

FOSSIL WOODS OF ANACARDIACEAE FROM THE TERTIARY OF SOUTH INDIA

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ABSTRACT

In the present paper three species of fossil woods belonging to the family Anacardiaceae have been described from near the villages Murattandichavadi, Thiruchitrambalam (Thiruchitambalam) and Kasippalayam, about 8-10 km. W.N.W of Pondicherry. One of them shows closest resemblance with the wood structure of *Mangifera* L. and hence designated as *Mangiferoxylon scleroticum* gen. et sp. nov. The other two species resemble the woods of *Gluta* and *Melanorrhoea* and have been referred to the genus *Glutoxylon* Chowdhury (1936). One of them is identical with *G. burmense* (Holden) Chowdhury (1952) and the other is a new species which is here described as *G. cuddalorensis*.

INTRODUCTION

IN the Tertiary rocks of South India near Pondicherry there occur a large variety of petrified woods. Some of them have been described by Sahnii (1931a, 1931b), Ramanujam (1953a, 1953b, 1953c, 1954, 1955, 1956a, 1956b, 1956c, 1957, 1958, 1960, 1961), Navale (1956, 1957, 1959, 1962, 1963a, 1963b, 1964a, 1964b, 1964c) and Lakhanpal & Awasthi (1964, 1965). They belong to several families of dicotyledons (Guttiferae, Dipterocarpaceae, Simaroubaceae, Sapindaceae, Anacardiaceae, Leguminosae, Combretaceae, Celastraceae, Sonneratiaceae & Euphorbiaceae), Palm and Conifers (Podocarpaceae & Taxodiaceae).

In the present paper three species of fossil woods belonging to the family Anacardiaceae have been described. These were collected by the author in 1962 and 1963 from an area surrounded by the villages Murattandichavadi, Thiruchitrambalam and Kasippalayam, about 8-10 km. W. N. W. of Pondicherry. The woods have been cut and their thin sections prepared by usual grinding method. One of these shows closest resemblance with the wood of *Mangifera* and the other two with those of *Gluta* and *Melanorrhoea* jointly.

GENERAL DESCRIPTION

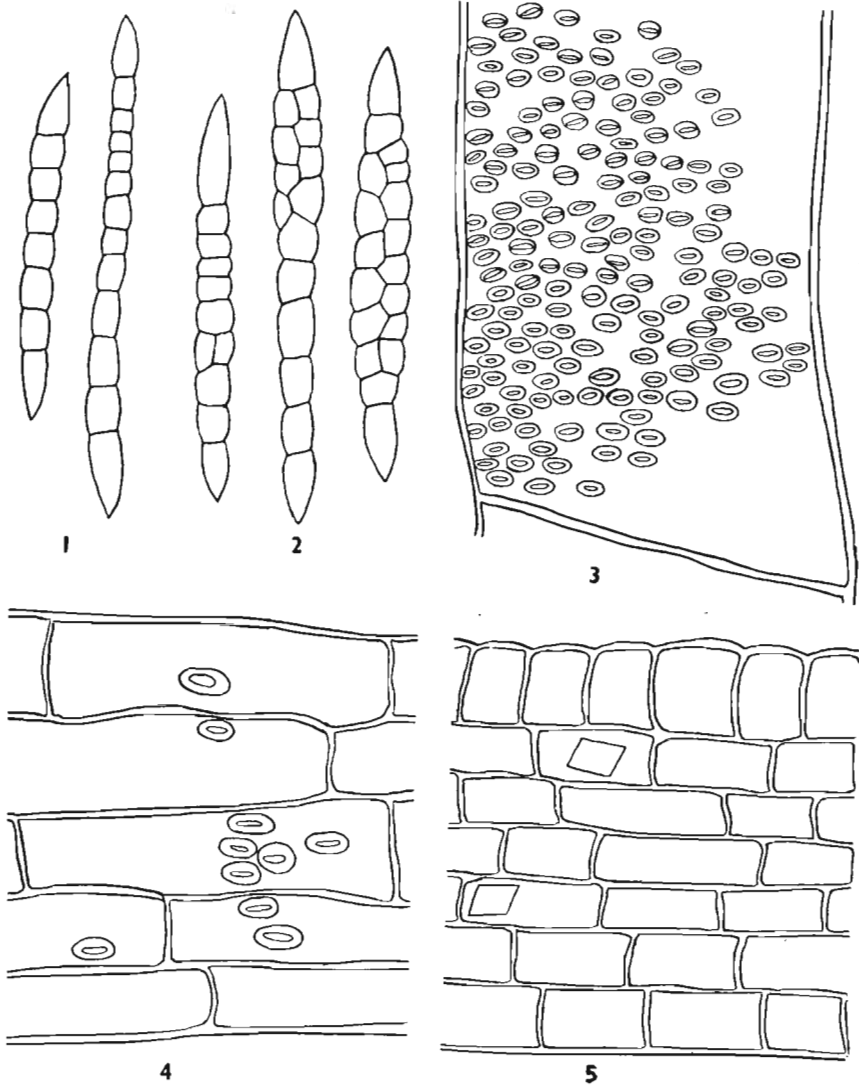
1. *Mangiferoxylon scleroticum* gen. et sp. nov.

Pls. 1-2, Figs. 1-11, Text-Figs. 1-5

DESCRIPTION

The fossil wood, upon which the present species is based, is represented by a number of well preserved pieces of silicified secondary wood.

Topography — Wood diffuse-porous (PL. 1, FIG. 1). *Growth rings* present, usually delimited by thin apotracheal (terminal) parenchyma (PL. 1, FIG. 1; PL. 2, FIG. 5). *Vessels* visible to the naked eye as dark dots, small to large, solitary as well as in radial multiples of mostly 2-3 (PL. 1, FIG. 1), sometimes more or less in irregular multiples of 4-10 small vessels or in clusters, 2-18 (mostly 2-10) vessels per sq. mm.; tyloses present (PL. 1, FIG. 1), abundant, sometimes completely occluding the vessels (PL. 2, FIGS. 5 & 7), sclerotic (with stone cells), dark in colour. *Parenchyma* paratracheal and apotracheal (PL. 1, FIG. 1; PL. 2, FIG. 5), paratracheal parenchyma mostly forming 2-4 cells wide vasicentric sheath, usually with short lateral extension forming eye-lets (aliform) with the vessels (PL. 1, FIG. 1; PL. 2, FIG. 5), occasionally locally confluent (PL. 1, FIG. 1); apotracheal parenchyma represented by mostly thin bands of 2-6 cells in width, usually delimiting the growth rings (PL. 1, FIG. 1; PL. 2, FIG. 5), 1-2 bands per mm.; besides, the other thin apotracheal bands also occur near the growth rings (PL. 1, FIG. 1). *Xylem rays* not clearly visible to the naked eye, visible with the help of hand lens in cross-section, fine, 16-48 μ wide, separated by 2-8 tangential rows of fibres, 1-2 seriate (TEXT-FIGS. 1-2), mostly uniseriate (PL. 1, FIG. 3); ray tissue heterogeneous (Kribs's type II B); rays heterocellular, consisting of procumbent cells through the median thickened portion and 1-3 (mostly 1) marginal rows of upright cells at both the ends (PL. 2, FIG. 11; TEXT-FIGS.



Mangiferoxylon scleroticum gen. et sp. nov.

TEXT-FIGS. 1-5 — 1. Uniseriate xylem rays. $\times 125$. 2. Biseriate xylem rays. $\times 125$. 3. Intersvascular pitting. $\times 350$. 4. Radial section of xylem rays showing vessel-ray pits. $\times 350$. 5. Radial longitudinal section showing ray cells with solitary crystals. $\times 200$.

