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Tertiary *Platanus* woods from the northalpine Molasse basin (Austria, Germany)

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With 17 text-figures and 2 tables

Abstract

In Tertiary sediments from the northalpine Molasse basin thousands of silicified wood pieces have been collected in the last decades. In continuation of studiing these fossils some further dicotyledonous woods are described. The anatomical features are similar to extant *Platanus* spieces, assigned to the genus *Platanoxylon* ANDREÁNSKY (1951) emend. SUSS & MÜLLER-STOLL (1977). Problems of nomenclature are discussed.

Zusammenfassung

In den tertiären Sedimenten des nordalpinen Molassebeckens sind in den letzten Jahrzehnten tausende verkieselter Holzreste gesammelt worden. In Fortsetzung früherer Arbeiten werden weitere Laubhölzer anatomisch beschrieben. Sie gehören zu *Platanoxylon* ANDREÁNSKY (1951) emend. SUSS & MULLER-STOLL (1977). Fragen der Nomenklatur werden diskutiert.

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1. Introduction

The present investigation is in continuation of the systematic study carried out on a collection of some thousand silicified wood samples from the northalpine Molasse basin deposited in the Bavarian State Collection of Palaeontology and historical Geology, Munich. In previous papers the author (SEIMEIER 1989b, 1995) described in detail gymnosperm and dicotyledonous woods, representing different genera (*Dacrydium, Pinus, Taxodium; Albizia, Anacardium, Bombax, Bumelia, Carapa, Carya, Castanea, Castanopsis, Cedrela, Celtis, Crataegus, Dichrostachys, Diospyros, Grewia, Juglans, Laurus, Lithocarpus, Morus, Platanus, Populus, Prunus, Pterocarya, Quercus, Robinia, Zanthoxylum*).

The number of fossil-bearing localities known in the Upper Freshwater Molasse has increased greatly during the last 20 years. New faunal informations permit development of a detailed stratigraphy for the northalpine Molasse basin within the framework of European Tertiary stratigraphy (Mammal Neogene Units; MN 4 to MN 9). The fossil woods described below are fairly well preserved and show partly fine structural details of minute anatomy.

2. Nomenclature

The problematic affinities of fossil *Platanus* and platanoid woods have been discussed in different length by many authers: PRAKASH & BARGHORN (1961); PAGE (1968, 1981); GREGUSS (1969); PRAKASH, BŘEZINOVA & BŮŽEK (1971); SUSS (1971); BRETT (1972); SUSS & MÜLLER-STOLL (1977); WHEELER, SCOTT & BARGHORN (1977); SCOTT & WHEELER (1982); WILKINSON (1984); CRAWLEY (1989); SEIMEIER (1989a). All authors distinguish between the form genus *Plataninium* UNGER (1842) and the organ genus *Platanoxylon* ANDREANSKY (1951).

Platanninum UNGER 1842

The genus *Platanninum* was established by UNGER without illustrations for fossil woods resembling the wood structure of *Platanus*.

UNGER (1842: 174), Conspectus diagnosticus:

Platanninum Ung. Ligni strata concentrica linean lata. Radii medullares uniformes magni (usquo 1/8 ‴ lati) corpore subelongato, cellulis magnis pachytichis. Vasa numerosa, aequabiliter distributa, subsimplicia, angustiora, vacua, continua, poroso-spiralia, dissepimentis distantibus, scalariformibus, obliquis, latera versus spectantibus. Cellulae ligni pachytichae. - 1) *Pl. acerinum* Ung. Pori vasorum dissiti. - E formatione ignota. - E museo Universitatis Graecae sublatum.

A first emended diagnosis has been given by VATER (1884: 842). In this diagnosis *Phegonium* (*Fegonium*) UNGER (VATER 1884, Taf. 28, Fig. 7-14) has been united with *Plataninium* UNGER 1842. Specific diagnosis has been given by FELIX (1894: 101-102, Taf. 9, Fig. 5; 1896: 251-252; Felix 1887).

A second emended diagnosis for *Platanninum* has been given by PAGE (1968: 168):

Diagnosis: A form genus for fossil woods resembling certain members of the Fagaceae (*Fagus*), Platanaceae (*Platanus*), Eupteleaceae (*Euptelea*), and Icacinaceae (*Citronella*, *Ottoschultzia*), whose familial relationship cannot be determind with certainty, but which have these structural features: solitary pores, scalariform to opposite vessel pitting, scalariform or scalariform-simple perforation plates, broad rays up to 10 or more cells wide and more or less homogeneous, apotracheal parenchyma diffuse or in short uniseriate tangential lines. The

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diagnosis given by PAGE (1968) is in general terms and not in the usual style of diagnosis (BRETT 1972: 499).

An third emended diagnosis for "Organ-genus *Plataninium* UNGER" has been given by BRETT (1972: 497), and in addition a specific diagnosis for *Plataninium decipiens* from the Isle of Sheppey, Kent.

According to PAGE (1968: 168) *Plataninium* UNGER is a "form genus", according to BRETT (1972: 497) an "Organ-genus".

An emended specific diagnosis has been given by

a) PRAKASH, BŘEZINOVA & BŮŽEK (1971: 121) for *Plataninium europeanum* from northern Bohemia,

b) WHEELER, SCOTT & BARGHORN (1977: 142-143) for *Plataninium haydeni* FELIX 1896

c) CRAWLEY (1989: 613) for *Plataninium brettii* (1972) from Mull, Inner Hebrides.

Platanoxylon ANDREÁNSKY 1951

SUSS & MULLER-STOLL (1977) have published a comprehensive monograph with 70 references of the genus *Platanoxylon* ANDREANSKY 1951 including a critical survey of all platanoid wood fossils. In this monograph both authors exclude the form genus *Plataninium* UNGER 1842 from their list of fossil woods allied to *Platanus* (1977: 5-7, 55-58).

For the first time a diagnosis for the genus *Platanoxylon* ANDREANSKY has been given by SUSS & MULLER-STOLL (1977: 4). Generotype of *Platanoxylon* is *Platanoxylon andreanszkyi* from Szökehegy near Mikofalva, Hungary. The following diagnosis for the generotype has been given by SUSS & MULLER-STOLL (1977: 9):

Sekundärholz mit Stammholzstruktur, Jahresringe schmal aber deutlich, 100 Gefäße je mm² gleichmäßig über Jahresringe zerstreut, Durchmesser der Gefäße im Mittel radial 105 µm, tangential 75 µm, Gefäßdurchbrechungen einfach und leiterförmig, 1-28 Sprossen, Hoftüpfel auf den Längswänden der Gefäße opponiert, Spiralverdickungen fehlend, Holzfasern hofgetüpfelt, Wände im Mittel 5,4 µm, Holzparenchym apotracheal in kurzen einreihigen tangentialen Bändern und einzeln zerstreut, Markstrahlen sehr hoch und bis 14 Zellen breit, an den Jahrringgrenzen stark verbreitert, Anteil der Markstrahlen an der Masse des Holzes 24%, Markstrahlquotient 13, homogen, Markstrahlzellen im Mittel 26 µm hoch.

