The fossil macroflora of the Vulche Pole Molasse formation (SE Bulgaria)

Vladimir Bozukov, Emanuel Palamarev† & Adriana Petkova

Institute of Botany, Bulgarian Academy of Sciences, Acad. Georgi Bonchev St., bl. 23, 1113 Sofia, Bulgaria, e-mail: bzk@bio.bas.bg

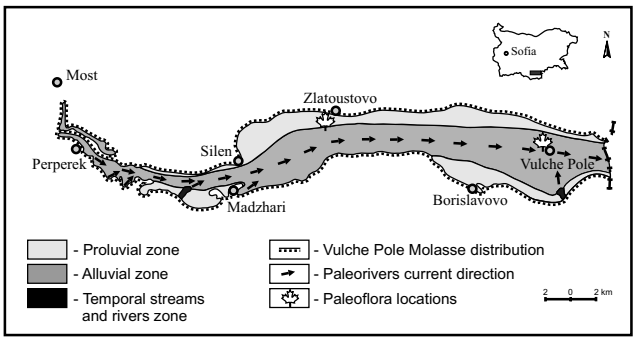
Received: December 20, 2007 ▷ Accepted: April 02, 2008

Abstract. Thirty-eight species of material originating from the uppermost sediments of the Vulche Pole Molasse formation (SE Bulgaria) have been found (two taxa of the same material have been determined up to genus level). The species *Myrica kymeana*, *Zanthoxylum juglandinum* and *Sapindus graecus* have been registered for the first time for the Bulgarian fossil flora. On the basis of the dominant role of *Lauraceae* and the ancient species *Macclintockia basinervis* in the composition of that flora, the age of the flora-bearing sediments was presumed to be rather late Oligocene than the formerly considered late Oligocene–early Miocene.

Key words: Bulgaria, early Miocene, fossil macroflora, late Oligocene, Vulche Pole Molasse formation

Introduction

The Vulche Pole Molasse formation fills a subequatorial post-sedimentary structure: Bryagovo depression. It is located to the south of Ibredzhek horst and along Zlatoustovo fault (East Rhodopes). The formation comprises mainly conglomerates, sandstones, shales, and lignite coal seams, etc. (Harkovska & al. 2005). It was considered as deposited in continental (lake-marshy or alluvial) environment (Goranov 1960; Lambeva & Tonchev 1988) during late Oligocene – early Miocene (Vaptsarov 1970; Boyanov & Goranov 2001).



Material and methods

The researched material represents 135 rock fragments with vegetation macroimprints on them. It was collected in the period 1986-1988 by Prof. E. Palamarev, A. Petkova and R. Ardzhiyska in the vicinities of the villages Vulche Pole and Zlatoustovo (Fig. 1). According to A. Goranov (personal commun.), the macroflora originated from shallow excavations of the uppermost and, respectively, the latest sediments of the Molasse formation.

The ichnophytological method (Zhilin 1969) was used for determining the macroremains. The morphological characteristics of the leaf imprints belonging to the species new for the Bulgarian paleoflora are described according to Dilcher (1974). The order of the families in the text and table follows Takhtajan (1987), while the genera and species are arranged in alphabetical order.

Fig. 1. Sketch map of the Vulche Pole Molasse formation and the paleoflora localities (after Lambeva & Tonchev (1988), supplemented).

Results

Composition of the flora

Lauraceae

Daphnogene bilinica (Unger) Kvaček & Knobloch (Pl. I, Fig. 5)
Material: 2 leaf impressions (HVP-109, Zl-252).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Daphnogene cinnamomea (Rossm.) Knobloch (Pl. I, Fig. 4)
Material: 12 leaf impressions (HVP-10, 19, 20, 30, 103, 109, 122, 144a, 156, 158, 169, 252).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & al. (1999). The specimens studied here showed no deviations.

Daphnogene cinnamomifolia (Brongn.) Unger (Pl. I, Fig. 3)
Material: 1 leaf impression (HVP-3).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Daphnogene lanceolata Unger (Pl. I, Fig. 6)
Material: 22 leaf impressions (HVP-1, 11, 17, 24, 35, 36, 37, 67, 89, 105, 124, 126, 127, 141, 165, 168, 187, 188, 202, 209; Zl-179, 181).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev (1964). The specimens studied here showed no deviations.

Daphnogene spectabilis (Heer) Knobloch (Pl. II, Fig. 3)
Material: 2 leaf impressions (HVP-129, 208).
Remarks: In the article by Palamarev & Staneva (1995) the species was only mentioned in the composition of the paleoflroa, without any description of the fossil material, or a photograph. The fragmentation of our material did not permit any integral description of the lamina, but its correspondence to the type material of Heer (1856) gave us grounds to mention the presence of this species in the paleoflora of the Vulche Pole Molasse formation.

Daphnogene ungeri Heer (Pl. IV, Fig. 6)
Material: 2 leaf impressions (HVP-82, 85).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Bozukov (1998). The specimens studied here showed no deviations.

Laurophyllum acutimontanum Mai (Pl. I, Fig. 2)
Material: 3 leaf impressions (HVP-26, 144b, 182).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & al. (1999). The specimens studied here showed no deviations.

Laurus pliocenica (Saporta & Marion) Kolak**.** (Pl. III, Fig. 3)
Material: 3 leaf impressions (HVP-117, 149, 189).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Litsea ocoteifolia (Ettingsh.) Imkhan**.** (Pl. I, Fig. 7)
Material: 4 leaf impressions (HVP-169, 214, 221, 223).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev (1963). The specimens studied here showed no deviations.

Litsea primigenia (Unger) Takht. (Pl. II, Fig. 1)
Material: 2 leaf impressions (HVP-191, 192).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Neolitsea palaeosericea Takht**.** (Pl. III, Fig. 7)
Material: 10 leaf impressions (HVP-33, 80, 87, 96, 107, 174, 176, 195, 217; Zl-178).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Bozukov (1998). The specimens studied here showed no deviations.

