FOSSIL WOODS FROM THE TERTIARY OF BURMA

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ABSTRACT

Fossil woods representing the genera *Dipterocarpus* and *Shorea-Pentacme* of Dipterocarpaceae, *Gluta-Melanorrhoea* of Anacardiaceae, *Sterculia* of Sterculiaceae, *Acacia*, *Cynometra*, *Cassia* and *Afzelia-Intsia* of Leguminosae, *Lagerstroemia* of Lythraceae, and a dicot wood of uncertain affinities have been investigated from the Tertiary beds of Burma. These woods are noteworthy owing to their fine structural preservation and from the standpoint of their palaeogeographical distribution. Modern comparable forms of these fossils are still found in the forests of Burma indicating thereby that there has been no appreciable change in the climatic conditions of this region since the existence of this flora, which flourished under the tropical, mesophytic conditions. An attempt has also been made to assign a precise age to the woods based on the floral assemblage.

INTRODUCTION

IN 1934, late Professor Birbal Sahni received a collection of fossil woods from the Tertiary of Burma, sent to him by a Rangoon University botanist. This material was given to me for investigation in 1964. As the age of these fossil woods was mentioned only as Tertiary, I wrote a letter to Professor of Botany, Rangoon University, to find out the exact age and location of this material in Burma. In September 1964, a reply was received from Professor Ko Ko Gyi, Professor of Botany, Arts & Science University, Rangoon, who said, " I could not find any record of fossil woods from Burma, sent to late Prof. B. Sahni. All prewar records were lost ". Thus it was not possible to know the exact horizon, in the Tertiary of Burma, from where these fossil woods were collected by the Burmese botanist.

The Tertiary system of Burma is composed of rocks which differ considerably in lithological characters from those of North-west India. The main exposure of the Burmese Tertiary occupies the valley of Irrawaddy and that of its chief tributary, the Chindwin, on the east side of Arakan Yoma. Following is the succession of Tertiary rocks in Burma (Wadia, 1966, p. 324).

These Tertiary rocks abound in the petrified woods which have been reported from the Eocene of Upper Burma as well as from the Upper Pegu and Irrawaddy series of Miocene to Pliocene age. In the Eocene, fossil woods are present in the Tilan and Pondaung sandstones (Pascoe, 1963, pp. 1595, 1598; Krishnan, 1960, p. 520), while they are quite abundant in upper beds of the Pegu strata and in the

	Irrawady System	Fresh-water sandstones, with abundant fossil woods, mammalian fossils	Pliocene to Upper Miocene
	Unconformity		
Pegu System	Upper Pegu	Sandstones, clays and shales, with many fossils	Middle & Lower Miocene
	Unconformity		
	Lower Pegu	Mainly sandstones above, shales in the middle, and shallow-water sandstones with coal-seams at the base; fossiliferous	Oligocene
Eocene System	Yaw Stage	Shaly clays, marine with *Nummulites*	
	Pondaung Stage	Marine sandstones and clays passing up into fluviatile sandstones and deeply coloured clays containing the earliest mammalian fauna	Upper Eocene
	Tabyin Clay	Green shales with thin coal-seams	
	Tilin Sandstone	Marine sands and sandstones with *Nummulites*	Middle Eocene
	Laungshe Shales	Shales containing *Orbitoides* and *Gastropoda*	Lower Eocene
	Paunggyi conglomerate	Conglomerates containing *Orthopragmina*	
		Basal unconformity	

overlying Irrawaddy series which is known as "Fossil Wood Group" on account of the abundance of silicified woods in it. Hundreds and thousands of entire trunnks of silicified trees and huge logs lying in the sandstones of Irrawaddy series suggest the denudation of thickly forested slopes of Arakan Yoma (Krishnan, 1960; Pascoe, 1963; Wadia, 1966).

The fossil woods of Burma have been the subject of cursory reference since the early accounts by Symes (1800), Crawfurd (1828) and Yule (1858). However, it was only in 1916 that Holden gave the first account of the anatomy of a fossil wood and named it as *Dipterocarpoxylon burmense* showing its affinities with the family Dipterocarpaceae. In 1933, Bancroft doubted its affinities and tentatively suggested that it might belong to a Meliaceous tree. Similarly, Gupta (1935a) also suggested a reference to Ebenaceae and Anacardaceae. Chowdhury (1952) confirmed its resemblance with the modern genera *Gluta* and some *Melanorrhoeas* of Anacardiaceae and transferred it to *Glutoxylon burmense*. In 1935b, Gupta described another fossil dicot wood as *Dipterocarpoxylon holdeni* from Irrawaddy series and also recorded a leguminous wood from the Tertiary of Burma (Gupta, 1936). A fossil wood of *Terminalia tomentosa* is also known from the Irrawaddy series of Burma (Chowdhury & Tandon, 1964).

It was in 1931 that Sahni first recorded three species of palm woods from Burma although previous authors in a few cases have discriminated between monocotyledonous and dicotyledonous woods. In 1964, Sahni further described in detail these as well as some other species of palm woods from there. These are *Palmoxylon burmense*, *P. caudatum*, *P. compactum*, *P. coronatum*, *P. pyriforme* and *P. sinuosum* from near Pegu-Irrawadian boundary in Burma (Sahni, 1931, 1964). From a detailed comparison with the living species of palms, Kaul (1938) has been able to show that *Palmoxylon coronatum* so closely resembles the modern, *Borassus flabellifer* anatomically that it is not easy to distinguish the two (Sahni, 1938).

Besides the woods, impressions of leaves and fruits are also known from the Tertiary of Burma. These are the leaves assigned to *Ficophyllum burmense* Edw., *Dipterocarpophyllum gregoryi* Edw. and *Phyllites* sp. and the leguminous pods named as *Leguminosites albizziformis* Edw. and *Leguminosites* sp. (Edwards 1923). From a locality near Taungu in Shewbo district, Dr. Iyer obtained fossil plant impressions on shales of Irrawaddian age, some of which resemble *Phyllites kamrupensis* Sew. from the Tertiary deposits of Assam (Fermor, 1931, p. 23). From the Irrawaddy series in Myithyina area impressions of leaves identified as *Tetranthera hwekonsis* Schuster, a close relative to the Bay tree, *Laurus*, has also been found (Pascoe 1963, p. 1844).

The present study is concerned with the detailed description and interpretation of the fossil woods from Burma sent to Professor Sahni. However, a brief description of three of these woods has recently been recorded (Prakash, 1965a, b, c).

The preservation of the structural details of the fossil woods, in the present collection, is fairly good. In order to make a detailed study many sections were prepared from different parts of the petrified woods.

SYSTEMATIC DESCRIPTION

Family — Dipterocarpaceae
Dipterocarpoxylon Holden emend. Den Berger, 1927

1. *Dipterocarpoxylon tertiarum* Prakash, 1965a
Pl. 1, Figs. 1, 3, 5, 6

The present species is represented by a small piece of secondary wood, measuring 4 cm. in length and 2-4 cm. in diameter. The wood is somewhat badly preserved.

Topography — *Wood* diffuse-porous (Pl. 1, Fig. 5). *Growth rings* absent. *Vessels* visible to the naked eye as pin holes, mostly large, sometimes medium-sized, the majority solitary (Pl. 1, Figs. 1, 5), occasionally paired, 3-5 per sq. mm. with rays contiguous on one or both the sides; tyloses present, sometimes with black deposits in the vessels. *Vasicentric tracheids* sparse, paratracheal associated with the parenchyma. *Parenchyma* mostly apotracheal (Pl. 1, Fig. 1), the paratracheal being very scanty; apotracheal parenchyma diffuse and diffuse-in-aggregate forming irregular pattern in the fibrous tract between the rays, more often with several rows of parenchyma cells surrounding gum ducts and forming a thick layer which frequently extend tangentially and unite with the parenchyma from neighbouring canals; paratracheal parenchyma scanty, appearing to be present around the vessels. *Xylem rays* not visible to the naked eye, appearing as fine lines under a hand lens (Pl. 1, Fig. 3), fine to broad, 1-8-(9) seriate; mostly broad (5-7 seriate), often uniseriate, 20-150 μ wide and upto about 1080 μ high, closely spaced, 4-7 per mm.; ray tissue heterogeneous (Pl. 1, Fig. 6) with rays composed of both upright and procumbent cells; uniseriate rays consisting of only upright cells or both upright and probumbent cells; broad rays 2-8-(9) cells and 45-150 μ wide with square to upright cells at one or both the ends and procumbent cells in the middle. Often sheath cells without any contents are present on the flanks in between the procumbent cells. *Fibres* not well preserved, appearing to be closely packed in between two consecutive rays. *Gum canals* abundant, vertical (Pl. 1, Figs. 1, 5), single or usually in pairs and sometimes in short tangential rows of 3-7.

Elements — *Vessels* thin walled, walls about 4 μ thick, t.d. 135-315 μ, r.d. 150-420 μ, usually round to oval in cross-section; vessel-members 150-600 μ long, with truncate or sometimes with abruptly tailed ends; perforations simple; intervessel pit-pairs large, about 8 μ in diameter, alternate, and bordered. *Parenchyma cells* thin walled, t.d. 16-24 μ, height 80-112 μ. *Ray cells* thicker walled; procumbent cells usually of polygonal shape in tangential section, vertical height 16-24 μ; radial length 80-112 μ; upright cells with vertical height 32-40 μ, radial length 20 μ. *Fibres* libriform, thickwalled, polygonal in cross-section; non-septate; interfibre pits not seen. *Gum canals* uniformly distributed, small, 70-120 μ in diameter, round to oval, encircled by 3-10 seriate parenchymatous sheath.

Affinities — The most important anatomical feature of the present fossil wood is the presence of vertical gun canals. Such canals are found cnly in a few dicotyledonous families, viz., Cornaceae, Connaraceae, Dipterocarpaceae, Leguminosae and Simaroubaceae. In addition to the gum canals, the fossil wood is also characterized by mostly solitary vessels, vasicentric tracheids, heterogenous ray tissue, and non-septate fibres. Considering the above features collectively, this fossil wood can be compared with the modern woods of the family Dipterocarpaceae. The family Dipterocarpaceae can be divided into the following two groups on the basis of the arrangement of gum canals.

I. Gum canals always in concentric rows, e.g. *Shorea* (*Isoptera*), *Doona*, *Hopea* =(*Dioticarpus*), *Parashorea*, *Pentacme*. *Balanocarpus* and *Dryobalanops*.
II. Gum canals diffuse, solitary, and also in short tangential rows, e.g. *Anisoptera*, *Dipterocarpus*, *Vatica* = (*Pachynocarpus*), *Vateria* =(*Monoporandra*, *Stemonoporus*), *Cotylelobium*.

Sinee in the present fossil wood, the gum ducts are diffuse, solitary and in short, tangential rows, it can be compared only with the genera of the second group. Out of these genera, *Anisoptera*, *Dipterocarpus*, *Vateria* and *Vatica* are worth comparing with the fossil wood; these can be distinguished from each other by the following characters (Chowdhury & Ghosh, 1958, p.107; Schweitzer, 1958, p. 5):

1. Vessels medium to large (mostly large); gum canals abundant, rarely solitary, mostly in short tangential groups, 2-8 or more; xylem rays with some sheath cells...... *Dipterocarpus*.
2. Vessels moderately large, mostly solitary; gum canals scanty, usually solitary, minute, appearing like white dots; parenchyma abundant, mainly diffuse; xylem rays with frequent sheath cells .... *Anisoptera*
3. Vessels small, often in pairs or clusters of 2-5, sometimes arranged in oblique rows; parenchyma not profuse, usually distinct round the pores or pore groups; gum canals numerous .....*Vateria*.
4. Vessels small; gum canals usually solitary, minute, appearing like white dots. .... *Vatica*.

From the distinguishing features given above, and the combination of structural features exhibited by the fossil wood, it is evident that the present fossil belongs to the genus *Dipterocarpus* Gaertn. f. and resembles closely the extant species *Dipterocarpus alatus* Roxb., *D. turbinatus* Gaertn. f. and *D. dyeri* Pierre ex De Laness, especially the first two. Thin sections of the woods of nineteen species of *Dipterocarpus* were examined at the Wood Anatomy Branch of the Forest Research Institute, DehraDun, besides studying description and photogarphs of a number of other species of this genus (Moll & Janssonius, 1906, pp. 348-360;

Reyes, 1938, pp. 280-296, Figs.40-54). The close agreement in major diagnostic features as well as in numerous microscopic details provides convincing evidence that the persent fossil wood is closely comparable with the modern wood of *Dipterocarpus*.

