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The Late Miocene Flora of Hungary

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Introduction

Investigation of the Hungarian Late Miocene floras started as late as the mid-20th century. This was partly due to the fact that Late Neogene and Quaternary sediments were often unexposed and geological age determinations were still imprecise or missing at all. The sporadic occurrence of the often poorly preserved fossil remains provided a rather incomplete fossil spectrum that was not suitable for a detailed flora and vegetation reconstruction. The intense collecting activities through the past decades and higher stratigraphic resolution of the Upper Miocene sedimentary structures achieved by recent geological research provided the basis for a detailed analysis of the late Miocene flora and vegetation and climatic implications in the form of a monograph.

In addition to the significant collections compiled recently, all the relevant, already existing fossil plant collections served as a basis for the study, i.e. collections stored in the Hungarian Natural History Museum (BP), Hungarian Geological and Geophysical Institute (BK), Savaria Museum (SAMU), Mátra Museum (MM) and Bakony Museum (ZIRC) housing altogether nearly ten thousand relevant specimens. The majority of the specimens are inventoried; inventory numbers and the official acronyms of collections are indicated respectively: BP, BK, SAMU, MM, ZIRC.

Nearly 90% of the collections discussed by the current study have not been subjected to scientific studies formerly. Thus, most of the taxonomical work was accomplished in the scope of this monograph whereas the relatively few number of specimens identified earlier were reinvestigated. The low number of the previously studied and identified specimens in the collections is even more conspicuous if the high number of publications based on these specimens is taken into account (see Historical survey). These works are frequently based on a single or a couple of specimens and often provide lists of taxa without proper documentation. The taxa listed in this way, without any reference of figures or inventory numbers are unidentifiable in the collections and these required reinvestigation.

The monograph is divided into a geological introduction and a systematic part, which gives a documentation of the plant taxa occurring at the late Miocene localities. Since several taxa are shared by the localities and it would be effluent to repeat them, just one description is given in the systematic part. Therefore, in chapter "Localities" the flora lists are given to the geological descriptions followed by flora, vegetation and environment reconstructions. In addition to the significant assemblages individual findings are also reported in order to have a more complete spectrum of plant life during this time slice. Documentation by means of figures forms essential part of palaeontological monographs. Taxa are documented mainly by photos; however in several cases drawings help a better recognition of the fossils.

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I express my thanks to the Wienerberger Zrt. for providing access to its mine in Balatonszentgyörgy and helping collecting activities through years.

I am grateful to my family, György Szakmány, Csaba Szakmány and Melinda Szakmányné Rákóczi for taking part in field work and to private collectors who provided access to their collections. I say my special thanks to Imre Magyar (Budapest) for suggestions and valuable information of age determinations of the localities and to Antónia Veresné Prohászka for the nice graphic illustrations of the reconstructed flora and vegetation. Furthermore I am grateful to István Rácz for taking photos of the fossil material and to Zoltán Lantos for taking pictures of the fossils from Balatonszentgyőrgy stored in the collections of MFGI.

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Historical overview

The high number of references found during the complete survey of the Hungarian palaeobotanical literature, contain only few thorough floristic analyses. Most works just report sporadic findings or remains that are mentioned during the survey of a taxon.

The erliest report of Pannonian fossil plants documented remains from Kőszeg – Pogány Valley (Hoffmann 1932), but unfortunatelly this material has been lost. Later, during the 1950s numerous authors published their studies based on various Pannonian localities, i.e. Kerecsend (Andreánszky 1952), Rózsaszentmárton-Petőfibánya (Pálfalvy 1952, 1965c, 1981; Vörös 1955), various localities from the Transdanubian region, Szombathely - Hungaria brickyard (Horváth 1958), Sótony (Horváth 1958, 1961, 1963), borehole Szilágy–III. (Cziffery-Szilágyi 1964), Kemenesmihályfa (Horváth 1964), Répcevis, Gersekarát, Hegyhátszentpéter, Hidegség, Olaszfa, Sé, Szeleste, Szombathely, Teskánd, Tömörd (Horváth 1971–72). Unfortunatelly, the collections published comprise extremely low number of specimens, and do not represent properly the former flora and vegetation. From Rudabánya (Nagy & Pálfalvy 1961, Kretzoi et al. 1974; Pálfalvy 1980, 1981) and Balatonszentgyörgy (Pálfalvy 1975) Pálfalvy published floristic lists, which provided neither illustrations nor inventory numbers of the fossil specimens studied. Consequently, these collections required reinvestigation. Based on the flora of Bükkábrány (László 1989, 1992; Wójcicki & Bajzáth 1997; Erdei et al. 2009; Erdei & Magyar 2011), and Visonta (László 1989, Bůžek & László 1992) thorough investigations were published with important systematic and floristic results. These studies were focussed on fruit and seed remains as well as wood anatomical structures. Important boreholes were deepened in both the western and eastern parts of Hungary, namely Iharosberény (Hably 1992c), and borehole Tiszapalkonya–I. (Hably 1992c), which unearthed Pannonian layers even from several hundred metres deep below the surface. The fossil assemblage from Tihany-Fehérpart (Hably 1992a) provided the first evidence of riparian forests in the Pannonian Basin. The thorough study of the flora from Dozmat (Hably & Kovar-Eder 1996) gives a detailed account of the typical Pannonian swamp forest.

The collectors of the earlier and newly recovered collections in alphabetical order are as follows: Bauer Norbert (Diszel - Kula Hill), Cziffery Gabriella (Felsőtárkány), Cseh Győző (Cserszegtomaj), Csillag Gábor (Alcsút), Dornyay Béla (Hévíz), Erdei Boglárka (Rudabánya), Futó János (Diszel - Kula Hill), Hably Lilla (Alcsút, Balatonszentgyörgy, Karmacs, Tihany-Fehérpart), Hír János (Felsőtárkány), Horváth Ernő (Dozmat, Győr-Sashegy, Hosszúpereszteg, Sótony, Kemenesmihályfa, Kerecsend, Répcevis, Gersekarát, Hegyhátszentpéter, Hidegség, Olaszfa, Sé, Szeleste, Szombathely, Teskánd, Tömörd), Jámbor Áron (Iharosberény, Tiszapalkonya), Lantos Zoltán (Alcsút), László József (Bükkábrány, Visonta), Magyar Imre (Diszel-Hajagos, Mindszentkálla, Pécs-Nagyárpád), Müller Pál (Pécs-Nagyárpád, Tihany-Fehérpart), Pálfalvy István (Balatonszentgyörgy, Bükkábrány, Rudabánya, Visonta), Sebe Krisztina (Pécs-Danitzpuszta), Selmeczi Ildikó (Alcsút), Szakmány Csaba (Balatonszentgyörgy, Karmacs), Szakmány György (Balatonszentgyörgy, Karmacs), Szakmányné Rákóczi Melinda (Balatonszentgyörgy), Szántó András (Karmacs), Szónoky Miklós (Pécs-Nagyárpád, Tihany-Fehérpart).

Based on photos there existed some small collections which are presumably stored by private collectors — therefore these are not included in this monograph.

Geological background
by Imre Magyar

The Upper Miocene of Hungary — an introduction

The Upper Miocene sedimentary sequence of Hungary, and that of the entire Pannonian Basin, was deposited in Lake Pannon and in adjacent deltaic, fluvial, and — subordinately — terrestrial environments. The lake's basin is a Neogene extensional feature located in the Central European segment of the convergence zone between the European and African plates. The basin experienced a highly complex deformation history (HORVÁTH et al. 2006). Extension, starting in the Early Miocene and culminating in the Middle Miocene, was heterogeneous and created irregular basement morphology. Thinning of the lithosphere caused subsidence starting from the late Middle Miocene or early Late Miocene. This latter process affected almost the entire area between the Alps, Carpathians, and Dinarides, and led to the formation of the geographically uniform and hydrographically closed Pannonian Basin.

During the Early and Middle Miocene the basin was part of the Central Paratethys, with repeatedly opening and closing aquatic connections towards the Mediterranean and the Eastern Paratethys (POPOV et al. 2004). Marine gateways, however, eventually closed by the Late Miocene (TER BORGH et al. 2013). The enclosed brackish water body of the Pannonian Basin is designated Lake Pannon. It existed with continuously changing shoreline and surface area from the beginning of the Late Miocene until ca. the beginning of the Late Pliocene (MAGYAR et al. 1999).

Sedimentation in Lake Pannon took place in several hundred metres deep water in the basin proper and in its slopes, and in a few tens of metre deep water in the shelfal region (SZTANÓ et al. 2013a). River deltas, prograding across the extended shelf of Lake Pannon, created a variety of shallow water environments (SZTANÓ et al. 2013b). The plant remnants discussed in this monograph were buried into the sediments in shallow water, near-shore parts of the lake, in the shoreface or in the shallow sublittoral zone, in interdistributary bays, lagoons, ponds of the delta plain, or in fluvial channels and floodplains. Where reducing conditions prevailed, the plant material was effectively preserved.

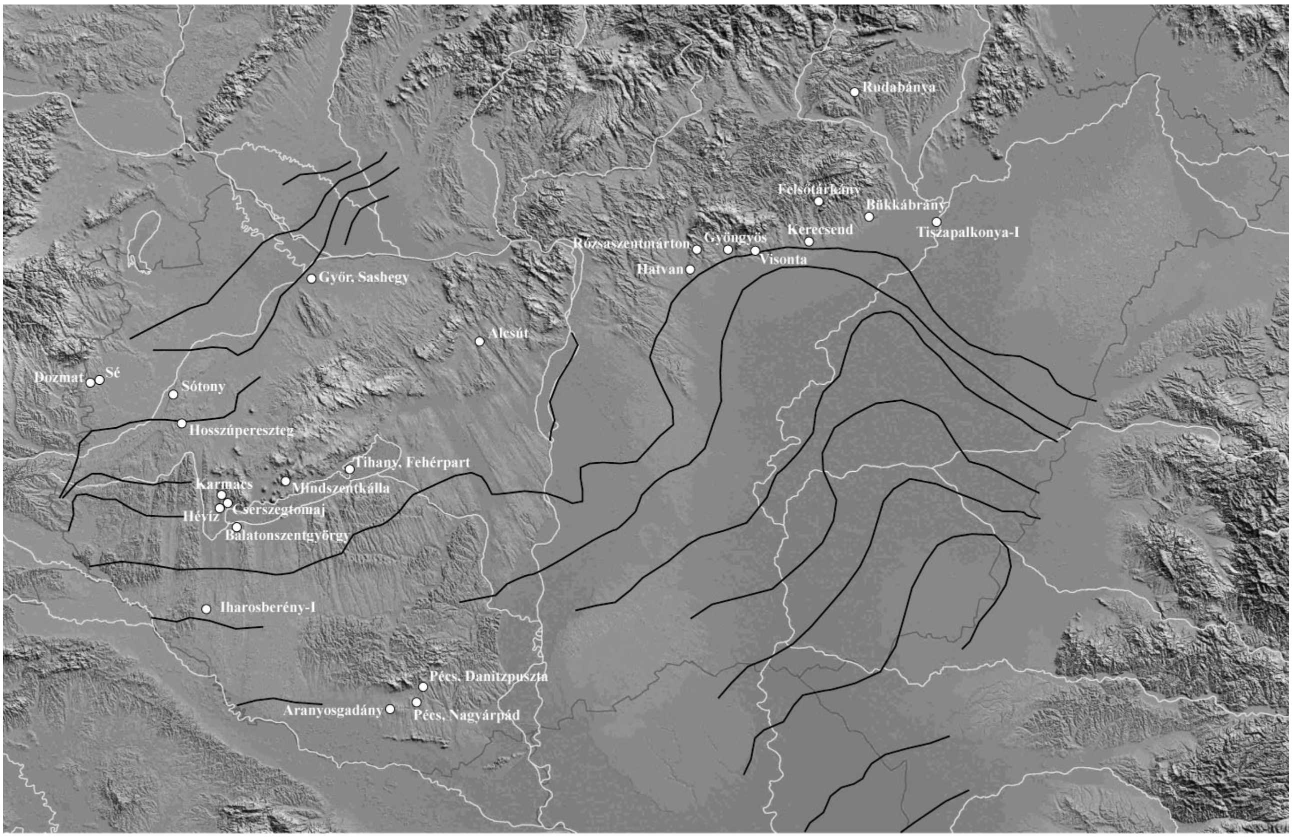
Subsidence anomalies at about the Miocene–Pliocene boundary mark the onset of structural inversion of the Pannonian Basin: basin centres continued to subside whereas basin flanks suffered uplift and erosion (HORVÁTH & CLOETINGH 1996, FODOR et al. 1999, MAGYAR & SZTANÓ 2008). Erosion of the Late Miocene to Quaternary fluvial and terrestrial blanket led to the exhumation of the shallow lacustrine and deltaic deposits along the basin margins; most of the plant fossils described in this volume were collected in such outcrops.

According to the "official" stratigraphic nomenclature of the Central Paratethys, the Upper Miocene – Pliocene is subdivided into 4 stages: Pannonian (Late Miocene), Pontian (latest Miocene – earliest Pliocene), Dacian (Early Pliocene), and Romanian (Late Pliocene). The stratotypes of the Pontian, Dacian, and Romanian stages are located in the Euxinian and Dacian basins, which were at least intermittently connected to each other and possibly even to the Mediterranean during the late Neogen. Lake Pannon, however, apparently remained a separate water body, thus identification and correlation of the Pontian, Dacian, and Romanian stages in the Pannonian Basin is very difficult if not impossible at the moment. These regional stages are mistakenly identified with outstanding, but not isochronous, lithostratigraphical boundaries in several countries of the Pannonian Basin. For instance, the shelf break (the clinoform topset-foreset rollover) is correlated with the Lower Pontian/Upper Pontian boundary in Slovenia, Croatia, and Serbia, and with the Pontian/Dacian boundary in Romania. Age difference along this lithological boundary across the entire Pannonian Basin, however, may amount to 6 million years (MAGYAR et al. 2013).

Recognizing the so far unresolvable difficulties of correlation of the Pontian, Dacian, and Romanian stages into the Pannonian Basin, Hungarian stratigraphers rather use the term "Pannonian" in the wide sense, encompassing the Upper Miocene and the Pliocene. This "Pannonian sensu lato" thus represents 9 million years, from 11.6 to 2.6 Ma (CSÁSZÁR ed. 1997). Although the Miocene/Pliocene (Messinian/Zanclean) boundary is also difficult to identify in the sedimentary fill of the Pannonian Basin, the present study is focussing on the Late Miocene palaeobotanical record, and does not include materials whose Pliocene age is convincingly proved (e.g. HABLY & KVAČEK 1997).

Palaeogeography

Distribution of the Late Miocene palaeobotanical sites plotted on the digital terrain model of Hungary (Figure 1) may seem to suggest that plant remnants were buried and preserved in the present-day basin margins, along the interface of the lacustrine and terrestrial environments. This impression, however, is misleading. The shoreline of Lake Pannon was not confined to, and did not even necessarily followed, the present-day basin margins. The actual shoreline frequently changed



Text-figure 1. Location of the Late Miocene palaeobotanical sites in Hungary

Black lines indicate the consecutive positions of Lake Pannon shelf break (approximate ages in million years, arrows indicate dip of the slope). The shelf break marked the boundary between the shallow-water environments with significant potential of plant fossilization and preservation and the deep water environments where plants were usually buried as transported fragments

its position, shifting either basinward or landward across the shelf as a function of the relative lake-level. Mapping of the palaeo-shoreline would therefore be a futile attempt. The shelf break, striking more or less parallel with the shoreline in a more basinward position, however, was a more permanent and much slower moving palaeomorphological feature. Maps of the shelf break for successive time slices reveal the process of gradual filling of the basin during the Late Miocene and Early Pliocene (Figure 1; MAGYAR et al. 2013).

Apparently, the most important agent of the shelf advance was the sediment dispersal system of the palaeo-Danube. This river started to discharge into Lake Pannon at about 11–10 million years ago (NEHYBA & ROETZEL 2004, HARZHAUSER et al. 2011). The first, north-east–south-west trending shelf margin was built about 10 million years ago in the Kisalföld/Danube subbasin, and during the subsequent 6 million years it prograded ca. 400 km to the SE, levelling much of the structurally complex Pannonian Basin. A less powerful, still significant dispersal system worked in the north-eastern part of the Pannonian Basin, with a NW–SE striking shelf margin (palaeo-Tisza system). Minor sediment supply systems existed in the southern and eastern margins of the basin (these are mostly located beyond the political borders of Hungary; MAGYAR et al. 2013).

As a consequence of these processes, shallow-water, near-shore, or fluvial deposits with a potential of plant fossil content can be found almost everywhere in the basin; they are either accessible along the modern basin margins as a result of late-stage tectonic inversion (see the surface outcrops in this study), or they are exposed by drilling in locations away from the modern basin margins.

Sedimentary environments and lithostratigraphy

Sedimentation in and around Lake Pannon took place in various environments. In the deep basin, lacustrine marls (Endrőd Formation, JUHÁSZ in CSÁSZÁR ed. 1997) and turbidite-bearing series (Szolnok Formation, JUHÁSZ et al. in CSÁSZÁR ed. 1997) were deposited. The redeposited sandstone layers of the latter often contain abundant plant fossils, typically small fragments not suitable for macrobotanical studies. The basin slope (shelf margin slope) trapped mainly fine-grained sediments (Algyő Formation, GAJDOS et al. in CSÁSZÁR ed. 1997), because sand was usually gravitationally transported to the toe of slope and further, towards the basin plain (SZTANÓ et al. 2013a). The upper slope sediments may exceptionally contain well-preserved palaeobotanical findings (see borehole Tiszapalkonya–I below the shelf edge, 1600–1970m).

Most of the investigated plant fossils were recovered from shelf deposits. The shelf deposits usually display a cyclic architecture: 30–50m thick coarsening upward units follow each other, representing individual delta progradations. Each unit consists of offshore shales, sandy deltaic lobes with distributary channel fills, crevasse splays, and huminitic clays or lignite seams deposited in interdistributary marshes (SZTANÓ et al. 2013b). These shelf deposits are comprehensively called Újfalu Formation (NÉMETH et al. in CSÁSZÁR ed. 1997), but, for the time being, “local” names (Edelény, Somló, Tihany, Bükkalja, Torony Fms) are also in formal use.

The Edelény Variegated Clay Formation (JÁMBOR in CSÁSZÁR ed. 1997) is interpreted as a delta plain deposit in northern Hungary, with frequent alternation of grey and variegated clay, calcareous silt, huminitic clay, even lignite seams. Of the palaeobotanical localities discussed in this study, Rudabánya belongs to this formation.

The Somló Formation (JÁMBOR in CSÁSZÁR ed. 1997) represents sublittoral deltaic sediments, deposited in a few tens of metre deep water, often with intercalations of littoral sand layers (SZTANÓ et al. 2013b). Lithologically it consists of grey clay marl and silt, laminated silt, and fine- to small-grained sand or sandstone. Macrobotanical localities in this formation include Alcsút, Diszel-Hajagos, Cserszegtomaj, Hévíz, and Karmacs. Aranyosgadány and Pécs-Nagyárpád may also belong here.

The Tihany Formation (JÁMBOR in CSÁSZÁR ed. 1997) was deposited mostly in interdistributary bays (SZTANÓ et al. 2013b). It consists of silt – fine sand – huminitic clay cycles, reflecting relative lake level changes of a few metres amplitude. The floras of Balatonszentgyörgy and Tihany-Fehérpart were collected from this formation.

The Bükkalja Lignite Formation (GAJDOS & PAP in CSÁSZÁR ed. 1997) comprises sedimentary cycles similar to those of the Tihany Formation, but its lignite seams can be as thick as 10–15 metres. The formation was and is being exposed in several underground and opencast lignite mines along the southern foot of the Bükk and Mátra Mts in northern Hungary. Palaeobotanical sites in this formation include Bükkábrány, Gyöngyös, Kerecsend, Rózsaszentmárton, and Visonta.

The Torony Lignite Formation (JÁMBOR in CSÁSZÁR ed. 1997) is very similar to the Bükkalja Formation, but its lignite seams are thinner. This formation was described from western Hungary. Of the palaeobotanical sites, Dozmat and Sé belong here.

Two thick borehole records in this study, Tiszapalkonya–I (1487–1600m) and Iharosberény–I (23–607m) can be assigned to the undifferentiated Újfalu Formation. (A proper hierarchical ranking of these lithostratigraphic units, so that the Újfalu Fm would include the other units as members, was suggested recently by SZTANÓ et al. 2013b).

Apart from the large, prograding shelf/slope systems, sedimentation also took place in more confined environments, such as along rocky shores and in small Gilbert-type deltas supplied from local sources (Békés Conglomerate Formation, Kálla Gravel Formation). Interestingly, these coarse-grained deposits occasionally preserved remarkable plant fossils. The Kálla Gravel Formation (Jámbor in Császár ed. 1997) is considered to have been deposited in Gilbert-type deltas and in adjacent wave-affected sandy shoals during a transgressive event along the margins of the Transdanubian Range (CSILLAG et al. 2010, SZTANÓ et al. 2010, TÓTH et al. 2010). It consists of gravel, pebbly sand, clean quartz sand and sandstone, all formed in Lake Pannon. The plant fossils of Diszel - Kula Hill and Mindszentkálla were collected from the same shoreface sand/sandstone body.

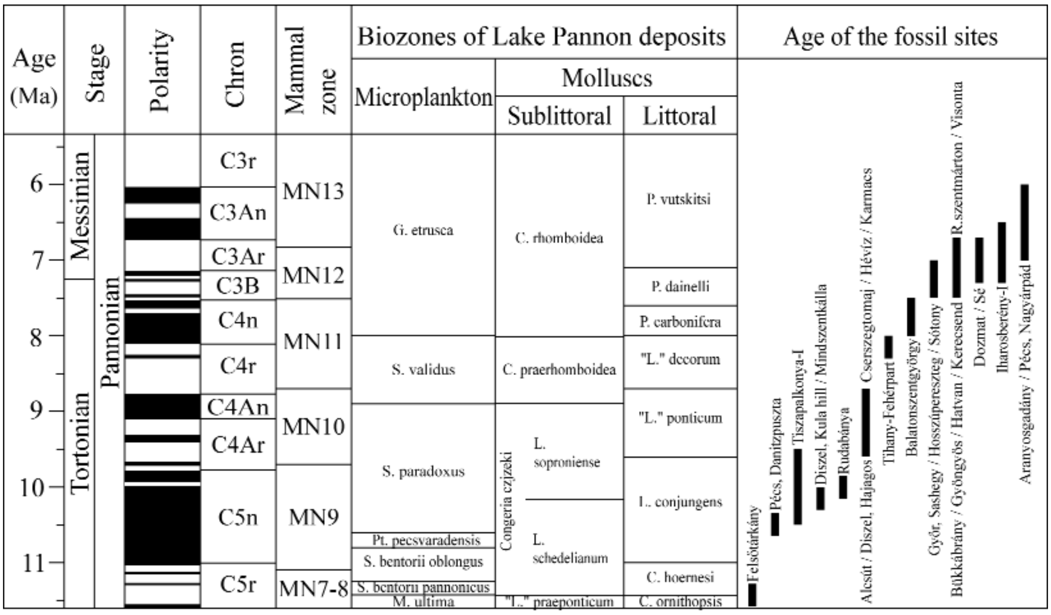
In areas protected from direct sediment influx either by large distance from the sources or by relative elevation, condensed sedimentation took place and calcareous marls and marls were deposited (Tótkomlós Member of Endrőd Formation). The white and grey marls of the Pécs, Danitzpuszta locality are tentatively assigned here.

The prograding deltas gradually gave way to fluvial and freshwater lacustrine sedimentation in the Pannonian plains. In the alluvial plain, sandy channel fills, variegated floodplain clays, and organic-rich pond and marsh clays, sometimes with lignite seams and palaeosols were deposited (Zagyva Formation, JUHÁSZ et al. in CSÁSZÁR ed. 1997). These layers, especially if formed under reducing conditions, may also contain well-preserved plant remnants (Győr-Sashegy, Hosszúpereszteg, Sótony).

Longer or shorter intervals of terrestrial sedimentation may have occurred almost any time and everywhere along the actual basin margins. The Felsőtárkány plant locality represents such a terrestrial environment. The lithostratigraphic assignment of the Felsőtárkány layers is equivocal.

Chronostratigraphy and geochronology

In this chapter we discuss the stratigraphic position of the Late Miocene plant localities and fossiliferous sequences, and infer their age. Where the plant-bearing layers were deposited in shallow lacustrine environment, we rely on the littoral or sublittoral mollusc biozonation of the Pannonian stage (MAGYAR et al. 1999b, MAGYAR & GEARY 2012). Where the fossiliferous layers are fluvial or terrestrial in origin, the accompanying mammal fauna and its assignement into the European mammal zones (MN zones) provides useful stratigraphic information. Two boreholes (Tiszapalkonya and Iharosberény) and one surface outcrop (Tihany-Fehérpart) were magnetostratigraphically investigated (LANTOS et al. 1992, ELSTON et al. 1994, SZTANÓ et al. 2013b). Seismic stratigraphy was extensively used to establish stratigraphic correlation between the plant-bearing localities (sequences) and distant biostratigraphic or magnetostratigraphic key data (Figure 2).



Text-figure 2. Stratigraphic position and estimated age of the Late Miocene palaeobotanical localities in Hungary. C: Congeria, G: Galeacysta, L: Lymnocardium, M: Mecsekia, P: Prosodacnomya, Pt: Pontiadinium, S: Spiniferites

The oldest flora discussed in this monograph was unearthed from terrestrial deposits at Felsőtárkány. Both the underlying and overlying layers contained microvertebrates and land and freshwater snails. The mollusc fauna, as a whole, seems to indicate Middle Miocene (Sarmatian) age. The great majority of the vertebrates belong to MN 7–8 zone, which spans the Middle/Upper Miocene (Sarmatian/Pannonian) boundary (11.6 Ma), but *Microtocricetus* (from the overlying layer) is considered a Vallesian (MN9, 11.1–9.7 Ma) hamster (HÍR et al. 2001, HÍR 2010). Here we suppose that the Felsőtárkány flora flourished through the Sarmatian/Pannonian boundary, and has an estimated age of about 11.5 Ma.

The marls of Pécs, Danitzpuszta contain a sublittoral mollusc fauna, including the cockle *Lymnocardium schedelianum*. The layers thus belong to the L. schedelianum zone, and their age is ca. 10.5 Ma.

An almost 500m thick (1487–1970m) cored interval from the Tiszapalkonya borehole yielded plant fossils. According to magnetostratigraphic correlations in this well by ELSTON et al. (1994), the top of the fossiliferous interval corresponds to the middle part of C4Ar, whereas the bottom of the interval falls within C5n. This interpretation is consistent with the occurrence of molluscs indicating the Lymnocardium ponticum Zone at 1444m (KORPÁSNÉ HÓDI 1991). The age of the plant fossil bearing interval is thus estimated to be 10.5–9.5 Ma.

Fossils of littoral molluscs from the Kálla Formation at Mindszentkálla indicate the upper part of the Lymnocardium conjungens Zone. The age of the Mindszentkálla and Diszel - Kula Hill plant remnants are thus estimated to be about 10 Ma or slightly more (MAGYAR 1988, CSILLAG et al. 2010).

In the lack of brackish molluscs, the age of the Rudabánya locality can be best assessed by the biochronologic interpretation of the diverse vertebrate fauna. This fauna includes both archaic Middle Miocene and younger Late Miocene forms. Based on the presence of advanced rodents and ungulates (Hippotherium), the locality is estimated to have an age of late MN9, i.e. around 10 Ma (KORDOS & BEGUN 2002; BERNOR et al. 2003a).

The rich littoral to sublittoral mollusc fauna of the Somló Formation indicates that this formation, at least in the vicnity of the Transdanubian Range, belongs to the Lymnocardium ponticum Zone (SZILAJ et al. 1999). Of the localities discussed in this study, Alcsút and Diszel-Hajagos yielded typical fauna of this zone. The sandstone body containing plant remains in Cserszegtomaj, Hévíz and Karmacs can also be correlated with the L. ponticum Zone. The age of these five localities is thus between 9.6 and 8.7 Ma.

The Tihany-Fehérpart outcrop yielded a rich mollusc fauna, typical of the Lymnocardium decorum Zone, and is overlain by volcanics dated 7.92 (ref) or 7.96 (ref) Ma. Mammal remains indicate the MN11 Zone (KORDOS 1989, MÉSZÁROS 2008). The magnetic polarity record of the Tihany-Fehérpart section includes a change from reverse (lowermost 2 metres) to normal (much of the profile, 20m) polarity. This polarity change can be most probably correlated to either the beginning of C4n.2n (8.1 Ma), or that of C4r.1n (8.3 Ma; SZTANÓ et al. 2013b). The age of the outcrop is thus estimated to be 8.3–8.0 Ma.

The mollusc fauna of the Balatonszentgyörgy outcrop belongs to the Prosodacnomya carbonifera Zone, thus the age of the locality is estimated to be 8.0–7.5 Ma.

A number of plant fossil localities described in this study, such as Bükkábrány, Gyöngyös, Kerecsend, Rózsaszentmárton, Visonta, and Hatvan, belong to the "Bükkalja sequence". The informal term "Bükkalja sequence" is used in this study for a lignite-bearing stratigraphic unit in the northern Pannonian Basin, bounded at the base by a prominent flooding surface indicating a northward backstepping of the shelf break of Lake Pannon, and at the top by a significant regional unconformity between the Upper Miocene and the Pliocene (JUHÁSZ et al. 1996; MAGYAR & SZTANÓ 2008). (The "Bükkalja sequence" more or less corresponds to the transgressive and highstand systems tracts of sequence Pa–3 in VAKARCS et al. (1994) and JUHÁSZ et al. [2007]). The most complete representation of the sequence is the 266–484m interval of the continuously cored Tiszapalkonya borehole (ELSTON et al. 1990). Palaeontological data from the Tiszapalkonya borehole by KORPÁSNÉ HÓDI (1991) indicate the presence of the Lymnocardium decorum Zone up to 892m; the "Bükkalja sequence" (484–266m) does not contain brackish molluscs in this borehole. In other boreholes located in more basinward position, however, the seismically identified flooding surface at the base of the „Bükkalja sequence" correlates with the Prosodacnomya dainellii Zone (e.g. Hajdúszovát–1 well). Mammal remains from the "Bükkalja sequence" are considered Late Turolian (MN12, MN13) in age. The best-studied mammal record from the sequence is that of Hatvan (GAÁL 1943), where the bones and the plant remnants were collected from the same layer. The age of the mammal fauna is considered either MN12 as in BERNOR et al. (2003b), or MN12–13 (KORDOS, pers. comm. 2013). Magnetostratigraphic correlations in the Tiszapalkonya borehole suggest that the "Bükkalja sequence" corresponds to chrons C3B (7.5 to 7.1) and C3Ar (7.1 to 6.7), displaying dominantly reverse magnetic polarity (ELSTON et al. 1994). This is consistent with polarity measurements on surface samples in the two largest outcrops of the sequnce: MÁRTON (in KRETZOI et al. 1982) measured mostly reverse polarity in a series of samples from the Visonta open-cast lignite mine, and the single sample analyzed from the Bükkábrány lignite pit also displayed reverse polarity (BABINSZKI 2007, pers. comm.). Therefore, the age of the "Bükkalja sequence" is probably within the interval of 7.5 to 6.7 Ma.

Pannonian plant fossils were recovered from cores of the Iharosberény borehole between 24 and 607m. According to an unpublished report by M. KORPÁS-HÓDI, *Prosodacnomya* sp. occurred at 766m and *Prosodacnomya* cf. *dainellii* at 730m. Magnetostratigraphic interpretations by LANTOS et al. (1992) and SACCHI & MÜLLER (2004) correlated the 23–607m interval with chrons C3Ar to C4n2n, suggesting an age of 7.8–6.5 Ma. This correlation, however, implies slightly older ages for the first appearance of *Prosodacnomya* (and of *P. dainellii* in particular) than indicated in Figure 2 (justified by stratigraphic data elsewhere; see SZTANÓ et al. 2013b). Therefore, we suggest a modification of this interpretation, implying somewhat younger age, ca. 7.3 Ma, for the base of the fossil plant bearing interval in the Iharosberény well.

The two localities lying within the Torony lignite area in western Hungary, Dozmat and Sé, expose part of a 100 m thick lignite-bearing sedimentary sequence ("Torony sequence"; JASKÓ 1964, 1975; DRAXLER et al. 1997; HABLY & KOVAR-EDER 1997). No age-diagnostic brackish molluscs or terrestrial mammals are known from these outcrops. The sequence dips to the SE, however, and some 5km SE of the outcrops, it is possible to establish a seismic correlation between the lignite sequence and the Iharosberény borehole profile. The bottom of the lignite sequence is in ca. 140m higher position than the 700m deep seismic horizon in the Iharosberény borehole (the latter representing the Prosodacnomya dainellii Zone). As a consequnce, the Torony sequence has an age very similar to that of the "Bükkalja sequence", ca. 7.3–6.7 Ma.

Plant fossil localities representing the Upper Miocene fluvial facies, such as Győr-Sashegy, Hosszúpereszteg, and Sótony, are difficult to date. They all expose the same (a few hundred m thick) stratigraphic interval, which is bracketed between the 700 m deep seismic horizon in the Iharosberény borehole (Prosodacnomya dainellii zone, less than 7.5 Ma) and the latest Miocene – earliest Pliocene volcanoes of the Little Hungarian Plain Volcanic Field (e.g. 4.8 Ma at Sitke, Hercseghegy, 6km NE of Sótony, or 5.5 Ma at Ság-hegy, 12km E of Sótony). Neighbouring large mammal localities, such as Bérbaltavár 10km to the SW of Hosszúpereszteg, or Pannonhalma 15km to the SE of Győr-Sashegy, are assigned to MN12 by KAISER & BERNOR (2006) and by GASPARIK (2001), respectively. Large mammals from the Hosszúpereszteg outcrop indicate Turolian (MN11 to MN13) age (KRETZOI 1982). Therefore, the age of the three localities is most probably 7.5–7.0 Ma, but somewhat older and younger ages (between 8 and 6 Ma) cannot be excluded either.

The Pécs-Nagyárpád locality yielded abundant mollusc fauna, including *Lymnocardium arpadense*, a species characteristic of the littoral Prosodacnomya vutskitsi Zone (SZÓNOKY et al. 1999). The exact locality of the Aranyosgadány macrobotanical material is not known. The Pannonian layers that are exposed under Quaternary loess in the vicinity of the village (KONRÁD & SEBE 2010), however, most probably stratigraphically correspond to, or at least not very different from, the silty and sandy sequence that is exposed a few kms to the east at Nagyárpád. Consequently, Nagyárpád and Aranyosgadány are probably the youngest localities discussed in this monograph with an age of ca. 7–6 Ma.

Palaeobotanical localities: geology, fossils, flora, vegetation and environment

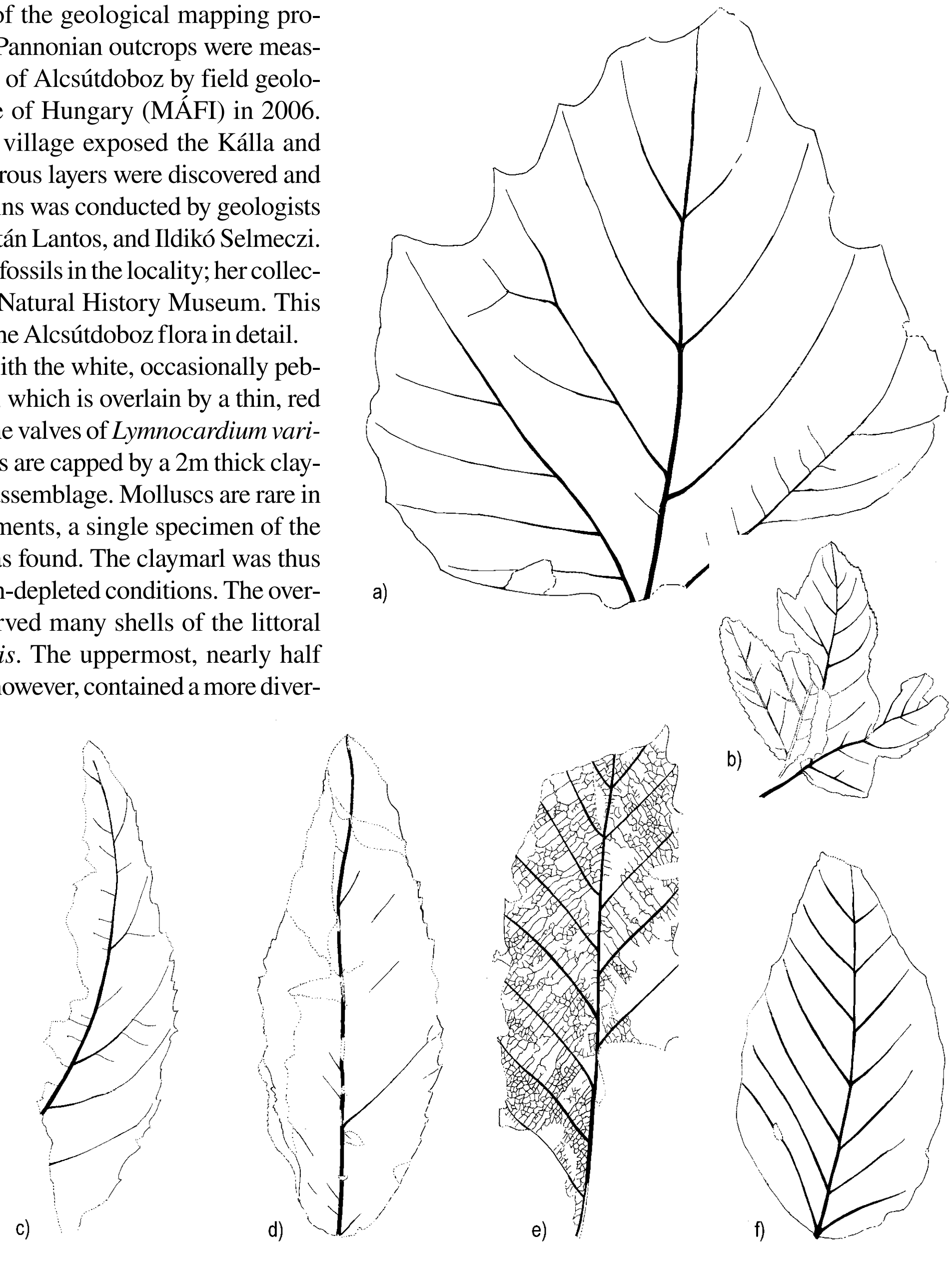
by Lilla Hably and Imre Magyar

During the terminal phase of the geological mapping program in the Vértes Mts, several Pannonian outcrops were measured and sampled in the vicinity of Alcsútdoboz by field geologists of the Geological Institute of Hungary (MÁFI) in 2006. Construction of a house in the village exposed the Kálla and Somló Formations. The fossiliferous layers were discovered and the first collection of plant remains was conducted by geologists of the MÁFI, Gábor Csillag, Zoltán Lantos, and Ildikó Selmeczi. Later Lilla Hably collected plant fossils in the locality; her collection is stored in the Hungarian Natural History Museum. This monograph is first to document the Alcsútdoboz flora in detail.

The exposed section starts with the white, occasionally pebbly sand of the Kálla Formation, which is overlain by a thin, red coloured sand layer preserving the valves of *Lymnocardium variocostatum* and *L.* sp. These layers are capped by a 2m thick claymarl yielding a rich fossil plant assemblage. Molluscs are rare in this layer: apart from shell fragments, a single specimen of the pioneer genus *Dreissenomya* was found. The claymarl was thus probably deposited under oxygen-depleted conditions. The overlying reddish sand layers preserved many shells of the littoral dreissenid *Dreissena auricularis*. The uppermost, nearly half metre thick layer of the outcrop, however, contained a more diversified, sublittoral mollusc association embedded into grey silt: *Congeria czjzeki*, *Lymnocardium* sp., *Paradacna* sp., *"Pontalmyra" otiophora*, and planorbid gastropods (Csillag et al 2008).

Lithostratigraphy: Somló Formation,

Age: 9.6–8.7 Ma



Text-figure 5. Floristic composition of locality Alcsút
a) *Platanus leucophylla,* b) *Liquidambar europaea,* c) *Alnus gaudini,* d) *Salix varians,* e) *Quercus kubinyii,* f) *Fagus haidingeri*

Flora:

Liquidambar europaea A. BRAUN
Platanus leucophylla (UNGER) KNOBLOCH
Fagus haidingeri KOVÁTS emend. KNOBLOCH
Quercus kubinyii (KOVÁTS ex ETTINGSHAUSEN) BERGER
Alnus gaudini (HEER) KNOBLOCH & KVAČEK
Salix varians GÖPPERT

Typical and characteristic riparian type vegetation can be outlined based on the relatively few specimens. Some of the most characteristic species of the riparian vegetation, *Liquidambar europaea* and *Platanus leucophylla* are accompanied by an alder, *Alnus gaudini* and by the most common willow species of the Pannonian, *Salix varians*. However, some species, e.g. *Fagus haidingeri* and *Quercus kubinyii*, occur that are rare elements in the Late Miocene floras of the Pannonian Basin indicating the presence of mesophytic forests adjacent to lowland vegetation.

Aranyosgadány

Although the collection of the Hungarian Natural History Museum contains only one leaf impression from Aranyosgadány, this specimen is included into the monograph because of its floristic importance.

The exact site where the fossil was found, as well as the name of the collector, remains unknown. Recent field studies indicate that Pannonian silt layers, outcropping from below Pleistocene loess in the vicinity, often contain poorly preserved plant remains and molluscs (Sebe, personal communication 2013).

Lithostratigraphy: ?Somló Formation.

Age: 7–6 Ma.

Flora:

Quercus kubinyii (KOVÁTS ex ETTINGSHAUSEN) BERGER

The occurrence of *Q. kubinyii* suggests the presence of mesophytic vegetation.

Balatonszentgyörgy

The claypit of the Balatonszentgyörgy brickyard is located 1.5 km south of the village centre, next to the monument “Csillagvár” (a fortified 19-century country house). Fossil plants were collected here at two distinct times and from two distinct embedding rocks. First Pálfalvy collected plant fossils and published them in a preliminary report (PÁLFALVY 1975). The very well-preserved leaf remains were found in hard, strongly cemented marl concretions. Pálfalvy’s collection is stored by the Hungarian Geological and Geophysical Institute. Ernő HORVÁTH also collected from the same layer for the Savaria Museum at Szombathely, but his material remained unpublished.

Recent visits to the claypit showed that the old outcrop had significantly changed, and that the layers with concretions from which Pálfalvy and Horváth collected are not accessible any more. The present-day outcrop is located a few hundred metres away from the old claypit, and the exposed layers are in a stratigraphically slightly higher position than in the old outcrop. Plant remains from the soft, sandy and silty clay layers were collected by Lilla Hably and co-workers. The fossil specimens of the new pit, housed by the Hungarian Natural History Museum, are first published in this monograph.

The old Balatonszentgyörgy outcrop and its fossil molluscs were described by BARTHA & SOÓS (1955) and BARTHA (1977). These studies clearly revealed the cyclic nature of the exposed sequence: a lower freshwater-terrestrial interval (which included the plant-bearing concretions) was followed by brackish layers, which in turn were overlain by a second freshwater-terrestrial unit. The present-day outcrop displays several such cycles, with 1–3m individual thickness. A complete cycle begins with marls, silts (with brackish fauna), followed by sands, and overlain by abundant organic-rich clays (with paludal fauna). Intercalations of medium- to fine-grained, cross-stratified sands with erosional base up to a thickness of 0.5–2m are common. The coarsening-upward cycles are interpreted as deltaic parasequences, deposited in interdistributary bays on the upper delta plain. The cross-bedded sand layers are of fluvial origin (SZTANÓ & MAGYAR 2007).

The cyclic architecture of the sediments suggests that the significant differences between the two Balatonszentgyörgy floras can be attributed to high-frequency changes in the sedimentary environment rather than to a long-term environmental trend.

Lithostratigraphy: Tihany Formation.

Age: 8.0–7.5 Ma.

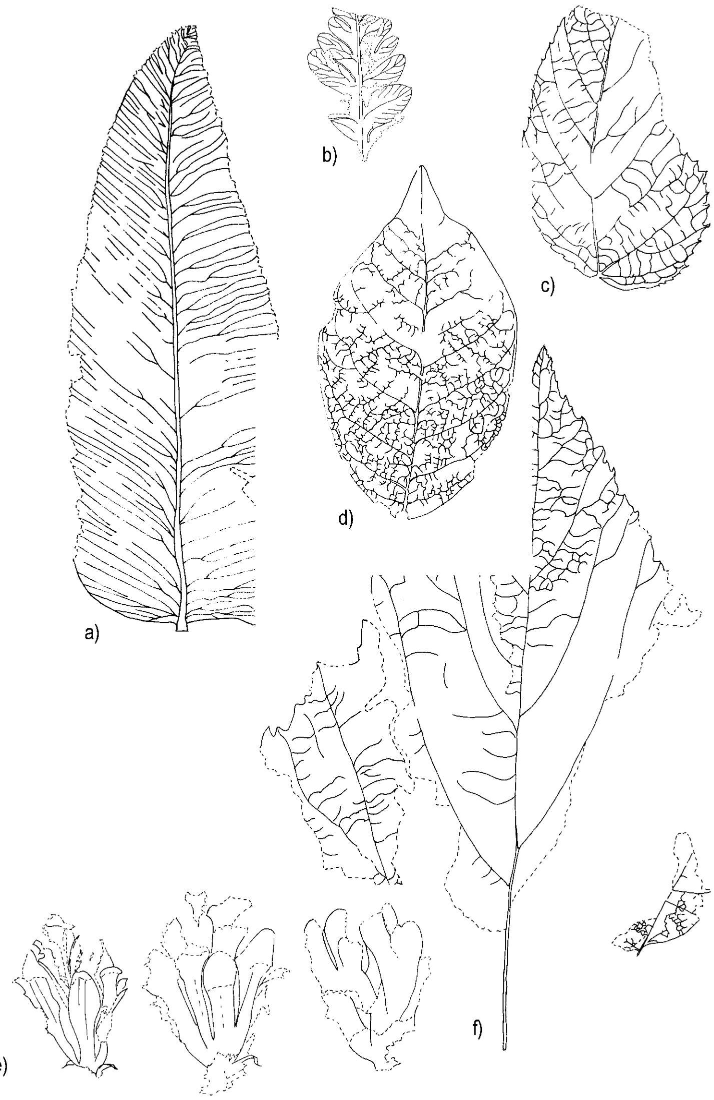
Flora:

New site (younger flora)

Equisetum sp.
Pronephrium stiriacum (UNGER) KNOBLOCH & KVAČEK
Osmunda parschlugiana (UNGER) ANDREÁNSZKY
Glyptostrobus europaeus (BRONGNIART) UNGER
"*Magnolia*" *szakmanycsabae* sp. nov.
Alnus menzelii RANIECKA-BOBROWSKA
Alnus gaudini (HEER) KNOBLOCH & KVAČEK
Alnus julianiformis (STERNBERG) KVAČEK et HOLÝ
Alnus sp.
Vitis szakmanygyorgyi sp. nov.
Monocotyledonae gen. et sp.

Old site (older flora)

Glyptostrobus europaeus (BRONGNIART) UNGER
„*Magnolia*" *szakmanycsabae* sp. nov.
Alnus sp.
Myrica lignitum (UNGER) SAPORTA
Cercidiphyllum crenatum (UNGER) BROWN
Acer jurenakii STUR
Acer sp. fructus
Vitis szakmanygyorgyi sp. nov.
Salix varians GÖPPERT
Salix sp. 1.
Salix sp. fruit capsule
Dicotylophyllum jungii KNOBLOCH & KVAČEK
Monocotyledonae gen. et sp. 1.
Monocotyledonae gen. et sp.

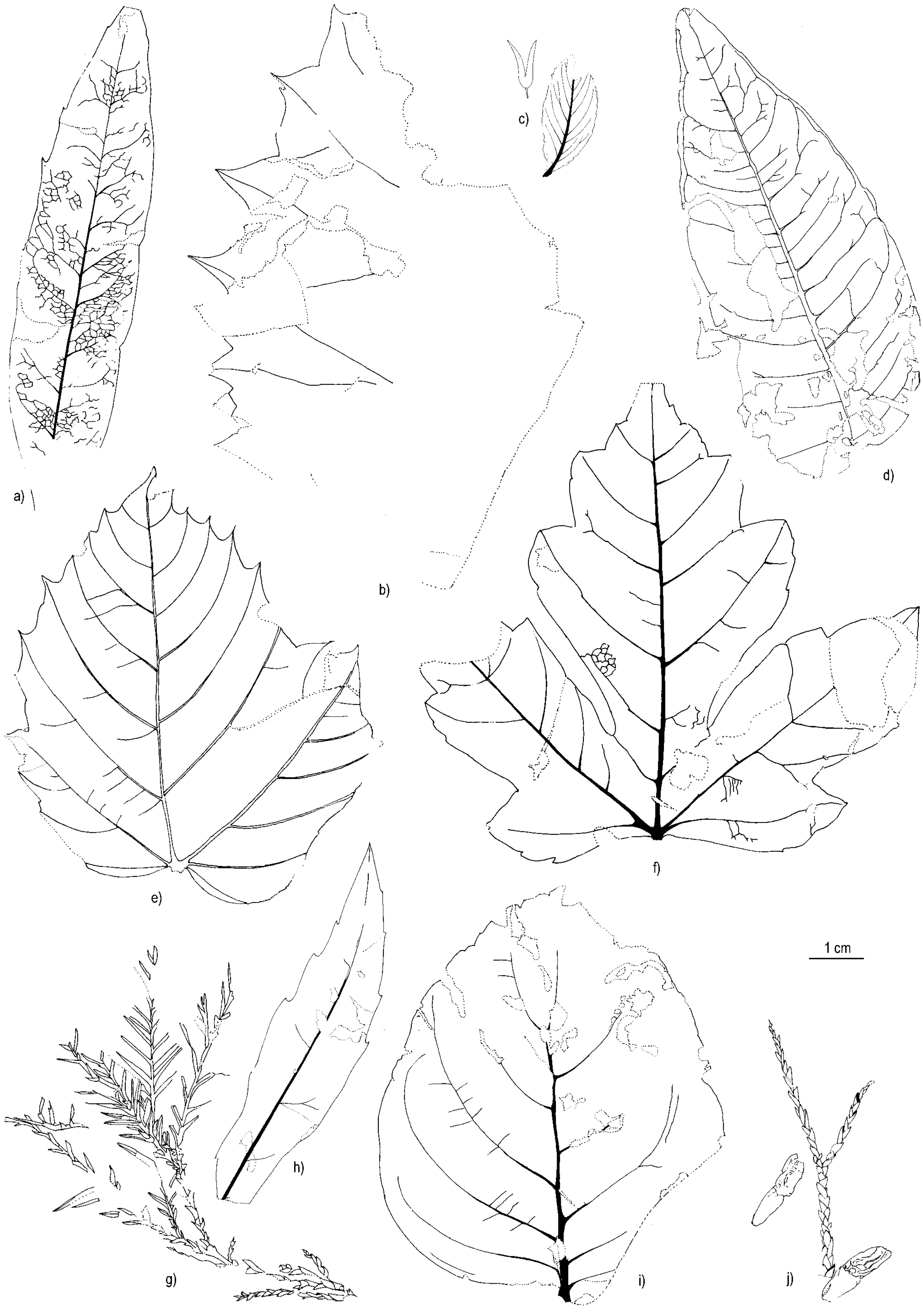


Text-figure 6. Floristic composition of locality Balatonszentgyörgy, younger flora a) *Osmunda parschlugiana,* b) *Pronephrium stiriacum, c) Vitis szakmanygyorgyi,* d) *"Magnolia" szakmanycsabae,* e) *Glyptostrobus europaeus,* f) *Alnus menzelii*

The assemblage collected from the area which is accessible since 2007 younger flora is dominated by *Glyptostrobus europaeus*. *Osmunda parschlugiana* occurs also frequently in this assemblage, however, *Pronephrium stiriacum*, *Alnus*, "*Magnolia*" *szakmanycsabae* and *Vitis szakmanygyorgyi* are rare elements. Interestingly, *Byttneriophyllum tiliifolium* is missing from this, otherwise typical swamp assemblage which was also recorded in Dozmat and numerous additional localities. The unexpected lack of *Byttneriophyllum* still awaits an explanation because floras of this characteristic type usually share *Byttneriophyllum tiliifolium* occurring even with extremely high number of leaves. The floristic composition suggests a typical swamp habitat, with the lack of aquatic elements.

Old sites yielded fossils in higher diversity (older flora) than the younger sites. Leaves of *Acer jurenakii*, *Myrica lignitum*, *Dicotylophyllum jungii* and *Salix varians*, etc. were collected here, but, *Glyptostrobus* is common in these layers similarly to the other sites.

There are rare elements shared by the lower and upper assemblages, i.e. "*Magnolia*" *szakmanycsabae* and *Vitis szakmánygyorgyi*, which are new species described by the current study. The older flora suggests swamp habitat, as well, but the area seems to have been flooded occasionally, therefore species of more mesophytic character accompanied to the swamp assemblage. The upper, younger flora seems to have flourished in deeper areas flooded probably permanently and swamp habitats were more extended.



Text-figure 7. Floristic composition of locality Balatonszentgyörgy (older flora) a) *Myrica lignitum,* b) *Vitis szakmanygyorgyi,* c) *Salix* sp. 1. and *Salix* sp. fruit capsule, d) *Dicotylophyllum jungii,* e) *Vitis szakmanygyorgyi*, f) *Acer jurenakii,* g) *Glyptostrobus europaeus,* h) *Myrica lignitum,* i) *"Magnolia" szakmanycsabae,* j) *Glyptostrobus europaeus*

Bükkábrány

Occurrences of plant fossils from the large open-air lignite mine of Bükkábrány have been published ever since mining operations started in 1985 (László 1989, 1992; Wójcicki & Bajzáth 1997). The discovery of a "standing forest" of 16 stumps, 4 to 6m high, on top of the main lignite seam hit the headlines in 2007 (Kázmér 2008, 2011; Erdei et al 2009; Császár et al. 2009, Erdei & Magyari 2011).

The Bükkalja lignite-bearing sequence is exposed along the southern foothills of the Mátra and Bükk Mountains in northern Hungary, and extends far to the south in the subsurface with a structural dip of 1–2°. The present-day Bükkábrány pit is 2 km long and 1.5 km wide, and the top of the main lignite seam is at 60m depth below the surface. The exposed sequence comprises a few parasequences, each consisting of silt in the bottom, then fine-grained sand, and lignite or lignitic clay in the top. The Upper Miocene is unconformably overlain by Plio–Pleistocene pebbly sand (Fischer 2009).

Lithostratigraphy: Bükkalja Formation.

Age: 7.5–6.7 Ma.

Flora:

Ginkgo adiantoides (Unger) Heer
Glyptostrobus europaeus (Brongniart) Unger
Glyptostroboxylon sp.
Taxodioxylon germanicum (Greguss) Van der Burgh
Ceratophyllum dubium (Ludwig) Kirchheimer
Alnus menzelii Raniecka-Bobrowska
Alnus sp.
Alnus sp. cones
Alnus sp. male catkins
Betulaceae gen. et sp.
Pterocarya sp.
Ulmus sp.
Zelkova zelkovifolia (Unger) Bůžek & Kotlaba
Trapa praehungarica Wójcicki et Bajzáth
Byttneriophyllum tiliifolium (A. Braun) Knobloch & Kvaček
Stratiotes sp.
Potamogeton sp.
Carex sp.

The flora includes elements of aquatic (open water) habitats and swamp forests. Bükkábrány indicates typical Late Miocene wetland vegetation characterized by low diversity.

Cserszegtomaj

Győző Cseh, a private collector found a fossil plant in the quarry of Cserszegtomaj in the 1980s. Lilla Hably and her colleagues organized field trips to the locality between 2009–2011, but by that time operation had been stopped in the quarry and there was no trace of any plant remains.

The Cserszegtomaj, Hévíz, and Karmacs outcrops all expose the same carbonate-cemented sandstone ridge that stands out in 4 km length along the western margin of the Keszthely Mts between Hévíz in the south and Karmacs in the north. The sandstone is "tabular", i.e. thinly bedded or laminated. It often shows cross-bedding and ripple marks (Budai et al. 1999). Moulds and prints of littoral bivalve shells, such as *Lymnocardium*, *Congeria* and *Dreissenomya*, are quite common.

Lithostratigraphy: Somló Formations.

Age: 9.6–8.7 Ma.

Flora:

Tilia sp.?

A reconstruction of the flora and vegetation is not available since a single fossil plant remain (*Tilia* sp.?) was recorded from this locality.

Diszel-Hajagos

From the silt and sand layers overlying the quartz sand of the Kálla Formation at Diszel, a single leaf specimen and a small mollusc fauna was collected by Imre Magyar. The fauna included *Lymnocardium* cf. *variocostatum*, *Caladacna steindachneri, Paradacna* sp., *Melanopsis* sp., *Lymnocardium* sp., and belongs to the L. ponticum Zone (Csillag et al. 2010).

Lithostratigraphy: Somló Formation.

Age: 9.6–8.7 Ma.

Flora:

Platanus leucophylla (UNGER) KNOBLOCH

The single plant remain collected at this locality confirms that *Platanus leucophylla* was widespread during the Pannonian in the Transdanubian region. Another locality at Karmacs situated close to Diszel yielded a flora, which is dominated by *P. leucophylla*.

Diszel - Kula Hill

The abandoned sand quarry in Diszel - Kula Hill, yielded goethite pseudomorphs of pine cones and wood fragments. The medium grained, strongly leached, white or light yellow pure quartz sand often contains pebbles of quartz and quartzite. The sand belongs to a few dozen metres thick sand body that once lined the embayment of Lake Pannon in the south-western part of the Transdanubian Range (TÓTH et al. 2010). It was derived from small gravelly deltas that prograded into Lake Pannon at the margins of the range (SZTANÓ 1995, SZTANÓ et al. 2010), and its deposition took place in wave-dominated shoreface environment (BABINSZKI et al. 2003).

Lithostratigraphy: Kálla Gravel Formation.

Age: ca 10 Ma.

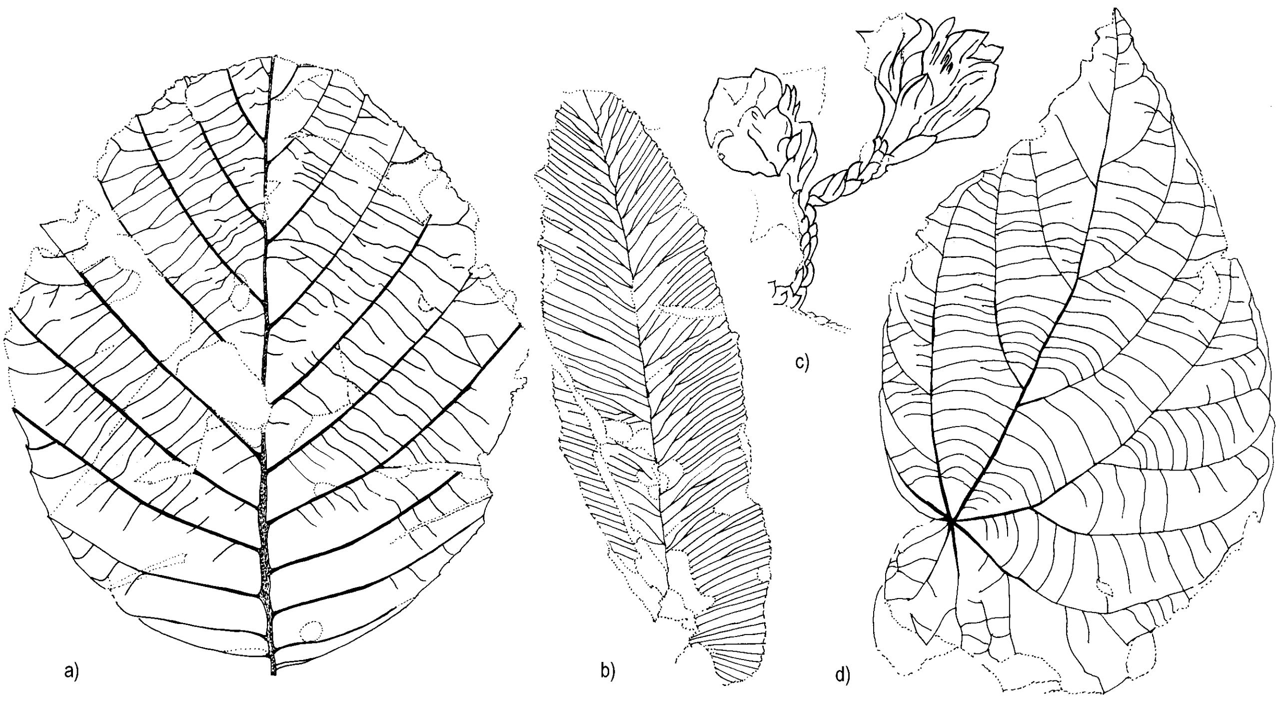
Flora:

Pinus sp.

Several pine cones were collected from the locality. Pine cones were also encountered in Mindszentkálla, which is located in the same region, in Balaton Uplands. However, type of preservation are different in these two localities. Due to taphonomic constraints other taxa were not preserved, therefore a detailed flora and vegetation reconstruction is not available. Nevertheless, the presence of a pine forest is indicated.

Dozmat

Thousands of plant remains were collected in the 1960s by Ernő Horváth in the surroundings of the small village of Dozmat. The collection is kept in the Savaria Museum, Szombathely, and was investigated by HABLY & KOVAR-EDER (1997). The latter authors made an attempt to find the original outcrop(s) where Horváth collected, but in the lack of any useful description of the locality, they failed. The entire administrative area of Dozmat, as well as that of Sé, however, lies with-



Text-figure 8. Floristic composition of locality Dozmat a) A*lnus cecropiifolia,* b) *Osmunda parschlugiana,* c) *Glyptostrobus europaeus,* d) *Byttneriophyllum tiliifolium* in the NE–SW striking zone where the south-east-dipping lignitiferous Torony sequence subcrops under a thin Quaternary blanket (JASKÓ 1975). Therefore, the fossils undoubtedly came from, and characteristic of, the 100–120m thick lignite-bearing Torony sequence. The sequence consists of several 4–20m thick, coarsening upward sedimentary cycles (parasequences).

The total thickness of the lignite and the sand within the sequence is 15 and 25 metres, respectively; most of the sequence consists of clay and silt (JASKÓ 1981). Both the molluscs (JASKÓ 1981) and the palynomorphs (DRAXLER et al. 1997) indicate freshwater depositional environments.

Lithostratigraphy: Torony Lignite Formation.

Age: 7.3–6.7 Ma

Flora:

Osmunda parschlugiana (UNGER) ANDREÁNSZKY
Glyptostrobus europaeus (BRONGNIART) UNGER
Alnus cecropiifolia (ETTINGSHAUSEN) BERGER
Alnus gaudini (HEER) KNOBLOCH & KVAČEK
Alnus sp. cones
Alnus sp. male catkins
Byttneriophyllum tiliifolium (A. BRAUN) KNOBLOCH & KVAČEK
Banisteriaecarpum giganteum (GÖPPERT) KRÄUSEL

The fossil assemblage from Dozmat is one of the most characteristic examples of the flora and vegetation in swamps of the Pannonian Basin. The assemblage is dominated by three taxa, and only few other taxa are accompanying as proved by thousands of specimens. The association comprising *Glyptostrobus europaeus*, *Byttneriophyllum tiliifolium* and *Alnus cecropiifolia*, is one of the most characteristic and dominant associations of swamp habitats during the Late Miocene. Leaves of *Alnus gaudini* and *Osmunda parschlugiana* occur with extremely low number of specimens (HABLY & KOVAR-EDER 1996).

Felsőtárkány

Felsőtárkány has been well-known for a long time as a palaeobotanical locality. First SÜMEGHY (1924) mentioned plant remains from the vicinity of the village. Later Andreánszky and his students collected and published a rich flora from Felsőtárkány (KUBÁT & BUBIK 1955, CZIFFERY & SZILÁGYI 1956, ANDREÁNSZKY & CZIFFERY, SZILÁGYI in ANDREÁNSZKY 1959). Recently ERDEI & HÍR (2002) summarized the geology and stratigraphy of the plant bearing sediments and reconstructed the vegetation and climate.