Ocotea heeri (Gaudin) Takht. (Pl. II, Fig. 2)
Material: 4 leaf impressions (HVP-22, 64, 98, 138).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Persea braunii Heer (Pl. III, Fig. 4)
Material: 1 leaf impression (HVP-29).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Sassafras ferretianum A. Massal**.** (Pl. I, Fig. 1)
Material: 1 leaf impression (HVP-73).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Platanaceae

Platanus platanifolia (Ettingsh.) Knobloch (Pl. V, Fig. 1)
Material: 1 leaf impression (HVP-213).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Ulmaceae

Ulmus pyramidalis Göpp**.** (Pl. III, Fig. 5)
Material: 5 leaf impressions (HVP-44, 90, 155, 195; Zl-191a, b).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Zelkova zelkovifolia (Unger) Bůžek & Kotl. (Pl. III, Fig. 2)
Material: 2 leaf impressions (HVP-25, 205).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Fagaceae

Dryophyllum dewalquei Saporta & Marion (Pl. II, Fig. 6)
Material: 5 leaf impressions (HVP-4, 40, 150, 178, 213).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1966). The specimens studied here showed no deviations.

Fagus pliocenica Saporta (Pl. IV, Fig. 1)
Material: 1 leaf impression (HVP-94).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Quercus lyellii Heer (Pl. V, Fig. 3)
Material: 1 leaf impression (HVP-228).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Trigonobalanopsis rhamnoides (Rossm.) Kvaček & H. Walther (Pl. V, Fig. 4)
Material: 1 leaf impression (HVP-200).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Betulaceae

Betula subpubescens Göpp**.** (Pl. II, Fig. 4)
Material: 2 leaf impressions (HVP-31, 253).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Carpinus grandis Unger emend. Heer (Pl. II, Fig. 8)
Material: 2 leaf impressions (HVP-188, 229).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Myricaceae

Myrica hakeaefolia Unger (Pl. IV, Fig. 9)
Material: 5 leaf impressions (HVP-47, 186, 154, 194, 216).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Konstantinov (1937). The specimens studied here showed no deviations.

Myrica kymeana (Unger) Berger (Pl. V, Fig. 2)
1953. Berger, p. 36, Fig-text 1.
1867. *Grevillea kymeana* Unger, p. 57, Pl. 6, Fig. 31; Pl. 8, Figs. 15-31.
Material: 1 leaf impression (HVP-28a, b).
Description: Shape linear; base and tip missing, probably acute; margin entire, slightly undulated. Venation reticulodromous; the midrib straight; secondary veins alternating, at 30º angle towards the midrib, strongly arched towards the lamina tip; intercalary veins absent; tertiary veins not observed. Size of the fragment: length 3.5 cm, width 0.8 cm.
Remarks: The species is new for the fossil flora of Bulgaria. Its stratigraphic area is the Lower-Middle Miocene, and its geographic area covers the Aegean parts

of Greece (Unger 1867; Berger 1953). During a revision of the species described by Unger, Berger (1953) did not point out a recent analogue to the fossil species. In our opinion, judging by the dentation of the lamina and by the angle formed by the secondary veins with the midrib, the fossils resemble the recent species *Myrica cerifera* L., distributed in the southern part of North America. The difference between the fossil and recent species is in the longer and narrower lamina of the fossil species.

Juglandaceae

Engelhardia orsbergensis (P. Wessel & C.O. Weber) Jähnichen, Mai & H. Walther (Pl. II, Fig. 5)
Material: 1 leaf impression (HVP-175).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Theaceae

Eurya* aff. *acuminatissima Merr. & Chun (Pl. IV, Fig. 3)
Material: 1 leaf impression (Zl-189).
Remarks: A detailed description of the taxa in the Bulgarian paleoflora was given by Bozukov & Palamarev (1995). The specimens studied here showed no deviations.

Ebenaceae

Diospyros anceps Heer (Pl. IV, Fig. 8)
Material: 3 leaf impressions (HVP-18, 63, 134).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Rosaceae

Rubus merianii (Heer) Kolak. (Pl. II, Fig. 7)
Material: 1 leaf impression (HVP-71).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Meliaceae

Cedrela attica (Unger) Palam. & Petkova (Pl. III, Fig. 6)
Material: 2 leaf impressions (HVP-49, 55).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Rutaceae

Zanthoxylum juglandinum A. Braun (Pl. IV, Fig. 2)
1851. *Z. juglandinum* A. Braun, p. 87.
1859. Heer, p. 86, Pl. 127, Figs 22-25; Pl. 154, Fig. 36.
1997. Petrescu & al., p. 77, Pl. 5, Fig. 12.
Material: 1 leaf impression (HVP-163).
Description: Shape narrow ovate; base acuneate asymmetrical; the upper part acute, margin entire and only close to the lamina tip some dentate outlines are observed. Venation brochidodromous; the midrib straight; secondary veins 6-7 pairs, alternate and opposite, arched, at an angle of 50º on the one side of the midrib and at 30º on the other; intercalary veins missing; network of tertiary veins obscure. Size: length 2.5 cm, width 1.1 cm.
Remarks: The species is new for the Bulgarian fossil flora. Its stratigraphic area is Oligocene–Upper Miocene, and its geographic area has so far comprised Switzerland and Romania (Heer 1859; Givulescu 1962; Petrescu & al. 1997). *Zanthoxylum americanum* Mill. distributed in North America has been accepted as contemporary analogue of the fossil species. This is a deciduous shrub or small tree with pinnate leaves. Shade-tolerant. It was probably part of the undergrowth. With its limited distribution in terms of geographic area and frequency of occurrence in the paleofloras, as well as with its lack of pretentiousness to living conditions, this species would hardly provide important information for reconstruction of the paleoflora.

Sapindaceae

Sapindus graecus Unger (Pl. III, Fig. 1)
1867. Unger, p. 73, Pl. 12, Figs 1-23.
Material: 2 leaf impressions (Zl-186, 196).
Description: Shape narrow elliptic; base acute, upper part attenuate; margin entire, slightly undulated. Venation brochidodromous; the midrib slightly arched; secondary veins 15-16 pairs, alternate or opposite, straight, at an angle of 55º towards the median; intercalary veins observed between most secondary veins, tertiary veins not observed. Size: length 4.9 cm, width 1.1 cm.
Remarks: The species is new for the Bulgarian fossil flora. Its stratigraphic area is Oligocene – Upper Miocene, while its geographic area has so far comprised the Euboea Island (Greece) (Unger 1867) and Armenia, Georgia (Palibin 1937, 1939). Our find confirms the limited distribution of this species only on the territory of Southeast Europe. According to Unger (1867), a recent analogue of the fossil species should be sought among the South African representatives of the genus.

