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UPPER EOCENE FLORA OF OVČE POLJE, MACEDONIA

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Abstract: Varied, mainly marine, turbidite formations are extensively developed in Ovče Polje (Štip area) of Eastern Macedonia, determined as Upper Eocene (Priabonian) using diverse marine fossils. Land macrofloral remains, dominantly of *Lauraceae*, *Fagaceae*, and *Zizyphus zizyphoides*, have been found in several places. Contained in deposits of an identified age, this fixed flora is very significant for correlations with other fossil floras.

Key words: Upper Eocene, Priabonian, Macedonia, macroflora.

Introduction

The Ovče Polje Basin, where Upper Eocene deposits have a large coverage, is at present only a part of a large sedimentation basin which, in the Upper Eocene, extended to the north including the present Pčinja and Poljanica-Tesovište Basins (extreme SE Serbia, Yugoslavia); while eastern part of the basin extended to the present Bulgarian border zone - the Kraistid (Fig. 1). Deposits formed in this sedimentation area, situated for the most part in Macedonia, are reffered to as Pčinja-Ovče Polje Group. Fossil plants, mainly represented by leaf impressions, have been found in Ovče Polje in many places.

Geology

The Pčinja-Ovče Polje Group in the Ovče Polje Basin is represented by various sedimentary members, which were given different interpretations in texts (Collective of Authors 1954; Temkova 1985; Dimitrijevič & Dimitrijevič 1987) and various geological maps. Dimitrijevič & Dimitrijevič (1987) differentiated in the upwards sequence the following:

– conglomerates (0 - 700 m, thickness increasing to the south, locally with limestones inclusions or limestone on the top);
– lower turbidite (0 - 700 m);
– lower yellow sandstones (up to 1500 m, sporadically with yellow sandstones or limestone bed).

Turbidites (sometimes interpreted as flysch) are notably dominant. Limestone levels in turbidites, with brackish or reef fauna, indicate the basin differentiation, that is, the presence of shallow and turbidity troughs. Geotectonically, Upper Eocene deposits covered the entire width of the Vardar zone and all of the Serbian-Macedonian massif visible in SE Serbia and in Macedonia.

Microfossils: pelagic and benthonic foraminifers, octracods, charas; and macrofossils: corals, gastropods, pelecypods, echinoids; and macroflora have been found in several places (Collective of Authors 1954; Temkova 1985). Chiefly based on microfauna: numulites (*Numulites fabiani*), operculinae, discocyclinae, etc., the deposits of Ovče Polje were determined as Upper Eocene (Priabonian).

Marine fauna has not been found in the northern part of the Pčinja-Ovče Polje Group (Pčinja-Poljanica-Tesovište Basins). Bulgarian geologists used marine fauna in identifying Upper Eocene and Lower Oligocene in the Kraistid.

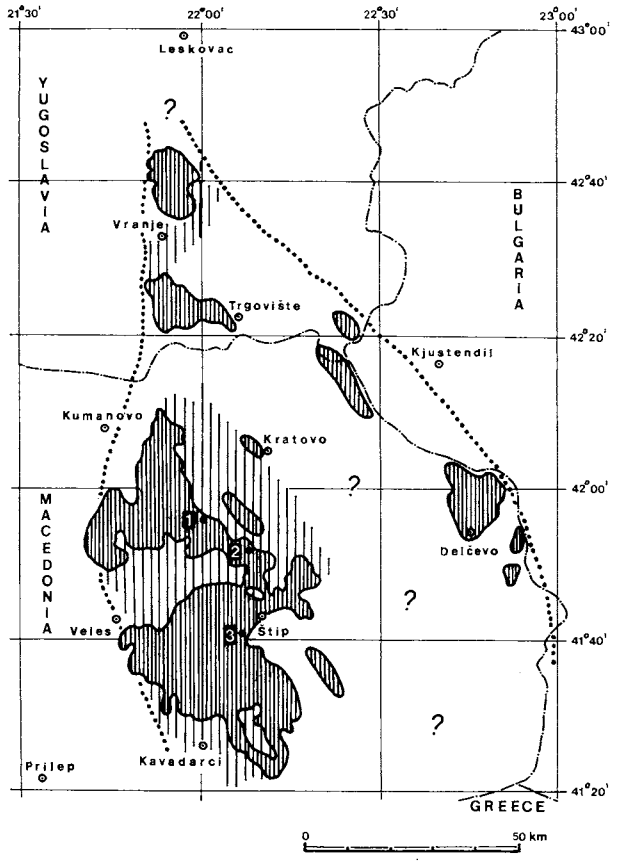


Fig. 1. Extension of the Pčinja-Ovče Polje Group. Dense hachure: outcrops; thin hachure: covered with younger deposits; dotted line: probable boundaries of the basin (from Dimitrijevič & Dimitrijevič, 1987). **1** - Nemanjice; **2** - Sudik; **3** - Ramadanice.

