructed forest vegetation at Bechlejovice is best called the Mixed Mesophytic Forest of the North American type with a low representation of evergreen elements. The uplands from very wide surroundings may have supplied the pollen spectra with the Pinaceae including *Tsuga*. It is difficult to trace the mother plant producing large quantities of inaperturate conifer pollen, but the probably coeval assemblage at Roudníky brought evidence of stands of a juniper (Kvaček 2002b), which might not have left any traces of megafossils at Bechlejovice, only the pollen. The *Glyptostrobus – Taxodium* swamp forests were certainly not developed at that time in the České středohoří Mountains. Very similar kind of mesophytic vegetation was developed also in most other sites of the centre in the České středohoří Mountains differing mainly in the proportion and composition of thermophile elements.

Conclusions on climate

To get climatic proxies from a plant megafossil assemblage, three methodologies have been currently applied. The first, intuitive, compares the reconstructed vegetation of the fossil site with the nearest similar one from among recent communities / biomes in the Northern Hemisphere. In this case, its synecological characteristics serve as a basis to derive analogue climatic conditions of the fossil vegetation. The second, ± objective, is the co-existence approach introduced by Mosbrugger and Utescher (1993). This methodology relies on a combined comparison of autecologies obtained from the nearest living relatives. The analysis is complemented using computer technique to derive the climatic proxies, under which most of the elements live today together. The third, also objective, employs the correlation between selected physiognomic features of dicotyledonous foliage with the type of climate. This approach called a CLAMP analysis by Wolfe and improved several times by the others (see Spicer's web site – http://tab:tha.open.ac.uk/spicer/CLAMP/Datasets.html) has been applied more often to the assemblages with many extinct and enigmatic types of leaves, particular of early angiosperms. We compare all three for the assemblage of Bechlejovice, which is rich enough to fulfil requirements for the analyses.

As noted above, the nearest living forest type corresponding to the Bechlejovice assemblage occurs today in the Panhandle area in Florida. This relictual area hosts the last populations of *Torreya taxifolia* and many deciduous hardwoods common with Bechlejovice, such as *Ostrya, Sassafras, Cornus, Diospyros, Carya, Acer, Alnus, Carpinus, Ulmus* besides evergreen as well deciduous magnolias and only few other evergreen trees. The climate is quite warm there: the mean annual temperature (MAT) ca. 20 °C, the July mean (WMMT) ca. 27 °C, the January mean (CMMT) slightly over 10 °C and mean annual precipitation (MAP) slightly over 1000 mm (data for *Torreya taxifolia* from Thompson et al. 2000).

The co-existence intervals of the nearest living relatives (courtesy A. Bruch) give the following data: MAT 15.3–16.6 °C, WMMT 24.3-27.0 °C, CMMT 10.0–10.2 °C and MAP 979–1250 mm. These proxy data are probably more accurate, although in general they fit in the above comparison with the analogue vegetation in northern Florida. The proxies from the co-existence methodology also depend on how accurately the individual nearest living relative has been chosen. From the list of taxa evaluated for Bechlejovice some of extreme elements have been excluded, e.g. *Platanus kerrii* as an analogue of *P. neptuni*, and some more that obviously deviate from the pattern. This is a risk and subjective influence in this methodology. However, in the present case the proxy data are obviously satisfactory and acceptable.

The data obtained from the CLAMP analysis (courtesy V. Teodoridis) roughly coincide: MAT 16.4 ± 1.17 °C, WMMT 25.5 ± 1.58 °C and CMMT 8.4 ± 1.88 °C, giving a colder MAT than the corresponding vegetation area today, as the co-existence approach also suggests. The value of the mean annual precipitation may not be quite reliable from this methodology and has not been calculated. A mere calculation of the rate between entire-margined and dentate foliage would not work in our case. The Bechlejovice assemblage comprises less than 30 % entire-margined dicots, which would indicate far colder climate for comparable East Asiatic vegetation (Wolfe 1979) than the proxies given above.

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Oligocenní květena z Bechlejovic u Děčína v neovulkanické oblasti Českého středohoří, Česká republika

Zlatko Kvaček – Harald Walther

Laminovaný diatomit z Bechlejovic na předměstí města Děčína (nyní městská část) v oblasti Českého středohoří v severních Čechách se stal světově proslulým nalezištěm paleogenních žab. V této práci je vyhodnocen po stránce květeny a vegetace podle makrofosilií. Zároveň je podán přehled údajů dosavadního paleontologického, geologického a geochemického výzkumu. Z rostlinných makrofosilií byl určen jeden mechorost, dvě kapradiny (*Polypodium*, *Rumohra*), jeden zástupce cykasovitých (?), jediný jehličnan (*Torreya*) a přes 70 krytosemenných rostlin, z nichž *Mahonia pseudosimplex* sp. nov., *Tilia brassicoides* (SAPORTA) comb. nov., *Zelkova zelkovifolia* (UNG.) BŮŽEK et KOTLABA forma *bechlejovicensis* forma nov., *Rosa milosii* sp. nov., *Leguminosites cladrastioides* sp. nov., *Ziziphus ziziphoides* (UNG.) WEYL. forma *bilinica* (ETT.) stat. nov. byly stanoveny nově. Poprvé byly na lokalitě zjištěny další pozoruhodné prvky, jako je *Platanus schimperi* (HEER) SAP. et MAR., *Sterculia crassinervia* (ETT.) PROCHÁZKA et BŮŽEK, cf. *Matudaea menzelii* WALTHER, *Haemanthophyllum* sp., *Diospyros brachysepala* A. BR., cf. *Pyracantha kraeuselii* WALTHER, *Ailanthus prescheri* WALTHER, *Dicotylophyllum deichmuelleri* Z. KVAČEK et WALTHER, *D. heerii* (ENGELH.) Z. KVAČEK et WALTHER, and Arecaceae gen. et sp. Rekonstrukce vegetace na základě lokálních souborů makrofosilií předpokládá, že pouze úzký pruh vodních rostlin („*Typha*“, *Haemanthophyllum*) vroubil vody jezera. Vyvýšená stanoviště kolem jezera byla pokryta na bohatých vulkanogenních půdách

smíšeným mesofytním lesem s malým podílem vysloveně teplomilných prvků (Lauraceae, *Platanus neptuni*, cf. *Quercus bavarica* (KNOBLOCH et Z. KVAČEK) Z. KVAČEK, Arecaceae gen. et sp.) a dobře vyvinutým keřovým (? Zamiaceae gen. et sp., *Rosa*, *Mahonia, Ziziphus*, *Toxicodendron*, *Ampelopsis*) a bylinným (*Rumohra recentior* (UNG.) BARTHEL, *Polypodium radonii* Z. KVAČEK, Monocotyledonae gen. et sp.) podrostem. Soudě podle četnosti výskytu listových otisků, ve vyšším i nižším stromovém patru v blízkosti jezera dominovaly různé hamamelidní prvky, jako je *Cercidiphyllum,* Juglandaceae (*Carya*, *Cyclocarya*), Betulaceae (*Alnus*, *Ostrya*, *Carpinus*) a další dřeviny, jako např. *Craigia*, *Tilia*, *Ulmus, Zelkova* a různé druhy rodu *Acer.* Luštěniny, *Populus*, Rosaceae, *Toxicodendron, Ampelopsis, Smilax* a další zčásti záhadné krytosemenné rostliny představovaly jen malou akcesorní příměs poblíž lokality. Palynologické údaje přesvědčují, že tato charakteristika se týká jen úzkého výseku krajiny, kdežto v širším okolí byly zastoupeny další jehličnany (Pinaceae, Cupressaceae) a listnaté dřeviny (včetně rodu *Engelhardia*). Věk lokality Bechlejovice je odhadován na spodní oligocén vzhledem k přítomnosti starobylých prvků (*Boehlensipollis hohlii*, *Platanus schimperi*, *Sterculia crassinervia*, *Haemanthophyllum*) a korelaci s radiometricky datovanou úrovní od Roudníků u Ústí nad Labem také s umbridními rybami a velmi podobnou květenou. Obě lokality náleží do spodní části vulkanického komplexu, který je charakterizován staršími čediči bohatými olivínem (ústecké souvrství ve smyslu Cajze).

Explanation of the plates

PLATE 1

Acer palaeosaccharinum STUR
1. UUG MP 42 (scale bar 10 mm).

Acer angustilobum HEER
2. UUG MP 41a (scale bar 10 mm).
3. NM G 7181 (scale bar 10 mm).
4. UUG MP 44 (scale bar 10 mm).

Acer integrilobum WEBER
5. UUG MP 45 (scale bar 10 mm).

Acer sp. 2 (fruit)
6. NM G 8360 (scale bar 10 mm).

Acer sp. 1 (fruit)
7. missing, orig. Knobloch 1994, pl. 1, fig. 6 (scale bar 10 mm).

? *Acer tricuspidatum* BRONN
8. NM G 8359 (scale bar 10 mm).

Acer tricuspidatum BRONN
9. UUG MP 40 (scale bar 10 mm).

PLATE 2

Ailanthus prescheri WALTHER
1. NM G 8361a, leaflet (scale bar 10 mm).
2. Detail of fig. 1 (scale bar 3 mm).

Alnus kefersteinii (GOEPPERT) UNGER
3. UUG 9154, female infructescence (scale bar 10 mm).
4. NM G 8362, male inflorescence (scale bar 10 mm).

Alnus gaudinii (HEER) KNOBLOCH et Z. KVAČEK
5. UUG 2669 (scale bar 10 mm).
6. UUG 3628 (scale bar 10 mm).
7. UUG 3696 (scale bar 10 mm).

PLATE 3

Ampelopsis hibschii BŮŽEK, Z. KVAČEK et WALTHER
1. UUG Be 1007, orig. Bůžek et al. 1981, pl. 1, fig. 6, text-fig. 4c (scale bar 10 mm).
2. UUG Be 1006, orig. Bůžek et al. 1981, pl. 3, fig. 4, text-fig. 4b (scale bar 10 mm).

Ampelopsis sp.
3. Leaflet, NM G 7176 (scale bar 10 mm).

Arecaceae gen. et sp.
4. Detail of fig. 5 (scale bar 5 mm).
5. NM G 8363 (scale bar 10 mm).

PLATE 4

Betula buzekii Z. KVAČEK et WALTHER
1. UUG 3490 (scale bar 10 mm).

Bryophyta gen. et sp.
2. NM G 8364 (scale bar 10 mm).

Carpinus grandis UNGER
3. UUG MP 8 (scale bar 10 mm).
4. UUG 3734 (scale bar 10 mm).
5. UUG MP 7 (scale bar 10 mm).

Carpinus cordataeformis MAI
6. NM G 8382 (scale bar 10 mm).
7. Missing (scale bar 10 mm).

Carpinus mediomontana MAI
8. Fragmentary infructescence, Mus. Teplice, s. n. (scale bar 10 mm).

Carpinus (vel *Ostrya*) sp. (male catkins)
9. NM G 8365 (scale bar 10 mm).

PLATE 5

Carya cf. *serrifolia* (GOEPPERT) KRÄUSEL (leaflets)
1. UUG MP 50 (scale bar 10 mm).
2. Detail of fig. 1. (scale bar 10 mm).
3. UUG MP 51 (scale bar 10 mm).
4. UUG MP 52 (scale bar 10 mm).

Carya sp. (leaflet)
5. NM G 6837a (scale bar 10 mm).

PLATE 6

Cercidiphyllum crenatum (UNGER) R. BROWN
1. NM G 8366 (scale bar 15 mm).
2. Fruits, UUG 9174 (scale bar 10 mm).
3. UUG MP 33 (scale bar 10 mm).
4. UUG 3478 (scale bar 10 mm).

Cornus studeri HEER
5. UUG 3668 (scale bar 10 mm).
6. UUG 3687 (scale bar 10 mm).
7. UUG 3629 (scale bar 10 mm).

PLATE 7

Comptonia cf. *difformis* (STERNBERG) BERRY
1. UUG MP 10 (scale bar 10 mm).

Crataegus pirskenbergensis KNOBLOCH
2. UUG MP 2a (scale bar 10 mm).
3. UUG MP 3a (scale bar 10 mm).
4. UUG MP 1a (scale bar 10 mm).
5. NM G 7215 (scale bar 10 mm).

PLATE 8

Cyclocarya sp.
1. UUG MP 46 (scale bar 10 mm).
2. Leaflet, UUG MP 48 (scale bar 10 mm).

3. Leaflet, UUG MP 49 (scale bar 10 mm).
4. UUG MP 47 (scale bar 10 mm).

PLATE 9

Dombeyopsis lobata UNGER

1. UUG MP 14a (scale bar 10 mm).
2. UUG MP 15 (scale bar 10 mm).
3. NM G 7183a (scale bar 10 mm).
4. UUG MP 9 (scale bar 10 mm).

Craigia bronnii (UNGER) Z. KVAČEK, BŮŽEK et MANCHESTER (fruit valves)

5. NM G 8367a (scale bar 10 mm).
6. NM G 8368 (scale bar 10 mm).
7. NM G 8369 (scale bar 10 mm).

PLATE 10

Dicotylophyllum deichmuelleri Z. KVAČEK et WALTHER

1. NM G 8370 (scale bar 5 mm).
2. UUG MP 29 (scale bar 10 mm).
3. NM G 8371 (scale bar 10 mm).

Dicotylophyllum heerii (ENGELHARDT) Z. KVAČEK et WALTHER

4. NM G 8372 (scale bar 10 mm).
5. UUG MP 32 (scale bar 10 mm).

Dicotylophyllum sp. 6

6. NM G 8373 (scale bar 5 mm).

Dicotylophyllum sp. 1

7. UUG 9179 (scale bar 10 mm).

Dicotylophyllum sp. 2

8. NM G 8349 (scale bar 10 mm).

PLATE 11

Dicotylophyllum sp. 3

1. UUG MP 37a (scale bar 10 mm).

Dicotylophyllum sp. 4

2. NM G 7193 (scale bar 10 mm).

Dicotylophyllum sp. 5

3. Detail of fig. 4 (scale bar 5 mm).
4. NM G 8374 (scale bar 10 mm).

Dicotylophyllum sp. 7

5. NM G 8375a (scale bar 10 mm).

Diospyros brachysepala AL. BRAUN (calyx)

6. NM G 8376 (scale bar 5 mm).

Diospyros sp.

7. UUG 3641 (scale bar 10 mm).
8. UUG MP 6 (scale bar 10 mm).
9. UUG MP 38 (scale bar 10 mm).

PLATE 12

Haemanthophyllum sp.

1. NM G 8378 (scale bar 10 mm).
2. Detail of fig. 1 (scale bar 2 mm).

Laurophyllum sp.

3. UUG 3675 (scale bar 10 mm).
4. UUG 3606 (scale bar 10 mm).
5. UUG 3642 (scale bar 10 mm).

Laurophyllum cf. *pseudoprinceps* WEYLAND et KILPPER

6. UUG 3702 (scale bar 10 mm).
7. UUG 3667 (scale bar 10 mm).

Laurophyllum acutimontanum MAI

8. NM G 8379 (scale bar 10 mm).
9. Adaxial cuticle, NM G 8380b (scale bar 50 µm).
10. Abaxial cuticle, NM G 8380b (scale bar 50 µm).

PLATE 13

Leguminosites cladrastioides sp. nov.

1. UUG MP 16 (scale bar 10 mm).
2. UUG MP 17 (scale bar 10 mm).
3. Holotype, NM G 5504 (scale bar 10 mm).

Leguminosites sp. 2 (fruit)

4. NM G 8381 (scale bar 10 mm).

Leguminosites sp. 1 (leaflets)

5. UUG MP 19 (scale bar 10 mm).
6. UUG MP 20 (scale bar 5 mm).
7. UUG MP 215 (scale bar 5 mm).

Mimosites haeringianus ETTINGSHAUSEN

8. NM G 7186 (scale bar 10 mm).
9. UUG MP 4 (scale bar 10 mm).
10. UUG MP 5a (scale bar 10 mm).

PLATE 14

Magnoliaceae gen. et sp.

1. UUG MP 13a (scale bar 10 mm).
2. UUG 3658 (scale bar 10 mm).

Monocotyledonae gen. et sp.

3. NM G 8383 (scale bar 10 mm).
4. Detail of fig. 3 (scale bar 2 mm).

Mahonia pseudosimplex sp. nov.