Sapindus falcifolius (A. Braun) A. Braun (Pl. V, Fig. 7)
Material: 5 leaf impressions (HVP-205; Zl-183, 185, 197, 202).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Celastraceae

Celastrus oeningensis Wonnacott (Pl. IV, Fig. 5)
Material: 1 leaf impression (HVP-250).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Rhamnaceae

Berchemia multinervis (A. Braun) Heer (Pl. V, Fig. 5)
Material: 1 leaf impression (HVP-197).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1987). The specimens studied here showed no deviations.

Apocynaceae

Apocynophyllum neriifolium Heer (Pl. IV, Fig. 4)
Material: 1 leaf impression (HVP-204).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Palamarev & Petkova (1994). The specimens studied here showed no deviations.

Asclepiadaceae

Periploca* cf. *kryshtofovichii Kornil**.** (Pl. IV, Fig. 7)
Material: 7 leaf impressions (Zl-184, 188, 193, 195, 198, 200, 254).
Remarks: A detailed description of the taxa in the Bulgarian paleoflora was given by Palamarev & Petkova (1975). The specimens studied here showed no deviations.

Arecaceae

***Palmophyllum* sp.** (Pl. V, Fig. 9)
Material: 1 leaf impression (HVP-251).
Remarks: A detailed description of the plants in the Bulgarian paleoflora was given by Palamarev & al. (1992). The specimens studied here showed no deviations.

Typhaceae

***Typha* sp.** (Pl. V, Fig. 6)
Material: 1 leaf impression (HVP-254).
Description: Shape linear; base and tip missing. Venation parallelodromous; veins without anastomoses between them. Size of the fragment: length 5.7 cm, width 0.6 cm.
Remarks: Such leaf fragments were described for the Bulgarian Middle Miocene (Petkova 1967) and Pliocene (Stefanov & Jordanov 1934; Kitanov & Nikolova 1956) under the name of *Typha angustifolia* L. foss. Owing to the insufficient material for a more precise determination and the earlier assumed age of the investigated flora, we reject the assumption that this is the recent species *Typha angustifolia* L. or its fossil form, but use the combination *Typha* sp. instead.

Incertae sedis

Macclintockia basinervis (Rossm.) Knobloch (Pl. V, Fig. 8)
Material: 19 leaf impressions (HVP-86, 96, 98, 103, 106, 110, 116, 157, 167, 168, 177, 180, 193, 210, 225, 226, 230; Zl-180, 182).
Remarks: A detailed description of the species in the Bulgarian paleoflora was given by Bozukov (1996). The specimens studied here were smaller in size than those described by Bozukov (op. c.) from the Middle Miocene flora of Satovcha (West Rhodopes) and are analogical to those from the Paleogene flora of Hvoina (Central Rhodopes) (Černjavska & al. 1988).

Discussion

The flora is composed of representatives of 19 families and genus *Macclintockia*, belonging to an undetermined family. The family *Lauraceae* stands out against the rest with the great number of its genera (eight), while its genus *Daphnogene* is represented by six species. On the other hand, genus *Daphnogene lanceolata* was dominant and outlined the pattern of the vegetation, judging by the greatest number of fossils in respect to the remaining species in the studied flora (Table 1). Next with the greatest number of genera comes family *Fagaceae* (four), but it was poorly represented quantitatively, considering the number of leaf imprints. The families *Ulmaceae* and *Betulaceae* are represented by two genera each. These two families, with the rest represented by one genus only and, respectively, by one or two species of that genus, are remarkable for their low percentage participation in the composition of the flora.

Table 1. Composition of the investigated fossil flora and distribution of the species in it in percentage. The species designated with (*) are new for the fossil flora of Bulgaria.

Taxa	Number of specimens		%
	VP	ZL	
1	2	3	4
Lauraceae			
1. Daphnogene bilinica	1	1	1.4
2. D. cinnamomea	12	–	8.3
3. D. cinnamomifolia	1	–	0.7
4. D. lanceolata	20	2	15.3
5. D. spectabile	2	–	1.4
6. D. ungeri	2	–	1.4
7. Lauropfyllum acutimontanum	3	–	2.1
8. Laurus pliocenica	3	–	2.1
9. Litsea ocoteifolia	4	–	2.7
10. L. primigenia	2	–	1.4
11. Neolitsea palaeosericea	9	1	6.9
12. Ocotea heeri	4	1	3.5
13. Persea braunii	1	–	0.7
14. Sassafras ferrettianum	1	–	0.7
Platanaceae			
15. Platanus platanifolia	1	–	0.7
Ulmaceae			
16. Ulmus pyramidalis	5	1	4.2
17. Zelkova zelkovifolia	2	–	1.4
Fagaceae			
18. Dryophyllum dewalquei	5	–	3.5
19. Fagus pliocenica	1	–	0.7
20. Quercus lyellii	1	–	0.7
21. Trigonobalanopsis rhamnoides	1	–	0.7
Betulaceae			
22. Betula subpubescens	2	–	1.4
23. Carpinus grandis	2	–	1.4
Myricaceae			
24. Myrica hakeaefolia	5	–	3.5
*25. M. kymeana**	1	–	0.7
Juglandaceae			
26. Engelhardia orsbergensis	1	–	0.7
Theaceae			
27. Eurya aff. *acuminatissima*	–	1	0.7
Ebenaceae			
28. Diospyros anceps	3	–	2.1
Rosaceae			
29. Rubus merianii	1	–	0.7
Meliaceae			
30. Cedrela attica	2	–	1.4
Rutaceae			
*31. Zanthoxylum juglandinum**	1	–	0.7
Sapindaceae			
*32. Sapindus graecus**	–	2	1.4
33. S. falcifolius	2	4	4.2
Celastraceae			
34. Celastrus oeningensis	1	–	0.7
Rhamnaceae			
35. Berchemia multinervis	1	–	0.7
Apocynaceae			
36. Apocynophyllum neriifolium	1	–	0.7
Asclepiadaceae			
37. Periploca krishtofovichii	–	7	4.5
Arecaceae			
38. Palmophyllum sp.	1	–	0.7
Typhaceae			
39. Typha sp.	1	–	0.7
Incertae sedis			
40. Macclintockia basinervis	17	2	11.8

***Legend*: VP – Vulche Pole; ZL – Zlatoustovo; % – percentage of the total number.**

The total number of taxa determined to the level of species in the paleoflora is 38. There are two taxa determined to generic level. No representatives of ferns and gymnosperms have been identified.

The palefloristic study of the Vulche Pole Molasse formation identified three species for the first time on the territory of Bulgaria: *Myrica kymeana*, *Zanthoxylum juglandinum*, and *Sapindus graecus*.

