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THE RESULTS OBTAINED HITHERTO IN STUDIES  
ON THE MIOCENE MACROFLORA FROM THE SALT-MINE  
AT WIELICZKA (S. POLAND)

Wyniki dorywczościowych badań nad florą mioceńską zachowaną w złożu solnym w Wieliczce

**ABSTRACT.** This paper comprises a discussion of the results of studies carried out so far by various authors and a critical list of taxons identified in the Miocene flora of Wieliczka. This flora, known for long and of great importance to the European Tertiary, consists of 136 taxons and still calls for further studies, which should cover, in the first place, the genera distinguished and also some of the species determined.

The allochthonic origin of the flora is evidenced by the predominance of arboreal plants (90% of the total), which grew over the raised shores of the Miocene Parathetis. The flora of Wieliczka belongs to the so-called younger mastixioid floras, known from the European Miocene and with some palaeotropical species still present in it. It is referred to the older part of the Upper Miocene (the former Lower Tortonian, now Badenian), i. e. the period when the salt series were formed.

INTRODUCTION

Studies on the Miocene flora preserved in the salt deposits at Wieliczka were started 150 years ago. We can mention quite a few palaeobotanists, who contributed — more or less — to the knowledge of this flora, with which however, above all, the name of the late Prof. Jan Zabłocki (d. 1978) is associated. He collected and solicitously preserved plant remains, which so readily break up after being extracted from salt deposits. He managed to study and publish only part of his material but had already a large number of preliminarily identified taxons. Because of the great significance and the unique mode of preservation of these floral remains the study of their rich collections is an important task. The material is stored in Toruń (J. Zabłocki's collection), Kraków (collections of B. Namysłowski and the Department of Palaeobotany, Institute of Botany, Polish Academy of Sciences) and Wieliczka (collection of the Museum of the Kraków Salt-Works at Wieliczka).

Information about the plants occurring in this flora is thinly scattered in palaeobotanical literature and can easily escape our attention. In view of this I have taken up the task of gathering all the existing data derived from both published papers and oral communications, correspondence and inventories of museum collections. I wish to take special pains to give a full list of the genera signalled by Prof. J. Zabłocki. Unfortunately, their study has not been concluded and published; nevertheless, we owe to the late Professor the extraction of numerous, often very fine remains from the deposits and their preliminary determinations, which add significantly to the composition of this flora.

When this paper was already in print I received the information that the collection of fossils left by Prof. J. Zabłocki in Toruń have been delivered to the Museum of Kraków Salt-Works at Wieliczka. Rich and very well preserved fossils are composed almost exclusively of small plant remains, all being segregated and preliminary identified. Among them there are some 80 new taxa not included in the presently published list.

#### A SURVEY OF STUDIES MADE SO FAR

Three distinct periods can be distinguished on the basis of the dates of publication in the studies on the flora of Wieliczka (cf. Tab. 1).

**1. 1825—1919:** First determinations of plants obtained from the salt deposits were made by Austrian, Czechoslovakian and German palaeobotanists. Studies conducted by Unger (1850) and Stur (1873) were of fundamental importance in that long period. The remains then found and described were big and frequently occurring in the deposit, e. g. cones of *Pinus* and nuts of the *Juglandaceae*. Much attention was besides given, more than ever afterwards, to the identification of wood pieces, which owing to their large size were easily found and extracted. In that period altogether 29 taxons were described, of which 6 species — *Pinus polonica* Stur, *P. salinarum* Partsch, *Juglans salinarum* (Sternb.) Pusch, *J. costata* (Presl) Ung., *Carya ventricosa* (Sternb.) Ung. and *Liquidambar europaea* A. Br. — and 4 genera or higher systematic units (exclusively pieces of wood of the *Coniferae*) withstood later revisions.

**2. 1928—1931:** Studies on the flora of Wieliczka were resumed by J. Zabłocki in Kraków; he became its main and virtually only investigator for many years. Zabłocki carried out revisions of the older determinations on the basis of Unger's and Stur's original specimens. He gathered new rich materials, containing numerous remains unrecorded before. In 1928 and 1930 he published the results of his studies, covering only part of his collection, and these publications were the main source of information about the flora of Wieliczka for a long time.

Thirty-two species (26 of them survived later revisions) and 2 genera were described in that period. In addition, J. Zabłocki (1928b, 1930b) writes about the occurrence of 18 new genera, but as regards 15 of them, his suggestions

Table 1

## A survey of the results of studies on the Miocene flora of Wieliczka

Dates of publication	Authors	Taxons determined			
		to specific level		to generic level or higher systematic units	
		newly described	after revision	newly described	after revision
1825	Sternberg K.	3	—		
1837	Pusch G. G.*	1	1		
1850	Unger F.	13	2	1	1
1850	Goeppert H. R.	2	—		
1873	Stur D.	6	3	1	1
1919	Kräusel R.			2	2
1928a	Zabłocki J.	12	11	3	3
1928b	Zabłocki J.	2	1	5	5
1930a	Zabłocki J.	15	11	1	1
1930b	Zabłocki J.			11	10
1931	Zabłocka W.	3	3		
1941	Kirchheimer F.	2	2		
1947	Szafer W.	1	—		
1959	Kostyniuk M. (det. J. Zabłocki)			34	23
1959	Zabłocki J., unpubl.			16	15
1960	Zabłocki J.	1	1		
1960, 61	Jentys-Szaferowa J.	1	1		
1961	Szafer W.	1	1		
1963	Szafer W.	1	1		
1963	Łańcucka-Środoniowa M.	3	1		
1964	Mai D. H.	6	4	1	1
1966	Łańcucka-Środoniowa M.	3	3	1	1
1970	Mai D. H.	2	2		
1971	Mai D. H.	1	1		
1978	Mai D. H. & Walther H.	1	1		
1978	Gregor H. J.	3	3		
1981	Kolasa K. (det. J. Zabłocki)	1	1		
1981	Kolasa K. (det. M. Łańcucka-Środoniowa)	9	6	4	2
1981—83	Łańcucka-Środoniowa M., unpubl.	11	11		
	Total	104	71	80	65

\* Cf. the note on p. 11.

are inaccurate and call for confirmation. There are no specimens representing these genera in the collections of the Department of Palaeobotany, Institute of Botany Polish Academy of Sciences, and the Museum of the Kraków Salt-Works at Wieliczka. Out of the numerous species determined by J. Zabłocki the newly described fossil species deserve particular attention: *Aesculus rouppertii*

Zabł., *Carpinus polonica* Zabł., *Carya rugosa* Zabł., *Cornus salinarum* Zabł., *Diospyros salinaria* Zabł., *Engelhardia salinarum* Zabł., *Hamamelis europaea* Zabł., *Juglans wandaе* Zabł., *J. szaferi* Zabł., *Olea oleastroides* Zabł., *Pterocarya raciborskii* Zabł. and *Pterostyrax europaea* Zabł. One of the fossil species, *Tetraclinis wandaе* Zabł., has been synonymized with *T. brongniartii* (Endlich.) Kräusel (cf. Mai & Walther 1978). The distinction of several of the above-mentioned species met with objections of some palaeobotanists (cf. the list of species further in this paper). Anatomical examination of Zabłocki's original specimens would be necessary to establish to what extent these remarks are justified.

3. 1941—1983: J. Zabłocki carried on his study of the Wieliczka flora at Toruń in 1946—1978. In consequence, he distinguished 2 species (one of them new — *Pinus królii* Zabł.) and 50 genera new to this flora. A small number of the genera named by J. Zabłocki (*Celtis*, *Cladium*, *Durania* = *Rehderodendron*, *Mastixia*, *Myrica*, *Nyssa*, *Stewartia*, *Symplocos*, *Torreya* and *Zanthoxylum*) have received specific names in the last few tens of years (Szafer 1961; Łaniczka-Środoniowa 1963, 1981—1983; Mai 1970, 1971).

Information about the newly distinguished genera was given by Prof. Zabłocki in his report presented at a palaeobotanical conference at the Institute of Botany, Polish Academy of Sciences in Kraków on 19 March 1959. It was presented in the proceedings of that conference (Kostyniuk 1959) and supplemented with notes taken down of that report by M. Łaniczka-Środoniowa (Zabłocki 1959, unpubl.). Only a few of the genera determined tentatively by J. Zabłocki occur in the collections of the Department of Palaeobotany, Institute of Botany Polish Academy of Sciences, and the Museum of the Kraków Salt-Works at Wieliczka.