In 1916, Holden instituted the form genus *Dipterocarpoxylon* to include the fossil woods of the family Dipterocarpaceae. Since then this name has been used by many workers in the comprehensive sense to designate the fossil dipterocarpaceous woods, although the type material of *Dipterocarpoxylon* Holden was shown to belong to *Gluta* and consequently transferred to the form genus *Glutoxylon* Chowddury (Chowdhury, 1952). As the family Dipterocarpaceae exhibits lot of heterogeneity in wood structure, the name *Dipterocarpoxylon* Holden for all the dipterocarpaceous fossil woods is also not justifiable. Consequently in 1927 Den Berger emended the diagnosis of *Dipterocarpoxylon* Holden, to restrict the usage of this term for the fossil woods of Dipterocarpeae comprising the genera *Dipterocarpus* and *Anisoptera* which are anatomically very close to each other. Further, in 1958 Ghosh & Kazmi instituted the form genus *Anisopteroxylon* to designate the fossil woods of *Anisoptera*. Since it is possible to separate the two genera anatomically and because the name *Anisopteroxylon* has been instituted, it is advisable to restrict the name *Dipterocarpoxylon* Holden emend. Den Berger (1927) for the fossil woods of *Dipterocarpus* only.

A number of dipterocarpaceous fossil woods, so far known, have been assigned to the form genus *Dipterocarpoxylon* Holden emended Den Berger; these are being listed as in Table below.

Two other fossil woods of *Dipterocarpoxylon* known from India and described as *D. indicum* Ramanujam (1956) and *D. cuddalorense* Navale (1963b) have recently been critically evaluated by Awasthi (1965) who revised their affinities after a thorough examination of their type slides. According to him, *Dipterocarpoxylon indicum* is a fossil wood of *Dryobalanops* and *D. cuddalorense* belongs to the genus *Terminalia*.

Similarly the fossil wood of *Dipterocarpoxylon holdeni* Gupta (1935b) from Burma with banded parenchyma and the absence of gum canals does not belong to family Dipterocarpaceae. However, its true affinities might be searched among the legumes.

All the species of *Dipterocarpoxylon* enumerated here, although somewhat resembling the present fossil, show marked differences from it in a number of important anatomical features. Thus *Dipterocarpoxylon gracile, D. resiniferum, D. perforatum, D. javanicum, D. krauseli* and *D. anisopteroides* differ from the present fossil wood in

Species	Modern Equivalents	Age	Locality
1. *Dipterocarpoxylon porosum* (Stopes) Krausel (Krausel, 1922; Schweitzer 1958)	*Dipterocarpus*	Upper Cretaceous (Apt)	Woburn Sands, England
2. *D. kraeuseli* (Den Berger) Edwards (Edwards, 1931; Schweitzer, 1958)	*Dipterocarpus*	Tertiary Pliocene	South Sumatra West Sumatra
3. *D. goepperti* Krausel (Krausel, 1926; Schweitzer, 1958)	—	Tertiary	Java
4. *D. africanum* Bancroft (1935) syn.	—	Tertiary	East Africa
D. scebelianum Chiarugi (1933) *D. somalense* Chiarugi (1933) *D. giubense* Chiarugi (1933)		Tettiary	East Africa
5. *D. schenki* (Felix) Schweitzer (1958)	—	Tertiary	Java
6. *D. resiniferm* Schweitzer (1958)	*Dipterocarpus*	Pliocene	West Java
7. *D. javanicum* (Hofmann) Schweitzer (1958)	*Dipterocarpus*	Tertiary	Java
8. *D. gracile* Schweitzer (1958)	*Dipterocarpus*	Pliocene	West Java
9. *D. perforatum* Schweitzer (1958)	*Anisoptera* ?	Quaternary	Middle Sumatra
10. *D. anisopteroides* Schweitzer (1958)	*Anisoptera*	Tertiary	West Java
11. *D. chowdhurii* Ghosh (1956)	*Dipterocarpus*	Tertiary	Assam, India
12. *D. malavii* Ghosh & Ghosh (1959)	*Dipterocarpus*	Tertiary	Kutch, India
13. *D. kalaicharparense* Eyde (1963)	*Dipterocarpus*	Tertiary	Garo Hills, Assam, India
14. *Dipterocarboxylon* sp. Rawat (1964)	*Dipterocarpus*	Tertiary (Siwaliks)	Mohand, Uttar Pradesh, India

the type of xylem rays besides having a number of other characters. *D. anisopteroides* can be further differentiated in possessing few and exclusively solitary gum canals. *Dipterocarpoxylon africanum* is also distinct from this fossil wood in having larger gum canals and narrower, upto 5 cells wide, xylem rays. *Dipterocarpoxylon goepperti* also differs in possessing scanty and solitary gum canals which are much less in comparison to the present fossil wood. Similarly *Dipterocarpoxylon porosum* is also different from *D. tertiarum* in having narrower, 1-7 (mostly 6) seriate xylem rays and mostly solitary gum canals. However, in the present fossil, the xylem rays are 1-9 seriate and the gum canals are mostly in pairs. Lastly *D. schenki* can also be distinguished from the present fossil wood in having narrower, 1-6 cells wide xylem rays and slightly smaller vessels.

Of the Indian species, *Dipterocarpoxylon chowdhurii* differs from the present Burma wood in having slightly smaller vessels (medium to large) and narrower (1-6 seriate) xylem rays with more frequent sheath cells. Similarly *D. malavii* differs from *D. tertiarum* in possessing slightly smaller vessels (t.d. 100-224 μ, r.d. 112-350 μ) and in having 1-5 seriate xylem rays. The vessels are larger (t.d. 135-315 μ, r.d. 150-420 μ) and the xylem rays are broader, 1-9 seriate in *D. tertiarum*. *D. kalaicharparense* is also quite distinct in having large gum canals and comparatively narrower, 1-5 (mostly 3-4) seriate xylem rays. Lastly *Dipterocarpoxylon* sp. Rawat is also distinct from *D. tertiarum* in having large gum ducts and somewhat narrower xylem rays. Since the fossil wood compares very well with the modern woods of *Dipterocarpus* and is quite distinct from all the species of *Dipterocarpoxylon* so far known, it has been described as *Dipterocarpoxylon tertiarum*. It constitutes an authentic record of the family Dipterocarpaceae in Burma; the ones reported earlier being doubtful.

The genus *Dipterocarpus* includes about 80 species, which grow mainly in the Indo-Malayan region, having maximum development in Borneo, Malaya Peninsula and Sumatra. The range of its distribution is from South India and Ceylon in the west to Philippines in the east. About 13 species grow in the Indian zone (Andamans, Burma, Ceylon, India and Pakistan), while only in Burma eleven species are known to occur; the two species, *Dipterocarpus indicus* and *D. bourdillonii* are exclusively confined to South India. The species *Dipterocarpus alatus*, *D. turbinatus* and *D. dyeri* which show close resemblance with the present fossil wood occur quite extensively in the region of South-east Asia. *D. alatus* occurs in evergreen moist forests of South Tipperah, Chittagong, Andamans, Burma, Thailand, Indo-China, Malay Peninsula, while *D. dyeri* grows in Burma, Indo-China, Thailand and Malay Peninsula. *D. turbinatus* is also distributed in Andamans, Assam, Burma, East Pakistan, Cochin-China and Thailand (Gamble, 1902; Pearson & Brown, 1932; Chowdhury & Ghosh, 1958).

SPECIFIC DIAGNOSIS

***Dipterocarpoxylon tertiarum* Prakash, 1965a**

Wood diffuse-porous. *Growth rings* absent. *Vessels* mostly large, sometimes medium-sized, t.d. 135-315 μ, r.d. 150-420 μ, mostly solitary, occasionally paired, round to oval, 3-5 per sq. mm.; tyloses present; vessel-members 150-600 μ with truncate or sometimes with abruptly tailed ends; perforations simple; intervessel pit-pairs large, about 8 μ in diameter, alternate and bordered. *Vasicentric tracheids* sparse, paratracheal, associated with the parenchyma. *Parenchyma* mostly apotracheal as diffuse and diffuse-in-aggregate, and more often surrounding the gum ducts by several layers of cells; paratracheal parenchyma scanty, present around the vessels. *Xylem rays* 1-8-(9) seriate, mostly 5-7 seriate, quite often uniseriate, 10-150 μ broad, upto 1080 μ high, 4-7 per mm.; ray tissue heterogeneous; rays both homocellular and heterocellular; sheath cells often present on the flanks of the multiseriate rays. *Fibres* libriform, polygonal, non-septate, 16-24 μ in diameter; interfibre pits could not be seen. *Gum canals* numerous, vertical, single, or usually in pairs, sometimes in short tangential rows of 3-7, small, 70-120 μ in diameter and round to oval in shape.

Holotype — B.S.I.P. Museum No. 34083.

2. *Dipterocarpoxylon chowdhurii* Ghosh, 1956

Pl. 2, Figs. 7-10

The fossil wood measures about 3·5 cm. in length and 2·5 cm. in diameter. It is greyish yellow in colour and shows satisfactory preservation.

Topography — *Wood* diffuse-porous (Pl. 2, Fig. 7). *Growth rings* absent. *Vessels* visible to the naked eye as pin holes, large to medium-sized, almost always solitary (Pl. 2, Fig. 7), occasionally in pairs, 6-8 per sq. mm., usually with rays contiguous on one or both the sides; tyloses quite profuse. *Vasicentric tracheids* present around the vessels along with parenchyma. *Parenchyma* mostly apotracheal (Pl. 2, Fig. 10), the paratracheal being scanty; apotracheal parenchyma abundant, diffuse and in irregular, broken, uniseriate, tangential lines, and also in several rows of cells around the gum ducts forming a thick layer; paratracheal parenchyma very little around the pores. *Xylem rays* not visible to the naked eye, appear as fine lines under a hand lens, fine to broad (Pl. 2, Fig. 8), 1-6 seriate, mostly uniseriate and 4-5 seriate, rarely 2-3 seriate, and 16-96 μ wide and 90-2240 μ high, closely placed, 6-9 per mm.; ray tissue heterogeneous (Pl. 2, Fig. 9) with rays composed of both upright and procumbent cells; uniseriate rays quite common, 2-15 cells and 90-450 μ high, consisting either only of upright cells or both upright and procumbent cells; multiseriate rays 2-6 cells and 18-96 μ wide and upto 74 cells or 1560 μ high with square and upright cells at one or both the ends and procumbent cells in the middle part, usually with a layer of sheath cells at the flanks. *Fibres* closely packed and not aligned in distinct radial rows. *Gum canals* numerous, vertical, solitary (Pl. 2, Figs. 7, 10) and often in pairs or in tangential groups of 2-4-(5).

Elements — *Vessels* thin-walled, walls about 4 μ thick, t.d. of solitary vessels 165-225 μ, r.d. 240-375 μ, oval to elliptical in cross-section, usually irregular in shape probably due to compression during fossilization; vessel-members 255-675 μ long, with truncate ends; perforations simple; intervessel pit-pairs 6-8 μ in diameter, bordered, alternate with linear apertures; vessel-parenchyma and vessel-ray pits not well preserved. *Parenchyma cells* thin-walled, t.d. 16-30 μ, height 76-150 μ; parenchyma strands usually 4-8 celled. *Ray cells* slightly thicker walled; procumbent cells of various shapes and sizes as seen in tangential section, vertical height 20-44 μ, radial length 52-100 μ; upright cells with vertical height 40-72 μ, radial length 28-48 μ. *Fibres* libriform, thickwalled, 12-20 μ in diameter and 960-1120 μ in length; interfibre pits not seen. *Gum canals* somewhat uniformly distributed, small to medium-sized, smaller than the vessels, 80-160 μ in diameter, round to oval encircled by several seriate parenchymatous sheath.

Affinities — The distribution of the vertical gum ducts and the presence of vasicentric tracheids at once show the affinities of the fossil wood with the family Dipterocarpaceae in which it exhibits the anatomical characters of the modern genus *Dipterocarpus*. It shows the nearest resemblance to the modern species *D. bourdillonii*.