Fossil flora

Fossil flora from the Ovče Polje Basin was already known. From four localities (the richest being Nemanjica, where from comes a part of the presented collection), Pantič (1954) describes a small assemblage of fossil plants. Some specimens of this collection, in the museum depository of the Institute for Regional Geology and Paleontology, and the illustrations in Pantič (1954) are subject of a taxonomic reinterpretation.

Nemanjica locality:

Pantič (1954):	**New interpretation:**
Sequoia sternbergii (Goepp.) Heer	?
Sequoia langsdorfii (Brong.) Heer	cf. *Protosequoia hardtii* (Goepp.) Mai
Myrica hakaefolia Unger	?
Cinnamomum polymorphum (A. Br.) Frentzen	*Daphogene cinnamomea* (Rossm.) Knobloch
Cinnamomum sp.	*Daphogene cinnamomea* (Rossm.) Knobloch
Laurus princeps Heer	*Eotrigonobalanopsis furcinervis* (Rossm.) Walther & Kvaček
Laurus sp.	?
Eucalyptus oceanica Unger	?
Neritinium longifolium Unger	?
Equisetites ebreichii A. Braun	*Equisetites* sp.

As a result of detailed preparation, some new forms have been determined: *Eotrigonobalanopsis furcinervis* (Rossm.) Walther & Kvaček (with toothed margin), *Zizyphus zizyphoides* (Ung.) Wayland, and *Daphnogene* sp. The last one mentioned one resembels specimens found in the latest investigation of this locality, and may be a new species.

Bekirli locality:

Pantič (1954):	**New interpretation:**
Flabellaria latania Rossmaessler	*Trachycarpus rhapifolia* (Sternb.) Takhtajan

Ramadanice locality:

Pantič (1954):	**New interpretation:**
Dryophyllum sp.	*Eotrigonobalanopsis furcinervis* (Rossm.) Walther & Kvaček
Myrica sp.	?
Eucalyptus oceanica Unger	?
Apocynophyllum carissa Unger	?

Šeoba locality:

Pantič (1954):	**New interpretation:**
Sequoia couttsiae Heer	cf. *Sequoia couttsiae* Heer

The plants from Krivi Do locality determined by Milakovič (1955) are the following:

Milakovič (1955):	**New interpretation:**
Cinnamomum scheutzeri (Heer) Frentzen	*Daphogene cinnamomea* (Rossm.) Knobloch
Cinnamomum lanceolatum Unger	*Daphogene lanceolata* Unger
Cinnamomum sp.	*Dicotylophyllum* indet.
Ficus sp.	*Dicotylophyllum* indet.
Rhamnus cf. *roeslerii* Ettingshausen	*Eotrigonobalanopsis furcinervis* (Rossm.) Walther & Kvaček
Eucalyptus oceanica Unger	cf. *Laurophyllum acutimontanum* Mai
?*Andromeda protogaea* Unger	*Dicotyllophyllum* indet.

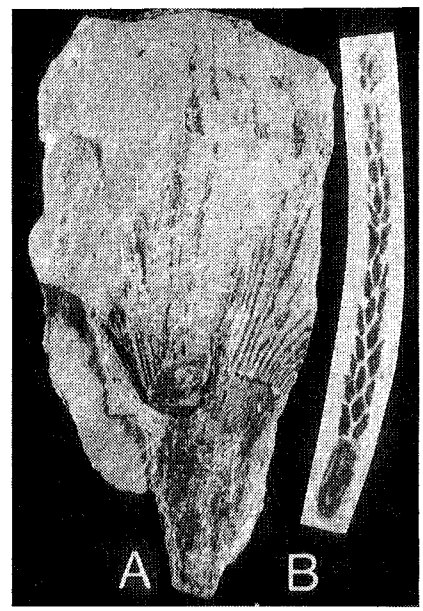


Fig. 2. A - *Trachycarpus rhapifolia* (Sternb.) Takhajan (Pantič collection); **B** - cf. *Sequoia couttsiae* Heer (from Pantič, 1954). Both figures in natural sizes.

Fossil flora from three localities: Nemanjica, Sudik and Ramadanice is presented in this paper. The remains of fossil plants are quite abundant in the former two localities, found in gray sandy shale and yellow incoherent sandstone. Unfortunately leaves are mostly preserved only in fragments of indistinct venation. Leaves are often in a mass of plant detritus. All this rendered accurate identification difficult. The commonest at Ramadanice were plant detritus and a large quantity of small-leaf fragments which could not be determined. The identified plant forms are following: see Table 1 on page 207.

