FOSSIL WOODS FROM THE TERTIARY OF ASSAM

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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 arc still found in the forests of Assam or Chittagong. The fossil woods of Homalium and Vitex arc 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. novo

1. Homalioxylon assamicum sp. novo.

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 semilibriform 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.

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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).

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. teteslui* Pellegr. *H. aubrevillei* 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; multisieriate 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; multisieriate 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 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; multisieriate 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, solitary 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 \( \mu \) in tangential height and 12-18 \( \mu \) in radial length. Fibres thin-walled, the walls about 4-5 \( \mu \) thick, non-septate, showing storous tendency, angular in cross section, 25-30 \( \mu \) in diameter, 500-2000 \( \mu \) in length; interfibre pits not observed.

Affinity—The most 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
- Bombacaceae
- Boraginaceae
- Burseraceae
- Caesalpiniae
- Combretaceae
- Elaeagnaceae
- Elaeocarpaceae
- Euphorbiaceae
- Hamamelidaceae
- Lecythidaceae
- Malvaceae
- Meliaceae
- Mimosaceae
- Morinaceae
- Myrtaceae
- Papilionaceae
- Proteaceae
- Rosaceae
- Scrophulariaceae
- Simaroubiaceae
- Sterculiaceae
- Styracaceae
- Vochysiaceae

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. campandulata Wall. ex Mast., S. cocinea Roxb., S. colorata Roxb., S. foetida Linn., S. fulgens Wall., and S. guttata Roxb. Besides this, published description and photographs of Sterculia alata Roxb., S. villosa Roxb., S. campandulata Wall. ex Mast., S. wrens Roxb. (Pearson & Brown, 1932; Desch, 1954; Henderson, 1953), S. blancoi Rolfe, S. carthaginensis Cav. (Metcalfe & Chalk, 1950), S. rhenanum Muller-Stoll, S. angustifolia Roxb., S. guttata Roxb., S. ornata Wall., S. cocinea 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 Sterculiuxylon Krausel (1939).

Only five species of fossil woods related to the modern genus Sterculia are known so far (Boureau, 1957a, p. 679). These are Sterculiuxylon aegypticum Krausel (1939) from the Tertiary of Egypt, S. giarabulense (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.

Sterculiuxylon aegypticum differs from the present fossil wood in having slightly larger (r.d. 100-300 \( \mu \), r.d. 100-430 \( \mu \)) 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 \( \mu \), r.d. 96-348 \( \mu \)), majority solitary, occasionally in pairs, the xylem rays are 1-10 (mostly 6-9) seriate, heterocellular, 17-140 \( \mu \) in width, 2-101 cells and 160-1500 \( \mu \) high, and the fibres are non-libriform and non-septate. S. giarabulense also differs markedly in possessing smaller vessels (165-245 \( \mu \) in diameter), in having vascentric 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. freudonii* 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. joetidense* also differs from *S. dattai* in having larger (Ld. 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 μ 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-ray 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, separte, 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). 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, 1909, 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 broad, 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.

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**Lauraceae**

*Laurinoxylon 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...
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 tapered 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, bordered round to oval with lenticular apertures (Pl. 4, Fig. 20); vessel-parenchyma and vessel-ray pits not preserved. Parenchyma cells thin walled, 10-15 μ in diameter, 30-60 μ in length. Ray cells thin walled, 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
- Aristolochiaceae
- Burseraceae
- Canellaceae
- Dilleniaceae
- Hernandiaceae
- Lauraceae
- Magnoliaceae
- Monimiaceae
- Myristicaceae
- Piperaceae
- Rutaceae
- Saurauziaceae
- Schisandraceae
- Winteraceae

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 cadium 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 Laurioidae (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 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.
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. litseooides* 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.
22. *L. ehrendorferi* Berger (1953a); Lower or Middle Miocene, Greenland.
24. *L. muller-stoll* Greguss em. Süss (Süss & Mädel, 1958); Lower Miocene, Hungary
27. *L. ebergi* (Platen) Süss (1958); Miocene, Colorado, U.S.A.
31. *L. perjectum* 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. caifornicum* (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 Kakhyan 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, r.d. 80-200, solitary as well as in short radial rows of 2-4, 8-10 per sq. mm., tylosed; vessel-members 384-624 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 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 40-80 in width, 4-24 cells and 140-600 in height, heterocellular, composed only of upright cells; multiseriate rays 2-3 (mostly 2) cells and 40-80 in width, 4-24 cells and 140-600 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 thick, septate, angular in cross section, 25-30 in diameter and 700-1620 in length. Oil cells 24-52 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.
REFERENCES


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...
rds and their distribution. \( \times 60 \). (slide no. 4336).

4. Tangential section of *Homalium tomentosum* showing similar ray type and distribution. \( \times 60 \).

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

6. Magnified cross-section of *Homalioxylon assamicum* \( \times 90 \). (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. \( \times 60 \). (slide no. 4338).

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

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

10. Tangential section of *Sterculia villosa* showing similar ray type and distribution. \( \times 60 \).

11. Magnified cross-section of the fossil wood of *Sterculioxylon dattai* showing the parenchyma distribution and the fibre structure. \( \times 140 \). (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. \( \times 30 \). (slide no. 4340).

**PLATE 3**

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

14. Cross-section of *Vitex canescens* showing similar vessel distribution and the parenchyma pattern. \( \times 30 \).

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

16. Tangential section from the modern wood of *Vitex canescens* showing similar ray type and distribution. \( \times 55 \).

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

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

**PLATE 4**

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

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

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

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

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

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

25. Radial longitudinal section of the fossil wood of *Laurinoxylon tertiarum*. \( \times 70 \). Note oil cell in the xylem ray. (slide no. 4347).
Plate 3

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