Additional information about the composition of the Wieliczka flora is provided in papers by Polish (Szafer, Jentys-Szaferowa and Łaniczka-Środoniowa) and German (Kirchheimer, Mai, Walther and Gregor) palaeobotanists. They added 45 new species (37 after revision) and 6 genera (4 after revision) to the flora of Wieliczka. However, most of the taxons distinguished were given without descriptions and illustrations. Particularly interesting was the determination of the fruits of *Mastixicarpum limnophilum* (Ung.) Kirchh. by Kirchheimer (1941): they were originally considered to be fruits of *Quercus* and next, for a long time, regarded as palm seeds. The nature of the fossil flora is well defined by such fossil species identified in this period as *Alangium dubium* (Ung.) Mai, *Eurya stigmosa* (Ludw.) Mai, *Mastixia amygdalaeformis* (Schloth.) Kirchh., *Rehderodendron ehrenbergii* (Kirchh.) Mai, *Sinomenium militzeri* Kirchh., *Symplocos lignitarum* (Quenst.) Kirchh., *S. poppeana* Kirchh., *S. salzhausenensis* Kirchh., *Toddalia latisiliquata* (Ludw.) Gregor, *T. maii* Gregor, *T. naviculaeformis* (E. M. Reid) Gregor, *Trigonobalanus exacantha* Mai and *Turpinia ettingshausenii* (Engelh.) Mai.

A survey of the data obtained so far shows that at the present time 71 species and 65 genera (or higher systematic units), or altogether 136 taxons, are known from Wieliczka. Their number will increase considerably, when

a close study of the genera distinguished — some of them contain several species — has been carried out. In a letter of 3 June 1976 Prof. Zabłocki wrote to me that he had 120 species new to the Wieliczka flora in his collection.

#### A LIST OF TAXONS DISTINGUISHED

Systematic arrangement has been adopted in the list and the specific names are given according to the binding nomenclature, with the previously used names added. In most cases it was possible to specify the remains that the authors had at their disposal. That is not the case with the genera signalled by Zabłocki, unless they are in the possession of the Palaeobotanic Museum of the Institute of Botany, Polish Academy of Sciences (IB PAN) or in the Museum of the Kraków Salt - Works at Wieliczka (MZKW). Each taxon is furnished with references to literature and illustrative material, remarks and opinions so far unpublished are also given (unpubl.). It would be advisable to check the determinations of some genera, but this would demand that the whole of Prof. Zabłocki's materials should be examined, which is impossible at the present time.

#### *Cryptogamae*

#### *Fungi*

1. *Rosellinites areolatus* (Fres. & Meyer) Kirchh. — fructifications. Zabłocka 1931, p. 183, Pl. 15, figs. 3,4: sub *Sphaerites areolatus* (Fresen) Mesch.
2. *Rosellinites congregatus* (Beck) Mesch. — fructification. Zabłocka 1931, p. 182, Pl. 15, figs. 1, 2.
3. *Trematosphaerites lignitum* (Heer) Mesch. — fructifications. Zabłocka 1931, p. 183, Pl. 15, fig. 5.

#### *Equisetinae*

4. *Equisetum* sp. — Zabłocki's report 1959, unpubl.

#### *Gymnospermae — Coniferae*

5. *Coniferae* gen. 1 — wood. Kräusel 1919, p. 225. Described by Goeppert (1850, p. 215, Pl. 31, figs. 7, 8) as *Pinites wieliczkensis* Goepp. According to Kräusel, it certainly does not belong to the *Abietinae*.
6. *Coniferae* gen. 2 — wood. Kräusel 1919, p. 225. Described by Goeppert (1850, p. 216, Pl. 32, figs. 1—3) as *Pinites zeuschnerianus* Goepp.

### Family *Taxaceae*

7. *Torreya miocenica* Kräusel — seeds. Łaćucka-Środoniowa 1963, Table 1. IB PAN, MŻKW. The genus mentioned in Zabłocki's report 1959 (Kostyniuk 1959, p. 377).
8. *Taxoxylon göppertiae* Ung. — wood. Unger 1850, p. 318: sub *Taxoxylum göppertiae* Ung.

### Family *Pinaceae*

9. *Pinus brevis* Ludwig — cone. Det. Zabłocki, 1966 (Kolasa 1981, p. 92), MŻKW.
10. *Pinus królii* Zabł. — cones, seeds. Zabłocki 1960, Pl. 1, figs. 1—4 and a specimen given as *P. salinarum* Partsch (Zabłocki 1928a, Pl. 7, fig. 3).
11. *Pinus polonica* Stur — cones. Stur 1873, pp. 7, 9; Zabłocki 1928a, p. 182, Pl. 8, figs. 1—5.
12. *Pinus salinarum* (Partsch) Stur — cones. Stur 1873, pp. 7, 9; Zabłocki 1928a, p. 184, Pl. 7, figs. 1, 2, 4. The specimen in Pl. 7, fig. 3 belongs to *P. królii* Zabł. (cf. item 10). Cones of this species were presented by Unger (1850, p. 318, Pl. 35, figs. 28, 29) sub *Pinites salinarum* Partsch.
13. *Pinus spinosa* Herbst — cones. Zabłocki 1928a, p. 186, Pl. 7, figs. 5, 6. Stur gave some cones of this species sub. *P. russeggeri* Stur (1873, pp. 7, 9).
14. *Pinus sylvestris* L. *miocenica* Zabł. — cones. Zabłocki 1928a, p. 183, Pl. 7, fig. 7.
15. *Pinus thomasiiana* (Goepp.) Reichenb. — cones. Mai 1964, p. 140.
16. *Pithyoxyylon* cf. *silesiacum* (Ung.) Kraus — wood. Stur 1873, p. 9, sub *Pithyoxyylon* cf. *silesiacum* Ung. Given by Unger (1850, p. 318) sub *Peuce silesiaca* Ung.

### Family *Taxodiaceae*

17. *Cunninghamia* sp. — cones. Zabłocki's report, 1959 (Kostyniuk 1959, p. 377). J. Zabłocki intended to describe a fossil species, *C. salinaria* sp. n. (letter of 3 June 1976 to M. Środoniowa).
18. *Glyptostrobus europaea* (Brongn.) Unger — Zabłocki 1928b, p. 7, sub *G. europaea* Brongn.
19. *Sequoia abietina* (Brongn. in Cuv.) Knobloch — seed scales. Zabłocki 1928a, p. 187, Pl. 8, figs. 6—9, sub *S. langsdorffii* Brongn.
20. *Taxodium dubium* (Sternb.) Heer — cone. Zabłocki 1930a, p. 140, Pl. 10, fig. 17, sub *T. distichum miocenum* Heer.

### Family *Cupressaceae*

21. *Chamaecyparis salinarum* Zabł. — seed scales. Zabłocki 1930a, p. 140, Pl. 10, figs. 14—16.
22. *Juniperus* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).
23. *Libocedrites salicornioides* (Ung.) Endlicher — leafy shoots. Zabłocki 1930a, p. 141, Pl. 10, figs. 1—13, sub *Libocedrus salicornioides* (Ung.) Heer.
24. *Tetraclinis bronniartii* (Endlich.) Kräuse — leafy shoots, cones. Mai & Walter 1978, p. 28. Previously given as *T. wandae* Zabł. (Zabłocki 1928a, p. 188, Pl. 8, figs. 10—17) and as *T. articulata* (Vahl.) Masters foss. (Łańcucka-Środoniowa 1963, Table 1).
25. *Thuja* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).

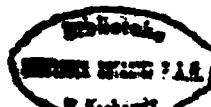
### *Angiospermae — Dicotyledones*

#### Family *Betulaceae*

26. *Alnus kefersteinii* (Goepp.) Unger — fruits, seeds. Zabłocki 1928a, p. 196, Pl. 10, figs. 41, 42, sub *A. kefersteinii* Ung.
27. *Betula* sp. — wood. Mai 1964, p. 140. Described by Unger (1850, p. 319) sub *Betulinium parisiense* Ung.
28. *Carpinus* type *betulus* L. — fruit. Jentys-Szaferowa 1961, p. 32, Pl. 14. This specimen was originally included in *C. polonica* Zabł. (cf. Jentys-Szaferowa 1960, Pl. 1, fig. J<sub>4</sub>).
29. *Carpinus polonica* Zabł. — fruits. Zabłocki 1928a, p. 196, Pl. 10, figs. 1—20. In his report of 1959 J. Zabłocki informed about the occurrence of 3 species of this genus.
30. *Ostrya* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).

