FOSSIL WOODS FROM THE TERTIARY OF ASSAM

U. PRAKASH & P. P. TRIPATHI*
Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

Fossil woods resembling modern woods of *Homalium, Sterculia, Vitex,* and a member of Lauraceae are described here from the Tipam sandstones of Rath Tila, near the town of Hailakandi, district Cachar, Assam. Modern equivalents of all these fossils are still found in the forests of Assam or Chittagong. The fossil woods of *Homalium* and *Vitex* are known for the first time from India and abroad.

INTRODUCTION

IN the present communication petrified dicot woods of *Homalium, Vitex, Sterculia* and a member of Lauraceae are described from near the town of Hailakandi (24°26′ N; 92°32′E) district Cachar, Assam. In addition to these, the fossil woods of *Adenanthera, Swintonia* (Prakash & Tripathi, 1969a), *Gluta-Melanorrhoea* (Prakash & Tripathi, 1969b), *Mangifera, Pometia, Lagerstroemia* (Prakash & Tripathi, 1970a), *Diospyros-Maba, Anisoptera* (Prakash & Tripathi, 1970b) and *Careya* and *Barringtonia* (Prakash & Tripathi, 1972) have already been recorded from the Tipam sandstones near the town of Hailakandi.

The age of these fossil woods is Upper Miocene being derived from the Tipam sandstones exposed near the town of Hailakandi in Rath Tila (Evans, 1932).

This work has been completed with the help of the modern wood slides so generously made available to the authors for comparison at the Wood Anatomy Branch of the Forest Research Institute, Dehra Dun. The authors wish to express their sincere appreciation to Mr K. Ramesh Rao, Officer Incharge, Wood Anatomy Branch of the Institute, for this kindness.

SYSTEMATIC DESCRIPTION

FLACOURTIACEAE

Homalioxylon gen. nov.

1. *Homalioxylon assamicum* sp. nov.

Pl. 1, Figs. 1, 3, 5, 6; Text-figs. 1, 2.

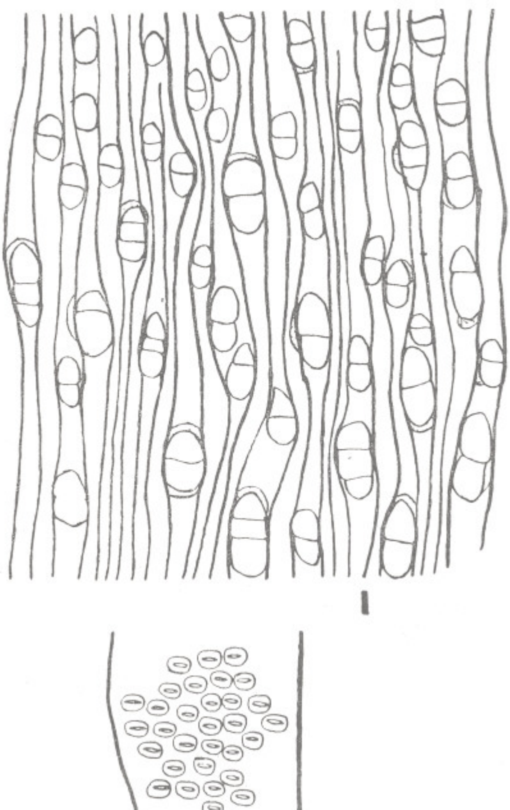
The present fossil wood is represented by a single piece of mature, secondary xylem measuring 4 cm. in length and 3 cm. in diameter. It shows satisfactory preservation.

Topography — Wood diffuse-porous (Pl. 1, Fig. 1). *Growth rings* indistinct. *Vessels.* small to large, mostly in radial rows of 2-5, sometimes solitary (Pl. 1, Fig. 1), evenly distributed, 11-14 vessels per sq. mm., contiguous with the rays on one or both the sides; tyloses absent. *Parenchyma* scanty paratracheal, limited to one or two cells around some vessels (Pl. 1, Fig. 6; Text-fig. 1). *Xylem rays* fine to medium, 1-5 (mostly 3-4) cells (Pl. 1, Fig. 3) and 12-100 μ wide, 12-16 per mm.; ray tissue heterogeneous (Pl. 1, Figs. 3, 5); uniseriate rays 2-12 cells and 100-844 μ high, 12-20 μ wide, homocellular, consisting only of upright cells; multiseriate rays, 2-5 (mostly 3-4) cells and 44-100 μ wide, 7-52 cells and 320-1240 μ high, heterocellular, consisting of procumbent cells through the median thickened portion and 1-7 marginal rows of upright cells at one or both the ends (Pl. 1, Fig. 3); end to end ray fusion quite frequent. *Fibres* aligned in radial rows.

Elements — Vessels thinwalled, the walls 4-5 μ thick, t.d. 32-160 μ, r.d. 48-220 μ, oval to irregular in shape due to pressure during fossilization, those in radial multiples flattened at the places of contact (Pl. 1, Fig. 1; Text-fig. 1); vessel-members short to medium, 250-950 μ in length, with tailed or truncated ends; perforations simple; intervessel pit-pairs small, 4-5 μ in diameter, bordered, alternate, with linear apertures (Text-fig. 2); vessel-ray and vessel-parenchyma pits not preserved. *Parenchyma cells* thinwalled, 50-170 μ in length, 20-30 μ in diameter. *Ray cells* thinwalled, procumbent cells 15-20 μ in tangential height, 40 130 μ in radial length; upright cells 30-50 μ in tangential height and 20-30 μ in radial length; cells frequently crystalliferous (Pl. 1, Fig. 3). *Fibres* libriform to semi-libriform with small lumen (Pl. 1, Fig. 1), the walls 5-10 μ thick, septate, angular in the cross section, 18-30 μ in diameter, 600-1500 μ in length; interfibre pits not preserved.

*Now Lecturer in Botany, M.L.K. Post-Graduate College, Balrampur, Gonda.

Affinities — The most important anatomical features of the present fossil wood are: vessels small to large mostly in short radial rows of 2-5, sometimes solitary; perforations simple; intervessel pit-pairs small, 4-5 μ in diameter, bordered, alternate, with linear apertures; parenchyma scanty paratracheal with 1-2 cells around some of the vessels; xylem rays 1-5 (mostly 3-4) seriate, with heterogeneous ray tissue and frequent crystalliferous ray cells; and semi-libriform to libriform, septate fibres. Taking into consideration all these important anatomical features, the present fossil wood shows nearest resemblance to the modern wood of *Homalium* Jacq. of the family Flacourtiaceae (Pearson & Brown, 1932; Metcalfe & Chalk, 1950; Chowdhury & Ghosh, 1958).



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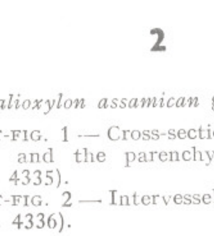

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Homalioxylon assamican gen. et sp. nov.

TEXT-FIG. 1 — Cross-section showing vessel distribution and the parenchyma pattern. × 25. (slide no. 4335).

TEXT-FIG. 2 — Intervessel pit-pairs. × 330. (slide no. 4336).

A survey of all available woods of the genus *Homalium* indicates that the closest affinity of the fossil within this genus is with *H. tomentosum* Benth. This survey included the study of thin sections of *Homalium zeylanicum* Benth., *H. minutiflorum* Kurz, *H. grandiflorum* Benth., *H bhamoense* Cubitt & Smith, *H. tomentosum* Benth., and the published description and photographs of *H. dictyoneuron* Pierre. (Lecomte, 1926, Pl. 57), *H. tomentosum* Benth. (Pearson & Brown, 1932, pp. 36-39, Fig. 15; Metcalfe & Chalk, 1950, p. 120, Fig. 31E; Chowdhury & Ghosh, 1958, pp. 49-51), *H. aylmeri* Hutch. & Dalz., *H. letestui* Pellegr. *H. aubreville* Keay and *H. molle* Stapf. (Brazier & Franklin, 1961, p. 38; Normand, 1960, Pl. 117, 118), *H. bhamoense* Cubitt & Smith, *H. grandiflorum* Benth., *H. minutiflorum* Kurz and H. *zeylanicum* Benth. (Chowdhury & Ghosh, 1958, pp. 49-51, Pl. 9, Fig. 49).

The present fossil wood resembles the modern wood of *Homalium tomentosum* in the size, shape and distributional pattern of the vessels, in the perforation plates, in the intervessel pit-pairs, in the parenchyma distribution and in the structure of the xylem rays and the fibres.