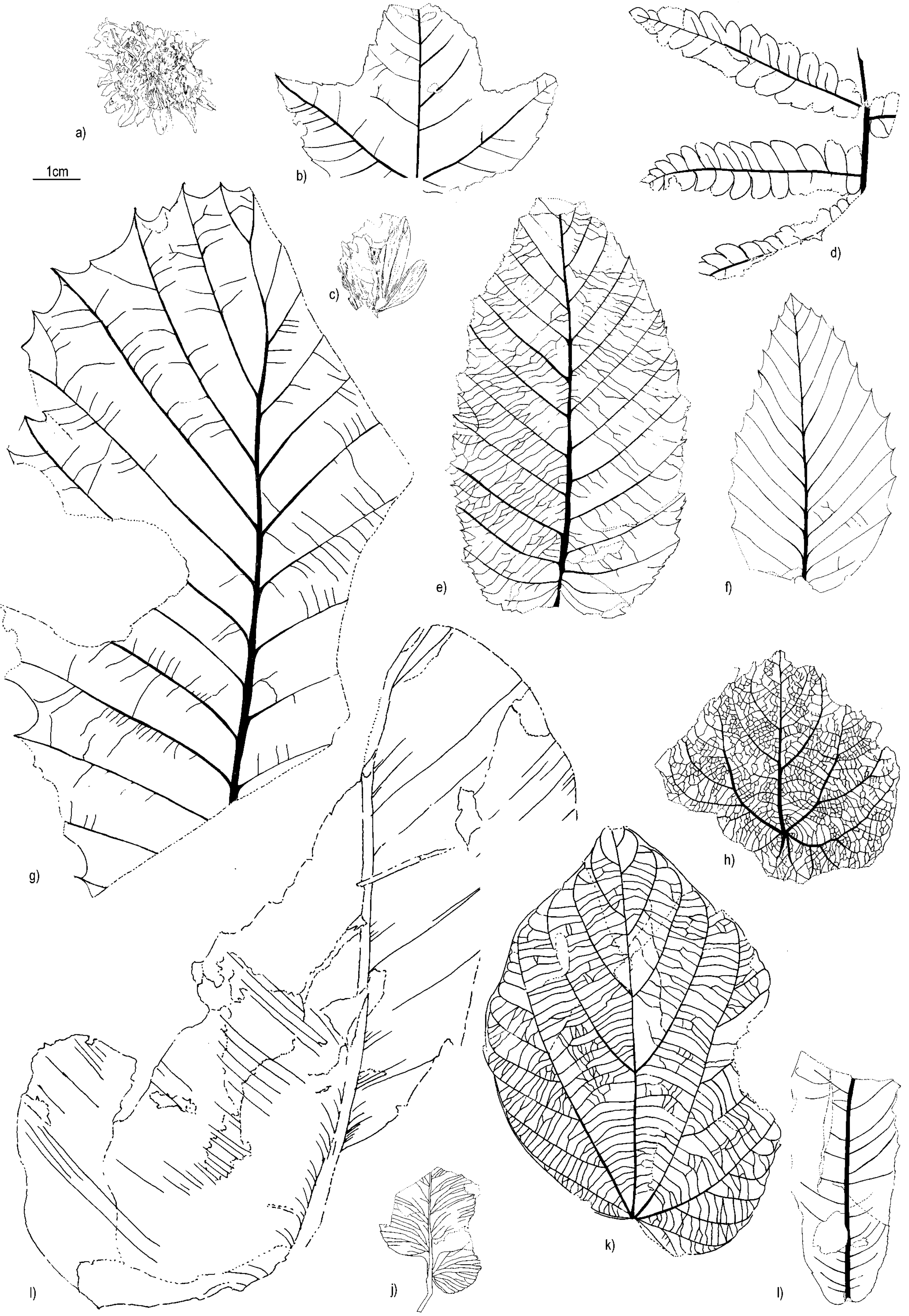
In the Felsőtárkány area, Sarmatian sandstone with brackish marine molluscs is overlain by rhyolite tuff, which in turn is capped by a fluvial-paludal series (HÍR 2007). One of the best outcrops of the latter, Güdör-kert, displays the following 4m thick sequence (from bottom to top): reworked rhyolite tuff, hard sand, grey clay with freshwater mollusc shells and vertebrate remains, sand, lignite, laminated clay with plant remnants, sand, green clay with freshwater mollusc shells and vertebrate remains (HÍR 2010). The plant-bearing laminate was probably deposited under oxygene-depleted conditions.

Lithostratigraphic assignement of the sequence is equivocal.

Age: ca. 11.5 Ma.

Flora:

Pronephrium stiriacum (UNGER) KNOBLOCH & KVAČEK
Osmunda parschlugiana (UNGER) ANDREÁNSZKY
Glyptostrobus europaeus (BRONGNIART) UNGER
Magnolia sp.
Quercus sp. fructus
Quercus pontica miocenica KUBÁT
Alnus menzelii RANIECKA-BOBROWSKA
Alnus sp. male catkins
Ulmus braunii HEER
Cercidiphyllum crenatum (UNGER) BROWN
Cercidiphyllum sp. fructus
Acer tricuspidatum BRONN
Acer sp. fructus
Salix varians GÖPPERT
Byttneriophyllum tiliifolium (A. BRAUN) KNOBLOCH & KVAČEK
Musophyllum tárkányense BUBIK
Monocotyledonae gen et sp.


a)
b)
c)
d)
e)
f)
g)
h)
i)
j)
k)
l)
1cm

←***Text-figure 9.*** Floristic composition of locality Felsőtárkány a) *Quercus sp. fructus,* b) *Acer tricuspidatum,* c) *Cercidiphyllum* sp. fructus. d) *Pronephrium stiriacum,* e) *Quercus pontica miocenica,* f) *Alnus menzelii,* g) *Quercus pontica miocenica,* h) *Cercidiphyllum crenatum* i) *Musophyllum tárkányense,* j) *Osmunda parschlugiana,* k) *Byttneriophyllum tiliifolium,* l) *Salix varians*

Felsőtárkány has been well-known for a long time as a palaeobotanical locality. First SÜMEGHY (1924) mentioned plant remains from the vicinity of the village. Later Andreánszky and his students collected and published a rich flora from Felsőtárkány (KUBÁT & BUBIK 1955, CZIFFERY & SZILÁGYI 1956, ANDREÁNSZKY & CZIFFERY, SZILÁGYI in ANDREÁNSZKY 1959). Recently ERDEI & HÍR (2002) summarized the geology and stratigraphy of the plant bearing sediments and reconstructed the vegetation and climate.

This assemblage shows the highest diversity among the sites discussed in this monograph. This maybe due to the fact that sediments preserving the flora of Felsőtárkány were presumably formed during the Sarmatian/Pannonian boundary, thus, this flora is the oldest one among floras discussed here. The most important elements of the Pannonian floras characterizing swamps, i.e. *Glyptostrobus europaeus*, *Byttneriophyllum tiliifolium*, *Alnus menzelii*, and other accompanying elements, i.e. ferns, *Pronephrium stiriacum*, *Osmunda parschlugiana*, were all recorded here. At the same time numerous additional taxa, i.e. *Acer tricuspidatum*, *Cercidiphyllum crenatum*, *Ulmus braunii*, *Quercus pontica miocenica* and *Musophyllum tárkányense* were recorded here, as well. This is the oldest record of the swamp flora and vegetation that displayed already the floristic composition characteristic throughout the Pannonian.

However, the flora is still relatively species-rich and comprises additional swamp and aquatic taxa that were either present exclusively in this flora and disappeared in younger floras, or were recorded from floras of the Early Pannonian, e.g. *Cercidiphyllum* from Rudabánya.

Gyöngyös

In the old collection of the Hungarian Natural History Museum, a single leaf specimen labelled "Gyöngyös - Silbermann Mine" was found. Several mines exploited lignite from the Bükkalja sequence in the area of Gyöngyös; this shaft produced lignite between 1919 and 1925 (SZABÓ et al. 2004).

Lithostratigraphy: Bükkalja Formation.

Age: 7.5–6.7 Ma.

Flora:

Platanus leucophylla (UNGER) KNOBLOCH

The remain suggests that a riparian forest dominated by *Platanus leucophylla* must have been present, which accompanied the predominantly swamp vegetation. This is the sole occurrence of the species in Northern Hungary.

Győr-Sashegy

A relatively large collection of plant fossils from Győr-Sashegy is deposited in the Savaria Museum, Szombathely. Plant remains were collected by Ernő Horváth several decades ago, unfortunately without any detailed information on the exact location. The flora is first published in this monograph.

Sashegy is located in the south-eastern part of the town of Győr. Pleistocene gravel was mined here, and the underlying fluvial Pannonian layers were exposed in the bottom of a gravel pit (Kordos, personal communication 2013). The plant fossils most probably came from these Upper Miocene beds.

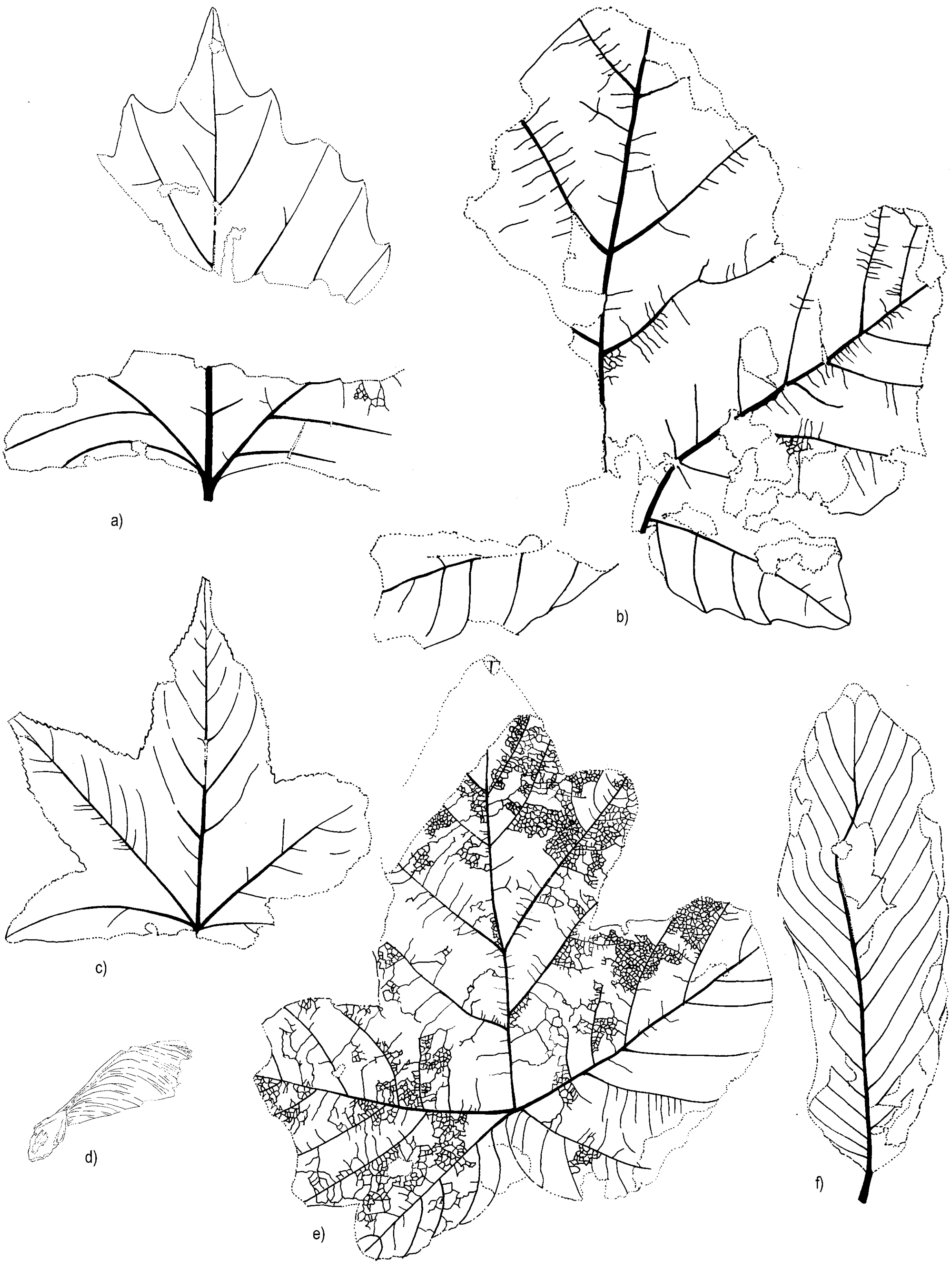
Lithostratigraphy: Zagyva Formation.

Age: 7.5–7.0 Ma.

Flora:

Liquidambar europaea A. BRAUN
Platanus leucophylla (UNGER) KNOBLOCH
Ulmus carpinoides GÖPPERT emend. MENZEL
Cercidiphyllum crenatum (UNGER) BROWN
Acer subcampestre GÖPPERT
Acer sp. fructus
Vitis sp.
Monocotyledonae gen. et sp.

The locality yielded a flora typical of riparian habitats during the Pannonian. The fossil assemblage is well-preserved and comprises high number of specimens, however, indicates a relatively low diversity with the dominance of species characteristic of the riparian vegetation type, e.g. *Liquidambar europaea*, *Platanus leucophylla*, *Ulmus carpinoides*. Additional species occur only rarely, e.g. *Acer subcampestre*, *Cercidiphyllum crenatum*, and *Vitis* sp.



Text-figure 10. Floristic composition of locality Győr-Sashegy a) *Platanus leucophylla,* b) *Acer subcampestre,* c) *Liquidambar europaea,* d) *Acer* sp. fructus, e) *Vitis* sp., f) *Ulmus carpinoides*

Hatvan

The brickyard claypit of Hatvan is located NE of the town. RÁSKY (in GAÁL 1943) published the photographs of *Fagus* sp. and *Betula brongniarti* from the outcrop. Poorly preserved plant remains, kept in the Savaria Museum of Szombathely, were collected by Ernő Horváth in Hatvan, most probably also from the sandy-clayey sediments of the brickyard. In spite of its poor preservation, the flora provides good additional information about the "non-lignite" floras of Northeast Hungary. The flora is first published in this monograph.

The sketchy profile of the brickyard outcrop was published by VIGH (1939), GAÁL (1943), and more recently by BERNOR et al. (2003b). The outcrop consists of clay, sand, and sandstone layers, some of them with fossils of freshwater molluscs. The plant remains, as well as the mammal bones, were yielded by grey clay, overlain by cross-bedded sandstone. The whole sequence was interpreted to have been deposited in floodplain and freshwater, shallow lacustrine environments. The cross-bedded sand indicates either fluvial or beach setting (BERNOR et al. 2003b).

Lithostratigraphy: Bükkalja Formation.

Age: 7.5–6.7 Ma.

Flora:

Alnus sp.
Ulmus sp.

The poorly preserved leaf remains corroborate that wetland vegetation occupied extensive areas in the northern part of the basin. The absence of *Glyptostrobus* fossils suggests that the vegetation represented by this assemblage did not belong strictly to swamp forests.

Hévíz

This specimen comes from a 4 km long and 1 km wide, north–south trending sandstone ridge that follows the western margin of the Keszthely Mts, and includes the fossiliferous localities of Cserszegtomaj and Karmacs as well (BUDAI et al. 1999).

In the old collections of the Bakony Museum at Zirc, one specimen collected by Béla Dornyay from the Pannonian layers of Hévízszentandrás was found (currently the village belongs to the town of Hévíz).

Lithostratigraphy: Somló Formation.

Age: 9.6–8.7 Ma.

Flora:

Platanus leucophylla (UNGER) KNOBLOCH

Together with specimens from Diszel and Karmacs, this occurrence shows the wide distribution area of *P. leucophylla* during the Pannonian.

Hosszúpereszteg

Hundreds of plant specimens were collected by Ernő Horváth from the locality Hosszúpereszteg in the early 1970s. The specimens, although undetermined, are inventoried and stored in the Savaria Museum, Szombathely. The flora is first published in this monograph.

Although the plant bearing sediment is sandy and oxidized, and the leaf remains are thus poorly preserved, impressions of fruits are preserved in much higher number here than in other localities.

The outcrop displays cross-bedded fluvial sand with fossils of freshwater and terrestrial molluscs and large land mammals, such as *Deinotherium* and *Hipparion* (KRETZOI 1982).

Lithostratigraphy: Zagyva Formation.

Age: 7.5–7.0 Ma.

Flora:

Liquidambar europaea A. BRAUN
Platanus leucophylla (UNGER) KNOBLOCH
Platanus sp. fruit
Quercus kubinyii (KOVÁTS ex ETTINGSHAUSEN) BERGER
Quercus sp.
Quercus sp. fructus
Alnus sp.
Ulmus carpinoides GÖPPERT emend. MENZEL
Ulmus braunii HEER

Acer subcampestre GÖPPERT
Salix varians GÖPPER

The flora from Hosszúpereszteg is a unique assemblage documenting the mesophytic forest vegetation. Several leaf and fruit remains belonging to the genus *Quercus* suggest that this area must have been a refuge of the mesophytic vegetation. On the other hand, members of the riparian vegetation typical of the Pannonian were also found, i.e. *Liquidambar europaea*, *Platanus leucophylla*, *Ulmus carpinoides*, and some other accessory elements.

Iharosberény

The borehole Iharosberény–I was drilled with continuous coring by the Geological Institute of Hungary in 1987. The well penetrated the Upper Miocene between 24 and 1377m (SACCHI & MÜLLER 2004). Leaf remains from the cores down to 606.9m were collected by Áron Jámbor.

The stratigraphy of the Iharosberény borehole with sedimentological, cycle stratigraphic, and magnetostratigraphic interpretations was published in several papers (LANTOS et al. 1992; JUHÁSZ et al. 1996, 1997, 1999; SACCHI et al. 1998, 1999, MAGYAR et al. 1999b, SPROVIERI et al. 2003, SACCHI & MÜLLER 2004).

The fossil plant bearing interval displays a characteristic cyclicity with 5–12m thick genetic units, showing aggradational stacking patterns. These sediments are interpreted to have been deposited in delta plain environment (JUHÁSZ et al. 1996, 1997, 1999).

Lithostratigraphy: Újfalu Formation.

Age: 7.3–6.5 Ma.

Flora:

Osmunda parschlugiana (UNGER) ANDREÁNSZKY
Glyptostrobus europaeus (BRONGNIART) UNGER
cf. *Alnus cecropiifolia* (ETTINGSHAUSEN) BERGER
Alnus sp.
cf. *Myrica lignitum* (UNGER) SAPORTA
Salix varians GÖPPERT
Byttneriophyllum tiliifolium (A. BRAUN) KNOBLOCH & KVAČEK
Monocotyledonae gen. et sp.

The flora of Iharosberény comprises elements of a swamp vegetation characteristic of the Pannonian in the Transdanubian region. Dominant elements, e.g. *Glyptostrobus*, *Alnus*, *Byttneriophyllum* and *Osmunda*, are shared by Dozmat, and only few additional taxa that are all confined to wetland vegetation types, appear in this flora. The flora was first published by HABLY (1992c).

Karmacs

In an abandoned quarry near Karmacs, Gábor Csillag had discovered plant remains and later Lilla Hably collected some fossils. Relatively few fossil specimens were found in the grey, coarse-grained, compacted sandstone that forms a ridge between Hévíz and Karmacs (for more information see locality Cserszegtomaj). Fossils are generally poorly preserved but preservation seems to be taxon-dependent (see chapter "Taphonomy"). The flora is first published here.

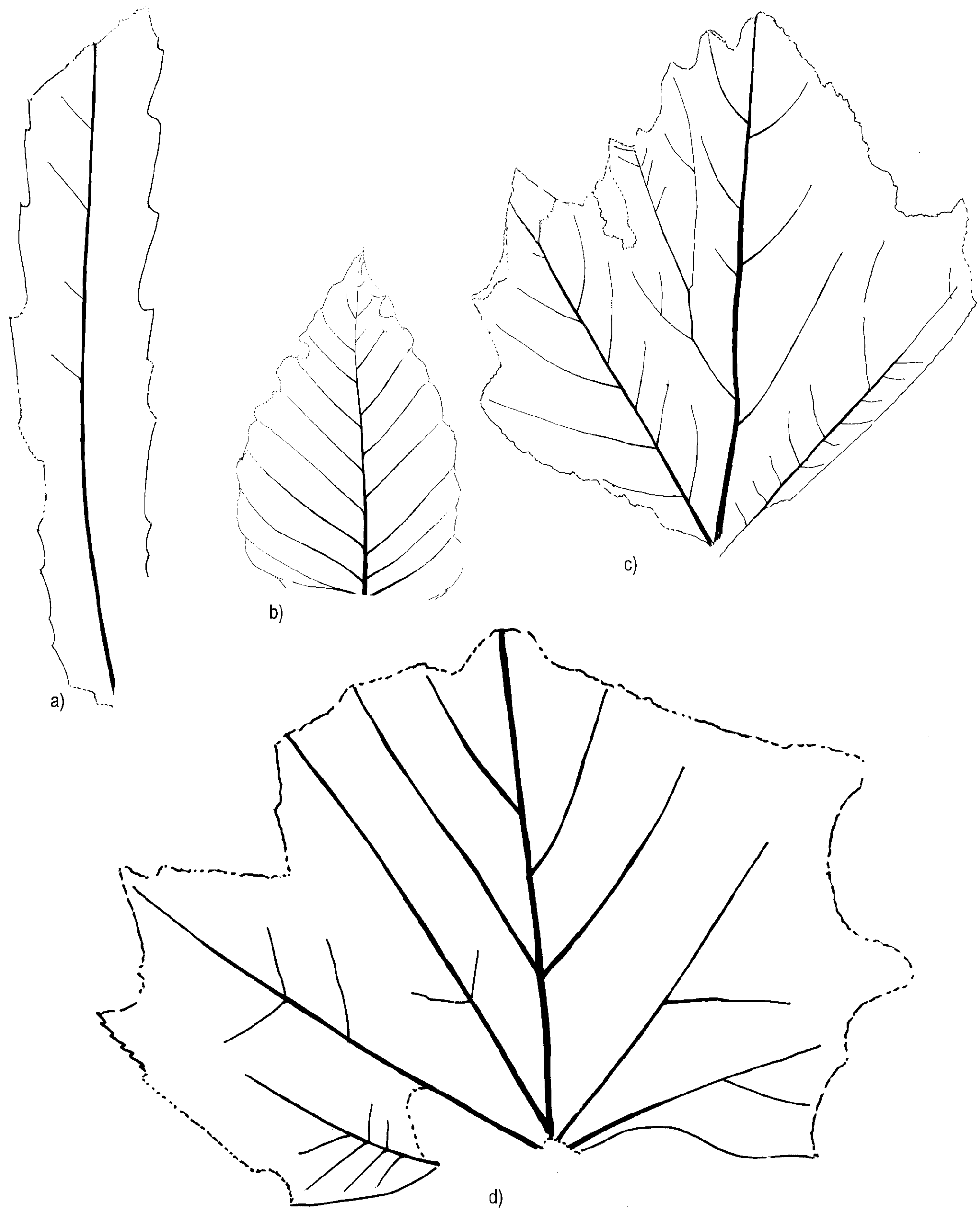
Lithostratigraphy: Somló Formation.

Age: 9.6–8.7 Ma

Flora:

Platanus leucophylla (UNGER) KNOBLOCH
Alnus sp.
cf. *Myrica lignitum* (UNGER) SAPORTA
Ulmus braunii HEER
Populus populina (BRONGNIART) KNOBLOCH
Monocotyledonae gen. et sp.

The flora of Karmacs, and other assemblages (Diszel-Hajagos, Hévíz) from the northern region of the Balaton indicate riparian vegetation cover dominated by *Platanus leucophylla* and *Ulmus braunii*. The considerably few records of *Populus populina*, which is a rare element in the Hungarian Pannonian, were documented from this locality and Sé. This species is assumed to be a member of the riparian vegetation. Poorly preserved, uncertain remains of *Myrica* suggest that swamp habitats probably also existed in the close vicinity of the site.



Text-figure 11. Floristic composition of locality Karmacs a) cf. *Myrica lignitum,* b) *Ulmus braunii,* c) *Platanus leucophylla,* d) *Platanus leucophylla*

Kerecsend

Several leaf fossils were collected in the 1960s from an old clay pit near the village of Kerecsend in Northern Hungary, within the Mátra–Bükkalja lignite area. This collection is reposited in the Mátra Museum in Gyöngyös, and in the Savaria Museum in Szombathely. The relatively well-preserved leaf impressions were embedded in yellow clay. The flora was partly published by ANDREÁNSZKY (1952).

Unfortunately, the locality is not accessible any more, because the clay pit was filled up.

Lithostratigraphy: Bükkalja Formation.

Age: 7.5–6.7 Ma.

Flora:

Pteridophyta gen. et sp.

Ginkgo adiantoides (UNGER) HEER

Glyptostrobus europaeus (BRONGNIART) UNGER
Alnus cecropiifolia (ETTINGSHAUSEN) BERGER
Alnus sp.
Salix varians GÖPPERT
Byttneriophyllum tiliifolium (A. BRAUN) KNOBLOCH & KVAČEK
Monocotyledonae gen. et sp.

The fossil assemblage from Kerecsend located in Northern Hungary, close to the Mátra–Bükkalja lignite area, represents wetland vegetation typical of the Pannonian. Characteristic elements of this flora, *Glyptostrobus europaeus*, *Alnus cecropiifolia* and *Byttneriophyllum tiliifolium* are shared by other floras, e.g. Dozmat and Iharosberény in the Transdanubian region. In addition to the dominant and most characteristic elements there are some other taxa that were common during the Late Miocene. The presence of *Ginkgo adiantoides* is noteworthy. The occurrence of *Ginkgo* fossils (Bükkábrány, Kerecsend, Rózsaszentmárton, Rudabánya, Visonta) suggests that its distribution must have been restricted to Northern Hungary during the Late Miocene of the Pannonian Basin.

Mindszentkálla

A small flora, consisting of impressions of pine cones and leaves, and a mollusc fauna with moulds of large, thick-shelled molluscs (*Congeria pancici, Lymnocardium* cf. *schedelianum, Lymnocardium* sp., *Unio atavus, Melanopsis* cf. *fossilis*) were found and saved by the workers of a sandstone quarry at Mindszentkálla in the north-western margin of the Kál Basin during the mid-1980s (MAGYAR 1988). The hard, tightly cemented, pebbly sandstone was originally deposited in wave-reworked sandy beaches and sand bars, and belongs to the same rock body as the sand of Diszel - Kula Hill outcrop (TÓTH et al. 2010). The sand in Mindszentkálla and in other localities of the Kál Basin, however, was silicified in irregular and discontinuous zones and lenses. Cementation was controlled by the groundwater table, and took place most probably in the Early Pleistocene (RUSZKICZAY-RÜDIGER et al. 2011, ANDRÁS 2012). Subsequent erosion of these groundwater silcretes led to the formation of the wind-blown "stone fields", a specific geomorphological feature of the Kál Basin.

Lithostratigraphy: Kálla Gravel Formation.

Age: ca. 10 Ma.

Flora:

Picea sp.
Pinus sp.
Leguminosae gen. et sp.
Monocotyledonae gen. et sp.

The assemblage is dominated by cones assigned to *Pinus* and *Picea*. These fossils show relation in part with the modern maritime pine, *Pinus pinaster* widespread in the western, south-western Mediterranean region, and in part with *Pinus heldreichii* growing today in the subalpine mountains of the Balkans and southern Italy, at an altitude of 1800–2400m.

Pécs-Danitzpuszta

The locality has been known as a textbook example of significant intra-Pannonian tectonic movements along the South Mecsek Line since the 1950s (VADÁSZ 1953, CSONTOS et al. 2002). In the outcrop, strongly tilted (almost vertical) white and grey marls are overlain by limonitic sand layers of changing tilt, probably with an unconformity representing significant hiatus. Whereas the sand is well-known about its reworked marine vertebrate fossils (KAZÁR et al. 2007, KONRÁD et al. 2010), the fossils of the marl, including the plant remnants, are much less known.

The marl was deposited in the sublittoral zone of Lake Pannon. The determination of its abundant mollusc fauna is in progress.

Lithostratigraphy: ?Endrőd Formation.

Age: 10.5 Ma.

Flora:

Myrica lignitum (UNGER) SAPORTA

The specimens discussed in this volume were collected recently by Krisztina Sebe. All the leaves, even fragmentary ones, are assigned to *Myrica lignitum*, which indicate the prevalence of swamp habitats.

Pécs, Nagyárpád

Nagyárpád, once an independent village south of Pécs, was a classic locality of Lake Pannon molluscs: 10 new bivalve species were described from here in the second half of the 19th century (Hörnes 1859–1867, Fuchs 1873, Lőrenthey 1894). The present-day outcrop is a 30m long and 14m high sand pit at the southern end of the village. The exposed sediments range from fine-grained sand to fine-grained silt, and represent the littoral to sublittoral environments of Lake Pannon (Szónoky et al. 1999). A laminated level in a medium-grained silt layer (Layer 7 in Szónoky et al. 1999) yielded deciduous leaf remnants. These laminites were deposited in a restricted, oxygene-depleted environment, without benthic fauna and biotubation.

Lithostratigraphy: ?Somló Formation.

Age: 7–6 Ma.

Flora:

Fagus haidingeri Kováts emend. Knobloch
Quercus sp.
Carpinus betulus L. fossilis
Acer cf. *tricuspidatum* Bronn
Salix varians Göppert
Populus populina (Brongniart) Knobloch

Although**,** this is a small flora comprising poorly preserved fossils from the Mecsek Mts, it is significant owing to the high number of specimens assigned to *Fagus haidingieri*, as well as the presence of *Quercus*. Fruits of *Carpinus* were recorded exclusively from this locality. The presence of these three genera indicates that this area served as a refugium of the mesophytic flora elements during the Pannonian. Moreover, it confirms that "inselbergs" of this region played significant role in the survival of the mesophitic flora during greatest expansions of Lake Pannon. Riparian elements, like *Salix* and *Populus* rarely occurred.

Rózsaszentmárton (Petőfi Mine)

A high number of plant remains were collected from the waste-heap of the mine, and deposited in the Mátra Museum, the Hungarian Geological Institute, and the Eötvös Loránd University. The latter collection was later donated to the Hungarian Natural History Museum. The flora of Rózsaszentmárton was studied and published by Pálfalvy (1952, 1965c, 1981) and Vörös (1955). Because these publications are often poorly documented with lists of taxa but without inventory numbers and illustrations, the entire Rózsaszentmárton material is reinvestigated in the present study.

One of the largest underground lignite mines cut into the Bükkalja sequence in the southern foothills of the Mátra Mountains was operated near Rózsaszentmárton, between 1917 and 1968 (Szabó et al. 2004).

The stratigraphy and structure of the Bükkalja sequence in the area was described in detail by Vigh (1939). In Rózsaszentmárton, the lignite seams are separated by bluish grey or greenish grey clay and sandy clay layers. The mollusc fauna is dominated by freshwater and terrestrial forms, but brackish cardiids (*Lymnocardium, Plagiodacna, Pontalmyra, Prosodacnomya*) also occur in some layers mainly towards the south and east, where there is more sand in the sequence (Pálfalvy 1952, Vigh 1939).

Lithostratigraphy: Bükkalja Formation.

Age: 7.5–6.7 Ma.

Flora:

Equisetum sp.
Ginkgo adiantoides (Unger) Heer
Glyptostrobus europaeus (Brongniart) Unger
Pinus sp.
cf. *Fagus haidingeri* Kováts emend. Knobloch
Alnus sp.
Engelhardia macroptera (Brongniart) Unger
Ulmus braunii Heer
Ulmus sp.
Ulmus sp. fructus
Ulmaceae gen et sp.
Trapa pannonica sp. nov.
Trapa rozsaszentmartoni sp. nov.

Acer vindobonensis (ETTINGSHAUSEN) BERGER
Acer tricuspidatum BRONN
Salix varians GÖPPERT
Byttneriophyllum tiliifolium (A. BRAUN) KNOBLOCH & KVAČEK
Potamogeton martinianus SITAR
Monocotyledonae gen. et sp.

A high number of plant remains were collected from the waste-heap of the mine, and deposited in the Mátra Museum, the Hungarian Geological Institute, and the Eötvös Loránd University. The latter collection was later donated to the Hungarian Natural History Museum. The flora of Rózsaszentmárton was studied and published by PÁLFALVY (1952, 1965c, 1981) and VÖRÖS (1955). Because these publications are often poorly documented with lists of taxa but without inventory numbers and illustrations, the entire Rózsaszentmárton material is reinvestigated in the present study.

The typical swamp forest vegetation is clearly represented by *Glyptostrobus europaeus*, *Byttneriophyllum tiliifolium*, *Alnus* sp., and other swamp elements, e.g. *Equisetum* sp. Remains of *Salix*, *Ulmus* and *Acer tricuspidatum* were also encountered, which were putatively elements of swamp or deep riparian forests. Aquatic vegetation is indicated by fruits and leaves of *Trapa* and fossils of *Potamogeton*. *Ginkgo* is a rare accessory element, but it appears in several Pannonian assemblages in Northern Hungary. Engelhardia macroptera is assumed as a relict species in the Pannonian floras, with a sole occurrence in the flora of Rózsaszentmárton. Evaluated as a thermophilous element, its presence confirms a warm temperate climate during the Pannonian. Another important element is *Fagus*, however, its occurrence in the assemblage is doubtful, and still awaits confirmation due to poor preservation. *Fagus* is a mesophytic element, and it is better represented in the Sarmatian record. Its survival through the Pannonian is indicated by the single, well-preserved and documented record from Alcsút.

Rudabánya

Rudabánya is one of the most important Eurasian localities of the early phase of hominization (BERNOR et al. 2003a). The flora of the outcrops was collected and published by Pálfalvy (NAGY & PÁLFALVY 1961; KRETZOI et al. 1976; PÁLFALVY 1980, 1981). These publications, however, generally contained pure taxonomic lists and lacked additional documentation, such as inventory numbers and photographs. The collection was therefore revisited and results of the revision are presented here.

At the time of deposition of the fossiliferous layers, the Borsod Basin was an embayment of Lake Pannon where the alternation of terrestrial environments and lacustrine floodings led to the formation of extensive swamps and bogs (KORDOS 1982). The Pannonian sequence in Rudabánya starts with a 3–4m thick basal detritus (sideritic clay with gravel layers) blanketing the uneven surface of the Lower and Middle Triassic basement. The overlying 8–10m thick, clayey-sandy series contains 8 lignite seams (KRETZOI et al. 1976; KORDOS 1982).

Most of the fossils were found in the upper black mud layers and the underlying grey and black clays. The clays contain black; organic-rich intercalations accumulated under low-energy depositional conditions, such as those prevailing in a calm, shallow lake (ERDEI et al 2011). KRETZOI et al. (1976) observed that the clay layer yielding the richest plant material completely lacked fossils of bivalves and non-pulmonate aquatic snails, and ostracods and fish remains were extremely rare. They concluded that the depositional environment was a stagnant, oxygen-poor water body, the bottom of which was covered by decaying organic mud. The fossils found in these sediments tend to be fairly complete. Remains of animals were deposited shortly after death under low-energy conditions, probably close to the water's edge. Occasionally large tree trunks and other plant parts, accompanied by disarticulated bones and isolated teeth, were washed into the site with considerable energy, which is typical of seasonal flooding.

Lithostratigraphy: Edelény Formation.

Age: 10 Ma.

Flora:

Osmunda parschlugiana (UNGER) ANDREÁNSZKY
Ginkgo adiantoides (UNGER) HEER
Glyptostrobus europaeus (BRONGNIART) UNGER
Daphnogene sp.
Alnus menzelii RANIECKA-BOBROWSKA
Alnus GAUDINi (HEER) KNOBLOCH & KVAČEK
Alnus sp. male catkins
Carpinus grandis UNGER emend. HEER
Ulmus sp.
Zelkova zelkovifolia (UNGER) BŮŽEK & KOTLABA

Cercidiphyllum crenatum (UNGER) BROWN
Cercidiphyllum sp. fructus
Trapa silesiaca GÖPPERT
Acer subcampestre GÖPPERT
Acer vindobonensis (ETTINGSHAUSEN) BERGER
Acer sp. fructus
Mastixia amygdalaeformis (SCHLOTHEIM) KIRCHHEIMER
Salix varians GÖPPERT
Byttneriophyllum tiliifolium (A. BRAUN) KNOBLOCH & KVAČEK
Banisteriaecarpum giganteum (GÖPPERT) KRÄUSEL
Nyssa disseminata (LUDWIG) KIRCHHEIMER
Stratiotes tuberculatus C. & E. M. REID
Potamogeton martinianus SITAR

The flora of Rudabánya shows numerous common elements and it is quite similar to several other Pannonian floras. The swamp assemblage characteristic of the Pannonian vegetation, with *Glyptostrobus europaeus*, *Alnus* div. sp., and *Byttneriophyllum tiliifolium*, is well-represented. This assemblage comprises *Osmunda parschlugiana* and *Banisteriaecarpum giganteum*, which latter is considerably rare in the Hungarian floras. In spite of this, it is described as characteristic element of Pannonian floras (see Systematic descriptions), and its occurrence is always accompanied by leaves of *Byttneriophyllum*. Aquatic associations are represented by *Trapa heerii*, *Stratiotes tuberculatus* and *Potamogeton martinianus*. *Ginkgo*, *Salix*, *Ulmus, Cercidiphyllum* and *Acer* represent wetland vegetation. Most of them are frequent elements in the Pannonian floras, with two exceptions, *Ginkgo*, the area of which is limited to Northern Hungary, and *Cercidiphyllum*, which shows mass occurrence in Rudabánya. Another flora, similarly dominated by *Cercidiphyllum*, is Felsőtárkány, which confirms that this species was characteristic of early Pannonian floras. It is noteworthy that elements of "Late mastixioid floras" were recorded, as well. Species of Daphnogene and *Mastixia* appear in the flora as relicts (HABLY & ERDEI submitted). The youngest occurrence of the genus *Daphnogene* inside the Pannonian Basin is recorded from this flora. Moreover, the sole occurrence of *Mastixia* in the Pannonian Basin has been proved here. *Zelkova zelkovifolia* was also recorded in Rudabánya, though, with just a single specimen. This indicates that *Zelkova* must have survived in refuges of the Pannonian Basin, nevertheless, a higher occurrence of *Zelkova* was proved from marginal areas of the basin.

Sé

Near the small village of Sé, Ernő Horváth collected numerous plant remains, which are stored in the Savaria Museum, Szombathely. The leaf impressions are preserved in yellow clay, with well observable details of leaf morphology. The flora was partly published by HORVÁTH (1971–72). Sé is located immediately next to Torony and Dozmat, in a zone where the Torony lignite-bearing sequence is exposed under a thin Quaternary cover. For more details see the description at Dozmat.

Lithostratigraphy: Torony Lignite Formation.

Age: 7.3–6.7 Ma.

Flora:

Pronephrium stiriacum (UNGER) KNOBLOCH & KVAČEK
Osmunda parschlugiana (UNGER) ANDREÁNSZKY
Glyptostrobus europaeus (BRONGNIART) UNGER
Liquidambar europaea A. BRAUN
Platanus leucophylla (UNGER) KNOBLOCH
Quercus kubinyii (KOVÁTS ex ETTINGSHAUSEN) BERGER
Myrica lignitum (UNGER) SAPORTA
Alnus menzelii RANIECKA-BOBROWSKA
Salix varians GÖPPERT
Populus populina (BRONGNIART) KNOBLOCH
Monocotyledonae gen. et sp.

The flora of Sé represents various plant assemblages. The characteristic swamp association was documented with *Pronephrium stiriacum*, *Osmunda parschlugiana*, *Glyptostrobus europaeus*, *Myrica lignitum* and *Alnus menzelii*, however, it is noteworthy, that *Byttneriophyllum tiliifolium* was not recorded. The flora of Balatonszentgyörgy shows similar character and both localities contain *Myrica lignitum*. This may suggest that *Myrica* and *Byttneriophyllum* were accompanying elements during the Pannonian. Another association with *Liquidambar europaea* and *Platanus leucophylla* suggests riparian vegetation characteristic of the Pannonian. *Populus* and *Salix* were potential members of this association. The occurrence of *Quercus kubinyii* indicates the presence of mesophytic forest vegetation; however, it must have played a subordinate role in vegetation cover.

Sótony

A large material of fossil leaves was collected and partly published from Sótony by Ernő Horváth (HORVÁTH 1958, 1961, 1963).

Lithostratigraphy: Zagyva Formation.

Age: 7.5–7.0 Ma.

Flora:

Salix varians GÖPPERT

Monocotyledonae gen. et sp.

Despite the size of the collection, the flora seems to be highly monotonous, and dominated by remains of *Salix*. HORVÁTH (1963) distinguished various species of *Salix*, and mentioned a few other taxa, but due to poor preservation of leaves these data cannot be confirmed. The assemblage indicates a riparian type of vegetation of low diversity.

Tihany-Fehérpart

The locality is situated close to the shore of Lake Balaton, 1600m to the south–south-east of the Tihany harbour. Plant remains were found for the first time by MÜLLER & SZÓNOKY (1988, 1989), later HABLY (1992a) collected fossils from the outcrop.

The Fehérpart outcrop is probably the most thoroughly examined Pannonian outcrop in Hungary. The history of its century-old study was recently summarized by SZTANÓ et al. (2013).

The almost vertical, 30m high wall consists of fine sand and silt layers, building several-metres-thick sedimentary cycles. A complete cycle starts with layers deposited in agitated water, at about the depth of the wave base, usually with a relatively diverse lacustrine fauna. The overlying layers reflect deposition in increasingly shallow water, and display a coarsening-upward pattern. The cycle is closed by marsh sediments, organic-rich, dark-coloured layers with purely freshwater, paludal fauna. These cycles correspond to lacustrine parasequences, formed on the delta front or in inter-distributary bays to delta-plain swamps and distributary channels, under the combined influence of high-frequency lake-level changes of a few metres amplitude, intense sediment supply, and small-scale changes in the patchy environment (SZTANÓ et al. 2013).

Lithostratigraphy: Tihany Formation.

Age: 8.3–8.0 Ma.

Flora:

Liquidambar europaea A. BRAUN

Platanus leucophylla (UNGER) KNOBLOCH

Alnus ducalis GAUDIN emend. KNOBLOCH

Alnus gaudini (HEER) KNOBLOCH & KVAČEK

Alnus sp.

Juglans acuminata A. BRAUN ex UNGER

Ulmus braunii HEER

Acer jurenakii STUR

Salix varians GÖPPERT

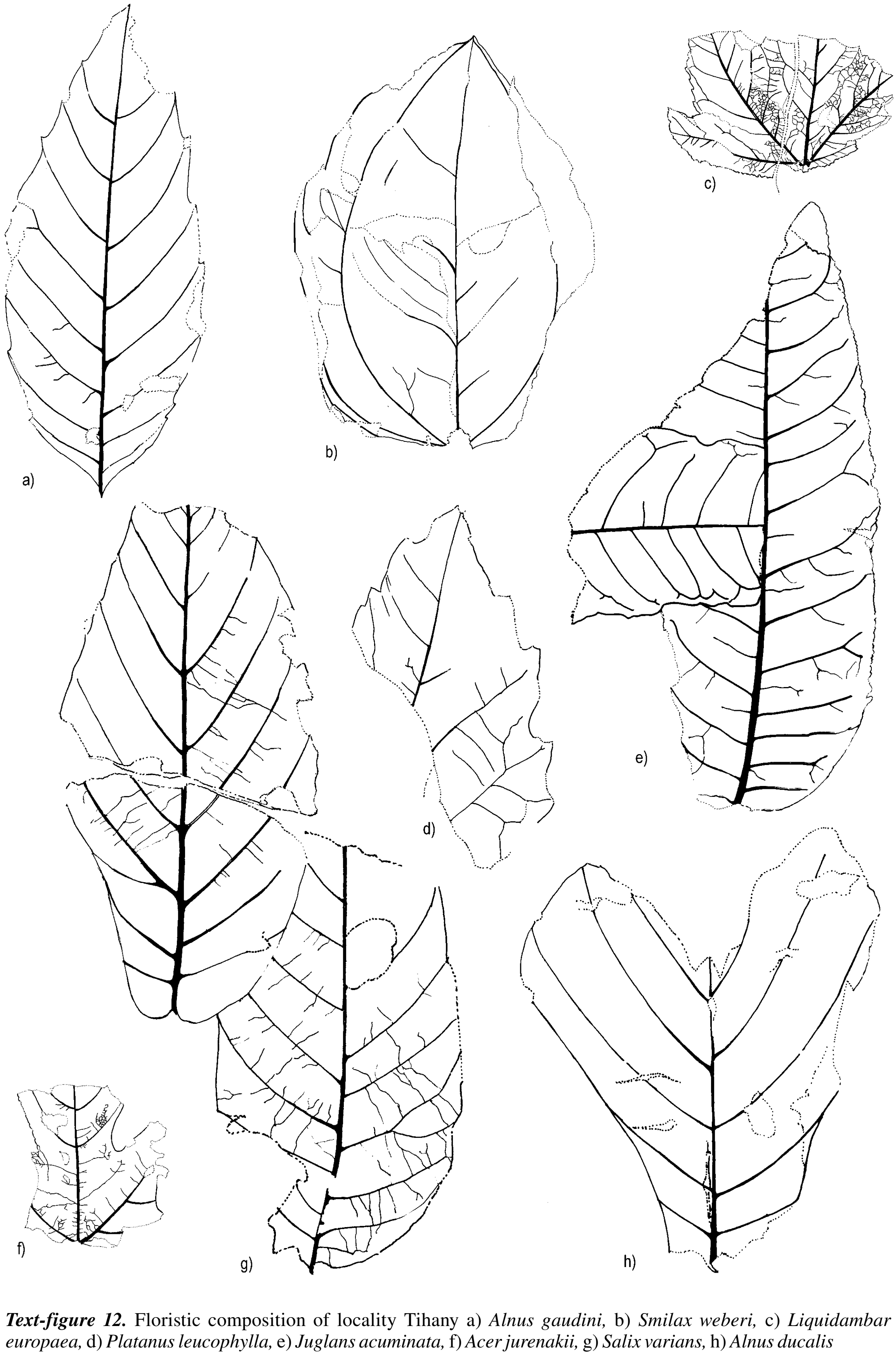
Smilax weberi WESSEL in WESSEL & WEBER

Monocotyledonae gen. et sp.

The flora of Tihany represents the characteristic riparian vegetation type of the Pannonian. Major elements of this assemblage are *Liquidambar europaea*, and *Platanus leucophylla*, and other taxa join this “core-assemblage”. Taxa indicating swamp habitats were not recorded. *Alnus ducalis*, a characteristic element of the flora, occurs in several European floras (see in Systematic part); however, among the Pannonian floras of Hungary it was recorded exclusively from Tihany. Similarly, another noteworthy element, *Smilax weberi* was described only from Tihany. It is a thermophilous element, and presumably possessed a liana growth habit, which indicates the presence of the liana level in the vegetation structure. The flora was first published by HABLY (1992a).

Tiszapalkonya

The borehole Tiszapalkonya–I is one of the dozen stratigraphic test borehole drilled with continuous coring by the Geological Institute of Hungary in the 1980’s. Leaf remains from the cores between 1487–1970m were collected by Áron



Text-figure 12. Floristic composition of locality Tihany a) *Alnus gaudini,* b) *Smilax weberi,* c) *Liquidambar europaea,* d) *Platanus leucophylla,* e) *Juglans acuminata,* f) *Acer jurenakii,* g) *Salix varians,* h) *Alnus ducalis*

Jámbor. Although the plant fossils are poorly preserved with only a few identifiable specimen, the flora is clearly dominated by the most characteristic elements of the Pannonian.

The stratigraphic column of the borehole Tiszapalkonya–I with sedimentological, cycle stratigraphic, and magnetostratigraphic interpretations was published in several papers (JUHÁSZ et al. 1996, 1997, 1999; ELSTON et al. 1990, 1994; POGÁCSÁS et al. 1988, 1989, 1994; LANTOS et al. 1992). The lower part of the inerval (1970–1600m) is dominated by marly silt with thin sand intercalations, and is interpreted to have been deposited in a low-angle basin slope ("lower aggradational unit" in JUHÁSZ et al. 1996, 1997). The upper part (1600–1487m), however, contains much more sand in coarsening-upward cycles, and thin lignite seams. This part was deposited on the shelf, in deltaic environments ("progradational unit" in JUHÁSZ et al. 1996, 1997).

Lithostratigraphy: Algyő Formation (1970–1600m), Újfalu Formation (1600–1487m).

Age: 10.5–9.5 Ma

Flora:

Glyptostrobus europaeus (BRONGNIART) UNGER
Nymphaeaceae gen. et sp.
Alnus cf. *cecropiifolia* (ETTINGSHAUSEN) BERGER
Alnus sp.
Ulmus braunii HEER
Acer subcampestre GÖPPERT
Acer tricuspidatum BRONN
Salix varians GÖPPERT
Byttneriophyllum tiliifolium (A. BRAUN) KNOBLOCH & KVAČEK
Monocotyledonae gen. et sp.

The typical swamp assemblage with *Glyptostrobus europaeus*, *Alnus* cf. *cecropiifolia*, *Alnus* sp., and *Byttneriophyllum tiliifolium* is well represented, and elements indicating the riparian vegetation, i.e. *Ulmus braunii*, *Salix varians* and *Acer* also appear. The presence of aquatic habitats is assumed, as well, based on the occurrence of fossils belonging to the Nymphaeaceae family. Composition of the flora supports the fact that swamp forests were widespread the in north-eastern part of Hungary.

Visonta

The Visonta opencast mine is lying in the area of four settlements, Detk, Ludas, Karácsond and Halmajugra. The outcrop exposes several parasequences of the Bükkalja sequence (SZOKOLAI 1982). Exploitation of the three major lignite seams began in 1964. Clayey layers below Seam II yielded leaf remains, whereas clayey layers above the same seam yielded leaves, fruits, and seeds, as well as a palynoflora (ERDEI et al 2011). Plant fossils have been collected since the 1960s, and were published by PÁLFALVY & RÁKOSI (1979), LÁSZLÓ (1989), and BŮŽEK & LÁSZLÓ (1992). Mainly fruit and seed flora was collected and published, leaf remains only rarely came to light. In situ stumps similar to those discovered at Bükkábrány in 2007 (ERDEI et al. 2009) were also exposed in the opencast mine of Visonta (PÁLFALVY & RÁKOSI 1979), and were determined as *Sequoioxylon gypsaceum* (GOEPPERT) GREGUSS.

Lithostratigraphy: Bükkalja Formation.

Age: 7.5–6.7 Ma

Flora:

Selaginella sp.
*Equisetu*m sp.
Pronephrium stiriacum (UNGER) KNOBLOCH & KVAČEK
Osmunda parschlugiana (UNGER) ANDREÁNSZKY
Salvinia cf. *intermedis* NIKITIN ex DOROFEEV
Ginkgo adiantoides (UNGER) HEER
Glyptostrobus europaeus (BRONGNIART) UNGER
Taxodioxylon gypsaceum (GÖPPERT) KRÄUSEL
Pinus sp.
Tsuga sp.
Picea sp.
Abies sp.
Liriodendron sp.
Ranunculus sp.
Nymphaea szaferi KNOBLOCH
Nuphar palfalvyi BŮŽEK & LÁSZLÓ

Pseudoeuryale cf. *dravertii* DOROFEEV
Ceratophyllum dubium (LUDWIG) KIRCHHEIMER
Lycopus cf. *europaeus* L.
Decodon gibbosus (E. M. REID) E. M. REID
Actinidia faveolata C. & E. M. REID
Oenanthe sp.
Fagus decurrens C. & E. M. REID
Quercus sp.
cf. *Prunus* sp.
Alnus sp.
Alnus sp. cones
Carpinus sp. ex gr. *betulus* L.
Pterocarya sp.
Ilex sp.
Cornus cf. *gorbunovii* DOROFEEV
Nyssa disseminata (Ludwig) KIRCHHEIMER
Sambucus pulchella C. & E. M. REID
Meliosma cf. *wetteraviensis* (LUDWIG) MAI
Caldesia cf. *cylindrica* (E. M. REID) DOROFEEV
Stratiotes tuberculatus C. & E. M. REID
Potamogeton sp. div.
Spirematospermum wetzleri (HEER) CHANDLER
Carex sp.
Hartziella miocenica SAFER
Salix varians GÖPPERT
Salix sp. bud.
Byttneriophyllum tiliifolium (A. BRAUN) KNOBLOCH & KVAČEK
Monocotyledonae gen. et sp.

A relatively diverse set of plant taxa were proved from this locality according to the fruit and seed assemblage (LÁSZLÓ 1989, BŮŽEK & LÁSZLÓ 1992). Based on few leaf remains, the majority of taxa indicate the presence of aquatic habitats, i.e. *Salvinia*, *Nymphaea, Nuphar*, *Ceratophyllum*, *Caldesia*, *Stratiotes*, *Potamogeton*, etc. However, swamp forest is also represented mainly by *Glyptostrobus europaeus*, *Alnus* sp. and *Salix* sp. *Pterocarya*, *Ginkgo* and several other species must have been growing close to the lake. *Fagus*, *Pinus*, *Picea* and *Abies* formed forest vegetation at higher levels.

Taphonomy

Pannonian sediments preserving plant remains are mainly clay, clayey sand, sandstone, and its cemented variations. The fossiliferous matrix definitely influences floristic evaluation through conditions and quality of preservation, and thus strongly influences the level of systematic identifications. Adopting grain size analysis (HABLY & SZAKMÁNY 2006), it was revealed that at least 50% of grains in the sediment should belong to the fraction of 0.063 mm or less grain size in order to recognize and identify leaf remains with certainty. A higher ratio of this fraction significantly increases potential recognition and identification of fossil remains, e.g. by a ratio of 70% preservation may be excellent. In coarse-grained sediments coriaceous and sclerophyllous leaves are likely to be preserved. In addition to grain size, the mineral composition of the sediment also influences the ratio of identifiable specimens. Carbonate content of sediments considerably increases the ratio of poorly preserved specimens, thus causing the decrease of the number of taxa identifiable in the assemblage (HABLY & SZAKMÁNY 2006).

Pannonian localities are really good examples of this problem. Fine-grained sediments with high clay content preserve well plant parts, even to the finest details. In floras fossilized in fine-grained sediments all taxa are potentially observable those were transported to the sedimentary basin and were buried. However, only a poor selection of the original assemblage is preserved by coarse-grained, sandy sediments. In the cemented, highly carbonaceous sandstone of Karmacs only two taxa, *Platanus leucophylla* and *Ulmus*, are identifiable. The assemblage seems to be incomplete and more taxa are assumed to be members of the flora. Similarly, in the flora of Mindszentkálla only pine cones and *Platanus leucophylla* are identifiable, and the systematic affinity of other remains is highly uncertain. Considering the above, the fine-grained, clayey sediments formed in lacustrine or swamp environment preserved a more complete set of the taxa that formed the former flora and vegetation. At the same time, these environments had the potential to preserve autochton or parautochton assemblages comprising plants transported from the close proximity of the sedimentary basin. Assemblages preserving the floodplain vegetation are transported by rivers to the sedimentary basin from larger area than in the case of swamp assemblages (MOLNÁR et al. 2004). If the assemblage comprises leaves that are intact, more or less undamaged, as it is the case in many floodplain assemblages of the Pannonian, transport must have been limited to a short distance. Fruits are rarely encountered in these assemblages. Winged fruits or other buoyant fruits or seeds may be fossilized. In the Pannonian assemblages fruits of *Acer* are the most frequent reproductive structures. The large fruits of *Banisteriaecarpum* were accompanied by high number of *Byttneriophyllum tiliifolium* leaves, and thus these two fossil organs are assumed to be related. Numerous beautiful specimens are documented from Rudabánya. Ernő HORVÁTH mentioned this fruit in his notes about Dozmat, however, it was not found in the collection (HABLY & KOVAR-EDER 1996). In the flora of Graz-Andritz, which has not been published yet, leaves of *Byttneriophyllum* are dominant, and numerous nice specimens of *Banisteriaecarpum* were recognized in the collection of LMJ. High number of autochtonous elements was documented in swamp environment, e.g. catkins of *Alnus* and *Salix*, cones and also seeds of *Glyptostrobus*. Compact fruits are more common in lacustrine sediments, e.g. *Trapa*, *Stratiotes*.

In sediments with a high sand content, e.g. in Hosszúpereszteg, fruits of *Platanus* and *Quercus*, in Mindszentkálla pine cones were recorded. The presence of *Musophyllum* is assumed to be constrained by taphonomical factors. It was described as *Musophyllum tárkányense* from the flora of Felsőtárkány (BUBIK in KUBÁT & BUBIK 1955). These large-sized, presumably soft leaves were rarely documented, mainly because they were probably not favoured by fossilization. Therefore, these leaves are mostly poorly preserved and difficult to recognize. However, the sporadic distribution of the records indicates a relatively huge area, since it was reported in the east, from Felsőtárkány (north-eastern Hungary) to the west by Kapfenstein in Austria (unpublished palaeobotanical collection of LMJ). Furthermore, a couple of specimens putatively related to

Musophyllum were encountered in the younger layers of the Balatonszentgyörgy sequence; however, poor preservation did not allow accurate identification.

Cuticles of leaves are only exceptionally preserved in Pannonian sediments. However, cuticular studies were often not required for taxonomical identifications, since the majority of species occurring in Pannonian assemblages possess macro-morphological traits allowing a proper identification.

Systematic descriptions

Selaginellaceae

Selaginella sp.

Material: Visonta: BK 5542 megaspore
Description: see BŮŽEK & LÁSZLÓ 1992, p. 50, pl. 3, figs 1, 2.

Equisetaceae

Equisetum sp.
Plate I: fig. 1

Material: Balatonszentgyörgy: BP 2008.307.2., Rózsaszentmárton: MM 73.18.1., Visonta: BK 5492
Description: Ribbed casts of stems preserved as cross sections. Maximum outer and inner diameter 9 mm and 7 mm, respectively.
Discussion: Similar remains have been recorded from localities both Neogene and Palaeogene (KVAČEK & HABLY 1991). In Central Europe, Equisetum remains are mentioned from the Late Miocene Wörth locality near Kirchberg (KOVAR-EDER & KRAINER 1990).

Polypodiaceae

Pronephrium stiriacum (UNGER) KNOBLOCH & KVAČEK
Plate I: figs 2–5, Plate XXXV: fig. 5

1847 *Polypodites stiriacus* UNGER — UNGER, p. 121, T. 36, figs 1–5.
1955 *Pteris* cf. *biaurita* L. — KUBÁT & BUBIK, p. 44, pl. 13. fig.1.
1957 *Pteris palaeoaurita* KOVÁCS — KOVÁCS, p. 434, text.-fig. 2.
1959 *Pteris palaeoaurita* KOVÁCS — ANDREÁNSZKY, p.46, fig.4.
1966 *Lastraea* cf. *oeningensis* (A. BRAUN) HEER — ANDREÁNSZKY, p. 16, text.-fig. 1.
1985 *Pronephrium stiriacum* (UNGER) KNOBLOCH & KVAČEK — HABLY, p. 83, 136, pl. 3, figs 1, 4.
1991 *Pronephrium stiriacum* (UNGER) KNOBLOCH & KVAČEK — KVAČEK & HABLY, p. 52, pl. 1, fig. 2.
1990 *Pronephrium stiriacum* (UNGER) KNOBLOCH & KVAČEK — KOVAR-EDER & KRAINER, p. 17, T. 1, figs 5, 6.

Material: Balatonszentgyörgy: BP 2008.295.2–2008.301.1., 2008.425.1., SAMU 2008.27.9., Felsőtárkány BP 69.703.1., 69.716.1., 69.755.1., 69.756.1., 69.793.1., 69.803.1–69.812.1–69.814.1., 69.817.1–69.820.1., 69.822.1., 69.824.1., 69.825.1., 71.1.1., 71.4.1., 71.5.1., 71.7.1-71.9.1., 71.14.1. (holotype of *Pteris palaeoaurita* KOVÁCS1957), 71.15.1–71.17.1., 71.22.1., 71.27.1., 83.273.1. (original in ANDREÁNSZKY 1959), 83.373.8., 85.228.1., MM 56.567.1., 56.962.2., Sé: SAMU 65.3.109. = 65.3.114 (counterpart), 65.3.766., 65.3.1181., Visonta: BK 1021
Description: Fragments of pinnae, in some cases pinnae attached to rachis. Preserved length of pinnae up to 7 cm, width 1.0–1.5 cm. Apex acute, base missing. Pinnae deeply incised, generally close to the rachis. Venation goniopterid. Strong

midvein gives off slightly curved delicate veinlets. Veinlets fuse with each other between adjoining pinnules. Veins frequently bifurcate.

Discussion: The first Hungarian record of this species has been documented from Late Oligocene floras, e.g. Csolnok (ERDEI & WILDE 2004) and Wind brickyard (KVAČEK & HABLY 1991). As regards younger records fossils were described from the Ottnangian assemblage near Ipolytarnóc (HABLY 1985). It was reported from the Late Miocene of Austria, from Wörth near Kirchberg/Raab (KOVAR-EDER & KRAINER 1990). In the Hungarian Pannonian this is the first evidence of the taxon. Fossils assigned to Pronephrium have been recorded from various localities of the European Middle Miocene, e.g. Arjuzanx (KVAČEK et al. 2011).

Osmundaceae

Osmunda parschlugiana (UNGER) ANDREÁNSZKY
Plate I: fig. 6, Plate II: figs 1–6, Plate XXXV: fig. 7

1847 *Pteris parschlugiana* UNGER — UNGER, p. 122, pl. 36, fig. 6.
1858 *Osmunda strozzi* GAUDIN — GAUDIN & STROZZI, p. 9, pl. 1, figs 1–4.
1955 *Pteris parschlugiana* UNGER — KUBÁT & BUNIK, p. 43, text.-fig. 12.
1959 *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY — ANDREÁNSZKY, p. 45, pl. 7, fig. 4, text.-fig.2.
1996 *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY — HABLY & KOVAR-EDER, p. 71, pl. 1, figs 3, 5, pl. 3, fig.2.
1971 *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY — BŮŽEK, p. 33, pl. 5, figs 1–15.
1992c *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY — HABLY, p. 8, pl. 1, fig. 1.
1996 *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY — HABLY & KOVAR-EDER, p. 71, pl. 1, figs 3, 4, pl. 3, fig.2.
2003 *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY — KOVAR-EDER & MELLER, p.285, pl.1., figs 15–17.

Material: Balatonszentgyörgy: BP 2008.272.2–2008.294.1., 2008.425.1., 2010.80.1., 2010.84.1., 2010.106.1–2010.132.2., 2011.117.1–2011.122.1., Dozmat: BP 2005.31.1., 2005.32.1., 2005.65.1., SAMU: 66.5.197, 66.5.784, 66.5.830, 66.5.955, 66.6.40., Felsőtárkány: BP 55.1751.1., 55.1752.1., 55.1762.1., 55.1767.1., 55.1775.1., 55.1781.1., 55.1787.1., 55.1790.1., 55.1794.1., 55.1804.1., 55.1822.1., 55.1827.1., 55.1841.1., 55.1842.1., 55.1839.1., 55.1841.1., 55.1842.1., 55.1845.1., 55.1847.1–55.1849.1., 55.1857.1., 55.1858.1., 55.1860.1., 55.1861.1., 55.1869.1., 55.1870.1., 55.1873.1–55.1875.1., 55.1877.1., 55.1880.1., 55.1885.1., 55.1886.1., 55.1895.1., 55.1904.1., 55.1907.1–55.1909.1., 55.1915.1., 55.1920.1., 55.1930.1., 55.1933.1., 55.1935.1., 55.1940.1., 55.1941.1., 55.1965.1., 55.1973.1., 60.1791.1., 60.1892.1., 60.1904.1., 62.1083.1., 62.1113.1., 62.1120.1., 62.1194.1., 62.1401.1., 69.700.1., MM 55.5055.2., 55.5065.1., 55.5085.1., 55.5095.1., 55.5096.1., 55.5107.1–55.5109.1., 55.5111.1., 55.5115.1., 55.5118.1., 55.5120.1., 55.5123.1., 55.5124.1., 55.5127.1., 55.5131.1., 55.5132.1.,55.5139.1., 55.5142.1., 55.5156.1., 55.5160.1., 55.5167.1., 55.5172.1., 55.5173.1., 55.5184.1., 55.5187.1., 55.5188.1., 55.5193.1., 55.5196.1., 55.5200.1., 55.5202.1., 55.5205.1., 55.5211.1., 55.5212.1., 55.5214.1., 55.5218.1., 55.5228.1., 55.5229.1., 55.5232.1., 55.5234.2., 55.5237.1–55.5239.1., 55.5246.1., 55.5248.1., 55.5252.2., 55.5254.2., 55.5257.1., 55.5259.1., 55.5266.1., 55.5269.2., 55.5271.2., 55.5273.1., 55.5278.1., 55.5279.1., 55.5282.1., 55.5284.1., 55.5287.1., 55.5289.1., 55.5290.1–55.5292.1., 55.5296.1., 55.5297.2., 55.5308.1., 55.5314.1., 55.5334.1., 55.5339.1., 55.5343.1., 55.5345.1., 56.405.1., 56.417.1., 56.512.1., 56.552.1., 56.553.2., 56.555.1., 56.556.1., 56.559.1., 56.567.1., 56.576.1., 56.578.1., 56.581.2., 56.582.1., 56.585.1., 56.586.1., 56.588.1–56.590.1., 56.593.1–56.595.1., 56.601.1., 56.604.1., 56.607.1., 56.608.1., 56.611.1–56.613.1., 56.615.1., 56.617.1., 56.620.1–56.622.1., 56.627.1., 56.628.1., 56.629.1., 56.632.1., 56.634.1– 56.636.1., 56.637.1., 56.640.1., 56.641.1., 56.644.1., 56.645.1., 56.648.1., 56.965.2., 56.985.1., 56.1257.1., 61.408.1., 64.1093.1., Iharosberény: BP 2009.271.1., 2009.272.1., Rudabánya Andrássy: BK 3, 355, Rudabánya Vilmos: BK 556., Sé: SAMU 65.2.392., Visonta: BK 1015, 1017, 1027–1029

Description: Isolated pinnules, preserved length and width up to 8 cm and 2.8 cm, respectively. Shape of lamina oblong, apex acute, base mostly asymmetric, truncate to cordate. Margin finely serrate. Midvein stout and straight. Finer veins arise from the midvein and bifurcate either close to the midvein, or by the margin, but also in between. Veins run parallel with each other, and equally spaced. Veins end in marginal sinuses.