As the present fossil is identical to the species, *Dipterocarpoxylon chowdhurii*, briefly described by Ghosh (1956) from the bed of Buri-Dehing river in north-east Assam, it is assigned to the same species. Because Ghosh (1956) did not give any diagnosis of the species, it is being given as follows:

SPECIFIC DIAGNOSIS

Dipterocarpoxylon chowdhurii Ghosh, 1956

Wood diffuse-porous. *Growth rings* absent. *Vessels* large to medium-sized, t.d. 165-225 μ, r.d. 240-375 μ, almost always solitary, oval to elliptical in shape, 6-8 per sq. mm.; tyloses quite abundant; vessel-members 255-675 μ in length with truncate ends; perforations simple; intervessel pits 6-8 μ in diameter, bordered, alternate with linear apertures. *Vasicentric tracheids* sparse, paratracheal, associated with parenchyma. *Parenchyma* mostly apotracheal, as scattered cells and in irregular, broken, uniseriate, tangential lines, also surrounding the gum ducts; paratracheal parenchyma very little round the pores. *Xylem rays* 1-6 seriate, 16 to 96 μ wide and 2-74 cells or 90-2240 μ high, closely placed, 6-9 per mm.; ray tissue heterogeneous with rays composed of both procumbent and upright cells; sheath cells quite common at the flanks. *Fibres* libriform, polygonal, non-septate, 12-204 μ in diameter and 960-1120 μ in length; interfibre pits not seen. *Gum canals* numerous, vertical, solitary and often in pairs or in tangential groups of 2-4-(5), 80-160 μ in diameter and round to oval in shape.

Specimen — B.S.I.P. Museum No. 34084.

Shoreoxylon Den Berger, 1923

3. *Shoreoxylon burmense* Prakash, 1965b

Pls. 2-3, Figs. 11-14

This fossil is represented by a single piece of petrified wood measuring 11 cm, in length and about 4 cm. in diameter. It is greyish in colour with yellow patches. The preservation is not very good.

Topography — *Wood* diffuse-porous (Pl. 3, Fig. 13). *Growth rings* absent; concentric bands of vertical resin canals simulate growth marks with the naked eye. *Vessels* visible to the naked eye as pin holes, large to medium-sized (Pl. 3, Fig. 13), mostly solitary, often in radial multiples of 2-3 cells, 5-6 per sq. mm., usually with the rays contiguous on one or both the sides; tyloses and gummy deposits present. *Vasicentric tracheids* very rare associated with the vessels along with the paratracheal parenchyma. *Parenchyma* both paratracheal and apotracheal (Pl. 2, Fig. 11), the former is vasicentric to occasionally aliform, sometimes with a tendency to join two or rarely more adjacent vessels; the apotracheal type is either diffuse occurring as solitary or groups of cells, occasionally forming short, irregular lines in the fibrous tract between the rays or in long tangential bands associated with the resin canals. *Xylem rays* not visible to the naked eye, distinct with a hand lens, broad to medium (Pl. 2, Fig. 12), 1-5 seriate, mostly 4-5 seriate, 12-75 μ broad, closely spaced, 7-10 per mm.; ray tissue almost homogeneous (Pl. 3, Fig. 14) with rays composed mostly of procumbent cells; uniseriate rays about 12 μ in width, variable in height, 3-12 cells and 100-272 μ high; multiseriate rays up to 75 cells or 1275 μ high. *Fibres* aligned in distinct radial rows. *Gum canals* vertical, arranged in long, often 1-2 or 3, rarely 4, tangential rows (Pl. 3, Fig. 13) embedded in parenchymatous bands, usually round to oval and 45-150 μ in diameter.

Elements — *Vessels* thin-walled, the walls about 3-4 μ thick, t.d. of solitary vessels 135-240 μ, r.d. 225-360 μ, oval to mostly elliptical, sometimes somewhat irregular probably due to compression during fossilization, those in radial multiples flattened at the places of contact; vessel-members about 225-345 μ or more, with truncate ends; perforations simple; intervessel pit-pairs 5-7 μ in diameter, alternate, bordered, oval to orbicular in shape; vessel-tracheid pits bordered, 1-2 seriate, aperture not clear; vessel-parenchyma pits not preserved. *Parenchyma cells* thin-walled, t.d. 14-20 μ, height about 64-80 μ. *Ray cells* slightly thick-walled; procumbent cells variously shaped in tangential section, t.d. 8-20 μ, radial length 270-375 μ, vertical height 14-24 μ. *Fibres* libriform, very thick-walled with small lumina, appear thin-walled at some places due to degradation of secondary walls, non-septate, polygonal in cross section; t.d. 12-20 μ, r.d. 10-20 μ, length could not be taken due to bad preservation; interfibre pits not seen. *Gum canals* arranged in long concentric, tangential rows, small, 45-150 μ in diameter and usually round to oval in shape embedded in long bands of apotracheal parenchyma.

Affinities — Structural features of the fossil wood indicate, after extensive comparison, that its closest affinities are with woods of the family Dipterocarpaceae. The presence of normal, vertical gum canals in concentric tangential rows, at once shows its resemblance with the genera of the first group, viz., *Shorea* (*Isoptera*), *Doona*, *Hopea*, = (*Dioticarpus*), *Parashorea*, *Pentacme*, *Balanocarpus* and *Dryobalanops*. These genera are further classified into the following two tribes:

Tribe Dryobalanopseae

1. *Dryobalanops*

Tribe Shoreae

1. *Shorea*
2. *Doona*
3. *Hopea*
4. *Parashorea*
5. *Pentacme*
6. *Balanocarpus*

The members of these tribes can be distinguished anatomically by the presence of almost exclusively solitary vessels and tne fibres with bordered pits in Dryobalanopseae, while the vessels are solitary as well as in radial multiples and the fibres are with simple pits in Shoreae. As it has not been possible to ascertain the type of fibre pits in the fossil due to bad preservation, it is not possible to apply this criteria. However, the combination of anatomical features of this Burma fossil indicates its affinity with members of the Shoreae, sepecially with *Shorea*, *Pentacme* and *Parahorea*. Chowdhury & Ghosh (1958, p. 108) classify the Indian members of these genera into the following two groups:

1. Soft tissues mostly forming prominent eye-lets round the pores. Pores not plugged with tyloses ....*Parashorea*, *Shorea* in part.
2. Soft tissues abundant, vasicentric and diffuse arrangement prominent, pores often plugged with tyloses....*Pentacme* *Shorea* in part.

According to the above classification, the present fossil belongs to the second group, where the parenchyma is abundant, vasicentric and diffuse and the pores are often plugged with tyloses. A survey of the thin sections and published description and figures of the members of Shoreae reveals its resemblance with the modern woods of *Shorea obtusa* and *Pentacme suavis* (Pearson & Brown, 1932, pp. 104-105, 115-116). As it is not possible to separate these two species of *Shorea* and *Pentacme* anatomically, the fossil wood might belong to any one of them. Because the present fossil belongs to Shoreae group it has been assigned to the form genus *Shoreoxylon* Den Berger (1923).

So far about fourteen species of the genus *Shoreoxylon* Den Berger (1923) have been described from India and abroad. These are listed in the Table below.

The species *Shoreoxylon holdeni* Ramanujam (1956), *S. mortandranse* Ramanujam (1956) and *S. megaporosum* Ramonujam (1960), has been changed to *Dryobalanoxylon holdeni* (Ramanujam) comb. nov. by Awasthi (1965), who critically re-examined their type slides and noted the presence of bordered pits in the fibres.

From a detailed comparison of this fossil wood from the above species of *Shoreoxylon*, it has been seen that the fossil wood is quite different from all these species in having abundant, diffuse and paratracheal prenchyma. Thus *Shoreoxylon speciosum* differs from this wood in having smaller vessels (175-230 μ diameter), in multiseriate, 3-6 cells broad xylem rays and in possessing septate fibres. Similarly. *Shoreoxylon evidens* is also quite distinct from the present fossil in possessing aliform and banded apotracheal parenchyma embedding the gum canals. Lastly, *Shoreoxylon krauseli* although nearly resembling the present fossil also differs from it in having smaller vessels (t.d. 150-200 μ) and in possessing short, 1-3 seriate, tangential strips of apotracheal parenchyma. However, in the present fossil wood, the short, irregular lines of apotracheal parenchyma are almost always uniseriate.

As this fossil wood is quite distinct from all the species of *Shoreoxylon* and shows a near resemblance with the modern woods of *Shorea obtusa* and *Pentacme suavis*, it has been assigned to *Shoreoxylon burmense* Prakash.

Shorea obtusa Wall. also known as Burma sal, occurs sometimes gregariously in Ava, Prome, Martaban to Tenasserim in lower hill forests of Burma upto 600 m. It grows often in association with *Dipterocarpus tuberculatus* and *Pentacme suavis* and is often sold commercially mixed up with the latter with which it is difficult to distinguish.

Pentacme suavis grows all over Burma but more in North Burma and in Pegu Yomas and in Shan states; also grows in Indo-China, Thailand and Malay Peninsula (Chowdhury & Ghosh, 1958, pp. 132, 137).

SPECIFIC DIAGNOSIS

Shoreoxylon burmense Prakash, 1965b

Wood diffuse-porous. *Growth* rings absent. *Vessels* large to medium-sized, t.d. of solitary vessels 135-240 μ, r.d. 225-360 μ, mostly solitary, often in radial multiples of 2-3, oval to elliptical in shape, tylosed

Species	Age	Locality
1. *Shoreoxylon palembangense* (Krausel, 1922) Den Berger, 1923	Pliocene	South Sumatra
2. *S. djambiense* Den Berger (Den Berger, 1923; Schweitzer, 1958)	Tertiary, Pliocene	South Sumatra, West Java
3. *S. moroides* Den Berger, 1927	Pliocene	Java
4. *S. swedenborgi* (Schuster) Schweitzer, 1958	Pliocene	East Indies
5. *S. parvum* Schweitzer, 1958	Pliocene	West Java
6. *S. asiaticum* Schweitzer, 1958	Tertiary	Sumatra
7. *S. maximum* Schweitzer, 1958	Tertiary	Middle Sumatra
8. *Shoreoxylon* cf. *posthumi* Schweitzer, 1958	Tertiary	Sumatra
9. *S. pulchrum* Schweitzer, 1958	Quaternary	Middle Sumatra
10. *S. multiporosum* Schweitzer, 1958	Quaternary	Middle Sumatra
11. *S. posthumi* Schweitzer, 1958	Quaternary	Middle Sumatra
12. *S. speciosum* Navale, 1963b	Mio-Pliocene	South India
13. *S. evidens* Eyde, 1963	Tertiary	Garo Hills, Assam
14. *S. krauseli* Ramanujam & Raghu Rama Rao, 1969	Mio-Pliocene	South India
15. *S. tipamense* Prakash & Awasthi 1970	Upper Miocene	Jaipur, Assam
16. *S. diomaliense* Prakash & Awasthi 1971	Mio-Pliocene	Deomali, NEFA

or with gummy deposits, 5-6 per sq. mm.; vessel-members about 225-345 μ or more with truncate ends; perforations simple; intervessel pit-pairs 5-7 μ in diameter, alternate, bordered, oval to orbicular in shape. *Vasicentric tracheids* scanty, associated with the vessels along with paratracheal parenchyma; vessel-treacheid pits bordered, 1-2 seriate. *Parenchyma* both paratracheal and apotracheal; paratracheal parenchyma vasicentric to occasionally aliform, sometimes with a tendency to join two or more adjacent vessels; apotracheal parenchyma either diffuse occurring as solitary or groups of cells, sometimes forming short, irregular lines, or in long tangential bands embedding the canals. *Xylem rays* 1-5 (mostly 4-5) seriate, 12-75 μ broad and upto 1275 μ high; ray tissue almost homogeneous. *Fibres* libriform, nonseptate and polygonal; interfibre pits not well preserved. *Gum canals* arranged in 1-3 rarely 4, concentric, tangential rows, embedded in parenchymatous bands, round to oval in shape, about 45-150 μ in diameter.

Holotype — B.S.I.P. Museum No. 34085.

FAMILY — STERCULIACEAE

***Sterculioxylon* Krausel, 1939**

4. *Sterculioxylon foetidense* sp. nov.

Pls. 3-4, Figs. 15-20

The present description is based on a small piece of decorticated secondary wood measuring about 2 cm. in length and 1 cm. in diameter. The preservation of the fossil wood is not very satisfactory.