Because of the close resemblance of the present fossil wood with the wood structure of *Homalium tomentosum* Benth., the fossil wood is assigned to a new form genus *Homalioxylon* and specifically named as *H. assamicum* sp. nov.

As far as the authors are aware, the present finding is the first record of a fossil wood of *Homalium* from India and abroad.

The genus *Homalium* Jacq. consists of 200 species (Willis, 1966, p. 552) widely distributed throughout the tropics, with numerous representatives in Africa, the Indo-Malayan region and in tropical America. At least 10 species are indigenous to India and Burma. *Homalium tomentosum* Benth. with which the present fossil wood shows nearest resemblance grows in Northern Circars, Ganjam district of Madras, Chittagong and all over Burma (Gamble, 1902, p. 380; Pearson & Brown, 1932, p. 36; Chowdhury & Ghosh, 1958, pp.. 49-50). In relation to the geographic locale of the fossil, the nearest tree species of *Homalium* is *H. bhamoense* which occurs in Cachar, Kamrup, Garo Hills and Chittagong (Kanjilal, Kanjilal & Das, 1934).

Generic Diagnosis

Homalioxylon gen. nov.

Wood diffuse-porous. *Growth rings* distinct to indistinct, when distinct delimited by thicker walled fibres and smaller vessels. *Vessels* small to large, solitary as well as in radial rows of 2 or more; vessel-segments short to medium; perforations simple; intervessel pit-pairs, small, alternate, bordered, oval to angular, with linear orifices. *Parenchyma* scanty paratracheal. *Xylem rays* 1-5 or more cells wide; ray tissue heterogeneous; uniseriate rays composed of upright cells; multiseriate rays consisting of procumbent cells through the median portion and 1-several marginal rows of upright cells at one or both the ends; ray cells crystalliferous. *Fibres* libriform to semi-libriform, septate.

Genotype —*Homalioxylon assamicum* sp. nov.

SPECIFIC DIAGNOSIS

Homalioxylon assamicum sp. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* small to large, t.d. 32-60 μ, r.d. 48-220 μ, mostly in radial rows of 2-5, sometimes solitary, evenly distributed; vessel-members short to medium, 250-950 μ in length, with tailed or truncated ends; perforations simple; intervessel pit-pairs small, 4-5 μ in diameter, bordered, alternate with linear apertures. *Parenchyma* scanty paratracheal, occurring as 1-2 cells in association with some vessels. *Xylem rays* fine to medium, 1·5 (mostly 3-4) seriate, 12-100 μ in width, 12-16 per mm; ray tissue heterogeneous; uniseriate rays 12-20 μ wide, 2-12 cells and 100-844 μ high, homocellular, consisting only of upright cells; multiseriate rays, 2-5 (mostly 3-4) seriate, 44-100 μ wide, 7-52 cells and 320-1240 μ high, heterocellular, consisting of procumbent cells in the median thickened portion with 1-7 marginal rows of upright cells at one or both the ends; ray cells frequently crystalliferous; end to end ray fusion frequent. *Fibres* libriform to semi-libriform, the walls 5-10 μ thick, septate, angular in cross section, 18-30 μ in diameter, 600-1500 μ in length.

Holotype — B.S.I.P. Museum No. 33922.

Locality — Kuchila (24°38′ N; 92°35′ E), near the town of Hailakandi, district Cachar, Assam.

Sterculiaceae

Sterculioxylon Krausel, 1939.

2. *Sterculioxylon dattai* sp. nov.

Pl. 2, Figs 7, 9, 11, 12.

The present species is based on a piece of decorticated secondary wood measuring about 5 cm. in length and a few centimetres in diameter showing good preservation.

Topography — *Wood* diffuse-porous (Pl. 2, Fig. 12). *Growth rings* indistinct. *Vessels* small to large, majority solitary (Pl. 2, Figs. 7, 12)‘ occasionally in pairs, 6-9 per sq. mm., heavily tylosed (Pl. 2, Fig. 11), sometimes with brownish-black deposits. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, forming 1-4 (mostly 1-2) cells thick sheath around some of the vessels (Pl. 2, Fig. 11); apotracheal parenchyma in fine, 1-2 cells thick, closely spaced lines, forming a sort of irregular reticulum, sometimes occurring as solitary cells, present also around the gum ducts, sometimes forming tangential bands, 1-6 (mostly 3-4) cells thick (Pl. 2, Fig. 7, 11, 12). *Xylem rays* fine to moderately broad (Pl. 2, Fig. 9), 1-10 (mostly 6-9) seriate, 17-140 μ in width, 4-6 per mm.; ray tissue heterogeneous (Pl. 2, Fig. 9); uniseriate rays, 17-32 μ in width, 2-15 cells and 160-500 μ high, homocellular, consisting of upright cells only; multiseriate rays 2-10 cells and 24-140 μ in width, 9-101 cells and 250-1500 μ high, heterocellular, consisting of procumbent cells in the median thickened portion and 1-3 rows of upright cells at one or both the ends; sheath cells frequently present at the flanks (Pl. 2, Fig. 9). *Fibres* not aligned in distinct radial rows. *Gum canals* frequent, traumatic, vertical, soliary as well as in tangential bands of 2-6 (Pl. 2. Fig. 12), 180-384 μ in diameter.

Elements — *Vessels* thick walled, the walls about 8-12 μ thick, t.d. 72-310 μ, r.d. 96-348 μ, the solitary vessels round to circular in cross section (Pl. 2, Fig. 11), those in pairs flattened at the places of contact; vessel-members 90-750 μ in length with truncated or short tailed ends; perforations simple; intervessel pit pairs indistinct; vessel-parenchyma and vessel-ray pits not preserved. *Parenchyma cells* thinwalled, 12-32 μ in, diameter, 40-208 μ in length, storied. *Ray cells* thinwalled, tangential height of procumbent cells 11-20 μ, radial length 30-80 μ;

upright cells 20-40 μ in tangential height and 12-18 μ in radial length. *Fibres* thin-walled, the walls about 4-5 μ thick, non-septate, showing storied tendency, angular in cross section, 25-30 μ in diameter, 500-2000 μ in length; interfibre pits not observed.

Affinityies—The mo st important structural feature of the fossil wood under investigation, is the presence of traumatic, vertical gum canals. There are 25 families of the dicotyledons in which traumatic, vertical gum canals have been observed (Metcalfe & Chalk, 1950, p. 1353). These are:

Ampelidaceae	Mimosaceae
Bombacaceae	Morinagaceae
Boraginaceae	Myrtaceae
Burseraceae	Papilionaceae
Caesalpiniaceae	Proteaceae
Combretaceae	Rosaceae
Elaeagnaceae	Rutaceae
Elaeocarpaceae	Sapindaceae
Euphorbiaceae	Simaroubiaceae
Hamamelidaceae	Sterculiaceae
Lecythidaceae	Styracaceae
Malvaceae	Vochysiaceae
Meliaceae	

Taking into consideration the parenchyma pattern, the ray structure and the nature of the fibres, it is with the members of the family Sterculiaceae only that the present fossil wood shows resemblance. On further scrutiny the genus *Sterculia* shows nearest affinity. Detailed microscopic examination of thin sections from the modern woods of fifteen available species of *Sterculia* has been made in order to find out the nearest living counterpart of the present fossil wood. The species examined are *Sterculia alata* Roxb., *S. angustifolia* Roxb., *S. campanulata* Wall. ex Mast., *S. coccinea* Roxb., *S. colorata* Roxb., *S. foetida* Linn. *S. fulgens* Wall., *S. guttata* Roxb., *S. oblonga* Mast., S. *ornata* Wall., *S. populifolia* DC., *S. rhinopetala* K. Schum., *S. scaphigera* Wall., *S. urens* Roxb. and *S. villosa* Roxb. Besides this, published description and photographs of *Sterculia alata* Roxb., *S. villosa* Roxb., *S. campanulata* Wall., ex. Mast. *S. urens* Roxb. (Pearson & Brown, 1932; Desch, 1954; Henderson, 1953), S. *blancoi* Rolfe, *S. carthaginensis* Cav. (Metcalfe & Chalk, 1950), *S. rhinopetala* K. Schum., *S. oblonga* Most. (Henderson, 1953; Kribs, 1959; Brazier & Franklin, 1961), *S. hypochra* Pierre (Lecomte, 1926, Pl. 29), *Sterculia* spp. (Desch, 1954, pp. 581-583), *S. foetida* Linn., *S. colorata* Roxb., *S. populifolia* Roxb., *S. angustifolia* Roxb., *S. guttata* Roxb., *S. ornata* Wall., *S. coccinea* Roxb., *S. fulgens* Wall. and *S. scaphigera* Wall. (Chowdhury & Ghosh, 1958).

