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A silicified *Pistacia* wood, Anacardiaceae, from the Upper Miocene of southern Franconian Alb, Germany

Ein verkieseltes *Pistacia*-Holz, Anacardiaceae, aus dem oberen Miozän der südlichen Frankenalb, Deutschland

By Alfred Selmeier*)

With 7 Figures

Abstract

This paper deals with a small silicified *Pistacia* wood collected from a farming field east of the village Attenfeld (map 1 : 25000 No. 7233 Neuburg a.d. Donau), southern Franconian Alb, Bavaria. It is the first xylem-anatomical record of *Pistacia*, family Anacardiaceae, in the Tertiary northalpine Molasse basin. The genus *Pistacia* indicates a Mediterranean biotope with the probability of a well defined dry season.

Kurzfassung

Dünnschliffe eines kleinen Kieselholzes zeigen die xylem-anatomischen Merkmale von *Pistacia*, Familie Anacardiaceae. Die Gattung *Pistacia* ist durch diesen Lesestein, gefunden östlich von Attenfeld (TK 7233 Neuburg a.d. Donau), im nordalpinen Molassebecken erstmals holzanatomisch nachweisbar. Das jungtertiäre *Pistacia*-Holz ist ein Beleg für ein mediterran geprägtes Biotop innerhalb der obermiozänen Vegetation.

1. Introduction

The southern Franconian Alb, situated about 70 km north of Munich, is covered to a large extent with residual loam deposits derived from different source sediments (Trappe 1998). Silicified wood remains are fairly abundant. The Tertiary sediments and silicified woods are dated Upper Miocene, Upper Freshwater Molasse; Mammal Neogene unit MN 5; 16–16,5 Ma.

Placidius Schärl (1794) reported already two centuries ago about the abundant occurence of silicified wood remains in meadows, farming fields and roads. Detailed locality information was given on these fossil woods of the southern Franconian Alb and certain aereas around the Danube river. An effort of extensive systematic collecting fossils in the southern Franconian Alb during the last century is associated primarily with the names of (fossil hunters) Ludwig

*) Prof. Dr. Alfred Selmeier, c/o Institut für Paläontologie und historische Geologie, Universität München, Richard-Wagner-Straße 10, D-80333 München. Email: a.selmeier @lrz.uni-muenchen.de

Fruth, Peter Holleis and Ludwig Lang (Holleis 1992, Holleis & Gregor 1986, Selmeier 1998; Wellnhofer 1996).

Julius Felix (1882) studied for the first time using thin slides the anatomical structure of a silicified wood from the Bavarian Molasse basin (*Sapotoxylon* sp.).

Since the publication of Felix (1882) trunklike fragments of a fern stem, coniferous, dicotyledonous and monocotyledonous taxa were described till now: *Tempskya*, an extinct fern genus (Holleis & Gregor 1986); Taxodiaceae; Dipterocarpaceae, Ebenaceae, Fagaceae, Juglandaceae, Lauraceae, Leguminosae, Platanaceae, Rosaceae, Sapotaceae, Ulmaceae; Arecaceae (Palmae). The present wood sample, identified as *Pistacia*, Anacardiaceae, is to be added.

2. *Pistacioxylon holleisii* n. sp. from Attenfeld

Anacardiaceae

Pistacioxylon Dupéron (1973)

Type species: *Pistacioxylon muticoides* Dupéron (1973) from France, found in the „Molasse de l'Agenais", formation, Chattian.

Pistacioxylon holleisii n. sp.

Material: A silicified specimen, 4,5 x 2,6 x 10 cm, weight 15 gr, color grey-yellowish to brown; 3 thin sections. Collection Historischer Verein Neuburg a. d. Donau e.V., No.VI 25. Duplicates of the material are deposited in the Bavarian State collection of Palaeontology and Geology, Munich.

Locality: Attenfeld, map 1 : 25000 No. 7233 Neuburg a. d. Donau, southern Franconian Alb, sandy field east of the village Attenfeld, 430 m NN; collected on 15.10.1983 by Peter Holleis.