5. Holotype, NM G 8384a (scale bar 10 mm).
6. Detail of fig. 5 (scale bar 10 mm).

cf. *Matudaea menzelii* WALTHER

7. UUG 3677 (scale bar 10 mm).
8. UUG 3678 (scale bar 10 mm).

PLATE 15

Ostrya atlantidis UNGER

1. UUG 3573 (scale bar 10 mm).
2. UUG 3574 (scale bar 10 mm).
3. UUG 3580 (scale bar 10 mm).
4. Involucre, missing (scale bar 10 mm).
5. Involucre, missing (scale bar 10 mm).

Platanus neptuni (ETTINGSHAUSEN) BŮŽEK, HOLÝ et Z. KVAČEK f. *reussii* (ETTINGSH.) Z. KVAČEK et MANCHESTER

6. NM G 8387a, orig. Knobloch 1994, pl. 1, fig. 1 (scale bar 10 mm).
7. Detail of fig. 7 (scale bar 10 mm).
8. Stoma, NM G 8387b (scale bar 12.5 µm).

Platanus schimperi (HEER) SAPORTA et MARION

9. NM G 8385 (scale bar 10 mm).

PLATE 16

cf. *Quercus bavarica* (KNOBLOCH et Z. KVAČEK) Z. KVAČEK

1. NM G. 8388 (scale bar 10 mm).

? *Quercus* sp. (cupule)

2. NM G 8344a (scale bar 10 mm).
3. NM G 8344b (scale bar 10 mm).

cf. *Pyracantha kraeuselii* WALTHER

4. NM G 8347 (scale bar 10 mm).
5. UUG MP 26 (scale bar 10 mm).

Populus zaddachii HEER

6. NM G 8389, orig. Knobloch 1994, pl. 1, fig. 2 (scale bar 10 mm).
7. UUG MP 22a (scale bar 10 mm).

Pungiphyllum cruciatum (AL. BRAUN) FRANKENHÄUSER et WILDE

5\. NM G 8390, orig. Kvaček and Walther 1981, pl. 7, fig. 3 (scale bar 10 mm).

PLATE 17

Rosa lignitum HEER
1. PRC Be 227 (scale bar 10 mm).
2. NM G 8398a (scale bar 10 mm).
3. Detail of fig. 2 (scale bar 1 mm).

Rosa milosii sp. nov. (fruits)
4. NM G 8396 (scale bar 10 mm).
5. NM G 8392 (scale bar 10 mm).
6. NM G 8395 (scale bar 10 mm).
7. NM G 8393a (scale bar 10 mm).
8. Holotype, NM G 8391a (scale bar 10 mm).

PLATE 18

Rosaceae gen. et sp. 1
1. NM G 7168 (scale bar 10 mm).
2. UUG 9171 (scale bar 10 mm).

Rosaceae gen. et sp. 4
3. Detail of fig. 4 (scale bar 2 mm).
4. Leaflet, NM G 8400 (scale bar 10 mm).

Rosaceae gen. et sp. 3
5. Leaflet, NM G 8399 (scale bar 10 mm).
6. Detail of fig. 5 (scale bar 10 mm).

Rosaceae gen. et sp. 2
7. Detail of fig. 8 (scale bar 10 mm).
8. Leaflet, NM G 8401 (scale bar 10 mm).

PLATE 19

Polypodium radonii Z. KVAČEK
1. Frond, UUG 9150 (scale bar 10 mm).

Rumohra recentior (UNGER) BARTHEL
2. Partial pinna, missing (scale bar 10 mm).
3. Partial pinnule, missing (scale bar 5 mm).

Saportaspermum sp. (seeds)
4. Missing (scale bar 5 mm).
5. Missing (scale bar 5 mm).

Sassafras (vel *Lindera*) sp. (scale bar 10 mm).
6. Missing.

Smilax weberi WESSEL
7. UUG MP 30 (scale bar 10 mm).

PLATE 20

cf. *Sloanea artocarpites* (ETTINGSHAUSEN) Z. KVAČEK et HABLY
1. UUG MP 31 (scale bar 10 mm).

Sterculia crassinervia (ETTINGSHAUSEN) PROCHÁZKA et BŮŽEK
2. NM G 8402 (scale bar 10 mm).
3. UUG MP 27 (scale bar 10 mm).
4. UUG MP 28 (scale bar 10 mm).
5. NM G 7173a (scale bar 10 mm).

PLATE 21

Tilia gigantea ETTINGSHAUSEN
1. NM G 7680 (scale bar 10 mm).
2. UUG MP 27 (scale bar 10 mm).
3. UUG MP 28 (scale bar 10 mm).

Tilia brassicoides (SAPORTA) comb. nov. (bracts)
4. NM G 8903, orig. Hably et al. 2000, pl. 1, fig. 12 (scale bar 10 mm).
5. NM G 8904 (scale bar 10 mm).
6. NM G 7169 (scale bar 10 mm).
7. Holotype, Manosque (Museum Paris), orig. Saporta 1890, pl.13, fig. 2 (scale bar 10 mm).

PLATE 22

Toxicodendron herthae (UNGER) Z. KVAČEK et WALTHER (leaflets)
1. NM G 8405a (scale bar 10 mm).
2. UUG MP 25 (scale bar 10 mm).
3. UUG MP 24 (scale bar 10 mm).
4. UUG 9178 (scale bar 10 mm).

Torreya bilinica SAPORTA et MARION
5. NM G 8406a (scale bar 10 mm).
6. NM G 8407 (scale bar 10 mm).
7. Adaxial cuticle of fig. 5 reflecting prosenchymous cells, NM G 8406b (scale bar 50 µm).
8. Abaxial cuticle of fig. 5 with papillate stomatal band, NM G 8406b (scale bar 50 µm).

PLATE 23

cf. *Quercus bavarica* (KNOBLOCH et Z. KVAČEK) Z. KVAČEK
1. UUG 3639 (scale bar 10 mm).

cf. *Sloanea artocarpites* (ETTINGSH.) Z. KVAČEK et HABLY
2. UUG 3643 (scale bar 10 mm).

"*Typha*" *latissima* AL. BRAUN
3. UUG MP 39 (scale bar 10 mm).

Ziziphus ziziphoides (UNGER) WEYLAND
4. NM G 8408 (scale bar 10 mm).

Ziziphus ziziphoides (UNGER) WEYLAND forma *bilinica* (ETTINGSHAUSEN) stat. nov.
5. NM G 8409 (scale bar 10 mm).

? Zamiaceae gen. et sp.
6. Missing (scale bar 10 mm).

PLATE 24

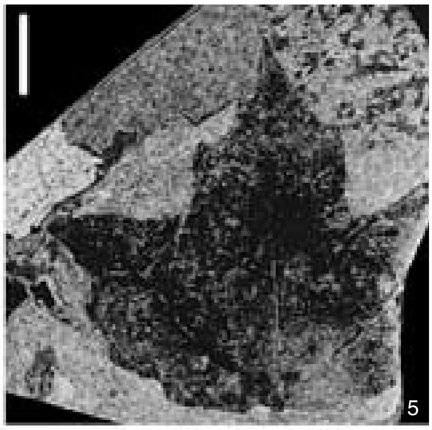
Zelkova zelkovifolia (UNGER) BŮŽEK et KOTLABA
1. Leafy twig, UUG 3543 (scale bar 10 mm).
2. Leafy twig, UUG 3572 (scale bar 10 mm).

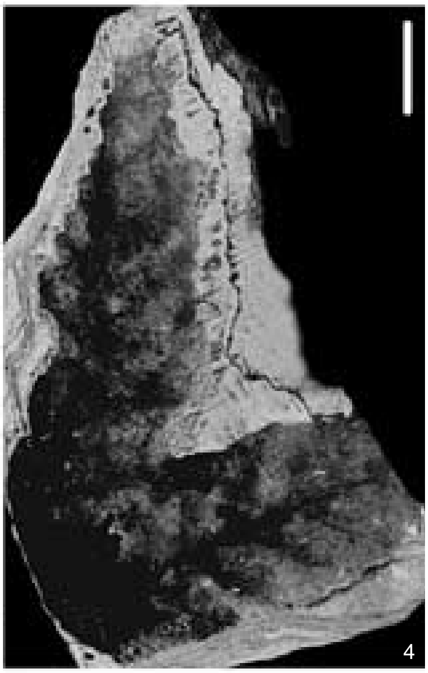
Zelkova zelkovifolia (UNGER) BŮŽEK et KOTLABA forma *bechlejovicensis* f. nov.
3. Holotype, NM G 8410 (scale bar 10 mm).
4. UUG 3473 (scale bar 10 mm).

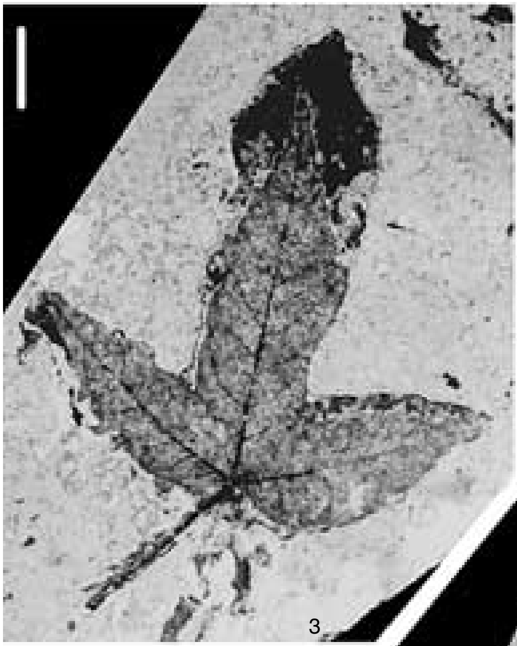
Ulmus fischeri HEER
5. UUG 3712 (scale bar 10 mm).
6. UUG 3480 (scale bar 10 mm).
7. UUG 3722 (scale bar 10 mm).
8. UUG 3466 (scale bar 10 mm).

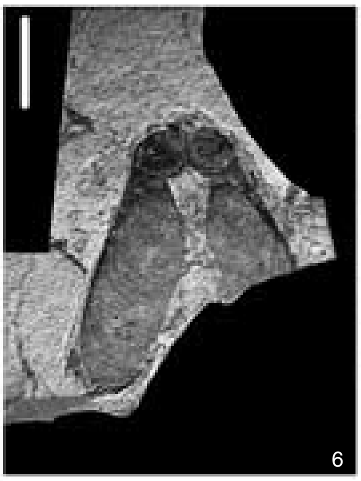
Cover: *Acer palaeosaccharinum* STUR, Bechlejovice, UUG MP 42, pl. 1, fig. 1, × 1.5.

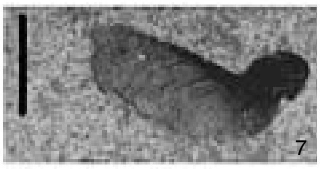
Plate 1

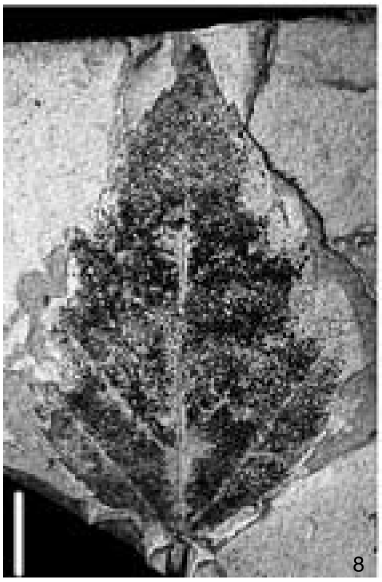


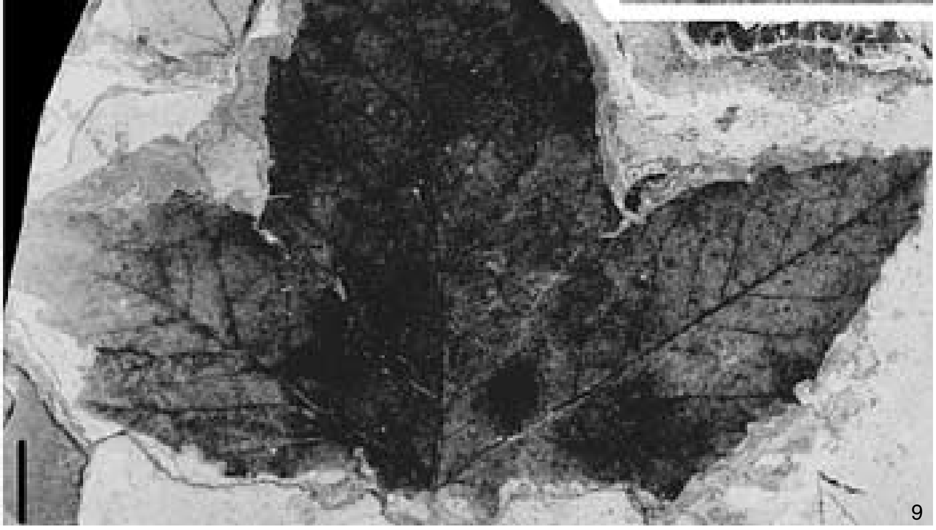












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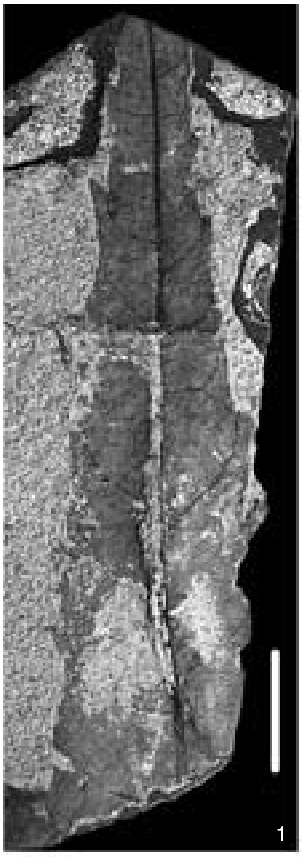
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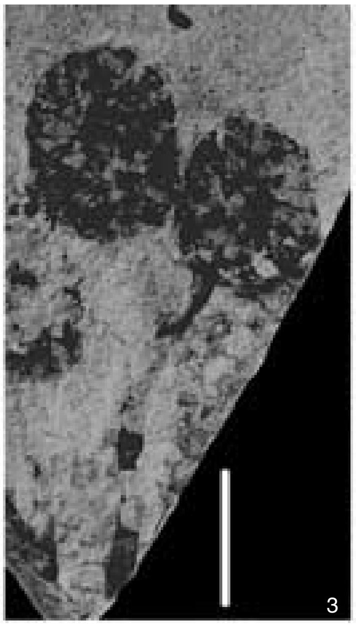
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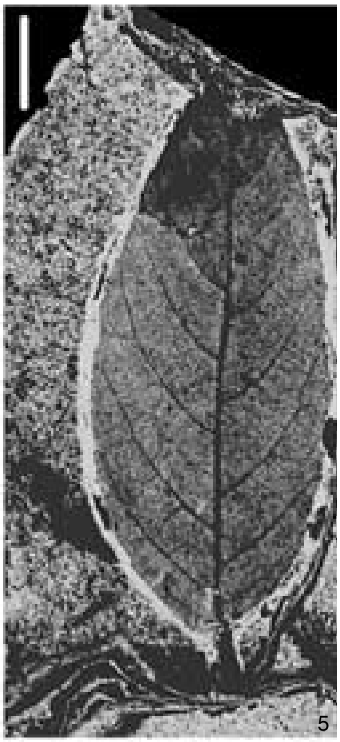
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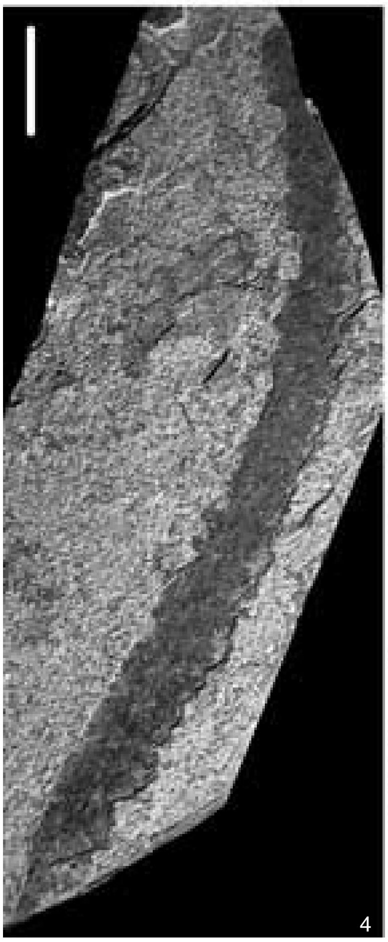
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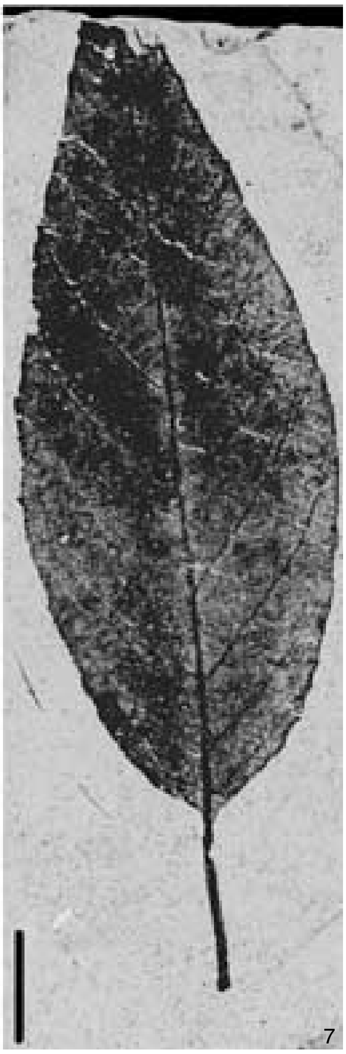
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Plate 3