After SUSS-MULLER-STOLL (1977: 5-6) the name *Plataninium* is a useless name, no longer valid, a nomen abiguum: Der Name *Plataninium* ist aus mehreren Gründen unbrauchbar. Zunächst ist die erste hierzu gestellte Art UNGERS kein Platanenholz. In späterer Zeit wurde der Name in recht verschiedenem Sinne verwendet, und nach der neuerdings von PAGE (1968: 168; Diagnosis) vorgenommenen inhaltlichen Erweiterung ist die Gattung zur Bezeichnung einer Abstammungsgemeinschaft vollends unbrauchbar geworden und wurde in jüngster Zeit nur noch für von vornherein als zweifelhaft angesehene Reste gebraucht. Damit ist *Plataninium* als nomen abiguum auch für tatsächlich zu den Platanen gehörige Fossilien vollends unbrauchbar geworden.

The anatomical features of *Platanoxylon/Platanus* woods, as mentioned above were discussed in detail and critically reviewed by SUSS & MULLER-STOLL (1973, 1975, monograph 1977). The authors found characteristic differences between trunc and root wood.

Trunc wood structure of four *Platanoxylon* species - rays < 30% of the wood

ray-quotient	15	rays	14-20 cells wide
ray-quotient	20	rays	13-26 cells wide
ray quotient	30	rays	18 cells wide

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Root wood structure of four *Platanoxylon* species -rays > 30% of the wood

ray quotient	7	rays	45%
ray quotient	10	rays	33-40-56%

Tab. 1. Comparison of some anatomical features between the form-genus *Plataninium* UNGER 1842 (emend.) and the organ-genus *Platanoxylon* ANDREANSKY 1951 (emend.) according CRAWLEY (1989), SCOTT & WHEELER (1982), SUSS (1971), SUSS & MULLER-STOLL (1977) and WHEELER, SCOTT & BARGHORN (1977).

Anatomical features	*Plataninium*	*Platanoxylon, Platanus*
vessel perforations	exclusively or predominantly scalariform	predominantly simple, scalariform present
intervessel pits	opposite	opposite
spiral thickenings	partly present	absent
rays uniseriate	many	very rare
ray cells	markedly heterocellular	homocellular
height ray cells	mean < 30 µm	mean >30 µm

3. Anatomical description

The silicified wood pieces from Frankenmarkt (3.1), Pfaffing (3.2) and Unterbachham (3.3) are partly good preserved. Thin sections were prepared in the 3 standard orientations for observation by optical microscop. The average density of vessels per unit area was determined by counting as an individual any vessel present, whether or not it occured as a solitary vessel or as one component of a radial or tangential multiple (WHEELER 1986). The description of the woods follows the outline and terminology recommend by an International Association of Wood Anatomists (IAWA) Commitee (1989).

Comparison with descriptions and illustrations of extant woods:

BAAS (1969); BAREFOOT & HANKINS (1982); BRAZIER & FRANKLIN (1961); CARLQUIST (1988); CUTLER, RUDALL, GASSON & GALE (1987); GREGUSS (1959); GROSSER (1977); FAHN, WERKER & BAAS (1986); ILIC (1991); NILOOFARI (1961); METCALFE & CHALK (1950); MILES (1978); PANSHIN & DE ZEEUW (1970); SCHWEINGRUBER (1978, 1990); SUSS & MULLER-STOLL (1973, 1975); WAGENFUHR & SCHEIBER (1985) and standard references als listed in GREGORY (1994: 118-119).

Comparison with thin slides: Xylothek, Dr. D. GROSSER, Institut für Holzforschung, University Munich, STERN's Index Xylariorum p. 229-230 (STERN 1988).

Comparison with descriptions and illustrations of fossil woods:

ANDREÁNSKY (1951); BRETT (1972); FELIX (1894, 1896); GREGUSS (1969); HOFMANN (1952); PAGE (1968); PRAKASH & BARGHORN (1961); PRAKASH, BŘEZINOVÁ & BŮŽEK (1971); SCOTT & WHEELER (1982); SELMEIER (1975, 1989); SUSS (1971,1980); SUSS & MULLER-STOLL (1977); SUZUKI (1976); UNGER (1842a): VATER (1884); WHEELER, SCOTT & BARGHORN (1977); WHEELER (1991c) and Fossil Wood Database 11 March 1991, p. 23, with 25 *Platanus* records (WHEELER 1991a,b).

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3.1 The *Platanus* wood from Frankenmarkt

Ordnung Hamamelidales

Familie Platanaceae

Platanoxylon sp.

Organgattung: *Platanoxylon* ANDREÁNSKY 1951

Typusart: *Platanoxylon andreanskyi*, SÜSS & MÜLLER-STOLL 1977: 7-9, Abb. 1, Taf. I, Fig. 1-4, Taf. II, Fig. 1-2.

Minute anatomy
(Fig 1-7)

Fig. 1. Cross section (Frankenmarkt). Wood diffuse-porous with five growth bounderies, vessels very numerous, evenly distributed. × 25.

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The present description is based on 6 thin slides, maximum ca. 3 x 3 cm (cross section). The petrified secondary xylem shows only in transversal section good preservation.

Growth rings

Present, partly visible to the naked eye, boundaries marked by few rows of radially flattened latewood fibres and swollen rays, narrow, e. g. 20 growth rings per 2,3 mm, growth rings width variable, 0,7-2,2 mm, boundaries often bended between two rays.

Vessels

Diffuse-porous; vessels numerous and fairly evenly distributed, within some growth rings vessels slightly more crowded and larger in the early wood, solitary pores oval or tending to be angular in outline, mean tangential diameter 71 µm , range 48-121µm; multiple pores in various directions or in clusters, vessels thin-walled; 161 vessels per sq. mm; perforation plates

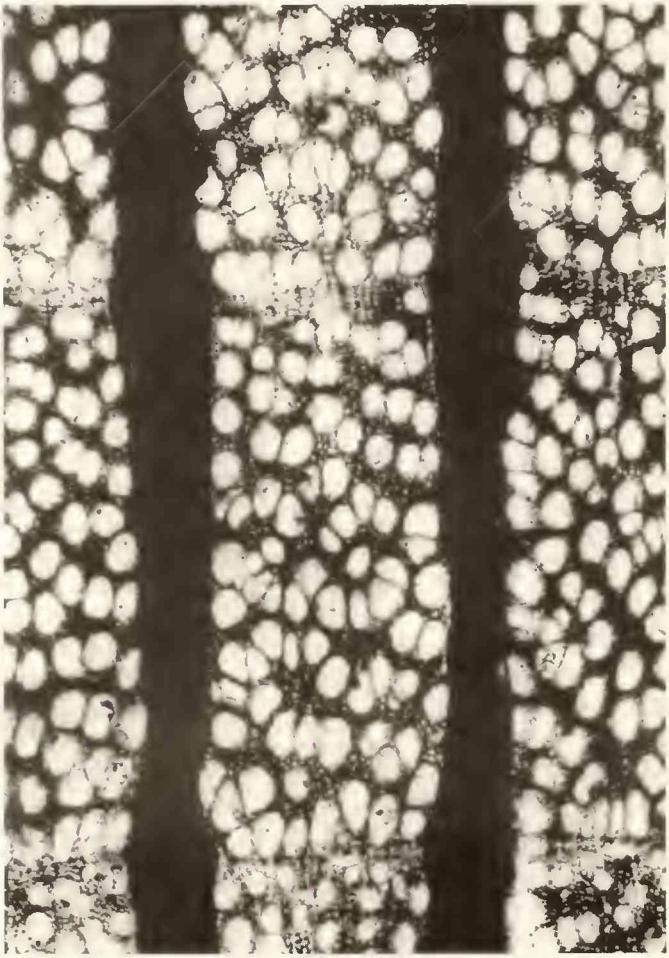

Fig. 2. Cross section (Frankenmarkt). Radially flattened latewood fibres on the growth boundaries, dark rays comparatively wide and broader at the growth rings, shape of vessel outline partly angular. × 50.