Plate I: Fig.1 - cf. *Dryophyllum album* Rüffle, Müller-Stoll & Litke, Nemanjice. **Figs. 2, 10** - *Daphogene cinnamomea* (Rossmaessler) Knobloch, Sudik. **Figs. 3, 7-9, 11** - *Eotrigonobalanopsis furcinervis* (Rossmaessler) Walther & Kvaček; 3, 7 - Nemanjice, 8, 9, 11 - Sudik; **Figs. 4, 5** - *Zizyphus zizyphoides* (Unger) Wayland; 4 - Sudik; 5 - Nemanjice. **Figs. 6, 16** - cf. *Trigonobalanopsis rhamnoides* (Rossmaessler) Kvaček & Walther. 6 - Sudik; 16 - Nemanjice. **Figs. 12-15** - cf. *Protosequoia hardtii* (Goeppert) Mai, Sudik. All figures in the natural size.

PLATE I

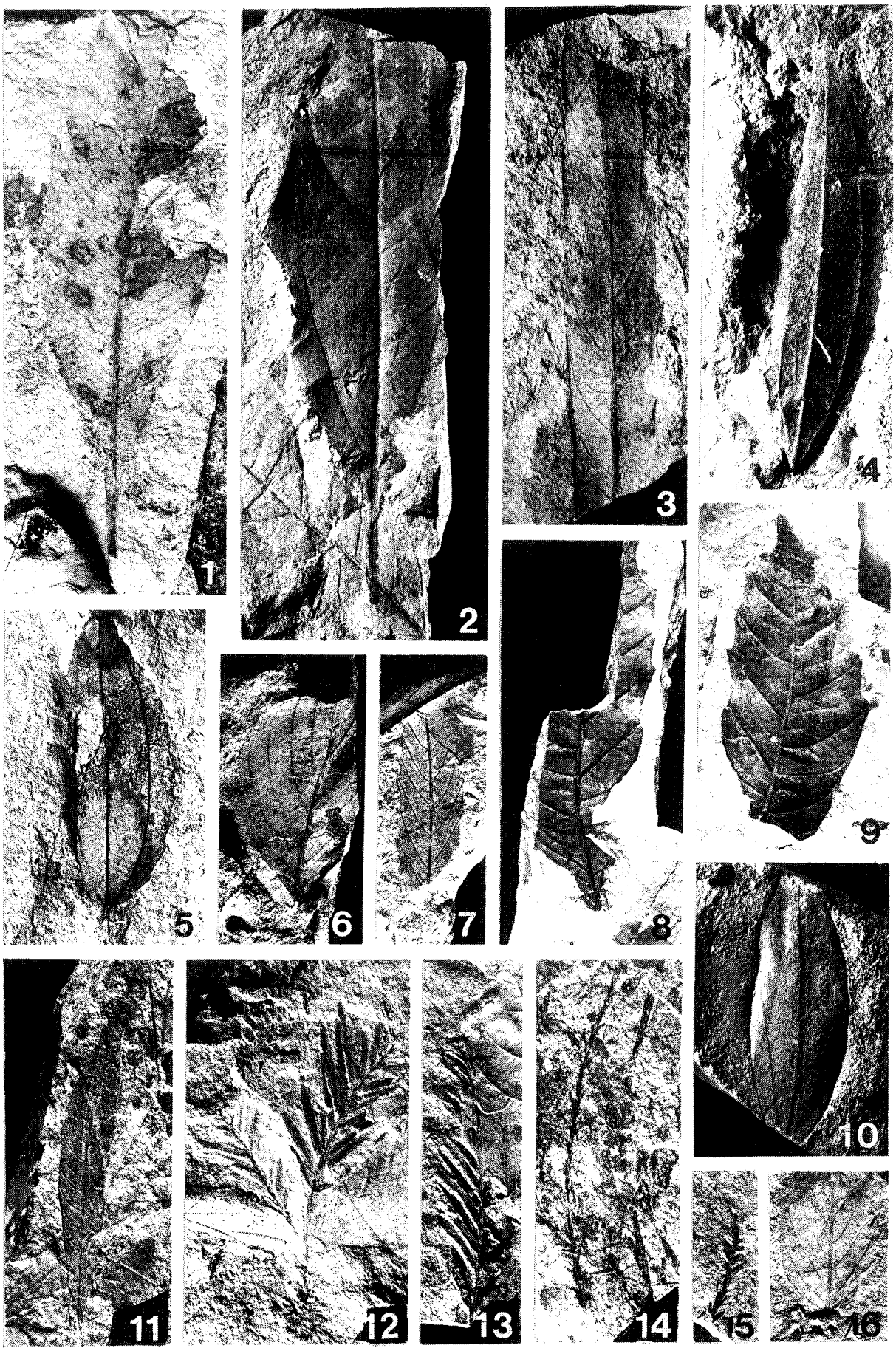
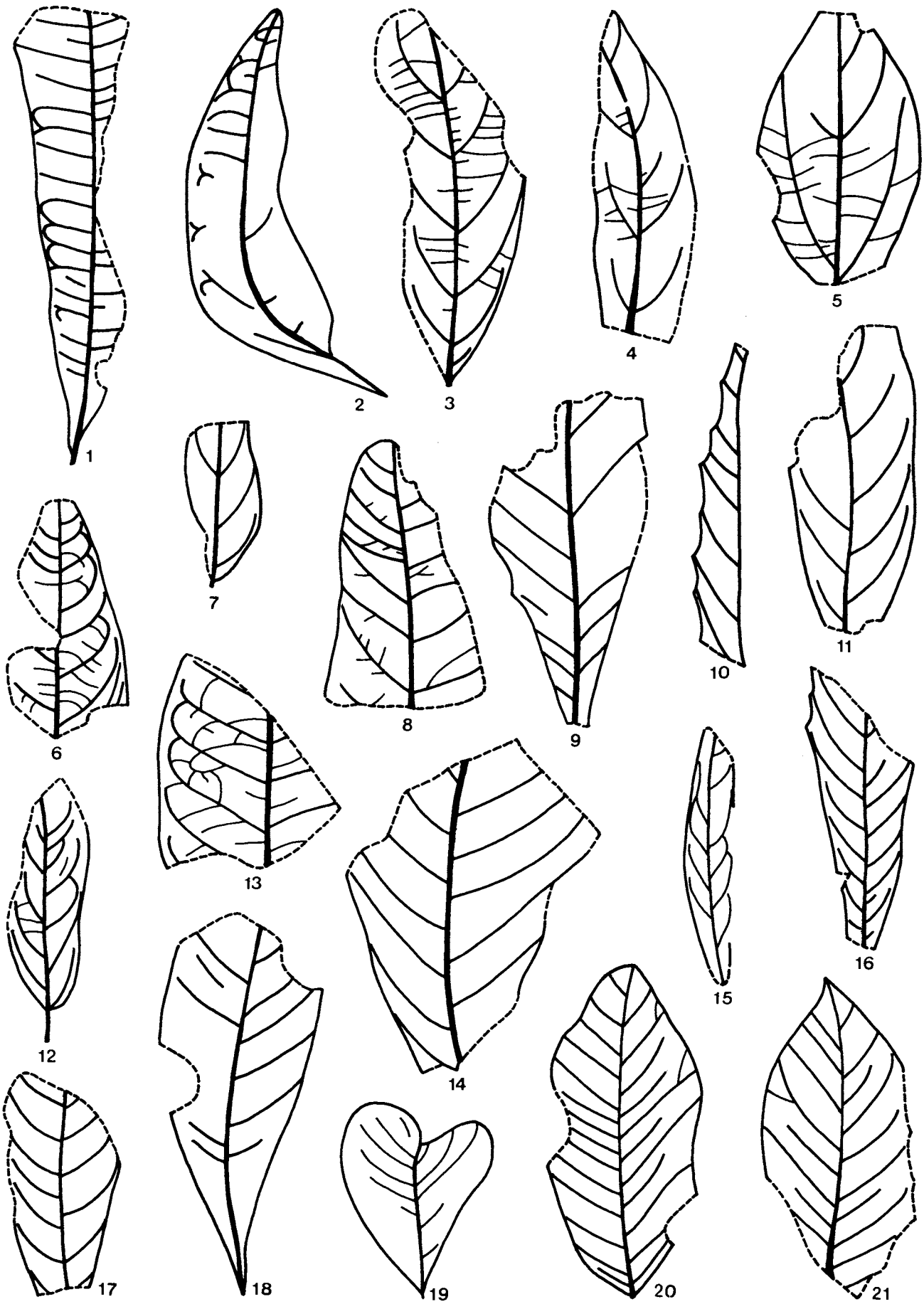


PLATE II



The list of determined taxa shows* the dominance of *Lauraceae* (*Daphnogene, Laurophyllum*), *Fagaceae* (*Eotrigonobalanopsis, Trigonobalanopsis, Dryophyllum, Quercus*), and *Rhamnaceae* (*Zizyphus*) over the conifers represented only by *Taxodiaceae* (*Protosequia*). Other forms are either few or single specimens used only to get a general picture of the vegetation.

