

# THE MIDDLE-MIOCENE FLORA OF WIELICZKA REVISION OF JAN ZABŁOCKI'S COLLECTION\*

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**ABSTRACT.** The results of a study of macroscopic plant remains from the fossil flora of Wieliczka are presented on the basis of a revision of Prof. Jan Zabłocki's original materials housed in the Cracow Salt-Works Museum at Wieliczka. The other collections of plant remains extracted from rock salt and also leaf impressions from sandstones underlying the salt are discussed. The Wieliczka flora is of Middle Badenian age. The Arcto-Tertiary element predominates in it with only one third of the taxa being Palaeotropical. The floral assemblage of Wieliczka is characterized by a specifically differentiated mesophytic mixed forest of deciduous trees and shrubs and a rich evergreen shrub layer typical for mastixian floras. A taxon new to the Tertiary is *Juniperus succinifera* Zabłocki sp. nov. with seeds bearing resin nodules (resinocysts) on their surface.

**KEY WORDS:** fossil flora, carpology, leaves, revision, Middle Miocene, Wieliczka

## INTRODUCTION

Wieliczka (Fig. 1) is a small town, famous for its salt-mine with the fossil flora in the salt deposits. The first specification of the fossil flora from Wieliczka was published by M. Łańcucka-Środoniowa in 1984. It contained 136 plant taxa, only some of which had been included in earlier papers published by Zabłocki (1928a, b, 1930a, b, 1960) and Zabłocka (1931). The remaining data are from papers of other authors (Unger 1850, Stur 1873) or from oral communications, correspondence, inventories of the museum collections of the Department of Palaeobotany, W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków and, finally, from the lectures, dealing mainly with unpublished materials, delivered by Professor Jan Zabłocki in Kraków in 1959. Moreover, most of the revised determinations of individual taxa of the Wieliczka flora found in the available literature (i.e. Kirchheimer 1941, 1950, 1957, Mai 1964, 1971, 1975, 1981, 1986 and Gregor 1977) were also included. After the publication of the above-mentioned catalogue M. Łańcucka-Środoniowa was given access to Professor Jan Zabłocki's original materials.

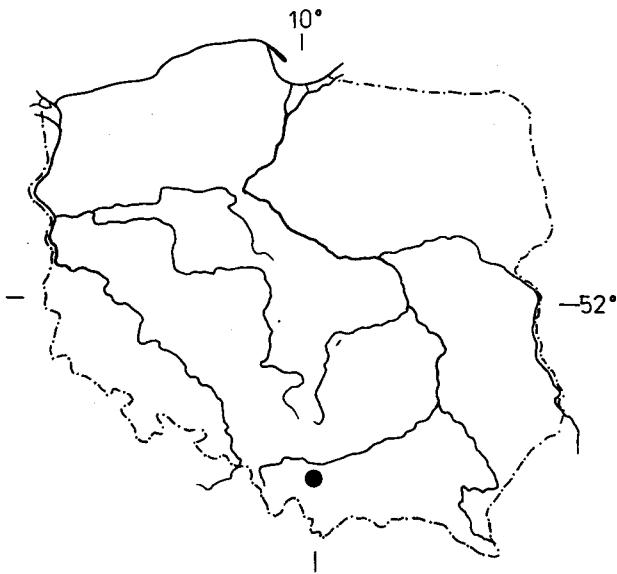


Fig. 1. Plan of the Wieliczka site

After his death these had been transferred by the authorities of the N. Copernicus University in Toruń to the Cracow Salt-Works Museum at Wieliczka in accordance with the wishes expressed in his will. The management of the Cracow Salt-Works Museum at Wieliczka made all the materials of the Wieliczka flora accessible to M. Łańcucka-Środoniowa for

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**Table 1.** Corrections and comments to the publication about fossil flora at Wieliczka by Łaniczka-Środoniowa (1984)

Name of taxon in the publication of MŁS 1984	No.	Result of the revision
<i>Torreya miocenica</i> Kräusel	7	<i>Cephalotaxus miocenica</i> (Kräusel) Gregor
<i>Pinus królii</i> Zabłocki	10	<i>Pinus salinarum</i> (Partsch) Zabłocki
<i>Pinus polonica</i> Stur	11	<i>Pinus hampeana</i> (Unger) Heer
<i>Pinus silvestris</i> L. <i>miocenica</i> Zabłocki	14	<i>Pinus hampeana</i> (Unger) Heer
<i>Chamaecyparis salinarum</i> Zabłocki	21	specimen missing
<i>Libocedrites salicornioides</i> (Unger) Endlicher	23	<i>Tetraclinis salicornioides</i> (Unger) Kvaček
<i>Tetraclinis brongniartii</i> (Endlicher) Kräusel	24	<i>Tetraclinis salicornioides</i> (Unger) Kvaček
<i>Castanea</i> sp.	31	genus does not occur, specimen missing
<i>Castanopsis salinarum</i> (Unger) Kirchh.	32	<i>Castanopsis salinaria</i> (Unger) Kirchh.
<i>Fagus ferruginea</i> Ait. var. <i>miocenica</i> Menzel	33	<i>Fagus decurrens</i> C. & E. M. Reid
<i>Fagus</i> sp.	35	specimen missing
<i>Trigonobalanus exacantha</i> Mai	38	<i>Trigonobalanopsis exacantha</i> (Mai) Kvaček & Walther
<i>Myrica</i> cf. <i>suppani</i> Kirchheimer	40	<i>Myrica suppani</i> Kirchheimer
<i>Engelhardtia salinarum</i> Zabłocki	45	<i>Palaeocarya salinaria</i> (Zabłocki) Zast.
<i>Pterocarya raciborskii</i> Zabłocki	51	<i>Cyclocarya cyclocarpa</i> (Schlechtendal) Iljinskaja
<i>Phytolacca</i> sp.	56	genus does not occur, incorrect determination
<i>Corylopsis</i> sp.	57	genus does not occur, incorrect determination
<i>Hamamelis europaea</i> Zabłocki	58	specimen missing
<i>Liriodendron</i> sp.	61	genus does not occur, incorrect determination
<i>Annonaespermum</i> sp.	64	cf. <i>Annonaespermum</i> sp., needs elaboration
<i>Cinnamomum</i> sp.	65	<i>Daphnogene</i> sp.
<i>Menispermum</i> sp.	67	genus does not occur, incorrect determination
<i>Brasenia</i> sp. div.	69	cf. <i>Brasenia</i> sp.
<i>Ceratophyllum</i> sp.	70	genus does not occur, incorrect determination
<i>Aldrovanda</i> sp.	71	genus does not occur, incorrect determination
<i>Actinidia</i> sp.	72	genus does not occur, incorrect determination
<i>Campylospermum</i> sp.	73	determination doubtful
<i>Gordonia</i> sp.	75	determination doubtful
<i>Stewartia beckerana</i> (Ludwig) Kirchheimer	76	incorrect determination, genus does not occur in J. Zabłocki's materials
<i>Amelanchier</i> sp.	77	determination doubtful
<i>Ceratonia</i> sp.	80	genus does not occur, specimen missing
<i>Robinia</i> sp.	81	genus does not occur, specimen missing
<i>Myrtus</i> sp.	84	Myrtaceae gen. div.
<i>Sterculia</i> sp.	87	determination doubtful
<i>Phellodendron</i> sp.	88	<i>Phellodendron elegans</i> C. & E. M. Reid
<i>Pistacia</i> sp.	93	genus does not occur, specimen missing
<i>Schinus</i> sp.	94	determination doubtful
<i>Sapindoidea</i> sp. div.	95	<i>Koelreuteria margaritifera</i> (Ludwig) Mai
<i>Acer</i> sp.	96	<i>Acer</i> sp. div.
<i>Coriaria</i> sp. div.	98	<i>Coriaria</i> cf. <i>collinsonae</i> Gregor
<i>Meliosma</i> cf. <i>wetteraviensis</i> (Ludwig) Mai	99	<i>Meliosma wetteraviensis</i> (Ludwig) Mai
<i>Ceanothus</i> sp.	103	genus does not occur, determination incorrect
<i>Ampelopsis ludwigii</i> (A. Br.) Dorofeev	106	<i>Ampelopsis malvaeformis</i> (Schlotheim) Mai
<i>Tetrastigma</i> sp.	107	genus does not occur, determination incorrect
<i>Vitis teutonica</i> A. Br.	109	<i>Vitis</i> cf. <i>teutonica</i> A. Br.
<i>Aralia</i> sp.	110	<i>Aralia</i> sp. div.
<i>Cornus salinarum</i> Zabłocki	111	specimen missing
<i>Mastixia amygdalaeformis</i> (Schlotheim) Kirchheimer	113	<i>Mastixia lusatica</i> Mai
<i>Andromeda</i> sp.	115	cf. <i>Andromeda</i> sp.
cf. <i>Arctostaphyloides</i>	116	<i>Arctostaphyloides menzelii</i> Kirchheimer
<i>Corema</i> sp.	117	determination doubtful

**Table 1.** Continued

Name of taxon in the publication of MŁS 1984	No.	Result of the revision
<i>Diospyros salinaria</i> Zabłocki	118	specimen missing
<i>Symplocos salzhausenensis</i> Kirchheimer	124	<i>Symplocos salzhausenensis</i> Kirchheimer
<i>Nerium</i> sp.	125	genus does not occur, specimen missing
<i>Fraxinus</i> sp.	126	genus does not occur, specimen missing
<i>Limnocarpus</i> sp.	130	<i>Eulimnocarpus major</i> (Szafer) Collinson
<i>Potamogeton</i> sp.	131	<i>Potamogeton</i> sp. div.
<i>Carex</i> sp.	132	<i>Carex</i> sp. div.
<i>Cladium macrocarpum</i> Dorofeev	134	<i>Cladium oligovasculare</i> Mai
<i>Stewartia beckerana</i> (Ludwig) Kirchheimer	Pl. 1/13	<i>Tilia preplatyphyllos</i> Szafer
<i>Rehderodendron ehrenbergii</i> (Kirchheimer) Mai	Pl. 2/8	Indeterminata

inspection, making it possible to verify the taxonomic composition of the flora. The results of these studies constitute the main content of the present paper, but also discussed are materials left in the Museum of Natural History of the N. Copernicus University of Toruń, and others also materials belonging to the W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków, the Institute of Botany, Jagiellonian University, the Institute of Geology, Polish Academy of Sciences in Kraków and the Naturhistorishes Museum in Vienna.

M. Łaniccka-Środoniowa is the author of the revision of the carpological flora of Wieliczka presented in this publication in the second chapter (Jan Zabłocki's collection). She is also responsible for the result of the revision (p. 27–29) and the tabulated lists (Tab. 1 and 7 with additions by E. Zastawniak, and Tab. 2–6). Moreover, she is the author of the drawings of fossil fruits and seeds (Figs 2–8) and she selected the illustrative material of the carpological flora for the photographic plates.

Professor Maria Łaniccka-Środoniowa died on March 21, 1995. After her death the text was augmented with additional complementary chapters and as whole prepared for publication.

The documentation of the study is included in the working record of M. Łaniccka-Środoniowa (Archives of the Department of Palaeobotany, W. Szafer Institute of Botany, PASc, in Kraków). A copy of J. Zabłocki's card index, complemented by M. Łaniccka-Środoniowa, is stored in the same archive. J. Zabłocki's original card index is in the Cracow Salt-Works Museum at Wieliczka.

Abbreviations: p.p. = pro parte; "JZ" and "MŁS", followed by numbers, in the latter case

in parentheses indicate storage tubes bearing numbers allocated by J. Zabłocki and M. Łaniccka-Środoniowa respectively; MŻKW – Cracow Salt-Works Museum at Wieliczka, KRAM-P – Palaeobotanical Museum, W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków, MKUT – Museum of Natural History of the N. Copernicus University, Toruń, MGPAN – Geological Museum of the Institute of Geological Sciences, Polish Academy of Sciences in Kraków

## JAN ZABŁOCKI'S COLLECTION

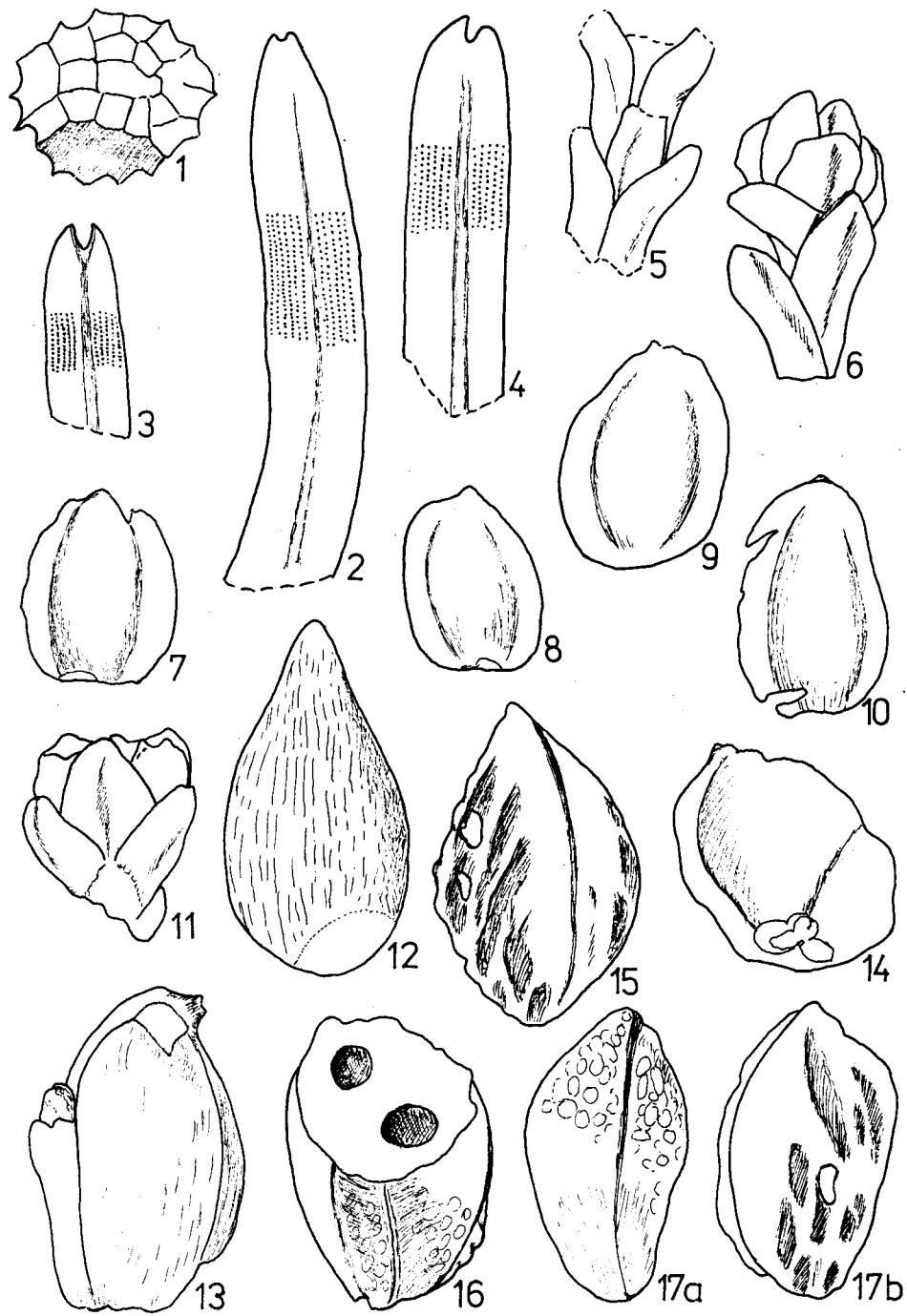
The materials collected and described by J. Zabłocki comprise a set of fossil remains (829 items) and a card index of taxa (320 cards). The plant remains are kept in narrow glass tubes, some of which (489 storage tubes, see item "a" below) had been internally numbered by J. Zabłocki. The remaining 353 storage tubes (see item "b") were not numbered. The larger specimens were stored in thick glass tubes, plastic boxes or china bowls. All the storage tubes were placed in flat boxes.

a) The numbered storage tubes contain 3 slips with serial number, data concerning the site and name of the taxon. The tube number corresponds to that of the taxon card in J. Zabłocki's card index.

Thirteen of the 489 numbered storage tubes bear double numbers. In some cases the name of the taxon given in the tube differs from that in the card index (11 items) or the taxon name is missing in the tube but appears on the card with the proper card index number (102 tubes). We failed to find storage tubes Nos 4, 82 and 97.

b) Materials not numbered by J. Zabłocki. Some of the unnumbered tubes (109) bore taxon names determined by him and served as the basis for introducing these names into the

card index. The fossils in the other unnamed storage tubes (116) were identified by M. Łancka-Środoniowa and also introduced into the card index.

