East-Asiatic element in the fossil flora of the salt mine at Wieliczka (S. Poland)

Ewa Zastawniak

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East-Asiatic element is of particular significance in the Tertiary floras of Europe. This statement is also confirmed by the studies of carpological remains that have survived in the Tertiary deposits of the Wieliczka salt-mine. The East-Asiatic elements are represented in this fossil flora by the following families : Pinaceae, Cephalotaxaceae, Taxodiaceae, Cupressaceae, Magnoliaceae, Menispermaceae, Eucommiaceae, Fagaceae, Juglandaceae, Theaceae, Symplocaceae, Styracaceae, Ulmaceae, Sapindaceae, Staphyleaceae, Rutaceae, Vitaceae, Cornaceae, Mastixiaceae, and Alangiaceae. The taxon *Palaeocarya salinarum* (Zablocki 1930) comb. nov. is a new combination for the Tertiary floras.

Key-words—Fossil flora, Carpology, Salt deposits, Miocene, Poland.

Ewa Zastawniak, W. Szafer Institute of Botany, Polish Academy of Sciences, 31-512 Kraków, Lubicz 46, Poland.

साराँश

वीलिक्ज़ा (दक्षिणी पोलैंड) में खारी झील के अश्मित वनस्पतिजात में पूर्व एशियाई अवयव

इवा जस्तावनिआक

यूरोप के तृतीयक युगीन वनस्पतिजातों में पूर्वी एशियाई अवयवों का विशेष महत्व है। इस प्रमाण की पुष्टी कार्पोलॉजिकल अवशेषों से भी होती है जो कि वीलिक्ज़ा लवणीय खान के तृतीयक निक्षेपों में विद्यमान हैं। ये अवयव वनस्पतिजात में पाइनेसी, सिफेलोटेक्ससी, टैक्सोडिएसी, क्यूप्रेसेसी, मैग्नोलिएसी, मैनिस्पर्मेसी, यूकोमिरग्सी, फैगेसी, जुग्लैंडेसी, थीएसी, सिम्पलोकेसी स्टाइरेकेसी, अल्मेसी, सैपिन्डेसी, स्टेफिलिएसी, रूटेसी, वाइटेसी, कोर्नेसी, मैस्टाक्सिएसी एवं ऍलेन्जिएसी नामक कुलों के हैं। *पैलियोकैरिया सालिनेरम* (जैब्लोस्की, 1930) तृतीयक वनस्पतिजात के लिए एक नव संयोजन है।

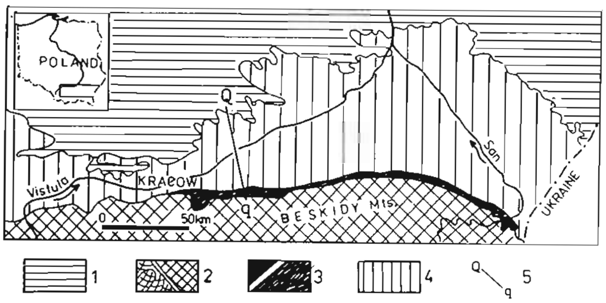
WIELICZKA is a small town, situated about 10 km south-east of Cracow, famous for its salt mine, which has been continuously worked since the 13th century.

The Wieliczka salt deposit extends for a distance of about 10 km from west to the east and is up to 1.5 km wide. The localisation of the salt bearing formation at Wieliczka is illustrated on Text-figure 1 (after Gonera, 1994).

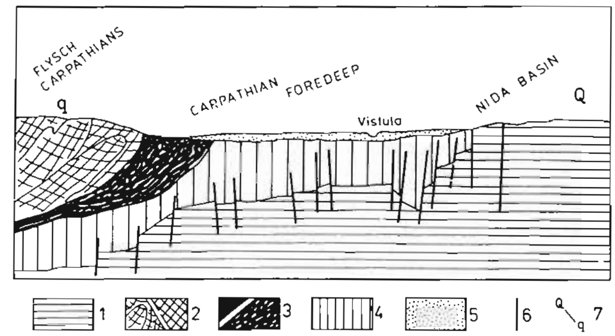
In this area deposits of rock salt precipitated are from sea water about 15 million years ago. In the warm climate of that time a periodical isolation of the sea, filling the Carpathian foredeep, resulted in an increase in the evaporation of water, followed by the precipitation of sodium chloride (rock salt). The rock salt deposit at Wieliczka lies on the edge of the thrust Carpathian nappe and, in consequence, is strongly folded (Text-figure 2; Gawel, 1962; Gonera, 1994).

The complex of salt-bearing formations in the mine is the stratotype of the Wieliczka Formation, corresponding to the middle part of the middle Badenian in the biostratigraphic division of the Miocene of the Parathetis (Luczkowska, 1978).