	totally	Ramadanice	Sudik	Nemanjice
cf. *Protosequoia hardtii* (Goepp.) Mai	1	6	–	7
Daphogene cinnamomea (Rossm.) Knobloch	9	19	–	28
Daphogene sp.	2	–	1	3
cf. *Laurophyllum acutimontanum* Mai	4	7	3	14
?*Lauraceae* gen. et sp. indet.	–	1	–	1
Quercus neriifolia A. Braun var. *moeselensis* Walther	2	2	–	4
Eotrigonobalanopsis furcinervis (Rossm.) Walther & Kvaček	8	19	–	27
?*Eotrigonobalanopsis furcinervis* (Rossm.) Walther & Kvaček	1	1	1	3
cf. *Trigonobalanopsis rhamnoides* (Rossm.) Kvaček & Walther	3	4	–	7
cf. *Dryophyllum album* Rüffle, Müller-Stoll & Litke	1	–	–	1
Zizyphus zizyphoides (Ung.) Wayland	5	12	1	18
Comptonia schrankii (Sternb.) Berry	–	–	2	2
cf. *Rhodomyrtophyllum sinuatum* (Bandul.) Walther	1	–	–	1
?*Leguminosae* gen. et sp. indet.	4	–	2	6
?*Alnites reussi* Ettingshausen	2	–	–	2

Table 1

Taxodiaceae are represented by several specimens of distinctly heterophyllous foliage shoots. Without cuticle and cones preserved, their taxonomic place is difficult to establish. Notably heterophylous, they resemble the species *Protosequoia hardtii* (Goepp.) Mai. Very similar foliage shoots, which have cones preserved, were found in Häring (Ettingshausen 1853) and assigned to *Chamaeocyparites hardtii* (Goepp.) Endlicher. Based on cone features, Mai (Mai & Walther 1985) included them in *Taxodiaceae*, the genus *Protosequoia* Miki.

Daphogene is represented by *Daphogene cinnamomea* (Rossm.) Knobloch. The broad-leafed forms ("cinnamomea" type) are more frequent than the narrow-leafed forms of "bilinica" type. Two specimens of *Daphnogene*, determined as *Daphnogene* sp. (Pl. III, Figs. 15, 19), show some specific features. They may be, according to Kvaček (letter dated April 8, 1992), a new species, and are very similar to the undetermined forms found in Upper Eocene flora of the Staré Sedlo Formation (Bohemia).

Another representatives of *Lauraceae* is cf. *Laurophyllum acutimontanum* Mai. Leaves with irregularly looping secondaries and mostly narrow laminae belong to this species. For an accurate determination of *Lauraceae* or similar types of leaves one should know the epidermal layer features; otherwise, the systematic place of such leaves remains a partly open question. Kvaček informs (letter of April 8, 1992) that leaves of a very similar type were found among the flora of the Staré Sedlo Formantion and were identified as leaves of *Laurophyllum acutimontanum* Mai.

Eotrigonobalanopsis furcinervis (Rossm.) Walther & Kvaček, a frequent species in the Ovče Polje flora, is represented by both common toothed-margin and entire-margin leaves, which are abundant in the flora of the Staré Sedlo Formation. Leaves of this species with entire margin were earlier assigned to a number of genera (Knobloch 1990), but the latest investigations, including cuticular analysis (Kvaček & Walther 1989), identified their equivalence to *Eotrigonobalanopsis furcinervis*.

