FOSSIL WOODS OF LEGUMINOSAE AND ANACARDIACEAE FROM THE TERTIARY OF ASSAM

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ABSTRACT

Three fossil woods from the Tertiary of Assam are described here. One, resembling the modern wood of *Lannea*, is from a road cutting at mile-stone 9 on Dimapur-Diphu road in Mikir Hills, and the others comparable with *Adenanthera* and *Swintonia* are from near the town of Hailakandi (24°26′N; 92°32′E) in district Cachar. Recently, these have been briefly described by us (Prakash & Tripathi, 1967, 1968).

INTRODUCTION

CONSIDERING the extent and size of Tertiary deposits in Assam, not many plant fossils are known so far. It is because the area is much disturbed geologically and covered with thick forests which make it difficult to collect the plant fossils. Whatever little is recorded is by Chowdhury, Prakash and their associates on fossil woods (CHOWDHURY, 1936, 1938; CHOWDHURY & GHOSH, 1946; CHOWDHURY & TANDAN, 1949; GHOSH, 1956; EYDE, 1963; PRAKASH, 1966; PRAKASH & NAVALE, 1963) and Lakhanpal (1952, 1955a, 1955b) on leaf-impressions and fruits.

The present study is concerned with description and interpretation of fossil woods of *Adenanthera*, *Swintonia* and *Lannea* belonging to the families Leguminosae and Anacardiaceae. Wood of *Lannea* was collected by the senior author in 1963 from a road cutting at mile-stone 9 on the Dimapur-Diphu road in Mikir Hills, while those of *Adenanthera* and *Swintonia* were sent to us in June 1964 by Mr. A. N. Datta, Vijnan Mandir Officer, Hailakandi, district Cachar, Assam. These were collected from near the town of Hailakandi (24°26′N; 92°32′E).

The age of the fossil woods is Tertiary, probably Middle Miocene, possibly being derived from the Tipam sandstones exposed in the vicinity of the fossil occurrence (EVANS, 1932; DAS GUPTA, EVANS, METRE & VISVANATH, 1964).

The preservation of the structural details of the fossil woods is fairly good. In order to make a detailed study, many sections were prepared from different parts of the petrified woods. This helped us to find out the range of variation.

SYSTEMATIC DESCRIPTION

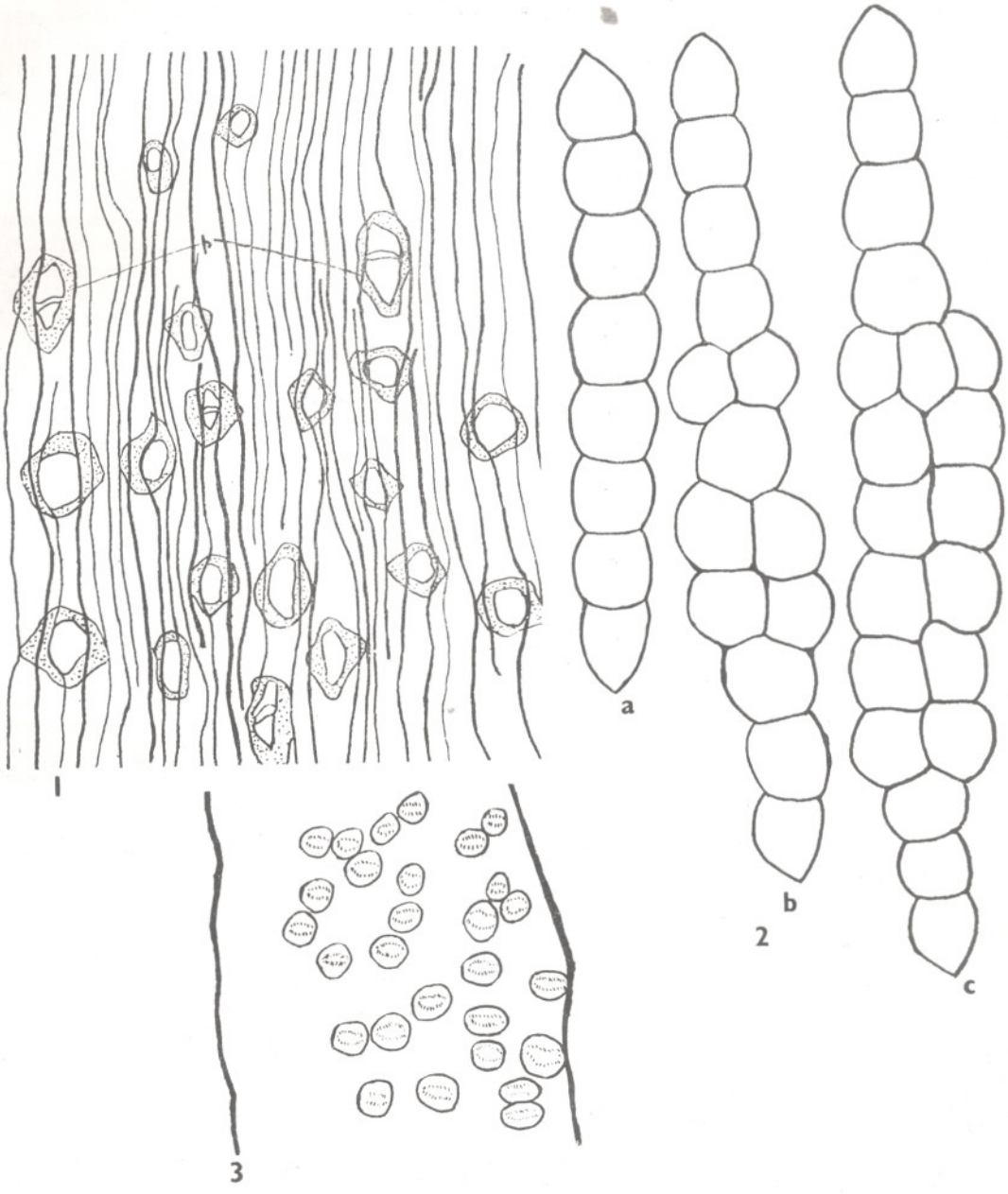
Family — LEGUMINOSAE

Adenantheroxylon Prakash & Tripathi, 1968

Adenantheroxylon pavoninium Prakash & Tripathi, 1968

The fossil described here is a piece of petrified secondary wood measuring about 5·6 cm. in length and 2 cm. in diameter. The preservation of the fossil is not very satisfactory, due to which the structures are not very clearly visible even under the high power of a microscope.