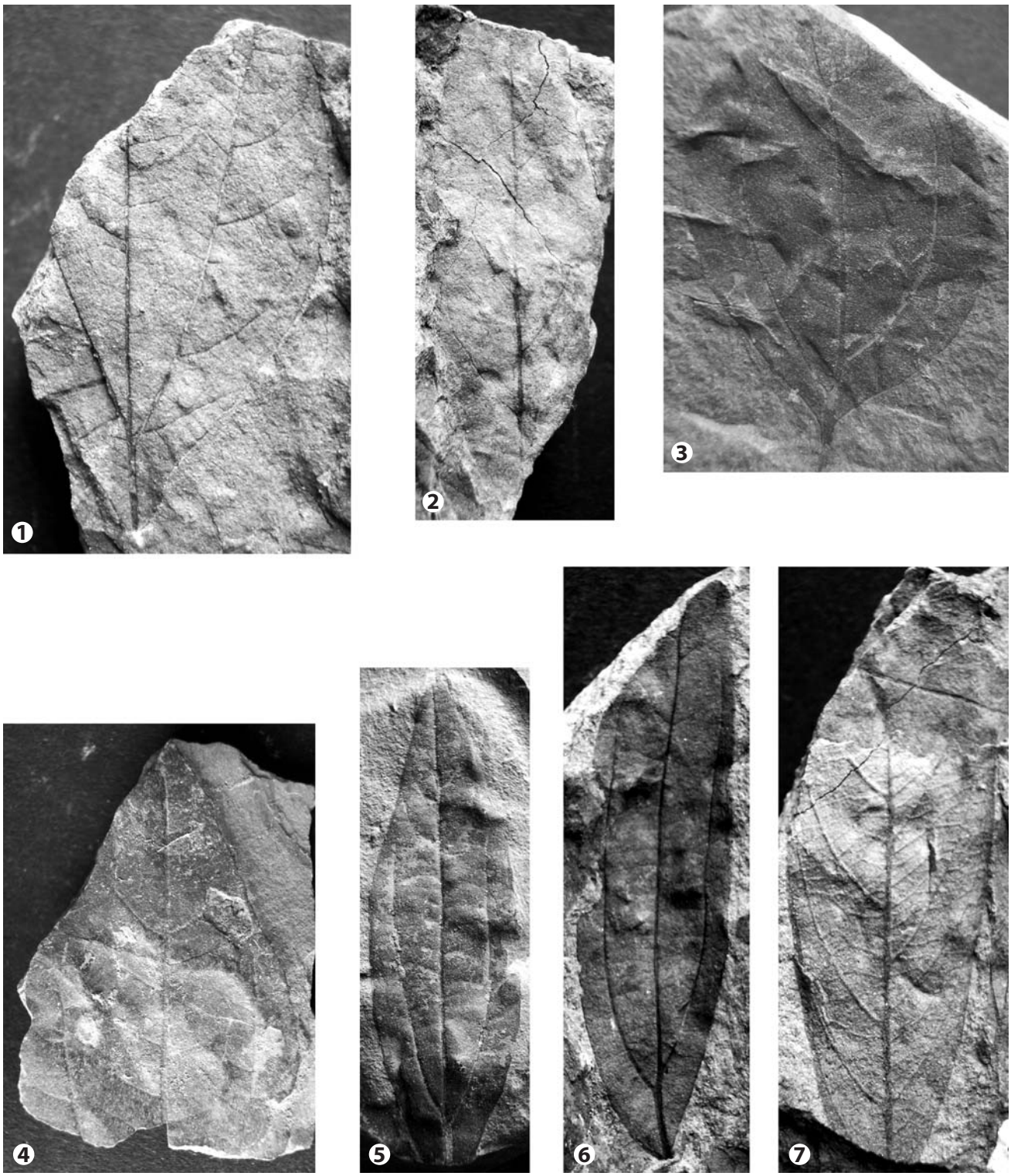
In the composition of the analysed flora, special mention deserves the species *Macclintockia basinervis*. Its ancient origin (see Bozukov 1996) and the fact that it was widely distributed in the Vulche Pole Molasse formation, almost as widely as the species *Daphnogene lanceolata* (Table 1), testify to its uniqueness for the territory of Bulgaria. Besides from the studied deposits (Bozukov 2005), the species *Macclintockia basinervis* is also known in Bulgaria from the floras of Hvoina (late Eocene–early Oligocene) (Černjavska & al. 1988) and Satovcha (middle Miocene) (Bozukov 1996; 2000), but it has played an insignificant role there. The paleoflora where that species had dominated is known from the Eocene in the Ukraine (Stanislavskiy 1956), hence the co-dominant role of *M. basinervis* in the studied flora could serve as evidence of its relatively ancient character. Along with this, the obvious supremacy of family *Lauracee* over the rest, both in terms of species diversity and quantity, suggests that the age of the flora-bearing element was rather late Oligocene.

Another argument in support of this assumption is provided by the early Oligocene flora of Kamenity (Czech Republic) (Knobloch 1963). The author determined the paleoflora from this location as an association of the *Sequoia–Castanopsis–Daphnogene–Macclintockia–Steinhauera* type.

One of the reasons for the genera *Macclintockia* and *Daphnogene* to retain their co-dominant role until late Oligocene in the flora of Vulche Pole Molasse was probably the geographic location. The investigated location lies far more to the south than those in the Ukraine and Czechia and, respectively, the climatic conditions had longer favoured the development of representatives of the paleotropic vegetation and their dominant role.