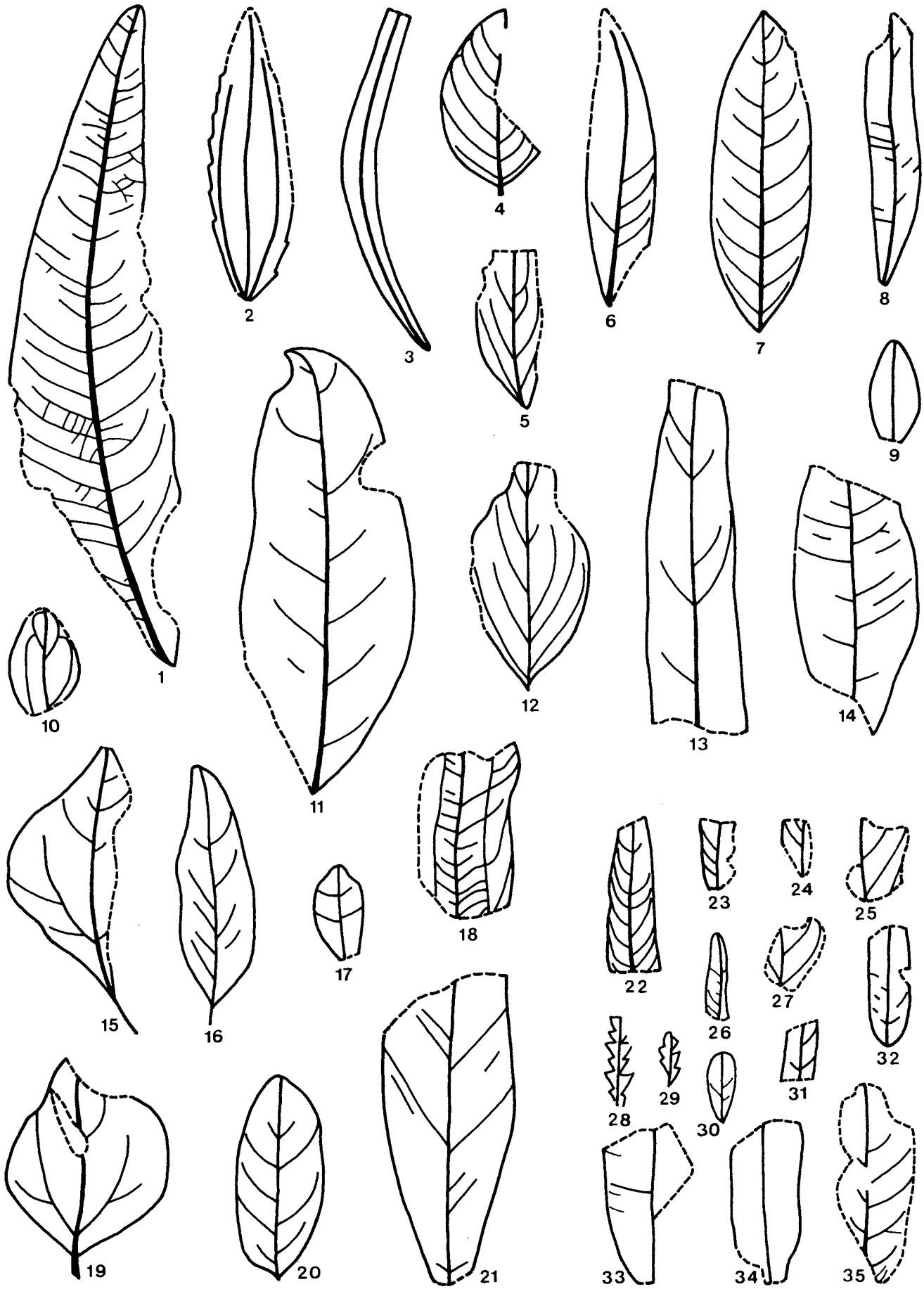
Leaves with entire margins and eucamptodromous or, rarer, brochidodromous venation belong to the species cf. *Trigonobalanopsis rhamnoides* (Rossm.) Kvaček & Walter. Until the article Kvaček & Walther (1988), leaves of similar morphology were assigned to different genera (*Rhamnus, Cornus, Berchemia, Castanopsis*).

There are a few elongated leaves with entire margins, brochidodromous or eucamptodromous venation which belong to *Quercus neriifolia* A. Braun var. *moeselensis* Walther. Leaves of this type were generally determined as *Quercus neriifolia* A. Braun. Walther (Mai & Walther 1985) seems right in proposing that Paleogene representatives should be separated as a variety for their difference from similar forms in Miocene deposits. The same attitude is sharped by Knobloch (1990).

Plate II: Figs. 1, 2 - *Quercus neriifolia* A. Braun var. *moeselensis* Walther, Nemanjice. **Figs. 3, 4, 6 - 11, 13 - 18** - *Eotrigonobalanopsis furcinervis* (Rossmaessler) Walther & Kvaček. 3, 4, 6, 8, 10, 13 -16 - Sudik; 7, 9, 11, 17, 18 - Nemanjice. **Fig. 5** - *Daphnogene cinnamomea* (Rossmaessler) Knobloch, Nemanjice. **Fig. 12** - ?*Lauraceae* gen. et sp. indet., Sudik. **Fig. 19** - cf. *Rhodomyrthophyllum sinuatum* (Bandulska) Walther, Nemanjice. **Figs. 20, 21** - ?*Alnites reussi* Ettingshausen, Nemanjice. All figures in the natural size.