#### Family *Fagaceae*

31. *Castanea* sp. — Zabłocki 1930b, p. 229. So far unconfirmed suggestion.
32. *Castanopsis salinarum* (Ung.) Kirchh. — fruits. Kirchheimer 1941, p. 613, Text-fig. 6. Previously given under the names *Castanea salinarum* Ung. (Unger 1850, p. 320, Pl. 35, figs. 11—13), *Pavia salinarum* Ung. (Zabłocki 1928a, pp. 181, 200, Pl. 11, figs. 13, 14) and *Castanopsis schmidtiana* (Gein) Kräuse (Zabłocki 1930a, p. 140).
33. *Fagus ferruginea* Ait. var. *miocenica* Menzel — fruits. Zabłocki 1928a, p. 197, Pl. 11, figs. 1—12. Given under the names *F. ferruginea* Ait. (Łańcucka-Środoniowa 1963, Table 1) and *F. attenuata* Goepf. (Mai 1964, p. 140).



34. *Fagus* cf. *orientalis* Lipsky — fruits. The species mentioned in Zabłocki's report, 1959 (Łańcucka-Środoniowa 1966, p.62).
35. *Fagus* sp. — leaves in salt-underlying sandstones. Zabłocki 1928b, p. 6.
36. *Fagus* sp. — pieces of wood. Zabłocki 1928a, p. 197. Described by Unger (1850, p. 321) sub *Fegonium vasculosum* Ung.
37. *Quercus* sp. div. — fruits. Zabłocki 1928a, p. 199, Pl. 11, figs. 15—20. In his report of 1959 J. Zabłocki informed about the occurrence of 3 species of this genus.
38. *Trigonobalanus exacantha* Mai — fruits. Det. Łańcucka-Środoniowa, 1980 (Kolasa 1981, p. 105), MŻKW.

Family *Myricaceae*

39. *Myrica ceriferiformis* Kownas — endocarps. Det. Łańcucka-Środoniowa' 1981 (unpubl.), IB PAN, MŻKW.
40. *Myrica* cf. *suppanii* Kirchh. — endocarp. Det. Łańcucka-Środoniowa, 1980 (Kolasa 1981, p. 105), MŻKW.  
In his report of 1959 J. Zabłocki informed about the occurrence of 2 species of this genus.

Family *Juglandaceae*

41. *Carya pusilla* Ung. — nuts. Zabłocki 1928a, p. 195, Pl. 8, figs. 20, 21; Mai 1981, pp. 359, 360. Kirchheimer (1957, p. 202) included this species in *C. ventricosa* (Sternb.) Ung.
42. *Carya rugosa* Zabł. — nuts. Zabłocki 1930a, p. 144, Pl. 12, figs. 1—4.
43. *Carya ventricosa* (Sternb.) Ung. — nuts. Zabłocki 1928a, p. 194, Pl. 8, figs. 18, 19, sub *C. ventricosa* (Brongn.) Ung. Its remains are frequently met with and described by Unger in 1850 as *Juglans ventricosa* Brong. (p. 321, Pl. 35, figs. 14—16), *J. costata* Ung. (p. 321, Pl. 35, figs. 19, 22), *Castanea compressa* Ung. (p. 320, Pl. 35, figs. 9, 10) and *Quercus glans saturni* Ung. (p. 319, Pl. 35, figs. 5—7). Cf. Stur 1873, pp. 7—9; Zabłocki 1928a, p. 193; Kirchheimer 1957, pp. 202, 203 and Mai 1981, pp. 367—371.
44. *Carya* vel *Pterocarya* sp. — pieces of wood. Zabłocki 1928a, p. 197. Described by Unger (1850, p. 320, Pl. 35, figs. 25—27) under the name of *Fegonium salinarum* Ung.; frequent in the Wieliczka deposits.
45. *Engelhardia salinarum* Zabł. — fruits. Zabłocki 1930a, p. 147, Pl. 11, figs. 11—14. The suggestion that this name should be changed for *E. salinaria* Zabł. (Jähnichen, Mai & Walther 1977, p. 351) is not just, for the original name is correct — *E. salinarum* Zabł., and not *E. salinarium* Zabł., as the above-mentioned authors write.

46. *Juglans bergomensis* (Bals.-Criv.) Massal. — nut. Mai 1964, p. 140. The species given by Zabłocki (1930 a, p.144) sub *J. tephrodes* Ung. — cf. Kirchheimer 1957; Łaniczka-Środoniowa 1963, Table 1.
47. *Juglans costata* (Presl) Ung. — nut. Described as *J. costata* Ung. (Unger 1850, p. 321, Pl. 30, fig. 23; Zabłocki 1928a, p. 193, Pl.9, fig. 13). The remaining specimens referred by Unger to this species, belong — according to Zabłocki — to *Carya ventricosa* (cf. item 43) and *Juglans szafieri* (cf. item 49). This species is placed by some investigators in the genus *Carya* — cf. Mai 1981, pp. 356, 357.
48. *Juglans salinarum* (Sternb.) Pusch \* — nut. Unger 1850, p. 321, Pl. 35, figs. 17, 18, sub *J. salinarum* Ung. The specimen described by Zabłocki (1928a, p. 194, Pl. 9, fig. 8) comes from the salt deposit at Bochnia.
49. *Juglans szafieri* Zabł. — nuts. Zabłocki 1928a, p. 192, Pl. 9, figs. 7, 9—11. Two specimens described by Unger (1850, Pl. 35, figs. 20, 21) as *J. costata* Ung. also belong in this species.
50. *Juglans wandae* Zabł. — nuts. Zabłocki 1930 a, p. 143, Pl. 11, figs. 1—3, 10. According to Mädler (1939, p. 61), they are nuts of *Juglans* (*Carya*) *costata* (Presl.) Ung.
51. *Pterocarya raciborskii* Zabł. — nuts. Zabłocki 1928a, p. 189, Pl. 10, figs. 21—34.
52. *Pterocarya* sp. div. — Zabłocki's report, 1959, unpubl.

#### Family *Ulmaceae*

53. *Celtis lacunosa* (Reuss) Kirchh. — fruits. Det. Łaniczka-Środoniowa, 1982, unpubl. IB PAN. The genus mentioned in Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).
54. *Zelkova* sp. — Zabłocki 1930 b, p. 232. Unconfirmed suggestion.

#### Family *Eucommiaceae*

55. *Eucommia* sp. — leaf fragments. Łaniczka-Środoniowa 1966, p. 67.

#### Family *Phytolaccaceae*

56. *Phytolacca* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377). Suggestion so far unconfirmed.

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\* The specimen described by Sternberg (1825) as *Juglandites salinarum* was numbered by Pusch in the genus *Juglans* in 1837 (cf. Kirchheimer 1957, p. 201).

Family *Hamamelidaceae*

57. *Corylopsis* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).
58. *Hamamelis europaea* Zabł. — seed. Zabłocki 1930a, p. 148, Pl. 12, fig. 13. Kirchheimer (1957, p. 491) calls this generic determination in question.
59. *Liquidambar europaea* A. Br. — fructifications, leaves. Unger (1850, p. 318) mentioned these fructifications under the name of *Steinhauera subglobosa* Sternb., whereas Stur (1873, p. 9) and Zabłocki (1928a, p. 201, Pl. 9, figs. 1—6) classified it in *Liquidambar europaeum* A. Br. Its leaves occur in the salt-underlying sandstones (Zabłocki 1928b, p. 6).

Family *Platanaceae*

60. *Platanus* sp. — fruits. Zabłocki 1930a, p. 149, Pl. 12, figs. 10, 11. In Kirchheimer's (1957, p. 579) opinion the determination is questionable.

Family *Magnoliaceae*

61. *Liriodendron* sp. — Zabłocki 1930b, p. 229. Unconfirmed suggestion.
62. *Magnolia burseracea* (Menzel) Mai — seeds. Mai 1975, p. 567. It was given previously as *M. attenuata* Web. (Zabłocki 1930a, p. 150, Pl. 12, figs. 20, 21) and *M. sinuata* Kirchh. (Mai 1964, p. 140).
63. *Magnolia lusatica* Kirchh. — seeds. Mai 1964, p. 140. Previously determined as *M. kobus* Reid foss. (Zabłocki 1930a, p. 150, Pl. 12, fig. 23), *M. ultima* Kirchh. (Kirchheimer 1957, pp. 221, 539) and *M. cor* Ludw. (det. Łaniczka-Środoniowa, 1958 in Kolasa 1981, p. 97).

Family *Annonaceae*

64. *Annonaesperrimum* sp. — Zabłocki's report, 1959, unpubl. Suggestion ought to be confirmed.

Family *Lauraceae*

65. *Cinnamomum* sp. — leaves in sandstones which underlie the salt. Zabłocki 1928b, p. 6.
66. *Lauraceae* gen. div. — fruits. Zabłocki's report, 1959 (Kostyniuk 1959, p. 377). *Laurus* and *Ocotea* are probable genera (Zabłocki 1959, unpubl.).