Topography — Wood diffuse-porous (PL. 1, FIG. 1). *Growth rings* indistinct, appearing to be delimited by smaller vessels. *Vessels* visible with the naked eye as pin-pricks on the cross surface, medium to large in size, usually solitary, sometimes in short radial rows of 2, rarely 3-4 (PL. 1, FIG. 1; PL. 1, FIG. 5), somewhat graded, being large in the early wood, 3-7 per sq. mm.; tyloses absent but black gummy deposits seen in some vessels. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, rarely aliform and aliform-confluent joining two adjacent vessels (PL. 1, FIG. 1; TEXT-FIG. 1); parenchyma sheath 2-6 cells thick around the vessels; apotracheal parenchyma appears to be diffuse with crystals. *Xylem rays* not visible to the naked eye, distinct only under the microscope, 1-3 seriate, mostly biseriate, rarely uniseriate and triseriate (PL. 1, FIG. 3; TEXT-FIG. 2a, b, c), 20-60 μ broad and 2-30 cells or 40-300 μ high, 14-22 per mm.; ray tissue homogeneous, rays homocellular consisting only of procumbent cells (PL. 1, FIG. 3; PL. 1, FIG. 7). *Fibres* not very clearly visible due to bad preservation of the tissues, arranged more or less in radial rows.



TEXT-FIGS. 1-3 — *Adenantheroxylon pavoninium* Prakash & Tripathi (Semi-diagrammatic camera lucida drawings). 1 — Cross-section showing the distribution of parenchyma (p). × 33. (Slide No. 3262). 2. a — Uniseriate xylem ray with procumbent cells. × 300. (Slide No. 3263). b — Biseriate xylem ray with procumbent cells. ×300 (Slide No. 3263). c — Triseriate xylem ray with procumbent cells. × 300. (Slide No. 3263). 3 — Magnified vestured intervessel pits. × 766. (Slide No. 3264).

Elements — *Vessels* thin walled, walls about 4-8 μ thick, tangential diameter 144-204 μ, radial diameter 142-260 μ, oval to round in shape when solitary and well preserved, most of the vessels irregular in shape probably due to pressure during fossilization (PL. 1, FIG. 1), those in radial groups flattened at the places of contact (PL. 1, FIG. 5); vessel-members with truncate ends; perforations could not be ascertained; intervessel pit-pairs not very distinct, appear bordered and vestured (PL. 1, FIG. 6; TEXT-FIG. 3); vessel-ray and vessel-parenchyma pits not observed. *Parenchyma cells* thin-walled, about 64-240 μ in length and 8-28 μ in diameter; chambered parenchyma appears to be present. *Ray-cells* thin-walled, round to oval in shape in tangential section; tangential diameter 16-24 μ, radial diameter 20-80 μ. *Fibres* thin-walled with big lumina, walls 4 μ thick, somewhat irregular in shape due to pressure during fossilization, non-septate, 400-1240 μ in length, 16-20 μ in diameter; interfibre pits not preserved.

Affinities — There is a close agreement in almost all the structural details of the present fossil wood with the wood structure of the modern genus *Adenanthera* Linn. of the family Leguminosae (METCALFE & CHALK, 1950; DESCH, 1957; MOLL & JANSSONIUS, 1914, FIG. 166; KANEHIRA, 1924). An examination of the thin sections, published descriptions and photographs of the species of *Adenanthera* reveals that the present fossil wood shows nearest resemblance with the wood structure of *A. pavonina*, Linn. Our study included the examination of thin sections of *A. bicolor* Moon and *A. pavonina* Linn. and published descriptions and photographs of *A. microsperma* Teysm. et Binn., *A. pavonina* Linn. (MOLL & JANSSONIUS, 1914), *A. bicolor* Moon (DESCH, 1957) and *A. intermedia* Merrill (KANEHIRA, 1924).

The modern wood of *Adenanthera pavonina* Linn. has been studied from a large number of thin sections belonging to different specimens, and the variations seen are as follows. The vessels are mostly solitary in some specimens, while they are in radial chains in others; the parenchyma is diffuse, vasicentric to aliform, rarely confluent to usually confluent with thicker sheaths around the pores; the xylem rays are 1-3 seriate, mostly biseriate in some, while both uni- and biseriates are more or less equal in other specimens.

In both the fossil wood and the modern wood of *A. pavonina*, Linn. (F.R.I. slide no. A 3657/B 5659) the vessels are large to medium-sized, the intervessel pit-pairs are alternate, bordered, the parenchyma is paratracheal and apotracheal; paratracheal parenchyma vasicentric, rarely aliform and aliform-confluent; apotracheal parenchyma diffuse; the rays are 1-3 (mostly biseriate) seriate and homogeneous, and the fibres are non-libriform and non-septate. However, the chambered parenchyma has not been clearly seen in the fossil wood like that of the modern wood of *A. pavonina*.

Because of the close resemblance of the fossil wood with the wood structure of the modern genus *Adenanthera* Linn., it has been assigned to a new genus *Adenantheroxylon* Prakash & Tripathi. It is specifically named as *Adenantheroxylon pavoninium* in view of its near resemblance with the wood of the modern species *Adenanthera pavonina* Linn.

The genus *Adenanthera* Linn. consists of 5 species distributed through tropics of the Old World (Willis, 1957). The species *A. pavonina* Linn., with which the fossil wood shows nearest resemblance, has a wide distribution, growing in east Himalayas (ascending to 1233 meters in Sikkim), Western Peninsula, Ceylon, Malaya Isles, Timor, China and Philippines (HOOKER, 1879, p. 287; GAMBLE, 1902, p. 287; TROUP, 1921, p. 485).

A large number of fossil woods of the family Leguminosae are known from India and abroad but the present discovery forms the first fossil record of *Adenanthera*. Its wood structure differs quite markedly from all the known fossil woods of the Leguminosae.

DIAGNOSES

Adenantheroxylon Prakash & Tripathi

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* large to medium-sized, usually solitary sometimes in short radial rows of 2 (rarely 3-4), round to oval in cross section; perforations simple; intervessel pit-pairs vestured and alternate. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, aliform and confluent; apotracheal parenchyma diffuse; chambered parenchyma present. *Xylem rays* fine to very fine and short, 1-3 seriate;

ray tissue homogeneous; rays homocellular composed of procumbent cells. *Fibres* non-septate, semi-libriform with big lumina.

Adenantheroxylon pavoninium Prakash & Tripathi

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* large to medium-sized, round to oval in cross section, t.d. 144-204 μ, r.d. 142-260 μ, mostly solitary, sometimes in short radial rows of 2 (rarely 3-4); 3-7 per sq. mm.; tyloses absent, black gummy deposits seen in some vessels; vessel-members with truncate ends; intervessel pit-pairs vestured; perforations could not be seen. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, rarely aliform and aliform-confluent joining two adjacent vessels; apotracheal parenchyma diffuse; chambered parenchyma present. *Xylem rays* 1-3 (mostly 2) cells and 20-60 μ broad, 2-30 cells and 48-300 μ high, 14-22 per mm.; ray tissue homogeneous; rays homo-cellular composed of procumbent cells. *Fibres* thinwalled, with big lumina, non-septate, somewhat irregular in shape due to pressure during fossilization, 400-1240 μ in length, 16-20 μ in diameter.

Holotype — B.S.I.P. Museum No. 33748.

Locality — Hailakandi, district Cachar, Assam.

Horizon — Probably Tipam series.