Discussion: Fossils of *Osmunda parschlugiana* are known from both the Palaeogene and Neogene of Europe. In the Pannonian floras of Hungary it is an accessory element of the characteristic assemblage comprising *Glyptostrobus europaeus, Byttneriophyllum tiliifolium* and *Alnus cecropiifolia* (HABLY & KOVAR-EDER 1996). It is a remarkably frequent element of the flora recorded from Balatonszentgyörgy, from the upper layers of the sequence, which is dominated by *Glyprostrobus europaeus. O. parschlugiana* is a frequent accessory element in the flora of Dozmat being quite similar to the upper level flora of Balatonszentgyörgy. In addition, it is also an important member of the assemblage collected from Felsőtárkány, which shows higher diversity than the above mentioned floras. *Osmunda* seems to be a quite important element of wetland associations comprising *Glyptostrobus*, *Byttneriophyllum* and *Alnus*.

Salviniaceae

Salvinia cf. *intermedia* NIKITIN ex DOROFEEV

Material: Visonta: BK 5457, 5530 sori
Description: see BŮŽEK & LÁSZLÓ 1992, p. 51, pl. 2, figs 1–4.

Polypodiopsida gen. et sp.

Material: Kerecsend: SAMU 2008.16.56.
Description: A small fragment with characteristic venation of ferns.

Ginkgoaceae

Ginkgo adiantoides (UNGER) HEER
Plate III: figs 1–5

1845 *Salisburia adiantoides* UNGER, UNGER, p. 211, nomen nudum
1859 *Salisburia adiantoides* UNGER; MASSALONGO & SCARABELLI p. 163, pl. 6, fig. 18, pl. 7, fig. 2, pl. 39, fig. 12.
1959 *Ginkgo adiantoides* (UNGER) HEER; ANDREÁNSZKY, p. 48, pl. 7, fig. 8, pl. 8, figs 2, 5.
1988 *Ginkgo adiantoides* (UNGER) HEER; KOVAR-EDER, p. 26, pl. 1, figs 1-3.
1989 *Ginkgo adiantoides* (UNGER) HEER, LÁSZLÓ, p. 31, 33 text.-figs 1, 2.
1994 *Ginkgo adiantoides* (UNGER) HEER; KVAČEK, HABLY & Szakmány, p. 79, pl. 1, figs 1, 2.
1997 *Ginkgo adiantoides* (UNGER) HEER; HABLY & KVAČEK, p. 12, pl. 1, figs 1-4, pl. 2, figs 5, 6, pl. 3, figs 7, 8.
2007 *Ginkgo adiantoides* (UNGER) HEER; HABLY, L. & FERNÁNDEZ MARRÓN, p. 68, pl. fig. 2.

Material: Bükkábrány: BK 4476, 4478, *Kerecsend* MM 6179, *Rózsaszentmárton:* BK without number, *Rudabánya Andrássy*: BK 7, cf. 430, *Visonta*: BK 4529,

Description: Fan-shaped simple leaves, petiole not preserved. The most complete leaf more than 5 cm long and 9.3 cm wide. Base not preserved, apex strongly eroded, emarginated. Margin entire at the base and shallowly undulate at the apical side. Dense fine venation arises from the base, and diverges toward the margin.

In coastal areas cells elongated with rectangular or acute ends and slightly wavy anticlinal cell walls on the adaxial cuticle. In intercostal areas cells mainly polygonal, sometimes elongated, cell walls slightly undulate. Abaxial cuticle finely striated and papillate, anticlinals not well reflected. Stomata randomly oriented and surrounded by thick and papillate rim made up of adjacent cells.

Discussion: Ginkgo adiantoides is an accessory element in floras of the European Neogene. In Hungary Ginkgo appears in the Sarmatian (ANDREÁNSZKY 1959). During the Late Miocene it is a member of floras from Moravia (KNOBLOCH 1969), Austria (KOVAR-EDER 1988), Iberian Peninsula (HABLY & FERNANDEZ MARRÓN 2007), Greece (KVAČEK et al. 2002) and several other localities. It is a typical element of the Pliocene floras of Europe: Romania (GIVULESCU 1963), southern France (Rhon Valley; DEPAPE 1922, Coiron; GRANGEON 1958, Pichegu; ROIRON 1981). In numerous localities the identification of the leaf fossils has been confirmed by cuticle. The well preserved leaf from the flora of Rudabánya allowed for leaf micromorphological studies, as well. *G. adiantoides* had been present in the flora of the Pannonian Basin from the Sarmatian up the the Pliocene. In the volcanic Pliocene flora of Gérce and Pula (Hungary) it occurs as accessory element (HABLY & KVAČEK 1997).

Pinaceae

Pinus sp. 1
Plate XXVIII: fig. 3, Plate XXXV: fig. 8

Material: Mindszentkálla: BP 2007.502.1., 2008.463.1., cf. 2008.464.1.

Description: Length of cones up to 7.1 cm, width 4.1 cm. Near the apical part of cones the apophyses strongly elevated. Basal part of the cone rounded.

Discussion: From the locality several other cones were recognized by the collector Imre Magyar, who made plastic moulds of the cones. Unfortunately, the original fossil specimens were not received by the museum, but the plastic counterparts helped to identify the closer taxonomic position of these pine species. The cones are very similar to those of the living *Pinus pinaster* (pers. communication I. Rácz), an atlanto-mediterranean species living today along the coast of North Africa and elsewhere in the western parts of the Mediterranean, in frost-free areas (DEBRECZY & RÁCZ 2011). Another group of the fossil pine cones excavated by Mindszentkálla resembles *Pinus heldreichii*, which is living today in the subalpine mountains of the Balkan and South Italy, at about 1800–2400 m above sea level. Another cone type resembles cones of *Pinus nigra* s.l., a rather diverse species that covers scattered (usually montane) habitats from North Africa, the Iberian Peninsula, the Cévennes, Corsica, Sicily, the southern Apennines, the western Alps, Dalmatia, southern Carpathians, the Balkan Peninsula, to Anatolia and Crimea (DEBRECZY & RÁCZ 2011). We cannot exclude the presence of haploxylon pines as it can be seen on the sample BP 2007.502.1. resembling the living *Pinus peuce* of the Balkan Peninsula (pers. communication I. Rácz).

Pinus sp. 2
Plate XXXII: figs 7–8, Plate XXXIII: figs 1–5

Material: Diszel-Kula: BP 2008.30.1., ZIRC 95.123.5.,
Description: Length of cones up to 6.2 cm, width 3.2 cm. Apical part of the cone acute, basal part rounded. Apophyses not preserved.
Discussion: From the Diszel-Kula Hill whole cones or fragments of cones turned up. Cones are strongly eroded, and resemble *Pinus nigra*. In general this species is a montane element currently occupying habitats between 200 and 1800 m (usually 300–1500 m) (DEBRECZY & RÁCZ 2011).

Pinus sp.

Material: Rózsaszentmárton: BP 71.271.1., *Visonta:* BK 5474, 5488, 5489, 5499, 5532, 5536 brachyblasts and needles
Description: For fossils from Visonta see BŮŽEK & LÁSZLÓ (1992), p. 52, pl. 3, figs 10–12.; for Rózsaszentmárton see VÖRÖS, I. 1955, pl. 16. fig.1.

Tsuga sp.
Material: Visonta: BK 5455, 5525 leaves
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 52, pl. 3, figs 6–8.

Picea sp.
Plate XXVIII: fig. 4

Material: Mindszentkálla: BP 2007.503.1., *Visonta:* BK 5467, 5500, 5528 needles
Description: Fragmented cone, length 7.2 cm, width 1.8 cm. Imprints of numerous seeds observable by the axis (cone was presumably damaged by squirrels to get the seeds). Visonta see in BŮŽEK & LÁSZLÓ (1992)
Discussion: The cone resembles *Picea abies*, a species currently distributed in Europe from the Alps to the Balkan Peninsula and the Carpathians, extending up to northern and north-eastern Europe (DEBRECZY & RÁCZ 2011).

Abies sp.

Material: Visonta: BK 5480, 5506, 5535
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 53, pl. 3. figs 15–20.

Cupressaceae

Glyptostrobus europaeus (BRONGNIART) UNGER
Plate III: figs 6–7, Plate IV: figs 1–2

1833 *Taxodites europaeum* BRONGNIART — BRONGNIART, p. 168.
1850b *Glyptostrobus europaeus* (BRONGNIART) — UNGER, p. 434.
1988 *Glyptostrobus europaeus* (BRONGNIART) UNGER — KOVAR-EDER, p. 28, pl. 1, figs 4–7.
1992c *Glyptostrobus europaeus* (BRONGNIART) UNGER — HABLY, p. 8, p. 24, pl. 1, fig. 3.
1996 *Glyptostrobus europaeus* (BRONGNIART) UNGER — HABLY & KOVAR-EDER, p. 71, pl. 2, figs 2–4, 6.
2009 *Glyptostrobus europaeus* (BRONGNIART) UNGER — ERDEI et al., p. 75, pl. 4, figs 3–7, pl. 5, figs 1–9.
2011 *Glyptostrobus europaeus* (BRONGNIART) UNGER — ERDEI et MAGYARI, p. 140. text.-figs 2–5.

Material: Balatonszentgyörgy: BP 97.210.1., 2005.469.1., 2005.470.1., 2007.535.1., 2005.536.1., 2008.286.2–2008.294.1., 2008.301.1–2008.303.1., 2008.308.2–2008.355.2., 2008.425.1., 2008.426.1., 2010.80.1–2010.85.1., 2010.87.1–2010.105.1., 2010.124.1–2010.160.2., 2010.168.1., 2010.169.1., 2011.108.1–2011.116.1., 2011.121.1., 2011.122.1., BK 1478, 1480–1495, 1498–1500, 1502–1505, 1507, 1509–1512, 1523–1535, 1537–1541, 1544–1548, 1551–1553, 1556–1558, 1561–1563, 1565–1566, 1572, 1569, 1571, 1573–1574, 1578, 1580–1582, 1584–1588, 1593–1595, 1613–1617, 1619–1623, 1625, 1632, 1626–1627, 1630, 1633–1634, 1637–1638, 1640–1642, 1645, 1647–1650, 1652, 1662–1666, 1671, 1674, 1677, 1686–1687, 1710–1713, 1715, 1724, 1726–1729, 1731, 1733–1734, 1738, 1742, 1744, 1748–1750, 1754, 1751–1752, 17551763, 1758, 1761, 1765, 1767–1768, 1772, 1777, 1783, 1785, 1788, 1796–1798, 1800–1803, 1806–1807, 1809, 1812–1813, 1819–1820, 1815, 1817, 1821., SAMU 2008.6.1., 2008.6.5–2008.6.12., 2008.6.14–2008.6.22., 2008.6.24–2008.6.25., 2008.6.27., 2008.6.28., 2008.6.31–2008.6.34., 2008.6.36–2008.6.38., 2008.6.41–2008.6.43., 2008.6.45–2008.6.57., 2008.6.59–2008.6.61., 2008.6.63–2008.6.70., 2008.6.72., 2008.6.74., 2008.6.76–2008.6.77., 2008.6.79., 2008.6.82., 2008.6.84., 2008.6.85., 2008.6.90., 2008.6.92., 2008.6.104–2008.6.105., 2008.6.108–2008.6.109., 2008.6.112., 2008.6.115–2008.6.116., 2008.6.119–2008.6.135., 2008.6.138., 2008.6.140., 2008.6.142–2008.6.147. *Bükkábrány:* BP 2008.99.6., 2008.100.20., 2011.230.10., *Dozmat:* BP 2005.8.1., 2005.11.1., 2005.14.1., 2005.16.1., 2005.23.1., 2005.26.1., 2005.30.1–2005.34.1., 2005.43.1., 2005.44.1., SAMU: 66.5.390., 66.5.422., 66.5.427., 66.5.603., 66.5.641., 66.5.1210. (plus more than 1000 specimens). *Felsőtárkány:* BP 55.1751.1., 55.1765.1., 55.1769.1., 55.1773.1., 55.1776.1., 55.1791.1., 55.1793.1., 55.1797.1., 55.1802.1., 55.1803.1., 55.1815.1., 55.1838.1., 55.1844.1., 55.1865.1., 55.1870.1., 55.1893.1., 55.1914.1., 55.1934.1., 55.1938.1., 55.1943.1., 55.1951.1., 55.1954.1., 55.1964.1., 55.1969.1., 55.1752.1., 551760.1., 55.1768.1., 55.1788.1., 55.1795.1., 55.1814.1., 55.1829.1., 55.1843.1., 55.1855.1., 55.1859.1., 55.1889.1., 55.1900.1., 55.1919.1., 55.1921.1., 55.1928.1., 55.1944.1., 55.1950.1., 55.1917.1., 55.1957.1., 55.1974.1., 59.51.2., 59.222.1., 59.225.1., 59.255.1., 60.1655.1., 60.1799.1., 60.1833.1., 60.1894.1., 60.1907.0., 60.1913.1., 60.1916.1., 60.1919.1., 62.1098.1., 62.1123.1., 62.1140.1., 62.1143.1., 62.1144.1., 62.1169.1., 62.1170.1., 62.1179.1., 62.1249.1., 62.1250.1., 62.1390.1., 62.1394.1., 62.1438.1., 62.1445.1., 62.1446.1., 62.1448.1., 69.693.1., 69.699.1., 69.715.1., 69.723.1., 69.724.1., 69.746.1., 69.747.1., 69.749.1., 69.754.1., 69.772.2., 69.788.1., 69.810.1., 69.830.1., 71.3.1., 71.22.1., 71.27.1., 71.39.1., 71.47.1., 71.57.1., 71.65.1., 71.71.1., 71.75.1., 71.80.1., 71.81.1., 71.86.1., 71.104.1., 71.107.1., 71.119.1., 71.123.1., 71.131.1., 71.132.1., 71.138.1., 71.451.1., 85.224.1., 85.227.1., 85.230.1., 85.232.1., 85.234.1., 85.240.1., 85.241.1., 85.245.1., 85.246.1., 2002.946.1., 2003.191.1., 2003.200.1., 2003.202.1., 2003.203.1., 2003.208.1., 2003.210.1., 2003.211.1., 2003.213.1., 2003.214.1., 2003.216.1., 2003.219.1., 2003.220.1., 2003.223.1–2003.225.1., 2003.230.1., 2003.233.1., 2003.235.1., 2003.238.1., 2003.240.1–2003.244.1., 2003.249.1., MM 55.5052.1., 55.5064.1., 55.5067.1., 55.5075.1., 55.5082.1., 55.5090.1., 55.5096.2., 55.5100.1., 55.5105.1., 55.5109.1., 55.5122.1., 55.5124.1., 55.5132.1., 55.5133.1., 55.5135.1., 55.5151.2., 55.5155.1., 55.5158.1., 55.5162.1., 55.5165.1., 55.5166.1., 55.5167.1., 55.5171.1., 55.5177.1., 55.5200.1., 55.5201.1., 55.5203.1. – 55.5205.1., 55.5207.2., 55.5220.1., 55.5225.1., 55.5243.1., 55.5244.1., 55.5251.1., 55.5252.2., 55.5261.1., 55.5279.1., 55.5282.1.-55.5284.1., 55.5286.1., 55.5289.1., 55.5291.1., 55.5292.1., 55.5296.1., 55.5303.1., 55.5306.1., 55.5314.1., 55.5316.1., 55.5325.1., 55.5334.1., 55.5335.2., 55.5341.1., 55.5345.1., 55.5347.1., 56.517.1., 56.523.1., 56.524.2., 56.558.1., 56.609.1., 56.619.1., 56.622.1., 56.626.1., 56.630.1., 56.631.1., 56.634.1., 56.635.1., 56.641.1–56.643.1., 64.1092.1., 64.1099.2., 64.1101.2., *Iharosberény:* BP 2009.257.4., 2009.264.1., 2009.270.1., 2009.273.1., 2009.278.3–2009.281.3., 2009.284.2., 2009.295.1–2009.297.2., *Kerecsend*: BP 95.339.1., SAMU 2008.16.32.; 2008.16.35., 2008.16.59.; 2008.16.62., *Rózsaszentmárton:*BP 71.270.1., 2005.4611 –2005. 463.1., 2005.468.1., 2008.468.1., MM 64.1156.1., 64.1157.1., 64.1167.1., *Rudabánya-Andrássy:* BK 6, 13, 17, 19, 22, 23, 25, 32, 34, 38, 40, 58, 253, 264, 315, 318, 378, 448, *Sé:* SAMU 65.2.395., *Tiszapalkonya:* BP 2009.351.3., 2009.353.1., 2009.354.6., 2009.361.2., 2009.367.1. *Visonta:* BK 986, 987, 1002, 4516, 5452, 5453, 5456, 5458, 5471–5473, 5475, 5478, 5482, 5494–5496, 5533, 5546–5594.

Description: Twigs with 1.2–2.5 mm long, 0.5–1.0 mm wide, scale-like, helically arranged cupressoid type leaves. Well preserved cones both detached and attached to twigs. Seed cones terminal, obovate, 1.5×1.0 cm. Cone scales woody, helically arranged, imbricate, oblong, distally rounded, proximally cuneate.

Discussion: Twigs of *Glyptostrobus* are frequent members of the floras. In some of the assemblages cones are quite common, whereas in others they are rare. Some of the floras, like Balatonszentgyörgy, comprise a mass of isolated seeds, in some others they do not occur or very rare, like in Rudabánya. *Glyptostrobus* is one of the most characteristic and widespread elements of the Pannonian floras in Hungary. It was dominant in peat forming vegetation suggesting a swamp habitat with abundant water-supply. In most floras it is associated with *Byttneriophyllum tiliifolium* and *Alnus cecropiifolia.* Some of the localities are dominated by the above species, i.e. Dozmat, Iharosberény and Balatonszentgyörgy, although, in the latter *Byttneriophyllum* is missing. In Balatonszentgyörgy it seems to be common in the older layers, in a more diverse flora. In the younger layers it seems to be dominant suggesting an almost monotypic *Glyptostrobus* forest, with few other elements, i.e. *Osmunda* occurring more frequently, and subordinate fossils of *Alnus*. The first record of *Glyptostrobus* in the Hungarian fossil floras is known from a few Upper Oligocene (Egerian) localities, representing mainly the Mány Formation (Hably & Seleczi 2009). During the Ottnangian–Karpatian *Glyptostrobus* fossils occur only in the flora of Magyaregregy, but later from the Middle Miocene some more records are encountered. A mass occurrence of this species has been recorded only from the Pannonian (Late Miocene), which is presumably attributable to the huge extension of Lake Pannon and thus of swamp habitats.

The genus is today monotypic with one species *Glyptostrobus pensilis* (STAUNTON ex D. DON) K. KOCH, distributed in SE China. Generally, it occurs in river deltas and grows always in the proximity of water. It is a heliophilous species usually found in pure stands and is restricted to tropical and subtropical coastal lowlands (ERDEI et al. 2009).

Glyptostroboxylon sp. CONWENTZ, emend. DOLEZYCH and VAN DER BURGH

Material: Bükkábrány: Wood of the upright trunks, Palaeobotanical Coll. Musei Hist. Nat. Hung. Department of Botany, Budapest, No. 090907/1, 090907/4, 080907/5

Description: see ERDEI et al. 2009, p. 75. pl. 3, figs 1–8., pl. 4, figs 1–2.

Taxodioxylon germanicum (GREGUSS) VAN DER BURGH

1967 *Sequoioxylon gypsaceum* (GÖPPERT) GREGUSS — GREGUSS, p. 78, pl. 69, figs 1–4, pl. 70, 1–8.
1979 *Sequoioxylon gypsaceum* (GÖPPERT) GREGUSS — PÁLFALVY & RÁKOSI, p. 48, pl. 3, figs 1–4, pl. 4. figs 1–4, pl. 5, figs 1–3, pl. 6, figs 1–3.

Material: Bükkábrány: Wood of the upright stumps, Palaeobotanical Coll. Musei Hist. Nat. Hung. Department of Botany, Budapest, No. 090907/10, 090907/12, 080907/13. Description: see ERDEI et al. 2009, p. 73. pl. 2, figs 1–8., pl. 3, figs 1–8.

Visonta: Description: see in PÁLFALVY & RÁKOSI 1979 as *Sequoioxylon gypsaceum* (GÖPPERT) GREGUSS.

Discussion: From Visonta an in situ, very large, bifurcate stump was published by PÁLFALVY & RÁKOSI (1979) as *Sequoioxylon gypsaceum* (GÖPPERT) GREGUSS. Unfortunately, wood samples are not available to carry out taxonomic revision. However, according to the photo plates Martina Dolezych assumed that it represents *Taxodioxylon germanicum* (DOLEZYCH pers. comm.), the same species as described from Bükkábrány, similarly as in situ trunks (ERDEI et al. 2009). On the other hand, it must be added that these species indicate similar autecology. *Glyptostroboxylon rudolphii*, *Taxodioxylon germanicum* as well as *T. gypsaceum* were the main constituents of brown coal forming vegetation (DOLEZYCH & SCHNEIDER 2006). It may be assumed, as well, that all the three species thrived in the Pannonian Basin during the Late Miocene.

Magnoliaceae

Magnolia sp.

Material: Felsőtárkány: BP 59.119.1. = 62.1332.1. (counterpart), 60.1694.1. (Original of ANDREÁNSZKY) = 62.1236.1. (counterpart)

Description: see in ANDREÁNSZKY 1959, p. 59, text.-fig. 16, pl. 12., fig. 2.

Liriodendron sp.

Material: Visonta: BK 5476, 5519 seeds-pair

Description: see in BŮŽEK & LÁSZLÓ (1992), p. 53, pl. 2. fig. 13.

Lauraceae

Daphnogene sp.
Plate XXXIII: fig. 7

Material: Rudabánya borehole Rb–494, 60.1–64.4 m: BK 542

Description: Basal part of a simple leaf. Length of fragment 2.8 cm, width 2.3 cm. Apex not preserved, base cuneate, margin entire, venation camptodromous, brochidodromous with two suprabasal veins.

Discussion: This leaf is the single record of the genus *Daphnogene* in the Pannonian floras of Hungary. The specimen turned up among borehole samples, at about 60 m depth. Rudabánya is one of the earliest Pannonian localities in the Pannonian Basin, and it gives evidence of the survival of relics, like *Daphnoge*. Daphnogene is a thermophilous, dominant element in Europe during the Palaeogene and the older Neogene. The current state of its fossil record suggests that this is the youngest occurrence of the genus in Hungary.

Ranunculaceae

Ranunculus sp.

Material: Visonta: BK 5531 fruit
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 53, pl. 3. fig. 9.

Nymphaeaceae

Nymphaea szaferi KNOBLOCH

Material: Visonta: BK 5540 seed
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 53, pl. 4. fig. 7.

Nuphar palfalvyi BŮŽEK & LÁSZLÓ

Material: Visonta: BK 5485, 5539 seeds
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 54, pl. 4. figs 1–5., pl. 10, figs 3, 4.

Nymphaeaceae gen. et sp.
Plate V: fig. 2

1955 *Nelumbo* sp. — VÖRÖS, p. 65, pl. 16, fig. 2.

Material: Tiszapalkonya: BP 2009.349.1., *Rózsaszentmárton* (without number in VÖRÖS I. 1955, p. 65, pl. 16, fig. 2)
Description: Middle part of the rounded leaf. Veins, up to 16, arising from the middle.

Pseudoeuryale cf. *dravertii* DOROFEEV

Material: Visonta: BK 5511, 5524 seeds
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 54, pl. 4. figs 11–15., pl. 10, figs 1, 2.

Ceratophyllaceae

Ceratophyllum dubium (LUDWIG) KIRCHHEIMER

1992 Ceratophyllum demersum L. — LÁSZLÓ, pl. 1, fig. 4.

Material: Visonta: BK 5465, 5469, 5523 fruits
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 55, pl. 2. figs 5–11.
Bükkábrány BK without number
Description: see in LÁSZLÓ (1992), pl. 1. fig. 4.

Lamiaceae

Lycopus cf. *europaeus* L.

Material: Visonta: BK 5464 fruits
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 55, pl. 2. fig. 16.

Actinidiaceae

Actinidia faveolata C. & E. M. REID

Material: Visonta: BK 5515 seed
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 55, pl. 4. fig. 6.

Apiaceae

Oenanthe sp.

Material: Visonta: BK 5508 fruits

Description: see in BŮŽEK & LÁSZLÓ (1992), p. 55, pl. 2. fig. 14-15.

Hamamelidaceae

Liquidambar europaea A. BRAUN

Plate V: figs 3–7, Plate VI: figs 1–3

1836 *Liquidambar europaeum* A. BRAUN — A. BRAUN, p. 513.
1851 *Liquidambar europaeum* A. BRAUN — ETTINGSHAUSEN, p. 15, T. 2, fig. 21.
1955b *Liquidambar europaea* A. BRAUN — BERGER, p. 97, tex.-figs 104–105.
1959 *Liquidambar europaea* A. BRAUN — ANDREÁNSZKY, p. 69, Text.-figs 26–30.
1969 *Liquidambar europaea* A. BRAUN — KNOBLOCH, p. 94, T. 44. figs 1, 3, 4–7, T 45. figs 1, 2, 6, T. 46, figs 1, 4, T. 59, f. 2.
1971–72 *Acer séensis* HORVÁTH — HORVÁTH, p, 42, pl. 6, fig. 4.
1972 *Liquidambar europaea* A. BRAUN — ZASTAWNIAK, p. 42, T. 10, figs 10–11, T. 26, figs, 3, 3a.
1980 *Liquidambar europaea* A. BRAUN — ZASTAWNIAK, p. 64, T. 8, figs 14–16.
1988 *Liquidambar europaea* A. BRAUN — KOVAR-EDER, p. 30, T. 2, figs 1–5.
1992a *Liquidambar europaea* A. BRAUN — HABLY, p. 199, Pl. 1, fig. 1.

Material: Alcsút: BP: 2009.429.2., *Győr–Sashegy:* SAMU: 2008.9.1.(7 specimens), 2008.9.2., 2008.9.5. (5 specimens), 2008.9.7., 2008.9.9., 2008.9.10–2008.9.12., 2008.9.17., 2008.9.19(3 specimens)., 2008.9.20. (2 specimens) – 2008.9.22 (2 specimens), 2008.9.23. (2 specimens), 2008.9.28–2008.9.29. (2 specimens), 2008.9.30., 2008.9.36., 2008.9.40., 2008.9.43., 2008.9.45., 2008.9.48. (2 specimens), 2008.9.50., 2008.9.53., 2008.9.57., 2008.9.58., 2008.9.61. (3 specimens), 2008.9.62., 2008.9.67., 2008.9.70., 2008.9.73. (2 specimens), 2008.9.74. (3 specimens), 2008.9.77. (3 specimens), 2008.9.78., 2008.9.82., 2008.9.83., 2008.9.85., 2008.9.87., 2008.9.89., 2008.9.91., 2008.9.97., 2008.9.98., 2008.9.102., 2008.9.104., 2008.9.105.(3 specimens), 2008.9.110., 2008.9.112–2008.9.114., 2008.9.117., 2008.9.119.(3 specimens), 2008.9.120., 2008.9.122., 2008.9.125., 2008.9.128. (7 specimens), 2008.9.129., 2008.9.132, 2008.9.134. *Hosszúpereszteg*: SAMU: 73.3.224, 73.3.916., 73.3.1199., 73.3.1255., 73.3.1362., 73.3.1407., 86.13.138., 86.13.496., 86.13.530., 86.13.541.2., 86.13.544., 86.13.791., 86.13.845., 86.13.861., 86.13.863., 86.13.873., 86.13.936., 86.13.1175., 86.13.1195., 86.13.1217., 86.13.1280., 86.13.1285., 86.13.1292., 86.13.1317.2., 86.13.1321., 86.13.1323., 86.13.1333., 86.13.1337., 86.13.1372., 86.13.1419., 86.13.1427., 86.13.1437., 86.13.1465.1., 86.13.1466., *Sé:* SAMU 70.2.1., 70.2.6., cf. 70.2.8. = 73.2.3., *Tihany:* BP cf. 85.116.1., 85.117.2., 85.118.1., 85.125.1., 85.126.1., cf. 85.130.1., 85.135.1., 85.138.1., 85.139.1., 85.142.1., 85.143.1., 85.145.1., 85. 148.1., 85.149.1., 85.150.1., 85.153.1., 85.156.1., 85.161.1., 85.162.1., 85.163.2., 85.165.1., 85.166.1., 85.181.2., 85.187.1., 85.192.3., 85.197.3., 85.204.1., 85.210.2.

Description: Simple petiolate leaves, petiole occasionally preserved 0.7–2.8 cm. Lamina palmately five-lobed, rarely three-lobed. Lamina generally wider, than its length. Largest length by the central lobe 2.5–8.0 cm, width of the whole lamina 4–10 cm. Side lobes shorter than middle lobe. Base truncate, lobe apices acute. Margin toothed. Teeth simple, small, regular, teeth apices and sinuses rounded. Venation palinactinodromous. Midvein straight and stout, a pair of primaries starts from the base, run to the two main lobes in acute angle, and ends in their apices. Another pair of primaries starts suprabasally, runs to the lower lobes almost perpendicularly to the midvein, and ends in the apices of the lower lobes. From each primary vein secondaries diverge in the upper half of the lobes and form loops near the margin.

Discussion: The first record of this species in the Pannonian Basin is reported from the Sarmatian (ANDREÁNSZKY 1959) as an accessory element. Later, during the Pannonian it becomes dominant or at least frequent accessory element of fossil floras, e.g. Győr–Sashegy, Tihany–Fehérpart and Sé. It is assumed to be a member of hard wood riparian forests or gallery forest together with *Platanus leucophylla*, *Salix* and other species. It was widespread in Europe during the Late Miocene. It is well known in the Pannonian floras of the Alpine Molasse in Austria (KOVAR-EDER 1988), Moravia (KNOBLOCH 1969), Chiuzbaia (GIVULESCU 1990), Sośnica (GÖPPERT 1855), Carpathian Ukraina (Rika, Berezinka =Nyírhalom) (ILJINSKAJA 1968) and in numerous Pliocene floras, e.g. Willershausen (KNOBLOCH 1998), Domanski Wierch (ZASTAWNIAK 1972). In Hungary the species disappeared from the fossil record after the Pannonian.

Hamamelidaceae gen. et sp.

Plate XXXVI: fig. 3

Material: Balatonszentgyörgy BK 1564

Description: Simple leaf, no petiole preserved. Lamina ovate, length of lamina 6.8 cm, width of the half lamina 2.7 cm, reconstructed width of the whole leaf 5.4 cm. Apex acute, base cordate. Venation semicraspedodromous. Secondaries spaced at

1.3–1.5 cm from each other. Veins arise from the first pair of secondaries, run to the basal part of the lamina and end in tooth apices. Other veins join each other. Margin toothed. Teeth large, sides convex, apical side shorter than the basal. Tooth apex mucronate.

Discussion: The leaf does not show characteristic traits referring to hamamelidaceous genera or species described in the Pannonian floras or in the Neogene floras of Central Europe. The taxonomic position of this leaf is highly uncertain however its morphology suggests an affinity with Hamamelidaceae.

Platanaceae

Platanus leucophylla (UNGER) KNOBLOCH
Plate VI: figs 4–6, Plate VII: figs 1–7, Plate VIII: figs 1–2

1850a *Populus leucophylla* UNGER — UNGER, p. 417.
1952 *Platanus aceroides* GÖPPER — BERGER, p. 101, figs 86, 87, 88.
1955 *Platanus aceroides* GÖPPER — BERGER, p. 98, figs 107-117.
1968 *Platanus aceroides* GÖPPERT — ILJINSKAJA, p. 65, T. 2, fig. 8, pl. 10, figs 4–6, pl. 11. fig. 7, pl. 16, figs 1, 2.
1969 *Platanus platanifolia* (ETTINGSHAUSEN) KNOBLOCH — KNOBLOCH, p. 97, text.-figs 219-236, T. 46, fig. 2., T. 47. figs 1–8, T. 48, figs 1–5, T. 49. figs 1–5, T. 53, fig. 10, T. 72, fig. 6, T. 74, fig. 2, T. 75, fig. 7.
1988 *Platanus platanifolia* (ETTINGSHAUSEN) KNOBLOCH — KOVAR-EDER p.31, T. 3, figs 1–6.
1989 *Platanus* cf. *leucophylla* (UNGER) KNOBLOCH — MELLER, p. 45, pl. 17, figs 1–5.
1992a *Platanus platanifolia* (ETTINGSHAUSEN) KNOBLOCH — HABLY, p. 199, Pl. 1, figs 2, 3.

Material: Alcsút: BP 2009.421.2., 2009.422.3., cf. 2009.430.1., *Diszel-Hajagos:* BP 2007.504.2., *Gyöngyös-Silbermann mine:* BP 2007.506.1.; *Győr-Sashegy:* SAMU 2008.9.1. (9 specimens), 2008.9.2., 2008.9.3. (4 specimens), 2008.9.4., 2008.9.5. (2 specimens) – 2008.9.8. (3 specimens), 2008.9.11., 2008.9.15–2008.9.22. (2 specimens), 2008.9.23., 2008.9.25., 2008.9.27., 2008.9.29., 2008.9.31–2008.9.33., 2008.9.35., 2008.9.37–2008.9.39., 2008.9.41., 2008.9.42.= 2008.9.59. (2 specimens), 2008.9.47., 2008.9.48. (2 db), 2008.9.49–2008.9.52., 2008.9.54–2008.9.56., 2008.9.59., 2008.9.61. (3 specimens) – 2008.9.66., 2008.9.68., 2008.9.69., 2008.9.71–2008.9.76., 2008.9.78., 2008.9.80., 2008.9.81., 2008.9.89–2008.9.91. (3 specimens), 2008.9.92–2008.9.101., 2008.9.103., 2008.9.104., 2008.9.106., 2008.9.107., 2008.9.109., 2008.9.111 (3 specimens), 2008.9.114–2008.9.116., 2008.9.118., 2008.9.119. (3 specimens), 2008.9.121. (3 specimens), 2008.9.122., 2008.9.124. (3 specimens), 2008.9.125–2008.9.127. (3 specimens), 2008.9.130, 2008.9.131., 2008.9.133., 2008.9.135.; *Hévíz*: ZIRC 92.101.1., *Hosszúpereszteg:* SAMU 73.3.815., 73.3.908., 73.3.944., 86.13.81., 86.13.496., 86.13.856., 86.13.1119., cf. 86.13.1240., 86.13.1352., 86.13.1374., *Karmacs:* BP 2007.488.1–2007.490.1., 2008.430.1–2008.436.1., 2008.460.1., 2008.461.1.; *Sé:* SAMU 73.2.4., *Tihany:* BP 85. 112.2., 85.122.2., 85.144.1., cf. 85.175.1., 85.186.4., 85.192.3., 85.203.1., 85.206.2., 85.207.1.

Description: Simple leaves, petiole often preserved. Petiole 1.2–5.6 cm long. Lamina palmately lobed, usually with three lobes, small leaves occasionally non-lobed. Length of lamina 3–16 cm, width 2.3–14 cm. Shape of lamina wide ovate, base cuneate or decurrent, apex acute to acuminate. Margin simple serrate. Teeth irregular. Tooth apex acute, acuminate or obtuse. Apical side of the teeth concave, rarely straight and generally shorter, then the basal side. Basal side convex, rarely straight. Sinuses rounded. Venation palinactinodromous. Midvein stout and strait. Primary veins diverge suprabasally from the midvein, and run into the apices of the side lobes. Slightly curved secondaries start from the midvein more or less regularly, and end in the teeth apices. Venation of the side lobes asymmetrical, at their basal side stout secondaries run to the side lobes and terminate in the teeth apices.

Discussion: Leaves of *Platanus* display a coriaceous texture therefore there is a good chance for fossilization. Presumably, this is the reason for the dominant occurrence of *Platanus* leaves in some assemblages, e.g. Karmacs and Diszel-Hajagos, where the preservation of most other taxa is very poor. In a specific vegetation type (hardwood riparian forest, gallery forest) it is dominant associated with *Liquidambar*, *Ulmus*, *Alnus* ducalis and other elements. As regards the Pannonian floras of Hungary it is important element at Győr-Sashegy, Hosszúpereszteg, Tihany, but occurs at other localities, as well. *Platanus leucophylla* is broadly distributed and characteristic element of the Pannonian assemblages in the Pannonian Basin and surrounding areas. It is well represented in the Carpathian Ukraine (localities Rika, Berezinka= Nyírhalom, Uzsgorod=Ungvár: ILJINSKAJA 1968), Sośnica (GÖPPERT 1855), Moravia (KNOBLOCH 1969), Alpine Molasse of Austria (KOVAR-EDER 1988), Chiuzbaia (=Kisbánya) (GIVULESCU 1990) and numerous other localities. Records in floras older or younger than the Pannonian are not known from Hungary.

Platanus sp. leaf
Plate XXXI: fig. 5

Material: Balatonszentgyörgy: BK 1675

Description: Simple, petiolate leaf. Length of lamina 4.5 cm (reconstructed length 5 cm), width 4.2 cm, petiole 1.5 cm long. Lamina ovate, lobed up to five lobes. Apex not preserved, base almost truncate. Margin toothed. Teeth large, teeth apices acute. Apical side of teeth convex to straight, basal side convex to straight or rarely concave. Midvein stout and curved at the basal part of the lamina. From the midvein thick secondaries arise, run to the side lobes and end in teeth apices. Higher order veins arise from the secondaries and run to the large teeth.

Discussion: The morphology of the leaf does not correspond to the leaves of *P. leucophylla*. Both its shape and teeth are different from those of *P. leucophylla*. There are simple, small leaves of *P. leucophylla* documented from other assemblages, e.g. Győr-Sashegy, but the teeth displayed by these leaves are typical of the species. The specimen from Balatonszentgyörgy possesses different type of teeth. Its base and venation are quite characteristic of *Platanus* leaves; however, additional specimens would be required to identify it at the species level.

Platanus sp. fruit
Plate VIII: fig. 7, Plate IX: figs 1–4

Material: Hosszúpereszteg: SAMU 73.3.1251., 73.3.1281., 73.3.1497., 73.3.1565., 73.3.1502., 73.3.1575.

Description: Rounded fruits with numerous seeds, diameter 1.9–3.0 cm. Seeds densely arranged, shape elongated. Broadest at the surface of the fruit, seeds narrower in the central part of the fruit.

Discussion: The fruits may belong to *Platanus leucophylla*, which is quite common with its leaves in the flora of Hosszúpereszteg. The preservation of fruits was favoured by the soft sandstone.

Fagaceae

Fagus haidingeri KOVÁTS emend. KNOBLOCH
Plate VIII: fig. 3, Plate XXXVI: figs 5–7

1856 *Fagus Haidingeri* KOVÁTS — KOVÁTS, p. 24, pl. 4, figs 6, 7.
1969 *Fagus haidingeri* KOVÁTS — KNOBLOCH, p. 79, pl. 36, figs 2–8, 10, 11, pl. 37. figs 1–11, pl. 38, figs 2–11, text-figs 184–209.
1969 *Fagus haidingeri* KOVÁTS sensu KNOBLOCH — SITAR, p. 124, pl. 34, figs 3, 4, pl. 35, figs 1–3, 5, 6.
1972 Fagus haidingeri KOVÁTS sensu KNOBLOCH — ZASTAWNIAK, p. 23, pl. 4, figs 3–7, pl. 5, figs 1–6, pl. 17, figs 5, 6, pl. 18, figs 1–5.
1988 *Fagus haidingeri* KOVÁTS emend. KNOBLOCH — KOVAR-EDER, p. 31, pl. 2, figs 11–17, pl. 4, figs 3, 4.

Material: Alcsút: BP 2009.421.2., 2009.427.2., *Pécs-Nagyárpád*: BP cf. 97.223.1., 97.224.2., cf. 97.226.1., cf. 97.230.1., cf. 97.231.1., cf. 97.235.1., 97.236.1., 97.238.1–1997.240.1., 97.242.1., 97.243.2., 97.246.1., *Rózsaszentmárton:* BP cf. 2001.276.1.

Description: Simple leaves, petiole not preserved. Lamina ovate, (preserved) length of lamina 5.0–6.2 cm, width 2.4–3.8 cm. Base rounded, slightly asymmetrical, apex acute, the tip of the apex not preserved. Margin serrate, teeth simple. Venation craspedodromous. Primary vein „zig-zag" in the upper part of lamina.

Discussion: Fagus haidingeri is a rare element in the Pannonian floras of the Pannonian Basin; it was recorded from Alcsút, and from Pécs-Nagyárpád. In the latter locality the species was a dominant element of the flora. It was widespread in Europe and western Asia from the Sarmatian up to the Pliocene. In the Pannonian Basin floras it appears in the Sarmatian (e. g. Erdőbénye; KOVÁTS 1856), in the younger Sarmatian (Pannonian?) in the Turiec Basin, which is located at the northern margin of the Pannonian Basin. In the Carpathian Mts. at the localities Lehotka, Bystrička, Martin (=Túrócszentmárton) (SITAR 1969) it was also recorded. In the Pannonian of the Pannonian Basin it is a rare element. In Central Europe it was widespread during the Pannonian, e.g. in the Alpine Molasse in Austria (KOVAR-EDER 1988), in Moravia (KNOBLOCH 1969). Its rare occurrence in the Pannonian Basin may be attributed to the dominance of wetland environments during the Pannonian.

Fagus decurrens C. & E. M. REID

Material: Visonta: BK 5543–5545 cupules, fruits

Description: see in BŮŽEK & LÁSZLÓ (1992), p. 57, pl. 7. figs 1–12, 13, 14, pl. 8. figs 1–9.

Quercus kubinyii (KOVÁTS ex ETTINGSHAUSEN) BERGER
Plate VIII: figs 4–6

1851 *Castanea kubinyii* KOVÁTS — KOVÁTS, p. 178.
1852 *Castanea kubinyii* KOVÁTS — ETTINGSHAUSEN, p. 6, Pl. 1, fig. 12.
1856 *Castanea kubinyii* KOVÁTS — KOVÁTS, p. 25, pl. 3, figs 1-7.
1952 *Castanea atavia* UNGER — BERGER, p. 89, figs 37, 39–41.
1952 *Quercus* cf. *drymeja* UNGER — BERGER, p. 92, figs 48–50.
1952 *Quercus kubinyii* (KOVÁTS) — BERGER, p. 92, fig. 47.

1955b *Castanea atavia* UNGER — BERGER, p. 91, figs 64–67.
1971–72 *Quercus kubinyi* (KOVÁTS) CZECZOTT — HORVÁTH, p. 34, pl. 2, figs 4, 5.
1971–72 *Quercus castaneaefolia* C. A. Mey — HORVÁTH, p. 34, pl. 2, figs 4, 5, text.-figs 2, 3b, 4b.
1972 *Quercus kubinyii* (KOVÁTS ex ETTINGSHAUSEN) BERGER — ZASTAWNIAK, p. 26, pl. 4, fig. 15, pl. 5, figs 7, 8, pl. 21, figs 1–3.
1988 *Quercus kubinyii* (KOVÁTS ex ETTINGSHAUSEN) BERGER — KOVAR-EDER, p. 35, pl. 5, fig. 1, pl. 3. figs 7, 8.
1997 *Quercus kubinyii* (KOVÁTS ex ETTINGSHAUSEN) BERGER — HABLY & KVAČEK, p. 23, Pl. 9, figs 37, 38, 40, 41, Pl. 10, figs 42–47.

Material: Alcsút: BP 2009.422.3., 2009.426.1., 2009.428.2., *Aranyosgadány*: BP 97.251.1., *Hosszúpereszteg*: SAMU cf. 86.13. 97., 86.13.486. 86.13.497., 86.13.502., cf. 86.13.540., 86.13.618., 86.13.636., 86.13.752., cf. 86.13.809., 86.13.875., 86.13.882., 86.13.895., 86.13.910., 86.13.916., 86.13.919., 86.13.920., 86.13.924., 86.13.988., 86.13.997, 86.13.1015., 86.13.1017, 86.13.1027, 86.13.1028., 86.13.1140., 86.13.1232., 86.13.1239., *Sé:* SAMU 70.2.3–73.2.5., 70.2.7., 70.2.9., 73.2.1., 73.2.3., 73.2.5.

Description: Fragmentary, simple leaves. Lamina lanceolate, length up to 12 cm, width up to 5 cm. Base and apex not preserved. Margin simply toothed. Teeth apices acute or attenuate, apical side of teeth convex to concave, basal side convex. Sinuses rounded. Venation craspedodromous. Midvein stout and straight, secondaries regularly spaced, cc. 0.6–0.8 cm from each other, and terminate in teeth apices. Tertiary venation well observable, dense, perpendicular to the secondaries.

Discussion: Quercus kubinyii was described first by KOVÁTS (1856) from Erdőbénye from the Hungarian Sarmatian. The species appeared during the Ottnangian/Karpatian in the Pannonian Basin (HABLY 2005), and became dominant in the Sarmatian floras (ANDREÁNSZKY 1959, ERDEI 1995, ERDEI & HIR 2002). It is a rare element in the Late Miocene of the Pannonian Basin (HABLY 2003), but quite frequent along the margin of Lake Pannon (BERGER 1952, 1955b, KOVAR-EDER 1988) as well as in numerous Late Neogene floras of Europe. Its rare occurrence in the Pannonian Basin during the Pannonian is attributed to changing habitats and environmental conditions. *Quercus kubinyii* is assumed to prefer volcanic habitats, e.g. Erdőbénye. Later, during the Pliocene it withdrew to the basin as a dominant element, e.g. Pliocene crater lakes (HABLY & KVAČEK 1997). However, the current review reveals a higher role of *Q. kubinyii* in the flora and vegetation than it was reported by earlier studies. In the flora of Hosszúpereszteg it is dominant indicating that this area must have served as a refuge in the Pannonian Basin. Its more frequent occurrence in the marginal floras, e.g. in Slovakia (LEHOTKA, SITAR 1969), or in Austria (KOVAR-EDER 1988) shows, that it survived the Pannonian wetland conditions in the marginal areas and in "inselbergs"). This theory is confirmed by Pliocene fossil plant assemblages near Gérce and Pula, where *Q. kubinyii* plays again a dominant role in the flora and vegetation, similarly to the Sarmatian volcanic floras.

Quercus sp.
Plate XXXV: fig. 6, Plate XXXVI: fig. 8

Material: Hosszúpereszteg: SAMU 73.3.1295., 73.3.1357., 73.3.1404., 73.3.1520., 86.13.15., 86.13.18., 86.13.79., 86.13.770., 86.13.771., 86.13.780., 86.13.781., 86.13.785., 86.13.786., 86.13.789., 86.13.795., 86.13.810., 86.13.822., 86.13.829., 86.13.830., 86.13.840., 86.13.874., 86.13.917., 86.13.934., 86.13.985., 86.13.962., 86.13.973., 86.13.987., 86.13.991., 86.13.992., 86.13.995., 86.13.1201., 86.13.1244., 86.13.1245., 86.13.1275., 86.13.1302., 86.13.1338., 86.13.1383., 86.13.1353., 86.13.1403., 86.13.1418., 86.13.1531., *Pécs-Nagyárpád:* BP 97.227.1., cf. 97.232.1. - 97.234.1., cf. 97.241.1., 97.245.1., cf. 97.248.1., *Visonta:* BK without inventar number

Description: Fragmentary leaves, margin toothed. Teeth generally large, often incomplete due to fragmentation.

Discussion: Most of the fragments probably belong to the species *Q. pontica miocenica* (leaves from Hosszúpereszteg) and *Q. kubinyii* (leaves from Pécs-Nagyárpád), but poor preservation hinders identification at the species level.

Quercus sp. fructus
Plate IX: figs 5–7

Material: Felsőtárkány BP 71.122.1., *Hosszúpereszteg*: SAMU 86.13.1108., 86.13.111.

Description: acorn (Hosszúpereszteg) three dimensional, rounded, diameter 1.8 cm, height 0.5 cm. Poorly preserved, radially arranged upper scales. Other specimen (Felsőtárkány) compressed, rounded fruit, nearly 3 cm in diameter measured with the scales. Scales 0.6–0.8 cm long, 0.2–0.25 cm wide measured at the basis.

Discussion: The fruit from Felsőtárkány was identified earlier by KUBÁT & BUBIK (1955) as *Quercus* sp.

Quercus pontica-miocenica KUBÁT
Plate X: figs 1–6

1955 *Quercus pontica-miocenica* KUBÁT — KUBÁT & BUBIK, p. 47, pl. 11, fig. 4, pl. 12, fig. 5, text.-figs 16–17.
1959 *Quercus pontica-miocenica* KUBÁT — ANDREÁNSZKY, p. 107, pl. 29, fig. 2, pl. 30, fig. 2, pl. 67, fig. 1.

1968 *Quercus pontica-miocenica* KUBÁT — ILJINSKAJA, p. 58, pl. 3, figs 5, 6, pl. 23, fig. 6, pl. 28, fig. 7., pl. 36, figs 4, 5., pl. 37, figs 1–4, pl. 42, figs 1, 2.
1972 *Quercus pontica-miocenica* KUBÁT — ZASTAWNIAK, p. 27, pl. 6, figs 3–6, pl. 20, figs 1–3.

Material: Felsőtárkány: BP 55.1965.1., 59.62.1., 59.225.1., 60.1662.1., 60.1792.1., 60.1798.1., 60.1806.1., 60.1822.1., 60.1836.1., 60.1841.1., 60.1847.1., 60.1859.1., 60.1856.1., 60.1903.1., 60.1920.1., 60.1925.1., 62.1088.1., 62.1100.1., 62.1107.1., 62.1136.1., 62.1139.1., 62.1153.1., 62.1182.1., 62.1312.1., 62.1348.1., 62.1351.1., 62.1353.1., 62.1411.1., 62.1422.1., 62.1424.1., 62.1449.1., 62.1450.1., 69.693.1., 69.695.1–69.697.1., 69.701.1., 69.705.1., 69.711.1., 69.704.1., 69.718.1., 69.725.1., 69.741.1., 69.746.1., 69.751.1., 69.752.1., 69.754.1., 69.757.1., 69.765.1–69.767.1., 69.771.1., 69.775.1., 69.778.1., 69.783.1., 69.786.1., 69.794.1., 69.797.1., 69.800.1., 69.815.1., 69.821.1., 69.829.1., 69.830.1., 69.833.1., 69.787.1., 69.788.1., 69.791.1., 69.810.1., 69.813.1., 69.837.1., 71.4.1., 71.11.1., 71.21.1., 71.25.1., 71.38.1–71.41.1., 71.44.1., 71.46.1., 71.49.1., 71.51.1., 71.53.1. – 71.55.1., 71.57.1., 71.58.1., 71.60.1., 71.61.1., 71.62.1–71.64.1., 71.66.1., 71.67.1., 71.70.1., 71.73.1., 71.74.1., 71.76.1., 71.77.1., 71.83.1., 71.85.1., 71.88.1., 71.90.1. – 71.104.1., 71.108.1., 71.110.1., 71.112.1–71.118.1., 71.122.1., 71.126.1. - 71.128.1., 71.130.1., 71.134.1., 71.141.1., 71.632.1., 85.218.1., 85.220.1., 85.221.1., 85.227.1., 85.238.1., 85.243.1., 85.247.1., 85.248.1., 85.250., 85.251., 85.380.1., 85.460.1., 2003.204.1., 2003.206.1., MM 55.5146.1., 55.5176.1., 55.5182.1., 55.5223.1., 55.5224.1., 55.5314.1., 56.577.2., 56.616.1., 64.1092.1., 64.1104.1., 64.1279.1., 64.1281.1., 64.1296.1., 64.1297.1.

Description: Simple leaves, shape of lamina obovate, length and width up to 22 cm, and 12 cm, respectively. Apex acute, base rounded. Venation craspedodromous, 15–20 pairs of secondaries arise from the midvein. Secondaries spaced at 1.2–1.3 cm from each other, spread out toward the margin and end in teeth apices. Tertiary venation dense. Teeth large, tooth apex acute to attenuate, basal and apical sides of teeth concave, sinuses large and rounded.

Discussion: Q. pontica-miocenica was described from the flora of Felsőtárkány, as a dominant element. There are no younger records of the species from the Pannonian Basin implying that it disappeared from the basin after the Pannonian. Numerous records were published from the Middle Miocene (Seravallian/Sarmatian), as well as from the Late Miocene and Pliocene floras of Europe. ILJINSKAJA (1968) mentioned the species from the Late Miocene of the Carpathian Ukraine (Ilonca, Ungvár, Bereznek), STRIEGLER (1985) reported it from the Middle Miocene flora of Wischgrund, Germany and specimens were also documented by ZASTAWNIAK (1972) from the Pliocene flora of Domanski Wierch, Poland.

Betulaceae

Alnus cecropiifolia (ETTINGSHAUSEN) BERGER
Plate X: figs 7–8, Plate XI: figs 1–4

1851 *Artocarpidium cecropiaefolium* ETTINGSHAUSEN — ETTINGSHAUSEN, p. 15, pl. 2, figs 3, 4.
1955b *Alnus cecropiaefolia* (ETTINGSHAUSEN) BERGER — BERGER, p. 87, text-fig. 30.
1972 *Alnus cecropiaefolia* (ETTINGSHAUSEN) BERGER — ZASTAWNIAK, p. 12, pl. 1, figs1–6, pl.2, fig. 1., pl. 13, figs 1–4, pl. 14, figs 1, 2.
1996 *Alnus cecropiifolia* (ETTINGSHAUSEN) BERGER — HABLY & KOVAR-EDER, p. 72, pl. 3, figs1, 3–6,, pl. 4. figs 2–6.
1998 *Alnus cecropiaefolia* (ETTINGSHAUSEN) BERGER — ZASTAWNIAK & WALTHER, p. 96, Text-fig. 4:7, pl. 2, figs 2, 3.

Material: Dozmat: BP 2005.1.1–2005.8.1., 2005.10.1–2005.13.1., 2005.16.1–2005.18.1., 2005.20.1–2005.21.1., 2005.23.1–2005.29.1., 2005.34.1–2005.41.1., 2005.43.1., 2005.45.1., 2005.47.1., 2005.49.2., 2005.51.1.2005.54.2., 2005.56.1–2005.64.1. SAMU: 66.517., 66.5.52., 66.5.70., 66.5.79., 66.5.80., 66.5.115., 66.5.194., 66.5.205., 66.5.207., 66.5.216., 66.5.225., 66.5.227., 66.5.236., 66.5.241., 66.5.254., 66.5.288., 66.5.300., 66.5.307.,66.5.311., 66.5.332., 66.5.363.,66.5.376., 66.5.388., 66.5.406., 66.5.420., 66.5.422., 66.5.468., 66.5.480., 66.5.507., 66.5.541., 66.5.552., 66.5.560., 66.5.566., 66.5.578., 66.5.603., 66.5.620., 66.5.667., 66.5.672., 66.5.681., 66.5.682., 66.5.705., 66.5.718., 66.5.728., 66.5.749., 66.5.754., 66.5.766., 66.5.785., 66.5.875., 66.5.895., 66.5.937., 66.5.940., 66.5.949., 66.5.975., 66.5.1041., 66.5.1042., 66.5.1069., 66.5.1098., 66.5.1117., 66.5.1210., 66.5.1222., 66.5.1389., 66.5.1414., 66.5.1417., 66.6.64 (plus more than 1000 secimens). *Iharosberény:* BP cf. 2009.253.2–2009.255.1., 2009.258.2–2009.262.1., 2009.267.1., 2009.268.1., 2009.275.2., 2009.281.3., 2009.286.1., 2009.287.1–2009.291.2., 2009.293.2., 2009.294.4., 2009.297.2– 2009.306.1., *Kerecsend:* SAMU 2008. 16.4., 2008.16.5., cf. 2008. 16.19., 2008.16.36., 2008.16.37., 2008.16.53., 2008.16.54., 2008.16.61., 2008.16.63., cf. 2008.16.65., 2008.16.72., 2008.16.73., *Tiszapalkonya:* 2009.354.6., 2009.355.3., cf. 2009.358.2., cf. 2011.79.2.

Description: Leaves 2.6–14 cm in length, 1.6–11 cm in width, larger sized leaves predominate. Lamina usually broad elliptic, rarely slightly ovate or obovate, base rounded obtuse, truncate, occasionally slightly cordate, rarely asymmetric. Petiole straight, slender, length up to 4.2 cm. Apex short acute or short acuminate. Leaf margin double serrate, teeth variable in size and shape. Large leaves possess usually small-sized teeth, rarely prominent ones. Teeth apices and sinuses acute. Venation craspedodromous, pattern of 7–11 pairs of secondary veins subparallel to slightly divergent towards the leaf margin. Basal secondaries gently sinuous at point arising from the midvein. Secondary veins often terminate distinctly in primary teeth; sometimes only finer veins arising from the secondaries enter directly the teeth. Dense tertiary veins originate approximately perpendicular from the secondaries. Close to the margin tertiaries form loops from which small veins arise and enter secondary teeth. Occasionally distinct tertiary veins arise from the basal side of the secondaries close to the margin; they run slightly curved to enter teeth and end in tooth apices or sinuses.

Discussion: Leaves are generally large, only few small ones occur among the large number of specimens, presumably representing juvenile leaves. The large and broad leaves may indicate uniformly humid habitat and conditions. The species grew prevailingly in Late Miocene swamp assemblages. Accompanied by *Glyptostrobus europaeus* and *Byttneriophyllum tiliifolium* it was a dominant member of the association. The swamp association was described from Dozmat, which yielded hundreds of impressions (HABLY & KOVAR-EDER 1996).

Alnus menzelii RANIECKA-BOBROWSKA
Plate XI: figs 5, 7–8, Plate XII: figs 1–7

1954 *Alnus menzelii* RANIECKA-BOBROWSKA — RANIECKA-BOBROWSKA , p. 11, fig. 4, photos 11–13.
1954 *Betula prisca* ETTINGSHAUSEN — RANIECKA-BOBROWSKA , p. 9, fig. 3, photo 8.
1957 *Alnus crebrinervis* KOVÁCS — KOVÁCS p. 436, pl. 22, fig. 5.
1998 *Alnus menzelii* RANIECKA-BOBROWSKA — ZASTAWNIAK & WALTHER, p. 100, Text.-figs 3:6, 14; 4:3, 10, 12, 13; 8:2, 3, 5, 8, 10, 13, 14; 13:2, 19; pl. 9, fig. 9.
2001 *Alnus menzelii* RANIECKA-BOBROWSKA — KOVAR-EDER & WÓJCICKI, p. 224, Text.-fig. 3: 7–9, pl. 1, figs 14–18, pl. 4, figs 2–8.

Material: Balatonszentgyörgy: BP 2008.354.3., 2008.356.2., 2008.357.2., 2008.366.1., 2008.428.1., 2010.159.1., 2010.160.2., cf. 2011.125.2., cf. 2011.126.1., cf. 2011.127.1., cf. 2011.130.1. *Bükkábrány:* BK 4506, *Felsőtárkány:* BP 55.1754.1., 55.1758.1–55.1760., 55.1769.1., 55.1771– 55.1773.1., 55.1782.1., 55.1786.1., 55.1791.1–55.1793.1., 55.1800.1., 55.1801.1., 55.1805.1., 55.1806.1., 55.1809.1., 55.1819.1., 55.1823.1., 55.1828.1., 55.1835.1., 55.1846.1., 55.1850.1., 55.1883.1., 55.1886.1., 55.1887.1., 55.1891.1., 55.1893.1., 55.1901.1–55.1903.1., 55.1910.1., 55.1913.1., 55.1914., 55.1921.1., 55.1924.1., 55.1927.1., 55.1929.1., 55.1935.1., 55.1943.1., 55.1948.1., 55.1949.1., 55.1951.1–55.1956.1., 55.1958.1., 55.1962.1., 55.1963.1., 55.1971.1., 55.1975.1., MM 55.5052.1., 55.5054.1., 55.5056.1., 55.5063.1., 55.5066.1–55.5068.1., 55.5069.1., 55.5071.1., 55.5075.1., 55.5082.1., 55.5084.1., 55.5086.1., 55.5087.1., 55.5090.1., 55.5092.1., 55.5094.1–55.5096.1–55.5100.1., 55.5105.1., 55.5106.1., 55.5108.1., 55.5103.1., 55.5104.1., 55.5122.1., 55.5125.1., 55.5139.1., 55.5147.1., 55.5149.1., 55.5151.2., 55.5157.1., 55.5160.1., 55.5170.1., 55.5171.1., 55.5185.1., 55.5189.1., 55.5214.1., 55.5225.1., 55.5228.1., 55.5232.1., 55.5235.1., 55.5242.1., 55.5243.1., 55.5247.1., 55.5253.1., 55.5255.1., 55.5267.1., 55.5279.1., 55.5283.1., 55.5286.1., 55.5288.1., 55.5289.1., 55.5292.1., 55.5298.1., 55.5308.1., 55.5315.1., 55.5316.1., 55.5325.1., 55.5327.1., 55.5328.1., 55.5330.1., 55.5334.1., 56.476.1., 56.548.1., 56.558.1., 56.580.2., 56.608.1., 56.609.1., 56.626.1., 56.630.1., 56.635.1., 56.641.1., 56.644.1., 56.648.1., 56.981.1, 56.992.1., 56.995.1., 61.408.1., 64.407.1., 64.1105.1., *Rudabánya-Andrássy*: BK 2, 4, 17, 61, 64, 109, 137, 143, 163, 165, 252, 253–255, 264, 266, 268, 273, 275, 277, 278, 280, 283, 384, 291, 296, 301-306, 308, 310, 314–320, 323–325, 326–333, 335–365, 368–371, 373–375, 376–381, 383, 385, 389–397, 398, 400, 402–409, 411–414, 416–428, 431–434, 437, 439, 440, 442, 443, 449–455, 457, *Rudabánya-Vilmos*: BK 545, 560, 569, 688, 689, 694, 706, 707, 771, 775, 779, 788, 909, 943, *Sé:* SAMU 65.2.2560., 65.3.101., 65.3.109., 65.3.1174.

Description: Simple, petiolate leaves. Length of petiole up to 0.8 cm. Lamina length and width up to 11 cm, and 7.5 cm, respectively. Shape of lamina ovate, apex acute, base cordate, margin doubly serrate. Teeth relatively large, tooth apex acute, apical side of teeth concave to convex, sinuses rounded to angular. Venation craspedodromous. Midvein stout, often slightly curved. Up to 14 pairs of secondaries arise from midvein. Secondaries regular, spaced at 1 cm from each other, slightly curved, end in teeth apices. Secondaries often bifurcate near the margin. Tertiary venation relatively strong, dense, anastomosing, and perpendicular to secondaries.

Discussion: Members of the genus *Alnus* were recorded as a diversified group during the Neogene. *Alnus menzelii*, a quite common species, was described under various names. In the flora of Felsőtárkány it was documented as a new species, *A. crebrinervis* KOVÁCS, and its leaves dominated the fossil assemblage. It is a significant element in Rudabánya, as well. As the fossil record indicates it was a characteristic, often dominant element of floras during the early Late Miocene. Along the northern margin of Lake Pannon, its leaves were described variously as *Carpinus grandis* (SITAR 1994, Pl. 5, figs 1, 2), *Alnus hoernesi* (SITAR 1994, Pl. 2. figs 1, 2) or *Betula macrophylla* (SITAR 1994, Pl. 2, fig. 5.) in floras from the Žiar Basin. It is frequently accompanied by *Glyptostrobus europaeus*, *Byttneriophyllum tiliifolium*, *Salix varians* and monocots. The species must have been a member of swamp associations that were similar to the vegetation type described from older Pannonian localities. The latter, however, was dominated by *A. cecropiifolia*.