This paper is dedicated in memory of Professor Maria Lancucka-Srodoniowa. The work was supported by the State Committee for Scientific Research (Grant No PB 0649/P2/94/06 to Ewa Zastawniak). The determination of fossil remains and drawings on the Plates are by M. Lancucka-Srodoniowa, and new combinations of two fossil taxa by the present author. Information concerning distribution of taxa based mostly on Mai (1995).



Text-figure 1—The localisation of the salt bearing formation at Wieliczka in relation to the structural units of south-eastern Poland (from Gonera 1994, modified). **1**-Palaeozoic-Mesozoic formations of the substratum and border of the Carpathian Foredeep, **2**-Palaeogene deposits of Carpathian flysch, **3**-folded Miocene in the foreground of the Carpathian flysch, **4**-non-folded formations of Miocene in the Carpathian Foredeep, **5**-line of geological section.



Text-figure 2—Simplified geological section of the salt-bearing formation at Wieliczka (from Gonera 1994, modified). **1**-Palaeozoic-Mesozoic formations of the substratum and border of the Carpathian Foredeep, **2**-Palaeogene deposits of Carpathian flysch, **3** folded Miocene in the foreground of the Carpathian flysch, **4**-non-folded formations of Miocene in the Carpathian Foredeep, **5**-cover of Quaternary deposits, **6**-faults, **7**-line of geological section.

The deposits contain abundant assemblages of a marine fauna as well as fossil flora, e.g., megaspores, nuts, cones, seeds, fruits, fructifications, needles, shoots and pieces of branches.

PREVIOUS INVESTIGATIONS

The earliest determination of plants recovered from the salt deposits at Wieliczka were made in the mid-19th century by Austrian, Bohemian and German palaeobotanists, above all, Unger (1850) and Stur (1873). At that time large remains, such as cones, nuts and pieces of wood occurred frequently. Many were found and described.

In 1928, Jan Zablocki, a Polish paleobotanist, undertook a study of the Wieliczka flora. He collected abundant new material and published preliminary results of his study (Zablocki, 1928a, 1928b, 1930a, 1930b). In later years the study was continued (Zablocki, 1960) and a total of 136 taxa altogether were known by the 1980s (Lancucka-Srodoniowa, 1984).

THE EAST-ASIATIC FLORISTIC ELEMENT

The notion of the East-Asiatic floristic element was first formulated at the turn of the century by the German scientist Ferdinand Pax. In his work of 1908 devoted to the Oligocene fossil flora from Petrosani in Romania he stated that the fossil flora examined by him very closely resembled the present-day vegetation of Central and East Asia. He also found even then that these relationships are much closer than the relationships of the fossil flora with the contemporary vegetation of the Mediterranean Region and the Atlantic part of North America.

Later investigations carried out by many European palaeobotanists (among others Szafer, 1946-1947, 1961), continually supplied more evidence that the East-Asiatic element was the most important one in the Young Tertiary floras of Europe. The first to try and illustrate it was a Swedish palaeobotanist, Hans Tralau (1963). In his publication entitled "Asiatic Dicotyledonous affinities in the Cainozoic flora of Europe" he discusses more than 20 genera and groups of species showing Euro-Asiatic floristic affinities. These are, among others, *Actinidia, Ailanthus, Carpinus* subgen. *Dipterocarpus, Cercidiphyllum, Corylopsis, Cyclocarya, Eucommia, Hemiptelea, Koelreuteria, Magnolia* sect. *Buergeria, Phellodendron, Pterocarya, Sinomenium, Trichosanthes* and *Zelkova*. Apart from the genera which today have an exclusively East-Asiatic distribution, there is an entire group of important genera frequent in the European Tertiary, whose ranges show the so-called Asa Gray-Disjunction, that is, they occur both in East Asia and in North America, notably in its Atlantic part (Li, 1952). In the fossil floras of the Tertiary of Europe the following genera occur which show Asa Gray-Disjunction : *Chionanthus, Carya, Catalpa, Diervilla-Weigela, Halesia, Hamamelis, Itea, Lindera, Liriodendron, Lyonia, Magnolia,* *Menispermum, Nyssa, Pachysandra, Parthenocissus, Pieris, Sassafras, Saururus, Schizandra* and *Stewartia* (Mai, 1995).

In "The forest of China" Wang (1961) gave an extensive list of relicts in the East-Asiatic Region covering the Western Himalayas, Burma, Vietnam, China, Taiwan, Korea and Japan. This list was next complemented by Mai (1980, 1995).

TAXA REPRESENTING EAST-ASIATIC ELEMENTS IN THE FOSSIL FLORA OF WIELICZKA

Conifers

Pinus hampeana (Unger) Heer (Pinaceae) : Cones are preserved in salt (Pl. 1, fig. 1). This species is comparable with the present-day *Pinus thunbergii* Parl., from Japan and southern Korea (Mai, 1986).

Pinus cf. *spinosa* Herbst (Pinaceae) : Section of a pine cone in the salt (Pl. 1, fig. 2).