Age — Tertiary (Middle Miocene).

Family — ANACARDIACEAE

***Swintonioxylon* Prakash & Tripathi, 1968**

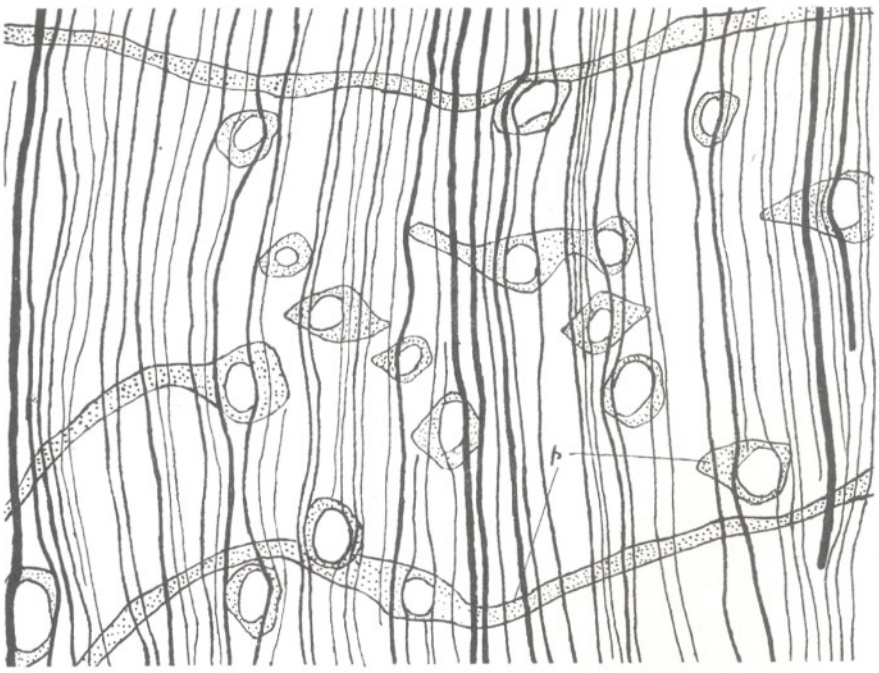
Swintonioxylon hailakandiense Prakash & Tripathi, 1968

The fossil described here is a piece of decorticated secondary wood measuring about 8·0 cm. in length and 3·0 cm. in diameter. It is brown in colour showing satisfactory preservation.

Topography — Wood diffuse-porous (PL. 2, FIG. 8). *Growth rings* indistinct. *Vessels* distinct with the naked eye, orifices visible as pin-pricks, medium-sized to large, the majority solitary but also in short radial rows of 2-4 (mostly 2) (PL. 2, FIG 8), contiguous with the rays on one or both the sides; tyloses abundant (PL. 3, FIG. 15), occluding many vessels, deposits of reddish-brown colour probably gum occasional in the tyloses; 2-9 per sq. mm. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, aliform and aliform-confluent, forming 2-4 cells thick sheath around the vessels (PL. 2, FIG. 8; PL. 3, FIG. 15; TEXT-FIG. 4); aliform-confluent parenchyma occuring as short bands joining 2-3 vessels; apotracheal parenchyma in long and short bands distributed irregularly (PL. 2, FIG. 8; PL. 3, FIG. 15); parenchyma bands 3-6 cells thick. *Xylem rays* distinct with a hand lens on the cross-section of the wood, normally 1-3 (mostly 2) seriate (PL. 2, FIG. 10) and 15-90 μ broad; fusiform rays with normal (PL. 2, FIG. 13) and traumatic gum-canals also present (PL. 2, FIG. 12); fusiform rays with normal gum-canals occasional, 6-12 seriate, but those with traumatic gum-canals frequent, 15-32 seriate; rays 14-18 per mm.; ray tissue heterogeneous (PL. 2, FIG. 11; PL. 3, FIG. 16); rays heterocellular, consisting of procumbent cells in the middle portion and upright cells at one or both the ends (PL. 2, FIG. 11; PL. 3, FIG. 16); reddish-brown probably gummy infiltration abundant in ray cells; crystals present in ray cells. *Fibres* aligned in radial rows in cross-section, interrupted by parenchyma bands. *Intercellular canals* horizontal, both normal and traumatic, confined to the xylem rays, 45-255 μ in diameter.

Elements — Vessels thin-walled, 4-6 μ thick, t.d. 100-288 μ, r.d. 110-320 μ, round to oval in cross-section, those in groups flattened at the places of contact; vessel-members 220-700 μ long, truncate or with tailed ends; perforations simple; intervascular pit-pairs large, 8-12 μ, bordered, oval to angular through crowding, with lenticular orifices (PL. 2, FIG. 14); vessel-parenchyma and vessel-ray pits not observed. *Parenchyma cells* thin-walled, round to oval in cross section, 75-225 μ in length and 6-20 μ in diameter. *Ray cells* thick walled; tangential length of procumbent cells 12-28 μ, radial length 68-124 μ; upright cells 32-64 μ in tangential and 20-56 μ in radial length. *Fibres* non-libriform, non-septate, angular in shape, walls 2-3 μ thick, 330-1200 μ long, 20-30 μ in diameter; interfibre pits not preserved.

Affinities — The most important anatomical feature of the fossil wood is the presence of normal gum-canals in the fusiform rays. Among the dicotyledons there are only 24 families and about 152 genera which possess normal horizontal gum-canals



TEXT-FIG. 4 — *Swintonioxylon hailakandiense* Prakash & Tripathi. Cross-section showing the distribution of parenchyma (p). × 33. (Slide No. 3266).

in the xylem rays (METCALFE & CHALK, 1950, pp. 1353-1354). These are as follows:

Anacardiaceae, Apocynaceae, Araliaceae, Burseraceae, Cactaceae, Cochlospermaceae, Compositae, Crypteroniaceae, Dipterocarpaceae, Euphorbiaceae, Guttiferae, Hamamelidaceae, Julianiaceae, Loganiaceae, Moraceae, Myrtaceae, Rosaceae, Rubiaceae, Rutaceae, Sapindaceae, Solanaceae, Thymelaeaceae, Ulmaceae, Umbelliferae.

Besides the presence of normal gum-canals in the fusiform rays, the fossil also shows some other important anatomical features. These are the presence of large pores (t.d. 100-288 μ) profusely occluded with tyloses, continuous or broken tangential bands of parenchyma, 1-3 (mostly 2) seriate, heterocellular normal xylem rays and thin-walled, non-septate fibres.