***Alnus julianiformis* (STERNBERG) KVAČEK et HOLÝ**
Plate XII: fig. 8

1974 *Alnus julianaeformis* (STERNBERG) KVAČEK et HOLÝ — KVAČEK et HOLÝ, p. 367, pl. 1, figs 1–7, pl. 2, figs 1–7.
1976 *Alnus julianaeformis* (STERNBERG) KVAČEK et HOLÝ — KNOBLOCH & KVAČEK, p. 29, pl. 7, figs2, 6, pl. 13, fig. 1, 3, 7, 10, 12, pl. 28, fig. 7, pl. 30, figs 8.

1998 *Alnus julianaeformis* (STERNBERG) KVAČEK et HOLÝ — ZASTAWNIAK & WALTHER, p. 100, Text-figs 5:1–17, 6:1–4, pl. 7, figs 2–5, 7, 9–10, pl. 8. figs 1–4, 8, 10.
2001 *Alnus julianiformis* (STERNBERG) KVAČEK et HOLÝ — KOVAR-EDER & WÓJCICKI, p. 227, Text.-fig. 3:5, pl. 1, fig. 8, pl. 4, fig. 1.

Material: Balatonszentgyörgy: BP 2008.363.1.

Description: Simple leaf, lamina asymmetric, length 7.3 cm, width 5.3 cm. Venation craspedodromous, 9 pairs of secondaries arise from the midvein. Secondaries slightly curved, end in teeth apices. Tertiary venation dense. Margin finely toothed, teeth small with acute apices.

Discussion: The species was described from the Miocene of the North Bohemian Basin (KVAČEK & HOLÝ 1974, KNOBLOCH & KVAČEK 1976). It is a member of a characteristic association occupying swamp habitats. During the Miocene it persisted through the subtropical climate phases (KVAČEK & HOLÝ 1974). *A. julianiformis* also occurs in the Late Miocene floras of the Carpathian Ukraine (ILJINSKAJA 1968), as well as in the Lower Pliocene flora of Sośnica, Poland (GÖPPERT 1855). In the Late Miocene of the Pannonian Basin it is a rare element.

Alnus ducalis GAUDIN emend. KNOBLOCH
Plate XIII figs 1–3

1858 *Rhamnus ducalis* GAUDIN — GAUDIN & STROZZI, p. 39, T. 9, figs 6–9.
1867 *Alnus hoernesi* STUR — STUR, p. 153, T. 4, fig. 9.
1959 *Alnus hoernesi* STUR — ANDREÁNSZKY, p. 87, tex.-fig. 62.
1968 *Alnus stenophylla* SAPORTA et MARION — ILJINSKAJA, p. 57, pl. 8, figs 10–13.
1969 *Alnus ducalis* (GAUDIN in GAUDIN et STROZZI) — KNOBLOCH, p. 69, text.-figs 159–165, T. 28., figs 1–3, 6, T. 29, figs 1–5, T. 31, figs 1, 2, T. 32, fig. 5., T. 33, figs 4, 5, T. 34, figs 1, 2, T. 35, fig.5., T. 53, fig. 9, T. 75, f. 4.
1986 *Alnus ducalis* GAUDIN emend. KNOBLOCH — KNOBLOCH & VELITZELOS, p. 13, pl. 9, figs 4, 7.
1988 *Alnus ducalis* GAUDIN emend. KNOBLOCH — KOVAR-EDER, p. 40, T. 5, figs 2–5.
1992a *Alnus ducalis* GAUDIN emend. KNOBLOCH — HABLY, p. 200, Pl. 1, figs 4, 5.

Material: Tihany: BP 84.1.2–84.17.1., 84.21.1., 84.22.1., 85.126.1., 85.146.1., 85.147.1., cf. 85.151.1., 85. 152.2., 85.153.1., 85.156.1., 85.160.1., 85.167.1., 85.168.2., 85.190.1., 85.191.1., 85.214.1., 2007.517.1., 2007.518.1., 2007.521.

Description: Leaves simple, 4.5–7.1 cm long, 3.8–5.5 cm wide. Shape of lamina obovate, slightly asymmetrical. Apex emarginate, swelling approximately 2 cm deep, the tip of apex mucronate. Base rounded. Margin toothed, teeth simple and small. Venation craspedodromous. Midvein straight, ends in apex. Secondaries relatively regular; spaced at ca. 1 cm from each other. Secondaries curved, run steeply upwards, end in teeth. Tertiary venation dense, random reticulate.

Discussion: This species appeared during the Sarmatian, in the flora of Sály (Hungary), and was described by ANDREÁNSZKY as *Alnus hoernesi* (ANDREÁNSZKY 1959). It became frequent and dominant in riparian vegetation types during the Pannonian. It does not appear in the most typical wetland association of the Pannonian Basin; nevertheless, it proved to be an important element in riparian vegetation from Tihany (HABLY 1992a). In the surroundings of Lake Pannon it appears in the Carpathian Ukraine: Rika near Huszt, mentioned by ILJINSKAJA (1968) as *A. stenophylla*, in Romania, Chiuzbaia (GIVULESCU 1990), in the Vienna Basin: Moravská Nová Ves (Czech Republik, KNOBLOCH 1969), Wien-Laaerberg (Austria, BERGER 1955b); Schneegattern, in the Austrian Alpine Molasse (KOVAR-EDER 1988), Gabbro (Italy, BERGER 1957), and sevaral other localities, but the origin of *Alnus ducalis* is not clear yet (KOVAR et. al. 1996). There is no record from the Pliocene of Hungary and the surrounding area.

Alnus gaudini (HEER) KNOBLOCH & KVAČEK
Plate XI: fig. 6, Plate XIII: figs 4–7

1859 *Rhamnus gaudini* HEER — HEER, p. 79–80, pl. 124, figs 4–15, pl. 125, figs 1, 7, 13.
1976 *Alnus gaudini* (HEER) KNOBLOCH & KVAČEK — KNOBLOCH & KVAČEK, p. 33, pl. 6, figs, 1, 3, pl. 7, figs 1, 5.
1996 *Alnus gaudini* (HEER) KNOBLOCH & KVAČEK — HABLY & KOVAR-EDER, p. 73, pl. 4, fig. 1.
1998 *Alnus gaudini* (HEER) KNOBLOCH & KVAČEK — ZASTAWNIAK & WALTHER, p. 96, Text-figs 6:5–8, 7, pl. 7, figs1, 6, 8.

Material: Alcsút: 2009.444.2., 2009.445.1., *Balatonszentgyörgy*: BP 2008.358.2., 2008.360.2., 2008.365.1., 2010.155.1., 2010.157.1., *Dozmat:* BP 2005.16.1., 2005.19.1., 2005.48.1., SAMU: 69.10.112., 69.10.124., 69.10.238., 69.10.245., 69.10.254., *Rudabánya-Andrássy:* BK 144, 165, 375, 392, 399, 401, 413, 445, *Tihany:* BP 85.107.1., 85.108.1., 85.114.2., 85.115.1., 85.116.1., 85.124.1., 85.129.1., 85.132.1., 85.133.1., 85.141.2., 85.143.1., 85.144.1., 85.157.2., 85.165.2., 85.169.1., 85.179.1., 85.180.1., 85.182.1., 85.184.1., 85.193.3., 85.201.1., 85.202.2., 85.205.5., 85.206.2., 85.209.2., 85.210.2., 85.211.1., 85.212.2., 85.217.2.

Description: Simple leaves, petiole not preserved. Lamina shape ovate, narrow ovate to lanceolate, rarely oblong to elliptic. Maximum length and width up to 8 cm, and 4.2 cm, respectively. Apex and base acute. Teeth small, tooth apex acute. Venation craspedodromous, secondaries thin, slightly curved, end in teeth.

Discussion: In the Hungarian Late Miocene floras it occurs as an accessory element. Contrasting most other species of the genus occurring either in swamp or in riparian assemblages, *A. gaudini* is shared by both swamp and riparian vegetation types. However, judging from its occurrence in fossil floras it prefered riparian environment. In Europe the earliest records of *A. gaudini* are mentioned from the Early Oligocene flora of Flörsheim, Germany (Kvaček 2004). In the Miocene flora of Europe it is quite common (Knobloch & Kvaček 1976).

Alnus sp.
Plate XIV: figs 1–3

Material: Balatonszentgyörgy: BP 85.382.1., 2011.108.1, 2011.109.1., 2011.111.2., 2011.112.1., BK 1617, 1632, *Bükkábrány:* BP 2011.232.1., *Hatvan:* SAMU 2006.4.5., 2006.4.6., *Iharosberény:* BP 2009.314.2., cf. 2009.323.2., cf. 2009.324.2., *Karmacs:* BP cf. 2007.491.1., cf. 2008.459.1., *Kerecsend* BP 95.338.1., 95.339.1., MM 56.9991.1, SAMU 2008.16.1., 2008.16.2., 2008.16.20., 2008.16.21., 2008.16.26., 2008.16.28., 2008.16.34., 2008.16.36., 2008.16.38., 2008.16.49., 2008.16.52., 2008.16.55., 2008.16.57., 2008.16.58., 2008.16.62., 2008.16.67., 2008.16.69., 2008.16.70., 2008.16.74., 2008.16.78., 2008.16.79., 2008.16.81., 2008.16.82., 2008.16.83., 2008.16.84., 2008.16.85., *Hosszúpereszteg:* SAMU 86.13.1., *Rózsaszentmárton:* BP 2005.446.1., 2005.458.1. – 2005.460.1., 2008.50.1., *Tihany:* BP 85.140.1., 85.145.1., 85.183.1., *Tiszapalkonya:* BP 2009.360.2., cf. 2011.83.1., cf. 2011.100.1., *Visonta:* BK 999, 1019, 5449-5451, 5486, 5490, 5491, 5498, 5509

Description: Poorly preserved leaf fragments.

Discussion: In the flora of Visonta there are leaves with cuticle preserved and reproductive organs, as well: see in Bůžek & László (1992), p. 56, pl. 3, fig. 13, pl. 5, figs 1–17, pl. 8 and fig. 10. In the flora of Bükkábrány the genus was confirmed by cuticle (reproductive organs, cone scales); see in Erdei & Magyari (2011), p. 141, text.-fig. 8. *Alnus* is one of the most frequent elements of the Pannonian floras. A great number of species were mentioned from various localities. In many cases leaves are heavily fragmented without characteristic traits allowing for identification at the species level.

Alnus sp. female catkins, “cones”
Plate XIV: fig. 5

Material: Bükkábrány: BK 4492, 4497, 4498, 4502, 4504, *Dozmat:* BP 2005.51.1., SAMU: 66.6.56., 66.5.225., 66.5.567., 66.5.641., 66.5.686., 66.5.831.66.6.65., *Visonta:* BK 4525, 4526

Description: Female catkins with pedunculus, 1.3–1.9 cm long, 0.8–1.0 cm wide; pedunculus 1.3–1.6 cm long. Some of the “cones” still closed, some of them widely open.

Discussion: Female catkins of *Alnus* are relatively rare in the Pannonian floras. In the flora of Dozmat high number of specimens was found.

Alnus sp. male catkins
Pl. XIV: figs 6–7, Plate XV: fig. 1

Material: Bükkábrány: BK 4497, 4498, *Dozmat:* SAMU: 66.5.197., 66.5.225., 66.5.567., 66.5.641., 66.5.784., 66.5.798., 66.5.837., 66.5.1007., *Felsőtárkány:* MM 56.1473.1., 64.1098.1., *Rudabánya-Andrássy:* BK 85, 257, 382, 384, 273/13 and mass of the catkins, *Rudabánya-Vilmos:* BK 906.

Description: Length up to 5 cm; some catkins with closed bracts, some partly fallen apart.

Discussion: Male catkins are more frequent in the Pannonian floras than the female ones. High number of catkins appears in assemblages yielding mass occurrence of *Alnus* leaves, e.g. Rudabánya, Dozmat (Hably & Kovar-Eder 1996).

Carpinus grandis Unger emend. Heer
Plate XV: fig. 2

1845 *Carpinus grandis* Unger — Unger, p. 220 (nomen nudum)
1852 *Carpinus grandis* Unger — Unger, p. 39, pl. 21, figs 4, 5.
1972 *Carpinus grandis* Unger — Zastawniak, p. 17, pl. 2, figs13, 14, pl. 3, figs 1–4, 4a, 5–13, pl. 4, figs 1, 2, pl. 15, figs 1, 1a, pl. 16, figs 1, 5., pl. 30, fig. D.

1988 *Carpinus grandis* UNGER emend. HEER — KOVAR-EDER, p. 37, pl. 6, figs 1–8.
1998 *Carpinus grandis* UNGER emend. HEER — KNOBLOCH, p. 45, pl. 20, figs 7, 8, pl. 21, figs 2, 3, 10, 11, pl. 22. fig. 7, pl. 23, fig. 5, pl. 32, figs 5, 6.

Material: Rudabánya-Andrássy: BK 375

Description: Simple petiolate leaf, petiole 0.8 cm. Shape of lamina lanceolate, length 6.2 cm, width 2.7 cm, base obtuse, apex not preserved. Margin serrate. Teeth small, densely packed, teeth apices acute. Venation craspedodromous. Midvein strong, secondary venation dense, secondaries straight.

Discussion: Carpinus grandis is a rare element in the Pannonian Basin during the Late Miocene. Along the margin of the basin it becomes more frequent with reports from Slovakia, in Polerieka-Kolisky and Bystricka, (Turiec Basin, SITAR 1969, 1982), from the Austrian Molasse zone (KOVAR-EDER 1988), and the Transcarpathian Region of Ukraine (ILJINSKAJA 1968). During the Late Oligocene and Miocene it was widespread in Europe.

Carpinus betulus L. fossilis
Plate XXXVI: fig. 9

1856 *Carpinus producta* UNGER — KOVÁTS, p. 24, pl. 4, fig. 5.
1908 *Carpinus betulus* L. fossilis — ENGELHARDT & KINKELIN, p. 232, pl. 8, fig. 10.
1955b *Carpinus pyramidalis* GAUDIN — BERGER, p. 89, figs 37–41.
1959 *Carpinus pyramidalis* (GÖPPERT) HEER — ANDREÁNSZKY, p. 89, pl. 21, fig. 5, text.-fig. 67, 70.
1959 *Carpinus grandis* UNGER — ANDREÁNSZKY, p. 89, pl. 21, fig. 7.
1982 *Carpinus grandis* UNGER vel *Carpinus pyramidalis* (GÖPPERT) HEER — GREGOR, p. 91, pl. 2, figs 1–5, 10, 14.
1986 *Carpinus grandis* UNGER *s. l.* — GREGOR, p. 51, pl. 21, figs 1-3.
1988 *Carpinus pyramidalis* GAUDIN in GAUDIN & STROZZI — KOVAR-EDER, p. 38, pl. 5, figs 7–9.
1994 *Carpinus betulus* L. type — KVAČEK et al. p. 79, pl. 2, fig.1.
1997 *Carpinus betulus* L. fossilis — HABLY & KVAČEK, p. 30, pl. 13, figs 62, 64, 67.

Material: Pécs-Nagyárpád: BP 97.244.1., 97.247.1.

Description: Only the central lobe of the involucre preserved in both specimens. Length of the central lobe 2.5–3.0 cm, width 0.5–0.8 cm. Margin of bract entire. Main vein runs into to central lobe, and fine dense brochidodromous venation runs perpendicularly to the main vein. On the right side of both specimens a longer basal vein visible, characteristic of *Carpinus* bracts (see Gregor 1986, Fig. 5. A. 3–4, B 4, etc.)

Discussion: This type of involucre is often mentioned as *C. grandis* UNGER, or *C. pyramidalis* GÖPPERT, which are generally used for the leaf fossils. According to MAI & WALTHER (MAI & WALTHER 1988) and HABLY & KVAČEK (HABLY & KVAČEK 1997), the name of the modern species is applied, since there is no significant difference between the fossil and the modern species.

From the Late Miocene several Austrian localities comprise fruit impressions assigned to this species. BERGER (BERGER 1955b) mentioned several specimens from Laaer Berger in Vienna, and Kovar-Eder (KOVAR-EDER 1988) mentioned the species from localities near Grossenreith, Lohnsburg and Ebersbrunn from the Austrian Molasse. From the Late Miocene flora of Achldorf, (Germany, Lower Bavaria) and from the Pliocene flora of Thüringen (Germany) Gregor (GREGOR 1986) and Mai & Walther (MAI & WALTHER 1988) reported the species. From Hungary this type of fruit is known from the Sarmatian flora at Erdőbénye named as *C. producta* (KOVÁTS 1856), and from Sály (ANDREÁNSZKY 1959). The species also appeared in the Hungarian Pliocene flora at Gérce (HABLY & KVAČEK 1997). From the Late Miocene this is the first record.

Carpinus sp. ex gr. *betulus* L.

Material: Visonta: BK 5463, 5481, 5527 fruits (nuts)

Description: see in BŮŽEK & LÁSZLÓ (1992), p. 57, pl. 6. figs 1–4.

Betulaceae gen. et sp.

Material: Bükkábrány: BP 2011.231.1.

Description: see in ERDEI & MAGYARI (2011), p. 141, text.-figs 6, 7.

Myricaceae

Myrica lignitum (Unger) Saporta
Plate XV: figs 3–9, Plate XXXVI: fig. 4

1847 *Quercus lignitum* Unger — Unger p. 113, T. 31, figs 5–7.
1988 *Myrica lignitum* (Unger) Saporta — Kovar-Eder, p. 41, T. 10, fig. 6.
1990 *Myrica lignitum* (Unger) Saporta — Kovar-Eder & Krainer, p. 19, pl. 3, figs 1-5, text.-fig. 8/1–6.

*Material: Balatonszentgyörgy:*BK 1482, 1488, 1501, 1542, 1549, 1554, 1560, cf. 1567, 1569, 1575, 1591, 1593, 1595, 1611–1612, 1617, 1628, 1636–1638, 1642, 1644, 1648, 1657–1659, 1661, 1676–1678, 1685, 1714, 1740–1741, 1743, 1742, 1744–1746, 1749–1750, 1753–1755, 1763, 1758, 1766–1768, 1773, 1776, 1784, 1788–1790, 1797, 1799–1800, 1803, 1808, 1812–1814, 1816–1817, 1820, 1822–1823, SAMU: 2008.6.3., 2008.6.4., 2008.6.8., 2008.6.22., 2008.6.26., 2008.6.30., 2008.6.32., 2008.6.37., 2008.6.39., 2008.6.40., 2008.6.45., 2008.6.59., 2008.6.66., 2008.6.73., 2008.6.75., 2008.6.77., cf. 2008.6.80., 2008.6.81., 2008.6.83., 2008.6.88., 2008.6.89., 2008.6.93., 2008.6.94., 2008.6.104., 2008.6.106., 2008.6.107., 2008.6.118., 2008.6.136., 2008.6.137., 2008.6.139., 2008.6.141., *Karmacs:* BP cf. 2008.462.1., *Pécs-Danitzpuszta* BP 2013.85.1., *Sé:* SAMU 65.3.1157

Description: Simple leaves, petiole not preserved. Shape of lamina lanceolate, often asymmetrical, length and width 3.1–9.5 cm, and 1.1–1.9 cm, respectively. Apex acute, base acute to decurrent. Margin dentate, rarely entire. Teeth frequently irregular, variably with few teeth per leaf or nearly serrate along the margin. Size of teeth variable, both smaller or larger teeth occur. Teeth apices acute, apical side of teeth concave to straight, and shorter than basal side. Basal side straight to convex. Venation brochidodromous or semi-craspedodromous. Midvein stout, secondaries fine, dense tertiary venation between secondaries.

Discussion: Myrica is a typical thermophilous swamp element. In the Late Miocene of the Austrian Molasse Zone only one specimen was recorded (Kovar-Eder 1988), in the Late Miocene flora of Wörth (Kovar-Eder & Krainer 1990) the species occurs more frequently. In the Pannonian Basin abundant material was yielded by older Pannonian strata in Balatonszentgyörgy accompanied by *Glyptostrobus.* In the flora of Sé, *Myrica* is accompanied by *Glyptostrobus*, *Alnus*, and other swamp elements, but *Byttneriophyllum tiliifolium* is missing from the assemblage. It may be recognized that *Myrica* and *Byttneriophyllum* do not occur simultaneously in the Pannonian assemblages, e.g. Bükkábrány, Dozmat, Felsőtárkány, Iharosberény, Kerecsend, Rózsaszentmárton, Rudabánya and Tiszapalkonya. The species was more frequent in older Miocene floras of Europe.

Juglandaceae

Engelhardia macroptera (Brongniart) Unger

1952 *Engelhardtia brongniarti* Saporta — Pálfalvy, p. 64, text.-fig. 1.
1952 *Engelhardtia Brongniarti* Saporta — Vitális & Zilahy, p.165, pl. 20, fig. 5a, pl. 21, fig. 5b.
1955 *Engelhardtia brongniarti* Saporta — Vörös, p. 66. sine icon
1981 *Engelhardia macroptera* (Brongniart) Unger — Pálfalvy, p. 492, pl. 1. , figs 5-11.
2004 *Engelhardia macroptera* (Brongniart) Unger — Kovar-Eder et al. P. 65, pl. 6, figs 8, 9.

Material: Rózsaszentmárton: without inventory number; published in Pálfalvy 1952, p. 64, text.-fig. 1, 1981, pl. 1., figs 10–11, Vörös 1955, p. 66. sine icon; whereabouts of specimens unknown.

Discussion: Engelhardia has been recorded exclusively from Rózsaszentmárton during the Late Miocene of the Pannonian Basin. Both Pálfalvy (1952, 1981) and Vörös (1955) mentioned a specimen representing *Engelhardia* in their works, but unfortunately it was found neither among the fossil material stored in MÁFI nor in the collection of the Hungarian Natural History Museum. Pálfalvy figured the specimen in a publication (Pálfalvy 1952), and it is undoubtedly a fruit of *Engelhardia*. In both publications by Pálfalvy and Vörös only one specimen is mentioned suggesting that it must have been a rare element. This is the youngest occurrence of *E. macroptera* in the Hungarian fossil record. A leaf assigned to the genus *Engelhardia*, *E. orsbergensis*, appears in the Pliocene locality of Gérce (Hably & Kvaček 1997) as a relict element. *Engelhardia* appeared in the Hungarian fossil record during the Eocene. It was dominant in Early Oligocene floras (Tard Clay Formation) as well as in the Early Miocene flora of Ipolytarnóc (Hably 1985). The genus obviously flourished in Europe linked mainly to warmer periods. During the Pannonian of the Pannonian Basin it is assumed to be a relict, thermophilous member of the flora.

Pterocarya sp.

Material: Visonta: BK 5487, 5522 endocarps

Description: see in Bůžek & László (1992), p. 58, pl. 6. figs 6–7. *Bükkábrány:* BK without number (László 1992, pl. 4, fig. 1.)

Ulmaceae

Ulmus carpinoides GÖPPERT emend. MENZEL
Plate XVI: figs 1–5

1855 *Ulmus longifolia* UNGER — GÖPPERT, p. 28, T. 13, figs 1–3.
1855 *Ulmus carpinoides* GÖPPERT — GÖPPERT, p. 28, T. 13, figs 4–9, T. 14, fig. 1.
1855 *Ulmus pyramidalis* GÖPPERT — GÖPPERT, p. 29, T. 13, figs 10–12.
1855 *Ulmus laciniata* GÖPPERT — GÖPPERT, p. 30, T. 13, fig. 13.
1855 *Ulmus urticaefolia* GÖPPERT — GÖPPERT, p. 30, T. 14, figs 2, 3.
1855 *Ulmus elegans* GÖPPERT — GÖPPERT, p. 30, T. 14, figs 7–9.
1855 *Ulmus quadrans* GÖPPERT — GÖPPERT, p. 30, T. 14, figs 4–6.
1855 *Ulmus sorbifolia* GÖPPERT — GÖPPERT, p. 30, T. 14, fig. 10.
1955b *Ulmus longifolia* UNGER — BERGER, p. 96, figs 94–97.
1968 *Ulmus longifolia* UNGER — ILJINSKAJA, p. 61, pl. 2, fig. 7, pl. 8, fig. 17, pl. 21, fig. 3., pl. 36, fig. 6, pl. 42, fig. 3.
1969 *Ulmus pyramidalis* GÖPPERT — KNOBLOCH, p. 103, T. 35, fig. 10, T. 50, figs 1, 4, 5, 9–11, T. 51, figs 1, 7, T. 52, figs 1, 6, 7, 9, T. 53. figs 1, 6, 11, T. 73, fig. 8, T. 77, fig. 9.
1969 *Ulmus longifolia* UNGER — SITAR, p. 138, pl. 52, fig. 2.
1988 *Ulmus carpinoides* GÖPPERT emend. MENZEL — KOVAR-EDER, p. 41, T. 7, figs 22–27.

Material: Győr-Sashegy: SAMU: 2008.9.4. 2008.9.13., 2008.9.14., 2008.9.24., 2008.9.26., 2008.9.28., 2008.9.29., 2008.9.34., 2008.9.44., 2008.9.45., 2008.9.46., 2008.9.56., 2008.9.67., 2008.9.70., 2008.9.74., 2008.9.85., 2008.9.86., 2008.9.88., 2008.9.97., 2008.9.108., 2008.9.119., 2008.9.127. *Hosszúpereszteg*: SAMU 73.3.1581., 86.13.8., 86.13.128., 86.13.767., 86.13.901., 86.13.918., 86.13.1168., 86.13.1438., cf. 86.13.1459.1.

Description: Simple leaves, petiole frequently preserved. Maximum length of petiole 0,7 cm. Shape of lamina ovate to lanceolate, asymmetric, length and width of lamina 4.5–11 cm, and 2.1–4.2 cm, respectively. Base asymmetric, obtuse, apex acute, margin craspedodromous. Dense secondary venation, secondaries spaced at 0.3–1.0 cm from each other, arise at acute angle and bifurcate in many cases. Secondaries end in teeth apices. Tertiary venation dense, perpendicular to secondaries. Margin toothed, teeth compound, apex acute, apical side straight, basal side slightly convex to straight.

Discussion: This *Ulmus* species was widespread in the Late Miocene floras of Central Europe. In the Hungarian Miocene floras it occurs mainly in riparian vegetation, but it is not a characteristic element of these floras. In the floras of Győr-Sashegy and Hosszúpereszteg it seems to be an important member of assemblages, but in Tihany it does not occur at all, although this latter assemblage comprises riparian vegetation. In the Late Miocene of the surrounding area its fossils are recorded in the Turiec Basin (localities: Lehotka, Martin, Priekopa; SITAR 1969), in the Austrian Molasse Zone (KOVAR-EDER 1988) as well as in the Transcarpathian Region of the Ukraine (ILJINSKAJA 1968).

Ulmus braunii HEER
Plate XVI: figs 6–7

1856 *Ulmus braunii* HEER — HEER, p. 59, pl. 79, figs 14–21.
1856 *Ulmus plurinervia* UNGER — KOVÁTS, p. 26, pl. 4, figs 8–13.
1988 cf. *Ulmus plurinervia* UNGER — KOVAR-EDER, p. 42, pl. 7, figs 1–9.
1989 *Ulmus braunii* HEER — SITAR ET AL., p. 50, pl. 29, figs 11–13, 15–16.
1991 *Ulmus ruszovensis* HUMMEL — FISCHER & HABLY, p. 29, pl. 1, figs 2–7, pl. 2, fig. 4, text-figs 12–15.
1991 *Ulmus* sp. 1 — FISCHER & HABLY, p. 29, pl. 5, fig. 1, text-fig. 18.
1994 *Ulmus ruszovensis* HUMMEL — KVAČEK, HABLY & SZAKMÁNY, p. 79.
1997 *Ulmus braunii* HEER — HABLY& KVAČEK, p. 32, pl. 14, figs 68–72.

Material: Felsőtárkány: MM 55.5067.1., 55.5079.1., 55.5081.1., 55.5089., 55.5159.1., 55.5160.1., 55.5161.1., 55.5243.1., 55.5271.1., 55.5273.2., 55.5276.2., 55.5329.1., 55.5341.1., 55.5580.1., 56.563.1., 56.566.1., 56.572.2., 56.574.1., 56.583.1., 56.584.1., 56.590.1., 56.595.1., 56.597.1., 56.611.1., 56.645.1., 56.647.1., 56.979.1., 56.980.1., 56.1254.1., 64.1097.1., 64.1290.2., 64.1301.1., 73.8.1., *Hosszúpereszteg*: SAMU 73.3.321.1., 73.3.1089., 73.3.1250., 73.3.1262., 73.3.1275., 73.3.1296., 73.3.1297., 73.3.1299., 73.3.1304., 73.3.1311., 73.3.1313., 73.3.1314., 73.3.1320., 73.3.1363., 73.3.1355., 73.3.1335., 73.3.1365., 73.3.1394., 86.13.12., 86.13.13., 86.13.70., 86.13.117., 86.13.230., 86.13.487., 86.13.490., 86.13.784., 86.13.836., 86.13.844., 86.13.871., 86.13.921., 86.13.990., 86.13.993., 86.13.996., 86.13.967., 86.13.1011., 86.13.1159., 86.13.1161., 86.13.1164., 86.13.1180., 86.13.1182., 86.13.1184., 86.13.1233., 86.13.1234., 86.13.1237., 86.13.1241., 86.13.1246., 86.13.1270., 86.13.1272., 86.13.1276., 86.13.1285., 86.13.1303., 86.13.1305., 86.13.1308., 86.13.1313., 86.13.1324., 86.13.1333., 86.13.1350., 86.13.1351., 86.13.1353., 86.13.1358., 86.13.1368., 86.13.1373., 86.13.1376., 86.13.1380., 86.13.1387., 86.13.1389., 86.13.1399., 86.13.1409., 86.13.1415., 86.13.1420., 86.13.1421., 86.13.1426., 86.13.1436., 86.13.1444., 86.13.1447., 86.13.1454.2., 86.13.1455., 86.13.1458., 86.13.1460., 86.13.1469., cf. 86.13.1461., 86.13.1462., 86.13.1468., 86.13.1472., 86.13.1480., 86.13.1494., 86.13.1495., 86.13.1498., 86.13.1499., 86.13.1501., 86.13.1518., 86.13.1534., 86.13.1536., 86.13.1538., 86.13.1539., 86.13.1543., 86.13.1544., *Karmacs:* BP 2008.439.1–2008.460.1., *Rózsaszentmárton:* BP 2008.47.1., *Tihany:* BP 85.122.2., 85.178.1., 85.189.1., 85.210.2., *Tiszapalkonya:* BP 2009.363.1., 2009. 364.1., cf. 2009.365.2., 2009.366.2.

Description: Petiole rarely preserved, length up to 0.4 cm. Lamina length and width 1.7–6.5 cm and 1.2–3.2 cm, respectively. Lamina ovate, apex attenuate, base cordate, strongly or slightly asymmetrical. Margin toothed, teeth compound along the middle part of lamina. Teeth along the margin of the apical and basal parts of leaves and teeth of small leaves simple. Secondary venation dense, secondaries often form "Y" shape in middle part of lamina.

Discussion: Ulmus leaves of definitely small size occur frequently in floras of the Sarmatian up to the Pliocene in the Pannonian Basin and the surrounding area. In the Late Miocene floras of the Pannonian Basin *U. braunii* is dominant in the flora of Hosszúpereszteg, accessory element in the flora of Felsőtárkány and rare accessory element at several other localities, Karmacs, Rózsaszentmárton and Tiszapalkonya. The species occurs also in the Pliocene volcanic flora of Gérce (Hably & Kvaček 1997). It presumably persisted in the Pannonian Basin from the Sarmatian up to the Pliocene.

Ulmus sp.
Plate XIV: fig. 4, Plate XVII: figs 1–2

Material: Bükkábrány: BK 4487, *Hatvan:* SAMU 83.13.3., *Rózsaszentmárton:* BP 2005.404.1., 2008.48.1., *Rudabánya-Andrássy:* BK 525

Description: Poorly preserved simple, non-petiolate leaves. Fragmentary length of lamina 3.8, width 1.8 cm. Lamina ovate, base strongly asymmetric, cordate, apex not preserved. Margin dentate, teeth compound. Teeth of specimens from Rudabánya poorly preserved. Teeth of specimens from Rózsaszentmárton compound, doubly serrate. Venation craspedodromous, midvein stout, secondary venation dense, straight, ends in teeth apices.

Discussion: Poorly preserved, mainly fragmentary leaves with few traits for identification at the species level.

Ulmus sp. fructus
Plate XVII: fig. 3

Material: Rózsaszentmárton: BP 85.382.1.

Description: Samara 10 mm long, 9 mm wide, without spitate. Dense venation of wing.

Discussion: Fruits of *Ulmus* are rare in the Pannonian localities of Hungary. One specimen was mentioned from Rózsaszentmárton (Vörös 1955), however, neither figured nor described. This specimen was found in the original collection of Vörös stored in the Hungarian Natural History Museum.

Zelkova zelkovifolia (Unger) Bůžek & Kotlaba
Plate XXXIV: figs 1, 7, Plate XXXV: fig. 1

1843 *Ulmus zelkovaefolia* Unger — *partim* Unger, pl. 24, figs 9–13, non fig. 7 (fructus)
1851 *Planera Ungeri* Ettingshausen — Anonymo ref. Ettingshausen, p. 145.
1856*a Zelkova Ungeri* Kováts — Kováts, p. 27, pl. 5, figs 1–12, pl. 6, figs 1–6.
1936 *Zelkova Ungeri* Kováts — Pop, p. 71, pl. 7, fig. 2, pl. 18, figs 1–5.
1959 *Zelkova ungeri* Kováts — Andreánszky, p. 133, pl. 37, fig. 5, pl. 39, fig. 6, pl. 41, figs 1, 2.
1971 *Zelkova zelkovaefolia* (Unger) Bůžek et Kotlaba — Bůžek, p. 58, pl. 21, figs 8–9, pl. 22, figs 4–14, text-fig. 5.
1991 *Zelkova zelkovaefolia* (Unger) Bůžek et Kotlaba — Fischer & Hably, p. 29, pl. 2, figs 1–3, 5, text-figs 19, 23.
?1991 *Ulmus* sp. 2 — Fischer & Hably, p. 30, pl. 1, fig. 8, text-fig. 17.
?1991 *Ulmus* sp. 3 — Fischer & Hably, p. 30, pl. 1, fig. 9, text-fig. 16.
1994 *Zelkova zelkovifolia* (Unger) Bůžek et Kotlaba — Kvaček, Hably & Szakmány, p. 79, pl. 1, fig. 6.
1997 *Zelkova zelkovifolia* (Unger) Bůžek et Kotlaba — Hably & Kvaček, p. 34, pl. 15, figs 76-80, pl. 16, figs 81–83, p. 57, pl. 31, fig. 162.

Material: Bükkábrány: BK 4474, 4484, *Rudabánya, borehole Rb–617, 21,0–31,6 m*: BK 749.

Description: Simple leaf, shape of lamina obovate to ovate, length 5.5–6.5 cm, width 2.7–3.1cm. Apex and base acute. Venation craspedodromous. Midvein stout, straight, 12 pairs of secondaries end in teeth apices. Some secondaries bifurcate nearly their half way forming a "Y". Margin toothed. Teeth regular, large, apical and basal side convex. Sinuses angular.

Discussion: Zelkova zelkovifolia was a dominant element in the Pannonian Basin during the Sarmatian (Andreánszky 1959, Erdei 1995, 2002). During the Late Miocene nearly disappeared from the Pannonian Basin, but reappeared in the Pliocene again as a dominant element, e.g. Gérce (Hably & Kvaček 1997). During the Pannonian it survived as evidenced by few localities, especially by the basin margin. By the northern margin of the Basin several localities comprise Zelkova, e.g. Lehotka, Bystricka (Slovakia; SITAR 1969, 1982).

The species was recorded from Sośnica (Southwestern Poland, Silesia; WALTHER & ZASTAWNIAK 2005), as well as eastwards in Transcarpathia (ILJINSKAJA 1968), moreover it is known from the flora of Borszék in the Transylvanian Basin.

Ulmaceae gen. et sp.
Plate XVII: fig. 5

1955 *Zelkova ungeri* KOVÁTS — VÖRÖS, p. 66.

Material: Rózsaszentmárton: BP 2008.469.2.

Description: Simple leaf, lamina length 3.4 cm, width 1.2 cm. Lamina obovate, margin dentate, teeth relatively large, poorly preserved. Venation hardly visible.

Discussion: VÖRÖS (1955) mentioned this specimen and assigned it to *Zelkova*. She did not provide any figure of it but in her original collection the labeled specimen was found. It is a poorly preserved specimen, and does not show leaf traits indicating the genus *Zelkova*.

Cercidiphyllaceae

Cercidiphyllum crenatum (UNGER) BROWN
Plate XXIV: figs 1–8, Plate XXV: figs 1–5

1850a *Dombeyopsis crenata* UNGER — UNGER, p. 449.
1853 *Dombeyopsis crenata* UNGER — HEER , p. 145.
1935 *Cercidiphyllum crenatum* (UNGER) BROWN — BROWN, p.575, pl. 68., figs 1, 6, 8–10.
1957 *Cercidiphyllum ANDREÁNSZKYi* KOVÁCS — KOVÁCS, p. 435, text.-fig. 3, pl.22, fig.3.
1959 *Cercidiphyllum crenatum* (UNGER) BROWN — ANDREÁNSZKY, p. 63, text.-fig. 19, pl. 11, fig. 4, pl. 12, fig. 4.
1959 *Cercidiphyllum andreánszkyi* KOVÁCS — ANDREÁNSZKY, p. 63, pl. 12, fig. 5, pl. 13. fig. 4.
1959 *Cercidiphyllum novemnervium* ANDREÁNSZKY — ANDREÁNSZKY, p. 64, text.-fig. 20., pl. 13, figs 1, 3.
1971 *Cercidiphyllum crenatum* (UNGER) BROWN — BŮŽEK, p. 40, pl. 8, fig. 7.
1996 *Cercidiphyllum crenatum* (UNGER) BROWN — KVAČEK & Konzalová, p. 149–152, pl. 1, figs 1–4, pl. 2, figs 2–8, pl. 3, figs 3–7, pl. 4.
1998 *Cercidiphyllum crenatum* (UNGER) BROWN — KNOBLOCH, p. 17, pl. 5, fig. 4.
2004 *Cercidiphyllum crenatum* (UNGER) BROWN — KVAČEK & WALTHER, p. 25, pl. 6, figs 1–4.

Material: Balatonszentgyörgy: SAMU:2008.6.71., *Felsőtárkány:* BP 55.1764.1., 55.1772.1., 55.1774.1., 55.1777.1., 55.1789.1., 55.1796.1., 55.1798.1., 55.1799.1., 55.1807.1., 55.1817.1., 55.1818.1., 55.1827.1., 55.1841.1., 55.1847.1–55.1849.1., 55.1852.1., 55.1879.1., 55.1884.1., 55.1887.1., 55.1892.1., 55.1894.1., 55.1911.1., 55.1931.1., 55.1933.1., 55.1959.1., 55.1960.1., 55.1966.1., 59.64.1., 60.1766.1., 60.1781.1., 60.1802.1., 60.1810.1., 60.1831.1., 60.1832.1., 60.1849.1., 60.1852.1., 60.1885.1., 60.1911.1., 60.1912.1., 62.1082.1., 62.1126.1., 62.1129.1., 62.1130.1., 62.1177.1., 62.1756.1., 62.1329.1., 62.1354.1., 62.1399.1., 62.1402.1., 62.1432.1., 62.1442.1., 62.1447.1., 62.1448.1., 62.1461.1., 69.691.1., 69.700.1., 69.734.1., 69.778.1., 69.781.1., 69.796.1., 69.798.1., 69.826.1., 69.827.1., 71.45.1., 71.52.1., 71.451.1., 71.120.1., 71.124.1., 71.129.1., 85.239.1., 85.261.1., 2003.192.1., 2003.193.1., 2003.196.1., 2003.201.1., 2003.205.1., 2003.211.1., 2003.214.1., 2003.217.1., 2003.221.1., 2003.225.1., 2003.226.1., 2003.228.1., 2003.231.1., 2003.234.1., 2003.238.1., 2003.239.1., 2003.247.1., MM 55.5073.1., 55.5079.1., 55.5081.1., 55.5083.1., 55.5091.1., 55.5096.2., 55.5114.1., 55.5117.1., 55.5129.1., 55.5133.1., 55.5140.1., 55.5141.1., 55.5144.1., 55.5149.1., 55.5152.2., 55.5156.1., 55.5160.1., 55.5161.1., 55.5163.1., 55.5169.1., 55.5172.1., 55.5174.1., 55.5178.1–55.5180.1., 55.5183.1., 55.5187.1., 55.5191.1., 55.5192.1., 55.5194.1., 55.5200.1., 55.5209.1., 55.5210.2., 55.5213.1., 55.5215.1., 55.5235.1., 55.5246.1., 55.5250.1., 55.5252.1., 55.5257.1., 55.5258.1., 55.5260.1., 55.5265.1., 55.5268.1., 55.5277.1., 55.5285.1., 55.5306.1., 55.5310.1., 55.5313.1., 55.5314.1., 55.5321.1., 55.5326.1., 55.5342.1., 55.5347.1., 55.5867.1., 56.512.1., 56.548.1., 56.558.1., 56.559.1., 56.561.1., 56.562.1., 56.564.1., 56.569.1., 56.573.1., 56.575.1., 56.577.2., 56.588.1., 56.590.1., 56.593.1., 56.596.1., 56.598.1., 56.605.1., 56.611.1., 56.616.1., 56.619.1., 56.620.1., 56.631.1., 56.632.1., 56.634.1., 56.635.1., 56.643.1., 56.645.1., 56.962.2., 56.973.1., 56.980.1., 56.1257.1., 56.1476.1., 64.1083.1., 64.1286.1., 73.8.1., *Győr-Sashegy:* SAMU: 2008.9.118., 2008.9.135., Description: kicsi levél h: 1,8, sz: 1,5, nyél 1,2*, Rudabánya-Andrássy:* BK 35, 60–65, 69, 70–75, 77, 78, 80–87, 89, 91, 92, 94, 95, 97, 100–104, 107–109, 116, 252, 253, 259, 260, 268, 271, 274, 275, 280, 301, 316, 320, 332, 374, 378, 391, 392, 396, 408–411, 429, 435, 436, 446, 447, 451. *Rudabánya-Vilmos:* BK 549, 558,

Description: Simple leaves, petiole often preserved. Length of petiole up to 2 cm. Lamina very wide ovate, length 2.0–6.6 cm, width 1.4–6.1 cm. Apex acute to obtuse, base cordate, margin densely crenate, smoothly rounded. Two or three pairs of basal veins start from the base, run upwards. Basal veins strong and curved. Additional veins branch out from basal veins, and form loops near the margin. Midvein strong, in the upper part of the leaf 2–4 pairs of secondaries arise from the midvein, form loops with each other, as well as with basal veins. Tertiary veins generally strong, dense, run perpendicular to basal and secondary veins. Between tertiary veins, dense quaternary venation of anastomosing type.

Discussion: A fruiting twig from the Late Oligocene of North Bohemia (Bechlejovice) and consistent association of fruits and leaves in the fossil records justify the use of a single specific name *C. crenatum* (UNGER) R. W. Brown for different organs of this plant (KVAČEK & KONZALOVÁ 1996).

Although, the species occurs in several Late Miocene localities of the Pannonian Basin it is dominant only in the flora of Felsőtárkány and Rudabánya. However, in these assemblages both leaves and fruits were recorded. From the Hungarian Sarmatian there are few, uncertain occurrences (ANDREÁNSZKY 1959), and there are no earlier records at all. The species was not recorded from the Pliocene floras of the Pannonian Basin, as well, thus it seems, that conditions in the Pannonian Basin were optimal and favourable for *Cercidiphyllum* during the Pannonian. Contrasting the Bohemian record (Late Oligocene, Early Miocene) in volcanic area, *Cercidiphyllum* favoured wetland habitats in the Pannonian Basin and did not appear in volcanic floras.

Cercidiphyllum sp. fructus
Plate XXV: figs 6–8, Plate XXVI: fig. 1

Material: Felsőtárkány: MM 56.619.1., 56.966.1., 56.971.1., 56.977.1., 56.982.1., 56.985.1–56.989.1., 56.990.1., *Rudabánya:* BK 389, several specimens without number.

Description: Fruit, cluster of 2–4 small pods. Pods 1.4–1.9 cm long, 0.4–0.7 cm wide. Fruit rounded, pods elongated, slightly asymmetrical with acute apex.

Discussion: The fruit and leaves of *Cercidiphyllum crenatum* are assumed to belong to the same plant. In Felsőtárkány and Rudabánya both leaves and fruits of *Cercidiphyllum* occur, however, leaves are more frequently recorded than fruits.

Rosaceae

cf. *Prunus* sp.

Material: Visonta: BK 5516 valve
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 56, pl. 6. fig. 5.

Leguminosae

Leguminosae gen et sp.
Plate XXVIII: fig. 5

Material: Mindszentkálla: BP 2007.500.2., 2008.466.1.

Description: Simple, sessile leaf. Lamina length 3.2 cm, width 1.8 cm. Lamina obovate, apex rounded, base obtuse, margin entire. Midvein straight, 5 pairs of secondary veins. Venation faintly visible.

Discussion: Remains of legumes are very rare in the Late Miocene floras of Hungary. Neither leaves nor pods have been encountered in the other Pannonian localities. The most frequent legume of the Sarmatian floras, *Podocarpium podocarpum* could not survive the Sarmatian/Pannonian boundary, and disappeared from Central Europe by the end of the Sarmatian. Although, legumes played an important role in forming the vegetation during the Middle Miocene their fossils are only exceptionally recorded during the Pannonian.

?Onagraceae

Hartziella miocenica SAFER

Material: Visonta: BK 5466, 5512 fruits
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 59, pl. 2. fig. 17.

Lythraceae

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

Material: Visonta: BK 5503, 5538 seeds
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 55, pl. 2. fig. 12.

Trapa praehungarica WÓJCICKI & BAJZÁTH
Plate XVIII: fig. 2

Material: Bükkábrány: BP 95.407.15., BP 95.542.30, BP 543.20, BK 4505, 4513, 4510 (as *Trapa heeri* in LÁSZLÓ 1992, pl. 2, figs 1, 2) fruits

Description: see in WÓJCICKI et BAJZÁTH 1997, p. 51, text.-fig. 1.

Trapa silesiaca GÖPPERT emend. WÓJCICKI & ZASTAWNIAK
Plate XVIII: figs 4–5

1855 *Trapa silesiaca* GÖPPERT — GÖPPERT, p. 38, pl. 25, fig. 14.
1979 *Trapa heeri* FRITSCH — KOVAR, p. 110, pl. 1, figs 1–6.
1988 *Trapa heeri* FRITSCH — KOVAR-EDER & KRAINER, p. 36, pl. 1, fig. 4.
2002 *Trapa silesiaca* GÖPPERT — WÓJCICKI & ZASTAWNIAK, p. 30, figs 1, 2.
2005 *Trapa silesiaca* GÖPPERT — KOVAR-EDER et al., p. 167, Fig 2:1–40.

Material (fruits): Rudabánya-Vilmos: BK 239, 277, 540-543, 545, 546, 555, 561, 565, 569, 572, 574, 604, 668, 688, 707,

Description: Fruits obtriangular with two massive horns, 1.5 cm high including neck, width of fruit with horns up to 3.8 cm. Horns 1.2–1.5 cm long, tapering towards the apex, width at the basal part 0.3 cm, at the apical part less than 0.1 cm.

Discussion: Trapa silesiaca was described by GÖPPERT (1855) from the Late Miocene flora of Sośnica and later revised and re-illustrated by WÓJCICKI & ZASTAWNIAK (2002). Subsequently, it was described from several Late Miocene floras of Austria (KOVAR-EDER et al. 2005). *T. silesiaca* was probably the most common representative of the genus in the Central European Late Miocene; however, there are no records from younger time slices (KOVAR-EDER et al. 2005).

Trapa pannonica sp. nov.
Plate XVIII: fig. 3, Plate XXXIV: figs 2–4

1955 *Trapa natans* L. — VÖRÖS, p. 67, pl. 17, fig. 7.

Holotype: Rózsaszentmárton BP 2001.354.1.
Paratypes: Rózsaszentmárton MM 64.1166.1., 73.17.2.
Derivatio nominis: After Lake Pannon
Locus typicus and stratum typicum: Rózsaszentmárton, the former lignite mine, Upper Miocene, Pannonian

Description: Impressions of fruits. Fruits with two massive horns, fruit body symmetrical, height 2.0–3.1 cm including corona, width with horns 4.7–5.0 cm. Base of fruit body rounded, corona rises from fruit body up to 0.4 cm. Apex of corona rounded. Ribs start from corona apex, densely spaced, run downwards, but do not reach base. Horns short and wide, poorly distinguished from fruit body. From level of corona ends shoulders of horns shortly sweep up, then longer descend till ending in an acute apex.

Discussion: The fruit was first assigned to the modern species, *T. natans* (VÖRÖS 1955). It is much larger and more robust than *T. silesiaca* GÖPPERT (WÓJCICKI & ZASTAWNIAK 2002), which was found in Rudabánya, and seemingly differs from *T. praehungarica* WÓJCICKI & BAJZÁTH (1997), which was described from Bükkábrány. From localities in the surrounding area *T. srodoniana* WÓJCICKI (WÓJCICKI & ZASTAWNIAK 1998), *T. spectabilis* WÓJCICKI & KOVAR-EDER (KOVAR-EDER et al 2005), and *Trapa moravica* OPRAVIL & KNOBLOCH (OPRAVIL & KNOBLOCH 1967) show definitely different characters. Another Late Miocene water caltrop, *Trapa kvačekii* WÓJCICKI & VELITZELOS (WÓJCICKI & VELITZELOS 2007) from Greece shows traits disparate from *T. pannonica*, i.e. elongated shape of the nuts and narrow long horns. From the Late Miocene flora of Cerdanya (Spain) another species, *Trapa ceretana* Rérolle was described (RÉROLLE 1885). The shape of these fruits shows similarity to *T. pannonica*, but the hornes are much thinner, and are distinguished definitely from the fruit body. From the Late Miocene of Europe numerous localities are known preserving the fruits of *Trapa*, from Czech Republic (OPRAVIL & KNOBLOCH 1967), Austria (KOVAR 1979, KOVAR-EDER & KRAINER 1988, KOVAR-EDER et al 2005), Poland (WÓJCICKI & ZASTAWNIAK 2002), Germany, Greece (WÓJCICKI & VELITZELOS 2007), Spain (RÉROLLE 1885). Based on fruits three clearly distinct species of *Trapa* are recognizable in the Late Miocene of Hungary. The oldest one, *T. silesiaca*, is known from Rudabánya and seems to be the most common species in Central Europe (KOVAR-EDER et al. 2005). Later, in younger Pannonian sequences endemic species occurred, like *T. praehungarica* and *T. pannonica*. Both of them are more distinct from other European species than from each other.

Trapa rozsaszentmartoni sp. nov.
Plate XVIII: figs 6–8

1955 *Trapa natans* L. — Vörös, p. 67, pl. 17, fig. 8.

Holotype: Rózsaszentmárton MM 64.1149.1.
Paratypes: Rózsaszentmárton BP 2001.355.1., MM 64.1150.1., 64.1153.1.
Derivatio nominis: From the village (locality) Rózsaszentmárton.
Locus typicus and stratum typicum: Rózsaszentmárton, the former lignite mine, Upper Miocene, Pannonian.

Description: Simple, petiolate leaf, shape of lamina trapezoidal, length of lamina 3.9–4.2 cm, width up to 5.2 cm. Petiole thin at point of attachment to lamina, otherwise expanded showing inflated petiole type. Leaf margin irregularly and coarsely crenulate. Venation irregular. Strong midvein and two basal veins arise from base. Secondary veins arise from midvein. Veins bifurcate near margin.

Discussion: One of the leaves from Rózsaszentmárton (No. BP 2001.355.1.) was assigned to *Trapa natans* (Vörös 1955). Fruits of *Trapa* generally occur more frequently in the fossil material than leaves. Leaves assigned to the family Trapaceae were described from Pellendorf, Austria (Kovar-Eder et al. 2002) as *Mikia pellendorfensis*. However, these leaves differ from leaves of Rózsaszentmárton in both petiole and lamina characters. The petiole of *Mikia* leaves is strong, broad along the entire length, and do not display an inflated character. Venation also differs from that of *Mikia*, in the latter no midvein or secondaries can be distinguished.

Sapindaceae

Acer subcampestre Göppert
Plate XIX: figs 1–4, Plate XXII: fig. 3

1855 *Acer subcampestre* Göppert — Göppert, p. 34, pl. 22, figs 16, 17.
1968 *Acer subcampestre* Göppert — Iljinskaja, p. 76, pl. pl. 4, fig. 6, pl. 51, fig. 7.
1990 ? *Acer tricuspidatum* Bronn — Kovar-Eder & Krainer, pl. 4, fig. 5.
1997 *Acer* cf. *subcampestre* Göppert — Hably & Kvaček, p. 44, text.-figs 33, 34, 36, pl. 21, figs 112, 113, pl. 22, figs 114, 116.
2005 *Acer subcampestre* Göppert — Zastawniak, p. 93, figs 5, 6.

Material: Győr-Sashegy: SAMU 2008.9.115., *Hosszúpereszteg:* SAMU 86.13.1027., *Rudabánya-Vilmos:* BK 546, cf. 575, 577, 578, *Tiszapalkonya:* BP 2009.356.4., 2011.84.1–2011.86.1., cf. 2011.94.1., 2011.95.1., cf. 2011.96.1., 2011.97.1., cf. 2011.104.1.

Description: Leaf palmately lobed with 5 lobes, length (fragmentary) of lamina 6.5 cm, width 6.5 cm, base subcordate to cordate. Similar sized terminal and lateral lobes, basal lobes smaller, lobe apices acute. Margin toothed, teeth large and rounded.

Discussion: Highly variable species, similarly to the specimens from Sośnica, the type locality. The Pannonian localities discussed in this work yielded low number of specimens, which were often fragmentary.

Acer vindobonensis (Ettingshausen) Berger
Plate XIX: figs 6–8

1955 *Acer campestre* L. — Vörös, p. 67, pl. 17, fig. 10.
1955 *Acer polymorphum pliocenicum* Saporta — Vörös, p. 67, pl. 17, fig. 9.
1955 *Acer opulifolium pliocenicum* Saporta — Vörös, p. 68, pl. 18, fig. 11.
1968 *Acer sanctae-crucis* Stur — Iljinskaja, p. 76, pl. 4, figs 4, 5, pl. 21, figs 4–6.
1988 *Acer vindobonensis* (Ettingshausen) Berger — Kovar-Eder, p. 48, pl. 11, figs 1–3.
2005 *Acer vindobonense* (Ettingshausen) Berger — Zastawniak, p. 86, Fig. 1 (1–3).

Material: Rózsaszentmárton: BP 70.333.1, 2005.464.1., 2005.465.1., 2005.467.1., 2009.486.1., *Rudabánya* BK-566

Description: Leaves palmately lobed, number of lobes 7, lamina length up to 5.5 cm, width 7.1 cm. Base cordate, apex of lobes acute or attenuate. Central lobe and two neighbouring lateral lobes similar sized. Other lobes smaller, lowermost lobes the smallest. Sinuses between lobes acute and deep. Margin irregularly and sparsely toothed. Venation basal actinodromous. Primary veins end in lobe apices. Delicate secondary veins arise perpendicularly from primary veins of the individual lobes, and recede towards lobe apices.

Discussion: The species is rarely documented in the Hungarian Pannonian. In the flora of Rózsaszentmárton and Rudabánya it is accompanied by elements, e.g. *Trapa*, *Potamogeton*, etc. *Acer vindobonensis* is assumed to be a wetland element and it flourished in vegetation close to the lake shore. The species was formerly described with various names in the Pannonian floras of the surrounding areas.

Acer jurenakii STUR
Plate XX: figs 1–8, Plate XXI: fig. 1

1867 *Acer Jurenaki* STUR — STUR, p. 195, T. 5, fig. 5.
1955a cf. *Acer (Palaeo-Spicata) jurenaki* STUR — BERGER, p. 78, fig. 19.
1955b *Acer (Spicata) jurenaki* STUR — BERGER, p. 101, fig. 133.
1963 *Acer jurenaky* STUR — JUNG, p. 141, T. 37, fig. 47., text.-fig. 14.
1969 *Acer jurenakii* STUR — KNOBLOCH, p. 132, text.-figs 290-292, T. 66, figs 5, 7, 8.
?1971–72 *Acer séensis* HORVÁTH — HORVÁTH, p. 42, T. 6, fig. 4, text.-fig. 5.
1986 *Acer jurenakyi* STUR — KOVAR, p. 208.
1988 *Acer jurenakii* STUR — KOVAR-EDER, p. 50, T. 12, fig. 1.
1990 *Acer jurenakii* STUR — KOVAR-EDER & KRAINER, p. 22, T. 5, figs 2–5, text.-figs 6/4–5, 7/1–7.

Material: Balatonszentgyörgy: BK 1691, 1743, 1748, 1754, 1756–1757, 1759–1760, 1762, 1769–1771, 1774–1776, 1778–1780–1782, 1790, 1792–1794, 1795, 1801, 1810, *Tihany:* BP 2007.496.1–2007.498.1.

Description: Leaves palmately lobed with three lobes, petiole rarely preserved, 0.9–1.7 cm long. Middle lobe longest, length 3.5–14 cm, width 4.1–15 cm. Side lobes smaller. Middle lobe slightly asymmetrical, shape obovate, broadest in the upper third. Side lobes strongly asymmetrical. Apex acute to obtuse, base truncate, decurrent on the petiole. Margin toothed at the apical part of the lobes and at the basal part of leaf lamina, other parts of leaf entire. Teeth large, obtuse to mucronate. Apical side of teeth convex, rarely straight, basal side convex, sinuses angular. Venation basal actinodromous to palinactinodromous. Midvein strong, straight, ends in middle lobe apex. A pair of primary veins arises from the base runs to lateral lobes and ends in their apices. A pair of stout secondary veins arise suprabasally from the lateral primary veins. Secondaries generally craspedodromous, end in teeth, but rarely brochidodromous, if margin entire. Intersecondaries observable. Tertiary venation random reticulate.

Discussion: Ströbitzer-Hermann (STRÖBITZER-HERMANN 2002) synonymised it in *A. subcampestre*, however I do not agree with this assignment based on the characteristic, well observable distinct form of the leaves. Furthermore, specimens described as *A. subcampestre* seem to form a rather heterogenous morphological group whereas leaves of *A. jurenakii* display a distinct and well-definable morphology. Retaining the species *A. jurenakii* is also justified by the fact that none of the specimens described by Göppert (GÖPPERT 1855) as *A. subcampestre* belong to this characteristic form group. *A. jurenakii* must have been a member of floodplain forests and did not favour swamp habitats.

Acer tricuspidatum BRONN
Plate XXI: figs 2–6, Plate XXII: figs 1–2

1825 *Phyllites trilobatus* STERNBERG — STERNBERG, p. 42, pl. 50, fig. 2.
1838 *Acer tricuspidatum* BRONN — BRONN, p. 865, pl. 25, figs 10a, b.
1968 *Acer tricuspidatum* BRONN — WALTHER, p. 363, pl. 2, fig. 1.
1976 *Acer tricuspidatum* BRONN — KNOBLOCH et KVAČEK, p. 71, pl. 1, fig. 7, pl. 14, fig. 1., pl. 28, fig. 9., pl. 31, fig. 5.
2005 *Acer tricuspidatum* BRONN — ZASTAWNIAK, p. 88, figs 2–4.

Material: ***Felsőtárkány:*** BP 55.1755.1., 55.1758.1., 55.1763.1., 551765.1., 55.1776.1., 55.1780.1., 55.1786.1., 55.1787.1., 55.1790.1., 55.1794.1., 55.1808.1., 55.1809.1., 55.1821.1., 55.1826.1., 55.1832.1., 55.1837.1., 55.1844.1., 55.1853.1., 55.1860.1., 55.1862.1., 55.1865.1., 55.1871.1., 55.1872.1., 55.1881.1., 55.1884.1., 55.1888.1., 55.1897.1., 55.1898.1., 55.1904.1., 55.1905.1., 55.1907.1 –55.1909.1., 55.1916.1., 55.1917.1., 55.1922.1., 55.1924.1., 55.1930.1., 55.1932.1., 55.1933.1., 55.1936.1., 55.1938.1., 55.1940.1., 55.1945.1., 55.1947.1., 55.1949.1., 55.1955.1., 55.1956.1., 55.1959.1., 55.1963.1., 55.1964.1., 55.1968.1., 55.1973.1., 55.1975.1., 55.1976.1., 59.222.1., 59.225.1., 59.231.1., 60.1767.1., 60.1771.1., 60.1779.1., 60.1784.1., 60.1788.1., 60.1794.1., 60.1795.1., 60.1801.1., 60.1820.1., 60.1825.1., 60.1844.1., 60.1846.1., 60.1857.1., 60.1864.1., 60.1870.1., 60.1887.1., 60.1888.1., 60.1915.1., 60.1917.1., 60.1921.1., 62.1086.1., 62.1089.1., 62.1101.1., 62.1104.1., 62.1113.1., 62.1123.1., 62.1134.1., 62.1135.1., 62.1146.1., 62.1151.1., 62.1152.1., 62.1154.1., 62.1157.1., 62.1161.1., 62.1183.1., 62.1185.1., 62.1188.1., 62.1237.1., 62.1244.1., 62.1245.1., 62.1252.1., 62.1329.1., 62.1334.1., 62.1338.1., 62.1340.1., 62.1346.1., 62.1352.1., 62.1390.1., 62.1393.1., 62.1395.1., 62.1397.1., 62.1407.1., 62.1409.1., 62.1413.1., 62.1415.1., 62.1422.1., 62.1428.1., 62.1431.2., 62.1434.1–62.1437.1., 62.1443.1., 62.1451.1., 62.1454.1., 62.1457.1., 62.1458.1., 69.692.1–69.696.1., 69.698.1., 69.712.1., 69.694.1., 69.718.1., 69.721.1., 69.732.1., 69.733.1., 69.735.1., 69.751.1., 69.759.1., 69.768.1., 69.776.1., 69.780.1., 69.778.1., 69.830.1., 69.840.1., 70.32.1., 71.21.1., 71.32.1. 71.33.1., 71.36.1., 71.48.1., 71.56.1., 71.62.1., 71.85.1., 71.93.1., 71.125.1., 71.137.1., 71.140.1., 71.451.1., 85.236.2., 2001.267.1., 2003.198.1., 2007.513.1., 2007.514.1. **MM** 55.5052.1., 55.5053.1., 55.5085.1., 55.5067.1., 55.5081.1., 55.5090.1., 55.5093.1., 55.5095., 55.5096.2., 55.5101.1., 55.5102.1., 55.5108.1., 55.5109.1., 55.5112.1., 55.5119.1., 55.5124.1., 55.5125.1., 55.5128.1., 55.5133.1., 55.5135.1., 55.5136.1., 55.5145.1., 55.5150.1., 55.5152.1., 55.5153.1., 55.5157.1., 55.5163.1., 55.5164.1–55.5166.1., 55.5169.1., 55.5170.1., 55.5175.1., 55.5177.1., 55.5180.1., 55.5181.1., 55.5183.1., 55.5186.1., 55.5189.1., 55.5192.1., 55.5197.2., 55.5199.1., 55.5202.1., 55.5219.1., 55.5221.1., 55.5226.1., 55.5227.1., 55.5231.1., 55.5233.1., 55.5238.1., 55.5241.1.-55.5243.1., 55.5244.1., 55.5247.1., 55.5251.1., 55.5253.1., 55.5259.1., 55.5261.1., 55.5265.1., 55.5272.1., 55.5279.1., 55.5283.1., 55.5285.1., 55.5286.1., 55.5288.1., 55.5289.1., 55.5292.1., 55.5296.1., 55.5304.2., 55.5305.1., 55.5309.1., 55.5312.1., 55.5314.1., 55.5321.1.-55.5323.1., 55.5334.1., 55.5337.1., 55.5338.1., 55.5340.1. – 55.5342.1., 56.405.1., 56.417.1., 56.557.1., 56.558.1., 56.563.1., 56.564.1., 56.566.1., 56.568.1., 56.577.2., 56.579.1., 56.582.1., 56.592.1., 56.595.1., 56.601.1., 56.612.1., 56.615.1., 56.618.1., 56.619.1., 56.630.1., 56.632.1., 56.641.1., 56.642.1., 56.644.1., 56.646.1., 56.992.1., 56.995.1., 56.1476.1., 64.1288.1., 64.1300.1., 64.1302.1., *Pécs-Nagyárpád:* BP cf. 97.229.1., *Rózsaszentmárton*: MM cf. 64.1163.1., *Tiszapalkonya:* BP 2011.105.1.