Cephalotaxus miocenica (Kräusel) Gregor (Cephalotaxaceae) : It is represented by a whole seed and a fragment of the upper part of another (Pl. 1, figs 3, 4). This fossil species is comparable with the present-day *Cephalotaxus fortunei* Hook. from China and *C. harringtoniana* K. Koch from China, Japan and Korea. It was a component of mixed coniferous and broad-leaved deciduous forests known from the Tertiary not only of Europe but also of Asia, from the Oligocene to the Pliocene.

Cunninghamia miocenica Ett. (Taxodiaceae)(Mai, 1995) : A cone of this plant was found. It was a typical component of subtropical forests in the Tertiary of Europe, rain forests and laurel forests in the Palaeogene and the so-called *Cunninghamia-Taiwania* forests from the Eocene to the Upper Pliocene (Mai, 1995). Its modern counterpart is *Cunninghamia lanceolata* Hook. from China.

Glyptrostrobus europaeus (Brongn.) Unger (Taxodiaceae) : It is represented by shoots (Pl. 1, figs 5, 6). Now-a-days, it is a monotypic genus, whose only species, *Glyptostrobus pensilis* K. Koch., grows along the banks of streams and rivers in the southern provinces of China, in Kwantung and Fukien (Li, 1952). Its fossil remains are known from the Cretaceous of Europe, whereas in the Tertiary it was one of the most important coal-forming plants. It was dominant in riparian forests and marginal swamp forests, widely spread from the Upper Oligocene to the Pliocene of the Central Europe (Mai, 1955) .

Chamaecyparis salinarum Zablocki (Cupressaceae) : It is represented by cone scales (Pl. 1, figs 7, 8). This species is comparable with present-day *Chamaecyparis obtusa* (Sieb. et Zucc.) Endl. from Japan. It was a component of mixed coniferous and broad-leaved deciduous forests (Mai, 1955).

Angiospermae

Magnolia burseracea (Menzel) Mai (Magnoliaceae) : It is represented by seeds (Pl. 1, fig. 10). No similar modern species has been found so far, but after Mai (1975), it certainly exists among the Asiatic evergreen magnolias. This species was common in the Younger Tertiary, particularly often found in brown-coal deposits. It grew in subtropical forests in marshy areas.

Magnolia lusatica Kirchheimer (Magnoliaceae) : It is represented by seeds (Pl. 1, fig. 9). Morphologically, this fossil species most resembles present-day *Magnolia dawsoniana* Rehd. et Wils., which now grows in evergreen broad-leaved forests in the Sikiang Province in China (Mai, 1975).

Sinomenium militzeri Kirchh. (Menispermaceae) : It is represented by endocarps (Pl. 1, fig. 15). This fossil species is comparable with modern *Sinomenium acutum* (Thunb.) Rehd. et Wils. from China and Japan. In all probability, it was a liana growing in mixed coniferous and broad-leaved forests, especially in the Miocene and Pliocene of eastern and central Europe (Mai, 1975).

Eucommia sp. (Eucommiaceae) : A fragment of a leaf has been preserved. The family Eucommiaceae is monotypic, archaic and of Laurasian origin (Mai, 1975). Now only one species, *Eucommia ulmoides* Oliv. is known; it is an endemic species growing in deciduous forests in the mountains of central China. Only one fossil species is known from Europe, from the Oligocene-Upper Pliocene Period, and it was particularly frequent in mesophytic deciduous broad-leaved forests with deciduous oaks, and in mixed oak-hornbeam-chestnut forests in the Miocene and Pliocene.

Castanopsis salinarum (Ung.) Kirchheimer (Fagaceae) : The species, described from Wieliczka on the basis of fruits (Pl. 1, fig. 11), is comparable with today's *Castanopsis indica* (Roxb.) A.DC. from north-eastern Asia (Mai, 1989b). Now, this genus related to *Castanea*, occurs in evergreen broad-leaved forests in subtropical-tropical areas. In the Tertiary of Europe it was a characteristic component of the so-called Castanopsietum oligo-miocenicum sensu Mai 1989b or of pine-laurel forests, the presence of which is noted from the Eocene to the Upper Pliocene.

Trigonobalanopsis exacantha (Mai) Kvacek et Walther (Fagaceae) : This is an extinct genus. Its fruits are illustrated on Pl. 1, figs 13, 14. This tree was an important component of warm-temperate evergreen deciduous forests, the so-called mixed laurel forests, in which Fagaceae and Lauraceae were dominant (Mai, 1995). These forests occurred in Europe from the Middle Oligo-cene to the Upper Miocene and in Colchis also in the Pliocene.

Palaeocarya salinarum (Zablocki) comb. nov. Zastawniak (Juglandaceae) : This fruit (Pl. 1, fig. 12) was described previously as *Engelhardtia salinarum* Zablocki (1930a). The genus *Paleocarya* Saporta is an extinct genus. This fossil plant played an important role in the so-called mesophytic *Engelhardtia* forests, known from the Upper Oligocene-Upper Miocene period of Europe and from the Pliocene of Colchis (Mai, 1995).