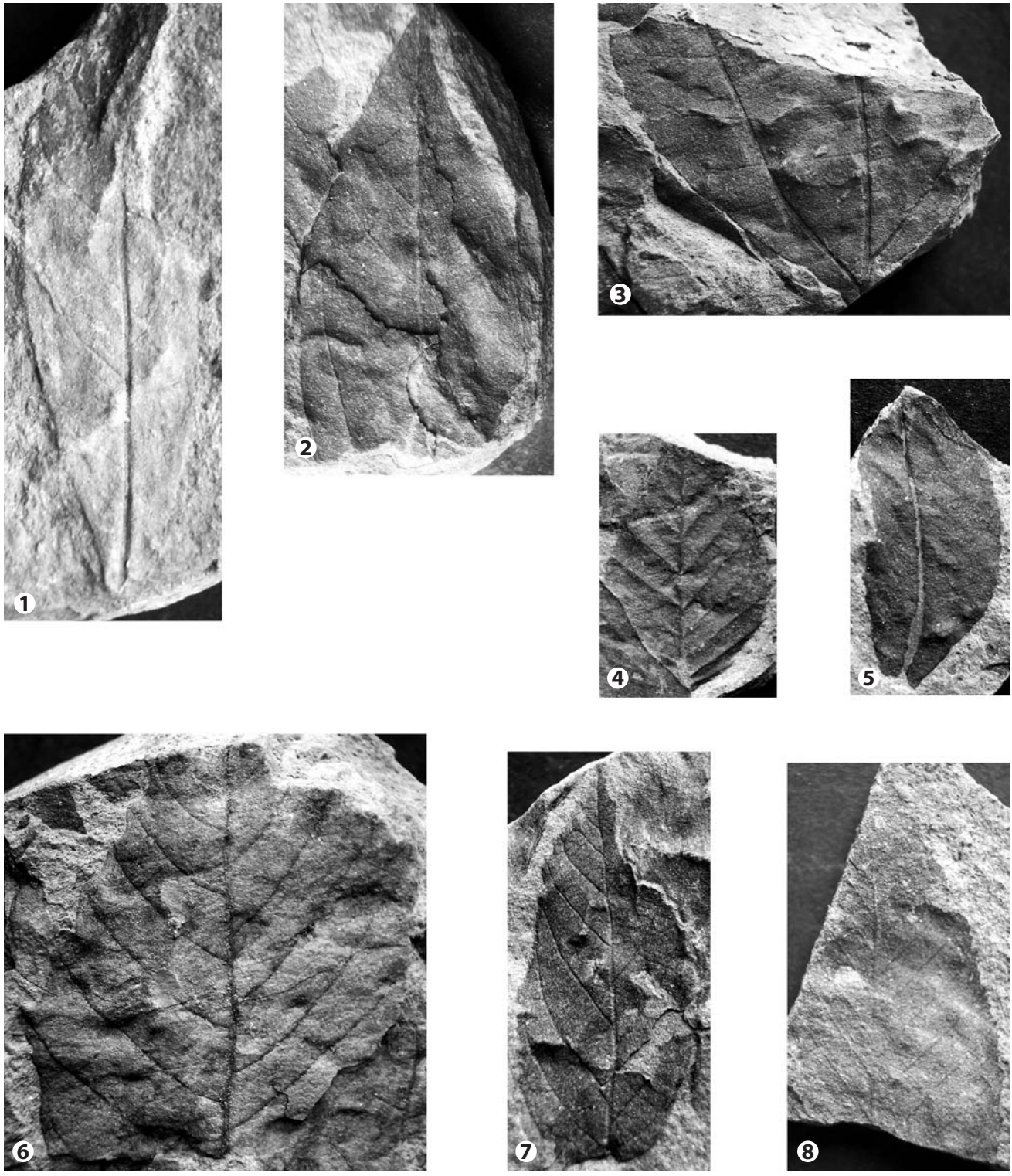
Acknowledgments. This study is a contribution to the Project B-1525 (NSF, Bulgaria).

Plate I



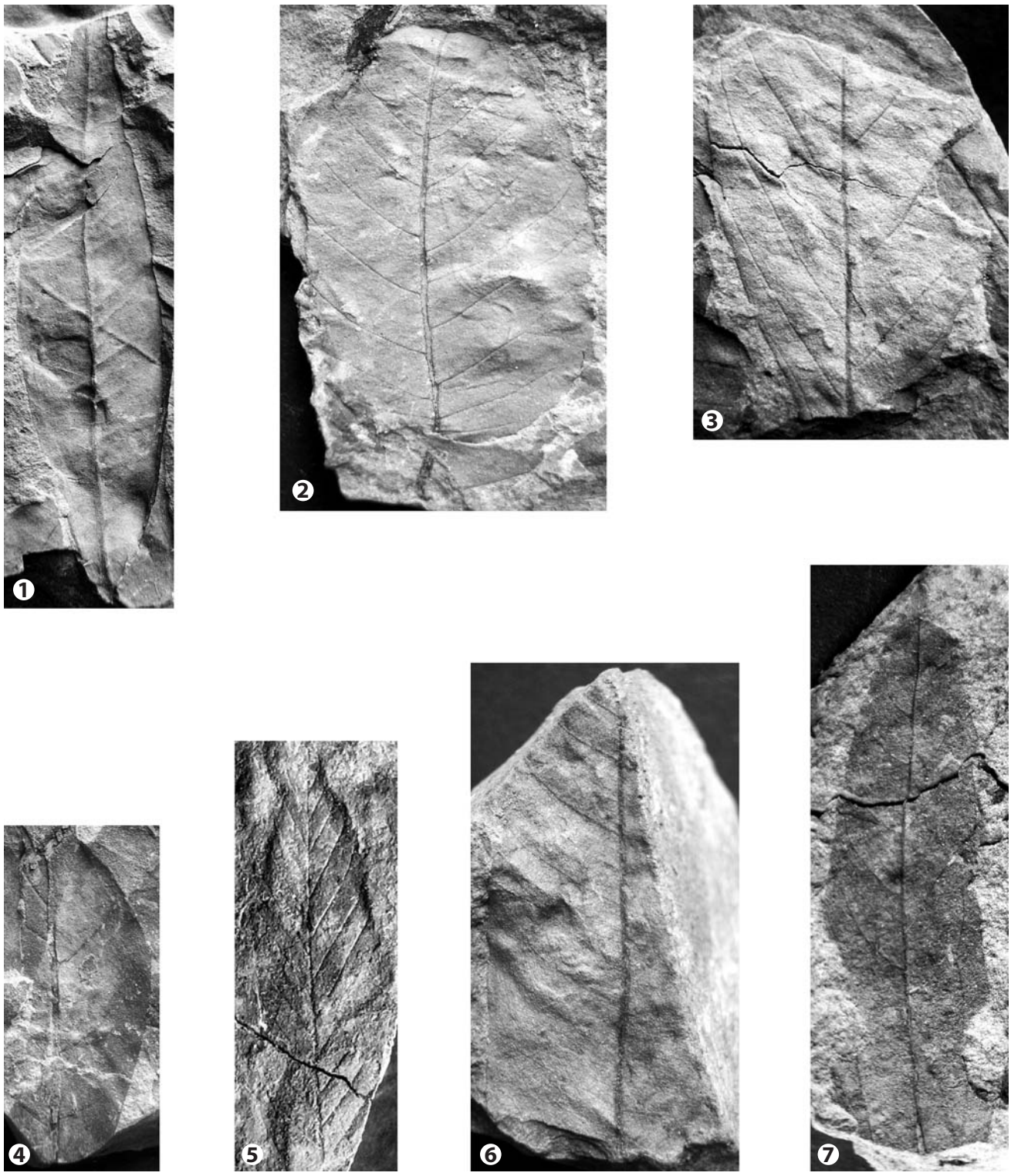
Figs 1-7. Photographs of fossil specimens:
1, *Sassafras ferrettianum*, HVP-73 (×2); **2,** *Lauropfyllum acutimontanum*, HVP-26 (×2); **3,** *Daphnogene cinnamomifolia*, HVP-3 (×2); **4,** *D. cinnamomea*, HVP-252 (×2); **5,** *D. bilinica*, Zl-252 (×2); **6,** *D. lanceolata*, HVP-187 (×2); **7,** *Litsea ocoteifolia*, HVP-214 (×2).

