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Fossil flora from Paleogene sediments in the northern area of the Mesta Graben in the Western Rhodopes. II. Analysis and stratigraphic importance of the flora

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Abstract. A floristic, paleoecological and biostratigraphic analysis was made of the fossil flora from Eleshnitsa locality in the westernmost part of the Rhodopi Mts. Four types of paleocoenoses were differentiated, with the most important role assigned to the hygromesophytic to mesophytic forest communities and the coastal palm communities. The vegetation represented a transition from notophyllous broad-leaved evergreen forest to mixed mesophytic, or microphyllous broad-leaved evergreen sclerophyllous forest. Stratigraphically, the flora was divided into two early-age floristic complexes: 1. *Acrostichum lanzaeanum - Persea palaeomorpha - Sabal longirachis* complex and 2. *Cyclosorus dalmaticus - Eotrigonobalanus furcinervis - Laurophyllum acutimontanum* complex. The first belonged to Late Eocene and the second to Early Oligocene.

Key words: paleogene macroflora, paleoecology, biostratigraphy, Southwest Bulgaria.

Introduction

The first part of this study presented a geological characteristic of the locality and a taxonomic analysis of the fossil material (P a l a m a r e v & al. 1999). Two levels, a lithological and a floristic one (E_1 and E_2), were outlined, corresponding to two successive development phases of the Graben and the flora from Eleshnitsa.

This second part of the work is dedicated to the floristic, ecological and phytostratigraphic analysis of the flora.

Analysis of the flora

1. Floristic characteristics

A total of 53 species have been identified which, when distributed between the two differentiated levles (E_1 and E_2), showed an almost balanced correlation 33:35 (Table 1).

Mention deserve the following floristic characteristics:

a) Presence of 3 famillies and 3 genera of the group of ferns, with represntatives of family *Dryopteridaceae* (*Rumohra*) and family *Pteridaceae* (*Acrostichum*) featured only in E1. Representatives of the third family, *Thelypteridaceae* (*Cyclosorus*), however, were present as components in both levels.

b) A very poor participation of conifers. They were represented by the genera *Pinus* and *Doliostrobus*, the second featured only in E_1, and the first only in E_2.

Table 1. Composition of the paleoflora and its distributuion by flora-bearing levels.