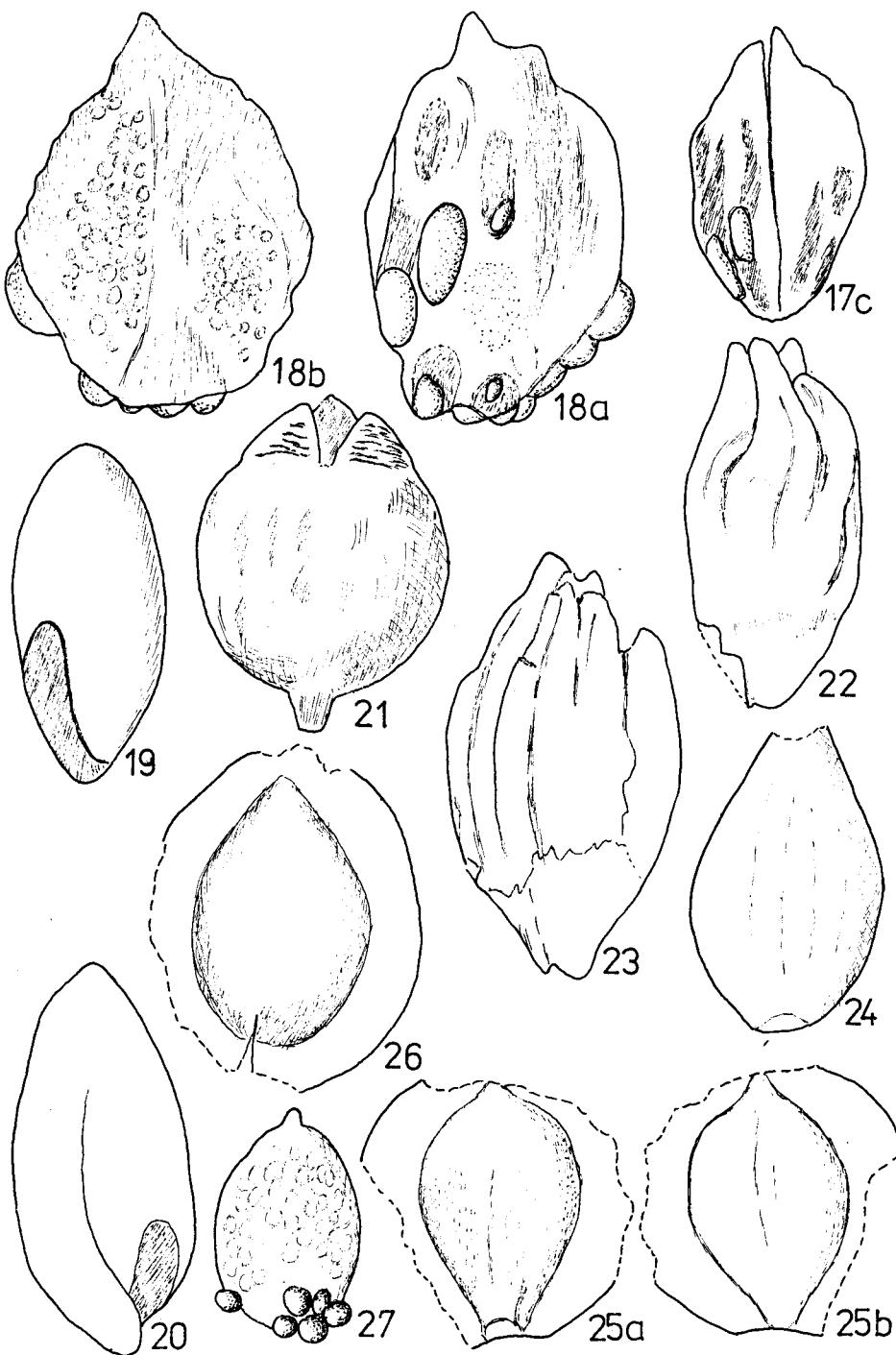


**Fig. 2.** 1 – *Selaginella saxonica* Mai, megasporangium,  $\times 16$ , JZ 127, MŻKW/ III/978/34/Pb; 2 – *Abies alba* Mill. type, fragment of needle,  $\times 7$ , JZ –, MŁS (656), MŻKW/III/774/8/Pb; 3, 4 – *Abies* sp. (taxon related to an East-Asiatic species of *Abies*), fragment of needle,  $\times 7$ , JZ –, MŁS (656), MŻKW/ III/774/8/Pb; 5 – *Glyptostrobus europaea* (Brongniart) Unger, shoot fragment,  $\times 7$ , JZ –, MŁS (655), MŻKW/III/775/1/Pb; 6 – *Glyptostrobus europaea* (Brongniart) Unger, shoot fragment,  $\times 12$ , JZ –, MŁS (559), MŻKW/III/774/8/Pb; 7–10 – cf. *Cupressus* sp., seeds,  $\times 8$ , JZ –, MŁS (657), MŻKW/ III/774/8/Pb; 11 – *Thuja* sp., fragment of leafy shoot,  $\times 20$ , JZ –, MŁS (633), MŻKW/III/917/1/Pb; 12 – *Thuja* sp., seed,  $\times 10$ , JZ –, MŁS (634), MŻKW/III/916/1/Pb; 13 – *Thuja* sp., fragment of cone with two cone scales,  $\times 7$ , JZ –, MŁS (633), MŻKW/III/917/1/Pb; 14 – *Juniperus succinifera* Zabłocki sp. nov., fruit damaged in the upper part,  $\times 6.5$ , JZ 421, MŻKW/III/816/10/Pb; 15 – *Juniperus succinifera* Zabłocki sp. nov., seed with pits and amber concretions (resinocysts),  $\times ca 8$ , JZ 426, MŻKW/ III/815/25/Pb; 16 – *Juniperus succinifera* Zabłocki sp. nov., two locules visible in the cross-section of the seed,  $\times 8$ , JZ 439, MŻKW/ III/815/25/Pb; 17 – *Juniperus succinifera* Zabłocki sp. nov.,  $\times ca 8$ , JZ 436, MŻKW/III/816/10/Pb; a – interior view of seed showing papillae; b – exterior view of the same side showing locules and one amber concretion

All materials not numbered by J. Zabłocki received numbers in accordance with their position in the working record of M. Łaćucka-

Środoniowa. These numbers appear in brackets.

Slips with catalogue numbers of the Cracow



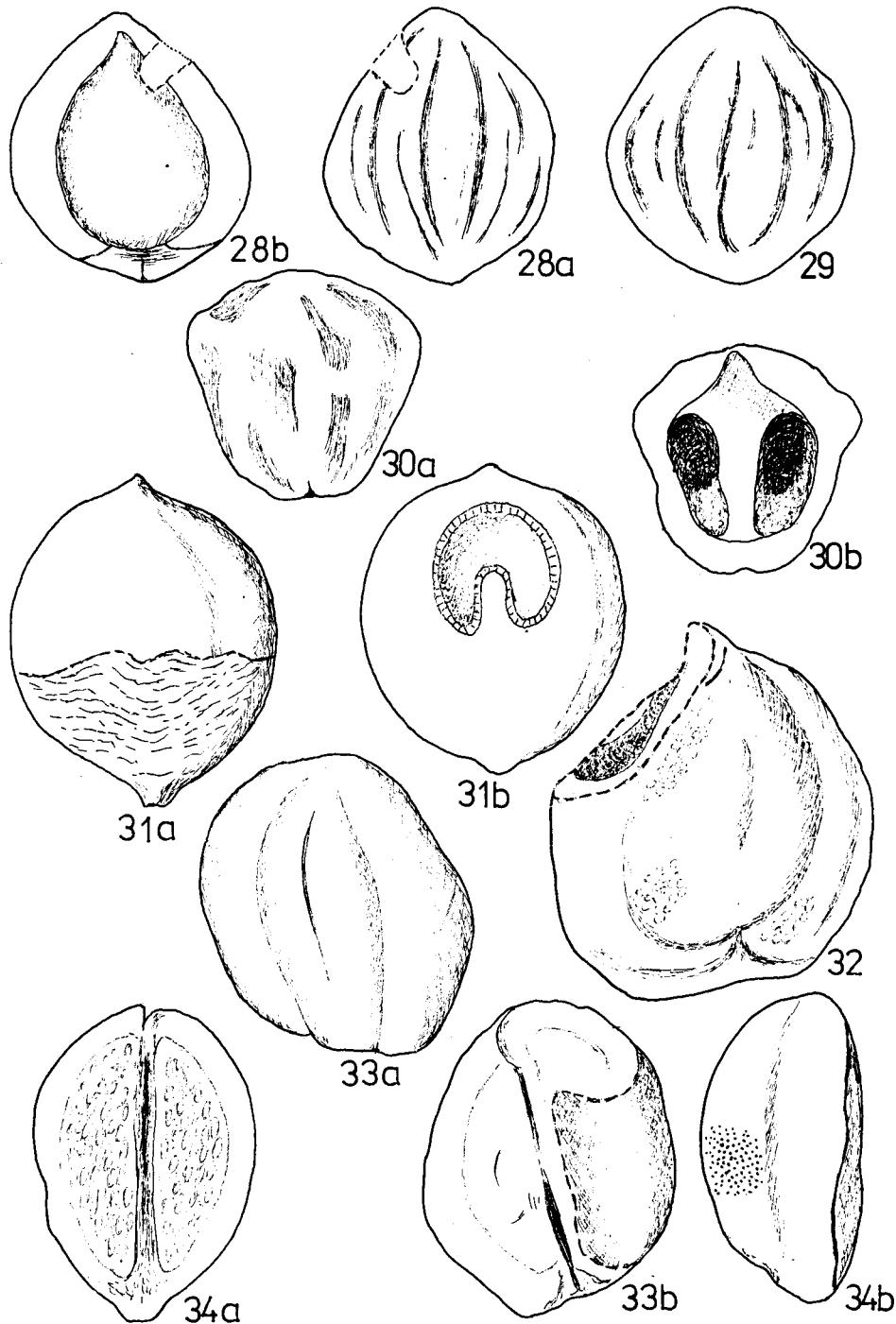
**Fig. 3. 17c –** *Juniperus succinifera* Zabłocki sp. nov.,  $\times$  ca 8, JZ 436, MŻKW/III/816/10/Pb – another exterior view of the same side as on 17a showing two amber concretions; **18 –** *Juniperus succinifera* Zabłocki sp. nov., holotype with the original label of J. Zabłocki,  $\times$  8, JZ 423, MŻKW/III/816/10/Pb; **a** – exterior view of seed showing amber concretions in the deep locules; **b** – interior view of the same side showing papillae; **19 –** Hamamelidaceae seed,  $\times$  7, JZ 270, MŻKW/III/783/3/Pb; **20 –** Hamamelidaceae, seed,  $\times$  7, JZ 269, MŻKW/III/810/3/Pb; **21 –** Hamamelidaceae, seed,  $\times$  ca 6.5, JZ 7, MŻKW/III/810/3/Pb; **22 –** *Trigonobalanopsis exacantha* (Mai) Kvaček & Walther, cupule,  $\times$  4.5, JZ 50, MŻKW/III/978/14/Pb; **23 –** *Trigonobalanopsis exacantha* (Mai) Kvaček & Walther, cupule,  $\times$  4.5, JZ 50, MŻKW/III/978/14/Pb; **24 –** *Ostrya* sp., nut,  $\times$  10, JZ –, MŁŚ (682), MŻKW/III/848/1/Pb; **25a, b –** Betulaceae, nut from both sides with part of wing,  $\times$  ca 10, JZ –, MŁŚ (567), MŻKW/III/978/166/Pb; **26 –** *Myrica suppani* Kirchheimer, half of fruit,  $\times$  10, JZ –, MŁŚ (625), MŻKW/III/978/226/Pb; **27 –** *Myrica ceriferiformis* Kownas, exterior view of fruit with papillae,  $\times$  13, JZ –, MŁŚ (615), MŻKW/III/978/216/Pb

Salt-Works Museum are provided in all the storage tubes ("a" and "b").

c) J. Zabłocki's card index consists of 320 taxon cards. Quite often the name given on the index card disagrees with that in the storage

tube. This is particularly true of the tubes with remains belonging to the genera *Sambucus*, *Ostrya*, *Styrax* and *Zelkova*.

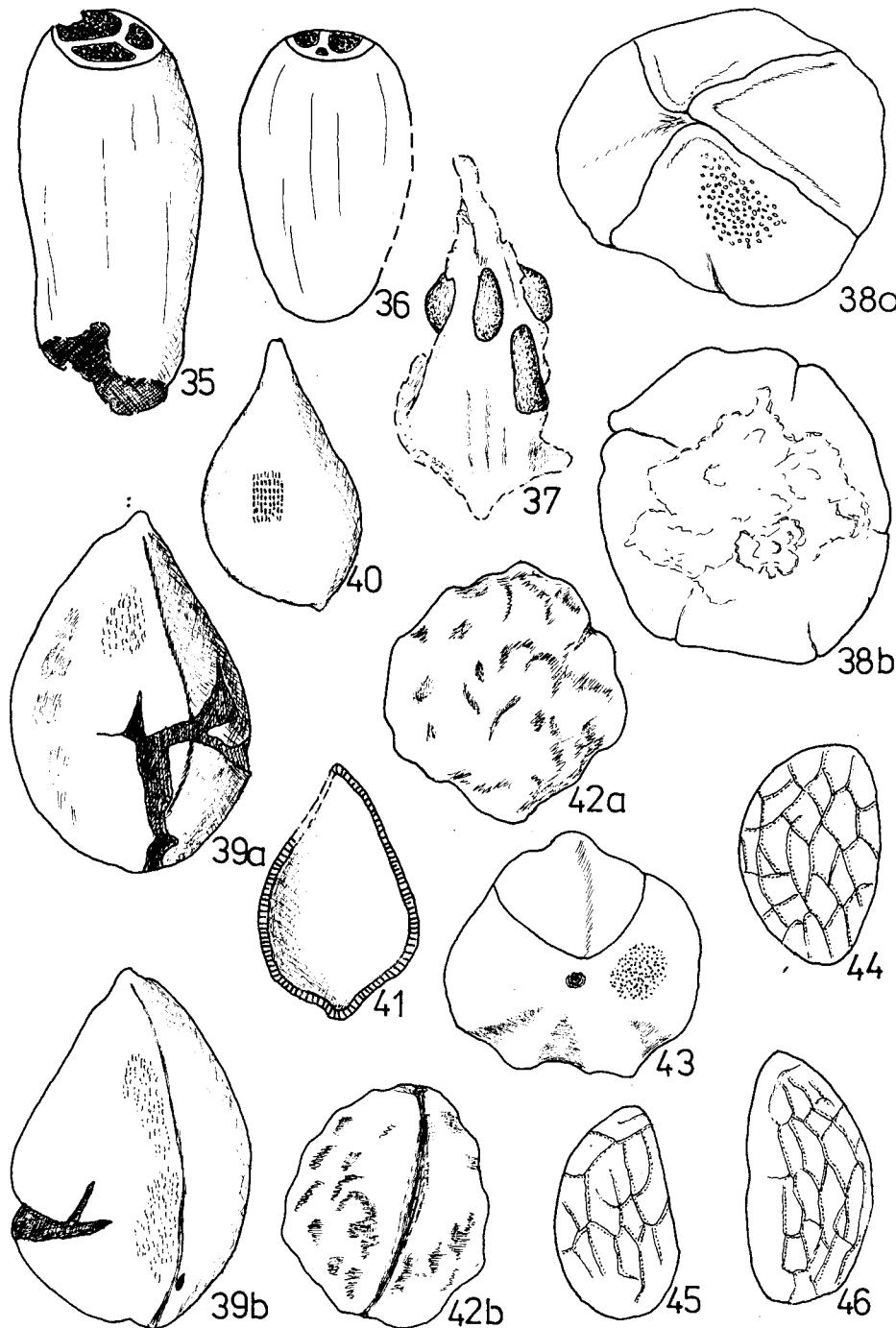
Some cards are annotated with the most important titles of literature concerning the



**Fig. 4.** 28 – *Comptonia* cf. *aldanensis* Dorofeev, × 12, JZ 380, MŽKW/ III/978/103/Pb; **a** – fruit (exterior view); **b** – the same fruit (interior view); 29 – *Comptonia* cf. *aldanensis* Dorofeev, fruit, × 12, JZ 380, MŽKW/III/978/103/Pb; 30 – *Cyclocarya cyclocarpa* (Schlechtendal) Iljinskaja, × ca 8, JZ –, MŁS (582), MŽKW/III/978/183/Pb; **a** – nut (exterior view); **b** – nut (interior view); 31 – *Eurya* sp., × 10, JZ –, MŁS (404), MŽKW/III/978/106/Pb; **a** – fruit (exterior view); **b** – another exterior view of the same fruit showing a half of the unusually large seed. The seed is also visible from within occupying the large reniform chamber; 32 – *Eurya* sp., fruit damaged in the upper part, × 10, JZ –, MŁS (404), MŽKW/III/978/106/Pb; 33 – *Arctostaphyloides menzelii* Kirchheimer, × 12, JZ 410, MŽKW/ III/925/9/Pb; **a** – half of fruit (exterior view); **b** – half of fruit (interior view); 34 – *Arctostaphyloides menzelii* Kirchheimer, × 12, JZ 160, MŽKW/ III/978/255/Pb; **a** – half of fruit (interior view) showing two seed chambers with characteristic wall structure; **b** – exterior view of the same fruit showing the isodiametric cells on the surface

given taxon (59 cards), J. Zabłocki's remarks on the taxa (21 cards) and sometimes rather detailed descriptions (*Juniperus succinifera* sp. nov., *Liquidambar*, *Phellodendron*, *Thymelocarpus gengnoideum* gen. nov. et sp. nov., *Tradescantia* and *Zanthoxylum*).