Family *Menispermaceae*

67. *Menispermum* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377). Unconfirmed suggestion, probably endocarps of *Sinomenium*.
68. *Sinomenium militzeri* Kirchh. — endocarp. Det. Łaniczka-Środoniowa, 1982, unpubl., IB PAN.

Family *Nymphaeaceae*

69. *Brasenia* sp. div. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).

Family *Ceratophyllaceae*

70. *Ceratophyllum* sp. — Zabłocki's report, 1959, unpubl. Suggestion ought to be confirmed.

Family *Droseraceae*

71. *Aldrovanda* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).

Family *Actinidiaceae*

72. *Actinidia* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).

Family *Theaceae*

73. *Campylospermum* sp. — Zabłocki's report, 1959, unpubl. Suggestion ought to be confirmed.
74. *Eurya stigmosa* (Ludw.) Mai — seed. Łaniczka-Środoniowa 1966, p. 80, Pl. 5, fig. 9, IB PAN.
75. *Gordonia* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).
76. *Stewartia beckerana* (Ludw.) Kirchh. — fruits. Mai 1971, p. 340. The genus given by Zabłocki in 1959 (Kostyniuk 1959, p. 377), IB PAN.

Family *Rosaceae*

77. *Amelanchier* sp. — Zabłocki's report, 1959, unpubl.
78. *Crataegus* sp. div. — endocarps. Zabłocki 1928b, p. 7, Pl. 1, fig. 11. According to Zabłocki (1959, unpubl.), there may be 3 species.

79. *Prunus* sp. div. — Zabłocki's report, 1959, unpubl. The species *P. crassa* (Ludw.) Schimper is possible. Stone of *Prunus* sp. — det. Łaniczka-Środoniowa, 1980 (Kolasa 1981, p. 103), MŻKW.

Family *Papilionaceae*

80. *Ceratonia* sp. — Zabłocki 1930b, p. 232. Unconfirmed suggestion.  
 81. *Robinia* sp. — Zabłocki 1930b, p. 229. Unconfirmed suggestion.

Family *Alangiaceae*

82. *Alangium dubium* (Ung.) Mai — stone. Mai 1970, p. 474. R. H. Eyde and M. Łaniczka-Środoniowa distinguished this genus in the collection of IB PAN in 1967.

Family *Nyssaceae*

83. *Nyssa disseminata* (Ludw.) Kirchh. — fruit-stones. Det. Łaniczka-Środoniowa, 1982, unpubl., IB PAN, MŻKW. The genus is mentioned in Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).

Family *Myrtaceae*

84. *Myrtus* sp. — Zabłocki 1930b, p. 232; 1959, unpubl.

Family *Onagraceae*

85. *Hartziella miocenica* Szafer — fruits. Szafer 1963, pp. 5, 27; IB PAN. Previously described as *Carpolithes rosenkjaeri* Hartz or the genus *Hartzia* related to the family *Cornaceae*.

Family *Tiliaceae*

86. *Tilia preplatyphyllos* Szafer — fruits. Det. Łaniczka-Środoniowa, 1982, unpubl., IB PAN, MŻKW. The genus found present by Zabłocki (1930b, p. 232).

Family *Sterculiaceae*

87. *Sterculia* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).

### Family *Rutaceae*

88. *Phellodéndron* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).
89. *Toddalia latisiliquata* (Ludw.) Gregor — seeds. Gregor 1978, p. 26, Pl. 3, figs. 4, 5. IB PAN, MŻKW.
90. *Toddalia maii* Gregor — seeds. Gregor 1978, p. 27, Pl. 5, fig. 4; Pl. 6, fig. 7. IB PAN, MŻKW.
91. *Toddalia naviculaeformis* (E.M. Reid) Gregor — seeds. Gregor 1978, p. 28. IB PAN, MŻKW.
92. *Zanthoxylum ailanthiforme* (Gregor) Gregor — seeds. Det. Łanckucka-Środoniowa, 1980 (Kolasa 1981, p. 105), IB PAN, MŻKW. The genus was distinguished by Zabłocki (Kostyniuk 1959, p. 377).

### Family *Anacardiaceae*

93. *Pistacia* sp. — Zabłocki 1930 b, p. 232. Unconfirmed suggestion.
94. *Schinus* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).

### Family *Sapindaceae*

95. *Sapindoidea* sp. div. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377); the probable species are *S. globosa* (Ludw.) Kirchh. and *S. margaritifera* (Ludw.) Kirchh. (unpubl.).

### Family *Aceraceae*

96. *Acer* sp. — fruits. Zabłocki 1930 b, p. 229. IB PAN.

### Family *Hippocastanaceae*

97. *Aesculus rouppertii* Zabł. — seed. Zabłocki 1928 a, p. 202, Pl. 9, fig. 12. According to Kirchheimer (1957, p. 470), this determination calls for an anatomical study to confirm it.
98. *Coriaria* sp. div. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).

### Family *Sabiaceae*

99. *Meliosma* cf. *wetteraviensis* (Ludw.) Mai — endocarp. Det. Łanckucka-Środoniowa, 1982, unpubl., IB PAN.

### Family *Staphyleaceae*

100. *Staphylea* sp. div. — seeds. Zabłocki's report, 1959 (Kostyniuk 1959, p. 377), IB PAN, MŻKW.
101. *Staphylea* cf. *bessarabica* Negru — seeds. Det. Łaniczka-Środoniowa, 1982, unpubl., IB PAN, MŻKW.
102. *Turpinia ettingshausenii* (Engelh.) Mai — seed. Det. Łaniczka-Środoniowa 1983, unpubl., IB PAN.

### Family *Rhamnaceae*

103. *Ceanothus* sp. — Zabłocki's report, 1959, unpubl. Suggestion unconfirmed.
104. *Paliurus* sp. — Zabłocki's report, 1959. (Kostyniuk 1959, p. 377).
105. *Rhamnaceae* gen. — Zabłocki's report, 1959, unpubl.

### Family *Vitaceae*

106. *Ampelopsis ludwigiae* (A. Br.) Dorof. — seed. Szafer 1947, p. 144, sub *Vitis ludwigiae* A. Br., IB PAN.
107. *Tetrastigma* sp. — seeds and fruits. Zabłocki's report, 1959, unpubl. Suggestion unconfirmed.
108. *Vitis parasyllvestris* Kirchh. — seeds. Łaniczka-Środoniowa 1963, Table 1, as *V. sylvestris* Gmel. foss., MŻKW.
109. *Vitis teutonica* A. Br. — seeds. Zabłocki 1928a, p. 203, Pl. 10, fig. 43. In Szafer's (1947, p. 144) opinion, these are seeds of *Vitis* (*Ampelopsis*) *ludwigiae*. Zabłocki's specimens need verifying.  
In his report of 1959, J. Zabłocki informs about the occurrence of several species of the genus *Vitis*, among other things, about seeds resembling the Mediterranean species *V. vinifera* L.

### Family *Araliaceae*

110. *Aralia* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).

### Family *Cornaceae*

111. *Cornus salinarum* Zabł. — endocarp. Zabłocki 1930a, p. 151, Pl. 12, fig. 8. According to Kirchheimer (1957, p. 140), this determination demands confirmation.  
J. Zabłocki, in his report of 1959, informed about the occurrence of several species of this genus.
112. cf. *Cornaceae* gen. — fruit. Det. Łaniczka-Środoniowa, 1980 (Kolasa 1981, p. 105), MŻKW.

### Subfamily *Mastixioideae*

113. *Mastixia amygdalaeformis* (Schloth.) Kirchh. — fruit-stones. Szafer 1961, p. 77. IB PAN, MŽKW. The genus mentioned in Zabłocki's report (Kostyniuk 1959, p. 377).
114. *Mastixicarpum limnophilum* (Ung.) Kirchh. — fruits. Kirchheimer 1941, p. 614, Text-fig. 7. It was described as *Quercus limnophila* Ung. (Unger 1850, p. 319, Pl. 35, figs. 1, 2), *Raphia ungeri* Stur (Stur 1873, pp. 8, 9) and „Palmenkerne” (Zabłocki 1928b, p. 7, Pl. 1, figs. 6, 7, 9). IB PAN, MŽKW.

### Family *Ericaceae*

115. *Andromeda* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).
116. cf. *Arctostaphyloides* sp. — fruit. Det. Łanucka-Środoniowa, 1980 (Kolasa 1981, p. 103), MŽKW.

### Family *Empetraceae*

117. *Corema* sp. — Zabłocki's report, 1959, unpubl. Suggestion ought to be confirmed.

### Family *Ebenaceae*

118. *Diospyros salinaria* Zabł. — calyx. Zabłocki 1930a, p. 152, Pl. 12, figs. 14, 15. Doubtful determination (cf. Mai 1964, p. 140).