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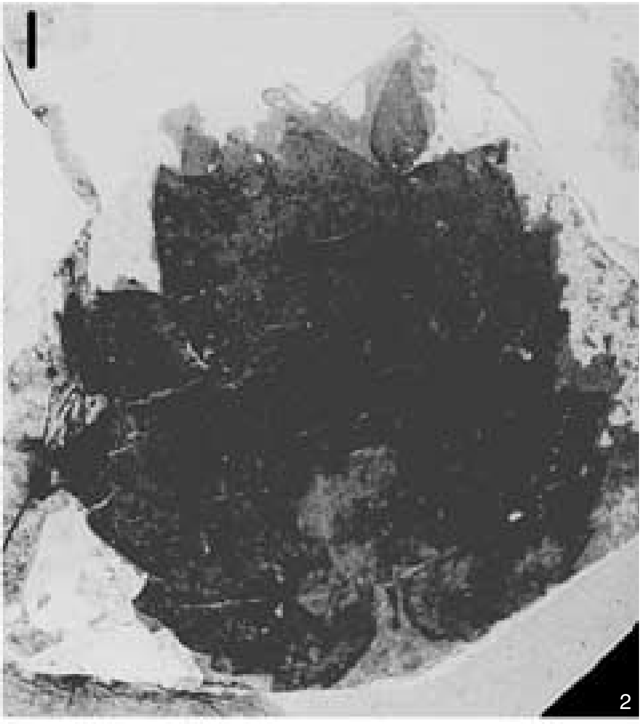
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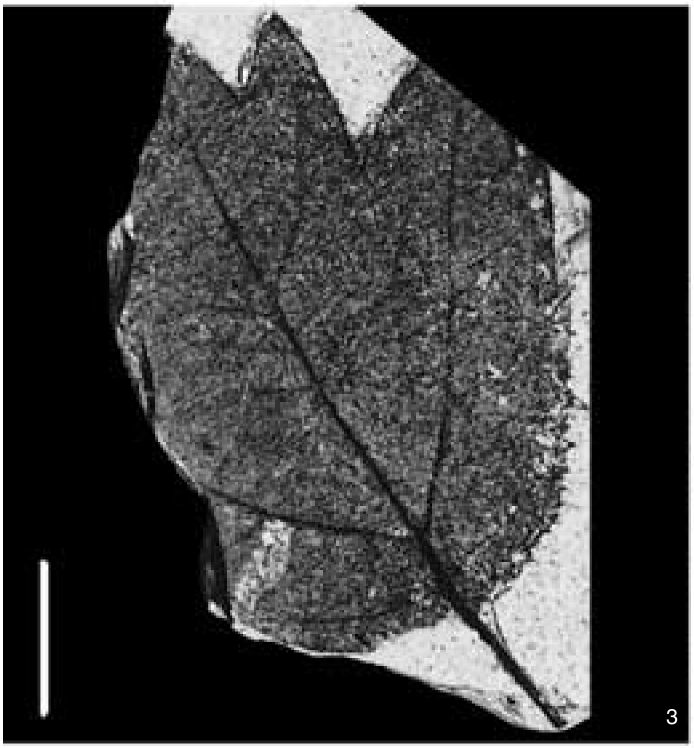
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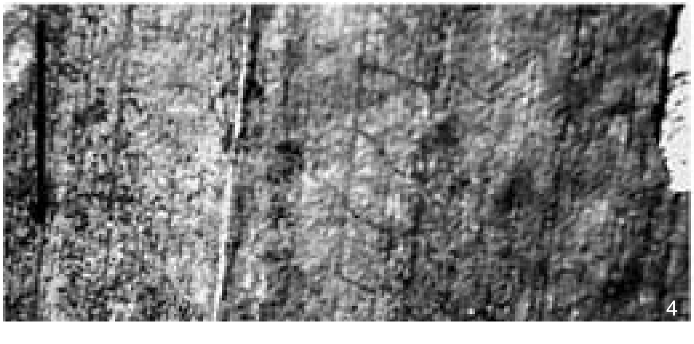
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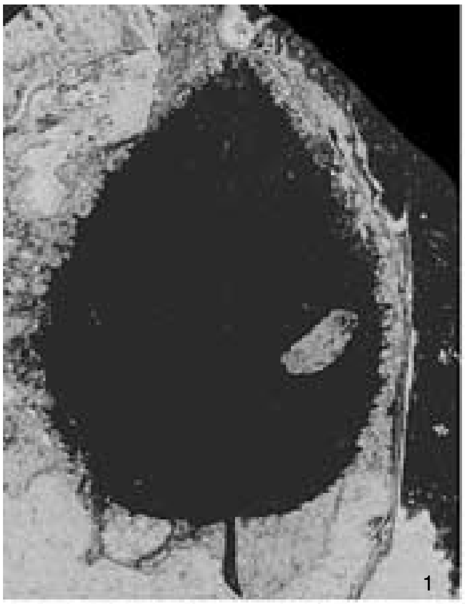
Plate 4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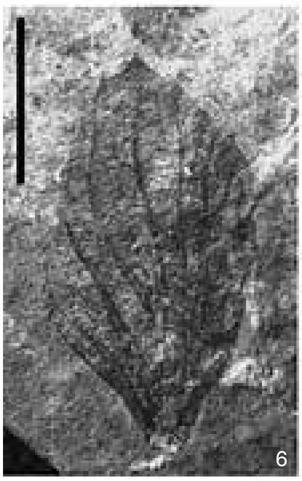
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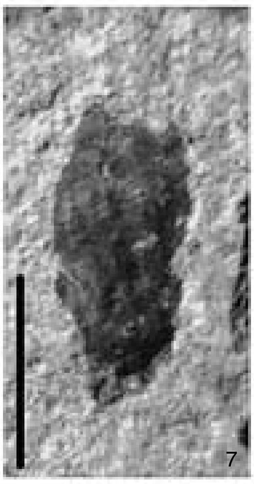
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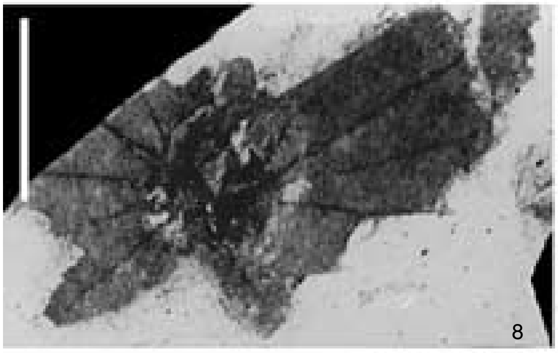
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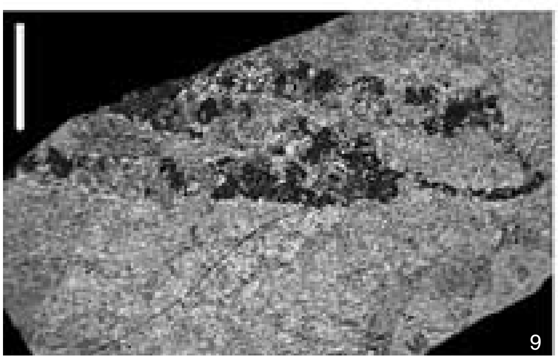
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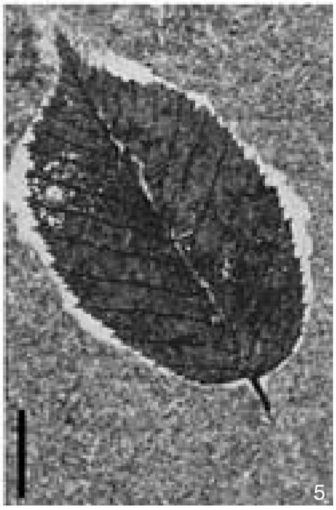
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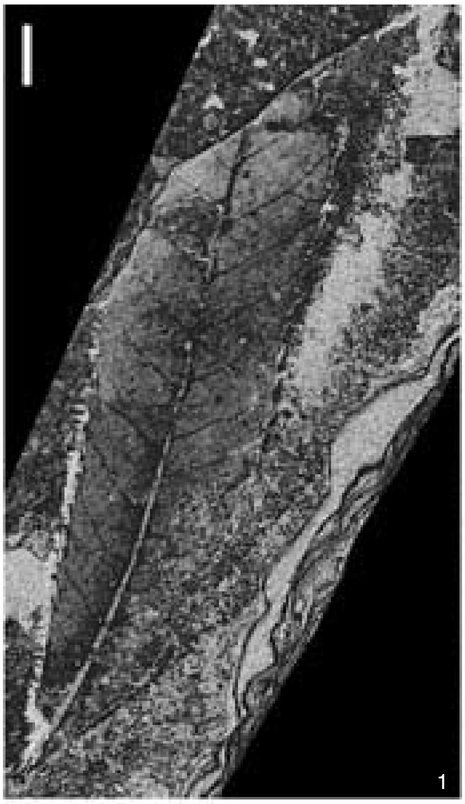
Plate 5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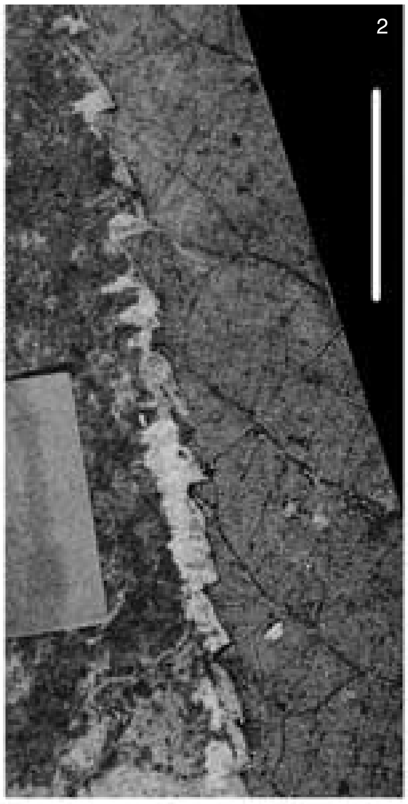
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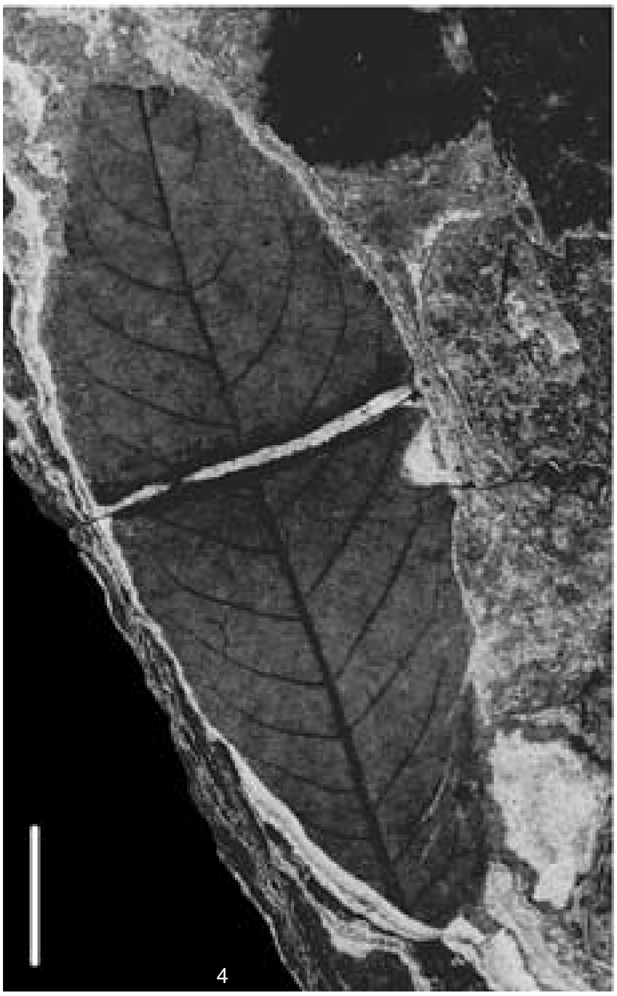
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Plate 6


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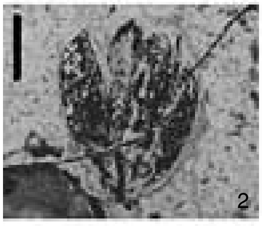
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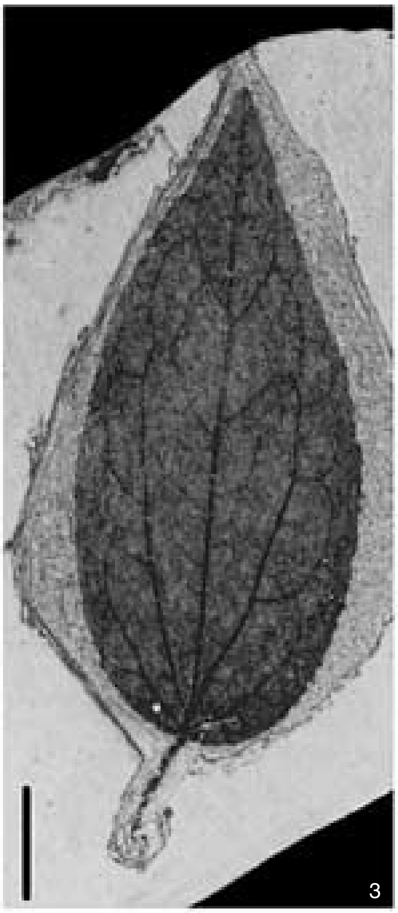
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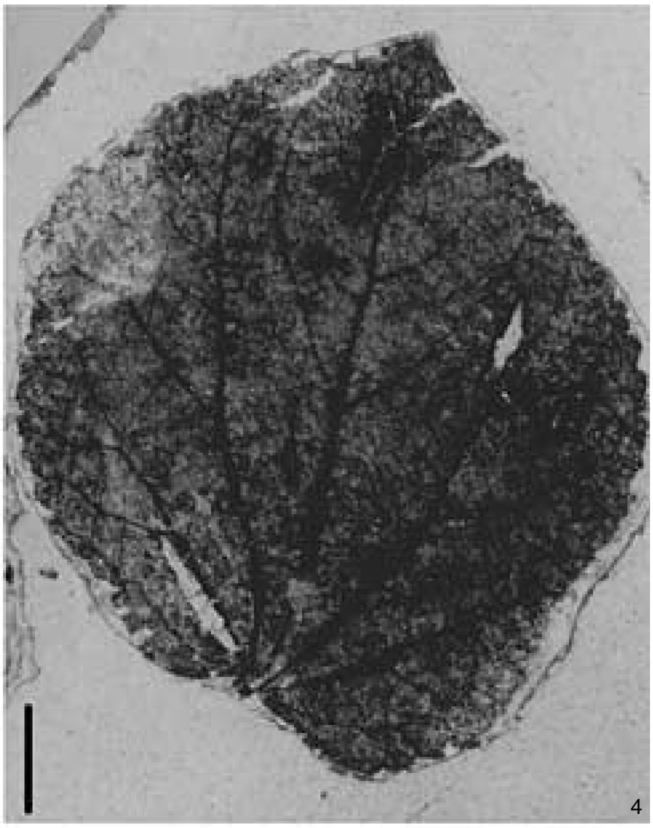
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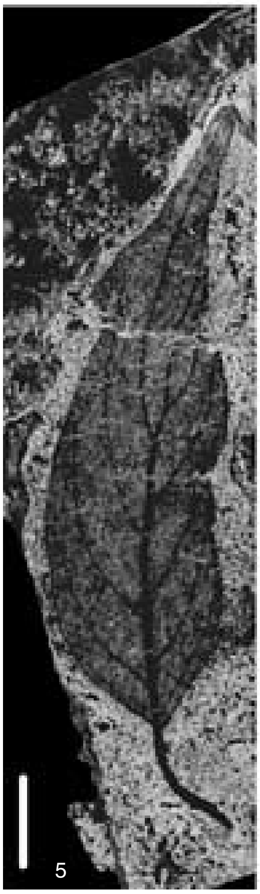
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6