From this detailed study, it is evident that the present fossil wood shows resemblance with the wood structure of the modern species *Sterculia angustifolia* Roxb., *S. guttata* Roxb., *S. ornata* Wall. and *S. villosa* Roxb. These species are somewhat similar anatomically and can not be distinguished easily. Among these species, it is with *Sterculia villosa* that the present fossil wood shows nearest resemblance. The fossil wood resembles the modern wood of *Sterculia villosa* in the shape, size and distributional pattern of the vessels, in the perforation plates, in the parenchyma distribution and in the structure of the xylem rays and the fibres.

As the present fossil wood resembles the modern wood of *Sterculia* Linn. of the family Sterculiaceae, it is placed in the form genus *Sterculioxylon Krausel* (1939).

Only five species of fossil woods related to the modern genus *Sterculia* are known so far (Boureau, 1957a, p. 679). These are *Sterculioxylon aegyptiacum* Krausel (1939) from the Tertiary of Egypt, *S. giarabubense* (Chiarugi) Krausel (1939) from the Lower Oligocene to Lower Miocene of Somaliland, North Africa, *S. rhenanum* Muller-Stoll (1949) from the Eocene of South-West Germany, *S. freulonii* Boureau (1957b) from the Tertiary of Sahara, and *S. foetidense* Prakash (1973) from the Tertiary of Burma.

Sterculioxylon aegyptiacum differs from the present fossil wood in having slightly larger (r.d. 100-300 μ, r.d. 100-430 μ) vessels which are solitary or in groups of 2-3 or 4 cells and in less broader (2-6-7 seriate) and shorter (only up to 60 cells high) xylem rays. In the present fossil wood, the vessels are small to large (t.d. 72-310 μ, r.d. 96-348 μ), majority solitary, occasionally in pairs, the xylem rays are 1-10 (mostly 6-9) seriate, heterocellular, 17-140 μ in width, 2-101 cells and 160-1500 μ high, and the fibres are non-libriform and non-septate. *S. giarabubense* also differs markedly in possessing smaller vessels (165-245 μ in diameter), in having vasicentric parenchyma only, and in less broader (1-5) seriate) xylem rays. Similarly, *S. rhenanum* differs from the present fossil wood in the presence of growth rings and in having smaller vessels (t.d. 110-200 μ, r.d. 150-300 μ). *S. freulonii* Boureau (1957b) is also distinct in possessing smaller vessels (t.d. 120-200 μ, r.d. 200-300 μ) and libriform fibres, in the absence of paratracheal parenchyma, and in having less broader (1-6 seriate) xylem rays. Lastly *S. foetidense* also differs from *S. dattai* in having larger (t.d. 160-400 μ, r.d. 240-480 μ) vessels and in less broader (1-8 seriate) and somewhat higher xylem rays.

As the present fossil wood is quite distinct from all the species of *Sterculioxylon* Krausel (1939) known so far, it is described here as a new species, *Sterculioxylon dattai*. This species is named after Mr. A. N. Datta, Officer Incharge, Vijnan Mandir, Hailakandi, Assam, who helped the authors in collecting the fossil woods.

The genus *Sterculia* consists of 300 species (Willis, 1966, p. 1074) distributed throughout the tropics, and reaches its best development in tropical Asia (Pearson & Brown, 1932, p. 145). The species *Sterculia villosa* Roxb. with which the present fossil wood shows its nearest resemblance, is a medium-sized to large tree of the tropical forests reaching its best development in the Andamans and Burma, where it attains a height of 18-24 m. and a girth of 1·5-2·5 m. In India proper it is a much smaller tree reaching only 1-1·5 m. in girth in favourable localities in Uttar Pradesh. It ascends to over 1,000 m. and is found throughout India, Burma and the Andamans except in the arid regions (Chowdhury & Ghosh, 1958, p. 217).

SPECIFIC DIAGNOSIS

Sterculioxylon dattai sp. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* moderately small to very large, t.d. 72-310 μ, r.d. 96-348 μ, majority solitary, occasionally in pairs, round to circular, 6-9 per sq. mm., heavily tylosed; vessel-members 90-750 μ long, with truncated or tailed ends; perforations simple. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric forming 1-4 (mostly 1-2) cells thick sheath around some of the vessels; apotracheal parenchyma abundant, in fine, 1-2 cells thick, closely spaced lines forming a sort of irregular reticulum, sometimes occurring as solitary cells, also present around the gum ducts, and forming tangential bands, 1-6 (mostly 3-4) cells thick; parenchyma strands storied. *Xylem rays* fine to moderately broad, 1-10 (mostly 6-9) seriate, 17-140 μ in width, 4-6 per mm; ray tissue heterogeneous; uniseriate rays 17-32 μ in width, 2-15 cells and 160-500 μ high, homocellular consisting of upright cells only; multiseriate rays 2-10 cells and 24-140 μ in width, 9-101 cells and 250-1500 μ high, heterocellular, consisting of procumbent cells in the median thickened portion and 1-3 rows of upright cells at one or both the ends; sheath cells present. *Fibres* non-libriform, thin walled, the walls about 4-6 μ thick, non-septate, angular in cross-section, 25-30 μ in diameter, 500-2000 μ in length, storied. *Gum canals* frequent, traumatic, vertical, solitary, sometimes arranged also in tangential rows of 2-6, t.d. 180-350 μ, r.d. 200-384 μ.

Holotype — B.S.I.P. Museum No. 33912.

Locality — Sultanicherra (24°18′N; 92°33′ E), near the town of Hailakandi, district Cachar, Assam.

VERBENACEAE

Vitexoxylon Ingle, 1972 emend.

3. *Vitexoxylon miocenicum* sp. nov.

Pls. 3-4, Figs. 13,15,17-19

The fossil wood consists of a single piece of petrified mature secondary xylem measuring 5 cm. in length and 4 cm. in diameter. It shows good preservation.

Topography — *Wood* diffuse-porous (Pl. 3, Fig. 13). *Growth rings* distinct, delimited by thicker walled fibres and smaller vessels. *Vessels* moderately small to very large, majority solitary, often in short radial multiples of 2-3 (mostly 2) (Pl. 3, Fig. 13), 12-18 per sq. mm., tylosed, brown gummy deposits also present. *Parenchyma* paratracheal mostly scanty to vasicentric, forming 1-4 (mostly 2-3) cells thick sheath around some of the vessels, rarely confluent joining the adjacent vessels (Pl. 3, Figs. 13, 17). *Xylem rays* broad to fine, 1-6 (mostly 3-4) seriate (Pl. 3, Fig. 15), 12-144 μ in width, 14-19 per mm.; ray tissue weakly heterogeneous (Pl. 3, Fig. 18); uniseriate rays 18-30 μ in width, 1-5 cells and 20-80 μ high, homocellular, consisting only of upright cells; multiseriate rays 2-6 (mostly 3-4) seriate, 25-144 μ in width, 2-62 cells and

109-2400 μ high, homocellular and heterocellular, when homocellular consisting only of procumbent cells, when heterocellular consisting of procumbent cells in the middle portion and 1-2 (mostly 1) marginal rows of upright cells at one or both the ends (Pl. 3, Fig. 15). *Fibres* aligned in more or less distinct radial rows between the two consecutive xylem rays (Pl. 3, Fig. 13).

Elements — *Vessels* thickwalled, the walls about 5-10 μ thick, t.d. 70-210 μ, r.d. 81-322 μ, the solitary vessels round to oval, those in radial multiples flattened at the places of contact; vessel-members 448-800 μ long, with truncated or tailed ends; perforations simple; intervessel pit-pairs small, 4-6 μ in diameter, bordered, alternate with linear-lenticular apertures (Pl. 4, Fig. 19); vessel-parenchyma pits numerous, opposite, large, 15-20 μ in diameter, simple and more or less elliptical in shape; vessel-ray pits not seen. *Parenchyma cells* thin walled, 21-39 μ in diameter, 109-161 μ in length. *Ray cells* thinwalled, procumbent cells 20-56 μ in tangential height, 72-160 μ in radial length; upright cells 48-64 μ in tangential height and 32-52 μ in radial length. *Fibres* thick walled, the walls about 4-7 μ thick, sometimes appearing thinwalled due to cell wall degradation, semi-libriform to libriform, septate, angular in cross-section, 12-16 μ in diameter, 624-1240 μ in length; interfibre pits not preserved.