### Family *Styracaceae*

119. *Pterostyrax europaea* Zabł. — fruit. Zabłocki 1930a, p. 153, Pl. 12, fig. 6. According to Kirchheimer (1957, p. 282), this determination calls for confirmation.
120. *Rehderodendron ehrenbergii* (Kirchh.) Mai — fruits. Mai 1970, p. 490. IB PAN, MŽKW. It was given previously as the genus *Durania* (Zabłocki's report in Kostyniuk 1959, p. 377) and *D. ehrenbergii* Kirchh. (Mai 1964, p. 140).
121. *Styrax* sp. — Zabłocki 1930b, p. 232 and his report of 1959 (Kostyniuk 1959, p. 377).

Family *Symplocaceae* \*\*

122. *Symplocos lignitarum* (Quenst.) Kirchh. — fruit-stones. Det. Łaniczka-Środoniowa, 1980 (Kolasa 1981, p. 99), MŻKW.
123. *Symplocos poppeana* Kirchh. — fruit-stones. Det. Łaniczka-Środoniowa, 1980 (Kolasa 1981, p. 99), IB PAN, MŻKW.
124. *Symplocos salzhausenensis* Kirchh. — fruit-stones. Det. Łaniczka-Środoniowa, 1980 (Kolasa 1981, p. 99), IB PAN, MŻKW. Given as *S. globosa* Ludw., *S. casparyi* Ludw. (Zabłocki 1928b, p. 7) and *S. gothanii* Kirchh. (Łaniczka-Środoniowa 1963, Table 1).

Family *Apocynaceae*

125. *Nerium* sp. — leaves in salt-underlying sandstones. Zabłocki 1928b, p. 6.

Family *Oleaceae*

126. *Fraxinus* sp. — Zabłocki 1930 b, p. 232. Unconfirmed suggestion.
127. *Olea oleastroides* Zabł. — fruit-stone. Zabłocki 1930a, p. 154, Pl. 12, figs. 19, 22. According to Kirchheimer (1957, pp. 244, 454), this determination is questionable, because similar endocarps occur also in other genera of the family *Oleaceae*.

Family *Caprifoliaceae*

128. *Sambucus* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).
129. *Viburnum* sp. — Zabłocki's report, 1959 (Kostyniuk 1959, p. 377).

*Angiospermae — Monocotyledones*

Family *Potamogetonaceae*

130. *Limnocalyx* sp. — fruit-stones. Zabłocki's report, 1959 (Kostyniuk 1959, p. 377). The probable species: *L. headonensis* (Gardner) Reid & Chandler (Zabłocki 1959, unpubl.).
131. *Potamogeton* sp. — fruit-stones. Zabłocki's report, 1959, unpubl., IB PAN.

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\*\* Determination of *Symplocos* and *Turpinia* were kindly confirmed by Dr. D. H. Mai, whereas *Zanthoxylum* by Dr H. J. Gregor.

Family *Cyperaceae*

132. *Carex* sp. — Zabłocki 1928b, p. 7.
133. *Cladiocarya* sp. — Zabłocki's report, 1959, unpubl.
134. *Cladium macrocarpum* Dorof. — fruits. Det. Łaniczka-Środoniowa, 1983, unpubl., IB PAN. This genus was mentioned in Zabłocki's report, 1959, unpubl.
135. *Scirpus* sp. — Zabłocki's report, 1959, unpubl.

Family *Sparganiaceae*

136. *Sparganium* aff. *neglectum* Beeby — endocarp. Det. Łaniczka-Środoniowa, unpubl., IB PAN.

AN EVALUATION OF THE RESULTS OF THE STUDIES CARRIED OUT SO FAR

It is for a long time that large numbers of various plant remains have been obtained from the salt deposits at Wieliczka but only part of them have been studied palaeobotanically. And so, e. g., well-preserved and frequently found pieces of wood were investigated only by Goeppert and Unger in the middle of the previous century. Pieces of wood (lignites) gathered together in the Museum of the Kraków Salt-Works at Wieliczka are still waiting for a study. The determination of the flora of fruits and seeds, initiated by Unger and Stur, was carried on for many years by Zabłocki. Some of the determinations (about 40 species) have been made by other Polish and German scientists on the occasion of their studies on various localities of Tertiary floras.

Up to now 136 taxons have been distinguished, of which 71 determined to specific level and 65 only to genus or a higher systematic unit. These figures do not mean that the flora of Wieliczka is already well known, for only 42 species have been described and even so some of them should still be verified by close anatomical investigation. Out of the signalled taxons, 85, including 29 determined to specific level, need elaborating. The dicotyledons are represented most abundantly (104 taxons), coniferous trees and shrubs being also fairly numerous (21 taxons). Scarcely one-third of the dicotyledonous forms distinguished have been studied in detail (cf. Tab. 2). The monocotyledons, poorly represented, have not, as yet, been studied at all.

The results of palaeobotanic studies carried out so far are fragmentary and abounding in gaps as regards diagnostic characters. Only J. Zabłocki devoted many years of work to the flora of Wieliczka; however, he published but a part of his materials. The collections of specimens of this interesting flora call for a modern and versatile study, carried out not only by the morphological method but also by the anatomical method, difficult in use with this flimsy material saturated with salt.

Table 2

Systematic groups of plants in the Miocene flora of Wieliczka

	Taxons distinguished	Taxons described	Taxons to be studied
<i>Cryptogamae</i>	4	3	1
<i>Coniferae</i>	21	14	7
<i>Dicotyledones</i>	104	34	70
<i>Monocotyledones</i>	7	—	7
Total	136	51	85

The salt series of Wieliczka have not, as yet, been examined palynologically, although analyses made preliminarily showed the presence of fairly numerous sporomorphs (Kirchheimer 1950; M. Pautsch, Institute of Botany, Polish Academy of Sciences, oral communication).

#### THE NATURE AND AGE OF THE FLORA

Accumulations of carbonized remains of plants (chiefly wood pieces and big fruits and seeds) occur at various depths of the Wieliczka mine. They have been collected for many years, but it is not possible to localize the exact places from which particular specimens have been derived (cf. Kolasa 1982). It may be said in general that remains of fairly large size occur, above all, in the upper part of the „spiza” complex („spiza” salt), whereas fine vegetable detritus is met with in sterile bands which separate salt layers (mudstones). Leaf prints were found exclusively in salt-underlying sandstones.

Trees and shrubs prevail in the composition of the flora (about 90%), whereas herbs are distinctly few (about 10%). Such a ratio of the arboreal to herbaceous plants is due to the allochthonous origin of the flora. Large and usually sturdily built remains of trees and shrubs could reach the shore of the Miocene sea in a relatively good state of preservation, even from far-off hill slopes. Water transport, especially at the time of periodical floods, may have played the main part in that, which is suggested by frequently found wood pieces water-worn and round to such an extent that they look exactly like fruits varying in size. The allochthonous origin of the flora is indicated also by the great differentiation of habitats with which particular plants might have been associated, and notably the distinct predomination of plants from the higher elevated grounds surrounding the Miocene sea (cf. Tab. 3).

The remains of aquatic and sea-shore marsh plants are not numerous. Such genera found in the flora of Wieliczka as *Aldrovanda*, *Brasenia*, *Ceratophyllum*, *Limnocarpus* or *Potamogeton* may have come from water bodies cut off from the sea and freshened. There are also few plants associated with clearly arid habitats; of these only one genus, *Tetraclinis*, occurs in semidesert areas of North Africa nowadays.