Some of the plant taxa given in the card index and, more importantly, both published taxa and those preliminarily distinguished by J. Zabłocki, were not discovered in his collection. This applies to, among others, the types of the species *Chamaecyparis salinarum*, *Cor-*

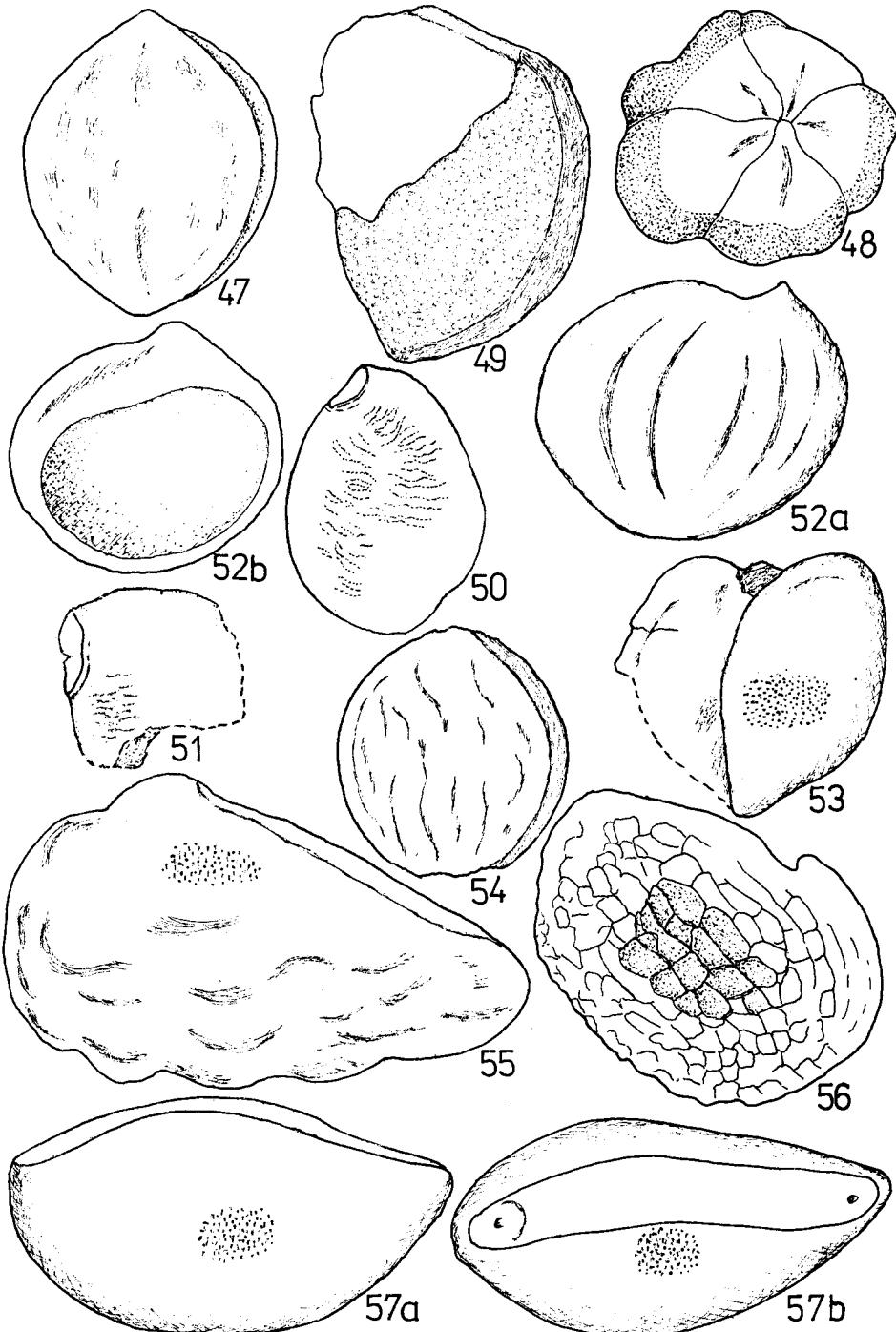


**Fig. 5.35** – *Symplocos minutula* (Sternberg) Kirchheimer, fruit-stone, × 5, JZ 339, MŻKW/III/904/10/Pb; **36** – *Symplocos minutula* (Sternberg) Kirchheimer, fruit-stone, × 5, JZ 342, MŻKW/III/904/10/Pb; **37** – *Tilia* sp., fragment of fruit tissue with four abortive seeds, × ca 10, JZ –, MŁŚ (506), MŻKW/III/806/1/Pb; **38** – cf. *Andromeda* sp., × 17, JZ 21, MŻKW/III/744/1/Pb; **a** – fruit from the apical side; **b** – fruit from the basal side with remains of calyx; **39a, b** – cf. *Morus* sp., endocarp from both sides, × 8, JZ 125, MŻKW/III/841/2/Pb; **40** – *Daphne* sp. vel *Thymelea* sp., half of seed (exterior view), × ca 12, JZ 267, MŻKW/III/790/1/Pb; **41** – *Daphne* sp. vel *Thymelea* sp., half of seed (interior view), × 10, JZ 266, MŻKW/III/978/62/Pb; **42a, b** – *Trema lusatica* Mai, fruit from two sides, showing raphe, × 12, JZ 273, MŻKW/III/871/3/Pb; **43** – *Harziella miocenica* Szafer, fruit from apical side with sprout valve, × 20, JZ 21, MŻKW/III/744/1/Pb; **44–46** – *Rubus microspermus* C. & E. M. Reid, endocarps, × 18, × 20, × 18, JZ 393, MŻKW/III/876/3/Pb

*nus salinarum*, *Diospyros salinaria*, *Hamamelis europaea* and *Pterostyrax europaea* (Zabłocki 1930a). The new combination *Fortunearia sinensis* (Zabłocki) Gregor created by Gregor (1977) on the basis of the missing holo-

type of *Hamamelis europaea* Zabłocki from Wieliczka (Zabłocki 1930a, Pl. 12, fig. 13) must be regarded as not valid.

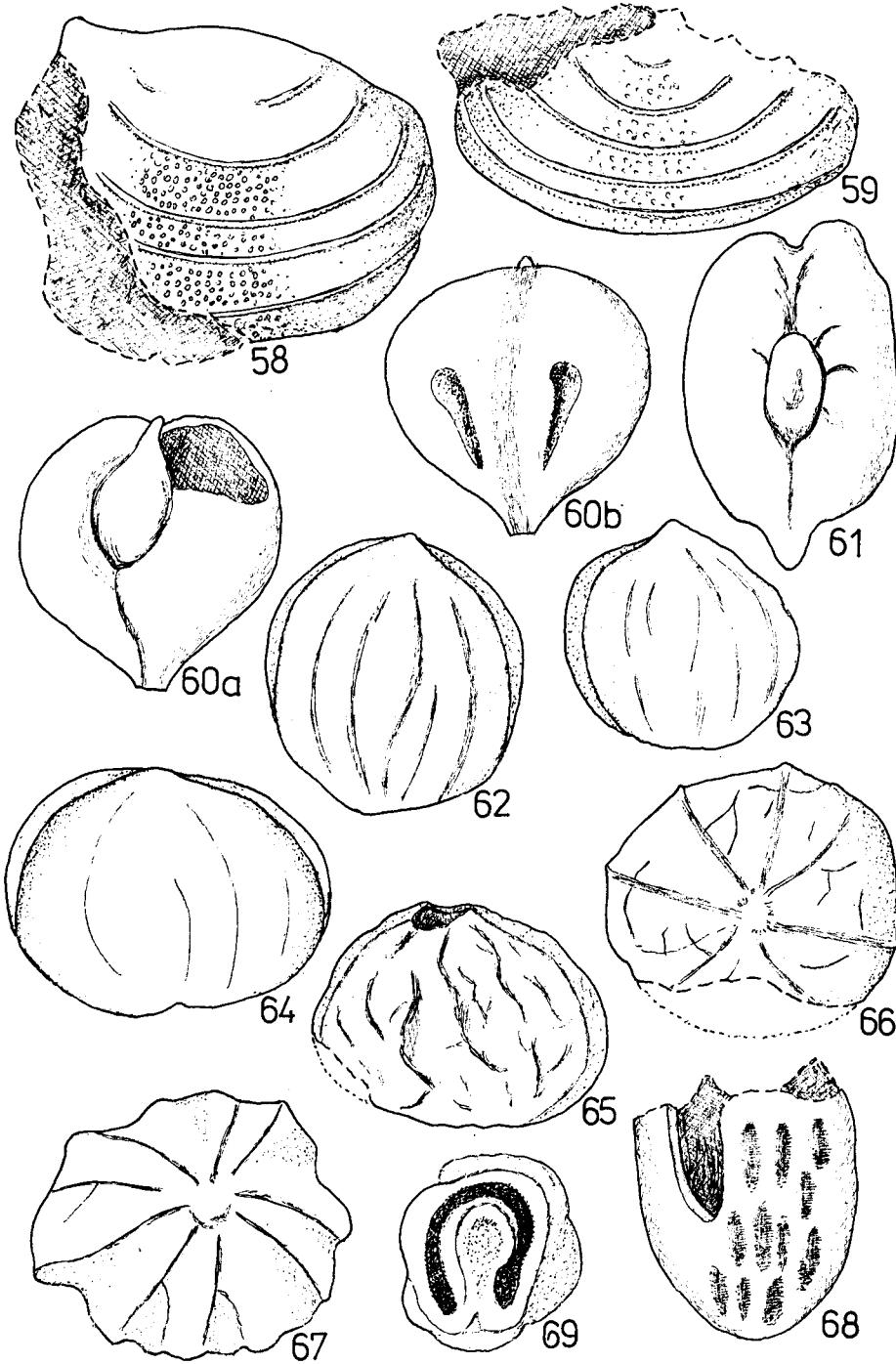
The other species described by Zabłocki were included in the list (Tab. 7). It should be added



**Fig. 6.** 47 – *Prunus aff. spinosa* L., fruit-stone,  $\times 6.5$ , JZ 153, MŽKW/ III/867/6/Pb; 48 – *Pyracantha acuticarpa* (C. & E. M. Reid) Szafer, fruit from apical side,  $\times 10$ , JZ 224, MŽKW/III/978/366/Pb; 49 – *Pyracantha acuticarpa* (C. & E. M. Reid) Szafer, simple endocarp with lustrous apical part and mat basal one,  $\times 14$ , JZ 227, MŽKW/III/978/366/Pb; 50 – *Staphylea microsperma* Negru, seed,  $\times 12$ , JZ 298, MŽKW/ III/881/2/Pb; 51 – *Staphylea microsperma* Negru, upper part of seed, JZ –, MŁS (487), MŽKW/III/978/133/Pb; 52 – *Meliosma miessleri* Mai,  $\times 6$ , JZ 171, MŽKW/III/888/1/Pb; a – half of endocarp (exterior view); b – the same (interior view); 53 – *Meliosma wetteraviensis* (Ludwig) Mai, endocarp,  $\times 7$ , JZ 1, MŽKW/III/836/1/Pb; 54 – *Padus cf. mediocra* Negru, seed (lateral view),  $\times 8.5$ , JZ 154, MŽKW/III/813/1/Pb; 55 – *Zanthoxylum giganteum* (Gregor) Gregor, seed (lateral view),  $\times 12$ , JZ 188, MŽKW/III/930/1/Pb; 56 – *Zanthoxylum cf. kristinae* (Holý) Gregor, seed (lateral view),  $\times 12$ , JZ 186, MŽKW/III/800/1/Pb; a – seed (lateral view); b – seed (apical view)

that the specimens belonging to the species described by Zabłocki (1928a, 1930a), viz. *Carpinus polonica*, *Carya rugosa*, *Engelhardia salinaria* (= *Palaeocarya salinaria* Zast.), *Juglans szaferi*, *Juglans wandae* and *Olea oleastroides*

occur in the collection of the Cracow Salt-Works Museum at Wieliczka. The lectotyp of *Aesculus roupperti* Zabłocki is stored in the Museum of the W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków.

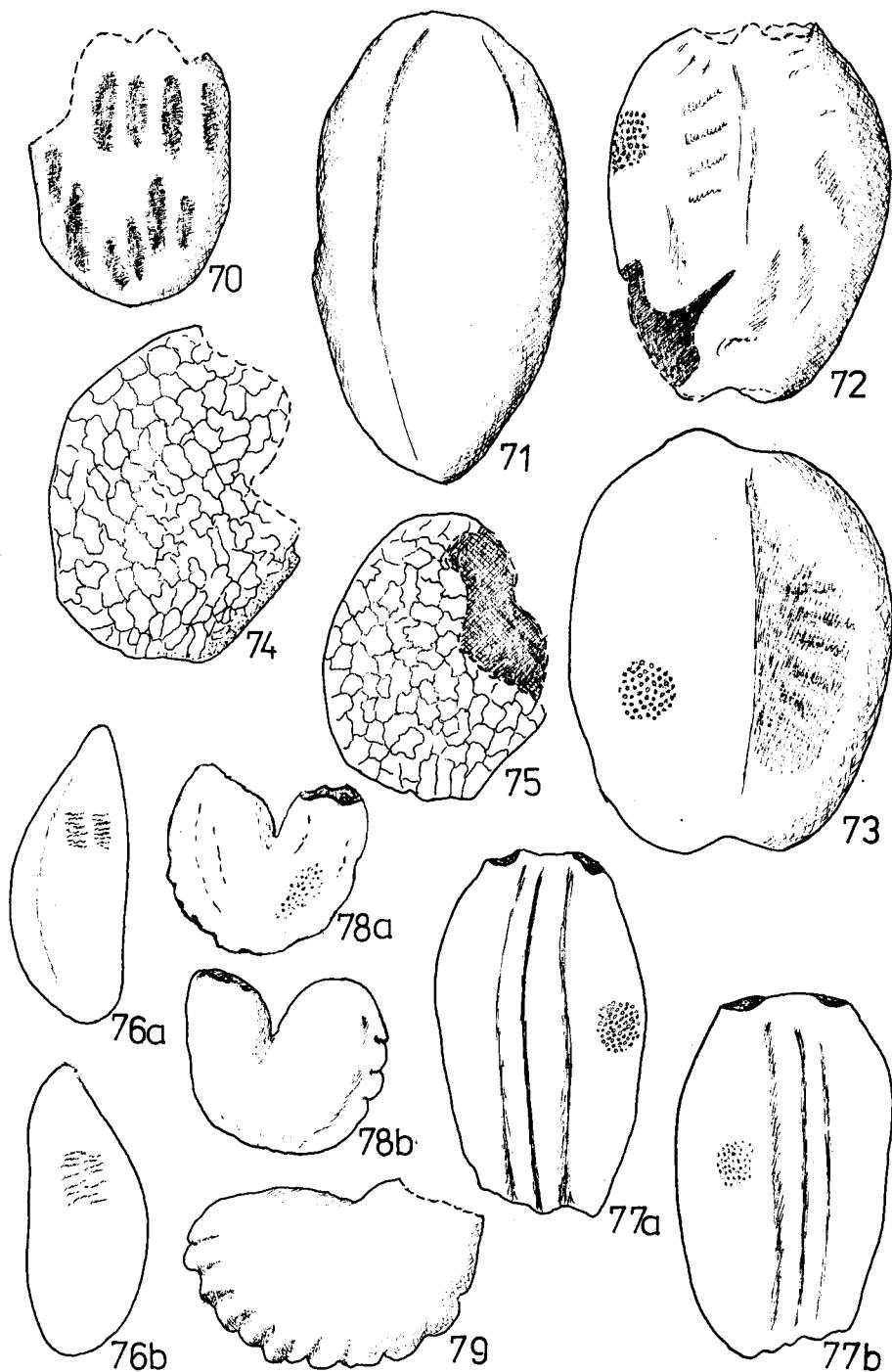


**Fig. 7.** 58 – *Coriaria cf. collinsonae* Gregor, part of seed,  $\times 10$ , JZ –, MŁS (801), MŻKW/III/978/353/Pb; 59 – *Coriaria cf. collinsonae* Gregor, part of seed,  $\times 15$ , JZ –, MŁS (801), MŻKW/III/978/353/Pb; 60 – *Ampelopsis rotundatoides* Dorof.,  $\times 12$ , JZ 416, MŻKW/ III/928/1/Pb; a – seed (dorsal view); b – seed (venral view); 61 – *Vitis cf. lusatica* Czeczott & Skirgielło, seed (dorsal view),  $\times 8$ , JZ 413, MŻKW/III/927/5/Pb; 62 – *Swida bessarabica* Negru, fruit-stone,  $\times 12$ , JZ 379, MŻKW/ III/779/10/Pb; 63 – *Swida bessarabica* Negru, fruit-stone,  $\times 12$ , JZ 370, MŻKW/ III/779/10/Pb; 64 – *Swida cf. bugloviana* Negru, fruit-stone,  $\times 12$ , JZ 379, MŻKW/ III/779/10/Pb; 65 – *Swida roshkii* Negru, fruit-stone,  $\times 12$ , JZ 369, MŻKW/ III/978/99/Pb; 66 – *Swida roshkii* Negru, apical part of fruit-stone,  $\times 12$ , JZ 368, MŻKW/978/98/Pb; 67 – *Swida roshkii* Negru, apical part of fruit-stone,  $\times 12$ , JZ –, MŁS (574), MŻKW/III/978/175/Pb; 68 – *Eomastixia saxonica* (Menzel) Holý, part of fruit-stone,  $\times 1.2$ , JZ –, MŁS (816), MŻKW/III/835/1/Pb; 69 – *Eomastixia saxonica* (Menzel) Holý, cross-section of fruit-stone with hippocrepian loculus,  $\times 1.6$ , JZ –, MŁS (816), MŻKW/III/835/1/Pb

J. Zabłocki gathered fossil remains for many years and fixed them with paraffin (Zabłocki 1928a). Generally, they are little deformed but have often crumbled and, as a result, are hard to verify. Some storage tubes contained several pieces of the remains of vari-

ous taxa. Not all of them were in a state allowing identification.