Affinities — Structural features of the fossil wood indicate, after extensive comparison, that its closest affinities are with the wood of the modern genus *Vitex* Linn. of the family Verbenaceae (Pearson & Brown, 1932, pp. 803-812; Metcalfe & Chalk, 1950, pp. 1035-1038; Kribs, 1959; pp. 161-162).

A survey of all available woods of the genus *Vitex* indicates that the nearest affinity of the fossil within this genus is with the wood of *Vitex canescens* Kurz. This survey included the study of thin-sections of *Vitex negundo* Linn., *V. altissima* Linn., *V. limonifolia* Wall., *V. canescens* Kurz, *V. pubescens* Heyne ex Wall., *V. peduncularis* Wall., *V. leucoxylon* Schan. and *V. glabrata* F. Muell., supplemented by published description and photographs of *Vitex altissima* Linn., *V. peduncularis* Wall. and *V. leucoxylon* Linn. (Pearson and Brown, 1932, pp. 805-811, Figs. 253-255), *V. coriaceae* C.B. Clarke (Desch, 1954, p. 628), *V. pubescens* Heyne ex Wall. (Lecomte, 1926, Pl. 65; Desch, 1954, p. 628), *V. parviflora* Jussieu, *V. aherniana* Merrill (Kanehira, 1924, pp. 44-45), *V. keniensis* Turrill, *V. fosteri* C.H. Wright, *V. lignum-vitae* A. Cunn. (Metcalfe & Chalk, 1950, pp. 1036-1037, Figs. 248B & H), *V. micrantha* Gurke (Normand, 1960, Pl. 154), *V. gaumeri* Green, *V. kuylenii* Standl., *V. cooperi* Standl., *V. pachyphylla* Baker (Kribs, 1959, pp. 161-162, Figs. 473-475).

The present fossil wood resembles the modern wood of *Vitex canescens* Kurz in the size and distributional pattern of the vessels, in the perforation plates and the intervessel pit-pairs, in the parenchyma distribution and the fibre and ray structure.

As the present fossil wood shows anatomical characters of the extant genus *Vitex* Linn., it has been assigned to form genus *Vitexoxylon* and specifically named as *V. miocenicum* sp. nov. Recently Ingle (1972) described a fossil wood as *Vitexoxylon indicum* from the Deccan Intertrappean series of Mandla district in Madhya Pradesh. From its photographs and text-figures, it does not appear to show any affinities with the wood of *Vitex*. However, it would be appropriate to say more about its relationship only after the examination of its type slides. Therefore, the present finding is the first authentic record of a fossil wood of *Vitex* from India and abroad. As the description given by Ingle (1972) does not properly diagnose and include all the woods of *Vitex*, an emended diagnosis for the genus *Vitexoxylon* Ingle is being given here.

The genus *Vitex* Linn. consists of 250 species (Willis, 1966, p. 1184) distributed in the tropical and warm temperate regions of both the hemispheres, but from the standpoint of timber production the importance of this genus is mainly centered in the Indo-Malayan region. At least, 15 species grow in the Indian region (Pearson & Brown, 1932, p. 803). The species *Vitex canescens* Kurz, with which the present fossil wood shows nearest affinity, grows in Assam and dry forests of Burma (Gamble, 1902, p. 541).

EMENDED GENERIC DIAGNOSIS

Vitexoxylon Ingle emend. Prakash & Tripathi

Wood diffuse-porous. *Growth rings* distinct, delineated by thicker walled fibres and/or terminal parenchyma and smaller vessels. *Vessels* small to large, solitary as well as in short radial multiples, round to oval; perforations simple; intervessel pit-pairs, bordered, alternate, with linear to lenticular apertures. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma scanty to vasicentric rarely confluent, joining adjacent vessels; apotracheal parenchyma diffuse and terminal if present. *Xylem rays* 1-7 or more cells wide; ray tissue heterogeneous to homogeneous. *Fibres* non-libriform to libriform; septate or nonseptate.

SPECIFIC DIAGNOSIS

Vitexoxylon miocenicum sp. nov.

Wood diffuse-porous. *Growth rings* distinct, delineated by thicker walled fibres and smaller vessels. *Vessels* thick walled, the walls about 5-10 μ thick, t.d. 70-210 μ, r.d. 81-322 μ, mostly solitary, often in short radial rows of 2-3 (mostly 2), solitary vessels round to oval in cross-section, 12-18 vessels per sq. mm.; tyloses present; vessel-members 448-800 μ in length, with truncated or tailed ends; perforations simple; intervessel pit-pairs small, 4-6 μ in diameter, bordered, alternate, with linear-lenticular apertures; vessel-parenchyma pits simple, numerous, opposite, large, 15-20 μ in diameter. *Parenchyma* paratracheal, mostly scanty to vasicentric, forming 1-4 (mostly 2-3) cells thick sheath around some of the vessels, rarely confluent joining two adjacent vessels. *Xylem rays* fine to brord, 1-6 (mostly 3-4) seriate, 12-144 μ in width, 14-19 per mm.; ray tissue weakly heterogeneous; uniseriate rays 18-30 μ in width, 1-5 cells and 20-80 μ high, homocellular, consisting only of upright cells; multiseriate rays 2-6 (mostly 3-4) seriate, 25-144 μ in width, 2-62 cells and 109-2400 μ high, homocellular and heterocellular, when homocellular consisting only of procumbent cells, when heterocellular consisting of procumbent cells in the median thickened portion and 1-2 (mostly 1) marginal rows of upright cells at one or both the ends. *Fibres* semilibriform to libriform, the walls 4-7 μ thick, septate, angular in shape, 12-16 μ in diameter, 624-1240 μ in length.

Holotype — B.S.I.P. Museum No. 33927.

Locality — Kartikcherra (24°20′N; 92° 31′E), near the town of Hailakandi, district Cachar, Assam.

LAURACEAE

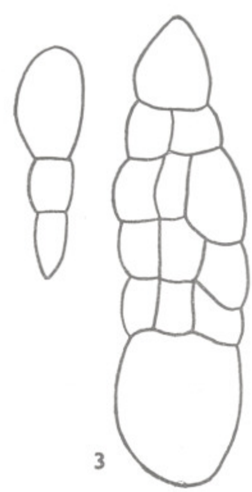
***Lourinoxylon* Felix, 1883**

4. *Laurinoxylon tertiarum* sp. nov.

Pl. 4, Figs. 20-25; Text-fig. 3

Fossil wood is represented by a single specimen of secondary wood about 6 cm. in length and 3 cm. in diameter. The preservation is quite satisfactory.

Topography — *Wood* diffuse-porous (Pl. 4, Fig. 23). *Growth rings* distinct, delimited by thicker walled fibres (Pl. 4, Fig. 22). *Vessels* moderately small to medium-sized, solitary as well as in short radial rows of 2-4 (Pl. 4, Figs. 22, 23), 8-10 per sq. mm.; tyloses present, brownish deposits probably gum also occasionally present. *Parenchyma* paratracheal, scanty to vasicentric, forming 1-3 (mostly 1-2) cells thick sheath around some of the vessels, sometimes aliform rarely confluent, joining 2-3 adjoining vessels (Pl. 4, Fig. 23). *Xylem rays* 1-3 (mostly 2) seriate (Pl. 4, Fig. 24; Text-fig. 3), 6-8 per mm.; ray tissue heterogeneous (Pl. 4, Fig. 26); uniseriate rays 12-32 μ broad, 1-4 cells and 80-120 μ high, homocellular, composed wholly of upright cells; multiseriate rays 2-4 cells and 40-80 μ in width, 4-24 and 140-600 μ in height, heterocellular, composed of procumbent cells in the median thickened portion and upright cells at one



3

Laurinoxylon tertiarum sp. nov.

TEXT-FIG. 3 — Two xylem rays with swollen oil cells. × 330. (slide no. 4346).

or both the ends (Pl. 4, Figs. 24); special oil-bearing marginal secretory cells quite frequent, resulting from the enlargement of upright cells (Pl. 4, Figs. 24, 25; Text-fig. 3); secretory cells 100-180 μ high along the grains. *Fibres* aligned in distinct radial rows. *Oil cells* 24-52 μ in diameter associated with the parenchyma, the xylem rays and the fibres (Pl. 4, Figs. 24, 25; Text-fig. 3).