* Plant remains from Ramadanice, with only few forms determined, were not included in the phytoassociation for quantitative and qualitative analyses.

PLATE III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Only one specimen was included in cf. *Dryophyllum album* Rüffle, Müller-Stoll & Litke for its leaf architecture. This species was defined in the Middle Eocene flora of Geiseltales (Rüffle et al. 1976) and has been known from other Paleogene localities under a different name.

Rhamnaceae are represented by several specimens of *Zizyphus zizyphoides* (Ung.) Wayland. The species is distinguished by a specific architecture of lamina (three-vein leaf with toothed margin) and is one of the most typical species of the Tethyan phytogeographic province. It is generally taken for a xerophytic plant of great significance for paleoecological interpretations.

Besides the above mentioned species, other plant representatives are rarely found in Nemanjica and Sudik localities. These are small *Leguminosae* type leaves which may belong to leguminosae. One leaf with emarginate apex (Pl. II; Fig. 19) resembles in architecture those of *Rhodomyrtophyllum sinuatum* (Bandul.) Walther. This species is quite common in the Middle and Upper Eocene floras of Central Europe (dominant in Zeitz Complex) and very rare in the Oligocene. It is, however, rarely found in synchronous localities of Southern Europe. It was found in the Hvoyna Basin (Bulgaria) of the uppermost Upper Eocene-Lower Oligocene (Černjavskaja et al. 1988). In the Pčinja Basin, at least one specimen determined as *Ficus athadaeformis* Andreanszky & Novak (Mihajlović 1985; Pl. III; Fig. 11) corresponds to this species. Two leaves from Nemanjica (Pl. II; Figs. 20, 21) have much resemblance to the forms known from an older bed with Häring flora (coal hanging wall) as *Alnites reussi* Ettinghausen (Ettingshausen 1853; Pl. III; Figs. 14 - 17). The systematic position of the species is known at present.

Only one species was found in Ramadanice that has not been found in Nemanjica and Sudik. It is *Comptonia schrankii* (Sternb.) Berry, characterized by a specific lamina architecture (linear lamina with large teeth and deep sinuses reaching almost up to the midvein). It is taken for a xerophyte (same as *Zizyphus zizyphoides*). This species is quite common in Paleogene floras of the Tethyan phytogeographic province.

The determined plant species from Ovče Polje indicate at least two paleocommunities: **A** - Woody mesic to subhumid communities to which most of the determined species belonged. These include representatives of the families *Taxodiaceae (Protosequoia), Lauraceae (Daphogene, Laurophyllum), Fagaceae (Eotrigonobalanopsis, Trigonobalanopsis, Dryophyllum, Quercus), Myrtaceae (Rhodomyrtophyllum),* and probably *?Alnites reussi,* too. It also includes cf. *Sequoia couttsiae* (Pantič 1954). **B** - Open xerophytic shrub communities composed of *Rhamnaceae (Zizyphus)* and *?Leguminosae. Comptonia schrankii* from Ramadanice also belongs to this community. *Trachycarpus rhapifolia* (Pantič 1954) probably belongs to riparian communities. Dominant plant components suggest a vegetation of the mixed Oak-Laurel-Zizypus forests.

Plate III: Fig. 1 - *Quercus neriifolia* A.Braun var. *moeselensis* Walther, Sudik. **Fig. 2** - *Zizyphus zizyphoides* (Unger) Wayland, Nemanjice. **Figs. 3, 6, 8, 11, 13, 14, 21, 33 - 35** - cf. *Laurophyllum acutimontanum* Mai. 3,6,11 - Sudik; 8,13,14,21 - Nemanjice; 33 -35 - Ramadanice. **Figs. 4, 5, 12** - cf. *Trigonobalanopsis rhamnoides* (Bandulska) Kvaček & Walther. 4 - Nemanjice; 5,12 - Sudik. **Figs. 7, 22** - *?Eonotrigonobalanopsis furcinervis* (Rossmaessler) Walther & Kvaček. 7 - Sudik; 22 - Ramadanice. **Figs. 9, 16, 17, 20, 30, 32** - *?Leguminosae* gen. et sp. indet. 9,16,17,20 - Nemanjice; 30,32 - Ramadanice. **Figs. 10, 18** - *Daphogene cinnamomea* (Rossmaessler) Knobloch. 10 - Nemanjice; 18 - Sudik. **Figs. 15, 19** - *Daphogene* sp., Sudik. **Figs. 23-27, 31** - *Dictylophyllum* indet., Ramadanice. **Figs. 28, 29** - *Comptonia schrankii* (Sternberg) Berry, Ramadanice. All figures in the natural size.

