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The late Oligocene flora of Hungary

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*In remembrance of Professor Tamás Báldi and Dr. András Nagymarosy,
two prominent geologists and experts of the geology of the Hungarian upper Oligocene*

ABSTRACT. In Hungary, late Oligocene (Chattian, reg. str. Kiscellian and Egerian) plant remains have been preserved in sediments of the Törökbálint (Mány and Kovačov members) and Eger formations. An overview and revision of these late Oligocene macrofloras, both newly excavated and already published, are presented. Nearly a hundred plant taxa are described from the localities Andornaktálya, Csörög, Eger Wind-brickyard, Kesztölc, Környe, Leányfalu, Máriahalom, Nagysáp, Pomáz, Pusztaberki, Rétság, Tarján, Verőcemaros, and Vértesszőlős. Floristic results help understand and interpret the flora and vegetation change during the Oligocene. The appearance of temperate floristic elements in the late Oligocene floras may have been related to habitats strongly influenced by edaphic factors and the better adaptability of the new, temperate elements to a quickly changing environment.

KEYWORDS: Egerian, Kiscellian, Chattian, Eger Formation, Törökbálint Formation, macroflora, flora and vegetation change, temperate elements

INTRODUCTION

The flora of the late Oligocene (Paratethyan regional stages: late Kiscellian and early Egerian) is well represented in Hungary; plant remains have been recovered in most areas where upper Oligocene strata had been explored. Therefore, the flora of extended regions can be outlined and characterized for this time interval. An overview and revision of the late Oligocene macrofloras, both newly excavated and so far published, are presented.

The Hungarian upper Oligocene strata were first described in a modern stratigraphic context by Báldi (1963a, b, 1965, 1966; 1967, 1969, 1970, 1973, 1974,1976, 1980, 1983, 1985, 1998) and his colleagues (Báldi and Radócz, 1965, 1971; Báldi and Nagymarosy, 1976; Báldi et al., 1975, 1976, 1984; Báldi and Tari, 1989; Báldi-Beke, 1977; 1984; Nagymarosy and Báldi-Beke, 1988; Nagymarosy, 2012; Babinszki et al., 2023). Báldi described six formations (Mór, Mány, Törökbálint, Kovačov, Ózd, and Eger formations), from which four (Mány, Törökbálint, Kovačov, and Eger formations) yielded plant fossil localities. According to recent studies on stratigraphy, the former Mány and Kovačov formations are not separate formations, but incorporated in the Törökbálint Formation as the Mány Member and Kovačov Member (Babinszki et al., 2023). Based on the updated stratigraphy of the Central Paratethyan region (Babinszki et al., 2023; Fig. 1), the lower boundary of the Central Paratethyan stage, Egerian is set at 25 Ma, therefore the Kiscellian regional stage corresponds to the Rupelian and Lower Chattian stages. Although the Egerian regional stage corresponds to the upper Chattian and lower Aquitanian, the NP25 and NN1 nannoplankton zones are clearly distinguishable and separate Oligocene and Lower Miocene layers. Consequently, the Eger Formation represents

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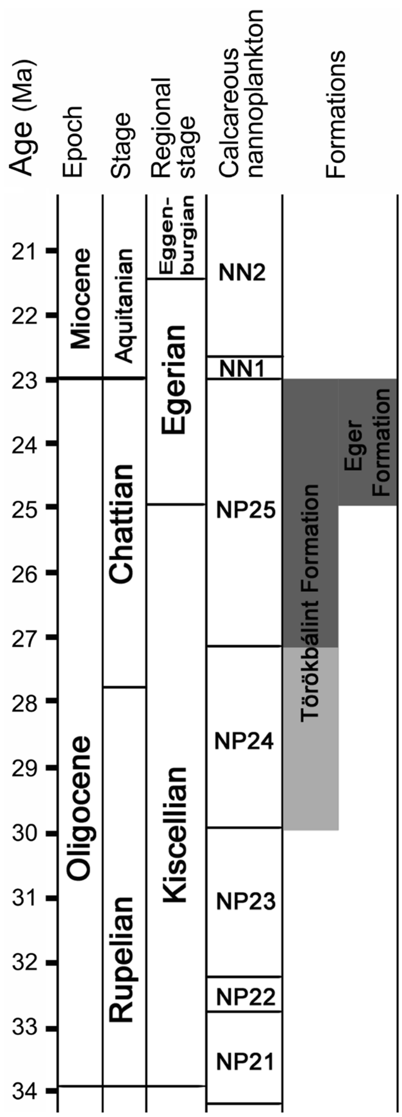

Figure 1. Oligocene chronostratigraphy and nannoplankton zonation. Formations yielding late Oligocene plant fossils are indicated (after Babinszki et al., 2023, modified)

the Egerian stage whereas the Törökbálint Formation extends from the Kiscellian, with older sections belonging to the NP24 nannoplankton zone. The localities of the Törökbálint Formation discussed herein all belong to the NP25 zone, ranging from the upper Kiscellian up to the lower Egerian.

According to the updated terminology, the Törökbálint Formation (with the Mány, Solymár, and Kovačov members) and Eger Formation (Andornaktálya Member) comprise localities of plant fossils, which are as follows: Andornaktálya, Csörög, Eger Wind-brickyard, Kesztölc, Környe, Leányfalu, Máriahalom, Nagysáp, Pomáz, Pusztaberki, Rétság, Tarján, Verőcemaros, and Vértesszőlős. Additionally, there are several locations with sporadic coalified plant fragments, but these are not discussed here in detail.

The Oligocene floras presented here have been preserved in cyclic strata, in sandy, aleuritic, and clayey sediments and the preservation of fossils varies accordingly. The majority of the plant fossil localities had been unknown until their discovery by Tamás Báldi during field work. Some sites, however, had been well known earlier, such as Csörög and Kígyó-hegy, from where János Tuzson collected as early as 1915. The most well-known locality in Eger, the Wind-brickyard (later in the text simply referred to as Wind-brickyard), yielded a diverse flora, which was first studied and published in a monograph by Gábor Andreánszky (Andreánszky, 1966).

Unfortunately, scarce information is available on the micro-flora of the upper Oligocene formations of Hungary. This is due to the lithology of the sediments that are rich in sands and sandstones not unfavourable for the preservation of pollen. Only two of the late Oligocene localities, Wind-brickyard and Kesztölc, yielded a poor micro-flora (pollen and spores), which were studied in the 1960s (Nagy and Pálfalvy, 1963; Pálfalvy, 1965).

MATERIAL AND METHODS

This study focuses on the late Oligocene localities hitherto discovered in Hungary, namely Andornaktálya, Csörög, Wind-brickyard, Kesztölc, Környe, Leányfalu, Máriahalom, Nagysáp, Pomáz, Pusztaberki, Rétság, Tarján, Verőcemaros, and Vértesszőlős. The fossil floras comprise predominantly impressions of leaves, whereas reproductive structures – fruits, seeds and cones – are subordinate in the collections. The sediments embedding the fossils are clay, aleurolite, sands, clayey sand or sandy clay. Depending on the type of embedding sediments, the preservation of the fossils is often poor, with fragmented leaves and poorly preserved macro-morphological details. The majority of specimens are held in the palaeobotanical collection of the Botanical Department, Hungarian Natural History Museum, with inventory numbers starting with the epithet "HNHM-PBO". Specimens of the Wind-brickyard locality are partly stored in the Mátra Museum of the Hungarian Natural History Museum indicated with the epithet "MM". Specimens from Vértesszőlős and some fossils from Máriahalom enrich the collections of the Kúny Domokos Museum in Tata, marked as "Tata". The Mining and Geological Survey of Hungary houses fossils from Nagysáp and findings from Kesztölc, which are marked as "BK". The complete list of material with collection numbers are specified in the Supplementary File[1].

[1] Supplementary File. The complete list of material with collection numbers

Mostly simple mechanical methods were adopted for the preparation of specimens. Plant fossils were studied using macro-morphological methods (Olympus SZX9 dissecting microscope). Photos were edited with the software Adobe Photoshop Elements 4.0. Morphological descriptions follow Dilcher (1974) and Ellis et al. (2009). Systematics follows APG IV (Angiosperm Phylogeny Group et al., 2016).

LOCALITIES – NOTES ON STRATIGRAPHY

ANDORNAKTÁLYA

There is a disused sandpit stretching in N–W direction between the town of Eger and Andornaktálya village, at the northern border of the latter. In the pit, loose sand strata with a thickness of ~60 m have been exposed. There are thin pelite beds in the lower part of the sand strata, some of which are extremely rich in leaf fossils. The sequence is topped by a thick pelite bed. The lithology of the sequence (Sztanó and Tari, 1991) is very similar to that of the upper part of the nearby Wind-brickyard in Eger, suggesting the upper part of the Eger Formation for this locality (Sztanó et al. in Varga et al., 1989), as the Andornaktálya Member of the Eger Formation (Babinszki et al., 2023). Although the extremely poor nannoflora does not provide any stratigraphic data, the fossil-species recognized – *Reticulofenestra hesslandii* (Haq) Roth, *R. ornata* Muller, *R. bisecta* (Hay, Mohler et Wade) Roth and *R.* ex aff. *tokodensis* Báldi-Beke – indicate an age not younger than late Oligocene (Nagymarosy in Varga et al., 1989). Leaf fossils have been discovered at the locality by scientists of the Department of Geology, Eötvös Loránd University (Budapest, Hungary). The plant fossils are dominantly leaf impressions, whereas fruits and seeds and stem fragments are subordinate in the assemblage. The fossils recovered from the coarse sediments in the outer wall of the pit are relatively poorly preserved.

CSÖRÖG

The lithostratigraphic unit called the Kovačov Member of the Törökbálint Formation, which was previously defined as Kovačov Formation (Báldi, 1973), is a lateral equivalent of the Mány Member of the Törökbálint Formation (Báldi, 1976, 1998). It is situated northeast of the distributional area of the Mány Member, in the Buda Hills and the Dorog Basin, overlying sediments of the Kiscell Clay. The Oligocene-Miocene layers and biostratigraphy of the Börzsöny Mts were studied and published by Báldi (1973). The stratigraphic results corroborated a late Oligocene (Egerian) age of the flora and revealed the position of the Kovačov Member in the Törökbálint Formation.

The first, as well as the richest collection from Kígyó Hill in Csörög was made in 1917 by János Tuzson, botany professor at the University in Budapest. Later, plant fossils were collected by Professor Gábor Andreánszky, followed by Lajos Czimboray Jr. between 1949 and 1951. The two collections originated from different locations. The specimens collected by Tuzson – based on the type of embedding sediments – originated presumably from the quarry of Pokolvölgytető, directly near the andesite course. This locality was also discovered by Czimboray as "sampling site II". Czimboray's gathering, however, covered an additional area as well (sampling site I), where plant fossils were preserved in fine-grained, micaceous, clayey sandstone and sandy clay rich in molluscs and sea-urchins. These collections were studied by György Vitális and Lidia Zilahy (1952), led by Gábor Andreánszky who also collected and published plant remains from the locality (Andreánszky, 1952, 1956, 1965a). The taxonomic revision of the flora has partly been made by Hably (1998).

EGER, WIND-BRICKYARD

The holostratotype section of the Egerian (Central Paratethys regional stage) has been designated in the Wind-brickyard in Eger and its sediments have been classified in the Eger Formation. The detailed description of the section had been given by Báldi (1973) and was later cited in additional papers (Kvaček and Hably, 1991; Babinszki et al., 2023). The section is quite rich in plant fossils, moreover, Andreánszky (1966) mentioned three successive layers, the age of which, as a consequence, is slightly different. Unfortunately, papers usually mention these successive floras as a whole, uniform one, albeit a thorough study shows a change of the flora through the sequence. Although the flora of the lower level belongs already to the upper Oligocene according to the section by Báldi (1973), it is preserved approximately 30 metres below the upper level flora, in a different sedimentary matrix formed in different conditions. Consequently, the age of the upper and lower level floras may also be different. Mostly fossils of the upper layers, some thousands of specimens, have been collected, but the flora of the lower layers is also represented in the collections.

KESZTÖLC

A section yielding plant fossils has been opened on the bank of a watercourse, south of Kesztölc village. This excavation had already been mentioned by Schréter (1953), and altogether seven fossil species of molluscs had been reported. The stratigraphy of the section and the study of its mollusc fauna were published by Báldi (1973). Leél-Őssy completed Báldi's study and analized the upper layers, contributing to the knowledge of its mollusc fauna as well (Leél-Őssy, 1984, 1992). Based on the stratigraphic observations and the mollusc fauna, the age of the flora is late Oligocene and embedding sediments belong to the Kovačov Member of the Törökbálint Formation.

The fossil flora of Kesztölc was studied by Pálfalvy (1965), who defined 30 taxa based on macro-remains and many other taxa based on palynological studies. Unfortunately, Pálfalvy did not publish descriptions, figures or other documentations in his paper, even identifying labels or notes were not made in the collections, therefore, Hably (1988) revisited the material. The collections made by Klára Rásky and László Rákosi have been completed with the material collected by Hably in the Botanical Department of the HNHM.

KÖRNYE

The Mány Member of the Törökbálint Formation is composed of fine-grained siliciclastic rocks (sand–silt–clay and their cemented variants). Sands and sandstones, which are cemented by carbonate, are rich in muscovite. Subordinately gravel, conglomerate and variegated clay beds, and coal stringers occur in the succession. The pebbles are usually small-grained, medium- to well-sorted, and basically of metamorphic origin. The majority of the pebbles are composed of quartzite, lydite, sandstone-quartzite, gneiss, phyllite, and sericite shale (Korpás, 1981). The colour of the rocks belonging to the Mány Member is grey, greenish grey or yellowish grey (and yellowish brown if they are altered). Fossils comprise predominantly poorly preserved molluscs and plant remains. The deposition of the Mány Member may have started already at the end of the Kiscellian (Selmeczi and Fodor, 2008). The Mesozoic basement of the study area is made up of Upper Triassic carbonates (Dachstein Limestone or the transitional beds between Dachstein Limestone and Hauptdolomit). Oligocene sediments are underlain either by Upper Triassic carbonates or by Eocene formations of various facies. After a long period of terrestrial sedimentation, in the early late Oligocene the continental terrain may have been covered by a shallow sea which gradually invaded the area from the E–NE, and a brackish-water environment (locally with swamps) came into being by the end of the Kiscellian. The sediments belonging to the Mány Member of the Törökbálint Formation (formerly Mány Formation) were deposited in a shallow lagoonal environment characterized by various brackish salinities and normal marine ones (Selmeczi and Fodor, 2008). This lithostratigraphic unit is widespread in the basins situated E of the Gerecse Mts and can be studied in several outcrops. Groundworks of the "Környe Industrial Park" exposed fossiliferous beds of the Mány Member of the Törökbálint Formation. The industrial park is located to the southwest of Tatabánya, in the western forelands of the Vértes-Gerecse Mts, close to Patár Hill. Collections of the plant remains preserved in the sandy-clayey sediments were made initially by researchers from the Geological and Geophysical Institute of Hungary who discovered the locality, Gábor Csillag, Zoltán Lantos, and Ildikó Selmeczi. Later, LH and BE continued collecting activities. The in situ succession, dominated by sandy layers (greyish yellow and yellow, medium- to fine-grained sand and loose sandstone) was exposed in a thickness of 3–6 m. In some places strongly cemented, calcareous sandstone nodules occurred. The sandy succession comprised thin yellowish grey clay/clay marl layers and greyish white calcareous clay beds in which the plant remains were found. Small and poorly preserved fossil molluscs, especially bivalves (*Polymesoda* sp., *Ostrea* sp.) refer to marine environment. Based on its mollusc fauna and regional stratigraphy (borehole data), the age of the fossiliferous sedimentary unit was estimated as late Oligocene and layers were assigned to the Mány Member of the

Törökbálint Formation (Báldi, 1976; Korpás, 1981). The flora was studied by Hably et al. (2015).

Mainly leaves, more than 300 specimens, have been collected. Fossils are preserved as impressions in fine-grained, clayey sediments which allows for the study of macro-morphological details. Plant tissue is strongly oxidized therefore cuticular details have not been preserved. Plant fossils are preserved in masses along the laminated layers of the sediments.

LEÁNYFALU

The sequence and mollusc fauna of the locality, situated in the valley of the Dóra Stream near Leányfalu, were investigated and published by Báldi (1965). The fossiliferous sequence belongs to the Kovačov Member of the Törökbálint Formation. Although the fossil plants are mostly fragmented, clayey layers rarely yielded nicely preserved specimens. Collections made earlier (in 1974, 1976, and 1985) are studied and published here for the first time.

MÁRIAHALOM

Sediments of the outcrop, providing the plant fossil locality, are identified as the Solymár Member of the Törökbálint Formation. The site is primarily known for its mollusc fauna, but a low number of plant fossils occur as well. Leaf remains are poorly preserved in the cemented sandstone layers. The sequence and its mollusc fauna were studied and published by Báldi and Ságoly (Báldi et al., 1975).

NAGYSÁP

Based on sediment character and stratigraphic position, the fossil-bearing layers are upper Oligocene and belong to the Kovačov Member of the Törökbálint Formation. Plant fossils were first collected by István Pálfalvy in 1965. On the labels of the specimens held in the Mining and Geological Survey of Hungary the indication for the locality is given as follows: "to the southwest of the village, the outcrop near the power-line". Twenty years later the locality had no trace at all, but a bit further from the site given by Pálfalvy, some poorly preserved leaf fossils came to light from the outcropping sediments. The study of the specimens collected from Nagysáp was later carried out by Hably (Hably, 1989).

POMÁZ

The locality, which is quite rich in plant fossils, can be found within the city precincts of Pomáz, on the side of a gully of Kartálja lying by Mesélő Hill (Báldi, 1973). The outcrop was first published by Koch (1871) who also provided a short list of fauna. Similarly to other late Oligocene localities, Tamás Báldi discovered the plant fossils of Pomáz. In addition to his geological and palaeo-zoological studies Báldi mentioned plant fossils, such as impressions of "*Sequoia* Endl." and "*Cinnamomum* Schaeff." leaves from the light grey, fine-grained clay belonging to the Kovačov Member of the Törökbálint Formation (Báldi, 1965). The flora was later studied by Hably (1994).

The nannoplankton content of the fossiliferous layers was investigated by András Nagymarosy (unpublished). Based on the poor nannoflora, the layers yielding the plant fossils can be assigned with high certainty to the nannoplankton zone NP 25. Among the fossil-species identified in the nannoflora, *Helicopontosphaera recta* Haq became extinct by the end of zone NP 25, while the fossil-species *Triquetrorhabdulus carinatus* Mart. appeared at present-day latitudes only at the bottom of zone NP 25 (Nagymarosy, pers. comm.).

PUSZTABERKI

In the West-Cserhát Mts, the Kovačov Member of the Törökbálint Formation is formed of aleurites, clayey sand and sandstone with occasional plant remains. The upper Oligocene layers of the East-Cserhát Mts are quite different in exposing schlieren, glauconites, and clayey sandstones which are devoid of plant remains (Báldi, 1973). The plant fossils in Pusztaberki were discovered by Báldi (1963a) who mentioned remains of plants in his field notes, but has never reported them in his papers. From the two outcrops near the village, one was mentioned as Pusztaberki-1. in Báldi's field report with the following sequence: the bottom 5 m of the sequence is composed of light grey, homogenous coarse-grained sand without pebbles, the next 2 m is formed of poorly sorted, slightly clayey coarse-grained sand preserving the plant fossils. The lower layer is crosslaminated, pebbly coarse-grained sand overlain by clayey aleurite, which is rich in molluscs, i.e. *Pholadomya puschi* Goldfuss, *Diplodonta rotunda* Montagu, and *Textularia* *deperdita* d'Orbigny (Báldi, 1963a). Plant fossils are poorly preserved, especially in layers with high sand content.

The outcrop, named Pusztaberki-2, is indicated on the map published by Noszky (1940) but no plant fossils are mentioned. Further on Báldi discussed the geology of the outcrop (Báldi, 1963a), however, due to its poor macrofauna no detailed study was carried out. Clay and poorly cemented yellow sandstone of 1.5 m thickness with fragments of molluscs (*Glycymeris* da Costa) and hardly observable plant fossils are overlain by coarse-grained sandstone of 2.5 m thickness with occasional limonitic laminae. Subsequent layers are composed of grey clay of 0.5 m thickness containing sand laminae and high number of plant fossils, which are better preserved in the upper levels of the clay lense. The sediments of the outcrop are more clayey towards its southwestern edge then turn into coal laminae. Overlying layers are coarse-grained sandstones of 2.5 m thickness containing driftwoods and poorly preserved plant fragments. The top layers are coarse-grained sandstones with small pebbles with a maximum diameter of 0.5 cm. Mollusc remains are fragmentary and poorly preserved, e.g. *Pitar beyrichi* Semper, *Venus multilamella* Lamarck, and *Cardium* sp. (Báldi, field notes).

RÉTSÁG

The Oligocene sediments and mollusc fauna of the Börzsöny and the adjacent West-Cserhát Mts were studied by Báldi (1973). During fieldwork, Báldi had discovered plant fossils, which were later collected by LH, in several layers belonging to the Kovačov Member of the Törökbálint Formation. The coarse-grained sediments characterized by high sand content have yielded poorly preserved plant remains.

TARJÁN

In the eastern foreland of the Gerecse Mts, by the eastern border of the village of Tarján, sediments belonging to the Mány Member of the Törökbálint Formation were exposed on the hillside, on the eastern side of Szent László Brook. The upper Oligocene succession is dominated by sand and sandstone beds. Two silty-clayey interbeddings of the 4-m-thick sandy succession yielded plant fossils. The flora was studied by Hably et al. (2017).

VERŐCEMAROS

Verőcemaros is currently the administrative name of the settlement (its former official name was Nógrádverőce). Ádám Boros, a renowned Hungarian bryologist, made a small collection in 1973, which is stored in the HNHM. Boros indicated on the specimens' slips only the name of the locality without any other details. The sediments embedding the flora belong to the nannoplankton zone NP 25 indicated by the record of diagnostic fossil-taxa, i.e. *Zygrablithus bijugatus* Deflandre, *Helicopontosphaera recta*, and *Sphenolithus conicus* Bukry. Both the overall spectrum of the nannoflora and the sedimentary characteristics of the fossiliferous layers support an Egerian age for the sequence (András Nagymarosy, pers. comm.). The fossiliferous layers were assigned to the Kovačov Member of the Törökbálint Formation. The sedimentary matrix of the relatively well-preserved plant fossils is clayey sandstone, but no cuticles or other organic fragments are available. The flora was studied by Hably (1982).

VÉRTESSZŐLŐS

The Mány Member of the Törökbálint Formation was exposed in the area between Tatabánya and Vértesszőlős during highway constructions. From this excavation plant fossils were collected by István Skoflek (Kuny Domokos Museum, Tata, Hungary) and his student, Attila Csaba in the early 1970s. The mollusc fauna co-occurring with the plant remains suggested an Egerian age for the fossiliferous layers (Báldi, 1976). It was corroborated by András Nagymarosy (pers. comm.) based on nannoplankton studies, which indicated nannoplankton zone NP 25 (updated stratigraphy: late Kiscellian to early Egerian in Babinszki et al., 2023). Leaf impressions are embedded in clayey, fine-grained sandstones. The flora from Vértesszőlős is the most westerly and one of the richest late Oligocene floras of Hungary. The flora was studied by Hably (1976, 1979a, b, 1983, 1990; Hably and Csaba, 1977; Ambrus and Hably, 1979).

SYSTEMATIC PART

EQUISETALES DC. ex Bercht. et J.Presl

EQUISETACEAE Michx. ex DC.

Equisetum L.

***Equisetum* sp. div.** (stem fragments)

Fig. 2.1–2.4

1955a *Equisetum braunii* Unger ex Heer; Andreánszky, p. 37, pl. 1, fig. 1.
1955a *Equisetum* cf. *maximum* L.; Andreánszky, p. 37, pl. 1, fig. 2.
1991 *Equisetum* sp. div.; Kvaček and Hably, p. 51, pl. 1, fig. 3.

Material. Eger Wind-brickyard (upper flora).

Description. Ribbed casts of horsetail stems. Stems 13–20 mm across, partly flattened with nodes at various (15–35 mm) intervals.

Discussion. Andreánszky (1955a) compared the more robust specimens with *E. maximum* Lam. (synonym of *E. fluviatile* L.), and the slender ones with *E. braunii* Milde. Members of Equisetales have been reported exclusively from the Wind-brickyard, where it is sporadic in the upper flora. The occurrence of horsetails suggests wetland habitats.

POLYPODIALES Link

ASPLENIACEAE Newman

Asplenium L.

?*Asplenium* sp. (foliage)

Fig. 2.5

1952 *Asplenium* sp. cf. *Asplenium mexicanum* M.Martens et Galeotti; Vitális and Zilahy, p. 162, pl. 20, fig. 2.
1956 *Asplenium matrense* Andr.; Andreánszky, p. 221.

Material. Csörög.

Description. Fragmentary, apical part of pinna preserved. Length of fragment 3 cm, width 0.6 cm. Apex of pinna acute, margin lobed.

Discussion. Andreánszky assigned the specimen to the fossil-species *Asplenium matrense* established on a specimen from Mátraderecske, which is larger and better preserved than that from Csörög. The poor preservation of the specimen from Csörög does not allow its proper comparison and identification. Another specimen from Csörög, described by Andreánszky as *Asplenium csörögiense* Andr. (Vitális and Zilahy, 1952: p. 162, pl. 20, fig. 1) is missing from the collection.

THELYPTERIDACEAE Ching ex Pic.Serm

Pronephrium C.Presl

Pronephrium stiriacum (Unger) Erw.Knobloch et Kvaček (foliage)

Figs 2.6–2.11, 3.8

1966 *Lastraea* cf. *oeningensis* (A.Braun) Heer; Andreánszky, p. 16, fig. 1.
1991 *Pronephrium stiriacum* (Unger) Erw.Knobloch et Kvaček; Kvaček and Hably, p. 52, pl. 1, fig. 2.
?1991 Polypodiaceae vel Aspidiaceae; Kvaček and Hably, p. 52, pl. 1, fig. 1.
1994 *Pronephrium stiriacum* (Unger) Erw.Knobloch et Kvaček; Hably, p. 7, pl. 23, fig. 1.
2015 *Pronephrium stiriacum* (Unger) Erw.Knobloch et Kvaček; Hably et al., p. 4, figs 3(1–4).

Material. Eger Wind-brickyard (upper flora), Környe, Pomáz.

Description. Sterile and fertile fronds, fronds more or less complete. Fronds with more than 10 pinnae, small frond fragments in large amount. Length of fronds up to 35 cm. Rachis longitudinally ribbed, rachis width up to 8 mm. Pinnae up to 10 cm, width more than 2 cm. Pinnae shallow crenulate to more deeply incised, with goniopterid type venation. Pinna base asymmetric, cordate. Fertile frond with 8–10 sori per pinna. Sori orbicular, 0.5 mm in diameter, arranged in two rows between veinlets.

Discussion. Among ferns the fossil-species, *Pronephrium stiriacum*, is the most widespread in the late Oligocene floras of Hungary. The fossil-species was described from three localities, the Wind-brickyard, Környe and Pomáz (Kvaček and Hably, 1991; Hably, 1994; Hably et al., 2015). In Környe, it is dominant, and has nicely preserved whole compound leaves suggesting a short or no transport at all. The fossil-species *Pronephrium stiriacum* was widespread in the Paleogene/Neogene floras

Figure 2. **1–4**. *Equisetum* sp., Eger Wind-brickyard (upper flora). **1**. HNHM-PBO 67.75.1., **2**. HNHM-PBO 71.449.1., **3**. HNHM-PBO 67.184.1., **4**. HNHM-PBO 67.127.1.; **5**. ?*Asplenium* sp., Csörög, HNHM-PBO 85.50.1.; **6**, **7**. *Pronephrium stiriacum* (Unger) Erw.Knobloch et Kvaček, Eger Wind-brickyard (upper flora), HNHM-PBO 2010.566.1., **7**. Detail of 6.; **8–11**. *Pronephrium stiriacum* (Unger) Erw.Knobloch et Kvaček, Környe, HNHM-PBO 2009.125.2.; **9–11**. Detail of 8. Scale bars = 1 cm

of Hungary. It was a frequent member of late Oligocene floras, mostly appearing in wetland habitats, but also occured as a rare element in the Early Miocene flora of Ipolytarnóc (Hably, 1985a), and in Late Miocene localities, e.g. Balatonszentgyörgy (Hably, 2013).

BLECHNACEAE Newman

Blechnum L.

Blechnum dentatum
(Göpp.) Heer (foliage)

Fig. 3.1–3.4

1991 *Blechnum dentatum* (Göpp.) A.Braun; Kvaček and Hably, p. 52, pl. 2, fig. 3.

Material. Eger Wind-brickyard (upper flora).

Description. Middle parts of pinnae with slightly dentate margin, width variable, ranging between 11 and 33 mm. Parallel veinlets arise from midrib of pinnae, run to the margin. Veinlets frequently fork close to midrib.

Discussion. The relatively high variety of ferns suggests the presence of wetland habitats at the Wind-brickyard locality (Kvaček and Hably, 1991). In addition, their preservation was also favoured by the fine-grained sedimentary matrix.

POLYPODIACEAE
J.Presl et C.Presl

Polypodiaceae gen. et sp. indet.
(foliage)

Fig. 3.5–3.7

1952 *Lygodites bipartitus* Andr.; Andreánszky, p. 398, pl. 20, fig. 2.
1952 *Lygodites bipartitus* Andr.; Vitális and Zilahy, p. 162.
1976 *Adiantum capillus-veneris* L.; Hably, p. 196, fig. 1.
1988 cf. Pteridophyta sp.; Hably, p. 35, pl. 1, fig. 1.
1990 *Adiantum capillus-veneris* L.; Hably, p. 6, pl. 1, fig. 1.

Material. Csörög, Eger Wind-brickyard (upper flora), Kesztölc, Vértesszőlős.

Description. Fragmentary pinnules. Length up to 15 mm, width 6–8 mm, venation forking.

Discussion. The fragmentary state of the remains does not allow a proper identification.

PINALES Gorozh

PINACEAE Spreng. ex Rudolphi

Pinus L.

***Pinus* sp. 1** (foliage)

Fig. 3.9

1990 *Pinus* sp.; Hably, p. 6.

Material. Vértesszőlős.

Description. Needles fragmented, fragmentary length up to 3 cm, width less than 1 mm. Two needles per fascicle.

Discussion. The needle fossils occured only at Vértesszőlős suggesting a rare fossil-species.

***Pinus* sp. 2** (foliage)

Fig. 3.10–3.12

1989 *Pinus* sp.; Hably, p. 83, pl. 1, fig. 1.
1990 *Pinus tuzsonii* E.Novák; Hably, p. 6.

Material. Eger Wind-brickyard (upper flora), Nagysáp, Vértesszőlős.

Description. Needles fragmented, fragmentary length up to 6 cm, width up to 2 mm. Three needles per fascicle.

Discussion. Pines with three needles per fascicle were often described as *P. tuzsonii* E.Novák, however, no specific diagnostic traits are observable. Three needle pines seem to be relatively frequent since recorded from three localities distant from each other. Nevertheless, pines are subordinate in the late Oligocene floras.

***Pinus* sp. div.** (seed cones)

Fig. 4.1–4.3

1952 *Pinus* sp. conus; Vitális and Zilahy, p. 163, pl. 20, fig. 3.
1966 *Pinus* sp.; Andreánszky, p. 20, figs 3, 4.
1991 *Pinus* sp. div.; Kvaček and Hably, p. 53, pl. 2, fig. 1.

Material. Csörög, Eger Wind-brickyard (lower flora), Máriahalom.