	Taxon	Levels	
		E_1	E_2
1	*Rumohra recentior* (Unger) Barthel	+	
2	*Acrostichum lanzaeanum* (Visiani) Reid & Chandler	+	
3	*Cyclosorus stiriacus* (Unger) Ching & Takhtajan	+	+
4	*C. dalmaticus* (Heer) Palamarev & Petkova		+
5	*Pinus* sp. 1		+
6	*Pinus* sp. 2		+
7	*Doliostrobus taxiformis* (Sternberg) Kvacek	+	
8	*Daphnogene cinnamomea* (Rossmassler) Knobloch *	+	
9	*D. lanceolata* Unger	+	+
10	*Laurophyllum acutimontanum* Mai *	+	+
11	*Litsea muelleri* Friedrich	+	+
12	*L. ocoteifolia* (Ettingshausen) Imchanitzkaja		+
13	*L. primigenia* (Unger) Takhtajan	+	+
14	*Ocotea laurifolia* Vassilevskaja *	+	
15	*Persea belenensis* Watelet *	+	
16	*P. braunii* Heer	+	+
17	*P. palaeomorpha* Saporta & Marion *	+	
18	*P. princeps* (Heer) Schimper	+	+
19	*Nymphaea calophylla* Saporta *	+	+
20	*Nymphaea* sp.	+	+
21	*Platanus neptuni* (Ettingshausen) Buzek & al.	+	+
22	*Dryophyllum dewalquei* Saporta & Marion	+	
23	*D. intermedium* (Friedrich) Palamarev & Mai *	+	
24	*Eotrigonobalanus furcinervis* (Rossmassler) Kvacek & Walther	+	+
25	*Lithocarpus palaeorhodopensis* Palamarev & Mai	+	
26	*Quercus indjatschaensis* Kassumova *		+
27	*Q. lyellii* Heer		+
28	*Q. neriifolia* A. Braun ex Heer	+	+
29	*Trigonobalanopsis rhamnoides* (Rossm.) Kvacek & Walther		+
30	*Myrica acuminata* Unger *		+
31	*M. lignitum* (Unger) Saporta		+
32	*M. longifolia* Unger	+	
33	*Camellia cf. abchasica* Kolakovskyi		+
34	*Ternstroemites* cf. *floerscheimensis* Kvacek & Walther *		+
35	*Bumelia minor* Unger	+	+
36	*Ulmus drepanodonta* Grubov *		+
37	*Acacia sotzkiana* Unger		+
38	*Cassiophyllum ambiguum* (Unger) comb. n.	+	+
39	*Ceratonia emarginata* A. Braun		+
40	*Dalbergia bella* Heer		+
41	*Gleditsia lyelliana* (Heer) Hantke	+	+
42	*Ailanthus confucii* Unger		+
43	*Pistacia aquensis* Saporta *		+
44	*Rhodomyrtophyllum reticulosum* (Rossm.) Knobloch & Kvacek *	+	
45	*Apocynophyllum neriifolium* Heer	+	
46	*Celastrophyllum andromedae* (Unger) comb. n.		+
47	*C. serratum* Saporta & Marion	+	
48	*Ziziphus ziziphoides* (Unger) Weyland		+
49	*Dewalquea fraxinifolia* Johnson & Gilmore	+	
50	*Cyperites chavannesii* (Heer) Schimper		+
51	*Phoenicites salicifolius* (Presl) Unger	+	+
52	*P. spectabilis* Unger	+	
53	*Phoenicites* sp.	+	
54	*Sabal longirachis* (Unger) Palamarev & al.	+	

* New species for the Bulgarian fossil flora

c) Of the angiosperms, family *Lauraceae* showed the greatest generic and species abundance. A total of 11 species belonging to 5 genera of that family have been identified. Of these, genus *Persea* was represented best (with 4 species). Second came family *Fagaceae* (with 5 genera and 8 species).

d) Floristic composition, especially in E_1, showed considerable concentration of ancient (Early Paleogene) species, such as the representatives of *Doliostrobus*, *Dryophyllum*, *Rhodomyrtophyllum*, *Apocynophyllum*, *Celastrophyllum*, *Persea* p.p., *Dewalquea*, *Phoenicites*, and *Sabal*.

e) The highest occurrence in the samples had the species *Daphnogene cinnamomea*, *Laurophyllum acutimontanum*, *Dryophyllum dewalquei*, *Eotrigonobalanus furcinervis*, *Dewalquea fraxinifolia* and *Phoenicites salicifolius*.

f) Palms claimed a considerable share and concentration in E_1. Identification of 3 species and 1 unidentified taxon of family *Arecaceae* in only one limited lithological complex is a very rare pohenomenon in the Tertiary floras in general.

g) *Lithocarpus palaeorhodopensis* has been identified for the third time in the Bulgarian Paleogene (P a l a m a r e v & M a i 1999), which demonstrated its important role in the paleolandscape of the Rila-Rhodopean Mountain Massive. It could be regarded as an important endemic species to the Bulgarian Tertiary flora.

h) A comparatively poor aquatic and swamp flora, manifested by representatives of the genera *Acrostichum*, *Nymphaea*, *Myrica*, *Cyperites*, and *Bumelia*.

i) Ten new species have been established for the Bulgarian Teritary flora (marked with an asterisk in Table 1).

j) An interesting paleofloristic fact was the discovery of *Quercus indjatschaensis* in the investigated flora. Our find outlined a new partial area of that species after its discovery in the Oligocene flora of the Caucasus (K a s s u m o v a 1966).

2. Paleoecological characteristics

Taphonomically, the fossil flora is a polytopic complex. The following phytocoenotic combinations could be distinguished within its composition:

a) Hydrophytic and hygrophytic grass and shrub paleocoenoses.