Table 3

Plants of various communities represented in the Miocene flora of Wieliczka  
 (numbers of species or taxons distinguished are given in brackets)

Marsh and aquatic communities	Various forest communities on elevated grounds	Communities of arid habitats	Plants of habitats not known exactly
<i>Aldrovanda</i>			
<i>Alnus</i>			
<i>Brasenia</i>			
<i>Carex</i>			
<i>Ceratophyllum</i>			
<i>Cladioarya</i>			
<i>Cladium</i>			
<i>Equisetum</i>			
<i>Glyptostrobus</i>			
<i>Hartziella</i> (?)			
<i>Limnocarpus</i>			
<i>Nyssa</i>			
<i>Potamogelon</i>			
<i>Scirpus</i>			
<i>Sparganium</i>			
<i>Taxodium</i>			
	<i>Aesculus, Acer, Actinidia, Alangium, Amelanchier, Ampelopsis, Andromeda, Annonaespermum, Aralia, Arctostaphyloides, Betula, Campylospermum, Carpinus</i> (2), <i>Carya</i> (4), <i>Castanea, Castanopsis, Ceanothus, Celtis, Chamaecyparis, Cinnamomum, Coniferae</i> (2), <i>Corema, Coriaria, Cornus, Cornaceae, Corylopsis, Crataegus, Cunninghamia, Diospyros, Engelhardia, Eucommia, Eurya, Fagus</i> (4), <i>Fraxinus, Gordonia, Hamamelis, Juglans</i> (5), <i>Juniperus, Lauraceae, Libocedrites, Liquidambar, Liriodendron, Magnolia</i> (2), <i>Mastixia, Mastixicarpum, Meliosma, Menispermum, Myrica</i> (2), <i>Ostrya, Phellodendron, Phytolacca, Pinus</i> (6), <i>Pitheoxylon, Platanus, Prunus, Pterocarya</i> (2), <i>Pterostyrax, Quercus, Rehderodendron, Rhamnaceae, Robinia, Sambucus, Sapindoidea, Schinus, Sequoia, Sinomenium, Staphylea</i> (2), <i>Stereulia, Stewartia, Styraza, Symplocos</i> (3), <i>Taxoxylon, Tetrastigma, Thuja, Tilia, Toddalia</i> (3), <i>Torreya, Trigonobalanus, Turpinia, Viburnum, Vitis</i> (2), <i>Zanthoxylum, Zelkova</i>	<i>Ceratonia</i> <i>Myrtus</i> <i>Nerium</i> <i>Olea</i> <i>Paliurus</i> <i>Pinus salinarum</i> <i>Pistacia</i> <i>Tetraclinis</i>	<i>Rosellinites</i> (2) <i>Trematosphaerites</i>
16	109	8	3

At first palaeobotanists referred the flora of Wieliczka to the Helvetician or the Middle Miocene (Zabłocki 1930b; Raniecka-Bobrowska & Czeczott 1958; Szafer 1961). Kirchheimer (1941) supposes that this flora contains Lower-Tertiary elements (*Mastixicarpum limnophilum* and *Castanopsis salinorum*) redeposited in the Miocene sea. The exceptionally good and uniform state of preservation of all the remains makes it impossible to accept that supposition and we must agree that the whole flora known comes from the period of deposition of the salt-bearing series (Łańcucka-Środoniowa 1963, 1966; Stuchlik 1980). Many years studies conducted by geologists and palaeontologists have proved that it happened at the beginning of the Upper Miocene (formerly Lower Tortonian, now Middle Badenian, M<sub>4</sub>: Wielicien — Łuczakowska 1978). This statement is not at variance with the results of palaeobotanical studies.

Considering the occurrence of members of the family *Mastixioideae* (*Mastixia*, *Mastixicarpum*) and the so-called accompanying species of the genera *Alangium*, *Aretostaphyloides*, *Castanopsis*, *Cinnamomum*, *Engelhardia*, *Eurya*, *Gordonia*, *Myrica*, *Rehderodendron*, *Sterculia*, *Symplocos*, *Terastigma*, *Trigonobalanus* and *Zanthoxylum* in it, the flora of Wieliczka is numbered among the so-called "mastixioid" floras (Mastixioideen Floren, according to Kirchheimer). The mastixioid floras, which comprise a number of plants with great climatic requirements (tropical and subtropical elements) were initially known in Europe chiefly from the Lower Tertiary, especially from the Eocene and Oligocene. They bear evidence of the fact that at that time there were evergreen laurel-leaf woods, rich as regards their composition, in Western, Southern and Central Europe. As the climatic conditions deteriorated, this palaeotropical vegetation was gradually dying out, its impoverishment being discontinuous, proceeding at cyclic intervals (Mai 1965, 1981). As shown by studies carried out recently, notably by German palaeobotanists, the elements of that palaeotropical flora were not becoming radically extinct before the decline of the Miocene or before the Pliocene. As the mastixioid floras known in Europe come from various periods of the Tertiary and their composition includes a more or less marked proportion of plants of a palaeotropical nature, they can be divided into older and younger mastixioid floras (Mai, l. c.). The older mastixioid floras (Palaeocene, Eocene and Oligocene) belong to the group of palaeotropical floras, in which the evergreen laurel-leaf woods play the main role, whereas the younger mastixioid floras (Miocene) are referred to the group of arctic Tertiary floras with associations of mixed and deciduous forests, in which owing to favourable climatic conditions some palaeotropical species were still preserved.

The Miocene flora of Wieliczka belongs to the so-called younger mastixioid floras (Mai 1965, 1967 — Florenzone XII). The dominant role in its floristic composition is played by trees and shrubs of mixed and deciduous forests, the family *Mastixioideae* is represented only by two genera, while the "accompanying species" are fairly numerous and — which is an important features of the younger mastixioid floras — the presence of the so-called Mediterranean element

is marked conspicuously. The Mediterranean type of vegetation is represented in the flora of Wieliczka by such genera as *Ceratonia*, *Myrtus*, *Nerium*, *Olea*, *Paliurus*, *Pinus* (*P. salinarum* — a fossil species similar to *P. brutia* and *P. halepensis*), *Pistacia*, *Tetraclinis* (*T. brongniartii* — similar to *T. articulata*), *Vitis* (*V. parasylyvestris* — like *V. sylvestris* and *V. vinifera*). Probably the still unidentified species of such genera as *Juniperus*, *Quercus*, *Castanea* and *Crataegus* will also belong here.

The present range of information on the flora of Wieliczka permits us to refer its age to the older part of the Upper Miocene (formerly Lower Tortonian, now Badenian: Wielicien) i. e. to the period in which in the light of geological and palaeontological studies the salt deposits comprising this flora were formed.

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#### REFERENCES

- Goeppert H. R. 1950. Monographie der fossilen Coniferen. *Natuurk. Verh. Holland. Maatsch. Wetensch. Haarlem*, 2 (6): 1—286, 1—73.
- Gregor H.J. 1978. Subtropische Elemente in europäischen Tertiär III. *Rutaceae*, die Gattungen *Toddalia* und *Zanthoxylum*. *Acta Palaeobot.*, 19 (1): 21—40.
- Jähnichen H., Mai D. H. & Walther H. 1977. Blätter und Früchte von *Engelhardia* Lesch. ex Bl. (*Juglandaceae*) aus dem europäischen Tertiär. *Feddes Rep.*, 88 (5,6): 323—363.
- Jentys-Szaferowa J. 1960. Morphological investigations of the fossil *Carpinus* — nutlets from Poland. *Acta Palaeobot.*, 1 (1): 3—42.
- 1961. Anatomical investigations on fossil fruits of the genus *Carpinus* in Poland. *Ibid.*, 2 (1): 3—33.
- Kirchheimer F. 1941. Bemerkenswerte Funde der Mastixioideen Flora. II. Das Vorkommen der Mastixioideen im Steinsalz von Wieliczka. *Braunkohle*, 40 (45,46): 610—617.
- 1950. Mikrofossilien aus Salzablagerungen des Tertiärs. *Palaeontographica*, Abt. B, 90 (4—6): 127—160.
- 1957. Die Laubgewächse der Braunkohlenseit. Halle (Saale).
- Kolasa K. 1981. Katalog zbiorów geologicznych Muzeum Źup Krakowskich Wieliczka (Catalogus monumentarum geologiae quae in Museo Zupparum Cracoviensium Vieliciae asservantur). Muzeum Źup Krakowskich Wieliczka, Dział paleobot.: 83—106.
- 1982. Miocene flora kopalna w złożu solnym Wieliczki (summary: Miocene fossil flora in the Wieliczka salt deposit). *Stud. Mater. Dziej. Źup Solnych w Polsce*, 11: 45—57.
- Kostyniuk M. 1959. Trzecia konferencja paleobotaniczna w Krakowie. *Kosmos*, A (6): 376—381.
- Kräusel R. 1919. Die fossilen Koniferenhölzer. *Palaeontographica*, 62 (5,6): 185—284.
- Łańcucka-Środoniowa M. 1963. Palaeobotanical investigations on the Miocene of Southern Poland. *Roczn. Pol. Tow. Geol.*, 33 (2): 129—158.
- Tortonian flora from the Gdów Bay in the south of Poland. *Acta Palaeobot.*, 7 (1): 1—135.