It was impossible to determine the total number of specimens in some groups of plants, because many of them had crumbled. It can, however, be stated that the following genera



**Fig. 8.** 70 – *Eomastixia saxonica* (Menzel) Holý, fruit-stone,  $\times 1.2$ , JZ –, MŁŚ (790), MŁKW/III/786/3/Pb; 71 – *Cornus* aff. *mas* L., stone,  $\times 1.2$ , JZ 373, MŁKW/III/779/10/Pb; 72 – *Viburnum* sect. *Lantana* Spach, endocarp,  $\times 9$ , JZ 14, MŁKW/III/946/3/Pb; 73 – *Viburnum* sect. *Lantana* Spach, endocarp,  $\times 6.5$ , JZ 16, MŁKW/III/946/3/Pb; 74 – Solanaceae, seed,  $\times 25$ , JZ 22, MŁKW/III/736/2/Pb; 75 – Solanaceae seed partly damaged,  $\times 25$ , JZ 22, MŁKW/III/736/2/Pb; 76a, b – Araliaceae, endocarp from both sides,  $\times 10$ , JZ 126, MŁKW/III/841/1/Pb; 77a, b – *Sparganium* aff. *neglectum* Beeby fossilis Mai, endocarp from both sides,  $\times 12$ , JZ 30, MŁKW/III/978/4/Pb; 78a, b – *Urospathites cristatus* (Nikitin) Gregor & Bogner, seed from both sides,  $\times 10$ , JZ 122, MŁKW/III/798/1/Pb; 79 – *Urospathites cristatus* (Nikitin) Gregor & Bogner, seed,  $\times 12$ , JZ 99, MŁKW/III/978/26/Pb

**Table 2.** New taxa distinguished in the fossil flora at Wieliczka by J. Zabłocki (unpublished materials)

Abbreviations: s – seed, c – cone, strobile fr – fruit, r – root, sc – sclerotium, d – different remains, indet. – indeterminata

Name of taxa	Remains	Number of specimens	J. Zabłocki's determination
cf. <i>Chenopodium</i> sp.	s	2	<i>Chenopodium, Celosia</i>
cf. <i>Cupressus</i> sp.	c, s	7	<i>Cupressus, Sequoia?, Cupressus?</i>
cf. <i>Daphne</i> sp.	s	3	<i>Daphne? Daphne minima</i> sp. nov.
cf. <i>Decodon</i> sp.	fr, s	10	<i>Decodon?,</i>
cf. <i>Urospathites cristatus</i> (Nikitin) Gregor & Bogner	s	2	indet., <i>Epipremnum cristatum</i> Nikitin
Fungi gen. div.	d	?	Fungi gen. div.
<i>Juniperus succinifera</i> Zabłocki sp. nov.	c, s	39	<i>Juniperus succinifera</i> sp. nov.
Mycorrhiza	r	1	mykorhiza
<i>Cenococcum graniforme</i> (Sow.) Ferd. & Winge	sc	many	sclerotium
cf. <i>Morus</i> sp.	s	1	<i>Morus</i>
Myrtaceae gen. div.	fr	11	Myrtaceae
<i>Rubus</i> sp.	fr	12	<i>Rubus</i>
<i>Ruppia maritima</i> L. <i>miocenica</i> Szafer	fr	38	<i>R. major, Potamogeton, Ruppia, R. marit. miocenica</i>
<i>Koelreuteria margaritifera</i> (Ludwig) Mai	fr	2	<i>Sapindoidea margaritifera</i> Kirchh.
<i>Sparganium camenzianum</i> Kirchheimer	fr	2	<i>Sparganium camenzianum</i> Kirchheimer

are particularly abundant in the Wieliczka flora: *Acer*, *Aralia*, *Carpinus*, *Cladium*, *Eurya*, *Fagus*, *Hartziella*, *Juniperus*, *Eulimnacarpus*, *Pinus*, *Quercus*, *Ruppia*, *Symplocos*, *Swida*, *Tetraclinis*, *Toddalia*, *Vitis* and *Zanthoxylum*. Additionally the families Lauraceae and Myrtaceae as well as Cornaceae, Ericaceae, Hamamelidaceae and Theaceae are well represented. Buds of trees and shrubs, zoocecidia, fungal sclerotia, etc are numerous.

All the taxa new to the Wieliczka flora, determined by M. Łąćucka-Środoniowa while she was revising Jan Zabłocki's collection, are listed in Tab. 3. There are 38 taxa: 27 species, 6 genera and 5 families.

Tab. 4–6 show lists of taxa distinguished by J. Zabłocki as new whose confirmation requires more detailed study or whose determinations are doubtful or incorrect.

Tab. 7 gives a list of all the taxa determined so far from the Miocene flora of Wieliczka. After its validation the list consists of 185 taxa, of which 107 have been determined to species, 56 to genus and 22 to family level. In the course of more detailed studies in the future, this list should be complemented with new species within the distinguished genera and within some of the families very abundantly represented in this flora, such as Lauraceae, Myrtaceae, Theaceae, Araliaceae, Hamamelidaceae and Rhamnaceae.

Three species described by Zabłocki (1930a) – *Cornus salinarum*, *Diospyros salinaria* (flower) and *Hamamelis europaea* – and the genus *Nerium* (leaves), have not been included in the list of all taxa. These determinations were considered uncertain (Kirchheimer 1957, p. 140, Mai 1964, p. 140, Gregor 1977, p. 211) and since the original specimens are missing their verification has proved impossible.

## RESULTS OF THE REVISION OF THE JAN ZABŁOCKI COLLECTION

Data obtained from Jan Zabłocki's collection are presented in Tab. 2–6. Examination of the remains of the Wieliczka flora has made it possible in many cases to remove doubts concerning the occurrence of some fossil taxa named in the 1984 list (Łąćucka-Środoniowa 1984). Corrections and remarks concerning this list are shown in Tab. 1. Some of the old determinations still remain unreliable either because they have not been found in the fossil material or their confirmation would demand more detailed morphological and anatomical studies.

Tab. 2 contains a list of taxa distinguished as new by J. Zabłocki on the basis of his notes in the card index and the names given on the slips in the storage tubes. These data have not been published hitherto.

**Table 3.** New taxa distinguished by M. Łąćucka-Środoniowa in the J. Zabłocki collection of the fossil flora at Wieliczka

Abbreviations: frt – fructification, meg – megaspore, n – needle, fr – fruit, s – seed, indet. – indeterminata

Name of taxa	Remains	Number of specimens	J. Zabłocki's determination
<b>CRYPTOGAMAE</b>			
cf. <i>Polyporites</i> sp.	frt	7	indet., Fungi
cf. <i>Pyrenomycetes</i>	frt	1	indet.
<i>Selaginella saxonica</i> Mai	meg	1	seed, spore?
<b>PINOPHYTA</b>			
<i>Abies alba</i> Mill. type	n	2	Coniferae
<i>Abies</i> sp.	n	2	Coniferae
<b>MAGNOLIOPHYTA – DICOTYLEDONIDAE</b>			
<i>Acer</i> sect. <i>Goniocarpa</i> Pojark.	fr	2	<i>Acer</i>
<i>Acer</i> sect. <i>Platanoidea</i> (Pax) Pojark.	fr	3	<i>Acer</i>
<i>Ampelopsis rotundatoides</i> Dorofeev	s	1	<i>Vitis teutonica</i> Kirchheimer
Araliaceae	fr	1	<i>Morus</i>
<i>Arctostaphyloides menzelii</i> Kirchheimer	fr	3	indet.
Betulaceae gen. (cf. <i>Betula</i> sp.)	fr	1	indet.
<i>Comptonia</i> cf. <i>aldanensis</i> Dorofeev	fr	5	indet., <i>Cornus</i> , indet.
<i>Cornus</i> aff. <i>mas</i> L.	fr	2	<i>Cornus?</i> , <i>Cornus</i> aff.
<i>Cyclocarya cyclocarpa</i> (Schlechtendal) Iljinskaja	fr	1	indet.,
<i>Eomastixia saxonica</i> (Menzel) Holý	fr	2	<i>Cupressus?</i> indet., <i>Mastixicarpum</i>
<i>Eurya</i> sp.	fr, s	6	<i>Caryophyllaceae</i> , <i>Vitis</i> , <i>Tetrastigma</i>
Hamamelidaceae	fr	1	<i>Hamamelis</i>
<i>Meliosma miersleri</i> Mai	fr	1	<i>Sapotispernum</i>
<i>Padus</i> cf. <i>mediocra</i> Negru	fr	4	<i>Prunus</i> (3x), ( <i>Nyssa</i> )
<i>Phellodendron elegans</i> C. & E. M. Reid	s	1	<i>Phellodendron limburgene</i> Kirchheimer
<i>Prunus</i> aff. <i>spinosa</i> L.	fr	1	<i>Prunus</i>
<i>Pyracantha acuticarpa</i> (C. & E. M. Reid) Szafer	fr	9	( <i>Ilex</i> ) 4x, <i>Aralia</i> , indet., indet.
<i>Rubus microspermus</i> C. & E. M. Reid	fr	11	<i>Rubus</i>
Solanaceae	s	2	<i>Actinidia?</i>
<i>Staphylea microsperma</i> Negru	s	2	<i>Sambucus</i> , indet.
<i>Swida bessarabica</i> Negru	fr	8	( <i>Nyssa</i> ), <i>Cornus</i> , ( <i>Cornus</i> ), <i>Cornus</i> aff. <i>amomum</i> , <i>Cornus</i>
<i>Swida</i> cf. <i>bugloviana</i> Negru	fr	ca 20	<i>Cornus</i> 2x, ( <i>Cornus</i> ), <i>Cornus</i> aff. <i>amomum</i> , ( <i>Cornus</i> ) ( <i>Cornus</i> ) 2x, indet.
<i>Swida roshkii</i> Negru	fr	5	<i>Symplocos</i> 2x
<i>Symplocos minutula</i> (Sternberg) Kirchheimer	fr	2	<i>Ulmus?</i> , <i>Pteroceltis?</i> Ulmaceae, <i>Zelkova</i>
<i>Trema lusatica</i> Mai	fr	5	<i>Viburnum?</i>
<i>Viburnum</i> sect. <i>Lantana</i> Spach	fr	2	<i>Vitis parasylvestris</i> Kirchheimer
<i>Vitis</i> cf. <i>lusatica</i> Czeczott & Skirgielło	s	1	<i>Zanthoxylum</i> sp.
<i>Zanthoxylum giganteum</i> (Gregor) Gregor	s	1	<i>Zanthoxylum oxyphylloideum</i> sp. nov.
<i>Zanthoxylum</i> cf. <i>kristinae</i> (Holý) Gregor	s	2	<i>Evodiispernum pulcherrimum</i> sp. nov.
<i>Zanthoxylum tiffneyi</i> Gregor	s	1	<i>Vitis ludwigii</i> A. Br.
<i>Zelkova ungeri</i> Kováts	fr	2	
<b>MAGNOLIOPHYTA – MONOCOTYLEDONIDAE</b>			
cf. <i>Epipremnites reniculus</i> (Kirchheimer) Mai	s	1	Araceae
<i>Eulimnocarpus major</i> (Szafer) Collinson	fr	>20	<i>Ruppia major</i> Szafer, <i>Ruppia</i> , <i>R. maritima miocenica</i>

**Table 4.** New taxa distinguished by J. Zabłocki which should be verified after detailed studies

Abbreviations: fr – fruit, s – seed, c – cone, w – wood, u – undefined remains

Name of taxa	Remains	Number of specimens	J. Zabłocki's determination
Boraginaceae	fr/s	1	Boraginaceae?
<i>Capparis</i> sp.	fr/s	1	<i>Capparis</i>
<i>Cladium crassesculptum</i> Zabłocki sp. nov.	fr	ca 30	<i>Cladium crassesculptum</i> sp. nov.
<i>Cladium longum</i> Zabłocki sp. nov.	fr	2	<i>Cladium longum</i> sp. nov.
<i>Cladium marisciformae</i> Zabłocki sp. nov.	fr	20	<i>Cladium marisciformae</i> sp. nov.
<i>Celosia</i> sp.	s	2	<i>Celosia</i> , Amaranthaceae
<i>Grewia</i> sp.	fr	14	<i>Grewia</i>
<i>Ilex</i> sp.	fr	1	( <i>Ilex</i> )
<i>Kerria</i> sp.	fr	3	<i>Kerria</i>
<i>Onobrychis</i> sp.	fr, s	3	<i>Onobrychis</i>
Palmae	s	2	Palmae fructus? Palmaceae
Papilionaceae	s, fr	3	Papilionaceae?
<i>Thujopsis</i> sp.	c	4	<i>Thujopsis</i>
<i>Tradescantia salinaria</i> Zabłocki sp. nov.	s	1	<i>Tradescantia salinaria</i> sp. nov.
<i>Trichosanthes</i> sp.	s	2	<i>Trichosanthes fragilis</i> E. M. Reid
<i>Pinus</i> sp.	w, s	2	<i>Pinus</i> , <i>Pinus</i> ?
<i>Tremella</i> sp.	u	2	<i>Tremella</i> ? Myxophyta?

**Table 5.** Doubtful new taxa distinguished by J. Zabłocki

Abbreviations: s – seed, fr – fruit, indet. – indeterminata

Name of taxa	Remains	Number of specimens	Comments by Łaniccka-Środoniowa
<i>Acorus</i> sp.?	s	1	no morphological features of <i>Acorus</i>
<i>Bambusa</i> ? Gramineae?	fr/s	7	indet.
<i>Campylospermum hordvellense</i> Chandl.	fr/s	1	poorly preserved
<i>Caxtonia glandulosa</i> M. E. J. Chandler	fr	1	indet.
<i>Centrospermum</i> gen. nov.	fr/s	1	poorly preserved
Cycadinae?	fr/s	1	indet.
<i>Lithospermoides</i> gen. nov.	fr	1	no similarity to <i>Lithospermum</i>
<i>Podocarpus</i>	s	1	needs anatomical studies
<i>Sapindus</i>	fr/s	1	poorly preserved
<i>Eomastixia bilocularis</i> Chandl.	fr	1	damaged

### TAXA NEW TO THE FOSSIL FLORA AT WIELICZKA

According to the data contained in his card index, J. Zabłocki intended to describe several new taxa in the fossil flora of Wieliczka, namely, *Daphne minimum* sp. nov., *Juniperus succinifera* sp. nov., *Centrospermum* gen. nov., *Evdiospermum pulcherrimum* sp. nov., Malvaceae gen., *Thymeleocarpus gengnoideum* gen. nov. et sp. nov. and *Zanthoxylum oxyphyllodium* sp. nov. In consequence of the revision of these materials M. Łaniccka-Środoniowa found that most of these species are referable

known members of the genera *Zanthoxylum* and *Toddalia*, while the affiliations of the remaining ones are unknown or uncertain, except for *Juniperus succinifera* Zabłocki sp. nov. In this connection, we present the holotype of the new species, chosen by the authors of this publication, and its diagnosis.

#### *Juniperus succinifera* Zabłocki sp. nov.

Pl. 1, figs 6, 7, Fig. 2: 14 – 17b, Fig. 3: 17c – 18

Arctostaphyloides globulus Kirchh., Szafer 1961, p. 80, Pl. 21, figs 18, 22.

Holotypus. Specimen No JZ 423, MŻKW/III/816/10/Pb, Pl. 1, fig. 7, Fig. 3: 18;

**Table 6.** New taxa determined incorrectly by J. Zabłocki

Abbreviations: s – seed, fr – fruit, c – cone, co – coprolit, cs – cone scale, indet. – indeterminata, u – undefined remains

Name of taxa	Remains	Number of specimens	Determination by Łaniczka-Środoniowa
<i>Acanthopanax</i>	fr	9	cf. <i>Aralia</i> sp. <i>Tilia</i> sp.
<i>Broussonetia rugosa</i> E. M. Chandler	fr/s	1	indet.
<i>Callitrich?</i>	fr	1	<i>Eurya stigmosa</i> (Ludwig) Mai
<i>Caryophyllaceae</i>	s	8	<i>Eurya stigmosa</i> (Ludwig) Mai, <i>Eurya</i> sp.
<i>Cedrus</i>	s	4	cf. <i>Cupressaceae</i>
<i>Centrospermum</i> gen. nov.	fr/s	1	indet.
<i>Cephalanthus</i> aff. <i>occidentalis</i> L.	fr	3	indet.
<i>Corydalis pulchrum</i> Chandl.	s	5	indet., <i>Sambucus</i>
<i>Dianthus</i>	s	2	indet., cf. <i>zoocecidiae</i>
<i>Diclidocarya</i>	s	2	<i>zoocecidiae</i> , <i>Fungi</i>
<i>Elatine?</i>	fr	3	<i>Pyracantha</i> , cf. <i>Ilex</i>
<i>Evodiospermum pulcherrimum</i> sp. nov.	s	1	<i>Zanthoxylum tiffneyi</i> Gregor
<i>Halesia?</i>	fr/s, u	4	indet
<i>Hibiscus</i> cf. <i>syriacus</i>	s	>40	<i>Toddalia latisiliquata</i> (Ludwig) Gregor, <i>Toddalia maii</i> Gregor
<i>Illicium</i>	fr/s	3	indet.
<i>Iodes</i> (Icacinaceae)	s	1	<i>Zanthoxylum giganteum</i> (Gregor) Gregor
<i>Leguminosae</i>	s	2	<i>Toddalia naviculaeformis</i> (E. M. Reid) Gregor, <i>Toddalia latisiliquata</i> (Ludwig) Gregor
<i>Lindera?</i> Lauraceae?	fr	1	indet.
<i>Liriodendron</i>	fr/s, u	3	<i>Acer</i> , cf. <i>Fagus</i> , indet.
<i>Malvaceae</i>	s	>40	<i>Toddalia latisiliquata</i> (Ludwig) Gregor, <i>Toddalia maii</i> Gregor
<i>Malvaceae</i>	s	many frag- ments	<i>Toddalia maii</i> Gregor
<i>Mapania</i>	fr	1	indet. (cf. Ericaceae)
<i>Mariscus</i> , Cyperaceae	fr	1	cf. <i>Carex</i> sp.
<i>Martynia</i>	co	1	coprolit of caterpillars of butterfly
<i>Meliosma cantiensis</i> Reid, Chandler	fr	2	<i>Meliosma wetteraviensis</i> (Ludwig) Mai
<i>Meliosma?</i>	fr	1	indet.
<i>Menyanthes</i>	fr/s	2	indet.
<i>Papaver</i>	s	1	cf. <i>Rubus</i> sp.
<i>Platycarya richardsonii</i> (Bowerbank) Chandler	c	4	cf. <i>Pinus</i> sp.
<i>Phytolacca</i>	s	1	cf. <i>Toddalia maii</i> Gregor
<i>Platycarya</i>	u	1	cf. <i>zoocecidiae</i>
<i>Polanisia sibirica</i> Nikitin	s	5	<i>Eurya stigmosa</i> (Ludwig) Mai
<i>Portulacaceae</i>	s	7	<i>Eurya stigmosa</i> (Ludwig) Mai
<i>Pteroceltis</i>	fr	4	<i>Trema lusatica</i> Mai
<i>Punica</i>	fr/s	1	indet.
<i>Rumex?</i>	u	1	indet. (cf. <i>zoocecidiae</i> )
<i>Sapindoides globosa</i> (Ludwig) Kirchheimer	fr	1	<i>Styrax</i> sp.
<i>Sapotispermum</i>	fr	1	<i>Meliosma miessleri</i> Mai
<i>Sequoia couttsiae</i> Heer?	c, cs	4	<i>Sequoia abietina</i> (Brongniart) Knobloch
<i>Sphenotheeca incurva</i> Kirchheimer	fr	2	indet.
<i>Spondiacarpum turbinatum</i> Menzel	fr	1	indet.
<i>Stephanandra minima</i> Dorofeev	u	1	cf. <i>zoocecidiae</i>
<i>Symplocos gothani</i> Kirchheimer	fr	15	<i>Myrica ceriferiformis</i> Kownas, <i>Hartziella miocenica</i> Szafer, cf. Cornaceae
<i>Symplocos gregaria</i> A. Braun	fr	2	<i>Symplocos</i> sp., <i>S. poppeana</i> Kirchheimer
<i>Symplocos jugata</i> E. M. Reid	fr	2	<i>Symplocos lignitarum</i> (Quenst.) Kirchheimer
<i>Symplocos minutula</i> (Sternberg) Kirchheimer	fr	5 fragments	indet.