Description. Csörög (HNHM-PBO 85.52.1.) – Seed cone length 6.2 cm, width 1.2 cm. Shape of cone narrowly ovate. Cone scales heavily damaged; Máriahalom (HNHM-PBO 2001.647.1.) – Two seed cones, the more complete one ovate, 4.7 cm long, 2.1 cm wide. Cone

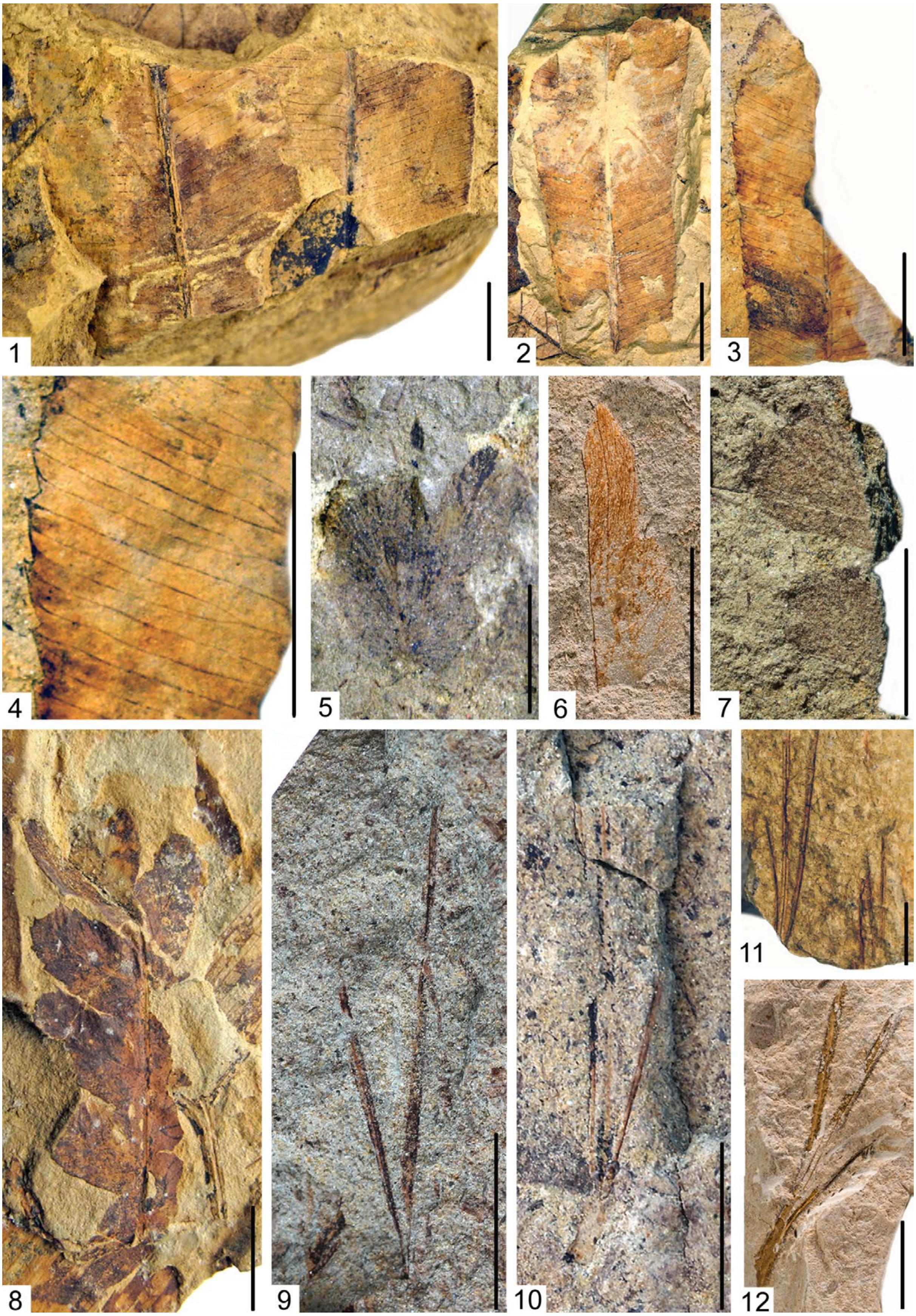

Figure 3. **1–4**. *Blechnum dentatum* (Göpp.) Heer, Eger Wind-brickyard (upper flora). **1**. HNHM-PBO 2010.587.1., **2**. HNHM-PBO 2013.82.1., **3**. HNHM-PBO 2010.341.1., **4**. detail of 3.; **5–7**. Polypodiaceae gen. et sp. indet., **5**. Csörög, HNHM-PBO 85.95.1., **6**. Kesztölc, BK 2483., **7**. Vértesszőlős, Tata 76.101.1.; **8**. ?*Pronephrium stiriacum* (Unger) Erw.Knobloch et Kvaček, Eger Wind-brickyard (upper flora), MM 56.1344.1.; **9**. *Pinus* sp. 1., Vértesszőlős, Tata 76.59.1.; **10–12**. *Pinus* sp. 2., **10**. Vértesszőlős, Tata 76.104.1., **11**. Eger Wind-brickyard (upper flora), HNHM-PBO 2010.337.1., **12**. Nagysáp, BK 1170. Scale bars = 1 cm

scales mostly damaged. Some scales, preserved at the apical part of cone, 1.2 cm long. Umbo acute; Eger, Wind-brickyard (lower flora; HNHM-PBO 2007.991.1.) – Seed cone length 8 cm, width 2.5 cm, peduncle 1 cm. Shape of cone narrowly ovate. Cone scales heavily damaged.

Discussion. Pine cones are relatively rare at Csörög and Máriahalom. In the lower flora of the Wind-brickyard locality, cones turned up relatively frequently.

CUPRESSACEAE Gray

Tetraclinis Mast.

***Tetraclinis* sp.** (twig fragment)

Fig. 4.4

1990 *Libocedrites salicornioides* (Unger) Endl.; Hably, p. 8.
1993a *Tetraclinis salicornioides* (Unger) Kvaček; Hably, p. 6.

Material. Andornaktálya, Vértesszőlős.

Description. Part of twig segment, length 0.6–0.8 cm, width 0.5 cm. Shape cuneiform.

Discussion. The isolated segments cannot be assigned unambiguously to a fossil-species of *Tetraclinis*. Fossil leaf and twig fragments of *Tetraclinis* were frequent in floras of the lower Oligocene Tard Clay Formation. Later, the genus occurred in high numbers in the Early Miocene flora of Ipolytarnóc (Hably, 1985a). The absence of the genus in late Oligocene assemblages may be attributable to both habitat differences and taphonomical reasons. These localities represent mostly fossils of wetland habitats probably not favoured by *Tetraclinis* and embedding sediments are much coarser grained than the clayey sediments of the Tard Clay or the riolithic tuff in Ipolytarnóc.

***Tetraclinis* sp.** (seed cone)

Fig. 4.5

1955a *Callitrites brongniartii* Endl.; Andreánszky, p. 37, pl. 1, fig. 3.
1991 *Tetraclinis* sp.; Kvaček and Hably, p. 53, pl. 2, fig. 6.

Material. Eger Wind-brickyard (upper flora).

Description. Seed cone, detached, unripen. Shape rounded, length 10 mm, width 12 mm.

Discussion. *Tetraclinis* was a rare member of late Oligocene floras, its cone was reported only in the upper flora of the Wind-brickyard.

TAXODIOIDEAE
Endl. ex K.Koch

Glyptostrobus Endl.

Glyptostrobus europaeus
(Brongn.) Unger (twigs, foliage, cones)

Figs 4.6–4.10, 4.12–4.14, 5.1

2015 *Glyptostrobus europaeus* (Brongn.) Unger; Hably et al., p. 4, figs 4(1, 2, 5–11).

Material. Twigs: Eger Wind-brickyard (upper flora), Környe; Cones: Környe.

Description. Leafy shoots – twig fragments up to 10 cm, with distinct leaf types. Taxodioid leaves helically arranged, partly distichous. Length up to 13 mm, width up to 1.5 mm. Leaf apex acute, base slightly rounded to acute, margin entire. Cupressoid type leaves helically arranged, 1.1–2.5 mm long, 0.5–1.0 mm wide. Apex acute, base decurrent, margin entire. Cryptomerioid type leaves helically arranged, needle-like, length up to 11 mm, width up to 0.8 mm; Seed cones – Terminal, solitary, obovate, or subglobose, 15–25 mm in length, 15–20 mm in width. Cone scales min. 12, woody, helically arranged, imbricate, 10–20 × 5–7 mm in length and width. Scales mostly oblong, distally broad, rounded. Definite finger-like lobes along the distal margin. Proximally cuneate subcentral lobe (~ 2 × 1 mm) abaxially; Seeds – Elliptical, slightly curved. Wing preserved. Seed length 3–5 mm, width 1.5 mm. Wing 3–4 mm long, 2–3 mm wide, relatively robust, triangular; ?Pollen cones – Terminal, solitary, globose to ovate. Length and width 1.5–2 mm. Microsporophylls hardly observable.

Discussion. The fossil-species is reported from two localities, both represent dominantly wetland habitats. Leafy twigs are described from both localities, but cones occur only in the flora of Környe. The genus *Glyptostrobus* was a widespread element of the Miocene floras of Europe. The much older Paleogene appearance of the genus in the European floras is still unclear (LePage, 2007). It was an important and typical element of the Central European

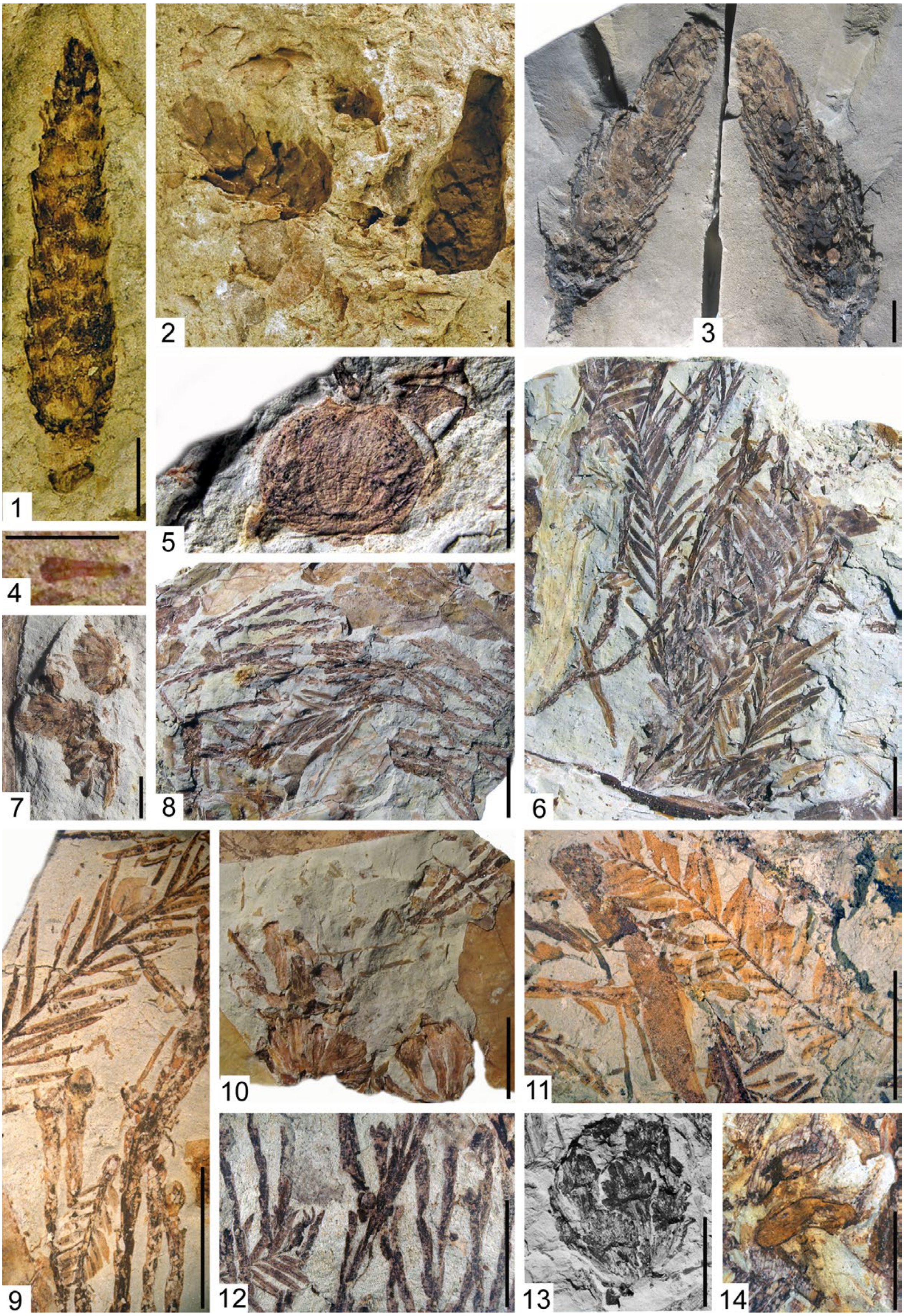

Figure 4. **1–3**. *Pinus* sp., cone. **1**. Csörög, HNHM-PBO 85.52.1., **2**. Máriahalom, HNHM-PBO 2001.647.1., **3**. Eger Wind-brickyard (lower flora), HNHM-PBO 2007.991.1.; **4**, **5**. *Tetraclinis* sp., **4**. scale leaf, Vértesszőlős, Tata 76.116.1., **5**. seed cone, Eger Wind-brickyard (upper flora), MM 56.1390.1.; **6–10**, **12–14**. *Glyptostrobus europaeus* (Brongn.) Unger, Környe, **6**. HNHM-PBO 2009.99.4., **7**. HNHM-PBO 2009.202.1., cones, **8**. HNHM-PBO 2009.161.2., **9**. HNHM-PBO 2009.193.1., ?male cones, **10**. HNHM-PBO 2009.180.1., seed cones, **12**. HNHM-PBO 2009.229.2., ?male cones, **13**. HNHM-PBO 2009.388.2., seed cone, 14. HNHM-PBO 2009.193.1. seed; **11**. Taxodioideae gen. et sp. indet., Környe, HNHM-PBO 2009.381.1. Scale bars in 1–13 =1 cm, in 14 = 0.5 cm

wetland vegetation, and often occurred as dominant member of swamps, coal swamps during the Late Miocene, e.g. Dozmat (Hungary; Hably and Kovar-Eder, 1996; Hably, 2013), and the lignite floras of Bükkábrány and Visonta (Hungary; Bůžek and László, 1992; Erdei et al., 2009; Erdei and Magyari, 2011; Hably, 2013).

Taxodioideae gen. et sp. indet.
(foliage)

Figs 4.11, 5.2, 5.3, 5.6

1952 *Sequoia langsdorfii* (Brongn.) Heer; Vitális and Zilahy, p. 163.
1988 *Taxodium dubium* (Sternb.) Heer; Hably, p. 36, pl. 1, figs 2–4.
1989 cf. *Taxodium dubium* (Sternb.) Heer; Hably, p. 84, pl. 1, fig. 2.
1990 *Taxodium dubium* (Sternb.) Heer; Hably, p. 7, pl. 1, fig. 3, pl. 2, fig. 1.
1990 cf. *Sequoia abietina* (Brongn.) Erw.Knobloch; Hably, p. 8, pl. 1, fig. 2.
1990 *Cephalotaxus harringtonii* (Knight ex J.Forbes) K.Koch foss.; Hably, p. 9, pl. 2, figs 2, text.-fig. 2.
1994 *Taxodium dubium* (Sternb.) Heer; Hably, p. 8, pl. 1, figs 1, 2.
1994 cf. *Sequoia abietina* (Brongn.) Erw.Knobloch; Hably, p. 9, pl. 1, figs 3, 4.
2015? *Taxodium dubium* (Sternb.) Heer; Hably et al., p. 7, figs 4(3–4).

Material. Környe, Csörög, Kesztölc, Nagysáp, Pomáz, Vértesszőlős.

Description. Leafy shoots with taxodioid type leaves. Leaves helically arranged, partly distichous. Length of leaves up to 25 mm, width up to 3 mm. Leaf apex acute, base slightly rounded to acute, margin entire.

Discussion. The morphology of the taxodioid type leaves of modern *Sequoia* Endl. and *Taxodium* Rich. are quite comparable. Short shoots of modern *Glyptostrobus* trees also develop bilaterally flattened leaves arranged spirally and in a distichous manner (Farjon, 2005). Since no cuticular details, providing diagnostic traits, are available we assign the taxodioid leaf forms to the Taxodioideae subfamily of Cupressaceae.

Leafy shoots with taxodioid type leaves were documented from several late Oligocene localities but usually with few specimens. In Vértesszőlős and Környe, however, the high number of taxodiaceous twigs refers to an occurrence closer to the depositional basin.

SEQUOIOIDEAE
Saxton

Quasisequoia Srinivasan et Friis

Quasisequoia couttsiae
(Heer) L.Kunzmann (seed cone)

Fig. 5.4, 5.5

1966 *Sequoia couttsiae* Heer; Andreánszky, p. 22, fig. 6.
1991 *Sequoia couttsiae* Heer; Kvaček and Hably, p. 53, pl. 2, figs 4, 5.

Material. Eger Wind-brickyard (upper flora).

Description. Female cones, terminal, diameter up to 2 cm. Cone scales peltate, diameter up to 8 mm. Cones partly attached, partly associated with twigs bearing appressed, helically arranged scale leaves.

Discussion. The fossil-species *Sequoia couttsiae* has been synonymized in the extinct fossil-species *Quasisequoia couttsiae* (Kunzmann, 1999). Its cones were recorded as a rare element from one locality, the upper flora of the Wind-brickyard.

LAURALES
Juss. ex Bercht. et J.Presl

LAURACEAE Juss.

Sassafras L. ex Nees

Sassafras lobatum Saporta
(foliage)

Fig. 5.7

1966 *Sassafras lobata* Saporta; Andreánszky, p. 26, fig. 10.
1991 *Sassafras lobatum* (Saporta) Andr.; Kvaček and Hably, p. 54, pl. 3, fig. 1.

Material. Eger Wind-brickyard (upper flora).

Description. Trilobate leaves, length up to 6 cm. Lobes mostly narrow; middle lobe widest, width up to 1.8 cm. Base concave, lobe apices acute or missing, margin entire. Midvein strong. Suprabasally a pair of strong secondary veins, running into lobes. Higher order veins run towards margin and form loops.

Discussion. The fossil-species was recorded only in the upper flora of the Wind-brickyard.

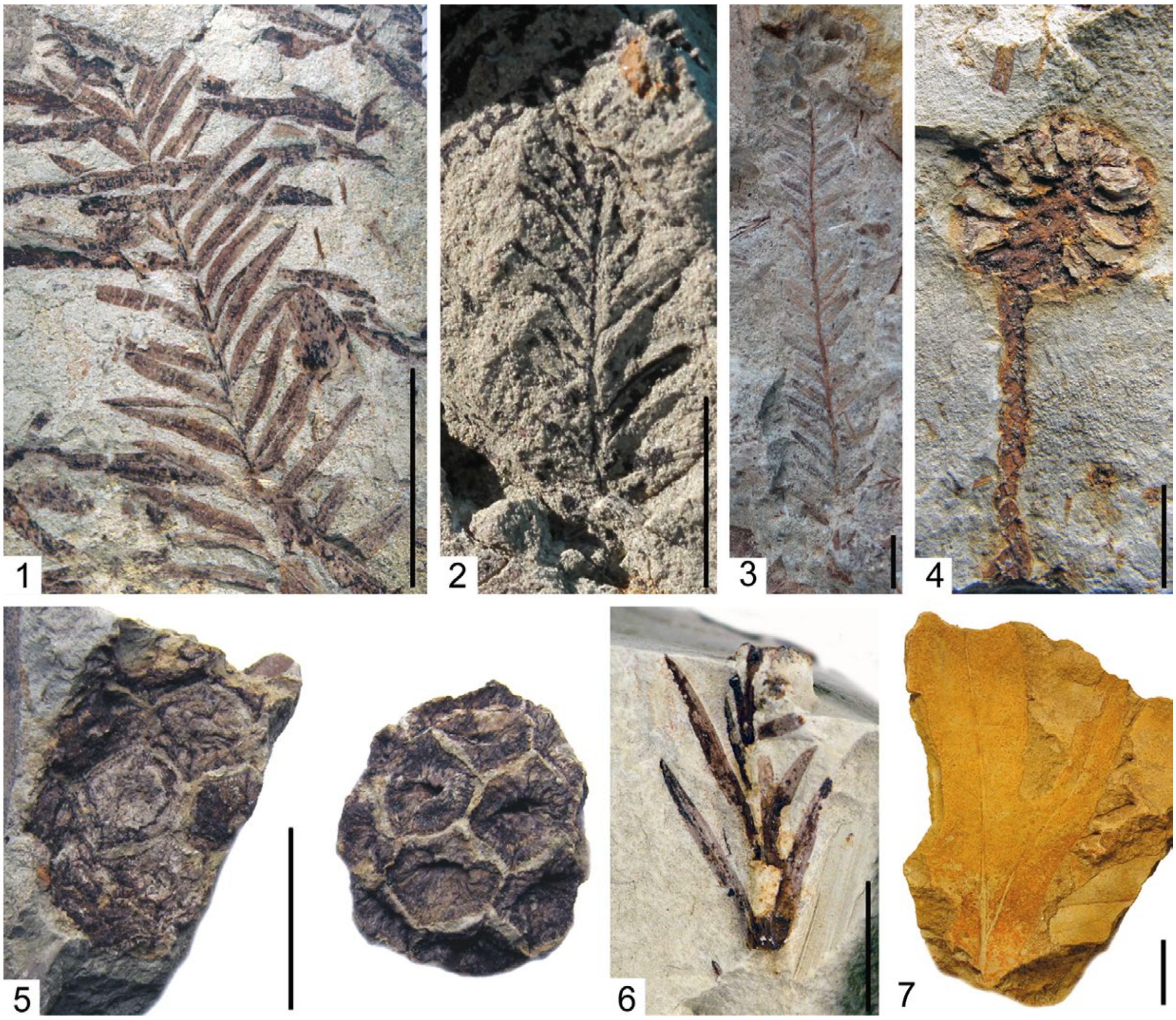

Figure 5. **1**. *Glyptostrobus europaeus* (Brongn.) Unger, Környe, HNHM-PBO 2009.229.2.; **2**, **3**, **6**. Taxodioideae gen. et sp. indet., **2**. Vértesszőlős, Tata 76.101.1., **3**. Vértesszőlős, Tata 76.104.1., **6**. Pomáz, HNHM-PBO 85.562.2.; **4**, **5**. *Quasisequoia couttsiae* (Heer) L.Kunzmann, Eger Wind-brickyard (upper flora), cone, **4**. MM 56.1287.1., **5**. MM 55.5827.1.; **7**. *Sassafras lobatum* Saporta, Eger Wind-brickyard (upper flora), HNHM-PBO 2010.565.1. Scale bars = 1 cm

Daphnogene Unger

Daphnogene cinnamomifolia (Brongn.) Unger (foliage)

Fig. 6.1–6.10

1952 *Cinnamomum polymorphum* (A.Braun) Heer; Vitális and Zilahy, p. 164.

1962 *Litsea europhylla* Andr.; Andreánszky, p. 219, pl. 1, pl. 2, fig. 1.

1982 *Daphnogene lanceolata* Unger; Hably, p. 91, pl. 1, figs 1, 2, 7, 8, pl. 4, figs 1–4.

1982 *Daphnogene bilinica* (Unger) Kvaček et Erw. Knobloch; Hably, p. 93, pl. 1, fig. 5, pl. 4, fig. 6.

1988 *Daphnogene bilinica* (Unger) Kvaček et Erw. Knobloch; Hably, p. 36, pl. 3, figs 1–5, pl. 4, fig. 6, pl. 7, fig. 3.

1988 *Daphnogene cinnamomifolia* (Brongn. in Cuvier) Unger; Hably, p. 37, pl. 5, figs 1–5, pl. 6, fig. 1.

1988 *Daphnogene polymorpha* (A.Braun) Ettingsh.; Hably, p. 38, pl. 4, figs 1–5.

1988 *Daphnogene lanceolata* Unger; Hably, p. 37, pl. 1, figs 5–7, pl. 2, figs 1–6, pl. 8, fig. 3.

1989 *Daphnogene polymorpha* (A.Braun) Ettingsh.; Hably, p. 86, text.-figs 31–35, pl. 1, fig. 7, pl. 2, figs 3–5.

1989 *Daphnogene bilinica* (Unger) Kvaček et Erw. Knobloch; Hably, p. 84, pl. 1, figs 5, 6, pl. 2, figs 1, 2, text.-figs 1–13.

1989 *Daphnogene cinnamomifolia* (Bongn. in Cuvier) Unger; Hably, p. 84, pl. 2, fig. 1, pl. 3, fig. 4, text.-figs 14–16.

1989 *Daphnogene lanceolata* Unger; Hably, p. 85, pl. 1, figs 3, 4, pl. 3, fig. 5, text.-figs 18–30.

1990 cf. *Daphnogene cinnamomifolia* (Brongn. in Cuvier) Unger; Hably, p. 9, pl. 4, fig. 2, pl. 6, figs 1, 2, pl. 7, figs 1, 2, pl. 8, figs 1–3, pl. 9, fig. 2, text.-figs 4, 5, 7, 9–13, 21, 27, 83.

1990 cf. *Daphnogene lanceolata* Unger; Hably, p. 11, text.-figs 3, 15, 17, 29, 35, 38.

1990 cf. *Daphnogene bilinica* (Unger) Kvaček et Erw. Knobloch; Hably, p. 12, pl. 9, figs 1–3, pl. 10, figs 1–3, pl. 11, figs 1–3, pl. 12, figs 1, 2, text.-figs 6, 8, 14, 16, 18–20, 23–26, 28, 30–34, 37, 39.

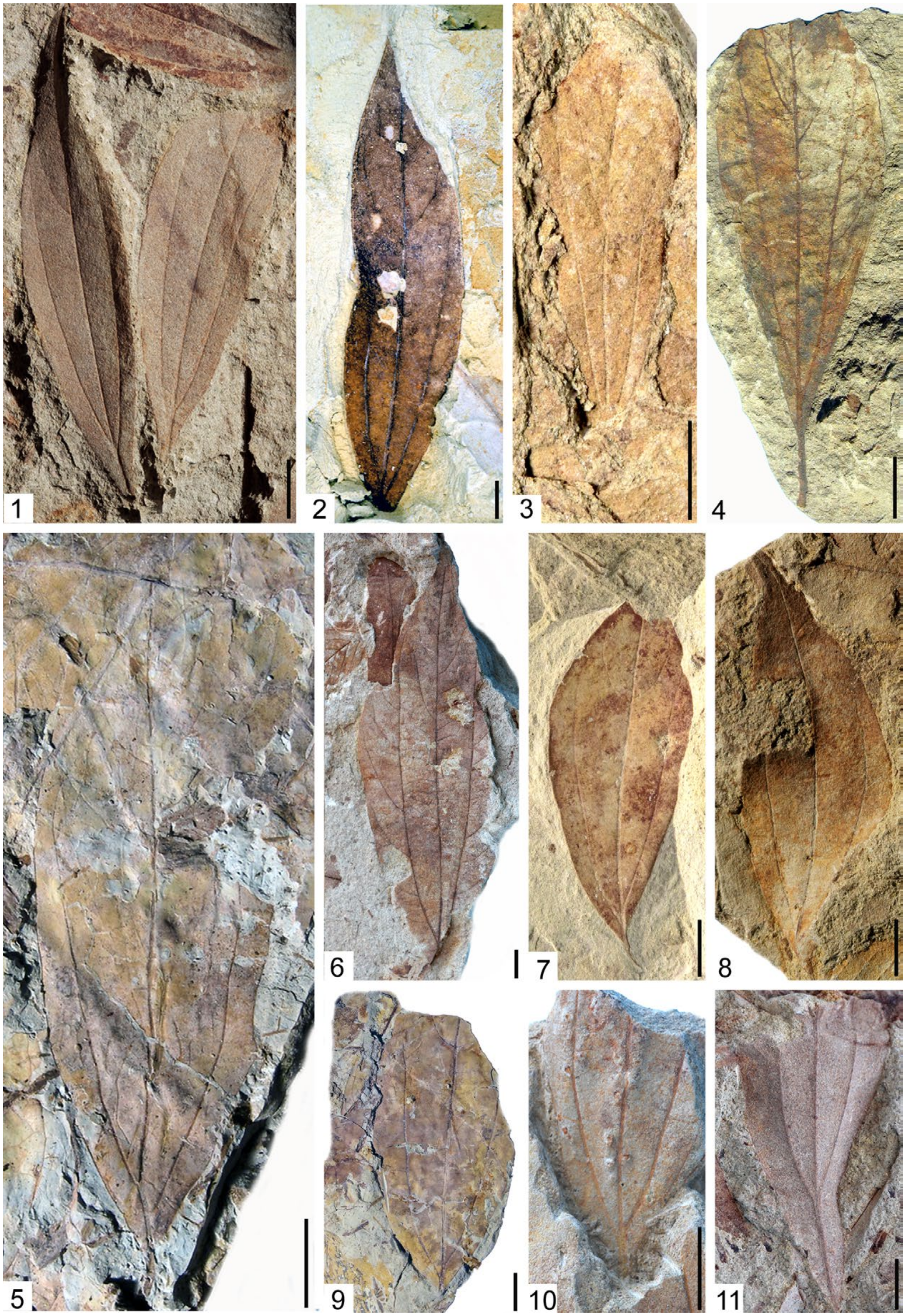

Figure 6. **1–10**. *Daphnogene cinnamomifolia* (Brongn.) Unger., **1**. Vértesszőlős, Tata 76.6.1., **2**. Pomáz, HNHM-PBO 86.407.1., **3**. Tarján, HNHM-PBO 2014.261.2, **4**. Csörög, HNHM-PBO 2005.436.1., **5**. Környe, HNHM-PBO 2009.158.1., **6**. Vértesszőlős, Tata 76.6.1., **7**. Tarján, HNHM-PBO 2014.265.2., **8**. Vértesszőlős, Tata 76.1.1., **9**. Környe, HNHM-PBO 2009.182.1., **10**. Vértesszőlős, Tata 76.92.1.; **11**. *Daphnogene* sp., Vértesszőlős, Tata 76.106.1. Scale bars = 1 cm

1991 *Daphnogene cinnamomifolia* (Brongn. in Cuvier) Unger; Kvaček and Hably, p. 54, pl. 3, figs 4, 5.

1993a *Daphnogene bilinica* (Unger) Kvaček et Erw. Knobloch; Hably, p. 9.

1994 cf. *Daphnogene bilinica* (Unger) Kvaček et Erw. Knobloch; Hably, p. 10, pl. 1, fig. 5, pl. 2, fig. 4, text.-figs 12, 20.

1994 cf. *Daphnogene lanceolata* Unger; Hably, p. 11, pl. 2, figs 5, 6, pl. 3, fig. 4, text.-figs 10, 15, 18, 19.

1994 cf. *Daphnogene cinnamomifolia* (Brongn. in Cuvier) Unger; Hably, p. 10, pl. 2, figs 1–3, text.-figs 7, 16, 21, 24, 25.

1994 *Daphnogene polymorpha* (A.Braun) Ettingsh.; Hably, p. 13, pl. 3, figs 1–3, pl. 4, figs 1, 4, text.-figs 5, 14.

2017 *Daphnogene cinnamomifolia* (Brongn.) Unger; Hably et al., p. 304, figs 6(1, 2).

Material. Broader (ovate) leaves: Kesztölc, Környe, Máriahalom, Nagysáp, Pomáz, Verőcemaros, Vértesszőlős; Elongate leaves: Csörög, Kesztölc, Környe, Leányfalu, Nagysáp, Pomáz, Pusztaberki, Verőcemaros, Vértesszőlős; Fragmented leaves: Andornaktálya, Eger Wind-brickyard (upper flora), Pusztaberki, Tarján.

Description. Leaves simple, shape of lamina ovate, elongate ovate. Apex and base acute, margin entire. Midvein strong. A pair of strong, major secondary veins suprabasal imperfect. Major secondaries brochidodromous, arise in the apical part of the lamina and form loops close to the margin. From the basal pair of veins minor secondaries arise towards the margin and form loops close to the margin. Fine tertiary veins percurrent, opposite, form a chevron between the midvein and major secondaries.

Discussion. Kvaček and Walther (1974; 1995) suggested the putative sun and shade leaves of the fossil-species and classified them accordingly into two forms which often co-occur (e.g. Hably et al., 2015). The broader and the more elongate leaves are assigned to forma *cinnamomifolia* (shade leaves) and forma *lanceolata* (sun leaves), respectively. *Daphnogene cinnamomifolia* is one of the most characteristic and dominant elements of the Hungarian late Oligocene floras, it occurs at all the localities. It seems to be a member of both wetland and mesophytic associations, e.g. Pomáz (Hably, 1994). Such a mass occurrence of the fossil-species was characteristic of the late Oligocene and Early Miocene floras, e.g. Ipolytarnóc (Hably, 1985a).

The genus *Daphnogene* has been reported in localities from the Eocene up to the Late Miocene (Pannonian) (Hably and Sebe, 2016). *Daphnogene cinnamomifolia* appeared also at the majority of the Oligocene localities in Europe. In volcanic floras it has often been recorded as a common, but also as an accessory element (Kvaček and Walther, 1995).

Galls of gall mites (*Eriophyes daphnogene* Ambrus et Hably, 1979: p. 55, fig. 1)

On the basal fragment of a *Daphnogene* leaf (3.5 cm long and 1.1 cm wide; material – Vértesszőlős; Tata 76.92.1.) numerous galls (diameter 1 mm) can be observed along the midvein and a major secondary vein. The presumable host of the mites was *D. cinnamomifolia*. Present-day species of gall mites (*Eriophyinae*) are hosted by various plant species (Ambrus and Hably, 1979).

***Daphnogene* sp.** (foliage)

Fig. 6.11

1988 *Daphnogene* sp.; Hably, p. 38, pl. 6, figs 2, 3.

