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Palaeoflora of Kamenica (Pranjani Basin, western Serbia)

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Key words:

Macroflora, Late Oligocene,
Pranjani Basin, Kamenica

Abstract. Palaeofloras of the Paleogene in Serbia are relatively rare, especially in comparison with floras from Neogene sediments. Most Paleogene phytoassociations from the territory of Serbia existed in a dry and warm climate. The youngest Paleogene phytoassociation originates from the Pranjani Basin (Western Serbia), locality Kamenica. The age of this palaeoflora is determined as Late Oligocene. This fossil plant assemblage is different from other Paleogene phytoassociations. The palaeoflora from Kamenica is characterized with leaf imprints larger than in other Paleogene fossil floras. Furthermore, it differs in taxonomical composition. The prevailing forms are conifers and representatives of broad-leaved evergreen forests. In other Paleogene phytoassociations, elements of broad-leaved evergreen forests are extremely rare. The dominating elements in the palaeoflora of Kamenica are the conifers, especially *Glyptostrobus*, *Pinus*, *Sequoia* and *Tetraclinis*. The representatives of the broad-leaved evergreen forests are *Laurus*, *Magnolia*, “*Quercus*”, etc.

Апстракт. Палеогене флоре у Србији су релативно ретке, посебно у поређењу са неогеним флорама. Већина палеогених фитоасоцијација са територије Србије је егзистовала у сувим и топлим климатима. Најмлађа палеогена фитоасоцијација је флора Каменице (Прањански басен, западна Србија). Старост палеофлоре Каменице је одређена као млађе олигоценска. Састав ове фосилне флоре се разликује од осталих палеогених фитоасоцијација. Палеофлору Каменице карактеришу лисни отисци већих димензија него у другим флорама палеогена. Такође, флора Каменице се разликује и по таксономском саставу. У овој палеофитоасоцијацији преовлађују четинари и елементи широколисне вечнозелене вегетације. У другим палеогеним флорама елементи широколисно-вечнозелене вегетације су изузетно ретки.

У палеофитоасоцијацији Прањанског басена доминирају конифери, посебно *Glyptostrobus*, *Pinus*, *Sequoia* и *Tetraclinis*. Представници широколисне вечнозелене вегетације су заступљени родовима *Laurus*, *Magnolia*, “*Quercus*” и др.

Кључне речи:

макрофлора, млађи олигоцен,
Прањански басен, Каменица

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Introduction – geological setting

The Pranjani Basin is part of the West Morava Graben (also known as the Čačak-Kraljevo Basin).

Located on the northwestern border of the Čačak-Kraljevo Basin, the Pranjani Basin covers an area of 45 km² and is elongated in an east-west direction (Fig. 1). On the southeast it is limited by the slopes of Maljen and Suvobor, while the north side is framed by peridotite-serpentine massif. (EREMIJA et al., 1977).

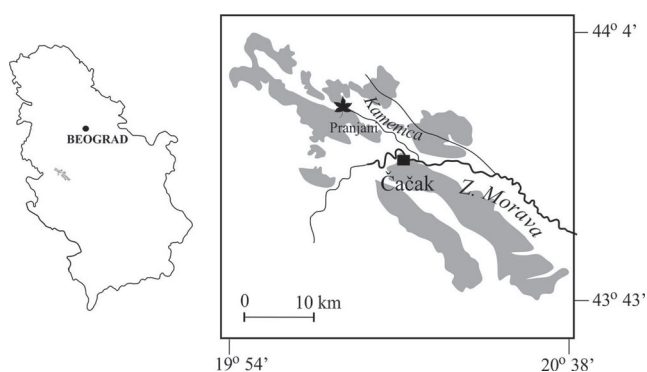


Fig. 1. Position of Čačak-Kraljevo Basin and position of palaeoflora locality.

According to the changes of lithological composition it is possible to divide the Pranjani Basin into three horizons:

The oldest horizon is located in the western part of the basin (the village of Kamenica) and it consists of well cemented conglomerates and breccias lying directly over the peridotite-serpentine rock. Above them is a sequence of alternating sandstones, conglomerates and marlstones. Well preserved remains of fossil plants and fish have been found in these sediments. The second horizon is a “multicoloured series”, of a depth of about 100 m. There is no observed direct contact with the layers of the older horizon. This horizon is composed of sandstones and sands with thin layers of conglomerates, dolomitic limestones and shales as well as one intercalation of tuffites. The third horizon consists of marls and shales (EREMIJA et al., 1977).

The fossil fish *Smerdis minutus* (BLAINVILLE) (ANĐELKOVIĆ, 1989) was found in the first horizon’s marls. This finding confirms the Oligocene age of the

sediments. The remains of the fossil plants, which are the subject of this paper, originate from the same sediments.

Based on fossil fish finding and comparison with other similar Early Miocene floras, the deposits of the first horizon probably correspond to the upper parts of the Late Oligocene-Early Miocene.