Elements — *Vessels* thin walled, the walls about 4-5 μ thick, t.d. 60-152 μ, r.d. 80-200 μ, the solitary vessels round to oval in cross-section, those in radial multiples flattened at the places of contact (Pl. 4, Fig. 23); vessel-members 384-624 μ in length, with truncated or tailed ends; perforations simple as well as scalariform, the latter with 8-10 bars (Pl. 4, Fig. 21); intervessel-pit-pairs large, 8-10 μ in diameter, bordered, border round to oval with lenticular apertures (Pl. 4, Fig. 20); vessel-parenchyma and vessel-ray pits not preserved. *Parenchyma cells* thinwalled, 10-15 μ in diameter, 30-60 μ in length. *Ray cells* thinwalled, procumbent cells 16-32 μ in tangential height, 80-120 μ in radial length; upright cells 40-48 μ in tangential height, 12-20 μ in radial length. *Fibres* non-libriform to semi-libriform, the walls about 2-6 μ thick, septate, angular in cross-section, 25-30 μ in diameter, 700-1620 μ in length; interfibre pits not preserved.

Affinities — The most important diagnostic feature of the present fossil wood is the presence of oil cells in the parenchyma, fibres and the xylem rays. Oil cells have been reported in the following 15 families among the dicotyledons (Metcalfe & Chalk, 1950, p. 1354). These are:

Annonaceae	Monimiaceae
Aristolochiaceae	Myristicaceae
Burseraceae	Piperaceae
Canellaceae	Rutaceae
Dilleniaceae	Saurauiaceae
Hernandiaceae	Schisandraceae
Lauraceae	Winteraceae
Magnoliaceae	

Taking into consideration the septate fibres found in the present fossil wood, the following eight families only need further comparison:

Burseraceae	Monimiaceae
Hernandiaceae	Myristicaceae
Lauraceae	Piperaceae
Magnoliaceae	Rutaceae

The families Burseraceae and Rutaceae can be easily distinguished from the present fossil wood in possessing exclusively simple perforations and intercellular canals.

The family Hernandiaceae can also be separated from the present fossil wood in having oil cells in the parenchyma only. The families Magnoliaceae, Monimiaceae and Piperaceae can also be distinguished from the fossil wood under investigation in the presence of oil cells in the xylem rays only. The family Myristicaceae is also quite distinct from the present fossil wood in possessing oil cells only in the parenchyma and xylem rays. In addition to this, the family Myristicaceae possesses tanniniferous tubes in the xylem. Therefore, it is only with the family Lauraceae that the present fossil wood resembles most (Kanehira, 1924, pp. 46-47; Tupper, 1927, pp. 520-525; Janssonius, 1928, pp. 5-292; 1930, pp. 293-835; Pearson & Brown, 1932, pp. 823-857; Dadswell & Eckersley, 1940, pp. 9-48; Metcalfe & Chalk, 1950, pp. 1145-1156; Stern, 1954, pp. 1-72; Desch, 1957, pp. 239-250). From a detailed comparison with the modern lauraceous woods it is seen that the present fossil wood is nearer to the woods of *Dehaasia cuneata* Bl., *Cinnamomum caudatum* Nees., *C. glanduliferum* Meissn. and *C. pauciflorum* Nees. in a number of features.

The study of wood structure of the family Lauraceae has received considerable attention by several wood anatomists, although, such investigations have been confined to describing specialized tissues in this family and the anatomical structure of individual species or groups. Macbride (1931) has pointed out that morphologically and anatomically species within a genus of the family Lauraceae often differ more from each other than they do from members of other genera.

Dadswell and Eckersley (1940) distinguished the Australian woods of the Persoideae (*Cinnamomum, Litsea* and *Persea*) from those of Lauroideae (*Beilschmiedia, Cryptocarya* and *Endiandra*) largely by means of the presence of concentric bands of parenchyma in the latter and their absence from the Persoideae. They also noted that the anatomical differences between genera are not clear cut and it is difficult to list features by which the various genera in each sub-group may be readily classified. It was found that species from two different genera were in some cases more similar than species with the same genus.

According to Metcalfe and Chalk (1950) the family Lauraceae is a remarkably uniform family throughout in its wood anatomy, and though some individual species, such as *Ocotea rodiaei* Mez, can be comparatively easily distinguished, the genera are by no means sharply defined.

Stern (1954) and Desch (1957) have studied the modern woods of a large number of species of the family Lauraceae and have remarked that individual genera of the family Lauraceae can not be distinguished.

An extensive study of the modern woods of the family Lauraceae was carried out by the authors at the Xylarium of the Forest Research Institute, Dehra Dun, and also at the Birbal Sahni Institute of Palaeobotany, Lucknow, which indicated that there are no clear cut anatomical structures in different genera of this family due to which it is difficult to separate them from one another.

Since taxonomic entities in this family are ill-defined groupings, and it is not possible to discern the limits of variation in wood patterns in any meaningful way, an unknown can be compared only with a known specimen and not with a generic complex. In short for our purposes only the family itself can be considered the significant taxon. For this reason it may be more useful in the future to define fossil wood species on the basis of only the few characters that are significant in modern lauraceous woods.

The name *Ulminium diluviale* was applied by Unger (1842) to a fragment of fossil wood which was later found by Felix (1883) to have the characteristics of a laurel wood rather than of elm as Unger had thought. After examining a fragment from the collection from which Unger had obtained his original specimen, Felix changed the name of this wood to *Laurinoxylon diluviale*. Süss (1958) agreed with his identification and suggested that the name *Laurinoxylon* Felix be conserved over *Ulminium* Unger to include all fossil woods anatomically similar to the modern woods of the family Lauraceae so as to avoid a lot of nomenclatural confusion.

Süss (1958) studied all the fossil woods of Lauraceae so far described and reclassified them into three groups (Süss, 1958, pp. 38-42). Those showing definite relationship with the family Lauraceae have been referred to the form genus *Laurinoxylon* Felix (1883). These as well as those recorded by Süss (1958), Huard (1967) and Selmeier (1967, 1968) are being listed below. The two fossil woods of Lauraceae described by Page (1967) as *Ulminium pattersonensis* and *U. mulleri* from the Upper Cretaceous of California are transferred here to *Laurinoxylon* and included in the following list:

1. *Laurinoxylon tigurinum* (Schuster) Berger (1950); Upper Cretaceous, Germany.
2. *L. radiatum* (Schonfeld) Berger (1953b); Upper Cretaceous, Germany.
3. *L. hofmannae* Berger (1950); Upper Cretaceous, Austria.
4. *L. weylandii* Berger (1953b); Upper Cretaceous, Austria.
5. *L. pattersonensis* (Page, 1967) comb. nov. Upper Cretaceous, California.
6. *L. mulleri* (Page, 1967) comb. nov. Upper Cretaceous, California.
7. *L. antiquum* (Felix) Berger (1950); Cretaceous ?, Hungary.
8. *L. haasii* (Wetzel) Berger (1953b); Upper Cretaceous, Germany.
9. *L. linderoides* Schonfeld (1933); Cretaceous or Tertiary, Germany.
10. *L. bakeri* Berry (1924); Eocene, Texas, U.S.A.
11. *L. algovicum* (Schuster) Süss (1958); Upper Oligocene, Germany.
12. *L. hasenbergense* Süss (1958); Middle to Upper Oligocene, Germany.
13. *L. bergeri* Süss (1958); Middle to Upper Oligocene, Germany.
14. *L. endiandroides* Süss (1958); Middle to Upper Oligocene, Germany.
15. *L. litseoides* Süss (1958); Middle to Upper Oligocene, Germany.
16. *L. microtracheale* Süss (1958); Middle to Upper Oligocene, Germany.
17. *Laurinoxylon* sp. Süss (1958); Oligocene, Germany.
18. *L. czechense* Prakash, Brezinova & Buzek (1971); Oligocene, Czechoslovakia.
19. *L. nectandroides* Krausel et Schonfeld (1924); Miocene, Holland.
20. *L. desioi* Chiarugi (1929); Miocene, Libyen.
21. *L. machiliforme* (Watari) Süss (1958); Lower Miocene, Japan.
22. *L. ehrendorferi* Berger (1953a); Lower or Middle Miocene, Greenland.
23. *L. aniboides* Greguss em. Süss (Süss & Mädel, 1958); Lower Miocene, Hungary.

24. *L. müller-stoll* Greguss em. Süss (Süss & Mädel, 1958); Lower Miocene, Hungarv

25. *L. seemannianum* Mädel (Süss & Mädel, 1958; Selmeier, 1967, 1968); Upper Miocene, Bavaria, ?Mio-Pliocene, Lower Bavaria, South Germany.