Juglans szaferi Zablocki (Juglandaceae) : It is represented by nuts (Pl. 1, figs 16, 16a). This species is comparable with modern *Juglans sinensis* (D.C.) Dode from East Asia (Zablocki, 1928a).

Juglans wandae Zablocki (Juglandaceae, Pl. 1, fig. 17) : It is comparable with *J. avellana* Dode also from East Asia (Zablocki, 1928a).

Eurya stigmosa (Ludwig) Mai (Theaceae) : It is represented by seeds (Pl. 1, figs 18, 18a). This species most resembles modern *Eurya japonica* Thunb., growing in China in mixed Mesophytic forests, and in Japan. In the Tertiary, it was an important component of marsh vegetation, present in Europe from the Palaeocene to the Upper Miocene. As a shrub, it grew also in mixed beech-oak-hornbeam forests and in marsh forests with Lauraceae (Mai, 1995).

Symplocos lignitarum (Quenst.) Kirchheimer (Symplocaceae) : The stones are illustrated in Pl. 2, figs 1-3. The modern related species are *Symplocos glandulifera* Brand, *S. yunannensis* Brand and *S. touranensis* Guill. from China, Thailand and Vietnam (Mai, 1989a). About 25 fossil species are known; they occurred in numerous fossil communities, starting from warm-temperate evergreen broad-leaved forests to mixed mesophytic deciduous forests (Mai, 1995).

PLATE 1 →

The fossil plant remains from the salt mine of Wieliczka (Abbreviations: KRAM-P - Palaeobotanical Museum of the Institute of Botany, Polish Academy of Sciences in Cracow, MZKW Museum of Cracow Salt-Work Museum at Wieliczka, MKUT - Natural Science Museum of the M. Kopernik University in Torun GMCr - Geological Museum, Institute of Geological Sciences, Polish Academy of Sciences in Cracow).

1. *Pinus hampeana* (Unger) Heer, cone in the salt, natural size, GMCr, Specimen no. 214.
2. *Pinus* cf. *spinosa* Herbst, piece of salt with the cone in the cross section, natural size, MKUT, without number.
3. *Cephalotaxus miocenica* (Kräusel) Gregor, seed, x ca 3, MZKW III/605/2/Pb (from Lancucka-Srodoniowa, 1984, pl. 1, fig. 1).
4. *Cephalotaxus miocenica* (Kräusel) Gregor, seed fragment, x 3, KRAM-P 37/51 (from Lancucka-Srodoniowa 1984, pl. 1, fig. 2).
5. *Glyptostrobus europaeus* (Brongn.) Unger, fragment of the shoot, x ca 8, MZKW III/775/1.
6. *Glyptostrobus europaeus* (Brongn.) Unger, fragment of the shoot, x ca 8, MZKW III/774/8.
7. *Chamaecyparis salinarum* Zablocki, cone scale, x 3.5 (after Zablocki, 1930a, pl. 10, fig. 15).
8. *Chamaecyparis salinarum* Zablocki, cone scale, x 3.5 (after Zablocki, 1930a, pl. 10, fig. 16).
9. *Magnolia lusatica* Kirchheimer, seed, x 3 from Zablocki, 1930a, pl. 12, fig. 23.
10. *Magnolia burseracea* (Menzel) Mai, seed x 3 from Zablocki, 1930, pl. 12, fig. 21.
11. *Castanopsis salinarum* (Unger) Kirchh., fruit, x 1.4 (after Zablocki, 1930a, pl. 11, fig. 16 = *Castanopsis schmidtiana* (Geinitz) Kräusel).
12. *Palaeocarya salinarum* (Zablocki) Zastawniak comb. nov., fruit from below, x Ca 4 (from Zablocki, 1930a, pt. II, fig. 13.= *Engelhardtia salinarum* Zablocki.
13. *Trigonobalanopsis exacantha* (Mai) Kvacek et Walther, fruit, x ca 5, MZKW III/710/1/Pb (from Lancucka-Srodoniowa 1984, pl. 1, fig. 4).
14. *Trigonobalanopsis exacantha* (Mai) Kvacek et Walther, fruit, x ca 5, MZKW III/710/2/Pb (from Lancucka-Srodoniowa 1984, pl. 1, fig. 3).
15. *Sinomenium militzeri* Kirchheimer, endocarp, x ca 8, KRAM-P 37/45 (from Lancucka-Srodoniowa 1984, pl. 1, fig. 11).
16. *Juglans szaferi* Zablocki, nut, x 1, 2, KRAM-P 37/27.

16a. The same nut from below (from Zablocki 1928a, pl. 9, fig. 9a).

17. *Juglans wandae* Zablocki, nut, x .1.2 (after Zablocki, 1930a pl. 11, fig. 2).
18. *Eurya stigmosa* (Ludwig) Mai, fruit from outside, x ca 12, MZKW III/978/106.