The Zapadna Morava Graben, also known as the Čačak-Kraljevo Basin, is the largest Intradinaric depression which extends NW–SE. Block downthrows along NW–SE faults and later ruptures of E–W and some of NE–SW trends, controlled the formation of the Graben and its geometry. A characteristic of the Zapadna Morava Graben is the large subsidence of the Ottnangian-Karpatian, probably superposed upon similar movements of the Oligocene-Miocene. The central Graben sank the most, over a relatively wide area. (MAROVIĆ et al., 2007).

A gravity anomaly map (Fig. 2) was compiled in order to check the correlation between the position of Neogene basins and the distribution of gravity anomalies. Neogene basins are filled with sediments of low density, in comparison to the density values of the basement and surrounding rocks. In the presented study area (Fig. 2), the position of Neogene basins mostly coincides with low gravity values, but it is not a general case. Gravity anomalies are strongly influenced by the complex configuration of the basin basements and surrounding geology, implying a relatively shallow basin depth. The location of the Kamenica paleontological site is in a zone of abrupt changes of gravity anomaly values, probably

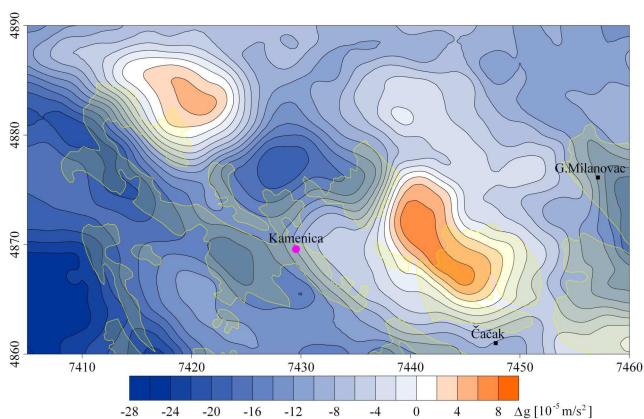


Fig. 2. Gravity anomaly map (Dg) with the position of Neogene basins (yellow shaded areas) and the location of the paleontological site Kamenica (pink dot)

in the vicinity of a steep (gravitational or reverse) fault of SE–NW direction.

The Paleogene and Neogene deposits in last few years were investigated from different aspects (e.g. ĐORĐEVIĆ-MILUTINOVIĆ, 2018; RADOVIĆ, 2018; JOVANOVIĆ et al., 2019a, b) and this paper is one more contribution to knowledge of these deposits.

Palaeofloristic composition:

The leaf imprints, presently being studied, originate from dark-gray, very compact marls which lie across the serpentine. These sediments are characterized with considerable depth.

Palaeoecology and palaeoclimatology

About one hundred leaf imprints have been collected at the Kamenica locality. Considering the relatively small number of specimens, there is a rich taxonomical diversity (Table 1).

Analyzing the character of the leaf imprints morphology it can be observed that leaves with entire margin and brochidodromous or eucamptodromous venation, which correspond to subtropical dendroflora, prevail (categorization WOLFE, 1971). Most plant taxa have brochidodromous or eucamptodromous venation. Most abundant are microphyllous leaves, while the presence of notophyllous

Table 1. Identified taxa from Kamenica locality.

Taxon	No specimen
<i>Pinus palaeontaphylla</i> TANAI & ONOE	7
<i>Pinus hepios</i> (UNGER) HEER	5
<i>Pinus</i> sp. – cone	1
<i>Pinus</i> sp. – seed	1
<i>Sequoia abietina</i> (BRONGNIART) KNOBLOCH	6
<i>Taxodium dubium</i> (STERNBERG) HEER	4
<i>Glyptostrobus europaeus</i> (BRONGNIART) UNGER	12
<i>Glyptostrobus</i> sp. – seed	3
<i>Tetraclinis salicornioides</i> (UNGER) KVAČEK	6
<i>Magnolia mirabilis</i> KOLAKOVSKIY	1
" <i>Laurus</i> " <i>princeps</i> HEER	5
<i>Daphnogene polymorpha</i> (AL. BRAUN) Ettingshausen forma <i>bilinica</i> (UNGER) SITAR & KVAČEK	2
" <i>Quercus</i> " <i>cruciata</i> AL. BRAUN	2
<i>Myrica lignitum</i> (UNGER) AL. BRAUN	2
<i>Juglans acuminata</i> AL. BRAUN ex UNGER	1
<i>Acer</i> sp. (FRUCTUS)	1
<i>Acer</i> sp.	1
<i>Rhodomyrthophyllum reticulosum</i> (ROSSMASSLER) KNOBLOCH & KVAČEK	3
<i>Mahonia bilinica</i> (UNGER) KVAČEK & BUŽEK	4
<i>Ziziphus ziziphoides</i> (UNGER) WEYLAND	5
<i>Ziziphus</i> sf. <i>Tiliaefolius</i> ETTINGSHAUSEN	3
<i>Platanus neptuni</i> (Ettingshausen) Bužek, Holy & Kvaček	2
<i>Ulmus pyramidalis</i> GOEPPERT	1
Betulaceae gen. et sp. indet.	1
" <i>Bumelia</i> " <i>minor</i> (UNGER) UNGER	1
<i>Nyssa</i> sp. – seed	1
<i>Leguminosites</i> sp.	1
<i>Dicotylophyllum</i> sp.	1