Description: Leaves three-lobed, petiolate. Petiole up to 3 cm, lamina symmetrical, length and width 2.8–8 cm, and 2.6–7.2 cm, respectively. Middle lobe larger and longer than side lobes. Base slightly cordate, apex acute. Margin dentate, along the basal part more or less entire margined. Teeth large, irregular, teeth apices acute. Venation actinodromous. Midvein strong, runs in middle lobe, ends in leaf apex. Several pairs of secondaries arise from midvein, and end in the teeth apices. Two additional primary veins run in the side lobes, and end in side lobe apices. Several secondaries arise from these veins, and form loops with each other close to margin.

Discussion: Acer tricuspidatum was widespread in the Miocene floras of Europe. Hennersdorf, Salzhausen, Westerburg, Rott, Münzenberg and several other localities from Germany are well known (Walther 1972). It was reported from the North-Bohemian Basin (Petipsy Area, Bůžek 1971), the Baked Rocks (Kvaček & Hurník 2000), Western Bohemia (Cypris shale, Bůžek et al. 1996) and Arjuzanx (SW France, Kvaček et al. 2011). In Hungary it was frequently recorded in the Late Oligocene (Egerian) flora of the Wind-brickyard (Andreánszky 1966, Kvaček & Hably 1991). In the flora of Felsőtárkány, which represents stratigraphically the Sarmatian/Pannonian boundary, it was a dominant element. During the Late Miocene it is a subordinate element of fossil assemblages, with very few records, which frequently represent poorly preserved, and hardly identifiable specimens. Leaves of *A. tricuspidatum* are accompanied by leaves of taxa occupying swamp or riparian habitats suggesting that it was presumably a member of the wetland vegetation.

Acer sp. fructus
Plate XXII: figs 4–7

Material: Balatonszentgyörgy: SAMU: 2008.6.7=2008.6.111. counterpart, *Felsőtárkány:* MM 55.5160.1., 55.5346.1., 56.635.1., 56.965.2., 66.79.1., 66.80.1., *Győr-Sashegy:* SAMU: 2008.9.78., 2008.9.87.2008.9.112., *Rudabánya-Andrássy:* BK 258, 592

Description: Winged fruit, length of fruit 2.4–3.3 cm, length and width of seeds 0.5–0.7 and 0.7–0.8 cm, respectively. Apex of wing distally rounded, apical side strait. Veins run parallel with apical margin, and bend downwards to the wing at various distances, forming dense venation.

Discussion: Fruits of *Acer* are commonly encountered in the Pannonian floras, but generally represented with few specimens. Fruits were most frequently recorded in the flora of Felsőtárkány where leaf remains of *Acer* are dominant, as well. In the Pannonian floras there are leaves obviously representing various species of *Acer*. Supposedly fruits represent various taxa, as well, but due to their low representation, and morphological overlaps distinct species could not been identified. Based on various assemblages it is assumed that fossil members of the genus were often bound to wetland conditions and appeared in vegetation types in both swamp and riparian environments, however, some species occur in the zonal vegetation, as well.

Mastixiaceae

Mastixia amygdalaeformis (Schlotheim) Kirchheimer
Plate XXXVI: figs 1–2

1822 *Carpolithus amygdalaeformis* Schlotheim — Schlotheim p. 98, pl. 21, fig. 7.
1838 *Carpolithus venosus* Presl. in Sternberg — Sternberg, p. 208, pl. 58, figs 18–20.
1850a *Ziziphus pistacina* Unger — Unger, p. 463.
1864 *Ziziphus pistacina* Unger — Unger, p. 16, pl. 3, fig. 38.
1935b *Mastixia pistacina* (Unger) Kirchheimer — Kirchheimer, p. 292, fig. 13.
1935a *Mastixia pistacina* (Unger) Kirchheimer — Kirchheimer, p. 748, fig. 2a–c.

1957 *Mastixia amygdalaeformis* (SCHLOTHEIM) KIRCHHEIMER — KIRCHHEIMER, p. 223, 549.
1964 *Mastixia amygdalaeformis* (SCHLOTHEIM) KIRCHHEIMER — MAI, p. 42, Abb. 8c.
1970 *Mastixia amygdalaeformis* (SCHLOTHEIM) KIRCHHEIMER emend. MAI — MAI, p. 467, pl. 64, fig. 11, pl. 65, figs 1–13.
1975b *Mastixia amygdalaeformis* (SCHLOTHEIM) KIRCHHEIMER — HOLÝ, p, 130, pl. 1, figs 1–8.
1996 *Mastixia amygdalaeformis* (SCHLOTHEIM) KIRCHHEIMER — BŮŽEK et al., p. 42, pl. 22, figs 5–6.
1998 *Mastixia amygdalaeformis* (SCHLOTHEIM) KIRCHHEIMER — MELLER, p 541, pl. 19, figs 7–10.
2013 *Mastixia amygdalaeformis* (SCHLOTHEIM) KIRCHHEIMER — HABLY& ERDEI, p. 220, pl. 1, figs 1–7, pl. 2, figs 1-8, pl. 3, figs 1–2.

Material: Rudabánya 2013.1.1. (BK–9036); 2013.1.5. (BK–9037); Geological and Geophysical Institute of Hungary.

Description: Endocarp spindle-shaped, strongly ribbed, length 25 mm, maximum diameter 8.2 mm, rounded, unilocular, single-seeded. Surface longitudinally ribbed and marked with grooves. Grooves 0.4–0.9 mm deep. Thickness of endocarp wall (without ribs) 1.1–2.0 mm, with ribs 1.5–2.6 mm. Detailed description see in HABLY & ERDEI 2013.

Discussion: This is the first record of the genus in the Pannonian Basin, as well as the first evidence of the presence of "mastixioid floras" in Hungary. The so-called "younger mastixioid" floras of Europe have been described from the Early up to the Middle Miocene of Europe. From Germany (MAI 1964, 1970, 1995), the Czech Republic (HOLÝ 1975a, b, 1982, KVAČEK & TEODORIDIS 2007, TEODORIDIS 2003, TEODORIDIS & KVAČEK, 2006, ŠEVČIK et al. 2007), Poland (ŁAŃCUCKA-ŚRODONIOWA & ZASTAWNIAK 1997), and Austria (MELLER 1995, 1996, 1998) several floras classified as "younger mastixioid" floras were documented. The reinvestigation of fossils formerly described as *Mastixia* from Romania (GIVULESCU 1995) did not support the assignment.

Vitaceae

Vitis szakmanygyorgyi sp. nov.
Text-fig. 3, Plate XXIII: figs 1–7

Holotype: Balatonszentgyörgy BK–4705

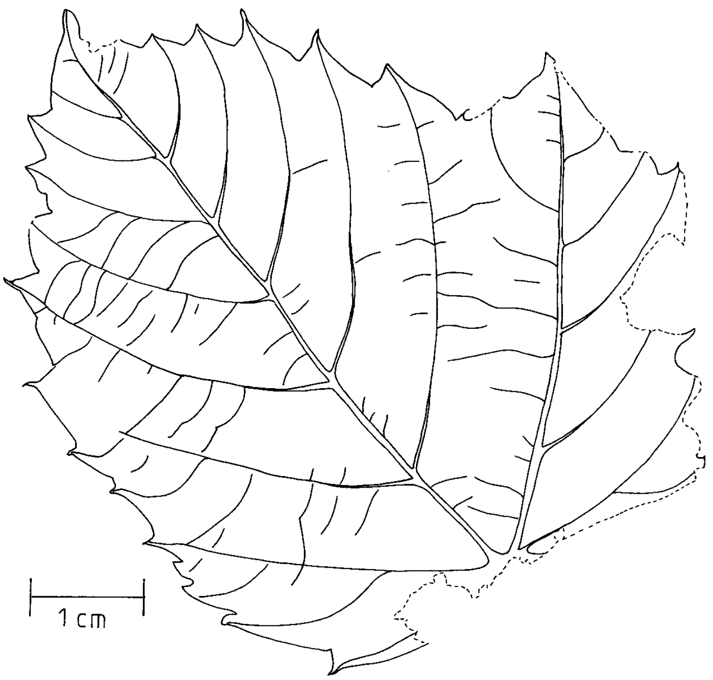
Paratype: Balatonszentgyörgy BK 1725, 4705, BP 2011.106.1., 2011.107.1., 2011.110.1., 2011.143.2., SAMU 2008.6.98.2.

Additional material: Balatonszentgyörgy BP cf. 2010.164.2.

Derivatio nominis: szakmanygyorgyi, after the collector of the paratypes among several specimens from the Balatonszentgyörgy locality, Szakmány György, geologist

Locus typicus and stratum typicum: Balatonszentgyörgy, brickyard, Pannonian, Uppermost Miocene.

Description: Simple, strongly to slightly asymmetric leaves, often definitely two lobed, petiole often preserved. Generally one, often both side lobes poorly or not developed at all. Length of lamina 4.1–7.0 cm, width 2.9–6.0 cm, apex acute, base slightly cordate, margin toothed. Teeth large, irregular. Tooth apex acute to attenuate, apical and basal sides straight to convex. Venation actinodromous. Middle primary vein strong. Strong basal primary vein runs to the side lobe. Secondaries slightly curved, end in teeth apices. Tertiary venation dense, occasionally bifurcating, perpendicular to secondaries.



Text-figure 3. *Vitis szakmanygyorgyi* sp. nov holotype, Balatonszentgyörgy, BK-4705.

Discussion: The species shows similarity to *Ampelopsis cordataeformis* KNOBLOCH (KNOBLOCH 1998) but leaves of the latter species described from Willershausen possess a base more deeply cordate, smaller teeth and more regular and straight venation. The specimens from Balatonszentgyörgy definitely differ from leaves of *Vitis strictum* (GÖPPERT) KNOBLOCH and other putative *Vitis* leaves occurring frequently in younger Neogene floras (GÖPPERT 1855: *Acer strictum* p. 35, pl. 23, figs 1–5; BERGER 1955b: *Vitis teutonica* p. 103, Text.-figs 152, 153; ILJINSKAJA 1968: *Acer trilobatum* p. 77, pl. 5, fig. 3.; KNOBLOCH 1969: *Vitis strictum* p. 125, text-fig. 269, pl. 64. fig. 9.; Givulescu 1990: *Vitis strictum* p. 136, pl. 8, figs 5–8, pl. 9, figs 1, 2, pl. 14, fig. 5, pl. 22, fig. 14, pl. 39. fig. 4.). Leaves of *V. strictum* have three lobes, the definitely tapering side lobes point upwards and have attenuate apices. Specimens from Balatonszentgyörgy possess only one side lobe. Leaves are generally of larger size and just one small-sized leaf came to light, which is presumably a juvenile specimen. It is a rare accessory element in the flora. Members of the genus *Vitis* frequently appear in younger Miocene and Pliocene floras, however, they mostly occur with few specimens. *Vitis subintegra* SAPORTA was described from the Pliocene flora of Kodor (KOLAKOVSKI 1964).

Vitis sp.
Plate XIX: fig. 5

Material: Győr-Sashegy: SAMU: 2008.9.1=2008.9.123.

Description: Leaf with three lobes and more small basal lobes. Lamina slihtly asymmetrical, length of lamina 8.8 cm, width 8.7 cm. Apex not preserved, base deeply cordate. Five primary veins arise from the base, three veins stronger, two basal veins towards side lobes weaker. Primaries end in lobe apices. Secondaries arise from primary veins, end in teeth apices, or join each other. Dense tertiary venation perpendicular to secondaries. Quaternary veins frequently anastomose.

Discussion: The leaf differs from *V. szakmanygyorgyi* in many characters of the lobes, margin and teeth suggesting assignment to another species. It strongly differs from *Vitis tokajensis*, or *V. strictum*, as well. The latter was frequent element of Late Miocene floras. This leaf was not accompanied by remains of *V. szakmanygyorgyi*. Its occurrence suggests that *Vitis* was an accessory element of the Pannonian flora in the Pannonian Basin.

Theaceae

cf. *Stuartia beckerana* (LUDWIG) KIRCHHEIMER

Material: Visonta: BK 5520 fruit.

Description: see in BŮŽEK & LÁSZLÓ (1992), p. 60, pl. 7. figs 17–18.

Salicaceae

Salix varians GÖPPERT
Plate XXVI: figs 2–9, Plate XXVII figs 1–8, Plate XXVIII: figs 1–2

1855 *Salix varians* GÖPPERT — GÖPPERT, p. 26, pl. 20, figs 1, 2.
1855 *Salix wimmeriana* GÖPPERT — GÖPPERT, p. 26, pl. 21, figs 1–3.
1968 *Salix varians* GÖPPERT — ILJINSKAJA, p. 50, pl. 12, figs 7, 8, pl. 19, figs 7, 8, pl. 24, figs 10, 11, pl. 45, figs 1–3, pl. 46, figs 1–6.
1971 *Salix varians* GÖPPERT — BŮŽEK, p. 67, pl. 29, figs 1–8.
1976 *Salix varians* GÖPPERT — KNOBLOCH & KVAČEK, p. 56, pl. 4, fig. 11, pl. 19, fig. 13, pl. 31, fig. 3.

Material: Alcsút: BP 2009.424.2., 2009.430.1., *Balatonszentgyörgy:* BK 1504–1506, 1515-1522, 1536, 1550, 1559, 1568, 1570, 1578-1579, 1589, 1592, 1629, 1670, 1736, 1747, 1814, without number: 19/164, 57/5 (176) drower; SAMU:2008.6.1., 2008.6.2., 2008.6.6., 2008.6.9., 2008.6.10., 2008.6.13., 2008.6.15., 2008.6.19., 2008.6.27., 2008.6.29., 2008.6.33., 2008.6.36., 2008.6.41., 2008.6.42., 2008.6.64., 2008.6.65., 2008.6.68., 2008.6.72., 2008.6.74., 2008.6.76., 2008.6.78., 2008.6.79., cf. 2008.6.80., 2008.6.82., 2008.6.84., 2008.6.86., 2008.6.87., 2008.6.90., 2008.6.91., cf. 2008.6.92., 2008.6.105., 2008.6.109., 2008.6.112., 2008.6.113., 2008.6.115., 2008.6.119., 2008.6.138., 2008.6.140., 2008.6.142., 2008.6.144., 2008.6.146., 2008.6.148., *Felsőtárkány:* BP 60.1774.1., 60.1777.1., 60.1790.1., 60.1805.1., 60.1809.1., 60.1812.1., 60.1813.1., 60.1817.1., 60.1842.1., 60.1843.1., 60.1850.1., 60.1855.1., 60.1862.1., 62.1110.1., 62.1137.1., 62.1344.1., 62.1441.1., 69.745.1., 85. 226.1., 85.242.1., 85.244.1., *Hosszúpereszteg:* SAMU 86.13.1381., 86.13.1365.1., 86.13.1369.1., *Iharosberény:* BP 2009.248.3., 2009.249.2., 2009.259.3., 2009.292.1. *Kerecsend*: BP 95.339.1., SAMU 2008.16.6., 2008.16.13., 2008.16.26., 2008.16.29., 2008.16.30., 2008.16.35 = BP 95.339.1. counterpart, 2008.16.39., 2008.16.42., 2008.16.43., 2008.16.44., 2008.16.45., 2008.16.47., 2008. 16.66., 2008.16.68., 2008.16.71., 2008.16.80., *Pécs-Nagyárpád:* BP 97.237.1., *Rózsaszentmárton:* MM 73.18.1., *Rudabánya-Andrássy:* BK 256, 276-278, 283, 288, 296, 410, 452, 492, 498, 502, 506, 514, *Sé:* SAMU 65.3.312., 65.3.771., 65.3.1174., 65.3.777., 70.179., *Sótony:* SAMU 60.26.1-120, 62.5.1-96, 62.6.1-59, *Tihany:* BP 85.109.1–85.111.1., 85.113.1., 85.121.1., 85.123.1., 85.135.1., 85.145.1., 85.154.1., 85.155.1., 85.157.2., 85.159.1., 85.163.2., 85.164.1., 85.186.4., 85.170.1., 85.171.1., 85.175.1–85.177.1., 85.178.1., 85.180.1., 85.183.1., 85.188.1., 85.192.3–85.198.1., 85.199.1., 85.200.1., 85.203.1–85.206.2.., cf. 85.213.1., *Tiszapalkonya:* BP 2009.357.2., 2009.361.2., 2011.78.2., 2011.87.1., 2011.99.1., *Visonta:* BK 4519.

Description: Simple, petiolate leaves, oblong, ovate to lanceolate, size variable, length up to 12 cm, width 2.6–3.2 cm. Base rounded or cuneate, apex acuminate, margin denticulate. Teeth densely packed, very fine, teeth apices acute to obtuse.

Apical side straight or convex, basal side straight, convex, sometimes concave. Sinuses rounded. Midrib strong, sometimes slightly curved. Secondaries numerous, dense, and thin, arise alternately, curved upward and form loops close to margin. Tertiary veins very closely spaced, arise at acute angles to secondary and intersecondary veins, rarely branch. Higher order venation polygonal.

Discussion: The species is very frequent in the Late Miocene floras of the Pannonian Basin, as well as, in the surrounding area. It was abundantly recorded from many localites in Europe.

Salix varians is assumed to be a member of riparian vegetation. It proved to be dominant in some of the floras, e.g. Sé, but it is often a frequent or accessory element or even absent in other floras.

Salix sp. fruit capsule
Plate XXVIII: fig. 6

Material: Balatonszentgyörgy: BK 1688

Description: Fruit capsule. Short petiole of 0.2 cm length. Length of capsule 1 cm, width at base 0.25 cm and base rounded. Apical side open, capsule parts equal, apex acute.

Discussion: Fruits of *Salix* are well known from several floras of Europe, preserved mainly in fine-grained sediments. In the Pannonian flora of Hungary it was documented only in the flora of Balatonszentgyörgy (old locality), which comprises leaves of *Salix* abundantly.

Salix sp. 1.
Plate XXVIII: figs 6–9, Plate XXIX: fig. 1

*Material: Balatonszentgyörgy:*BK 4704, 1555, 1669, 1688, 1699–1700, 1720, 1722, 1739

Description: Simple leaves, short petiole often preserved. Lamina ovate to elliptic. Length of lamina 2.0–2.9 cm, width 0.8–1.2 cm, apex acute, base rounded, lamina densely serrate. Teeth small, teeth apices acute to rounded, in some cases glands observable in tooth apex. Venation semicraspedodromous. Midvein strong, especially at the basal part. 8–10 pairs of secondaries form loops close to margin, end in teeth apices.

Discussion: The leaves do not show characters useful for identification at the species level. The leaves are presumably juvenile forms and may represent the frequent species, *S. varians*. Similar small leaves were recognized in older layers of the brickyard at Balatonszentgyörgy, where fossils are better preserved.

Salix sp. bud

Material: Visonta: BK 5454, 5468, 5479, 5502, 5514 bud scales or buds

Description: see in BŮŽEK & LÁSZLÓ (1992), p. 57, pl. 6, figs 8–11.

Populus populina (BRONGNIART) KNOBLOCH
Plate XXIX: fig. 2

1971–72 *Populus* cf. *tremula* L. — HORVÁTH, p. 39., pl. 5, fig.5., text.-fig. 4.
1988 *Populus populina* (BRONGNIART) KNOBLOCH — KOVAR-EDER, p. 53, pl. 10, figs 13–15.
1997 *Populus populina* (BRONGNIART) KNOBLOCH — HABLY & KVAČEK, p. 48, pl. 25, fig. 129, pl. 26, fig. 133, pl. 27, fig. 136.pl. 28, fig. 140.

Material: Karmacs: BP 2008.429.1., *Pécs-Nagyárpád:* BP 97.225.1., cf. 97.228.1., *Sé:* SAMU 73.2.1., 73.2.3.

Description: Poorly preserved simple leaves. Petiole occasionally preserved, length up to 3.3 cm. Lamina 4.6–8.2 cm long, 4.7–6.1 cm wide, very wide ovate. Apex obtuse, base poorly preserved. Margin crenate, smoothly rounded, without pointed apex. Midvein strong, secondaries curved, more details not observable.

Discussion: Although it is a riparian element, *Populus populina* is not frequent in the Pannonian floras of the basin. Three localities comprise very few specimens. In the Hungarian Neogene *Populus* proved to be the most frequent during the Badenian, in the flora of Nógrádszakál (ANDREÁNSZKY 1959), and survived up to the Pliocene (HABLY & KVAČEK 1997). During the Late Miocene it was more frequent in the surrounding, extrabasinal floras than inside the basin. It was mentioned from the Austrian Late Miocene from Neuhaus, (KOVAR-EDER et al. 1995), Wörth (KOVAR-EDER & KRAINER 1990) and from the Austrian Molasse floras (KOVAR-EDER 1988). The genus *Populus* was recorded with various species mostly as accessory element from the Carpathian Ukraine (Iljinskaja 1968), Slovakia, Turiec Basin (Sitar 1969) and several other localities.

Malvaceae

cf. *Tilia* sp.
Plate XXII: fig. 8

Material: Cserszegtomaj: BP 95.343.1.

Description: Simple leaf, petiole not preserved. Shape of lamina wide ovate, length 6 cm, width 5.7 cm. Base partly preserved, rounded, apex acute. Teeth small, details not visible. Midvein stout, straight. Four strong pairs of secondaries arise from the midvein, and end in teeth apices. Distance between secondaries large, 1.7 cm the largest, measured by basalmost secondaries. Secondaries arise suboppositely. Thick tertiary veins arise from basalmost secondaries, run towards margin at basal part of leaf, and terminate in teeth apices.

Discussion: From Cserszegtomaj only this single specimen was collected. The fossiliferous sediment is coarse, sandy, probably silicified. Finer details of the leaf are not visible. Remains of *Tilia* were not recorded from other Late Miocene floras of the Pannonian Basin.

Byttneriophyllum tiliifolium (A. Braun) Knobloch & Kvaček
Plate XXIX: figs 3–8, Plate XXX: figs 1–7, Plate XXXIV: figs 5–6

1955 *Ficus tiliaefolia* (A. Braun) Heer — Vörös, p. 66.
1955 *Ficus tiliaefolia* (A. Braun) Heer — Kubát & Bubik, p. 51.
1959 *Ficus tiliaefolia* (A. Braun) Heer — Andreánszky, p. 128, pl. 37, figs 1, 3, 4, pl. 38, fig. 1, pl. 68, fig. 1.
1988 *Byttneriophyllum tiliaefolium* (A. Braun) Knobloch & Kvaček — Kovar-Eder, p. 54, pl. 12, fig. 6.
1992c *Byttneriophyllum tiliaefolium* (A. Braun) Knobloch & Kvaček — Hably, p. 11, pl. 1,. figs 2, 4, pl. 2,. figs 1, 3, pl. 3, fig. 1, pl. 5, fig.2, text.-figs 3:1, 3, 6.
1996 *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Kvaček — Hably & Kovar-Eder, p. 72, pl. 1, figs 1, 2, 4, 6, pl. 2, figs 1, 5.

Material: Bükkábrány: BK 4487, 4491, 4496, *Dozmat*: BP 2005.5.1., 2005.9.1., 2005.13.1–2005.15.1., 2005.21.1., 2005.22.1., 2005.26.1–2005.28.1., 2005.36.1., 2005.41.1–2005.43.1., 2005.46.1., 2005.50.1., 2005.52.1., 2005.55.1–2005.59.1., 2005.63.1–2005.66.1., SAMU: 66.5.98., 66.5.294.,66.5.340., 66.5.482., 66.5.489., 66.5.508., 66.5.723., 66.5.757., 66.5.784., 66.5.906., 66.5.919., 66.5.1210., 66.5.1378., 66.6.28., 66.6.45., 69.10.71 (plus more than 1000 specimens). *Felsőtárkány:* BP 59.64.1., 59.222.1., 59.280.1., 60.1666.1., 60.1765.1., 60.1770.1., 60.1772.1., 60.1783.1., 60.1785.1., 60.1787.1., 60.1789.1., 60.1796.1., 60.1803.1., 60.1804.1., 60.1808.1., 60.1816.1., 60.1818.1., 60.1819.1., 60.1821.1., 60.1838.1–60.1840.1., 60.1851.1., 60.1854.1., 60.1876.1., 60.1878.1., 60.1880.1., 60.1882.1., 60.1891., 60.1896.1., 60.1898.1., 60.1902.1., 60.1905.1., 60.1908.1., 60.1914.1., 60.1929.1., 62.1112.1., 62.1155.1., 62.1164.1., 62.1171.1., 62.1173.1., 62.1174.1., 62.1176.1., 62.1182.1., 62.1191.1., 62.1342.1., 62.1343.1., 62.1345.1., 62.1348.1., 62.1398.1., 62.1399.1., 62.1405.1., 62.1414.1., 62.1420.1., 62.1436.1., 62.1437.1., 62.1444.1., 62.1445.1., 62.1448.1., 62.1454.1., 62.1455.1., 62.1456.1., 62.1457.1., 62.1460.1., 69.697.1., 69.698.1., 69.702.1., 69.706.1., 69.709.1., 69.713.1., 69.704.1., 69.714.1., 69.715.1–69.717.1., 69.719.1., 69.726.1., 69.728.1., 69.729.1–69.731.1., 69.737.1–69.740.1., 69.742.1., 69.743.1., 69.748.1., 69.755.1., 69.766.1., 69.769.1., 69.770.1., 69.774.1., 69.775.1., 69.781.1., 69.791.1., 69.823.1., 69.828.1., 69.829.1., 69.833.1., 69.834.1., 69.835.1., 69.838.1., 69.839.1., 71.2.1., 71.10.1., 71.18.1., 71.20.1., 71.28.1., 71.30.1., 71.31.0., 71.37.1., 71.38.1., 71.49.1., 71.59.1., 71.62.1., 71.67.1., 71.68.1., 71.69.1., 71.79.1., 71.82.1., 71.85.1., 71.86.1., 71.89.1., 71.96.1., 71.105.1., 71.106.1., 71.109.1., 71.107.1., 71.108.1., 71.118.1., 71.121.1., 71.136.1., 71.139.1., 71.143.1., 71.122.1., 71.128.1., 71.130.1., 71.451.1., 71.616.1., 85.253.1., 85.254.1–85.260.1., 85.263.1., 2001.383.1., 2003.192.1., 2003.193.1., 2003.197.1., 2003.201.1., 2003.202.1., 2003.212.1., 2003.216.1., 2003.218.1., 2003.220.1., cf. 2003.222.1., 2003.227.1., 2003.229.1., cf. 2003.236.1., cf. 2003.245.1., cf. 2003.248.1., 2007.508.1., 2007.512.1., 2007.513.1., MM 55.5113.1., 55.5214.1., 55.5292.1., 55.5296.1., 56.514.1., 56.519.1., 56.571.1., 64.911.1., 64.1096.2., 64.1292.1., *Iharosberény:* BP 2009.250.2–2009.252.1., 2009.256.2., 2009.257.4., 2009.265.1., 2009.266.1., 2009.269.1., 2009.274.1., 2009.277.2., 2009.278.3., 2009.279.1., 2009.282.1., 2009.283.1., 2009.285.1., 2009.290.5., 2009.294.1., *Kerecsend:* MM 15/2004, *Rózsaszentmárton:* BP 71.631.1., 2001.275.1., 2005.466.1., 2008.45.1., 2008.46.1., 2008.49.1., MM 64.1153.1., 64.1155.1., 64.1157.1., 64.1159.1–64.1161.1., *Rudabánya-Andrássy:* BK 116, 117, 118, 122–130, 132–142, 163, 164, 252, 273, 296, 354, 388, 407, 438, 439, 445, 502, *Rudabánya-Vilmos:* BK 538, 539, 541, 544, 545, 547, 555, 559, 560–562, 568, 571, 573–575, 578, 579, 582, 584, 588, 589, 590, 592, 593, 595, 596, 604, 608, 610, 614, 617–621, 623, 624, 626–628, 630, 631, 633, 634, 637, 640–657, 660, 661, 666, 668–675, 680–686, 688–708, 710–720, 723–735, 737, 738, *Tiszapalkonya:* BP 2009.352.1., 2011.76.1., 2011.77.1., 2011.80.1–2011.82.1., *Visonta:* BK 1011, 1012, 4515, 4527.

Description: Simple, conspicuously asymmetrical leaves, size highly variable. Petiole straight, extremely thick, width in large leaves about 5 mm, length at least 35 mm. Lamina wide ovate, length 4–18 cm, width 2.8–13.0 cm, base clearly asymmetric, cordate, sometimes rounded. Apex acute, rarely acuminate, margin entire. Venation palinactinodromous, camptodromous. Primary veins, 5 to 9, arise directly from base, midvein stronger than lateral primaries. Primaries straight or slightly curved due to asymmetric shape of lamina. Secondary veins arise from primaries, spaced sparsely, and form distinct marginal loops. Tertiary venation forms a perpendicular network between primary and secondary veins.

Discussion: The systematic affinity of this species appearing frequently and often with high number of leaves is still a matter of debate. Earlier students of palaeobotany synonymised leaves of similar type with this taxon, however these often turned out to represent various taxonomic groups. UNGER (1850c) described *Dombeyopsis tiliaefolia* UNGER described from the Early Oligocene flora of Sotzka. However the specimen from Sotzka (UNGER 1850c, pl. 25. fig. 1.) is not identical with *Byttneriophyllum tiliifolium*. Leaves definitely representing *B. tiliifolium* are figured on the same plate (Figs. 4–5) and plate 26 (figs. 1–2) in UNGER's Sotzka volume (1850c), however these leaves were described from the younger Miocene flora of Kainberg (Steiermark).

Leaves described frequently as *Ficus tiliaefolia* from the younger Neogene floras, mostly represent this species, but their systematic affinity is still in question. KNOBLOCH & KVAČEK (1965) related the leaves with the families Sterculiaceae or Tiliaceae and assumed that it was a wetland element, probably a member of swamp vegetation. It was presumably a shade tolerant shrub in the lower storey but a smaller tree habit should not be excluded. It is dominant in several floras in Romania (GIVULESCU 1991), but also occurs in Southern Poland in lignite formations (WOROBIEC, G. & KASIŃSKI 2009) as dispersed cuticle.

In Hungary it appears in the flora of Felsőtárkány, which is assumed to represent stratigraphically the Sarmatian-Pannonian boundary. Later, during the Pannonian, it became dominant in the wetland vegetation. It is a member of a widespread swamp association accompanied by *Glyptostrobus europaeus* and *Alnus cecropiifolia* or *A. menzelii.*

Banisteriaecarpum giganteum (GÖPPERT) KRÄUSEL
Plate XXXI: figs 1–2

1852 *Acer giganteum* GÖPPERT — GÖPPERT, p. 279, pl. 38, figs 1a b c, 2, 3.
1890 *Banisteria gigantea* (GÖPPERT) SCHENK — SCHENK, p. 572, text.-fig. 325-10.
1951 *Banisteriaecarpum giganteum* (GÖPPERT) KRÄUSEL — KRÄUSEL, p. 79, pl. 41, pl. 42, figs 1–5, pl. 43, figs 1, 3–6.
1996 *Banisteriaecarpum giganteum* (GÖPPERT) KRÄUSEL — HABLY & KOVAR-EDER, p. 73, text.-fig. 3.

Material: Dozmat SAMU lost specimen (see in HABLY & KOVAR-EDER 1996)**,** *Rudabánya-Vilmos:* BK 554, 559, 560, 562-564, 568, 570, 571, 573, 574, 579, 580–582, 586, 587, 590, 625

Description: Large fruits resembling maple fruits, length up to 20 cm and width up to 10 cm. Seed not preserved. Venation of wing very dense. Along upper margin of wing some veins run parallel with margin, other veins turn downwards and form meshes.

Discussion: Banisteriaecarpum is generally accompanied by the leaves of *Byttneriophyllum tiliifolium*. Based on their obvious co-occurrence the leaves and fruits are presumed to belong to the same plant. Among the Pannonian floras of Hungary, the flora of Dozmat and Rudabánya yielded remains of *Banisteriaecarpum* as well as high number of leaves of *Byttneriophyllum*. *Byttneriophyllum*, associated with *Banisteriaecarpum* was also encountered as an important element in a late Middle Miocene (Sarmatian) locality at Sajókaza (PÁLFALVY 1961). Among unpublished material, excavated at Graz-Andritz (Landesmuseum Joanneum, Graz), several nice specimens of *Banisteriaecarpum* were recorded (No. 80.003, 80.006) and were associated with *Byttneriophyllum tiliifolium* as a dominant element. In addition, fruits accompanied by *Alnus*, *Glyptostrobus* and *Byttneriophyllum* were reported in a fossil flora from Ihrác near Kremnica (Slovakia); this collection is stored in the Slovak National Museum (No. B 371).

Records were published in Romania (GIVULESCU 1991), as well, from the Oas Basin where *Banisteriaecarpum* is accompanied by *Byttneriophyllum tiliifolium*. The observation that *Banisteriaecarpum* fruits are generally associated with leaves of *Byttneriophyllum*, is further supported by our studies. It is a characteristic but rare element of the wetland vegetation during the Late Miocene.

Aquifoliaceae

Ilex sp.

Material: Visonta: BK 5513 endocarp
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 59, pl. 6, fig. 15.

Cornaceae

Cornus cf. *gorbunovii* DOROFEEV

Material: Visonta: BK 5470, 5507 endocarp
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 59, pl. 6, figs 12–14.

Nyssaceae

Nyssa disseminata (LUDWIG) KIRCHHEIMER

Material: Rudabánya-Vilmos: BK without number*, Visonta:* BK 5526
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 58, pl. 6, figs 8–9.

Adoxaceae

Sambucus pulchella C. & E. M. REID

Material: Visonta: BK 5504, 5541 seeds
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 59, pl. 3, fig. 14, pl. 4, fig. 10.

Sabiaceae

Meliosma cf. *wetteraviensis* (LUDWIG) MAI

Material: ***Visonta:*** **BK** 5517 endocarp
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 58, pl. 7, figs 15–16.

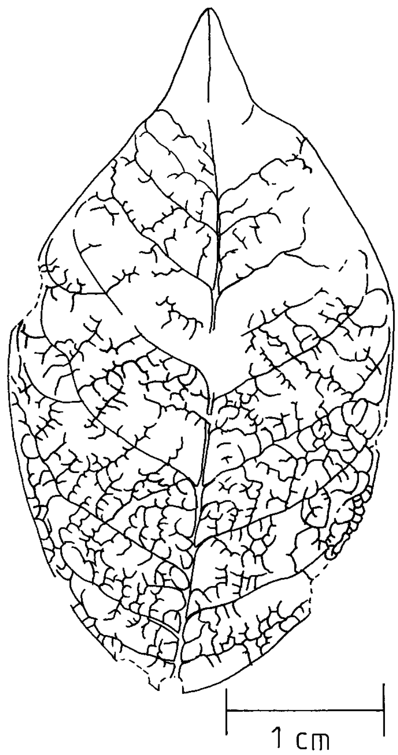
Plantae incertae sedis

"*Magnolia*" *szakmanycsabae* sp. nov.
Text-figure 4; Plate IV: figs 3–6, Plate V: fig. 1

Holotypus: BP 2011.128.1.
Derivatio nominis: After the collector, Szakmány Csaba.
Locus typicus and stratum typicum: Balatonszentgyörgy, brickyard, Pannonian, uppermost Miocene
Material: Balatonszentgyörgy: BP 2011.128.1.-2011.130.1., 2011.133.1., 2011.139.1., BK 1578
Additional material: from *Paldau-Monscheinkiesgrube* (Austria), LMJ 78.142, 78.270.

Description: Simple leaves, shape ovate to obovate, length and width of lamina up to 10 cm and 7 cm, respectively. Apex attenuate, base rounded, margin entire. Venation camptodromous, brochidodromous. Midvein broad, but not stout. Secondaries arise from midvein at small angles (~5°), but shortly diverge more steeply at angles 40–45°. Secondaries widely spaced, distance between neighbouring secondaries more than 1 cm in the middle part of the lamina of large leaves. Intersecondary veins arise from the midvein between secondaries, and anastomose with the dense tertiary venation. Secondaries form loops near the margin, with larger loops at the upper part of the lamina.

Discussion: Similar leaves were described as aff. *Magnolia* sp. 2. from the Neogene of Willershausen (KNOBLOCH 1998. p. 15. pl. 3, figs 2, 3, 5, 8), but these leaves are smaller, and the venation is more stout, the description suggests lauraceous leaves. From the flora of Chiuzbaia (Transylvania, Romania) similar leaves were described as *Celastrus barbui* by Givulescu (GIVULESCU 1990, p 131, pl. 19, figs 1, 2). The leaves from Balatonszentgyörgy are more similar to the leaves of the Willershausen flora, than to those from Chiuzbaia. At Balatonszentgyörgy and Willershausen leaves are generally small and venation strong. Unfortunately,



Text-figure 4. *"Magnolia" szakmanycsabae* sp. nov., holotype, Balatonszentgyörgy, BP 2011.128.1.

no cuticle is preserved to support the taxonomic identification, but the attenuate apex, brochidodromous venation strongly suggest a relation to Magnoliaceae–Lauraceae. According to the leaf morphology, as well as the plant association the leaves may represent a deciduous Magnoliaceae. The presence of *M. szakmanycsabae* is important because similar type of leaves have not been observed earlier in the Pannonian wetland vegetation of Hungary. Its occurrence is accessory. There are fragments of similar, but larger leaves, however due to heavy fragmentation it is not possible to identify them.

Juglans acuminata A. BRAUN ex UNGER
Plate XVII: figs 6–8, Plate XVIII: fig. 1

1845 *Juglans* (*Carya*?) *acuminata* A. BRAUN — BRAUN, p. 170. nomen nudum.
1845 *Juglans latifolia* A. BRAUN — BRAUN, p. 170. nomen nudum.
1850a *Juglans acuminata* A. BRAUN — UNGER, p. 468.
1971 *Juglans acuminata* A. BRAUN ex UNGER — BŮŽEK, p. 42, text.-fig. 3, pl. 9, figs 9–15, pl. 10, figs 1–6, pl. 11, figs 1–3.
1988 *Juglans acuminata* A. BRAUN ex UNGER — KOVAR-EDER, p. 44, pl. 9, figs 1–8.
1990 *Juglans acuminata* A. BRAUN ex UNGER — KOVAR-EDER & KRAINER, p. 19, pl. 2, figs 5–6, text.-figs 6: 2, 3.

Material: Tihany: BP 85.127.1., 85.128.1., 85.134.1., 85.141.2., 85.150.1., cf. 85.204.1., 85.205.5., 85.209.2., 85.212.2., 85.215.3., 85.216.1., 85.208.2., 85.211.1.

Description: Leaflets, no petiole preserved, length of lamina up to 18 cm, width 4 cm. Shape of lamina narrow ovate to lanceolate, apex acute, base cordate, symmetrical to asymmetrical, margin entire. Venation camptodromous, brochidodromous, intersecondaries frequent between secondaries. Secondaries curved distally and connected to each other in the marginal region by definite loops, and close to the margin in a series of small loops.

Discussion: Taxonomic position of this species is not clear enough. *Juglans acuminata* was mentioned from several time slices of the Cenozoic of Europe. Similar leaflets were described from the Hungarian Neogene as *Cedrela sarmatica* (ANDREÁNSZKY 1959). It is quite probable, that systematically diverse taxa are represented by this species. In the Late Miocene of Austria it was mentioned from several localities, e.g. Wörth bei Kirchberg (KOVAR-EDER & KRAINER 1990) or Mataschen (KOVAR-EDER 2004).

Dicotylophyllum jungii KNOBLOCH & KVAČEK
Plate XXXI: figs 3–4

1976 *Dicotylophyllum jungii* KNOBLOCH & KVAČEK — KNOBLOCH & KVAČEK , p. 75, pl. 35, figs 2–4, text.-fig. 36.

Material: Balatonszentgyörgy: BK 1514, 4703, 1616; 4706, without number: 57/4(175) drower, SAMU: 2008.6.145.

Description: Simple leaves, length up to 12 cm, width 3.6 cm. Lamina symmetrical, ovate, apex acute, base cordate, margin entire. Venation camptodromous, brochidodromous. Midvein stout. Secondary veins arise from midvein nearly perpendicularly, and join each other close to margin. After joining secondaries strong, and run parallel with margin.

Discussion: A quite characteristic venation distinguishes this species from other similar leaves. *Dicotylophyllum jungii* was described from Miocene deposits of Germany, by the margin of the Bohemian Massif. This is the first record of this type of leaf from the Hungarian Neogene. It seems to be a rare accessory element inhabiting mainly wetland associations.

Alismataceae

Caldesia cf. *cylindrica* (E. M. REID) DOROFEEV

Material: Visonta: BK 5497, 5518 fruits (endocarps)

Description: see in BŮŽEK & LÁSZLÓ (1992), p. 60, pl. 9, fig. 5.

Hydrocharitaceae

Stratiotes tuberculatus C. & E. M. REID

Material: Rudabánya-Vilmos: BK 902, 907, *Visonta:* BK 5459, 5505, 5537 fruits (endocarps)

Description: see in BŮŽEK & LÁSZLÓ (1992), p. 60, pl. 8, figs 13–15, pl. 9, figs 7–12.

Stratiotes sp.

Material: Bükkábrány: BP 2011.234.10. seeds
Description: see in ERDEI & MAGYARI (2011), p. 143, text.-figs 10–12.

Potamogetonaceae

Potamogeton martinianus SITAR
Plate XXXI: figs 7–8, Plate XXXII: figs 1–2

?1851 *Potamogeton Bruckmannii* (nomen nudum) — A. BRAUN in STIZENBERGER: 76.
?1855 *Potamogeton Bruckmannii* A. BRAUN — HEER, p. 102, T. 47, fig. 7.
1955 *Potamogeton fluitans* L. — Vörös, p. 68.
1969 *Potamogeton martinianus* SITAR — SITAR, p. 112, T. 22, fig. 4, T. 23, figs 3–4, T. 27, figs 1–2, Text.-fig. 2.
1990 *Potamogeton Bruckmannii* A. BRAUN in HEER — KOVAR-EDER & KRAINER, p. 25, T. 3, fig. 10, T. 7, fig. 1., T. 9, figs 1–4.
1991 *Potamogeton martinianus* Sitar — Kovar & KRAINER, p. 746, T. 7, figs 4–6, 10, 11,

Material: Rózsaszentmárton: BP 2001.277.1., *Rudabánya-Andrássy*: BK 261, 262, 270, 271, 285, 286, 322, *Rudabánya-Vilmos:* BK 559, 857, 858, 861–869, 871–876, 880, 881, 884, 886, 888, 890, 896,

Description: Base slightly asymmetrical, decurrent. Apex acute to rounded, margin entire. Venation parallel, 6–6 veins on both sides of leaf arise from base and join in apex. Dense, fine, perpendicular venation between main parallel veins.

Discussion: Potamogeton is a characteristic element of floras representing aquatic habitats. In the floras of Rudabánya and Rózsaszentmárton the species is a rare accessory element. It is widespread in the Pannonian floras of Austria (KOVAR & KRAINER 1990), and it was described (SITAR 1969), as well, from the Late Miocene flora of Martin in the Turiec Basin (Slovakia). In this latter assemblage it is accompanied by *Nelumbium*, *Glyptostrobus*, *Ulmus* and *Betula*.

Potamogeton sp. div.

Material: Visonta: BK 5459, 5505, 5537 fruits (endocarps).
Bükkábrány: BK without number (LÁSZLÓ 1992, pl. 4, fig. 2), BP 2011.233.1.
Description: see in BŮŽEK & LÁSZLÓ (1992), p. 60, pl. 9, fig. 6., ERDEI & MAGYARI (2011), p. 142, text.-fig. 9.

Smilacaceae

Smilax weberi WESSEL in WESSEL & WEBER
Plate XXXII: figs 3–4

1847 *Smilacites grandifolius* UNGER — UNGER, p. 129, pl. 40, fig. 3.
1855 *Smilax grandifolia* (UNGER) HEER — HEER, p. 82, pl. 30, fig.8.
1855 *Smilax weberi* WESSEL — WESSEL & WEBER, p. 127, pl. 21, fig. 1.
1971 *Smilax weberi* WESSEL — BŮŽEK, p. 89, pl. 44, figs 1–5, pl. 45, figs 1–4, text.-fig. 14.
1975 *Smilax weberi* WESSEL — CHRISTENSEN, p. 21, pl. 5, figs 1–8, pl. 6, figs 2, 4–6, text.-figs 6A–F, 7, 8.
1976 *Smilax weberi* WESSEL — KNOBLOCH & KVAČEK, p. 85, pl. 39, figs 1, 3, 6, 7, pl. 40, figs 1–3.
1992a *Smilax weberi* WESSEL — HABLY, p. 204, pl. 2, figs 5, 6.

Material: Tihany: BP 85.205.5., 85.209.2.

Description: Simple leaves, length 6.8–8.4 cm, width 4.6–6.8 cm. Lamina broadly ovate, apex acute, base rounded to cordate. Margin entire. Venation campylodromous, 5 primary veins, middle vein strong, tapering, straight. Lateral primary veins slender, curve upwards and bend towards the apex of lamina.

Discussion: Smilax weberi is a rare accessory element in the Pannonian of the Pannonian Basin. It was recorded at only one locality, Tihany-Fehérpart, as the youngest occurrence of the species in the Pannonian Basin. It was presumably a relict during the Pannonian. In the Hungarian fossil record its oldest occurrence is documented from Oligocene floras (HABLY 1990), later it appeared in several Miocene floras (ANDREÁNSZKY 1959). GIVULESCU (1990) mentioned the genus from the Late Miocene, but described another species, *S. aspera* from Chiuzbaia (Transylvania, Romania).

Musaceae

Musophyllum tárkányense BUBIK
Plate XXXI: fig. 6

1955 *Musophyllum tárkányense* BUBIK — KUBÁT& BUBIK, p. 52, text.-fig. 19.
1959 *Musophyllum tárkányense* BUBIK — ANDREÁNSZKY, p. 181, pl. 59.

Material: Felsőtárkány: BP 55.1780.1., 55.1792.1., 55.1804.1., 55.1825.1., 55.1851.1., 55.1857.1., 55.1906.1., 55.1912.1., 55.1937.1., 59.118.1., 60.1692.1., 60.1807.1., 60.1814.1., 60.1830, 60.1848.1., 60.1860.1., 60.1879.1., 62.1162.1., 62.1180.1., 62.1187.1., 62.1392.1., 62.1461.1., 69.707.1., 71.89.1., 71.111.1., 83.301.1., 85.233.1., MM 55.5270.1., 55.5310.1., 56.641.1., 56.964.1., 64.1305.1., 64.1293.1.,

Description: see in KUBÁT & BUBIK (1955), p. 52, 177, text.-fig. 19, ANDREÁNSZKY 1959, p. 181, Taf. 59.

Zingiberaceae

Spirematospermum wetzleri (HEER) CHANDLER
Plate XXXV: figs 2–4

Material: Visonta: BK 4670 fruit, 5477, 5510 seeds,

Description: see in BŮŽEK & LÁSZLÓ (1992), p. 61, pl. 8, fig. 11. *Bükkábrány:* BK 4495, 4508, 4665–4669, 4671 (LÁSZLÓ 1992, pl. 4, fig. 3., pl. 5, fig. 1.)

Cyperaceae

Carex sp.

Material: Visonta: BK 5460, 5483, 5529 utriculi with nuts, isolated nuts, *Bükkábrány*: BP 2011.235.6.

Description: see in BŮŽEK & LÁSZLÓ (1992), p. 61, pl. 9. figs 1–4., in ERDEI & MAGYARI (2011), p. 144, text.-figs 13–14.

Monocotyledonae inc. fam.

Monocotyledonae sp. 1.
Plate XXXII: fig. 5

Material: *Balatonszentgyörgy:*BK 1478, 1486, 1497, 1510, 1524, 1532, 1537, 1556, 1561, 1573, 1577, 1583, 1584, 1593, 1616, 1624, 1627, 1631, 1634–1635, 1637, 1639, 1643, 1646–1647, 1651, 1660, 1668, 1672-1673, 1738, 1766, 1796, 1812—1813, 1815

Description: Ovate leaves, length up to 12.4 cm, width 2.0 cm. Base slightly asymmetric and truncate, apex acute, margin entire. Dense parallel venation with expressed midvein.

Discussion: Similar leaves were described by KOLAKOVSKI (1964) from the Miocene flora of Kodor as Sasa kodorica, but these leaves differ in having cuneate base. From Bełchatów G. Worobiec (in WOROBIEC, E. & WOROBIEC, G. 2005) mentioned leaves sharing many characters with leaves from Balatonszentgyörgy, however, their base, as well as venation display different traits.

Monocotyledonae gen. et sp.
Plate XXXII: fig. 6

Material: Balatonszentgyörgy: BP 2008.304.1–2008.306.1., 2010.170.1., 2011.357.1., 2011.358.1., 2011.371.1., 2008.373.1., BK 1486, 1494, 1576, 1674; SAMU: 2008.6.5., 2008.6.7., 2008.6.23., 2008.6.34., 2008.6.35., 2008.6.38., 2008.6.44., 2008.6.62., 2008.6.63., 2008.6.87., 2008.6.114., 2008.6.119., 2008.6.120., 2008.6.123., 2008.6.131., 2008.6.144., 2008.6.146. *Felsőtárkány*: MM 55.5328.1., 55.5243.1., 60.1874. 1., *Győr-Sashegy:* SAMU: 2008.9.6., *Iharosberény:* BP 2009.248.3., 2009.276.2., *Karmacs:* BP 2008.437.1., 2008.438.1., *Kerecsend:* SAMU 2008.16.64.; 2008.16.71., *Mindszentkálla:* BP 2007.501.1., *Rózsaszentmárton:* MM 73.11.1., 73.19.1., 2001.352.1. *Sé:* SAMU 65.2.392., 65.3.101., 65.3.312., 65.3.1174., 70.1.493., *Sótony:* SAMU 60.27.1–81, 62.3.1–26, *Tihany:* 2007.522.1–2007.524.1., *Tiszapalkonya:* BP 2009.350.1., 2009.351.3., 2009.355.3–2009.357.2., 2009.360.2., 2011.101.1., 2011.102.1., *Visonta:* BK 1004.

Description: Leaf fragments of various size with entire margin and parallel venation.

Discussion: Most of the localities comprise fragments of leaves belonging to monocots, however, displaying few traits for taxonomic identification. Their occurrence suggests wetland habitats.

Late Miocene (Pannonian) flora of the Pannonian Basin

The flora of the Pannonian Basin was basically determined by the presence of Lake Pannon. The lake occupied most part of the basin with its huge water mass and the former rich Sarmatian flora was displaced by floras and vegetation types more or less dependent on lowland or aquatic habitats. The majority of plant taxa described from the Pannonian are assumed to appear in the Pannonian Basin by the end of the Sarmatian. The locality by Felsőtárkány, which yielded a strongly "selected" flora showing higher similarity to the Pannonian floras than to the Sarmatian ones, gives support to the assumption. This flora was already dominated by wetland elements, e.g. *Acer tricuspidatum*, *Cercidiphyllum crenatum*, *Byttneriophyllum tiliifolium*, *Osmunda*, *Pteris*, *Alnus menzelii*. Pannonian floras share just a few taxa, e.g. *Quercus kubinyii* or *Zelkova zelkovifolia*, with Sarmatian floras, e.g. Erdőbénye, however other taxa, such as *Podocarpium podocarpum* dominating some older floras, had their last occurrence during the Sarmatian. Sarmatian floras, called by ANDREÁNSZKY (1959) as "sandstone floras", comprise high number of elements that were still subordinate, but later, due to more favourable environmental conditions became frequent or even dominant by the Pannonian. *Liquidambar europaea*, which is a characteristic element of Pannonian floras, was already present in the floras of Buják and Bánhorváti, whereas *Alnus ducalis* (as *A. hoernesi*, ANDREÁNSZKY 1959) appeared in the flora of Sály. *Byttneriophyllum tiliifolium*, a dominant element of Pannonian floras, was first recorded from the younger Sarmatian, from Felsőtárkány and Sajókaza (PÁLFALVY 1961). Consequently, the Pannonian flora and vegetation developed basically from Sarmatian elements, namely from those tolerating wetland conditions. The former, dominant mesophytic arboreal elements virtually disappeared or at least considerably withdrew, e.g. *Zelkova zelkovifolia*, *Quercus kubinyii*, *Quercus pontica-miocenica*, *Podocarpium podocarpum*, *Fagus haidingeri*, *Parrotia pristina* and *Smilax*. Some of these mesophytic elements show sporadic occurrence in the Pannonian floras. Therefore, these elements should not be regarded as extinct; however, they share a relict character. *Fagus* was recorded in the floras of Alcsút, Pécs-Nagyárpád, Rózsaszentmárton and Visonta, *Zelkova zelkovifolia* turned up in the floras of Bükkábrány and Rudabánya, and *Quercus kubinyii* leaves were documented from the floras of Alcsút, Aranyosgadány, Hosszúpereszteg and Sé. *Quercus pontica miocenica* was recorded in the flora of Felsőtárkány, and *Quercus* sp. was yielded by the floras of Felsőtárkány, Hosszúpereszteg and Pécs-Nagyárpád. *Smilax* turned up exclusively from Tihany. Leaves of *Parrotia pristina*, which was a common element of Badenian–Sarmatian floras, were frequently recorded in floras by the basin margin; however, they are missing from floras inside the basin. Leaves were documented from the western margin in Paldau (Austria) with few specimens (KRENN 1998), along the northern margin from several localities in Slovakia (SITAR 1969), from the north-eastern part in Ukraine (ILJINSKAJA 1968), and from the southern margin from the flora of Kostolac (Serbia, MIHAJLOVIČ & LAZAREVIČ 1999). *Zelkova zelkovifolia*, which was dominant in Sarmatian floras, is a putative relict element during the Pannonian, with scarce records from the basinal floras, i.e. well-confirmed remains from Bükkábrány and Rudabánya. However, this arboreal element survived successfully since later; during the Pliocene its leaves turned up again even in large quantities from deposits of volcanic craterlakes suggesting its dominance in the vegetation (HABLY & KVAČEK 1997). Similarly, another Pannonian relict, *Quercus kubinyii* became dominant in volcanic flora and vegetation during the Pliocene. Fossil leaves and fruits of *Engelhardia* were first proved in the Pannonian Basin as early as the Palaeogene. The species became dominant in some of the Oligocene and Early Miocene floras, whereas during the Pannonian it showed relict occurrence with a single fruit recorded from Rózsaszentmárton. From the assemblages of the Pliocene volcanic craterlakes a single leaf was assigned to *Engelhardia*, thus the genus seems to represent a relict element of both Pannonian and Pliocene floras (HABLY & KVAČEK 1997). *Engelhardia* must have displayed an excellent survival strategy as it reappeared several times through the Palaeogene and Neogene; however, it was strongly dependent on warmer periods.

Podocarpium podocarpum, another characteristic element of Sarmatian floras showed a distinct fossil history. This species is unknown from Pannonian assemblages neither from basinal nor from marginal areas. A single occurrence of *Podocarpium podocarpum* from Borszék published by POP (1936) was proved to be a false record based on a recent revision. The species did not reappear in the Pliocene volcanic floras, thus, based on currently available data the species became extinct by the end of the Sarmatian. The youngest occurrence of the species was recorded from the younger Sarmatian flora of Gratkorn in Austria (HABLY & MELLER in progress). However, a great number of additional taxa which could not be adapted to habitat changes brought about by Lake Pannon; seem to disappear by the end of the Sarmatian. Therefore, the Pliocene flora is characterized by lower diversity than the older, Sarmatian floras.

One of the most significant outcomes of recent investigations is the record of the "younger mastixioid floras" evidenced by the flora of Rudabánya (HABLY & ERDEI in press.). This is the first record of mastixioid type floras from Hungary. This flora is characterized by the occurrence of the genus *Mastixia*, and some other related genera, e.g. *Eomastixia*, *Mastixicarpum*, *Retinomastixia*, *Tectocarya*, and it represents a specific assemblage tolerating humid and warm climate. Mastixioid floras were first recognized in the Late Cretaceous and the first expansion of "early mastixioid floras" was encountered during the Eocene. The second expansion of "younger mastixioid floras" was presumed from the Early up to the Middle Miocene (KIRCHHEIMER 1938; MAI 1964, 1995; TEODORIDIS 2003). Later, mastixioid type floras became restricted and were relict until the Pliocene. MAI (1995) assumed refuges of the flora in the Kolchis, with the occurrence of the genus *Tectocarya*, and another area in Germany (Herzogenrath and Düren), with the genus *Mastixia*.

The record of a mastixioid type flora in Rudabánya gives evidence of refuge areas in a larger scale, in Europe. Moreover, contrasting the formerly known refuge in Germany with the Late Miocene – Pliocene species (*M. menzelii* and *M. thomsonii*), the most common species of the European Miocene, *M. amygdalaeformis* is the mastixioid member of the Rudabánya assemblage. The occurrence of this species implies that after the Middle Miocene it survived inside Europe, in the Pannonian Basin. It is assumed that due to levelling effect of the huge water mass a humid, warm temperate climate was sustained, which was favourable to *Mastixia*. *Daphnogene*, which is listed among thermophilous elements and was a characteristic member of the European Palaeogene and Neogene, was also recorded from Rudabánya. This is the youngest record of the genus from Hungary; it was documented from neither younger Pannonian nor Pliocene assemblages. Local conditions of the basin inundated by Lake Pannon, determined whether floodplain or swamp forests were formed. Riparian forests displayed considerably higher diversity than swamp forests. In this vegetation type, the flora is richer in species and the more or less constant elements, *Platanus leucophylla* and *Liquidambar europaea* are generally present. In addition, frequent members of these associations are *Alnus ducalis*, *Alnus gaudini*, *Juglans acuminata*, *Ulmus braunii*, *Ulmus carpinoides*, *Acer jurenakii*, *Acer subcampestre*, *Populus populina*, *Salix varians*, and *Vitis* sp. Remnants of mesophytic forests also appear with *Fagus* and *Quercus* species. Some of these species even predominate certain assemblages. This assemblage type was recorded in Alcsút, Diszel-Hajagos, Gyöngyös - Silbermann Mine, Győr-Sashegy, Hévíz, Hosszúpereszteg, Karmacs, and in part Sé and Tihany.

The majority of the localities are situated in the northern Transdanubian part of the basin. The flora of Tihany-Fehérpart displays a floristic composition similar to the flora of Paldau (Austria), which is situated by the basin margin. This implies that both localities must have been at an elevated position at the time their floras were flourishing. Alcsút, which still comprises some relict mesophytic elements (*Fagus*, *Quercus kubinyii*), should be referred to this floristic group. Hosszúpereszteg is related to this group, as well, with lots of *Quercus*, *Platanus*, *Liquidambar* and *Ulmus* remains. The assemblage comprising a high number of *Quercus* remains indicates a refuge of *Quercus kubinyii*. The flora of Karmacs and localities from the Balaton region, Hévíz and Diszel-Hajagos seem to be related to this floristic group mainly based on the dominance of *Platanus*.

Swamp forests display lower diversities. Generally, three dominant species, *Glyptostrobus europaeus*, *Byttneriophyllum tiliifolium* and *Alnus cecropiifolia*, occasionally replaced by *A. menzelii*, characterise assemblages related to swamp habitats. This type of assemblage was recorded from Balatonszentgyörgy, Bükkábrány, Dozmat, Felsőtárkány, Iharosberény, Kerecsend, Rózsaszentmárton, Rudabánya, in part Sé, Tiszapalkonya, and Visonta.

One of the most typical assemblages representing swamp associations is Dozmat (HABLY & KOVAR-EDER 1996) comprising almost exclusively the dominant species mentioned above and *Osmunda parschlugiana*. This association is known from the upper level assemblage of Balatonszentgyörgy, as well, however, *Glyptostrobus* is dominant whereas *Byttneriophyllum* is missing from this flora. At the same time, high number of specimens was assigned to *Osmunda* and *Pronephrium*, though the latter occurs with fewer specimens. There are some additional, rare elements, e.g. species of *Alnus*, "*Magnolia*" *szakmanycsabae*, *Vitis szakmanygyorgyi*. The lower, older layers in Balatonszentgyörgy provide a richer assemblage, which must have flourished in higher, more elevated habitats. In addition to the typical swamp elements, *Glyptostrobus* and *Myrica lignitum*, there are taxa indicating riparian habitats, e.g. *Acer jurenakii*, *Acer* sp., *Salix varians*, *Salix* sp., "*Magnolia*" *szakmanycsabae* and *Vitis szakmanygyorgyii*. Due to the gradual increase of inundation, most of these species disappeared, and an oligotypic, low diversity swamp forest became dominant. A similar habitat change and floristic consequences were discussed by GROSS (1998) based on floras of Paldau.

Similarly, the flora of Iharosberény is dominated by *Byttneriophyllum* and *Glyptostrobus*, and remains of *Osmunda*, *Alnus* and *Salix* are also present. In the flora of Tiszapalkonya, this assemblage is completed with *Acer* and *Ulmus*. One of the most diverse swamp associations was recorded in Felsőtárkány. The fossiliferous levels are correlated with the end of Sarmatian or beginning of Pannonian, and its relatively older stratigraphic position may be the reason for its high floristic diversity. Species mentioned above as dominant, show the highest frequency and ferns that are commonly encountered later in younger floras, contribute to the diversity of the assemblage, e.g. *Pronephrium stiriacum*, *Osmunda parschlugiana*. In addition, *Cercidiphyllum crenatum*, *Acer tricuspidatum*, *Ulmus braunii* and *Quercus pontica miocenica* were recorded with high number of specimens.

The swamp association in Rudabánya, which is of similar age to Felsőtárkány, yielded high number of *Cercidiphyllum crenatum* specimens, and maples are present in the assemblage. Noteworthy members of the Rudabánya flora are remains of *Ginkgo*, which came to light exclusively from localities in north-eastern Hungary, and *Trapa*, a member of the aquatic vegetation.

The unequivocal representation of aquatic vegetation was encountered only from lignite deposits of north-eastern Hungary, mainly of the Bükk and Mátra Mts, i.e. Bükkábrány, Rózsaszentmárton, Visonta and Rudabánya. The rich fruit-seed floras indicate the presence of open water habitats, i.e. *Trapa*, *Stratiotes* and *Potamogeton* in Bükkábrány, and Rudabánya, *Trapa* and *Potamogeton* in Rózsaszentmárton. A more abundant assemblage was described from Visonta (Bůžek & László 1992), yielding remains of *Salvinia, Nymphaea szaferi, Nuphar palfalvyi, Pseudoeuryale* cf. *dravertii*, *Ceratophyllum dubium, Stratiotes tuberculatus, Potamogeton* and *Spirematospermum wetzleri*. Morphological evolution observed in the case of *Trapa* fruits provides evidence of the gradual appearance of endemic species in aquatic habitats. The oldest occurrence of the genus was recorded from Rudabánya (*Lymnocardium conjungens* zone, older than 10 Ma), with a species, *Trapa silesiaca*, which was widespread in Central European assemblages. In the much younger assemblage from Bükkábrány (approximately 7 Ma) *Trapa praehungarica* was described, whereas in the nearly coeval flora of Rózsaszentmárton, which occupied a position more to the west in the Mátra–Bükkalja basin, *Trapa pannonica* was recorded. This species is quite distinct from the other species both in morphology and dimension.

The endemic species developing at nearly contemporaneous habitats indicate some kind of isolation of the basin.

Pine cones were recorded from Mindszentkálla and Diszel-Kula. These pines are related to extant, warm demanding species and must have occupied higher levees, or elevated, rocky shores. The fossils are very similar to the modern *Pinus pinaster*, an atlanto-mediterranean species growing along the coast in North Africa and elsewhere in the western parts of the Mediterraneum, in frost-free areas during the entire year (Debreczy & Rácz 2011). Another group of the pine fossils from Mindszentkálla resembles *Pinus heldreichii*, which is native to the subalpine mountains of the Balkan and South Italy, ranging between 1800–2400 m above sea level. Furthermore, a fossil cone shows similar morphology to the cones of *Pinus nigra* s.l., a rather diverse species covering scattered (usually montane) habitats from North Africa, the Iberian Peninsula, the Cévennes, Corsica, Sicily, the southern Apennines, the western Alps, Dalmatia, southern Carpathians, the Balkan Peninsula, to Anatolia and Crimea (Debreczy & Rácz 2011). It should not be excluded that a haploxylon pine which resembles modern *Pinus peuce* native to the Balkan Peninsula was also present. Some cones of *Picea* were encountered, as well. Pine cones were recorded from localities close to the current western edge of Lake Balaton, moreover, cones of Pannonian age were published as *Pinus kotschyana* (Unger) Tuzson from localities in Transylvania, e.g. Siklód (Solt et al 2010), Dolmány, Segesvár, Segesd, Szászkisalmás, Ilyefalva, Erked, Sárpatak, and Mesztakény (Tuzson 1913). Short shoots and needles are known from Rózsaszentmárton and Visonta, however cones have not been reported from these localities.