7

Plate 7


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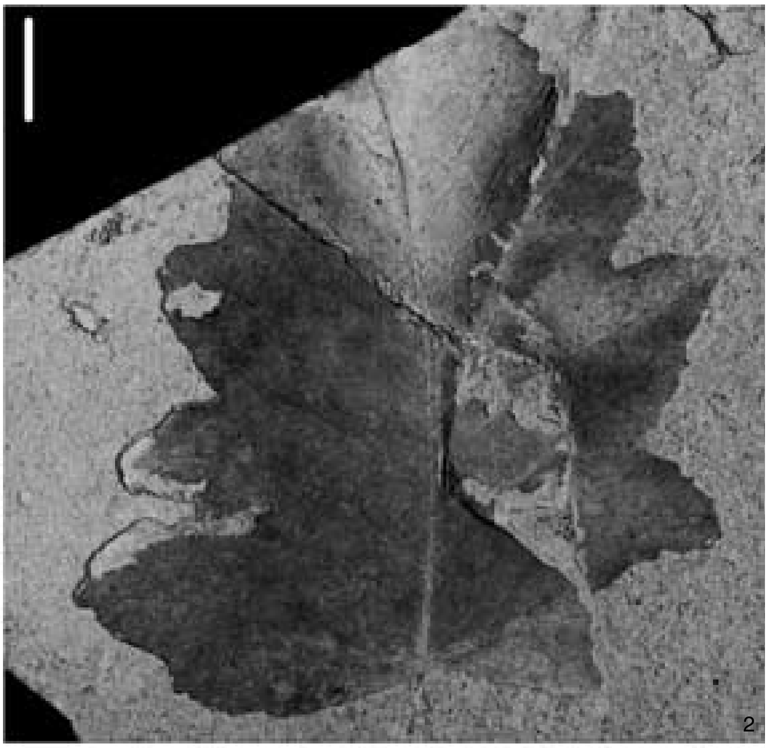
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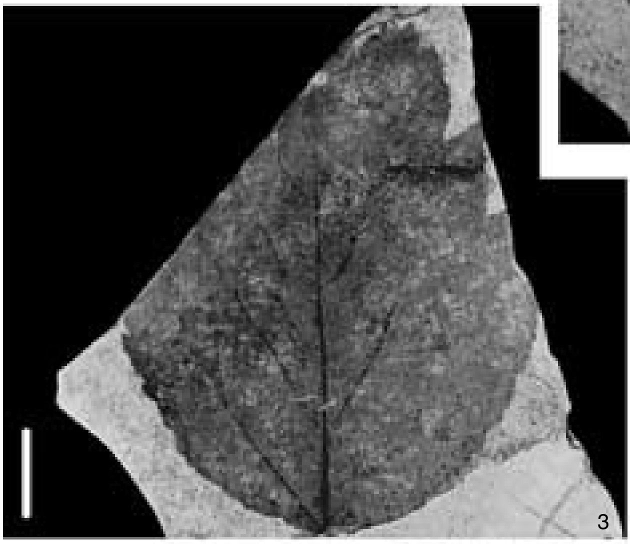
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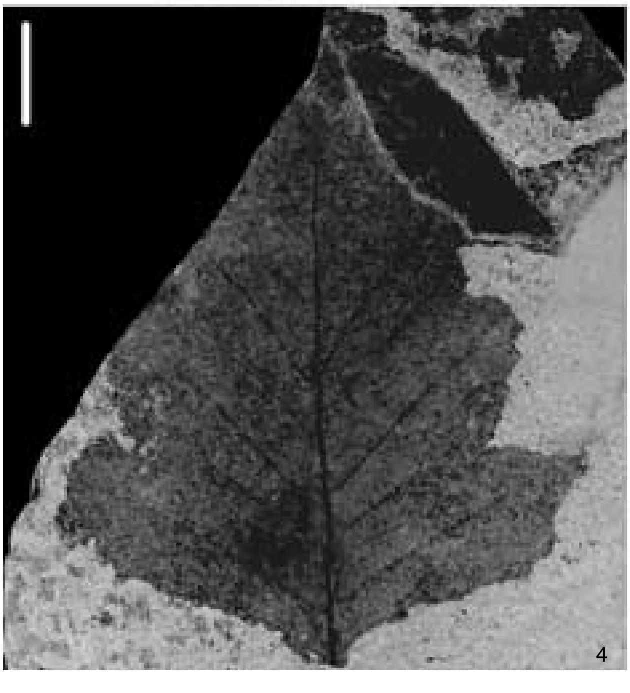
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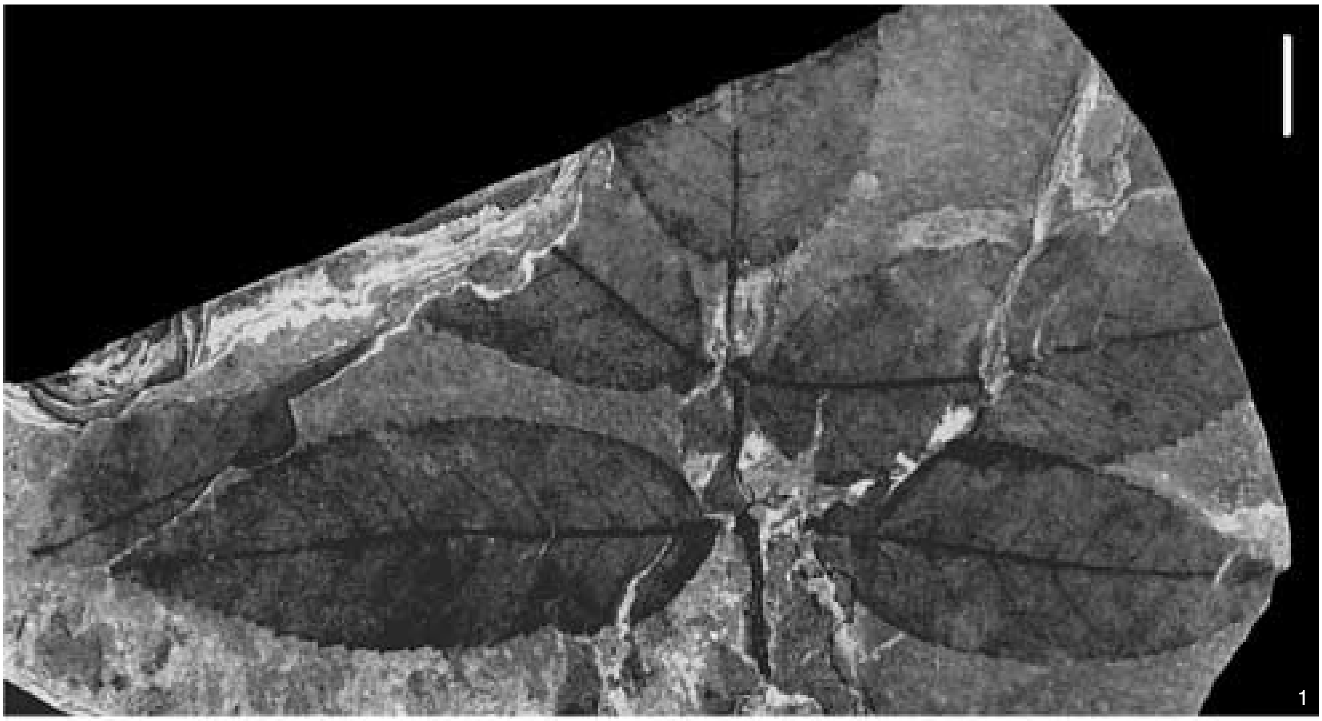
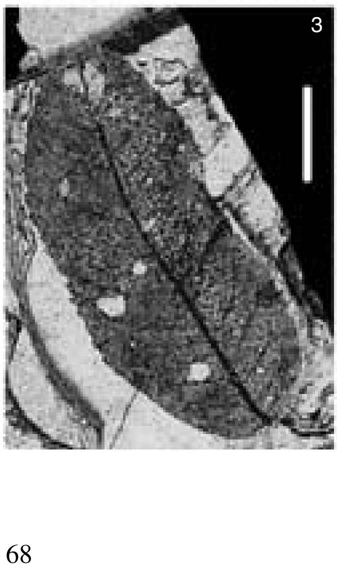
Plate 8





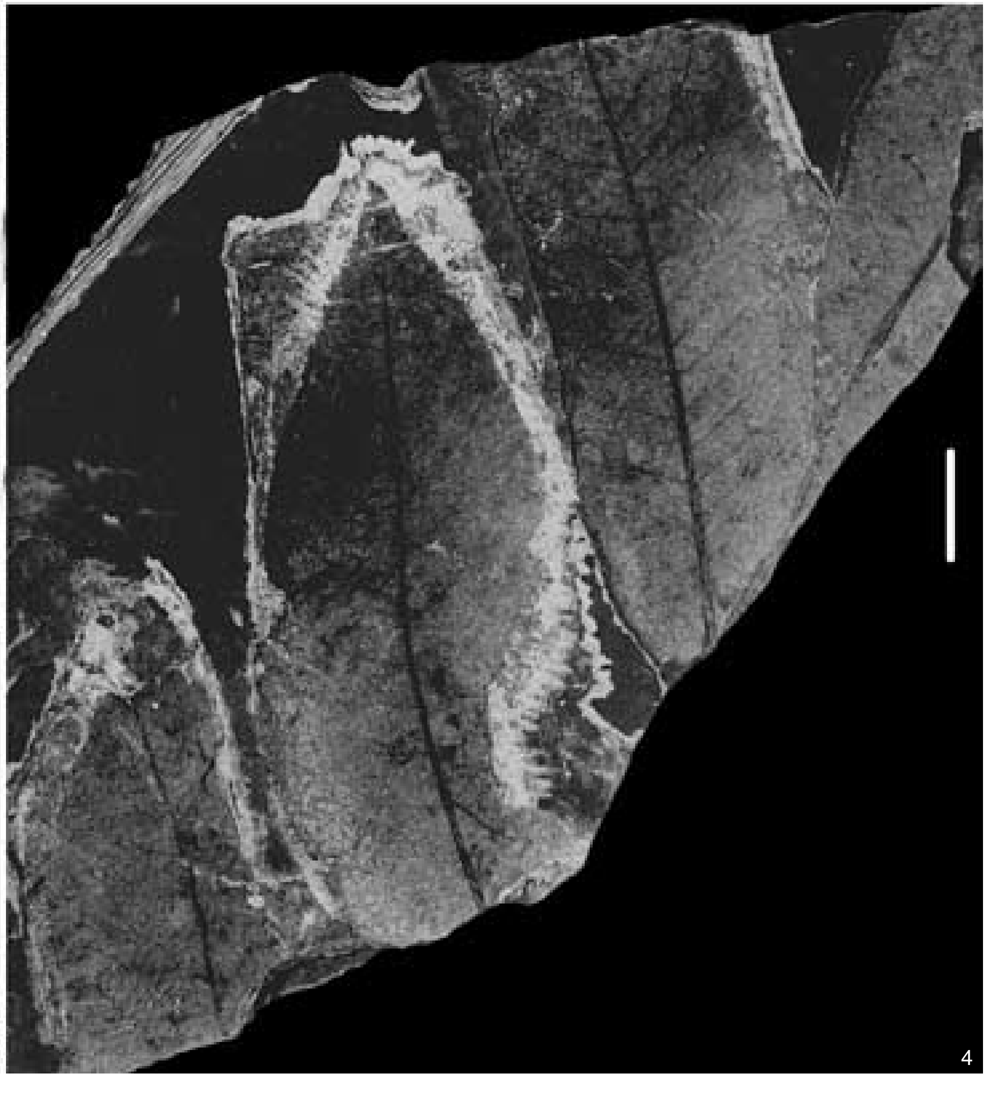
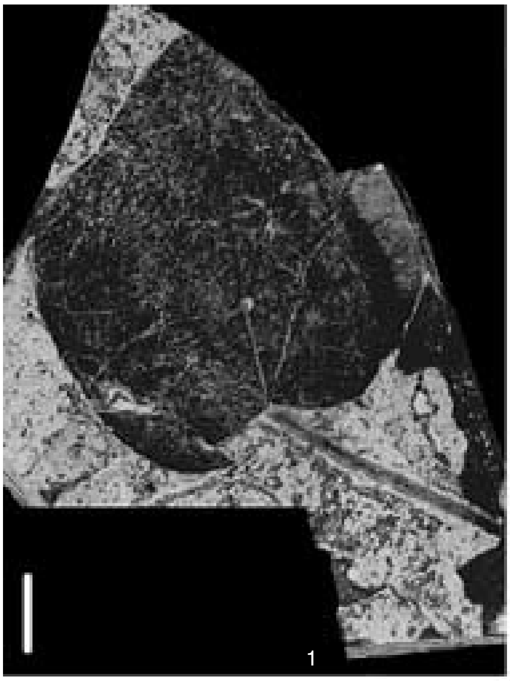


