# FOSSIL WOODS FROM THE TERTIARY OF EASTERN INDIA, 11

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## ABSTRACT

Fossil woods resembling those of *Calophyllum, Shorea, Gluta-Melanorrhoea, Cynometra, Afzelia-Intsia* and *Terminalia* are described here from the Tertiary of Assam and NEFA. They were collected from the beds of Buri-Dihing River near Jaipur and Namsang River at Deomali.

## INTRODUCTION

IN 1963 Drs. R. N. Lakhanpal and M. N. Bose made a rich collection of fossil woods from the beds of Buri-Dehing River near Jaipur, Assam, and the Namsang River near the headquarter of the Khonsa Forest Division at Deomali, NEFA (*see* TEXT-FIG. 1 in PRAKASH & AWASTHI, 1970). Out of this collection, Prakash (1965a, 1966) and Prakash and Awasthi (1970) have already described a number of fossil woods resembling those of *Calophyllum, Terminalia, Afzelia-Intsia, Shorea, Holigarna, Cassia, Duabanga* and *Sideroxylon*.

In the present paper two new fossil woods resembling *Shorea* and *Terminalia* are being described. Besides, the woods of *Calophyllum, Gluta-Melanorrhoea, Cynometra* and *Afzelia-Intsia* are also being recorded from these localities.

As mentioned in our earlier paper (PRAKASH & AWASTHI, 1970), the fossil woods collected from the beds of Buri-Dehing River are most probably from the Tipam series indicating an Upper Miocene age, while those from the bed of Namsang River near Deomali may be considered as Mio-Pliocene in age, probably being derived from the Namsang Beds (KRISHNAN, 1960; PASCOE, 1963).

## SYSTEMATIC DESCRIPTION

### GUTTIFERAE

**_Calophylloxylon_ Lakhanpal & Awasthi, 1965**

1. *Calophylloxylon eoinophyllum* Prakash, 1966

Pl. 1, Figs. 1, 2

The fossil wood recorded here is a fairly well preserved piece of secondary xylem measuring about 6 cm in length and 4 cm in diameter. It shows the following important anatomical features:

*Wood* diffuse-porous, without distinct growth marks. *Vessels* 100-480 μ in diameter, exclusively solitary, arranged characteristically in oblique radial lines. *Vasicentric tracheids* present, forming 2-3 seriate sheath around the vessels. *Parenchyma* apotracheal in continuous or broken, closely spaced, tangential lines or bands of 2-4 cells wide. *Xylem rays* 1-2 seriate and 2-22 cells in height, heterocellular, consisting of 1-2 marginal rows of upright cells and the rest procumbent cells. *Fibres* nonseptate, thin-walled.

As these features are identical with those of *Calophylloxylon eoinophyllum* Prakash (1966), the fossil wood is placed under the same species.

*Specimen* — B.S.I.P. Museum No. 34049.
*Locality* — Buri-Dehing River bed near Jaipur, Assam.
*Horizon* — Tipam Sandstones.
*Age* — Upper Miocene

### DIPTEROCARPACEAE

**_Shoreoxylon_ Ded Berger, 1923**

2. *Shoreoxylon deomaliense* sp. nov.

Pl. 1, Figs. 3, 4

This species is based on a single piece of fairly well-preserved fossil wood measuring 12 cm in length and 5 cm in width.

*Topography — Wood* diffuse-porous (PL. 1, FIG. 3). *Growth rings* not seen. *Vessels*

visible to the naked eye as small pin holes, small to large (mostly large), solitary, occasionally in radial multiples of 2, evenly distributed, about 8-16 vessels per sq. mm; tyloses present, thin-walled. *Vasicentric tracheids* not well preserved, difficult to distinguish from neighbouring fibres in cross-section. *Parenchyma* paratracheal and apotracheal, paratracheal parenchyma usually forming thin vasicentric sheath around the vessels, occasionally aliform to aliform-confluent (PL. 1, FIG. 3); apotracheal parenchyma associated with the gum canals, forming concentric, tangential rings (Pl. 1, Fig. 3); diffuse parenchyma occasionally present. *Xylem rays* fine to moderately broad, 1-7 seriate, 6-9 rays per mm, each separated by 1-10 tangential rows of fibres; ray tissue heterogeneous; rays heterocellular, consisting of procumbent cells through the median portion and 1-8 marginal rows of upright cells at one or both the ends, 4-65 cells in height. *Fibres* aligned in radial rows between the two consecutive xylem rays. *Gum canals* vertical, in concentric tangential rings (PL. 1, FIG. 3).