Thus, the flora and vegetation of the Pannonian Basin was definitely changed due to the formation of Lake Pannon and subsequent habitat variations. Numerous floristic elements that were presumed to be extinct were recognized in the flora owing to the current thorough investigations. Some of these species must have survived in elevated areas or higher levees less threatened by inundation inside the basin. From this point of view it is interesting to discuss what happened along the basin margin and in levees or regions inundated for short periods.

Pannonian flora and vegetation of adjacent marginal, extrabasinal areas

A good example of extrabasinal flora and vegetation is the Pannonian flora of Paldau in Austria (Gross 1998, Krenn 1998) situated on the basin margin. Various associations can be distinguished in this assemblage. Swamp forest with *Equisetum* sp., *Osmunda parschlugiana*, *Pteris* sp., *Pronephrium stiriacum*, *Glyptostrobus europaeus*, *Myrica lignitum*, *Byttneriophyllum tiliifolium*, *Acer tricuspidatum*, "*Magnolia*" *szakmanycsabae*, *Alnus menzeli*, *Comptonia oeningensis*, *Nyssa* sp., seems to show higher diversity than swamp forests preserved by basinal assemblages. Riparian vegetation cover comprises *Liquidambar europaea*, *Platanus leucophylla*, *Ulmus carpinoides*, *Ulmus* sp., *Acer jurenakii*, *Acer* sp., *Juglans acuminata*, *Populus balsamoides*, *Salix holzeri*, which indicates quite similar floristic composition as the basinal riparian associations have, but with a couple of distinctive species. Aquatic habitats are indicated by fossils of *Potamogeton martinianus*, *Salvinia* cf. *mildeana*, *Limnobiophyllum expansum*. The main distinctive feature of extrabasinal assemblages is the unequivocal presence of mesophytic elements which are missing from the basin, i.e. *Parrotia pristina*, *Rosa* sp., *Paliurus* sp., *Quercus pseudorobur*. Based on the occurrence of these elements, high numbers of taxa that are members of mesophytic forests are assumed to have survived in marginal areas of the basin. Mataschen (Kovar-Eder & Hably 2006) is a significant Late Miocene flora from the western margin of the Pannonian Basin. An extremely high ratio of mesophytic elements, moreover the majority of mesophytic taxa (60%) are putative evergreens in this noteworthy assemblage. Five species of Lauraceae, four species of Theaceae and two species of Hamamelidaceae, as well as, numerous thermophilous taxa requiring a mean annual temperature of 15–19 °C, were recorded in the assemblage. Therefore, it seems reasonable to consider this assemblage as a member of the so-called "younger mastixioid floras", even without the presence of *Mastixia*.

Slovakian floras by the northern margin provide good examples of floral change towards marginal areas. Localities published by Sitar (1969, 1982), i.e. Polerieka-Kolisky, Martin, Lehotka, Bystricka and Priekopa were presumed to be of Sarmatian age. Recent stratigraphic investigations (Kováč et al 2011) prove a Late Miocene (Pannonian) age of the fossiliferous deposits. The ratio of zonal taxa to the total number of taxa occurring in the assemblage is definitely higher in the flora of Polerieka-Kolisky than the same ratio measured in assemblages inside the basin. There are records of *Zelkova zelkovifolia*, which was documented from the basin floras only with three specimens. *Daphnogene*, which has a single occurrence in the flora of Rudabánya was recorded, as well. Significant number of specimens assigned to *Quercus* occurs in the locality by the northern basin margin, however, interestingly the characteristic species of the Pannonian, i.e. *Glyptostrobus europaeus*, *Alnus ducalis*, *Acer tricuspidatum* and other maple species are dominant in the flora. The flora of Martin gives evidence of *Parrotia pristina* and thus, supports the theory that species flourishing earlier in the basin floras became restricted or found refuge in marginal areas. In the flora of Lehotka, the mass occurrence of *Zelkova zelkovifolia* and *Quercus kubinyii* indicates the survival of zonal elements in marginal habitats, whereas the characteristic swamp and riparian elements of the Pannonian, e.g. *Glyptostrobus europaeus*, *Byttneriophyllum tiliifolium*, *Salix varians*, *Ulmus braunii*, *Acer tricuspidatum* and *Platanus leucophylla* were recorded, as well. In the flora of Bystricka, zonal elements are proved by *Parrotia pristina*, *Zelkova zelkovifolia*, *Quercus kubinyii*, *Fagus*, and *Carpinus* but the typical Pannonian wetland elements are almost missing from the assemblage with just few species shared by the basin floras, e.g. *Acer tricuspidatum*, *Myrica lignitum* and *Cercidiphyllum crenatum*. The flora of Priekopa is characterized by the presence of *Alnus*, *Fagus*, *Quercus* and *Ulmus*. In conclusion, fossil records of the Turiec Basin demonstrate a flora and vegetation definitely distinct from floristic data of the Pannonian Basin, and comprise high ratio of zonal elements, the majority of which played significant role in the Pannonian Basin during the Sarmatian. Nevertheless, assemblages indicating the Pannonian type swamp habitats are also known from Slovakia, e.g. Ihráč near Kremnica (Körmöcbánya; collection of the Slovakian National Museum, Bratislava/Pozsony), with typical taxa of swamp habitats, i.e. *Glyptostrobus*, *Alnus* and *Banisteriaecarpum giganteum*. In the same region, a flora in the Žiar Basin (SITAR 1994) provides another example of Pannonian swamp vegetation with *Glyptostrobus*, *Alnus menzelii*, *Alnus* sp., *Byttneriophyllum tiliifolium* and *Salix varians*. WOROBIEC G. & KASIŃSKI (2009) published a flora based on dispersed cuticles from southern Poland (Lower Silesia, Ruja lignite deposits), which comprises taxa, e.g. *Osmunda parschlugiana*, *Glyptostrobus europaeus*, *Alnus julianiformis*, *Byttneriophyllum tiliifolium*, *Myrica lignitum* and *Salix varians*, all shared by Late Miocene floras of the Pannonian Basin. This flora is dated as Middle Miocene; however, this may be erroneous due to unclear stratigraphic settings.

The flora of Sośnica (Southwest Poland, Silesia) is dated as definitely Pannonian by a recent revision (WALTHER & ZASTAWNIAK 2005). This flora represents plant cover outside the Pannonian Basin. Species were recorded that were frequent elements of Sarmatian floras in the Pannonian Basin, but disappeared or became relict elements by the Pannonian, i.e. *Zelkova zelkovifolia*, *Parrotia pristina*, *Populus balsamoides* and *Taxodium dubium*. At the same time, there are numerous taxa shared by coeval floras of the Pannonian Basin, i.e. *Ulmus carpinoides*, *Platanus leucophylla*, *Liquidambar europaea*, *Salix varians*, *Acer subcampestre*, *Populus populina*, *Acer tricuspidatum* and *Trapa silesiaca*. Distinctive elements of this flora are *Acer aegopodipholium*, *Quercus gigas* (GÖPPERT 1855), *Fagus silesiaca* and *Vitis strictum*, which were not recorded in floras of the Pannonian Basin. Stróża (Striese) is a less known locality in Silesia with records of *Byttneriophyllum tiliifolium*, *Alnus cecropiifolia*, *Salix* sp. and *Populus* sp. (collection of IB PAN Cracow). This flora yielded taxa favouring swamp habitats, similarly to the Pannonian Basin floras, however, *Glyptostrobus*, a generally dominant element of the latter floras is not shared by the assemblage from Stróża. The survey of floras clearly indicates that the typical swamp vegetation of the basin is definitely represented by the northern margin of the Pannonian Basin, however, numerous zonal elements that seemed to withdraw from basinal floras, are still present in marginal assemblages.

By the north-eastern margin of the basin, in Transcarpatia, Ukraine the characteristic Pannonian floras were described (ILJINSKAJA 1968) with elements of swamp habitats, i.e. *Glyptostrobus europaeus*, *Byttneriophyllum tiliifolium*, *Alnus* div. sp. and fern species known from similar assemblages. A riparian association dominated by *Liquidambar europaea* and *Platanus leucophylla* was also documented here. These assemblages and the basin floras share numerous species; however, the presence of *Zelkova zelkovifolia*, *Parrotia pristina*, and *Rosa* sp. suggests a refuge of zonal elements that withdrew from the basin.

The well-known, Late Miocene flora of Borszék from Romania, by the eastern margin of the basin, indicates the survival of zonal elements based on the occurrence of *Zelkova zelkovifolia*, *Rosa* sp. and the high number of specimens assigned to *Quercus kubinyii*.

From Serbia, the southern margin of the Pannonian Basin, three Late Miocene floras were published (Late Pontian, MIHAJLOVIČ & LAZAREVIČ 1999). From the lignite mine of Kolubara a flora comprising *Glyptostrobus europaeus*, *Magnolia cunneifolia*, *Sassafras ferretianum*, *Byttneriophyllum tiliifolium*, *Quercus gigas*, *Acer tricuspidatum*, and Betulaceae was described. The flora is dominated by *Glyptostrobus*, *Magnolia* and Betulaceae. The authors reconstructed an intrazonal association in swamp habitat. There are no records of similar floristic composition among the Hungarian assemblages; however, a feature shared by the flora of Balatonszentgyörgy is the dominance of *Glyptostrobus*, and the presence of *Magnolia* and *Acer*, although these two latter genera were described as different species. The single occurrence of *Sassafras* has been documented from this assemblage, which demonstrates its survival by the southern margin of the basin. Later, during the Pliocene it reappeared in the basin floras as it is evidenced by its record from Gérce (HABLY & KVAČEK 1997). Another Pontian flora from Serbia comprising elements of the swamp vegetation was described from the brown coal mine by Kostolac (MIHAJLOVIČ & LAZAREVIČ 1999). This assemblage recalls the characteristic Pannonian vegetation of swamp habitats with records of *Glyptostrobus europaeus*, *Alnus cecropiifolia*, *Byttneriophyllum tiliifolium*, *Parrotia pristina*, *Fraxinus ungeri* and *Fagus krauseli*. The first three species played dominant role in the typical Pannonian floras, e.g. Dozmat (HABLY & KOVAR-EDER 1996), and in floras by the western boundary of Romania (GIVULESCU 1991). At the same time, a distinct character is the presence of *Parrotia*, which withdrew from the basin during the Pannonian but appeared by the southern basin margin, as well, in numerous localities. Remains of *Fraxinus* and *Fagus* have rarely been recorded in localities inside the basin. Riparian vegetation is also represented by the southern margin, in Serbia. The locality by Grocka yielded an assemblage with records of *Ginkgo adiantoides*, *Daphnogene* sp., *Liquidambar europaea*, *Platanus leucophylla*, *Ulmus carpinoides*, *Zelkova zelkovifolia*, *Carpinus grandis*, *Alnus* sp., Betulaceae, *Fagus pliocenica*, *Quercus* div. sp., *Juglans acuminata*, *Salix varians*, *Populus* sp., Leguminosae, *Tilia* sp., *Acer subcampestre*, *Vitis teutonica* and *Smilax hastata* (MIHAJLOVIČ & LAZAREVIČ 1999). As it was already reflected by basin assemblages, riparian vegetation seems to be more diverse than swamp vegetation, and shares quite a lot species with the riparian vegetation inside the basin. Dominant elements of the riparian vegetation are present, i.e. *Liquidambar europaea*, *Platanus leucophylla*, *Ulmus carpinoides*, *Salix varians*, as well as *Juglans acuminata*, *Populus* sp., *Carpinus grandis*, and *Zelkova zelkovifolia*, which are rarely recorded elements. The occurrence of *Smilax* is also noteworthy. This genus, with *S. weberi* was recorded from the basin in the flora of Tihany (HABLY 1992a). Presumably, the southern margin of the basin served as a refuge of numerous species, since a higher ratio of thermophilous elements, e.g. *Magnolia*, *Daphnogene*, *Sassafras*, was recorded from assemblages located by the southern margin than from those in the basin or by the northern margin.

Pannonian vegetation of the Pannonian Basin

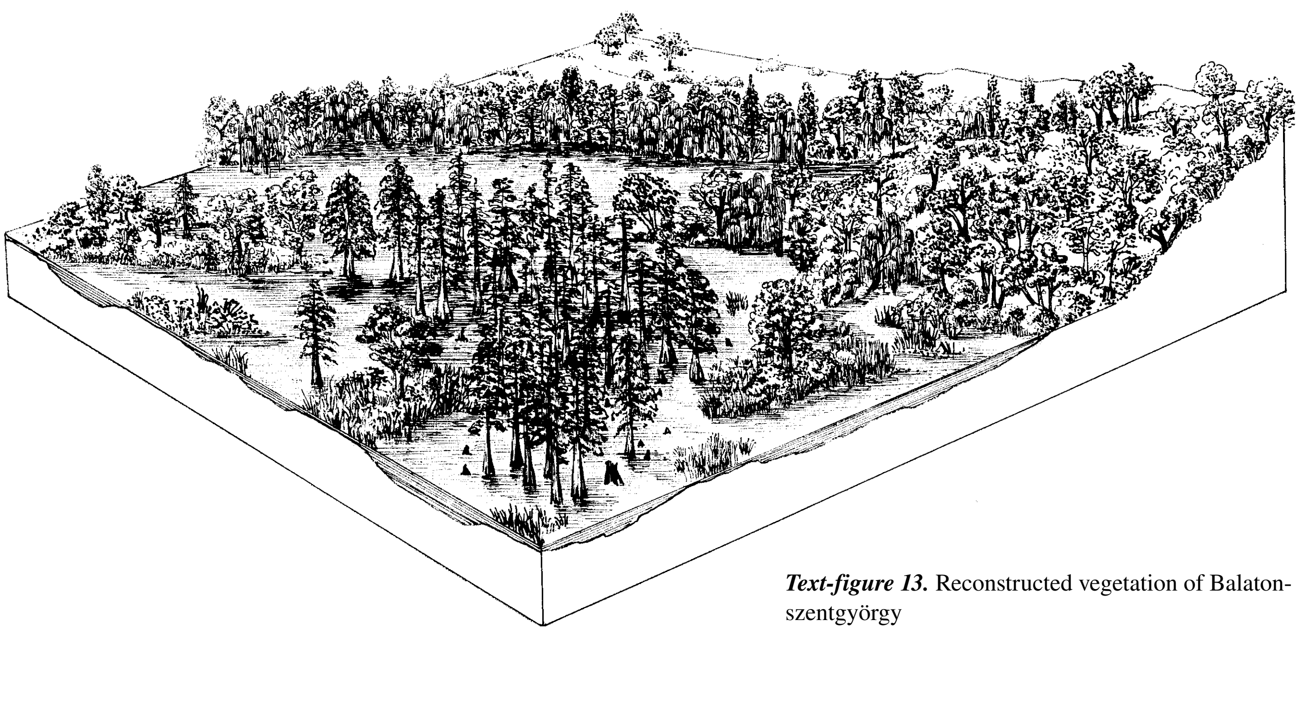
During the Pannonian less inundated, non-aquatic habitats must have been covered by dense forests. Extensive swamps were occupied by swamp forests, and rivers were fringed upon by gallery forests. Forests with pines of Mediterranean character flourished on higher levees, and rocky, elevated shores.

The unlimited availability of water and warm temperate conditions supported the formation of multilevel, dense forest vegetation. Pteridophytes, mainly ferns and horsetails thrived in the herbaceous level with the frequent occurrence of *Osmunda*, *Pronephrium* and *Pteris*. The shrub layer was composed of mainly *Byttneriophyllum* and occasionally *Myrica* in swamps. The crown layer of mixed forests was composed of some gymnosperms, i.e. *Glyptostrobus europaeus*, and angiosperms, e.g. species of *Alnus*, *Salix* and *Myrica*. The vegetation of older Pannonian was completed with additional species (see chapter "Pannonian flora of the Pannonian Basin").

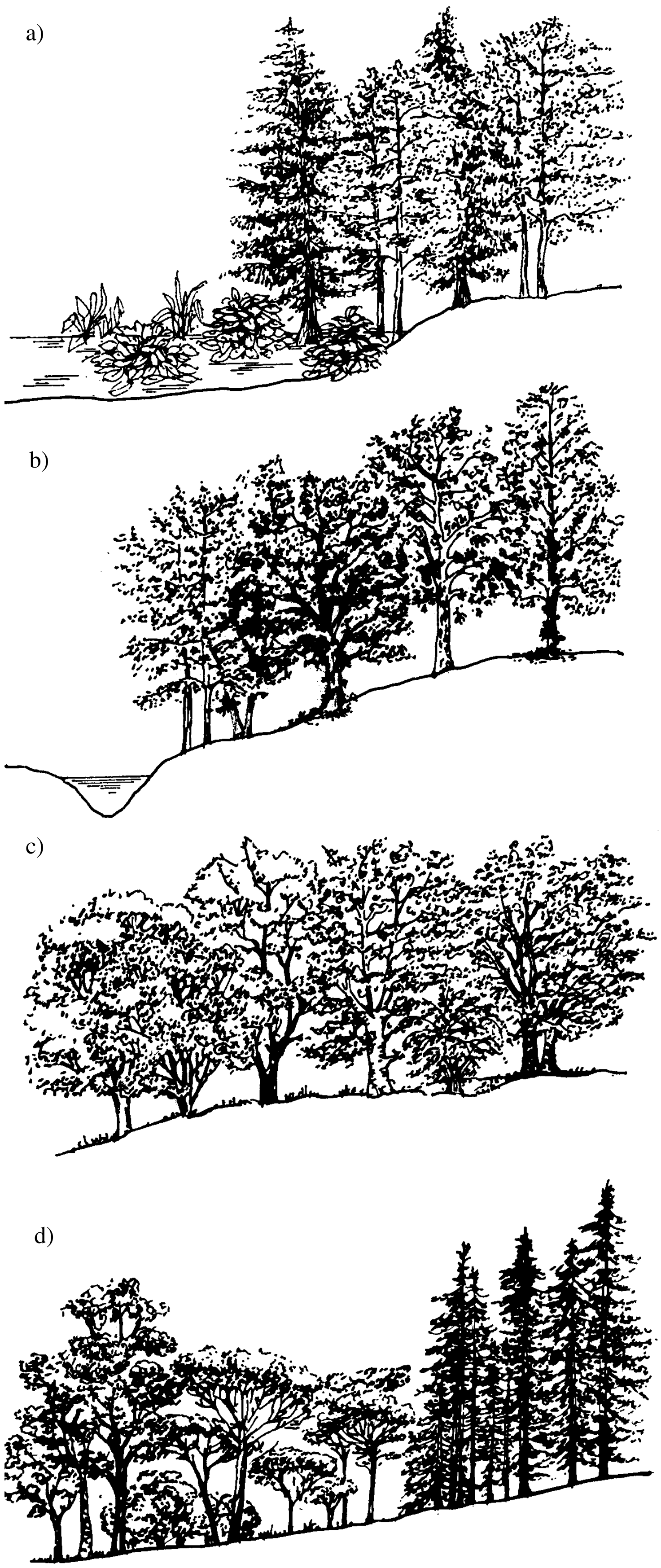
The crown layer of riparian forests was composed of *Platanus*, *Liquidambar*, *Ulmus*, *Alnus*, *Salix* and other genera. Occasionally, the liana layer is indicated, e.g. by *Smilax* in Tihany. Members of the shrub layer were primarily *Alnus*, *Salix* and *Ulmus*. Records suggesting the herbaceous layer are missing from assemblages that documents riparian forests.

In addition to the main dominant vegetation types, pine forests composed of *Pinus* and *Picea* are also assumed, developing occasionally in drier habitats, on rocky slopes and outcrops far from the banks. Remains of these forests are documented in Mindszentkálla and Diszel - Kula Hill. Occasionally, e.g. in Mindszentkálla, the pine forest was mixed with broadleaved deciduous taxa, mainly *Platanus*.

Aquatic vegetation was described from permanently inundated, open water habitats mainly in the foothills of the Mátra and Bükk Mts. In addition to aquatic floating and submerged plants, sedges favouring habitats on swampy meadows or banks were also described, e.g. *Carex*.



Text-figure 13. Reconstructed vegetation of Balatonszentgyörgy



Text-figure 14. Vegetation in the Pannonian basin during the Pannonian age. Swamp (a), riparian (b), mesophytic forest (c), mixed-mesophytic forest with pines (d)

Mesophytic forest vegetation is scarcely encountered inside the basin. These forests withdrew from the basin due to extensively inundated areas by Lake Pannon and persisted in refuges, e.g. in elevated so-called "inselbergs". Mesophytic forest vegetation is indicated by remains of *Quercus kubinyii* and *Fagus* in Alcsút, Aranyosgadány, Hosszúpereszteg and Sé.

By the lake margin, however, mesophytic forests must have been present, which is supported by the floras of Mataschen (KOVAR-EDER & HABLY 2006), Paldau (GROSS 1998, KRENN 1998), and the Turiec Basin (SITAR 1969, 1982) comprising numerous, often thermophilous elements assumed to represent mesophytic vegetation.

As it was discussed above, main part of the Pannonian Basin was covered by dominantly intrazonal or azonal, edaphic associations during the Late Miocene, which was obviously determined and influenced by the formation of Lake Pannon. Zonal associations were just fragmented remnants of the former extensive mesophytic forests.

Vegetation was reconstructed adopting a quantitative method that uses "pfts" (plant functional types) (ERDEI et al. 2013). It is the main advantage of the method that results obtained by establishing "pft" groups enable direct comparisons with potential vegetation distributions simulated by dynamic vegetation models (e.g. CARAIB: CARbon Assimilation In the Biosphere, dynamic vegetation modell, FRANCOIS et al. 2011). Taxa, present at the various sites are assigned to one or more model classes (plant functional types, pft) based on the morphological and physiological traits of their modern relatives. Finally, a fossil plant assemblage may be characterized by a "pft" distribution or spectrum. The "pft" spectra are comparable, and "pft" categories may be grouped according to the study design, e.g. evergreen/deciduous,needleleaved/ broadleaved, warm temperate / cool temperate, xerophytic, etc., furthermore, biomes may be defined applying "pfts".

Compared to earlier studies where 13 (UTESCHER et al. 2007) and 15 "pft" groups (FRANCOIS et al. 2011) were applied, a more detailed "pft" scheme (40 "pft" categories) is adopted. Grouping of "pfts" considers growth froms (tree, shrub, herb) and nonzonal, e.g. wetland elements, to approximate the intrazonal "impact" of the individual assemblages. Late Miocene vegetation of the Pannonian Basin was reconstructed as vegetation layers for five time slices, and was put in a palaeogeographic context. The palaeogeographic background was set by a series of detailed palaeogeographic maps published by MAGYAR et al. (1999). Maps represent configurations at 10.8, 9.5, 9.0, 8.0, and 6.5 Ma, respectively, thus, document the extension and shrinkage of Lake Pannon during the Late Miocene.

The ratio of evergreen “pfts” indicates a weak temporal decrease by the end of the Miocene, which may be explained by the slightly lower values of mean annual temperature (lower values of coldest month temperature). The presence of evergreen elements is more pronounced far from the water mass of the lake, and more expressed by the southern and western marginal localities. The ratio of warm temperate elements seems nearly unchanged during the Early and younger Late Miocene. Its nearly insignificant decrease coincides with the largest extension of the lake, and this may be attributed to the influence of the huge water mass. The slight climate change outlined by climate reconstructions had no observable impact on the ratio of warm and cool temperate elements. Results of quantitative climate reconstructions (ERDEI et al. 2007) assume a 0.5–1.0 °C decrease of the upper limit of mean annual temperature interval by the Pliocene. Climate analyses of the Late Miocene floras of the Pannonian Basin estimated broad intervals, which, however, do not contrasts earlier results calculated for the late Middle Miocene and Pliocene (ERDEI et al. 2013).

Late Miocene climate in the Pannonian Basin

The Late Miocene is known to have been a time of profound global climate change. Attempts to reconstruct the Late Miocene climate of the Pannonian Basin and its vicinity and to quantitatively estimate the mean annual temperature (MAT) and mean annual precipitation (MAP) were based on the botanical, palynological, and vertebrate record.

The Late Miocene climate of the Pannonian Basin is unequivocally described as warm temperate. With the application of the Coexistence Approach (Mosbrugger & Utescher 1977) to the Bükkábrány, Rózsaszentmárton, and Visonta floras and to the Hidas palynological record (all based on former literature), the MAT is estimated to have been 14–16 °C (Bruch et al. 2006). From the comparison of Sarmatian and Pliocene floras, Erdei et al. (2007) suggested that the MAT gradually decreased during the Late Miocene from 15 °C to 13 °C. Nagy (2005) also calculated 13 °C based on the palynological record from several boreholes in Hungary. The flora of the Early Pannonian Mataschen section from the Styrian basin, Austria, however, is inferred to indicate significantly higher temperatures (15–19 °C, Kovar-Eder & Hably 2006).

Estimates for the MAP in the Late Miocene Pannonian Basin show a considerably wide range, and sometimes include the interpretation of a temporal trend. Bruch et al. (2006) calculated 1020–1130 mm for the floras of the Bükkalja sequence. Erdei et al. (2007) predicted a slow decrease through the Late Miocene from 1000 to 900 mm. The Mataschen flora indicates extremely high MAP for the earliest Pannonian (1280–1950 mm, Kovar-Eder & Hably 2006). Based on the present-day relations between small-mammal community structure and rainfall, van Dam (2006) predicted the Late Miocene MAP of the Pannonian Basin as generally decreasing from 1235 mm to 589 mm between 10 and 6 Ma, showing a temporary peak of 1057 mm at 7 Ma. A similar aridification trend was outlined by Böhme et al. (2008) on the basis of the ecophysiological structure of herpetological assemblages (amphibians and reptiles). They found that in the early Late Miocene, the MAP gradually increased in the Pannonian Basin up to 1766 mm, then after 10 Ma a long-lasting decrease followed with 354 mm at the end of the Miocene.

Non-quantified changes in the Late Miocene climate (especially precipitation) of the Pannonian Basin were also inferred from patterns observed in large mammal hypsodonty (Fortelius et al. 2006), mammal diversity (Nargolwalla et al. 2006), land snail communities (Lueger 1978), and stable isotope records from mollusc shells (Mátyás et al. 1996, Harzhauser et al. 2007). Cyclic sedimentation in Lake Pannon and in the surrounding freshwater environments is often assigned to Milankovitch-scale climate changes (e.g. Juhász et al. 1997, Sprovieri et al. 2003, Sacchi & Müller 2004, Harzhauser et al. 2004, Juhász et al. 2007, Lirer et al. 2009).

The Pannonian Basin is covered mainly by intrazonal, edaphic associations (see chapter "Pannonian vegetation of the Pannonian Basin"), which are less relevant for the estimation of climate variables. At the same time, intrazonal elements are not independent of climate, and numerous taxa may be applied for the reconstruction of temperature variables. On the other hand floras comprising zonal elements were also recorded from the basin margin.

The Coexistence Approach method (Mosbrugger & Utescher 1997) follows the nearest living relative concept. Based on the climatic requirements of the nearest living relatives (NLRs) of fossil plant taxa in a fossil assemblage, it calculates "coexistence intervals" for various climate parameters allowing a maximum number of NLR taxa that co-exist. By means of parameter ranges the palaeoclimate can be characterized.

Two taxa, *Glyptostrobus europaeus* and *Byttneriophyllum tiliifolium*, dominating vegetation in swamp habitats are definitely thermophilous. Another species, "*Magnolia*" *szakmanycsabae*, which was recorded only sporadically, is presumed to require warm climate, as well. Similarly, some *Quercus* species, *Q. kubinyii*, *Q. pontica-miocenica* and *Q.* sp., showing relatively high abundance are also assumed to represent thermophilous elements. Records of *Mastixia amygdalaeformis* and *Daphnogene* sp. in Rudabánya and *Engelhardia macroptera* in Rózsaszentmárton indicate definitely warm periods. Based on the occurrence of *Mastixia*, the flora of Rudabánya is a member of the "younger mastixioid" floras, and a humid, warm temperate climate seems to be supported unambiguously.

Warm climatic conditions are also indicated by *Zelkova zelkovifolia*, *Parrotia pristina* and *Quercus kubinyii* (GÖPPERT 1855, ILJINSKAJA 1968, SITAR 1969, KOVAR-EDER & HABLY 2006), appearing still with high number of specimens in marginal floras. The most convincing evidence of warm climatic conditions is provided by the flora of Mataschen (KOVAR-EDER & HABLY 2006), in which a diverse set of thermophilous elements and numerous evergreen taxa were described. Records of *Magnolia liblarensis*, *Daphnogene polymorpha*, *Laurophyllum pseudoprinceps*, *L. pseudovillense*, *Laurus abhasica*, *Laurophyllum* sp., *Distylium heinickei*, *Symplocos rara*, *Gordonia emanuelii*, *G. pannonica* and *G. stiriaca*, all give support to prevailing warm climatic conditions. Based on this assemblage, climate analysis estimates a mean annual temperature of 15–19 °C, average temperature of the coldest month well above zero, and 1280–1950 mm mean annual rainfall. Along the southern marginal areas, in Serbian floras, the abundance of thermophilous elements was recorded, e.g. *Magnolia*, *Daphnogene* and *Sassafras* (MIHAJLOVIČ & LAZAREVIČ 1999).

According to the climate reconstruction based on most of the published fossil floras in the Pannonian Basin and nearby marginal areas, the mean annual temperature is estimated between 10–16 °C. The broad intervals are attributable to the relatively low diversity of the assemblages. Values of the mean temerature of the coldest month indicate a frostless climate and an annual range of temperature less than 20 °C. Mean annual rainfall was reconstructed between 700–1300 mm (ERDEI et al. 2007, 2013). Thus, climate must have been warming temperate, a much warmer one than today.

Consequently, changes of the Pannonian flora and vegetation must have been evoked primarily by the significant habitat change related to the development of Lake Pannon, and not by the deterioration of climate. This is corroborated by the reappearance of numerous mesophytic elements during the Pliocene (HABLY & KVAČEK 1997), which following the shrinkage of Lake Pannon could spread from refuges and reoccupy their former habitats inside the basin, e.g. *Zelkova zelkovifolia* and *Quercus kubinyii* in the Pliocene floras of Gérce and Pula (HABLY & KVAČEK 1997). Nevertheless, the former species-rich Sarmatian flora and vegetation of the Pannonian Basin could not reappear with the same level of diversity after the late Miocene.

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Appendix

	Alcsút	Aranyosgadány	Balatonszentgyörgy (older flora)	Balatonszentgyörgy (younger flora	Bükkábrány	Cserszegtomaj	Diszel-Hajagos	Dozmat	Felsőtárkány	Gyöngyös	Győr-Sashegy	Hatvan	Hévíz	Hosszúpereszteg	Iharosberény	Karmacs	Kerecsend	Mindszentkálla	Pécs-Danitzpuszta	Pécs-Nagyárpád	Rózsaszentmárton	Rudabánya	Sé	Sótony	Tard	Tihany	Tiszapalkonya	Visonta
Selaginella sp.																												x
Equisetum sp.				x																	x							x
Pronephrium stiriacum (Unger) Knobloch & Kvaček				x					x														x					x
Osmunda parschlugiana (Unger) Andreánszky				x				x	x						x							x	x					x
Salvinia cf. *intermedia*																												x
Pteridophyta gen. et sp.																	x											
Ginkgo adiantoides					x												x				x	x						x
Glyptostrobus europaeus			x	x	x			x	x						x		x				x	x	x				x	x
Glyptostroboxylon sp.					x																							
Taxodioxylon germanicum					x																							x
Pinus sp.																		x			x							x
Tsuga sp.																												x
Picea sp.																		x										x
Abies sp.																												x
"Magnolia" szakmanycsabae			x	x																								
Magnolia sp. 1.									x																			
Liriodendron sp.																												x
Ranunculus sp.																												x
Nymphaea szaferi																												x
Nuphar palfalvyi																												x
Nymphaeaceae gen. et sp.																											x	

	Alcsút	Aranyosgadány	Batatonszentgyörgy (older flora)	Balatonszentgyörgy (younger flora	Bükkábrány	Cserszegtomaj	Diszel-Hajagos	Dozmat	Felsőtárkány	Gyöngyös	Győr-Sashegy	Hatvan	Hévíz	Hosszúpereszteg	Iharosberény	Karmacs	Kerecsend	Mindszentkálla	Pécs-Danitzpuszta	Pécs-Nagyárpád	Rózsaszentmárton	Rudabánya	Sé	Sótony	Tard	Tihany	Tiszapalkonya	Visonta
Pseudoeuryale cf. *dravertii*																												x
Ceratophyllum dubium					x																							x
Lycopus cf. *europaeus*																												x
Decodon gibbosus																												x
Actinidia faveolata																												x
Oenanthe sp.																												x
Liquidambar europaea	x										x			x									x			x		
Platanus leucophylla	x						x			x	x		x	x		x							x			x		
Platanus sp. fruit														x														
Fagus haidingeri	x																			x	x							
Fagus decurrens																												x
Quercus kubinyii	x	x												x									x					
Quercus sp.														x						x								x
Quercus sp. fructus									x					x														
Quercus pontica-miocenica									x																			
cf. *Prunus* sp.																												x
Alnus cecropiifolia								x							x		x										x	
Alnus menzelii				x	x				x													x	x			x		
Alnus julianiformis				x																								
Alnus ducalis																										x		
Alnus gaudini	x			x				x														x				x		
Alnus sp.			x	x	x							x		x	x	x	x				x						x	x
Alnus sp. cones					x			x																				x
Alnus sp. male catkins					x			x	x													x						
Carpinus grandis																						x						
Carpinus sp. ex gr. *betulus*																												x
Betulaceae gen. et sp.					x																							
Myrica lignitum			x												x	x			x				x					
Ulmus carpinoides											x			x														
Ulmus braunii									x					x		x					x					x	x	
Ulmus sp.					x							x									x	x						
Ulmus sp. fructus																					x							
Ulmaceae gen. et sp.																					x							
Juglans acuminata																										x		
Engelhardia macroptera																					x							
Pterocarya sp.					x																							x
Trapa pannonica																					x							
Trapa praehungarica					x																							
Trapa silesiaca																						x						
Trapa rozsaszentmartoni																					x							
Acer subcampestre											x			x								x					x	
Acer vindobonensis																					x	x						

	Alcsút	Aranyosgadány	Batatonszentgyörgy (older flora)	Balatonszentgyörgy (younger flora	Bükkábrány	Cserszegtomaj	Diszel-Hajagos	Dozmat	Felsőtárkány	Gyöngyös	Győr-Sashegy	Hatvan	Hévíz	Hosszúpereszteg	Iharosberény	Karmacs	Kerecsend	Mindszentkálla	Pécs-Danitzpuszta	Pécs-Nagyárpád	Rózsaszentmárton	Rudabánya	Sé	Sótony	Tard	Tihany	Tiszapalkonya	Visonta
Acer jurenakii			x																							x		
Acer tricuspidatum									x											x	x						x	
Acer sp. fructus			x						x		x											x						
Tilia sp. ?						x																						
Byttneriophyllum tiliifolium					x			x	x						x		x				x	x			x		x	x
Banisteriaecarpum giganteum								x														x						
Ilex sp.																												x
Cornus cf. *gorbunovii*																												x
Nyssa disseminata																						x						x
Sambucus pulchella																												x
Meliosma cf. *wetteraviensis*																												x
Dicotylophyllum jungii			x																									
Caldesia cf. *cylindrica*																												x
Stratiotes tuberculatus																						x						x
Stratiotes sp.					x																							
Potamogeton martinianus																					x	x						
Potamogeton sp. div.					x																							x
Smilax weberi																										x		
Musophyllum tárkányense									x																			
Spirematospermum wetzleri					x																							x
Carex sp.					x																							x
Monocotyledonae sp. 1.			x																									
Monocotyledonae gen. et sp.			x	x					x		x				x	x	x	x			x		x	x		x	x	x
Cercidiphyllum crenatum			x						x		x											x						
Leguminosae gen. et sp.																		x										
Hartziella miocenica																												x
Vitis szakmanygyorgyi			x	x																								
Vitis sp.											x																	
cf. *Stuartia beckerana*																												x
Salix varians	x		x						x					x	x		x			x	x	x	x	x		x	x	x
Salix sp. fruit capsule			x																									
Salix sp. 1.			x																									
Salix sp. bud																												x
Populus populina																x				x			x					
Zelkova zelkovifolia					x																	x						
Daphnogene sp.																						x						
Cercidiphyllum sp. fructus									x													x						
Mastixia amygdalaeformis																						x						
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Plates

Plate I

1. *Equisetum* sp., Balatonszentgyörgy, BP 2008.307.2.
2. *Pronephrium stiriacum* (Unger) Knobloch & Kvaček, Balatonszentgyörgy, BP 2008.297.2.
3. *Pronephrium stiriacum* (Unger) Knobloch & Kvaček, Felsőtárkány, BP 71.14.1., holotype of *Pteris palaeoaurita* Kovács; Kovács, p. 434, text.-figure 2., original of *Pteris* cf. *biaurita* L.; Kubát & Bubik, p. 44, pl. 13. Figure1.
4. *Pronephrium stiriacum* (Unger) Knobloch & Kvaček, Balatonszentgyörgy, BP 2008.295.2.
5. *Pronephrium stiriacum* (Unger) Knobloch & Kvaček, Balatonszentgyörgy, BP 2008.297.2. (apical part of the leaf)
6. *Osmunda parschlugiana* (Unger) Andreánszky, Balatonszentgyörgy, BP 2008.275.1.

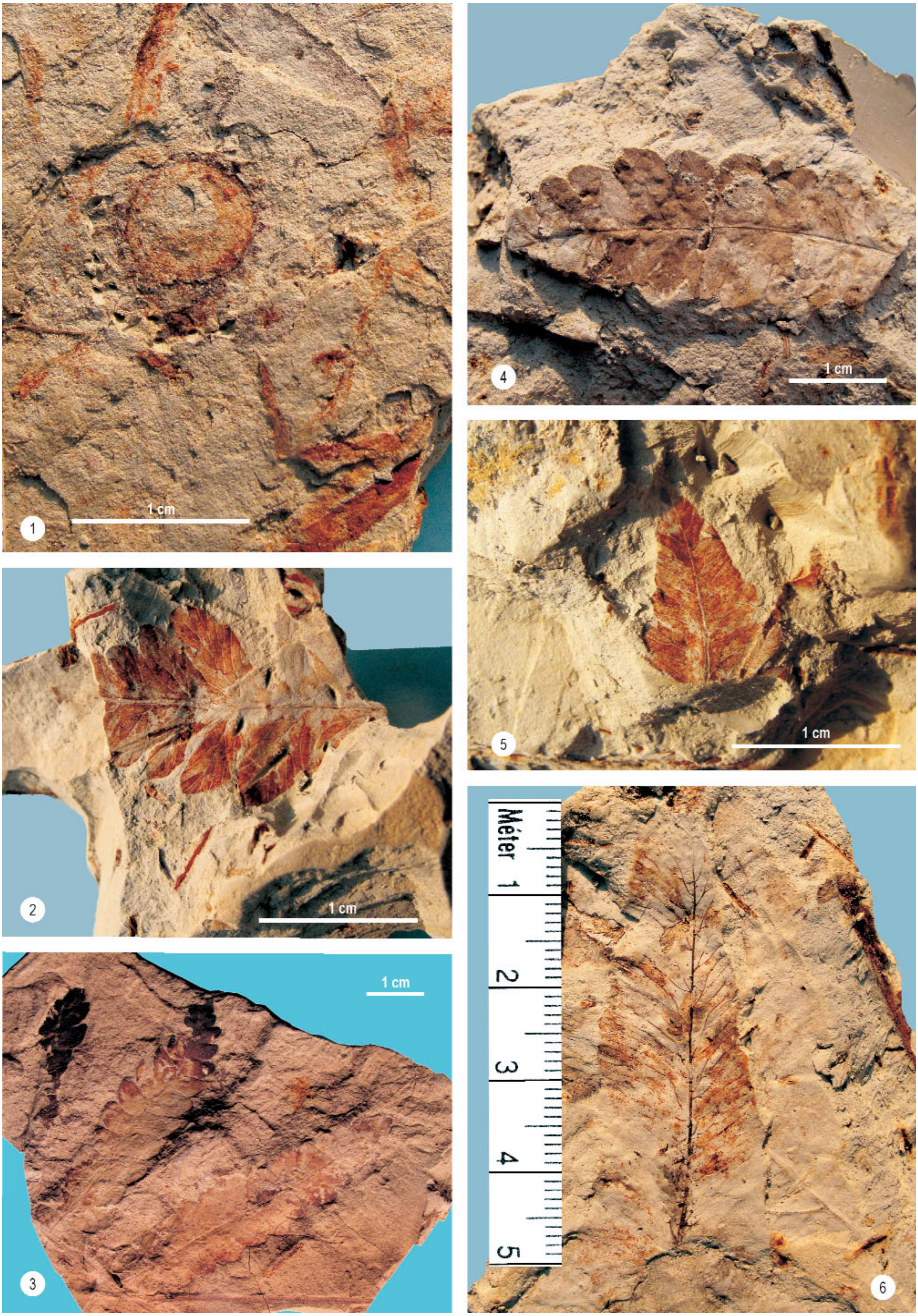

1
1 cm
2
1 cm
3
1 cm
4
1 cm
5
1 cm
6
Méter 1 2 3 4 5

Plate II

1. *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY, Balatonszentgyörgy, BP 2010.115.1.
2. *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY, Felsőtárkány, BP 55.1775.1.
3. *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY, Iharosberény, BP 2009.271.1.
4. *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY, Balatonszentgyörgy, BP 2008.288.1.
5. *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY, Felsőtárkány, BP 69.700.1. mass of leaves
6. *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY, Dozmat, BP 2005.65.1.

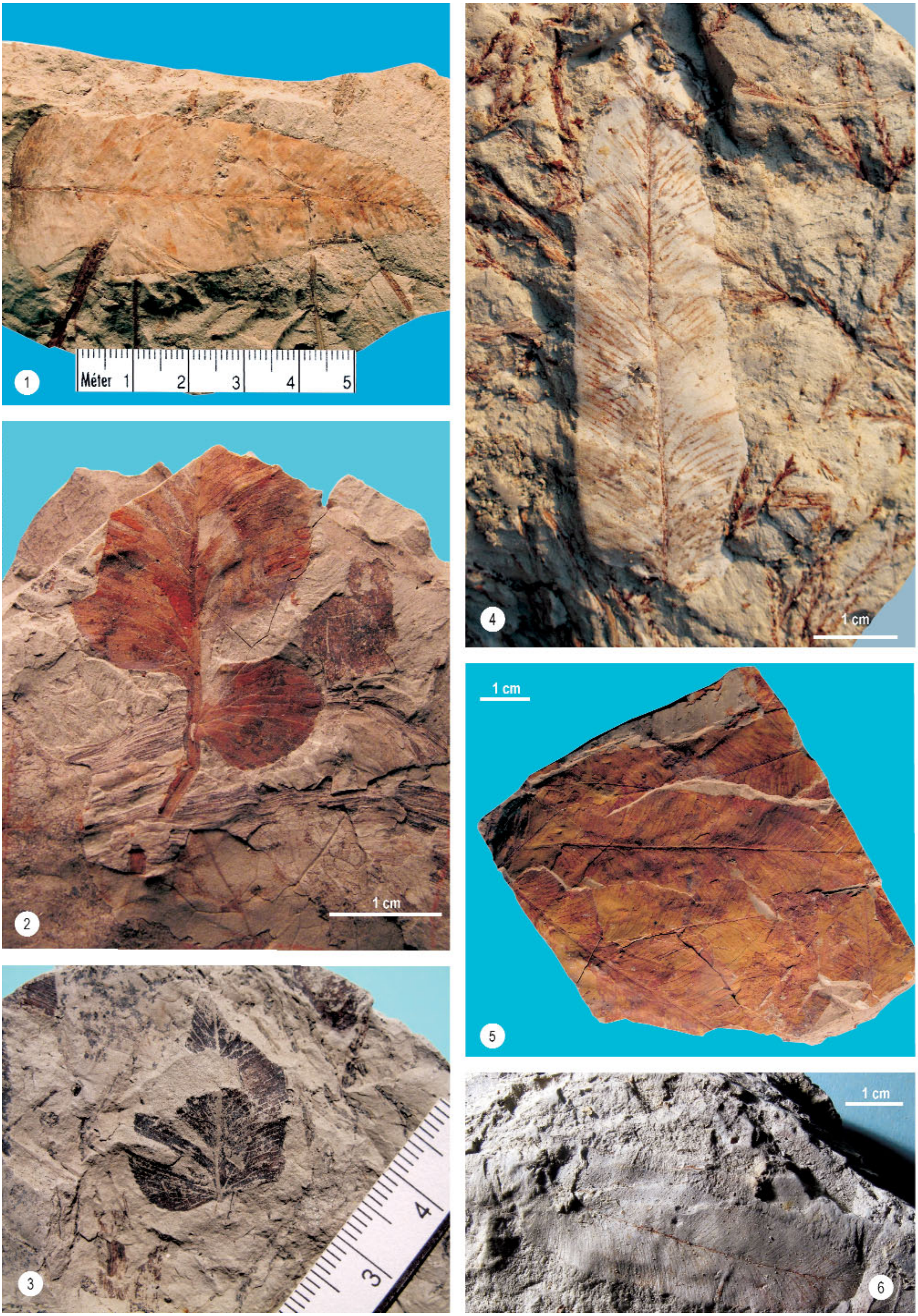

1
Méter 1 2 3 4 5
2
1 cm
3
4
1 cm
5
1 cm
6
1 cm

Plate III

1. *Ginkgo adiantoides* (UNGER) HEER, Rudabánya, BK–7
2. *Ginkgo adiantoides* (UNGER) HEER, Rudabánya, BK–7, lower cuticle, × 200
3. *Ginkgo adiantoides* (UNGER) HEER, Rudabánya, BK–7, lower cuticle, × 500
4. *Ginkgo adiantoides* (UNGER) HEER, Rudabánya, BK–7, upper cuticle, × 200
5. *Ginkgo adiantoides* (UNGER) HEER, Kerecsend, MM 6179
6. *Glyptostrobus europaeus* (BRONGNIART) UNGER, Balatonszentgyörgy, BK–1671, attached short and elongated leaves
7. *Glyptostrobus europaeus* (BRONGNIART) UNGER, Balatonszentgyörgy, BK–1498, separated seeds

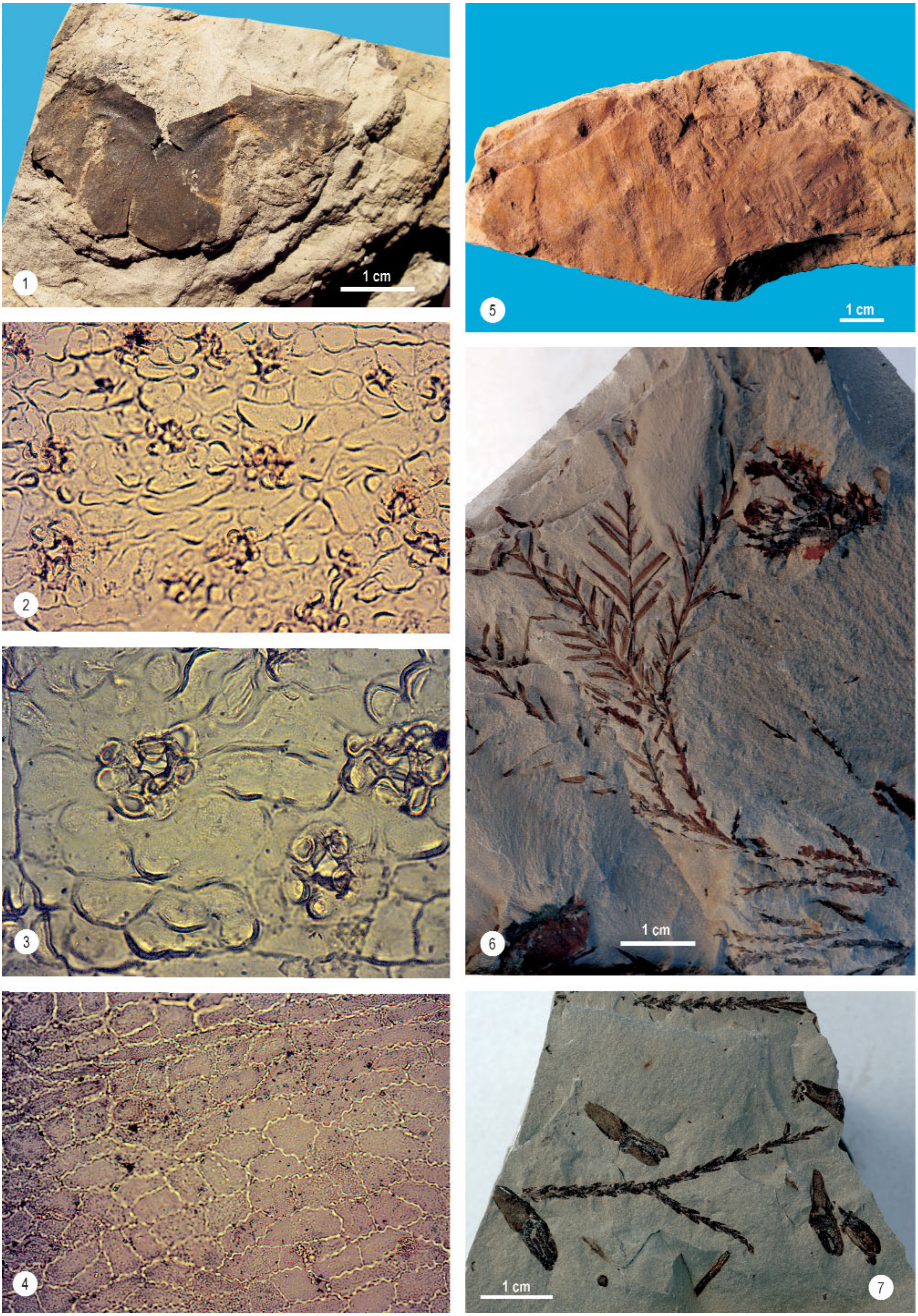

1
1 cm
5
1 cm
2
3
6
1 cm
4
1 cm
7

Plate IV

1. *Glyptostrobus europaeus* (BRONGNIART) UNGER, Balatonszentgyörgy, BK–1511, male cone
2. *Glyptostrobus europaeus* (BRONGNIART) UNGER, Balatonszentgyörgy, BP 2008.348.1., female cones
3. "*Magnolia*" *szakmanycsabae* sp. nov., holotype, Balatonszentgyörgy, BP 2011.128.1.
4. "*Magnolia*" *szakmanycsabae* sp. nov., Balatonszentgyörgy, BP 2011.133.1.
5. "*Magnolia*" *szakmanycsabae* sp. nov., Balatonszentgyörgy, BP 2011.139.2.
6. "*Magnolia*" *szakmanycsabae* sp. nov., Paldau, LMJ 78.270

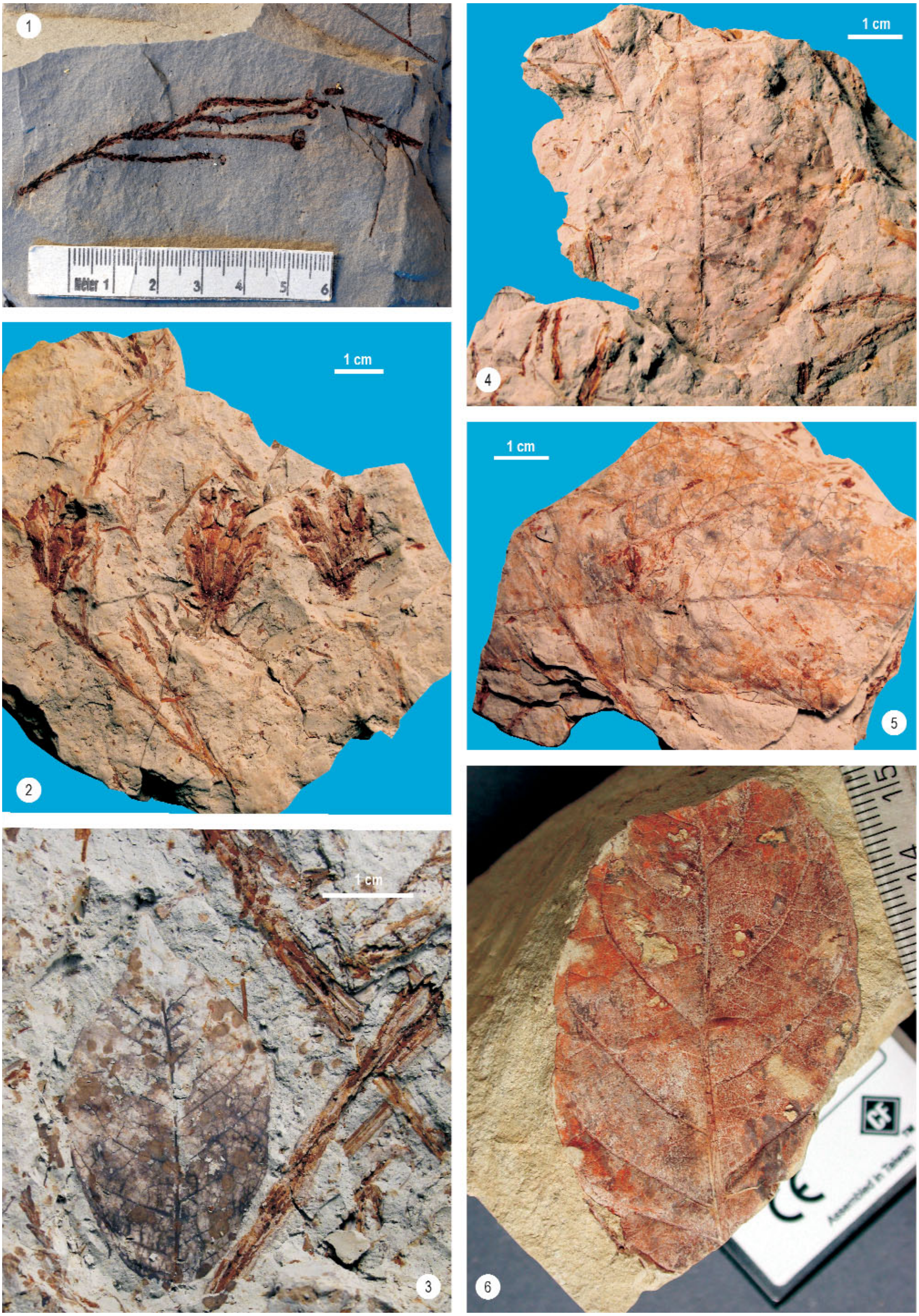

1
2
3
4
5
6
1 cm
1 cm
1 cm
1 cm

Plate V

1. "*Magnolia*" *szakmanycsabae* sp. nov., Paldau, LMJ 78. 142
2. Nymphaeaceae gen. et sp., Tiszapalkonya, BP 2009.349.1.
3. *Liquidambar europaea* A. BRAUN, Alcsút, BP 2009.429.2.
4. *Liquidambar europaea* A. BRAUN, Győr-Sashegy, SAMU 2008.9.82.
5. *Liquidambar europaea* A. BRAUN, Győr-Sashegy, SAMU 2008.9.128.
6. *Liquidambar europaea* A. BRAUN, Győr-Sashegy, SAMU 2008.9.1.
7. *Liquidambar europaea* A. BRAUN, Tihany, BP 85.204.2.

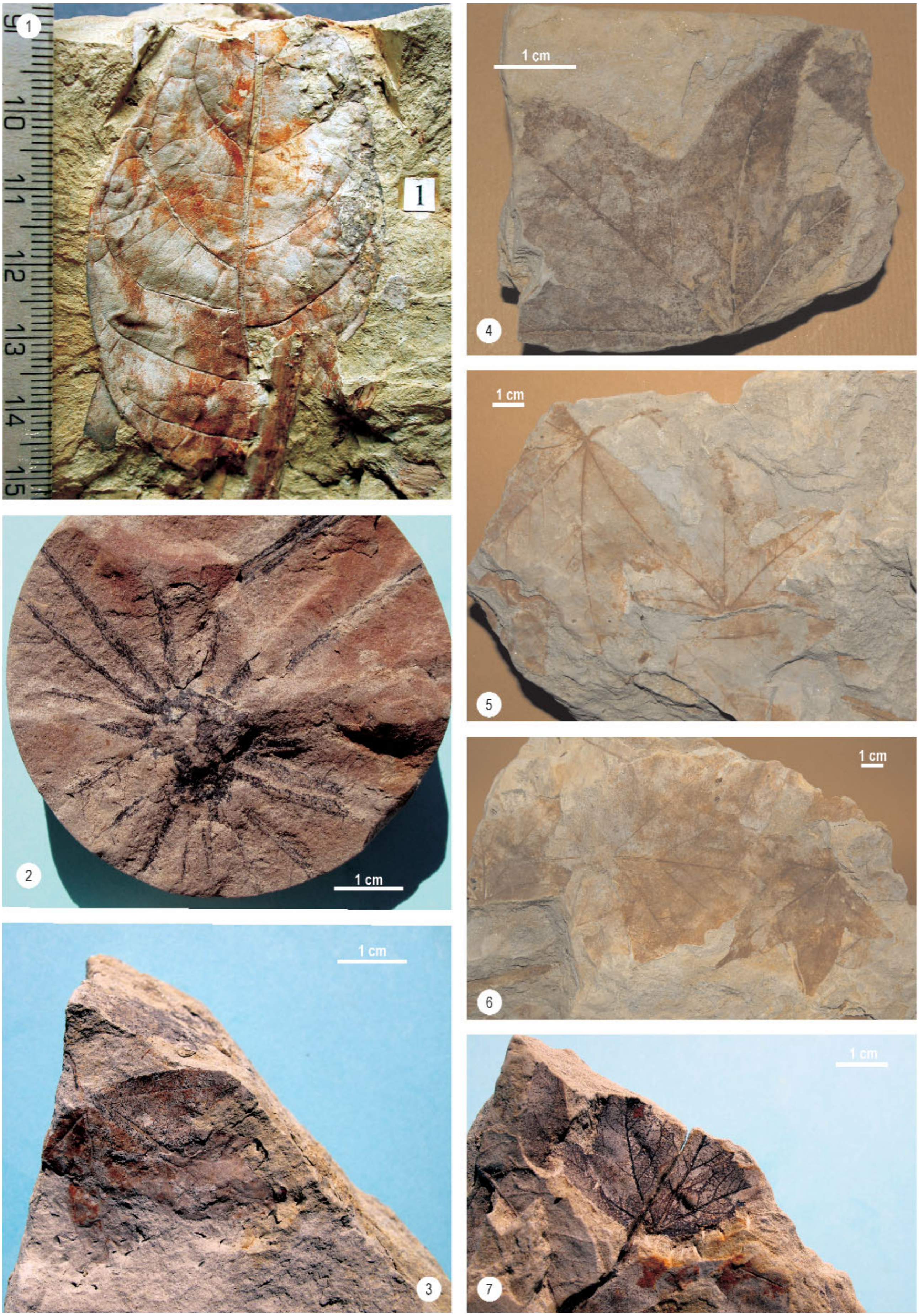

1
1
1 cm
4
1 cm
5
1 cm
6
2
1 cm
1 cm
3
1 cm
7

Plate VI

1. *Liquidambar europaea* A. BRAUN, Tihany, BP 85.161.1.
2. *Liquidambar europaea* A. BRAUN, Tihany, BP 85.149.1.
3. *Liquidambar europaea* A. BRAUN, Hosszúpereszteg, SAMU 86.13.541.2.
4. *Platanus leucophylla* (UNGER) KNOBLOCH, Alcsút, BP 2009.421.2.
5. *Platanus leucophylla* (UNGER) KNOBLOCH, Diszel-Hajagos, BP 2007.504.2.
6. *Platanus leucophylla* (UNGER) KNOBLOCH, Győr-Sashegy, SAMU 2008.9.21.

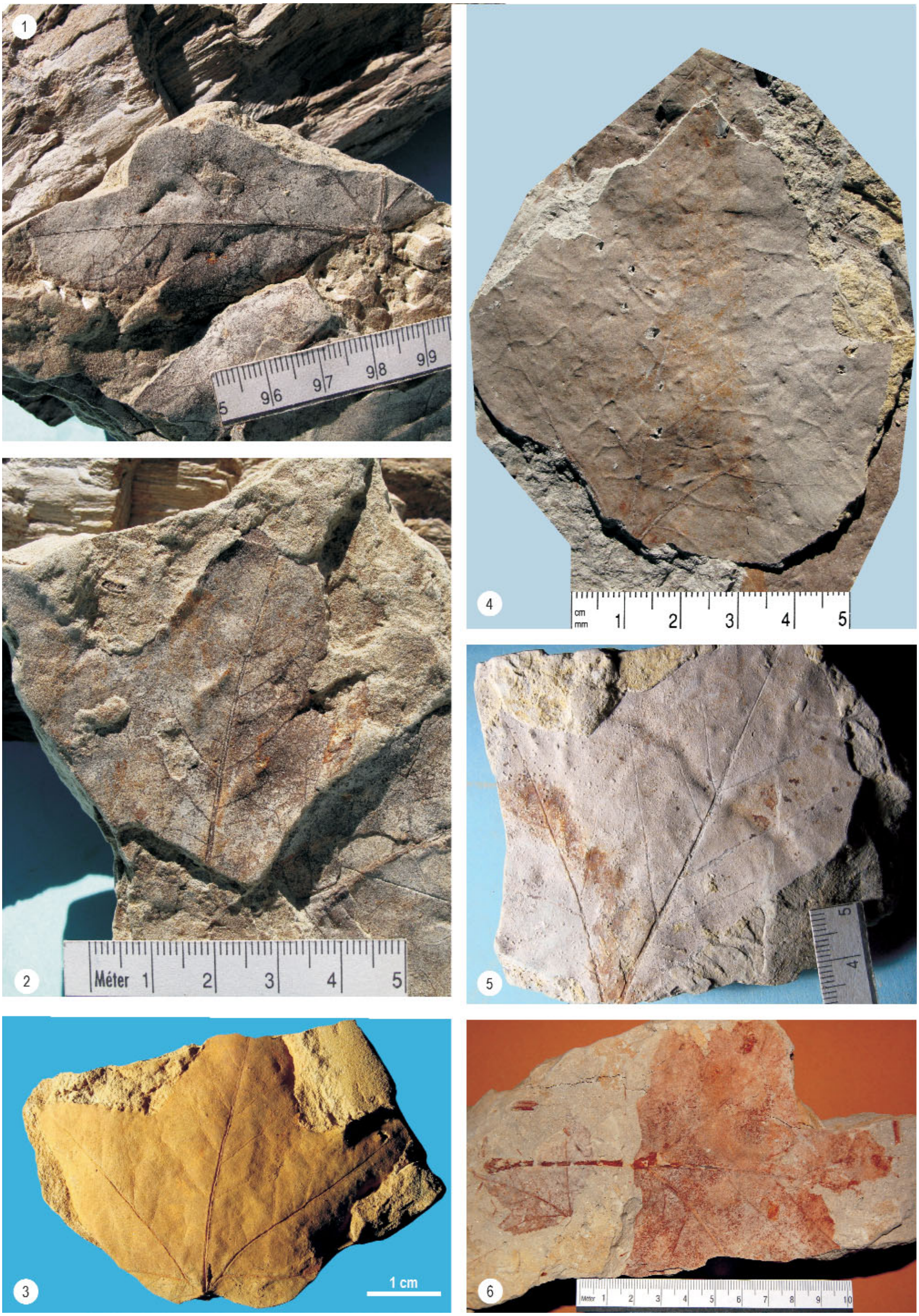

1
2
Méter 1 2 3 4 5
3
1 cm
4
cm
mm
6
Méter

Plate VII

1. *Platanus leucophylla* (UNGER) KNOBLOCH, Győr-Sashegy, SAMU 2008.9.27.
2. *Platanus leucophylla* (UNGER) KNOBLOCH, Győr-Sashegy, SAMU 2008.9.91.
3. *Platanus leucophylla* (UNGER) KNOBLOCH, Győr-Sashegy, SAMU 2008.9.91. base of a large leaf
4. *Platanus leucophylla* (UNGER) KNOBLOCH, Győr-Sashegy, SAMU 2008.9.126.
5. *Platanus leucophylla* (UNGER) KNOBLOCH, Karmacs, BP 2008.431.1.
6. *Platanus leucophylla* (UNGER) KNOBLOCH, Karmacs, BP 2007.489.1.
7. *Platanus leucophylla* (UNGER) KNOBLOCH, Karmacs, BP 2008.435.1.