Plate II



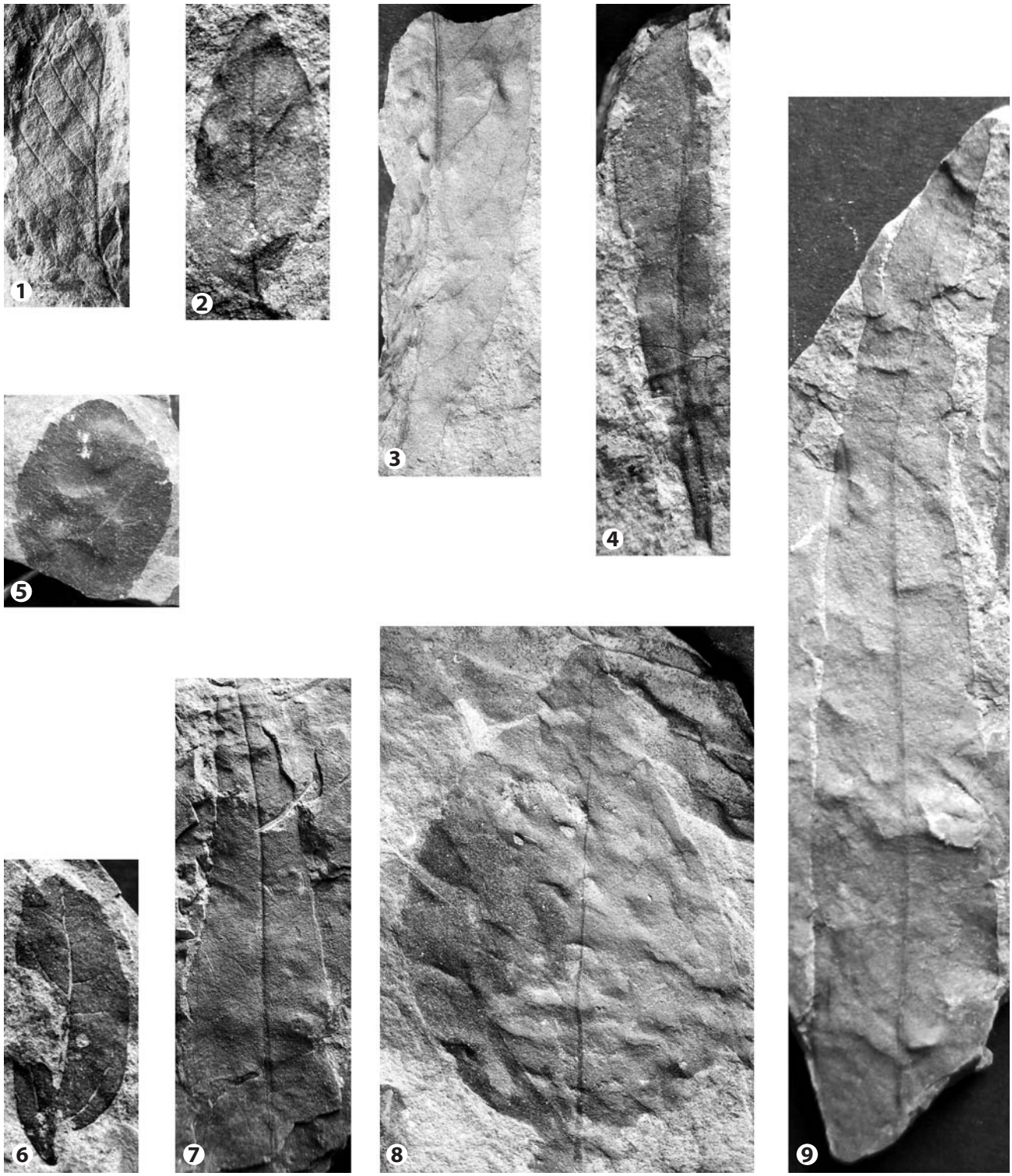
Figs 1-8. Photographs of fossil specimens:
1, *Litsea primigenia*, HVP-192 (×2); **2,** *Ocotea heeri*, HVP-22 (×2); **3,** *Daphnogene spectabilis*, HVP-208 (×2); **4,** *Betula subpubescens*, HVP-253 (×2); **5,** *Engelhardia orsbergensis*, HVP-175; **6,** *Dryophyllum dewalquei*, HVP-4 (×2); **7,** *Rubus merianii*, HVP-71 (×2); **8,** *Carpinus grandis*, HVP-188 (×2).