*Elements — Vessels* circular to oval, t.d. 64-256 μ, r.d. 64-320 μ, thin-walled; vessel-members 160-960 μ in length, with truncate ends; perforations simple, intervessel pits and pits leading to contiguous tracheids large, about 6-10 μ in diameter, vestured; vessel-ray and vessel-parenchyma pits similar to intervessel pits. *Vasicentric tracheids* 40-60 μ in diameter, as long as fibres; pits aligned in vertical rows, similar to vessel-tracheid pits. *Parenchyma* cells circular or oval, 32-60 μ in diameter; crystals present. Upright *Ray cells* 40-72 μ in tangential height, 28-48 μ in radial length; procumbent cells 16-32 μ in tangential height, 40-160 μ in radial length. *Fibres* angular (mostly hexagonal), about 12-32 μ in diameter, non-septate, thick-walled, walls 4-8 μ in thickness. *Gum canals* circular, 35-240 μ in diameter.

## AFFINITIES

Considering all the important anatomical features the present fossil shows a close similarity with the tribe Shoreae (especially with the genus *Shorea*) of the family Dipterocarpaceae (METCALFE & CHALK, 1950). However, it has not been possible to find its equivalent out of the modern species of *Shorea*, which are very similar to each other in anatomical details.

Two species of *Shoreoxylon* are already known from the Tertiary of Eastern India (Assam), viz. *Shoreoxylon evidens* Eyde (1963) and *S. tipamense* Prakash & AWASTHI (1970), described from the Garo Hills and Buri-Dehing River bed near Jaipur respectively. Both these species show some resemblance with the present fossil. However, these can also be distinguished from it in the vessel distribution, and in the ray and fibre structure. Thus in *Shoreoxylon evidens* the vessels are solitary as well as in radial multiples of 2-4, the xylem rays are about 13-25 cells in height with a single marginal row of upright cells at one or both the ends, whereas in the present fossil specimen the vessels are mostly solitary, rarely in radial multiples of 2 and the xylem rays are upto 65 cells in height with 1-8 marginal rows of upright cells at one or both the ends. Similarly, the main difference between the present fossil wood and *Shoreoxylon tipamense* is that in the former the fibres are very thick-walled than those of the latter. Moreover, the vessels in *S. tipamense* are mostly in radial multiples of 2-3.

In addition to this, the other species of *Shoreoxylon* known so far from the Cenozoic rocks of India and abroad (DEN BERGER, 1923, 1927; SCHWEITZER, 1958; NAVALE, 1963; PRAKASH, 1965b; RAMANUJAM & RAGHU RAMA RAO, 1967), are also quite different from the present fossil wood. Therefore, the present fossil is described as a new species of *Shoreoxylon*, *Shoreoxylon deomaliense*, the specific name is after the fossil locality Deomali.

## DIAGNOSIS

*Shoreoxylon deomaliense* sp. nov.

*Wood* diffuse-porous. *Growth rings* absent. *Vessels* small to large, t.d. 64-256 μ, r.d. 64-320 μ, mostly solitary, occasionally in radial multiples of 2, evenly distributed, 8-16 per sq. mm; tyloses present, thin-walled; perforations simple; intervessel pits and pits leading to contiguous tracheids large, about 6-10 μ in diameter, alternate, circular, vestured. *Vasicentric tracheids* forming a narrow sheath of 1-2 cells around the vessels; pits vestured. *Parenchyma* paratracheal and apotracheal; paratracheal

parenchyma vasicentric to aliform, occasionally aliform-confluent; apotracheal parenchyma occasionally diffuse and also associated with the tangential rings of gum canals. *Xylem rays* 1-7 seriate; ray tissue heterogeneous; rays heterocellular, consisting of procumbent cells through the median thickened portion and 1-8 marginal rows of upright cells at one or both the ends, 4-65 cells in height. *Fibres* angular (mostly hexagonal), 12-32 μ in diameter, non-septate, thick-walled, walls 4-8 μ in thickness. *Gum canals* normal, vertical, in concentric tangential rings, 35-240 μ in diameter.