Derivatio nominis: The specific epithet „*holleisii*" is dedicated to Mr. Peter Holleis for his invaluable collection of silicified wood samples from the southern Franconian Alb, Bavaria.

Age: Upper Miocene, Upper Freshwater Molasse; Mammal Neogen unit MN 5; 16-16,5 Ma.

2.1 Wood anatomical description

Specific Diagnosis

Silicified secondary xylem of a dicotyledonous wood. Growth rings distinct. Ring-porous. Vessels of early wood closely spaced, forming a 4–5-seriate zone of medium-sized pores, solitary or in radial multiples of 2–(3), tangential diameter 112 -180 µm, thin-walled tyloses common, abrupt transition to the latewood on the same growth ring. Late wood pores in a radial pattern, radial multiples and clusters, tangential diameter 10–28 µm. Vessel perforation simple, intervessel pits alternate, 7–10 µm, spiral thickening present, vessel-ray pits not visible. Axial parenchyma sparse. Rays 1–3-seriate, heterocellular, partly upright marginal cells, a single radial gum canal present. Rhomboid crystals in tyloses.

Fig. 1. Cross section. Ring porous wood with marked differences in vessel diameter between late wood and early wood. x 40.

Anatomical features

The preservation of the wood sample is relatively poor and not satisfactory concerning the clarity of its tissues, especially the longitudinal sections. Vessel-ray pits are not more visible. It was doubtful to count vessels per square millimeter separately (WHEELER 1986), doubtful to calculate an index of vessel grouping (CARLQUIST 1988) or to follow all the recommendations of the IAWA Commitee of Nomenclature (1989). However the present fossil wood retains sufficient qualitative anatomical features for the family and genus of the wood to be identified.

G r o w t h r i n g s distinct and conspicuous, visible with the naked eye, deliminated by a zone of medium-sized springwood pores; four growth rings are 2,75–4,75 (3,71) mm thick. Early wood zones with 20–35 percentage on the respective growth ring. The minimum diameter of the stem (or branch), plotted out of the weak growth ring curvatures, as being about 30 cm.

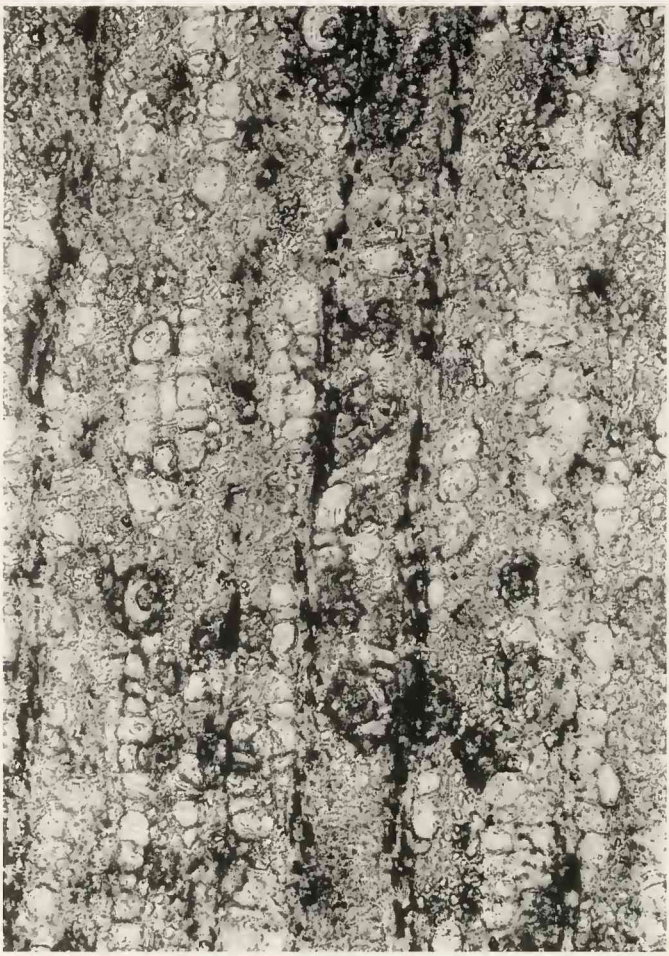

Fig. 2. Cross section. Late wood with clusters and radial multiples, ground tissue and rays poorly preserved. x 130.