19a. *Eurya stigmosa* (Ludwig) Mai, the seed from inside with big kidney-shaped chamber, x ca 12, MKW III/978/106. 1-4, 13-16- phot. A. Pachonski 9,12- plot. S. Luczdo.

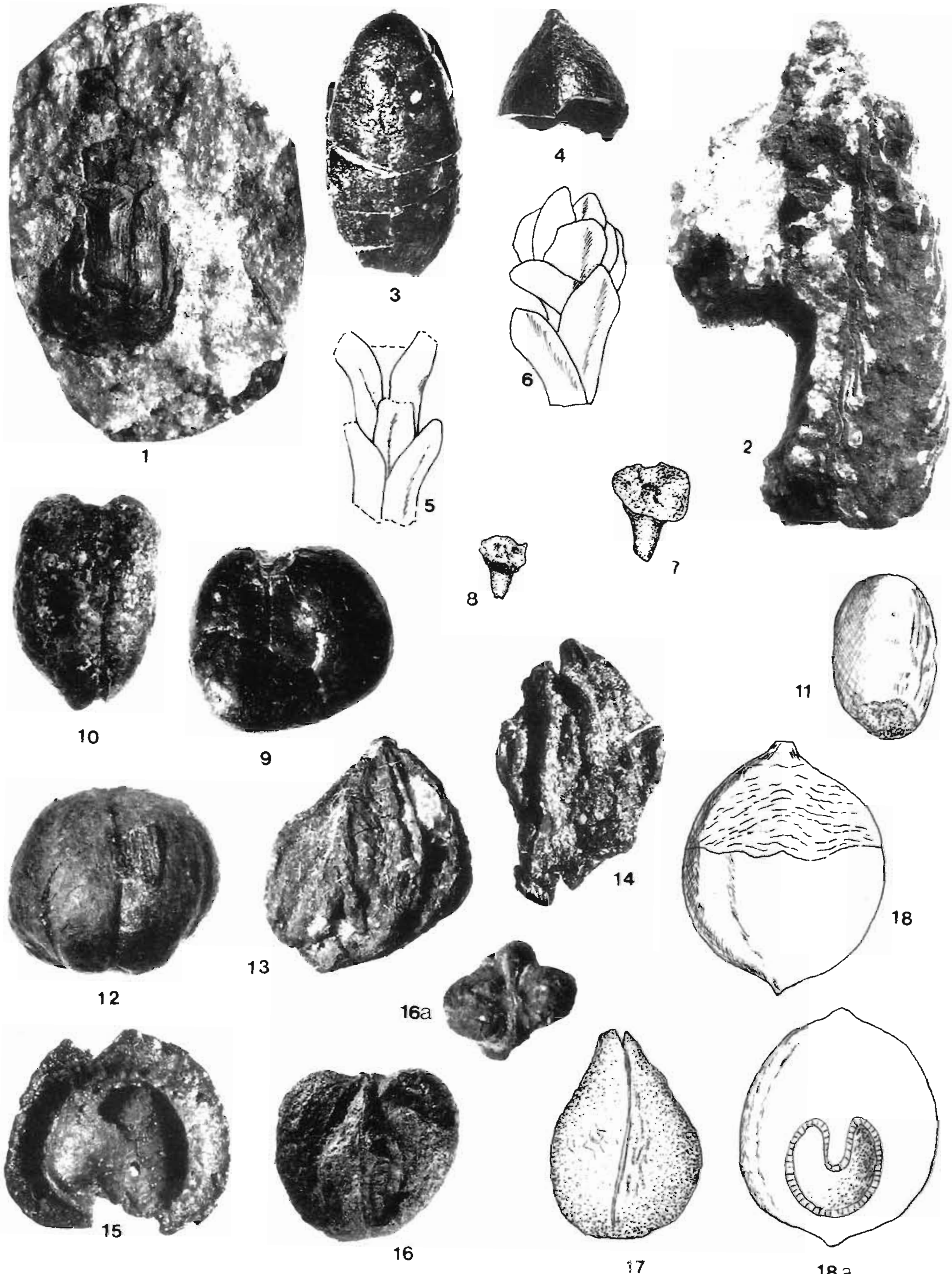


PLATE 1

Styrax maxima (Weber) Kirchheimer (Styracaceae) : The seeds of this species are comparable with modern *Styrax japonica* Sieb. et Zucc. from China and Japan. The fossil species is known from the European mixed mesophytic forests from the Lower Oligocene to the Upper Miocene.

Pterostyrax europaea Zablocki (Styracaceae) : It has fruits (Pl. 2, fig. 4) similar to those of modern *Pterostyrax hispida* Sieb. et Zucc. from China and Japan (Zablocki, 1930a).