Topography — *Wood* diffuse-porous (Pl. 3. Figs. 15, 17). *Growth rings* indistinct. *Vessels* visible as dots to the naked eye, the orifices clearly seen with a hand lens, evenly distributed, large to moderately large and sometimes medium-sized and small, solitary or in short radial multiples of 2-3 or rarely 4, sometimes in clusters, appear to have been round in shape but elliptical and irregular due to compression during fossilization, 2-3 per sq. mm.; tyloses absent but some of the vessels plugged with brownish black deposits. *Parenchyma* of two types — paratracheal and apotracheal; paratracheal (Pl. 3, Figs. 15, 17; Pl. 4, Fig. 19) in narrow sheath around the vessels; apotracheal parenchyma diffuse to diffuse-in-aggregate (Pl. 4, Figs. 9, 20), predominantly occurring as irregular, broken or continuous, closely spaced lines usually uniseriate. *Xylem rays* of two sizes, broad to moderately broad and fine (Pl. 3, Fig. 16), 1-8 seriate and 20-208 μ wide, and 160-2700 μ high; 3-4 per mm.; ray tissue heterogeneous with sheath cells abundant (Pl. 3, Fig. 18); uniseriate rays sparse; multiseriate rays npto 208 μ wide and 2700 μ high consisting of procumbent cells in the middle part and marginal rows of upright cells at the ends; sheath cells present at the periphery of the rays. *Fibres* not well preserved.

Elements — *Vessels* thin-walled, walls about 4 μ thick, t.d. of solitary vessels, 160-400 μ, r.d. 240-480 μ, mostly irregular to elliptical in cross-section, few, circular, those in radial multiples slightly flattened at the places of contact; vessel-members 288-480 μ long, with truncate or slightly inclined ends; perforations simple; intervessel pit-pairs 4-8 μ in diameter, rounded or polygonal, alternate, bordered. *Parenchyma cells* thin-walled with black infiltration in some, 20-32 μ in diameter as seen in cross-section *Ray cells* thin-walled; procumbent cells of various shape and size, vertical height 30-40 μ, radial length 48-100 μ; upright cells vertical height 72-80 μ, radial length 28-56 μ. *Fibres* nonlibriform to libriform, secondary walls usually degraded, polygonal in cross-section; interfibre pits not preserved.

Affinities — Structural features of this Burmese wood indicate, after extensive comparison, that its closest resemblance is with the modern genus *Sterculia*, especially with the extant species *Sterculia foetida* Linn. It also shows a superficial resemblance to the mature secondary xylem of *Salmalia* (*Bombax*) of the family Bombacaceae However, the predominance of sheath cells in the xylem rays of the fossil wood as seen in cross section at once differentiates it from that of *Salmalia*. Thin sections of fifteen species of *Sterculia* were examined at the Forest Research Institute, Dehra Dun, besids studying published description and photographs of these and three other species, viz., *Sterculia blancoi* Rolfe, *S. carthaginensis* Cav. and *S. hypochra* Pierre (Lecomte, 1926, Pl. 29; Pearson & Brown, 1932, pp. 146-152, Figs. 52-55; Chattaway, 1932, Pls. 3, 5, Figs. 1-6; Metcalfe & Chalk, 1950, pp. 243-251, Fig. 61J; Henderson, 1953, Pls. 68, 69, Figs. 362-364; Desch, 1954, pp. 581-583, Pl. 114, Fig. 2; Chowdhury & Ghosh, 1958, pp. 212-221, Pls. 27, 28, Figs. 159, 160, 163, 164, 165; Kribs, 1959, pp. 153, 154, Figs. 468, 469; Brazier & Franklin, 1961, p. 79). The species examined at the Forest Research Institute are *Sterculia alata* Roxb., *S. angustifolia* Roxb., *S. campanulata* Wall. ex. Mast., *S. coccinea* Roxb., *S. colorata* Roxb., *S. foetida* Linn., *S. fulgens* Wall., *S. guttata* Roxb., *S. oblonga* Mast., *S. ornata* Wall. *S. populifolia* DC., *S. rhinopetala* K. Schum., *S. scaphigera* Wall., *S. urens* Roxb., and *S. villosa* Roxb.

The fossil wood resembles the modern wood of *Sterculia foetida* in the shape and distributional pattern of the vessels, parenchyma distribution and in the nature of xylem rays and fibres. However, the vessels are slightly bigger in the modern wood of *S. foetida*.

Since the fossil wood compares very well with the modern wood of *Sterculia foetida*, it is assigned to the form genus *Sterculioxylon* Krausel (1939) and described as *Sterculioxylon foetidense* sp. nov., being different from all the known species of this genus.

Four species of the genus *Sterculioxylon* are so far known. These are *S. aegyptiacum* (Ung.) Krausel (1939) from the Tertiary of Egypt and the Post Eocene of Tibesti in Sahara (Boureau, 1949), *S. giarabubense* (Chiarugi) Krausel (1939) from the Lower Oligocene to Lower Miocene of North Africa, *S. rhenanum* Müller-Stoll (1949) from the Eocene of South-west Germany, and *S. freulonii* Boureau (1957) from the Post Eocene of Libya in Sahara. All these species differ quite distinctly from the present fossil wood as indicated below.

Sterculioxylon aegyptiacum (Krausel, 1939) differs from the present fossil wood in having slightly smaller vessels (t.d. 100-240 μ, r.d. 100-430 μ), and narrower (1-7 seriate) xylem rays and in possessing aliform, confluent and banded metatracheal parenchyma and the secretory canals. Similarly *S. giarabubense* (Chiarugi, 1929; Krausel, 1939) differs from *S. foetidense* in possessing smaller vessels, narrower xylem rays (1-5 seriate), aliform and metatracheal bands of parenchyma and in having secretory canals. *S. rhenanum* (Müller-Stoll, 1949) is also quite distinct in having smaller vessels (t.d. 100-200 μ, r.d. 150-300 μ), in possessing vasicentric to aliform, confluent and banded metatracheal parenchyma, and in broader, 1-15 seriate xylem rays. Lastly *S. freulonii* (Boureau, 1957) is also distinct from *S. foetidense* in having mostly concentric bands of parenchyma, sometimes with aliform type, narrower (1-6 seriate) xylem rays, slightly smaller vessels (t.d. 120-200 μ; r.d. 200-300 μ), and in the presence of tangential rows of traumatic secretory canals.

The genus *Sterculia* Linn. consists of 300 species (Willis, 1966, p. 1074) distributed throughout the tropics, and reaches its best development in tropical Asia (Pearson & Brown, 1932, p. 145). The species *Sterculia foetida*, with which the present fossil wood shows nearest resemblance, is found on the west coast at low elevations from Konkan southwards, Ceylon and Martaban and upper Tenasserim in Burma. Outside the Indian region it has a wide distribution from tropical East Africa to North Australia (Chowdhury & Ghosh, 1958, p. 214).

SPECIFIC DIAGNOSIS

Sterculioxylon foetidense sp. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* large to moderately large and sometimes medium-sized, t.d. 160-400 μ, r.d. 240-480 μ, solitary or in short radial multiples of 2-3 or rarely 4, round to elliptical in shape, 2-3 per sq. mm.; tyloses absent but vessels plugged with brownish black deposits; vessel-members 288-480 μ long with truncate or silghtly inclined ends; perforations simple; intervessel pit-pairs 4-8 μ in diameter, rounded or polygonal, alternate and bordered. *Parenchyma* both paratracheal and apotracheal; paratracheal parenchyma in narrow sheath around the vessels; apotracheal parenchyma predominantly diffuse to diffuse-in-aggregate occurring as irregular, broken or continuous, usually uniseriate lines. *Xylem rays* broad to moderately broad and fine, 1-8 seriate and 20-208 μ wide and 160-2700 μ high with uniseriate rays quite sparse; ray tissue heterogeneous with many sheath cells at the periphery of the rays. *Fibres* not well preserved, nonlibriform to libriform, secondary walls usually degraded, polygonal in cross-section, quite long but exact length could not be measured due to bad preservation; interfibre pits not preserved.

Holotype — B.S.I.P. Museum No. 34086.

Family — Anacardiaceae

Glutoxylan Chowdhury, 1934

5. *Glutoxylon burmense* (Hold.) Chowdhury 1952
Pl. 4, Figs. 21, 22

The following are important anatomical features of a silicified piece of wood measuring about 3 cm. in length and 1·5 cm. in diameter.

Wood diffuse-porous with growth rings. *Vessels* round to oval, solitary vessels 90-210 μ in t.d., 120-300 μ in r.d., solitary as well as in radial multiples of 2-7 (Pl. 4 Fig. 21) with abundant tyloses and alternate, large intervessel pits with lenticular apertures. *Parenchyma* paratracheal and apotracheal (Pl. 4, Fig. 21); paratracheal parenchyma scanty to vasicentric; apotracheal parenchyma in continuous or broken, tangential lines mostly 2-4 cells in thickness and somewhat wider at some of the growth rings. *Xylem rays* simple and fusiform (Pl. 4, Fig. 22); simpe rays 1-2 (mostly 1) seriate, homocellular consisting of procumbent cells; fusiform rays 3-5 seriate with horizontal gum canals (Pl. 4. Fig. 22). *Fibres* nonseptate and thick-walled.

The present fossil wood is identical to *Glutoxylon burmense* (Hold.) Chowdhury. This is already known from several Cenozoic localities in India (Chowdhnry, 1936, 1952; Awasthi, 1966; Prakash & Tripathi 1969; Prakash & Awasthi, 1971).

Specimen — B.S.I.P. Museum No. 34087.

Family — Leguminosae

***Enacacioxylon* Müller Stoll & Mädel, 1967**

6. *Euacacioxylon ferrugineum* sp. nov.
Pls. 4, 5, Figs. 23. 25, 27, 28

The present description is based on a very small piece of decorticated secondary wood. The preservation of the fossil wood is not very satisfactory and some twisting of the tissues is visible.

Topography — *Wood* diffuse-porous (Pl. 4, Fig. 23). *Growth rings* delimited by narrow bands of terminal parenchyma (Pl. 5, Fig. 27) and smaller vessels. *Vessels* visible as dots to the naked eye against the ground mass of the wood, their orifices clearly seen with a hand lens (Pl. 4, Fig. 23), large to medium-sized and smaller at the rings, the majority solitary and in radial rows of 2-4 (mostly 2), 4-6 per sq. mm., and partly ccculuded with deposits of reddish brown gum.

Parenchyma of two types — terminal and paratracneal (Pl. 4, Fig. 23); terminal parenchyma at the growth rings usually in narrow lines; paratracheal parenchyma vasicentric to aliform or sometimes confluent joining the adjacent pores; parenchyma sheath few to several cells thick round the pores forming a light brown halo about the vessels or vessel groups. *Xylem rays* indistinct to the naked eye (Pl. 5, Fig. 25), clearly seen under the microscope, usually short and spindle shaped, medium, 1-4-(5) (mostly 3-4) cells and 15-76 μ wide and 120-480 μ high; uniseriate and biseriate rays very rare; biseriate rays upto 37 μ wide and 280 μ high; rays, 5-8 or 9 per mm.; ray tissue homogeneous (Pl. 5, Fig. 28) with rays composed of procumbent cells. *Fibres* not very well preserved and not aligned in distinct radial rows between the two consecutive rays.

Elements — *Vessels* moderately thick-walled, walls about 3 μ thick, solitary vessels about 320 μ in diameter, variously shaped due to crushing during fossilization, appear to have been round to oval; vessel-members with truncate ends; perforations not seen; intervessel pit-pairs about 6-8 μ in diameter, alternate, bordered, vestured; vessel-parenchyma and vessel-ray pits not seen. *Parenchyma cells* thin-walled, t.d. 20-28 μ, height upto 72 μ; cells sometimes crystalliferous. *Ray cells* thin-walled, oval in shape as seen in tangential section, vertical height of procumbent cells 16-20 μ, radial length 56-88 μ. *Fibres* moderately thick-walled, secondary walls mostly degraded, usually polygonal in cross-section, 12-20 μ in diameter, appear to be non-septate, although there is lot of filling which give the false appearance of septa; interfibre pits not seen.

Affinities — There is close agreement in almost all details of structure of this wood with that of *Acacia* belonging to the family Leguminosae. The fossil wood shows also a superficial resemblance to the mature secondary xylem of *Acrocarpus* which, however, differs from the fossil wood in having heterogeneous xylem rays.

A survey of the available woods of *Acacia* indicates that the nearest affinity of the fossil within this genus is with *Acacia ferruginea* and *A. lenticularis* but more so with the former. Our survey included the study of thin sections of the wood of nineteen species of the genus and published description of nine other species (Kanehira, 1921, pp. 89-90, Pl. 18. Fig. 106; Pearson & Brown. 1932, pp. 439-445, 450-452, Figs. 150, 151, 154; Kribs, 1959, pp. 60-62, Figs. 156, 158, 161, 394).