*Holotype* — B.S.I.P. Museum No. 34050.
*Locality* — Namsang River bed near Deomali, NEFA.
*Horizon* — Namsang Beds.
*Age* — Mio-Pliocene.

ANACARDIACEAE

***Glutoxylon* Cnowdhury, 1934**

3. *Glutoxylon burmense* (Hold.) Chowdhury, 1952

Pl. 1 Figs, 5, 6

The fossil wood consists of a single piece measuring about 6 cm in length and 6 cm in width.

The characteristic features of this wood are:

*Wood* diffuse-porous, without growth marks. *Vessels* 64-400 μ in diameter, solitary as well as in radial multiples of 2-8, with abundant tyloses and large, alternate, intervessel pits with lenticular apertures. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma scanty to vasicentric; apotracheal parenchyma in continuous or broken tangential lines, consisting of 1-3 cells in thickness, about 0·3 per mm. *Xylem rays* simple and fusiform; simple rays 1-2 (mostly 1) seriate, homocellular, consisting of procumbent cells only; fusiform rays 3-4 seriate with horizontal gum ducts in the centre; rays about 10-28 cells in height. *Fibres* non-septate, thin to thick-walled.

The fossil wood is identical to *Glutoxylon burmense* (Hold.) Chowdhury which has already been recorded from several Cenozoic localities in India (CHOWDHURY, 1936, 1952; AWASTHI, 1966; PRAKASH & TRIPATHI, 1969).

*Specimen* — B.S.I.P. Museum No. 34051.
*Locality* — Buri-Dehing River bed near Jaipur, Assam.
*Horizon* — Tipam Sandstones
*Age* — Upper Miocene

LEGUMINOSAE

***Cynometroxylon* Chowdhury & Ghosh, 1946**

4. *Cynometroxylon indicum* Chowdhury & Ghosh, 1946

Pl. 2, Figs. 14, 15

The following important anatomical features are based on a piece of highly silicified wood measuring 30 cm in length and 14 cm in diameter.

*Wood* diffuse-porous. *Growth rings* not seen. *Vessels* 80-384 μ in diameter, solitary as well as in radial multiples of 2-4, about 3-5 per mm with small to medium, vestured, intervessel pits. *Parenchyma* apotracheal in concentric tangential bands alternating with fibres bands of nearly same width, 4-6 bands per mm, each 3-6 cells in width. *Xylem rays* 1-3 seriate, heterocellular, consisting of procumbent and 1-2 marginal rows of upright cells at one or both the ends, about 5-25 cells in height. *Fibres* nonseptate, thick-walled.

The fossil wood is identical to already known species *Cynometroxylon indicum* Chowdhury and Ghosh (1946), described from the Tertiary of North Cachar Hills, Assam, and the Cuddalore Series of South India (RAMANUJAM & RAGHU RAMA RAO, 1966).

*Specimen* — B.S.I.P. Museum No. 34052.
*Locality* — Namsang River bed near Deomali, NEFA.
*Horizon* — Namsang Beds
*Age* — Mio-Pliocene.

***Pahudioxylon* Chowdhury, Chosh & Kazmi, 1960**

5. *Pahudioxylon sahnii* Ghosh & Kazmi, 1961

Pl, 2, Figs. 7, 8

The following are the important anatomical features of a silicified piece of wood measuring about 7 cm in length and 4 cm in diameter.

*Wood* diffuse-porous. *Growth rings* delimited by fine lines of parenchyma.