V e s s e l s variable in size, the wood ring-porous, springwood vessels medium-sized, a distinct ring of closely spaced early wood pores, forming 4 –(5)-seriate zones deliminating growth rings (Fig. 1), vessels solitary or in radial multiples of 2–(3), circular to oval in cross-section, tangential diameter of solitary vessels 105–165 (117) µm, radial multiples tangential maximal 182 µm.

Abrupt transition to the latewood of the same growth ring (Fig 1), late wood pores in a radial pattern, radial multiples up to 516 µm long, vessel outline in cross section angular or quadratic, extensive clusters including probably tracheids, clusters tangential 56–126 µm, radial 140–280 µm, tangential diameter of the late wood pores 21–42 µm (Fig. 2, 3).

Perforations simple, inter-vessel pits alternate (Fig. 4, left), round to polygonal, 7–10 µm in diameter, spiral thickening present (Fig. 4, right), vessel-ray pits due bad preservation not visible. Tyloses common, thin-walled, containing rhomboidal crystals (Fig. 5), maximum diameter 63–70 µm.

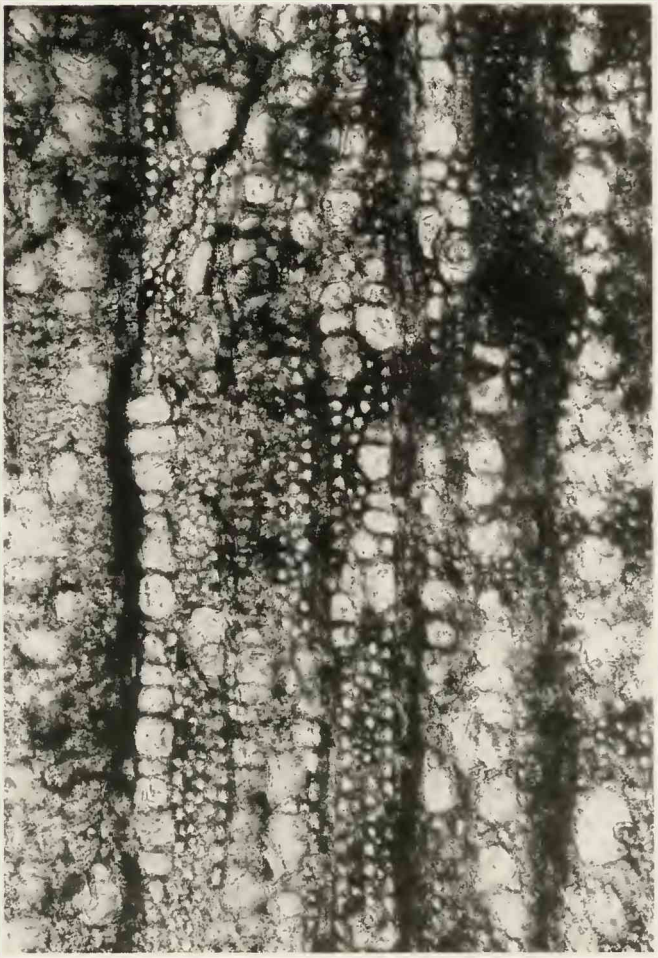

Fig. 3. Cross section. Late wood pores in long radial mutiples, fibres in radial rows forming solid tracts between rays and vessels. x 130.

Fibres medium thick, in radial rows forming solid tracts between the vessels and the rays, in cross section rounded to oval, 7–14 µm in diameter.

Axial parenchyma sparse, scanty paratracheal and probably diffuse apotracheal.