- 1980. In: Kolasa 1981. Taksony oznaczone w zbiorze Muzeum Žup Krakowskich Wieliczka.
- 1981—1983, npb. Taksony oznaczone w zbiorach Instytutu Botaniki PAN w Krakowie oraz Muzeum Žup Krakowskich Wieliczka.
- Łuczkowska E. 1978. Wieliczen. In: Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys. 6. M<sub>4</sub> Badenien (Moravien, Wieliczen, Kosovien): pp. 148—151. Veda, Bratislava.
- Mai D. H. 1964. Die Mastixioideen-Floren im Tertiär der Oberlausitz. Paläont. Abh. B, 2 (1): 1—192.
- 1965. Der Florenwechsel im jüngeren Tertiär Mitteleuropas. Feddes Rep., 70 (1—3): 157—169.
- 1967. Die Florenzonen, der Florenwechsel und die Vorstellungen über den Klimaablauf im Jungtertiär der Deutschen Demokratischen Republik. Abh. Zentr. Geol. Inst. Berlin, 10: 55—81.
- Subtropische Elemente im europäischen Tertiär I. Paläont. Abh. B, 3 (3,4): 441—503.
- 1971. Über fossile Lauraceae und Theaceae in Mitteleuropa. Feddes Rep., 82 (5): 313—341.
- 1975. Beiträge zur Bestimmung und Nomenklatur fossiler Magnolien. Ibid., 86 (9,10): 559—578.
- 1981a. Der Formenkreis der Vietnam-Nuss (*Carya poilanei* (Chev.) in Europe. Ibid., 92 (5,6): 339—385.
- 1981b. Entwicklung und klimatische Differenzierung der Laubwaldflora Mitteleuropas im Tertiär. Flora, 171: 525—582.
- Mai D. H. & Walther H. 1978. Die Floren der Haselbacher Serie im Weißelster-Becken (Bezirk Leipzig, DDR). Abh. Staatl. Mus. Mineral. Geol. Dresden, 28: 1—200.
- Mädler K. 1939. Die pliozäne Flora von Frankfurt am Main. Abh. Senkenb. Naturf. Ges., 446: 1—202.
- Raniecka-Bobrowska J. & Czeczott H. 1958. Flora śródkaowego i górnego miocenu Polski w świetle badań ostatnich dwunastu lat (summary: The Middle and Upper Miocene floras of Poland in view of last 12 years' investigations). Kwart. Geol., 2 (1): 161—172.
- Sternberg K. 1825. Versuch einer geognostisch-botanischen Darstellung der Flora der Vorwelt. Regensburg.
- Stuchlik L. 1980. Chronostratygrafia neogenu Polski Południowej (północna część Państwy centralnej) na podstawie badań paleobotanicznych (summary). Kwart. Geol., 2 (1): 161—172.
- Stur D. 1873. Beiträge zur genaueren Deutung der Pflanzenreste aus dem Salzstocke von Wieliczka. Verh. Geol. Reichsanst., 1873 (1): 6—10.
- Szafer W. 1947. Flora plioceńska z Krościenka n/Dunajcem, II (The Pliocene flora of Krościenko in Poland). Rozpr. Wydz. Mat.-Przyr. PAU, Dz. B, 72 (2): 1—213.
- 1961. Miocene flora ze Starych Gliwic na Śląsku (summary: Miocene flora from Stare Gliwice in Upper Silesia). Prace Inst. Geol., 33: 1—205.
- 1963. What is *Carpolithes rosenkjaeri* Hartz? Acta Palaeobot., 4 (1): 3—35.
- Unger F. 1850. Die Pflanzenreste im Salzstocke von Wieliczka. Denkschr. Akad. Wiss. Wien, 1: 311—322.
- Zabłocka W. 1931. Über fossile Pilze aus dem tertiären Salzlager von Wieliczka. Bull. Intern. Acad. Pol. Sci. Lett., Cl. Math. Natur., Sér. B (1), 1931 (6,7): 181—185.
- Zabłocki J. 1928a. Tertiäre Flora des Salzlagers von Wieliczka I. Acta Soc. Bot. Pol., 5 (2): 174—208.
- 1928b. Exkursionsführer durch das Salzbergwerk in Wieliczka. Cinquième Excurs. Phyto-geogr. Intern. 1928—Guide des excursions en Pologne, 8: 1—12. Kraków.
- 1930a. Tertiäre Flora des Salzlagers von Wieliczka II. Acta Soc. Bot. Pol., 7 (2): 139—156.
- 1930b. Flora kopalna Wieliczki na tle ogólnych zagadnień paleobotaniki trzeciorzędu (summary: Die fossile Flora von Wieliczka und die allgemeinen Probleme der Paleobotanik des Tertiärs). Ibid., 7 (2): 215—240.

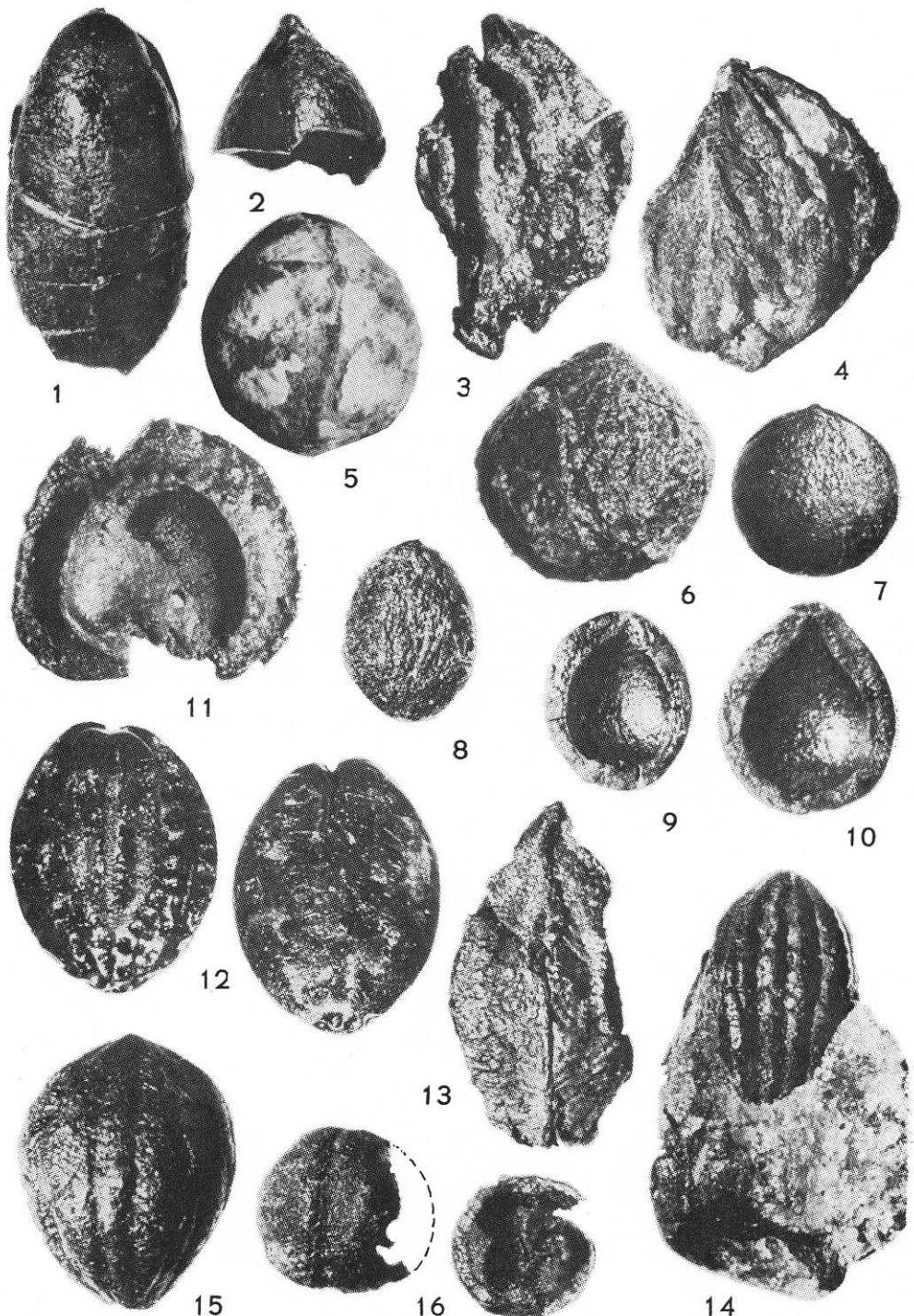
- 1959. Mioceńska flora Wieliczki. Referat wygłoszony na konferencji paleobotanicznej w Krakowie w dniu 19. III. 1959 \*\*\*.
- 1960. *Pinus króli*, nowy gatunek sosny trzeciorzędowej z pokładów soli kamiennej w Wieliczce (summary: *Pinus króli*, a new species of fossil pine from Tertiary salt deposits in Wieliczka). Stud. Soc. Sci. Torun., Sect. D, 4 (4): 1—6.
- 1966. In: Kolasa 1981. Gatunek *Pinus brevis* Ludw., oznaaczony w zbiorach Muzeum Żup Krakowskich Wieliczka.