*Vessels* 112-400 μ in diameter, solitary as well as in radial multiples of 2-4, 2-4 per sq. mm, with small to medium, alternate, vestured, intervessel pits. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma typically diamond-shaped, occasionally aliform-confluent; apotracheal parenchyma in fine lines delimiting growth rings. *Xylem rays* 1-3 seriate (mostly 2-3), homocellular, consisting of procumbent cells, about 5-18 cells in height, tending to become storied at some places. *Fibres* nonseptate, thin-walled.

In all the above important anatomical details the specimen is identical to *Pahudioxylon sahnii* Ghosh & Kazmi (1961), described from the Tertiary of Tripura, and also from Deomali (PRAKASH, 1966).

*Specimen* — B.S.I.P. Museum No. 34053.

*Locality* — Buri-Dehing River bed near Jaipur, Assam.

*Horizon* — Tipam Sandstones.

*Age* — Upper Miocene.

COMBRETACEAE

***Terminalioxylon* Schonfeld, 1947**

6. *Terminalioxylon coriaceum* sp. nov.

Pl. 2, Figs. 9, 11, 12

The present species is based on a single piece of silicified secondary wood measuring about 12 cm in length and 7 cm in diameter.

*Topography* — *Wood* diffuse-porous. *Growth rings* present, delimited by larger vessels towards the inner margin of the ring and broad and undulating terminal parenchyma bands (PL. 2, FIG. 12). *Vessels* small to large, solitary as well as in radial multiples of 2-5 (mostly 2), those of early wood larger in size, gradually becoming smaller towards the end of the annal rings, 5-14 vessels per sq. mm; tyloses present, vessels also filled with orange to brownish contents. *Parenchyma* abundant, paratracheal and apotracheal; paratracheal parenchyma aliform to aliform-confluent or sometimes in broad and regular bands especially at the beginning of the annal rings (PL. 2, FIG. 12); apotracheal parenchyma not so common, especially with a few short bands occurring in between the vessels. *Xylem rays* fine, close, 12-16 rays per mm, uniseriate, occasionally biseriate due to pairing of procumbent cells through the median portion, 2-24 cells in height; ray tissue homogeneous, rays homocellular, consisting of procumbent cells (PL. 2, FIG. 19). *Fibres* aligned in radial rows between the two consecutive xylem rays. *Gum canals* vertical, traumatic, present in tangential, concentric bands, surrounded by parenchyma (PL. 2, FIG. 11).

*Elements* — *Vessels* circular to oval, those of multiples, flattened at the places of contact, t.d. 48-320 μ, r.d. 12-288 μ, walls 8-16 μ in thickness; vessel-members 225-800 μ in length, with truncate ends; perforations simple; intervessel pits large, 8-10 μ in diameter, alternate, circular, vestured, orifices linear to lenticular. *Parenchyma cells* more or less circular or angular, 20-50 μ in diameter. *Ray cells* 22-48 μ in tangential height, 40-100 μ in radial length; swollen crystalliferous cells sometimes present. *Fibres* angular (mostly hexagonal), 12-24 μ in diameter, septate, thick-walled, walls 4-6 μ thick.

*Affinities* — *Comparison with the modern species*: Vestured inter-vessel pits, aliform to aliform-confluent parenchyma, predominant uniseriate, homogeneous xylem rays with crystal in some cells and the vertical traumatic gum canals are the important anatomical characters of this fossil wood. The presence of vestured intervessel pits and the traumatic vertical canals are restricted to a few families of the dicotyledons, viz. Euphorbiaceae, Myrtaceae, Vochysiaceae and Combretaceae (RECORD, 1936, pp. 18, 19; METCALFE & CHALK, 1950, pp. 1350, 1353). A detailed comparison of the present fossil wood with the modern woods of these families indicates its affinities with the wood of *Terminalia* L. With a view to find out modern equivalent of the present fossil wood, thin-sections of many species of *Terminalia* were examined, viz. *Terminalia tomentosa* Wight et Arn., *T. coriacea* Wight et Arn., *T. macrocarpa* Steud., *T. travancorensis* Wight et Arn., *T. oliveri* Brand., *T. bialata* Steud., *T. catappa* Linn., *T. chebula* Retz., *T. citrina* Roxb., *T. manii* King, *T. myriocarpa* Heurck et Muell., *T. pyrifolia* Kurz, *T. arjuna* Bedd., *T. paniculata* Roth., *T. belerica* Roxb., *T. procera* Roxb., *T. angustifolia* Roxb. Besides published description and figures of seven other species of *Terminalia*, viz., *T. nitens* Presl, *T. oocarpa* Merr., *T. edulis* Blanco, *T. calamansanai*