Both in the fossil species and the modern wood of *Acacia ferruginea* the shape. size and distributional pattern of the vessels, the ray and fibre structure, and the parenchyma distribution are almost similar. However, the uniseriate rays are rare in the fossil wood, but they are almost absent in the modern wood of *Acacia ferruginea*. The close agreement in major diagnostic features as well as in numerous microscopic details provides convincing evidence that the present fossil wood is closely comparable with the modern species *Acacia ferruginea*.

In 1883 Schenk established the form genus *Acacioxylon* to include the fossil woods of *Acacia*. Müller-Stoll and Mädel (1967) while critically examining the leguminous fossil woods, discovered that *Acacioxylon antiquum* Schenk (1883) the type of the genus *Acacioxylon* does not belong to *Dalbergia*, but instead, it is a fossil wood of *Albizzia*. Consequently *Acacioxylon* Schenk (1883) became the synonym of *Dalbergioxylon* Ramanujam (1960). Hence *Acacioxylon antiquum* has been transferred to *Dalbergioxylon dicorynioides* Müller-Stoll and Mädel (1967). Another fossil wood *Acacioxylon indicum* Ramanujam (1955) from the Cuddalore series of India was found to be resembling the modern wood of *Cassia fistula;* therefore it has been changed to *Peltophoroxylon indicum* (Ramanujam) Müller-Stoll & Mädel (1967). Similarly, *Acacioxylon tenex* Felix (1893) from the Upper Cretaceous of Mexico has been transferred to *Mimosoxylon tenax* (Felix) by Müller-Stoll & Mädel (1967).

As the form genus *Acacioxylon* Schenk was transferred to *Dalbergioxylon* Ramanujam, being its syncnym, Müller-Stoll & Mädel (1967) proposed the form genera, *Euacacioxylon* and *Paracacioxylon* to include the fossil woods resembling *Acacia*, but differing from one another in the presence and absence of septa in the fibres. In *Euacacioxylon* the fibres are non-septate, while in *Paracacioxylon* they are septate. Müller-Stoll & Mädel (1967) further recognised *Euacacioxylon bharadwajii* (Navale, 1963a) comb. nov. and *Paracacioxylon odonellii* (Menendez, 1962) comb. nov. as the type species of the form genera *Eucacioxylon* and *Paracacioxylon* respectively.

As the present fossil wood of Burma shows the characters of the form genus *Euacacioxylon* Müller-Stoll & Mädel (1967), it has been assigned to it and described as a new species, *Euacacioxylon ferrugineum*, being closely comparable to the modern wood of *Acacia ferruginea*. It is, however, quite distinct from its only other species, *Euacacioxylon bharadwajii* (Navale) Muller-Stoll & Madel (1967), in a number of features. Thus *E. bharadwajii* differs from the present fossil wood in possessing smaller vessels (t.d. 108-162 μ, r.d. 162-234 μ) and in having short, irregular bands of parenchyma and only 4-6 seriate xylem rays. In *E. ferrugineum* the xylem rays are 1-4 rarely 5 seriate and the parenchyma is usually vasicentric to aliform.

The genus *Acacia* consists of over 400 species of armed and unarmed trees and shrubs widely scattered over the tropics and subtropics of the Old and the New World. *Acacia ferruginea*, which compares the present fossil wood, occurs in Northern Circars, Deccan and Carnatic, Berar, Panch Mehals, Konkan, Gujarat, dry country of Ceylon and probably in Burma (Gamble, 1902, p. 298).

SPECIFIC DIAGNOSIS

Euacaioxylion ferrugineum sp. nov.

Wood diffuse-porous. *Growth rings* delimited by narrow bands of terminal parenchyma and smaller vessels. *Vessels* large to medium-sized and small, upto 320 μ in diameter, majority solitary and in radial rows of 2-4 (mostly 2), normally round to oval, 4-6 per sq. mm., and occuluded with deposits of reddish brown gum; vessel-members with truncate ends; perforations not seen; intervessel pit-pairs alternate, bordered, vestured, 6-8 μ in diameter. *Parenchyma* terminal at the growth rings, and vasicentric to aliform or sometimes confluent joining the adjacent pores; cells sometimes crystalliferous. *Xylem rays* 1-5 (mostly 3-4) seriate, 15-75 μ wide, 120-480 μ high, 5-8 or 9 per mm;. ray tissue homogeneous with rays composed of procumbent cells. *Fibres* thick-walled, polygonal in cross-section, appearing non-septate; interfibre pits not preserved.

Holotype — B.S.I.P. Museum No. 34088.

Cynometroxylon Chowdhury & Ghosh, 1946

7. *Cynometroxylon indicum* Chowdhury & Ghosh, 1946

Pl, 5, Figs, 29, 30

The fossil wood consists of a small piece of secondary wood 5 cm. in length and 3 cm. in width. It shows the following characteristic anatomical features:

Wood diffuse-porous. *Growth rings* not seen. *Vessels* 90-200 μ in diameter, solitary as well as in radial multiples of 2-3 (Pl. 5, Fig. 29); perforations simple; intervessel pit-pairs vestured, small to medium, 4-5 μ in diameter. *Parenchyma* apotracheal in concentric tangential bands (Pl. 5, Fig. 29) alternating with the fibre bands of nearly same thickness, 3-9 cells in width. *Xylem rays* 1-3 (mostly 2) seriate (Pl. 5, Fig. 30), very rarely 3 seriate, heterocellular, consisting of procumbent cells in the middle portion and 1-2 marginal rows of upright cells at one or both the ends; end to end ray fusion frequent. *Fibres* nonseptate and thick-walled.

The fossil wood is similar to already known species, *Cynometroxylon indicum* Chowdhury & Ghosh (1946) described from the Tertiary of North Cachar Hills and Mikir Hills, Assam, (Chowdhury & Ghosh, 1946; Prakash, 1967), from near Deomali in NEFA (Prakash & Awasthi, 1971) and from the Cuddalore series of South India (Ramanujam & Raghu Rama Rao, 1966).

Specimen — B.S.I.P. Museum No. 34089.

Pahudioxylon Chowdhury, Ghosh & Kazmi, 1960

8. *Pahudioxylon sahnii* Ghosh & Kazmi, 1961

Pl. 6, Figs, 31, 32

The present species is based on a single piece of silicified secondary wood measuring about 5 cm. in length and 2-3 cm. in diameter.

Wood diffuse-porous with growth rings delimited by narrow lines (Pl. 6, Fig. 31) of terminal parenchyma, 2-4 cells thick. *Vessels* round to oval (Pl. 6, Fig. 31), many deformed in shape, probably due to pressure during fossilization, t.d. 105-300 μ, r.d. 105-375 μ, mostly solitary, sometimes in radial multiples of 2-3-(4) with intervessel pit-pairs alternate, vestured, and about 6 μ in diameter. *Parenchyma* apotracheal and paratracheal; paratracheal parenchyma mostly aliform to sometimes aliform-confluent (Pl. 6, Fig. 31); apotracheal parenchyma occurring at the growth rings. *Xylem rays* 1-3 (mostly 2-3) seriate (Pl. 6, Fig. 32), homocellular consisting of procumbent cells, about 5-19 cells in height, tending to become storied at some places. *Fibres* non-libriform to semi-libriform, polygonal and appearing to be non-septate.

In all the above anatomical features, the present specimen shows resemblance to *Pahudioxylon sahnii* Ghosh & Kazmi (1961) described from the Tertiary of Tripura and also from the Namsang river beds at Deomali (Prakash, 1966).

Specimen — B.S.I.P. Museum No. 34090.

Peltophoroxylon Müller-Stoll & Mädel emend. Prakash & Awasthi, 1970

9. *Peltophoroxylon cassinodosum* sp. nov.

Pl. 6, Figs. 33-36

The present species is based on a small piece of silicified wood measuring 1·5 cm. in length and 1 cm. in diameter. The preservation is not very satisfactory.

Topography — *Wood* diffuse-porous (Pl. 6, Figs. 33, 35). *Growth rings* not clearly seen. *Vessels* vissible to the naked eye in cross-section, medium sized to large (Pl. 6, Fig. 35), solitary and in radial multiples 2-3, rarely upto 5, 2-4 per sq. mm., tyloses absent. *Parenchyma* aliform to mostly aliform-confluent (Pl. 6, Figs. 33, 35) forming irregular bands and joining few to many vessels; terminal parenchyma appears to be present. *Xylem rays* 1-2 (mostly 2) seriate (Pl. 6, Fig. 34); ray tissue homogeneous, rays homocellular consisting of procumbent cells only, 7-34 cells in height, 8-13 rays per mm. *Fibres* aligned in radial rows between the consecutive rays.

Elements — *Vessels* round to oval, mostly irregular in shape due to compression during fossilization, those in radial multiples flattened at the places of contact, t.d. 144-400 μ, r.d. 160-416 μ; vessel-members 160-640 μ in length usually with truncate ends; perforations simple; intervessel pits bordered, alternate, 6-8 μ in diameter with linear apertures (Pl. 6, Fig. 36). *Parenchyma strands* with crystalliferous cells; cells 24-32 μ in diameter. *Ray cells* oval in tangential section; exact tangential height and radial length could not be determined due to bad preservation. *Fibres* septate, thick-walled and polygonal.

Affinities — Comparison with the modern species: Among the modern woods, the anatomical features of the present fossil wood are found in *Cassia* of the family Leguminosae, although it also resembles superficially the wood of the genus *Afzelia* of the same family. However, in *Afzelia* the fibres are non-septate, but these are septate in the present fossil wood. A survey of available woods of *Cassia* indicates that the nearest affinity of the fossil within this genus is with *Cassia nodosa* Buch.-Ham. (F.R.I. slide no. A 916). Our survey included the study of thin sections of eight species of the genus and published description of two other species. Thin sections were examined from the woods of *Cassia auriculata* Linn., *C. fistula* Linn., *C. marginata* Roxb., *C. nodosa* Buch.-Ham., *C. siamea* Lam., *C. grandis* Linn., *C. javanica* Linn., and *C. aubrevillei* Pellegr., while publisned description and figures of *Cassia fastuosa* Willd. (Kribs, 1959, p. 70, Fig. 173) and *C. timorensis* DC. (Moll & Janssonius, 1914, pp. 106-107) were consulted for detailed comparison. Both in the fossil wood and the modern wood of *Cassia nodosa* the vessel size and their distribution, the nature of perforation plates, the intervessel pit-pairs, the parenchyma distribution, the ray and fibre structure are similar. However, the only obvious difference between the two is in the frequency of xylem rays which is slightly more in the fossil than in the modern wood of *Cassia nodosa*.

Comparison with the fossil species — In 1967 Müller-Stoll and Mädel established the form genus *Peltophoroxylon* to include the fossil woods of *Cassia*, *Peltophorum* and *Xylia*. So far only a few species of *Peltophoroxylon* are known. These are *Peltophoroxylon variegatum* (Ramanujam, 1960) Müller-Stoll & Mädel (1967) and *P. indicum* (Ramanujam, 1955) Müller-Stoll & Mädel (1967) from the Cuddalore series of South India, *P. borooahii* (Prakash, 1967) Prakash & Awasthi (1970) and *P. cassioides* Prakash & Awasthi (1970) from the Tertiary of Assam. All these differ quite distinctly from the present fossil wood. Thus *Peltophoroxylon variegatum* differs from the present fossil wood in possessing predominantly confluent parenchyma and 1-3 seriate, homocellular to weakly heterocellular xylem rays. *P. indicum* also differs in having smaller vessels (220-250 μ in diameter), and broader xylem rays which are 2-5 seriate. *P. borooahii* is quite distinct from *P. cassinodosum* in having banded parenchyma and in the nonseptate fibres. Similarly *P. cassioides* is different from the present species in having slightly smaller vessels (t.d. 96-240 μ), slightly broader (1-3 seriate) xylem rays and nonseptate fibres, besides differing in many other features.

Since the present fossil is quite distinct from the above-mentioned species of *Peltophoroxylon*, it is being described as a new species *P. cassinodosum*, the specific name indicating close similarity with the modern wood of *Cassia nodosa*.

Cassia nodosa is a large evergreen tree reaching a height of 50 feet. It grows in the forests of Chittagong, evergreen tropical forests of Burma, north to Myitkyna, Andamans, Malay isles and Philippines (Hooker, 1879, p. 261; Gamble, 1902, p. 273).