Rays 7–11/mm, 1-3-seriate, multiseriates 11-25 cells high, 170-410 (330) µm, heterocellular, composed of square, weakly procumbent or upright marginal cells and procumbent central cells, marginal cells vertical 30–45 µm; a single ray with radial gum canal clearly visible in tangential section (Fig. 6), epithelial cells present, canal orifices 51 µm, ray height 22 (309 µm) cells.

Features according IAWA list (1989): 1 3 7 10 11 13 22 23 26 36 41/42 56 60? 69 78 97 106 115 130 136 137?

2.2 Affinities

Comparison with extant woods

The combination of the anatomical features exhibited by the present fossil wood indicates a definite relation with the wood of *Pistacia* of the familiy Anacardiaceae.

Descriptions und illustrations compared: Dong & Baas 1993; Carlquist 1988; Dupéron 1973; Fahn 1953, 1955; Fahn, Werker & Baas 1986; Greguss 1959; Huber & Rouschal 1954; Ilic 1991; Jagiella & Kürschner 1987; Liphschitz, Lev-Yadun & Waisel 1985; Liphschitz & Lev-Yadun 1986; Metcalfe & Chalk 1950; Pearson & Brown 1932; Purkaystha 1996; Schultze-Motel 1966; Schweingruber 1990.

The Anacardiaceae are a large family of about 60 genera and 600 species of trees and shrubs, rarely woody climbers. The family is distributed chiefly in the tropics, few genera (*Pistacia*, *Rhus*) occurring in the Mediterranean region and partly in temperate regions of eastern Asia and America. The familiy is of considerable economic importance and includes several well known oleo-resins, gums and fruits yielding trees (*Mangifera indica* L.). The genus *Pistacia* consists of about 16 species of trees or shrubs widely distributed in the Old World from the Mediterranean region eastward to India, China and the Philippines. One species has been described from Mexico, a second occurs in Texas.

Pistacia atlantica Desf., Atlas pistache,
chinensis Bge., syn. *P. formosana* Matsum.,
*falca*ta Becc. ex Mart.,
khinjuk Stocks, syn. *P. integerrima* Stewart,
lentiscus L., mastix tree,
mexicana H.B.K., syn. *P. texana* Swingle,
mutica Fisch et Mey.,
nigricans Cr.,
officinarum Ait.,
palaestina Boiss.,
reticulata Willd.,
x *saportae* Burnat.,
terebinthus L., Cyprus Turpentine tree,
variifolia Salisb.,
vera L., source of Pistachio nuts,
weinmannifolia J. Poisson ex Franch.

Distribution of early wood pores of 10 *Pistacia* species in cross section:

Pistacia species	Growth ring boundaries	Early wood pores
P. atlantica	Distinct	One row of wide pores
P. chinensis	Distinct	One row of wide pores
P. falcata	Distinct	Two rows of wide pores
P. khinjuk	Distinct	One row of wide pores
P. lentiscus	Faint	Diffuse- to semi-ringporous
P. mutica	Distinct	Gradual decrease in pore diameter
P. x *saportae*	Distinct	Gradual decrease in pore diameter
P. terebinthus	Distinct	One row of wide pores
P. vera	Distinct	Usually several rows wide
P. weinmannifolia	Faint	Diffuse- to semi-ring porous