They were composed of representatives of the genera *Acrostichum*, *Myrica*, *Nymphaea*, *Bumelia*, and *Cyperites*. It was characteristic for this group that in the first phase of its existence *Acrostichum lanzaeanum* was the most typical component of its composition. It indicated presence of a biotope with brackish waters, for although genus *Acrostichum* is a mangrove element, it also invades the brackish zones in the estuaries of tropic rivers.

b) Hygromesophytic and mesophytic forest paleocoenoses.

Two-thirds of the identified species participated in their composition. Representatives of family *Lauraceae* and the genera *Dryophyllum* and *Eotrigonobalanus* had played the role of dominants, and probably also of edificators, in the different zones of the Paleogene basin. Species of the genera *Camellia*, *Ternstroemites*, *Celastrophyllum* took part in the undergrowth. The ground floor was composed of representatives of *Rumohra* and *Cyclosorus*.

Eevergreen paleotropic elements prevailed in that type of forest paleocoenoses, while the deciduous Arctotertiary representatives had a very limited participation. They were represented by species of the genera *Platanus*, *Ulmus*, *Ailanthus*. The

advent of Arctotertiary elements related to the transition from Eocene to Oligocene and was characteristic of the paleocoenoses of the second phase (E_2) of the development of vegetation.

c) Coastal hygromesophytic palm paleocoenoses.

Their presence was evidenced by the fact that some lithological bodies of E_1 abounded in palm remains, almost without any other admixtures. They were composed of *Phoenicites spectabilis*, *P. salicifolius*, *Phoenicites* sp. and *Sabal longirachis*. These groups were possibly related to the remains of the Eocene sea in the form of isolated coves with brackish waters, or spread along the estuaries of paleorivers where, besides the palms, the magrove fern *Acrostichum lanzaeanum* also developed.

These communities were probably formed in the peripheral zone of the hygromesophytic and mesophytic forest formations, chiefly in the first phase of the development of the flora. They deteriorated in the second phase and were represented only by *Phoenicites salicifolius*.

d) Sclerophyllous shrub paleocoenoses.

They were composed of representatives of the genera *Acacia*, *Pistacia*, *Celastrophyllum*, *Ziziphus*, and *Ceratonia*. Their distribution was rather limited and related to the second phase (E_2) of development of Eleshnitsa Paleogene, i.e. the beginning of Oligocene.

The investigated vegetation complex approaches in composition and character two types of Western and Central European floristic complexes: Hordle - Zeitz and Bembridge - Spechbach (M a i 1995), which belong to the evergreen notophyllous and laurophyllous vegetation, with dominating role of family *Lauraceae* and the genera *Dryophyllum* and *Eotrigonobalanus*.

Therefore, the floristic complex reflected in general a transition from the notophyllous broad-leaved evergreen forest to the mixed mesophytic forest or microphyllous broad-leaved evergreen sclerophyllous forest (W o l f e 1979; M a i 1981, 1995). That transition was carried out within the period of Late Eocene to Early Oligocene.

3. Stratigraphic characteristics

As it was alredy emphasized earlier in the article, floristic composition showed changes in the investigated profile and on that basis phases of its development were distinguihed. These phases were differentiated in time and probably corresponded to two subsequent stratigraphic levels (Fig. 1).

The first covered the lower series of the investigated profile and was distinguished by two important features in its floristic composition:

a) concentration of ancient (Early Paleogene) species, including the following index group for the Eocene: *Rumohra recentior, Doliostrobus taxiformis, Ocotea laurifolia, Daphnogene cinnamomea, Persea belenensis, P. palaeomorpha, Dryophyllum dewalquei, D. intermedium, Rhodomyrtophyllum reticulosum, Apocynophyllum neriifolium, Dewalquea fraxinifolia, Phoenicites spectabilis*.

b) presence of Upper Cretaceous-Paleocene relicts: *Persea palaeomorpha, Celastrophyllum serratum* and *Sabal longirachis*.