Plate 9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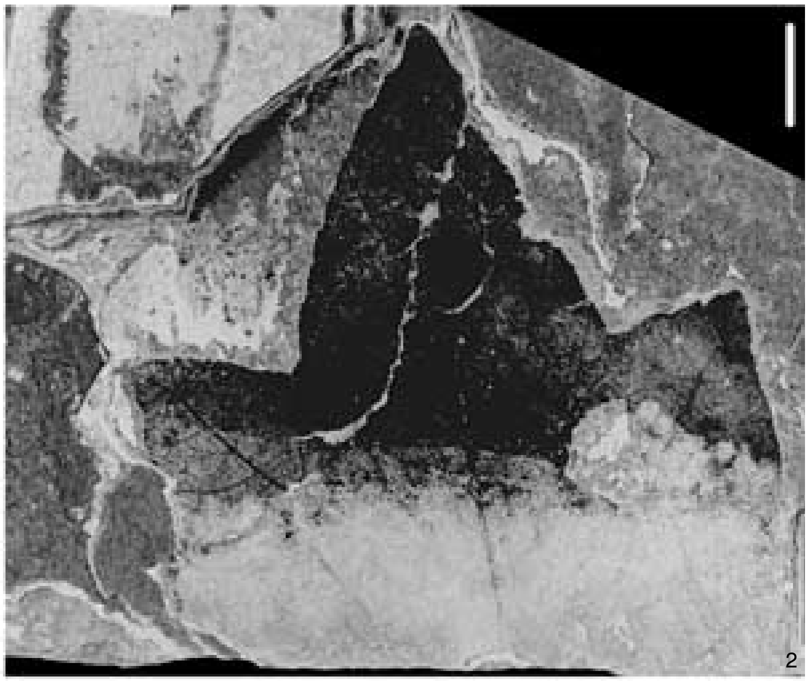
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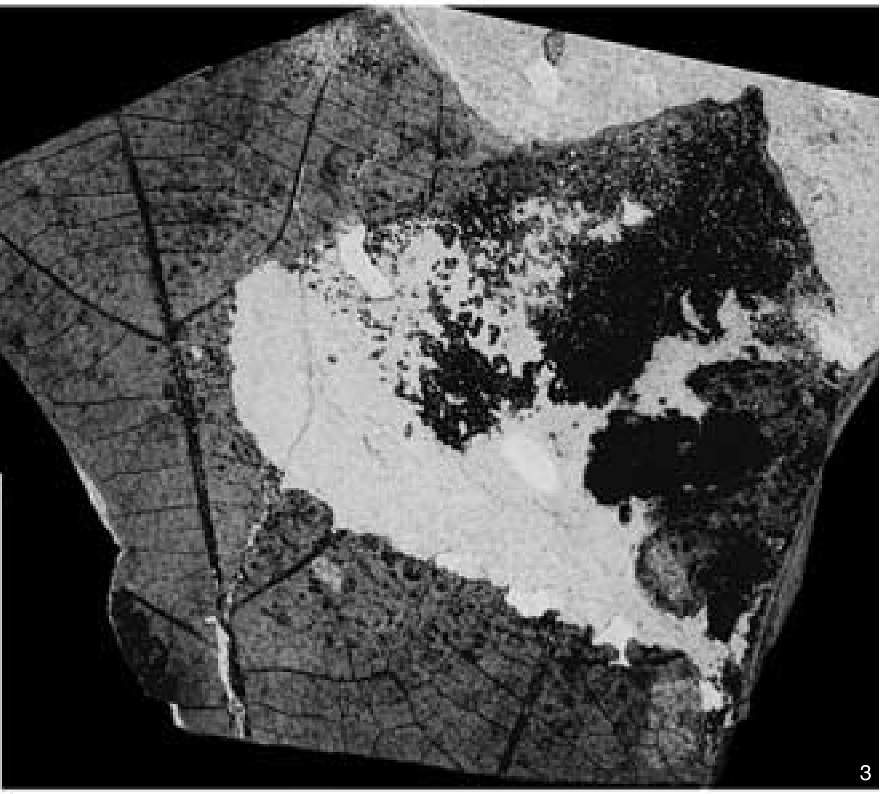
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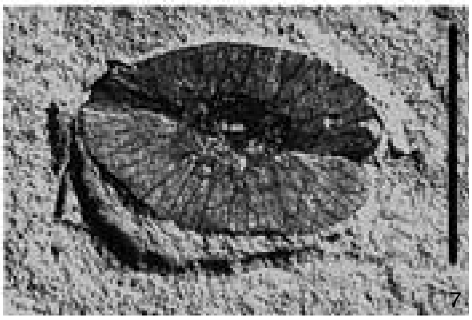
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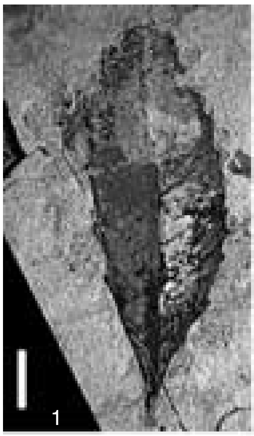
Plate 10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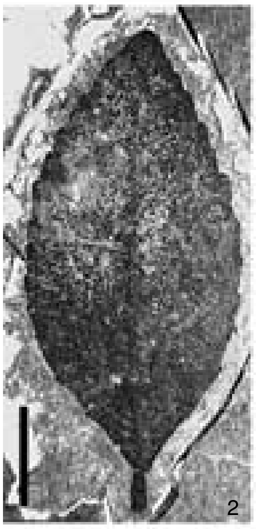
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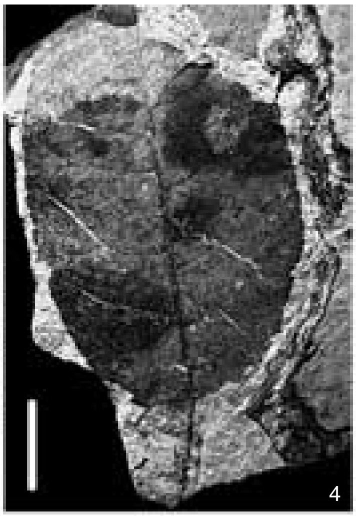
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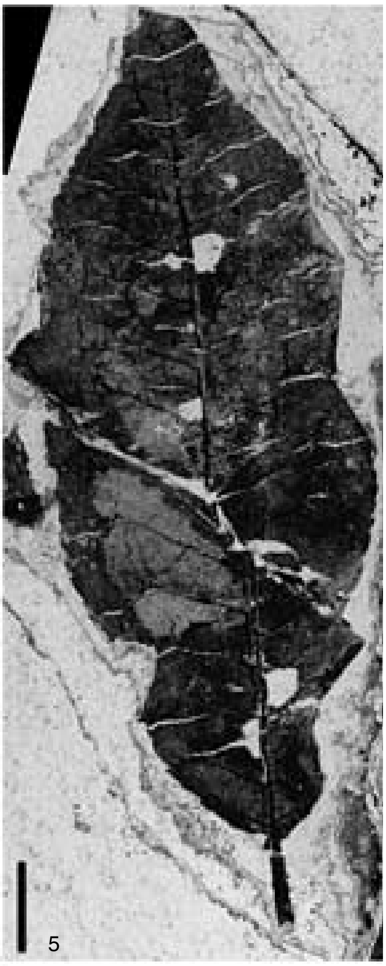
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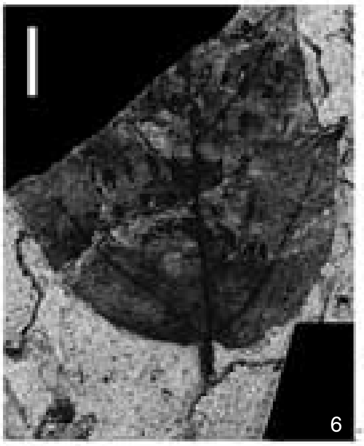
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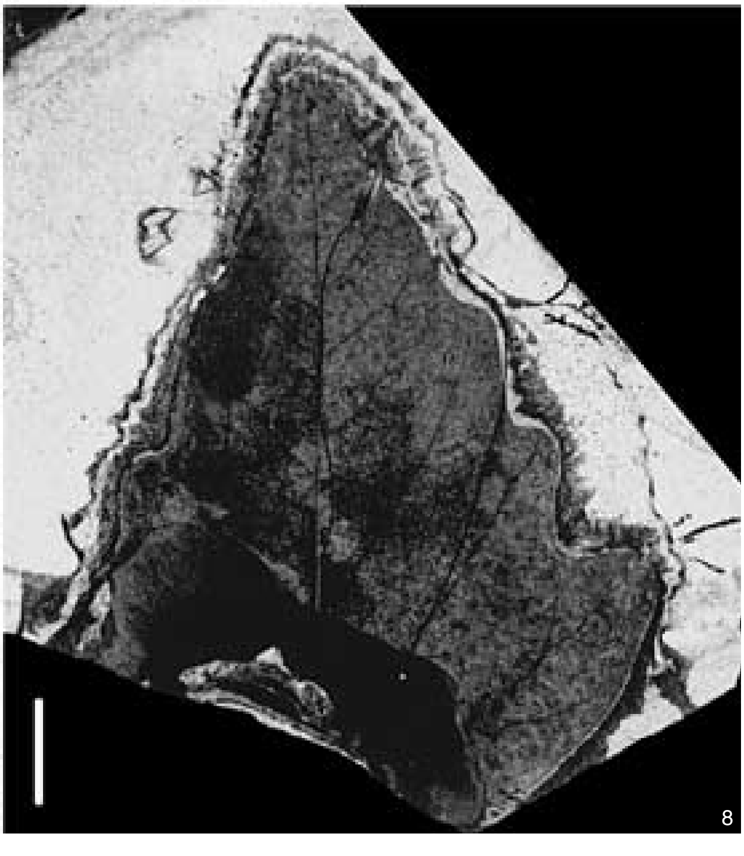
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Plate 11


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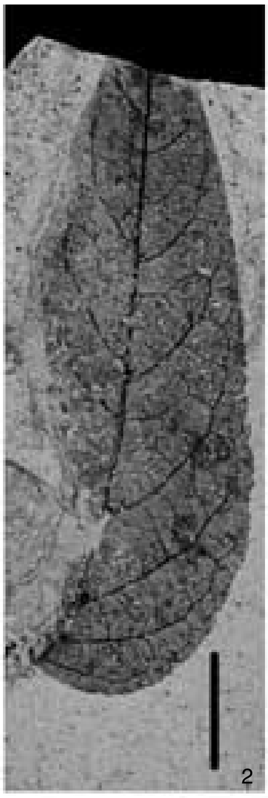
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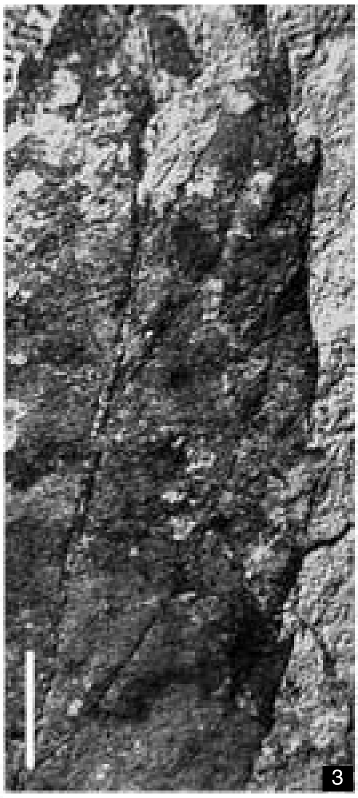
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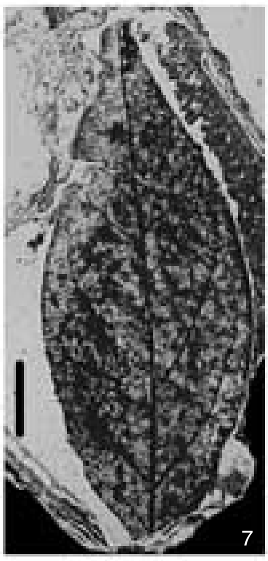
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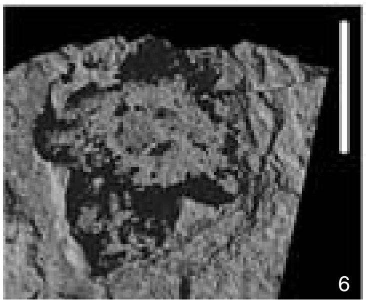
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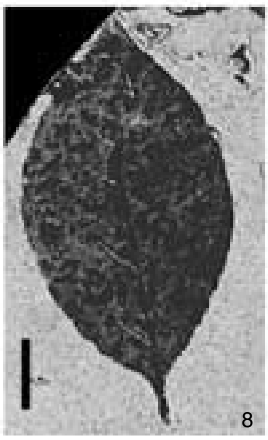
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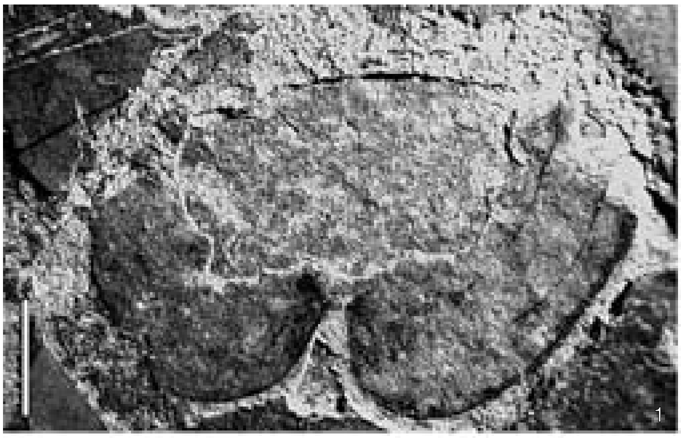
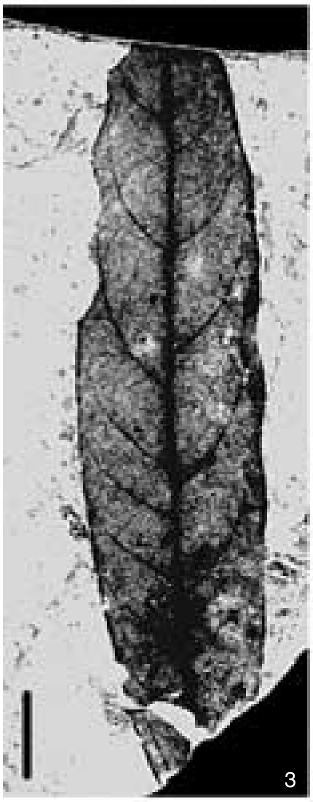
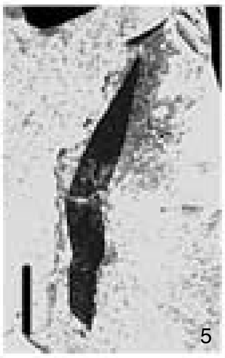
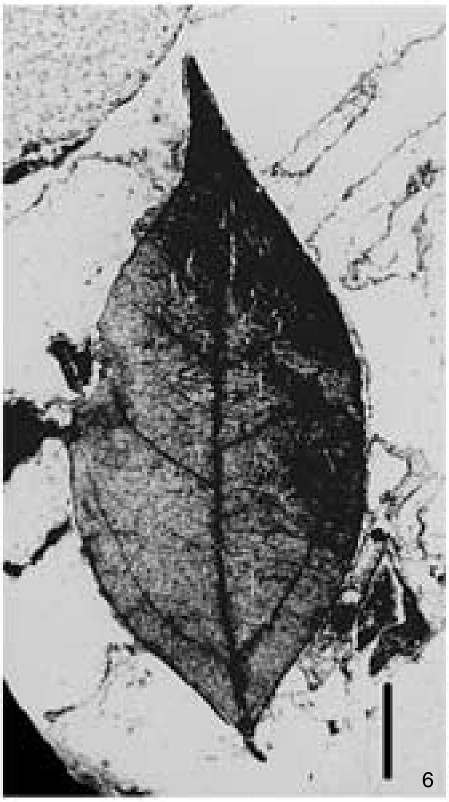
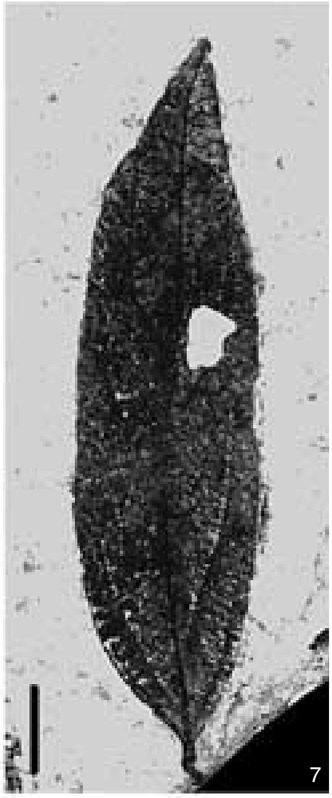
Plate 12

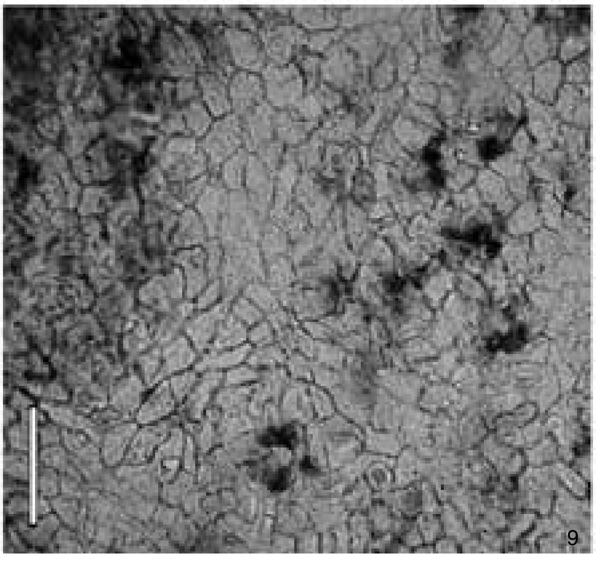












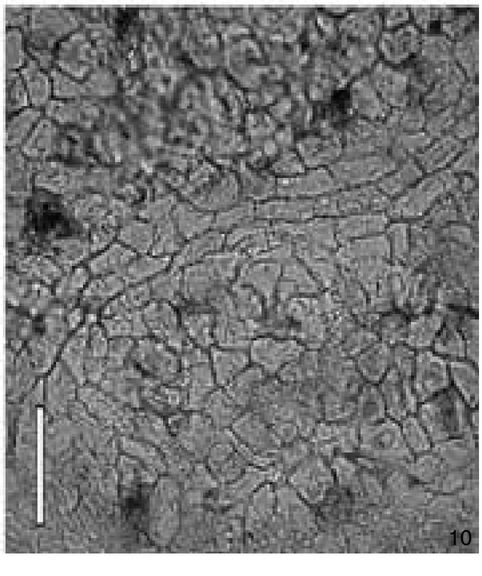


Plate 13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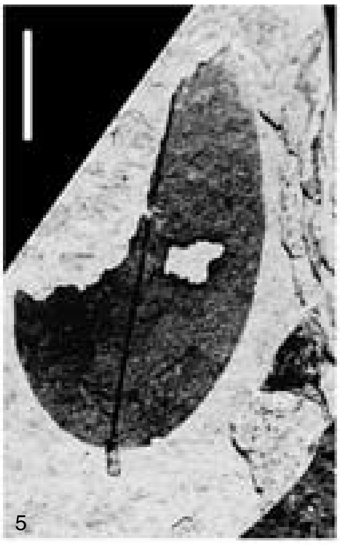
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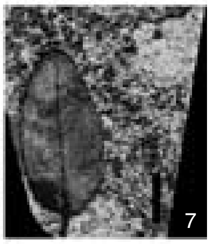
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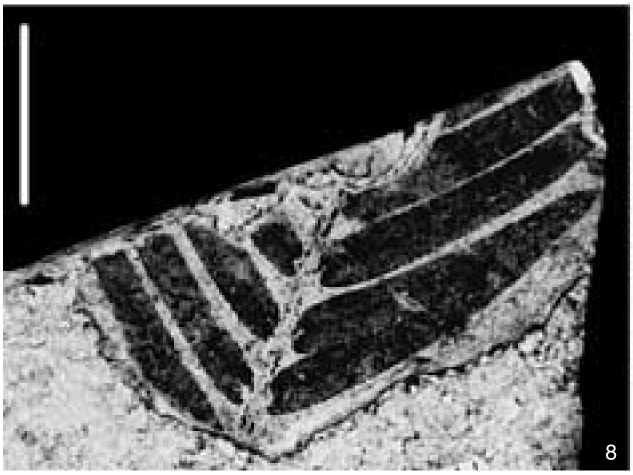
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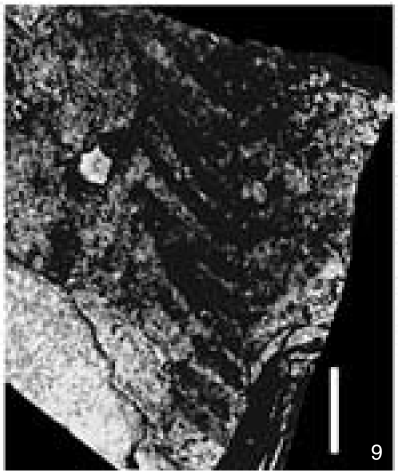
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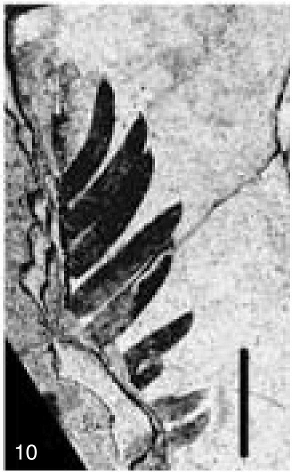
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Plate 14