Rolfe (KANEHIRA, 1924, pp. 32-33), *T. bialata* Steud., *T. comintana* (Blanco) Merr., *T. amazonia* (Gmel.) Exell., *T. ivorensis* A. Chev., *T. procera* Roxb., *T. superba* Engl. & Diels., *T. januarensis* DC., *T. guyanensis* Eichl, (KRIBS, 1959, pp. 29, 30, 31, FIGS. 103-110, 354), *T. javanica* Miq. and *T. teysmannii* Koord. et Valet. (MOLL & JANSSONIUS, 1914, pp. 374-375, 377-378, FIG. 188) were also consulted. Of these, *T. coriacea* shows similar anatomical features as present in this fossil wood. In both, *T. coriacea* and the present wood, the resemblance can be seen in the size and distributional pattern of vessels, inter-vessel pit-pairs, perforation plates, distribution of parenchyma, xylem rays and the fibres.

*Terminalia coriacea* was once regarded as a variety of *Terminalia tomentosa* (CLARKE in HOOKER, 1878, p. 448). For many years Forest Officers have been contented to regard this plant complex as one species and, following Beddome and Brandis, have generally called it *Terminalia tomentosa* (PARKINSON, 1937, p. 2). But they have frequently been struck with the apparent difference between the individual trees of the alleged, *T. tomentosa* occurring in widely separated tracts. The recognition of the specific distinction is, therefore, of some importance, especially as it is somewhat apparent that the botanical differences are accompanied by differences in the timbers. Consequently Parkinson (1937) recognized three natural groups of the plant complex, *Terminalia tomentosa*, and gave them specific rank. These are *Terminalia alata* Roth, *T. crenulata* Roth and *T. coriacea* Wight and Arn. Bor (1953, pp. 209-214) has also treated *Terminalia coriacea* as a full fledged species. It is a tree, growing on rocky and gravelly soil and is found in the drier and other parts of Madras State and of Central India.

*Comparison with the fossil species* — Nineteen species of fossil woods showing resemblance with the wood structure of the genus *Terminalia* are known from India and abroad (*see* PRAKASH, 1966, pp. 229-230; RAMANUJAM, 1966; MAHABALE & DESHPANDE, 1965; MUSSA, 1958; SERRA, 1966). Besides, there are two more fossil woods showing resemblance with that of *Terminalia tomentosa* from the Tertiary of Burma (CHOWDHURY & TANDON, 1964) and from Cutch in the Deccan Intertrappean Series (PRAKASH, & DAYAL, 1968). Out of these, *Terminalioxylon annamense* Boureau (1950), *T. edengense* Boureau (1958), *T. tertiarum* Prakash (1966) and *T. traumaticum* Ramanujam (1966) possess vertical, traumatic gum canals. All the species of *Terminalioxylon*, including those with gum canals, differ markedly from the present fossil wood in several features. The main differences between the present fossil wood and those species having gum canals are in the distribution of the parenchyma and the size and arrangement of the vessels. Therefore, the present fossil wood is described as a new species of *Terminalioxylon*, *T. coriaceum*, the specific name indicating closest resemblance with *Terminalia coriacea*.

## DIAGNOSIS

*Terminalioxylon coriaceum* sp. nov.