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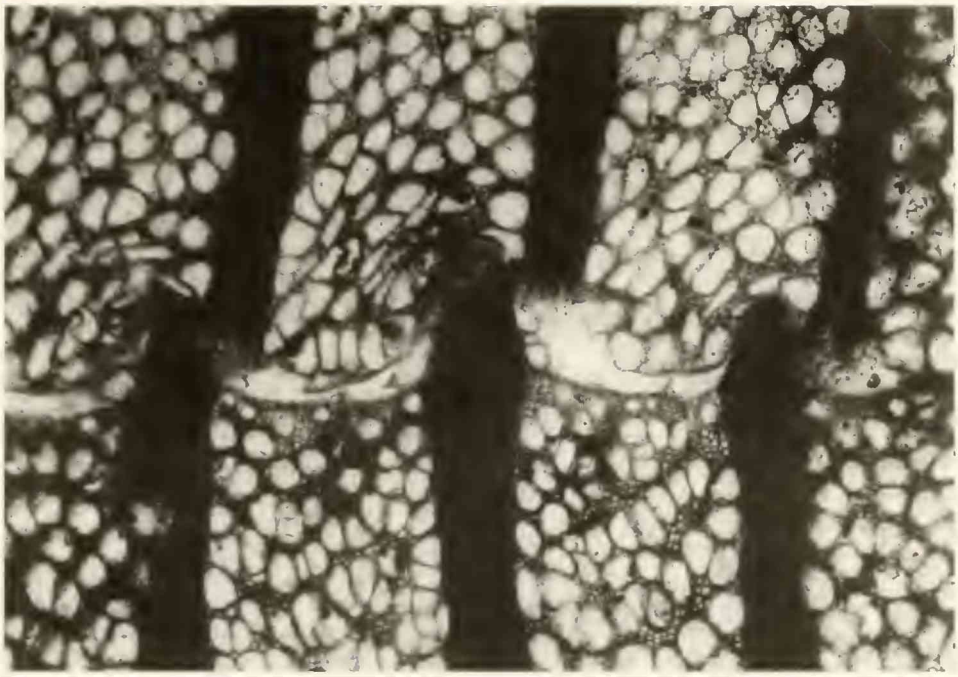

Fig. 3. Cross section (Frankenmarkt). Vessels solitary and in irregular groups, growth ring boundaries bended between the noded rays, wood tissue tangentially distorted before mineralisation. × 50.

with one exception (scalariform) exclusively simple with a single circular or elliptical opening, end wall of vessel elements transverse or oblique, locally also with truncated or tapered ends; intervessel pits opposite in horizontal rows, rarely alternate, elongated intervessel pits, e.g. 20 µm to 8 µm, opposite oval intervessel pits e.g. 6 per 75 µm transverse vessel wall, apertures invisible; vessel element length 148- 711 µm, mean 312 µm.

Rays

Visible to the naked eye, on the growth ring boundaries often abruptly swollen and broader, rays sometimes closely and vertically placed upon each other so as to appear as parts of the same ray dissected into smaller units. Multiseriate rays 3 to 21 cells (mean 13 cells), 40 to 351 µm (mean 210 µm) wide, multiseriate ray heigh 0,7 to 5,5 mm high (mean 2,1 mm), sheat and marginal cells absent; (1)-2-(3)seriate rays very rare, (1)-2seriate rays, e.g. 400 µm high, 35 µm wide; ray tissue almost homocellular, composed of procumbent cells, individual cells oval, round to polygonal in tangential section, ray cells in tangential section 12 to 39 µm high, mean 21,5 µm; ray cells thin-walled; occasionally apparently crystals in ray cells; ray quotient (proportion height to width) 6-16-(23), mean 10; ray percentage in the wood 22%; rays per mm 2-3.

Fibres

Fibres irregularly distributed in cross-section, libriform fibres tissue form only small spaces, partly a small network between the numerous vessels in cross section, cells polygonal, not thick-walled, diameter 11-18 µm.

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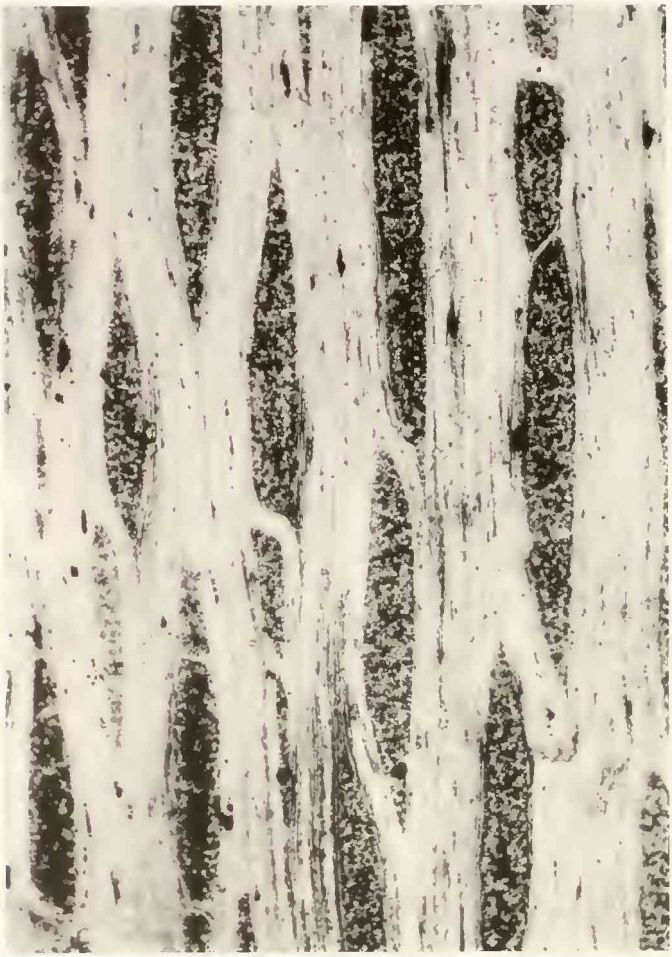

Fig. 4. Tangential section (Frankenmarkt). Rays mostly broad, sometimes closely and vertically placed upon each other. × 50.

Axial parenchyma

Parenchyma scarce paratracheal-and apotracheal diffuse, difficult to distinguish parenchyma cells from thin-walled fibres.

Occurence: Frankenmarkt, Austria, Oberösterreich, about 35 km NE of Salzburg.

Material: Silicified dicotyledonous wood, 18 × 6,5 × 4 cm, collection R. BAUMGARTNER; deposited in the Bavarian State Collection of Palaeontology and historical Geology, Munich, Inventar-Nr. BSP 1990 I 151.

Horizon: Upper Tertiary; ? reworked in glacial sediments.