SPECIFIC DIAGNOSIS

Peltophoroxylon cassinodosum sp. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* large to medium-sized, solitary and in radial multiples of 2-3, rarely upto 5, t.d. 144-400 μ, r.d. 160-416 μ; vessel-members 160-640 μ in length with truncate ends; intervessel pit-pairs bordered, alternate, 6-8 μ in diameter with linear apertures; tyloses absent. *Parenchyma* aliform to mostly aliform-confluent forming irregular bands and joining few to many vessels; crystalliferous parenchyma strands present. *Xylem rays* 1-2 (mostly 2) seriate, 7-34 cells in height, 8-13 rays per mm.; ray tissue homogeneous, rays homocellular consisting wholly of procumbent cells. *Fibres* septate, thick-walled and polygonal.

Holotype — B.S.I.P. Museum No. 34091.

Family — Lythraceae

Lagerstromioxylon Mädler, 1939

10. *Lagerstroemioxylon parenchymatosum* Prakash, 1965c

Pl. 7, Figs. 37, 39, 41, 42

The present species is based on a piece of decorticated secondary wood measuring about 5 cm. in length and 4-6 cm. in diameter. The fossil wood is greyish-white in colour and shows satisfactory preservation.

Topography — *Wood* semi-ring-porous (Pl. 7. Fig. 42). *Growth rings* distinct, delineated by narrow lines of terminal parenchyma and large spring wood vessels (Pl. 7. Fig. 37). *Vessels* visible as minute dots to the naked eye, large to medium-sized (Pl. 7. Fig. 42), largest in the inner portion of the ring, grading more or less gradually into smaller vessels in the outer portion of the ring, solitary as well as in radial multiples of 2-3-(4), 6-11 per sq. mm., with rays contiguous on both the sides; tyloses abundant. *Parenchyma* both apotracheal and paratracheal (Pl. 7, Figs. 37, 42); apotracheal parenchyma forming narrow bands at the growth rings and sometimes also confined to the fibrous tracts as solitary or groups of cells; paratracheal parenchyma quite abundant occurring in narrow, vasicentric sheath around some of the spring wood vessels, becoming aliform to aliform-confluent farther out in the ring and forming long bands in the outer part of the late wood; the aliform-confluent parenchyma joins the proximate vessels either by horizontal extensions or in oblique rows. *Xylem rays* not visible to the naked eye, fine (Pl. 7. Fig. 39), mostly uniseliate, occasionally locally biseriate, 3-24 cells high, close, 13-18 per mm.; ray tissue homogeneous (Pl. 7, Fig. 41) with rays composed of procumbent cells only; uniseriate rays 3-24 cells and 64-560 μ high and 12-15 μ broad. *Fibres* closely packed, and aligned more or less in radial rows.

Elements — *Vessels* slightly thicker-walled, round to oval in cross-section, tangential diameter of solitary vessels 105-270 μ, radial diameter 105-315 μ; vessel-members 165-390 μ long, usually with truncate ends; perforations simple; intervessel pit-pairs vestured, alternate to sub-opposite, 6-8 μ in diameter with horizontal, linear to lenticular apertures. *Parenchyma cells* thin-walled, t.d. 24-40 μ, height 80-120 μ; cells sometimes crystalliferous. *Ray cells* slightly thicker walled; procumbent cells round to oval or oblong in tangential section; vertical height 16-30 μ, radial length 60-170 μ. *Fibres* semilibriform, slightly thicker walled with big lumina, polygonal in cross-section, septate and 640-960 μ in length and 12-20 μ in diameter, sometimes appearing crystalliferous; inter-fibre pits not seen.

Affinities — The structural features of the present fossil wood indicate, after extensive comparison, that the closest resemblance of this fossil is with the modern genus *Lagerstroemia* of the family Lythraceae (Metcalfe & Chalk, 1950; Pearson and Brown 1932; Kribs, 1959), although it also shows superficial resemblance to the mature secondary xylem of *Terminalia crenulata*. However, the parenchyma pattern and the presence of crystalliferous fibres in the present fossil wood distinguish it from the wood of *Terminalia crenulata*. A survey of all available woods of the genus *Legerstroemia* Linn. shows that the nearest affinity of the fossil is with *L. villosa* Wall, ex Kurz and *L. parviflora* Roxb. but more so with the latter. Our survey included the study of thin-sections of *Lagerstroemia hypoleuca* Kurz, *L. tomentosa* Pres., *L. speciosa* (L.) Persl., *L. parviflora* Roxb., *L. lanceolata* Wall., *L. flosreginae* Retz., *L. villosa* Wall. ex Kurz, and *L. calyculata* Kurz, *L. colleni* Kurz., *L. floribunda* Jack. and *L. macrocarpa* Wall. and the photographs and published description of some of these and other species of *Lagerstroemia*, viz., *L. ovalifolia* Teysen. et Binn., *L. piriformis* Koehne, and *L. subcostata* Koehne (Lecomte, 1926, Pl. 51; Chowdhury, 1932, Pl. 5; 1945, p. 12, Pl. 1; Pearson & Brown, 1932, pp. 575-597, Figs. 190-196; Metcalfe & Chalk, 1950, pp. 652-654, Figs. 147A & B; Desch, 1957, pp. 307-308, Pl. 67, Fig. 2; Brazier & Franklin, 1961, p. 51; Kanehira 1921, Fig. 132; 1924, p. 36; Kribs 1959, p. 104, Figs. 233-234; Moll & Janssonius, 1914, pp. 585-593, Fig. 207; Henderson, 1953, Fig. 240).

The size and distribution of the vessels of this fossil wood agree with the distributional pattern in *Lagerstroemia parviflora*. Both in *L. parviflora* and in the fossil species the perforation plates are simple and the intervessel pit-pairs are vestured, alternate to sub-opposite. The distribution of parenchyma appears to be almost identical in both as is the fibre and ray structure. However, the vessels are slightly more closely placed in the fossil wood than in the modern wood of *Lagerstroemia parviflora*.

As the fossil wood shows close affinity with the wood of the modern genus *Lagerstoremia*, it has been assigned to the form genus *Lagerstroemioxylon* Mädler (1939) and described as *L. parenchymatosum* Prakash (1965c). Only two other fossil woods of *Lagerstoremia* known so far are *Lagerstoremioxylon durum* Mädler (1939) from the Pliocene of Frankfurt in Germany and *L. eoflosreginium* Prakash & Tripathi (1970) from the Tipam Sandstones near the town of Hailakandi, district Cachar, Assam. Both of them differ distinctly from the present fossil wood. Thus *L. durum* differs from the present fossil wood in having smaller (t.d. 30-110 μ, r.d. 19-170 μ) and mostly solitary vessels and in possessing 1-3 (mostly 1-2) seriate xylem rays in addition to a number of other minute anatomical details. Similarly, *L. eoflosreginium* also differs from the present fossil wood in possessing somewhat smaller (t.d. 52-200 μ, r.d. 56-260 μ) vessels showing ring-porosity and in having usually aliform-confluent to confluent parenchyma forming long and short bands. However, in the present fossil wood the vessels are larger (t.d. 105-270 μ, r.d. 105-370 μ), the parenchyma is usually aliform to aliform-confluent and the wood is semi-ring-porous.

The genus *Lagerstroemia* is confined to the Old World and consists of over 50 species of trees and shrubs with opposite, simple, entire leaves, showy flowers and capsular fruits. The centre of distribution is in south-eastern Asia, but the genus extends from Madagaskar through south-eastern Asia and the East Indies to tropical eastern Australia, China and Japan (Pearson & Brown, 1932, p. 573). Eighteen species occur in South-east Asia, extending to Australia; Burma being the centre of the genus (Hooker, 1879, p. 575). The species *Lagerstroemia parviflora* with which the fossil wood shows near resemblance is a tree varying very considerably in size according to locality. It is found in deciduous forests nearly all over India, from the Sutlej east-wards, through the Siwaliks, foot hill forests of United Provinces, Bihar and Orissa, Bombay and Madras, gradually disappearing in the South in the Nilgiris. It is common in Upper Burma (Pearson & Brown, 1932, p. 576).

SPECIFIC DIAGNOSIS

Lagerstromioxylon parenchymatosum Prakash, 1965c

Wood semi-ring porous. *Growth rings* distinct, delimited by terminal parenchyma and spring wood vessils. *Vessels* large to medium-sized or small, largest in the inner part of the ring, grading more or less gradually into smaller vessels, t.d. 105-270 μ, r.d. 105-370 μ, solitary as well as in radial multiples of 2-3 or 4, round to oval, 6-11 per sq. mm.; vessel-members snort usually with truncate ends, 165-390 μ in length; perforations simple; intervessel pit-pairs vestured, alternate to sub-opposite, 6-8 μ in diameter with horizontal, linear-lenticular apertures; tyloses absent. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma quite abundant occurring around some of the spring wood vessels and becoming aliform to aliform-confluent farther out in the ring also forming bands in the outer part of the late wood; apotracheal parenchyma terminal as well as diffuse occurring as solitary or groups of cells; cells sometimes crystalli-ferous, thin-walled, t.d. 14-40 μ, height 80-120 μ. *Xylem rays* mostly uniseriate, occasionally locally biseriate, 12-28 μ broad, 3-24 cells high, closely spaced, 13-18 per mm.; ray tissue homogeneous with rays composed of procumbent cells. *Fibres* polygonal in cross-section, semilibriform, slightly thicker walled with big lumina, septate, sometimes cryst-alliferous; interfibre pits not seen.

Holotype — B.S.I.P. Museum No. 34092.

INCERTAE SEDIS

Dryoxylon Schleiden in Schmid. 1853

11. *Dryoxylon asiaticum* sp. nov.

Pl, 8, Figs, 43-45

The present description is based on a small piece of badly preserved secondary wood measuring 3 cm. in length and 2·5 cm. in diameter.

Topography — *Wood* diffuse porous (Pl. 8, Figs. 43, 44). *Growth rings* not seen. *Vessels* round to oval, t.d. 128-250 μ, r.d.

192-336 μ, solitary as well as in radial multiples of 2-3 and empty with bordered, alternate, intervascular pitting. *Parenchyma* abundant (Pl. 8, Figs. 43-44), aliform to usually confluent, forming irregular bands sometimes also appearing diffuse in groups of cells; cells appearing storied, sometimes crystalliferous. *Xylem rays* 1-4 (mostly 3) seriate, probably homocellular consisting of procumbent cels only (Pl. 8, Fig. 45), irregularly storied. *Fibres* polygonal, thick-walled.

Holotype — B.S.I.P. museum No. 34093.

Affinities — Because of the unsatisfactory preservation of the fossil wood, it is not possible at present to assign it even to any family of the dicotyledons. However, its structural features, especially the type of parenchyma and the rays, indicate that it might belong to the family Leguminosae. In view of its uncertain affinities it is proposed to include this fossil under the noncommital genus *Dryoxylon* Schleiden (see Schmid, 1853), till further investigation of a better preserved specimen shows its undoubted affinity to some extant genus or family.

DISCUSSION

Considering the size and extent of the Tertiary deposits of Burma, the number of fossil plants described therefrom is rather small. Most of them are represented by the fossil woods known from the Pegu-Irrawaddy series; these have already been enumerated in the introductory part of this paper. The present detailed investigation on the petrified woods of Burma has further added to our knowledge of the past angiospermic flora of this region. It consists of modern woody plants distributed in 9 families, 18 genera and 26 species of the angiosperms, a list of which is given as below:

SYSTEMATIC LIST OF FAMILIES AND SPECIES

Palmaceae
Palmoxylon burmense Sahni
Palmoxylon sinuosum Sahni
Palmoxylon coronatum Sahni
Palmoxylon caudatum Sahni
Palmoxylon compactum Sahni
Palmoxylon pyriforme Sahni

Dipterocarpaceae
Dipterocarpophyllum gregoryi Edwards
Dipterocarpoxylon tertiarum Prakash
Dipterocarpoxylon chowdhurii Ghosh
Shoreoxylon burmense Prakash

Sterculiaceae
Sterculoxylon foetidense Prakash

Anacardiaceae
Glutoxylon burmense (Hold.) Chowdhury

Leguminosae
Leguminosites albizziformis Edwards
Leguminosites sp.
Leguminoxylon burmense Gupta
Euacacioxylon ferrugineum Prakash
Cynometroxylon indicum Chowdhury & Ghosh
Pahudioxylon sahnii Ghosh & Kazmi
Peltophoroxylon cassinodosum Prakash

Combretaceae
Terminalia tomentosa Wight et Arn.