All the above important anatomical features indicate the affinity of the fossil wood with the family Anacardiaceae (METCALFE & CHALK, 1950; ANONYMOUS, 1963; DESCH, 1957; PEARSON & BROWN, 1932; HEIMSCH, 1942; RECORD, 1925). Out of about 65 genera of the family Anacardiaceae only about 33 show normal horizontal gum-canals (ANONYMOUS, 1963; METCALFE & CHALK, 1950, p. 1353) in the xylem rays. Out of these, only nine Indian genera possess these gum-canals. These are *Buchanania, Gluta, Lannea, Parishia, Pistacia, Magnifera longipes, Rhus, Spondias* and *Swintonia* (ANONYMOUS, 1963, p. 266; PEARSON & BROWN, 1932, p. 310). On an extensive study of the thin sections of modern woods of these genera, it has been found that the fossil wood indicates its closest affinity to the modern genus *Swintonia* Griff. Thin sections of the species *S. griffithii* Kurz, *S. helferi* Hook., and *S. floribunda* Griff. syn. *S. schwenckii* (Teysm. et Binnend.) Kurz, were examined in detail besides studying published description and photographs of *S. floribunda* Griff. (PEARSON & BROWN, 1932, pp. 333-335, FIG. 120; HENDERSON, 1953, p. 9, FIG. 8; HEIMSCH, 1942, PL. 11, FIG. 65), *S. griffithii* Kurz (METCALFE & CHALK, 1950, p. 457), *S. penangiana* King, *S. spicifera* Hook., *S. floribunda* Griff. (DESCH, 1957, pp. 12-14),

S. specifera Hook. (HENDERSON, 1953, p. 9, FIG. 9) and *Swintonia* sp. (CHOWDHURY, 1936).

A detailed examination of all the important anatomical features indicates that the fossil wood resembles more closely the species *Swintonia floribunda* Griff. syn. *S. schwenckii*, (Teysm. et Binnend.) Kurz (F.R.I. slide no. 379/E 6068). The present fossil wood resembles the modern wood of *S. floribunda* in shape, size and distributional pattern of the vessels, in the nature of intervascular pitting, in parenchyma distribution and the fibre and ray structure. However, the fossil wood differs from *S. floribunda* in having very broad xylem rays with traumatic gum-canals and the crystalliferous ray cells. These are not very reliable charfcters; the traumatic gum-canals may be vormed due to injury in any part of a plant. Similarly, the crystals are sometimes present in some specimens of a plant while absent in others.

Since the present fossil wood shows closest resemblance with the wood structure of *Swintonia*, it has been designated as *Swintonioxylon* Prakash & Tripathi. It is specifically named as *S. haliakandiense* after the name of the locality Hailakandi from where the fossil wood has been collected.

As far as we are aware, there is no record of fossil *Swintonia* from India and abroad and this forms the first record of the fossil wood of *Swintonia* from the Tertiary of Assam.

So far only three genera of Anacardiaceae are represented by the fossil woods from the Tertiary of India and Burma. These are *Glutoxylon* Chowdhury (1934) from the Tertiary rocks of Bengal (*Glutoxylon* sp. MUKHERJEE, 1942a; *G. bengalensis* MUKHERJEE, 1942b, 1942c; *G. burmense* (Hold.) CHOWDHURY by CHOWDHURY & TANADN, 1952), Manipur (*G. chowdhuri* GHOSH, 1958), Tripura (*G. burmense* (Hold.) CHOWDHURY by GHOSH & TANEJA, 1961), Assam and Burma (*G. burmense* (Hold.) CHOWDHURY, 1950, 1952), South India near Pondicherry (*G. cuddalorense* AWASTHI, 1966), *Anacardioxylon* Felix (1882) from the Deccan Intertrappean series (*A. semecarpoides* PRAKASH & DAYAL, 1965) and the Mio-Pliocene of Cuddalore Series near Mortandra in South India (*A. mangiferoides* RAMANUJAM, 1960) and *Mangiferoxylon* Awasthi (1966) from the Tertiary of South India near Pondicherry (*M. sclerotictim* Awasthi, 1966). From outside India, a number of fossil woods belonging to the family Anacardiaceae are known (EDWARDS, 1931; EDWARDS & WONNACOTT, 1935; ANDREWS, 1955; BOUREAU, 1957, pp. 668-669) but these as well as those from India differ widely from the present fossil wood.

The genus *Swintonia*, Griff. consists of about 8 species (WILLIS, 1957) of tall evergreen trees. It is confined in the Old World and strictly Indo-Malayan in distribution. It occurs in East Pakistan, Burma and the Malay Peninsula extending to the Philippine Islands. Two species grow in Burma, one of which extends to Chittagong in East Pakistan (PEARSON W BROWN, 1932, p. 333; ANONYMOUS, 1963). The species *S. floribunda* syn. *S. schwenkii* with which our fossil wood shows nearest resemblance is represented in the modern flora of East Pakistan, about a distance of 288 kms. from the fossil locality. It is a tall tree with cylindrical bole and grows in Chittagong and Burma, along rivers and in tropical forests. In Chittagong forests, this is one of the most conspicuous trees, especially along the banks of the Karanfuli river (GAMBLE, 1902, p. 218).

DIAGNOSIS

Swintonioxylon Prakash & Tripathi

Wood diffuse-porous. *Growth rings* distinct or indistinct. *Vessels* large to medium-sized, majority solitary or in short radial rows, round to oval, profusely tylosed, with deposits of reddish-brown probably gum occasional in the tyloses; vessel-members with truncate or tailed ends; perforations simple; intervessel pit-pairs large, bordered, oval to angular through crowding with lenticular orifices. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, aliform and aliform-confluent; apotracheal parenchyma in long and short bands. *Xylem rays* both fine and fusiform containing gum-canals; ray tissue heterogeneous; rays heterocellular composed of procumbent cells in the middle portion and upright cells at one or both the ends; fusiform rays with radial gum canals. *Fibres* non-libriform, non-septate, with big lumina. *Intercellular canals*, horizontal, confined to the rays.

Swintonioxylon hailakandiense Prakash & Tripathi

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* large to medium-sized, t.d. 100-2·88 μ, r.d. 110-320 μ, majority solitary but also in short radial rows of 2-4, thin-walled, profusely tylosed, with deposits of reddish-brown probably gum occasional in the tyloses, 2-9 per sq. mm.; vessel-members short to medium-sized, 220-700 μ long with truncate or tailed ends; perforations simple; inter-vessel pit-pairs large, 8-12 μ in diameter, bordered, oval to angular through crowding. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, aliform and aliform-confluent; apotracheal parenchyma in short and long bands. *Xylem rays* both fine and fusiform; fine rays 1-3 (mostly 2) seriate and 15-90 μ broad, 2-23 cells and 90-1200 μ high; fusiform rays both with normal and traumatic gum canals; rays with normal gum-canals occasional, 6-12 seriate, but those with traumatic gum canals quite frequent, 15-32 seriate; rays 14-18 per mm.; ray tissue heterogeneous; rays heterocellular composed of procumbent cells in the median thickened portion and upright cells at one or both the ends. *Fibres* non-libriform, non-septate, thin walled, angular in cross-section, 330-1200 μ long and 20-30 μ in diameter. *Intercellular canals* horizontal in xylem rays, both normal and traumatic; normal canals 45 μ and traumatic canals 195-255 μ in diameter.