1989 *Daphnogene* sp.; Hably, p. 86, pl. 2, fig. 1, text.-figs 17, 36–45.

1990 *Daphnogene* sp.; Hably, p. 13, pl. 12, fig. 3, text.-figs 22, 36.

1993a *Daphnogene* sp.; Hably, p. 9.

1994 *Daphnogene* sp.; Hably, p. 13, pl. 4, fig. 2, pl. 5, fig. 1, text.-figs 3, 6, 8, 9, 11, 13, 17, 22, 23, 26.

2017 *Daphnogene* sp.; Hably et al., p. 307.

Material. Andornaktálya, Csörög, Eger Wind-brickyard (upper flora), Kesztölc, Leányfalu, Máriahalom, Nagysáp, Pomáz, Pusztaberki, Rétság, Tarján, Vértesszőlős.

Description. Fragmented leaves, usually with basal part of lamina preserved. Base of leaf acute, margin entire. A pair of strong major secondary veins suprabasal imperfect. Minor secondaries arise from the major veins towards leaf margin.

Discussion. The venation type, the pair of suprabasal major secondary veins and higher order venation, the acute leaf basis, and leaf texture suggest that leaves belong to *Daphnogene*. Due to the leathery, coriaceous texture of the leaves, *Daphnogene* has a higher chance to get fossilizied even in coarse-grained sediments with high carbonate content than other taxa developing thin leaves (Hably and Szakmány, 2006).

Laurophyllum Göpp.

Laurophyllum sp. div. (foliage)

Fig. 7.1–7.5

1952 *Magnolia* cf. *inglefieldii* Heer; Vitális and Zilahy, p. 163.
1952 *Anonaphyllum* sp.; Vitális and Zilahy, p. 164, pl. 21, fig. 4.
1988 *Laurophyllum* sp.; Hably, p. 39, pl. 6, fig. 4.
1989 cf. *Quercus apocynophyllum* Ettingsh.; Hably, p. 88, text.-figs 47, 57.
1989 incertae sedis type I.; Hably, p. 89, text.-figs 59, 61–64, pl. 3, fig. 2.
1990 *Laurophyllum* sp. I.; Hably, p. 13, pl. 5, fig. 1, text.-fig. 40.
1990 *Laurophyllum* sp. II.; Hably, p. 13, pl. 22, fig. 1, pl. 23, figs 2–4, text.-figs 41–43, 46, 47.
1990 *Laurophyllum* sp. III.; Hably, p. 13, pl. 21, fig. 4, text.-figs 44, 45.
1990 *Laurophyllum* sp. IV.; Hably, p. 14, pl. 24, fig. 1, pl. 25, fig. 1, text.-figs 48–52.
1990 *Laurophyllum* cf. *acutimontanum* Mai; Hably, p. 14, pl. 12, fig. 4.
1991 *Laurophyllum* div. sp.; Kvaček and Hably, p. 54, pl. 3, fig. 3.
1993a *Magnolia* cf. *dianae* Unger; Hably, p. 6, pl. 1, fig. 4.
1993a *Laurophyllum acutimontanum* Mai; Hably, p. 9.
1993a *Laurophyllum* sp.; Hably, p. 10.
1993a "*Laurus*" *princeps* Heer; Hably, p. 10.
1993a *Laurus* sp.; Hably, p. 10.
1994 cf. *Magnolia mirabilis* Kolakovski; Hably, p. 9, pl. 23, fig. 4, text.-fig. 41.
1994 cf. *Litsea ipolytarnocense* Hably; Hably, p. 14, pl. 23, fig. 2.
1994 *Laurus princeps* Heer; Hably, p. 14, pl. 5, fig. 2.
1994 *Laurophyllum* sp.; Hably, p. 16.
1994 "*Rhamnus*" *warthae* Heer; Hably, p. 30, pl. 6, figs 1, 2, text.-figs 42, 43.
2017 Lauraceae gen. et sp. indet; Hably et al., p. 307.

Material. Andornaktálya, Csörög, Eger Wind-brickyard (upper flora), Eger Wind-brickyard (lower flora), Kesztölc, Leányfalu, Nagysáp, Pomáz, Rétság, Vértesszőlős.

Description. Leaves elliptic to lanceolate. Apex acute, base acute to rounded. Margin entire. Midvein strong, major secondaries brochidodromous. Secondaries form irregular loops close to margin. Tertiary veins percurrent mixed (both alternate and opposite).

Discussion. Since fossil leaves of the Hungarian late Oligocene localities are preserved exclusively as impressions, cuticles are not available. These leaves were identified based on macroscopic characters. Besides *Daphnogene*, this taxon also occurs in high numbers at nearly all the studied localities. Leaves of *Laurophyllum* were identified under various names in earlier literature, e.g. *Magnolia* cf. *inglefieldi* Heer and *Anonaphyllum* from Csörög (Vitális and Zilahy, 1952; the leaves of the former fossil-species were not figured in the paper but the specimens are stored in the collection).

RANUNCULALES
Juss. ex Bercht. et J.Presl

BERBERIDACEAE Juss.

Berberis L.

Berberis andreanszkyi Kvaček et Erdei (foliage)

Fig. 7.6, 7.7

1966 *Lomatites aquensis* Saporta; Andreánszky, p. 36, fig. 21.
2001 *Berberis andreanszkyi* Kvaček et Erdei; Kvaček and Erdei, p. 2, figs 2 c–f.

Material. Eger Wind-brickyard (upper flora).

Description. Leaves incomplete, lanceolate, abruptly acuminate. Base not preserved. Width of lamina 10–13 mm. Margin widely simple toothed. Teeth blunt, minute, triangular. Venation semicraspedodromous, midvein straight, thick, secondaries wide apart, under 40–60°, looping along the margin and forming a nearly continuous intramarginal vein. Side veinlets from the loops steep, entering the teeth. Intersecondary and tertiary veins sinuous and irregular between the midvein and the intramarginal vein, form almost isometric meshes.

Discussion. These fossil leaves were first described as *Lomatites aquensis* Saporta (Cziffery-Szilágyi, 1955). Many modern species of *Berberis* from East Asia, mainly of sect. *Wallichianae* Schneider, e.g. *B. soulieana* Schneider, *B. triacanthophora* Fedde, *B. veitchii* C.K.Schneid., and *B. gagnepainii* C.K.Schneid. (Kvaček and Erdei, 2001: fig. 3 b–e) match in leaf forms. The first occurrence of the fossil-species in the Hungarian fossil record was documented in the flora of the Wind-brickyard. Later it appeared in the Karpatian (late Early Miocene) flora of Magyaregregy (Hably, 2020) and in the Sarmatian (late Middle Miocene) flora of Erdőbénye (Kvaček and Erdei, 2001).

PROTEALES Juss. ex Bercht. et J.Presl

PLATANACEAE T.Lestib.

Platanus L.

Platanus neptuni
(Ettingsh.) Bůžek, Holý et Kvaček (foliage)

Figs 7.8, 8.1, 8.2, 8.5, 8.7, 8.8, 9.1

1957 *Cunonia oligocaenica* Andr. et E.Novák; Andreánszky and Novák, p. 47, pl. 2, fig. 5.
1966 *Quercus leganyii* Andr. et Kovács; Andreánszky, p. 52, text.-figs 36, 37.
1966 *Pterocarya denticulata* (C.O.Weber) Heer; Andreánszky, p. 70.
1966 *Myrica matheronii* Saporta; Andreánszky, p. 72, fig. 56.
1966 *Cunonia oligocaenica* Andr. et E.Novák; Andreánszky, p. 86, text.-fig. 77.
1980 *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček; Hably, p. 300, pl. 1, figs 1–8, pl. 2, figs 1, 2, pl. 5, figs 2, 4–6.
1988 *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček; Hably, p. 39, pl. 6, fig. 5, pl. 7, figs 1–5, pl. 10, fig. 4.
1990 *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček; Hably, p. 15, pl. 13, figs 1–3, pl. 14, figs 1–3, pl. 15, figs 1–3, pl. 16, figs 1–3, pl. 17, figs 1, 2, pl. 18, fig.1, text.-figs 53–82.
1993a *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček; Hably, p. 10, pl. 2, fig. 1.
1994 *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček; Hably, p. 16, pl. 6, figs 3–6.
2017 *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček; Hably et al., p. 309, figs. 6(5, 6).

Material. Andornaktálya, Csörög, Eger Wind-brickyard (upper flora), Eger Wind-brickyard (lower flora), Kesztölc, Leányfalu, Nagysáp, Pomáz, Pusztaberki, Rétság, Tarján, Verőcemaros, Vértesszőlős.

Description. Simple leaves, frequently with petiole preserved. Shape of lamina ovate, generally elongated ovate. Lamina length up to 14 cm, width up to 5.4 cm. Base and apex acute. Margin serrate at the upper third of lamina, but generally entire at the lower third of lamina. Teeth small. Apex of teeth obtuse. Apical side of teeth straight or concave, basal side almost parallel to the margin of the leaf. Sinuses rounded. Venation semicraspedodromous. Midvein strong, secondaries arise at 60–80°, more or less regularly forming loops near the margin. Intersecondaries arise frequently between secondaries, run parallel to secondaries. Tertiary veins irregular reticulate.

Discussion. The fossil-species was a characteristic element of most late Oligocene floras in Hungary. Its specimens were first recorded in the early Oligocene Tard Clay floras, already in high numbers both from the localities in the Budapest region and Eger-Kiseged in eastern Hungary (Hably, 1985c). In the Wind-brickyard flora it was documented both from the lower and upper floras. Earlier studies on the Csörög flora did not mention the fossil-species (Andreánszky, 1952; Vitális and Zilahy, 1952), but it has been corroborated during a revision of the collections. Based on collection material the fossil-species has been identified in the unpublished floras of Leányfalu, Rétság, and Pusztaberki, although sediments are considerably coarse-grained, especially in the latter two localities making recognition of diagnostic leaf traits difficult.

The fossil-species was a warm-temperate to subtropical element of late Eocene to Late Miocene floras of Europe. *Platanus neptuni* was common in mesic, humid subtropical forests on volcanogenic substrates but also occurred in floras showing no signs of volcanic influence (Kovar-Eder, 1982; Kvaček and Manchester, 2004). A dominant occurrence of the fossil-species was reported from the Oligocene flora of Rauenberg, from non-volcanic palaeoenvironment (Kovar-Eder, 2016).

Platanus neptuni (Ettingsh.) Bůžek, Holý et Kvaček forma ***fraxinifolia*** (Johnson et Gilmore) Kvaček et Manchester (foliage)

Figs 7.9, 8.3, 8.4, 8.6, 8.9, 8.10

1982 *Incertae sedis*; Hably, p. 96, pl. 3, fig. 4, pl. 12, fig. 4.
1988 *Platanus fraxinifolia* (T.Johnson et J.G.Gilmore) Walther; Hably, p. 40, pl. 8, figs 1, 2, 4, pl. 7, fig. 3.
1989 *Platanus fraxinifolia* (T.Johnson et J.G.Gilmore) Walther; Hably, p. 87, text.-fig. 46, pl. 3, fig. 6, pl. 4, figs 5, 6.
1994 *Platanus fraxinifolia* (T.Johnson et J.G.Gilmore) Walther; Hably, p. 17, pl. 7, figs 1–5, pl. 8, figs 1–4, pl. 9, fig. 4, text.-fig. 27.

Material. Eger Wind-brickyard (upper flora), Kesztölc, Nagysáp, Pomáz, Verőcemaros.

Description. Leaves compound, trifoliate. Length of leaflets 3.5–8.5 cm, width 0.6–2.0 cm. Apex and base acute, base slightly asymmetrical. Shape of lamina lanceolate. Margin serrate, especially in the upper part of lamina, the lower part entire. Teeth small, sharp, frequent, and

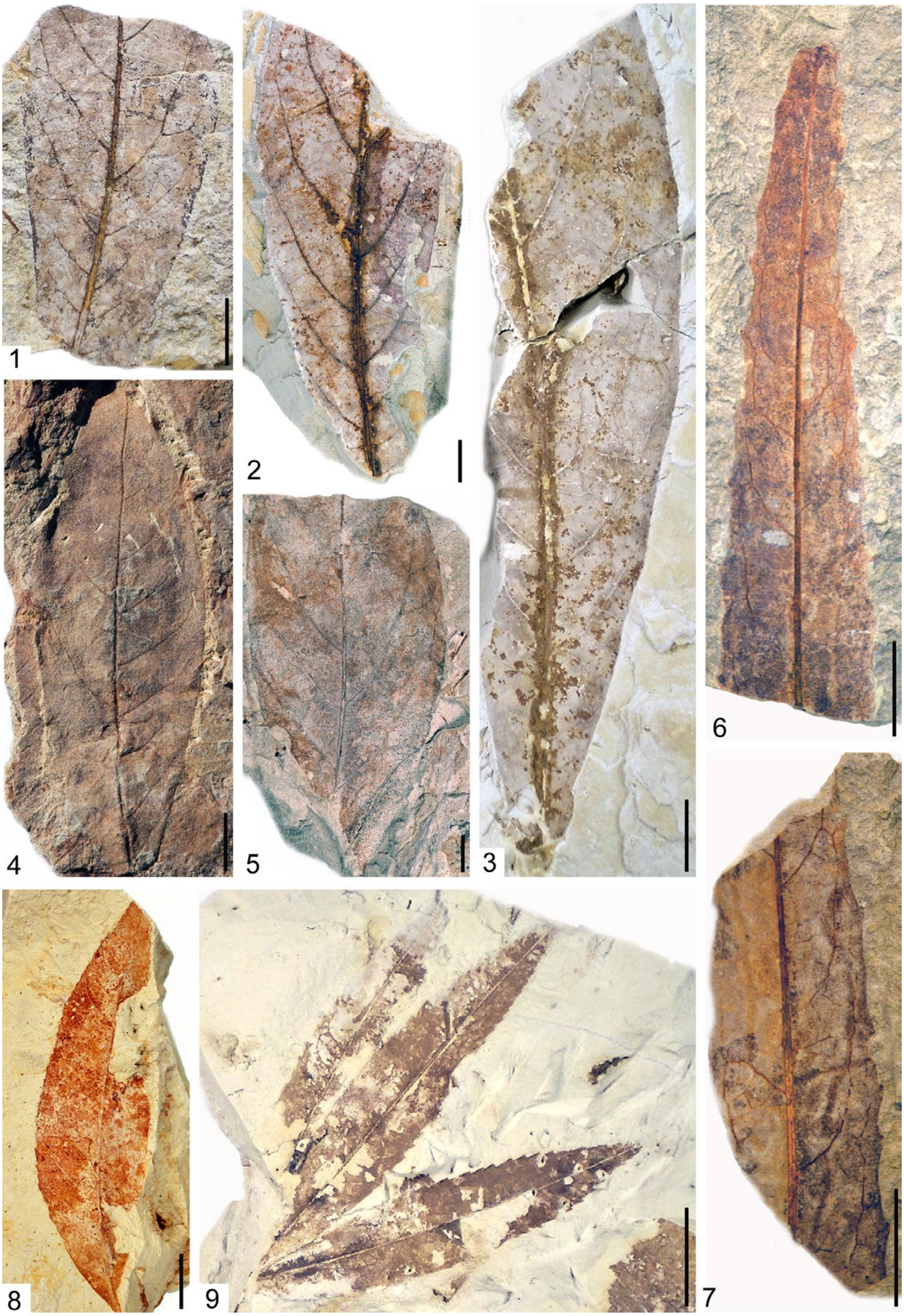

Figure 7. **1–5**. *Laurophyllum* sp., **1**. Leányfalu, HNHM-PBO 86.735.1., **2**. Pomáz, HNHM-PBO 86.373.2., **3**. Pomáz, HNHM-PBO 86.373.2., **4**. Vértesszőlős, Tata 76.107.1., **5**. Pomáz, HNHM-PBO 86.372.1.; **6**, **7**. *Berberis andreánszkyi* Kvaček et Erdei, Eger Wind-brickyard (upper flora), **6**. HNHM-PBO 67.249.1., **7**. HNHM-PBO 70.115.1.; **8**. *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček, Pomáz, HNHM-PBO 86.125.2.; **9**. *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček forma *fraxinifolia* (Johnson et Gilmore) Kvaček et Manchester, Pomáz, HNHM-PBO 86.115.2. Scale bars = 1 cm

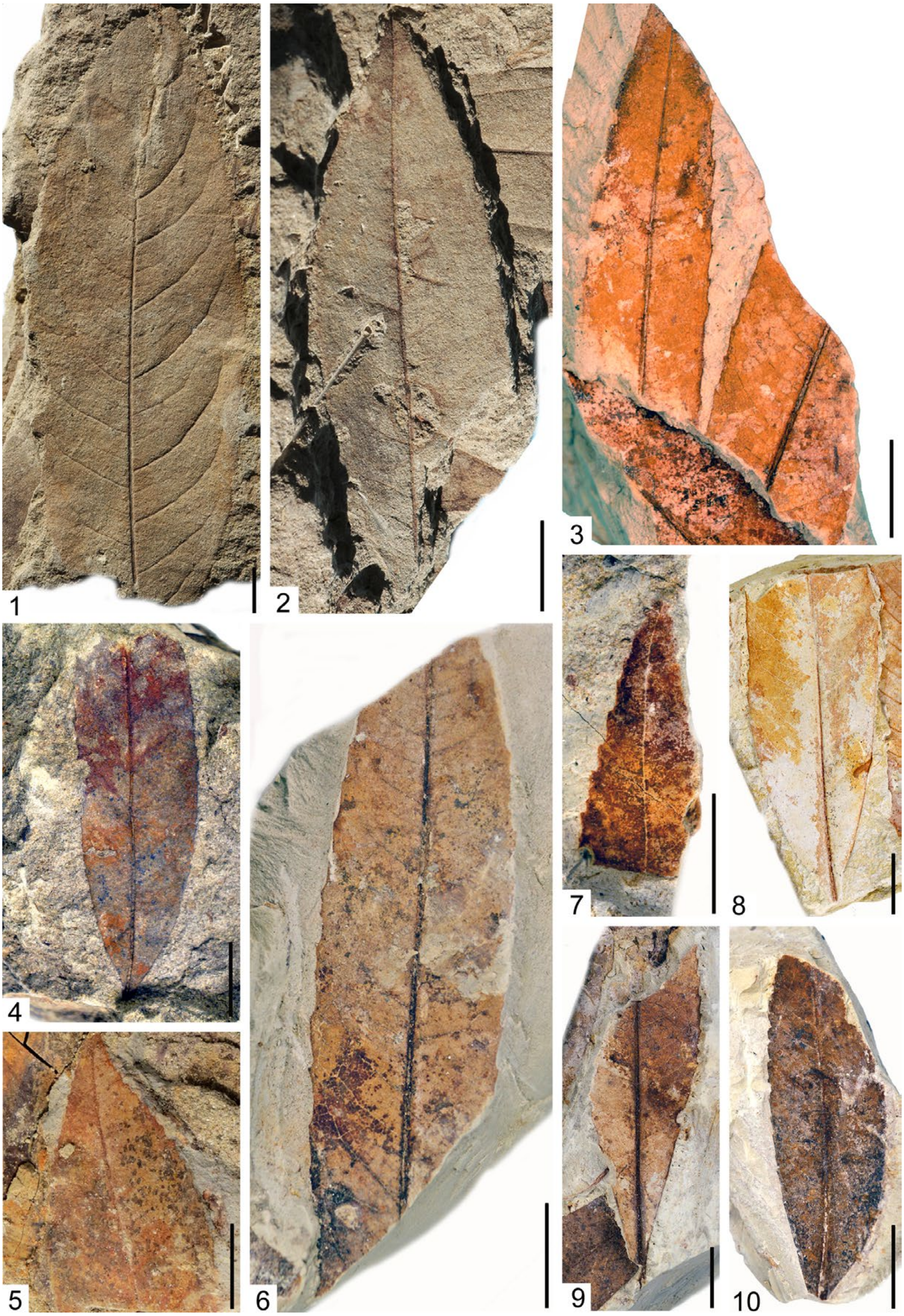

Figure 8. **1**, **2**, **5**, **7**, **8**. *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček, **1**. Vértesszőlős, Tata 76.300.1., **2**. Vértesszőlős, Tata 76.108.1., **5**. Tarján, HNHM-PBO 2014.285.1., **7**. Leányfalu, HNHM-PBO 86.733.1., **8**. Pomáz, HNHM-PBO 86.3.1.; **3**. *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček forma *fraxinifolia* (Johnson et Gilmore) Kvaček et Manchester, Pomáz, HNHM-PBO 86.116.1.; **4**, **6**, **9**, **10**. *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček ?forma *fraxinifolia* (Johnson et Gilmore) Kvaček et Manchester, Pomáz, **4**. HNHM-PBO 86.124.1., **6**. HNHM-PBO 86.129.1., **9**. HNHM-PBO 86.43.1., **10**. HNHM-PBO 86.124.1. Scale bars = 1 cm

regular. Apex of teeth acute, sinuses rounded. Venation semicraspedodromous. Midvein strong, secondaries thin, arise at 60–80°, forming loops near the margin. Intersecondaries arise frequently, run parallel to secondaries. Tertiary veins irregular reticulate.

Discussion. The fossil-species *Platanus fraxinifolia* (Mai and Walther, 1985a) with its trifoliate leaves was synonymized in the fossil-species *Platanus neptuni* as its morphoform (Kvaček and Manchester, 2004). The record of the simple and trifoliate leaves of the fossil-species co-occurring at several Hungarian sites contributes with further evidence to Kvacek and Manchester's theory. (In addition, the trifoliate form occurs only in sites providing the simple form as well). Interestingly, leaves of *Platanus neptuni* are quite common in both the early Oligocene Tard Clay flora and the Early Miocene Ipolytarnóc, but only with simple leaves, the trifoliate form is unknown from these localities.

Numerous leaves comparable to the trifoliate form turned up from the locality Verőcemaros and were described as ?*Debeya hungarica* Hably (Hably, 1982). Contrary to the assumption of Kvaček and Manchester (2004), however, these are not identical with *P. neptuni* forma *fraxinifolia*. The leaves of ?*Debeya hungarica* differ from the leaves of *P. neptuni* forma *fraxinifolia* in having shortly fused lobes at the base and in having entire leaf margin. Leaves of *P. neptuni* forma *fraxinifolia* have always teeth on the margin, though sometimes only at the apical part as it is observable in the simple leaves of *P. neptuni*. Leaves of *P. neptuni* forma *fraxinifolia* are also present in the flora of Verőcemaros, described earlier as "plantae incertae sedis" (Hably, 1982). A mass occurrence of the fossil-species was reported from an Oligocene leaf flora in Serbia (Djordjević-Milutinović and Dulić, 2009).

TROCHODENDRALES Takht. ex Cronquist

TROCHODENDRACEAE Eichler

Tetracentron Oliv.

Tetracentron agriense
(Andr.) Kvaček et Hably (foliage)

Fig. 9.2–9.7

1962 *Acer agriense* Andr.; Andreánszky, p. 230, pl. 3, fig. 3, text.-fig. 7.

1991 *Tetracentron agriense* (Andr.) Kvaček et Hably; Kvaček and Hably, p. 55, pl. 4, figs 1–4.

Material. Eger Wind-brickyard (upper flora).

Description. Leaves petiolate, shape of lamina orbiculate. Fragmentary length 8–12 cm, width 3.5–6 cm. Size of entire leaf presumably much larger. Base slightly cordate or rounded. Petiole fragmentary, 3.3 cm long. Margin simply coarsely crenulate, teeth glandular, blunt, sinuses mostly angular, rarely rounded. Venation palmate, secondaries semicraspedodromous. Basal primaries 5–7, secondaries steep (the angle of divergence 20–30°), forming loops along the margin. Side veins arising from secondaries form another row of small loops, from which small veinlets enter the teeth. Tertiary veins dense, mostly percurrent, arranged spidernet-like.

Discussion. The leaves may resemble species in Malvales, however, the glandular teeth do not support an affinity. The marginal venation and the character of the teeth are comparable to those in Trochodendraceae, i.e. *Tetracentron* (Kvaček and Hably, 1991). The fossil-species occurs only in the upper flora of the Wind-brickyard as a rare element.

OXALIDALES Bercht. et J.Presl

ELAEOCARPACEAE Juss.

Sloanea L.

***Sloanea* sp.** (fruit)

Fig. 9.8

1990 cf. Fructus; Hably, p. 40, pl. 31, fig. 3.

Material. Vértesszőlős.

Description. Spherical valved capsule, slightly elongated and partly undehisced, with a husk (pericarp) covered by closely spaced, long bristles. Capsule length 1.3 cm, width 0.8 cm, the maximum length of bristles 0.6 cm.

Discussion. The genus *Sloanea* is represented by a single fruit fossil, but no leaves in the late Oligocene floras. The scarce fossil record of *Sloanea* fruits includes *S. eocenica* (Rásky) Kvaček, Hably et Manchester described from the lower Oligocene Tard Clay Formation in Hungary (Kvaček et al., 2001a). Fruit remains were also mentioned as *Sloanea*

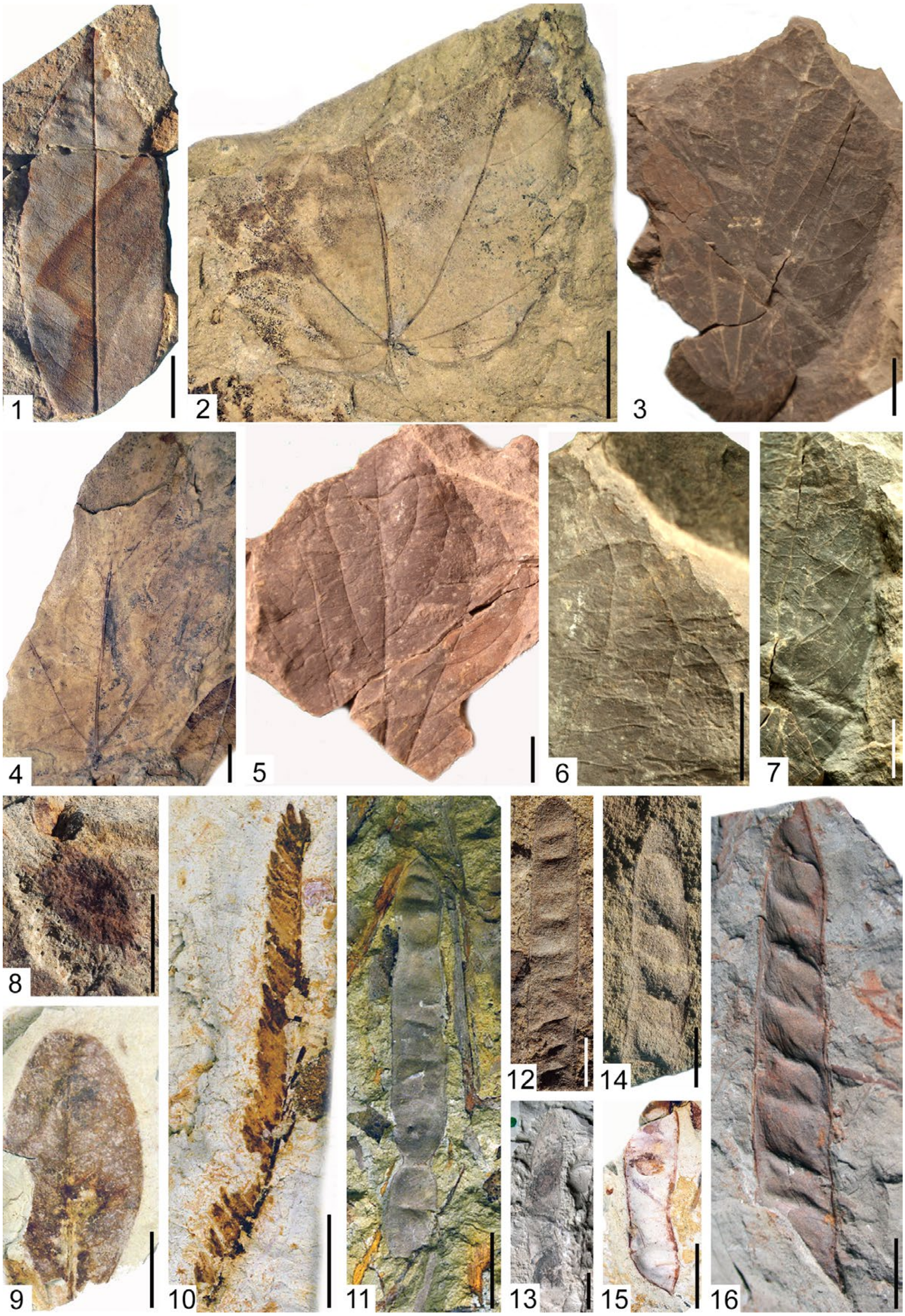

Figure 9. 1. *Platanus neptuni* (Ettingsh.) Bůžek, Holý et Kvaček, Verőcemaros, HNHM-PBO 79.10.1.; **2–7**. *Tetracentron agriense* (Andr.) Kvaček et Hably, Eger Wind-brickyard (upper flora), **2**. HNHM-PBO 2007.670.1., **3**. MM 78.11.2., **4**. HNHM-PBO 2007.669.1., **5**. MM 78.11.2., **6**. MM 78.11.2., **7**. MM 78.11.2.; **8**. *Sloanea* sp., Vértesszőlős, Tata 76.109.1., fruit; **9**. *Leguminophyllum* sp., Pomáz, HNHM-PBO-86.333.1.; **10**. "*Acacia*" *parschlugiana* Unger, Pomáz, HNHM-PBO 86.328.2.; **11–16**. *Leguminocarpon* sp., **11**. Eger Wind-brickyard (upper flora), HNHM-PBO 2001.463.1., **12**. Eger Wind-brickyard (upper flora), HNHM-PBO 2001.463.1., **13**. Vértesszőlős, Tata 76.314.1., **14**. Vértesszőlős, Tata 76.227.2., **15**. Pomáz, HNHM-PBO 86.56.2., **16**. Eger Wind-brickyard (upper flora), HNHM-PBO 90.63.1. Scale bars = 1 cm

sp. from the Eocene flora of Csordakút (Erdei and Rákosi, 2009). Fruit capsules of *S. eocenica* have recently been recorded from the Oligocene flora of the Petroşany Basin (Romania, Pirnea et al., 2022). Fruits were also reported as *Sloanea* sp. from the late Oligocene floras of Markvartice, Suletice-Berand, Holý Kluk (Czech Republic, Kvaček et al., 2001a), and Rott (Germany, Kvaček et al., 2001a). Leaf remains assigned to *Sloanea* have been reported from Eocene, early and middle Oligocene localities in Germany, Italy, the Czech Republic, Slovenia, and Hungary (Hably, 2007; Erdei and Rákosi, 2009; Kunzmann et al., 2019).

FABALES
Bromhead

FABACEAE Lindl.

"Acacia" parschlugiana Unger (foliage)

Fig. 9.10

1994 "*Acacia*" *parschlugiana* Unger; Hably, p. 23, pl. 19, fig. 6.

Material. Pomáz.

Description. Leaves pinnate, with 26–32 pairs of leaflets. Length of leaf 5 cm. Length of leaflets 0.4–0.45 cm, width 0.08–0.1 cm. Leaflet apex acute, base asymmetrical, rounded, margin entire. Venation of leaflets not preserved.

Discussion. This leaf form is rare, occurring only in the flora of Pomáz. Co-occurring pods have also been recorded, however, in the lack of organic connection, their systematic relation cannot be proved. *Acacia parschlugiana* was first described from the Miocene flora of Parschlug (Unger, 1864; Kovar-Eder et al., 2004). It rarely occurs in the European floras. In Hungary, an additional record was documented from the late Early Miocene (Karpatian) flora of Magyaregregy (Hably, 2020).

"Colutea" kvacekii Hably (foliage)

Fig. 10.2

1994 "*Colutea*" *kvacekii* Hably; Hably, p. 25, pl. 19, figs 3–5, 7, 8, text.-fig. 29.

Material. Pomáz.

Description. Leaves (leaflets?) shortly petiolate. Length of lamina 1.8–4.1 cm, width 1.0–2.5 cm. Shape of lamina obovate. Apex rounded, very rarely retuse. Base decurrent. Margin entire. Venation camptodromous. Secondary veins widely spaced, depart at 70–80°. Tertiary venation not preserved.

Discussion. The leaves (leaflets) recall fossil leaves described by Heer as fossil-species of *Colutea* L., e.g. *C. macrophylla* Heer (Heer, 1859: Pl. 132, figs 43–46, non 46 b), *C. salteri* Heer (Heer, 1859: Pl. 132, figs 47–57), and *C. antiqua* Heer (Heer, 1859: Pl. 132, figs 60–61). Due to poor preservation, however, the systematic affinity of the leaves is uncertain – they probably belong to the Fabaceae family.

"Cassia" aff. hyperborea Unger (foliage)

Fig. 10.1

1994 *Cassia* aff. *hyperborea* Unger; Hably, p. 22, pl. 10, fig. 3.