Trema lusatica Mai (Ulmaceae) : This species, whose endocarps have been preserved (Pl. 2, figs 5, 5a), is known from the Miocene of Central Europe. Today the genus *Trema* numbers about 40 tropical species; in the Miocene it occurred in temperate floras, among trees and shrubs for the most part deciduous, with a small percentage of the laurophyllous element (Mai, 1995).

Koelreuteria margaritifera (Ludwg.) Mai (Sapindaceae) : Fossil seeds of this species (Pl. 2, fig. 15) are known and they resemble the seeds of modern *Koelreuteria paniculata* Laxm. from China. This plant is known from mesophytic deciduous broad-leaved forests with deciduous oaks from the Oligocene to the Pliocene and Older Pleistocene throughout Europe (Mai, 1995).

Turpinia ettingshauseni (Engelhardt) Mai (Staphyleaceae) with seeds illustrated in Pl. 2, fig. 9. *Turpinia formosana* Nakai is the most similar modern species. It is a small evergreen tree common in forests up to 1500 m a.s.l. growing all over Taiwan.

Phellodendron elegans C. et E.M. Reid (Rutaceae): One seed was found. The fossil species is comparable with modern *P. japonicum* Maxim. from Japan. It grew in Mixed Mesophytic Forests of Eurasian type, i.e., in forests rich in genera and species, in which trees were deciduous, whereas shrubs were evergreen. Such forests existed in Europe from the Oligocene to the Upper Miocene, and in Colchis were still present today (Mai, 1995).

Seeds of three species of the genus *Toddalia* from the family Rutaceae : *T. latisiliquata* (Ludw.) Gregor, *T. maii* Gregor and *T. naviculaeformis* (Gregor) Gregor (this last species is illustrated in Pl. 2, figs 8, 8a). All three taxa are comparable with one modern species, *Toddalia asiatica* (L.) Lam. from south-eastern Asia and western Africa. Today the lianas grow in evergreen forests in subtropical and tropical climates. The fossil genus grew in broad-leaved deciduous riparian forests, widely spread in Europe from the Upper Cretaceous to the Early Pleistocene (Mai, 1995).

The genus *Zanthoxylum*, also from the family Rutaceae, had in the Wieliczka fossil flora four species : *Z. ailantiforme* (Gregor) Gregor (Pl. 2, fig. 7), *Z. kristinae* (Holy) Gregor (Pl. 2, fig. 11), *Z. tiffney*

PLATE 2

The fossil plant remains from the salt mine of Wieliczka (Abbreviations: KRAM-P - Palaeobotanical Museum of the Institute of Botany, Polish Academy of Sciences in Cracow, MZKW Museum of Cracow Salt-Work Museum at Wieliczka, MKUT - Natural Science Museum of the M. Kopernik University in Torun GMCr - Geological Museum, Institute of Geological Sciences, Polish Academy of Sciences in Cracow).

1. *Symplocos lignitarum* (Quenst.) Kirchh., stone, x 6, MZKW III/550/1/Pb (from Lancucka-Srodoniowa 1984, pl. 3, fig. 3).
2. *Symplocos lignitarum* (Quenst.) Kirchh., stone, x 6, MZKW III/550/2/Pb (from Lancucka-Srodoniowa 1984, pl. 3, fig. 4).
3. *Symplocos lignitarum* (Quenst.) Kirchh., stone, x 6, KRAM-P 37/48 (from Lancucka-Srodoniowa 1984, pl. 3, fig. 5).
4. *Pterostyrax europaea* Zablocki, seed, x 3 (after Zablocki 1930a, Pl. 12, fig. 16).
5. *Trema lusatica* Mai, fruit, x 13, MZKW III/871/3.

5a. The same fruit with visible raphe, x 13. from Zablocki, 1930a, pl. 12, fig. 23.

6. *Vitis* cf. *lusatica* Czeczott et Skirgiello, seed, x 9, MZKW III/927/5.
7. *Zanthoxylum ailanthiforme* (Gregor) Gregor, seed, x 10, KRAM-P 37/71 (from Lancucka-Srodoniowa 1984, pl. 2, fig. 4).
8. *Toddalia naviculaeformis* (E.M. Reid) Gregor, seed, x 6.5, KRAM-P 37/70 (from Lancucka-Srodoniowa 1984, pl. 2, fig. 7).

8a. The same seed from the upper part, x 6.5.

9. *Turpinia ettingshauseni* (Engelhardt) Mai, seed, x 6, KRAM-P 37/80 (from Lancucka-Srodoniowa 1984, pl. 3, fig. 12).
10. *Zanthoxylum giganteum* (Gregor) Gregor, seed from lateral side, x 9, MZKW III/813/1.
11. *Zanthoxylum kristinae* (Holy) Gregor, seed from lateral side, x 11, MZKW III/930/1.
12. *Mastixia amygdalaeformis* (Schloth.) Kirchh., stone, x 5, KRAM-P 37/25 (from Lancucka-Srodoniowa 1984, pl. 2, fig. 9).
13. *Mastixia amygdalaeformis* (Schloth.) Kirchh., stone, x 5, MZKW III/522/Pb (from Lancucka-Srodoniowa 1984, pl. 2, fig. 10).
14. *Eomastixia persicoides* (Unger) Mai, stone, x 1.5, MZKW III/835/1

14a. The same specimen, cross section with the chamber in the shape of horse-shoe, x 1.5.