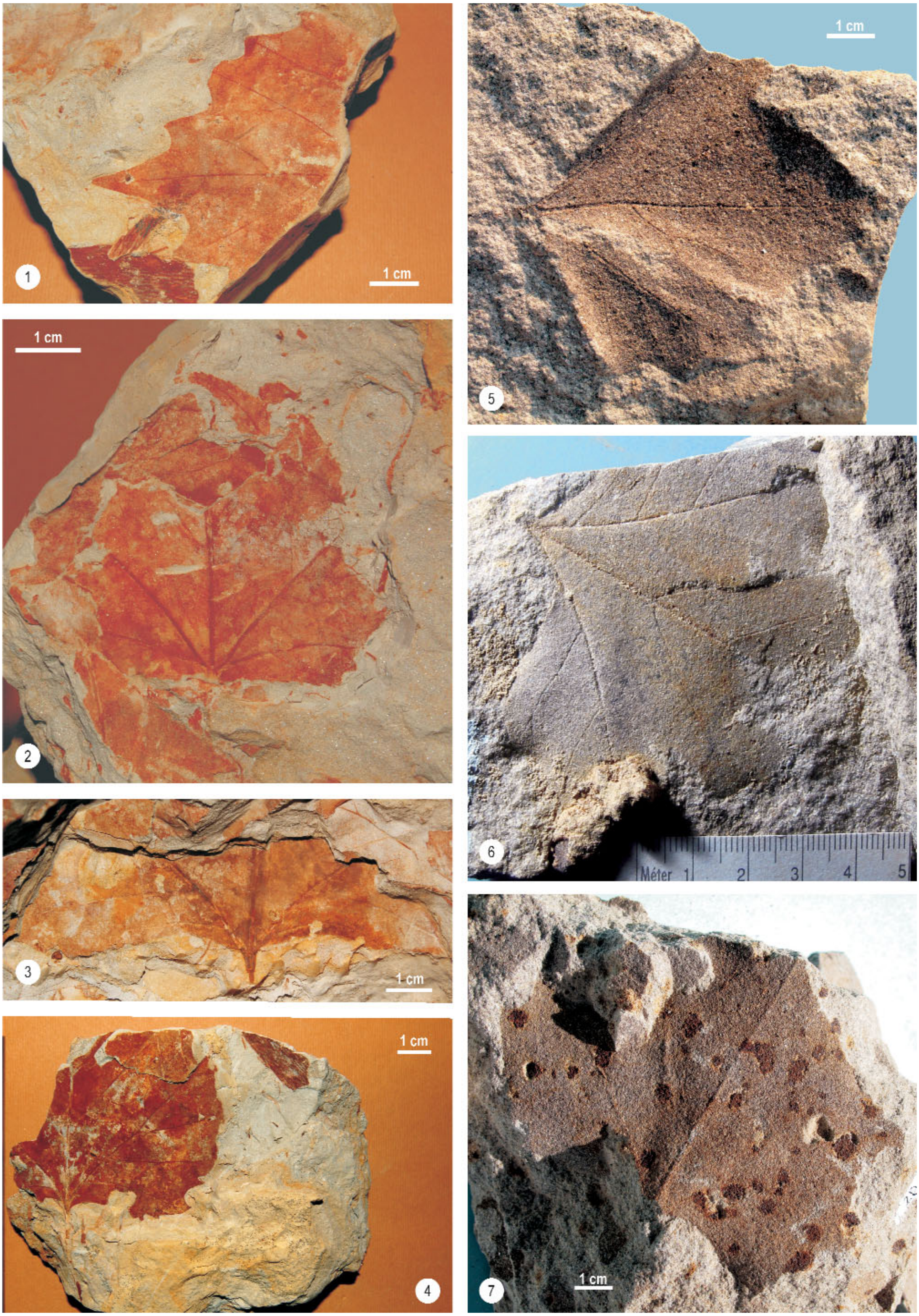

1
1 cm
2
1 cm
3
1 cm
4
1 cm
5
1 cm
6
Méter 1 2 3 4 5
7
1 cm

Plate VIII

1. *Platanus leucophylla* (UNGER) KNOBLOCH, Tihany, BP 85.192.3.
2. *Platanus leucophylla* (UNGER) KNOBLOCH, Tihany, BP 85.192.3.
3. *Fagus haidingeri* KOVÁTS emend. KNOBLOCH, Alcsút, BP 2009.427.2.
4. *Quercus kubinyii* (KOVÁTS ex ETTINGSHAUSEN) BERGER, Alcsút, BP 2009.422.3.
5. *Quercus kubinyii* (KOVÁTS ex ETTINGSHAUSEN) BERGER, Hosszúpereszteg, SAMU 86.13.1027.
6. *Quercus kubinyii* (KOVÁTS ex ETTINGSHAUSEN) BERGER, Hosszúpereszteg, SAMU 86.13.997.
7. *Platanus* sp. fructus, Hosszúpereszteg, SAMU 73.3.1565.

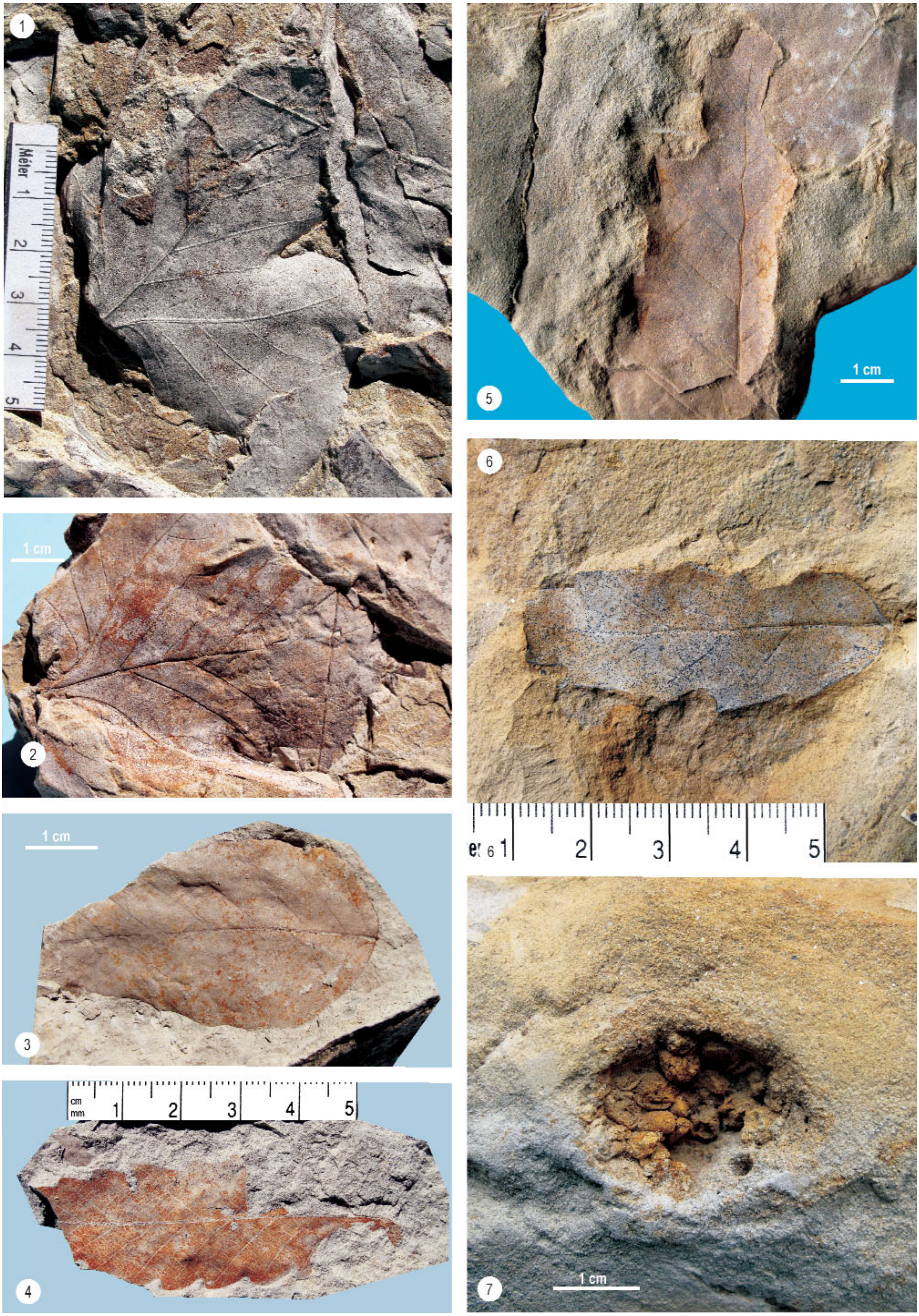

1
Méter
2
1 cm
3
1 cm
4
cm
mm
5
1 cm
6
7
1 cm

Plate IX

1. *Platanus* sp. fructus, Hosszúpereszteg, SAMU 73.3.1502.
2. *Platanus* sp. fructus, Hosszúpereszteg, SAMU 73.3.1497.
3. *Platanus* sp. fructus, Hosszúpereszteg, SAMU 73.3.1281.
4. *Platanus* sp. fructus, Hosszúpereszteg, SAMU 73.3.1575.
5. *Quercus* sp. fructus, Hosszúpereszteg, SAMU 86.13.1108.
6. *Quercus* sp. fructus, Hosszúpereszteg, SAMU 86.13.111.
7. *Quercus* sp. fructus, Felsőtárkány, BP 71.122.1.

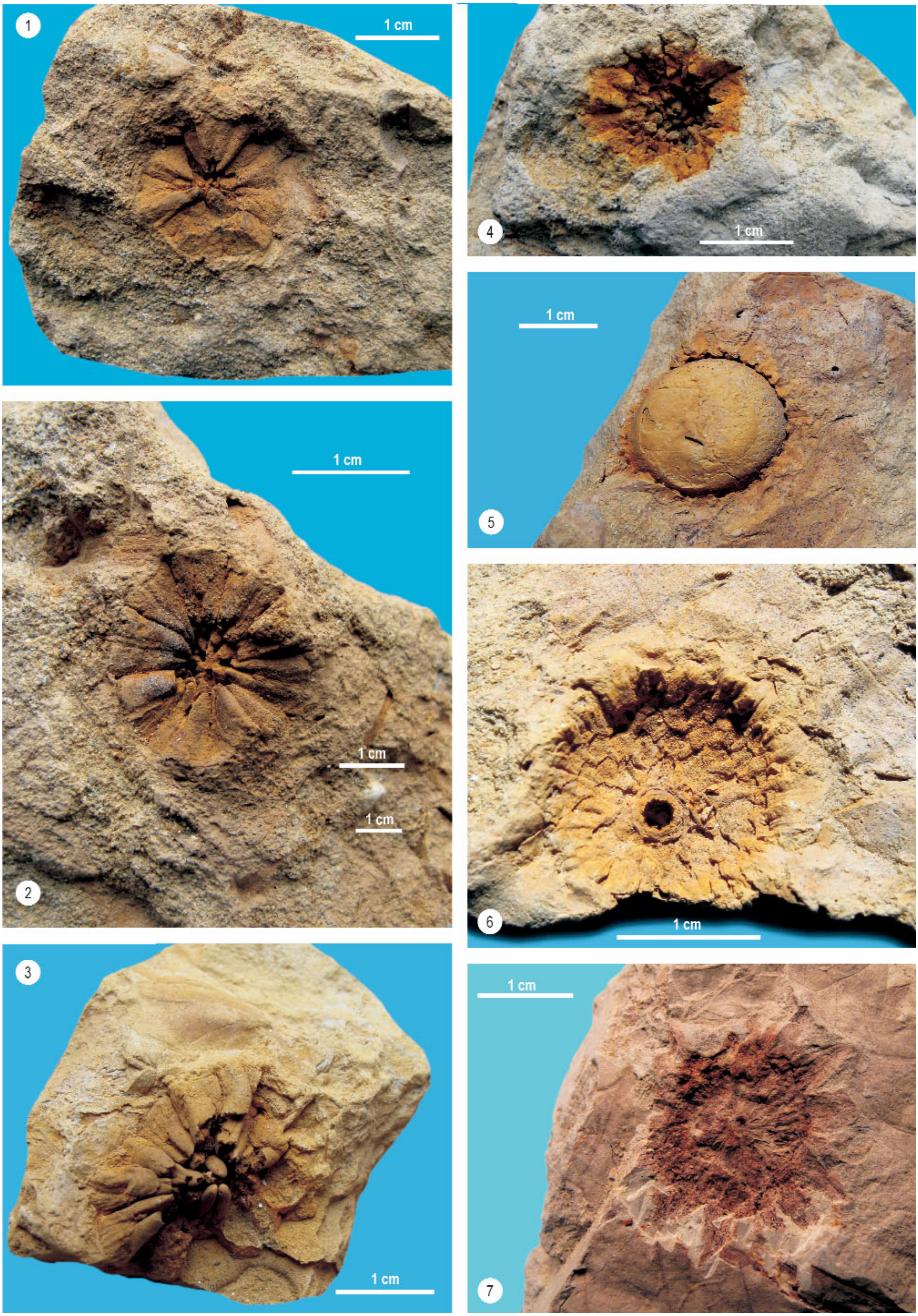

1
1 cm
2
1 cm
1 cm
1 cm
3
1 cm
4
1 cm
5
1 cm
6
1 cm
7
1 cm

Plate X

1. *Quercus pontica-mioce*nica KUBÁT, Felsőtárkány,MM 64.1080.1.
2. *Quercus pontica-miocenica* KUBÁT, Felsőtárkány,BP 69.754.1.
3. *Quercus pontica-miocenica* KUBÁT, Felsőtárkány,BP 69.786.1.
4. *Quercus pontica-miocenica* KUBÁT, Felsőtárkány,BP 60.1806.1.
5. *Quercus pontica-miocenica* KUBÁT, Felsőtárkány,BP 55.1965.1.
6. *Quercus pontica-miocenica* KUBÁT, Felsőtárkány,BP 60.1836.1.
7. *Alnus cecropiifolia* (ETTINGSHAUSEN) BERGER, Dozmat, BP 2005.35.1.
8. *Alnus cecropiifolia* (ETTINGSHAUSEN) BERGER, Dozmat, BP 2005.45.1.

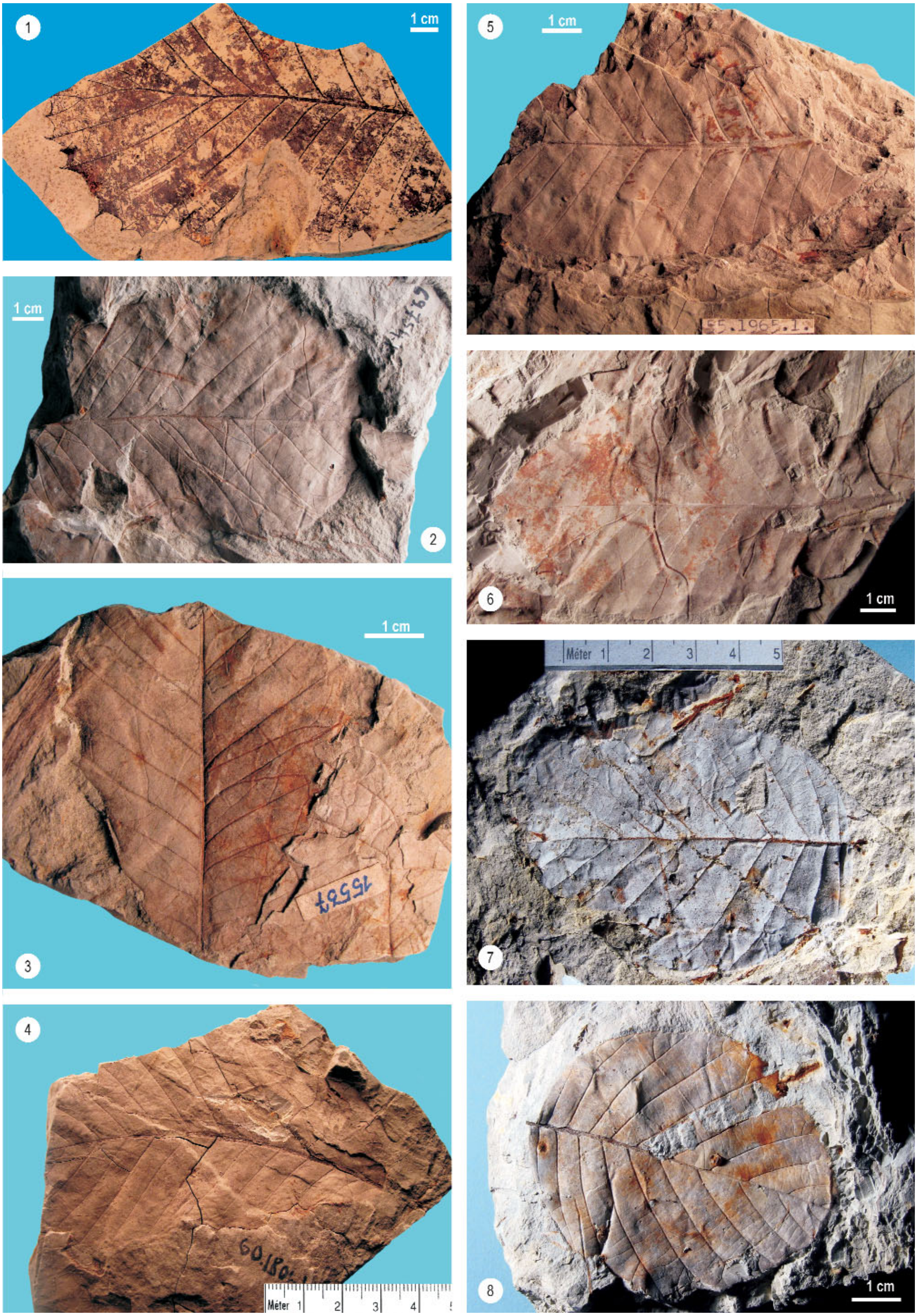
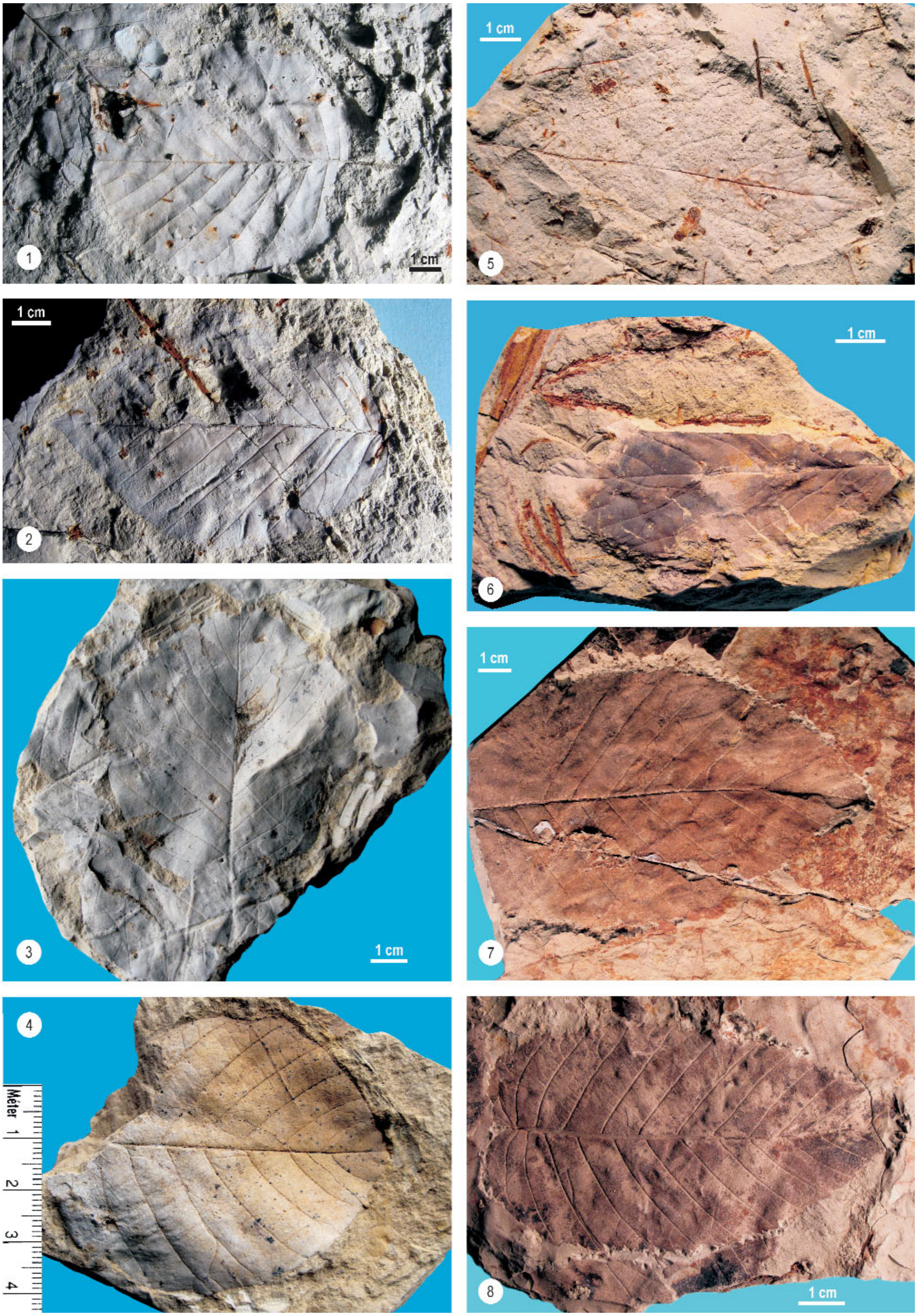

1
1 cm
1 cm
2
1 cm
3
4
Méter 1 2 3 4
5
1 cm
55.1965.1.
6
1 cm
Méter 1 2 3 4 5
7
8
1 cm

Plate XI

1. *Alnus cecropiifolia* (Ettingshausen) Berger, Dozmat, BP 2005.53.2.
2. *Alnus cecropiifolia* (Ettingshausen) Berger, Dozmat, BP 2005.61.3.
3. *Alnus cecropiifolia* (Ettingshausen) Berger, Kerecsend, SAMU 2008.16.61.
4. *Alnus cecropiifolia* (Ettingshausen) Berger, Kerecsend, SAMU 2008.16.36.
5. *Alnus menzelii* Raniecka-Bobrowska, Balatonszentgyörgy, BP 2008.356.2.
6. *Alnus gaudini* (Heer) Knobloch & Kvaček, Balatonszentgyörgy, BP 2008.365.1.
7. *Alnus menzelii* Raniecka-Bobrowska, Felsőtárkány, BP 55.1924.1.
8. *Alnus menzelii* Raniecka-Bobrowska, Felsőtárkány, BP 55.1819.1.


1
1 cm
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1 cm
2
1 cm
6
1 cm
3
1 cm
7
1 cm
4
Méter 1 2 3 4
8
1 cm

Plate XII

1. *Alnus menzelii* RANIECKA-BOBROWSKA, Felsőtárkány, MM 56.548.1.
2. *Alnus menzelii* RANIECKA-BOBROWSKA, Rudabánya, BK-361.
3. *Alnus menzelii* RANIECKA-BOBROWSKA, Rudabánya, BK-385.
4. *Alnus menzelii* RANIECKA-BOBROWSKA, Rudabánya, BK-378. several leaves of *A. menzelii*.
5. *Alnus menzelii* RANIECKA-BOBROWSKA, Rudabánya, BK-268.
6. *Alnus menzelii* RANIECKA-BOBROWSKA, Rudabánya, BK-61.
7. *Alnus menzelii* RANIECKA-BOBROWSKA, Rudabánya, BK-165.
8. *Alnus julianiformis* (STERNBERG) KVAČEK et HOLÝ, Balatonszentgyörgy, BP 2008.363.1.

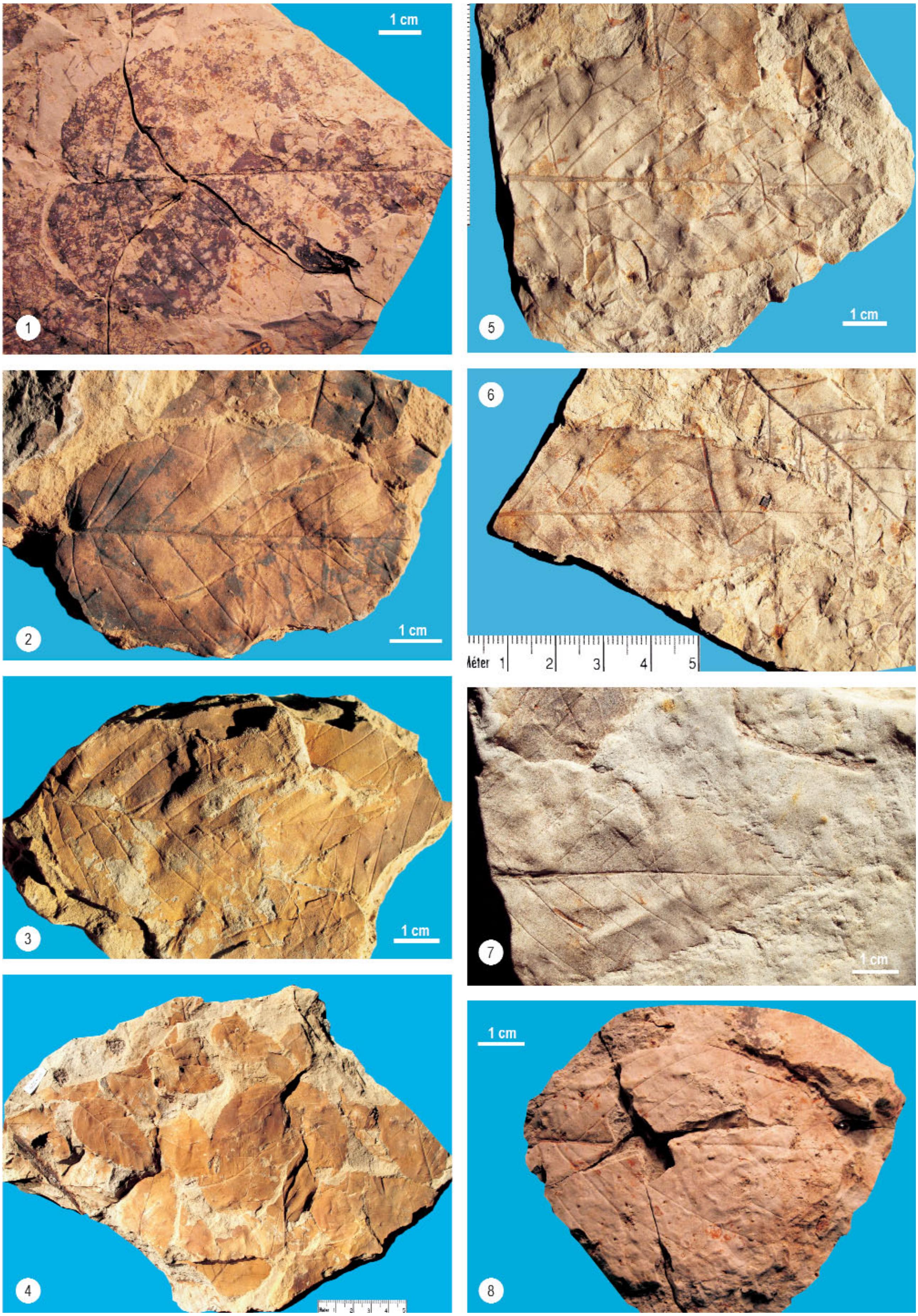
1 cm
1
1 cm
5
6
2
1 cm
Méter 1 2 3 4 5
1 cm
3
7
1 cm
1 cm
4
8

Plate XIII

1. *Alnus ducalis* GAUDIN emend. KNOBLOCH, Tihany, BP 85.214.1.
2. *Alnus ducalis* GAUDIN emend. KNOBLOCH, Tihany, BP 85.147.1.
3. *Alnus ducalis* GAUDIN emend. KNOBLOCH, Tihany, BP 85.168.2.
4. *Alnus gaudini* (HEER) KNOBLOCH & KVAČEK, Tihany, BP 2007.520.1.
5. *Alnus gaudini* (HEER) KNOBLOCH & KVAČEK, Tihany, BP 85.114.2.
6. *Alnus gaudini* (HEER) KNOBLOCH & KVAČEK, Tihany, BP 85.197.3.
7. *Alnus gaudini* (HEER) KNOBLOCH & KVAČEK, Tihany, BP 85.186.4.

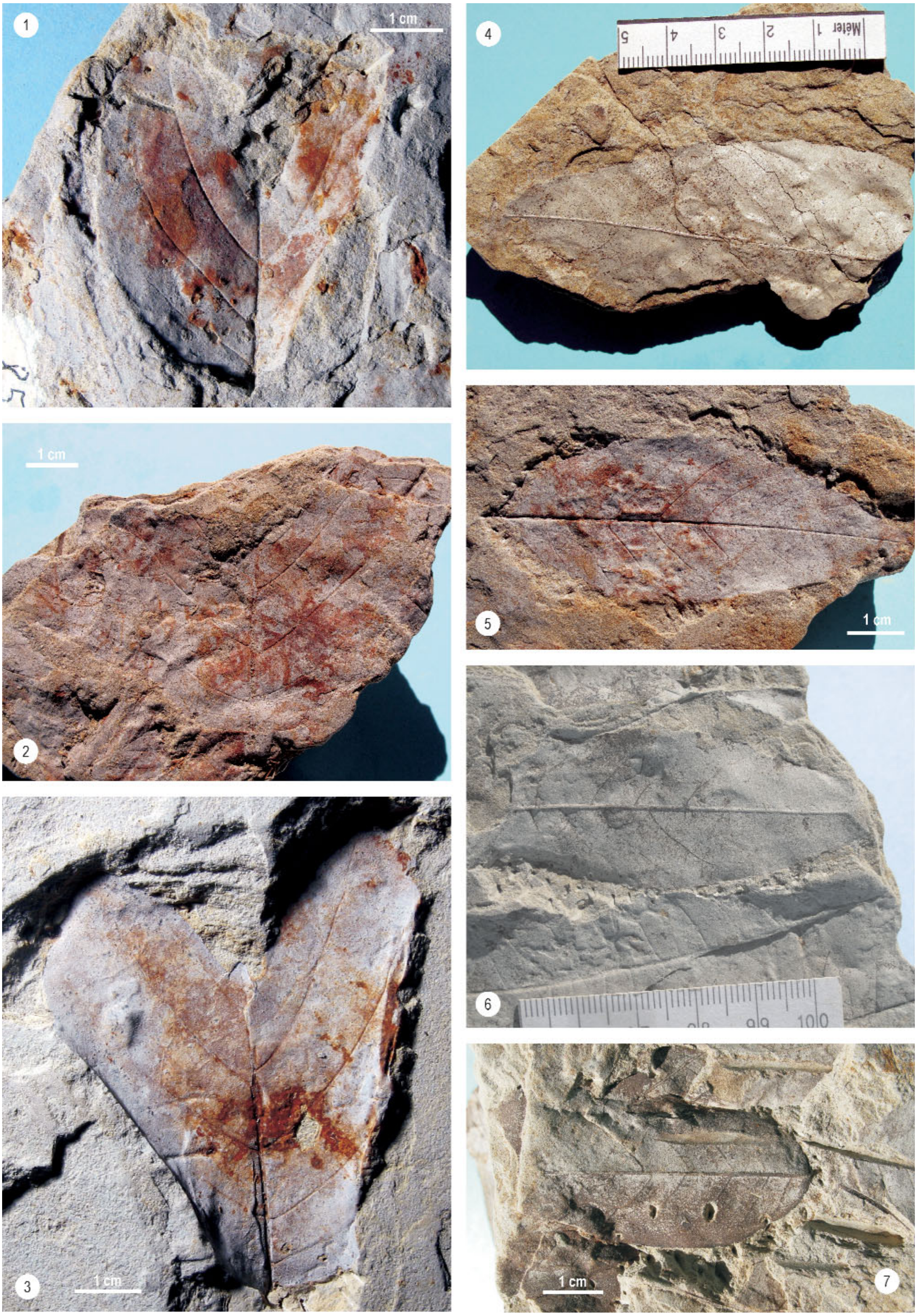
1
1 cm
2
1 cm
3
1 cm
4
5
1 cm
6
7
1 cm

Plate XIV

1. *Alnus* sp., Hatvan, SAMU 2006.4.5.
2. *Alnus* sp., Hatvan, SAMU 2006.4.6.
3. *Alnus* sp., Rózsaszentmárton, BP 2005.446.1.
4. *Ulmus* sp., Rózsaszentmárton, BP 2008.48.1.
5. *Alnus* sp. female catkins, “cones”, Dozmat, BP 2005.51.1.
6. *Alnus* sp. male catkins, Rudabánya, BK–382.
7. *Alnus* sp. male catkins, Rudabánya, BK–384.

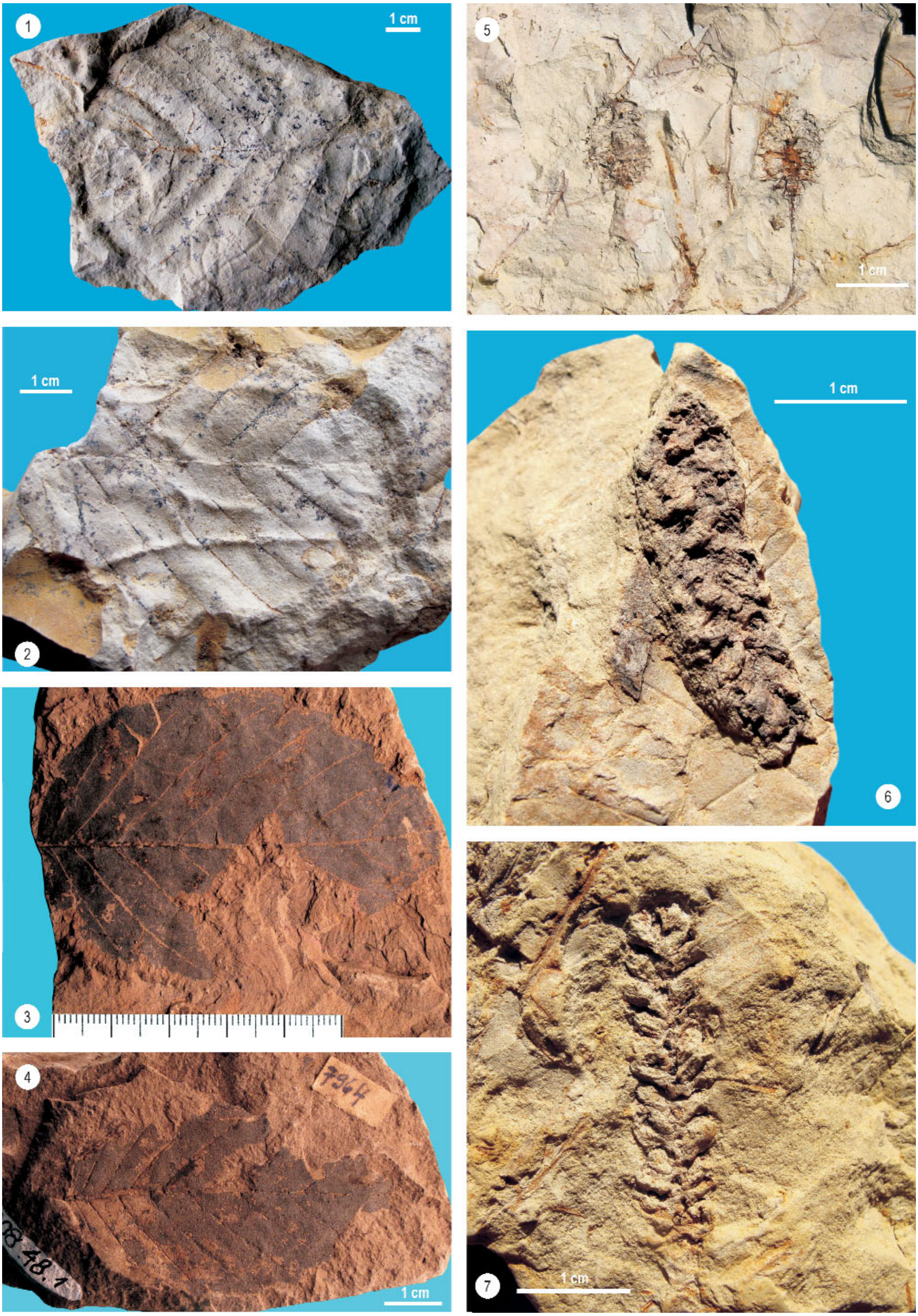
1
1 cm
5
1 cm
1 cm
2
1 cm
3
6
4
7364
1 cm
7
1 cm

Plate XV

1. *Alnus* sp. male catkins, Rudabánya, BK–257.
2. *Carpinus grandis* UNGER emend. HEER, Rudabánya, BK–375
3. *Myrica lignitum* (UNGER) SAPORTA, Balatonszentgyörgy, BK–1501.
4. *Myrica lignitum* (UNGER) SAPORTA, Balatonszentgyörgy, BK–1790.
5. *Myrica lignitum* (UNGER) SAPORTA, Balatonszentgyörgy, BK–1740.
6. *Myrica lignitum* (UNGER) SAPORTA, Balatonszentgyörgy, BK–1591.
7. *Myrica lignitum* (UNGER) SAPORTA, Balatonszentgyörgy, BK–1482.
8. *Myrica lignitum* (UNGER) SAPORTA, Balatonszentgyörgy, BK–1741.
9. *Myrica lignitum* (UNGER) SAPORTA, Sé, SAMU 65.3.1157.

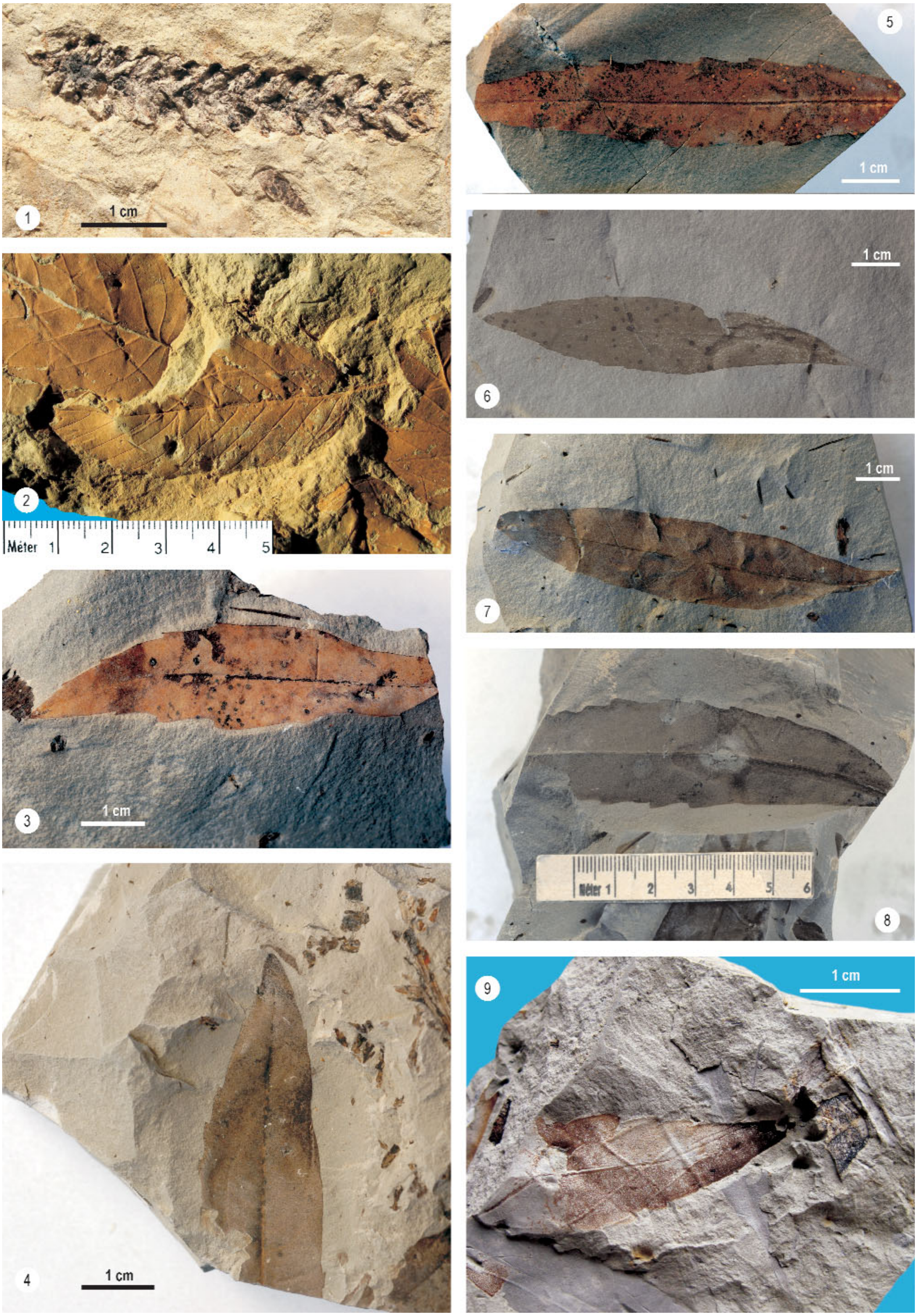
1
1 cm
2
Méter 1 2 3 4 5
3
1 cm
4
1 cm
5
1 cm
6
1 cm
7
1 cm
8
Méter 1 2 3 4 5 6
9
1 cm

Plate XVI

1. *Ulmus carpinoides* GÖPPERT emend. MENZEL, Győr-Sashegy, SAMU 2008.9.8.
2. *Ulmus carpinoides* GÖPPERT emend. MENZEL, Győr-Sashegy, SAMU 2008.9.13.
3. *Ulmus carpinoides* GÖPPERT emend. MENZEL, Győr-Sashegy, SAMU 2008.9.86.
4. *Ulmus carpinoides* GÖPPERT emend. MENZEL, Hosszúpereszteg, SAMU 73.3.1581.
5. *Ulmus carpinoides* GÖPPERT emend. MENZEL, Hosszúpereszteg, SAMU 86.13.767.
6. *Ulmus braunii* HEER, Karmacs, BP 2008.439.1.
7. *Ulmus braunii* HEER, Tiszapalkonya, BP 2009.363.1.

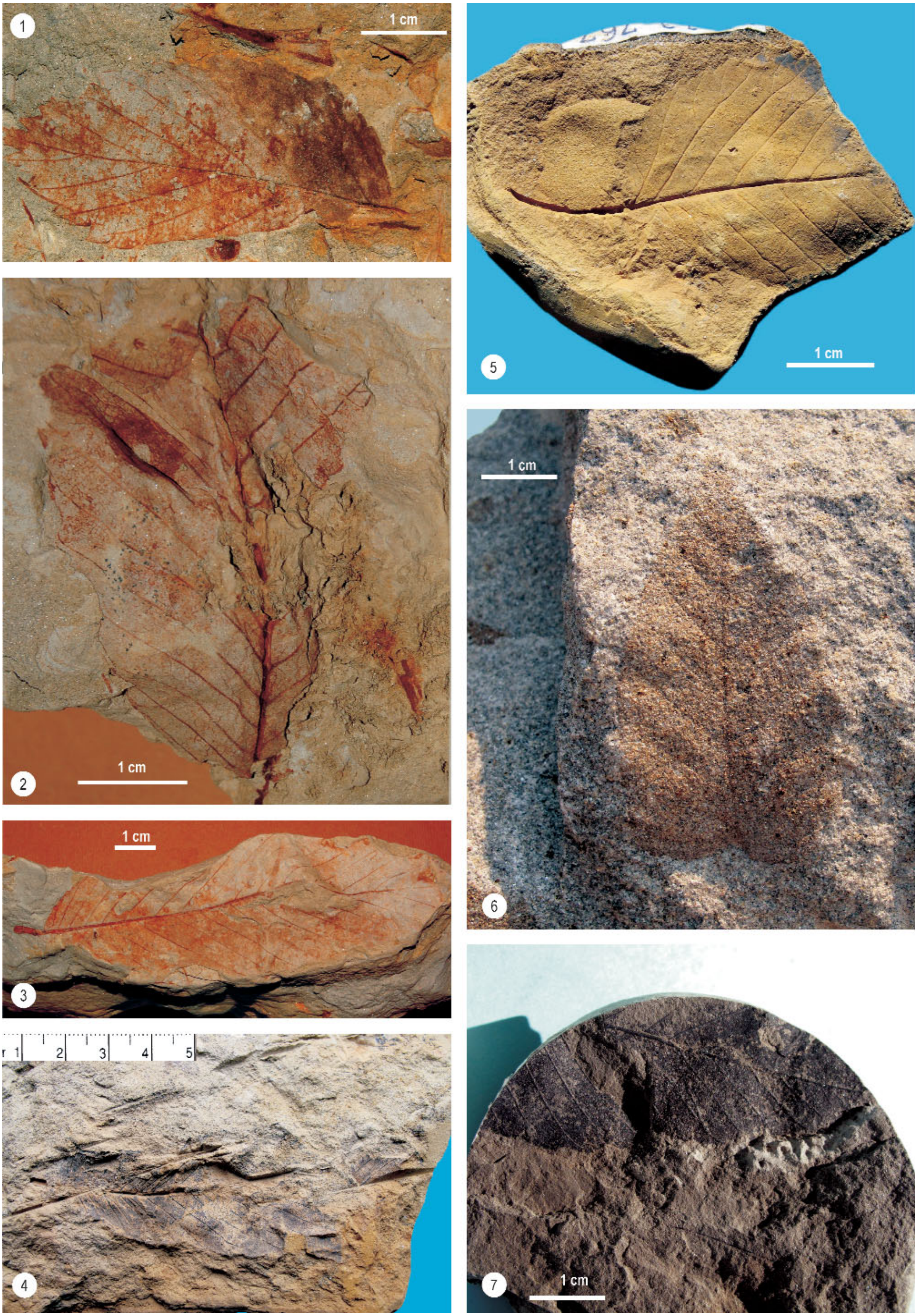
1
1 cm
2
1 cm
3
1 cm
4
5
1 cm
6
1 cm
7
1 cm

Plate XVII

1. *Ulmus* sp., Hatvan, SAMU 83.13.3.
2. *Ulmus* sp., Rudabánya, MÁFI BK–525
3. *Ulmus* sp. fructus, Rózsaszentmárton, BP 85.382.1.
5. Ulmaceae gen. et sp. Rózsaszentmárton, BP 2008.469.2.
6. *Juglans acuminata* A. Braun ex Unger, Tihany, BP 85.150.1.
7. *Juglans acuminata* A. Braun ex Unger, Tihany, BP 85.211.1.
8. *Juglans acuminata* A. Braun ex Unger, Tihany, BP 85.215.3.

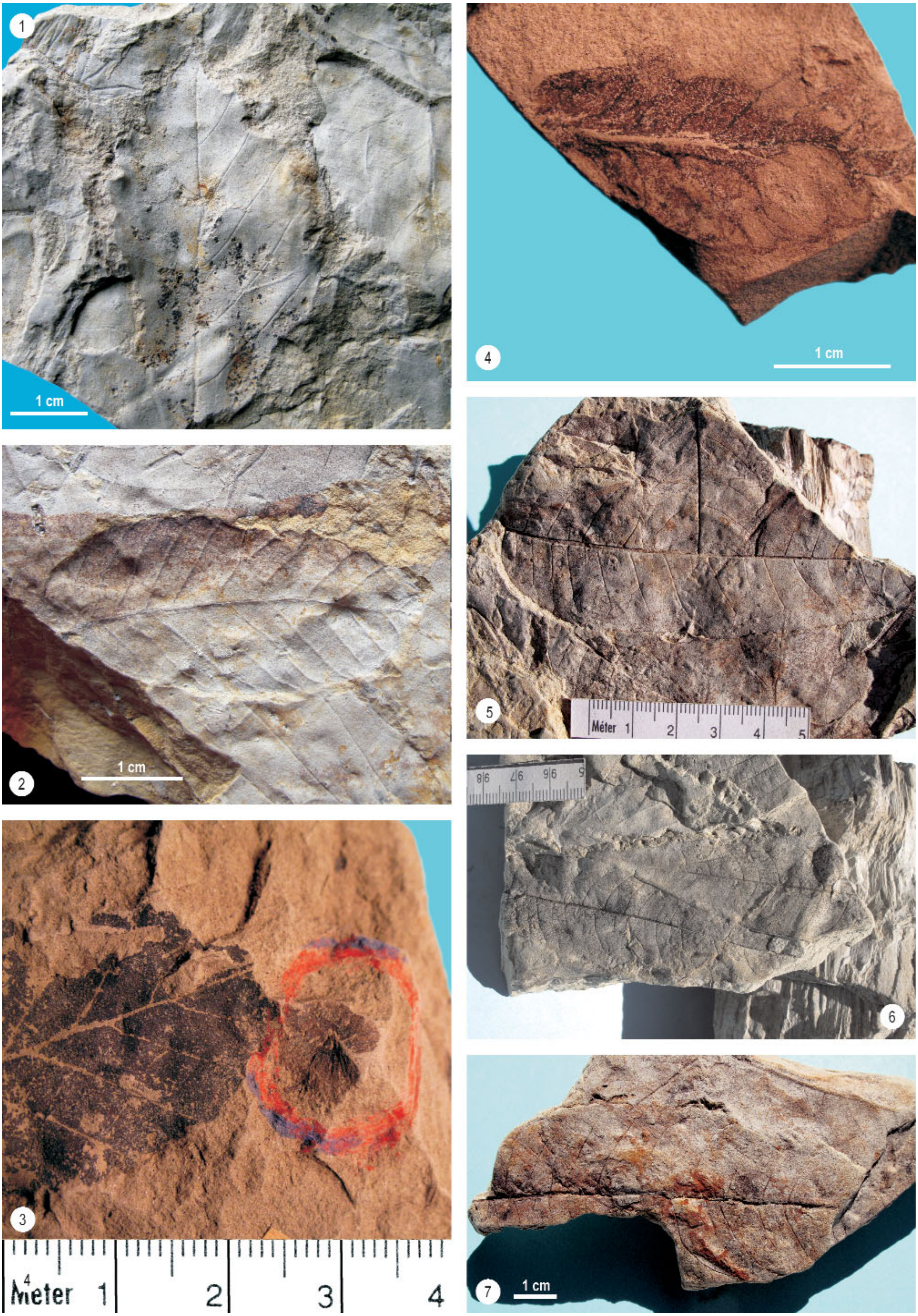
1
1 cm
2
1 cm
3
Meter 1 2 3 4
4
1 cm
5
Méter 1 2 3 4 5
6
7
1 cm

Plate XVIII

1. *Juglans acuminata* A. BRAUN ex UNGER, Tihany, BP 85.209.2.
2. *Trapa praehungarica* WÓJCICKI et BAJZÁTH, holotype, Bükkábrány, BP 97.407.15.
3. *Trapa pannonica* sp. nov., holotype, Rózsaszentmárton, BP 2001.354.1.
4. *Trapa silesiaca* GÖPPERT, Rudabánya, BK–543.
5. *Trapa silesiaca* GÖPPERT, Rudabánya, BK–541.
6. *Trapa rozsaszentmartoni* sp. nov., Rózsaszentmárton, BP 2001.355.1.
7. *Trapa rozsaszentmartoni* sp. nov., Rózsaszentmárton, MM 64.1153.1.
8. *Trapa rozsaszentmartoni* sp. nov., holotype, Rózsaszentmárton, MM 64.1149.1.


1
5 96 97 98 99 100
2
1 cm
3
1 cm
4
1 cm
5
1 cm
6
1 cm
7
1 cm
8
1 cm

Plate XIX

1. *Acer subcampestre* Göppert, Hosszúpereszteg, SAMU 86.13.1027.
2. *Acer subcampestre* Göppert, Rudabánya, BK–577.
3. *Acer subcampestre* Göppert, Rudabánya, BK–578.
4. *Acer subcampestre* Göppert, Tiszapalkonya, BP 2009.356.4.
5. *Vitis* sp., Győr-Sashegy, SAMU 2008.9.1.
6. *Acer vindobonensis* (Ettingshausen) Berger, Rózsaszentmárton, BP 2009.486.1.
7. *Acer vindobonensis* (Ettingshausen) Berger, Rózsaszentmárton, BP 70.333.1
8. *Acer vindobonensis* (Ettingshausen) Berger, Rudabánya, BK–566.


1
1 cm
2
1 cm
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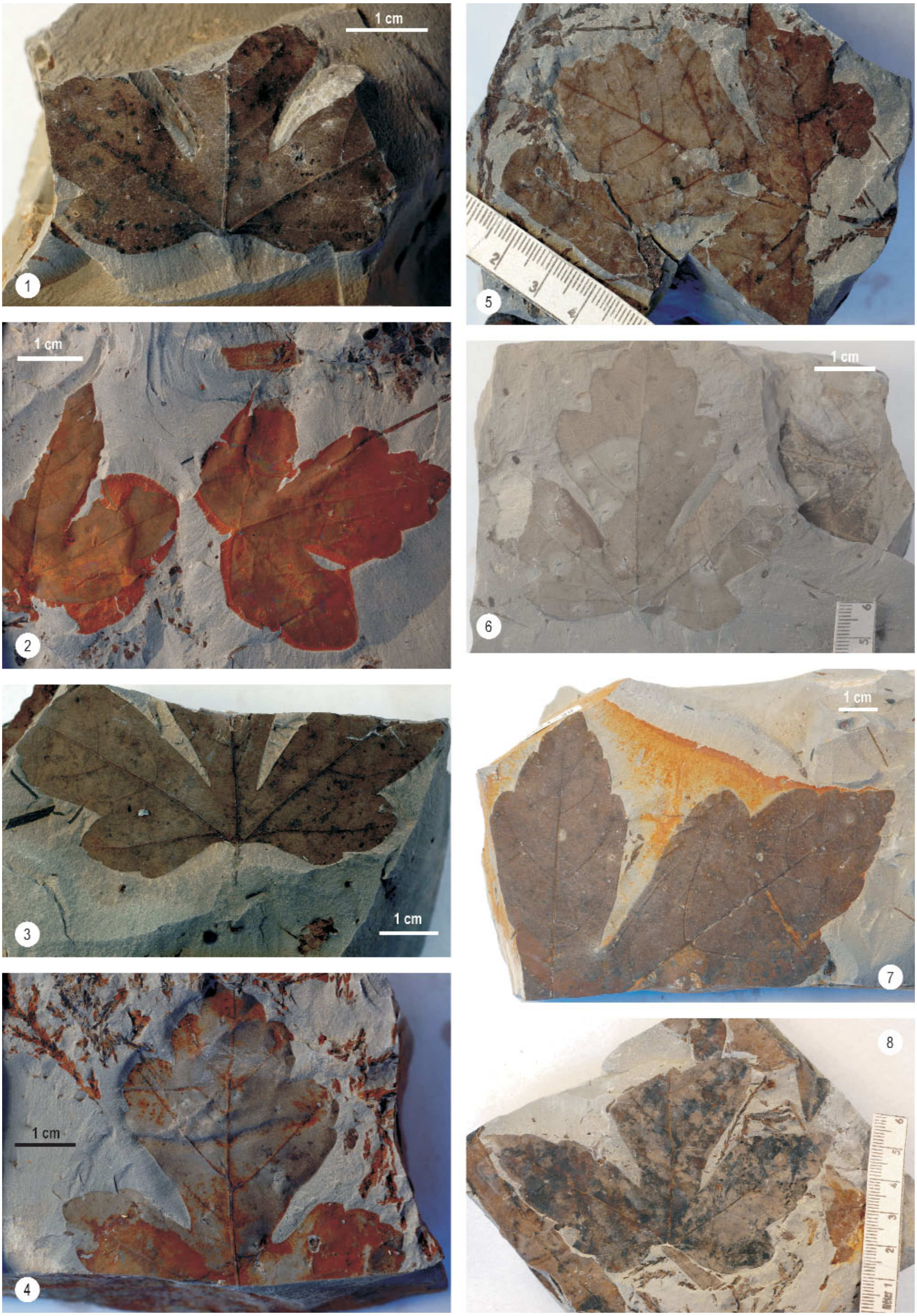
1 cm
1 cm
4
1 cm
5
1 cm
6
1 cm
7
1 cm
8

Plate XX

1. *Acer jurenakii* STUR, Balatonszentgyörgy, BK–1759.
2. *Acer jurenakii* STUR, Balatonszentgyörgy, BK–1757.
3. *Acer jurenakii* STUR, Balatonszentgyörgy, BK–1762.
4. *Acer jurenakii* STUR, Balatonszentgyörgy, BK–1769.
5. *Acer jurenakii* STUR, Balatonszentgyörgy, BK–1743.
6. *Acer jurenakii* STUR, Balatonszentgyörgy, BK–1756.
7. *Acer jurenakii* STUR, Balatonszentgyörgy, BK–1782.
8. *Acer jurenakii* STUR, Balatonszentgyörgy, BK–1793.


1 cm
1
1 cm
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3
1 cm
1 cm
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5
1 cm
6
1 cm
7
8

Plate XXI

1. *Acer jurenakii* STUR, Tihany, BP 2007.498.1.
2. *Acer tricuspidatum* BRONN, Felsőtárkány, BP 60.1825.1.
3. *Acer tricuspidatum* BRONN, Felsőtárkány, BP 62.1431.1.
4. *Acer tricuspidatum* BRONN, Felsőtárkány, BP 71.32.1.
5. *Acer tricuspidatum* BRONN, Felsőtárkány, BP 55.1949.1.
6. *Acer tricuspidatum* BRONN, Felsőtárkány, BP 55.1837.1.
7. *Acer tricuspidatum* BRONN, Felsőtárkány, BP 60.1890.1.
8. *Acer tricuspidatum* BRONN, Felsőtárkány, BP 71.48.1.

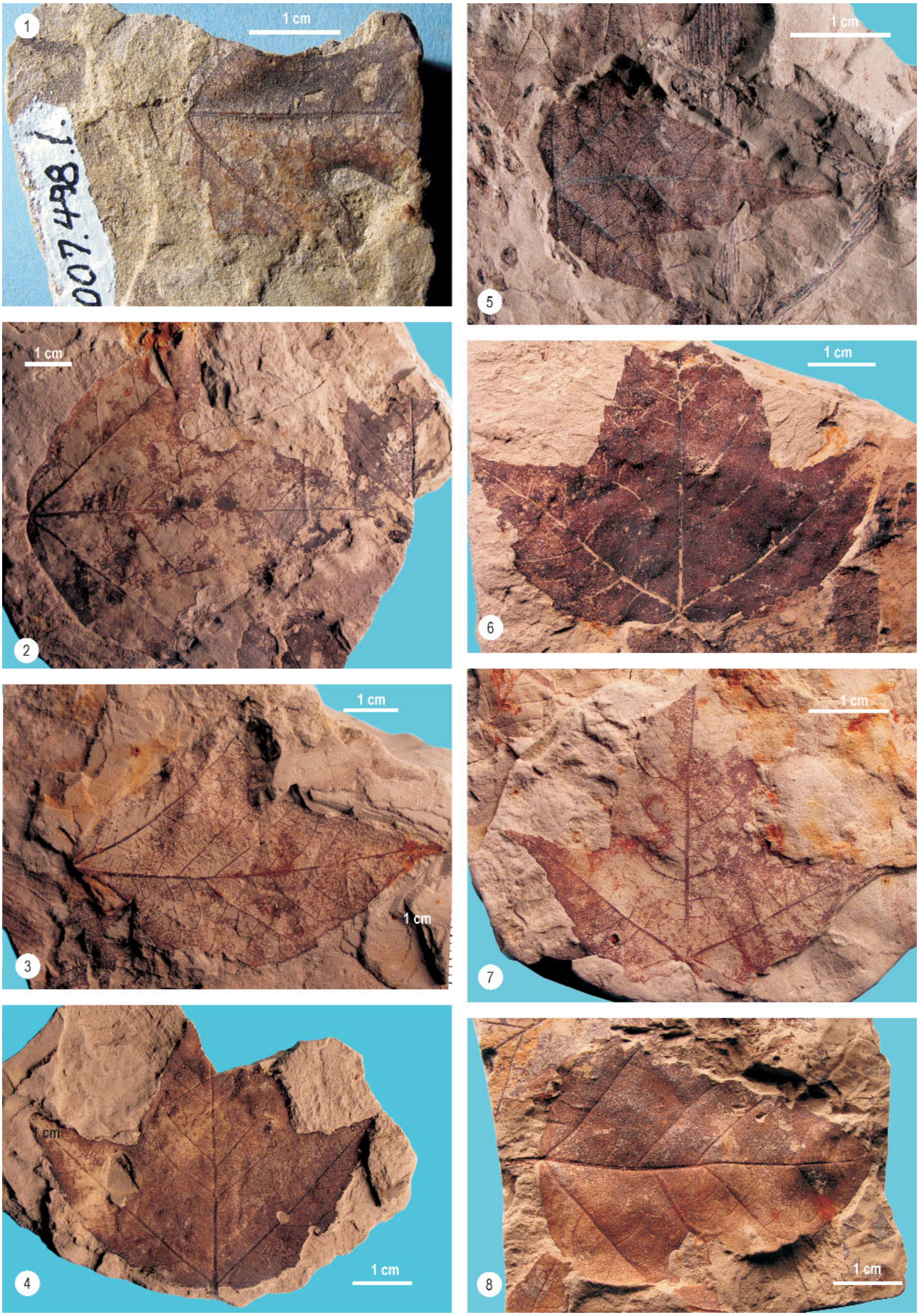
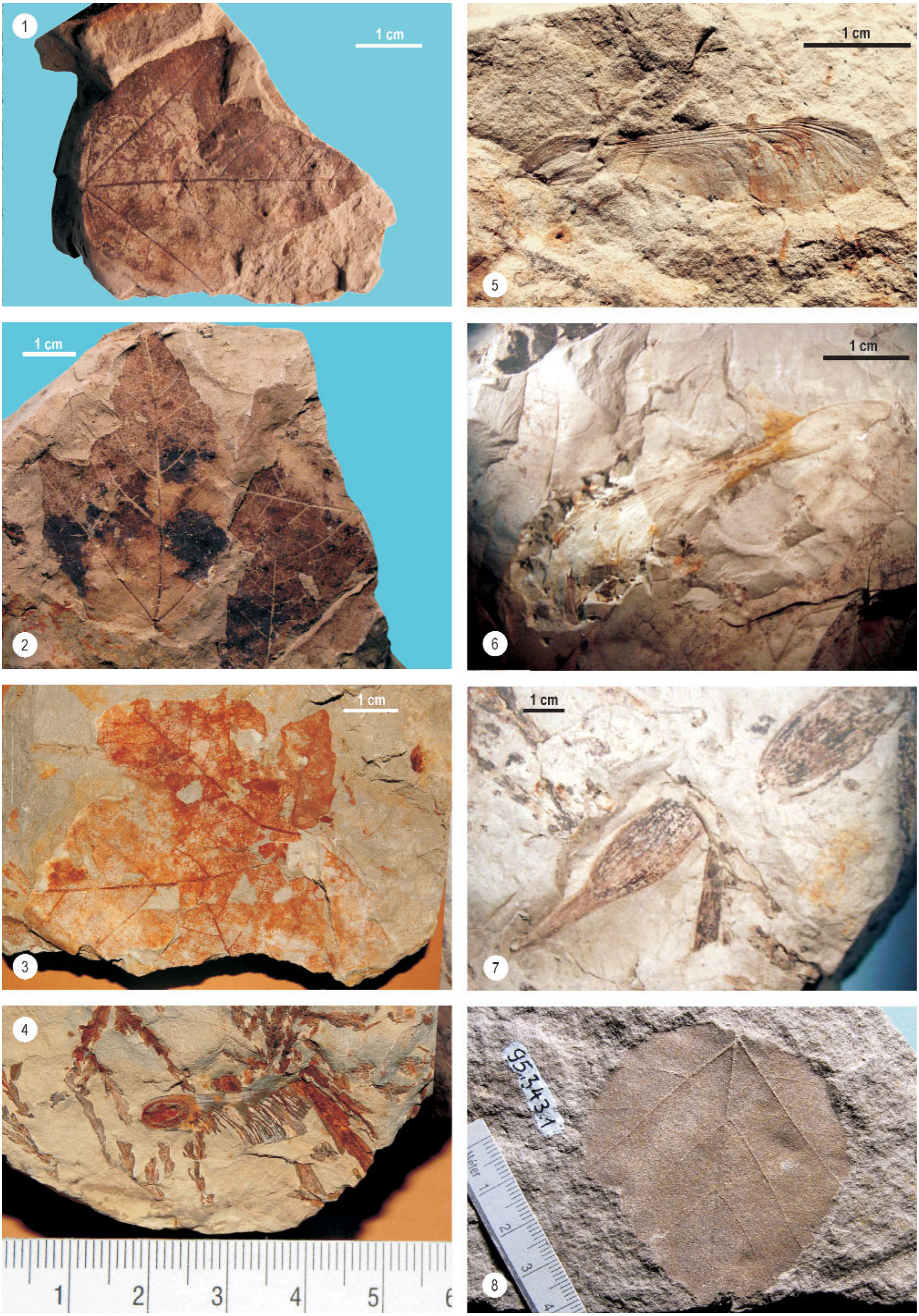

1
1 cm
5
1 cm
2
1 cm
6
1 cm
3
1 cm
1 cm
7
1 cm
4
1 cm
1 cm
8
1 cm

Plate XXII

1. *Acer tricuspidatum* BRONN, Felsőtárkány, BP 60.1784.1.
2. *Acer tricuspidatum* BRONN, Felsőtárkány, BP 55.1786.1.
3. *Acer subcampestre* GÖPPERT, Győr-Sashegy, SAMU 2008.9.115.
4. *Acer* sp. fructus, Balatonszentgyörgy SAMU 2008.6.111.
5. *Acer* sp. fructus, Rudabánya, BK–258.
6. *Acer* sp. fructus, Felsőtárkány, BP 55.1783.1.
7. *Acer* sp. fructus, endocarp, Felsőtárkány, BP 2007.510.1.
8. cf. *Tilia* sp., leaf, Cserszegtomaj, BP 95.343.1.