1-2); especially the marginal upright cells short radially and relatively broad tangentially giving characteristic appearance in cross-section (PL. 2, FIG. 5); rays 2-25 cells and 105-795 μ in height, 8-12 per mm. *Fibres* aligned in radial rows between two consecutive rays (PL. 2, FIG. 5).

Elements — *Vessels* circular to oval in cross-section (PL. 2, FIG. 5), t.d. 45-270 μ , r.d. 45-300 μ ; vessel-members short to medium,

250-675 μ in length with truncated or tailed ends; perforations simple; intervessel pits hardly seen due to plugging of the vessels with thickwalled (sclerotic) tyloses, seen at the places in thin sections, large, 8-10 μ in diameter, alternate (PL. 2, FIG. 9; TEXT-FIG. 3), circular to oval with lenticular aperture (PL. 2, FIG. 9; TEXT-FIG. 3); vessel-parenchyma pits not seen; vessel-ray pits occasionally seen, slightly bigger than intervessel

pits (TEXT-FIG. 4). *Parenchyma cells* orbicular to oval, those confined to the immediate vicinity of the vessels peripherally flattened (PL. 2, FIG. 5), 16-35 μ in diameter, 60-150 μ in length, thickwalled, filled with dark contents (PL. 2, FIG. 5). Upright *Ray cells* 40-108 μ in tangential height, 40-48 μ in radial length; procumbent cells 24-48 μ in tangential height, 40-100 μ in radial length; infiltration dark; solitary crystals present (TEXT-FIG. 5), cells filled with dark gum-like contents (PL. 1, FIG. 1; PL. 2, FIG. 11). *Fibres* oval to angular (hexagonal), often tangentially flattened (PL. 2, FIG. 5), t.d. 8-28 μ , r.d. 8-24 μ , non-septate, thickwalled (PL. 2, FIG. 5), common walls 2-4 μ in thickness; pits not seen.

DISCUSSION

Comparison with the Modern Woods — The important anatomical features exhibited by the fossil are: wood diffuse porous; vessels solitary and also in radial multiples of mostly 2-3, intervessel pit-pairs large with lenticular aperture; parenchyma paratracheal and apotracheal, paratracheal parenchyma vascentric to aliform and confluent, apotracheal (terminal) parenchyma usually delimiting the growth rings; 1-2 seriate, heterogeneous rays. Taking into consideration a combination of these features the fossil wood resembles the wood structure of *Mangifera* of the family Anacardiaceae (BRAZIER & FRANKLIN, 1961; HEIMSCH, 1942; METCALFE & CHALK, 1950; PEARSON & BROWN, 1932).

Besides *Mangifera*, it also shows many anatomical features similar to *Anacardium*, such as the shape, size and distribution of the vessels, intervessel pit-pairs, paratracheal, vascentric to aliform parenchyma, 1-2 seriate heterogeneous xylem rays and non-septate fibres. However, the genus *Anacardium* differs from the present fossil wood in the absence of terminal parenchyma bands delimiting the growth rings. Besides the terminal bands, in *Anacardium* the amount of paratracheal parenchyma is also comparatively less, and the sclerotic tyloses are not found.

Among the species of *Mangifera*, detailed comparison of the present fossil wood was made with the thin-sections of *Mangifera indica* Linn., *M. altissima* Blanco, *M. sylvatica* Roxb., *M. zeylanica* Hook., and also with the published descrip-

tion and figures of *M. indica*, *M. sylvatica* (PEARSON & BROWN, 1932, pp. 315-319, FIGS. 113-114), *M. laurina* Blume, *M. longipes* Griff., *M. odorata* Griff. (MOLL & JANSSONIUS, 108, pp. 466-468), *M. foetida* Lour. (BRAZIER & FRANKLIN, 1961) and *M. altissima* Blanco (KRIBS, 1959, p. 9; FIG. 69). All these species can be hardly differentiated anatomically since their basic structural pattern of various tissues is almost the same. Besides the foregoing important features, the fossil wood is also characterized by the presence of sclerotic tyloses (tyloses with stone cells) plugging the vessels completely and the vessel orifices can only be seen in some of the thin cross-sections. Among the modern species of *Mangifera* such tyloses have so far been reported only in some specimens of *Mangifera altissima* Blanco by Heimsch (1942). The author has also observed such tyloses in a specimen of *Mangifera* sp., received from Forest Research Institute, Selangor, Malaysia. Although no specific name of this specimen was given, most probably it was *M. altissima* as it had sclerotic tyloses. The present fossil wood not only resembles it in having abundant sclerotic tyloses but also in the nature and distribution of vessels, parenchyma, rays and the fibres. Thus in all anatomical details the fossil very closely resembles *Mangifera altissima* Blanco, Malaysian specimen, B.S.I.P. xylarium No. 1095.

Fossil records of the anacardiaceous woods and their comparison with the present fossil wood — Quite a number of fossil woods of this family are known from the Cretaceous onwards; they are *Rhodium juglandinum* Unger (1850) from the Tertiary of Hungary; *R. ungeri* Merchlin (1855, in EDWARDS, 1931, p. 70) from the ? Cretaceous of Russia; *R. philippinense* Crie (1889) from the Tertiary of Philippine; *Anacardioxylon spondiaeforme* Felix (1882) from the Tertiary of Antigua; *A. uniradiatum* Felix (1894) from the Eocene of Caucasus; *A. magniporosum* Platen (1907) from the Tertiary of California; *A. caracoli* Schönfeld (1947) from the Tertiary of Colombia, South America; *A. mangiferoides* Ramanujam (1960) from the Tertiary of South India; *A. semecarpoides* Prakash & Dayal (1965) from the Deccan Intertrappean Series of India; *Edenoxylon parviareolatum* and *Schinoxylon actinoporosum* Kruse (1954) from the Eocene of Eden Valley, Wyoming, U.S.A.; *Glutoxylon burmense* (Hold.)

Chowdhury (1934, 1936, 1952), Chowdhury & Tandan (1952), Ghosh & Taneja (1961) from the Tertiary of Assam, Bengal, Burma and Indochina; *Glutoxylon bengalensis* Mukherjee (1941, 1942) from the Tertiary of Bengal; *G. chowdhurii* Ghosh (1958) from the Pleistocene of Manipur. Besides these, two species were previously described under this family, viz., *Anacardioxylon mollii* Kräusel (1922) from the Miocene of Sumatra and *Schinus primaevum* Caspary (1889, in FELIX, 1894, p. 89) from the ? Tertiary of West Russia. These species have, however, been redescribed and renamed *Sumatroxylon mollii* (Kräusel) Den Berger (1923) under the family Burseraceae and *Rhamnacidium primaevum* (Caspary) Felix (1894) family Rhamnaceae respectively.

Of the above, a few can be compared with the present fossil wood. *Anacardioxylon magniporosum* resembles the present wood, in possession of paratracheal parenchyma which is vasicentric to aliform and the similar shape and size of the vessels. However, it differs from the present fossil wood in having 1-4 seriate rays and absence of terminal parenchyma. *Anacardioxylon uniradiatum* and *A. caracoli* also show some similarity with the present fossil wood, such as the type and arrangement of vessels, parenchyma and rays. However, both the species can be easily differentiated from the present wood in the absence of terminal parenchyma. Also the tyloses which are sclerotic in the present wood, while there is no mention of the occurrence of such tyloses in any of the anacardiaceous fossil woods.