leaves are rare. Representatives of humid subtropical forest dominated in paleophytocenosis of Kamenica: *Glyptostrobus* (Plate 1, Figs. 10, 14, 15, 17), *Sequoia* (Plate 1, Figs. 2, 8, 12; Plate 2, Fig. 2), *Taxodium* (Plate 1, Figs. 9, 11, 16; Plate 2, Figs. 10, 14), *Laurus* (Plate 3, Figs. 1–6, 8). These taxons prevail in Kamenica palaeoflora. The other representative of the humid subtropical forest is represented by the *Myrica* (Plate 5, Figs. 1, 5) and *Platanus neptuni* (Plate 4, Fig. 10). These plant forms inhabited the banks of the river and the margins of the lake basin.

A significant number of samples in this locality belongs to pines: *Pinus hepios* (Plate 1 Fig. 5), *Pinus palaeopentaphylla* (Plate 1, Figs. 1, 3, 4, 7).

Vegetation elements of temperate climate are very rare, and represented only by a few imprints of Betulaceae and Ulmaceae.

Based on the taxonomical composition of palaeophytoassociation and leaf morphology, it has been inferred that the climate was subtropical and humid during the existence of this plant association (WOLFE, 1971; WILF, 1997; TRAISET et al., 2005).

Comparisons between the flora of Kamenica and other Oligocene and Early Miocene floras in Serbia

The palaeoflora of Kamenica has been compared to the Oligocene and Lower Miocene floras from the territory of Serbia. Palaeovegetation from Kamenica differs from other Oligocene floras due to the existence in a wetter climate. The climatic conditions in the period when the Kamenica palaeophytoassociation existed were much more similar to those of the Early Miocene. The taxonomic composition of the palaeoflora of Kamenica is a mix of Late Oligocene and Early Miocene floras from Serbia.

The Late Oligocene flora of Bogovina (PANTIĆ & PAVLOVIĆ, 1977) from eastern Serbia is a palaeophytocenosis of subtropical-tropical climate. In this palaeoflora conifers prevail, especially *Sequoia* but broad-leaved elements are rare. In this palaeophytoassociation dominate xeromorphic leaves from angiosperms.

In the Oligocene flora of Divljana (Koritnica Basin - Southeastern Serbia) (MIHAJLOVIĆ, 1985) xerophytes

Ziziphus ziziphoides (UNGER) Weyland predominate. Contrary to the flora of Kamenica, there are also, rare humid forms and numerous xeromorphic elements of vegetation in the palaeovegetation of Divljana.

In the palaeoflora of Kosanička Rača (Central Serbia), (MIHAJLOVIĆ, 1985) Oligocene age, xeromorphic plant forms predominate. The climate during the existence of palaeovegetation was arid, subtropical-tropical.

Arid plant associations dominated by *Ziziphus ziziphoides* originate from Metohija Late Oligocene sediments (the Strezovac Basin, Southern Serbia) (MILOVANOVIĆ, 1969). In this palaeoflora xerophyllous and subxerophyllous plant forms predominate.

The palaeoflora of Kamenica is not as arid as most of Oligocene floras in Serbia. In most of Oligocene floras of Serbia, the dominant element is xerophytic *Ziziphus ziziphoides*, of which there are only two specimens in the Kamenica palaeoflora.

Lower Miocene floras of Serbia, such as the flora from the Valjevo-Mionica basin (Western Serbia) (PANTIĆ, 1956; LAZAREVIĆ et al., 2013), Žagubica basin (eastern Serbia) (MILOVANOVIĆ & MIHAJLOVIĆ, 1984; LAZAREVIĆ & MILIVOJEVIĆ, 2010) and Popovac (Central Serbia) (PANTIĆ, 1956; LAZAREVIĆ, 2008) are typically broad-leaved evergreen vegetation. In these palaeofloras Lauraceae, especially *Daphnogene* predominate. Conifers are more abundant in the Kamenica palaeoflora than in most of the Early Miocene floras of Serbia. During the Early Miocene paleoclimatic conditions in Serbia were warm and humid as can be inferred from the vegetation of that time. The flora of Kamenica also indicates the subtropical-tropical, humid character of the climate. Palaeovegetation of Kamenica is distinguished from the Early Miocene floras by a rare representation of *Daphnogene* and lower proportion of elements of evergreen broad-leaved vegetation.

Conclusions

Palaeofloras of the Paleogene in Serbia are relatively rare, especially in comparison with floras from Neogene sediments. Most Paleogene phytoassociations from the territory of Serbia existed in dry and warm climate. The youngest Paleogene phy-

toassociation originates from the “Pranjani Basin” (Western Serbia), locality Kamenica. The age of this palaeoflora is determined as the Late Oligocene based on fish fossil and comparison with other similar floras of Oligocene and Early Miocene in Serbia. This fossil plant assemblage is different from other phytoassociations of Paleogene and Early Miocene. The climatic conditions in the period when the Kamenica palaeophytoassociation existed were much more similar to those of the Early Miocene. The taxonomic composition of the palaeoflora of Kamenica is a mix of Late Oligocene and Early Miocene floras from Serbia.