Material. Pomáz.

Description. Leaf(let?) 3.4 cm long, 1.1 cm wide. Shape ovate, apex acute, base obtuse, margin entire. Midvein strong, secondaries thin. Secondaries arise at 50–60°, curve toward apex close to margin, run parallel with margin.

Discussion. It is a rare element in the flora of Pomáz. A similar fossil turned up from the Miocene flora of Ipolytarnóc in Hungary (Hably, 1985a). Knobloch (1969) reported it from the Miocene flora of Znojmo (Moravia, Czech Republic).

Leguminophyllum Escalup-Bassi

***Leguminophyllum* sp.** (foliage)

Fig. 9.9

1952 *Rhamnus rossmaessleri* Unger; Vitális and Zilahy, p. 168, pl. 21, fig. 7.
1989 *Cassia* sp.; Hably, p. 89.
1990 *Leguminosae* I.; Hably, p. 31, pl. 28, fig. 2.
1990 *Leguminosae* II.; Hably, p. 31, text.-fig. 112.
1990 cf. *Wisteria* aff. *fallax* (Nath.) Tanai et Onoe; Hably, p. 32, pl. 29, figs 3, 4, text.-fig. 114.
1991 *Leguminosites* sp. div.; Kvaček and Hably, p. 61.
1994 "*Dalbergia*" *bella* Heer; Hably, p. 24, pl. 20, fig. 1.
1994 "*Robinia regelii*" Heer; Hably, p. 24, pl. 19, fig. 2.
1994 *Wisteria* aff. *fallax* (Nath.) Tanai et Onoe; Hably, p. 24, pl. 15, figs 2–4.

Material. Eger Wind-brickyard (upper flora), Eger Wind-brickyard (lower flora), Máriahalom, Nagysáp, Pomáz, Vértesszőlős.

Description. Leaflets of variable shape and dimension, from narrow elliptic to ovate acuminate. Length up to 6 cm. Venation dense brochidodromous, fine and not always visible.

Discussion. Leaflets representing the Fabaceae family turned up in many late Oligocene localities, among them the highest number of specimens were documented from the Wind-brickyard. The leaflets show diverse morphology and co-occur with pods in nearly all sites. Their specific differentiation would be a difficult task. Leaflets of legumes are frequent members of the Paleogene and Neogene floras of Hungary, e.g. the floras of the Lower Oligocene Tard Clay (Hably and Erdei, 2015). The late Early Miocene flora of Magyaregregy is especially abundant in legume leaflets (Hably, 2020).

Leguminocarpon Givul.

***Leguminocarpon* sp. div.** (fruit)

Fig. 9.11–9.16

1951 *Leguminocarpon regelii* Heer; Pálfalvy, p. 68.
1951 *Leguminocarpon egerense* Pálfalvy; Pálfalvy, p. 69, pl. 1, fig. 3.
1951 *Leguminocarpon legányii* Pálfalvy; Pálfalvy, p. 69, pl. 1, fig. 7.
1951 *Leguminocarpon rectissimum* Pálfalvy; Pálfalvy, p. 70, pl. 1, fig. 1.
1962 *Leguminocarpon machaerioides* Andr.; Andreánszky, p. 227, text.-fig. 5.
1988 *Leguminocarpon* div. sp.; Hably, p. 44, pl. 10, figs 2, 3.
1990 "*Acacia*" *parschlugiana* Unger; Hably, p. 32, pl. 27, fig. 3, pl. 28, fig. 3, pl. 30, figs 1, 2.
1991 *Leguminocarpon* sp. div.; Kvaček and Hably, p. 61, pl. 10, figs 1–3.
1992d *Leguminocarpon* type I.; Hably, p. 170, pl. 2, figs 1–4.
1993a *Leguminocarpon* sp.; Hably, p. 14.
1994 *Leguminocarpon* sp.; Hably, p. 23, pl. 20, figs 2–9, pl. 21, figs 1–5.

Material. Andornaktálya, Eger Wind-brickyard (upper flora), Kesztölc, Pomáz, Vértesszőlős.

Description. Size and shape of legume pods variable. Length of pods up to 12 cm, width ranges between 0.6–2.2 cm. Apex attenuate to acute, base acute or missing. Occasional infolding of margin. At some pods distinct elongated reticulate venation preserved. Seed number variable, from 2 up to 9(<).

Discussion. The legume pods listed here are mostly fragmented (e.g. Pl. 8, figs 12, 16) and bear no diagnostic character allowing proper identification at the genus level. The min. and max. number of seeds may be more than 2 and 9, respectively.

Legume pods are frequent elements of the Oligocene floras of Hungary. Although they were relatively rare in the early Oligocene flora of the Tard Clay, in the late early Oligocene (Kiscellian) they became more frequent, e.g. the flora of Oroszlány (Selmeczi and Hably, 2009). The arboreal legumes may have been widespread close to the upper boundary of the early Oligocene (early Kiscellian). During the younger Egerian, legumes have probably belonged to the arboreal associations. One type of legume pod (having several seeds) still occurred during the late Early Miocene (Karpatian) (Hably, 2020). The one-seeded pod of *Podocarpium podocarpum* (A.Braun) Herendeen gained high role, even dominance in the younger Middle Miocene (regional stratigraphy: Sarmatian) floras, coupled with the absence of several-seeded pods.

ROSALES Bercht. et J.Presl

ROSACEAE Juss.

Rosa L.

Rosa lignitum Heer (foliage)

Fig. 10.3, 10.4

1990 *Rosa lignitum* Heer; Hably, p. 33, pl. 29, fig. 3.
1991 *Rosa lignitum* Heer; Kvaček and Hably, p. 60, pl. 9, fig. 3.
1994 *Rosa lignitum* Heer; Hably, p. 18, pl. 23, fig. 7.

Material. Eger Wind-brickyard (upper flora), Pomáz, Vértesszőlős.

Description. Length of leaflets up to 0.9 cm, width 0.5 cm. Shape of leaflets ovate, apex acute, base slightly asymmetrical, rounded. Margin finely serrate. Teeth small, generally sharp. Apex of teeth acute, sinuses acute. Dense secondaries arching towards the margin. Major secondary venation semicraspedodromous. Higher order venation not preserved.

Discussion. At Vértesszőlős a compound leaf with three apical leaflets, at the other localities only single leaflets were found. *Rosa lignitum* as a rare element probably occupied wetland

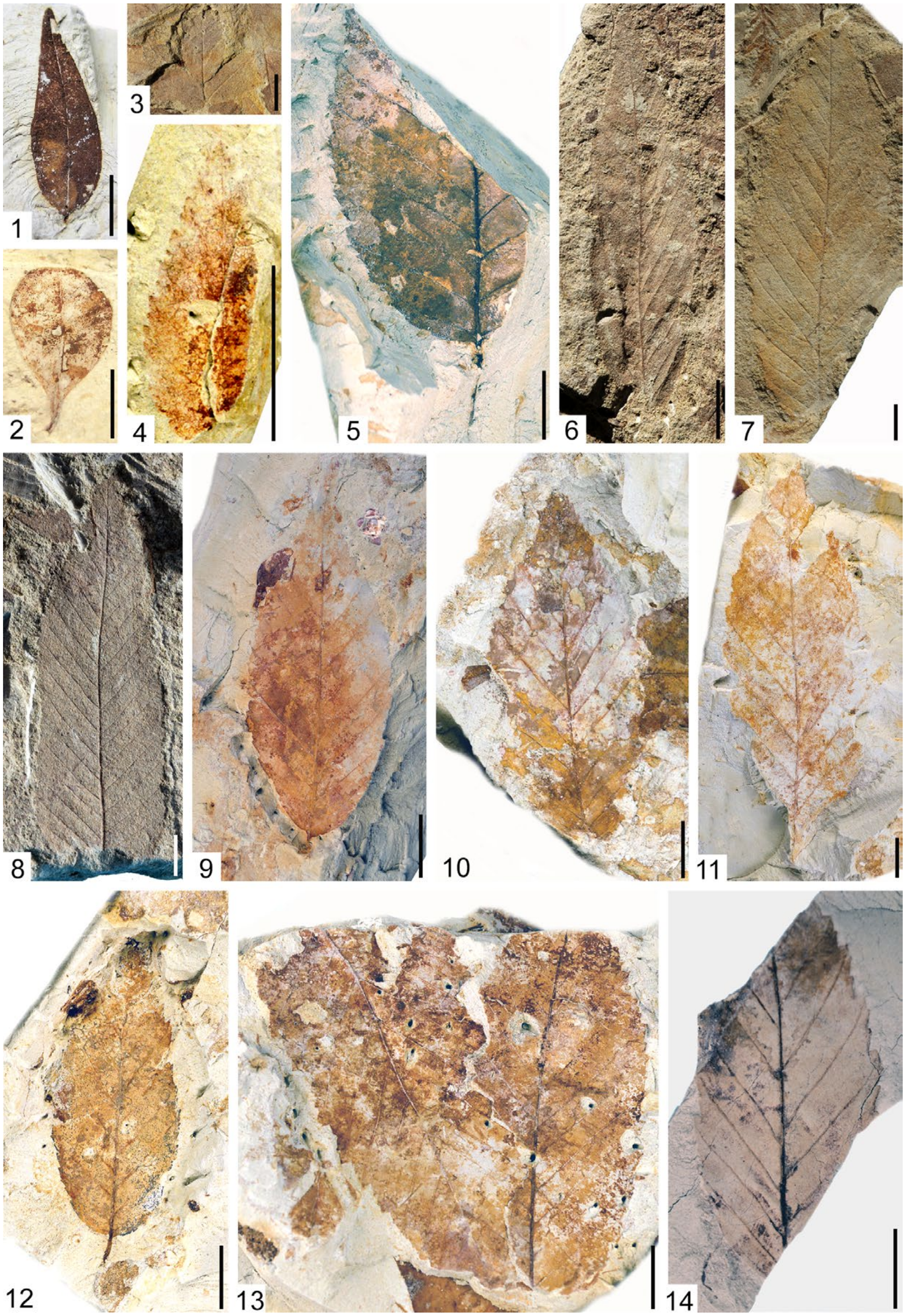

Figure 10. **1**. "*Cassia*" aff. *hyperborea* Unger, Pomáz, HNHM-PBO 86.429.1.; **2**. "*Colutea*" *kvacekii* Hably, Pomáz, HNHM-PBO 86.331.2.; **3**, **4**. *Rosa lignitum* Heer, **3**. Vértesszőlős, Tata 76.116.1., **4**. Pomáz, HNHM-PBO 86.466.1.; **5–14**. *Ulmus pyramidalis* Göpp., **5**. Pomáz, HNHM-PBO 85.598.1., **6**. Vértesszőlős, Tata 76.137.1., **7**. Vértesszőlős, Tata 76.1.1., **8**. Vértesszőlős, Tata 76.193.1., **9**. Pomáz, HNHM-PBO 85.579.1., **10**. Pomáz, HNHM-PBO 85.580.2., **11**. Pomáz, HNHM-PBO 85.565.2., **12**. Pomáz, HNHM-PBO 86.3.2., **13**. Pomáz, HNHM-PBO 85.584.3., **14**. Pomáz, HNHM-PBO 86.4.1. Scale bars = 1 cm

habitats. The genus has been recorded in the Hungarian floras up to the Pliocene (Hably and Kvaček, 1997) mostly as a rare element. Nevertheless, the fossil-species was a widespread element of the Paleogene and Neogene floras in Europe, probably representing more than one natural species. Based on comparative leaf architecture analyses, a potential relation of the fossil-species to some Southeast Asian species is assumed (Kellner et al., 2012). Many modern members of the genus are thermophilous, and thrive on forest margins and slopes.

ULMACEAE Mirb.

Ulmus L.

Ulmus pyramidalis Göpp. (foliage)

Fig. 10.5–10.14

1952 *Carpinus grandis* Unger; Vitális and Zilahy, p. 166.
1952 *Ulmus plurinervia* Unger; Vitális and Zilahy, p. 166.
1966 *Carpinus grandis* Unger; Andreánszky, p. 42, figs 28–30.
1966 *Castanopsis* sp. I.; Andreánszky, p. 47, fig. 31.
1988 *Ulmus pyramidalis* Göpp.; Hably, p. 41, pl. 9, figs 2, 3.
1989 *Ulmus pyramidalis* Göpp.; Hably, p. 88, pl. 4, figs 4a–b, text.-figs 54a–b.
1990 *Ulmus pyramidalis* Göpp.; Hably, p. 18, pl. 17, figs 3, 4, pl. 18, figs 2, 3, pl. 19, figs 1–3, pl. 20, figs 1, 2, pl. 21, fig. 1, text.-figs 84, 87–93, 110.
1990 *Ulmus plurinervia* Unger; Hably, p. 24, pl. 20, fig. 3.
1990 cf. *Betula prisca* Ettingsh.; Hably, p. 27, pl. 24, fig. 3, text.-figs 94–98.
1991 *Ulmus pyramidalis* Göpp.; Kvaček and Hably, p. 56, pl. 5, fig. 1.
1993a *Ulmus pyramidalis* Göpp.; Hably, p. 13, pl. 2, fig. 3.
1993a *Carpinus* sp.; Hably, p. 14, pl. 1, fig. 3.
1994 *Ulmus pyramidalis* Göpp.; Hably, p. 27, pl. 11, figs 3–6, pl. 12, figs 1–4, pl. 13, figs 1–4, pl. 14, figs 1–4, pl. 15, fig. 1, text.-figs 33, 34, 38–40.
2017 *Ulmus* cf. *pyramidalis* Göpp.; Hably et al., p. 310.

Material. Andornaktálya, Csörög, Eger Wind-brickyard (upper flora), Kesztölc, Leányfalu, Nagysáp, Pomáz, Pusztaberki, Tarján, Vértesszőlős.

Description. Leaves petiolate. Petiole length up to 0.5 cm. Length and width of lamina up to 11 cm and 3.8 cm, respectively. Shape of lamina narrow ovate to narrow elongate. Apex acute. Base obtuse, slightly asymmetrical, missing in many cases. Margin serrate, teeth compound. Apex of teeth acute. Venation craspedodromous. Secondaries arise at 30–60°, dense, straight, up to 16–20 pairs. Tertiaries percurrent alternate.

Discussion. The most widespread fossil-species of the genus occurring in nearly all localities of the Hungarian late Oligocene. The relative frequency of the fossil-species may be attributed to the fact that its leaves are relatively well preserved even in coarse-grained sediments (Hably and Szakmány, 2006). In the European fossil record it is also reported from younger, boreal floras, e.g. Wollbach (Kelber, 2020), Schrotzburg (Hantke, 1954), and Massenhausen (Jung, 1963).

Ulmus pseudopyramidalis
Kvaček et Hably (foliage)

Fig. 11.1–11.5

1966 *Ulmus* type II.; Andreánszky, p. 77, figs 62, 63.
1966 *Ulmus* type III.; Andreánszky, p. 78, figs 64, 65.
1991 *Ulmus pseudopyramidalis* Kvaček et Hably; Kvaček and Hably, p. 56, pl. 6, fig. 1.

Material. Eger Wind-brickyard (upper flora).

Description. Leaves asymmetrical. Petiole not preserved. Length of lamina 8–12 cm, width 2–4 cm. Shape of lamina oblong. Apex acuminate, base rounded to truncate, mostly markedly asymmetrical. Margin simple to finely double serrate. Teeth broad, mostly blunt, upper and lower sides slightly concave. Venation craspedodromous, midrib straight. Secondaries 2–20 pairs, depart at 40–90°, dense, mostly bent, rarely forked. Tertiary veins rarely preserved, dense, percurrent alternate.

Discussion. Andreánszky (1966) already mentioned that a high number of elm leaves different from *Ulmus pyramidalis* were present in the flora of the Wind-brickyard and mentioned these as *Ulmus* type II. It was described as a new fossil-species later by Kvaček and Hably (1991). Since it occurs only at one locality preserving the vegetation of swamp habitats, it may have been a swamp element contrary to *U. pyramidalis*. The latter fossil-species was widespread at nearly all localities representing also floodplains. The distribution and taphonomy of elms reported in the late Oligocene floras were also discussed by Hably and Zastawniak (2001).

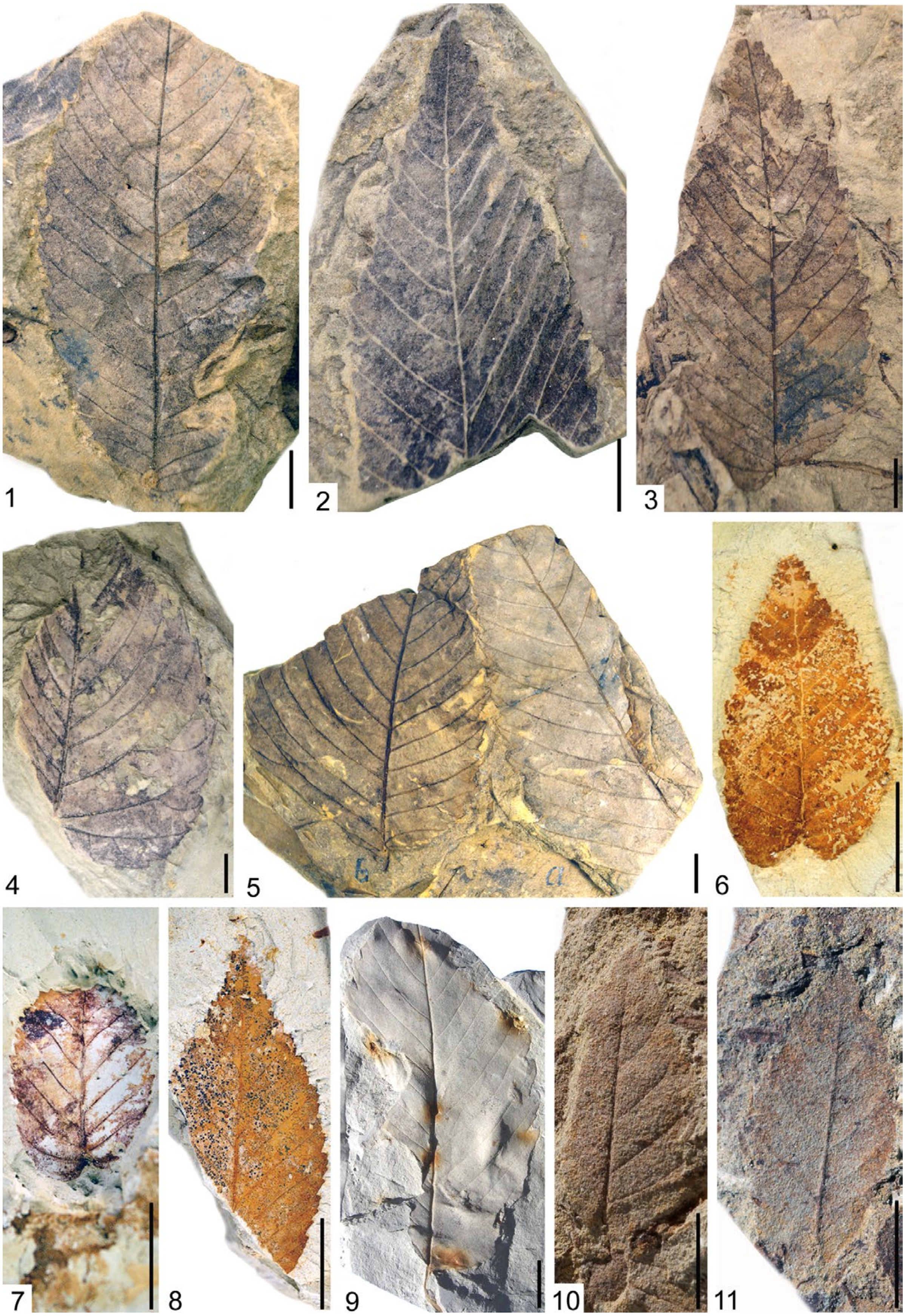

Figure 11. 1–5. *Ulmus pseudopyramidalis* Kvaček et Hably, Eger Wind-brickyard (upper flora), **1**. HNHM-PBO 2001.10.1., **2**. HNHM-PBO 2001.22.1., **3**. HNHM-PBO 2001.73.1., **4**. HNHM-PBO 2001.2.1., **5**. HNHM-PBO 2001.39.1.; **6–8**. *Ulmus braunii* Heer, Pomáz, **6**. HNHM-PBO 86.434.2., **7**. HNHM-PBO 86.420.2., **8**. HNHM-PBO 86.421.1.; **9**. *Ulmus* cf. *fischeri* Heer, Verőcemaros, HNHM-PBO 79.14.1.; **10**, **11**. ?*Zelkova zelkovifolia* (Unger) Bůžek et Kotl. in Kotl., Vértesszőlős, **10**. Tata 76.261.1.; 11. Tata 76.285.1. Scale bars = 1 cm

Ulmus* cf. *fischeri Heer (foliage)

Fig. 11.9

1966 *Ulmus* sp. type I.; Andreánszky, p. 77, figs 60, 61.
1982 *Ulmus* cf. *fischeri* Heer; Hably, p. 95, pl. 2, fig. 5, pl. 7, fig. 1.
1991 *Ulmus fischeri* Heer; Kvaček and Hably, p. 55, pl. 5, fig. 2.

Material. Eger Wind-brickyard (upper flora), Verőcemaros.

Description. Large leaves, length of fragmentary lamina more than 10 cm. Shape of lamina oval, asymmetrical. Apex ?acute, base missing, margin coarsely double serrate, in smaller specimens simply serrate. Venation craspedodromous.

Discussion. It differs markedly from other elm species of the late Oligocene floras. The fossil-species presumably thrived in wetlands.

Ulmus braunii Heer (foliage)

Fig. 11.6–11.8

1994 *Ulmus* cf. *minuta* Göpp. in Heer; Hably, p. 29, pl. 10, figs 4–6, pl. 11, figs 1, 2.

Material. Pomáz.

Description. Leaves small, length 2.2–4.3 cm, width 1.4–2.0 cm. Petiole not preserved. Shape of lamina ovate, apex acute, base cordate, slightly asymmetrical. Margin serrate. Teeth compound, with one main and two smaller teeth. Venation craspedodromous. Midvein strong, slightly zigzag. Secondaries 8–10 pairs, depart at 45–55°, mostly straight, end in tooth apices. Tertiary veins hardly visible, percurrent alternate. Thin veins branch out from secondaries near margin, end in second and third order teeth apices.

Discussion. It is a small-leaved fossil-species differing markedly from other elm species of the Hungarian late Oligocene floras. It was recorded only at one locality, Pomáz, however, similar leaves were mentioned from younger, Late Miocene (Pannonian) floras as well (Hably, 2013).

***Ulmus* sp.** (foliage)

1988 *Ulmus* sp.; Hably, p. 42.
1966 *Ulmus* type IV.; Andreánszky, p. 78, figs 66, 67.
1966 *Ulmus* type V.; Andreánszky, p. 79, figs 68, 69.
1991 *Ulmus* sp.; Kvaček and Hably, p. 56.

Material. Eger Wind-brickyard (upper flora), Kesztölc, Pusztaberki, Rétság.

Description. Small fragmented, asymmetrical leaves. Venation craspedodromous. Margin serrate, teeth compound.

Discussion. Numerous fragmented leaves show margin and venation character referable to *Ulmus* at the genus level (Andreánszky, 1966; Hably and Zastawniak, 2001).

Zelkova Spach

?Zelkova zelkovifolia
(Unger) Bůžek et Kotl. in Kotl. (foliage)

Fig. 11.10, 11.11

1988 *Zelkova zelkovifolia* (Unger) Bůžek et Kotl. in Kotl.; Hably, p. 42, pl. 9, fig. 4.
1990 *Zelkova zelkovifolia* (Unger) Bůžek et Kotl.; Hably, p. 25, pl. 20, fig. 4, pl. 21, figs 2, 3.
1991? *Zelkova zelkovifolia* (Unger) Bůžek et Kotl.; Kvaček and Hably, p. 56, pl. 5, fig. 3.

Material. Eger Wind-brickyard (upper flora), Kesztölc, Vértesszőlős.

Description. Fragmented leaves, petiole not preserved. Lamina length up to 8 cm, width 4.5 cm. Shape of lamina ovate, apex acute, base missing. Venation craspedodromous. Secondaries depart at 50–60°, angle larger (~70°) at basal pair of secondaries. Secondaries slightly curved, end in teeth. Margin serrate, teeth simple. Apex of teeth acute.

Discussion. Some poorly preserved leaves resemble *Zelkova zelkovifolia*. The first certain occurrence of the fossil-species in Hungary was recorded with relatively high number of specimens from the late Early Miocene (Karpatian) flora of the Mecsek (Hably, 2020). Later during the late Middle Miocene (Sarmatian), the fossil-species became a dominant element of floras (Kováts, 1856; Erdei, 1995; Erdei and Hír, 2002). In the Late Miocene (Pannonian), due to the inundation of the Pannonian Basin by Lake Pannon coupled with the extension of swamp areas, it disappeared from most floras, only a couple of specimens were recorded in the floras of Bükkábrány and Rudabánya (Hably, 2013). At higher levels, along the basin margin, however, it occurred in several floras even with high number of specimens (Hably, 2013). During the Pliocene, it reappeared in the floras of the Pannonian Basin. In Gérce the fossil-species was a dominant element of the flora (Hably and Kvaček, 1997).

MYRTALES Juss. ex Bercht. et J.Presl

LYTHRACEAE J.St.-Hil.

Decodon J.F.Gmel.

***?Decodon* sp.** (foliage)

Fig. 12.5–12.9

1994 *Quercus* cf. *seyfriedii* A.Braun ex Heer; Hably, p. 19, pl. 23, fig. 3.
1994 *Quercus elaena* Unger sensu Unger; Hably, p. 19, pl. 19, figs 2, 3, text.-fig. 35.
1994 *Quercus apocynophyllum* Ettingsh.; Hably, p. 20, pl. 9, fig. 1, pl. 10, fig. 1.
1994 *Dicotylophyllum* cf. *jungii* Erw.Knobloch et Kvaček; Hably, p. 34, pl. 22, figs 1, 4, text.-fig. 36.

Material. Pomáz.

Description. Leaves fragmented. Length of lamina up to 10 cm, width up to 3.4 cm. Shape lanceolate. Apex and base not preserved (?acute), margin entire, venation brochidodromous. Midvein strong. Secondaries arise at 70–80°, slightly curved, join near margin forming an intramarginal vein at ~1 mm to margin.

Discussion. The gross morphology of the leaves, especially the venation type including the intramarginal vein, resembles leaves in the genus *Decodon* (Hably, 1994; Kvaček and Sakala, 1999). In earlier studies leaves with this morphology had been described as *Quercus* and *Dicotylophyllum* cf. *jungii* (Hably, 1994). Leafy twigs, fruits and seeds of *Decodon* were described from the Early Miocene of Bohemia (Kvaček and Sakala, 1999) indicating typical wetland habitats. *Decodon* leaves were also reported in high number from a dominantly aquatic flora in the Late Miocene of Austria (Kovar-Eder et al., 2002).

FAGALES Engl.

FAGACEAE Dumort.

Quercus L.

***Quercus* sp. div.** (foliage)

Fig. 12.4

Material. Máriahalom, Vértesszőlős.

Description. Leaves fragmentary. Length and width up to 5 cm, and 3 cm, respectively. Apex acute, base not preserved. Shape of lamina elliptic, margin lobed. Venation hardly visible, ?craspedodromous with secondaries terminating in lobe apices.

Discussion. Fragmentary, poorly preserved leaves showing a gross morphology, i.e. lobed lamina, recalling the genus *Quercus*. Since the leaves are fossilized in coarse-grained sediments, finer details of the venation are not preserved.

MYRICACEAE Rich. ex Kunth

Myrica L.

Myrica longifolia Unger (foliage)

Fig. 12.10

1955a *Myrica longifolia* Unger; Andreánszky, p. 40.
1991 *Myrica longifolia* Unger; Kvaček and Hably, p. 58, pl. 7, fig. 1.

Material. Eger Wind-brickyard (upper flora), Eger Wind-brickyard (lower flora).

Description. Simple leaves. Length and width of lamina up to 5 cm and 0.5 cm, respectively. Shape of lamina lanceolate, apex acute, base longly cuneate. Margin widely serrate. Venation hardly visible.

Discussion. The fossil-species occurs mostly in the upper flora of the Wind-brickyard as the youngest Hungarian occurrence of the fossil-species. In addition, some specimens turned up from the lower flora as well. In Hungary the possible occurrence of the fossil-species was recorded in the middle Eocene flora of Csordakút (Erdei and Rákosi, 2009). The fossil-species was identified in numerous European Paleogene floras, e.g. Eocene flora of Geiseltal (Rüffle, 1976), early Oligocene flora of Häring (Ettingshausen, 1853), and the Oligocene flora of Haselbach (Weisselster Becken; Mai and Walther, 1978).

Myrica lignitum (Unger) Saporta (foliage)

Figs 12.11, 13.1, 13.2

1955a *Myrica lignitum* (Unger) Saporta; Andreánszky, p. 40, pl. 1, fig. 5.
1955a *Myrica onocleaefolia* Andr.; Andreánszky, p. 40, pl. 2, fig. 7.
1982 *Myrica banksiaefolia* Unger; Hably, p. 95, pl. 2, figs 3, 4, 6, 7, 11, pl. 8, figs 2, 3, pl. 9, figs 1–3.
1990 *Quercus* sp. type I.; Hably, p. 26, pl. 22, fig. 3, text.-fig. 108.

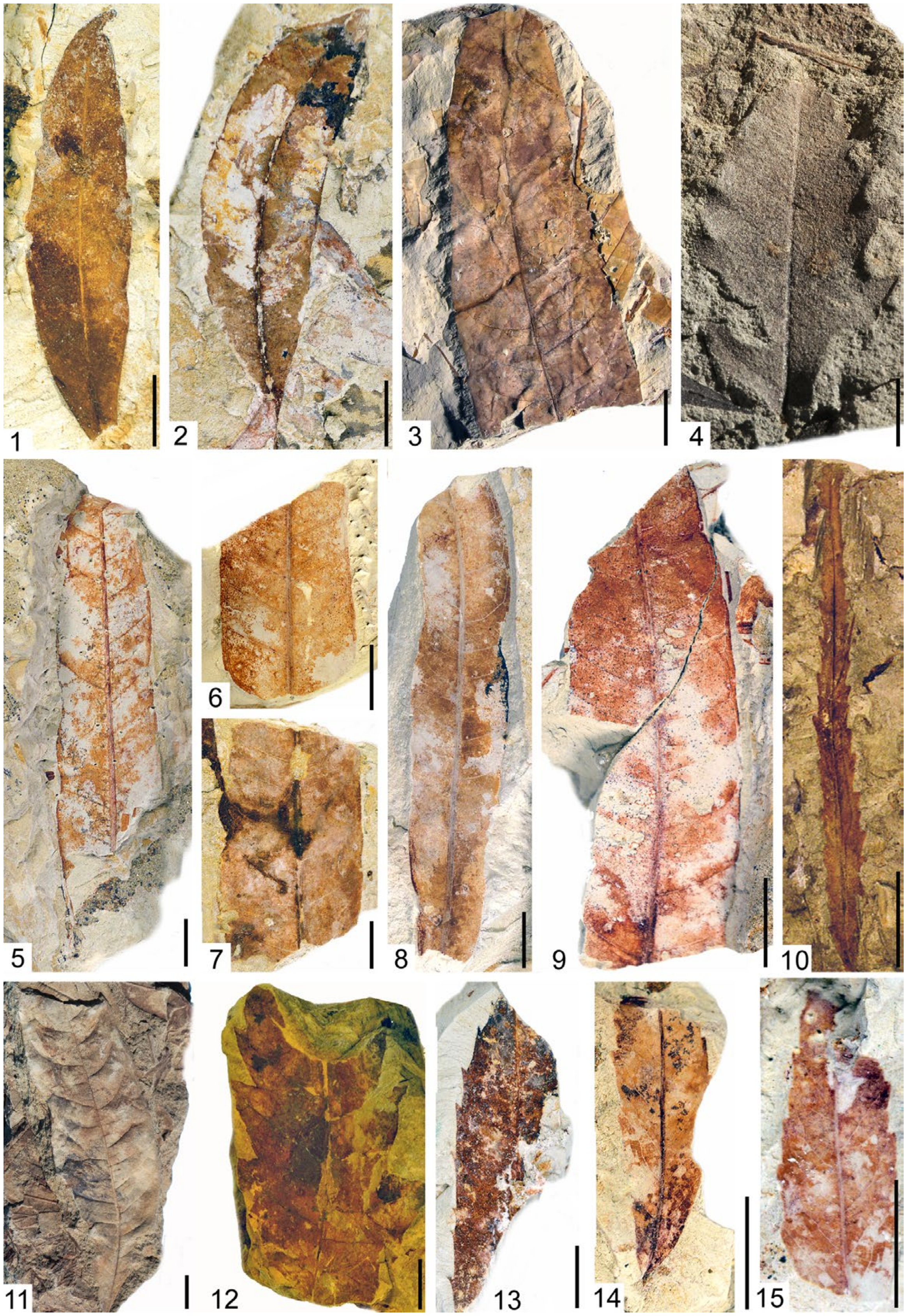

Figure 12. **1–3**. “*Quercus*” *rhenana* (Kräusel et Weyland) Erw.Knobloch et Kvaček, **1**. Pomáz, HNHM-PBO 86.407.1., **2**. Pomáz, HNHM-PBO 86.408.1, **3**. Környe, HNHM-PBO 2009.139.1.; **4**. *Quercus* sp., Vértesszőlős, Tata 76.101.1.; **5–9**. ?*Decodon* sp., Pomáz, **5**. HNHM-PBO 86.396.1., **6.** HNHM-PBO 86.366.1., **7**. HNHM-PBO 86.417.1., **8**. HNHM-PBO 86.501.1., **9**. HNHM-PBO 86.367.1.; **10**. *Myrica longifolia* Unger, Eger Wind-brickyard (upper flora), HNHM-PBO 70.47.1.; **11**. *Myrica lignitum* (Unger) Saporta, Vértesszőlős, Tata 76.222.1.; **12**. ?*Comptonia* sp., Eger Wind-brickyard (upper flora), HNHM-PBO 83.300.1.; **13**. “*Myrica*” *hakeaefolia* (Unger) Saporta, Pomáz, HNHM-PBO 86.430.1.; **14**, **15**. cf. “*Myrica*” *palaeogale* Pilar, Pomáz, **14**. HNHM-PBO 86.416.2., **15**. HNHM-PBO 86.416.2. Scale bars = 1 cm

1990 cf. *Juglans acuminata* A.Braun ex Unger; Hably, p. 29, pl. 27. fig. 2, pl. 28, fig. 1, text.-fig. 107.