*Wood* diffuse-porous. *Growth rings* present, delimited by larger vessels towards inner margin of the ring and broad terminal parenchyma bands. *Vessels* small to large, solitary as well as in radial multiples of 2-5 (mostly 2), t.d. 48-320 μ, r.d. 32 to 288 μ; vessel-members 225-800 μ; perforations simple; tyloses wanting; intervessel pits, large, 8-10 μ, vestured. *Parenchyma* abundant, paratracheal and apotracheal; paratracheal parenchyma aliform to aliform-confluent or zonate, especially those bands occurring in the beginning of the rings broad, regular and wavy; apotracheal parenchyma occasionally present as few short bands. *Xylem rays* uniseriate, occasionally biseriate due to pairing of procumbent cells through the median portion; ray tissue homogeneous, rays homocellular, consisting wholly of procumbent cells; crystalliferous cells often swollen containing solitary crystals. *Fibres* mostly hexagonal, 12-24 μ in diameter, septate, thick-walled, walls 4-6 thick.

*Holotype* — B.S.I.P. Museum No. 34054.

*Locality* — Namsang River bed near Deomali, NEFA.

*Horizon* — Namsang Beds.

*Age* — Mio-Pliocene.

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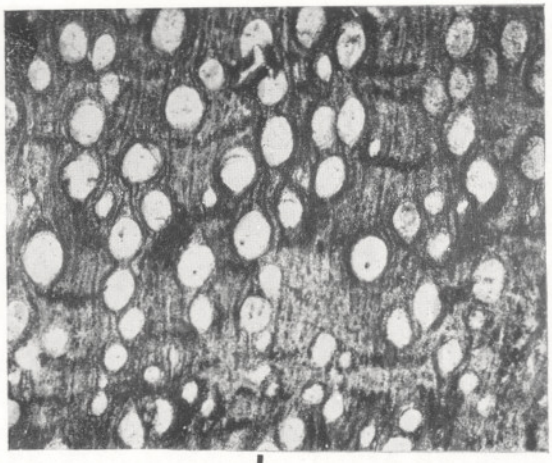

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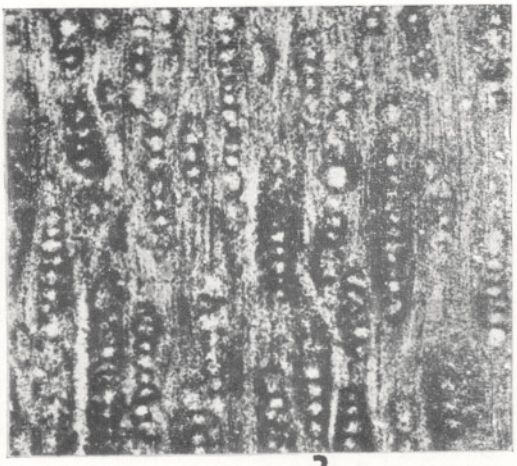

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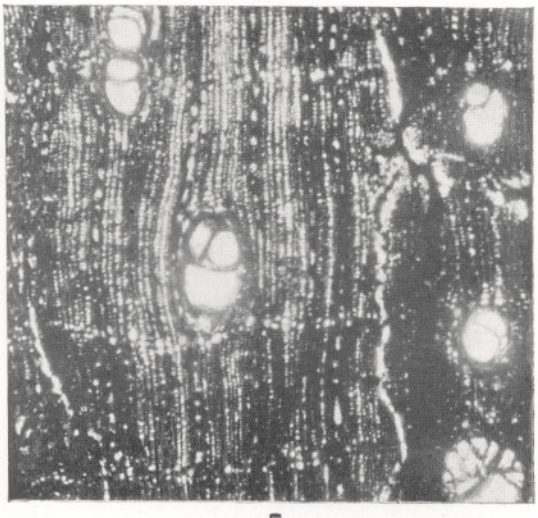