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\*\*\* Proceedings of the palaeobotanical conference published by M. Kostyniuk (1959) do not include all taxons that were mentioned in the report given by J. Zabłocki.

Plate I

1. *Torreya miocenica* Kräusel, seed — MŽKW III/605/2/Pb,  $\times$  ca. 3
2. *Torreya miocenica* Kräusel, fragment of seed — IB PAN 37/51,  $\times$  3
- 3,4. *Trigonobalanus exacantha* Mai, fruits — MŽKW III /710/1—2/Pb,  $\times$  ca. 5
5. *Celtis lacunosa* (Reuss) Kirchh., fruit — IB PAN 37/37,  $\times$  7
6. *Myrica cf. suppanii* Kirchh., endocarp — MŽKW III/575/Pb,  $\times$  6
- 7—10. *Myrica ceriferiformis* Kownas, endocarps
  7. IB PAN 37/75,  $\times$  11
  - 8,9. MŽKW III/546/1—2/Pb,  $\times$  ca. 9, ca. 10
  10. IB PAN 37/75,  $\times$  12
11. *Sinomenium militzeri* Kirchh., endocarp — IB PAN 37/45,  $\times$  ca. 8
12. *Alangium dubium* (Unger) Mai, stone — IB PAN 37/34,  $\times$  4
13. *Stewartia beckerana* (Ludw.) Kirchh., fragment of fruit — IB PAN 37/49,  $\times$  4
14. *Nyssa disseminata* (Ludw.) Kirchh., stone in the piece of salt — MŽKW III/542/Pb,  $\times$  3
15. *Nyssa disseminata* (Ludw.) Kirchh., stone — IB PAN 37/46,  $\times$  ca. 6
16. *Hartziella miocenica* Szafer, fruit from two sides — IB PAN 37/35,  $\times$  12



## Plate II

- 1,2. *Tilia preplatyphyllos* Szafer, fruits — MŽKW III/713/1—2/Pb  
1,2a — fruits from lateral side,  $\times$  6  
2b — fruit from apical part,  $\times$  5  
3. cf. *Meliosma wetteraviensis* (Ludw.) Mai, endocarp and its reconstruction — IB PAN 37/72,  $\times$  6  
4,5. *Zanthoxylum ailanthiforme* (Gregor) Gregor, seeds — IB PAN 37/71,  $\times$  9  
6. *Toddalia naviculaeformis* (E. M. Reid) Gregor, seed — MŽKW III/709/1/ Pb,  $\times$  5,5  
7. *Toddalia naviculaeformis* (E. M. Reid) Gregor, seed from two sides — (specimen determined by H. J. Gregor) — IB PAN 37/70,  $\times$  5,5  
8. *Rehderodendron ehrenbergii* (Kirchh.) Mai, fruit — IB PAN 37/42,  $\times$  2,3  
9. *Mastixia amygdalaeformis* (Schloth.) Kirchh., stone — IB PAN 37/25,  $\times$  4  
10. *Mastixia amygdalaeformis* (Schloth.) Kirchh., stone from two sides — MŽKW III/522/Pb,  
 $\times$  3,4  
11. *Vitis parasyvestris* Kirchh., seed from two sides — MŽKW III/535/1/Pb,  $\times$  9

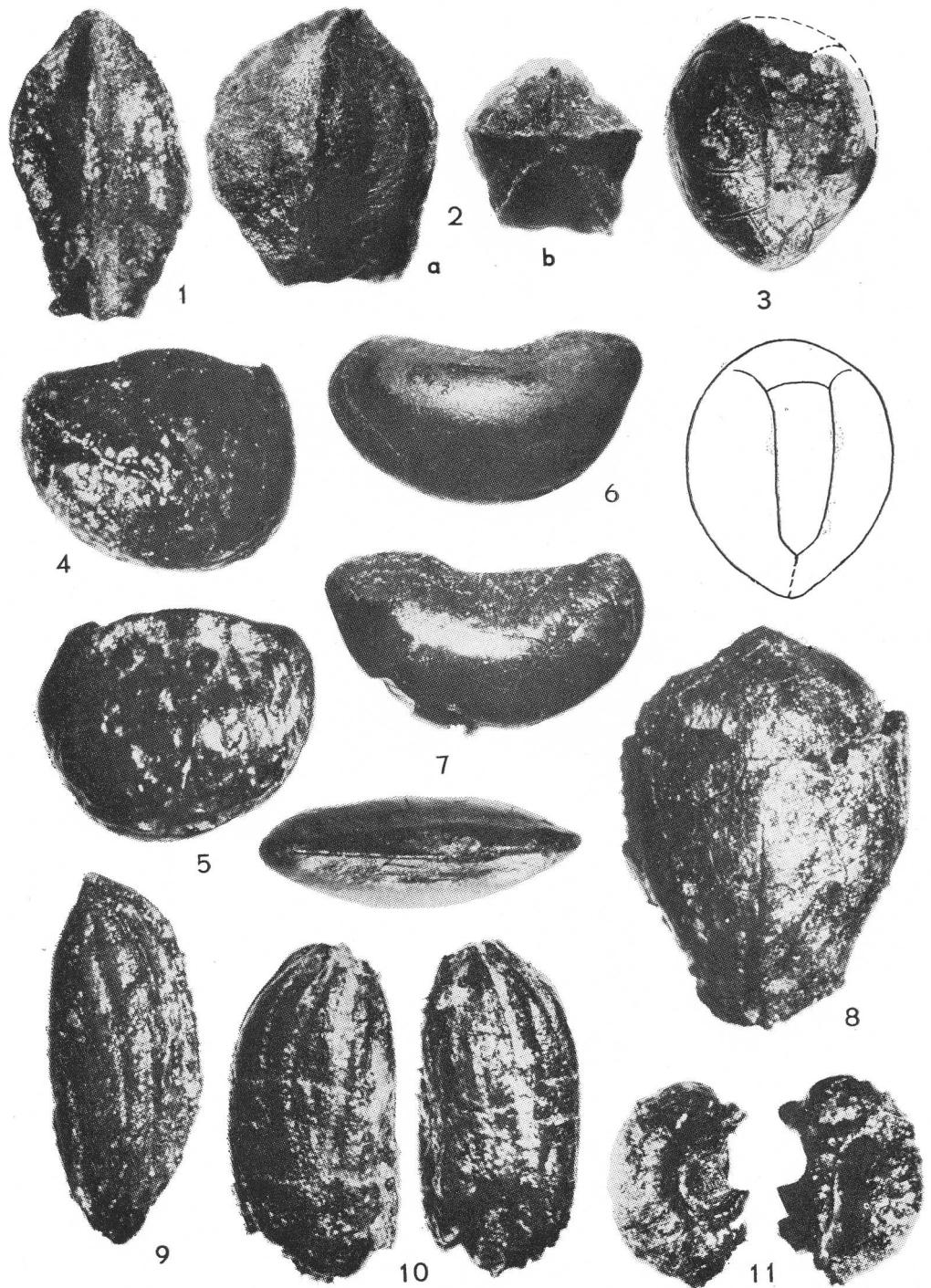


Plate III

1. *Ampelopsis ludwigii* (A. Br.) Dorof., seeds from two sides — IB PAN 37/47,  $\times$  ca. 9
2. *Vitis parasylvestris* Kirchh., seed — MŽKW III/535/2/Pb,  $\times$  8
- 3,4. *Symplocos lignitarum* (Quenst.) Kirchh., stones — MŽKW III/550/1-2/Pb,  $\times$  ca. 5
5. *Symplocos lignitarum* (Quenst.) Kirchh., stone — IB PAN 37/48,  $\times$  ca. 5
- 6,7. *Symplocos salzhausenensis* Kirchh., stones — IB PAN 37/48,  $\times$  5
8. *Symplocos poppeana* Kirchh., stone — MŽKW III/552/1/Pb,  $\times$  5
9. *Symplocos poppeana* Kirchh., stone — MŽKW III/551/Pb,  $\times$  5,5
10. *Symplocos* cf. *poppeana* Kirchh., stone — MŽKW III/552/2/Pb,  $\times$  5
11. *Staphylea* cf. *bessarabica* Negru, seed — IB PAN 37/52,  $\times$  9
12. *Turpinia ettingshausenii* (Engelh.) Mai, seed from three sides — IB PAN 37/80,  $\times$  5
13. *Sparganium* aff. *neglectum* Beeby foss., endocarp — IB PAN 37/73,  $\times$  10
- 14,15. *Cladium macrocarpum* Dorof., fruits — IB PAN 37/74,  $\times$  11