From the Tertiary rocks of South India Ramanujam (1953) reported the occurrence of fossil wood resembling that of *Mangifera* without any description and name. Later, in 1960, he described a wood with full description and diagnosis under the name *Anacardioxylon mangiferoides*. He referred the fossil specimen to the family Anacardiaceae showing nearest resemblance with the wood structure of *Mangifera* and *Anacardium*. The fossil wood from its description and figures appeared to be of most doubtful affinities as it possesses homogeneous ray tissue, i.e., the rays are homocellular, composed wholly of procumbent cells. Such rays are not found in *Mangifera* and *Anacardium*, where the ray tissue is heterogeneous and the individual rays are heterocellular composed of procumbent cells through the median portion and 1-3 marginal rows of

upright cells at both the ends. Not only these two genera but the woods of the Anacardiaceae as a whole have heterogeneous rays except the two genera, *Gluta* and *Melanorrhoea*. Again these two latter genera are quite different from *Mangifera* and *Anacardium* and as well as from *Anacardioxylon mangiferoides* in having fusiform xylem rays with horizontal (radial) gum ducts. Besides the ray characters, *Anacardioxylon mangiferoides* does not match with the woods of *Mangifera* and *Anacardium* in several other anatomical details as found after re-examination of the type-slides. At this moment it could not be possible to suggest its affinities and hence it is considered as a doubtful species. Thus it has no comparison with the present fossil wood.

As far as the author is aware, there is no record of fossil wood of *Mangifera*, however, leaf impressions of this genus *Mangifera* cf. *indica* L. Hofmann and *M. tertiaria* Engelhardt are known from the Eocene of Germany listed in the Fossilium Catalogue by Edwards & Wonnacott (1935).

The fossil wood under investigation closely resembles the wood of *Mangifera*, hence it has been designated *Mangiferoxylon* gen. nov. Its specific name *Mangiferoxylon scleroticum* indicates the presence of sclerotic tyloses.

PRESENT DISTRIBUTION OF *MANGIFERA* L.

The genus consists of 30 species (WILLIS, 1957, p. 408) distributed throughout the Indo-Malayan region. In India *Mangifera* is represented by two species, viz., *M. indica* and *M. sylvatica*. *M. allissima*, which has been proved to be very close to the present fossil wood, is found in Malayan region (S.E. Asian countries) being absent in India.

GENERIC DIAGNOSIS

Mangiferoxylon gen. nov.

Wood diffuse-porous. Growth rings usually present, delimited by apotracheal (terminal) parenchyma. Vessels small to large, solitary as well as in radial multiples of 2-4 or more; vessel-members medium to large with truncated or tailed ends; perforations simple; intervessel pit-pairs usually large, circular to oval, alternate, bordered, with linear to lenticular aperture; tyloses present. Parenchyma paratracheal and

apotracheal; paratracheal parenchyma vasicentric to aliform and aliform-confluent; apotracheal parenchyma usually in fine bands, usually delimiting the growth rings. *Xylem rays* fine, 1-2 seriate; ray tissue heterogeneous; rays heterocellular, consisting of procumbent cells through the median thickened portion and 1-3 marginal rows of upright cells at both the ends; rays usually up to 25 cells in height; crystals often present. *Fibres* non-septate, thin to thick-walled.

Genotype — *Mangiferoxylon scleroticum*

SPECIFIC DIAGNOSIS

Mangiferoxylon scleroticum sp. nov.

Wood diffuse-porous. *Growth rings* present, usually delimited by apotracheal (terminal) parenchyma. *Vessels* small to large, solitary and also in radial multiples of usually 2-3, some times in irregular multiples of 4-10 small vessels or in clusters, circular to oval, t.d. 45-270 μ , r.d. 45-300 μ ; vessel-members medium to large with truncated or tailed ends; perforations simple; inter-vessel pit-pairs large, 8-10 μ in diameter, alternate, bordered, with linear to lenticular aperture; tyloses abundant, sclerotic. *Parenchyma* paratracheal, apotracheal; paratracheal parenchyma vasicentric to aliform, occasionally aliform-confluent, apotracheal parenchyma fine, 2-6 cells wide bands usually delimiting the growth-rings. *Xylem rays* fine, 1-2 (mostly 1) seriate; ray tissue heterogeneous; rays heterocellular, consisting of procumbent cells through the median thickened portion and 1-3 (mostly 1) marginal rows of upright cells at both the ends, solitary crystals often present; rays 2-25 cells in height, 8-12 per mm. *Fibres* non-septate, thickwalled, common walls 2-4 μ in thickness.

Holotype — B.S.I.P. Museum No. 73631.

Locality — Between Murattandichavadi, Thiruchitrabal and Kasippalaiyam, 8-10 km. W.N.W. of Pondicherry, South Arcot district, Madras.

II. *Glutoxylon burmense* (Holden) Chowdhury

Pl. 3, Figs. 12-15; Text-figs. 6-10

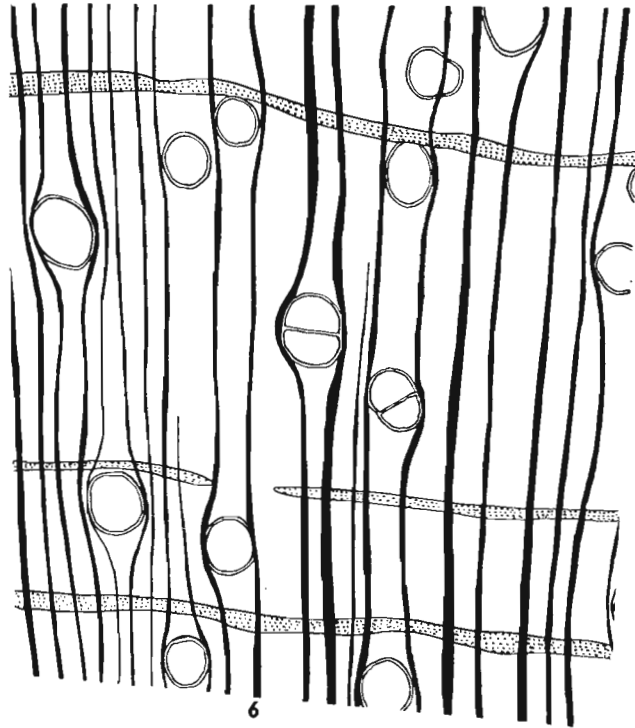
DESCRIPTION

This species is represented by 8 pieces of silicified secondary wood. The biggest

one is about 28 cm. in length and 20 cm. in diameter. Their preservation is fairly good and the colour varies from light brown to dark brown.

Topography — *Wood* diffuse-porous (Pl. 3, FIG. 12). *Growth rings* seen on careful examination, delimited by thin terminal parenchyma bands (Pl. 3, FIG. 12). *Vessels* clearly visible to the naked eye as dots against the ground mass of the wood, small to large (mostly medium to large), solitary as well as in radial multiples of 2-4 (Pl. 3, FIGS. 12-13; TEXT-FIG. 6), sometimes 2-10 small vessels, forming short radial chain, about 2-8 vessels per sq. mm.; tyloses abundant, sometimes completely occluding the vessels (Pl. 3, FIG. 13). *Parenchyma* paratracheal and apotracheal (Pl. 3, FIGS. 12-13; TEXT-FIGS. 6-7); paratracheal parenchyma scanty to vasicentric, often forming complete sheath of 1-3 cells around the vessels (Pl. 3, FIG. 13), occasionally tending to become aliform (TEXT-FIG. 7); apotracheal parenchyma visible to the naked eye as fine lines usually delimiting the growth rings (Pl. 3, FIGS. 12-13), a few other apotracheal bands also occur in between terminal bands (Pl. 3, FIG. 13; TEXT-FIG. 6), interrupted by the xylem rays (Pl. 3, FIG. 13; TEXT-FIGS. 6-7), 1-3 bands per mm., each 2-5 cells wide. *Xylem rays* not visible to the naked eye, simple and fusiform (Pl. 3, FIG. 14; TEXT-FIGS. 8-10); simple rays fine, 1-2 (mostly 1) seriate, homocellular, consisting of procumbent cells (Pl. 3, FIG. 15; TEXT-FIGS. 8-9), 3-20 cells in height; fusiform rays 3-4 seriate with single radial gum duct in the centre (Pl. 3, FIG. 14; TEXT-FIG. 10), slightly longer than simple rays, homocellular, consisting of procumbent cells (Pl. 3, FIG. 14; TEXT-FIG. 10), gum ducts lined with single row of epithelial cells (TEXT-FIG. 10); rays 9-12 per mm. *Fibres* aligned in radial rows between two consecutive xylem rays in cross-section (Pl. 3, FIG. 13), often gelatinous in some specimens, forming darker zone alternating with non-gelatinous (Pl. 3, FIG. 12).