Plate III



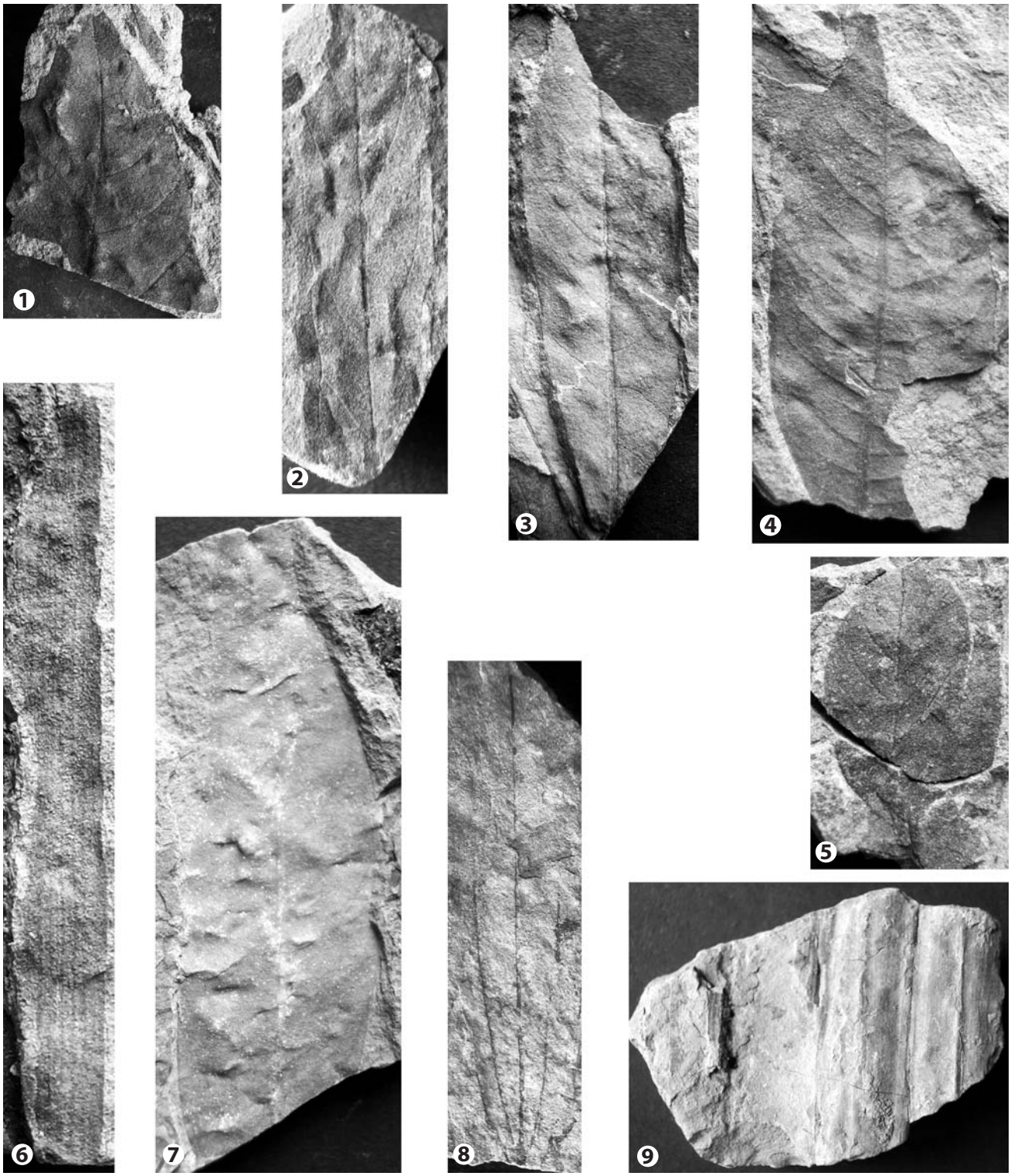
Figs 1-7. Photographs of fossil specimens:
1, *Sapindus graecus*, Zl-196 (×2); **2,** *Zelkova zelkovifolia*, HVP-163 (×2); **3,** *Laurus pliocenica*, HVP-117 (×2); **4,** *Persea braunii*, HVP-163 (×2); **5,** *Ulmus pyramidalis*, HVP-44 (×2); **6,** *Cedrela attica*, HVP-49 (×2); **7,** *Neolitsea palaeosericea*, HVP-217 (×2).

Plate IV



Figs 1-9. Photographs of fossil specimens:
1, *Fagus pliocenica*, HVP-94 (×2); **2,** *Zanthoxylum juglandinum*, HVP-163 (×2); **3,** *Eurya* aff. *acuminatissima*, Zl-189 (×2); **4,** *Apocynophyllum neriifolium*, HVP-204 (×2); **5,** *Celastrus oeningensis*, HVP-250 (×2); **6,** *Daphnogene ungeri*, HVP-82; **7,** *Periploca cf. krishtofovichii*, Zl-193 (×2); **8,** *Diospyros anceps*, HVP-134 (×2); **9,** *Myrica hakeaefolia*, HVP-186 (×2).

Plate V



Figs 1-9. Photographs of fossil specimens:
1, *Platanus platanifolia*, HVP-213 (×1.5); **2,** *Myrica kymeana*, HVP-28 (×2); **3,** *Quercus lyellii*, HVP-208 (×2); **4,** *Trigonobalanopsis rhamnoides*, HVP-200 (×2); **5,** *Berchemia multinervis*, HVP-197(×2); **6,** *Typha* sp., HVP-254 (×2); **7,** *Sapindus falcifolius*, HVP-205 (×2); **8,** *Macclintockia basinervis*, HVP-116 (×2); **9,** *Palmophyllum* sp., HVP-251 (×1).

References

Berger, W. 1953. Jungtertiäre Pflanzenreste aus dem Gebiete der Ägäis (Lemnos, Thessaloniki). – Ann. Géol. Pays Hellén., **5**: 34-64.

Bozukov, V. 1996. *Macclintockia basinervis* (Rossm.) Knobloch in the fossil flora of the Satovcha Graben in the Western Rhodopes. – Fitologiya, **48**: 68-72.

Bozukov, V. 1998. Miocene macroflora of the Satovcha Graben (Western Rhodopes). I. Systematics. 2. *Lauraceae, Magnoliaceae, Cercidiphyllaceae, Hamamelidaceae, Ulmaceae, Moraceae*. – Phytol. Balcan., **4**(3): 3-12

Bozukov, V. 2000. Miocene macroflora of the Satovcha Graben (Western Rhodopes). I. Systematics. 5. *Magnoliophyta*: *Araliaceae*, *Aquifoliaceae*, *Celastraceae*, *Rhamnaceae*, *Vitaceae*, *Apocynaceae*, *Caprifoliaceae*, *Convolvulaceae*, *Macclintockia*; *Smilacaceae*, *Cyperaceae*, *Sparganiaceae*, *Typhaceae*. – Phytol. Balcan., **6**(1): 15-29.

Bozukov, V. 2005. *Macclintockia basinervis* (Rossm.) Knobl. in Cenozoic sediments in the Rhodopes Mt. region (S Bulgaria). – Acta Palaeontol. Romaniae, **5**: 11-15.

Bozukov, V. & Palamarev, E. 1995. On the Tertiary History of the Theaceae in Bulgaria. – Fl. Medit., **5**: 177-190.

Boyanov, I. & Goranov, A. 2001. Late Alpine (Paleogene) superimposed depressions in parts of Southeast Bulgaria. – Geol. Balcan., **31**(3-4): 3-36.