Paleoclimate estimates derived from the woody dicotyledonous angiosperm from the Kamenica locality indicate the climate was warm and humid, subtropical-tropical.

Such favorable environmental and climatic conditions were reflected in the vigour of vegetation in the Late Oligocene.

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Резиме

Палеофлора Каменице (Прањански басен, западна Србија)

Палеогене флоре у Србији су релативно ретке, посебно у поређењу са флорама млађих периода. Већина палеогених фитоасоцијација са територије Србије су егзистовале у условима суве и топле климе. Најмлађа палеогена фитоасоцијација је са локалитета Каменица – Прањански басен (западна Србија). Старост ове палеофлоре је одређена као млађеолигоценска на основу одредбе врсте фосилне рибе, из истих седимената, *Smerdis minutus* (BLAINVILLE), која је карактеристична за олигоцен (АНЂЕЛКОВИЋ, 1989), као и поређењем са сличним палеофлорама олигоцена и доњег миоцена са територије Србије.

Прањански басен је део Западноморавског грабена и налази се на северозападном делу грабена. Има изглед плитког рова ограниченог раседима пружања СЗ–ЈИ и додатно је издељен на мање блокове системом раседа СИ–ЈЗ и И–З.

То је депозициони простор слабог интензитета тоњења (MAROVIĆ et al., 2007).

Биљни фосилни остаци су прикупљени са локалитета Каменичке реке у селу Каменица. Лисни отисци су из сивих, табличастих лапораца који леже преко серпентинита.

Лисни отисци су добро очувани и указују на то да је палеовегетација највероватније егзистовала у близини некадашњег језера.

Палеофитоасоцијација Каменице се карактерише лисним отисцима који су већи него у другим палеогеним флорама. У поређењу са осталим олигоценским флорама, палеофлора Каменице је хумиднија и има већи број таксона који указују на влажну климу док су ксерофилни вегетациони елементи слабо заступљени. За разлику од доњомиоценских флора Србије које се карактеришу доминацијом широколисне, вечнозелене вегетације и великом заступљеношћу Lauraceae, посебно *Daphnogene*, у флори Каменице ови флорни елементи су мање присутни.

На основу дрвенастих дикотиледоних скривеносеменица из Каменице може се рећи да је клима у време егзистовања ове вегетације била топла и влажна, суптропско-тропска. Овако пољни климатски услови погодују биљној асоцијацији млађег олигоцена.

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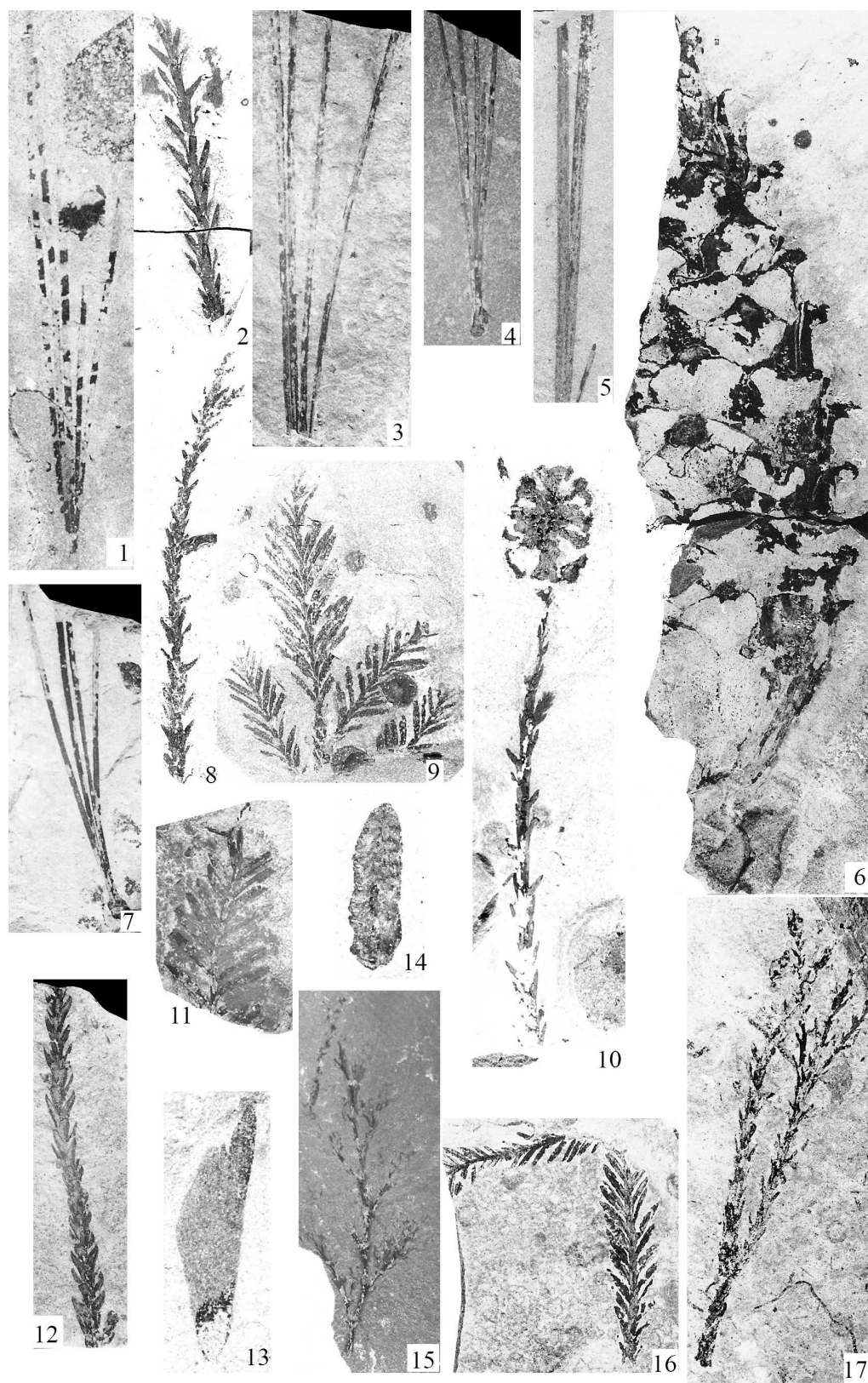