Holotype — B.S.I.P. Museum No. 33749.

Locality — Hailakandi, district Cachar, Assam.

Horizon — Probably Tipam series.

Age — Tertiary (Middle Miocene).

Lanneoxylon Prakash & Tripathi, 1967

Lanneoxylon grandiosum Prakash & Tripathi, 1967

The material on which the present study is based, comprises a pertified piece of decorticated secondary wood. It is about 4·5 cm. in length and 3·5 cm. in diameter. It is brown in colour with fairly good preservation.

Topography — Wood diffuse-porous (Pl. 3, Fig. 17). *Growth rings* indistinct. *Vessels* appearing as minute dots with the naked eye on the cross-surface, small to moderately large, solitary as well as in radial multiples of 2-4, evenly distributed, 7-11 per sq. mm., heavily occuluded with tyloses (Pl. 3, Fig. 17). *Parenchyma* scanty, paratracheal, not visible with the hand lens, difficult to locate even under the microscope, occurring as few cells about the vessels (Pl. 4, Fig. 21). *Xylem rays* not visible to the naked eye, distinct with a hand lens on the cross-surface of the wood, fine to moderately broad, rarely with gum canals, 1-7 (mostly 3-4) seriate (Pl. 3, Fig. 19) and 20-84 μ broad, 3-32 cells or 160-720 μ high; rays 6-8 per mm.; ray tissue heterogeneous; rays heterocellular consisting of procumbent cells in the middle portion and 1-2 rows of upright cells at one or both the ends (Pl. 3, Fig. 19). *Fibres* aligned in more or less distinct radial rows between the two consecutive xylem rays. *Intercellular canals* horizontal, normal, confined to the xylem rays, 25-35 μ in diameter (Pl. 4, Fig. 23).

Elements — Vessels thin-walled, walls 4-8 μ thick, t.d. 75-230 μ, r.d. 120-340 μ, the solitary vessels round to oval in cross-section, sometimes elliptical due to compression during fossilization, those in radial multiples flattened at the places of contact; vessel-members 180-360 μ long, truncate or with tailed ends; perforations could not be seen; intervessel pit-pairs large, 10-12 μ in diameter, bordered, alternate, border oval and angular due to crowding with linear-lenticular orifices (Pl. 4, Fig. 22); vessel-parenchyma and vessel-ray pits not observed. *Parenchyma cells* thin-walled, peripherally flattened in cross-section, 80-220 μ in length and 12-20 μ in diameter. *Ray cells* thin-walled occasionally crystalliferous; tangential length of procumbent cells 20-32 μ, radial length 80-140 μ; upright cells 32-64 μ in tangential and 24-48 μ in radial length. *Fibres* moderately thick-walled with big lumina, walls 2-4 μ thick, septate, angular in cross-section, 300-1500 μ long, 25-40 μ in diameter; interfibre pits not preserved.

Affinities — The most important anatomical feature of the present fossil wood is the presence of normal, horizontal gum canals in the xylem rays. Among the dicotyledons, there are only 24 families and about 152 genera in which the normal, horizontal gum canals are found (Metcalfe & Chalk, 1950; Record, 1925). Besides the presence of normal gum canals in the xylem rays, the fossil wood also shows small

to moderately large pores (t.d. 750 μ-23) profusely occuluded with tyloses; alternate, bordered, inter-vessel pits; scanty paratracheal parenchyma; 1-7 (mostly 3-4) seriate, hetrocellular xylem rays with 1-2 rows of upright cells; and moderately thick-walled, septate fibres. Considering all the features collectively some genera of the families Burseraceae and Anacardiaceae show greater resemblance with the present fossil wood.

In the family Burseraceae, there are about nine genera in which radial gum canals are found in the xylem rays. Among the Indian genera, radial gum canals which are occasionally visible under hand lens have been observed in *Balsamodendron*, *Boswellia* and *Garuga* (ANNONYMOUS, 1963, pp. 64-80; MOLL & JANSSONIUS, 1908, pp. 87-109; PEARSON & BROWN, 1932, pp. 217-233; HEIMSCH, 1942, pp. 122-124; METCALFE & CHALK, 1950, pp.345-347; RECORD, 1925, pp. 19-20). Of these only two genera *Garuga* and *Boswellia* are worth comparing.

Similarly in the family Anacardiaceae, there are number of genera which are characterized by the presence of radial gum canals (ANNONYMOUS, 1963; RECORD, 1925; 1939; MOLL & JANSSONIUS, 1908; PEARSON & BROWN, 1932; DESCH, 1957; HEIMSCH, 1942; METCALFE & CHALK, 1950). Amongst these, the Indian genera with radial gum canals are *Buchanania*, *Gluta*, *Lannea*, *Parishia*, *Pistacia*, *Mangifera* (only *M. longipes*), *Rhus*, *Spondias* and *Swintonia* among which *Lannea* is remarkably close to the fossil wood.

Considering the wood structure of the genera *Garuga*, *Boswellia* and *Lannea* for detailed comparison, it appears that the genus *Boswellia* is nearer in structural details to the fossil wood than *Garuga*. The wood of *Garuga* can be distinguished from the present fossil wood in possessing larger pores and rays with enlarged end cells containing crystals. *Garuga pinnata*, the only Indian species, can be further separated by the presence of large and frequent radial gum canals (PL. 4, FIGS. 26 & 27). It may be mentioned here that in *G. floribunda* described and figured by Reyes (1938, pp. 164, 165, PL. 25, FIG. 2) the intercellular radial canals are absent and the rays have oil-cells. *Boswellia* also differs from the fossil wood in having xylem rays without the crystals (PL. 4, FIGS. 24, 25) and the radial gum canals being larger and more frequent than the present fossil wood (PEARSON & BROWN, 1932, pp. 218-220). However, it is with the wood structure of *Lannea* A. Rich, especially *L. coromandelica* (Houtt.) Merr. [syn. *Lannea grandis* (Dennst.) Engler, *Odina wodier* Roxb., *L. Wodier* (Roxb.) Adelb] (RAIZADA, 1958 p. 491) that the fossil wood shows closest affinities. Besides examining the modern wood slides of *L. coromandelica* and *L. acidissima* the published describtion and photographs of *Lannea welwitschii* Engl. (KRIBS, 1959, p. 8, FIG. 336; NORMAND, 1955, PL. 89); *L. acidissima* A. Chev. (METCALFE & CHALK, 1950, FIG. 103 I); *L. barteri* Engl. (METCALFE & CHALK, 1950) and *L. coromandelica* syn. *Odina wodier* (MOLL & JANSSONIUS, 1908, FIG. 141; CHOWDHURY, 1943; PEARSON & BROWN, 1932) were also consulted.

The size, shape and distribution of vessels in the present fossil wood is similar to the distributional pattern in the modern species, *Lannea coromandelica* (Houtt.) Merr. Both in the fossil and the living species, the vessels are small to moderately large, solitary as well as in radial multiples of 2-4 and the intervessel pit-pairs are large, alternate, bordered with linear-linticular apertures. The amount and distribution of the parenchyma as also the nature and distribution of the xylem rays, the presence of radial canals and the type of fibres are basically similar in both the fossil and the modern wood of *L. coromandelica* (Houtt.) Merr.