Braun, A. 1851. Verzeichnungen der fossilen Pflanzen von Oehningen. Sitzenb. Ubers. Verst. Badens, Freiberg.

Černjavska, S., Palamarev, E. & Petkova, A. 1988. Micropaleobotanical and macropaleobotanical characteristics of the Paleogene sediments in the Hvojna Basin (Central Rhodopes). – Palaeontol., Stratigr., Litol., **26**: 26-36.

Dilcher, D. 1974. Approaches to the identification of angiosperm leaf remains. – Bot. Rev., **40**(1): 1-157.

Givulescu, R. 1962. Die fossile Flora von Valea Neagră. – Palaeontographica, **110**(5-6): 128-187.

Goranov, A. 1960. Lithologie der paläogenen ablagerungen in einem teil der Ostrodopen. – Trudove Varkhu Geol. Bulgaria, Ser. Geochim. Polezn. Izkop., **1**: 259-310 (in Bulgarian).

Harkovska, A., Stoykova, K. & Milakovska, Z. 2005. Vulche Pole Molasse (Eastern Rhodopes) – facts and problems. – In: **Yanev, Y. & Nedyalkov, R**. (eds), Proc. 80 Years Bulg. Geol. Soc. Pp. 11-13. Sofia Univ. Press, Sofia (in Bulgarian).

Heer, O. 1855-1859. Flora tertiaria Helvetiae. I-III. Winterthur.

Kitanov, B. & Nikolova, A. 1956. Neues Untersuchungsmaterial über die fossile Flora von Lozenec in Sofia. – Izv. Bot. Inst. (Sofia), **5**: 85-125 (in Bulgarian).

Konstantinoff, G. 1937. Paläobotanische Studien der tertiären Kohlenreviere Südwestbulgariens. – Abh. Bodensch. Bergbauindustr. Bulgariens, **9**: 257-277 (in Bulgarian).

Lambeva, N. & Tonchev, T. 1988. Lithofacial characteristics and paleogeographic features of Välčepole Molasse in the area between villages of Topolovo and Efrem (East Rhodopes). – Spis. Bulg. Geol. Druzh., **49**(2): 45-52 (in Bulgarian).

Palamarev, E. 1963. Beiträge zur Kenntnis der Tertiärflora Bulgariens. – Neues. Jahrb. Geol. Paläontol. Mh., **4**: 207-214.

Palamarev, E. 1964. Paläobotanische Untersuchungen des Čukurovo-Kohlebeckens. – Izv. Bot. Inst. (Sofia), **13**: 5-80 (in Bulgarian).

Palamarev, E., Kitanov, G., Bozukov, V. & Staneva, K. 1999. Fossil flora from Palaeogene sediments in the northern area of the Mesta Graben in the Western Rhodopes. I. Systematics. – Phytol. Balcan., **5**(2-3): 3-25.

Palamarev, E. & Petkova, A. 1966. Fossile Flora aus einigen paläogene Fundstätten in Bulgarien. – Izv. Bot. Inst. (Sofia), **16**: 49-78 (in Bulgarian).

Palamarev, E. & Petkova, A. 1975. Neue Daten über die paläogene Flora Bulgariens. – In: **Velchev, V. & al.** (eds), In Hon. Acad. Daki Jordanov. Pp. 203-236. Publishing House Bulg. Acad. Sci., Sofia (in Bulgarian).

Palamarev, E. & Petkova, A. 1987. La macroflore du Sarmatien. – In: **Tsankov, V.** (ed.), Les fossiles de Bulgarie, **8**(1), pp. 3-275. Publishing House Bulg. Acad. Sci., Sofia (in Bulgarian).

Palamarev, E. & Petkova, A. 1994. New species for the Palaeogene flora of Bulgaria and their systematic, ecological and biostratigraphic significanse. – God. Sofiisk. Univ "Kliment Ohridski" Biol. Fak., 2 Bot., **2**(85): 35-44.

Palamarev, E., Petkova, A. & Gogov, D. 1992. Die Palmen in alttertiärer Flora von Rhodopen-massiv in Bulgarien. – Doc. Natur., **76**:1-9.

Palamarev, E. & Staneva, K. 1995. On some characteristics of the macroflora of the Paleogene rocks in the Graben of Polkovnik Serafimovo (Central Rhodopes). – Geol. Balcan., **25**(5-6): 113-123.

Palibin, I. 1937. Fossil Flora of Godzersky Pass. – Trudy Bot. Inst. Akad. Nauk S.S.S.R., Ser. 1, Fl. Sist. Vyssh. Rast., **4**: 7-92 (in Russian).

Palibin, I. 1939. Materials on the Tertiary flora of Armenia. – In: On the 70th Birthday and 45th Anniversary of Scientific Work of Academician Vladimir Leontievich Komarov, President of the Acad. Sci. USSR (in Russian).

Petkova, A. 1967. Paläobotanische Untersuchung des Sarmats an der unteren Strümung des Iskar-Flusses. – Izv. Bot. Inst. (Sofia), **17**: 135-168 (in Bulgarian).

Petrescu, I., Givulescu, R. & Barbu, O. 1997. Oligocene macro- and microflora from Cornești-Aghireș, Romania. Editura Carpatica, Cluj-Napoca (in Romanian).

Stanislavskyi, F.A. 1956. About *Macclintockia* remains and the age of them holding Paleogene deposits in Ukrainian SSR. – Bot. Zhurn., **41**: 1188-1193 (in Russian).

Stefanov, B. & Jordanov, D. 1934. Weitere Materialien zur Kenntnis der fossilen Flora des Pliozän bei dem Dorf Kurilo (Bez. Sofia). – God. Sofiisk. Univ. Agric. & Forest. Fak., **2**: 1-55 (in Bulgarian).

Takhtajan, A. L. 1987. Magnoliophytes System. Nauka, Leningrad (in Russian).

Unger, F. 1867. Die fossile Flora von Kymi auf der Insel Eubaea. – Denkschr. Akad. Wiss. Wien, Math.-Naturwiss. Kl., **27**: 1-66.

Vaptsarov, I. 1970. Origine et développement de la depression morphostructurale de Bregovo – Välčepole dans le Rhodope Oriental. – Izv. Geogr. Inst., **13**: 21-36 (in Bulgarian).

Zhilin, S. G. 1969. Ichnophytology – one of the branches of paleobotany. – Trudy Vsesoyusn. Geol. Inst., **130**: 24-28 (in Russian).