26. *Laurinoxylon* sp. Selmeier, 1967; Upper Miocene, Bavaria, South Germany.

27. *L. ebergi* (Platen) Süss (1958); Miocene, Colorado, U.S.A.

28. *L. iwamiense* (Watari) Süss (1958); Miocene, Japan.

29. *L. kuteense* (Watari) Süss (1958); Miocene, Japan.

30. *L. parenchymatosum* Schonfeld (1956) Pliocene, Germany.

31. *L. perfectum* Huard (1967); Neogene, France.

32. *L. intermedium* Huard (1967); Neogene, France.

33. *L. compressum* Huard (1967); Neogene, France.

34. *L. diluviale* (Unger) Felix (1883); Tertiary, Bohemia.

35. *L. L. aromaticum* Felix (1884); Tertiary, Hungary.

36. *L. meyeri* (Felix), Süss (1958); Tertiary, New Guinea.

37. *L. caiflornicum* (Platen) Süss (1958); Tertiary, California.

From the study of the published description and photographs of the above forms, it is evident that the present fossil wood differs markedly from all of them.

Therefore, the fossil wood under investigation is placed under the form genus *Laurinoxylon* Felix (1883) and described as a new species *Laurinoxylon tertiarum*. This finding is the first record of a fossil wood of the family Lauraceae from India, although leaf impressions belonging to the family Lauraceae have been described by Lakhanpal (1955) from the Eocene of Assam.

The family Lauraceae is widely distributed throughout the warmer parts of the world but most abundant in tropical and subtropical regions, a few genera extending into the Malay Archipelago, the other in the American tropics, chiefly in Brazil; relatively few species occur in Europe and the African continent (Pearson & Brown, 1932, p. 823). The genus *Dehaasia* Bl. has 20 species (Willis, 1966, p. 337) and the species *D. cuneata* which is nearer to the present fossil wood grows in Andaman Islands, extending into the Pegu, Arakan and Tenasserim (Hooker, 1885, p. 125; Gamble, 1902, p. 560). The genus *Cinnamomum* Bl. is represented by 250 species distributed mainly in East Asia (Willis, 1966, p. 248). The species *C. caudatum* Nees. grows in Central and Eastern Himalayas, Nepal, lower hills of Sikkim upto 1500 metres and the Kakhyen hills of Burma. *C. glanduliferum* Meissn. is a tree of the Central Himalayas, extending west to Kumaon, and of Khasia hills, while the species *C. pauciflorum* Nees, grows in Assam valley, Khasia hills and Sylhet (Hooker, 1885, pp. 129, 134, 135; Gamble, 1902, pp. 560, 562).

SPECIFIC DIAGNOSIS

Laurinoxylon tertiarum sp. nov.

Wood diffuse-porous. *Growth rings* distinct, delimited by thicker walled fibres. *Vessels* small to medium-sized, t.d. 60-152 μ, r.d. 80-200 μ, solitary as well as in short radial rows of 2-4, 8-10 per sq. mm., tylosed; vessel-members 384-624 μ in length, with truncated or tailed ends; perforations simple as well as scalariform, the latter with 8-10 bars; intervessel pit-pairs large, 8-10 μ in diameter, bordered, border round to oval, with lenticular apertures. *Parenchyma* paratracheal, scanty to vasicentric, forming 1-3 (mostly 1-2) cells thick sheath around some of the vessels, sometimes aliform, rarely confluent, joining 2-3 adjoining vessels. *Xylem rays* 1-3 (mostly 2) seriate, 6-8 per mm.; ray tissue heterogeneous; uniseriate rays 1-4 cells and 80-120 μ high, 12-32 μ broad, homocellular, composed only of upright cells; multiseriate rays 2-3 (mostly 2) cells and 40-80 μ in width, 4-24 cells and 140-600 μ in height, heterocellular, composed of procumbent cells in the middle portion and upright cells at one or both the ends. *Fibres* non-libriform to semi-libriform, the walls about 2-6 μ thick, septate, angular in cross section, 25-30 μ in diameter and 700-1620 μ in length. *Oil cells* 24-52 μ in diameter, associated with xylem rays, parenchyma cells and fibres.

Holotype — B.S.I.P. Museum No. 33921.

Locality — Sultanicherra, near the town of Hailakandi, district Cachar, Assam.

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EXPLANATION OF PLATES

PLATE 1

1. Cross-section of the fossil wood of *Homalioxylon assamicum* showing vessel distribution and parenchyma pattern. × 30 (slide no. 4335).

2. Cross-section of *Homalium tomentosum* showing similar vessel distribution and the parenchyma pattern. × 30.

3. Tangential section of the fossil wood of *Homalioxylon assamicum* showing the type of xylem

rays and their distribution. × 60. (slide no. 4336).

4. Tangential section of *Homalium tomentosum* showing similar ray type and distribution. × 60.

5. Radial longitudinal section of *Homalioxylon assamicum* showing heterocellular xylem rays. × 120. (slide no. 4337).

6. Magnified cross-section of *Homalioxylon assamicum* × 90. (slide no. 4335).

PLATE 2

7. Cross-section of the fossil wood of *Sterculioxylon dattai* showing vessel distribution and parenchyma pattern. Also note the presence of vertical gum canals. × 60. (slide no. 4338).

8. Cross-section of *Sterculia villosa* showing similar vessel distribution, gum canals and the parenchyma pattern. × 60.

9. Tangential section of the fossil wood of *Sterculioxylon dattai* showing the type of xylem rays and their distribution. × 60. Note the sheath cells at the flanks. (slide no. 4339).

10. Tangential section of *Sterculia vilosa* showing similar ray type and distribution. × 60.

11. Magnified cross-section of the fossil wood of *Sterculioxylon dattai* showing the parenchyma distribution and the fibre structure. × 140. (slide no. 4340).

12. Another cross-section of the fossil wood of *Sterculioxylon dattai* in low power showing vessel distribution, parenchyma pattern and the gum canals. × 30. (slide no. 4340).

PLATE 3

13. Cross-section of the fossil wood of *Vitexoxylon miocenicum* showing vessel distribution and parenchyma pattern. × 30. (slide no. 4341).

14. Cross-section of *Vitex canescens* showing similar vessel distribution and the parenchyma pattern. × 30.

15. Tangential section of the fossil wood of *Vitexoxylon miocenicum* showing the type of xylem rays and their distribution. × 55 (slide no. 4342).

16. Tangential section from the modern wood of *Vitex canescens* showing similar ray type and distribution. × 55.

17. Magnified cross-section of the fossil wood of *Vitexoxylon miocenicum* showing parenchyma distribution. × 60. (slide no. 4343).

18. Radial longitudinal section of *Vitexoxylon miocenicum* showing a xylem ray. × 110. (slide no. 4344).

PLATE 4

19. Magnified longitudinal section of *Vitexoxylon miocenicum* showing intervessel pit-pairs. × 500. (slide no. 4345).

20. Magnified intervessel pit-pairs of *Laurinoxylon tertiarum*. × 500. (slide no. 4346).

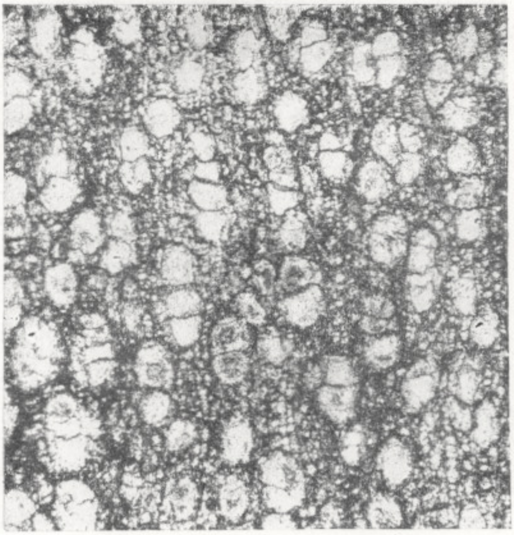
21. Magnified longitudinal section of *Laurinoxylon tertiarum* showing scalariform perforation plate. × 400. (slide no. 4347).

22. Cross-section of the fossil wood of *Laurinoxylon tertiarum* in low power showing vessel distribution and parenchyma pattern. × 30. (slide no. 4348).

23. Magnified cross-section of the fossil wood of *Laurinoxylon tertiarum* showing distributional pattern of vessels, parenchyma and the oil cells. ×60. (slide no. 4349).