Material. Andornaktálya, Eger Wind-brickyard (upper flora), Verőcemaros, Vértesszőlős.

Description. Simple leaves. Length of lamina more than 6 cm, width up to 2 cm. Apex acute, base cuneate. Margin serrate, in the lower part of the leaves mainly entire. Teeth irregular, large. Apex of teeth acute to rounded, sinuses irregular. Venation semicraspedodromous. Midvein strong. Secondaries curved, arise at 70–80°. Secondaries end in teeth apices, but also form loops. Intersecondary veins between secondaries. Higher venation not preserved.

Discussion. The fossil-species is rare, occurs only at some localities. Later, it became widespread in the late Early Miocene flora of the Mecsek (Hably, 2020). Moreover, it thrived even during the Late Miocene, at several localities. It was a well-known fossil-species of the European Miocene floras (Kovar-Eder and Krainer, 1990; Zidianakis et al., 2015).

Comptonia L'Hér.

Comptonia dryandroides Unger (foliage)

Fig. 13.3–13.8

1955a *Myrica acutiloba* var. *dentata* Andr.; Andreánszky, p. 41, pl. 2, fig. 11.
1991 *Comptonia dryandroides* Unger; Kvaček and Hably, p. 59, pl. 8, fig. 2.

Material. Eger Wind-brickyard (upper flora).

Description. Leaves linear lobate. Lobes directed towards the leaf apex, partly fully separated, partly incised halfway to the midrib. Lobes often finely toothed.

Discussion. The fossil-species was recorded only in the flora of the Wind-brickyard among the late Oligocene floras of Hungary. It was a frequent element of this flora, contrary to other European floras, in which, often assigned to various species names, it was usually rare (Kvaček and Hably, 1991).

?*Comptonia* sp. (foliage)

Fig. 12.12

1962 *Myrica macrodonta* Andr.; Andreánszky, p. 225, fig. 3.

Material. Eger Wind-brickyard (upper flora).

Description. Medial part of the leaf. Length of fragment 6 cm, original length more than ?12 cm. Width of lamina 4 cm, apex and base missing. Margin dentate. Teeth very large, irregular. Tooth apex acute, sinuses angular or rounded. Venation craspedodromous. Midvein strong. Secondaries depart at 70–90°, end in teeth apices. Loops formed by secondaries hardly visible. Intersecondaries between secondary veins. Tertiary veins percurrent.

Discussion. A single specimen turned up in the Wind-brickyard (upper flora) and was described as a new fossil-species of *Myrica* by Andreánszky (1962). The enormous teeth and venation are different from *Myrica* species. The leaf fragment may represent a leaf of a *Comptonia* species.

JUGLANDACEAE DC. ex Perleb

Engelhardia Lesch. ex Blume

Engelhardia orsbergensis
(P.Wessel et C.O.Weber) Jähnichen, Mai et H.Walther (foliage)

Figs 13.9–13.13, 14.1, 14.2

1952 *Myrica lignitum* (Unger) Saporta; Vitális and Zilahy, p. 166.
1956 *Carya falcata* Andr.; Andreánszky, p. 221, pl. 2, figs 3, 4.
1962 *Rhus succedanoides* Andr.; Andreánszky, p. 229, text.-fig. 6.
1988 *Palaeocarya orsbergensis* (P.Wessel et C.O.Weber) Jähnichen, Friedrich et Takáč; Hably, p. 43, pl. 9, fig. 5.
1988 *Palaeocarya orsbergensis* (P.Wessel et C.O.Weber) Jähnichen, Friedrich et Takáč; Hably, p. 25, pl. 15, fig. 5, pl. 16, figs 1–7, pl. 17, figs 1–4, pl. 18, fig. 1., text.-fig. 28.
1991 *Engelhardia orsbergensis* (P.Wessel et C.O.Weber) Jähnichen, Mai et H.Walther; Kvaček and Hably; p. 59, pl. 8, fig. 3.
1993a *Palaeocarya orsbergensis* (P.Wessel et C.O.Weber) Jähnichen, Friedrich et Takáč; Hably, p. 11.
2017 *Engelhardia orsbergensis* (P.Wessel et C.O.Weber) Jähnichen, Mai et H.Walther; Hably et al., p. 309, fig. 6(3).

Material. Andornaktálya, Csörög, Eger Wind-brickyard (upper flora), Eger Wind-brickyard (lower flora), Kesztölc, Pomáz, Pusztaberki, Tarján.

Description. Leaflets lanceolate, asymmetrical. Length 2.8–15 cm, width 0.5–2.5 cm. Apex acute, base acute or cordate, asymmetrical.

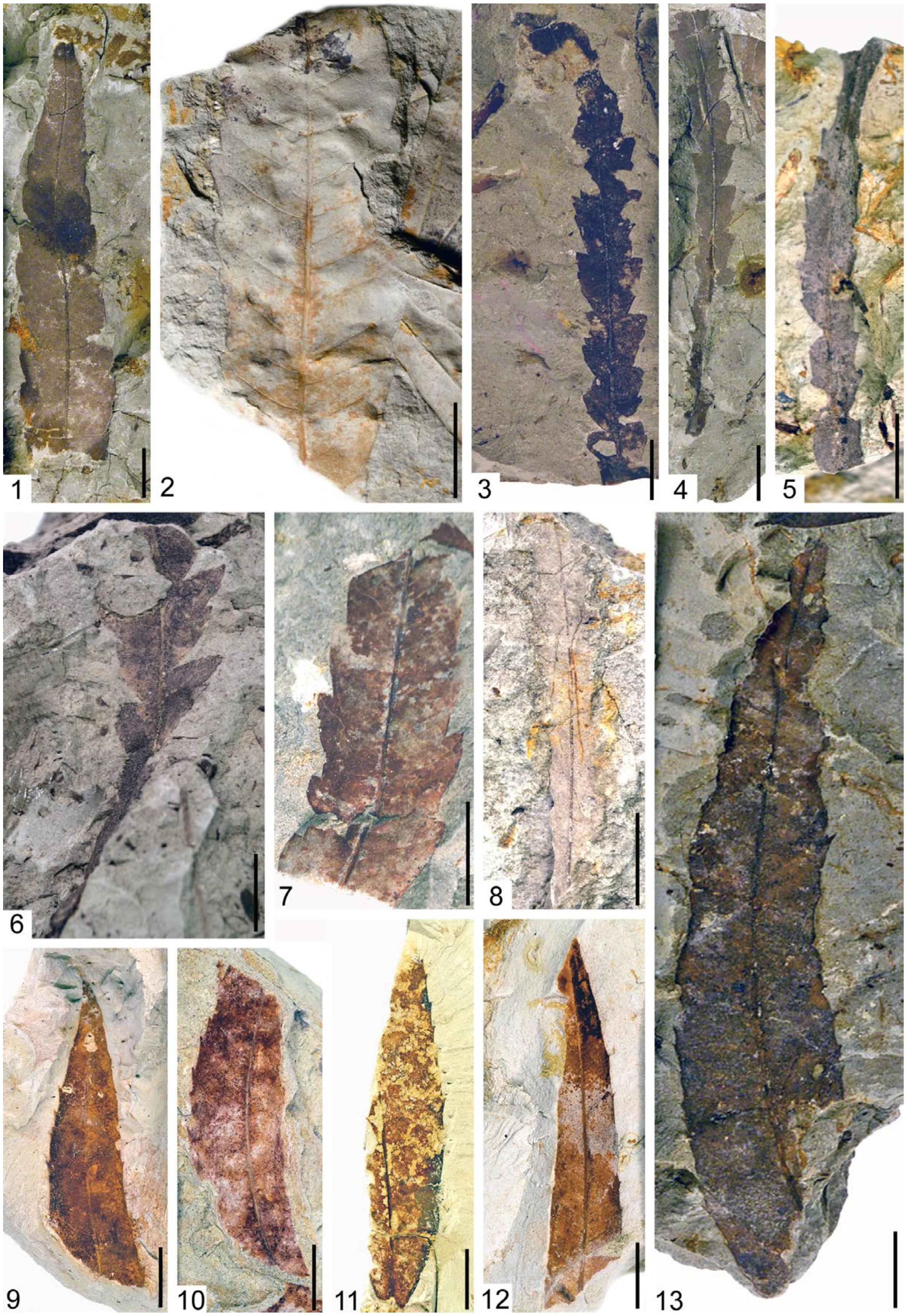

Figure 13. **1**, **2**. *Myrica lignitum* (Unger) Saporta, **1**. Eger Wind-brickyard (upper flora), HNHM-PBO 83.260.1., **2**. Verőcemaros, HNHM-PBO 79.8.2.; **3–8**. *Comptonia dryandroides* Unger, Eger Wind-brickyard (upper flora), **3**. HNHM-PBO 83.377.1., **4**. HNHM-PBO 67.242.1., **5**. HNHM-PBO 2010.550.1., **6**. HNHM-PBO 67.209.1., **7**. HNHM-PBO 2010.551.1., **8**. HNHM-PBO 2010.555.1.; **9–13**. *Engelhardia orsbergensis* (P.Wessel et C.O.Weber) Jähnichen, Mai et H.Walther, **9.** Eger Wind-brickyard (upper flora), HNHM-PBO 83.261.1, **10**. Csörög, HNHM-PBO 85.35.2., **11**. Pomáz, HNHM-PBO 86.85.1., **12**. Pomáz, HNHM-PBO 86.41.2., **13**. Pomáz, HNHM-PBO 86.71.2. Scale bars = 1 cm

Base mostly not preserved. Margin toothed. Teeth small, acute to acuminate, usually widely spaced. Venation semicraspedodromous. Midvein strong, secondaries thin, curved, depart at 50–60°, veinlets arising from secondaries end in teeth apices. Intersecondary veins between secondaries, depart at 60–70°. Higher order venation not preserved.

Discussion. Beside *Daphnogene* and *Platanus neptuni*, *Engelhardia orsbergensis* is one of the most frequent fossil-species of late Oligocene floras. It is present at most localities, but its preservation is largely influenced by the grain size of embedding sediments. Therefore, at localities characterized by coarse-grained sediments, the fossil-species has not been recognized. The highest number of specimens was reported from Pomáz. The fossil-species is a member of the Hungarian floras from the Eocene up to the Pliocene (Hably, 1985b; Hably and Kvaček, 1997), as a characteristic element of warm periods in the European Cenozoic. It is often related to wetland habitats, but at the Hungarian localities it occurs in other type of habitats as well, with a high number of specimens. It is a thermophilous species referring to warm climatic conditions during the late Oligocene.

Engelhardia macroptera (Brongn.) Unger (fruit)

Fig. 14.3

1952 *Engelhardtia brongniarti* Saporta; Vitális and Zilahy, p. 165, pl. 20, fig. 5a, pl. 21, fig. 5b.
1991 *Engelhardia orsbergensis* (P.Wessel et C.O.Weber) Jähnichen, Mai et H.Walther; Kvaček and Hably, p. 59.
1994 *Palaeocarya macroptera* (Brongn.) Jähnichen, Friedrich et Takáč; Hably, p. 27, pl. 18, fig. 2.

Material. Csörög, Eger Wind-brickyard (upper flora), Pomáz.

Description. Wing of nutlet, wing trilobate, deeply incised. Length up to 4 cm, width 3 cm. Length and width of lobes up to 3 cm and 0.8 cm, respectively. Central lobe at least twice as long as side lobes. Apex of lobes rounded. A middle vein present on each lobe, secondaries appear as weaker lateral veins. Secondaries alternately split off the midvein, fork several times and form loops.

Discussion. The fruits and leaves of *Engelhardia* may belong to one species. The fruits of *Engelhardia* occur much more rarely than leaf remains, appearing only at three localities. At Csörög, however, numerous specimens were recorded.

BETULACEAE Gray

Alnus Mill.

***Alnus oligocaenica* Andr.** (foliage)

Figs 14.4, 14.5, 14.7–14.9, 15.1

1962 *Alnus oligocaenica* Andr.; Andreánszky, p. 220, text.-fig. 1.
1966 *Alnus* cf. *nepalensis* Don; Andreánszky, p. 36, figs 22–24.
1966 *Rhamnus* cf. *purshiana* DC.; Andreánszky, p. 95, fig. 89.
1989 cf. *Alnus* sp.; Hably, p. 88, text.-figs 51–53, pl. 4, figs 1, 2.
1989 incertae sedis II.; Hably, p. 90, text.-fig. 48–50, pl. 4, fig. 3.
1990 *Betula* sp. type I.; Hably, p. 28, pl. 24, fig. 2, pl. 26, fig. 1, text.-figs 99, 100, 102, 103.
1990 *Betula* sp. type II.; Hably, p. 28, pl. 25, fig. 2, text.-fig. 101.
1990 *Betula* sp. type III.; Hably, p. 28, pl. 27, fig. 1.
1990 *Betula* sp. type IV.; Hably, p. 29, pl. 25, fig. 3, text.-figs 104–106.
1990 *Phyllites skoflekii* Hably; Hably, p. 39, pl. 3, figs 1, 2, pl. 4, fig. 1, pl. 5, fig. 2, text.-figs 122–127.
1991 *Alnus oligocaenica* Andr.; Kvaček and Hably, p. 58, pl. 7, figs 1–3.
2015 *Alnus oligocaenica* Andr.; Hably et al., p. 11, figs. 5(4, 5).
2017 cf. *Alnus oligocaenica* Andr.; Hably et al., p. 309, fig. 6(4).

Material. Eger Wind-brickyard (upper flora), Környe, Leányfalu, Nagysáp, Tarján, Vértesszőlős.

Description. Leaves simple. Length and width of lamina up to 10 cm and 6 cm, respectively. Shape of lamina elongate to broadly ovate. Apex acute to attenuate, base acute to obtuse. Margin toothed, simply serrate. Teeth very small. Apical and basal sides of teeth convex. Tooth apex obtuse to acute. Venation semicraspedodromous. Midvein moderately strong. Secondaries depart at 45–60°, curved, form loops near the margin. Secondaries frequently bifurcate. Dense tertiary venation, veins mixed percurrent.

Discussion. The fossil-species was described by Andreánszky from the upper flora of the Wind-brickyard. Some specimens from

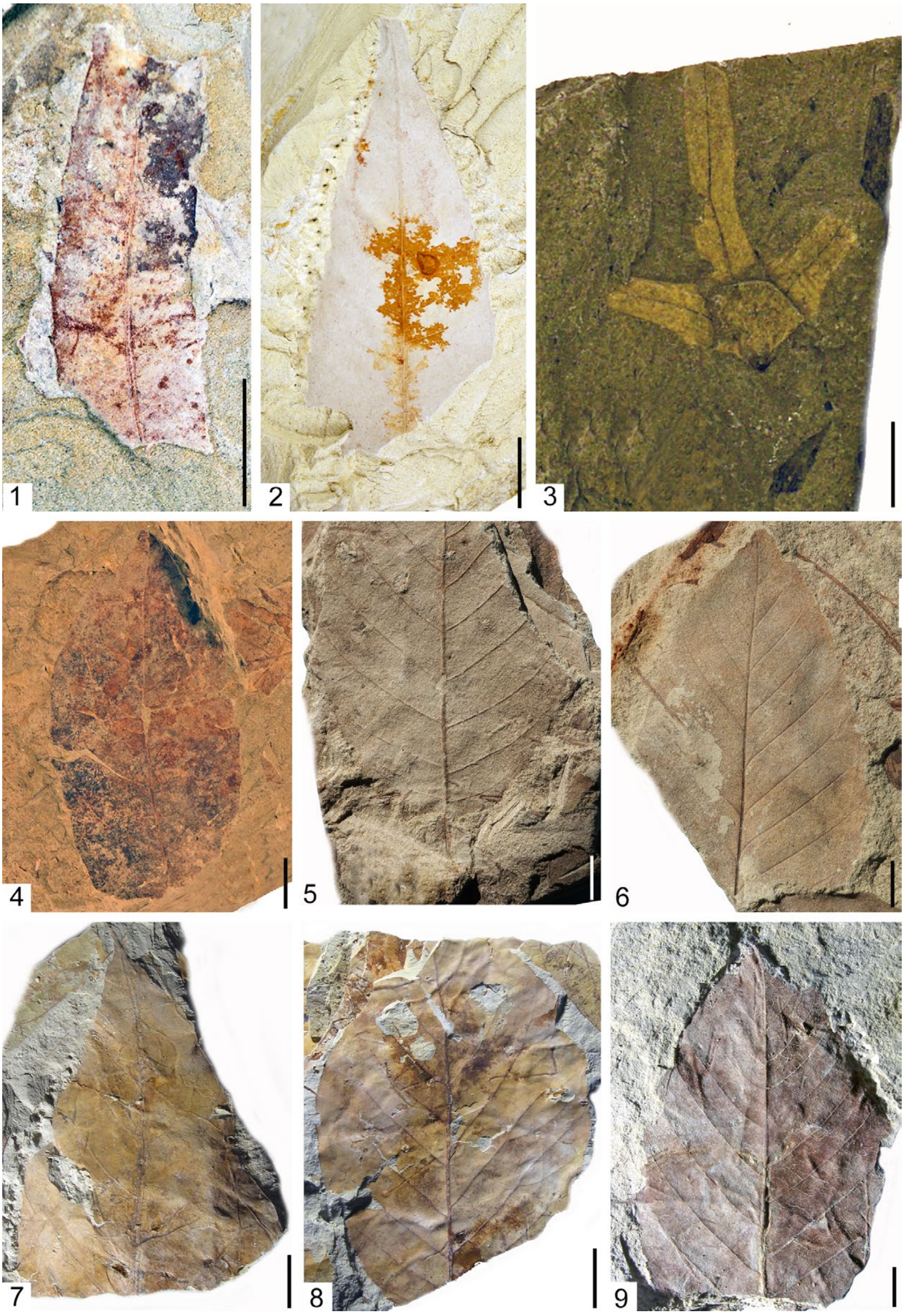

Figure 14. 1, **2**. *Engelhardia orsbergensis* (P.Wessel et C.O.Weber) Jähnichen, Mai et H.Walther, Pomáz, **1**. HNHM-PBO 86.90.1., **2**. HNHM-PBO 86.97.1.; **3**. *Engelhardia macroptera* (Brongn.) Unger, Csörög, HNHM-PBO 85.43.1.; **4**, **5**, **7–9**. *Alnus oligocaenica* Andr., **4**. Leányfalu, HNHM-PBO 86.727.1., **5**. Vértesszőlős,Tata 76.307.1., **7**. Környe, HNHM-PBO 2009.237.1., **8**. Környe, HNHM-PBO 2009.242.1., **9**. Környe, HNHM-PBO 2009.226.1.; **6**. *Alnus* sp., Vértesszőlős,Tata 76.125.1. Scale bars = 1 cm

Vértesszőlős were previously recorded as *Phyllites skoflekii* (Hably, 1990). In this flora the leaves seem to be entire margined probably due to coarser grained sediments. Some nicely preserved specimens were recorded from Környe, a typical wetland facies. *Alnus oligocaenica* appears in six late Oligocene floras accompanied with other swamp elements, thus it presumably occupied wetland habitats.

***Alnus* sp.** (female infrutescence)

Fig. 15.2–15.5

1966 *Alnus* sp. cone; Andreánszky, p. 42, fig. 27.
2015 *Alnus* sp. female inflorescence; Hably et al., p. 11, fig. 5(6).

Material. Eger Wind-brickyard (upper flora), Környe, Máriahalom, Pusztaberki.

Description. Pedunculate female infrutescences, length up to 17 mm, width up to 12 mm. Length of peduncle up to 22 mm, width 3 mm.

Discussion. Female infrutescence of *Alnus* probably belongs to the fossil-species *Alnus oligocaenica* since they are accompanied at two localities, Wind-brickyard and Környe.

***Alnus* sp.** (foliage)

Fig. 14.6

1988 *Alnus* sp.; Hably, p. 41.

Material. Kesztölc, Pusztaberki, Vértesszőlős.

Description. Fragmented leaves.

Discussion. Teeth and venation refer to the genus *Alnus*.

SAPINDALES Juss. ex Bercht. et J.Presl

SAPINDACEAE Juss.

Acer L.

Acer hungaricum Andr. (foliage)

Figs 15.6–15.9, 16.1–16.3

1952 *Acer trilobatum* A.Braun; Vitális and Zilahy, p. 167.
1955b *Acer hungaricum* Andr.; Andreánszky, pl. 25, figs 1, 2.
1965b *Platanus aceroides* Andr.; Andreánszky, p. 59, pl. 3, fig. 2.
1990 *Acer angustilobum* Heer sensu Hantke; Hably, p. 34, pl. 32, figs 1–3, pl. 33, fig. 1, text.-figs 115, 117–120.
1990 *Acer* sp.; Hably, p. 35.
1990 *Sassafras tenuilobatum* Andr.; Hably, p. 15, pl. 26, fig. 2.
1991 *Acer tricuspidatum* Bronn; Kvaček and Hably, p. 61, pl. 10, fig. 5.

Material. Csörög, Eger Wind-brickyard (upper flora), Vértesszőlős.

Description. Leaves palmately three-lobed to unlobed. Length and width up to 12 cm and 5 cm, respectively. Apex of lobes acute, base rounded to slightly cordate. Margin toothed. Teeth small, acute to sharp. Venation actinodromous with three major veins. Lateral main veins depart at 45° to midvein. Secondaries depart at 40–50° from middle vein at the upper half of lamina. Irregular secondaries depart from lateral main veins at 40–50°, curved, run toward the margin. Secondaries craspedodromous. Tertiary veins percurrent.

Discussion. A frequent fossil-species of the upper flora of the Wind-brickyard. Leaves display a slender form, in which the side lobes have an acute angle to the middle lobe. Based on this trait, Andreánszky (1955b) established a new fossil-species, *A. hungaricum*, for these leaves, which has been later accommodated as a form of *A. tricuspidatum* (Kvaček and Hably, 1991). The fossil-species *A. tricuspidatum* was variable in morphology in the European Paleogene and Neogene floras, therefore several forms have been described (Procházka and Bůžek, 1975). However, based on the distinct morphology of the leaves (side lobes at acute angle to midlobe) we accept Andreánszky's fossil-species *A. hungaricum*. *Acer tricuspidatum* was a frequent element of swamp habitats at several localities in Central Europe (Bůžek, 1971; Walther, 1972; Knobloch and Kvaček, 1976). Similarly, the fossil-species *A. hungaricum* may have thrived in swamp vegetation, at the late Oligocene localities of Hungary. The highest number of specimens was recorded in the upper flora of the Wind-brickyard. It also appeared in Vértesszőlős and Csörög, both yielding typical swamp elements.

***Acer* sp.** (foliage)

Fig. 16.4–16.6

Material. Eger Wind-brickyard (upper flora), Vértesszőlős.

Description. Leaves fragmentary, palmately three-lobed. Margin toothed, venation actinodromous.

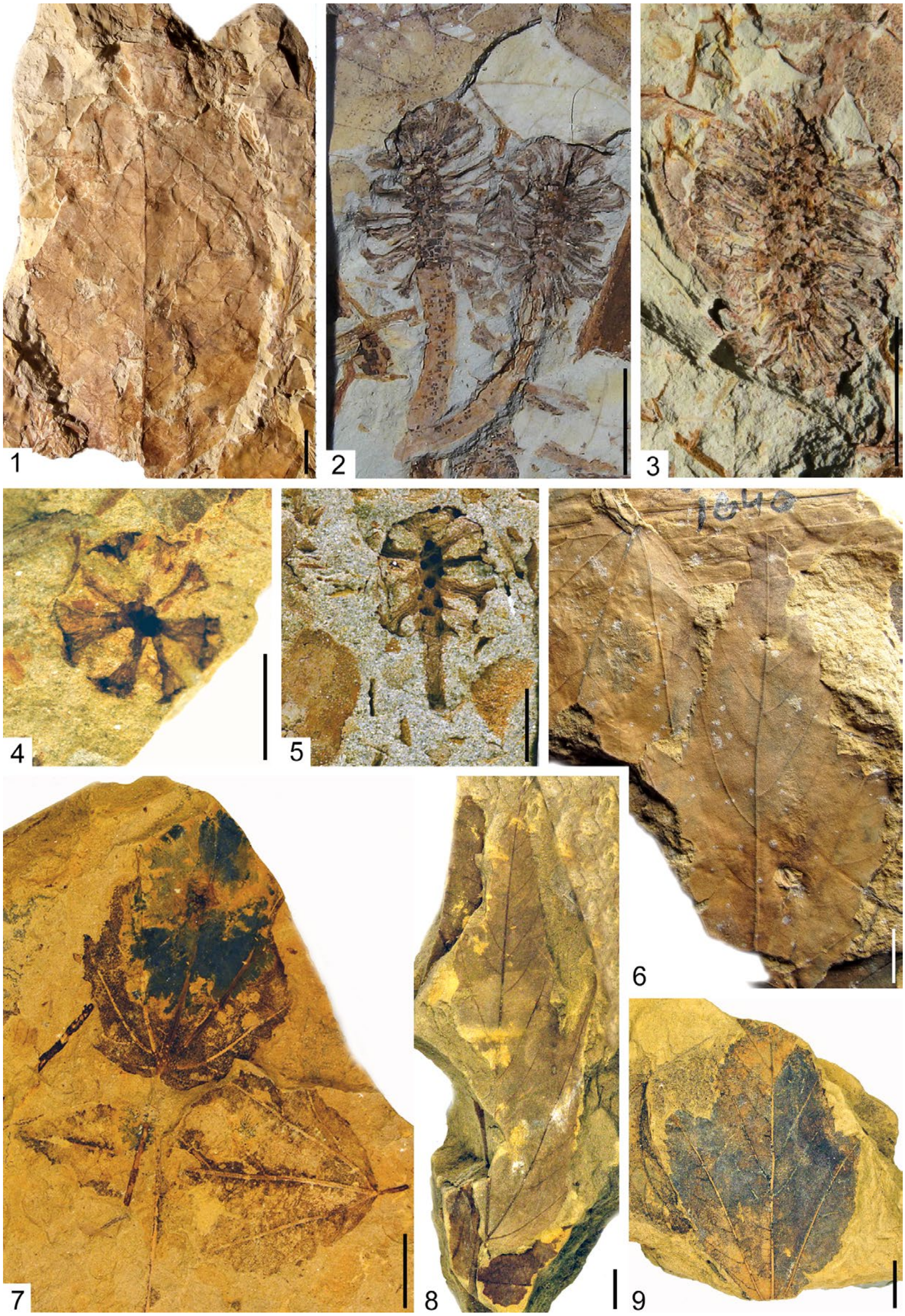

Figure 15. **1**. *Alnus oligocaenica* Andr., Környe, HNHM-PBO 2009.223.1.; **2–5**. *Alnus* sp., **2**. Környe, HNHM-PBO 2009.176.2., female infrutescence, **3**. Környe, HNHM-PBO 2009.175.1., female infrutescence, **4**. Pusztaberki, HNHM-PBO 95.492.2., female infrutescence, **5**. Pusztaberki, HNHM-PBO 95.492.2., female infrutescence; **6–9**. *Acer hungaricum* Andr., Eger Wind-brickyard (upper flora), **6**. HNHM-PBO 64.26.1., **7**. HNHM-PBO 2005.719.1., **8**. HNHM-PBO 2005.721.1., **9**. HNHM-PBO 92.3.2. Scale bars = 1 cm

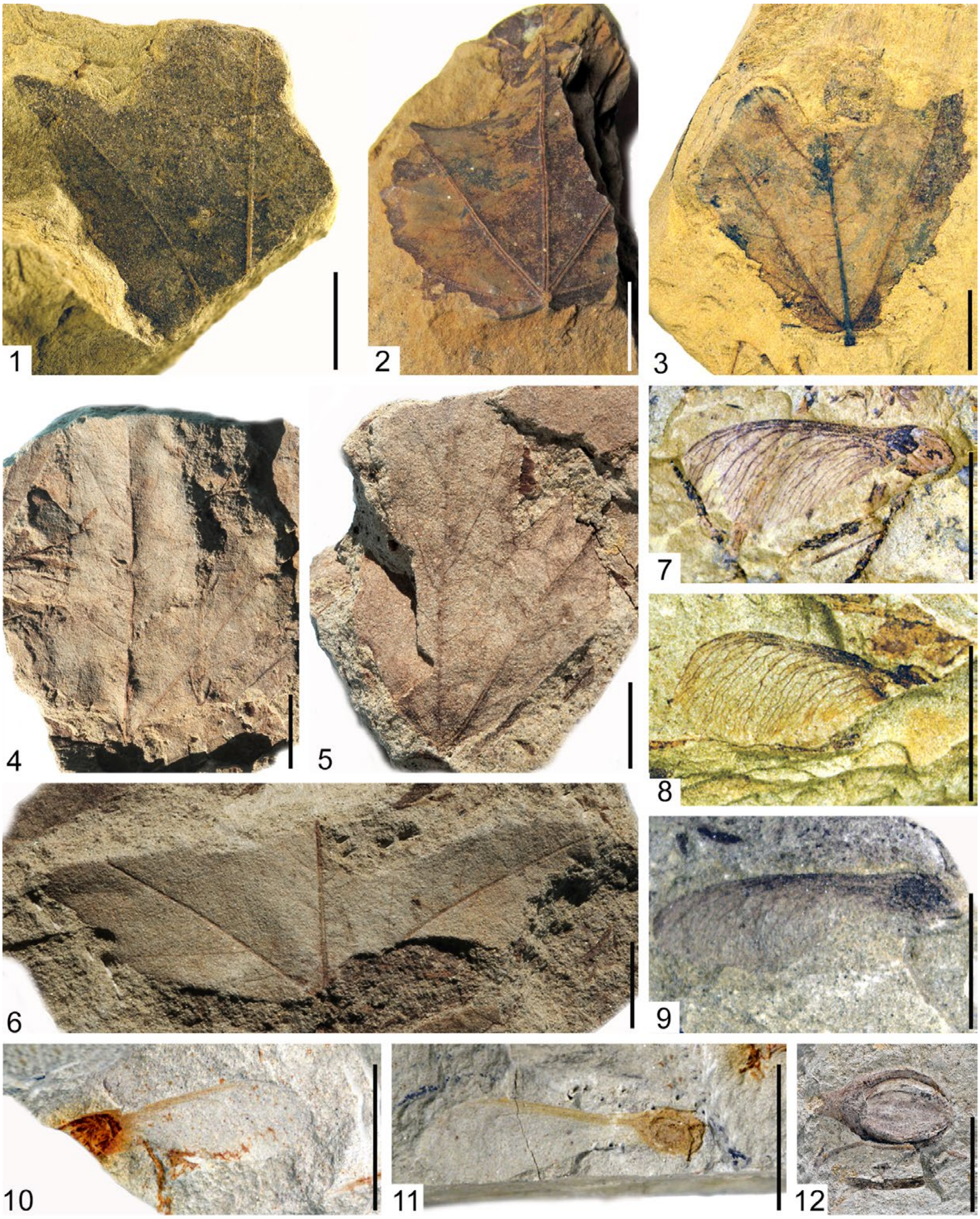

Figure 16. **1–3**. *Acer hungaricum* Andr., Eger Wind-brickyard (upper flora), 1. HNHM-PBO 2010.584.1., 2. MM 56.1344.1., 3. HNHM-PBO 2005.730.1.; **4–11**. *Acer* sp., **4**. Vértesszőlős, Tata 76.209.1., **5**. Vértesszőlős, Tata 76.285.1., **6**. Vértesszőlős, Tata 76.51.1., **7**. Eger Wind-brickyard (upper flora), HNHM-PBO 2011.343.1., fruit, **8**. Eger Wind-brickyard (upper flora), HNHM-PBO 2007.984.1., fruit, **9**. Eger Wind-brickyard (upper flora), HNHM-PBO 2005.731.1., fruit, **10**. Nógrádverőce, HNHM-PBO 79.12.2., fruit, **11**. Nógrádverőce, HNHM-PBO 79.12.2., fruit; **12**. cf. *Acer* sp., Kesztölc, BK 1131., fruit. Scale bars = 1 cm

Discussion. Due to poor preservation a proper identification is not possible at the species level, however, these may belong to a fossil-species of *Acer*.