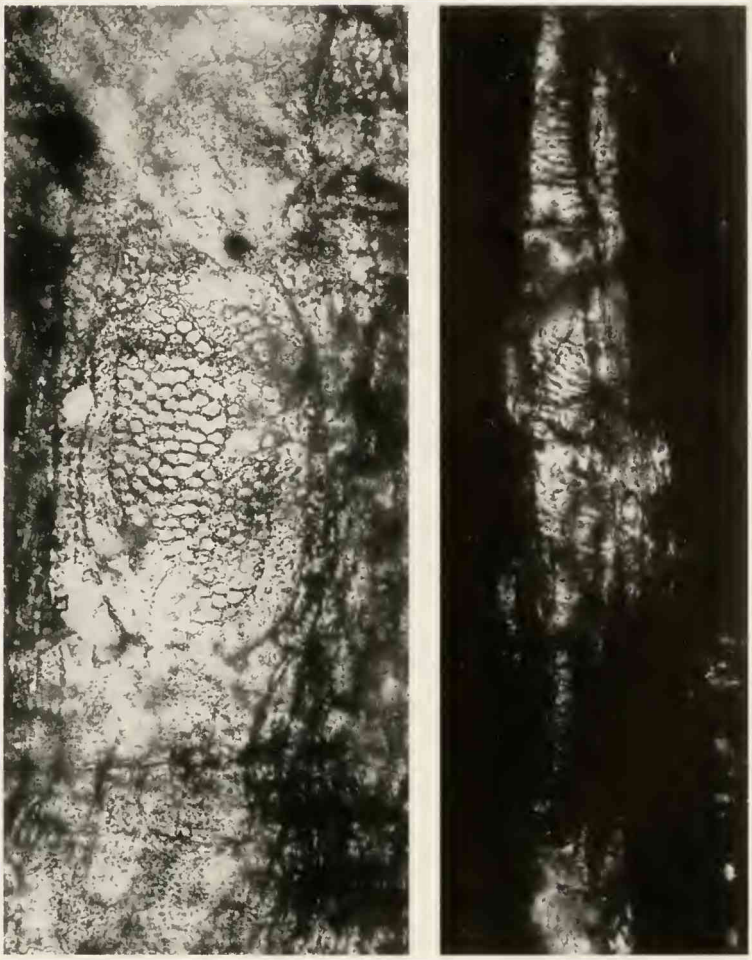

Fig. 4. Longitudinal sections. Alternate intervessel pits, left (x 250). Spiral thickening of vessel elements, rigth (x 240).

For purposes of comparison microscope slides (STERN 1988: 229–230), anatomical descriptions and photomicrographs from 12 extant *Pistacia* species were available (Literature previously cited). The nearest resemblance in cross section shows *P. vera* with several rows of medium-sized springwood pores. However, the late wood vessel arrangement of the fossil is similar to the late wood pattern of *P. terebinthus* (one row of early wood pores). In additon to this, there are a number of other differences in details between the fossil wood and the extant *Pistacia* species (FAHN, WERKER & BAAS 1986, p. 67–68; Table 4.3 and 'Key to *Pistacia* Species'). The present fossil wood shows unequivocal all the characteristic features of the genus *Pistacia*. But the assignment of the fossil to a particular extant *Pistacia* species is questionable and difficult.

Comparison with fossil woods

So far, only a single Tertiary wood of the genus *Pistacia* is recorded (WHEELER 1991a, b): *Pistacioxylon muticoides* DUPÉRON (1973), collected in the region of Grateloup, Lot-et-

Fig. 5. Tangential section. Small vessel elements with simple perforations and alternate pits, tyloses in medium-sized vessel with rhomboid crystal (arrows). x 180.

Garonne, South-West of France. *Pistacioxylon holleisii* resembles *Pistacioxylon muticoides* DUPÉRON in fundamental structure. However, it differs distinctly from the present fossil even in cross section: A single row of medium-sized early wood pores in *P. muticoides* DUPÉRON and 4 rows of early wood pores with 20-35 percentage of a growth ring in *P. holleisii* (Fig. 7). Other anatomical features, as ray size and shape or the late wood pattern, are also distinct different. The present sample is described under the fossil genus *Pistacioxylon* DUPÉRON (1973) and is specifically named as *Pistacioxylon holleisii* n.sp. The specific epithet is dedicated to Mr. PETER HOLLEIS, who found the specimen.

Tertiary remains (fruits, leaves) from *Pistacia* species are reported from different European brown coal mines (KIRCHHEIMER 1957, KILPPER 1968, MAI 1995). Tertiary pollen records: *Pistacia lentiscus* type and *P. vera* type (KRUTZSCH 2000).

Pleistocene leave remains in the Aegean, Greece, from Thera and Nissiros: *Pistacia lentiscus* with *Olea europaea* and *Tamarix* sp. (VELITZELOS et al. 2000).