15. *Koelreuteria margaritifera* (Ludw.) Mai, seed, x 8, MZKW III/883/2
16. *Mastixicarpum limnophilum* Kirchh., fruit, x 1.4, KRAM-P 37/24.

16a. The same taxon, in the cross section visible in the chamber in the shape of horse-shoe filled by salt, x 1.4, KRAM-P 37/24.

16b. Simplified drawing of 16a.

17. *Alangium dubium* (Unger) Mai, stone, x 5, KRAM-P 37/34 (from Lancucka-Srodoniowa 1984, pl. 1, fig. 12).
18. *Swida* cf. *bugloviana* Negru, stone, x 12, MZKW III/779/1. 1-3, 6-15, 17-phot. A. Pechonski 16a-phot. S. Luczko.

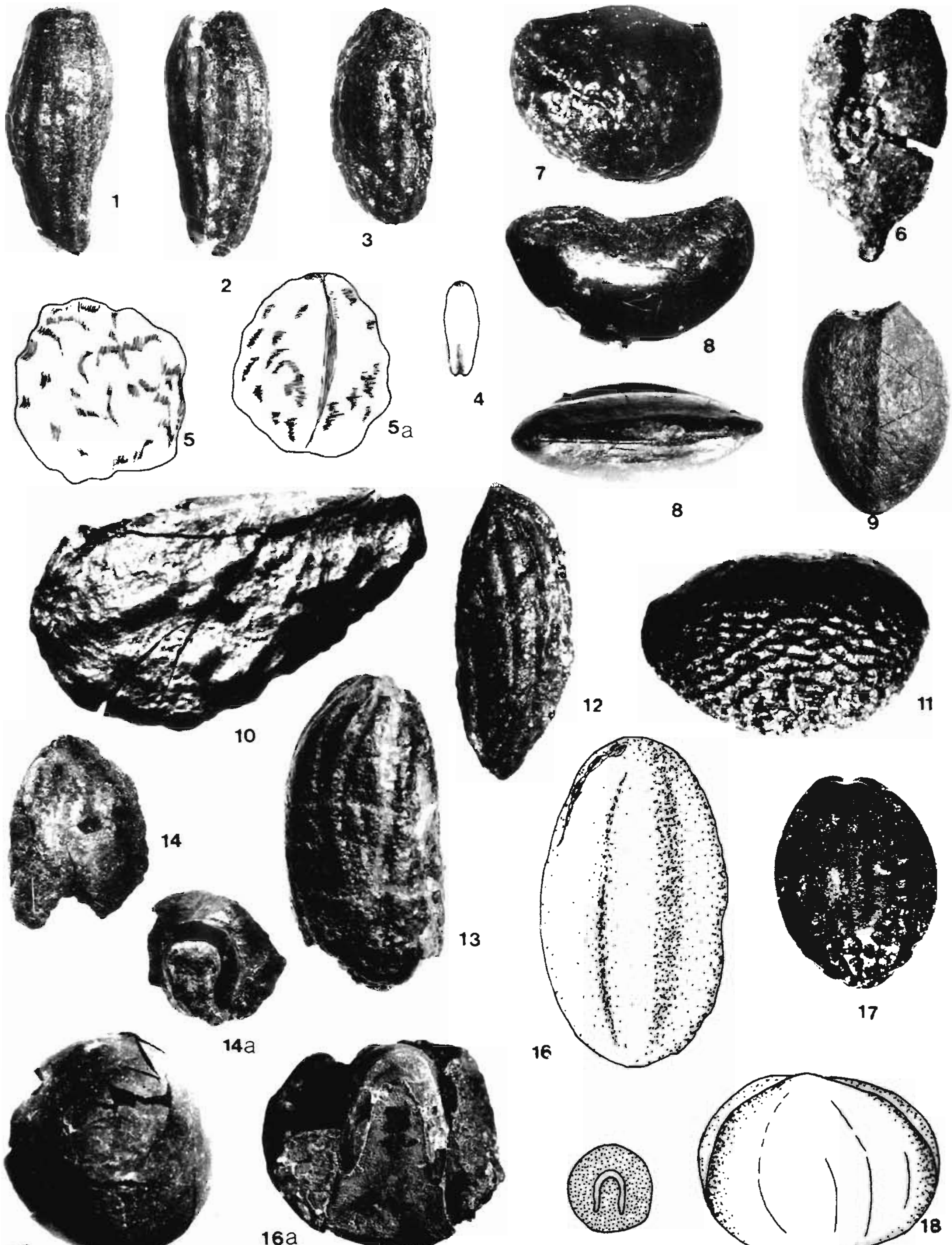


PLATE 2

Gregor and *Z. giganteum* (Gregor) Gregor (Pl. 2, fig. 10) but only *Z. ailantiforme* (Gregor) has East-Asiatic connections. It is comparable with modern *Z. ailanthoides* (Sieb. et Zucc.) Engler from China and Japan, *Z. bungi* Planch. from *China* and *Z. piperitum* (L.) D.C. from Japan (Gregor, 1978). This genus represented the palaeotropical element in the fossil floras of Europe from the Middle Eocene to the Lower Pliocene.