Plate 1. Figs. 1, 3, 4, 7. *Pinus palaeopentaphylla* TANAI & ONOE; Figs. 2, 8, 10, 12. *Sequoia abietina* (BRONGNIART) KNOBLOCH; Fig. 5. *Pinus hepios* (UNGER) HEER; Fig. 6. *Pinus* sp. - cone; Figs. 9, 11, 16. *Taxodium dubium* (STERNBERG) HEER; Figs. 15, 17. *Glyptostrobus europaeus* (BRONGNIART) UNGER; Fig. 13. *Pinus* sp. - seed ($\times 2$); Fig. 14. *Glyptostrobus* sp. - seed ($\times 2$).

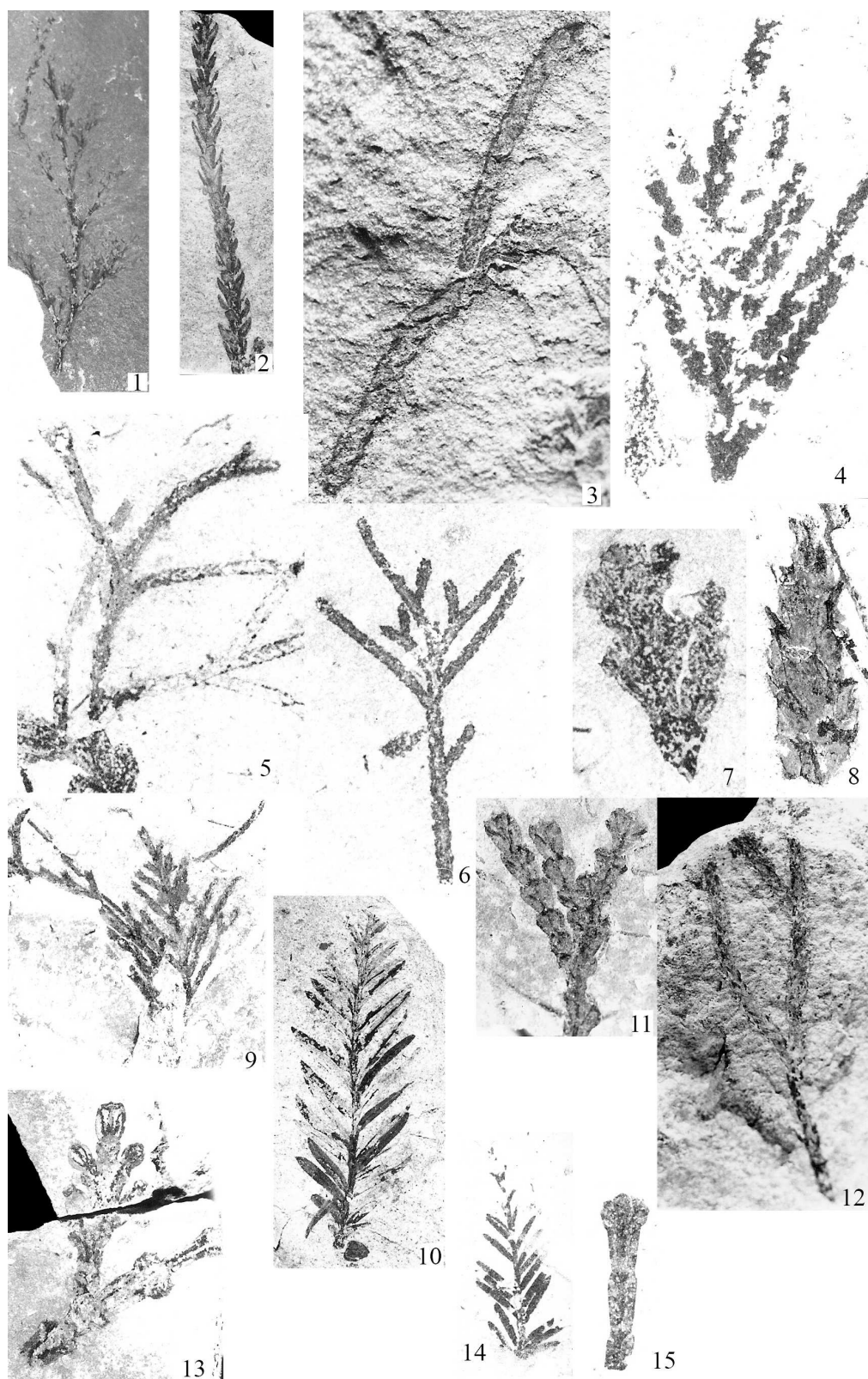


Plate 2. Figs. 1, 12. *Glyptostrobus europaeus* (BRONGNIART) UNGER; Fig. 2. *Sequoia abietina* (BRONGNIART) KNOBLOCH; Figs. 3, 5, 6, 9, 11, 12, 13. *Tetraclinis salicornioides* (UNGER) KVAČEK; Figs. 10, 14. *Taxodium dubium* (STERNBERG) HEER; Figs. 4, 7. *Tetraclinis salicornioides* (UNGER) KVAČEK (×2); Fig. 8. *Tetraclinis salicornioides* (UNGER) KVAČEK - cone (×2); Fig. 15. *Tetraclinis salicornioides* (UNGER) KVAČEK.