**Table 6.** Continued

Name of taxa	Remains	Number of specimens	Determination by Łańcucka-Środoniowa
<i>Symplocos urceolata</i> E. M. Reid	fr	6 fragments	indet.
<i>Ulmus</i>	fr	2	indet., <i>Trema lusatica</i> Mai
<i>Umbelliferae</i>	fr	1	<i>Sparganium</i> aff. <i>neglectum</i> Beeby <i>fossilis</i> Mai
<i>Vitis nodulosa</i> E. M. Reid	s	2	<i>Ampelopsis malvaeformis</i> (Schlotheim) Mai
<i>Zanthoxylum oxyphyolloideum</i> sp. nov.	s	1	<i>Zanthoxylum</i> cf. <i>kristinae</i> (Holý) Gregor

Muzeum Źup Krakowskich (Cracow Salt-Works Museum), Zamkowa 8, 32-020 Wieliczka, Poland.

**Locus typicus.** Wieliczka salt mine, Southern Poland.

**Stratum typicum.** Spiza-salt deposits, Middle Badenian (Wieliczien).

**Derivatio nominis.** From the succinic remains on the seed surface.

**Diagnosis.** Fruit (berry) 8.0 × 6.5 mm in size, globular, with verrucose surface, divided into three parts. Seeds 3.8–8.0 × 2.7–5.0 mm, elongate, angular, tapering towards the tip, thick-walled and two-chambered. On the surface there are several unequal, elongate, fairly deep pits, empty or with a resinocyst (resin nodule). Seed surface verrucose, notably so in the flat area touching the adjoining seed.

**Material.** 34 seeds and many seed fragments, 2 strobili (berries), MŽKW/III/815/25/Pb, III/816/10/Pb, Storage tube Nos: JZ 420-440, 442–459.

**J. Zabłocki's description:** "The seeds bear resin nodules of succinic consistency on the surface, corresponding in size and arrangement to resinocysts occurring in pseudoberries of some junipers. The shape and size of seeds correspond best with those of the seeds of *Juniperus macrocarpa* Sibth. & Sm., considered previously to be a variety of *Juniperus oxycedrus* L. The fossil specimens from Wieliczka undoubtedly belong to the section *Oxycedroides* Gausseen, because a whorl of three needles can be distinctly seen on one seed and there are three seeds in each pseudoberry. The largest seeds are equal to those of *J. macrocarpa* and the small ones are very similar to the seeds of *J. oxycedrus*. Their sculpture is alike to the extent that it is difficult to divide them into two species. The fossil specimens differ from the seeds of *J. macrocarpa* in the more numerous and more densely

arranged verrucae on the surface. Today the distribution of *J. macrocarpa* resembles that of *J. oxycedrus*; it grows in sandy places near the sea in the Mediterranean region from Spain to Bulgaria and Syria. I have named this species *J. succinifera* sp. nov. and the amber nodules juniperits. The fossil species must be considered to be very closely related to the modern species *J. macrocarpa* Sibth. & Sm".

The remaining new taxa distinguished by M. Łańcucka-Środoniowa in Jan Zabłocki's collection are listed in Tab. 3.

## LEAF REMAINS OF ANGIOSPERMS

The earliest mention of fossil leaves of Angiospermae from Wieliczka deposits appeared in Zabłocki's (1928b) publication. In the sandstone underlying the salt deposits he found remains of leaves of *Liquidambar europaea* A. Br., *Fagus* sp., *Nerium* sp., and *Cinnamomum* sp. Later, the leaf remains of *Eucommia* sp. were determined (J. Wąs in Łańcucka-Środoniowa 1966, p. 87, KRAM-P 37/84).

The whereabouts of J. Zabłocki's specimens remains unknown. More than ten specimens of salt-underlying sandstones, with impressions of about 20 leaf fragments, occur in the collections of the Cracow Salt-Works Museum at Wieliczka and the W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków. They include a leaf fragment of *Liquidambar europaea* A. Br. (Fig. 9: 9) and three fragments of leaves of *Daphnogene* sp. (=*Cinnamomum* sp., Pl. 1, figs 8, 9, Fig. 9: 1–3), which support J. Zabłocki's findings. However, no unequivocal evidence has been found for the occurrence of leaves of two other species distinguished by him: *Fagus* sp. and *Nerium* sp. Several fragments of leaves with craspedodromous venation might belong to beech, but their margins have not been preserved. The

**Table 7.** Macroscopic plant remains occurring in the fossil flora at Wieliczka

FUNGI	
<i>Cenococcum graniforme</i> (Sow.) Ferd. et Winge	<i>Aralia</i> sp. div.
cf. <i>Polyporites</i> sp.	cf. <i>Aralia</i> sp.
cf. <i>Pyrenomycetes</i>	<i>Araliaceae</i>
<i>Rosellinites areaolatus</i> (Fres. et Meyer) Kirchheimer	<i>Arctostaphyloides menzelii</i> Kirchheimer
<i>Rosellinites congregatus</i> (Beck) Mesch.	<i>Betula</i> sp. (wood)
<i>Trematosphaerites lignitum</i> (Heer) Mesch.	<i>Betulaceae</i> (cf. <i>Betula</i> sp.)
Fungi gen. div.	cf. <i>Brasenia</i> sp.
EQUISETOPHYTA	<i>Carpinus betulus</i> L. type
<i>Equisetum</i> sp.	<i>Carpinus europaea</i> Negru
PTERIDOPHYTA	<i>Carpinus polonica</i> Zabłocki
<i>Selaginella saxonica</i> Mai	<i>Carya costata</i> (Presl) Unger
PINOPHYTA	<i>Carya pusilla</i> Unger
<i>Abies alba</i> Mill. type	<i>Carya rugosa</i> Zabłocki
<i>Abies</i> sp. div.	<i>Carya ventricosa</i> (Sternberg) Unger
<i>Cephalotaxus miocenica</i> (Kräusel) Gregor	<i>Carya</i> sp. vel <i>Pterocarya</i> sp. (wood)
<i>Chamaecyparis salinarum</i> Zabłocki	<i>Carya</i> sp.
Coniferae gen. 1 ("Pinites" wood)	<i>Castanopsis salinaria</i> (Unger) Kirchheimer
Coniferae gen. 2 ("Pinites" wood)	<i>Celtis lacunosa</i> (Reuss) Kirchheimer
<i>Cunninghamia miocenica</i> Ett.	cf. <i>Chenopodium</i> sp.
cf. Cupressaceae	<i>Comptonia</i> cf. <i>aldanensis</i> Dorofeev
cf. <i>Cupressus</i> sp.	<i>Coriaria</i> cf. <i>collinsonae</i> Gregor
<i>Glyptostrobus europaea</i> (Brongniart) Unger	cf. <i>Cornaceae</i>
<i>Juniperus succinifera</i> Zabłocki sp. nov.	<i>Cornus</i> aff. <i>mas</i> L.
<i>Pinus brevis</i> Ludwig	<i>Crataegus</i> sect. <i>cuneatae</i> Rehder
<i>Pinus hampeana</i> (Unger) Heer	<i>Crataegus</i> sp. div.
<i>Pinus leitzii</i> Kirchheimer	<i>Cyclocarya cyclocarpa</i> (Schlechtendal) Iljinskaja
<i>Pinus salinarum</i> (Partsch) Zabłocki	<i>Daphne</i> sp. vel <i>Thymelea</i> sp.
<i>Pinus</i> cf. <i>spinosa</i> Herbst.	<i>Daphnogene</i> sp.
<i>Pinus thomasiiana</i> (Goepppert) Reichenbach	<i>Decodon</i> sp.
<i>Pinus</i> sp.	Dicotyledones gen. et sp. div.
cf. <i>Pinus</i> sp.	<i>Eomastixia saxonica</i> (Menzel) Holý
<i>Pithoxylon</i> cf. <i>silesiacum</i> (Unger) Kräusel	cf. <i>Ericaceae</i>
<i>Sequoia abietina</i> (Brongniart in Cuvier) Knobloch	<i>Eucommia</i> sp.
<i>Taxodium dubium</i> (Sternberg) Heer	<i>Eurya stigmosa</i> (Ludwig) Mai
<i>Taxoxylon göpperti</i> Unger	<i>Eurya</i> sp.
<i>Tetraclinis salicornioides</i> (Unger) Kvaček	<i>Fagus decurrens</i> C. & E. M. Reid
<i>Thuja</i> sp.	<i>Fagus</i> sp. (wood)
cf. <i>Thujopsis</i> sp.	<i>Fortunearia</i> cf. <i>sinensis</i> Rehder & Wilson
MAGNOLIOPHYTA – DICOTYLEDONIDAE	<i>Hamamelidaceae</i>
<i>Acer</i> sect. <i>Goniocarpa</i> Pojark.	<i>Hartziella miocenica</i> Szafer
<i>Acer</i> sect. <i>Platanoidea</i> (Pax) Pojark.	<i>Ilex lotschii</i> Mai
<i>Acer</i> sp. div.	cf. <i>Ilex</i> sp.
<i>Aesculus rouperti</i> Zabłocki	<i>Juglans bergomensis</i> (Bals.-Criv.) Massalongio
cf. <i>Aesculus</i> sp.	<i>Juglans costata</i> (Presl) Unger
<i>Alangium dubium</i> (Unger) Mai	<i>Juglans szaferi</i> Zabłocki
cf. <i>Alnus</i>	<i>Juglans wanda</i> Zabłocki
<i>Alnus kefersteinii</i> (Goeppert) Unger	<i>Koelreuteria margaritifera</i> (Ludwig) Mai
<i>Ampelopsis malvaeformis</i> (Schlotheim) Mai	Lauraceae gen. div.
<i>Ampelopsis rotundatoides</i> Dorofeev	<i>Lauraceae</i> type sensu Berger
cf. <i>Andromeda</i> sp.	Leguminosae type sensu Berger
cf. <i>Annonaespermum</i> sp.?	Leguminosae
	<i>Liquidambar europaea</i> A. Br.
	<i>Magnolia burseracea</i> (Unger) Mai
	<i>Magnolia lusatica</i> Kirchheimer