Acer **sp. div.** (fruit)

Fig. 16.7–16.11

1982 *Acer* sp.; Hably, p. 94, pl. 8, figs 5, 6.

Material. Eger Wind-brickyard (upper flora), Verőcemaros.

Description. Samaras with wing and seed preserved. Length of samaras 1.7–2.0 cm, width up to 0.7 cm. Wing narrowed by seed. Seed diameter 0.4 cm. Eger, Wind-brickyard: wing narrowed at ventral side. Verőcemaros: wing narrowed at ventral and slightly at dorsal side.

Discussion. Both leaves and fruits of *Acer* were recorded from the Wind-brickyard, thus these may belong to the same fossil-species. From Verőcemaros, only fruits were described. These, displaying a morphology being slightly different from those of the Wind-brickyard flora, may represent another maple species.

cf. ***Acer*** **sp.** (fruit)

Fig. 16.12

1988 cf. *Acer* sp.; Hably, p. 45, pl. 10, fig. 6.

Material. Kesztölc.

Description. Shape of endocarp oval, length 18 mm, width 11 mm. Wing partly (5 mm) preserved.

Discussion. The endocarp fragment may belong to *Acer*. At the locality (Kesztölc) no other fossils representing *Acer* were documented.

MALVALES Juss.

MALVACEAE Juss.

"Kydia" kraeuselii (Rásky) Hably (foliage)

Fig. 17.1–17.5

1943 *Ficus kräuseli* Rásky; Rásky, p. 516, pl. 17, fig. 1.
2010 *Kydia kraeuseli* (Rásky) Hably; Hably, p. 412, pl. 4, figs 1–8.

Material. Eger Wind-brickyard (lower flora).

Description. Petiolate leaves. Petiole stout, length up to 4 cm, width up to 0.2 cm. Petiole pulvinate by attachment to lamina. Shape of lamina wide ovate. Length of lamina 5–8.5 cm, width 6–7.7 cm. Basal part cordate to truncate. Apex rounded (preserved in one leaf, MM.62.646.1.). Margin sometimes undulate with blunt teeth. Venation basal actinodromous with five primary veins. Primary veins strong, arise from the base. Secondaries depart at 50–60° from lateral primaries, curved when reaching margin. Higher order venation not preserved.

Discussion. Leaves described from the Eocene floras of Lábatlan and Messel as *Byttneriopsis steueri* (Engelh.) Kvaček et V.Wilde (Kvaček and Wilde, 2010) are similar in gross morphology, but margin details (occasional blunt teeth in "*Kydia*") are different. The shape of lamina recalls the leaves of *Populus germanica* (Menzel) H.Walther (Reuschel and Walther, 2006) but both venation pattern and leaf margin of the latter fossil-species are unlike the present material. Nevertheless, the oldest evidence of the genus *Populus* L. in the Pannonian Basin is known from the late Early Miocene localities of the Mecsek area (Hably 2020). Unknown cuticular details of "*Kydia*" leaves do not allow a proper comparison of these taxa.

?Malvaceae gen. et sp. indet. (foliage)

Fig. 18.1

1990 *Sterculia* sp.; Hably, p. 33, pl. 31, figs 1, 2, text.-figs 85, 86.

Material. Vértesszőlős.

Description. Leaf three-lobed. Petiole not preserved. Length of lamina 5 cm, width 5.6 cm. Apex of middle lobe acute, apex of side lobes obtuse. Margin entire. Venation ?camptodromous. Midvein strong. Secondary veins depart at 50–65°, straight, form loops near margin. Secondaries longer at lower half of lamina. Higher order venation not preserved.

Discussion. A rare, single leaf with a morphology recalling leaves of Malvaceae, e.g. *Sterculia* L. It may also be referable to "*Kydia*" leaves described from the lower flora of the Wind-brickyard. Similar leaves were described from the late Early Miocene flora of Magyaregregy as *Sterculia* sp. (Hably, 2020).

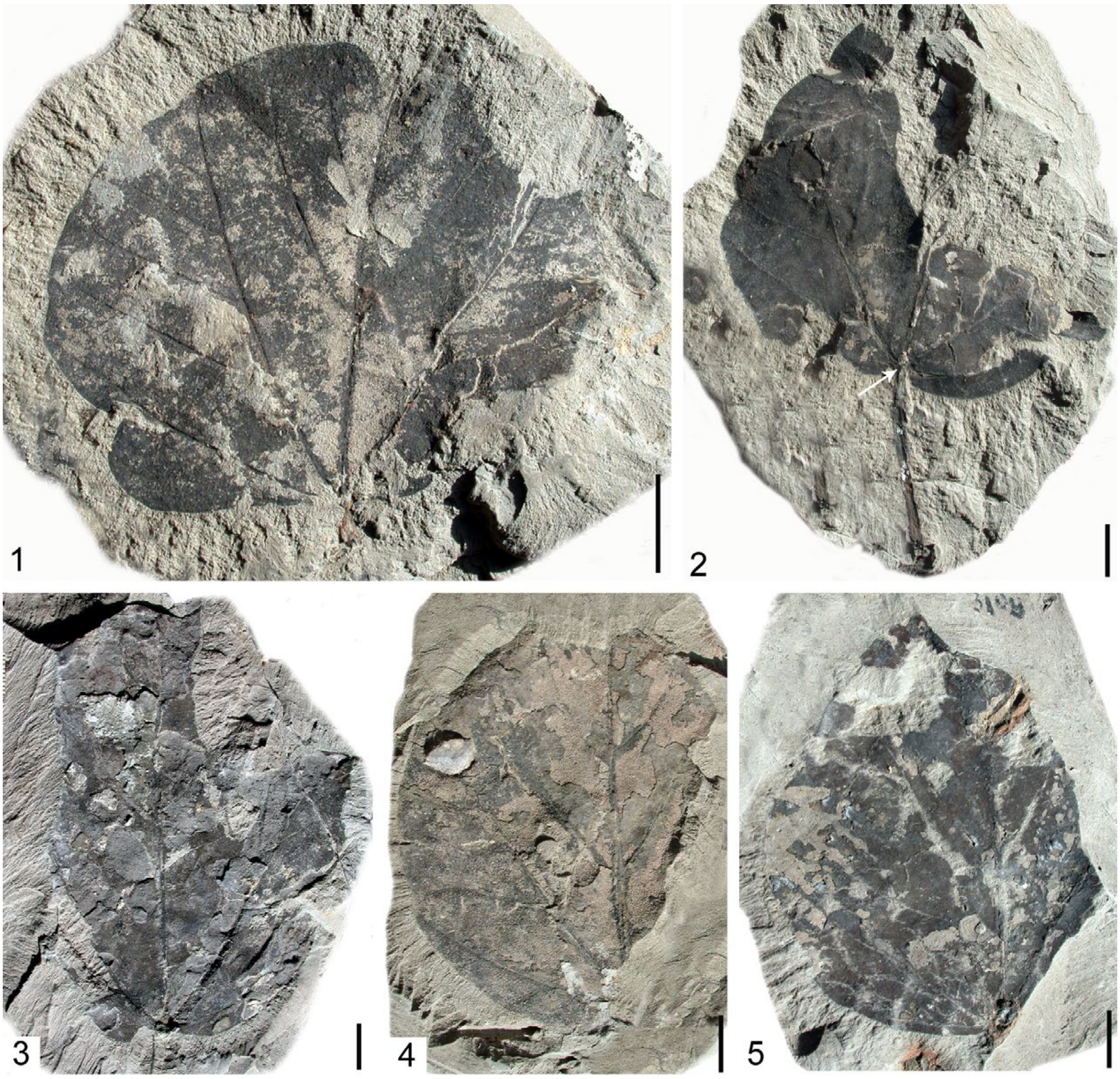

Figure 17. **1**–**5**. "*Kydia*" *kraeuselii* (Rásky) Hably, Eger Wind-brickyard (lower flora), **1**. MM 62.646.1. **2**. MM 62.645.1., arrow shows the pulvinate petiole at the lamina base, **3**. MM 64.88.1., **4**. MM 64.132.2., **5**. MM 61.821.1. Scale bars = 1 cm

CORNALES Link

cf. NYSSACEAE Juss. ex Dumort.

cf. *Nyssa* Gronov. ex L.

cf. *Nyssa* sp. (foliage)

Fig. 18.2

Material. Leányfalu.

Description. Leaf petiolate. Petiole strong, 0.4 cm long. Length of lamina 6.3 cm, complete width 6 cm. Shape of lamina obovate. Base decurrent, apex not preserved. Margin serrate. Teeth small, acute. Apical side of teeth concave, basal side straight. Venation semicraspedodromous. Midvein strong, straight. Secondaries depart at 45–50°, form loops near margin.

Discussion. *Nyssa* is a rare member of late Oligocene floras. In higher numbers and greater variability, it was recorded in the late Early Miocene flora of the Mecsek (Hably, 2020). Leaves of *Nyssa* were also described from Early Miocene localities of Central Europe (Kvaček and Bůžek, 1972).

cf. *Nyssa* sp. (fruit)

Fig. 18.3

2015 *Mastixia amygdalaeformis* (Schloth.) Kirchh. vel *Nyssa* sp.; Hably et al., p. 11, fig. 5(7).

Material. Környe.

Description. Endocarp ovate spindle shaped, deeply ribbed. Length 2 cm, width 1.1 cm. Longitudinal definite ribs up to six, base rounded, apex narrowed.

Discussion. The deep regular ribs of the endocarp recall those of *Nyssa*. Endocarps of *Nyssa* turned up in the late Early Miocene of the Mecsek (Hably, 2020). It was a thermophilous element of swamp associations. Endocarps of *Nyssa* were documented from the North Bohemian Basin (Czech Republic), from the Coal Formation of the Chomutov-Most-Teplice Basin in several mines and boreholes by Bůžek and Holý (1964), from the Petipsy Area (Bůžek, 1971), from the Early Miocene of Styria, Austria (Kovar-Eder and Meller, 2003), from Haselbach, Weisselster-Becken, Germany, by Mai and Walther (1978, 1985b), and from the Pliocene of Thüringen, Germany, by Mai and Walther (1988). Anatomically preserved endocarps with less regular and deep ribs were documented as *Mastixia* Blume from the Late Miocene flora of Rudabánya (Hably and Erdei, 2013).

CORNACEAE
Bercht. ex J.Presl vel Rhamnaceae Juss.

CORNACEAE gen. et sp. indet.
vel RHAMNACEAE gen. et sp. indet. (foliage)

Fig. 18.4, 18.5

1990 *Cornus praeamomum* É.Kovács; Hably, p. 35, pl. 33, fig. 3, text.-fig. 116.

1990 *Cornus* cf. *wrightii* Knowlt.; Hably, p. 36, pl. 34, fig. 2.

1990 *Cornus* sp.; Hably, p. 36, pl. 34, fig. 1, text.-fig. 121.

Material. Vértesszőlős.

Description. Leaves fragmentary. Complete length up to 15 cm, width 6.4 cm. Shape of lamina wide ovate to ovate. Apex acute, base not preserved. Margin entire. Venation camptodromous. Midvein strong. Secondaries depart at 70–80°, strongly curved, bend upwards near margin. Tertiary veins percurrent, perpendicular to secondaries.

Discussion. Similar leaves were mentioned from the Middle Miocene (Badenian) flora of Nógrádszakál, and from the late Middle Miocene flora of Balaton and Bánhorváti (Andreánszky, 1959).

ERICALES
Bercht. et J.Presl

THEACEAE Mirb.

cf. THEACEAE gen. et sp. indet. (foliage)

Fig. 18.6

1994 Theaceae gen. et sp. indet; Hably, p. 33, pl. 23, figs 5, 6, 8.

Material. Pomáz.

Description. Leaves 4.1–4.9 cm long, 1.8–2.0 cm wide. Shape of lamina obovate. Apex and base acute. Margin toothed in the upper third of lamina. Teeth small. Apex of teeth rounded, glandular, apical side of teeth very short, convex, basal side longer, convex. Sinuses rounded. Venation camptodromous. Midvein moderate. Secondary veins thin, depart at 45–60°, form loops. Thin veins depart from secondaries, end in teeth apices.

Discussion. Venation and teeth of the leaves recall the Theaceae family. This leaf form is rare, recorded from a single locality.

AQUIFOLIALES Senft

AQUIFOLIACEAE
Bercht. et J.Presl

Ilex L.

?Ilex andreanszkyi
Kvaček et Hably (foliage)

Fig.18.7–18.10

1991 *Ilex ? andreánszkyi* Kvaček et Hably; Kvaček and Hably, p. 62, pl. 11, figs 1–3.

Material. Eger Wind-brickyard (upper flora).

Description. Leaves very shortly petiolate. Petiole length 1 mm. Lamina broadly lanceolate, oblanceolate to broadly ovate. Length of lamina 6.5–8.0 cm, width 3.0–3.5 cm. Base acuminate, narrowly to widely cuneate. Margin simple coarsely and widely dentate in the upper part of lamina, indistinctly dentate towards the base. Teeth thickened, sharply pointed. Sinuses rounded. Venation semicraspedodromous. Midrib straight. Secondaries thin, indistinctly imprinted, diverge at 60°. Intersecondary veins one or two, parallel with the secondaries. Intersecondaries form irregular meshes with tertiary veins, partly parallel

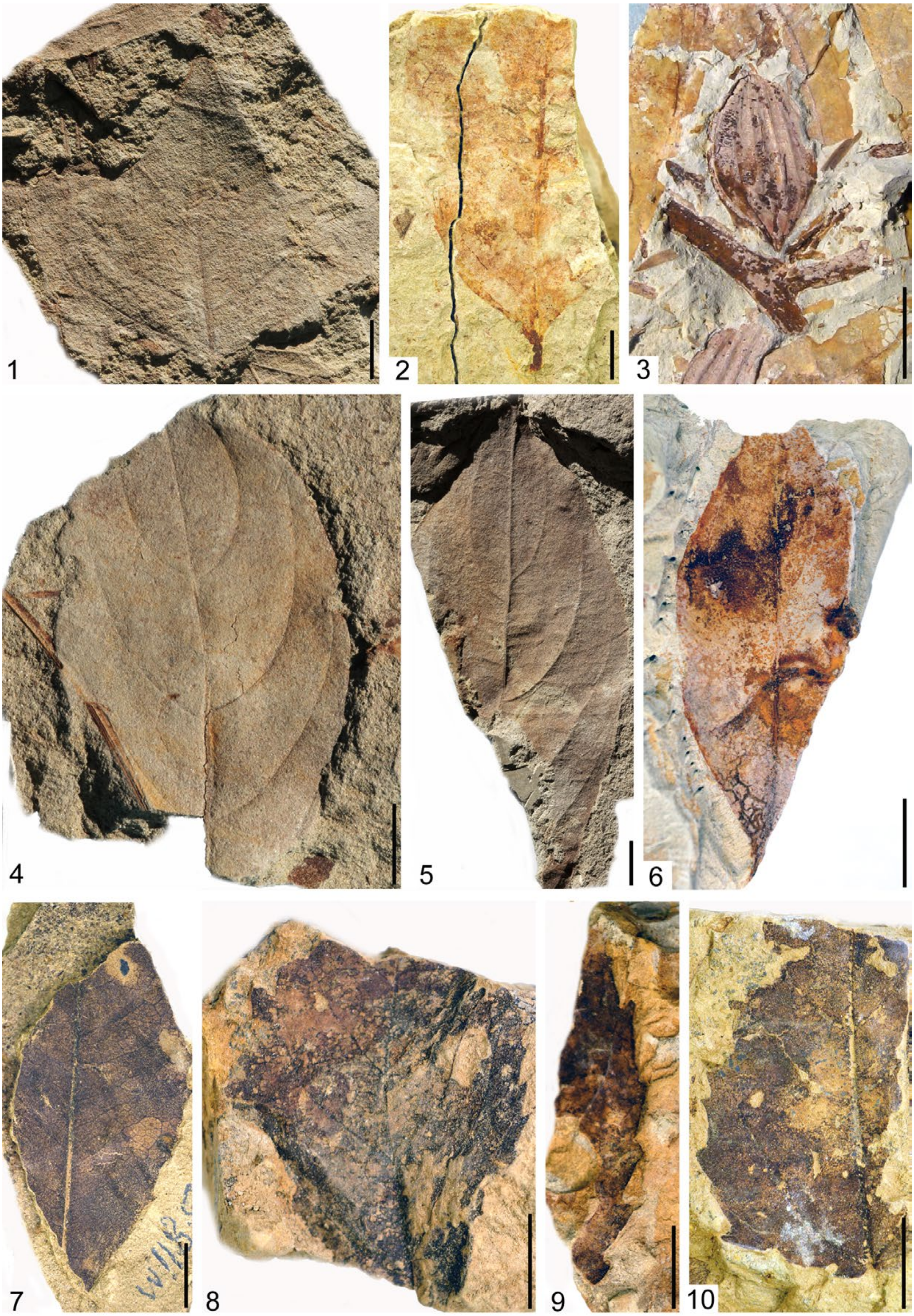

Figure 18. **1**. ?Malvaceae gen. et sp. indet., Vértesszőlős, Tata 76.115.1.; **2**, **3**. cf. *Nyssa* sp., **2**. Leányfalu, HNHM-PBO 86.740.1., **3**. Környe, HNHM-PBO 2009.195.1., fruit; **4**, **5**. Cornaceae gen. et sp. indet. vel Rhamnaceae gen. et sp. indet., Vértesszőlős, **4**. Tata 76.32.1., **5**. Tata 76.112.1.; **6**. cf. Theaceae gen. et sp. indet., Pomáz, HNHM-PBO 86.558.1.; **7–10**. ?*Ilex andreánszkyi* Kvaček et Hably, Eger Wind-brickyard (upper flora), **7**. HNHM-PBO 2006.255.1., **8**. HNHM-PBO 2006.256.2., **9**. HNHM-PBO 2012.22.1., **10**. HNHM-PBO 2010.421.1. Scale bars = 1 cm

with secondaries. Loops of secondaries join smaller loops towards the margin, give offside veins into the teeth. Higher order venation not preserved.

Discussion. Leaf morphology, venation and teeth, refer to the genus *Ilex*. In the absence of cuticular details, however, the leaves are tentatively assigned to the genus. The most comparable modern species of *Ilex* are *Ilex cassine* L. and *Ilex caroliniana* (Walter) Trel. from North America (Kvaček and Hably, 1991). The genus *Ilex* is a rare accessory element of the European Paleogene and Neogene floras (Kvaček et al., 2009, 2020).

LILIALES Perleb

SMILACACEAE Vent.

Smilax L.

Smilax tataensis Hably et Csaba (foliage)

Fig. 19.1, 19.2

1977 *Smilax tataensis* Hably et Csaba; Hably and Csaba, p. 23, text.-figs 1–8.
1990 *Smilax tataensis* Hably et Csaba; Hably, p. 37, pl. 35, fig. 1, pl. 36, fig. 1, pl. 37, fig. 1, pl. 38, fig. 1, text.-figs 128–133.

Material. Vértesszőlős.

Description. Length of lamina up to 14.5 cm, width 8.3 cm. Petiole not preserved. Shape of lamina broadly ovate. Apex acute, base lobate. Margin entire. Venation acrodromous, with 5 primary veins. Lateral primary veins strongly curved, run towards leaf apex. Higher order venation form loops close to margin.

Discussion. The fossil-species was established based on the extreme dimension of the leaves much larger from the other *Smilax* fossil-species, *S. weberi* P.Wessel in P.Wessel et C.O.Weber. It is, however, probable that larger leaves are attributable to habitat conditions. As a separate species, it was an endemic element of the flora of Vértesszőlős.

Smilax weberi
P.Wessel in P.Wessel et C.O.Weber (foliage)

Fig. 19.3–19.5

1966 *Smilax* cf. *china* L.; Andreánszky, p. 105, fig. 99.
1966 *Smilax grandifolia* (Unger) Heer; Andreánszky, p. 105.
1988 *Smilax weberi* P.Wessel in P.Wessel et C.O.Weber; Hably, p. 45.

Material. Eger Wind-brickyard (upper flora), Kesztölc.

Description. Original length of leaves up to 4.8 cm, width 3.0 cm. Petiole not preserved. Shape of lamina wide ovate. Apex acute, base decurrent. Venation acrodromous, with 5 primary veins. Middle vein stronger. Lateral veins strongly curved, run towards leaf apex. Maximum distance of lateral primary veins from middle vein 0.6 cm. Acute angles between primary veins at leaf base. Higher order venation percurrent, forms loops close to margin.

Discussion. This is a rare element in the late Oligocene floras occurring only at two localities with a couple of specimens. Similarly, few specimens of *Smilax* were described from the late Early Miocene flora of the Mecsek, both from the fish-scale marl and the volcanic (rhiolitic tuff) sediments. It was present in the palaeofloras as a relict element up to the Late Miocene (Hably, 1992c, 2013). It was a thermophilous member of liana vegetation.

ARECALES Bromhead

ARECACEAE Bercht. et J.Presl

Sabalites Saporta

***Sabalites* sp.** (foliage)

Fig. 19.6

1949 *Sabalites* sp.; Andreánszky, p. 33, pl. 3.
1991 *Sabal major* (Unger) Heer; Kvaček and Hably, p. 63, pl. 5, fig. 5.

Material. Eger Wind-brickyard (upper flora).

Description. Fragmented leaf fan. Leaf costapalmate. Basal part of leaf, with stout petiole. Width of petiole 4 cm. Length of fragmented leaf lamina up to 9 cm, width 13 cm. Leaf lamina segmented into narrow parts. Width of segments up to 0.5 cm.

Discussion. Andreánszky (1949) assumed that these leaves belong to *Tuzsonia hungarica* Andr., a fossil-genus and species established for palm inflorescences. However, no organic connection of the leaves and inflorescences (see below) has been proved. Since more than one type of palm leaves have been reported from

Figure 19. 1, **2**. *Smilax tataensis* Hably et Csaba, Vértesszőlős, **1**. Tata 76.230.1., **2**. Tata 76.232.1.; **3–5**. *Smilax weberi* P.Wessel in P.Wessel et C.O.Weber, **3**. Eger Wind-brickyard (upper flora), HNHM-PBO 70.135.1., **4**. Eger Wind-brickyard (upper flora), HNHM-PBO 2006.295.1., **5**. Kesztölc, HNHM-PBO 85.320.1.; **6**. *Sabalites* sp., Eger Wind-brickyard (upper flora), HNHM-PBO 83.288.1.; **7**, **8.** *Phoenicites* sp., Eger Wind-brickyard (upper flora), **7**. HNHM-PBO 2001.464.1., **8**. HNHM-PBO 67.213.1.; **9**. ?Arecaceae gen. et sp. indet., Eger Wind-brickyard (upper flora), HNHM-PBO 2014.164.1., ?stem fragment. Scale bars = 1 cm

the locality, we also assign the leaves to the fossil-genus *Sabalites* Saporta, which accumulates leaves recalling the leaves of modern *Sabal* Adans. palms. It rarely occurs in the upper flora of the Wind-brickyard. At the other late Oligocene localities only fragmented leaf segments of palms were recorded.

Phoenicites Brongn.

***Phoenicites* sp.** (foliage)

Figs 19.7, 19.8, 20.11, 20.12

1955a *Phoenicites leganyii* Andr.; Andreánszky, p. 48, pl. 3, fig. 15.
1955a *Phoenicites* sp.; Andreánszky, p. 49, pl. 3, figs 16, 17.
1982 cf. *Calamus noszkyi* Jabl.; Hably, p. 95, pl. 12, figs 2, 3, 5.
1991 *Calamus noszkyi* Jabl.; Kvaček and Hably, p. 63.

Material. Eger Wind-brickyard (upper flora), Verőcemaros.

Description. Fragmentary leaves. Leaf pinnate, paripinnate. Rachis width up to 1.5 cm. Margin entire. Midvein observable, dense parallel venation of two orders on midvein sides.

Discussion. Fragments of pinnate palm leaves were recorded from two localities with low number of specimens. Pinnate palm leaves were described as dominant flora elements in the late Early Miocene flora of Ipolytarnóc (Hably, 1985a).

Amesoneuron Göpp.

***Amesoneuron* sp.** (foliage)

Fig. 20.2–20.4, 20.6, 20.13

1988 cf. Palmae; Hably, p. 45, pl. 10, fig. 7.

Material. Eger Wind-brickyard (upper flora), Csörög, Kesztölc, Verőcemaros.

Description. Fragmentary leaves/leaf segments. Margin entire. Venation parallel, with two orders of veins on both sides of midvein.

Discussion. Fragmentary, unidentifiable palm leaves were recorded from several localities suggesting that palms were common members of the vegetation. The genus *Amesoneuron* accumulates fragments of palm leaves, i.e. unarmed, isolated fragments of lamina with nearly parallel margins and a strong midvein with two orders of finer, parallel veins on either side (Read and Hickey, 1972).

?ARECACEAE
Bercht. et J.Presl

Tuzsonia Andr.

Tuzsonia hungarica Andr. (inflorescence)

Fig. 20.5, 20.7

1949 *Tuzsonia hungarica* Andr.; Andreánszky, p. 31, figs 1–3, pl. 1, 2.
1991 *Tuzsonia hungarica* Andr.; Kvaček and Hably, p. 63, pl. 10, fig. 6.

Material. Eger Wind-brickyard (upper flora), Eger Wind-brickyard (lower flora).

Description. Numerous rachillae. Fragmentary length of rachillae up to 10 cm, width up to 1 cm. Stalk partly preserved. Stalk width 0.2–0.3 cm. Flowers staminate or bisexual, helically arranged, sessile. Length of flowers 0.3–0.5 cm, width 0.2–0.3 cm. Finer details not preserved.

Discussion. Andreánszky assigned the inflorescence specimens to palms (Andreánszky, 1949). Since fine details of the flowers are not clear, their relation to palms is uncertain. The peculiar inflorescence was recorded only from the Wind-brickyard, with relatively large number of specimens (Andreánszky, 1949). Andreánszky (1949) assumed that the leaves of *Sabalites* sp. and the inflorescence, described by him as bisexual, belonged to the same species, but organic attachment of the remains has not yet been proved. Based on its occurrence in the flora of the Wind-brickyard, this species may have favoured swamp habitats.

?**ARECACEAE** gen. et sp. indet.
(inflorescence)

Fig. 20.8–20.10

1993a *Spirematospermum wetzleri* (Heer) M.Chandler; Hably, p. 14, pl. 2, fig. 4.

Material. Andornaktálya, Pusztaberki.

Description. Fragmentary rachillae, width 1–1.2 cm, fragmentary length up to 6 cm. Flowers ?at pre-anthesis, ?staminate, sessile, small, helically arranged, closely packed. Length of flowers 0.4–0.6 cm, width 0.2–0.3 cm.

Discussion. Inflorescences were recorded from two localities, Andornaktálya and Pusztaberki. Similar finds were reported from Noszvaj-Nagyimány (HNHM-PBO 84.201.1.,

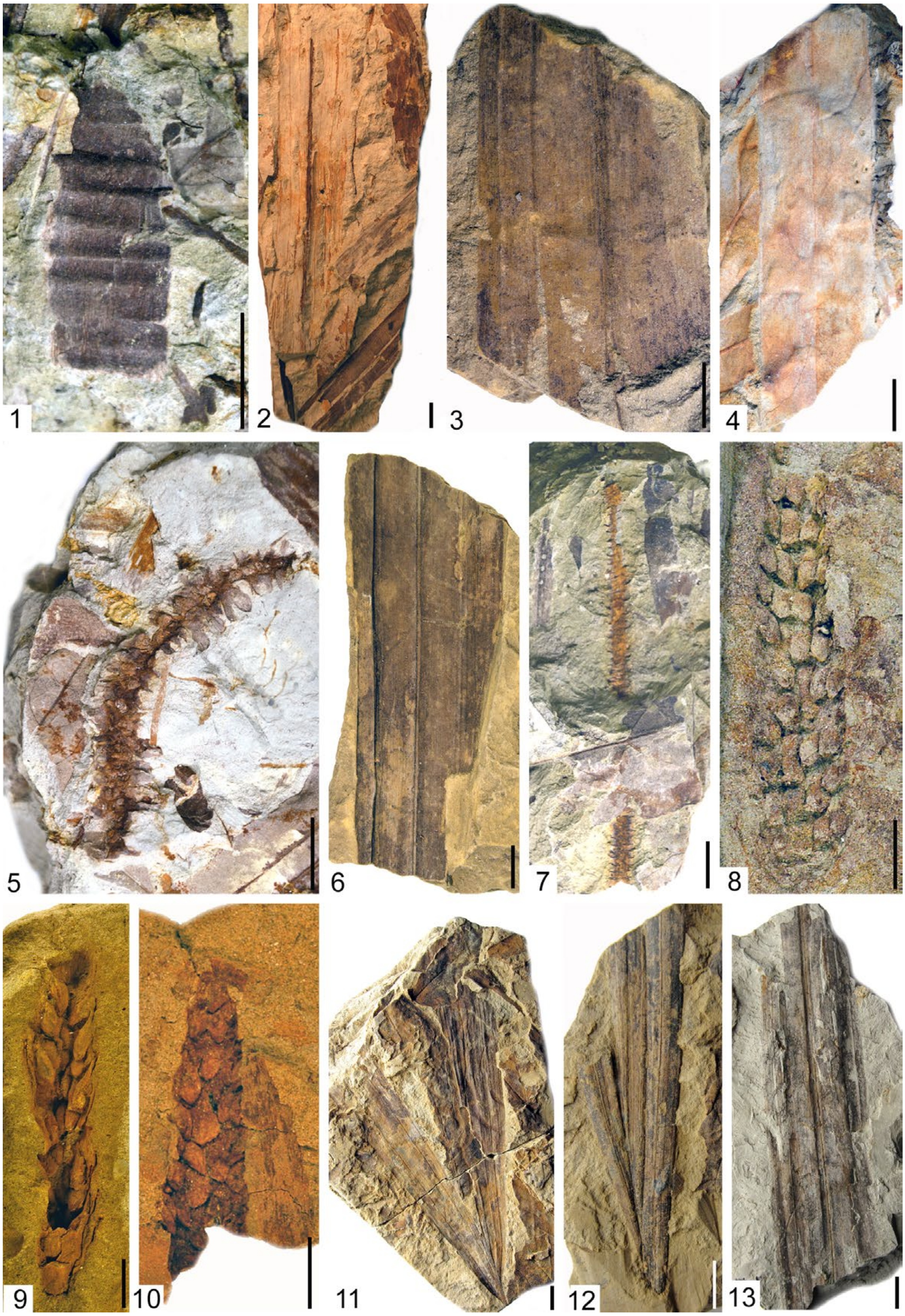

Figure 20. **1**, **8–10**. ?Arecaceae gen. et sp. indet., **1**. Eger Wind-brickyard (upper flora), HNHM-PBO 2010.369.1., ?stem fragment, **8**. Andornaktálya, HNHM-PBO 89.532.1., inflorescence, **9**. Noszvaj-Nagyimány, HNHM-PBO 84.201.1., inflorescence; **10**. Pusztaberki, HNHM-PBO 99.320.1., inflorescence; **2–4**, **6**, **13**. *Amesoneuron* sp., **2**. Eger Wind-brickyard (upper flora), HNHM-PBO 2005.744.1., **3**. Eger Wind-brickyard (upper flora), HNHM-PBO 2010.370.1., **4**. Verőcemaros, HNHM-PBO 79.9.1., **6**. Eger Wind-brickyard (upper flora), HNHM-PBO 84.37.1., **13**. Eger Wind-brickyard (upper flora), HNHM-PBO 56.1451.1.; **5**, **7**. *Tuzsonia hungarica* Andr., Eger Wind-brickyard (lower flora), **5**. HNHM-PBO 2010.257.1., inflorescence, **7**. HNHM-PBO 2005.738.1., inflorescence; **11**, **12**. *Phoenicites* sp., Eger Wind-brickyard (upper flora), **11**. HNHM-PBO 66.416.1., **12**. HNHM-PBO 66.367.1. Scale bars = 1 cm

Fig. 20.9), however, its age is probably older than late Oligocene. The locality was published by Andreánszky (1965b) as middle Oligocene.