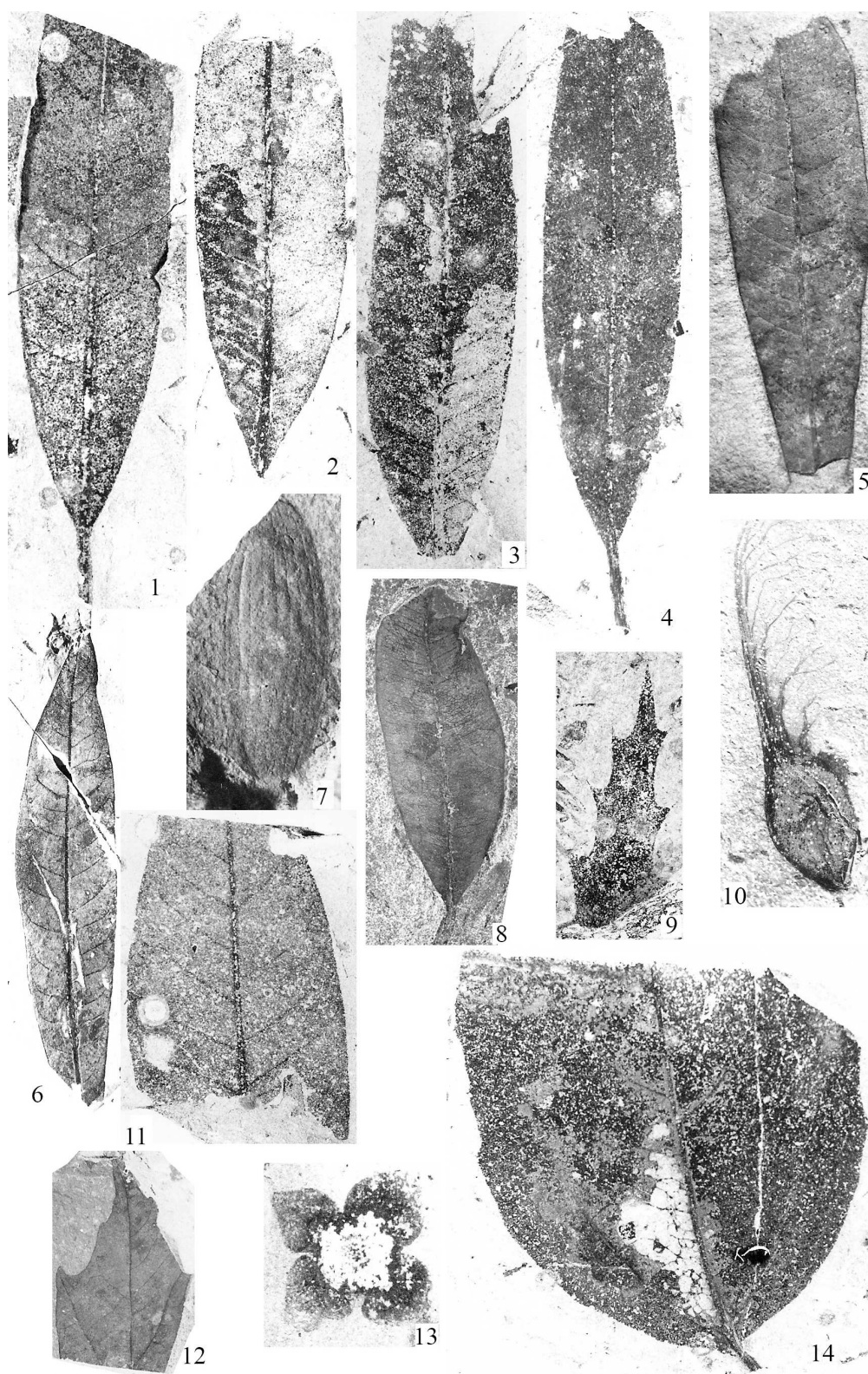


Plate 3. Figs. 1–6. *Laurus* *princeps* HEER; Fig. 7. *Nyssa* sp. – seed (×4); Fig. 8. *Rhodomyrthophyllum reticulosum* (ROSS-MÄSSLER) KNOBLOCH & KVAČEK; Fig. 9. *Mahonia bilinica* (UNGER) KVAČEK & BUŽEK; Fig. 10. *Acer* sp. (seed); Fig. 11. *Juglans acuminata* AL. BRAUN ex UNGER; Fig. 12. *Acer* sp.; Fig. 13. *Dicotylophyllum* sp.; Fig. 14. *Ziziphus* cf. *tiliaefolius* ETTINGSHAUSEN.