The flora of Ovče Polje includes only paleotropical elements. Plants with leaves of coriaceous texture and with entire margin are dominant. As to leaf size, leaves of the microphyllous class are dominant. Nanophyllous leaves are scarce. A few leaves of *Fagaceae* belong to the notophyllous class. Compared with some other European Upper Eocene floras, which had the leaf size analysed (Mai & Walther 1985), the Ovče Polje flora resembles the Schkopau flora, especially the Mosel flora, which according to Dilcher (1973), corresponds to the vegetation that existed in a subtropical seasonal dry climate.

A brief review of floras from other Pčinja-Ovče Polje Group localities

A number of fossil flora localities have been known in the northern extent of Pčinja-Ovče Polje Group (Pčinja and Poljanica-Tesovište Basins) in Serbia and the eastern area in Bulgaria (Kraistid).

Mihajlović (1985) describes Upper Eocene and probably Lower Oligocene flora in a number of localities of the Pčinja and Poljanica-Tesovište Basins. The basic characteristic of Upper Eocene flora is the dominance of plants with nanophyllous and smaller microphylous leaves. The dominate *Zizyphus zizyphoides* are various small and/or narrow leaves with entire margins which belong to plants of a chiefly uncertain systematic position. *Taxodiaceae* are nearly absent, while the main floral components (*Lauraceae* and *Fagaceae*) of Ovče Polje are few and only in some localities. The exception is the Pčinja 2 locality, where *Daphogene* is abundant. A massive occurrence of the palm *Sabal major* has been noted in two localities. Xeromorphic *Myricacea* are represented by *Myrica longifolia* and *Comptonia schrankii.* Excluding *Taxodiaceae*, all main floral components of Ovče Polje occur also in Pčinja and Poljanica-Tesovište Basins, but as secondary ones to xerophytic plants. The highest occurrence of xerophytes has been registered in the Ljiljanska Reka (locality 8), which seems to be equivalent to the lower level of the Lower Oligocene.

From eight localities (1 - 8 in Fig. 1) in the Kraistid (at the border on Serbia and Macedonia), Palamarev & Petkova (1975) considered a relatively small floral collection. The Bulgarian geologists distinguish in the Kraistid, the Upper Eocene (Priabonian) and Lower Oligocene. The floral community consits of dominant *Zizyphus zizyphoides* and ferns (*Acrostichum, Cyclosorus)* conifers (*Libocedrus), Lauraceae (Daphogene), Fagaceae (Dryophyllum, Castanopsis), Comptonia schrankii, Periploca* cf. *krysthofovichii*, and palms (*Trachycarpus, Sabal*). This flora is quite similar to that of Ovče Polje.

Conclusion

The considered flora of Ovče Polje is a significant contribution to the study of Upper Eocene vegetation in the southern Balkan regions, and the Tethyan phytogeographic province. It is characterized by a vegetation of mixed Oak-Laurel-Zizyphus forests.

Xerophytes (Zizyphus zizyphoides, xeromorphic *Myricaceae,* plants with *Leguminosae* type leaves, and the like) are commoner in the northern part of the sedimentation area (Pčinja and Poljanica-Tesovište Basins). This indicates a broad hinterland populated by xerophytes. Occasional torrents brought plant material from deeper inland or higher habitats. This is also indicated by certain sedimentological features that differ from those noted in Ovče Polje (Dimitrijević & Dimitrijević 1987): smaller deposit

thickness, thicker clastics and thinner turbidites, and a predominatly freshwater depositional environment. The presence of dinofflagelates in palinological spectra (Pantič 1983) indicates the likely short sporadic sea inrushes. All these suggest processes of rapid material downwash from a highly differentiated topography.

Generally, the Upper Eocene flora of Pčinja - Ovče Polje Group indicates a complex vegetation characterized by both humid Oak-Laurel and xerophytic Zizyphus communities. The climate was subtropical seasonal dry. The Oak-Laurel communities were probably restricted to regions with a higher soil moisture rate.

The fixed flora of the Pčinja-Ovče Polje Group is very important for correlation with other floras of the same or similar age. Particularly interesting are correlations with the lately well studied floras of Central Europe in Germany (Zeitz Complex; Mai & Walther 1985) and Bohemia (Staré Sedlo Formation; Knobloch 1990), which existed outside the Tethyan phytogeographic province. Briefly (without entering into detailed comparisons of taxonomic compositions), the main difference is the complete absence of xerophytes among the mentioned Central European floras. The flora of Ovče Polje indicates that differences in floral compositions between Central and South Europe are not as great as earlier assumed. A significant number of taxa were established among the representatives of Oak-Laurel communities, which link floras of the two regions.

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