Elements — *Vessels* circular to oval in cross-section (Pl. 3, FIGS. 12-13; TEXT-FIG. 6), those of radial multiples flattened at the places of contact (Pl. 3, FIGS. 12-13; TEXT-FIG. 6), t.d. 40-300 μ , r.d. 30-345 μ , thin to thickwalled, common walls 8-12 μ in thickness; vessel-members 375-800 μ in length with truncated or tailed ends; perforations simple; intervessel pit-pairs occasionally



Glutoxylon burmense (Holden) Chowdhury

TEXT-FIG. 6 — Cross-section showing type and distribution of vessels and apotracheal parenchyma— $\times 35$.

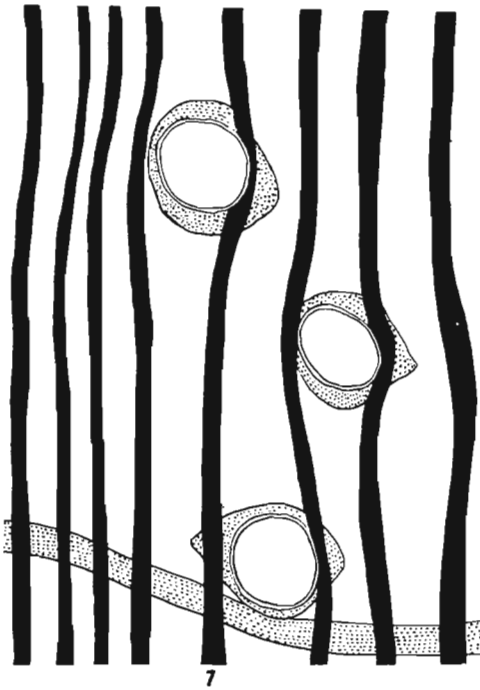
seen, large, 8-12 μ in diameter, bordered, alternate, oval to orbicular, with lenticular aperture; vessel-parenchyma and vessel-ray pits not observed. *Parenchyma cells* circular to oval, those in the immediate vicinity of the vessels peripherally flattened, t.d. 8-24 μ , r.d. 8-32 μ ; infiltration dark. Procumbent *Ray cells* 18-40 μ in tangential height, 40-120 μ in radial length. *Fibres* angular (mostly hexagonal), t.d. 8-20 μ , r.d. 8-16 μ , non-septate, thickwalled, common walls 3-4 μ in thickness; infiltration dark brown to black.

DISCUSSION

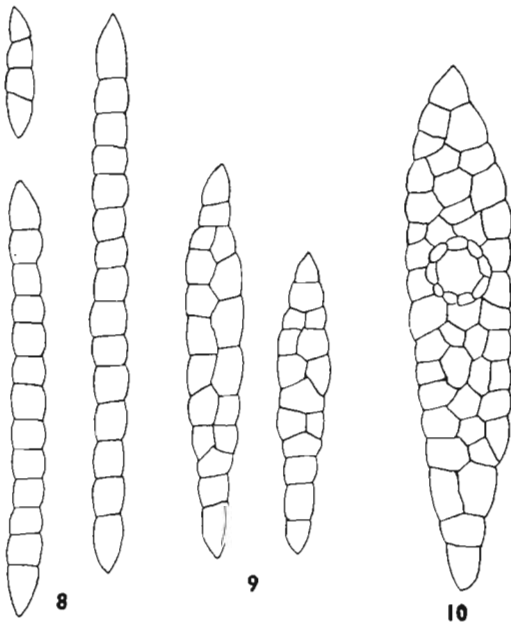
Comparison with the Modern Woods — The fossil wood is characterized by the following important anatomical features. Vessels medium to large as well as in radial multiples, pits large with lenticular aperture, tylosed; parenchyma paratracheal and apotracheal, paratracheal parenchyma usually forming vasicentric sheath, apotracheal parenchyma

represented by fine, tangential bands, some of them delimiting the growth rings; xylem rays of two types, simple rays 1-2 seriate, homocellular, fusiform rays 3-4 seriate with single radial gum duct. Taking into consideration these important anatomical features the fossil wood closely resembles the woods of *Gluta* and *Melanorrhoea* of the Anacardiaceae.

The name *Glutoxylon* was instituted by Chowdhury for the fossil woods resembling those of *Gluta* and *Melanorrhoea* (those melanorrhoeas which have thin apotracheal parenchyma bands) when he described *Glutoxylon assamicum* (CHOWDHURY, 1934, 1936) from the Tertiary of Assam. In 1952, he included a number of woods in the genus *Glutoxylon* which were previously described under different generic and specific names by Holden (1916), Colani (1919), Sen (1930), Gupta (1935) and Chowdhury (1942) from the Tertiary of Assam, Bengal, Burma and Indochina. As they were anatomically indistinguishable from each other



TEXT-FIG. 7. Cross-section showing paratracheal and apotracheal parenchyma. $\times 60$.



TEXT-FIGS. 8-10. 8. Simple, uniseriate xylem rays. $\times 125$. 9. Simple, biseriate xylem rays. $\times 125$. 10. Fusiform ray with gum duct. $\times 125$.

Chowdhury (1952) united all of them under one name: *Glutoxylon burmense* (Holden) Chowdhury. Besides, two more species of *Glutoxylon* have been described *G. bengalensis* Mukherjee (1941, 1942) from the Tertiary of Bengal and *G. chowdhurii* Ghosh (1958) from the Pleistocene of Manipur.

Before comparing the present fossil specimen with these species of *Glutoxylon* it would be apt to consider the affinities of *G. bengalensis* and *G. chowdhurii* more critically. Their respective authors have not given the points of difference from *G. burmense*. From their description (as summarized in Table 1) and illustrations it appears that both these species are very close and almost identical with *Glutoxylon burmense*. In view of such close resemblance bordering on identity, it is here suggested that both these species be merged with the already known *G. burmense* (Holden) Chowdhury which has the priority.

All the anatomical features of the present specimen are found in *Glutoxylon burmense* and there is no essential difference between the two. Therefore the Cuddalore fossil is placed under the same species, i.e. *Glutoxylon burmense*.

Present specimen — B.S.I.P. Museum No. 33672.

Locality — Between Murattandichavadi and Kasippalaiyam, 8-10 km. W.N.W. of Pondicherry, South Arcot district, Madras.

III. *Glutoxylon cuddaloreense* sp. nov.

Pl. 4, Figs. 16-21; Text-figs. 11-15

DISCUSSION

The present species is based on a single piece of silicified secondary wood. Prior to sectioning it measured about 13 cm. in length and 5 cm. in diameter. The preservation is fairly good.