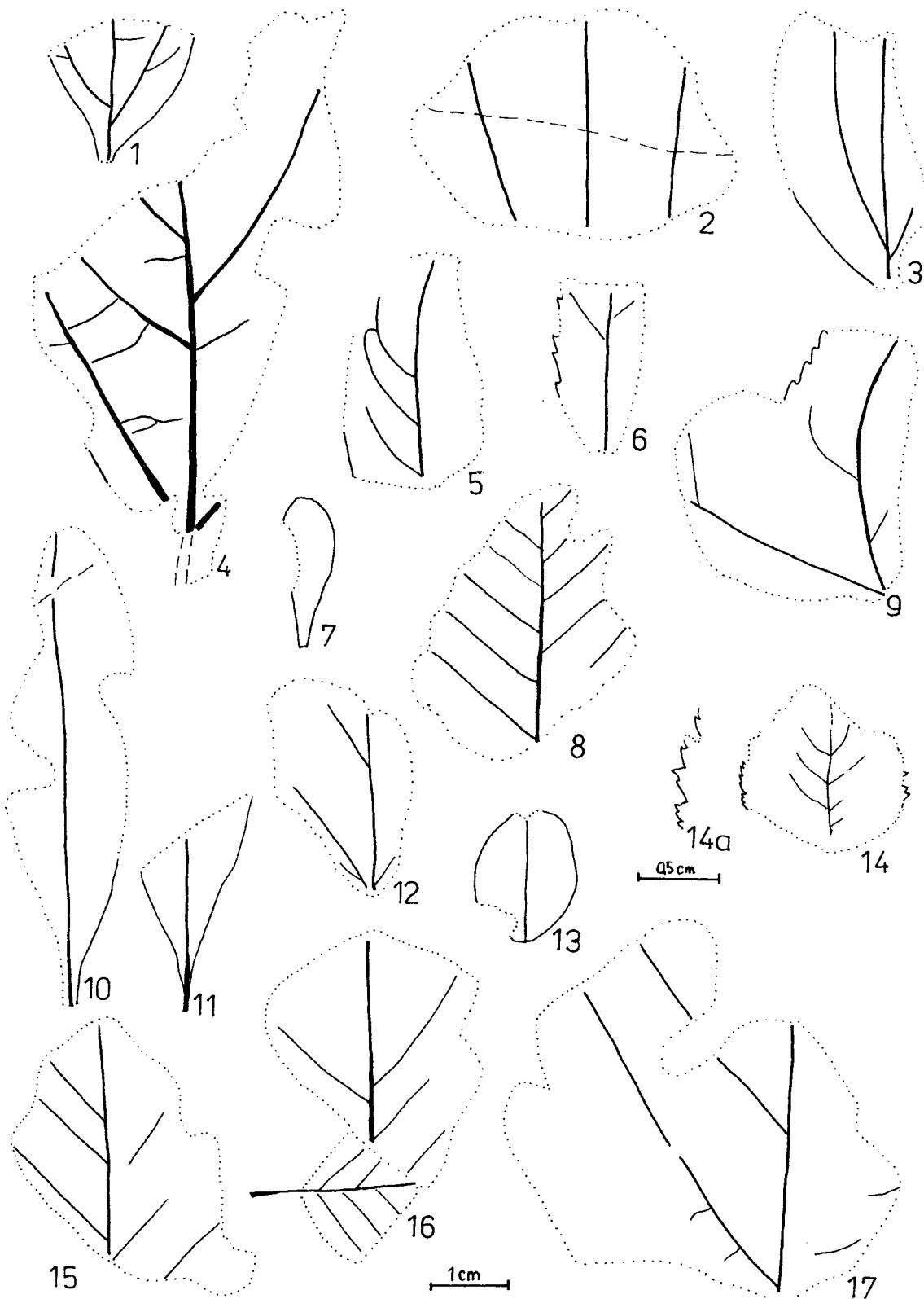
**Table 7.** Continued

<i>Magnolia</i> sp.	<i>Swida roshkii</i> Negru
<i>Mastixia lusatica</i> Mai	<i>Symplocos lignitarum</i> (Quensted) Kirchheimer
<i>Mastixicarpum limnophilum</i> (Unger) Kirchheimer	<i>Symplocos minutula</i> (Sternberg) Kirchheimer
<i>Meliosma miessleri</i> Mai	<i>Symplocos poppeana</i> Kirchheimer
<i>Meliosma wetteraviensis</i> (Ludwig) Mai	<i>Symplocos salzhausensis</i> Kirchheimer
cf. <i>Morus</i> sp.	<i>Symplocos</i> sp.
<i>Myrica ceriferiformis</i> Kownas	<i>Tilia preplatyphyllos</i> Szafer
<i>Myrica suppani</i> Kirchheimer	<i>Tilia</i> sp.
<i>Myrica vel Palaeocarya</i>	<i>Toddalia latisiliquata</i> (Ludwig) Gregor
Myrtaceae gen. div.	<i>Toddalia maii</i> Gregor
<i>Nyssa disseminata</i> (Ludwig) Kirchheimer	<i>Toddalia naviculaeformis</i> (E. M. Reid) Gregor
<i>Ocotea rhenana</i> Menzel	<i>Trema lusatica</i> Mai
<i>Olea oleastroides</i> Zabłocki	<i>Trigonobalanopsis exacantha</i> (Mai) Kvaček & Walther
<i>Ostrya</i> sp.	<i>Turpinia ettingshausenii</i> (Engelhardt) Mai
<i>Padus</i> cf. <i>mediocra</i> Negru	<i>Viburnum</i> sect. Lantana Spach
<i>Palaeocarya salinaria</i> (Zabłocki) Zast.	<i>Viscum morlotii</i> (Unger) Knobloch & Kvaček
<i>Paliurus</i> sp.	Vitaceae
<i>Phellodendron elegans</i> C. & E. M. Reid	<i>Vitis</i> cf. <i>lusatica</i> Czeczott & Skirgielło
<i>Platanus</i> sp.	<i>Vitis parasyvestris</i> Kirchheimer
<i>Platanus vel Populus</i>	<i>Vitis</i> cf. <i>teutonica</i> A. Br.
<i>Prunus</i> aff. <i>spinosa</i> L.	<i>Zanthoxylum ailanthiforme</i> (Gregor) Gregor
<i>Prunus</i> sp. div.	<i>Zanthoxylum giganteum</i> (Gregor) Gregor
<i>Pterocarya</i> sp. div.	<i>Zanthoxylum</i> cf. <i>kristinae</i> (Holý) Gregor
<i>Pterostyrax europaea</i> Zabłocki	<i>Zanthoxylum tiffneyi</i> Gregor
<i>Pyracantha acuticarpa</i> (C. & E. M. Reid) Szafer	<i>Zelkova ungeri</i> Kováts
<i>Quercus</i> sp. div.	MAGNOLIOPHYTA - MONOCOTYLEDONIDAE
cf. <i>Quercus</i> sp.	<i>Carex</i> sp. div.
<i>Rehderodendron ehrenbergii</i> (Kirchheimer) Mai	<i>Cladiocarya</i> sp.
Rhamnaceae	<i>Cladium oligovasculare</i> Mai
? Rosaceae	<i>Cladium</i> cf. <i>palaeomariscus</i> Dorofeev
<i>Rubus microspermus</i> C. & E. M. Reid	<i>Cladium</i> sp. div.
<i>Rubus</i> sp.	cf. <i>Cladium</i> sp.
cf. <i>Rubus</i> sp.	cf. <i>Epipremnites reniculum</i> (Ludwig) Mai
<i>Sambucus</i> sp.	<i>Eulimnocarpus major</i> (Szafer) Collinson
<i>Sinomenium cantalense</i> (E. M. Reid) Dorofeev	<i>Potamogeton prepectinatus</i> Negru
Solanaceae	<i>Potamogeton</i> sp. div.
<i>Staphylea</i> cf. <i>bessarabica</i> Negru	<i>Ruppia maritima</i> L. <i>miocenica</i> Szafer
<i>Staphylea microsperma</i> Negru	<i>Scirpus</i> sp.
<i>Staphylea</i> sp. div.	<i>Sparganium camenzianum</i> Kirchheimer
<i>Styrax</i> sp.	<i>Sparganium</i> aff. <i>neglectum</i> Beeby <i>fossilis</i> Mai
<i>Swida bessarabica</i> Negru	cf. <i>Sparganium</i> sp.
<i>Swida</i> cf. <i>bugloviana</i> Negru	<i>Urospathites cristatus</i> (Nikitin) Gregor & Bogner

determination of leaves of this type, devoid of margins, is impossible, because identical venation characterizes also the leaves of other families (e.g. Betulaceae, Ulmaceae).

The family Lauraceae is probably represented (in addition to the leaves of *Daphnogene*) by a fragment of a large leaf (Pl. 2, fig. 1, Fig. 9: 4), judging by the arrangement of its secondary and tertiary veins. A fine leaf of *Vis-*

*cum morlotii* (Unger) Knobloch & Kvaček (Pl. 3, fig. 5, Fig. 9: 7) from the family Loranthaceae is in a very good state of preservation. Another specimen with marginal teeth (Pl. 2, fig. 17, Fig. 9: 6) may be a leaf of *Myrica* (Myricaceae) or part of a compound leaf of *Palaeocarya* (Juglandaceae). However, this cannot be settled on the basis of leaf impreesions alone, requiring anatomical study of the structure of the cuticle.



**Fig. 9.** Fossil leaf impressions from the sandstones beneath the salt deposits. **1** – *Daphnogene* sp., basal fragment of leaf, KRAM-P 37/13; **2** – *Daphnogene* sp., middle fragment of leaf, KRAM-P 37/6; **3** – *Daphnogene* sp., leaf fragment, KRAM-P 37/2; **4** – Lauraceae gen., leaf fragment, MŽKW/III/1019/Pb; **5** – Dicotyledonous leaf fragment with campyodontromous venation, KRAM-P 37/1; **6** – *Myrica* vel *Palaeocarya*, leaf/leaflet fragment, KRAM-P 37/13; **7** – *Liquidambar europaea* A. Br., leaf fragment with characteristic teeth, KRAM-P 37/4; **8** – *Viscum morlotti* (Unger) Knobloch & Kvaček, leaf compression, MŽKW/III/1029/1/Pb; **9** – Lauraceae type sensu Berger, leaf impression, KRAM-P 37/10; **10** – Lauraceae type sensu Berger, leaf fragment, KRAM-P 37/3; **11** – Dicotyledonous leaf fragment with craspedodromous venation, KRAM-P 37/1; **12** – Dicotyledonous leaf fragment with actinodromous venation, KRAM-P 37/9; **13** – Leguminosae type sensu Berger, impression of leaflet(?), MŽKW/III/1029/2/Pb; **14** – ?Rosaceae, compression of leaf, MŽKW/III/1029/3/Pb; **15** – Dicotyledonous leaf fragment with craspedodromous venation, KRAM-P 37/5; **16** – Dicotyledonous leaf fragments with craspedodromous venation, KRAM-P 37/8; **17** – *Platanus* vel *Populus*, leaf fragment, KRAM-P 37/2

A leaf orbicular in shape with a dentate margin (Pl. 2, fig. 18, Fig. 9: 14) belongs most probably to the family Rosaceae, whereas another, considerably smaller and with an entire margin, represents the so-called Leguminosae type sensu Berger (Pl. 2, fig. 16, Fig. 9: 13). Another fragment of a fairly large leaf (Fig. 9: 17) may have been a leaf of *Platanus* or *Populus*.

The state of preservation of two fragments of lanceolate leaves, devoid of lateral veins (Lauraceae type sensu Berger, Pl. 4, fig. 7, Fig 9: 10, 11) indicates that they must have been rather thick and leathery, similar to the leaves of evergreen shrubs such as now occur in warmer climatic conditions.

## FOSSIL REMAINS OF THE WIELICZKA FLORA IN OTHER COLLECTIONS

The Cracow Salt-Works Museum contains in addition to Jan Zabłocki's collection, 82 specimens of the carpological flora from Wieliczka (Kolasa 1982), belonging to the following fossil taxa: *Carpinus polonica* Zabłocki (lectotype indicated here, MŻKW /III/507/4/Pb), *Carya pussilla* Unger, *Carya rugosa* Zabłocki (lectotype indicated here, MŻKW/III/529/1/Pb) *Carya ventricosa* (Sternberg) Unger, *Cephalotaxus miocenica* (Kräusel) Gregor, *Cyclocarya cyclocarpa* (Schlecht.) Iljinskaja, *Fagus decurrens* C. & E. M. Reid, *Juglans szaferi* Zabłocki (lectotype indicated here, MŻKW/III/526/2/Pb), *Juglans wandae* Zabłocki (lectotype indicated here, MŻKW/III/527/Pb), *Juglans* sp., *Liquidambar europaea* A. Br., *Magnolia burseracea* (Unger) Mai, *Magnolia lusatica* Mai, *Magnolia* sp., *Mastixicarpum limnophilum* Kirchheimer, *Myrica ceriferiformis* Kownas, *Nyssa dissemnata* (Ludwig) Kirchheimer, *Olea oleastroides* Zabłocki (lectotype indicated here, MŻKW/III/671/Pb), *Palaeocarya salinaria* (Zabłocki) Zast. (lectotype indicated here MŻKW/III/534/1/Pb, = *Engelhardtia salinarum* Zabłocki), *Pinus hampeana* (Unger) Heer, *P. salinarum* (Partsch) Zabłocki, *Pinus spinosa* Herbst, *Pinus* sp., *Sequoia abietina* (Brongniart in Cuvier) Knobloch, *Symplocos* sp. and *Tetraclinis salicornioides* (Unger) Kvaček.

Apart from the remains of fruits and seeds, there are also leaves preserved in the form of impressions in the salt underlying sandstones (see above). These represent *Viscum morlotii*

(Unger) Knobloch & Kvaček, Lauraceae gen., Leguminosae type sensu Berger, ?Rosaceae and Dicotyledones indeterminatae (coll. J. Wiewiórka 1965).

A detailed documentation of all the remains of fossil plants from the salt deposits stored in the Cracow Salt-Works Museum is given in the "Catalogue of geological collections of the Cracow Salt-Works Museum at Wieliczka" (Kolasa 1981).

The second largest collection of the Wieliczka flora is deposited in the W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków (KRAM-P No 37). It comprises:

1. J. Zabłocki's original materials, transferred by the author to the Physiographical Museum of the Polish Academy of Art and Sciences in Kraków and thence further to the W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków (KRAM-P 37/18, 19, 22, 23 (p.p.), 26, 27, 30 (p.p.), 31, 32 (p.p.), 50, 58, 59, 60, 68 (p.p.).

2. B. Namysłowski's collection from 1912, handed over to the Institute of Botany, Jagiellonian University in 1952 (KRAM-P 37/17, 20, 21 (p.p.), 23 (p.p.), 28 (p.p.), 38, 39, 40 (p.p.), 41 (p.p.), 42, 48 (p.p.), 55 (p.p.), 56, 61, 62 (p.p.), 63, 65, 66 (p.p.).

3. the collection of the Department of Palaeobotany, W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków (KRAM-P 37/1–16, 21 (p.p.), 23 (p.p.), 24–25, 28 (p.p.), 29, 30 (p.p.), 32 (p.p.), 33–37, 40 (p.p.), 41 (p.p.), 43–47, 48 (p.p.), 49, 51–54, 55 (p.p.), 57, 62 (p.p.), 64, 66 (p.p.), 67, 68 (p.p.), 70–84.

With the exception of a dozen or so specimens with leaf impressions (KRAM-P 37/1–13), all the other remains represent the carpological flora. They belong to the species *Aesculus rouperti* Zabłocki (lectotype indicated here, KRAM-P 37/26), *Alangium dubium* (Unger) Mai, *Alnus kefersteinii* (Goeppert) Unger, *Ampelopsis malvaeformis* Mai, *Carpinus europaea* Negru, *C. polonica* Zabłocki, *Carya ventricosa* (Sternberg) Unger, *Celtis lacunosa* (Reuss) Kirchheimer, *Cephalotaxus miocenica* (Kräusel) Gregor, *Cladium oligovasculare* Mai, *Fagus decurrens* C. & E. M. Reid, *Harziella rosenkjaeri* (Hartz) Szafer, *Ilex lotschi* Mai, *Juglans szaferi* Zabłocki, *Liquidambar europaea* A. Br., *Magnolia burseracea* (Menzel) Mai, *M. lusatica* Kirchheimer, *Mastixia lusatica* Mai (= *Mastixia amygdalaeformis* (v. Schlotheim) Kirchheimer), *Mastixicarpum*

*limnophilum* Kirchheimer, *Meliosma wetterwiensis* (Ludwig) Mai, *Myrica ceriferiformis* Kownas, *Nyssa disseminata* (Ludwig) Kirchheimer, *Ocotea rhenana* Menzel, *Palaeocarya salinaria* (Zabłocki) Zast. (=*Engelhardtia salinarum* Zabłocki), *Pinus hampeana* (Unger) Heer, *Pinus salinarum* (Partsch) Zabłocki, *Pinus spinosa* Herbst, *Potamogeton prepectinatus* Negru, *Rehderodendron ehrenbergii* (Kirchheimer) Mai, *Sequoia abietina* (Brongniart in Cuvier) Knobloch, *Sinomenium militzeri* Kirchheimer, *Sparganium aff. neglectum* Beeby *fossilis* Mai, *Staphylea cf. bessarabica* Negru, *Symplocos lignitarum* (Quenstedt) Kirchheimer, *S. cf. poppeana* Kirchheimer, *S. salzauhensis* (Ludwig) Kirchheimer, *Tetraclinis salicornoides* (Unger) Kvaček, *Tilia preplatyphyllos* Szafer, *Toddalia latisiliquata* (Ludwig) Gregor, *T. maii* Gregor, *T. naviculaeformis* (E. M. Reid) Gregor, *Turpinia ettinghausenii* (Engelhardt) Mai and *Zanthoxylum ailanthiformae* (Gregor) Gregor.

A small number of fossil specimens, mainly pine cones and nuts of Juglandaceae and *Mastixicarpum limnophilum* Kirchheimer, are stored in the Museum of Natural History, the M. Copernicus University at Toruń (MPUK), and in the collection of the Naturhistorishes Museum in Vienna.

## DERIVATION OF THE WIELICZKA FOSSIL FLORA

The upper bed of spiza salt and the overlying complex of salt megabreccia in the salt mine at Wieliczka are, in Ślączka and Kolasa's opinion (Ślączka & Kolasa 1985, Kolasa & Ślączka 1985), of sedimentary origin and their formation was due to submarine slides and flows. The palaeontological material derived from these beds is mixed up and this is true also of both the fossil fauna and flora (Kolasa 1990).

Łańcucka-Środoniowa (1984) writes that the fossil flora occurring in the Wieliczka deposits is of an allochthonous nature. And so plant remains reached the sedimentation area from communities growing in ecologically different habitats in areas either bordering the Paratethyd Sea or more or less distant from it, having been carried out by water (rivers, streams, floods) or by air (wind). The important role of water transport from considerable

distances is indicated by the heavily worn and rounded remains found in salt, often resembling large fruits (Łańcucka-Środoniowa 1984).

## AGE OF THE FOSSIL FLORA

The age of the salt deposits of Wieliczka was determined as middle part of the Miocene, Middle Badenian – Wieliczien (Łuczkowska 1978, Łuczkowska & Rolewicz 1990). The plant remains preserved in salt are therefore of the same age. It will be difficult to accept their redeposition from sediments of a different age because of their relatively good state of preservation (Łańcucka-Środoniowa 1984). The age of leaf impressions found in the salt underlying sandstone can also be determined as Badenian. It is the most recent period of the occurrence of *Daphnogene* remains in the Tertiary of Poland. The definite presence of Arcto-Tertiary genera in the leaf flora (e.g. *Liquidambar* and many leaves with craspedodromous venation) establishes the age of the fossil leaves as not older than Badenian.

It is worth adding here that for a long time Wieliczka was considered to be the youngest locality for the occurrence of species of the mastixian flora in Central Europe. This was so until their detection in the Pannonian floras of the Lower Rhine Basin (Van der Burgh 1983, 1987) or of western Poland (Łańcucka-Środoniowa in Dyjor et al. 1992, Łańcucka-Środoniowa & Zastawniak 1993).

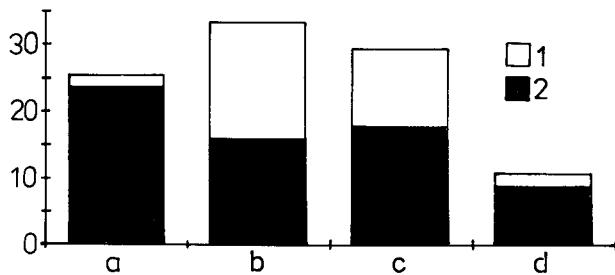
## FLORAL FOSSIL ASSEMBLAGE OF WIELICZKA

The composition of the Wieliczka flora is typical of the Middle Miocene floras from the area of the Transeuropaeo-Paratethys Bioprovince, distinguished by Mai (1995). Starting from the Badenian, the floras of this bioprovince were characterized by an increasing proportion of the Arcto-Tertiary element in comparison with the Palaeotropical. In the Wieliczka flora the Palaeotropical element is represented by genera still fairly numerous, of not very tall trees and shrubs almost exclusively of the Angiospermae (Tab. 8). The species belonging to them, present at Wieliczka, are typical of mastixian floras.

**Table 8.** Vertical distribution of Wieliczka genera (by Van der Burgh's (1994) method)

ARCTOTERTIARY GENERA			
Canopy	Understorey	Shrubs	Herbs
a	b	c	d
<i>Abies</i>	<i>Aesculus</i>	<i>Andromeda</i>	<i>Carex</i>
<i>Acer</i>	<i>Aralia</i>	<i>Cornus</i>	<i>Cladium</i>
<i>Alnus</i>	<i>Arctostaphyloides</i>	<i>Crataegus</i>	<i>Chenopodium</i>
<i>Betula</i>	<i>Cephalotaxus</i>	<i>Daphne vel Thymelea</i>	<i>Eulimnocarpus</i>
<i>Carpinus</i>	<i>Cupressus</i>	<i>Decodon</i>	<i>Potamogeton</i>
<i>Carya</i>	<i>Eucommia</i>	<i>Hamamelis</i>	<i>Ruppia</i>
<i>Celtis</i>	<i>Juniperus</i>	<i>Myrica</i>	<i>Scirpus</i>
<i>Chamaecyparis</i>	<i>Koelreuteria</i>	<i>Padus</i>	<i>Solanaceae</i>
<i>Cunninghamia</i>	<i>Morus</i>	<i>Phellodendron</i>	<i>Sparganium</i>
<i>Cupressus</i>	<i>Nyssa</i>	<i>Prunus</i>	
<i>Cyclocarya</i>	<i>Ostrya</i>	<i>Pyracantha</i>	
<i>Fagus</i>	<i>Pterostyrax</i>	<i>Rhamnaceae</i>	
<i>Glyptostrobus</i>	<i>Sinomenium</i>	<i>Rubus</i>	
<i>Juglans</i>	<i>Tetraclinis</i>	<i>Sambucus</i>	
<i>Liquidambar</i>	<i>Thuja</i>	<i>Staphylea</i>	
<i>Palaeocarya</i>	<i>Vitis</i>	<i>Stewartia</i>	
<i>Pinus</i>		<i>Swida</i>	
<i>Platanus</i>			
<i>Pterocarya</i>			
<i>Quercus</i>			
<i>Sequoia</i>			
<i>Taxodium</i>			
<i>Tilia</i>			
<i>Viburnum</i>			
<i>Zelkova</i>			
25	16	17	9

PALAEOTROPICAL GENERA			
Daphnogene	Alangium	Comptonia	Brasenia
Trema	Ampelopsis	Coriaria	Cladiocarya
	<i>Diospyros</i>	<i>Eurya</i>	
	<i>Eomastixia</i>	<i>Ilex</i>	
	<i>Epipremnites</i>	<i>Myrica</i>	
	<i>Hartziella</i>	<i>Myrtaceae</i>	
	<i>Lauraceae</i>	<i>Paliurus</i>	
	<i>Magnolia</i>	<i>Styrax</i>	
	<i>Mastixia</i>	<i>Symplocos</i>	
	<i>Mastixicarpum</i>	<i>Turpinia,</i>	
	<i>Meliosma</i>	<i>Viscum</i>	
	<i>Myrica</i>		
	<i>Ocotea</i>		
	<i>Rehderodendron</i>		
	<i>Tetraclinis</i>		
	<i>Toddalia</i>		
	<i>Trigonobalanopsis</i>		
	<i>Zanthoxylum</i>		
2	18	11	2



**Fig. 10.** Graph showing percentage representation of different growth forms in the Wieliczka flora: a – canopy trees, b – understorey trees, c – shrubs, d – herbs, 1 – Palaeotropical taxa, 2 – Arcto-Tertiary taxa

The Arcto-Tertiary element prevails in the Wieliczka flora (Tab. 8). It abounds in taxa of coniferous plants (particularly of the genus *Pinus*, rich in species and specimens) and numerous trees and shrubs of the Angiospermae, shedding leaves for the winter.