So far only three genera of the family Anacardiaceae are represented by fossil woods from the Tertiary of India. Recently, a fossil wood of *Swintonia*, *Swintonioxylon haliakandiense* Prakash & Tripathi (1968) has also been recorded from Hailakandi, district Cachar, Assam. From outside India, a number of fossil woods belonging to the family Anacardiaceae are known but these as well as those from India differ widely from the present fossil wood.

As far as we are aware there is no authentic record of fossil *Lannea* from India and abroad and this forms the first record of the fossil wood of *Lannea* from the Tertiary of Assam. However, Krausel (1922) described *Anacardioxylon mollii* from the Tertiary of South Sumatra which he compared with *Odina wodier* syn. *Lannea coromandelica*. Den Berger (1923) compared *A. mollii* with the members of the family Burseraceae and gave it a non-committal name *Sumatroxylon*

mollii. However, the affinities of this fossil wood are still uncertain.

Since the present fossil wood shows closest resemblance with the wood structure of *Lannea* it has been assigned to *Lanneoxylon* Prakash & Tripathi. It is specifically named as *L. grandiosum* as it is closely allied to the wood structure of the modern *Lannea grandis*.

The genus *Lannea* A. Rich, consists of about 15 species of small to large deciduous trees distributed in tropical Africa and Asia. The only species found in the Indian region is *Lannea coromandelica* syn. *Lannea grandis* Engl. The tree has a wide distribution in India and is found in the dry forests of all states except parts of Punjab, Rajasthan and Saurashtra. It is found in the sub-Himalayan tract and the lower Himalayas from the Indus eastwards ascending to 1,200 m., common in Siwaliks, Dehradun and Saharanpur forests, also throughout the area of Pilibhit, Oudh, Gorakhpur and Bundelkhand of Uttar Pradesh but not so common in Bengal and Assam and scattered in Bihar and Orissa. It is also common in Khandesh and Deccan forests, very common in Travancore and in the decidous forest of Mysore and Madras. In the Andamans the tree grows frequently in damp places along streams. It occurs also in Burma and Ceylon (ANONYMOUS, 1963).

DIAGNOSIS

Lanneoxylon Prakash & Tripathi

Wood diffuse-porous. *Growth rings* wanting or scarcely distinct. *Vessels* small to large, solitary or in radial multiples, round to oval, tylosed; vessel-members with truncate or tailed ends; perforations simple; intervessel pit-pairs large, bordered, oval or angular where crowded with linear-lenticular orifices. *Parenchyma* scanty paratracheal. *Xylem rays* fine to moderately broad; ray tissue heterogeneous, rays heterocellular. *Fibres* thin to moderately thick-walled with big lumina, septate. *Intercellular canals* horizontal, confined to some xylem rays.

Lanneoxylon grandiosum Prakash & Tripathi

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* small to moderately large, t.d. 75-230 μ, r.d. 120-340 μ, solitary as well as in radial multiples of 2-4, thin-walled, heavily tylosed, 7-11 per sq. mm.; vessel-members short to medium-sized, 180-360 μ long, with truncate or tailed ends; perforations simple; intervessel pit-pairs large, 10-12 μ in diameter, bordered, oval to angular, with linear-lenticular apertures. *Parenchyma* scanty paratracheal. *Xylem rays* fine to moderately broad with gum-canals in some, 1-7 (mostly 3-4) seriate and 20-84 μ broad, 3-32 cells or 160-720 μ high; rays 6-8 per mm.; ray tissue heterogeneous, rays heterocellular composed of procumbent cells through the median thickened portion and upright cells at one or both the ends; cells sometimes crystalliferous. *Fibres* moderately thick-walled with big lumina, walls 2-4 μ thick, septate, angular in cross-section, 300-1500 μ long and 25-40 μ in diameter. *Intercellular canals* horizontal, normal confined to some xylem rays, 25-35 μ in diameter.

Holotype — B.S.I.P. Museum no. 33792.

Locality — Road cutting at mile-stone 9 on Dimapur-Diphu road in Mikir Hills, Assam.

Horizon — Probably Tipam series.

Age — Tertiary, probably Middle Miocene.

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EXPLANATION OF PLATES

PLALE 1

1. Cross-section of the fossil wood of *Adenantheroxylon pavoninium* showing vessel distribution and the parenchyma pattern. × 30. (Slide No. 3262).
2. Cross-section of *Adenanthera pavonina* Linn. showing similar vessel distribution and the parenchyma pattern. × 30.
3. Tangential section of the fossil wood of *A. pavoninium* showing the type of xylem rays and their distribution. × 90. (Slide No. 3263).
4. Tangential section of *Adenanthera pavonina* Linn. showing similar ray type and their distribution. × 90.
5. Cross-section of the fossil wood of *A. pavoninium* magnified to show the shape of the vessel and paratracheal parenchyma. × 80. (Slide No. 3262).
6. Tangential section of the fossil wood of *A. pavininium* magnified to show intervessel pits. × 190. (Slide No. 3264).
7. Radial section of *A. pavoninium* showing the homogeneous xylem rays. × 130. (Slide No. 3265).

PLATE 2

8. Cross-section of the fossil wood of *Swintonioxylon hailakandiense* showing vessel and parenchyma distribution. × 30. (Slide No. 3266).
9. Cross-section of *Swintonia floribunda* Griff. showing similar vessel and parenchyma distribution. × 30.
10. Tangential section of the fossil wood *of S. hailakandiense* showing xylem rays and their distribution. × 110. (Slide No. 3267).
11. Tangential section of *Swintonia floribunda* Griff. showing the similar xylem rays and their distribution. × 110.
12. Tangential section of the fossil wood of *S. hailakandiense* showing traumatic gum-canals in the xylem rays. × 40. (Slide No. 3267).
13. Tangential section of the fossil wood of *S. hailakandiense* showing a normal gum-canal in the xylem rays. × 40. (Slide No. 3268).
14. Magnified intervascular pitting of *S. hailakandiense*. × 410. (Slide No. 3267).

PLATE 3

15. Cross-section of the fossil wood of *S. hailakandiense* magnified to show the aliform and banded parenchyma. × 100. (Slide No. 3266).
16. Radial section of the fossil wood of *S. hailakandiense* showing the heterogeneous xylem rays. × 90. (Slide No. 3269).
17. Cross-section of the fossil wood of *Lanneoxylon grandiosum* showing vessel distribution. × 43. (Slide No. 3270).
18. Cross-section of the modern wood of *Lannea coromandelica* (Houtt.) Merr., showing similar vessel distribution. × 43.
19. Tangential section of the fossil wood of *L. grandiosum* showing the type of xylem rays and their distribution. × 60. (Slide No. 3271).
20. Tangential section of the modern wood of *Lannea coromandelica* (Houtt.) Merr., showing similar ray type and their distribution. × 60.