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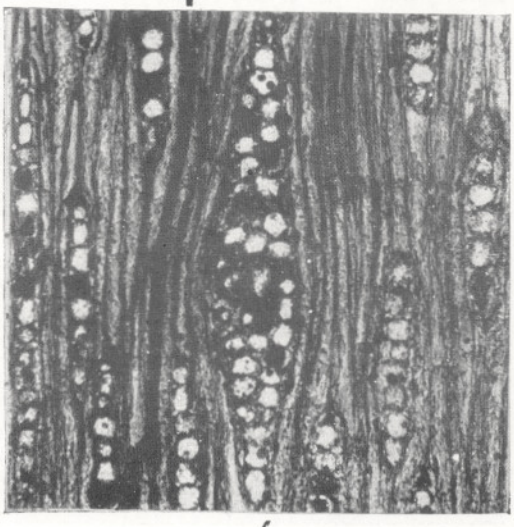

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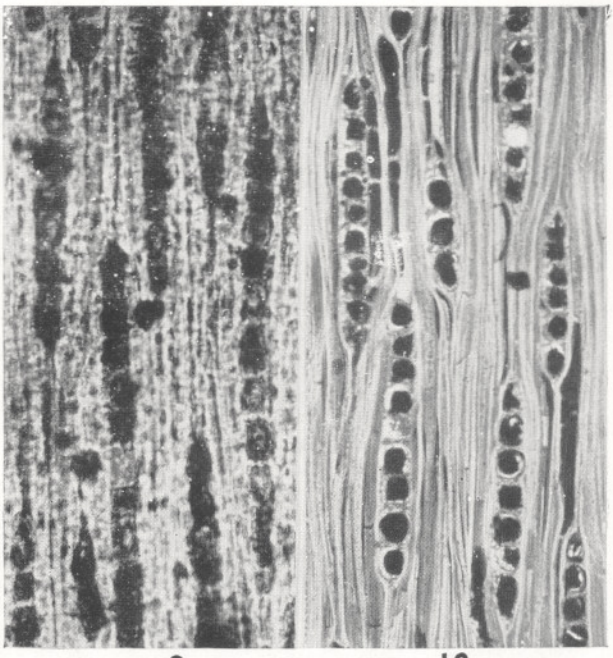

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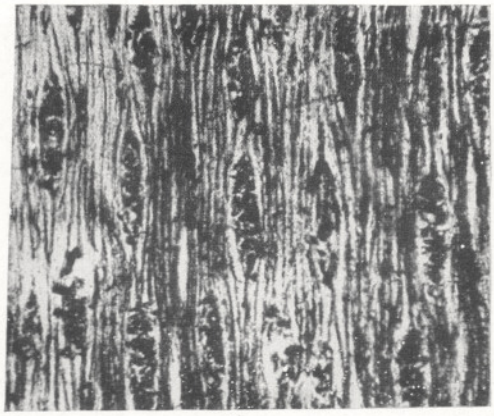

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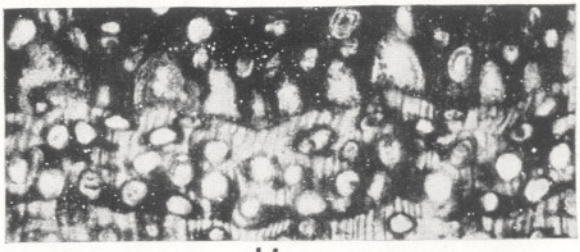

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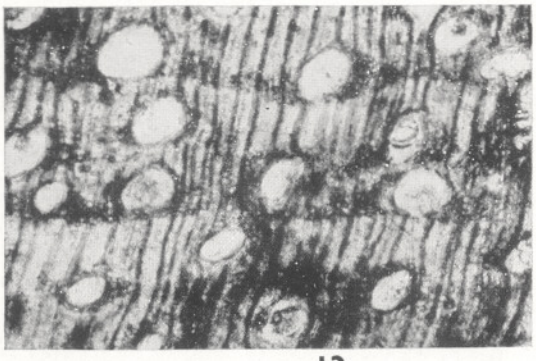

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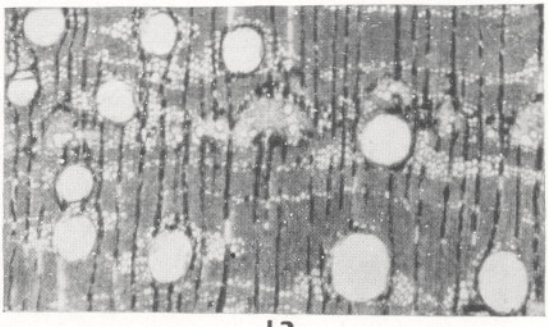