The numerical proportions of the two elements are illustrated by a graph (Fig. 10), constructed by Van der Burgh's method (Van der Burgh 1994). Two thirds of the total number of 100 genera are Arcto-Tertiary and one third Palaeotropical taxa. Such values should be assumed as characteristic of the floral assemblage of Wieliczka, which Mai (1995) characterized as follows: "a mesophytic mixed forest rich in species, in which trees shed leaves, while the shrub layer was made up of numerous laurel-leaved evergreen species and those typical of mastixian floras."

In respect of paleophytosociology Mai (1989) places the Wieliczka flora in the forest community with *Castanopsis*, which, in addition to *Castanopsis* is characterized by considerable proportions of the genus *Pinus* subgen. *Pinus*, and *Symplocos*. In the Wieliczka flora they are accompanied by such typical Tertiary genera as *Eomastixia*, *Mastixicarpum*, *Ocotea* and *Taxodium*. The presence of trees and shrubs from the genera *Acer*, *Carpinus*, *Carya*, *Fagus*, *Juglans*, *Liquidambar*, *Nyssa* etc in the community shows it to be closely related to the East-Asiatic Mixed Mesophytic Forests (Mai 1995). Numerous taxa in the fossil flora of the Wieliczka salt mine represent the East-Asiatic element (Zastawniak 1996). Quantitatively the East Asiatic element much exceeds the North American one (Tab. 9).

## BIOTOPIC CONDITIONS OF THE OCCURRENCE OF MIDDLE MIocene PLANT COMMUNITIES OF THE PARATETHYD COAST IN THE REGION OF TODAY'S WIELICZKA

In the fossil material under study the number of taxa which we can assume grew in salt or brackish water in situ is very small. There are, as a rule, only two such herbaceous genera: *Ruppia* and *Eulimnocalpus*. There are also few remains of submerged or floating plants from open, shallow freshwater lakes or pools (*Brasenia*, *Potamogeton*).

More heterogeneous and numerous are the plants of wet habitats, namely, marshes, peat-bogs and swamps close to the lake shores. There were, to a considerable extent, forest communities which mainly consisted of coniferous trees *Taxodium*, *Glyptostrobus* and some species of *Pinus* accompanied by deciduous trees from the genera *Nyssa* and *Alnus*, evergreen shrubs of *Myrica* and *Eurya* and, in the understorey, evergreen dwarf shrubs of *Andromeda*. As regards herbaceous plants, there may have been *Decodon* and *Scirpus*, horse-tails (*Equisetum*) and probably epiphytic bird's-nest mosses (*Selaginella*).

Slightly drier habitats were occupied by *Sequoia* trees.

In moist riverine habitats, on the banks of rivers, streams and lakes there grew mainly broad-leaved or mixed forests, in which trees shed leaves before winter. *Alnus* and various trees from the family Juglandaceae (*Carya*, *Cyclocarya*, *Palaeocarya* and *Pterocarya*) as well as *Liquidambar* and *Magnolia* grew in them. They may have been accompanied by conifers (*Chamaecyparis*), while the layer of lower trees and shrubs was composed of partly evergreen and partly deciduous plants from the family Araliaceae and the genera *Eomastixia*, *Eurya*, *Ilex*, *Mastixia*, *Meliosma*, *Myrica*, *Pterostyrax* and *Styrax*. Boughs and trunks of trees were encompassed by the climbers *Vitis*, *Epipremnites* and *Sinomenium*.

Some of the plant material was, to be sure, brought from fairly great distances, from the hills and elevations of the Carpathian Foreland, which were covered by rich, species diverse mixed and broad-leaved forests. In these forests coniferous trees were represented, above all, by fir (*Abies*) and some species of *Pinus*, the tall, evergreen trees *Ce-*

**Table 9.** Geographical elements in the fossil flora at Wieliczka

East Asiatic	North American	East Asiatic/North American
<i>Abies</i> sp. div. p.p.	<i>Carya rugosa</i>	<i>Acer</i> sp. div.
<i>Acer</i> sect. <i>Platanoidea</i>	<i>Comptonia</i> cf. <i>aldanensis</i>	<i>Aesculus rouperti</i>
<i>Alangium dubium</i>	<i>Fagus decurrens</i>	<i>Ampelopsis</i> sp.
<i>Carya pusila</i>	<i>Liquidambar europaea</i>	<i>Aralia</i> sp. div.
<i>Carya ventricosa</i>	<i>Myrica ceriferiformis</i>	<i>Betula</i> sp.
<i>Castanopsis salinarum</i>	<i>Nyssa dissemminata</i>	<i>Chamaecyparis salinarum</i>
<i>Cephalotaxus miocenica</i>	<i>Padus</i> cf. <i>mediocra</i>	<i>Cupressus</i> sp.
<i>Cunninghamia miocenica</i>	<i>Pinus leitzii</i>	<i>Hamamelidaceae</i>
<i>Eomastixia saxonica</i>	<i>Pinus thomasiana</i>	<i>Juglans bergomensis</i>
<i>Epipremnites reniculus</i>	<i>Sequoia abietina</i>	<i>Meliosma</i> sp.
<i>Eucommia</i> sp.	<i>Swida roshkii</i>	<i>Ocotea rhenana</i>
<i>Eurya stigmosa</i>	<i>Taxodium dubium</i>	<i>Ostrya</i> sp.
<i>Glyptostrobus europaea</i>	<i>Zanthoxylum giganteum</i>	<i>Phellodendron</i> sp.
<i>Juglans salinarum</i>	<i>Zanthoxylum tiffneyi</i>	<i>Quercus</i> sp.
<i>Juglans szafieri</i>		<i>Staphylea bessarabica</i>
<i>Juglans wandae</i>		<i>Styrax</i> sp.
<i>Koelreuteria marginiflora</i>		<i>Thuja</i> sp.
<i>Magnolia burseracea</i>		
<i>Magnolia lusatica</i>		
<i>Mastixia lusatica</i>		
<i>Mastixicarpum limnophilum</i>		
<i>Palaeocarya salinarum</i>		
<i>Phellodendron elegans</i>		
<i>Pinus hampeana</i>		
<i>Pinus spinosa</i>		
<i>Pterostyrax europaea</i>		
<i>Rehderodendron ehrenbergii</i>		
<i>Sinomenium militzeri</i>		
<i>Stewartia beckerana</i>		
<i>Styrax maxima</i>		
<i>Symplocos lignitarum</i>		
<i>Swida</i> cf. <i>bugloviana</i>		
<i>Toddalia latisiliquata</i>		
<i>Toddalia maii</i>		
<i>Toddalia naviculaeformis</i>		
<i>Trema lusatica</i>		
<i>Trigonobalanopsis exacantha</i>		
<i>Turpinia ettinghausenii</i>		
<i>Vitis</i> cf. <i>teutonica</i>		
<i>Zanthoxylum ailanthiformae</i>		

*phalotaxus*, *Cunninghamia*, *Cupressus* and *Thuja*. The layer of lower trees and under-shrubs consisted of both deciduous and evergreen plants: various species of *Acer*, *Aesculus*, *Alangium*, shrubs of various species of the Araliaceae, *Arctostaphyloides*, *Coriaria*, *Cor-nus*, *Eucommia*, various genera of the Hamamelidaceae, *Koelreuteria*, *Magnolia*, *Ostrya*, *Phellodendron*, *Rehderodendron*, *Staphylea*, *Stewartia*, *Styrax*, various species of *Swida*,

trees of several species of *Symplocos*, as well as *Zelkova* and shrubs of *Viburnum*.

Trees from the family Fagaceae within the genera *Castanopsis*, *Fagus*, *Quercus* and *Trigonobalanopsis*, shrubs of the Rosaceae (*Crataegus*, *Padus*, *Prunus*, *Pyracantha*, *Rubus*) and Lauraceae (*Ocotea*) played an important role in these forests. They were accompanied by numerous climbers and epiphytic lianas of the genera *Ampelopsis*, *Epipremnites* from the

Araceae, *Sinomenium*, *Toddalia*, species of *Vitis* and perhaps also woody climbers or trees of *Zanthoxylum*.

Within the fossil flora of Wieliczka have been found plant genera which now grow in arid and rocky habitats and which possibly had the same requirements in the past. They are not plentiful, mainly small trees or considerably branched shrubs of the genus *Juniperus*, trees of *Celtis*, shrubs of *Comptonia*, evergreen shrubs of *Olea*, spiny shrubs of *Paliurus*, low shrubs from the families Myrtaceae and Rhamnaceae and also some species of *Pinus* and *Libocedrites salicrioides* (Łańcucka-Środoniowa 1984).

The majority of trees and shrubs occurring in the fossil flora of Wieliczka belong to the Arcto-Tertiary element (Tab. 8). Their present-day ranges cover the regions of the Northern Hemisphere which have a temperate or moderately warm climate. This is true also for most genera of herbaceous plants. Only a group of small trees and shrubs (Tab. 8) represents the Palaeotropical element, that is plant genera which at the present time grow under subtropical conditions. This "storage" of a large number of plant taxa with higher temperature requirements in the layer of the understorey is a characteristic feature of the floras of the Middle Miocene of Europe (Van der Burgh 1994, Mai 1995).

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## STRESZCZENIE

Środkowo-mioceńska flora Wieliczki – rewizja kolekcji Jana Zabłockiego

Skład flory makroskopowej pochodzącej z osadów solnych Wieliczki został ustalony na podstawie rewizji oryginalnych materiałów z kolekcji Jana Zabłockiego, przechowywanej w Muzeum Żup Krakowskich w Wieliczce. Uwzględniono ponadto wyniki wcześniejszych badań (Łańcucka-Środoniowa 1984) oraz skład pozostały kolekcji z Muzeum Żup Krakowskich w Wieliczce, Muzeum Paleobotanicznego Instytutu Botaniki im. W. Szafera Polskiej Akademii Nauk w Krakowie, Muzeum Przyrodniczego Uniwersytetu im. M. Kopernika w Toruniu, Muzeum Geologicznego Polskiej Akademii Nauk w Krakowie oraz Naturhistorisches Museum w Wiedniu.

Autorką rewizji flory karpologicznej Wieliczki, jak również rysunków kopalnych owoców i nasion (Fig. 2–8) jest Maria Łańcucka-Środoniowa. Wyniki jej badań są zebrane w rozdziale o kolekcji Jana Zabłockiego i wynikach tej rewizji oraz w tabelarycznych zestawieniach (tab. 1 i 7 z uzupełnieniami E. Zastawniak oraz tab. 2–6). Dokumentacja badań znajduje się w protokole roboczym M. Łańcuckiej-Środoniowej (Archiwum Zakładu Paleobotaniki Instytutu Botaniki im. W. Szafera PAN w Krakowie). Oryginalna kartoteka kolekcji Jana Zabłockiego znajduje się w Muzeum Żup Krakowskich w Wieliczce.

Niektórych podanych w kartotece J. Zabłockiego taksonów roślin, i to zarówno opublikowanych, jak i wstępnie wyróżnionych przez tego autora, nie odnaleziono w kolekcji. Dotyczy to m.in. gatunków *Chamaecyparis salinarum* Zabłocki, *Cornus salinarum* Zabłocki, *Diospyros salinaria* Zabłocki, *Hamamelis europaea* Zabłocki i *Pterostyrax europaea* Zabłocki (Zabłocki 1930a). Lektotypy innych gatunków opisanych przez Zabłockiego (1928a, 1930a), a mianowicie *Carpinus polonica*, *Carya rugosa*, *Engelhardtia salinarum* (= *Palaeocarya salinarum*), *Juglans szaferi*, *Juglans*

*wandae*, *Olea oleastroides* i *Pinus salinarum* znajdują się w kolekcji Muzeum Žup Krakowskich w Wieliczce, a lektotyp *Aesculus rupperi* w Muzeum Paleobotanicznym Instytutu Botaniki im. W. Szafera PAN w Krakowie.

Szczególnie obficie są reprezentowane we florze wielickiej rodzaje: *Acer*, *Aralia*, *Carpinus*, *Cladum*, *Eurya*, *Fagus*, *Hartziella*, *Juniperus*, *Eulimnacarpus*, *Swida*, *Symplocos*, *Ruppia*, *Pinus*, *Quercus*, *Tetraclis*, *Toddalia*, *Vitis*, *Zanthoxylum*, a nadto rodziny Lauraceae i Myrtaceae, a także Cornaceae, Ericaceae, Hamamelidaceae i Theaceae. Taksomem nowym dla trzeciorzędu jest *Juniperus succinifera* Zabłocki sp. nov.

Z piaskowców podsolnych Wieliczki pochodzą szczątki liści (Fig. 9), z których zasługują na uwagę odciski fragmentów liści *Daphnogene* sp. i Lauraceae sensu Berger, należących najprawdopodobniej do zawszezielonych krzewów. Obok nich występuje *Liquidambar europaea* A. Br. oraz odciski liści o nerwacji kraspedodromowej, właściwej roślinom zrzucającym liście na zimę.

Skład flory wielickiej jest typowy dla flor śródmiocennego na obszarze wydzielonej przez Maja (1995) Bioprowincji Transeuropejsko-Paratetydzkiej. Poczytując od badenu flory tej bioprowincji charakteryzuje

rosnący udział elementu arktyczno-trzeciorzędnego w stosunku do elementu paleotropikalnego. Element paleotropikalny reprezentują we florze Wieliczki dość liczne jeszcze rodzaje drzew i krzewów, prawie wyłącznie Angiospermae (tab. 8). Należące do nich gatunki, obecne w Wieliczce, są typowe dla flor mastixiowych.

Dominuje jednak we florze Wieliczki element arktyczno-trzeciorzędowy (tab. 8), głównie taksony roślin szpilkowych (zwłaszcza obfita w gatunki i okazy sosna), oraz liczne drzewa i krzewy Angiospermae zrzucające liście na zimę.

Pod względem paleofitosocjologicznym Mai (1989) zalicza florę Wieliczki do oligo-mioceńskich lasów z *Castanopsis*, które charakteryzuje ponadto znaczny udział sosny oraz *Symplocos*. We florze wielickiej towarzyszą im takie typowo trzeciorzędowe rodzaje jak *Eomastixia*, *Mastixicarpum*, *Ocotea* i *Taxodium*. Współwystępowanie drzew i krzewów z rodzajów *Acer*, *Carpinus*, *Carya*, *Fagus*, *Juglans*, *Liquidambar* i *Nyssa* sprawia, że lasy te nawiązują w znacznym stopniu do współczesnych wschodnioazjatyckich mieszanych lasów mezofitycznych (Mai 1995). We florze kopalnej Wieliczki przeważają taksony reprezentujące element wschodnioazjatycki (tab. 9).