The second level extended to the topmost part of the investigated profile (Fig. 1). Its floristic composition showed the following significant changes:

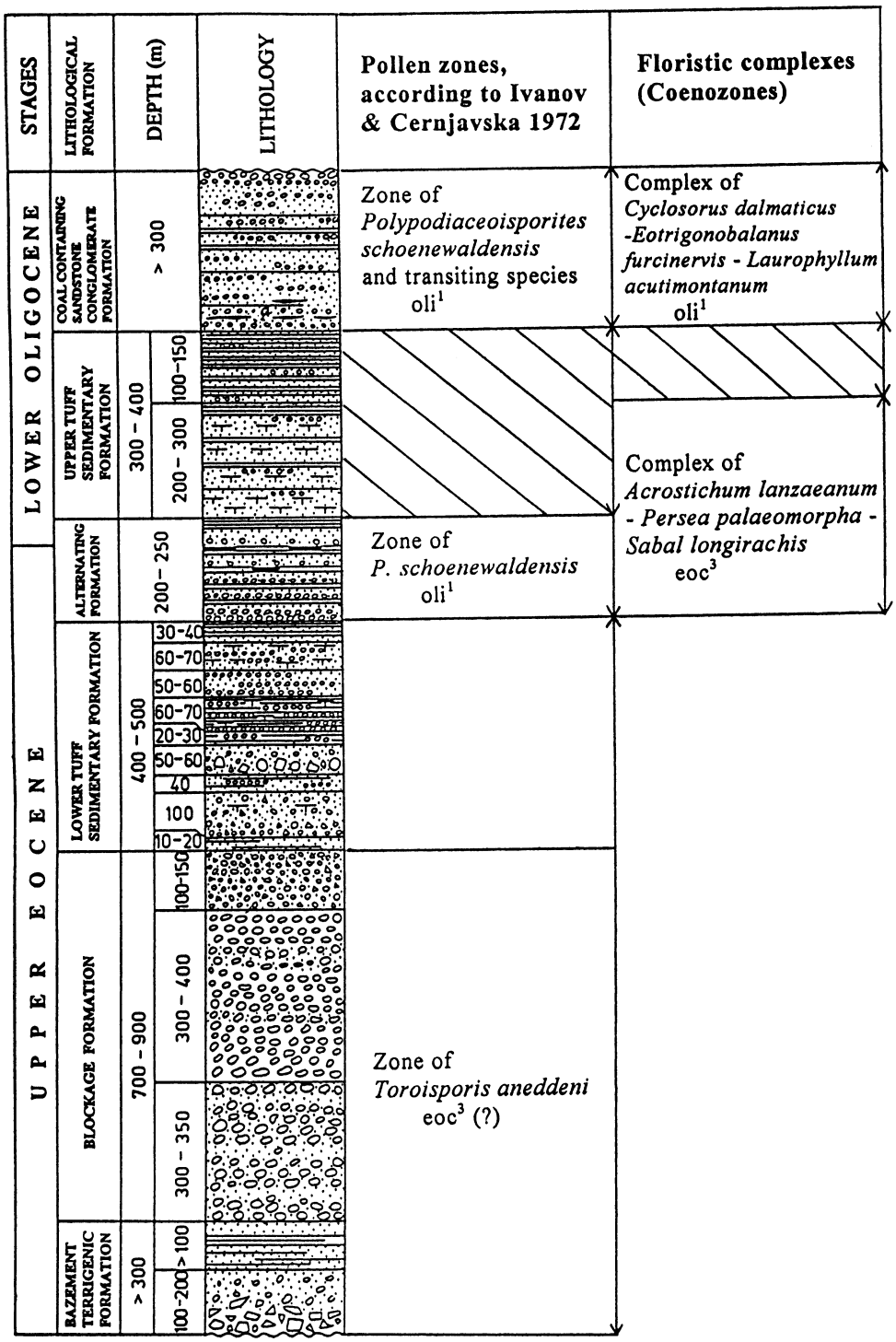

Fig. 1. Micro- and macropalaeobotanical zonation of the Palaeogene sediments in Eleshnitsa locality. Indications of the lithological units are as on Fig. 2 in Palamarev & al. (1999: 5).