Vitis cf. *lusatica* Czeczott et Skirgiello A. Br. (Vitaceae) : Seeds were found of this fossil species (Pl. 2, fig. 6) which is comparable with modern *Vitis balsameana* Planch. from Hainan and *Vitis thunbergii* Sieb. et Zucc from China, Korea and Taiwan. These are deciduous lianas, rather rarely evergreen, and was frequent in mixed deciduous broad-leaved forests with deciduous oaks from the Oligocene to the Pliocene and the Early Pleistocene all over Europe (Mai, 1995).

Swida cf. *bugloviana* Negru (Cornaceae) : Its stone is illustrated in Pl. 2, fig. 18. The fossil species is comparable with modern *Swida bretschneideri* (Henry) Negru from northern China and *Swida brachypoda* (C. A. Mey.) Sojak from China and Japan. It was an important genus in the Tertiary of Eurasia starting from the Oligocene, especially frequent in broad-leaved deciduous riparian forests (Mai, 1995).

The leading family of the Tertiary of western and central Europe is the Mastixiaceae (Mai, 1995). They played such a great role in the plant cover of that time that Kirchheimer (1938) introduced the term "mastixian flora" (Mai, 1995). Until recently it was thought that the Middle-Miocene flora of Wieliczka is just the youngest mastixian flora in Europe. The latest studies, among others those by van der Burgh (1983, 1987) of Upper Miocene floras of Rheinland or by Lancucka-Srodoniowa (Dyjor *et al.*, 1992) from Gozdnica in western Poland showed that the mastixian floras occurred in the area of Central Europe still in the Upper Miocene.

Three genera from the Mastixiaceae were found at Wieliczka; Endocarps of *Mastixia amygdalaeformis* (Schloth.) Kirchheimer (Pl. 2, figs 12, 13). The fossil species is comparable with modern *Mastixia subcaudata* Merr. from the Philippines (Mai, 1970).

Mastixicarpum limnophilum (Unger) Kirchheimer : The illustration shows specimens embedded in salt (Pl. 2, fig. 16) and the cross-section of an endocarp, with a shoe-shaped chamber filled with salt visible in its inside (Pl. 2, fig. 16a). The name *Mastixicarpum* Chandler was an organ-derived name of a plant that was regarded as extinct. However, as pointed out by Eyde and Xiang's (1990) study, the fruits of *Mastixicarpum* are identical with the fruits of a plant from China, called *Diplopanax* Hand.-Mazz., which was described until 7 years after *Mastixicarpum* had been described (Eyde & Xiang, 1990). The foregoing situation resembles that of *Metasequoia*, in which the fossil plant was described before its modern counterpart had been found. The genus *Diplopanax*, initially included in the family Cornaceae, undoubtedly belongs to the Mastixiaceae (Eyde & Xiang, 1990). Recent similar species *Diplopanax stachyanthus* Hand. Mazz is a tree which grows in moist mountain forests in Guangsi, Hunan, Guagdong, Yunnan and Vietnam.

In fossil floras *Mastixicarpum* represents the palaeotropical East-Asiatic element and is a component of the so-called Castnopsietum Oligo-Miocenicum sensu Mai 1989b.

Eomastixia persicoides (Kirchh.) Mai : It is a third taxon of this family in the flora of Wieliczka. It is an extinct genus; its endocarps with a shoe-shaped chamber are illustrated in Pl. 2, figs, 14, 14a.

Alangium dubium (Unger) Mai (Alangiaceae) whose stones are illustrated in Pl. 2, fig. 17. The species is comparable with modern *Alangium chinense* (Lour.) Harma from China and South Asia. Alangiaceae is a monotypic family, according to Raven and Axelrod (1974) it is of Laurasian origin. It occurs in the so-called younger mastixian floras of Central Europe (Mai, 1995).

Apart from the taxa mentioned above, in the Miocene of Wieliczka there occurred genera which may also be referred to the present-day plants of East Asia. There are *Phellodendron, Ostrya, Pterocarya, Acer, Betula, Quercus, Carya* and *Distylium*. Being in a poor state of preservation, they could not be identified to species level.

Summing up, from the taxa of higher plants distinguished in the fossil flora of Wieliczka, approximately 40 per cent are related to plants growing in the territory of East and South-East Asia now.

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