PLATE 4

21. Cross-section of thc fossil wood of *L. grandiosum* magnified to show scanty paratracheal parenchyma. × 80. (Slide No. 3270).
22. Magnified intervascular pitting of *L. grandiosum*. × 850. (Slide No. 3271).
23. Tangential section of the fossil wood of *L. grandiosum* showing gum-canal in a xylem ray. × 75. (Slide No. 3272).
24. Cross-section of the modern wood of *Boswellia serrata* Roxb. showing vessel and parenchyma distribution. × 43.
25. Tangential section of the modern wood of *Boswellia serrata* Roxb. showing the xylem rays. × 60.
26. Cross-section of the modern wood of *Garuga pinnata* Roxb. showing vessel and parenchyma distribution. × 43.
27. Tangential section of the modern wood of *Garuga pinnata* Roxb. showing the xylem rays with enlarged end cells containing crystals and a ray with a gum-canal. × 60.


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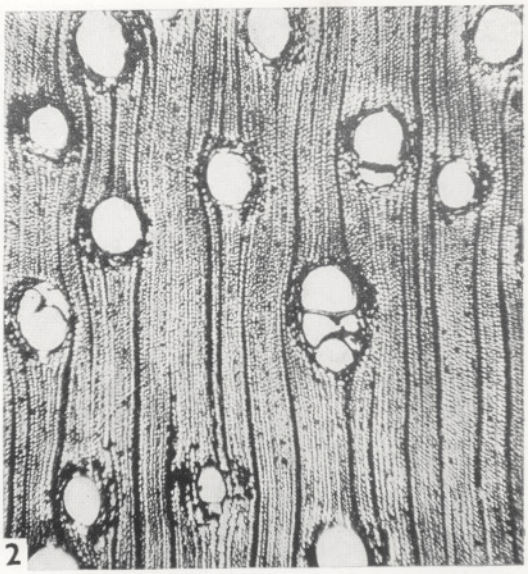
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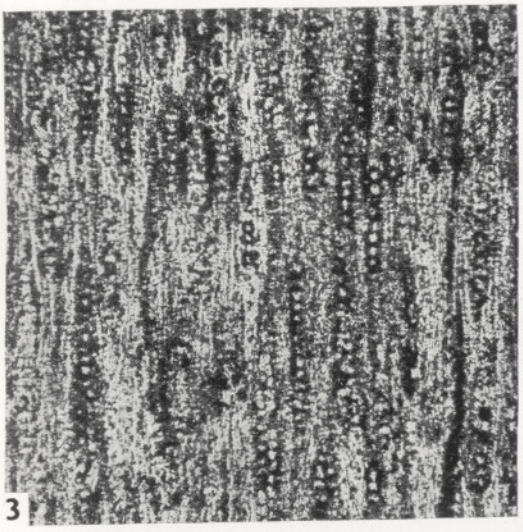
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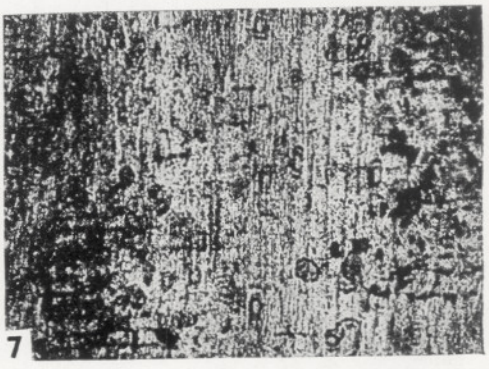
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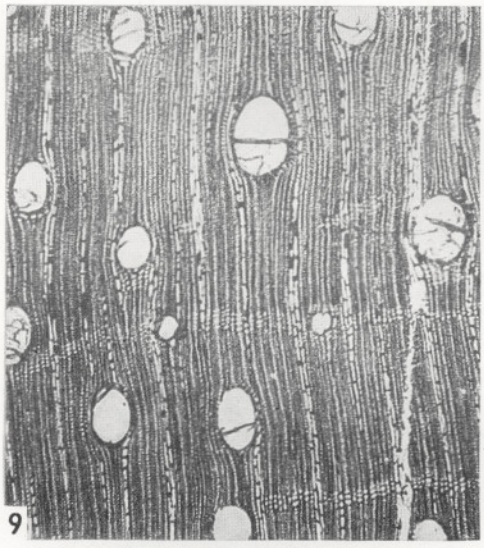
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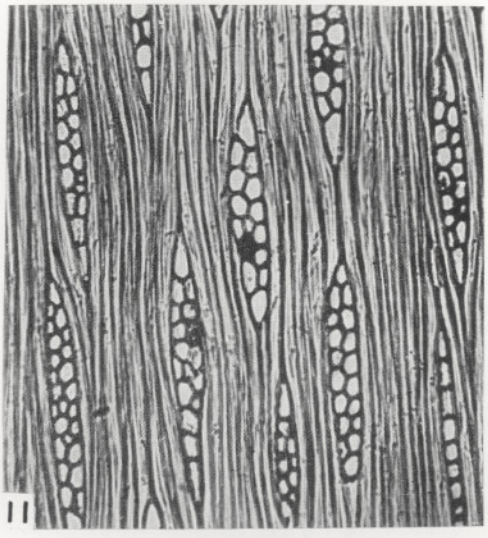
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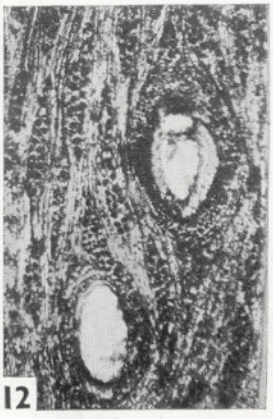
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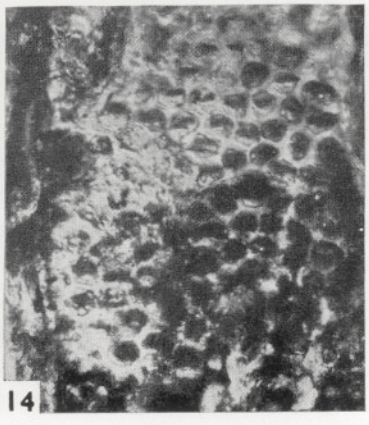
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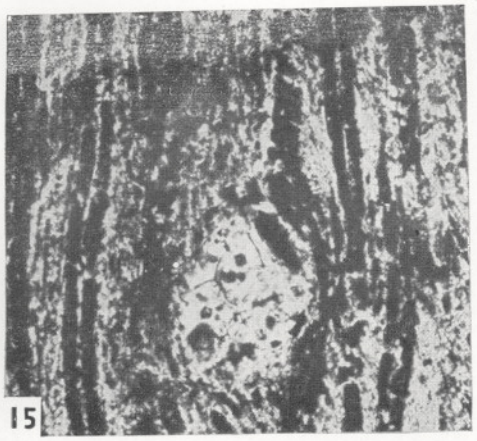