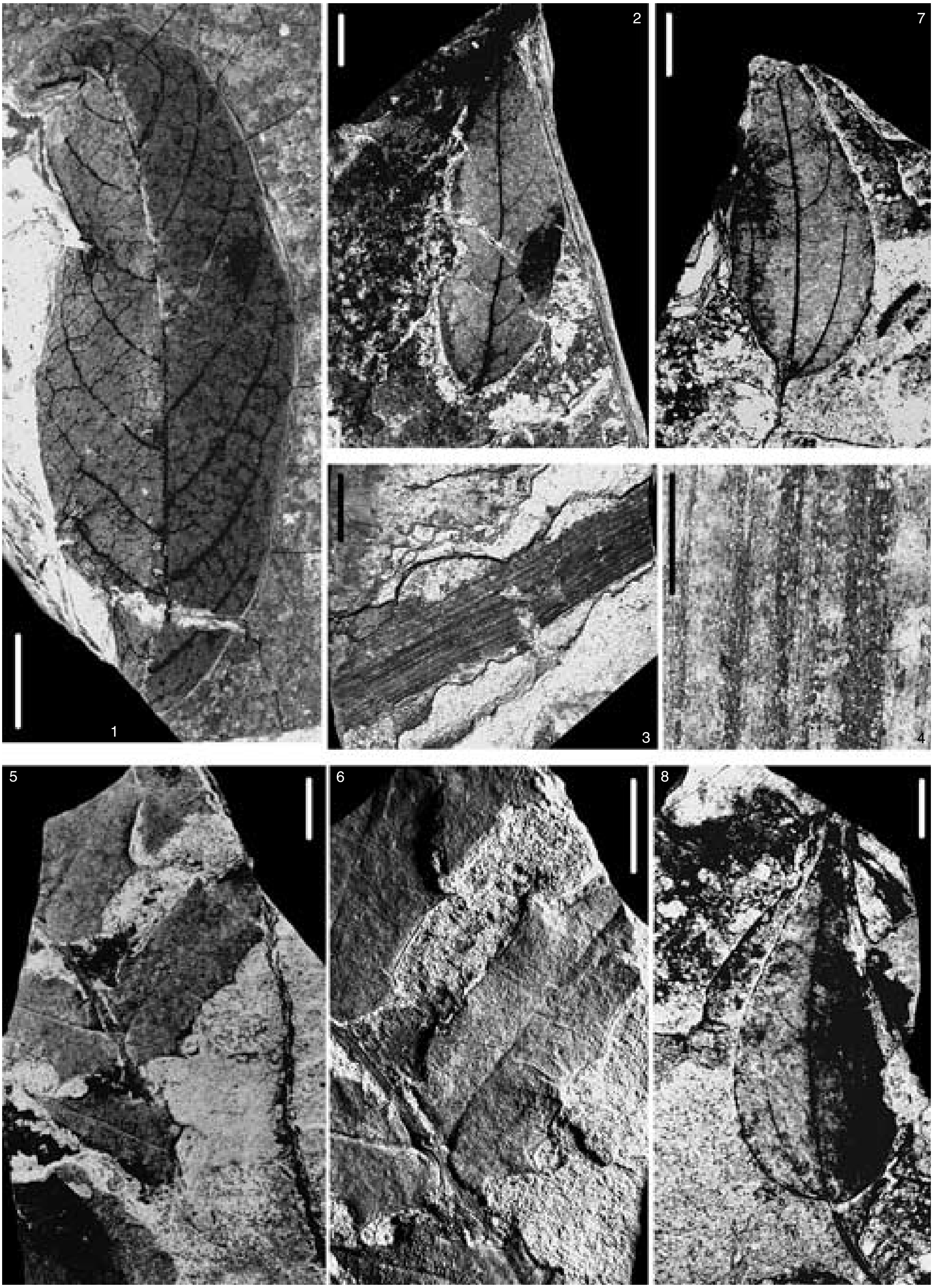
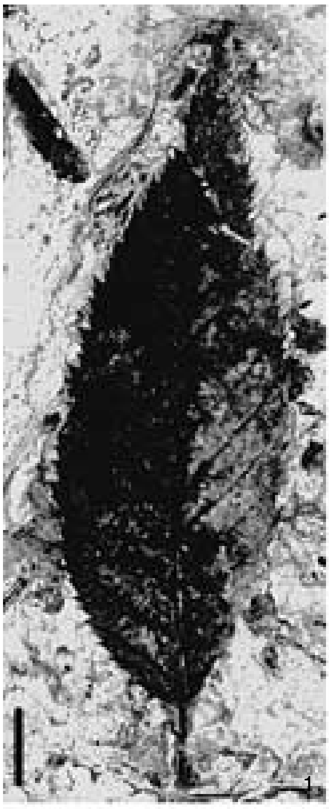
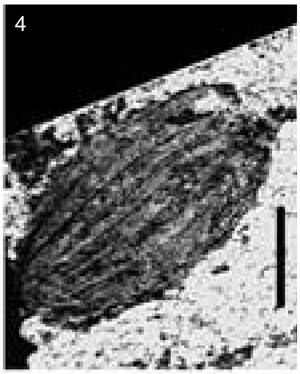
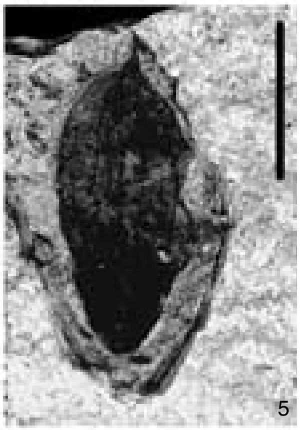
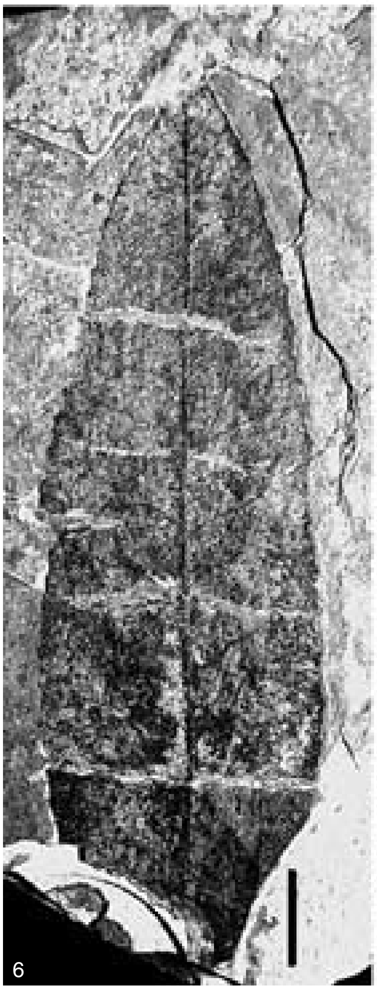


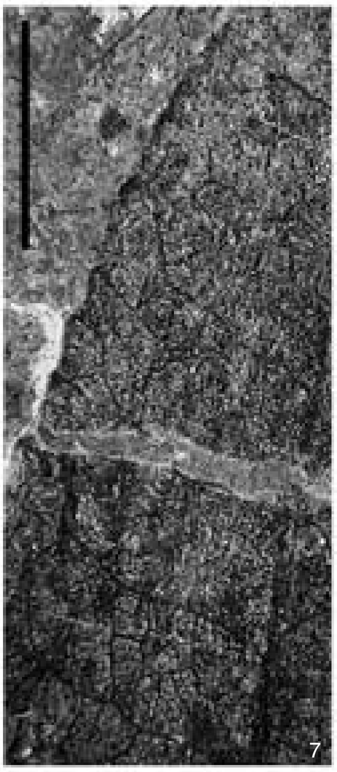
Plate 15











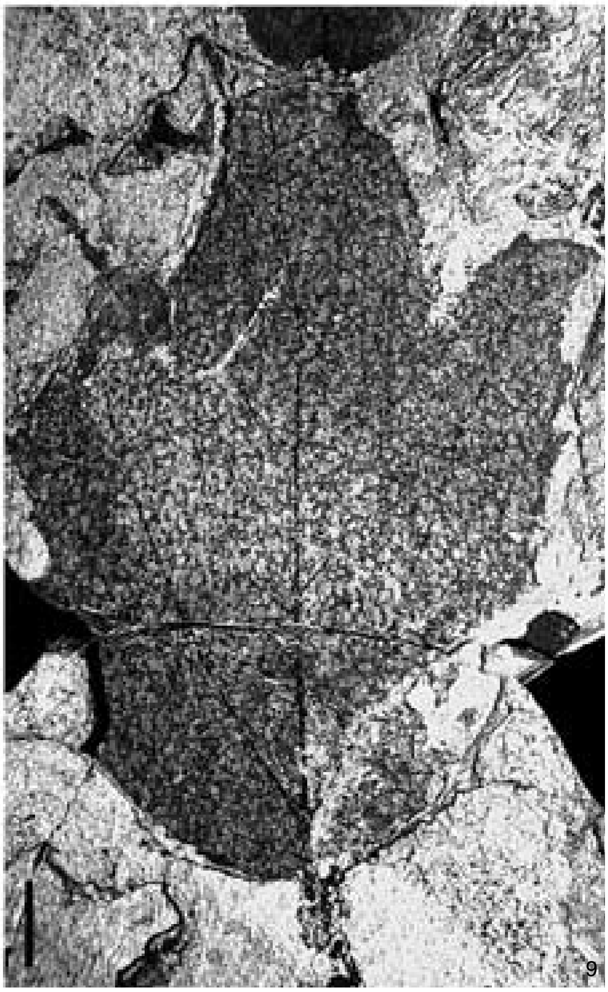
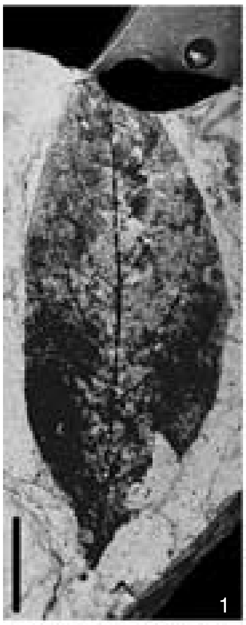
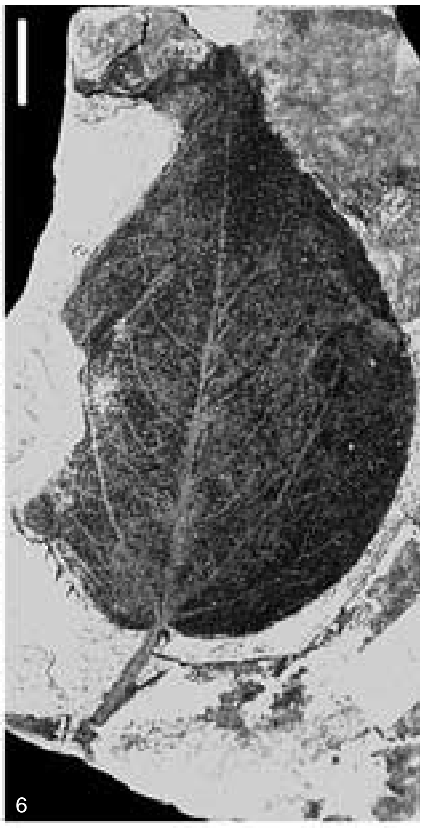
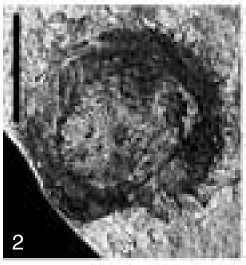
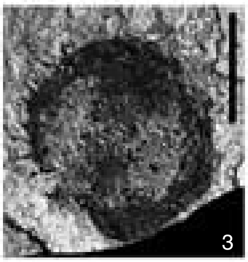


Plate 16









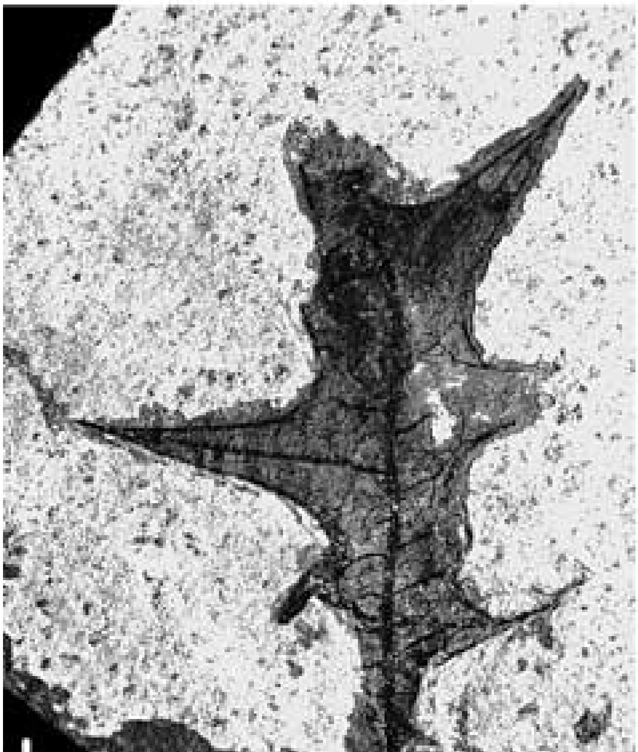
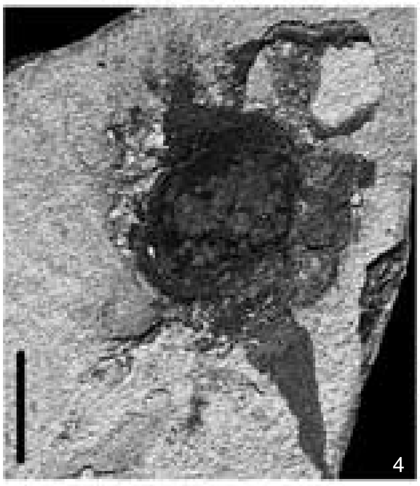
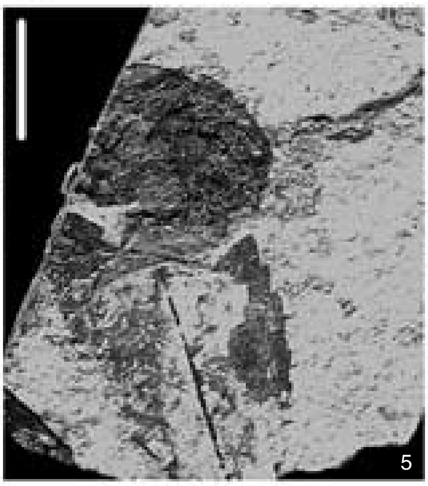
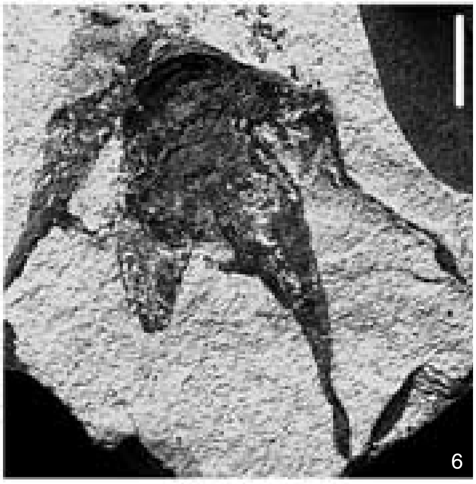