Lythraceae
Lagerstroemioxylon parenchymatosum Prakash

Lauraceae
Tetranthera hwekonsis Schuster

Moraceae
Ficophyllum burmense Edwards

Incertae sedis
Dipterocarpoxylon holdeni Gupta
Dryoxylon asiaticum Prakash
Phyllites kamrupensis Seward

MODERN DISTRIBUTION OF BURMESE FOSSIL GENERA AND SPECIES

Fossil plants are often reliable indicators of past climates; this is particularly the case with those that are referable to the modern taxa. Because it is generally assumed that the vegetational complexes of the past had environmental requirements similar to their counterparts of today, the degree of similarity with the modern vegetation is an expression of similar ecological conditions. In this connection reference may be made to the modern genera to which the Burmese plant fossils have been referred leaving out the doubtful forms (Table 1). These include *Borassus*, the

TABLE 1 — PRESENT DISTRIBUTION OF THE BURMESE FOSSIL PLANTS

(Only those plants are included whose modern generic relationships are reasonably certain)

FOSSIL SPECIES	LIVING EQUIVALENTS	BURMA	INDIA				SOUTH EAST ASIA (EXCEPT BURMA)
			Eastern India	Northern India	Western India	Southern India	
Palmoxylon coronatum	*Borassus*	+	+	+	+	+	+
Dipterocarpoxylon tertiarum	*Dipterocarpus*	+	+	–	–	+	+
Dipterocarpoxylon chowdhurii	*Dipterocarpus*	+	+	–	–	+	+
Shoreoxylon burmense	*Shorea-Pentacme*	+	Only *Shorea*	Only *Shorea*	–	Only *Shorea*	+
Sterculioxylon foetidense	*Sterculia*	+	+	+	+	+	+
Glutoxylon burmense	*Gluta-Melanorrhoea*	+	Only *Melanorrhoea*	–	–	Only *Gluta*	+
Euacacioxylon ferrugineum	*Acacia*	+	+	+	+	+	+
Cynometroxylon indicum	*Cynometra*	+	+	–	–	+	+
Pahudioxylon sahnii	*Afzelia-Intsia*	Only *Intsia*	+	–	–	–	+
Peltophoroxylon cassinodosum	*Cassia*	+	+	+	+	+	+
Terminalia tomentosa	*Terminalia*	+	+	+	+	+	+
Lagerstroemioxylon parenchymatosum	*Lagerstroemia*	+	+	+	+	+	+

toddy palm, *Dipterocarpus, Shorea-Pentacme, Sterculia, Gluta-Melanorrhoea, Acacia, Cynometra, Afzelia-Intsia, Cassia, Terminalia* and *Lagerstroemia*. A detailed study of their modern distribution indicates their presence in Burma. Upto a few years ago the genus *Borassus* was considered to be monotypical. Now it has been proved that there are atleast seven species belonging to this genus growing in the Indian region, Malay, Archepelago, Africa, Madagascar and Northern Australia. *Borassus flabellifer* with which *Palmoxylon coronatum* resembles closely, grows extensively all over India and Burma where immense groves are found on the banks of the Irrawaddy from the sea coast upto nearly as far as Ava or Amarapura (Blatter, 1926). The genus *Dipterocarpus* includes about 80 species of large trees widely scattered throughout the Indo-Malayan region. In Burma alone about eleven species are known to occur. *Shorea*, on the other hand, is widely distributed starting from Ceylon and India on the west and throughout Burma and other countries of South-East Asia, up to the Philippines on the east. The other diptercarpaceous genus *Pentacme* has three definite species with a very irregular distribution in South-East Asia. Only one species, *Pentacme suavis*, which closely resembles one of the fossil wood, grows in Burma, Indo-China, Thailand and Malay Peninsula, while *P. contorta* and *P. mindanensis* occur in the Philippines. As regards *Sterculia*, it is a large genus of usually soft and light wooded trees. It consists of well over hundred species distributed throughout the tropics and reaches its best development in tropical Asia. The genus *Gluta* of the family Anacardiaceae consists of about 8-10 species, mainly Indo-Malayan in origin. At present it is mainly confined to Burma, Thailand, Malay Peninsula, Indo-China and as far north-east as Hainan Island. However, two species are found to occur isolated from the present home of this genus — one, *Gluta turtur* in Madagascar and the other, *G. travancorica* in Travancore in the extreme south-west coast of India. The other anatomically similar genus *Melanorrhoea* also consists of 8-10 species of large trees restricted to Indo-Malayan region. Two species are indigenous to Burma, one of which *Melanorrhoea usitata* extends upto Manipur in India

(Gamble, 1902; Pearson & Brown, 1932; Coowdnury & Ghosh, 1958; Anonymous, 1963). The leguminous genus *Acacia* consists of over 400 species of trees and shrubs widely scattered over the tropics and subtropics of the Old and New World. *Acacia ferruginea,* which compares closely the fossil wood of *Euacacioxylon ferrugineum,* occurs in Northern Circars, Deccan and Carnatic, Berar, Panch Mehals, Konkan, Gujarat, dry country of Ceylon and probably in Burma (Gamble, 1902, p. 298). *Cynometra* includes over 75 species of unarmed trees or shrubs which are widely scattered through the tropics of both the hemispheres, extending through Africa into Madagaskar and eastward through the Indo-Malayan region to the Philippines, Australia and the Pacific Islands in the Old World. Atleast five species occur in the Indian region of which *Cynometra polyandra* grows in Khasia Hills, Sylhet and Cachar, in Assam, and *C. ramiflora* occurs in the sea coast tidal forests of Sunderbans, South India, Burma the Andamans and Ceylon. The anatomically similar genera *Afzelia* and *Intsia* are known to occur in Africa, Asia, Malaysia and Polynesia. *Intsia* (*Afzelia*) *bijuga,* which is very near to one of the fossil wood, occurs in the tidal coast forests of Bengal, the Andaman Islands and Burma. As regards, *Cassia,* over 300 species are known which are widely distributed throughout the warmer regions of the Old and the New World with the exception of Europe. About 20 woody species are found in the Indian region. The species *Cassia nodosa* which shows close resemblance with one of the fossils grows in forests of Chittagong, evergreen tropical forests of Burma, north Myitkyina and Andamans. *Terminalia tomentosa* is probably the most widely distributed of all the important Indian timber trees. It occurs all over Burma, except in the North Shan States, Arakan and South Tenasserim, where it is scarce. Lastly, the genus *Lagerstroemia* is confined to the Old World and consists of over 50 species of trees and shrubs. Its centre of distribution is south eastern Asia and the East Indies to tropical eastern Australia, China and Japan (Gamble, 1902; Pearson & Brown, 1932).

The existence of the genera *Borassus, Dipterocarpus, Shorea-Pentacme, Sterculia, Gluta-Melanorrhoea, Acacia, Cynometra, Afzelia-Intsia, Cassia, Terminalia* and *Lagerstroemia* during the Tertiary (? Upper Tertiary) of Burma, and their presence in the modern flora of that region indicates that there has been no appreciable change in the climatic or ecological conditions of Burma since the Miocene times. The modern distribution of these genera indicates that this fossil flora existed under the tropical, mesophytic conditions. This inference is further strengthened by a closer comparison of the fossils in terms of species which are found even today in Burma (Table 2).

TABLE 2 — DISTRIBUTION OF BURMESE FOSSIL FLORA BY ELEMENTS

(In the present list only those plants are included whose modern relationships are reasonably certain. Doubtful forms and those identified upto generic level are omitted)

Fossil species	Living Equivalents		
	Burma	India	South East Asia (except Burma)
Palmoxylon coronatum	*Borassus flabellifer*	*Borassus flabellifer*	—
Dipterocarpoxylon tertiarum	*Dipterocarpus alatus*	*Dipteroearpus alatus*	*Dipterocarpus alatus*
Dipterocarpoxylon chowdhurii	—	?*Dipterocarpus bourdillonii*	—
Shoreoxylon burmense	*Shorea obtusa* or *Pentacme suavis*	—	*Pentacme suavis*
Sterculioxylon foetidense	*Sterculia foetida*	*Sterculia foetida*	*Sterculia foetida*
Euacacioxylon ferrugineum	*Acacia ferruginea*	*Acacia ferruginea*	—
Cynometroxylon indicum	*Cynometra ramiflora*	*Cynometra ramiflora*	*Cynometra ramiflora*
Pahudioxylon sahnii	*Intsia bijuga*	*Intsia bijuga*	*Intsia bijuga*
Peltophoroxylon cassinodosum	*Cassia nodosa*	*Cassia nodosa*	*Cassia nodosa*
Terminalia tomentosa	*Terminalia tomentosa*	*Terminalia tomentosa*	*Terminalia tomentosa*
Lagerstroemioxylon parenchymatosum	*Lagerstroemia parviflora*	*Lagerstroemia parviflora*	—

Age of the Flora — As regards the question of a precise age of this flora from Burma, nothing could be definitely said than the Tertiary as mentioned in the introductory part of this paper, but an attempt could be made in fixing the age among the Tertiary by a critical survey of the flora known from the study of the present collection of fossil woods.

It may be mentioned here that in the Tertiary of Burma the fossil woods are known only from the Eocene of Tilin and Pondaung sandstones and from the Mio-Pliocene of Pegu and Irrawaddy series. So the present fossil flora of Burma based on the study of petrified woods may be either Eocene or Mio-Pliocene in age. From a detailed study of the world floras it has been recognized that "in general angiosperm remains from Late Tertiary horizons can be identified with modern genera and species with a considerable degree of confidence. In floras found within this time range we are dealing largely with plants whose modern equivalents may be found in the immediate vicinity or utmost a few hundred miles distant. Going down to Mid to Early Tertiary horizons, we find that the comparison with the adjacent floras or indeed with the living species, becomes progressively less distinct" (Andrews, 1961). This means that the degree of resemblance of the fossil forms with the modern plants gets more and more distant as we go down into older geological formations. The present study of fossil woods has revealed a very interesting assemblage of fossil plants (see Tables 1 & 2) whose modern equivalents in terms of species are still growing in Burma. Because of a closer comparison of the fossil and living flora of this region, it is most likely that this flora might belong to Upper Pegu and Irrawaddy series, of Mio-Pliocene age, which abound in fossil woods. It may also be mentioned here that the most important trees of the Irrawaddian terrain include some of the forms which are also known in the fossil condition from Burma (Table 2). These include *Pentacme suavis*, *Shorea obtusa*, *Terminalia tomentosa*, *Lagerstroemia parviflora* and the toddy palm, *Borassus flabellifer* (Champion, 1936; Pascoe, 1953, p. 1832).

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EXPLANATION OF PLATES

PLATE 1

1. *Dipterocarpoxylon tertiarum* — Cross-section showing shape, size and distribution of vessels, parenchyma and gum canals. × 40. Slide No. 4173.

2. *Dipterocarpus alatus* — Cross-section showing similar shape, size, distribution of vessels, parenchyma and gum canals. × 40.

3. *Dipterocarpoxylon tertiarum* —Tangential longitudinal section showing xylem rays. ×40. Slide No. 4174.

4. *Dipterocarpus alatus*— Tangential longitudinal section showing similar xylem rays. × 40.

5. *Dipterocarpoxylon tertiarum* — Another cross-section at low magnification showing nature and distribution of vessels and gum canals. ×15. Slide No. 4175.

6. *Dipterocarpoxylon tertiarum* — Radial longitudinal section showing the nature of xylem rays. × 80. Slide No. 4176.

PLATE 2

7. *Dipterocarpoxylon chowdhurii* — Cross section under low magnification showing nature and distribution of vessels and gum canals. × 15. Slide No. 4177.

8. *Dipterocarpoxylon chowdhurii* — Tangential longitudinal section showing xylem rays. × 65. Slide No. 4178.

9. *Dipterocarpoxylon chowdhurii* — Radial longitudinal section showing heterocellular xylem rays. × 70. Slide No. 4179.

10. *Dipterocarpoxylon chowdhurii* — Another cross-section magnified to show the parenchyma pattern. × 30. Slide No. 4180.

11. *Shoreoxylon burmense* — Cross-section showing shape and size of vessels and the parenchyma distribution. × 60. Slide No. 4182.

PLATE 3

13. *Shoreoxylon burmense*— Another cross-section under low magnification showing distribution of vessels and gum canals. × 15. Slide No. 4183.

14. *Shoreoxylon burmense* — Radial longitudinal section showing homocellular xylem rays. × 80. Slide No. 4184.

15. *Sterculioxylon foetidense*— Cross-section showing shape, size and distribution of vessels. × 15. Slide No. 4185.

16. *Sterculioxylon foetidense* — Tangential longitudinal section showing xylem rays. × 30. Slide No. 4186.

17. *Sterculioxylon foetidense* — Another cross-section slightly magnified to show the distribution of parenchyma. × 30. Slide No. 4185.

18. *Sterculioxylon foetidense* — Cross-section highly magnified to show the distribution of parenchyma. ×55. Slide No. 4187.