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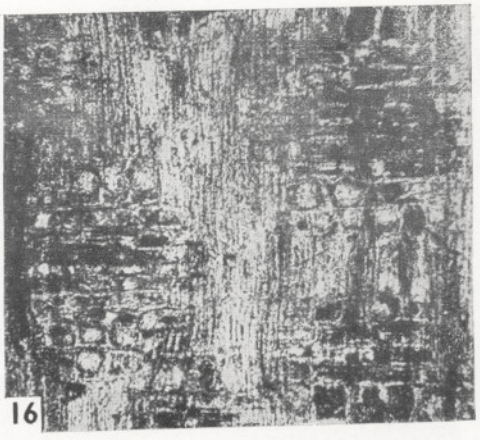

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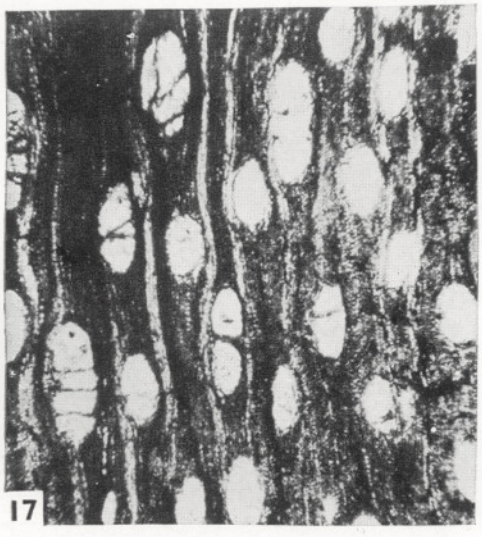

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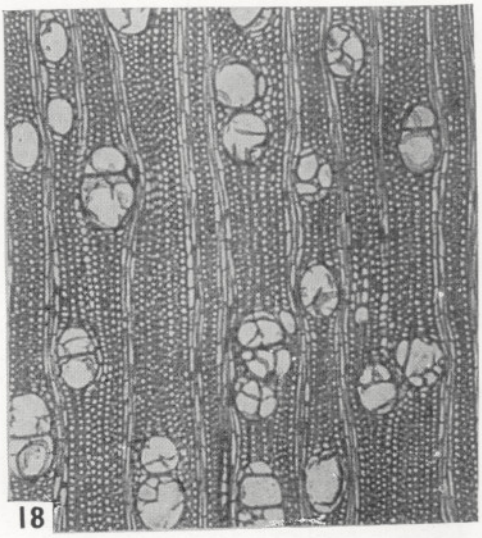

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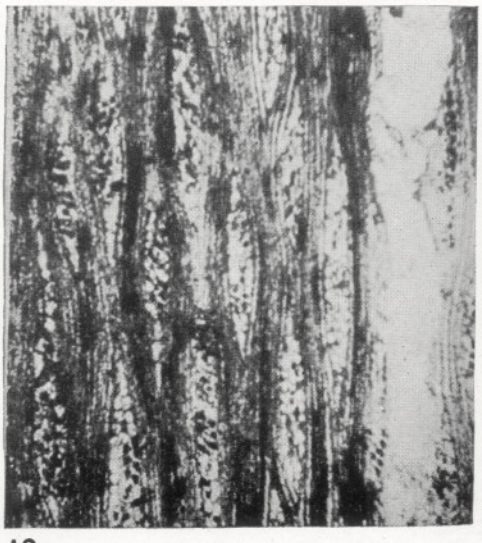

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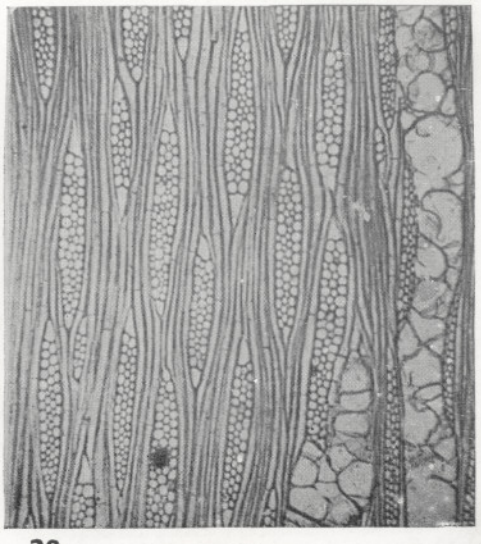

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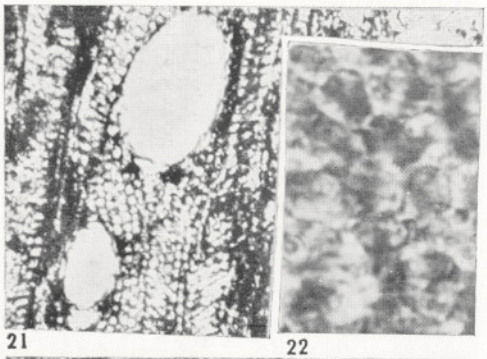

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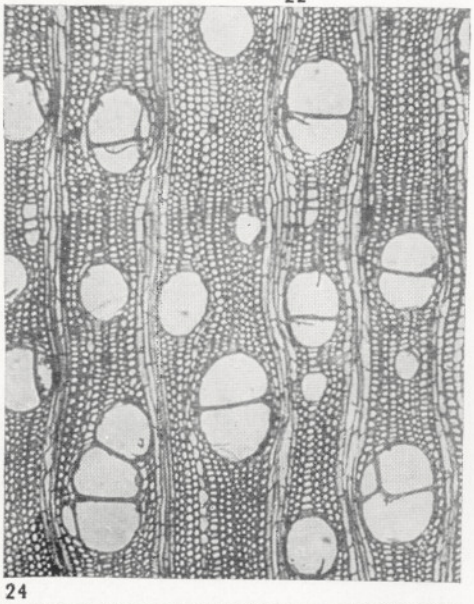

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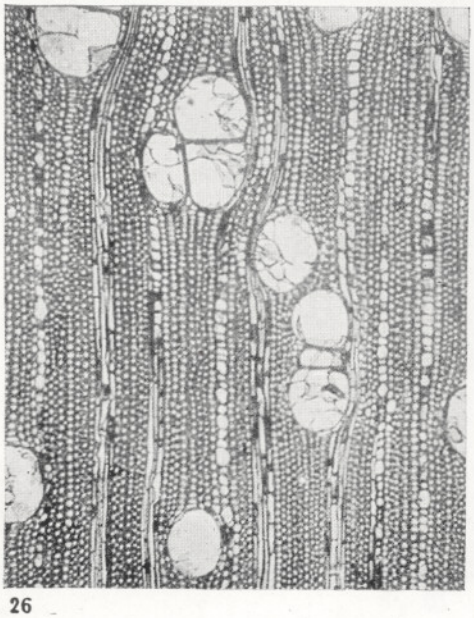

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