Affinities

The most outstanding feature of the silicified wood is the presence of conspicuously large rays already visible with the naked eye, diffuse porousness, exclusively simple perforation

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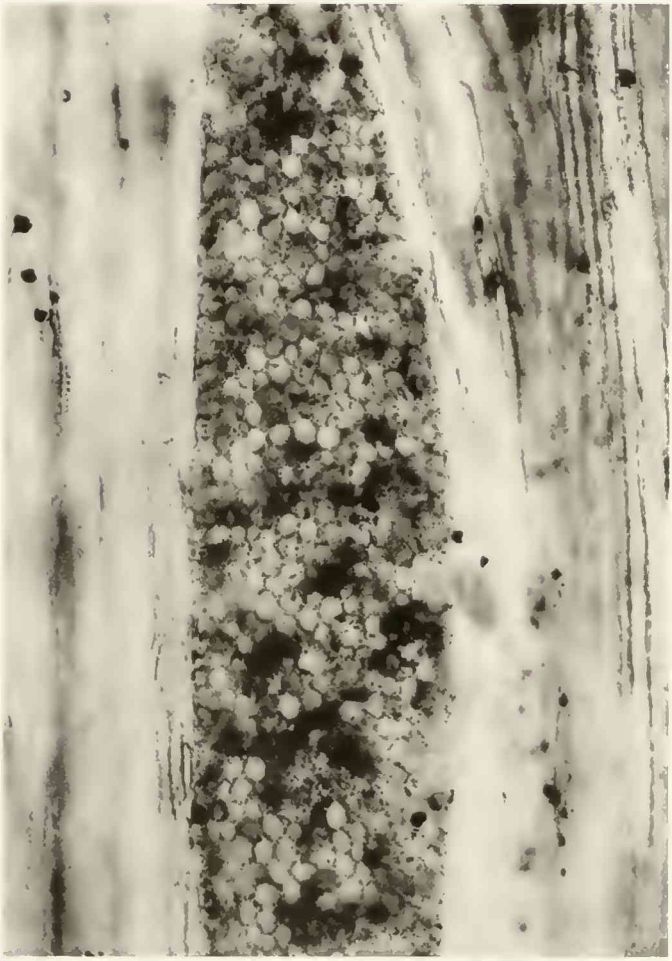

Fig. 5. Tangential section (Frankenmarkt). Broad rays up to 14 cells wide. × 125.

plates, opposite intervessel pits in horizontal rows, homocellular procumbent rays. The combination of these features and other characteristics indicate a close relationship with the genus *Platanus*. A survey of the available woods of the genus *Platanus* indicates that the nearest affinity of the fossil within the genus is with *Pl. occidentalis* L.(Tennessee, HMNr. 266) and *Pl. orientalis,* (Poland, RAKF Nr. 3968).

Vessel diameter, ray width, ray frequency and ray arrangement are variable, and even in the same silicified species examples may be found different other mean numbers (ranges). Because of this, mostly no actual measurements are given in anatomical descriptions and wood identification manuels of extant trees and shrubs. Consequently accurate measurements, as usual in palaeoxylotomic descriptions, are not always very useful in the process of identification.

The combination of features of this fossil is identical with *Platanoxylon* ANDREÁNSKY (1951), not with *Plataninium*, sensu PAGE (1968). A similarity in some features is apparently given with *Platanoxylon americanum* from the Columbia Lava Series of Vantage, e.g., vessels per sq. mm,

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Fig. 6. Tangential section (Frankenmarkt). Ray tissue almost homogenous, composed of procumbent cells. × 250.

140 to 161 (Frankenmarkt), intervessel pits opposite, cellular composition of the rays, ray percentage 25 to 22 % (Frankenmarkt). It differs, however in the absence of scalariform perforation plates.

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Fig. 7. Radial section (Frankenmarkt). Intervessel pits opposite. × 250.

3.2 The *Platanus* wood from Pfaffing

Ordnung Hamamelidales

Familie Platanaceae

Platanoxylon sp.

Organgattung: *Platanoxylon* ANDREANSKY 1951

Typusart: *Platanoxylon andreanskyi* SUSS & MÜLLER-STOLL 1977: 7-9, Abb. 1, Taf. 1, Fig. 1-4, Taf. II, Fig. 1-2.

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Minute anatomy
(Fig. 8-9)

The present description is based on 3 thin slides, maximum ca. 3,7 x 1,8 cm. The petrified secondary xylem is poorly preserved. The poor preservation, wood tissue decayed, obscures some critical anatomical features.

Growth rings

Present, visible to the naked eye, narrow, 15 growth rings, variable 0,4-3,0 mm wide, mean 1,5 mm; microscopically marked by bended boundaries and distended rays.

Vessels

Diffuse porous; vessels randomly arranged, solitary and in tangential multiples of 2 to 4; vessels more crowded and larger in the early wood, less abundant and widely spaced in the late summer wood, solitary vessels tending to be angular in outline; tangential diameter, range 31-112 µm, mean 67 µm; tangential diameter of early wood pores 53-112 µm, mean 81 µm; vessel

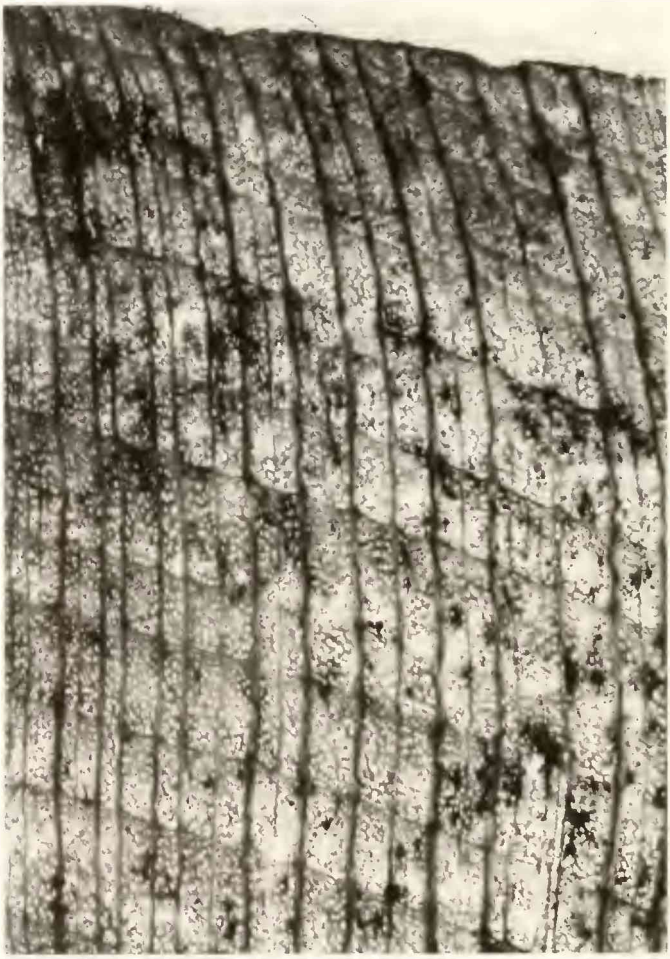

Fig. 8. Cross section (Pfaffing). Wood diffuse porous with 12 growth boundaries and dark rays. × 15.

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diameter tangential to radial in early wood e.g. 70 µm to 128 µm, 67 µm to 119 µm, 57 µm to 107 µm; tangential diameter of late wood pores 31-66 µm, mean 46 µm; vessels thin-walled; 91 vessels per sq. mm, range 80-103; perforation plates predominantly simple, occasional scalariform, 14-17 bars, opposite intervessel pits present, outline oval to elongate; vessel element length apparently 95-362 µm, mean 274 µm, end wall of vessel elements transverse, rarely something oblique.