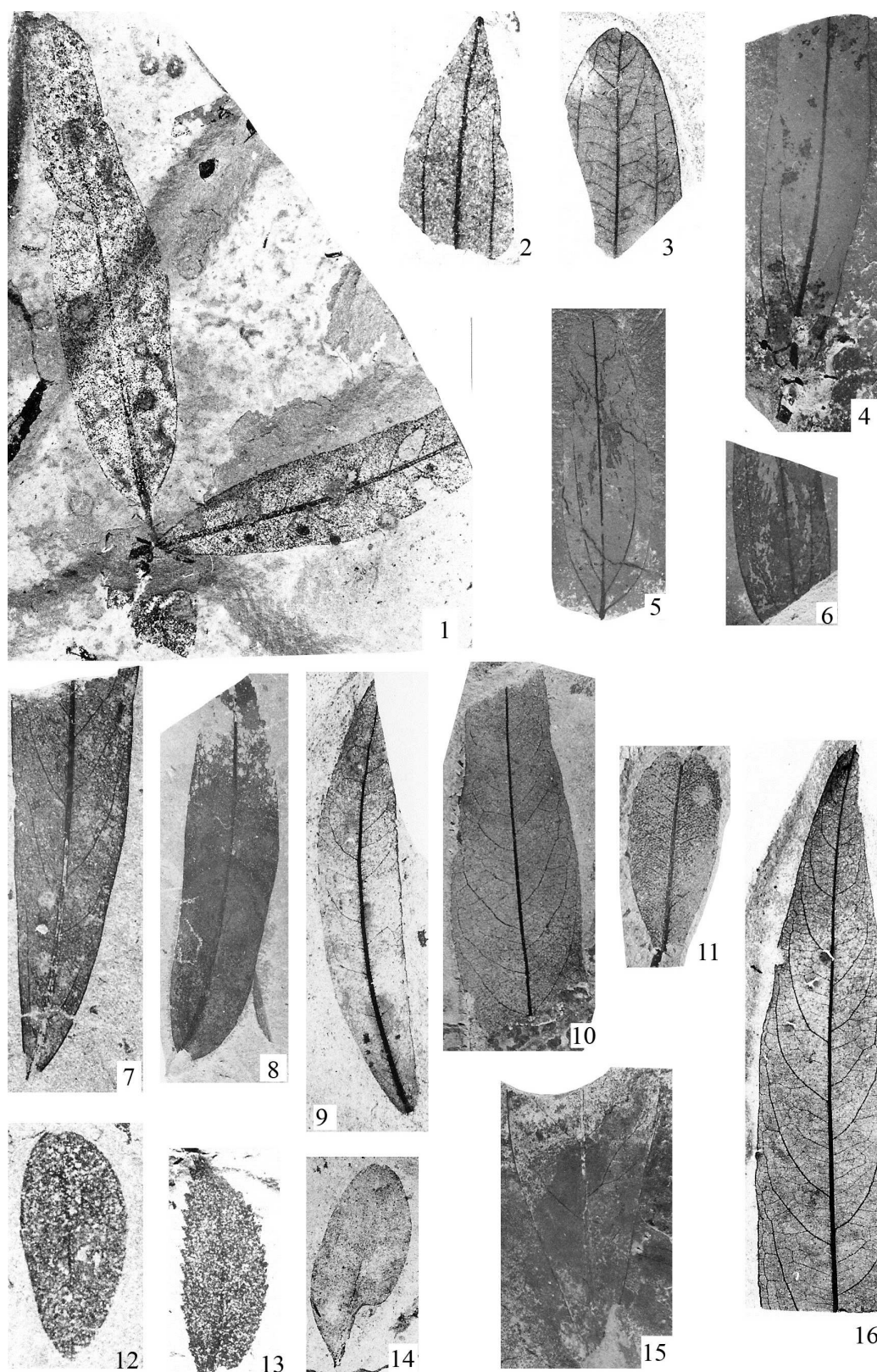


Plate 4. Figs. 1, 7, 9, 12, 16. "*Laurus*" *primigenia* UNGER sensu WEYLAND; Figs. 2, 3. *Ziziphus zizyphoides* (UNGER) WEYLAND; Figs. 4–6. *Daphnogene polymorpha* (AL. BRAUN) ETTINGSHAUSEN forma *bilinica* (UNGER) SITAR & KVAČEK; Figs. 11, 15. "*Bumelia*" *minor* (UNGER) UNGER; Fig. 10. *Platanus neptuni* (ETTINGSHAUSEN) BUŽEK, HOLY & KVAČEK; Fig. 14. *Ulmus pyramidalis* GOEPPERT