?**ARECACEAE** gen. et sp. indet. (?stem fragment)

Figs 19.9, 20.1

M a t e r i a l. Eger Wind-brickyard (upper flora).

D e s c r i p t i o n. Fragmentary, dimension 3 × 4 cm, no clear shape or venation observable. Texture parallel ribbed, with network of fibres(?).

D i s c u s s i o n. It is probably a stem fragment, assigned provisionally to palms.

MONOCOTYLEDONEAE gen. et sp. indet. (foliage)

Fig. 21.1, 21.2

1994 Monocotyledonae gen. et sp. 1.; Hably, p. 35.
1994 Monocotyledonae gen. et sp. 2.; Hably, p. 35.
2015 Monocots; Hably et al., p. 12, fig. 6(4).
2017 Monocotyledonae gen. et sp.; Hably et al., p. 310.

M a t e r i a l. Eger Wind-brickyard (upper flora), Környe, Leányfalu, Máriahalom, Pomáz, Pusztaberki, Tarján.

D e s c r i p t i o n. Strap shaped leaf fragments, length up to 10 cm, width 0.6–2.4 cm. Venation parallel.

D i s c u s s i o n. The leaf fragments represent various monocot genera. The frequent occurrence of monocots suggests swamp habitats and the autochthonous fossilization of the assemblage.

ANGIOSPERMAE incertae sedis

"Rhamnus" warthae Heer (foliage)

Figs 21.3–21.6, 22.1–22.3

1962 *Rhamnus angustifrons* Andr.; Andreánszky, p. 233, text.-fig. 9.
1966 *Styrax* cf. *japonica* Sieb. et Zucc.; Andreánszky, p. 85, fig. 76.
1966 *Elaeocarpus palaeolanceolatus* Kolakovski; Andreánszky, p. 94, fig. 87.
1988 *Symplocos* sp.; Hably, p. 44, pl. 9, fig. 6.
1989 *Symplocos* sp.; Hably, p. 89, text.-figs 55, 56, 58, pl. 3, fig. 1.
1993a "*Rhamnus*" *warthae* Heer; Hably, p. 12, pl. 2, fig. 2.
2001 "*Rhamnus*" *warthae* Heer; Hably, p. 6.
2015 "*Rhamnus*" *warthae* Heer; Hably et al., p. 12, fig. 6(2).

M a t e r i a l. Andornaktálya, Eger Wind-brickyard (upper flora), Eger Wind-brickyard (lower flora), Kesztölc, Környe, Nagysáp, Pusztaberki.

D e s c r i p t i o n. Leaves non-petiolate. Length of lamina 3.5–14 cm, width 2.1–5.5 cm. Shape of lamina obovate, ovate to lanceolate. Apex acute, base cuneate. Margin toothed. Teeth irregular, small, very thin, and sharp. Venation strong. Major secondary veins semicraspedodromous, some loops give off veins ending in teeth. Secondaries and tertiaries form compound loops. Secondary veins depart at 45–60°. Strong tertiary veins between major secondaries, depart at larger angles (but <90°) than secondaries. Tertiary veins mixed (opposite and alternate) percurrent. Quaternary veins regular reticulate.

D i s c u s s i o n. The systematic position of "*Rhamnus*" *warthae* is unclear. Kvaček and Hably (1991) suggested an affinity to the genus *Rubus* L., based on its mass occurrence in the wetland vegetation of the Wind-brickyard. Mass occurrence of its leaves is known from few localities, the Wind-brickyard (upper flora) (Hably, 2001), Környe (Hably et al., 2015), and the flora of the Zsil Valley (Romania; Staub, 1887; Givulescu, 1973). In addition, there are several specimens in the flora of Csolnok (Hungary) probably older than late Oligocene (Erdei and Wilde, 2004). In all of these localities vegetation of swamp habitats was documented. The palaeogeographic distribution of "*Rhamnus*" *warthae* is limited to the Intra-Carpathian area of the Central Paratethyan region, e.g. Hungary and Transylvania in Romania (Hably, 2001) suggesting an endemic species. Most of the floras comprising the fossil-species are dated as late Oligocene. The appearance of "*Rhamnus*" *warthae* Heer may be correlated with the abrupt floristic change at the boundary of early and late Oligocene (Hably, 1993b).

"Talauma" egerensis Andr. (foliage)

Fig. 22.4

1955a *Talauma egerensis* Andr.; Andreánszky, p. 38, pl. 1, fig. 4.

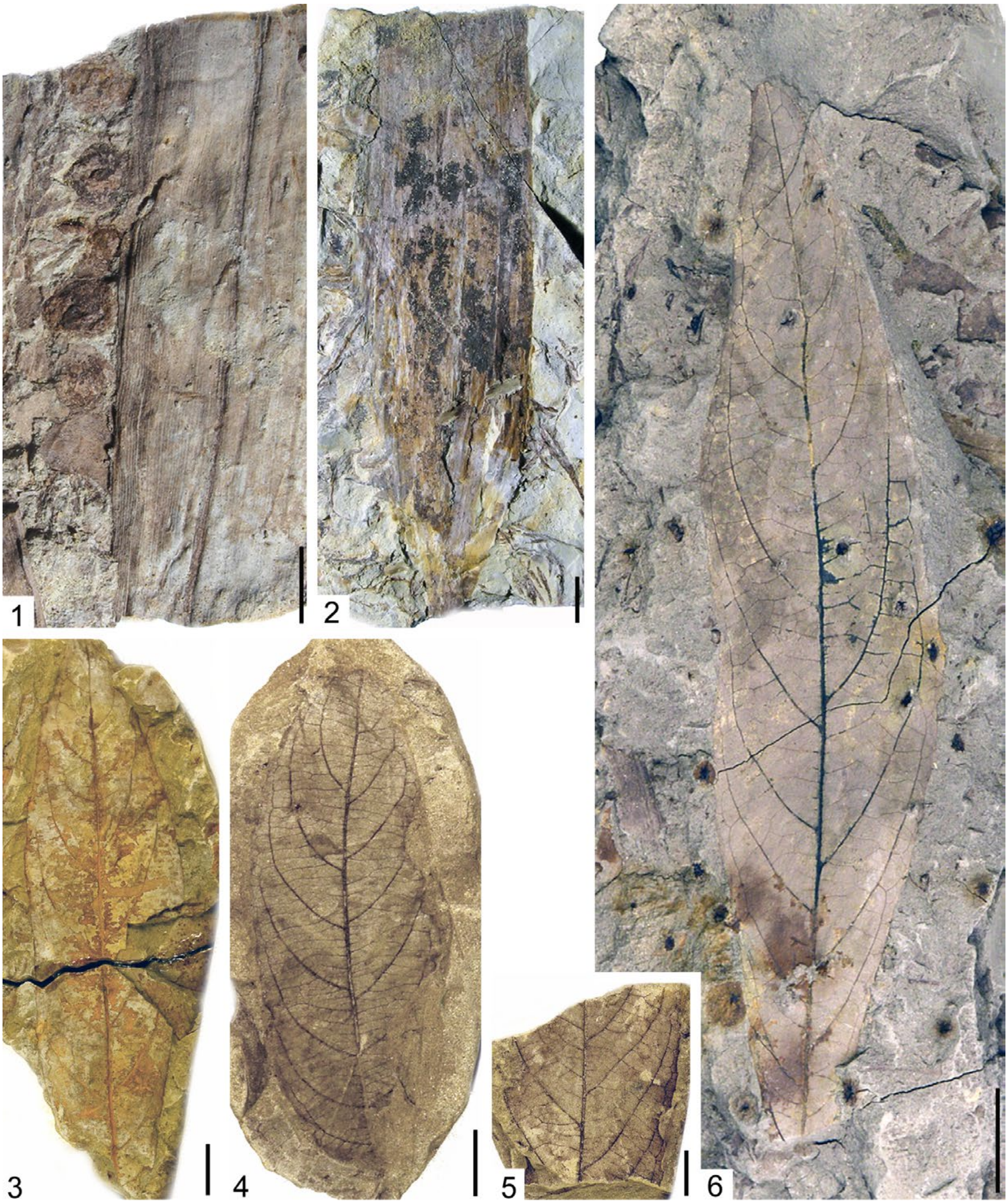

Figure 21. **1**, **2.** Monocotyledoneae gen. et sp. indet., Környe, **1**. HNHM-PBO 2009.200.2., **2**. HNHM-PBO 2009.204.1.; **3–6**. "*Rhamnus*" *warthae* Heer, Eger Wind-brickyard (upper flora), **3**. HNHM-PBO 90.48.1., **4**. HNHM-PBO 70.34.1., **5**. HNHM-PBO 90.16.1., **6**. HNHM-PBO 70.40.1. Scale bars = 1 cm

1991 "*Talauma egerensis*" Andr.; Kvaček and Hably, p. 64, pl. 12, figs 3, 5.

Material. Eger Wind-brickyard (upper flora).

Description. Shape of lamina oval to longly ovate-obovate. Length of lamina more than 15 cm, width up to 6 cm. Apex acute, base broadly cuneate. Margin entire. Venation camptodromous. Secondary veins depart at 56–60°, form loops along the margin. Intersecondary veins depart in the middle part of the lamina. Higher order venation not preserved.

Discussion. Andreánszky (1955a) assigned the leaves to *Talauma* Juss. currently treated as a section of *Magnolia* L. The systematic affinity of the leaves, however, is unclear. The leaves were recorded with a great number of specimens at one locality, the Wind-brickyard. Presumably they favoured swamp habitats.

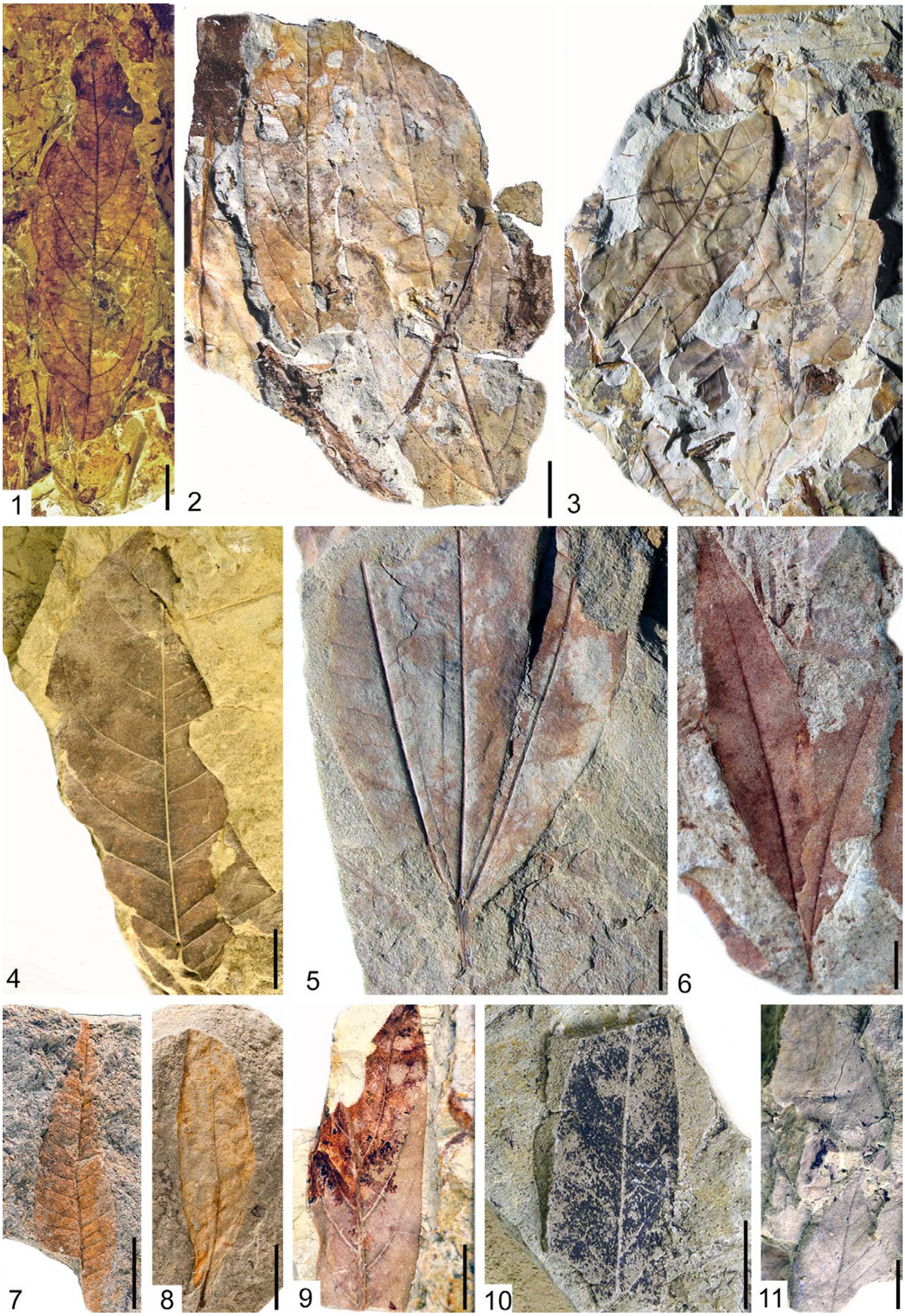

Figure 22. **1–3**. "*Rhamnus*" *warthae* Heer, **1**. Eger Wind-brickyard (upper flora), HNHM-PBO 90.23.1., **2**. Környe, HNHM-PBO 2009.161.2., **3**. Környe, HNHM-PBO 2009.132.1.; **4**. "*Talauma*" *egerensis* Andr., Eger Wind-brickyard (upper flora), HNHM-PBO 2010.584.1.; **5**, **6**. ?*Debeya hungarica* Hably, **5**. Verőcemaros, NHM-PBO 79.5.2., **6**. Vértesszőlős, Tata 76.105.1.; **7**, **8**. "*Sapindus*" sp., Kesztölc, **7**. BK 1138., **8**. BK 2467.; **9–11**. *Dicotylophyllum* sp. 1., **9**. Pomáz, HNHM-PBO 86.490.1., **10**. Kesztölc, HNHM-PBO 85.350.1., **11**. Kesztölc, HNHM-PBO 85.338.1. Scale bars = 1 cm

?Debeya hungarica Hably (foliage)

Fig. 22.5, 22.6

1982 *Debeya hungarica* Hably; Hably, p. 96, pl. 2, figs 8, 10, pl. 3, figs 1–3, 5–8, pl. 9, figs 4, 5, pl. 10, figs 1–4, pl. 11, figs 1–4, pl. 12, fig. 1.

Material. Verőcemaros, Vértesszőlős.

Description. Compound petiolate leaves, with three leaflets. Leaf petiole up to 1.7 cm. Leaflets non-petiolate. Length of leaflets up to 15 cm, width up to 2.5 cm. Apex of leaflets acute. Base of leaflets slightly asymmetrical, acute, slightly pulvinate. Margin entire. Venation of leaflets camptodromous. Midvein stout. Secondary veins depart at 70–80°. Higher order venation not preserved.

Discussion. The fossil leaves were formerly assigned to the extinct genus *Debeya* Miquel (Hably, 1982), which was established for Cretaceous trifoliate leaves (Miquel, 1853). These, however, differ in having petiolulate leaflets and in venation details. The leaves described here were later synonymized in *Platanus neptuni* (Kvaček et al., 2001b; Kvaček and Manchester, 2004), however, we think that they differ also from the trifoliate form of *Platanus neptuni* in having consequently entire margined and non-petiolulate leaflets. We do not exclude the platanaceous affinity of the leaves but in the lack of epidermal details it cannot be corroborated.

?"Quercus" rhenana
(Kräusel et Weyland) Erw.Knobloch et Kvaček (foliage)

Fig. 12.1–12.3

1966 *Lithocarpus* sp. II; Andreánszky, p. 51, fig. 35.
1966 *Quercus salicina* Saporta; Andreánszky, p. 57, fig. 42.
1966 *Quercus crassipetiolata* Andr.; Andreánszky, p. 64, figs 50–52.
1991 *Quercus rhenana* (Kräusel et Weyland) Erw. Knobloch et Kvaček; Kvaček and Hably, p. 57, pl. 6, figs 2, 3.
1994 cf. *Quercus neriifolia* A.Braun sensu Heer; Hably, p. 19, pl. 5, figs 4, 5, pl. 9, fig. 5.
2015 "*Quercus*" *rhenana* (Kräusel et Weyland) Erw. Knobloch et Kvaček; Hably et al., p. 9, fig. 6(1).

Material. Eger Wind-brickyard (upper flora), Környe, Pomáz.

Description. Leaves fragmentary. Length more than 10 cm, width up to 3 cm. Shape of lamina lanceolate. Apex acute, base cuneate. Margin entire. Venation hardly observable, (?)brochidodromous. Secondaries curved, form loops near margin.

Discussion. The fossil-species turned up in three localities (Kvaček and Hably, 1991; Hably, 1994; Hably et al., 2015). Since no cuticles are available, closer systematic relation of the leaves could not be revealed. The fossil-species "*Quercus*" *rhenana* was an important element of late Oligocene vegetation. Rich occurrences were documented in the Lower to Middle Miocene lignite areas, e.g. Oberdorf (Austria: Kovar-Eder, 1996).

"Myrica" hakeaefolia
(Unger) Saporta (foliage)

Fig. 12.13

1994 "*Myrica*" *hakeaefolia* (Unger) Saporta; Hably, p. 30, pl. 18, figs 3–5.

Material. Pomáz.

Description. Leaf fragmented, length up to 10.5 cm, width 2.3 cm. Shape of lamina elongated obovate. Apex and base not preserved. Margin toothed. Tooth apex acute. The apical side of teeth convex or straight, the basal side straight or concave. Sinuses angular. Distance between teeth 0.4–0.8 cm. Venation semicraspedodromous. Midvein strong. Secondaries depart at 50–60°, mostly straight. Intersecondaries between secondaries, parallel with secondaries. Higher venation not preserved.

Discussion. The systematic affinity of the leaves is uncertain, most probably not *Myrica*. Leaves of *Engelhardia* show similarity but have smaller teeth with different morphology (apex acuminate, apical side of teeth concave or straight).

cf. *"Myrica" palaeogale*
Pilar in Kutuzkina (foliage)

Fig. 12.14–12.15

1994 cf. *Myrica palaeogale* Pilar in Kutuzkina; Hably, p. 30, pl. 18, fig. 6.

Material. Pomáz.

Description. Leaves 3.4 cm long, 1.0 cm wide. Shape of lamina elliptic, slightly asymmetrical. Apex (?acute), base not preserved. Margin toothed. Tooth apex acute, apical and basal sides of teeth convex or straight. Venation semicraspedodromous. Midvein straight. Secondaries curved, slightly irregular, depart at 50–60°. Fine intersecondaries irregular between secondaries. Tertiary veins percurrent.

Discussion. The leaf shape and teeth are comparable to those of some *Myrica* species, however, leaf ventation is different in the form of secondaries (depart steeper, more irregular). The systematic affinity of the leaf is uncertain.

***"Sapindus"* sp.** (foliage)

Fig. 22.7, 22.8

1988 *Sapindus* sp.; Hably, p. 45, pl. 10, fig. 5.

Material. Kesztölc.

Description. Leaf fragments. Length up to 5.1 cm, width 1.2 cm. Shape of lamina elongated elliptical. Apex acute, base cuneate. Margin entire. Venation camptodromous. Secondaries dense, depart at 60–70°, slightly curved, form loops near margin. Higher order venation not preserved.

Discussion. The leaves superficially resemble leaves of *Sapindus* L., however, the intersecondary veins regularly departing between secondaries in the latter are not observable in the fossil. Leaf morphology recalls rather leaves of Anacardiaceae species, but poor preservation does not allow a proper identification. The fossil-species was a rare element in the late Oligocene floras.

"Cedrela" macrophylla Andr. (foliage)

Fig. 23.4

1990 *Cedrela macrophylla* Andr.; Hably, p. 30, pl. 27, fig. 4.
1991 *Cedrela macrophylla* Andr.; Kvaček and Hably, p. 61, pl. 10, fig. 4.

Material. Eger Wind-brickyard (upper flora), Vértesszőlős.

Description. Large leaves. Length of lamina more than 10 cm, width more than 5 cm. Shape of lamina lanceolate. Apex acute, base not preserved. Margin entire. Venation camptodromous.

Discussion. A leaf form also often described as "*Juglans*" *acuminata* A.Braun ex Unger (Bůžek, 1971). It probably accumulates more biological species developing morphologically comparable leaves. It occurs at localities indicating wetland habitats, e.g. Wind-brickyard and Vértesszőlős.

"Daphne"* cf. *aquitanica
Ettingsh. (foliage)

Fig. 23.5

1994 *Daphne aquitanica* Ettingsh.; Hably, p. 22, pl. 22, figs 2, 3.

Material. Pomáz.

Description. Leaf petiolate. Petiole strong, length more than 0.2 cm, width 0.1 cm. Shape of lamina elongated obovate. Length of lamina 3.2 cm, width 0.5 cm. Apex obtuse, base decurrent. Margin entire. Venation camptodromous. Midvein strong. Secondary veins arise steeply at the upper half of lamina, at 30–40°, curved, fork near margin. Secondaries denser at the upper part of lamina.

Discussion. This leaf form is a very rare element in late Oligocene floras. Similar leaves were mentioned from Znojmo (Moravia; Knobloch, 1969), as well as from Abkhazia (Kodor; Kolakovski, 1964).

"Daphne" oeningensis
(A.Braun) em. Weyland (foliage)

Fig. 23.6

1994 *Daphne oeningensis* (A.Braun) em. Weyland; Hably, p. 22, pl. 22, fig. 5, text.-fig. 32.

Material. Pomáz.

Description. Leaf petiolate. Petiole strong, length more than 0.2 cm, width 0.1 cm. Length of lamina 3.2–4.4 cm, width 0.7–1.2 cm. Shape of lamina elongated obovate. Apex obtuse, base decurrent. Margin entire. Midvein strong, secondaries very thin, not visible.

Discussion. A rare leaf form occurring only in the flora of Pomáz. Similar leaves were described from the younger, late Early Miocene floras of Ipolytarnóc (Hably, 1985a) and Mecsek (Hably, 2020).

***Dicotylophyllum* sp. 1.** (foliage)

Figs 22.9–22.11, 23.1–23.3

1988 cf. *Castanopsis toscana* (Bandulska) Kräusel et Weyland; Hably, p. 41, pl. 8, figs 5, 6, pl. 9, fig. 1.
1994 cf. *Castanopsis toscana* (Bandulska) Kräusel et Weyland; Hably, p. 20, pl. 10, fig. 2.

Material. Kesztölc, Pomáz.

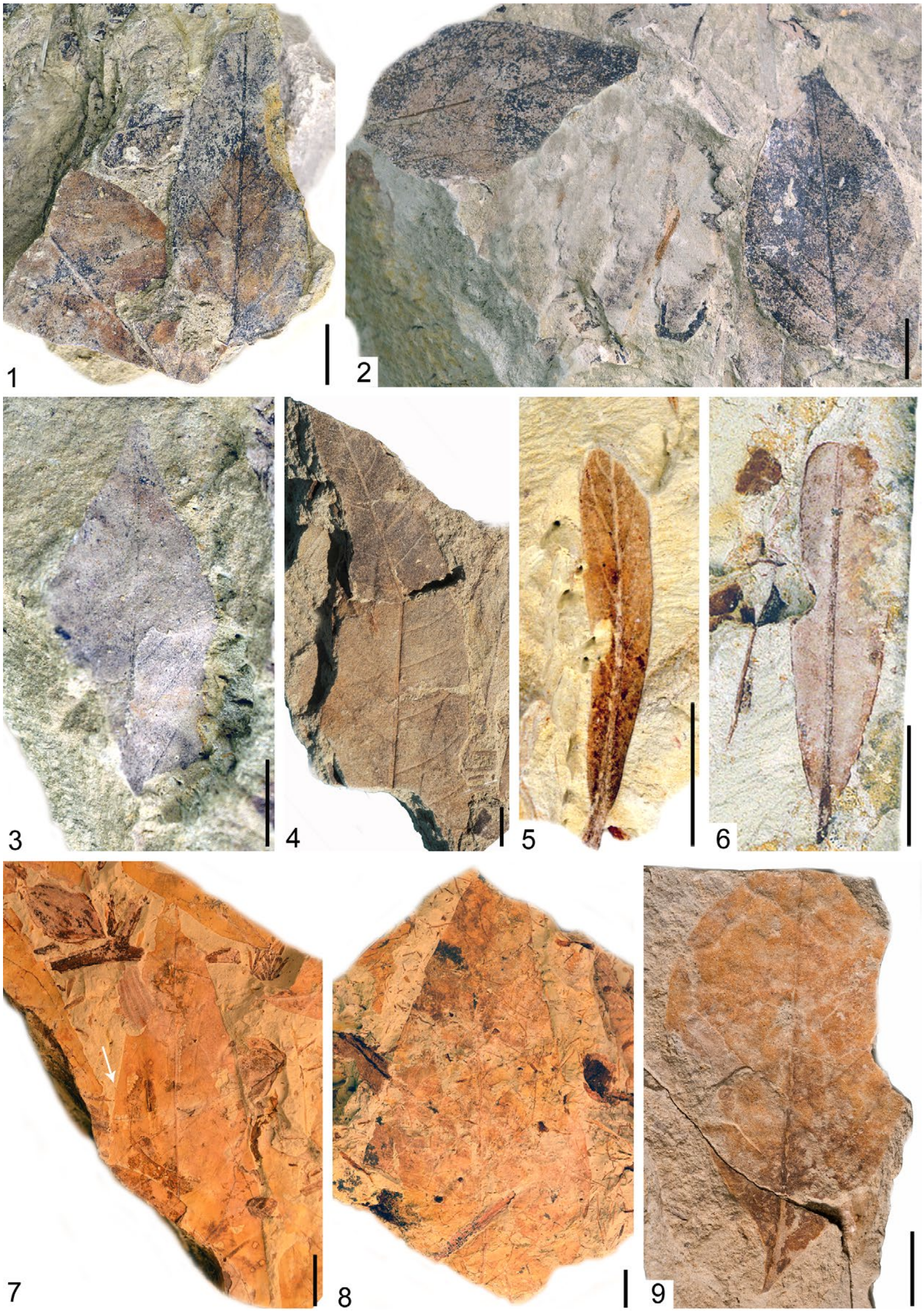

Figure 23. **1–3**. *Dicotylophyllum* sp. 1., Kesztölc, **1**. HNHM-PBO 85.340.1., **2**. HNHM-PBO 85.275.1., **3**. HNHM-PBO 85.282.1.; **4**. "*Cedrela*" *macrophylla* Andr., Vértesszőlős, Tata 76.123.1.; **5**. "*Daphne*" cf. *aquitanica* Ettingsh., Pomáz, HNHM-PBO 86.426.2.; **6**. "*Daphne*" *oeningensis* (A.Braun) em. Weyland, Pomáz, HNHM-PBO 86.425.1.; **7**, **8**. *Dicotylophyllum* sp. 2., Környe, **7**. HNHM-PBO 2009.195.1., arrow shows spinose tooth; **8**. HNHM-PBO 2009.243.1.; **9**. *Dicotylophyllum* sp. 3., Kesztölc, BK 1103. Scale bars = 1 cm

Description. Leaves fragmentary. Length of lamina up to 4.6 cm, width 2.5 cm. Shape of lamina ovate. Apex acute, base not preserved. Margin entire. Venation camptodromous. Midvein moderate. Secondary veins depart at 45–50°. Basal pair of secondary veins not parallel with other secondaries, departs at 40°. Higher order venation not preserved.

Discussion. These leaves were formerly described as cf. *Castanopsis toscana* (Hably, 1988, 1994) a synonym of *Trigonobalanopsis rhamnoides* (Rossm.) Kvaček et H.Walther (Fagaceae). With no cuticle preserved the systematic relation of the leaves is unclear.

***Dicotylophyllum* sp. 2.** (foliage)

Fig. 23.7, 23.8

2015 *Dicotylophyllum* sp.; Hably et al., p. 12, fig. 6(3).

Material. Környe.

Description. Leaves fragmented, upper half of lamina preserved. Length of fragments 8.4–13 cm, width 3.2–7 cm. Apex acute, base not preserved. Margin toothed. Teeth widely spaced, very tiny, thin, spinose. Major secondary veins brochidodromous. Midvein moderate, straight. Secondaries thin, curved upwards, depart at 70–80°. Higher order venation not preserved.

Discussion. Poor preservation does not allow the systematic identification of the leaves. The tiny teeth and venation type resemble those of "*Rhamnus*" *warthae*, however, lamina shape is quite different. It was a rare element of late Oligocene floras occurring with few specimens in only one locality. The large dimension of the leaves suggests wetland environment.

***Dicotylophyllum* sp. 3.** (foliage)

Fig. 23.9

1988 *Diospyros brachisepala* A.Braun sensu Hantke; Hably, p. 44, pl. 10, fig. 1.

1994 *Dicotylophyllum* sp. 2. ?*Diospyros*; Hably, p. 34, pl. 1, fig. 6.

Material. Kesztölc, Pomáz.

Description. Leaves shortly petiolate. Length of lamina 6.1–7.2 cm, width 3.4–3.8 cm. Shape of lamina ovate or obovate. Apex acute, rarely obtuse, base decurrent, slightly asymmetrical. Margin entire. Venation camptodromous. Secondaries arise at 50–60°, form loops near margin. Distance between secondaries variable. Tertiary veins thin.

Discussion. The leaves recall fossil leaves cited as *Diospyros* L. In the absence of cuticular details, however, it cannot be corroborated. A large number of similar leaves were recorded in the late Early Miocene flora of Ipolytarnóc (Hably, 1985a). The leaves might belong to the Leguminosae family.

***Dicotylophyllum* sp. 4.** (foliage)

Fig. 24.1, 24.2

Material. Pomáz.

Description. Leaves fragmented, petiole absent or not preserved. Shape of lamina wide ovate. Length of lamina 6.0–8.3 cm, width 2.3–4.0 cm. Apex not preserved, base decurrent. Margin finely serrate. Venation semicraspedodromous. Midvein strong. Secondaries arise at 70–80°. Intersecondaries between secondary veins. Secondary veins form loops close to margin. Tertiary venation dense, anastomosing.

Discussion. The leaves show similarity to leaves of some *Ilex* species but venation seems more regular and secondaries are more densely spaced than in *Ilex*.

***Carpolithes* sp.** (fruit)

Fig. 24.3–24.5

1994 "*Carpinus*" fructus; Hably, p. 34, pl. 21, figs 6, 7, text.-figs 30, 31

Material. Pomáz, Leányfalu.

Description. Winged fruit. Length of fruit 1–1.5 cm, width 0.5–0.7 cm. Wing lateral, length of wing 0.9–1.1 cm, width 0.5–0.7 cm. Shape of wing lanceolate. Apex acute rounded. Margin entire. Wing finely veined. Venation camptodromous /brochidodromous, midvein irregular, do not reach apex. Secondary veins depart irregularly from midvein. A strong secondary vein departs on one side at the apical third of wing. Fruit one-seeded. Nut length 0.3–0.5 cm, width 0.1–0.2 cm. Nut shape spindle-like, falcate or crescent.

Discusson. The fruits (nuts) of *Carpinus* L. are subtended by bracts, however, fruits of *Carpolithes* sp. seem to have wings laterally attached to the fruit. The wing displays a definite, brochidodromous type venation.