Rays

Visible to the naked eye, partly distended on the growth ring boundaries, rays frequent closely and vertically placed upon each other so as to appear as parts of the same ray dissected into smaller units, rays almost homocellular, sheat or marginal cells absent; small rays with (1)-3 cells very rare, larger rays commonly to 16 cells (266 µm) wide, multiseriate rays 0,6-4,3 mm high, mean 2,7 mm; ray quotient (proportion height to width) of large rays (4)-7-14; cells of small rays 14-32 µm high, mean 22,3 µm; cells of larger rays 18-36 µm high, mean 23,6 µm, ray cells thin-walled; ray percentage in the wood about 26 %; rays per mm 2-3-(4).

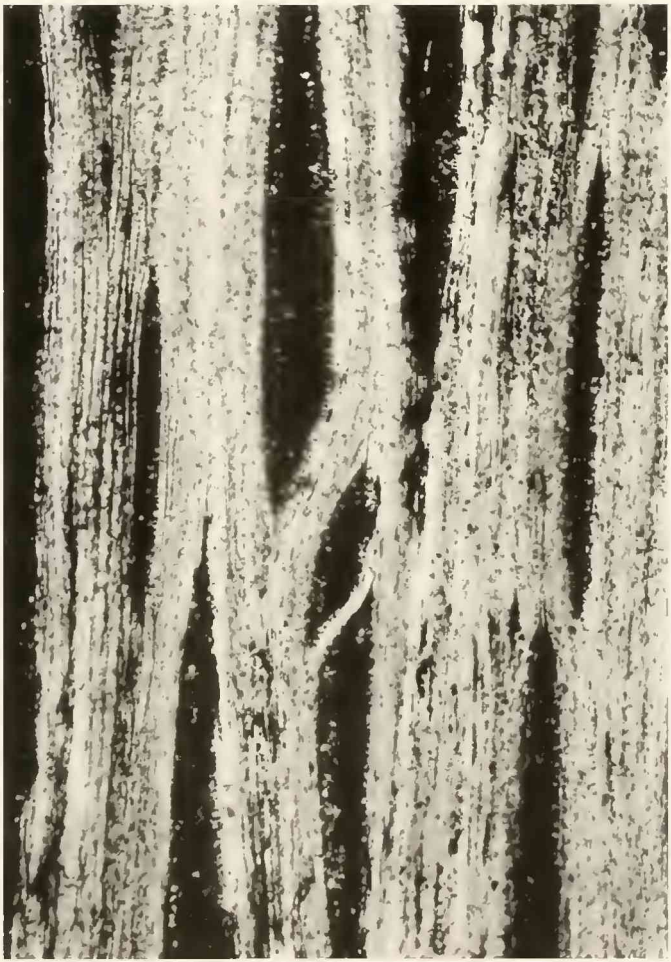

Fig. 9. Tangential section (Pfaffing). Rays mostly broad, sometimes vertically placed upon each other. × 60.

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Fibres

Poorly preserved, cells rectangular, diameter in cross section 17-24 µm.

Axial parenchyma

Parenchyma cells not preserved in detail, difficult to distinguish within the general pattern.

Occurence: Pfaffing near Munderfing, Austria, Oberösterreich, "am Rande des Kobernaußerwaldes" (letter J. MUHLBACHER, 17. 7.1972); leg. J. WERNDL, sawmill Pfaffing.

Material: A big silicified specimen, as notified, an historical border stone at the time of CHARLES THE GREAT (personel information Prof. W. JUNG, 18.12.1973); thin-section slides with Inventar-No. BSP 1972 I 25.

Horizon: Pliocene

Tab. 2. Comparison of some anatomical features of the woods described above

Anatomical features	Frankenmarkt	Pfaffing	Unterbachham
Growth rings	0,7-2,2 mm	0,4-3,0 mm	6,0-7,7 mm
Vessels			
mean per sq. mm,	161	91	78
mean tg. diameter	71µm	67 µm	65 µm
perforations	simple	simple and scalariform	simple and scalariform
intervessel pits	opposite	opposite	opposite
Rays			
(1)-2seriate	rare	rare	rare
multiseriate	21 cells	16 cells	18 cells
maximal heigh	5,5 mm	4,3 mm	3,4 mm
cellular composition	homocellular	homocellular	homocellular
height ray cells	mean 21,5 µm	mean 24,5 µm	mean 23 µm
ray quotient	6-16-23	4-7-14	5-18-27
% rays in wood	22%	32%	32-45%

Affinities

This fossil wood most closely resembles the anatomical features of the extant genus *Platanus* (diffuse porous, large rays visible with the naked eye, noded rays on growth ring boundaries, simple and scalariform perforations plates, opposite intervessel pits, homocellular rays, ray cells vertically 22-23 µm and other characteristics). The wood shows similarities with available extant microscopic samples, e.g. *Pl. orientalis* (Israel, No. 38), *Pl. occidentalis* L. (Madrid, Sp 19) and (USA, HMNr. 2032); *Pl. acerifolia* WILLD., (München, HMNr. 753).

As mentioned above (3.1), many anatomical (diagnostic) features are variable, and even in the same fossil species examples may be found different ranges. Consequently, accurate microscopic measurements are often useless in the process of identification.

The minute structure of this fossil is identical with the anatomical features of *Platanoxylon* ANDREANSKY (1951), not with *Plataninium*, sensu PAGE (1968). The fossil wood from Pfaffing, Austria, resembles in some features to the wood structure of *Platanoxylon andreanskyi* from Hungary, Mikófalva. There are only slightly differences in the mean numbers, e.g. vessels per sq. mm (100/91), vessel diameter tangential (75/67 µm), large rays (14/16 cells) wide, ray percentage in wood (24/26 %). But the fossil differs in some other anatomical aspects.

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3.3 The *Platanus* wood from Unterbachham

Ordnung Hamamelidales

Familie Platanaceae

Platanoxylon sarmaticum SÜSS & MULLER-STOLL 1977

Organgattung: *Platanoxylon* ANDREANSKY 1951

Typusart: *Platanoxylon andreanskyi*, SUSS & MULLER-STOLL 1977: 7-9, Abb. 1, Taf. 1, Fig. 1-4, Taf. II, Fig. 1-2.

Minute anatomy
(Fig. 10-15)