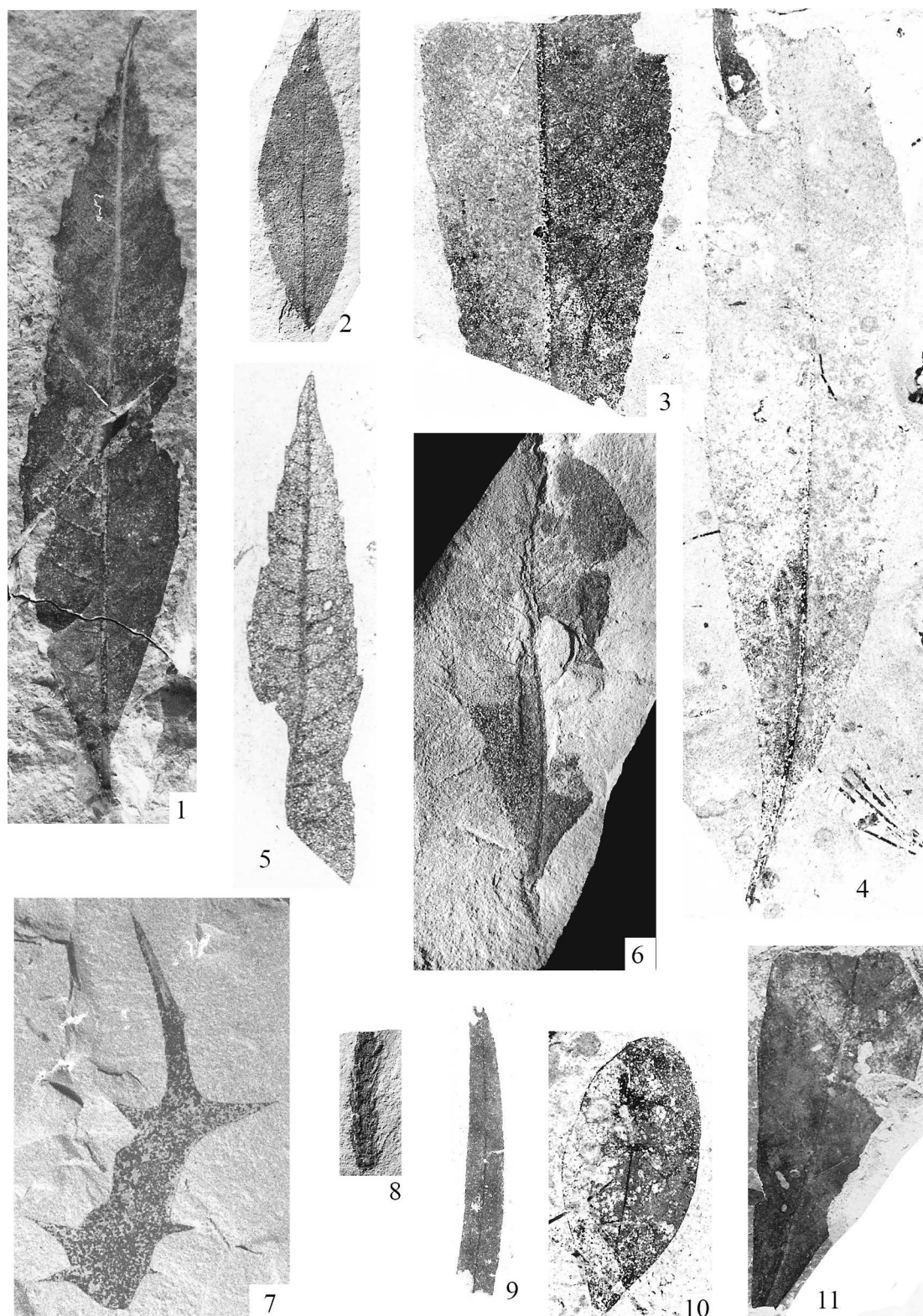


Plate 5. Figs. 1, 5. *Myrica lignitum* (UNGER) SAPORTA; Fig. 2. "*Laurus*" *princeps* HEER; Figs. 3, 4. *Platanus neptuni* (ETTING-SHAUSEN) BUŽEK, HOLY & KVAČEK; Fig. 6. *Magnolia mirabilis* KOLAKOVSKIY; Fig. 7. "*Quercus*" *cruciata* AL. BRAUN; Fig. 8. Betulaceae gen. et sp. indet.; Figs. 9, 10. *Leguminosites* sp.; Fig. 11. *Dicotylophyllum* sp.