a) disappearance of the Upper Cretaceous-Paleocene relicts;

b) disappearance of a number of species of families *Lauraceae, Fagaceae* and *Arecaceae* characteristic of the Eocene group (Table 1).

c) domination of *Laurophyllum acutimontanum*, an Eocene species from family *Lauraceae* characteristic for Central Europe.

d) emergence of a new component of Arctotertiary origin: *Pinus* sp., *Ulmus drepanodonta, Ailanthus confucii, Gleditsia lyelliana, Camellia abchasica, Platanus neptuni.*

e) increased participation of the transit species which, besides in Paleogne, also occured in some Miocene floras: *Cyclosorus dalmaticus, C. stiriacus, Daphnogene lanceolata, Lindera antiqua, Litsea ocoteifolia, Persea braunii, P. princeps, Quercus lyellii, Q. neriifolia, Trigonobalanopsis rhamnoides, Myrica lignitum, M. acuminata, M. longifolia, Dalbergia bella, Ziziphus ziziphoides, Celastrophyllum andromedae, Bumelia minor, Cyperites chavannesii*.

Changes in the floristic composition and stratigraphic range of some of the species (Table 2) gave grounds for differentiation of two floristic complexes within the Paleogene sedimentary section, both of biostratographic import. In their character they merited coenoses, but as they were identified in only one local paleoflora, we refrained from defining them as biozones.

A. Floristic complex of *Acrostichum lanzaeanum - Persea palaeomorpha - Sabal longirhachis* (Fig. 1)

Spatially, its distribution related to the lithographic units described by I v a n o v & Č e r n j a v s k a (1972) in the region of Tsingov Most - Eleshnitsa village: a Rhythmic Series and the lower levels of the Upper Tuffogenic-Sandstone Series. The boundaries of the complex were determined by emergence and disappearance of the characteristic species distributed in the above mentioned series, namely: *Acrostichum lanzaeanum, Rumohra recentior, Doliostrobus taxiformis, Daphnogene cinnamomea, Persea palaeomorpha, P. belenensis, Ocotea laurifolia, Dryophyllum dewalquei, D. intermedium, Rhodomyrtophyllum reticulosum, Celastrophyllum serratum, Dewalquea fraxinifolia, Sabal longirachis,* and *Phoenicites spectabilis*. The lower boundary was set in the argillite layers, rich in coal phytoremains containing the finds of the macroflora. These layers were from the upper part of the Rhythmic Series. The top part of the argillite-sandstone stack of the Upper Tuffo-Sandstone Series was regarded as the upper boundary of the complex. Vertical distribution of the index speceis was uniform within the boundaries of the specified coenosis. Transit species in the geological section were: *Cyclosorus stiriacus, Persea braunii, P. princeps, Daphnogene lanceolata, Litsea primigenia, Laurophyllum acutimontanum, Myrica longifolia, Nymphaea callophylla, Phoenicites salicifolius.*

Lithological characteristics: The Rhythmic Series was built of alternating polymictae and granite conglomerates to conglomeratobrecciae, gray-green argillites or sandy argillites. The top part of the Series featured argillite layers rich in coal phytoremains (I v a n o v & Č e r n j a v s k a 1972). The sedimentary record of the Series was 200-250 m and the argillite layer alone was 100 m thick. The facies in which the Series was developed was siltstone within the range of the carried investigations, and coarse-grained siltstone to the south. Some 200-300 m of arcosic sandstones, layered in the lower levels with riolite tuffs and tuffites (first stack) were the characteristic lithotypes of the Upper Tuffogenic-Sandstone Series. The total

Table 2. Index species from the composition of the fossil flora (L=Lower, M=Middle, U=Upper).