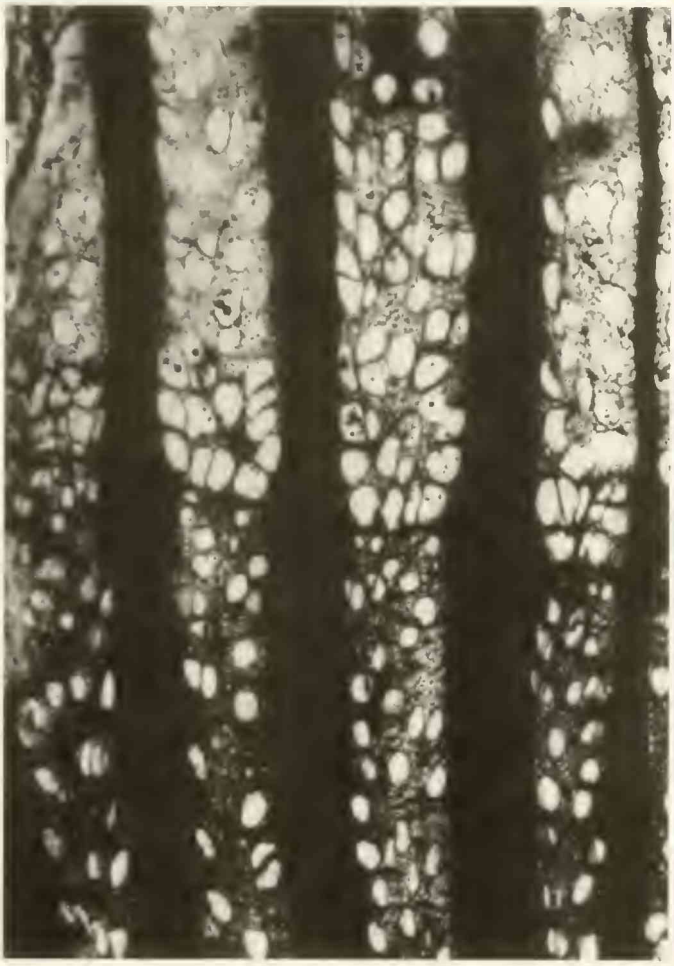

Fig. 10. Cross section (Unterbachham). Growth ring boundary distinct, vessels in the early wood are larger than those in the latewood of the previous growth ring. × 50.

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The present description is based on 6 thin slides, maximum ca. 3 x 3 cm (cross section). In comparison with the silicified wood specimens from Frankenmarkt (3.1) and Pfaffing (3.2), the longitudinal slides from Unterbachham show some more anatomically details; wood structure locally distorted by compression.

Growth rings

Present, distinct, visible to the naked eye, marked by a few rows of radially flattened fibres and distended rays; 3 relatively broad growth rings, 6,0-5,3-7,7 mm.

Vessels

Diffuse porous; vessels randomly arranged, solitary and in tangential multiples of 2 to 3, vessels more crowded and larger in the early wood, less abundant and widely spaced in the late summer wood, solitary vessels tending to be angular in outline; tangential diameter of early wood pores 82-122 µm, mean 95 µm, tangential vessel diameter of late wood pores 48-71 µm,

Fig. 11. Cross section (Unterbachham). Growth ring boundary between the dark rays, rays markedly broader on the growth ring boundary. × 125.

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vessel thin-walled; wood pores 78 per sq. mm, range 64-89, late wood pores 49 µm per sq. mm, range 27-62; perforation plates predominantly simple, occasionally scalariform, number and thickness of bars variable,(7)-12-22 bars; intervessel pits in horizontal opposite rows; vessel element length 108-362 µm, mean 294 µm, end walls of vessel elements transverse or oblique.

R a y s

Visible to the naked eye, on the growth ring boundaries often abruptly swollen and broader, some rays closely and vertically placed upon each other so as to appear as parts of the same ray dissected into smaller units; multiseriate rays 3 to 18 cells wide, mean 12 cells, 42 to 275 µm wide, mean 167 µm; 1(2)seriate rays very rare, e.g.12 cells (305 µm) high, 20-45 µm wide; ray tissue almost homocellular with sligthly tendency to heterocellular, individual cells oval to polygonal in tangential section, vertically 19-37µm, mean 23 µm, nearly all ray cells procumbent, marginal cells occasionally not procumbent, e.g. radial 71 µm, tangential 32 µm; ray cells thin-walled; solitary crystals present in procumbent cells (radial section) and in an individual

Fig. 12. Tangential section (Unterbachham). Rays mostly broad, closely associated with one another, some rays vertically placed upon each other. × 50.

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1(2)seriate ray (tangential section); ray quotient (proportion height to width) 5-18-27, mean 10; ray percentage in the wood 32-45-52%, mean 41%; rays per mm 3-4-(5).

Fibres

Fibres irregularly distributed in cross-section, libriform fibres thick-walled with small lumen, polygonal in cross-section, e.g. diameter 25 µm, lumen 6 µm.

Axial parenchyma

Parenchyma paratracheal-scanty, apotracheal diffuse, isolated cells and diffuse-in-aggregates, cells thin-walled, rectangular or flattened in cross section.

Material: Silicified dicotyledonous wood, 50 x 20 x 10 cm, collected by Dr. H. J. UNGER, 1994. Wood specimen deposited in Bayerisches Geologisches Landesamt, Munich, sectioned small samples and thin slides deposited in Bavarian State Collection of Palaeontology and historical Geology.

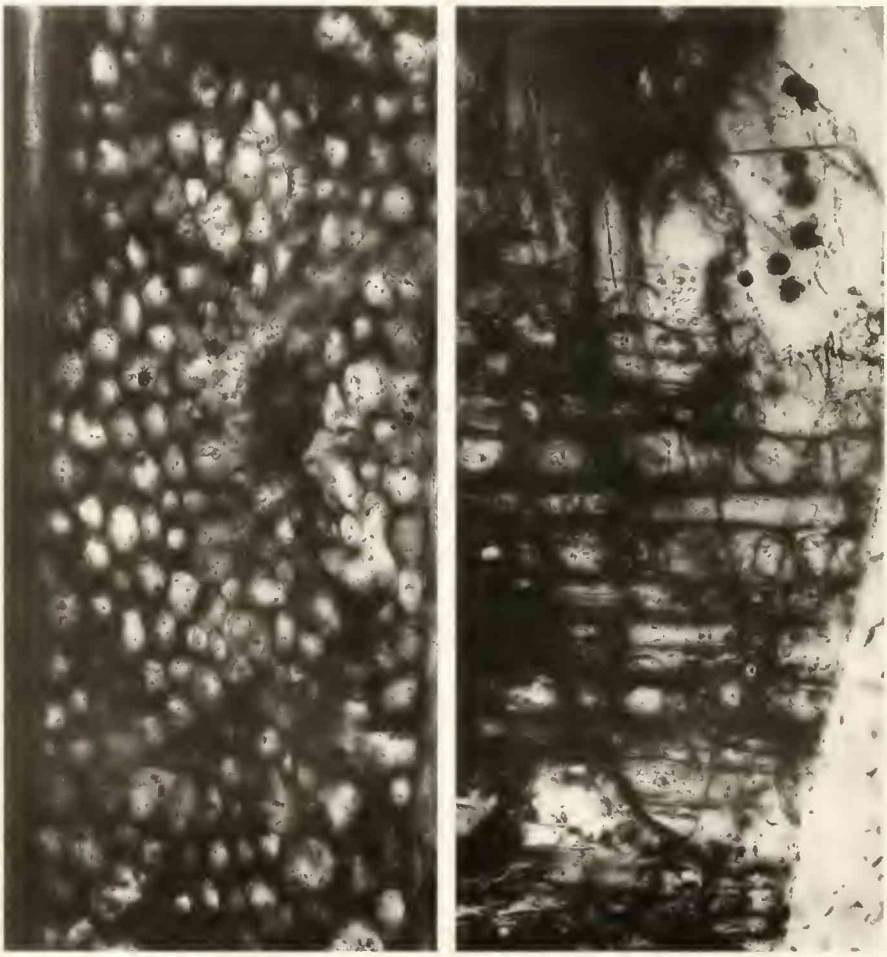

Fig. 13. Tangential section, left (Unterbachham). Ray tissue almost homocellular, partly destroyed. Radial section, right (Unterbachham). Procumbent ray cells with crystals. × 125.