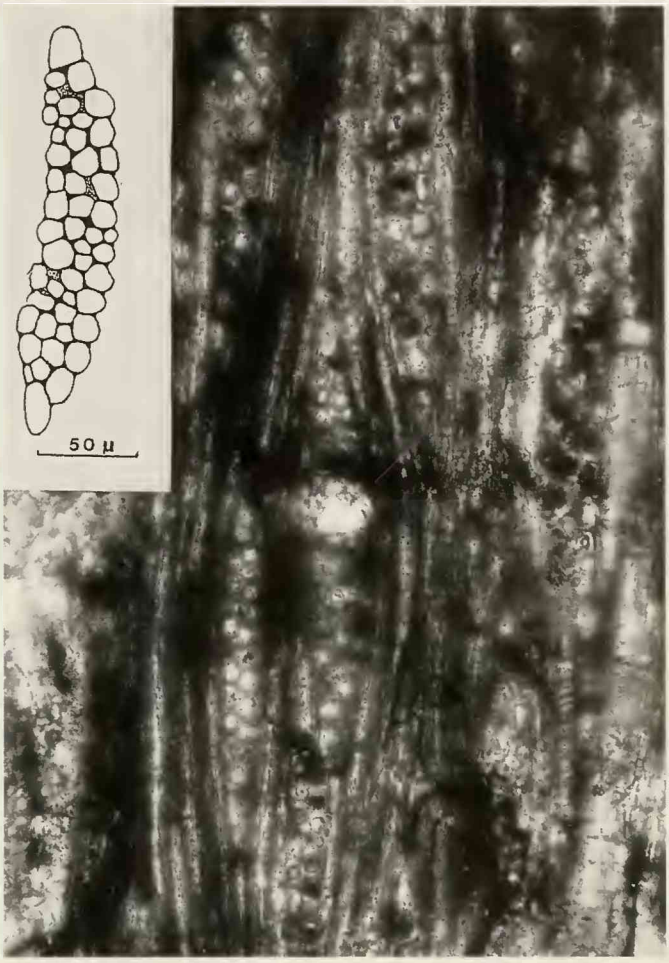

Fig. 6. Tangential section. Horizontal, radial gum canal with epithelial cells, rays mainly 2–3 seriate. x 230. – Different shape of rays in *Pistacioxylon muticoides* DUPÉRON 1973 (drawing).

2.3. Discussion

Growth rings

The identification of a Tertiary *Pistacia* wood confirms for the first time its existence in the northalpine Molasse basin. The *Pistacia* wood, distinctly ring porous, exhibits marked seasonal growth of a Mediterranean biotope. *Pistacioxylon holleisii* n. sp. may be added to the other silicified Tertiary wood species concerning a relative dry environmental construction described previously (*Crataegus, Dichrostachys*; SELMEIER 1984,1986,1988). The present fossil wood seems to be part of a tree or a thick branch, but not from a root. The growth ring boundaries are only weakly bended, the plotted diameter is presumable ca. 30 cm.

Annual wood ring development in maquis trees of Israel (Greece, Italy, France) was studied in 8 species of the genera *Ceratonia*, *Crataegus*, *Pistacia* and *Quercus*, which make up the principal compounds of the maquis of Israel (FAHN 1953, 1955; LIPHSCHITZ et al. 1985, 1986).