Topography — Wood diffuse-porous (PL. 4, FIG. 17). *Growth rings* present, delimited by apotracheal (terminal) parenchyma bands (PL. 4, FIG. 17). *Vessels* visible to the naked eye against the ground mass of the wood, medium to large, also small (especially those of multiples), solitary as well as in radial multiples of usually 2-4 (PL. 4, FIG. 17; TEXT-FIG. 11), sometimes forming short, radial chains consisting of up to 16 vessels (TEXT-FIG. 12), occasionally in short double rows also, uniformly distributed, about 4-10 vessels per sq. mm.; tyloses present, abundant,

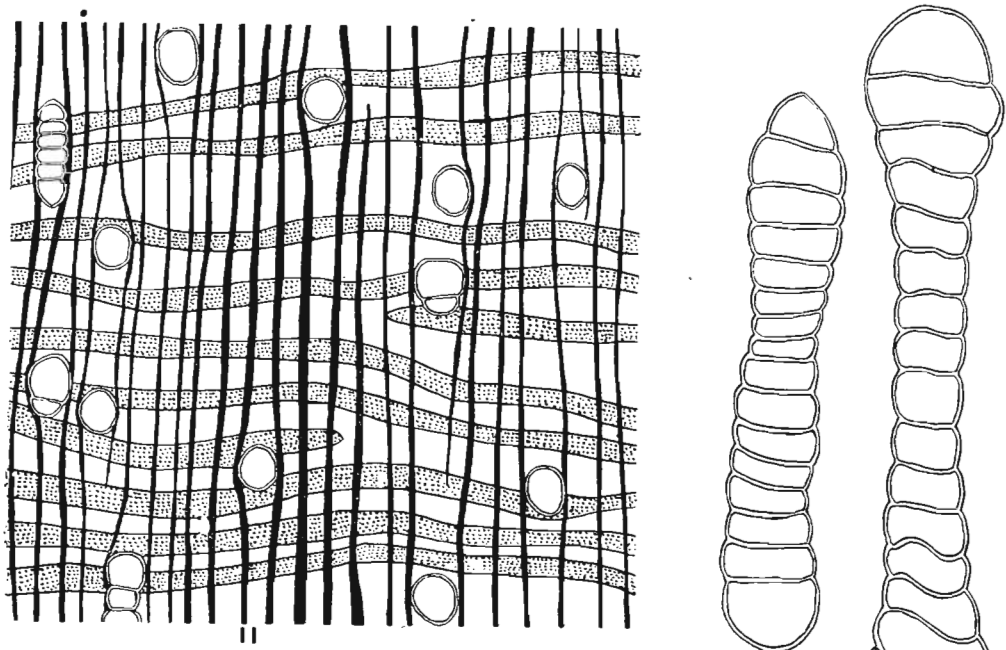
TABLE 1 — SHOWING IMPORTANT ANATOMICAL FEATURES OF THE WOODS REFERRED TO *GLUTOXYLON* CHOWDHURY

NAME OF FOSSIL WOOD	VESSELS	PARENCHYMA	RAYS	FIBRES
1. <i>Glutoxylon burmense</i> (Holden) Chowdhury, 1936, 1952.	Medium to large, solitary to radial multiples of 2-9 (mostly 2-4).	(1) Paratracheal, in a sheath of 1-2 cells, seldom forming eye-lets; (2) apotracheal (metatracheal) bands thin, 1-4 (mostly 2) cells wide, continuous or ending blindly, irregularly spaced; (3) diffuse not observed.	(1) Simple, 1-2 (mostly 1) seriate; (2) fusiform, 3-4 seriate with horizontal gum ducts, mostly one in a ray, seldom two.	Libriform to semi-libriform, thin to thick-walled
2. <i>G. bengalensis</i> Mukherjee, 1941, 1942.	Medium to large, solitary or in radial multiples of 2-9 (mostly 2-3).	(1) Paratracheal, in sheath round the vessels, rarely forming eye-lets; (2) apotracheal (paratracheal zonate); 2-9 cells (mostly 2-4); (3) diffuse (metatracheal) rare.	(1) Simple, 1-2 (mostly 1) seriate; (2) fusiform, usually 2-3 cells with horizontal gum canals.	Thin to thick-walled.
3. <i>G. chowdhurii</i> Ghosh, 1958.	Medium to large, solitary to radial multiples of 2-4 or more.	(1) Paratracheal mostly thin sheath round the pores, occasionally extending sideways; (2) apotracheal 1-6 cells wide, irregularly spaced.	(1) Simple, 1-2 (mostly 1) seriate; (2) fusiform, 3-4 cells wide with horizontal gum canals	Thin to thick-walled.

sometimes completely occluding the vessels (PL. 4, FIG. 16). *Parenchyma* paratracheal, apotracheal; paratracheal parenchyma forming scanty to vasicentric sheath of 1 to 3 cells (PL. 4, FIG. 19), occasionally tending to become aliform (PL. 4, FIG. 19); apotracheal parenchyma abundant, represented by regular, concentric tangential bands (PL. 4, FIGS. 16-17; TEXT-FIG. 11), those delimiting the growth rings (terminal) broad and straight (PL. 4, FIG. 17), interrupted by xylem rays; 3-6 bands per mm., each 2-6 cells wide. *Xylem rays* simple and fusiform (PL. 4, FIG. 18; TEXT-FIGS. 13-14); simple rays very fine, 12-20 μ in width, exclusively uniseriate (PL. 4, FIG. 18; TEXT-FIG. 13); ray tissue homogeneous (Kribs's type III); rays homocellular, composed wholly of procumbent cells (PL. 4, FIG. 20; TEXT-FIGS. 13-14), 3-25 cells in height; fusiform rays 3-4 seriate (PL. 4, FIG. 18; TEXT-FIG. 14), homocellular, composed wholly of procumbent cells and single radial gum duct in the centre (PL. 4, FIG. 18; TEXT-FIG. 14), up to 30 cells and 750 μ in height; rays including both the types

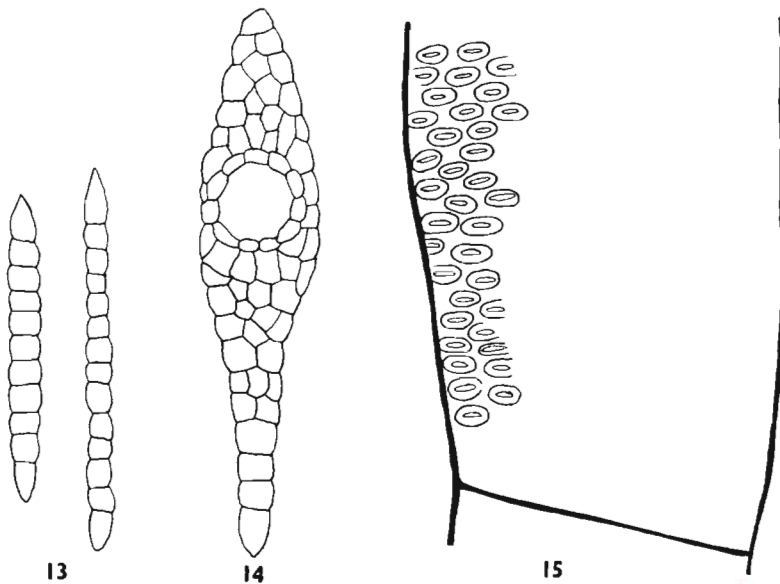
9-12 per mm., each separated by 2-8 tangential rows of fibres. *Fibres* aligned in radial rows between two consecutive rays in cross-section (PL. 4, FIG. 21); sometimes gelatinous, seen as dark zone (PL. 4, FIG. 17).