Plate 17







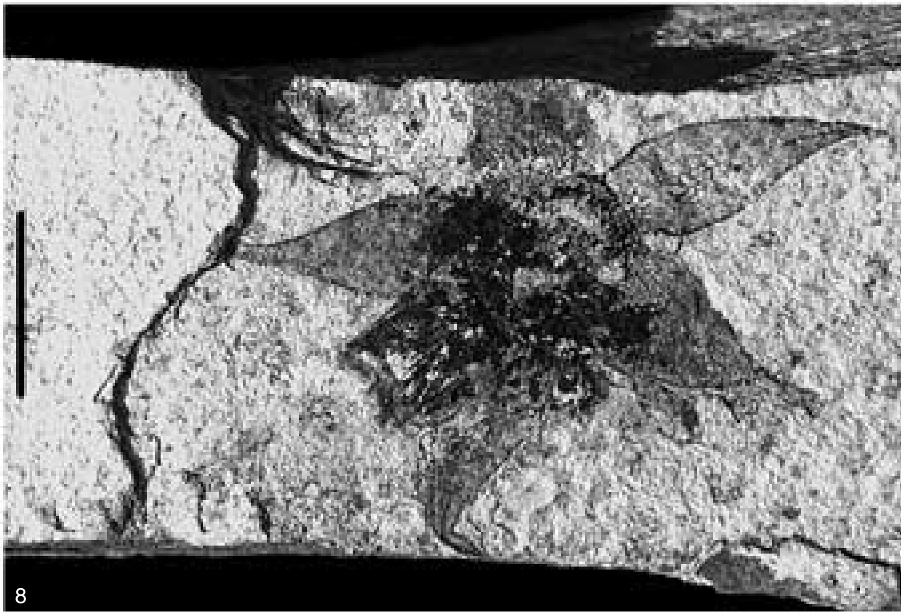


Plate 18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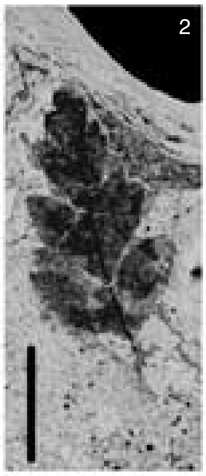
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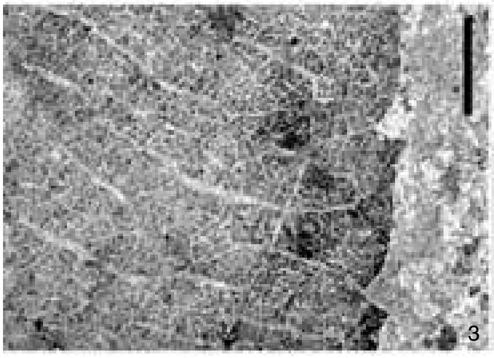
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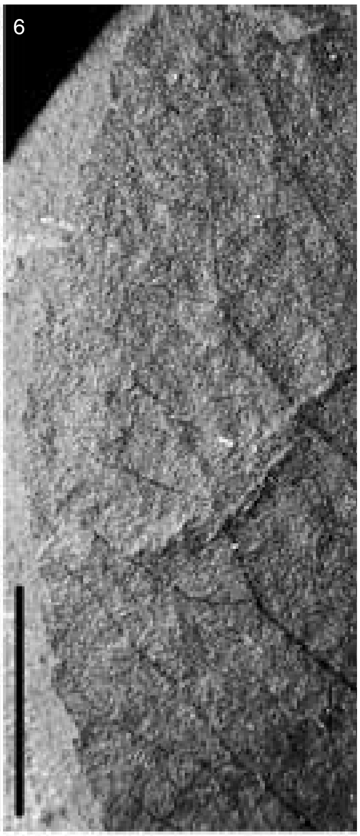
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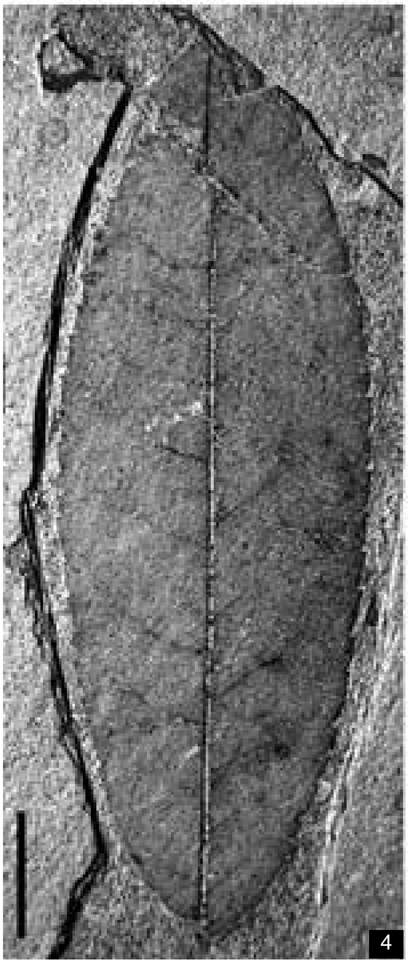
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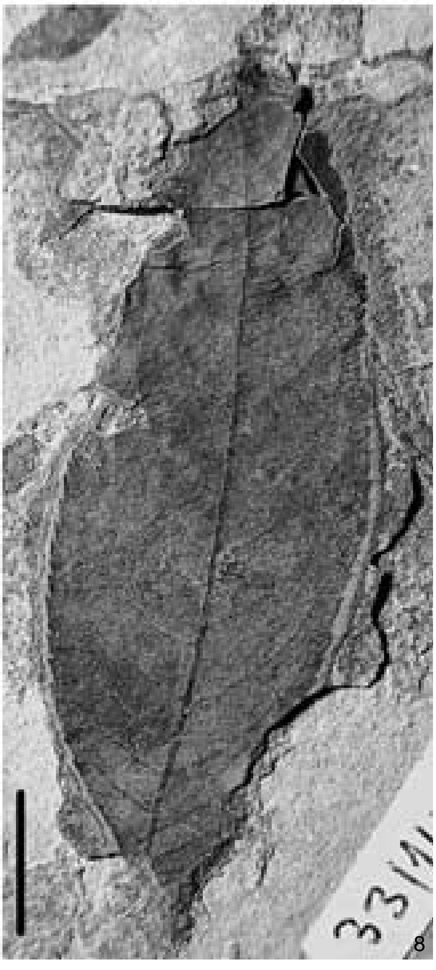

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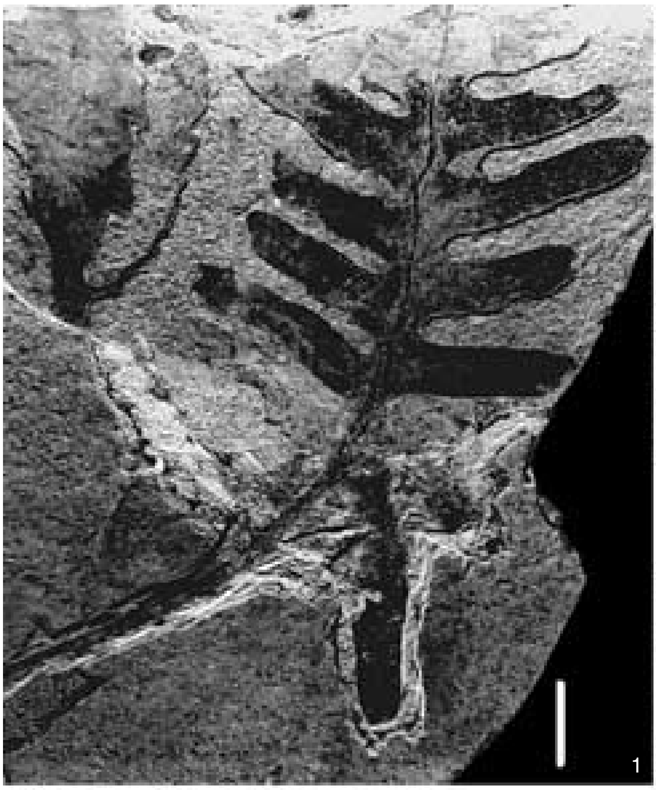
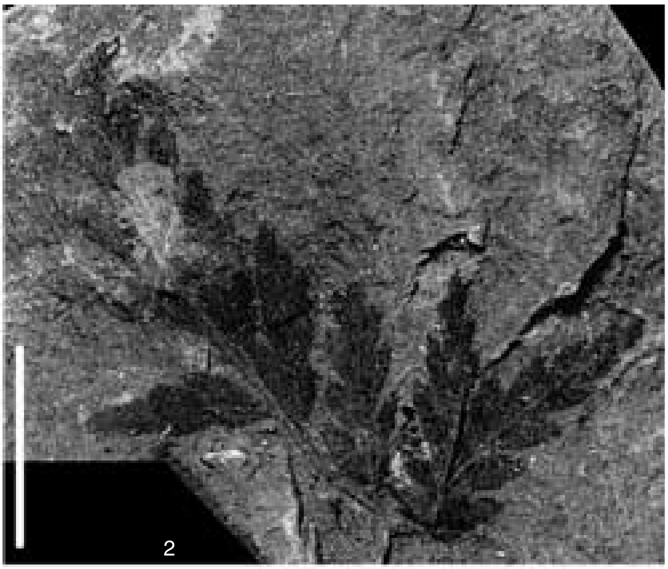
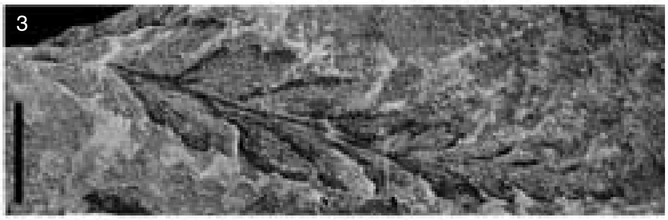
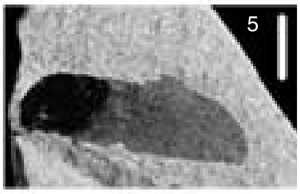
Plate 19