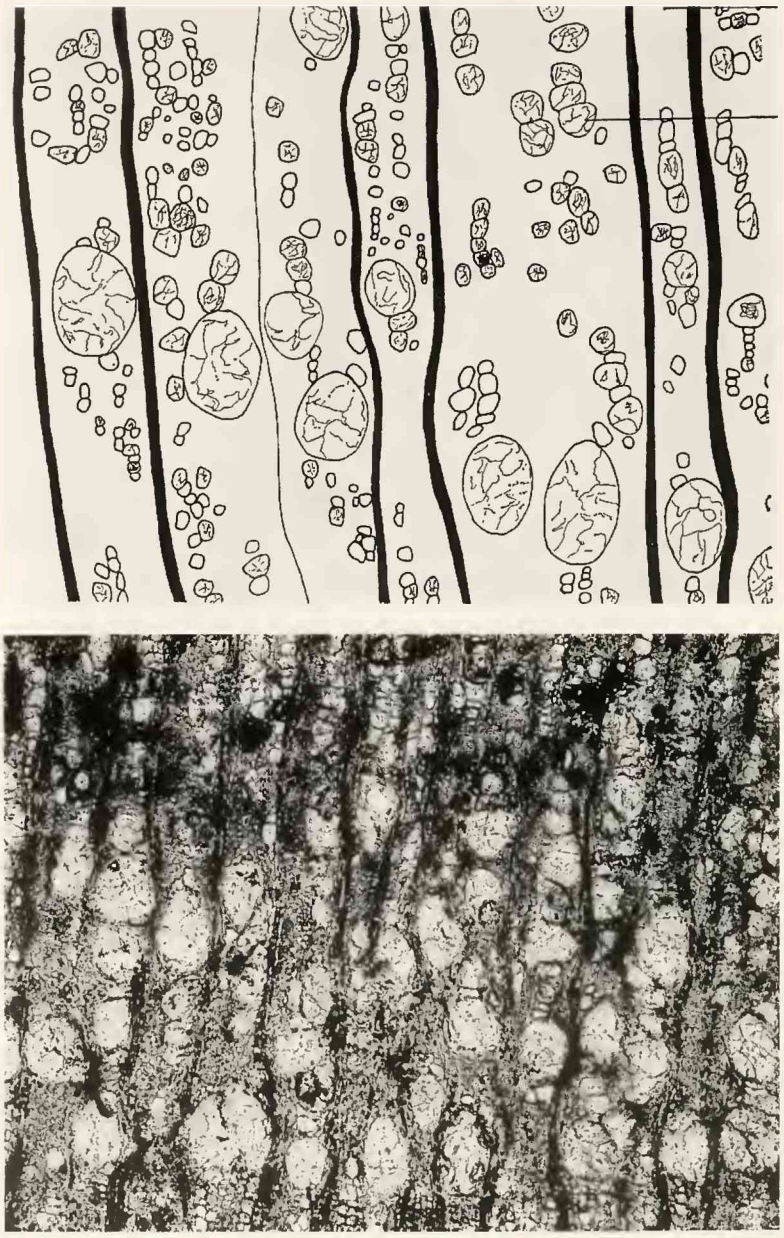

Fig. 7. Comparison of cross sections. *Pistacioxylon muticoides* DUPÉRON 1973 (above) and *Pistacioxylon holleisii* n. sp (below). x 60.

Two separate seasons of cambial activity with both summer and winter rest periods were distinguished in plants of *Pistacia lentiscus*. Under natural conditions xylem was produced in most cases during two separate seasons of the year (spring and autumn).

Ecological considerations

Detailed wood anatomical surveys (incidence of some wood anatomical features) exist for only few areas of the world. In recent years however, sufficient data have been accumulated to allow some trentative generalization.

Mediterranean species are subjected to a long dry period, but enjoy an annual rainfall of 400 –1,000 mm. Most of the Mediterranean species have simple vessel perforations and both solitary pores and radial vessel multiples with clusters. Fibre-tracheids are most common in the Mediterranean maquis. Many extant species from arid habitats show two vessel size classes like *Pistacioxylon holleisii* n. sp. as a presumed adaption to both safe and efficient xylem sap condition. Both vessel frequency and vessel diameter are relevant to the conductivity of a unit of functioning sapwood. Spiral or helical thickenings on the vessel walls are most common in the Mediterranean woody flora, e.g. *Pistacia*. The two vessel size classes of *Pistacia*, a) medium-sized solitary vessels in early wood, b) small vessels in a radial pattern and clusters in the late wood, can be considered of adaptive value: high transpiration rates during active growth (water is available), necessity of anatomical features insuring the safety of vessels during dry periods.

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