Index species	Flora-bearing level		Paleogene									Neogene				
			Paleocene			Eocene			Oligocene			Miocene			Pliocene	
	E_1	E_2	L	M	U	L	M	U	L		U	L	M	U	L	U
Rumohra recentior (Unger) Barthel	+															
Acrostichum lanzaeanum (Vis.) Reid & Chandler	+															
Doliostrobus taxiformis (Sternb.) Kvacek	+															
Daphogene cinnamomea (Rossm.) Knobloch	+															
Laurophyllum acutimontanum Mai		+														
Ocotea laurifolia Vassilevskaja	+															
Persea belenensis Watelet	+															
P. palaeomorpha Saporta & Marion	+															
Nymphaea calophylla Saporta	+	+														
Dryophyllum dewalquei Saporta & Marion	+															
D. intermedium (Friedrich) Palamarev & Mai	+															
Lithocarpus palaeorhodopensis Palamarev & Mai	+															
Quercus indjatschaensis Kassumova		+														
Ternstroemites floersheimensis Kvacek & Walther		+														
Pistacia aquensis Saporta		+														
Rhodomyrtophyllum reticulosum (Rossm.) Knobl. & Kvacek	+															
Celastrophyllum serratum Saporta & Marion	+															
Apocynophyllum neriifolium Heer	+															
Dewalquea fraxinifolia Johnson & Gilmore	+															
Phoenicites salicifolius (Presl) Unger		+														
P. spectabilis Unger	+															
Sabal longirachis (Unger) Palamarev & al.	+															

sedimentary record of the lithological section, where the complexs was differentiated, was 550 m. The described floristic complex was differentiated for the first time. Laterally, it correlated with the pollen zone *Polypodiaceoisporites schoenewaldensis*, dated according to I v a n o v & Č e r n j a v s k a (1972) to Late Eocene - Early Oligocene.

Age. On the basis of the determined macroflora and mainly of the index species, the first complex was dated to Late Eocene. The boundaries of the complex fell into the range of lithostratigraphic units. The lower boundary ran under the upper half of the Rhythmic Series, and the upper boundary ran within the range of the Upper Tuffogenic- Sedimentary Series.

B. Floristic complex of *Cyclosorus dalmaticus - Eotrigonobalanus furcinervis - Laurophyllum acutimontanum* (Fig. 1)

Spatially, is was distributed within the Coal-Bearing Sandstone-Conglomerate Series (I v a n o v & Č e r n j a v s k a 1972).

The boundaries of the complex were marked by emergence and disappearance of the floristic ensemble comprising some index species of the zone: *Cyclosorus dalmaticus, Litsea ocoteifolia, Platanus neptuni, Eotrigonobalanus furcinervis, Quercus indjatschensis, Lithocarpus palaeorhodopensis, Ternstroemites floersheimensis, Ulmus drepanodonta, Ailanthus confucii, Acacia sotzkiana, Pistacia aquensis*. The lower boundary ran along the lower part of the Coal-Bearing Sandstone-Conglomerate Series, and the upper boundary was set along the upper part of the same Series. Vertical distribution of the index species was all over the differentiated coenozone.

The transit species indentified in the complex were quoted in the preceding complex.

Lithological characteristics: The lithotypes characteristic of the lower part of the Coal-Bearing Sandstone Conglomerate Series were creamy arcosic sandstones with thin layers of coal argillites and brown coal. The sedimentary record of the described lithotypes was about 100-150 m. Within the investigated area, the Series was mainly developed in a finer-grained and coal-bearing facies, and to the south in a typical rough-grained facies (I v a n o v & Č e r n j a v s k a 1972).

The described complex was differentiated for the first time. Laterally, it correlated with the pollen zone *Polypodiaceoisporites schoenewaldensis*, dated accroding to I v a n o v & Č e r n j a v s k a (1972) to Late Eocene - Early Oligocene. The lower boundary of the complex coinsided with the lower part of the Coal-Bearing Sandstone-Conglomerate Series, whose upper boundary ran along the upper part of the coal-bearing layers.

Age. The analysis of stratigraphic distribution of the index species gave grounds to date this complex to Early Oligocene.

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