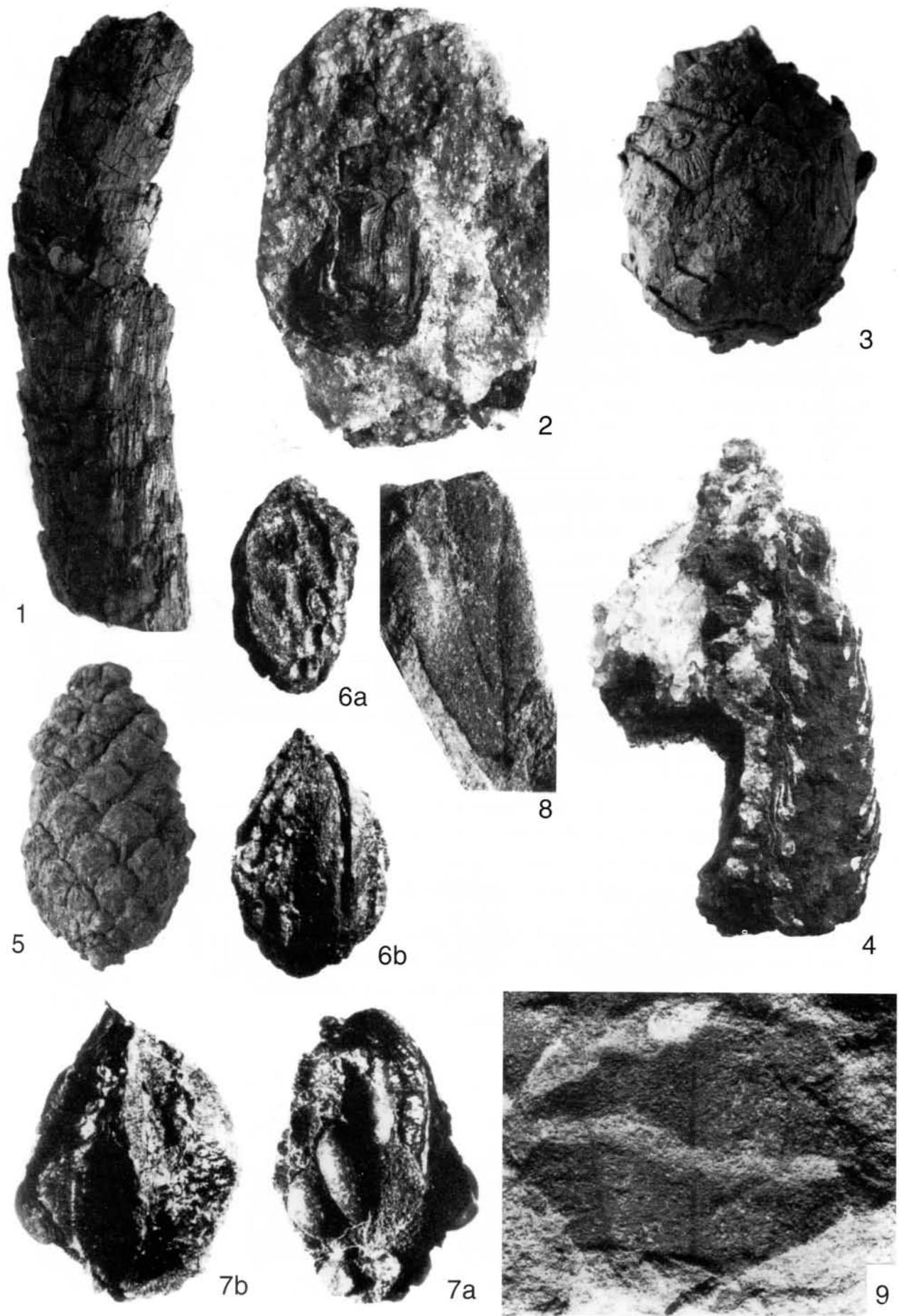
## PLATE

### Plate 1

1. *Pinus leitzii* Kirchheimer, cone, MKUT No 109,  $\times 1.3$ ,
2. *Pinus hampeana* (Unger) Heer, cone in salt, MG PAN No 214,  $\times 1$
3. *Pinus hampeana* (Unger) Heer, cone, MKUT No 92,  $\times 2$
4. *Pinus cf. spinosa* Herbst, piece of salt with cross-section of cone, MKUT without number,  $\times 1$
5. *Pinus* sp., cone, MKUT No 105a,  $\times 1.7$
6. *Juniperus succinifera* Zabłocki sp. nov., JZ 436, MŻKW/ III/816/10/Pb:  
a – seed (exterior view) with hollows and concretion of amber,  $\times 7$   
b – seed (exterior view) showing two resinocysts,  $\times 8$
7. *Juniperus succinifera* Zabłocki sp. nov., holotype with original label, JZ 423, MŻKW/III/816/10/Pb,  $\times 8$ :  
a – seed (exterior) view showing resinocysts in the deep hollows  
b – the same seed (interior view) showing papillae on the surface
8. *Daphnogene* sp., impression of basal part of leaf, KRAM-P 37/2,  $\times 1.5$
9. *Daphnogene* sp., impression of middle part of leaf, KRAM-P 37/6,  $\times 1.5$

1, 3, 5 – phot. B. Pawlak

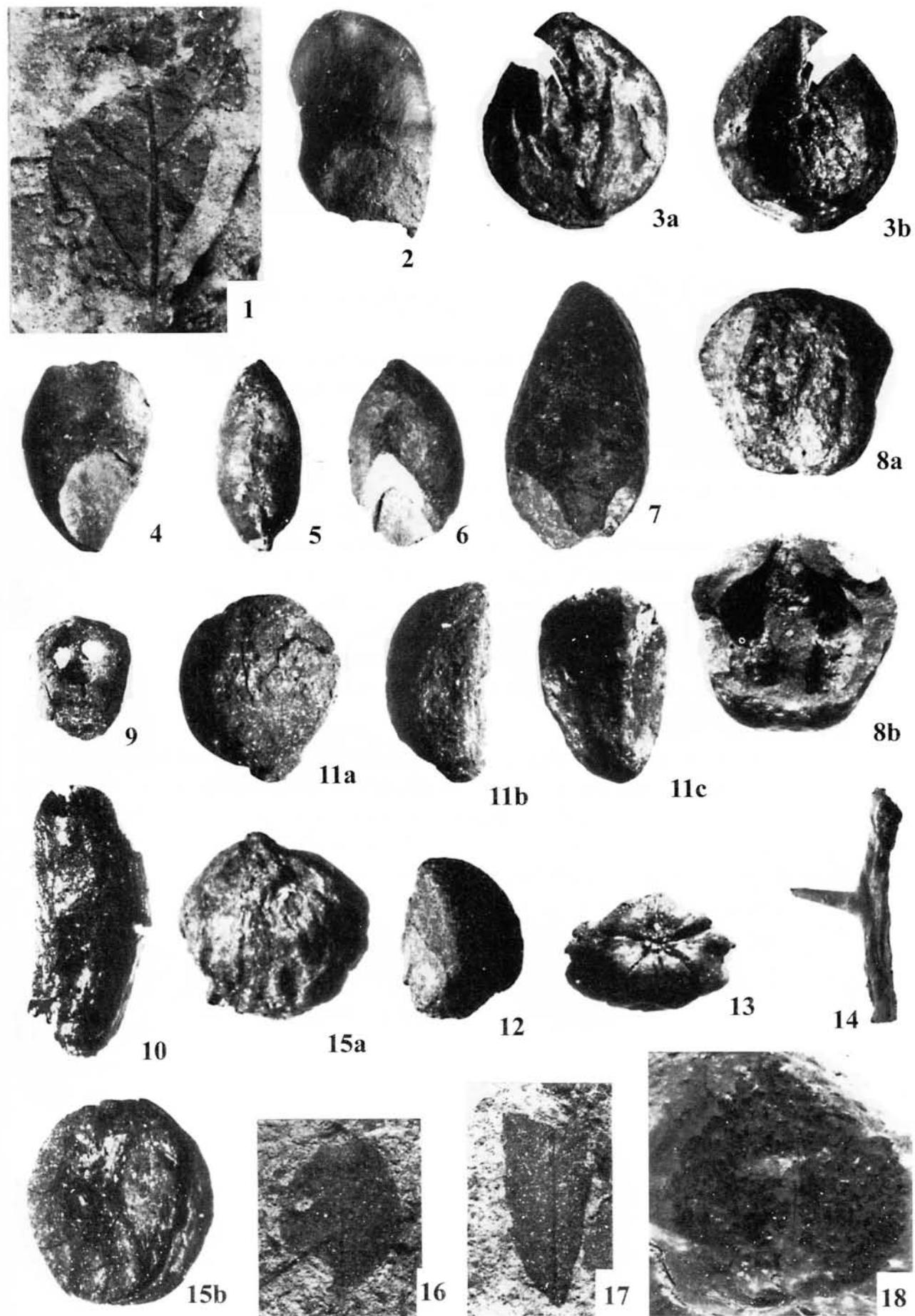
2, 4, 6–9 – phot. A. Pachoński



## Plate 2

1. Lauraceae, impression of leaf fragment, MŻKW/ III/1019/Pb, × 1
2. Hamamelidaceae, seed, JZ 271, MŻKW/III/783/3/Pb, × 5
3. *Comptonia cf. aldanensis* Dorofeev, JZ 380, MŻKW/ III/978/103 (366)/Pb, × ca 12:
  - a – fruit (exterior view)
  - b – fruit (interior view)
4. Hamamelidaceae, seed, JZ 272, MŻKW/III/783/3/Pb, × 6
5. Hamamelidaceae, seed, JZ 269, MŻKW/III/810/3/Pb, × 4.5
6. Hamamelidaceae, seed, JZ – , MŁŚ (628), MŻKW/ III/978/229 (366)/Pb, × 6.5
7. *Fortunearia cf. sinensis* Rehd. & Wils., seed, KRAM-P 37/81, × 4
8. *Cyclocarya cyclocarpa* (Schlechtendal) Iljinskaja, JZ – , MŁŚ (582), MŻKW/III/978/183 (366)/Pb, × 7
  - a – nut (exterior view)
  - b – half nut (interior view)
9. *Symplocos minutula* (Sternberg) Kirchheimer, stone from above, JZ 342, MŻKW/III/904/10/Pb, × 5
10. *Symplocos minutula* (Sternberg) Kirchheimer, stone, JZ 339, MŻKW/III/904/10/Pb, × 4
11. *Arctostaphyloides menzelii* Kirchheimer, JZ 160, MŻKW/ III/978/255 (366)/Pb
  - a – fruit (interior view), × 7
  - b – fruit (exterior view), × 8
  - c – part of fruit, × 8
12. *Pyracantha acuticarpa* (C. & E. M. Reid) Szafer, single endocarp, JZ 227, MŻKW/III/978/366/Pb, × 11
13. *Pyracantha acuticarpa* (C. & E. M. Reid) Szafer, fruit from above, JZ 224, MŻKW/III/978/366/Pb, × 7.5
14. *Crataegus* sp., thorn, MKUT, sine numero. × 1.5
15. *Trema lusatica* Mai, JZ 273, MŻKW/III/871/3/Pb, × ca 10
  - a – fruit
  - b – the same fruit from a different angle showing raphe
16. Leguminosae type sensu Berger, impression of leaflet (?), MŻKW/III/1029/2/Pb, × 1.5
17. *Myrica* vel *Palaeocarya*, impression of leaf or leaflet, KRAM-P 37/13. × 1.5
18. ?Rosaceae, compression of leaf, MŻKW/III/1029/3/Pb, × 2

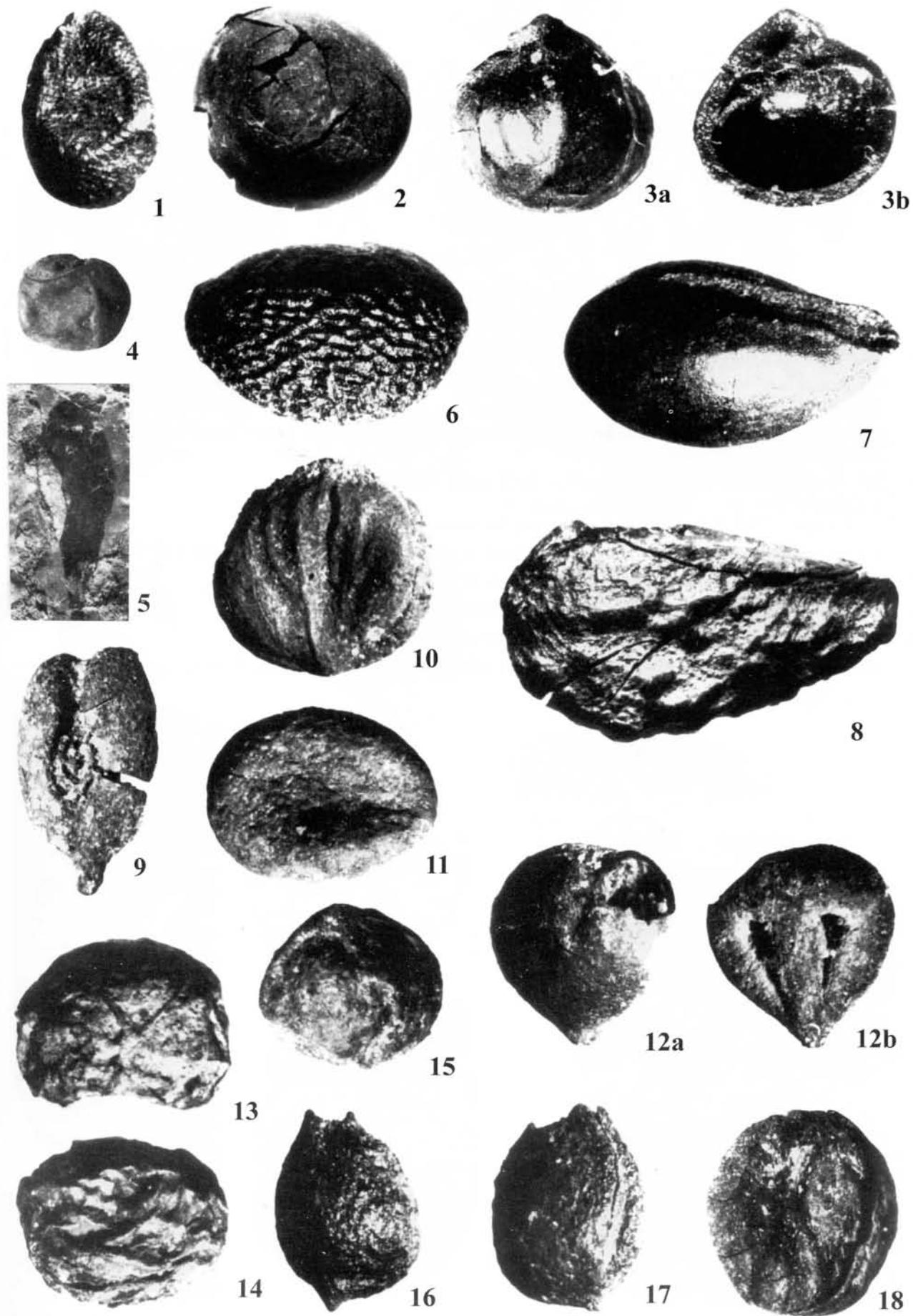
phot. A. Pachoński



## Plate 3

1. *Staphylea microsperma* Negru, seed, JZ 298, MŽKW/ III/881/2/Pb, × 11
2. *Koelreuteria marginatifera* (Ludwig) Mai, seed, JZ 384, MŽKW III/883/2, × 8
3. *Meliosma miessleri* Mai, JZ 171, MŽKW III/888/1/Pb, × 7.5  
a – half of endocarp (exterior view)  
b – the same (interior view)
4. cf. *Aesculus* sp., seed, MKUT sine numero, × 1
5. *Viscum morlotii* (Unger) Knobloch & Kvaček, leaf compression, MŽKW/III/1029/1/Pb, × 2
6. *Zanthoxylum* cf. *kristinae* (Holý) Gregor, seed, JZ 188, MŽKW/ III/930/1/Pb, × ca 10
7. *Zanthoxylum tiffneyi* Gregor, seed, JZ 186, MŽKW/ III/800/1/Pb, × 10
8. *Zanthoxylum giganteum* (Gregor) Gregor, seed, JZ 154, MŽKW/III/813/1/Pb, × 8
9. *Vitis* cf. *lusatica* Czeczott & Skirgiełło, seed from dorsal side, JZ 413, MŽKW/III/927/5/Pb, × 9
- 10, 11. *Swida bessarabica* Negru, stone, JZ 379, MŽKW/ III/779/10/Pb, × ca 13, × ca 10
12. *Ampelopsis rotundatoides* Dorof., seed, JZ 416, MŽKW/III/928/1/Pb, × 12  
a – dorsal side  
b – ventral side
13. *Swida roshkii* Negru, apical part of the stone, JZ 368, MŽKW/III/978/366 (978/98)/Pb, × 10
14. *Swida roshkii* Negru, apical part of the stone, JZ 369, MŽKW/ III/978/366 (978/99)/Pb, × 12
15. *Swida bessarabica* Negru, stone, JZ 370, MŽKW/ III/779/10/Pb, × ca 10
- 16, 17. *Eulimnocarpus major* (Szafer) Collinson, endocarps, JZ 104, MŽKW/III/880/1/Pb, × ca 13
18. *Padus* cf. *mediocra* Negru, stone, JZ 302, MŽKW/III/978/366/Pb, × ca 8

phot. A. Pachoński



## Plate 4

1. *Mastixicarpum limnophilum* (Unger) Kirchheimer, fruit, KRAM-P 37/24,  $\times 2$
2. *Mastixicarpum limnophilum* (Unger) Kirchheimer, cross-section of fruit-stone, loculum hippocrepian, KRAM-P 37/24,  $\times 2$
3. *Mastixicarpum limnophilum* (Unger) Kirchheimer, longitudinal section of half of fruit-stone, KRAM-P 37/24,  $\times 2$
4. *Eomastixia saxonica* (Menzel) Holý, JZ –, MŁŚ (816), MŻKW/ III/835/1/Pb,  $\times 1.5$   
a – part of fruit-stone (lateral view)  
b – the same fruit-stone from above showing the hippocrepian loculus
5. *Eomastixia saxonica* (Menzel) Holý, part of fruit-stone (lateral view), JZ –, MŻKW/III/786/3b/Pb,  $\times 1.5$
6. *Ruppia maritima* L. *miocenica* Szafer, endocarp, JZ 113, MŻKW/III/879/1/Pb,  $\times 15$
7. Lauraceae type sensu Berger, leaf impression, KRAM-P 37/10,  $\times 1.5$
8. Numerous leaf fragments in sandstone, KRAM-P 37/7,  $\times 1$
9. Dicotyledones gen. et sp. div. (Ulmaceae? p.p.), MŻKW/ III/1030/Pb,  $\times 1$ , coll. J. Wiewiórka 1965

phot. A. Pachoński