Elements — *Vessels* circular to oval, those in radial multiples flattened at the places of contact in cross-section (PL. 4, FIG. 17; TEXT-FIG. 11), t.d. 180-375 μ , r.d. up to 330 μ and those of multiples 14-100 μ in diameter, common walls 6-10 μ in thickness; vessel-members about 250-700 μ in length with truncated or tailed ends, perforations simple; intervessel pit-pairs poorly preserved, large, 10-12 μ in diameter, alternate, circular to oval or orbicular (TEXT-FIG. 15), sometimes hexagonal due to crowding, apertures lenticular (TEXT-FIG. 15); vessel-parenchyma and vessel-ray pits not observed; infiltration dark. *Parenchyma cells* oval to angular or squarish, those in the immediate vicinity of the vessels peripherally flattened (PL. 4, FIG. 19), t.d. 16-24 μ , r.d. 16-28 μ , infiltration dark. Procumbent *Ray cells* 20-40 μ in tangential height, 60-80 μ in radial length; gum ducts 60-135 μ in



Glutoxylon cuddalorensis sp. nov.

TEXT-FIGS. 11-12. — 11. Cross-section showing the type and distribution of vessels and apotracheal parenchyma bands. $\times 35$. 12. Vessels in radial multiples. $\times 75$.



TEXT-FIGS. 13-15. — 13. Simple, uniseriate xylem rays. $\times 125$. 14. Fusiform xylem ray with gum duct. $\times 125$. 15. A portion of vessel-member in tangential section showing pits. $\times 300$.

diameter, filled with dark gum-like contents (PL. 4, FIG. 18). *Fibres* oval or squarish in cross-section (PL. 4, FIG. 21), t.d. 16-20 μ , r.d. 12-16 μ , non-septate, moderately thick to thickwalled, common walls 2-4 μ in thickness; pits not observed; infiltration yellow to yellowish brown.

DISCUSSION

Comparison with the Modern Woods—The present fossil wood is also characterized by the presence of such important anatomical features as found in the previous fossil wood. Hence it also resembles the modern woods of *Gluta* and *Melanorrhoea* and should be placed under the genus *Glutoxylon*.

The present author has examined thin-sections of four species of *Gluta* (*G. coarctata* Hook. f., *G. rhengas* Linn., *G. tavoyana* Hook. f. and *G. travancorica* Bedd.) and five of *Melanorrhoea* (*M. apetra* King, *M. curtisii* Oliver, *M. pilosa* Lecomte, *M. torquata* King and *M. usitata* Wall.). None of the above mentioned species shows identity with the fossil specimen. Although it resembles them in all the basic structural features, such as the type, shape, size and distribution of vessels, the type of parenchyma and rays, gum canals and fibres, it is somewhat different from these species of *Gluta* and *Melanorrhoea*. All the species of *Gluta* and *Melanorrhoea* so far studied from their thin-sections and published description and figures possess apotracheal parenchyma, mostly terminal, delimiting the growth rings, and a few, usually short or regular bands also occur in between them. The frequency of these bands is very low, i.e., 1-3 per mm. or even less in some species. Whereas in present fossil wood the parenchyma bands are more abundant, i.e., 3-6 bands in between the terminal bands and their number is also about 3-6 per mm. Moreover, in the present fossil they are more regular, wavy and uniform in distribution. Besides the parenchyma, the simple rays are exclusively uniseriate, whereas in most of the modern species of *Gluta* and *Melanorrhoea* the simple rays are usually uniseriate and occasionally biseriate. In the closeness of parenchyma bands (which are also more regular and wavy) the fossil can be compared with *Melanorrhoea usitata* and *M. torquata*. However, *M. usitata* differs in having comparatively broad bands, which are not so

close as in the present fossil. In *M. torquata* the apotracheal parenchyma bands are comparatively thinner than the present fossil wood. It has been found that the present fossil wood does not resemble closely any of the above named modern species of *Gluta* and *Melanorrhoea*.

Comparison with the Fossil Woods—The present fossil wood being closely allied to the modern woods of *Gluta* and *Melanorrhoea* falls under the genus *Glutoxylon* and resembles all the fossil woods placed under *Glutoxylon burmense* (Holden) Chowdhury in a number of features, such as shape, size and distribution of the vessels, type of parenchyma, xylem rays and the fibres. However, it differs from *G. burmense* in one or two important features. In the present fossil the apotracheal parenchyma bands are abundant and closely spaced (i.e., their frequency is about 3-6 per mm.) while in the previously known species the apotracheal parenchyma bands are more widely spaced (i.e., 1-2 or at the most 3 bands per mm.). The simple xylem rays in the present fossil are exclusively uniseriate, whereas they are mostly uniseriate and occasionally biseriate in *G. burmense*.

The present fossil wood is thus different from *G. burmense* (Holden) Chowdhury. Therefore, it has been placed under a new species, *Glutoxylon cuddaloreense*, the specific name signifying its occurrence in the Cuddalore Series.

SPECIFIC DIAGNOSIS

Glutoxylon cuddaloreense sp. nov.

Wood diffuse-porous. *Growth rings* present, delimited by apotracheal (terminal) parenchyma bands. *Vessels* medium to large, solitary as well as in radial multiples of 2-4, occasionally up to 18 cells, forming a short chain along the radial plane, rarely in double rows, t.d. 180-375 μ , r.d. up to 330 μ ; vessel-members with truncated or tailed ends; perforations simple; intervessel pit-pairs large, 10-12 μ in diameter, alternate, circular to oval with lenticular aperture; tyloses abundant. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma forming scanty to vasicentric sheath of 1-3 cells occasionally tending to become aliform; apotracheal parenchyma abundant in concentric tangential bands, terminal as well as several other occurring

in between them, wavy, usually continuous, 3-6 bands per mm., each 2-6 cells wide. Xylem rays simple and fusiform; simple rays very fine, exclusively uniseriate, homocellular, consisting wholly of procumbent cells, 3-25 cells in height; fusiform rays 3-4 seriate with single radial gum canal in the centre, homocellular, consisting of procumbent cells; rays 9-12 per mm. Fibres gelatinous and non-gelatinous, non-septate, thickwalled, common walls 2-4 μ in thickness.

Holotype — B.S.I.P. Museum No. 33673.

Locality — Between Murattandichavadi and Pattanur, about 10 km. W.N.W. of Pondicherry, South Arcot district, Madras.

Present distribution of Gluta and Melanorrhoea — The genus *Gluta* consists of 6 species, distributed in tropical Asia and Madagascar (WILLIS, 1957, p. 294). Most of the species excepting three are confined to South-East Asia (including Thailand,

Malaya, Indochina) and as far as north-east as Hainan Islands. *G. turtur* occurs only in Madagascar, while *G. travancorica* and *G. tavoyana* grow in South India and Burma respectively. *G. travancorica* is distributed in Western ghats, evergreen forests of South Travancore and Tinnevely, ascending to about 1200 m. (GAMBLE, 1902) *Melanorrhoea* also consists of 6-8 species, confined to the area of South-East Asia where the bulk of the *Gluta* species occur being absent in Madagascar and India.

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EXPLANATION OF PLATES

PLATE 1

Mangiferoxylon scleroticum gen. et sp. nov.

1. Cross-section of the fossil wood showing type and distribution of vessels and parenchyma. $\times 12$.
2. Cross-section of *Mangifera* sp. (? *M. altissima*) showing similar type and distribution of vessels. $\times 12$.
3. Tangential longitudinal section of the fossil wood showing xylem rays. $\times 60$.