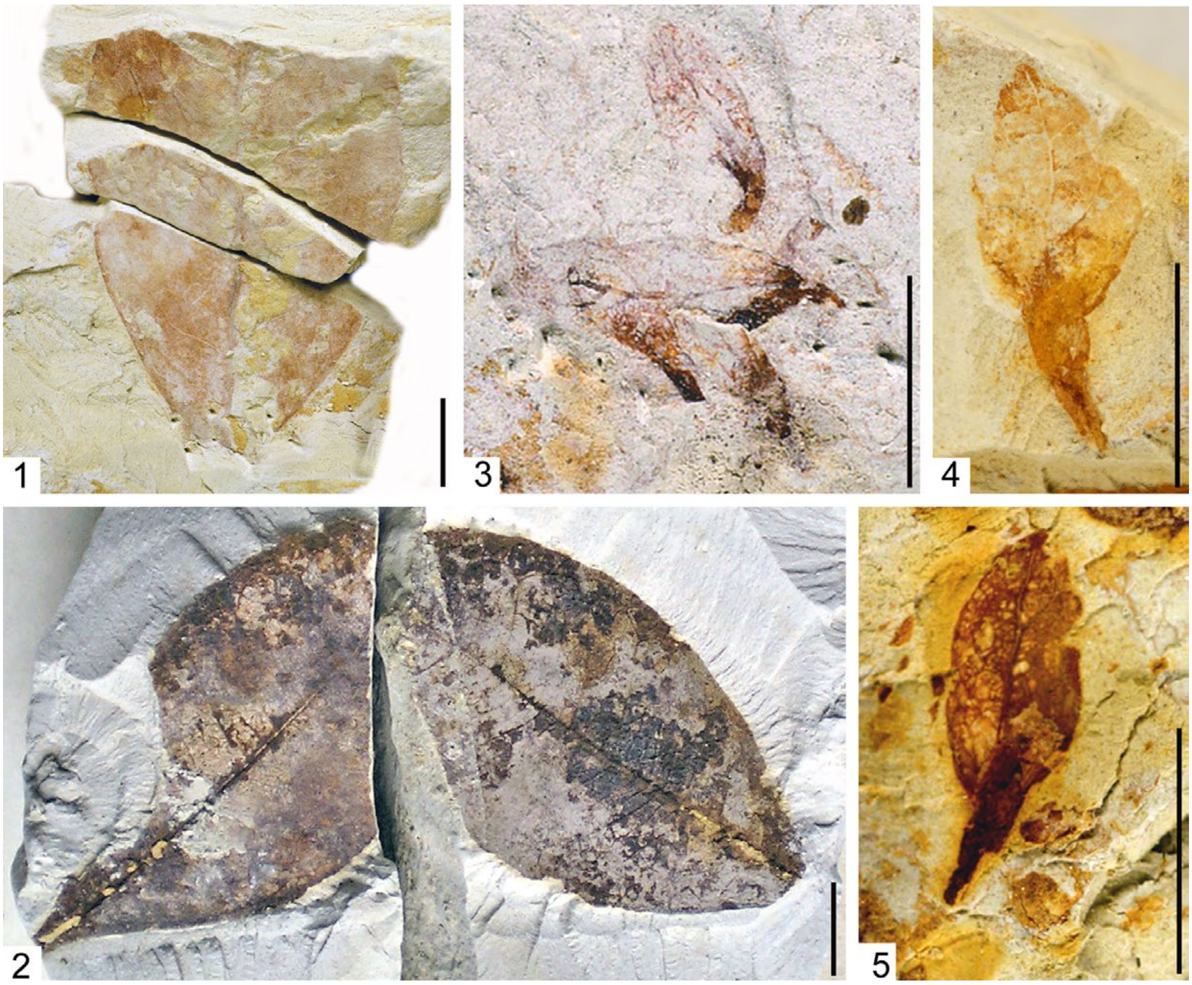

Figure 24. **1**, **2**. *Dicotylophyllum* sp. 4., Pomáz, **1**. HNHM-PBO 86.521.1., **2**. HNHM-PBO 86.520.1.; **3–5**. *Carpolithes* sp., Pomáz, **3**. HNHM-PBO 86.467.2., fruit, **4**. HNHM-PBO 86.557.2., fruit; **5**. HNHM-PBO 86.691.1., fruit. Scale bars = 1 cm

The involucres of *Carpinus* species are either toothed or entire margined and the bracts in the latter case are three lobed. Veins of toothed *Carpinus* bracts are craspedodromous and show no brochidodromous type venation. The elongated and crescent-like shape of *Carpolithes* sp. seeds differs from that of *Carpinus* seeds.

DISCUSSION

TAPHONOMICAL NOTES

At most of the late Oligocene localities, specimens have been poorly preserved in sandy layers or coarse-grained sediments of high sand content. The grain size of the sediments embedding fossils affects the fossilization of plant organs. The finer anatomical details of thin leaves or fruits are not or poorly preserved in coarse-grained sediments, whereas thick, coriaceous leaves may be relatively well preserved. Lauraceous leaves are frequently coriaceous, e.g. *Daphnogene cinnamomifolia* therefore these are abundant at nearly all the late Oligocene localities. The relationship between the grain size of sediments and the preservation of plant organs was tested by sedimentological analyses as well (Hably and Szakmány, 2006). The analyses suggested that sediments with at least 50% of the grains falling into the size category of 0.063 mm preserve most of the species with clear morphological details, allowing a proper identification of the remains. However, according to the study by Hably and Szakmány (2006), the ideal ratio would be 70 %. Increasing carbonate content causes increasingly poor preservation, which increases the number of taxa difficult to identify. Comparing taxonomic evaluation to the analyses of grain size and mineral content, certain sedimentary conditions for each taxon allowing its proper identification can be outlined. From this point of view, Pusztaberki and Rétság possess the worst sedimentological properties among late Oligocene localities.

Compared to a locality with sediments of the "ideal" grain size spectrum, only one-fifth of the flora is preserved. Consequently, low species number may just indicate poor conditions for fossilization and not an oligotypic flora.

The fossil flora of the Mány Member, Törökbálint Formation (formerly Mány Formation) – Környe, Tarján, Vértesszőlős

The fossil assemblages from Környe (Hably et al., 2015), Tarján (Hably et al., 2017), and Vértesszőlős (Hably, 1990) have been preserved in the sediments of the Mány Member of the Törökbálint Formation (formerly Mány Formation). The fossiliferous matrix is much more coarse-grained at Tarján and Vértesszőlős, than in Környe. These localities share some fossil-species, such as *Glyptostrobus europaeus*, *Daphnogene cinnamomifolia*, *Alnus oligocaenica*, however, many distinctive elements were recorded (Table 1). Floristic differences are partly due to taphonomic constraints, since in coarse-grained sediments some taxa are rather poorly preserved, lacking diagnostic traits (Hably and Szakmány, 2006). Some dominant taxa in the Vértesszőlős flora, such as *Ulmus pyramidalis*, *Platanus neptuni* and legume fruits, as well as some accessory elements, e.g. *Smilax* were not recorded from the Környe flora. Fossil-species of *Smilax* are extremely rare in the Hungarian late Oligocene floras, it was only described from Vértesszőlős (Hably, 1990) and Kesztölc (Hably, 1988). Interestingly, the occurrence of *Ulmus pyramidalis* and some legume pods seems to be "favoured" by coarse-grained sediments, e.g. in a nearby Oligocene locality, Oroszlány (Selmeczi and Hably, 2009) several legume pods were preserved in the coarse-grained sandstones of the heteropic Csatka Formation. Another example is the Early Miocene flora of Ipolytarnóc, in which *Ulmus pyramidalis* was recorded in high numbers, but exclusively from the coarse-grained sandstones, whereas the tuff flora is devoid of this taxon (Hably, 1985a).

The presence of legume pods and *Ulmus pyramidalis* in Vértesszőlős and the absence of these taxa in Környe may be explained in the same way. At the same time, *Pronephrium stiriacum* and the cones and seeds of *Glyptostrobus europaeus* are absent (only twigs occur) in Vértesszőlős probably also related to the coarse-grained sediments of this locality. Both floristic (e.g. the occurrence of *Ulmus pyramidalis*) and sedimentological features of the fossiliferous layers in Vértesszőlős suggest that due to the shallow water and probably fluviatile environment, riparian vegetation became dominant. It may be presumed that sedimentary successions of the Környe-Industrial Park locality were deposited in a lowland position and its fossil assemblage represents swamp vegetation. Additional sporadic outcrops of the Mány Member of the Törökbálint Formation are known from the Tarján road cut, which yielded only a low number of poorly preserved plant fossils. The flora comprises the dominant taxa of the Mány Member (Törökbálint Formation), i.e. *Daphnogene*, *Ulmus*, and Fabaceae (Hably, 1992a).

The fossil flora of the Kovačov Member, Törökbálint Formation – Verőcemaros, Kesztölc, Leányfalu, Nagysáp, Pomáz, Csörög, Rétság, Pusztaberki

Numerous plant fossil assemblages, some of them quite well known, were excavated from this sedimentary unit, such as Verőcemaros (Hably, 1982), Kesztölc (Hably, 1988), Nagysáp (Hably, 1989), Pomáz (Hably, 1992b, 1994), Csörög (Vitális and Zilahy, 1952; Hably, 1992a), Leányfalu, Pusztaberki, and Rétság. The latter three localities are published first in this study. Several taxa, mostly dominant, are shared by most of these localities, i.e. *Daphogene cinnamomifolia*, *Platanus neptuni*, *Engelhardia orsbergensis*, *E. macroptera*, *Ulmus pyramidalis,* and Fabaceae (Table 1). The floristic composition of these floras is apparently related to their former marginal or lowland position in the sedimentary basin. Among them the flora of Pomáz (Hably, 1992b, 1994) is the richest one, although its composition is basically similar to the others. The dominance of *Daphnogene cinnamomifolia*, *Laurophyllum*, *Platanus neptuni*, and Fabaceae (leaves and legume pods) remains is apparently observable. Taxa, characteristic of other late Oligocene floras, such as *Ulmus pyramidalis* and *Engelhardia orsbergensis*, are also present in the assemblage. Some other rare elements, possibly preserved due to the finer-grained matrix, are noteworthy, i.e. ?*Decodon* sp., *Rosa* sp., Theaceae, *Platanus neptuni* forma *fraxinifolia*, and *Carpolithes* sp. (fruit). The flora of Csörög comprises high numbers of *Engelhardia* remains, both leaves and fruits. The flora of

Table 1. Taxon lists of the late Oligocene floras of Hungary

Taxon	Andornaktállya	Csörög	Eger Wind-brickyard		Kesztölc	Környe	Leányfalu	Máriahalom	Nagysáp	Pomáz	Pusztaberki	Rétság	Tarján	Verőcemaros	Vértesszőlős
			Lower	Upper											
Equisetum sp. div.	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
?*Asplenium* sp.	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Pronephrium stiriacum	·	·	·	+	·	+	·	·	·	+	·	·	·	·	·
Blechnum dentatum	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Polypodiaceae gen. et sp. indet.	·	+	·	+	+	·	·	·	·	·	·	·	·	·	+
Pinus sp. 1.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Pinus sp. 2.	·	·	·	+	·	·	·	·	+	·	·	·	·	·	+
Pinus sp. div. (seed cones)	·	+	+	·	·	·	·	+	·	·	·	·	·	·	·
Tetraclinis sp.	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Tetraclinis sp. (cone)	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Glyptostrobus europaeus	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·
Taxodioideae gen. et sp. indet.	·	+	·	·	+	+	·	·	+	+	·	·	·	·	+
Quasisequoia couttsiae (cone)	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Sassafras lobatum	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Daphnogene cinnamomifolia	+	+	·	+	+	+	+	+	+	+	+	·	+	+	+
Daphnogene sp.	+	+	·	+	+	·	+	+	+	+	+	+	+	·	+
Laurophyllum sp. div.	+	+	+	+	+	·	+	·	+	+	·	+	+	·	+
Berberis andreanszkyi	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Platanus neptuni	+	+	·	+	+	·	+	·	+	+	+	+	+	+	+
Platanus neptuni forma *fraxinifolia*	·	·	·	+	+	·	·	·	+	+	·	·	·	+	·
Tetracentron agriense	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Sloanea sp. (fruit)	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
"*Acacia*" *parschlugiana*	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
"*Colutea*" *kvacekii*	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
"*Cassia*" aff. *hyperborea*	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
Leguminophyllum sp.	·	·	+	+	·	·	·	+	+	+	·	·	·	·	+
Leguminocarpon sp. div. (fruit)	+	·	?+	+	+	·	·	·	·	+	·	·	·	·	+
Rosa lignitum	·	·	·	+	·	·	·	·	·	+	·	·	·	·	+
Ulmus pyramidalis	+	+	·	+	+	·	+	·	+	+	+	·	+	·	+
Ulmus pseudopyramidalis	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Ulmus cf. *fischeri*	·	·	·	+	·	·	·	·	·	·	·	·	·	+	·
Ulmus braunii	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
Ulmus sp.	·	·	·	+	+	·	·	·	·	·	+	+	·	·	·
?*Zelkova zelkovifolia*	·	·	·	+	+	·	·	·	·	·	·	·	·	·	+
?*Decodon* sp.	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
Quercus sp. div.	·	·	·	·	·	·	·	+	·	·	·	·	·	·	+
Myrica longifolia	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·
Myrica lignitum	+	·	·	+	·	·	·	·	·	·	·	·	·	+	+
Comptonia dryandroides	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
?*Comptonia* sp.	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Engelhardia orsbergensis	+	+	+	+	+	·	·	·	·	+	+	·	+	·	·
Engelhardia macroptera (fruit)	·	+	·	+	·	·	·	·	·	+	·	·	·	·	·
Alnus oligocaenica	·	·	·	+	·	+	+	·	+	·	·	·	+	·	+
Alnus sp. (infrutescence)	·	·	·	+	·	+	·	+	·	·	+	·	·	·	·
Alnus sp.	·	·	·	·	+	·	·	·	·	·	+	·	·	·	+
Acer hungaricum	·	+	·	+	·	·	·	·	·	·	·	·	·	·	+
Acer sp.	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Acer sp. div (fruits)	·	·	·	+	·	·	·	·	·	·	·	·	·	+	·
cf. *Acer* sp. (fruit)	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
"*Kydia*" *kraeuselii*	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·

Table 1. Continued

Taxon	Andornaktállya	Csörög	Eger Wind-brickyard		Kesztölc	Környe	Leányfalu	Máriahalom	Nagysáp	Pomáz	Pusztaberki	Rétság	Tarján	Verőcemaros	Vértesszőlős
			Lower	Upper											
?Malvaceae gen. et sp. indet.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
cf. *Nyssa* sp.	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·
cf. *Nyssa* sp. (fruit)	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·
Cornaceae vel Rhamnaceae	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
cf. Theaceae gen. et sp. indet.	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
?*Ilex andreanszkyi*	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Smilax weberi	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·
Smilax tataensis	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Sabalites sp.	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Phoenicites sp.	·	·	·	+	·	·	·	·	·	·	·	·	·	+	·
Amesoneuron sp.	·	+	·	+	+	·	·	·	·	·	·	·	·	+	·
Tuzsonia hungarica (inflorescence)	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·
?Arecaceae gen. et sp. indet. (inflorescence)	+	·	·	·	·	·	·	·	·	·	+	·	·	·	·
?Arecaceae gen. et sp. indet. (stem)	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Monocotyledoneae gen. et sp. indet.	·	·	·	+	·	+	+	+	·	+	+	·	+	·	·
"*Rhamnus*" *warthae*	+	·	+	+	+	+	·	·	+	·	+	·	·	·	·
"*Talauma*" *egerensis*	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
?*Debeya hungarica*	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+
?"*Quercus*" *rhenana*	·	·	·	+	·	+	·	·	·	+	·	·	·	·	·
"*Myrica*" *hakeaefolia*	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
cf. "*Myrica*" *palaeogale*	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
"*Sapindus*" sp.	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
"*Cedrela*" *macrophylla*	·	·	·	+	·	·	·	·	·	·	·	·	·	·	+
"*Daphne*" cf. *aquitanica*	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
"*Daphne*" *oeningensis*	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
Dicotylophyllum sp. 1.	·	·	·	·	+	·	·	·	·	+	·	·	·	·	·
Dicotylophyllum sp. 2.	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·
Dicotylophyllum sp. 3.	·	·	·	·	+	·	·	·	·	+	·	·	·	·	·
Dicotylophyllum sp. 4.	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
Carpolithes sp.	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·

Nagysáp (Hably, 1989) is also a typical late Oligocene flora with the dominance of *Daphnogene*, but additional taxa, such as *Platanus neptuni*, *P. neptuni* forma *fraxinifolia*, *Ulmus pyramidalis*, *Alnus oligocaenica*, and the swamp element, "*Rhamnus*" *warthae* are also present.

The fossil flora of the Solymár Member, Törökbálint Formation – Máriahalom

Poorly preserved plants have been preserved in the upper Oligocene sediments of Máriahalom. The fossiliferous matrix is coarse-grained sandstone, thus, the preservation of only few taxa allows for identification, i.e., *Pinus* sp. cone, *Daphnogene cinnamomifolia, Daphnogene* sp., *Quercus* sp., Fabaceae, *Alnus* sp. (female infrutescence), Monocotyledoneae (Table 1). The average grain size of the sediments apparently delimited the preservation of plant remains in this locality and only those with resistant leaf structure or cones have been fossilized (Hably and Szakmány, 2006).

The fossil flora of the Eger Formation – Wind-brickyard; Andornaktálya member – Andornaktálya

The sediments of the well-known Wind-brickyard, which represent the stratotype section of the Egerian stage, yielded a swamp assemblage (Andreánszky, 1966; Kvaček and Hably, 1991), quite similar to the flora at Környe, the species of which are all shared by the Wind-brickyard assemblage, i.e. *Pronephrium stiriacum*, Taxodioideae, "*Rhamnus*" *warthae*, *Daphnogene cinnamomifolia*, *Alnus oligocaenica*, "*Quercus*" *rhenana* (Table 1). However, the flora of the Wind-brickyard is much more diverse, in which the upper level flora is presumably the youngest member of the Eger Formation. In this level many taxa are quite frequent, e.g. ferns, *Daphnogene cinnamomifolia, Acer hungaricum,* "*Rhamnus*" *warthae*, *Ulmus pyramidalis, Ulmus pseudopyramydalis, Comptonia dryandroides, Myrica longifolia, Leguminocarpon* sp. The richness of the Wind-brickyard flora may be attributable to the fine grain size of the clayey sediments and the huge extension of the fossiliferous sediments in many levels. The lower level flora, which is of older Egerian, is less diverse, with the subordinate role of ferns, Lauraceae, Myricaceae, *Engelhardia*, and legumes. The lower diversity may also be attributable to the much smaller number of specimens of the assemblage compared to the size of the upper flora. Important elements are a potential palm inflorescence and a leaf of "*Rhamnus*" *warthae* supporting the assignment of these layers to the late Oligocene. The occurrence of the putatively malvaceous "*Kydia*" leaves having no records in other floras is noteworthy as differentiating this flora from the other late Oligocene floras. Members of Taxodioideae, *Platanus neptuni*, *Ulmus*, *Alnus*, and *Acer* are all missing from the lower flora of the Wind-brickyard.

The flora of Andornaktálya (Hably, 1993a) is a small assemblage comprising the characteristic, mostly wetland taxa of the late Oligocene, e.g. *Daphnogene cinnamomifolia, Laurophyllum* div. sp., *Platanus neptuni*, *Leguminocarpon* div. sp., and *Ulmus pyramidalis*.

LATE OLIGOCENE FOSSIL FLORA AND VEGETATION IN HUNGARY

The fossil flora of the late Oligocene (late Kiscellian – early Egerian) of Hungary shows a diverse picture, ferns, gymnosperms, and angiosperms are all represented in the assemblages with varying diversity (Table 1). Ferns include the families Equisetaceae, Blechnaceae, Aspleniaceae, Thelypteridaceae, and Polypodiaceae. The most frequent fern is *Pronephrium stiriacum* (Thelypteridaceae), which was recorded in the floras of the Wind-brickyard, Környe, and Pomáz. Among gymnosperms the *Pinus* genus of the Pinaceae family provided a high number of fossils, mainly cones.

The Cupressaceae family proved to be quite diverse in the late Oligocene floras, with the genera *Glyptostrobus, Quasisequoia, Tetraclinis*, and high number of leafy shoots representing the Taxodioideae subfamily. *Glyptostrobus* and other remains of Taxodioideae must have characterized mainly swamps and coalswamps in Csörög, Wind-brickyard, Kesztölc, Környe, Nagysáp, Pomáz, and Vértesszőlős.

The most populous group was the angiosperms, first of all with dicots. The Lauraceae family, mainly with *Daphnogene* and *Laurophyllum* div. sp., was a dominant member of late Oligocene floras. Except for Rétság, its species turned up at all the localities, usually dominating the floras. In Rétság, the lack of lauraceous fossils may be explained by the highly coarse-grained sediments and the low number of fossil remains. A deciduous member of the Lauraceae family, *Sassafras lobatum*, was recorded from a single locality, the Wind-brickyard.

The fossil-species *Platanus neptuni* (Platanaceae), characteristic of the Oligocene floras of Europe, is one of the most frequent elements of Hungarian late Oligocene floras. Data on the fossil-species is missing at merely two localities, Környe and Máriahalom. The former is definitely a flora of wetland habitats (swamp) and the latter has coarse-grained sedimentary matrix, which may explain the absence of the fossil-species in these floras. One fossil-species of the Rosaceae family, *Rosa lignitum*, appeared as a rare element at three localities, in fine-grained sediments. The family Fagaceae was recorded with leaves assigned to the genus *Quercus*, but in several cases the systematic affinity of these remains is uncertain. The fossil leaves of ?*Decodon* sp. in the Pomáz flora may support the presence of wetlands. The Trochodendraceae family is present with one fossil-species of *Tetracentron* at the locality of Wind-brickyard. The *Sloanea* genus of the family Elaeocarpaceae, which was a frequent element of early Oligocene floras, has only scarce fossil record in the late Oligocene, a sole fruit fragment in Vértesszőlős. The Fabaceae family is much more diverse, besides "*Acacia*" *parschlugiana*, numerous leaflets turned up belonging to diverse genera. Legume diversity is corroborated by the high variety of legume pods at the localities of Andornaktálya, Wind-brickyard, Kesztölc, Pomáz, and Vértesszőlős. Moreover, these occur in high numbers at some of the localities, e.g.

Wind-brickyard and Pomáz. An even higher share of the legumes, nearly 50% of the fossil specimens, was recorded at the somewhat older locality near Oroszlány (Selmeczi and Hably, 2009). This may have taphonomical reasons as well, but the high ratio of legumes is unambiguous in the younger Oligocene. The Juglandaceae family is well represented, first of all with the genus *Egelhardia*. Leaflets of *E. orsbergensis* were recorded at the localities Andornaknaktálya, Csörög, Wind-brickyard, Kesztölc, Pomáz, Pusztaberki, and Tarján. Fruit remains of *E. macroptera*, were found in Csörög, Wind-brickyard, and Pomáz. In some of the floras, e.g., Csörög, the fossil-species occurs in a high number, with both fruit and leaf remains. The family Ulmaceae is also a dominant member of the late Oligocene floras, first of all with various fossil-species of the genus *Ulmus*, i.e., *U. pyramidalis, U. pseudopyramidalis, U. fischeri,* and *U. braunii*. Among them the most widespread fossil-species was *U. pyramidalis*, which was present at most of the localities, often as a frequent element. The fossil-species *Zelkova zelkovifolia*, a well-known member of Hungarian Miocene floras, is also present, but as a rare element in the floras of the Wind-brickyard, Kesztölc, Verőcemaros, and Vértesszőlős.

The Myricaceae family was present with several fossil-species, among which *M. lignitum* was the most widespread. Other fossil-species of *Myrica* turned up only as scattered, rare elements in the floras. It is noteworthy that *M. longifolia* and *Comptonia dryandroides* were dominant species in the rich wetland assemblage of the Wind-brickyard. The family Betulaceae was present with the genus *Alnus*. The fossil-species *A.oligocaenica* was present, but relatively rarery, in the floras of the Wind-brickyard, Leányfalu, Nagysáp, Tarján, and Vérteszőlős. Other alder fossils – leaves and female infrutescences, were recorded at numerous other localities. In this way, the genus turned up at nearly all the localities. The Malvaceae and Theaceae families are subordinate in the floras with a low number of specimens. Some remarkable, malvaceous specimens assigned putatively to the genus "*Kydia*" turned up in the lower flora of the Wind-brickyard locality. The Nyssaceae family was recorded with few remains of the genus *Nyssa*. The presumed occurrence of both vegetative and reproductive organs of *Nyssa* is noteworthy, since as a member of mastixioid floras it indicates a thermophilous flora and vegetation. The Berberidaceae family was represented with a single fossil-species, *B. andreanszkyi*, in the flora of the Wind-brickyard. Similarly, the Aquifoliaceae family was recorded with a single fossil-species, ?*Ilex andreanszkyi*, also at the Wind-brickyard. Among monocots, *Smilax weberi* (Smilacaceae) was documented as a rare element at the Wind-brickyard, Kesztölc, and Vértesszőlős.

The presence and diversity of palms are noteworthy. Most of the palm remains, both leaves and possible inflorescences, i.e., *Sabalites, Phoenicites,* and *Tuzsonia*, are recorded at the Wind-brickyard, both in the upper and lower floras. Palms also occurred in the floras of Nagysáp, Csörög, Kesztölc, and Verőcemaros.

Many taxa were documented that have uncertain systematic affinity. Some of them even predominated or were quite frequent elements in the floras. One of the most important "incertae sedis" taxa is "*Rhamnus*" *warthae*, which had numerous leaves at the fossil floras of Andornaktálya, Wind-brickyard, Kesztölc, Környe, Nagysáp, and Pusztaberki. In most of these floras the taxon was relatively rare, but in the flora of the Wind-brickyard it was dominant, similarly to the late Oliogcene flora of the Zsil Valley (Transylvania, Romania; Staub, 1887), or the flora of Petrusany (Petrozsény, Transylvania, Romania), though here with a smaller number of specimens (Hably, 2001). Its appearance in the lower flora of the Wind-brickyard supports a late Oligocene age of these layers. The fossil-species "*Rhamnus*" *warthae* was an endemic element of swamp habitats during the late Oligocene of the Inner Carpathian Region (Hably, 2001). Another species of unknown systematics is the extinct fossil-species, ?*Debeya hungarica,* which turned up with a high number of specimens in the flora of Verőcemaros. It was presumably an endemic and thermophilous element of Hungarian late Oligocene floras. Numerous taxa with uncertain systematics were documented from the Late Oligocene floras, many of which are potentially endemic elements, e.g., *Carpolithes* sp. (Pomáz) and "*Talauma*" *egerensis* (Wind-brickyard).

Based on the rich floristic information on the localities, some localities seem to reflect the azonal wetland vegetation, i.e. swamp (Wind-brickyard, Környe, partly Vértesszőlős) and riparian vegtation. At some localities, elements of both the zonal and azonal vegetation are documented, e.g. Vértesszőlős. Elements of the riparian vegetation often co-occur with members of the swamp or zonal vegetation. At most of the localities representing dominantly the zonal vegetation, wetland elements also appear, although rather subordinately, e.g. Pomáz, which may be attributed to the remote location of the swamp vegetation from the depositional basin. The presence of wetland vegetation can easily be interpreted with alternating shallow marine and brackish inundations formed by cyclic sedimentation. There is a high frequency of arboreal species indicating extended thermophilous forests during the late Oligocene. Fossil-species of *Daphnogene cinnamomifolia, Laurophyllum* sp., *Platanus neptuni, Engelhardia orsbergensis, Leguminocarpon* sp., Fabaceae, palms, and *Pinus* played an important role in these forests as dominant elements. In wetland (e.g. riparian) areas *Ulmus* (*U. pyramidalis*) may have participated in forming the vegetation. In swamps cupressaceous species frequently occurred, e.g. *Glyptostrobus europaeus* and other taxodiaceous taxa. Angiosperms, e.g., "*Rhamnus*" *warthae, Alnus,* and *Myrica*, were also significant elements of this vegetation. At some localities other swamp elements appeared, e.g., *Comptonia dryandroides, Acer hungaricum,* and *Nyssa*. Lianas were also part of the landscape with fossil-species of *Smilax* and possibly palms, which suggests lush vegetation.

COMPARISON OF THE LATE OLIGOCENE FLORAS OF HUNGARY AND EUROPE

The flora and vegetation of the Boreal Province occupying areas north of the Alpine-Carpathian orogenic system were influenced by the North Sea and the northern territories. The Paratethys Province, which the area of Hungary belonged to, occupied the Alpine-Carpathian-Pannonian region (Kvaček and Walther, 2001). The flora and vegetation of the two provinces had been distinct already in the Eocene and differences persisted even during the Oligocene. The flora of the Boreal Province was characterized by the frequent occurrence of deciduous broadleaved elements by the early Oligocene, e.g. fossil-species of *Alnus, Populus, Carya* Nutt., *Carpinus, Ulmus, Liquidambar* L., and *Acer*, clearly evidenced by the flora of Haselbach. These elements, which were formerly defined as "Arctotertiary elements", became frequent and abundant by the Neogene. In the Paratethys Province, however, the temperate deciduous floristic elements appeared much later, during the late Oligocene–Early Miocene, some of them even later, only in the Middle Miocene. The coeval North Bohemian and German floras belonging to the Boreal Province are quite distinct from Hungarian late Oligocene floras, although some species are shared. In the Paratethys Province late Oligocene floras are dominated by termophilous elements, evidenced by floras of Hungary and also Austria, e.g., flora of Linz (Kovar-Eder, 1982). In the latter flora, beside the frequently occurring aquatic plant species and gymnosperms, the high percentage of the fossil-species of *Daphnogene*, *Laurophyllum*, *Platanus neptuni*, and *Engelhardia orsbergensis*, accompanied by fossil-species of palms and *Smilax* was recorded. The swamp vegetation was partly composed of *Myrica lignitum* and *Comptonia acutiloba*. The frequent fossil-species of Central European Neogene floras, *Zelkova zelkovifolia* appeared only as a rare accessory element. Some characteristic fossil-species of boreal floras, e.g. *Fagus attenuata* Göpp. and *Alnus feroniae* (Unger) Czeczott, are missing from the late Oligocene (and also younger) floras of Hungary. The Hungarian late Oligocene floras are most comparable with the coeval floras of Transylvania (Romania) belonging also to the Alpine-Carpathian-Pannonian region and the same tectonic unit. One of the most well-known floras was described from the Zsil Valley in Transylvania (Staub, 1887; Givulescu, 1973). Thermophilous, lauraceous taxa, mainly fossil-species of *Daphnogene* and *Leguminophyllum* are dominating the flora. A similarity with the Hungarian late Oligocene floras is also supported by the occurrence of *Smilax*, *Alnus oligocaenica*, *Ulmus pyramidalis*, *Acer* and fossil-species of palms.

An important shared element is "*Rhamnus*" *warthae*, which appeared exclusively in the Oligocene floras of the Intra-Carpathian area of the Central Paratethyan region suggesting an endemic fossil-species (Hably, 2001).

CLIMATE OF THE INTRA-CARPATHIAN AREA DURING THE LATE OLIGOCENE

The change in climate conditions through the Paleogene in the studied area may be reflected by the diversity change of floras, a decline in the species richness of the broad-leaved evergreen vegetation (Utescher et al., 2021).

Although the proportion of the putatively azonal taxa is relatively high, most taxa indicate potential climate conditions. The floristic composition of the Intra-Carpathian late Oligocene floras, including the high proportion of lauraceous elements, the occurrence of taxodiaceous taxa, the numerous palm remains, and other definitely thermophilous taxa, e.g. *Engelhardia* and *Sloanea*, suggests a warm frostless climate. The lauraceous genera, e.g. *Daphnogene* and *Laurophyllum* can be considered subtropical elements, and similarly, *Nyssa* and *Glyptostrobus* are also members of the subtropical wetlands. The modern populations of *Glyptostrobus pensilis* are growing in areas with tropical monsoon climate in Vietnam characterized by a mean annual temperature of 20 to 23°C and an annual rainfall of 1300 to 1800 mm (LePage, 2007). However, LePage (2007) warns to use these data as a straightforward reference for the climatic requirements of the fossil-taxa based on the much larger distribution of *Glyptostrobus* during the Palaeogene and Neogene as compared to its present-day area. Nevertheless, we think that considering the accompanying flora the climate was unequivocally frostless subtropical. A habitat with abundant water supply, i.e. swamp, may be reconstructed in a warm and humid environment. Adopting the Coexistence Approach method climate variables were calculated for several late Oligocene floras in Hungary (Erdei and Bruch, 2004; Erdei et al., 2007). Omitting the lower and upper extreme values (in brackets), mean annual temperature and mean annual precipitation were outlined as (13.3) 15.6–18.8 (20.5)°C and 823–1294 mm, respectively.

TEMPERATE ELEMENTS IN LATE OLIGOCENE FLORAS

As a response for the complex climatic and ecological changes of the Paleogene period, the vegetation dynamics of Europe is mostly outlined as the gradual replacement of the thermophilous, dominantly evergreen forest types characteristic of the early Paleogene with temperate, mainly deciduous vegetation (Walther, 1994). This floristic transition took place from the late Eocene through the late Oligocene, however, was not uniform (Kvaček and Walther, 2001; Erdei et al., 2012). Temperate elements appeared in the Intra-Carpathian area of the Central Paratethyan region during the late Oligocene. Taxa regarded as temperate elements are species of the genera *Ulmus, Alnus,* and *Acer*, which mostly occurred in the vegetation of wetlands, in swamps or riparian areas. At the same time, both the dominant and frequently occurring species are thermophilous, e.g. various lauraceous taxa (*Daphnogene, Laurophyllum, Sassafras*), *Platanus neptuni, Engelhardia,* arboreal members of Fagaceae*, Mastixia, Berberis, Ilex, Smilax,* and palms. The species of the wetland vegetation also suggest warm climate conditions, e.g. *Myrica, Comptonia,* cf. *Nyssa, Glyptostrobus,* and *Quasisequoia*. The appearance of temperate elements may not be interpreted solely with the deterioration of climate since thermophilous elements are also present with high diversity. The temperate elements may have flourished in edaphically influenced, mainly riparian habitats, which suggests that their appearance may have been related to the establishment of new ecological niches in the region (Hably, 1989) or to the better adaptability of these species to a quickly changing disturbed environment.

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