24. Tangential section of the fossil wood of *Laurinoxylon tertiarum*. × 60. Note swollen oil cell of a xylem ray. (slide no. 4346).

25. Radial longitudinal section of the fossil wood of *Laurinoxylon tertiarum*. × 70. Note oil cell in the xylem ray. (slide no. 4347).



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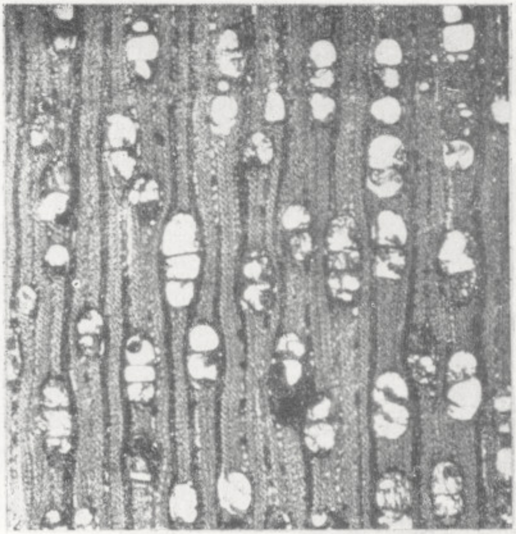

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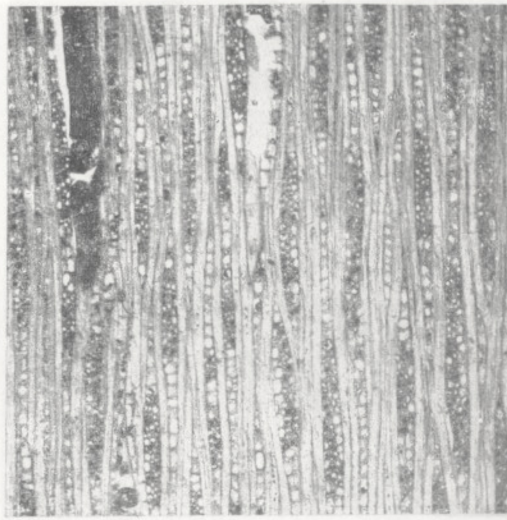

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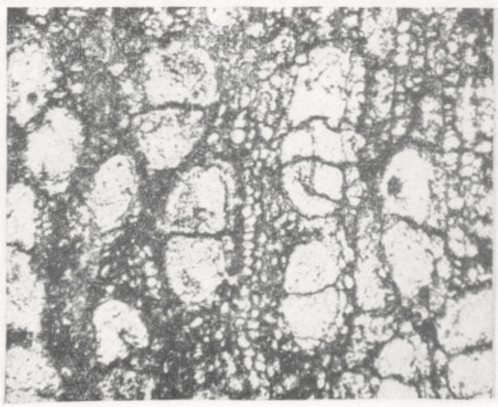

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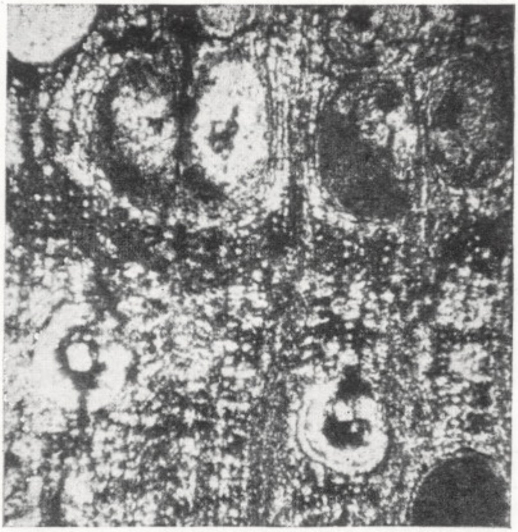

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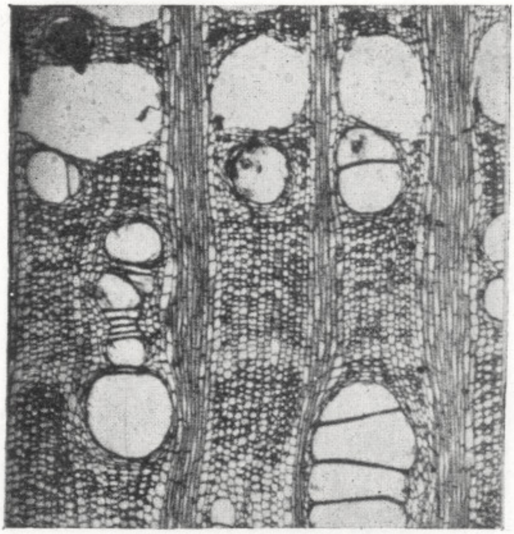

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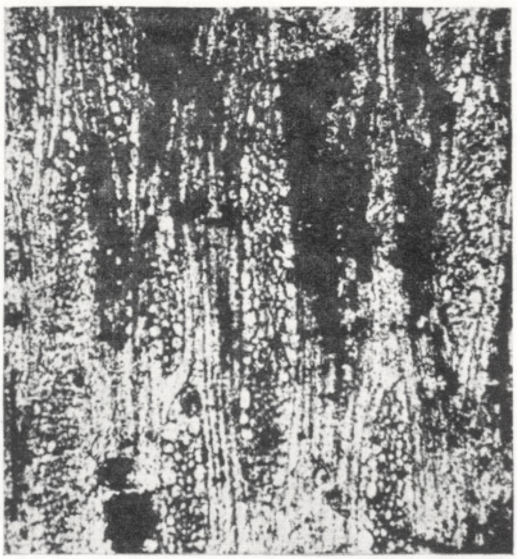

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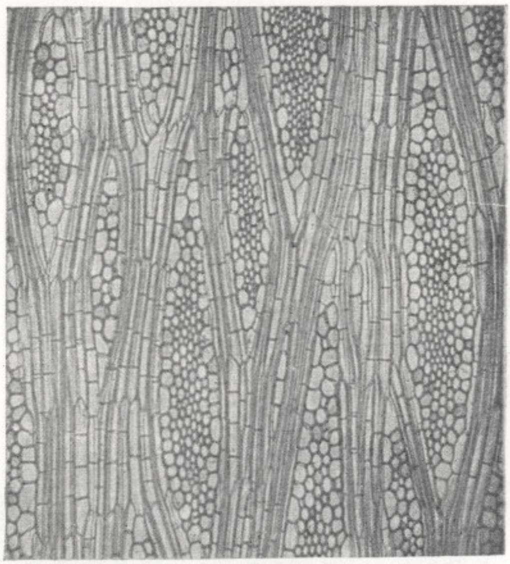

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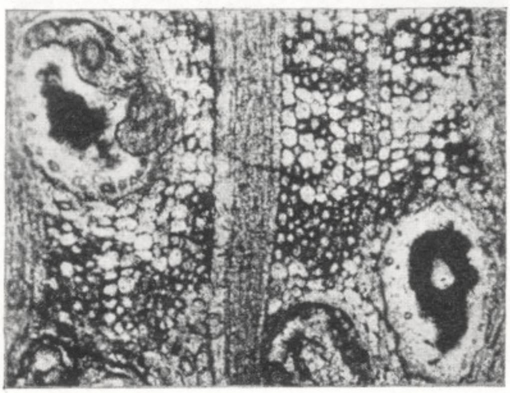

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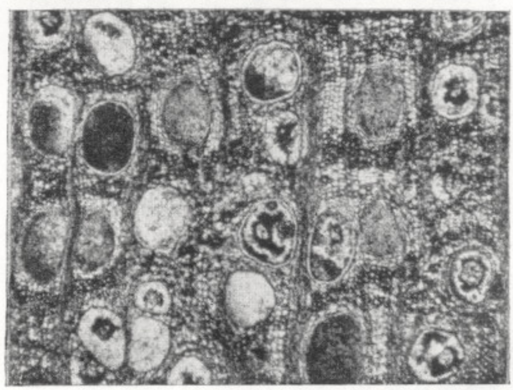

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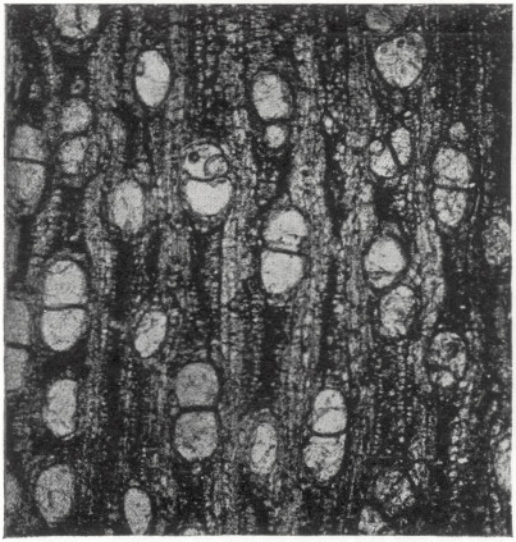