4. Tangential longitudinal section of *Mangifera* sp. (? *M. altissima*) showing similar type of rays. $\times 60$.

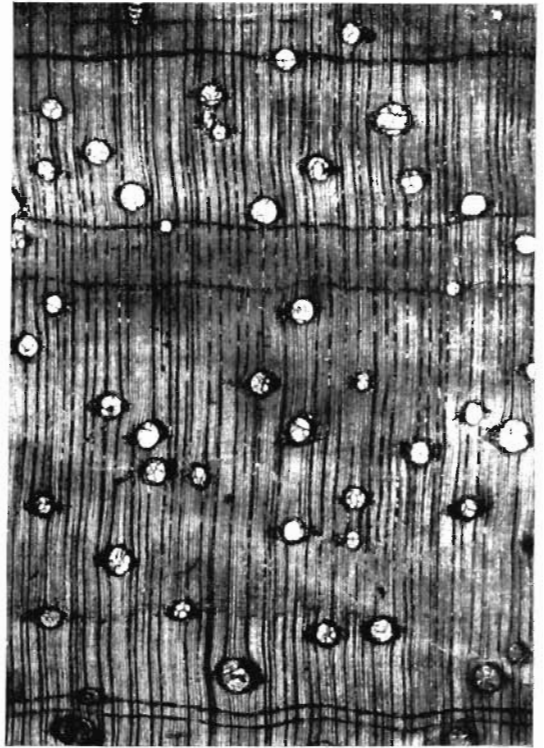
PLATE 2

Mangiferoxylon scleroticum gen. et sp. nov.

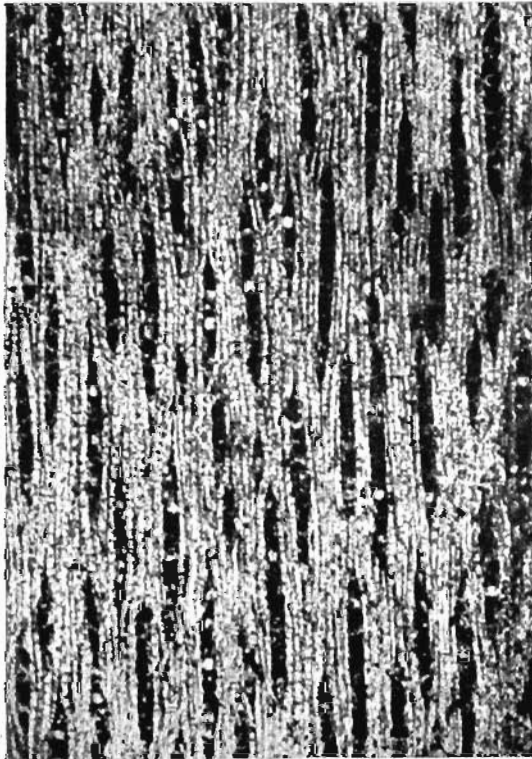
5. Magnified cross-section of the fossil wood to show the vessels plugged with sclerotic tyloses, paratracheal and apotracheal parenchyma and the fibres. $\times 95$.