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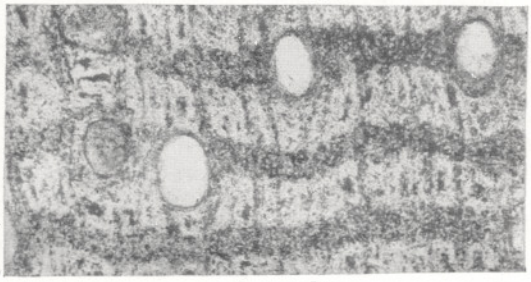

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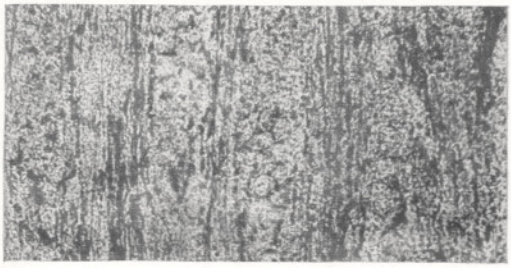

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## EXPLANATION OF PLATES

### Plate 1

1. *Calophylloxylon eoinophyllum* Prakash — Cross-section showing nature and distribution of vessels and parenchyma. × 15. (B.S.I.P. Museum, Slide No. 3876).

2. *Calophylloxylon eoinophyllum* Prakash — Tangential longitudinal section showing xylem rays. × 100. (B.S.I.P. Museum, Slide No. 3877).

3. *Shoreoxylon deomaliense* sp. nov.— Cross-section showing nature and distribution of vessels, parenchyma and gum canals. × 30. (B.S.I.P. Museum, Slide No. 3878).

4. *Shoreoxylon deomaliense* sp. nov.— Tangential longitudinal section showing xylem rays. × 60. (B.S.I.P. Museum, Slide No. 3879).

5. *Glutoxylon burmense* (Hold.) Chowdhury — Cross-section showing nature and distribution of vessels and parenchyma. × 43. (B.S.I.P. Museum, Slide No. 3880).

6. *Glutoxylon burmense* (Hold.) Chowdhury — Tangential longitudinal section showing xylem rays and horizontal gum canals. × 135. (B.S.I.P. Museum, Slide No. 3881).

### Plate 2

7. *Pahudioxylon sahnii* Ghosh & Kazmi — Cross-section showing nature and distribution of vessels and parenchyma. × 30. (B.S.I.P. Museum, Slide No. 3884.

8. *Pahudioxylon sahnii* Ghosh & Kazmi — Tangential longitudinal section showing xylem rays. × 60. (B.S.I.P. Museum, Slide No. 3885).

9. *Terminalioxylon coriaceum* sp. nov.— Tangential longitudinal section showing xylem rays. × 135. (B.S.I.P. Museum, Slide No. 3886).

10. *Terminalia coriacea* — Tangential longitudinal section showing similar xylem rays. × 135.

11. *Terminalioxylon coriaceum* sp. nov.— Cross-section under low magnification showing the nature and distribution of vessels, parenchyma and vertical traumatic gum canals. × 14. (B.S.I.P. Museum Slide No. 3887).

12. *Terminalioxylon coriaceum* sp. nov.— Cross-section showing type and distribution of vessels and parenchyma. × 30. (B.S.I.P. Museum Slide No. 3888).

13. *Terminalia coriacea* — Cross-section showing vessels, parenchyma and traumatic vertical gum ducts. × 28.

14. *Cynometroxylon indicum* Chowdhury & Ghosh — Cross-section showing type and distribution of vessels and parenchyma. × 30. (B.S.I.P. Museum, Slide No. 3882).

15. *Cynometroxylon indicum* — Tangential longitudinal section showing xylem rays. × 110. (B.S.I.P. Museum, Slide No. 3883).