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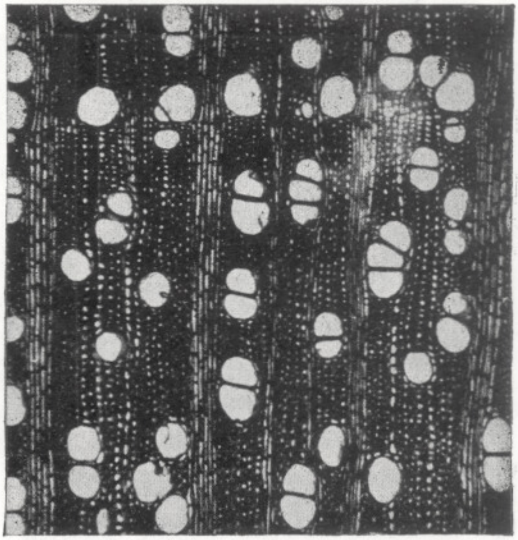

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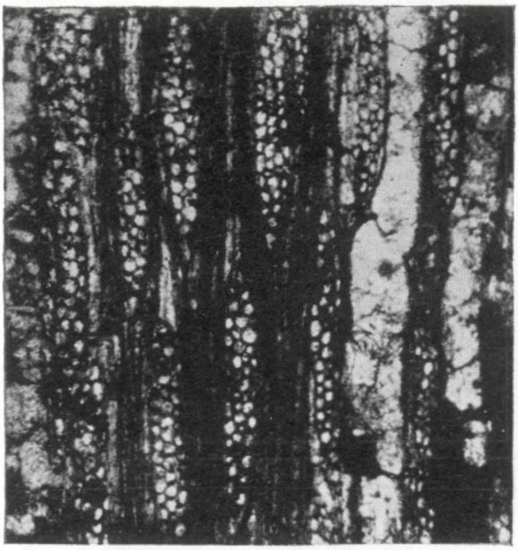

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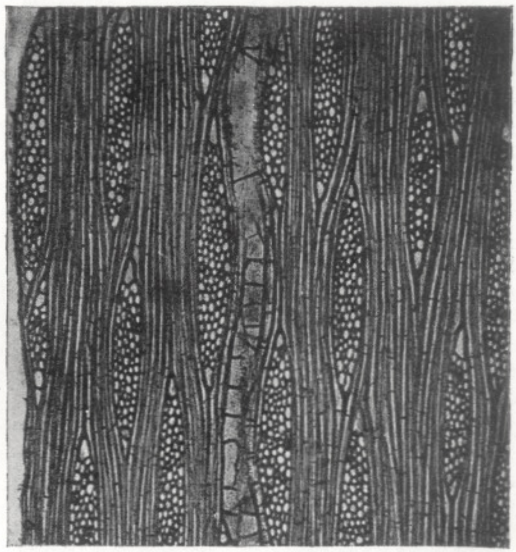

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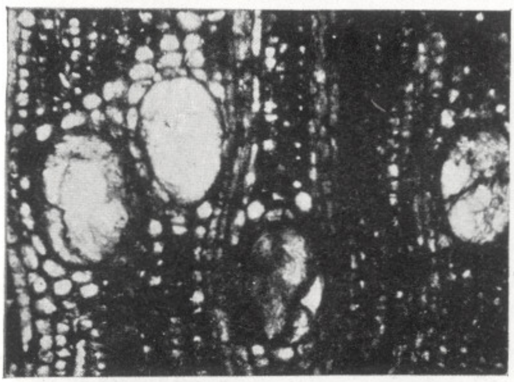

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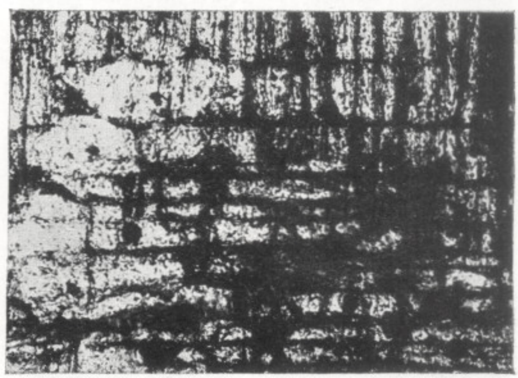

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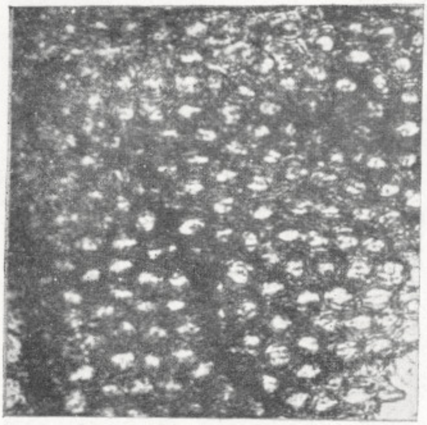

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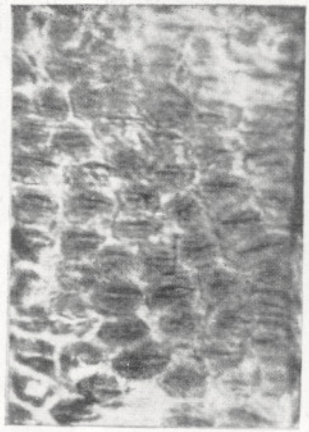

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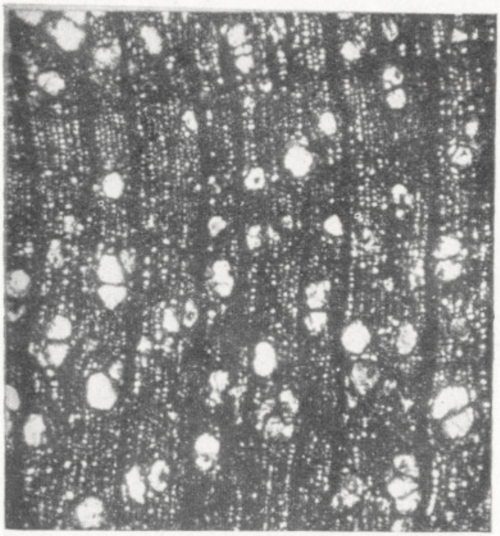

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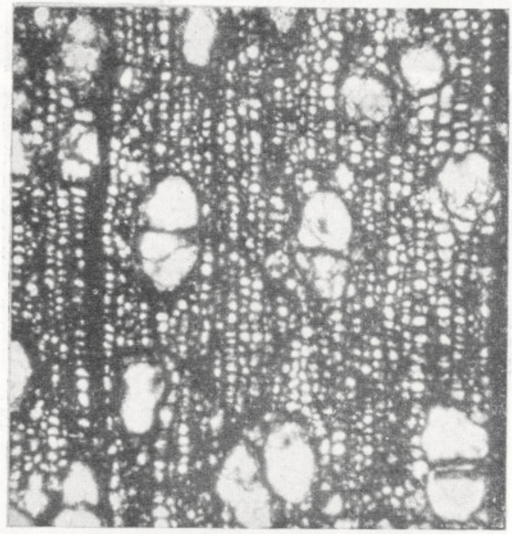

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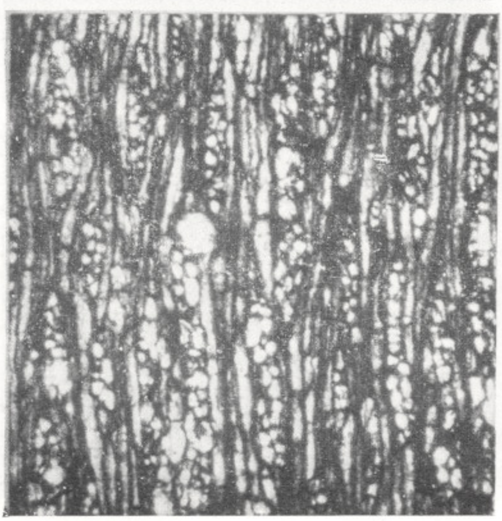

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