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Horizon: Tertiary, Upper Freshwater Molasse, middle Series, apparently Mammal Neogen Unit, MN 6. Detailed information about the geological and stratigraphic situation of the bentonite localities in the area of Unterbachham, Landshut and Mainburg has been published by geologists (UNGER 1981, 1991; UNGER & NIEMEYER 1985a,b).

Affinities

The wood described above do not differ in any anatomical detail from the wood of extant available species of *Platanus* (Xylothek Dr. D. GROSSER). The fossil exhibits the combination of features listed as diagnostic in the above cited literatature and listed in Tab. 1.

This silicified wood markedly resembles to the wood structure of *Platanoxylon sarmaticum* from the locality Thonstetten (SELMEIER 1989). Some anatomical features in comparison (in brackets anatomical details of the wood from Thonstetten): Growth rings maximal 7,7 (4,8) mm, vessels 78 (56) per sq. mm, perforation plates predominantly simple and scalariform,

Fig. 14. Radial section (Unterbachham). Vessel perforations simple and scalariform with about 15 bars. × 250.

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intervessel pits in transverse opposite rows, 1-(2)seriate rays rare, large rays maximal 3,4 (5) mm high, height ray cells mean 23 (23) µm, ray percentage in wood 32-45%, (43)%.

Marginal ray cells occur in the wood tissue of this fossil. In the "Root identification manual of trees and shrubs", (1987), ray cells of extant *Platanus* roots are described as "heterocellular, cells in RLS procumbent, square and upright" (CUTLER et al., 1987: 140).

Comparison between fossil trunk and root wood has been investigated by SUSS & MULLER-STOLL (1977), summarized by SELMEIER (1989: 252).

Ray percentage by *Platanoxylon* trunk wood (7 species)	18-26%
Ray percentage by *Platanoxylon* root wood (5 species)	33-50%
Ray percentage by *Platanoxylon*, locality Unterbachham	32-45%

The Tertiary wood from Unterbachham described above falls within in range of structural variability of *Platanoxylon sarmaticum* and, consequently, is given that name.

Fig. 15. Radial section (Unterbachham). Left: Vessel perforations simple and scalarifom with some bars. Right: Intervessel pits opposite. × 250.

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3.4 Fossil record of *Platanus* wood in Bavaria

Up today about 30 silicified platanoid and *Platanus* wood samples were found in Upper Tertiary sediments of southern Bavaria by L. Fruth, W.-D. Grimm, H. Holzl, M. Lengl, D. Müller, F. Pfeil, K.-H. Schrettenbrunner, A. Selmeier and J. Werndl. Thin slides and most of the wood samples are deposited in the Bavarian State Collection of Palaeontology and historical Geology (BSP), Munich. The four digit number in brackets following names of places always refers to the survey map number of topographical map 1: 25000 showing where the silicified wood specimens were found.

The more than 30 fossil wood samples were collected in the following localities within southern Bavaria: Bergham (7340), Bergheim (7233), Gammelsdorf (7437), Jettingen (7528), Joshofen (7233), Landshut (7438/39), Möckenlohe (72713), Obertürken (7744), Passau (7446),

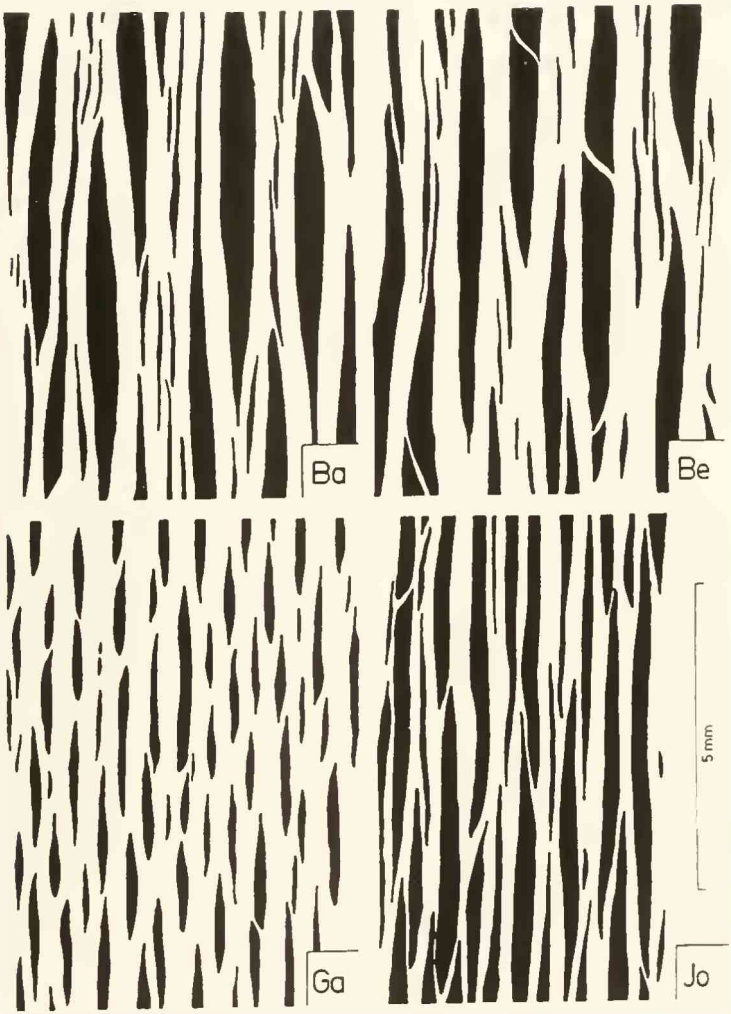

Fig. 16. Comparison of rays in tangential section from 4 different localities; Bergham (Ba), Bergheim (Be), Gammelsdorf (Ga), Joshofen (Jo).

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Prielhof (7133) - 13 specimens, leg. A. SELMEIER; Schrobenhausen (7433), Schloßberg (7445), Thonstetten (7537), SELMEIER (1989a); Unterbachern (7432) and Zanklau (7342). A comparison of the ray arrangement when viewed in tangential section is drawn in Figs. 16-17. The 30 silicified *Platanus* and platanoid woods represent only a small fraction of an extensive collection of about 5000 pieces made in the last decades. More than 2100 pieces of the BSP-collection L. LANG were cross sectioned by B. BEAUERY (1992).

Leaves and blossom rests of the family Platanaceae are known from Tertiary sediments of southern Bavaria and Austria (e.g., GREGOR 1982; JUNG 1963, 1968, 1970, 1986; KOVAR 1986; KOVAR-EDER 1988).