1
1 cm
2
1 cm
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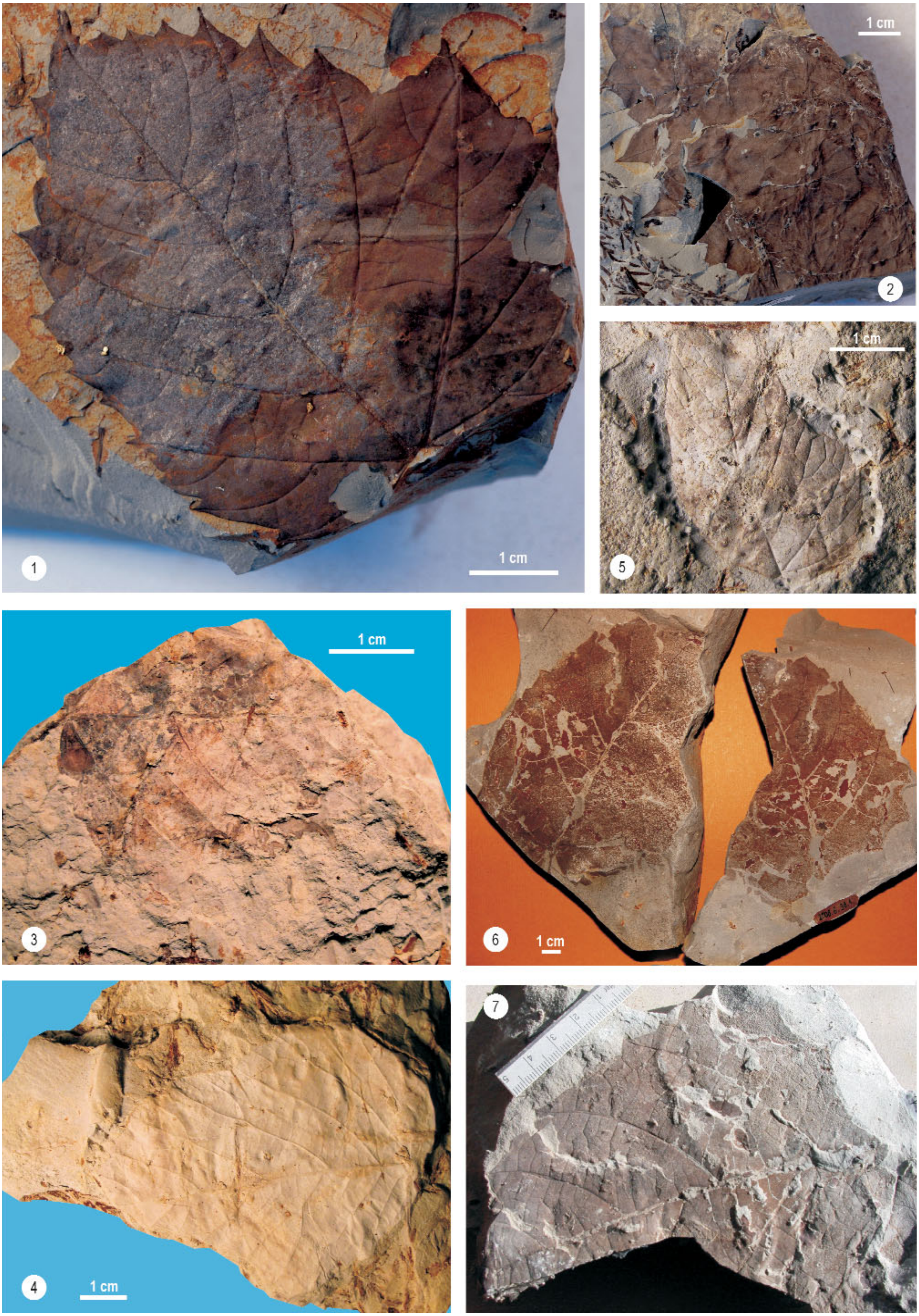
1 cm
4
1 2 3 4 5
5
1 cm
6
1 cm
7
1 cm
8
95.343.1

Plate XXIII

1. *Vitis szakmanygyorgyi* sp. nov., holotype, Balatonszentgyörgy, BK–4705.
2. *Vitis szakmanygyorgyi* sp. nov., Balatonszentgyörgy, BK 1725.
3. *Vitis szakmanygyorgyi* sp. nov., Balatonszentgyörgy, BP 2011.143.2.
4. *Vitis szakmanygyorgyi* sp. nov., Balatonszentgyörgy, BP 2011.107.1.
5. *Vitis szakmanygyorgyi* sp. nov., Balatonszentgyörgy, BP 2011.106.1.
6. *Vitis szakmanygyorgyi* sp. nov., Balatonszentgyörgy, SAMU 2008.6.98.2.
7. *Vitis szakmanygyorgyi* sp. nov., enlargement of the leaf margin, Balatonszentgyörgy, SAMU 2008.6.98.2.


1
1 cm
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1 cm
5
1 cm
3
1 cm
6
1 cm
4
1 cm
7

Plate XXIV

1. *Cercidiphyllum crenatum* (UNGER) BROWN, Balatonszentgyörgy, SAMU 2008.6.71.
2. *Cercidiphyllum crenatum* (UNGER) BROWN, Felsőtárkány, BP 69.781.1.
3. *Cercidiphyllum crenatum* (UNGER) BROWN, Felsőtárkány, BP 55.1879.1.
4. *Cercidiphyllum crenatum* (UNGER) BROWN, Felsőtárkány, BP 71.52.1.
5. *Cercidiphyllum crenatum* (UNGER) BROWN, Felsőtárkány, BP 55.1817.1.
6. *Cercidiphyllum crenatum* (UNGER) BROWN, Felsőtárkány, BP 71.120.1.
7. *Cercidiphyllum crenatum* (UNGER) BROWN, Felsőtárkány, BP 85.239.1.
8. *Cercidiphyllum crenatum* (UNGER) BROWN, Felsőtárkány, BP 62.1129.1.

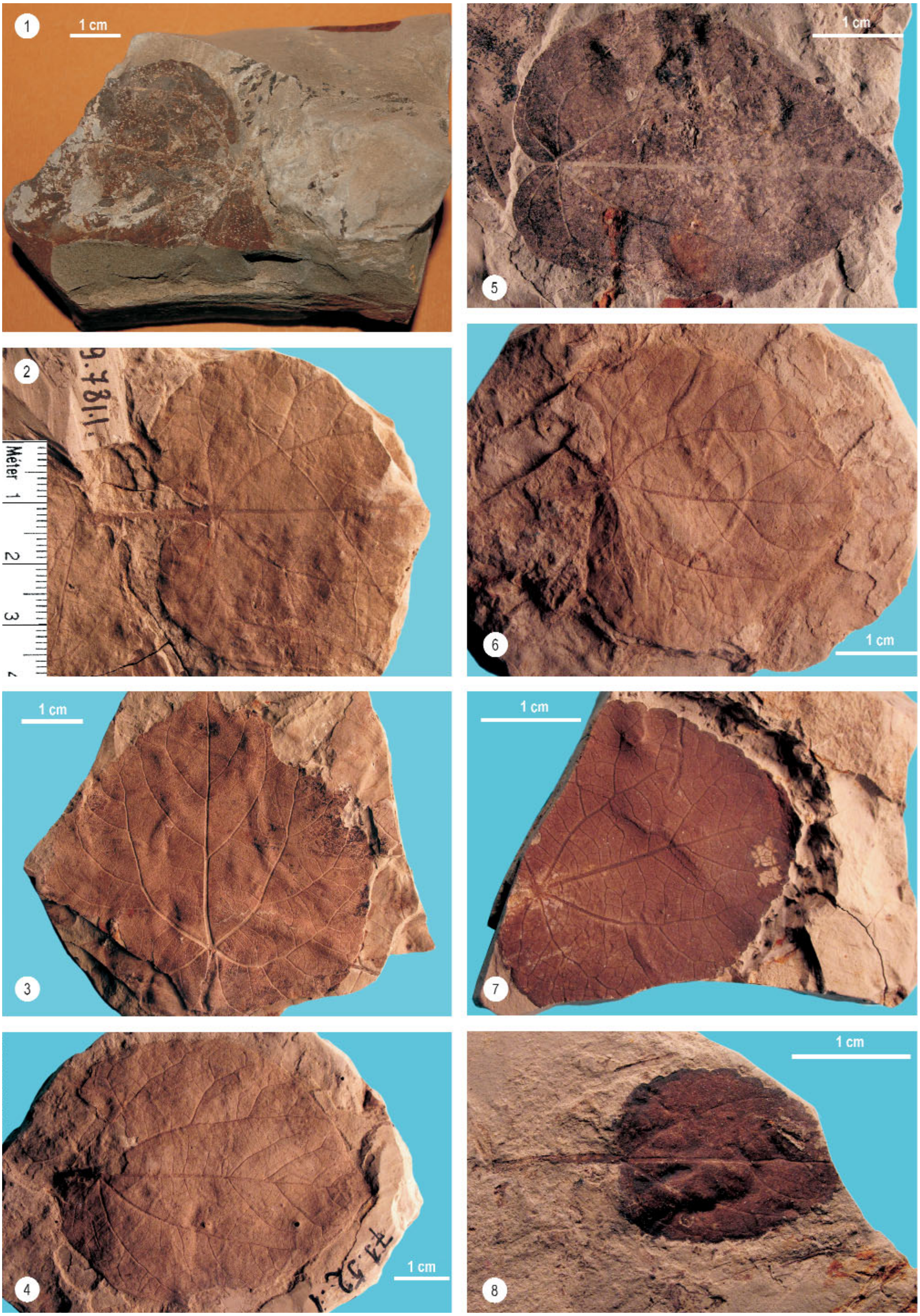

1
1 cm
5
1 cm
2
Méter 1 2 3
6
1 cm
3
1 cm
7
1 cm
4
1 cm
8
1 cm

Plate XXV

1. *Cercidiphyllum crenatum* (UNGER) BROWN, Felsőtárkány, BP 69.827.1.
2. *Cercidiphyllum crenatum* (UNGER) BROWN, Felsőtárkány, BP 55.1960.1.
3. *Cercidiphyllum crenatum* (UNGER) BROWN, Győr-Sashegy, SAMU 2008.9.118.1.
4. *Cercidiphyllum crenatum* (UNGER) BROWN, Rudabánya, BK–446.
5. *Cercidiphyllum crenatum* (UNGER) BROWN, Rudabánya, BK–447.
6. *Cercidiphyllum* sp., fruit, Felsőtárkány, MM 56.982.1.
7. *Cercidiphyllum* sp., part of fruit, Felsőtárkány, MM 56.988.2.
8. *Cercidiphyllum* sp., part of fruit, Rudabánya, BK–389.

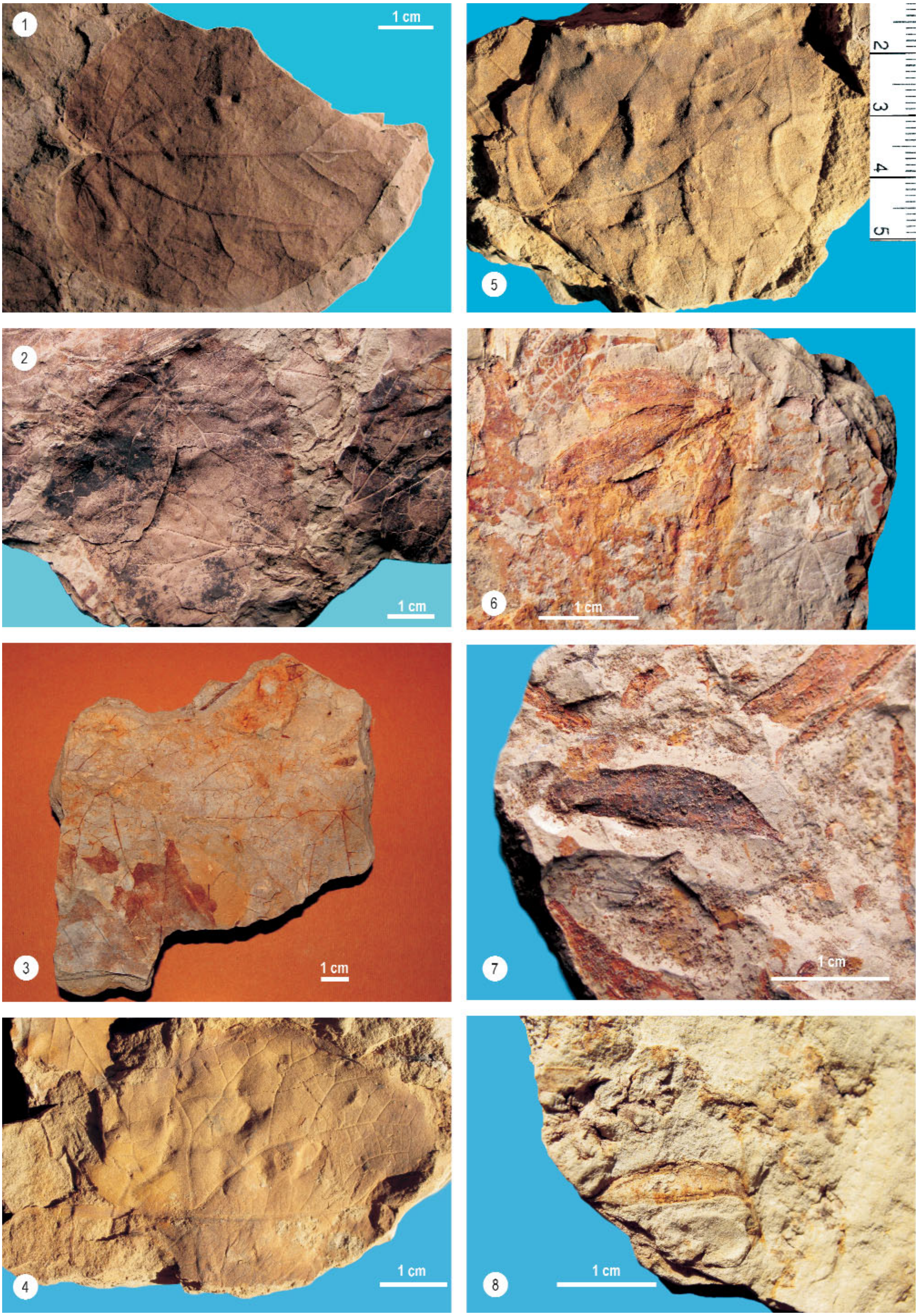

1
1 cm
2
1 cm
3
1 cm
4
1 cm
5
2
3
4
5
6
1 cm
7
1 cm
8
1 cm

Plate XXVI

1. *Cercidiphyllum* sp., part of fruit, Rudabánya, without number
2. *Salix varians* GÖPPERT, Alcsút, BP 2009.424.2.
3. *Salix varians* GÖPPERT, Alcsút, BP 2009.430.1.
4. *Salix varians* GÖPPERT, Balatonszentgyörgy, BK–1592.
5. *Salix varians* GÖPPERT, Balatonszentgyörgy, BK–1670.
6. *Salix varians* GÖPPERT, Balatonszentgyörgy, BK–1505.
7. *Salix varians* GÖPPERT, Balatonszentgyörgy, BK–4704.
8. *Salix varians* GÖPPERT, Balatonszentgyörgy, SAMU 2008.6.13.
9. *Salix varians* GÖPPERT, Balatonszentgyörgy, SAMU 2008.6.19.

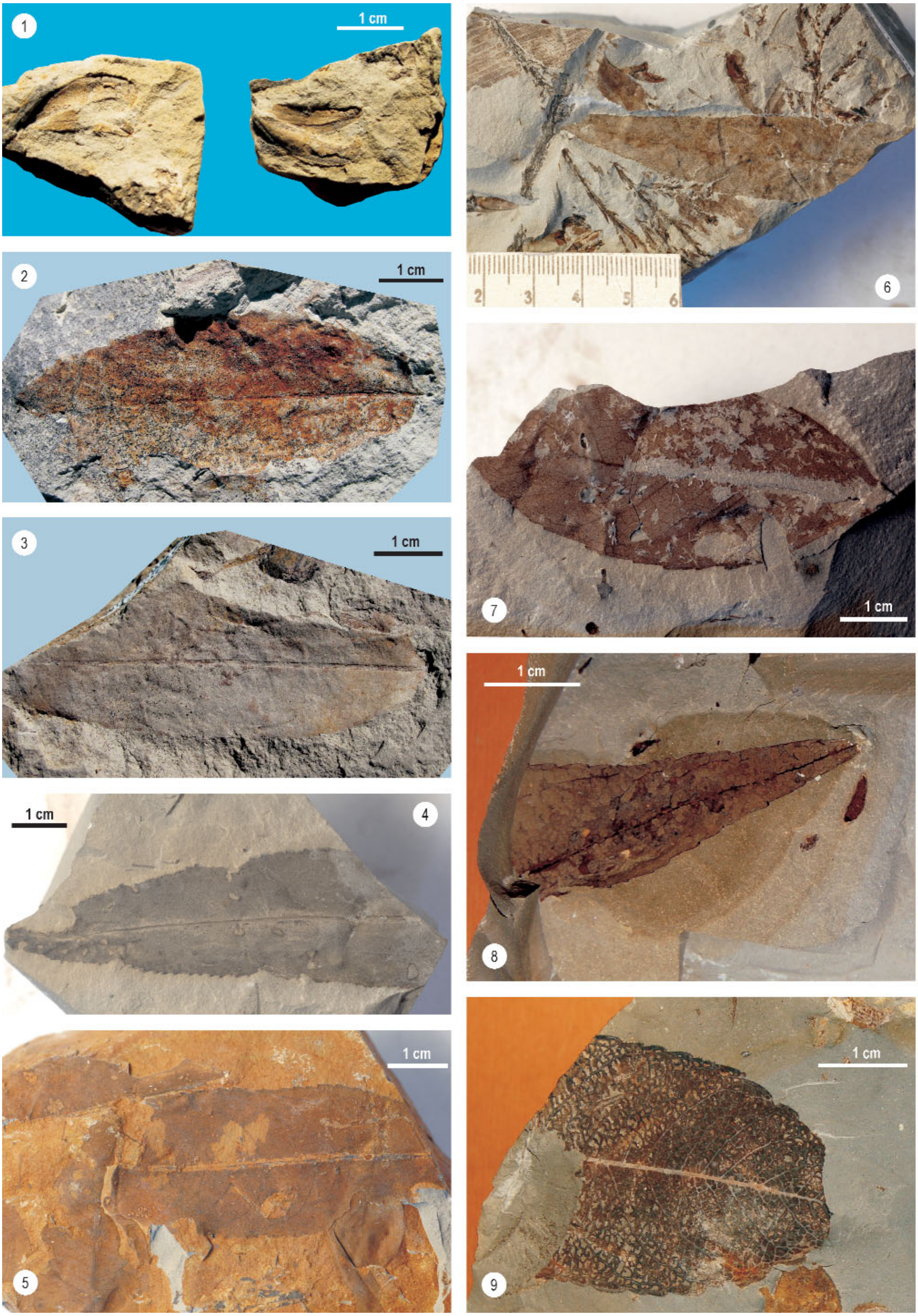

1
1 cm
2
1 cm
3
1 cm
4
1 cm
5
1 cm
6
2 3 4 5 6
7
1 cm
8
1 cm
9
1 cm

Plate XXVII

1. *Salix varians* GÖPPERT, Balatonszentgyörgy, SAMU 2008.6.64.
2. *Salix varians* GÖPPERT, Sé, SAMU 65.3.312.
3. *Salix varians* GÖPPERT, Rudabánya, BK–256.
4. *Salix varians* GÖPPERT, Sé, SAMU 70.179.1.
5. *Salix varians* GÖPPERT, Sé, SAMU 65.3.771.
6. *Salix varians* GÖPPERT, Sé, SAMU 65.3.777.
7. *Salix varians* GÖPPERT, Tihany, BP 85.192.3.
8. *Salix varians* GÖPPERT, Tihany, BP 85.197.3.


1
2
1 cm
3
Méter 1 2 3 4 5
4
1 cm
5
1 cm
6
1 cm
7
Méter 1 2 3 4
8
96 97 98 99 100

Plate XXVIII

1. *Salix varians* Göppert, Tihany, BP 85.206.2.
2. *Salix varians* GÖPPERT, Kerecsend, SAMU 2008.16.35.
3. *Pinus* sp., Mindszentkálla, BP 2007.502.1.
4. *Picea* sp., Mindszentkálla, BP 2007.503.1.
5. Leguminosae gen. et sp., Mindszentkálla, BP 2007.500.2.
6. *Salix* sp. fruit capsule and *Salix* sp. 1. leaf, Balatonszentgyörgy, BK-1688.
7. *Salix* sp. 1., Balatonszentgyörgy, BK–1699.
8. *Salix* sp. 1., Balatonszentgyörgy, BK–1555.
9. *Salix* sp. 1., Balatonszentgyörgy, BK–1669.

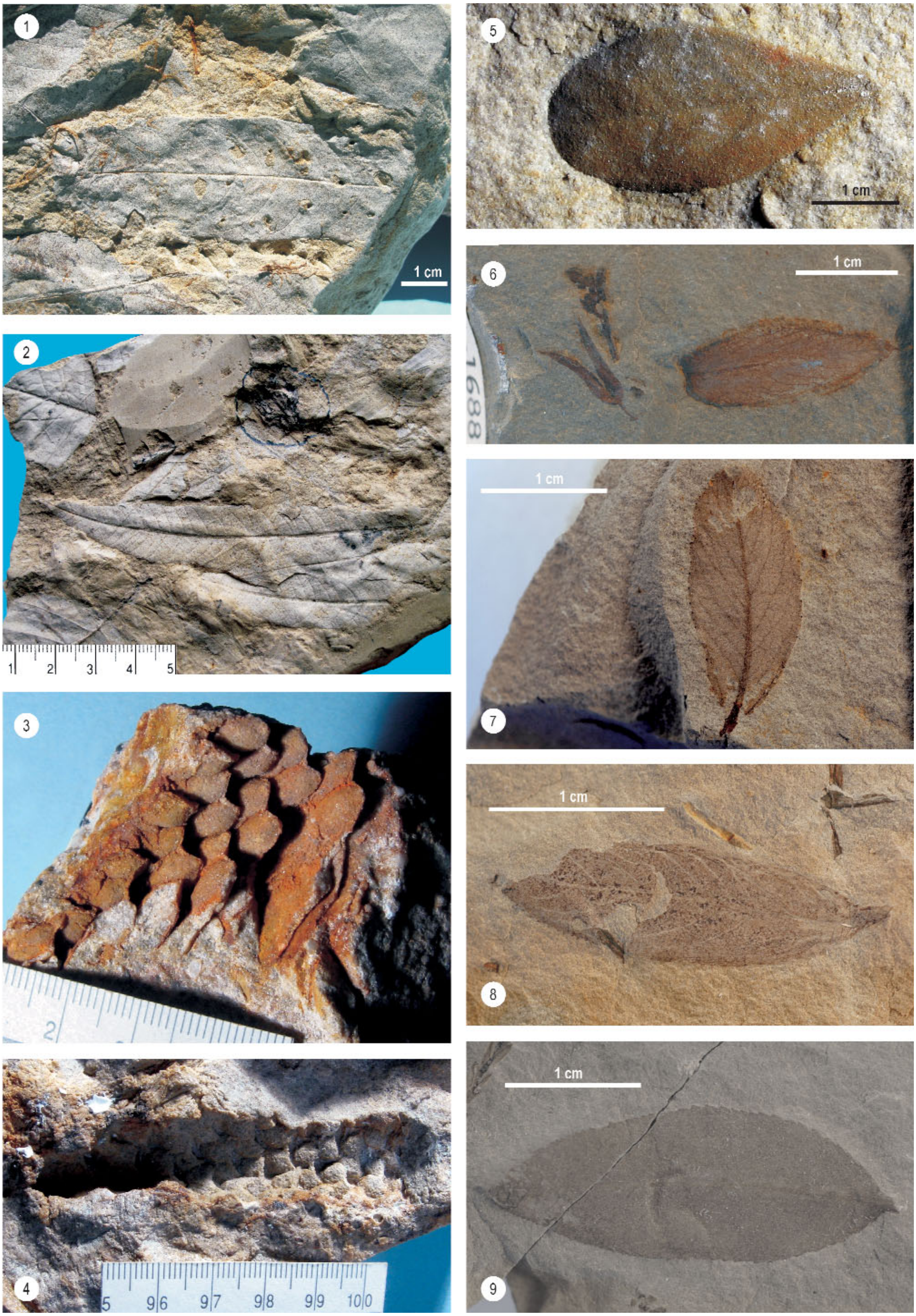

1
1 cm
2
1
2
3
4
5
3
2
4
96
97
98
99
100
5
1 cm
6
1 cm
1688
1 cm
7
1 cm
8
1 cm
9

Plate XXIX

1. *Salix* sp 1., Balatonszentgyörgy, BK–1739.
2. *Populus populina* (BRONGNIART) KNOBLOCH, Karmacs, BP 2008.429.1.
3. *Byttneriophyllum tiliifolium* (A. BRAUN) KNOBLOCH & KVAČEK, Dozmat, BP 2005.26.1.
4. *Byttneriophyllum tiliifolium* (A. BRAUN) KNOBLOCH & KVAČEK, Dozmat, BP 2005.36.1.
5. *Byttneriophyllum tiliifolium* (A. BRAUN) KNOBLOCH & KVAČEK, Dozmat, BP 2005.42.1.
6. *Byttneriophyllum tiliifolium* (A. BRAUN) KNOBLOCH & KVAČEK, Dozmat, BP 2005.66.1.
7. *Byttneriophyllum tiliifolium* (A. BRAUN) KNOBLOCH & KVAČEK, Felsőtárkány, BP 71.86.1.
8. *Byttneriophyllum tiliifolium* (A. BRAUN) KNOBLOCH & KVAČEK, Felsőtárkány, BP 2001.383.1.

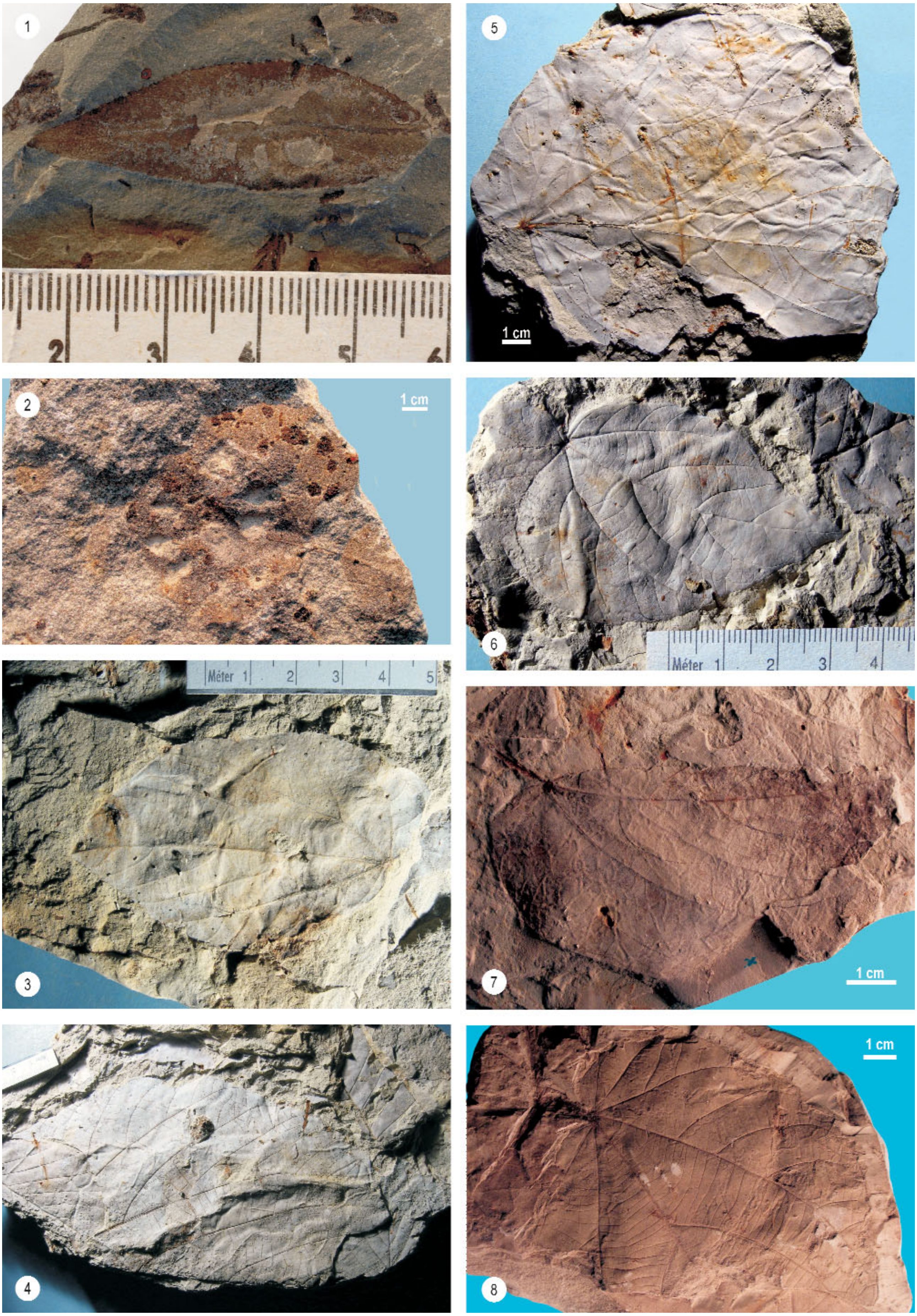

1
5
1 cm
2
1 cm
6
Méter 1 2 3 4
3
Méter 1 2 3 4 5
7
1 cm
4
8
1 cm

Plate XXX

1. *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Kvaček, Felsőtárkány, BP 60.1821.1.
2. *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Kvaček, Felsőtárkány, BP 60.1878.1.
3. *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Kvaček, Iharosberény, BP 2009.250.2.
4. *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Kvaček, Iharosberény, BP 2009.278.3.
5. *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Kvaček, Rózsaszentmárton, BP 2001.275.1.
6. *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Kvaček, Tiszapalkonya, BP 2009.352.1.
7. *Byttneriophyllum tiliifolium* (A. Braun) Knobloch & Kvaček, Rudabánya, BK–140.

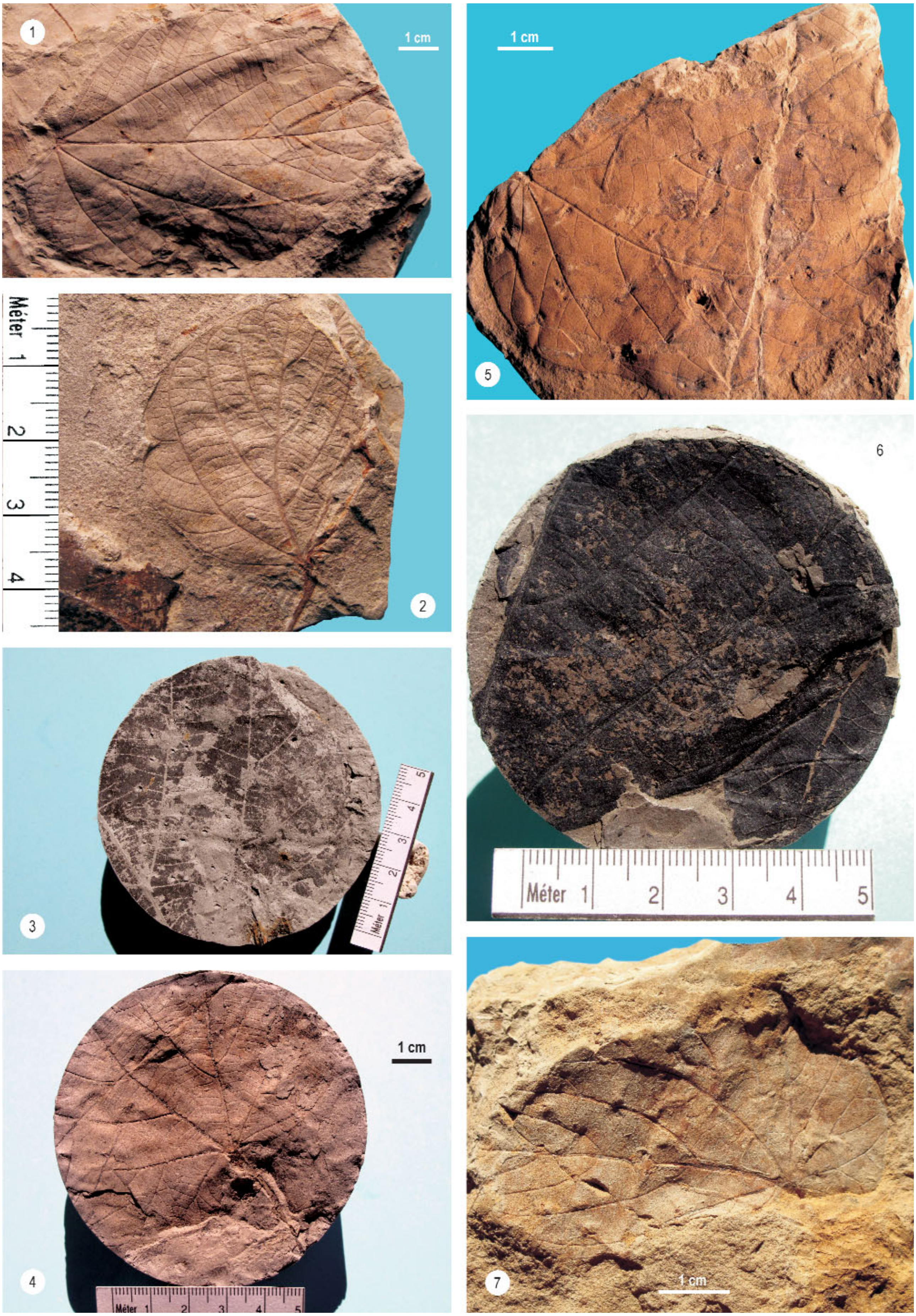

1
1 cm
Méter 1 2 3 4
2
3
4
1 cm
Méter 1 2 3 4 5
5
1 cm
6
Méter 1 2 3 4 5
7
1 cm

Plate XXXI

1. *Banisteriaecarpum giganteum* (GÖPPERT) KRÄUSEL, Rudabánya, BK–554.
2. *Banisteriaecarpum giganteum* (GÖPPERT) KRÄUSEL, Rudabánya, BK–579.
3. *Dicotylophyllum jungii* KNOBLOCH & KVAČEK, Balatonszentgyörgy, SAMU 2008.6.145.
4. *Dicotylophyllum jungii* KNOBLOCH & KVAČEK, Balatonszentgyörgy, BK– 4706.
5. *Platanus* sp. leaf, Balatonszentgyörgy, BK–1675.
6. *Musophyllum tárkányense* BUBIK, Felsőtárkány, BP 60.1830.1.
7. *Potamogeton martinianus* SITAR, Rózsaszentmárton, BP 2001.277.1.
8. *Potamogeton martinianus* SITAR, Rudabánya, BK–857.

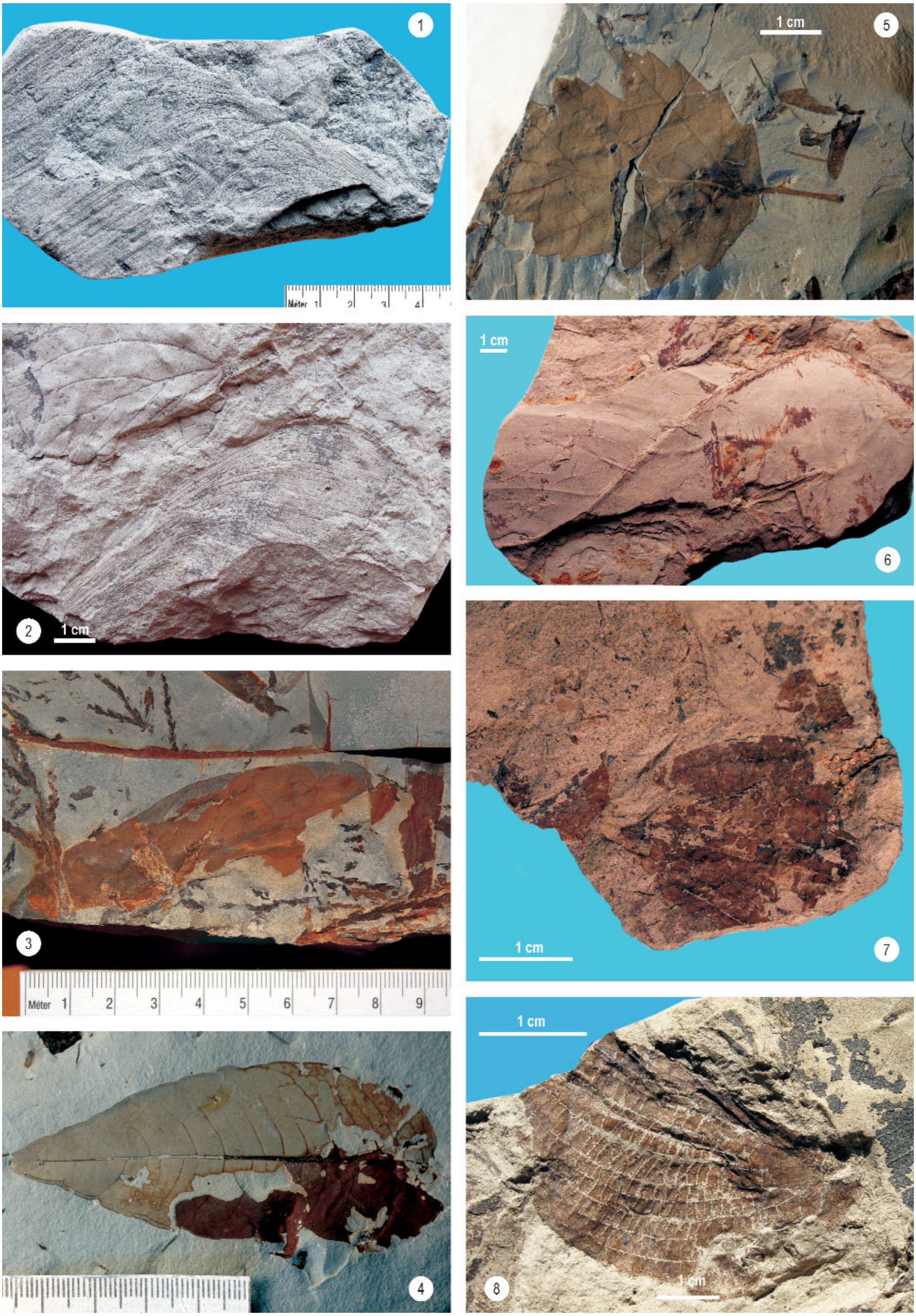

1
Méter 1 2 3 4
2
1 cm
3
Méter 1 2 3 4 5 6 7 8 9
4
5
1 cm
6
1 cm
7
1 cm
8
1 cm
1 cm

Plate XXXII

1. *Potamogeton martinianus* Sitar, Rudabánya, BK–271.
2. *Potamogeton martinianus* Sitar, Rudabánya, BK–262.
3. *Smilax weberi* Wessel in Wessel & Weber, Tihany, BP 85.209.2.
4. *Smilax weberi* Wessel in Wessel & Weber, Tihany, BP 85.205.5.
5. Monocotyledonae gen. et sp. 1., Balatonszentgyörgy, BK–1643.
6. Monocotyledonae gen. et sp., Felsőtárkány, BP 60.1874.1.
7. *Pinus* sp. 2, cone inner side, Diszel-Kula, BP 2008.30.1.
8. *Pinus* sp. 2, cone outer side, Diszel-Kula, BP 2008.30.1.

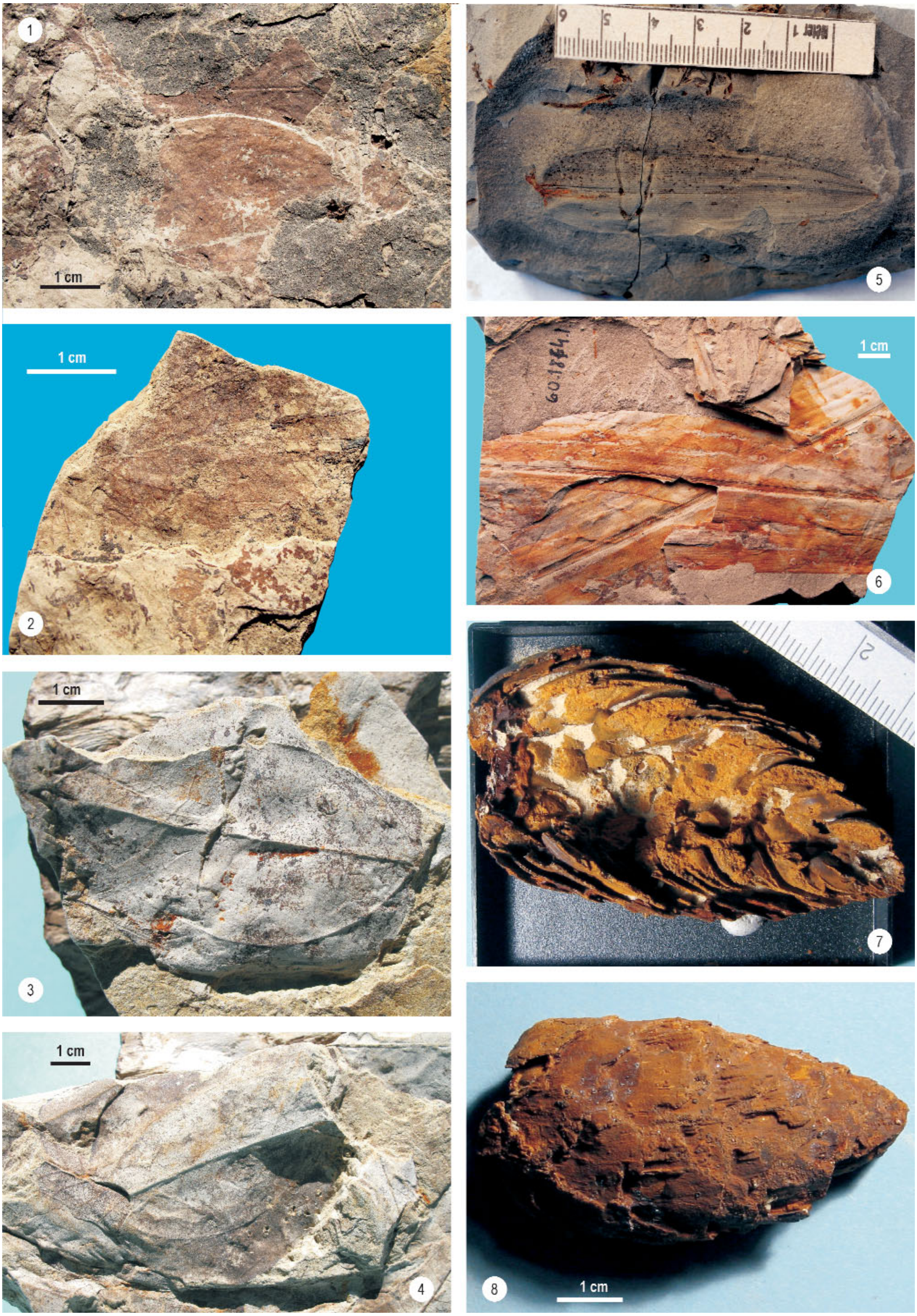
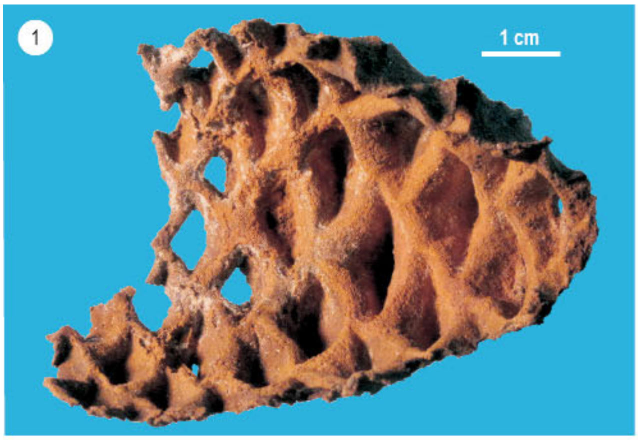

1
1 cm
2
1 cm
3
1 cm
4
1 cm
5
6
1 cm
7
8
1 cm

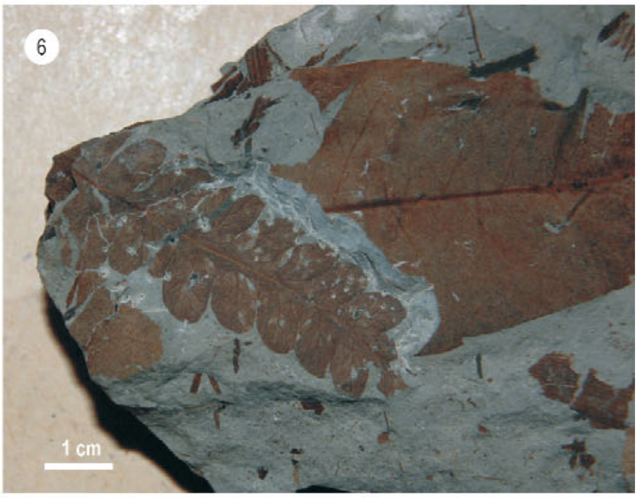
Plate XXXIII

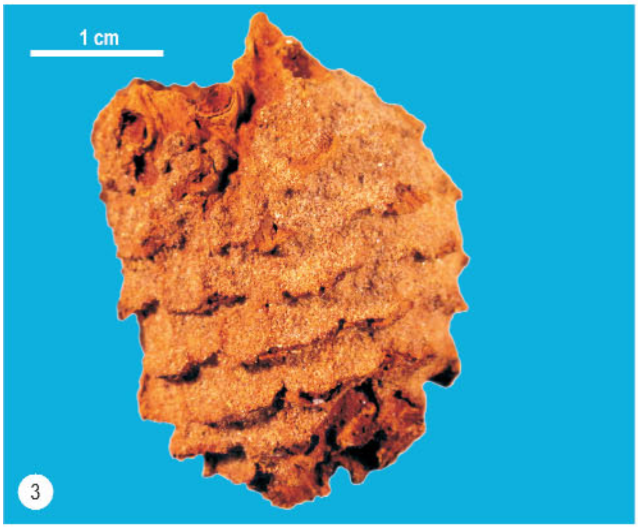
1. *Pinus* sp. 2, cone, Diszel-Kula, ZIRC 95.123.5a.
2. *Pinus* sp. 2, cone, Diszel-Kula, ZIRC 95.123.5b.
3. *Pinus* sp. 2, cone, Diszel-Kula, ZIRC 95.123.5c.
4. *Pinus* sp. 2, cone, Diszel-Kula, ZIRC 95.123.5d.
5. *Pinus* sp. 2, cone, Diszel-Kula, ZIRC 95.123.5e.
6. *Pronephrium stiriacum* (UNGER) KNOBLOCH & KVAČEK, Balatonszentgyörgy, SAMU 2008.27.9
7. *Daphnogene* sp., Rudabánya borehole Rb– 494, 60.1–64.4 m, BK–542.


1
1 cm


1 cm
5


1 cm
2


6
1 cm


1 cm
3


1
1 cm
2
3
4
4

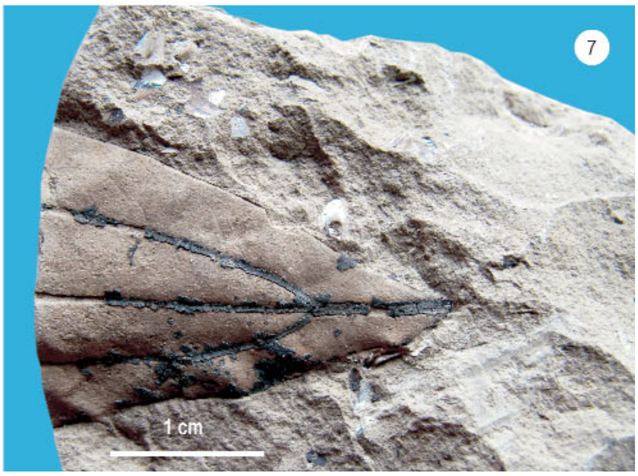

7
1 cm

Plate XXXIV

1. *Zelkova zelkovifolia* (UNGER) BŮŽEK & KOTLABA, Rudabánya, borehole Rb–617, 21.0–31.6 m, BK–749.
2. *Trapa pannonica* sp. nov., paratype, Rózsaszentmárton, MM 73.17.2.
3. *Trapa pannonica* sp. nov., paratype, Rózsaszentmárton, MM 64.1166.1.
4. *Trapa pannonica* sp. nov., paratype, Rózsaszentmárton, MM 64.1166.1. (second specimen on the same pice of stone, same inventar number)
5. *Byttneriophyllum tiliifolium* (A. BRAUN) KNOBLOCH & KVAČEK, Bükkábrány, BK 4491.
6. *Byttneriophyllum tiliifolium* (A. BRAUN) KNOBLOCH & KVAČEK, Visonta, BK 4515.
7. *Zelkova zelkovifolia* (UNGER) BŮŽEK & KOTLABA, Bükkábrány, BK–4484.

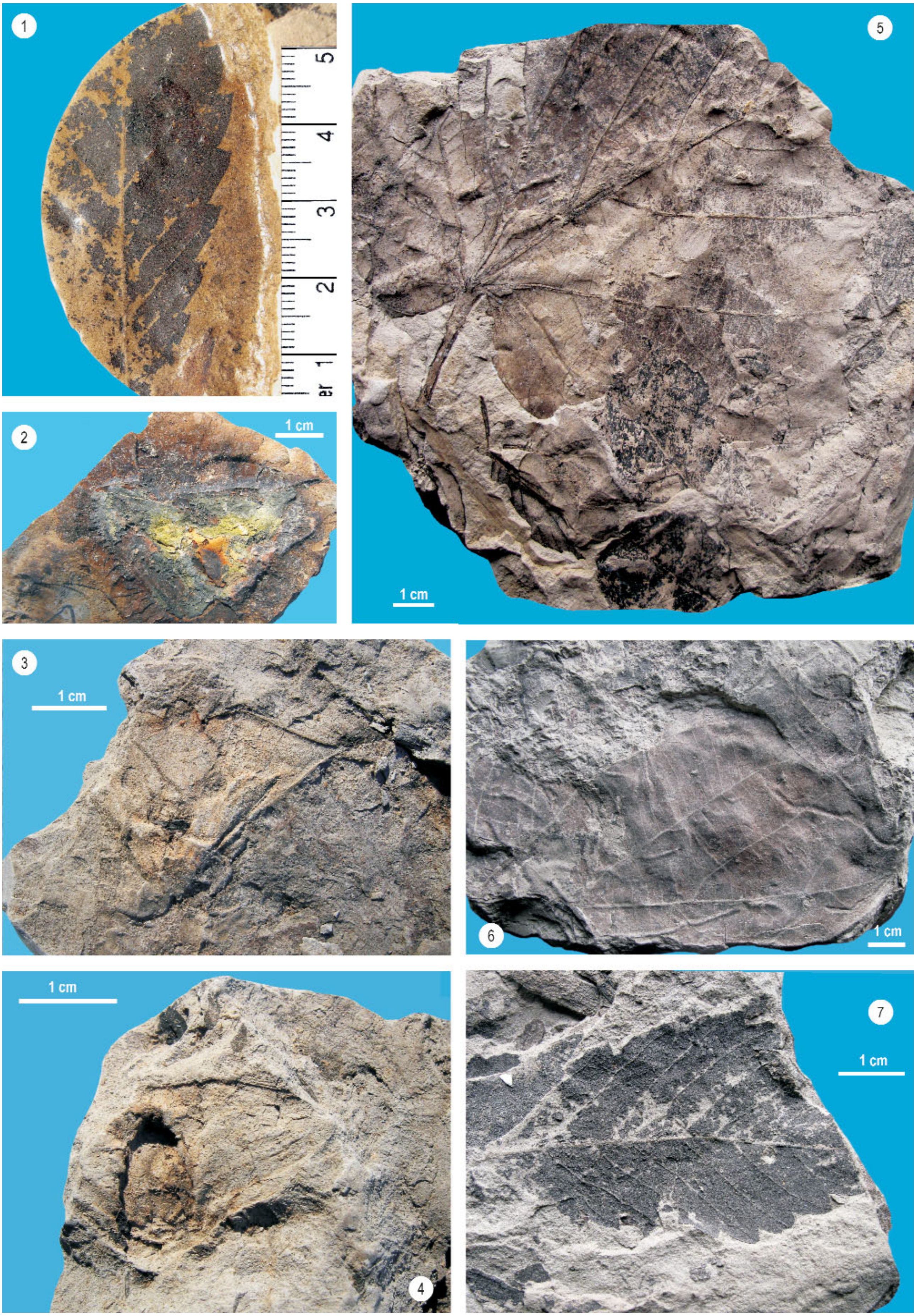

1
5
4
3
2
1
2
1 cm
5
1 cm
3
1 cm
6
1 cm
1 cm
4
7
1 cm

Plate XXXV

1. *Zelkova zelkovifolia* (UNGER) BŮŽEK & KOTLABA, Bükkábrány, BK–4474
2. *Spirematospermum wetzleri* (HEER) CHANDLER, fruit, Visonta, BK– 4670
3. *Spirematospermum wetzleri* (HEER) CHANDLER, fruit, Bükkábrány, BK–4665
4. *Spirematospermum wetzleri* (HEER) CHANDLER, fruit, Bükkábrány, BK–4667
5. *Pronephrium stiriacum* (UNGER) KNOBLOCH & KVAČEK, Visonta, BK–1021
6. *Quercus* sp., Visonta, BK without inventar number
7. *Osmunda parschlugiana* (UNGER) ANDREÁNSZKY, Visonta, BK–1027.
8. *Pinus* sp. 1, Mindszentkálla, BP 2008.463.1.

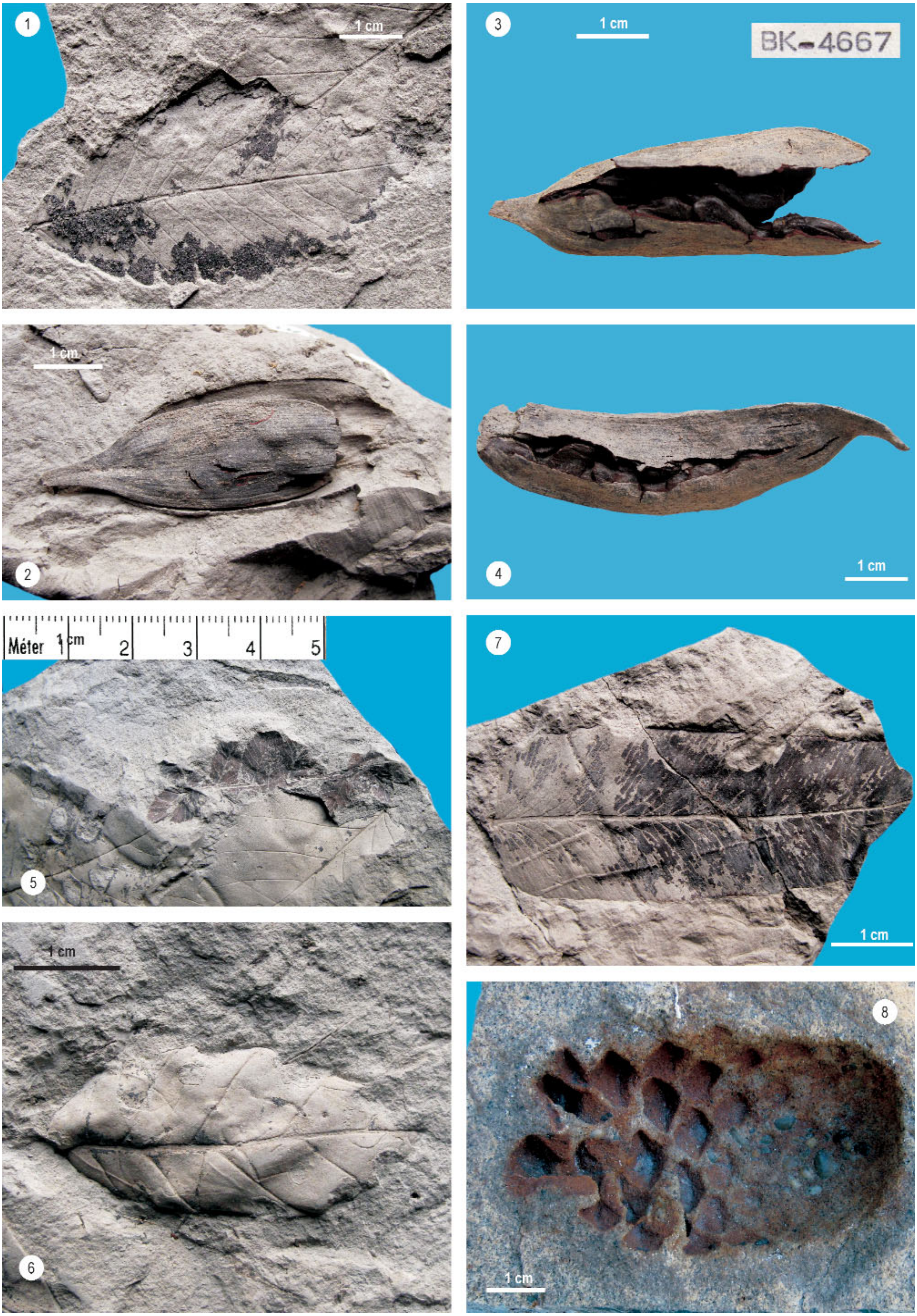
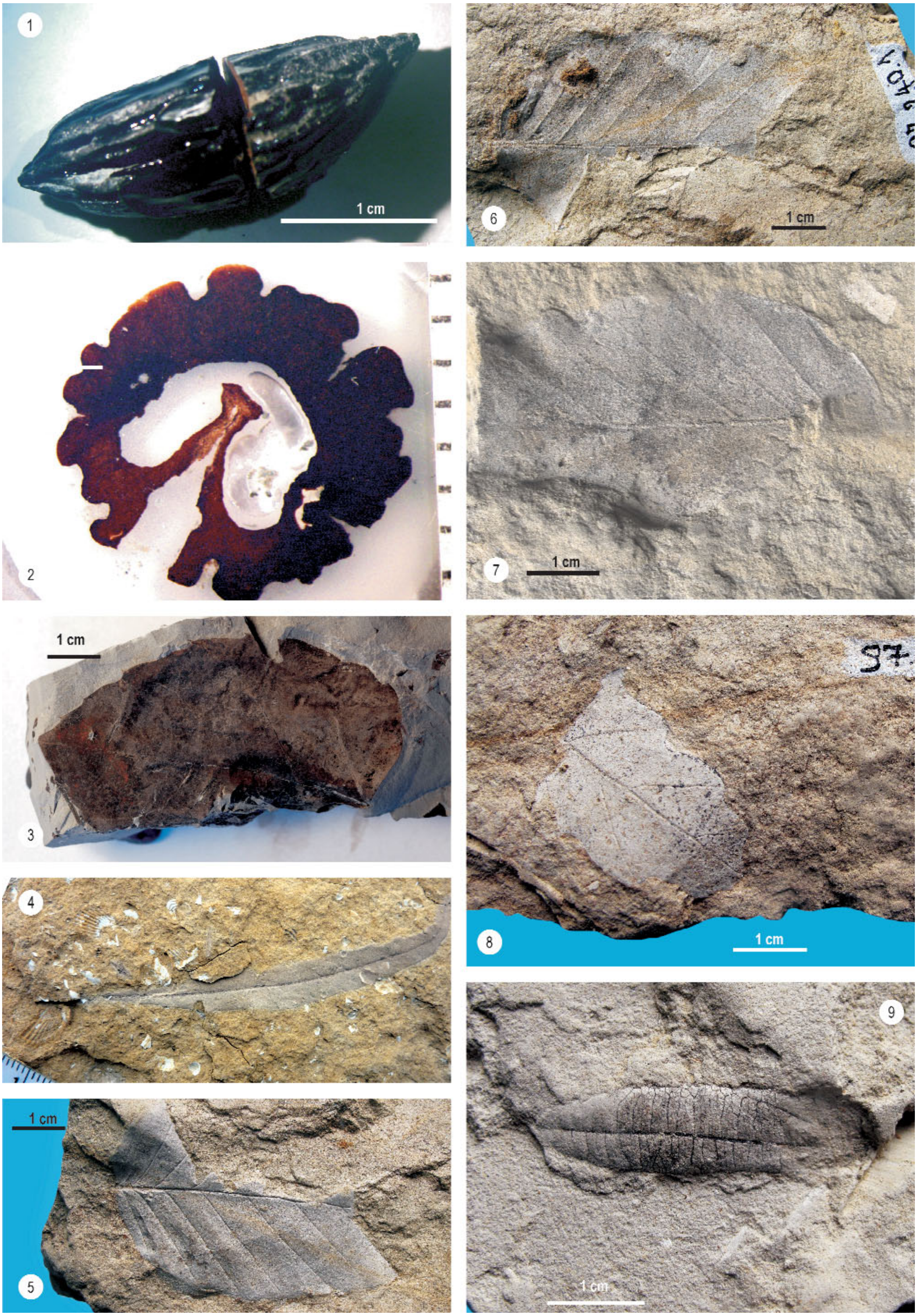

1
1 cm
3
1 cm
BK-4667
1 cm
2
4
1 cm
Méter 1 cm 2 3 4 5
5
7
1 cm
1 cm
6
8
1 cm

Plate XXXVI

1. *Mastixia amygdalaeformis* (SCHLOTHEIM) KIRCHHEIMER, fruit, Rudabánya, 2013.1.1. (= BK–9036)
2. *Mastixia amygdalaeformis* (SCHLOTHEIM) KIRCHHEIMER, cross section of the fruit, Rudabánya, 2013.1.1. (= BK–9036)
3. Hamamelidaceae gen. et sp., Balatonszentgyörgy, BK 1564
4. *Myrica lignitum* (UNGER) SAPORTA, Pécs-Danitz-puszta, BP 2013.85.1.
5. *Fagus haidingeri* KOVÁTS emend. KNOBLOCH, Pécs-Nagyárpád, BP 97.239.1.
6. *Fagus haidingeri* KOVÁTS emend. KNOBLOCH, Pécs-Nagyárpád, BP 97.240.1.
7. *Fagus haidingeri* KOVÁTS emend. KNOBLOCH, Pécs-Nagyárpád, BP 97.238.1.
8. *Quercus* sp., Pécs-Nagyárpád, BP 97.227.1.
9. *Carpinus betulus* L. fossilis, Pécs-Nagyárpád, BP 97.247.1.


1
1 cm
2
1 cm
3
4
1 cm
5
6
1 cm
7
1 cm
8
1 cm
9
1 cm