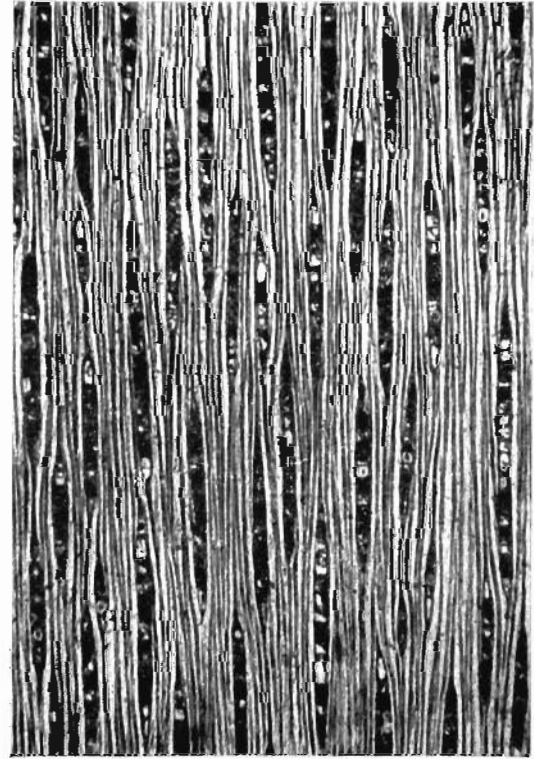
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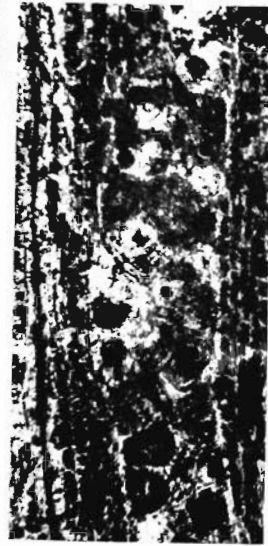
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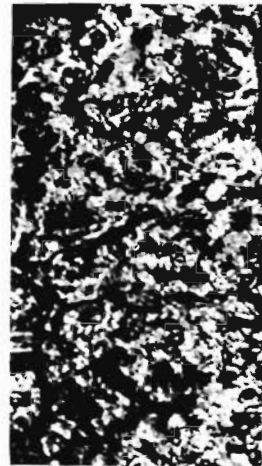
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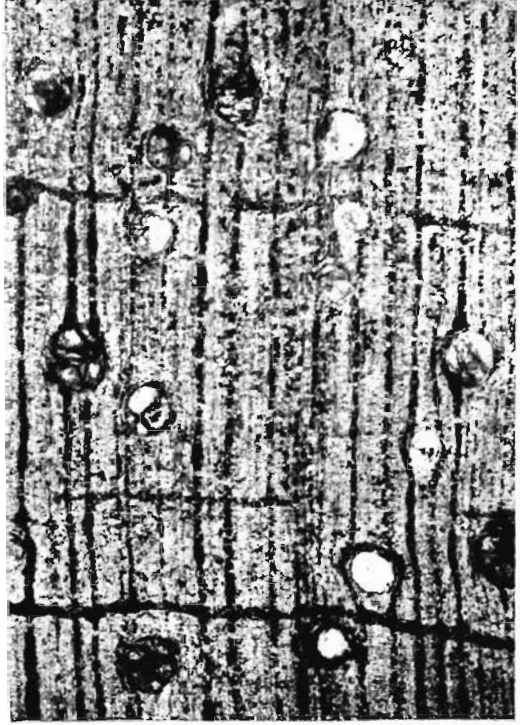
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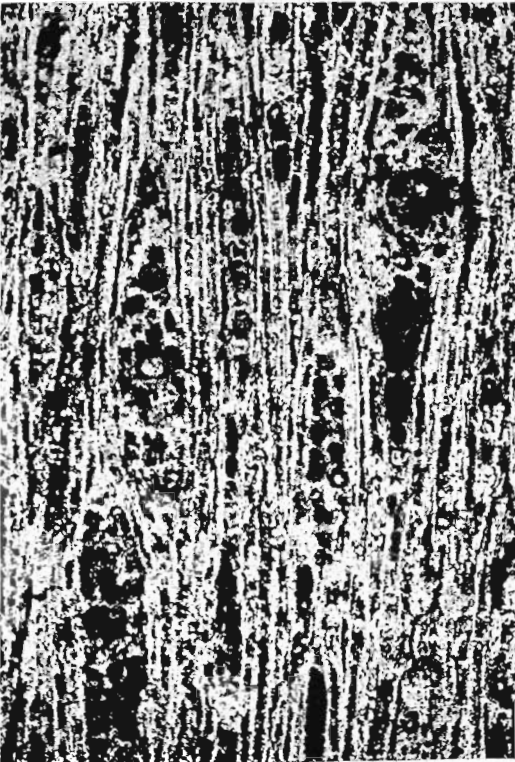
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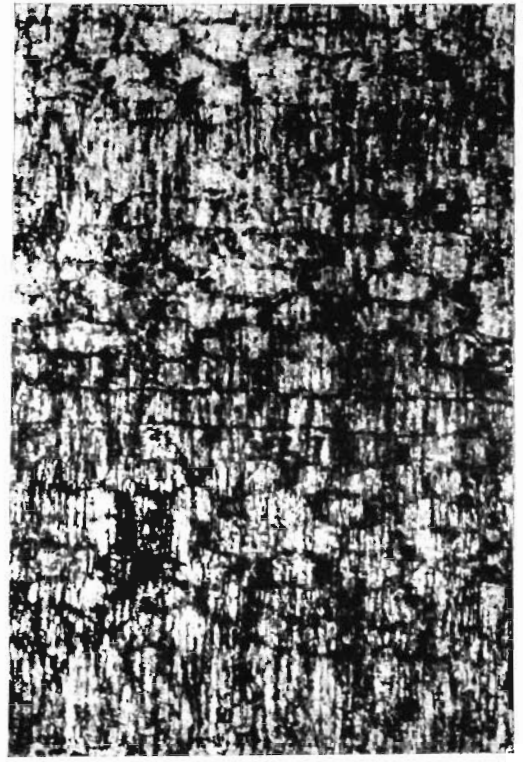
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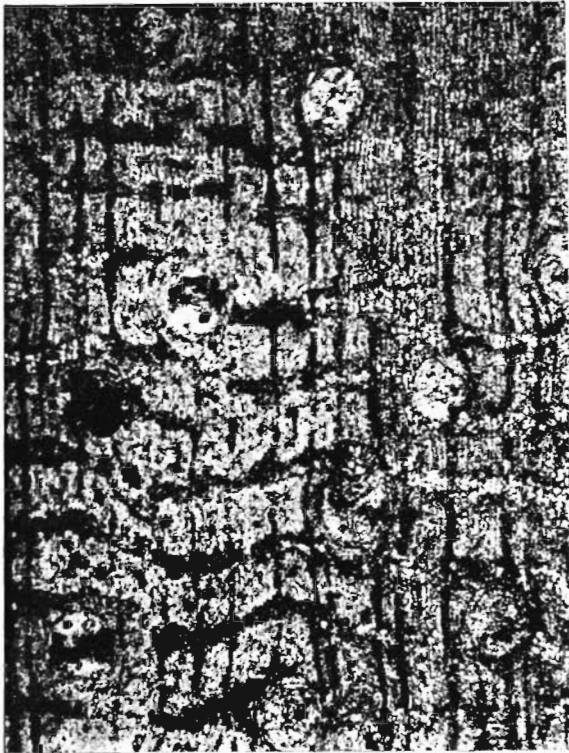
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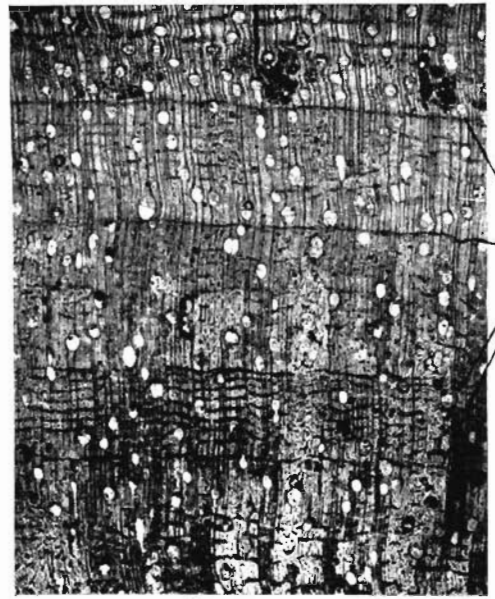
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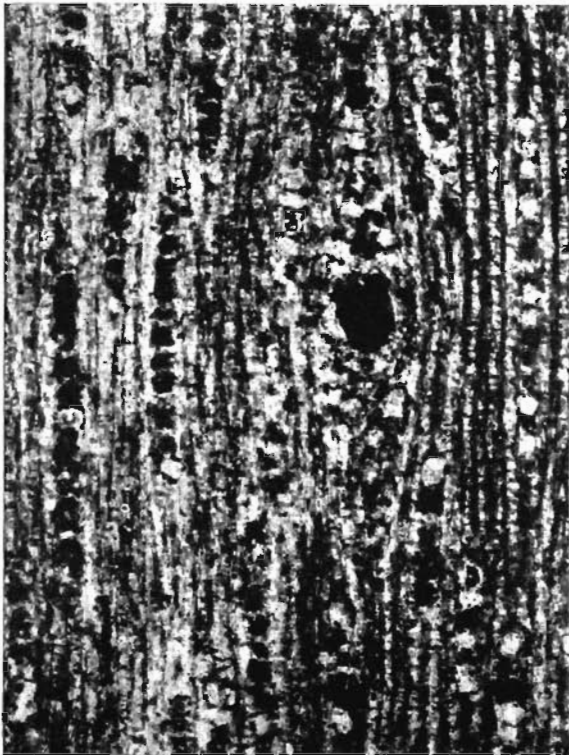


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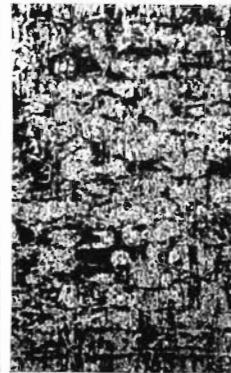
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6. Magnified cross-section of *Mangifera* sp. (?*M. altissima*) to show similar type of tyloses plugging the vessels, paratracheal and apotracheal parenchyma and the fibres. $\times 95$.

7. A portion of vessel of the fossil wood in tangential longitudinal section showing sclerotic tyloses. $\times 95$.

8. A portion of vessel of *Mangifera* sp. (?*M. altissima*) showing similar type of sclerotic tyloses $\times 95$.

9. Intervascular pitting of the fossil wood in tangential longitudinal section. $\times 330$.

10. Intervascular pitting of *Mangifera* sp. (?*M. altissima*) in tangential longitudinal section. $\times 330$.

11. Radial longitudinal section of the fossil wood showing heterocellular xylem ray. $\times 95$.

PLATE 3

Glutoxylon burmense (Holden) Chowdhury

12. Cross-section showing type and distribution of vessels and apotracheal parenchyma. $\times 6$.

13. Cross-section of another piece of fossil wood showing vessels with tyloses and parenchyma $\times 28$

14. Tangential longitudinal section showing xylem rays. $\times 88$.

15. Radial longitudinal section showing homocellular xylem rays. $\times 110$.

PLATE 4

Glutoxylon cuddaloreense sp. nov.

16. Cross-section showing vessels and apotracheal parenchyma. $\times 35$.

17. Cross-section under low magnification to show the type and distribution of vessels and apotracheal parenchyma. $\times 6$. t.p. = terminal parenchyma.

18. Cross-section magnified to show paratracheal parenchyma. $\times 90$.

19. Tangential longitudinal section showing xylem rays. $\times 100$.

20. Radial longitudinal section showing homocellular xylem rays. $\times 80$.

21. A portion of cross-section showing fibres. $\times 145$.