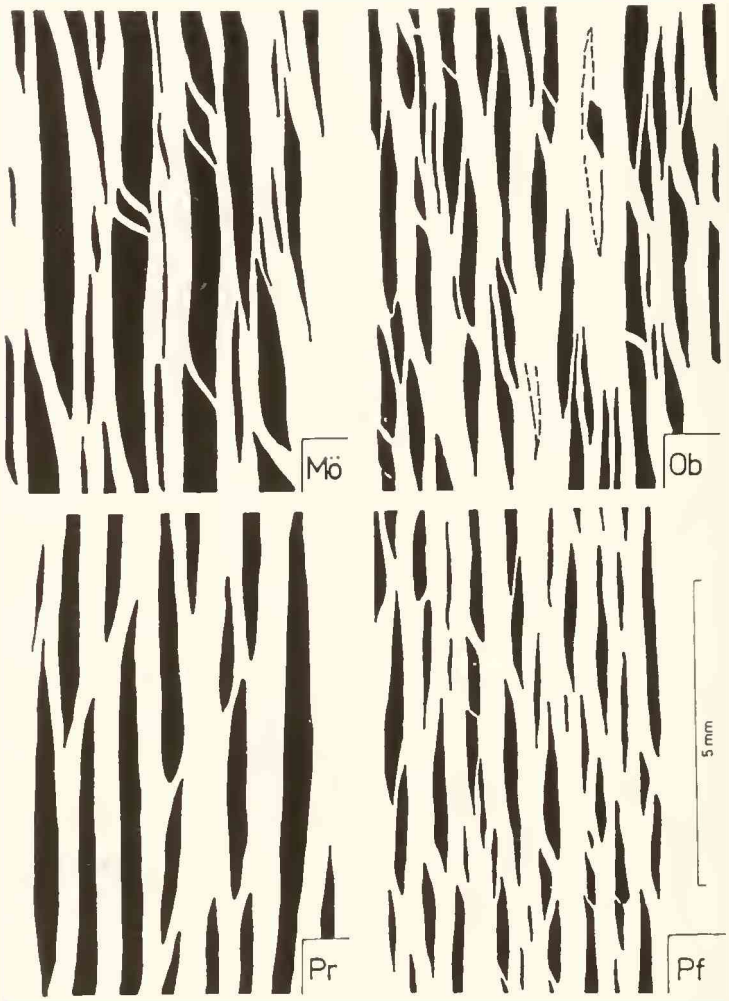

Fig. 17. Comparison of rays in tangential section from 4 different localities; Möckenlohe (Mö), Obertürken (Ob), Prielhof (Pr), Pfaffing, Austria (Pf).

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4. Discussion

The wood tissue of the three different samples from the localities Frankenmarkt, Pfaffing and Unterbachham seems to fall within the known range of variation of wood from the extant genus *Platanus*. The 3 silicified woods do not differ in any major anatomical detail from the wood of living species of *Platanus*. There can be little doubt about the similarity with extant *Platanus* species. The minute structure of the fossils from Frankenmarkt, Pfaffing and Unterbachham seems to fall within the known range of variation of wood from the extant genus.

The 3 silcified woods have distinct growth rings. It is suggested that these trees grew in a seasonal environment. Data support the hypothesis that correlations of wood anatomical features with environmental parameters have not been constant over geological time (BAAS 1990; WHEELER & BAAS 1993). External palaeoenvironmental influences on anatomical features in Cretaceous wood from Anatarctica and Alaska has been investigated by CHAPMANN (1994). Fossil wood has the potential to record several aspects of the palaeoenvironment in which it grew. It is known that the anatomical features vary considerable within a tree depending on especial position of the wood (trunk, stump, root, twig or branch). After CHAPMANN (1994: 19) it is therefore important that the grewing position of fossil fragments is exactly identified so that comparisons of wood characters between sites can be made. The three fossil wood specimens described here represent probably mature secondary xylem. But the exactly position of the three fossil fragments within the tree is unknown. In consideration of the percentage of the rays (SUSS & MULLER-STOLL 1977:43-44), the *Platanoxyylon* wood specimen of Unterbachham with 32-45% rays represents obviously secondary xylem from a root. *Platanoxylon sarmaticum* from the locality Thonstetten near Moosburg, Bavaria, also shows root structure with 37-50% ray percentage (SELMEIER 1989).

The major difference between *Plataninium* and *Platanoxylon/Platanus* (extant sycamore wood) seems to be the presence of predominantly or exclusively scalariform perforation plates by the fossil genus *Plataninium* (WHEELER, SCOTT & BARGHORN (1977: 296). Fossil forms with predominantly scalariform perforations plates have been assigned in the last decades to *Plataninium* UNGER (1842), fossil forms with numerous simple perforation plates have been placed in *Platanoxylon* ANDREÁNSKY (1951) or to extant *Platanus* (BRETT 1972: 496-497). A further difference between *Plataninium* (sensu PAGE) and *Platanoxylon/Platanus* is the frequence of uniseriate rays. *Platanoxylon/Platanus* have only occasionally 1(-2) seriate rays (Tab.1).

The fossil record for platanoid woods and Cretaceous woods (PAGE 1981: 442) support the Baileyan concept (BAILEY 1953; FROST 1930a, b) that scalariform perforation plates are more primitiv. The results of a comprehensive survey of incidences (frequency of occurence) of wood features through time has been investigated by WHEELER & BAAS (1991). The feature "exclusively scalarifom perforation plates" (1991: 282, Fig. 2) decreases in incidence from the Cretaceous to Pliocene. The *Platanoxylon* woods from Frankenmarkt (? Pliocene) and Pfaffing/Unterbachham (Upper Tertiary) support the Bayleyan concept. The genus *Platanus* apparently was undergoing complex genetic changes during Late Cretaceous and Paleogene time (WHEELER et al., 1977: 297). After SÜSS & MÜLLLER-STOLL (1975) characteristics of rays are presumably controlled more by internal (genetic) factors whereas the features of vessels are strongly dependant from environmental influences. Seasonal changes in the distribution of water in the outer growth rings were recently visualised by cryo-scanning electron microscopy using *Fraxinus mandshurica* var. *japonica* by UTSUMI et al. (1996).

MANCHESTER (1986) reviewed the fossil record and evolution of the Platanaceae. The family is abundant in the Early Tertiary of North America, records already in the Upper Cretaceas of Alasca and America (HIRMER 1942: 366-367; PAGE 1968, 1981). A great number of fossil woods belonging to the family Platanaceae are known from various localities in the world (Europe,

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North America, Japan). They are mentioned and partly critical reviewed by different authors (e.g., WHEELER et al. 1961; SUSS & MULLER & STOLL 1977: 46-58, Tab. 3; WHEELER 1991a - Fossil Database, p. 23). Fossil woods belonging to the family Platanaceae have been enumerated by PRAKASH & BARGHORN (1961) and SUSS & MULLER-STOLL (1977: 46-58). After TAYLOR & TAYLOR (1993: 761) *Platanmium* is a relatively common wood type at many localities containing *Platanus*-like leaves. Platanoid and *Platanus* woods and leave assemblages are known from the Cretaceous and Eocene of North America, from the Early and Late Tertiary of Europe (MAI 1995) and from the Palaeogene of Japan (SUZUKI 1976).

The only genus of the Platanaceae is *Platanus*. The genus Platanaceae includes about eleven species of large trees, three in southern Europe and Asia (Laos), eight in temperate North America, in Mexico and Guatemala. Five species are found only in Mexico. *Pl. orientalis* L. grows in North America, in South and Middle Europe, in Asia Minor and Iran.

Tertiary wood sites in Austria and southern Bavaria

The Molasse basin is a foreland basin located north of the European Alps. It is over 1000 km in length, extending west of Lake Geneva and east to the Carpathiens. Thousands of silicified wood specimens have been collected in the "Tertiary hilly region" in Bavaria and Austria during the last decades.

After experiencing a lapse in the second half of this century, research on fossil wood was revived by CICHOCKI (1988, 1992). In Austria there are extensive collections of silicified wood specimens. Many discovery areas and sites are recorded in papers from the last decade (CICHOCKI 1988, 1992; REITER 1989; SELMEIER 1994). The publications from CICHOCKI (1988) and REITER (1989) refer to 430 respectively 327 literary citations.

The finding sites (< 300) of Tertiary woods from Bavaria are also enumerated (SELMEIER 1989, 1997).

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