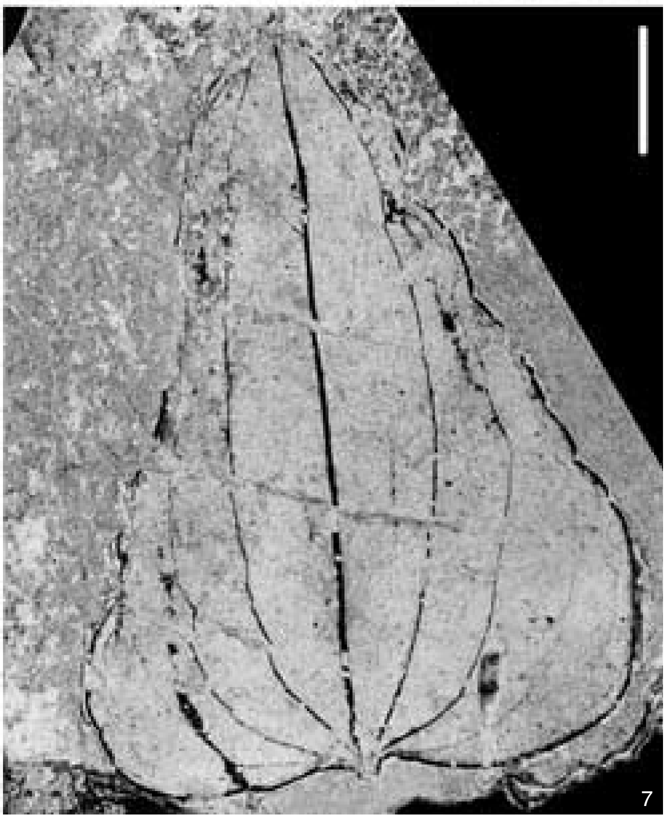


Plate 20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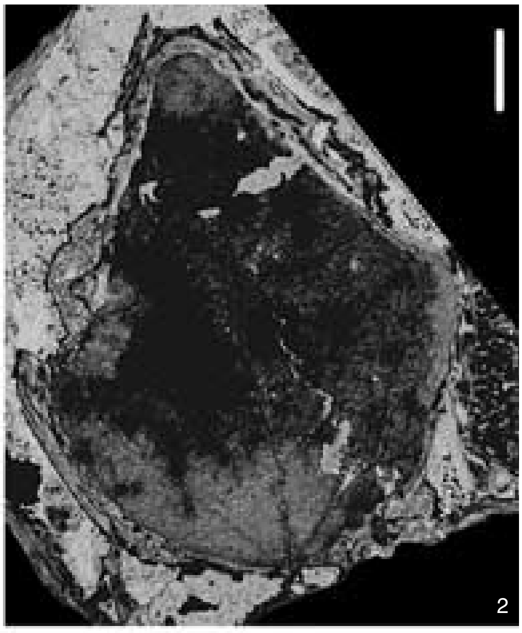
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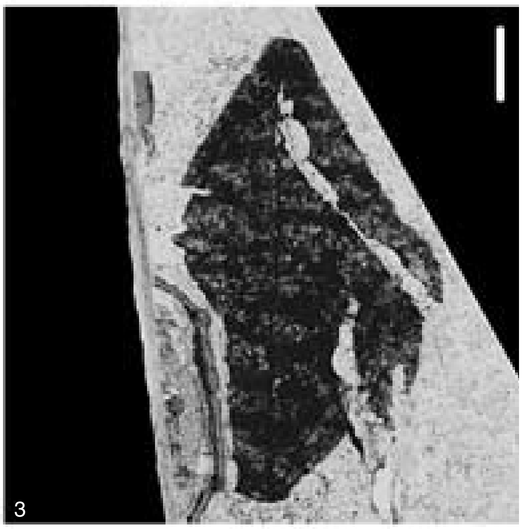
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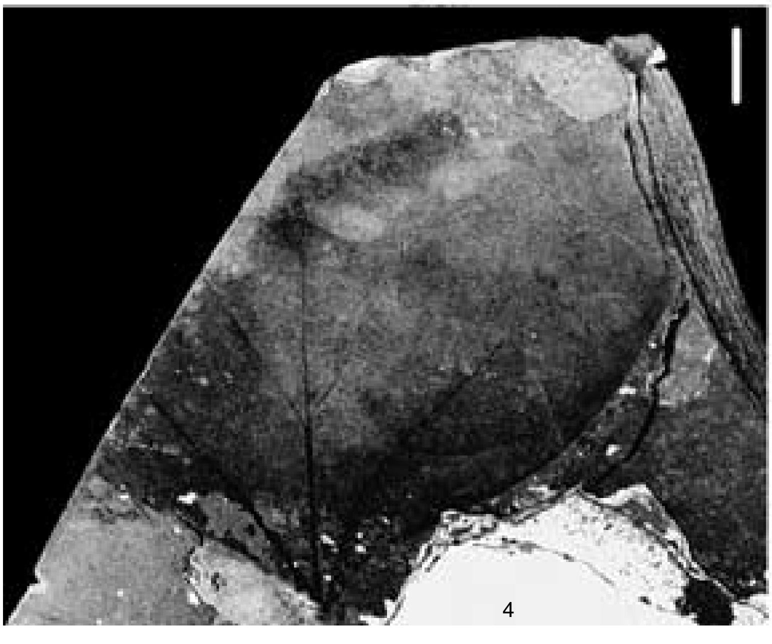
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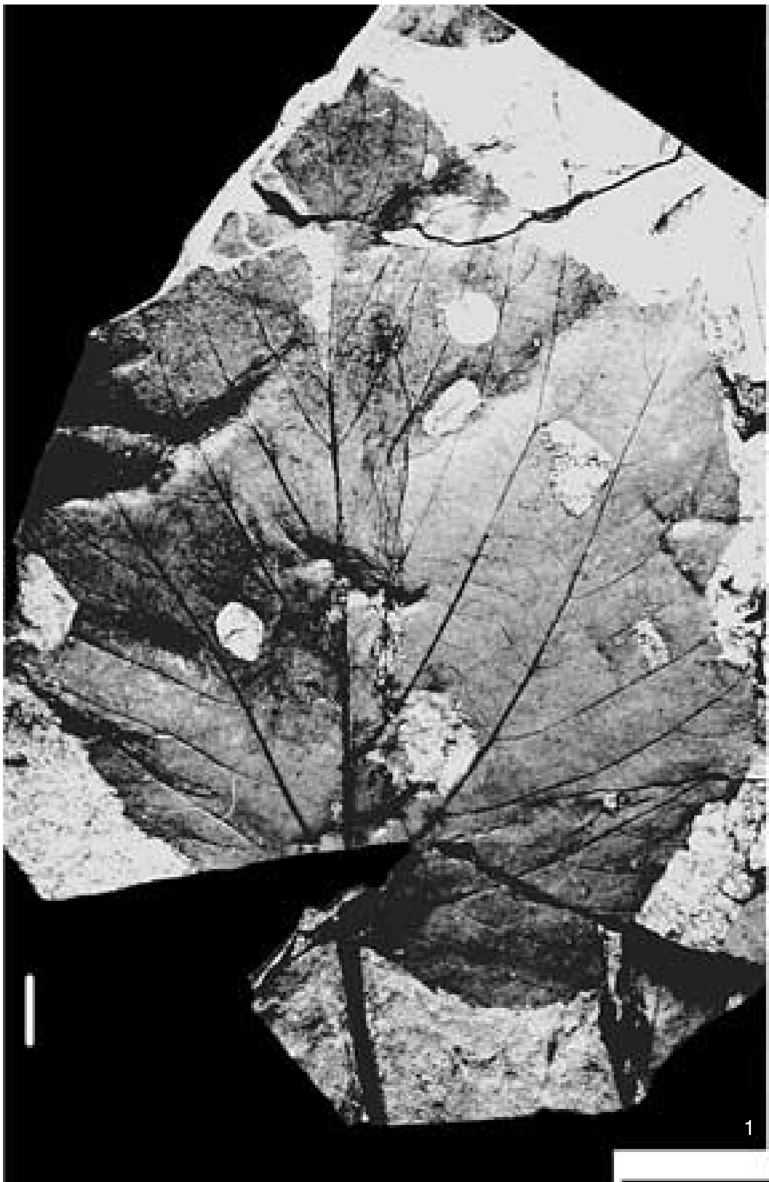
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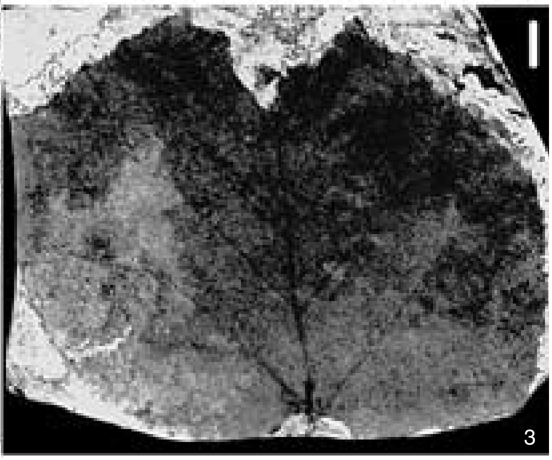
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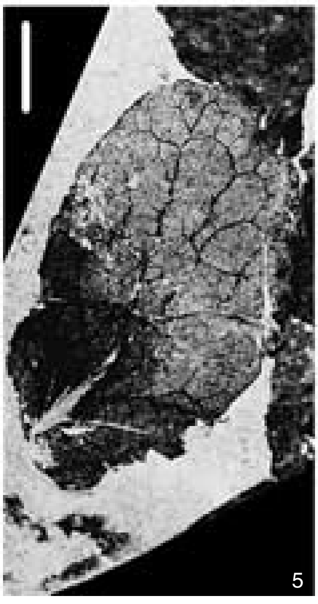
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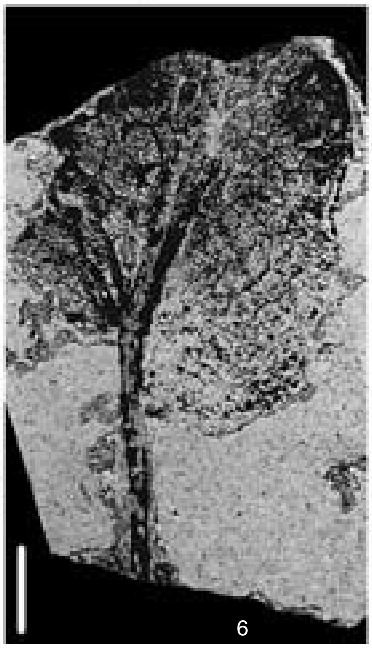
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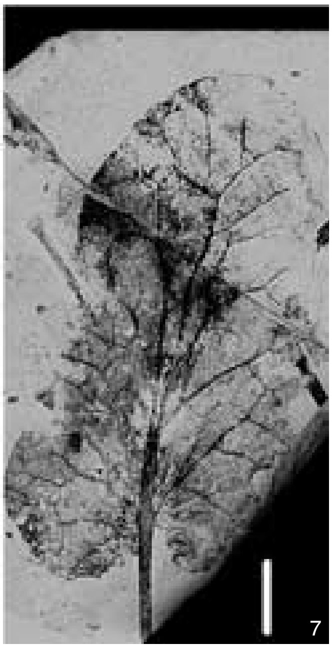
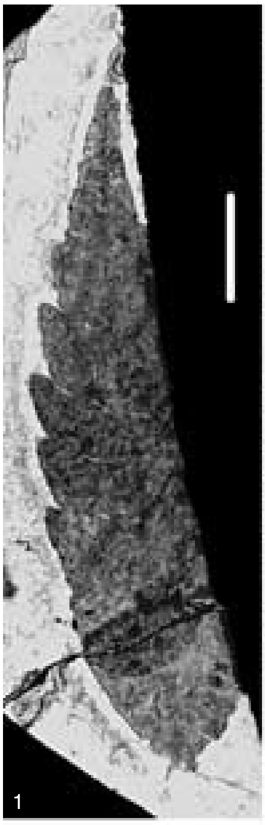
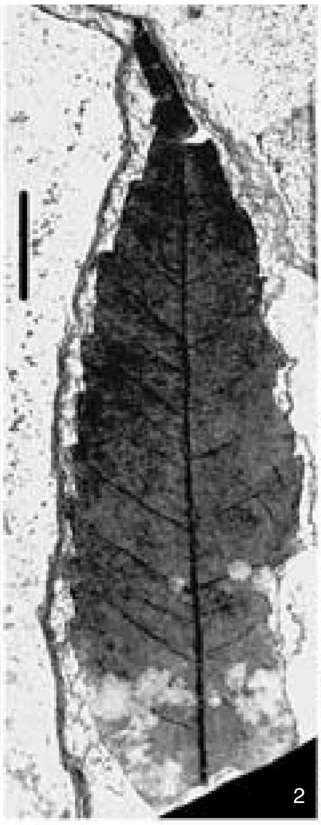
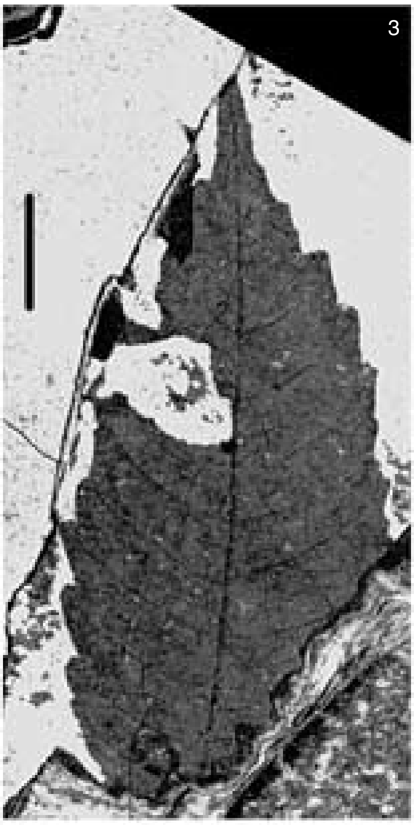
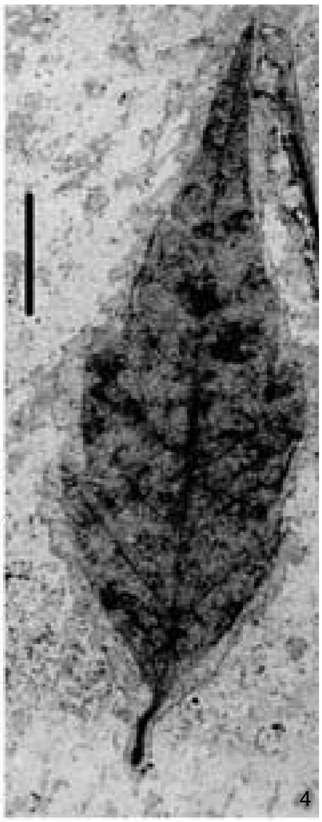

7

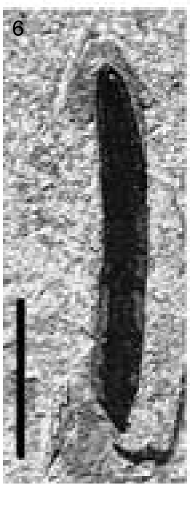
Plate 22

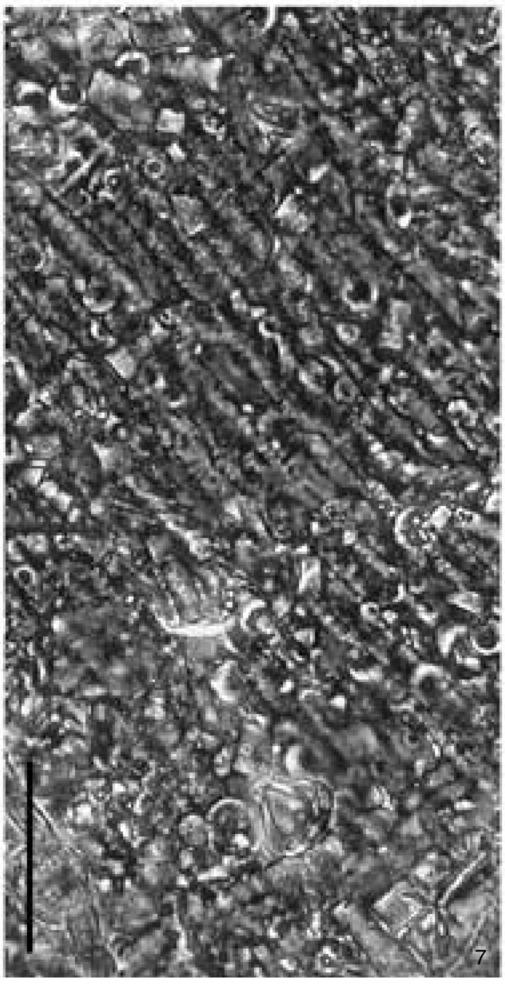


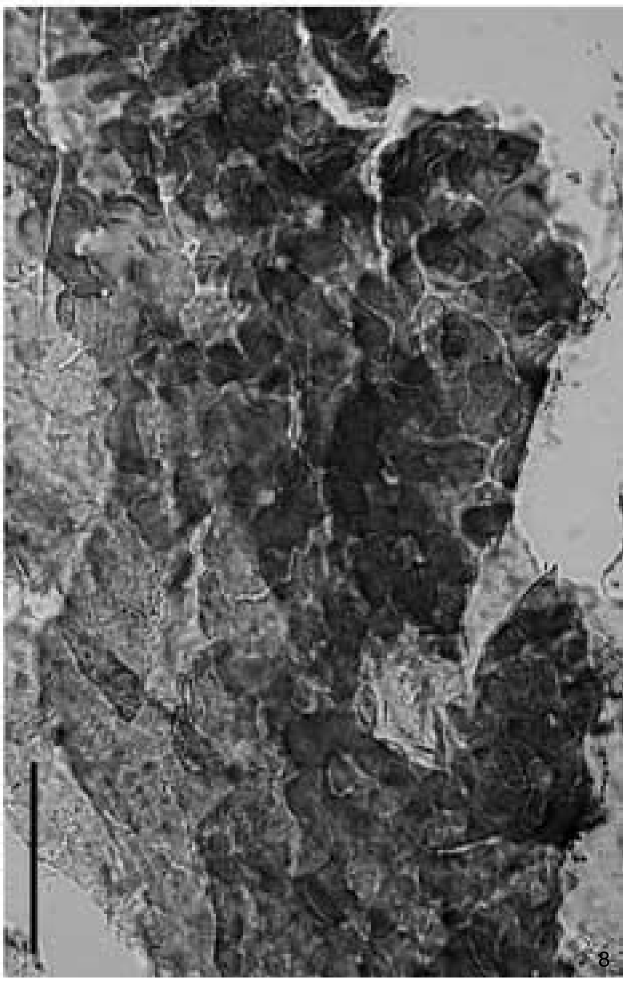










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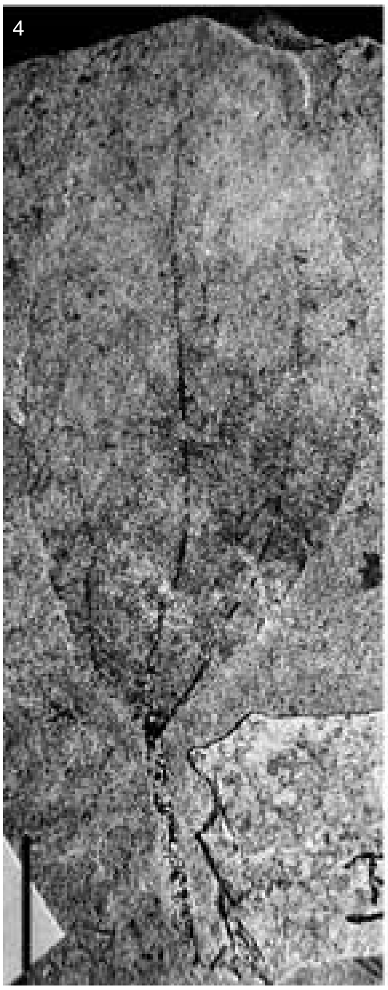
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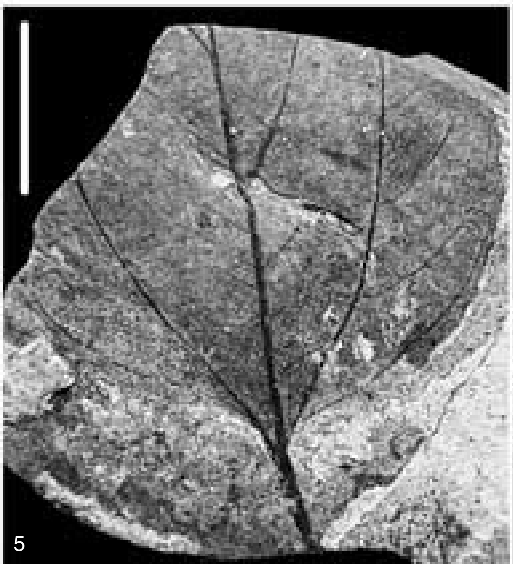
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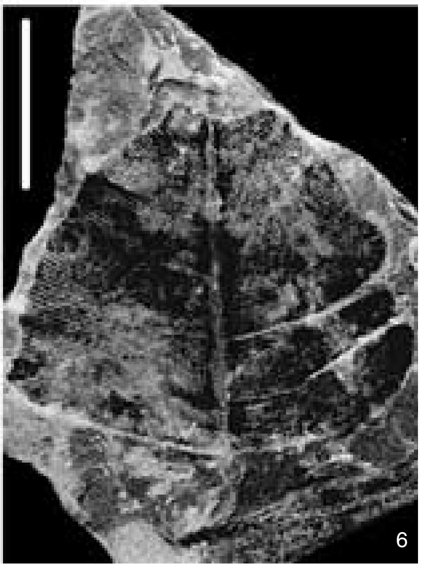
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Plate 24