PLATE 4

19. *Sterculioxylon foetidense* — Cross-section magnified to show the parenchyma near the vessel and in irregular lines. × 45. Slide No. 4188.

20. *Sterculioxylon foetidense* — Another cross-section highly magnified to show the apotracheal parenchyma in tangential lines. × 90. Slide No. 4188.

21. *Glutoxylon burmense* — Cross-section showing shape, size and distribution of vessels and the parenchyma pattern. × 30. Slide No. 4189.

22. *Glutoxylon burmense* — Tangential longitudinal section showing the xylem rays. × 100. Slide No. 4190.

23. *Euacacioxylon ferrugineum* — Cross-section showing the distribution of vessels and the parenchyma. × 30. Slide No. 4191.

24. *Acacia ferruginea* — Cross-section showing similar distribution of vessels and the parenchyma. × 30.

PLATE 5

25. *Euacacioxylon ferrugineum* — Tangential longitudinal section showing xylem rays. × 70. Slide No. 4192.

26. *Acacia ferruginea* — Tangential longitudinal section showing similar xylem rays. × 70.

27. *Euacacioxylon ferrugineum* — Another cross-section under low power showing a growth ring and the parenchyma pattern. × 15. Slide No. 4191.

28. *Euacacioxylon ferrugineum* — Radial longitudinal section showing the nature of xylem rays. × 130. Slide No. 4193.

29. *Cynometroxylon indicum* — Cross-section showing shape, size and distribution of vessels and parenchyma. × 35. Slide No. 4194.

30. *Cynometroxylon indicum* — Tangential longitudinal section showing xylem rays. × 65. Slide No. 4195.

PLATE 6

31. *Pahudioxylon sahnii* — Cross-section showing shape, size and distribution of vessels and the parenchyma. × 15. Slide No. 4196.

32. *Pahudioxylon sahnii* — Tangential longitudinal section showing xylem rays. × 80. Slide No. 4197.

33. *Peltophoroxylon cassinodosum* — Cross-section showing shape, size and distribution of vessels and the parenchyma. × 15. Slide No. 4198.

34. *Peltophoroxylon cassinodosum* — Tangential longitudinal section showing xylem rays. × 70. Slide No. 4199.

35. *Peltophoroxylon cassinodosum*— Another cross-section mognified to show the parenchyma pattern. × 30. Slide No. 4200.

36. *Peltophoroxylon cassinodosum* — Magnified intervascular pitting. × 220. Slide No. 4201.

PLATE 7

37. *Lagerstroemioxylon parenchymatosum* —Cross-section showing shape, size and distribution of vessels and the parenchyma. × 30. Slide No. 4202.

38. *Lagerstroemia parviflora*— Cross-section showing similar shape, size and distribution of vessels and parenchyma. × 30.

39. *Lagerstroemioxylon parenchymatosum* — Tangential longitudinal section showing xylem rays. × 100. Slide No. 4203.

40. *Lagerstroemia parviflora* — Tangential longitudinal section showing similar xylem rays. × 100.

41. *Lagerstroemioxylon parenchymatosum*— Radial longitudinal section showing homocellular xylem rays. × 70. Slide No. 4204.

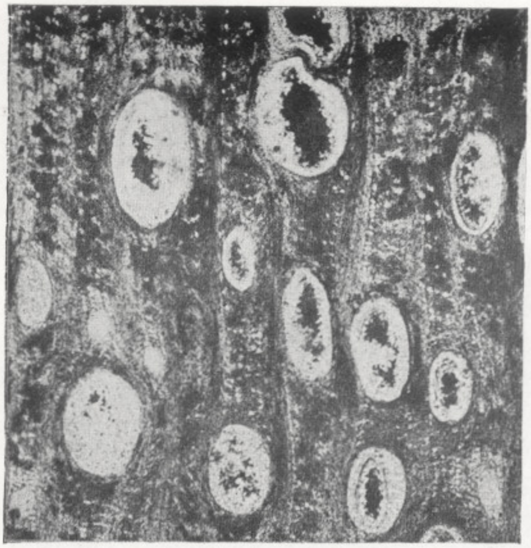
42. *Lagerstroemioxylon parenchymatosum* — Another cross-section under low power showing the distribution of vessels and the parenchyma. × 10. Slide No. 4205.

PLATE 8

43. *Dryoxylon asiaticum* — Cross-section of the fossil wood in low power showing distribution of vessels and parenchyma. × 15. Slide No. 4206.

44. *Dryoxylon asiaticum* — Cross-section slightly magnified to show parenchyma distribution. × 30. Slide No. 4206.

45. *Dryoxylon asiaticum* — Tangential longitudinal section showing xylem rays. × 90. Slide No. 4207.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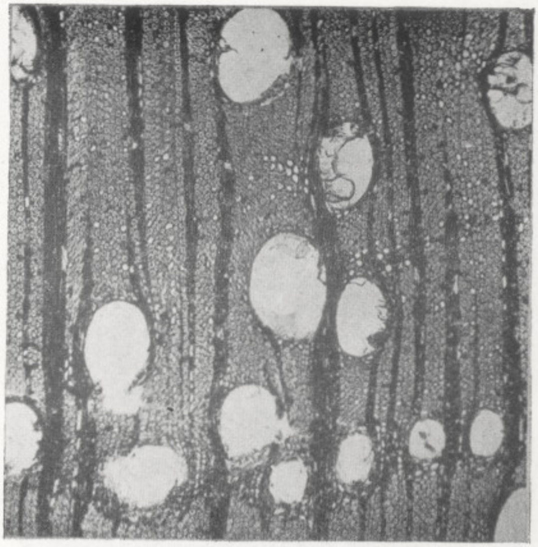
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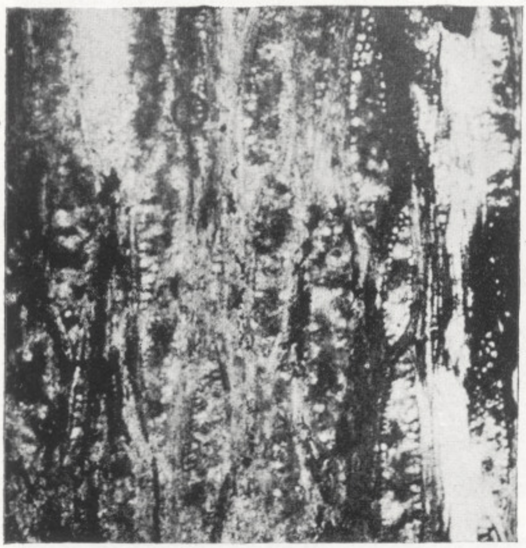
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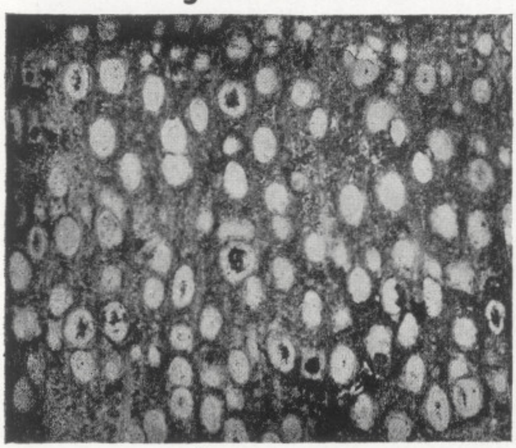
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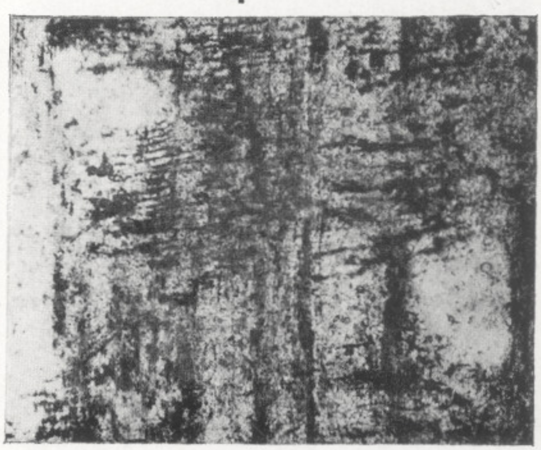
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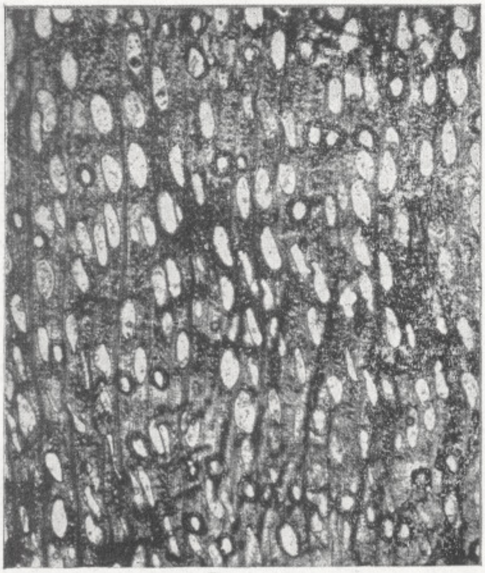

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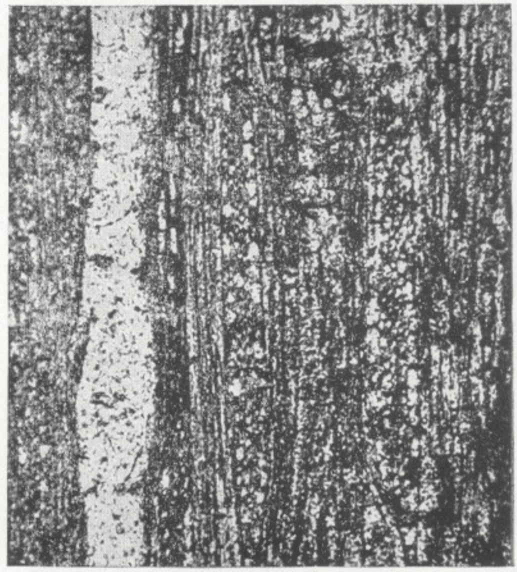

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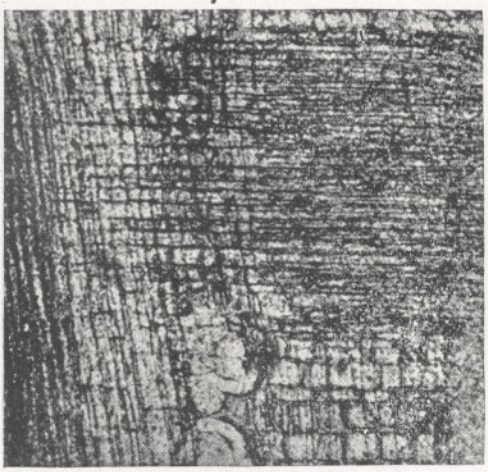

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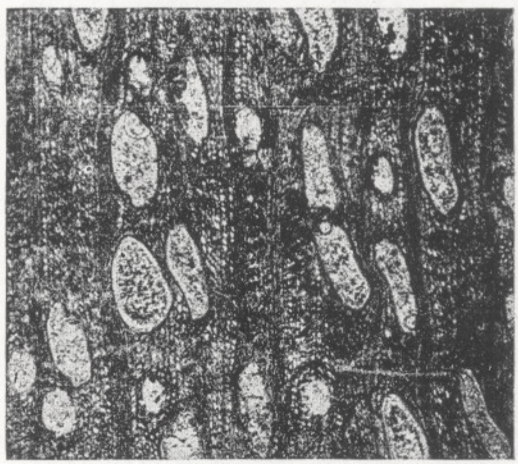

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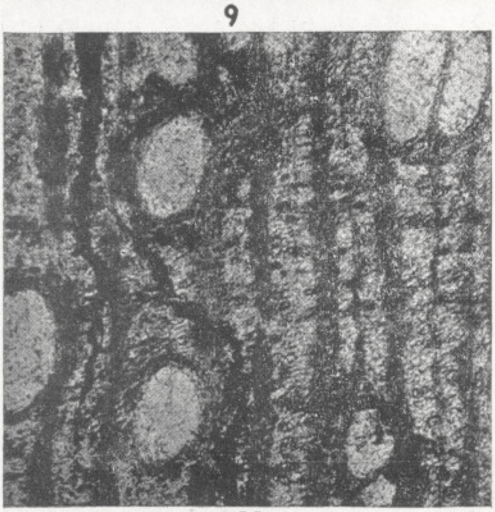

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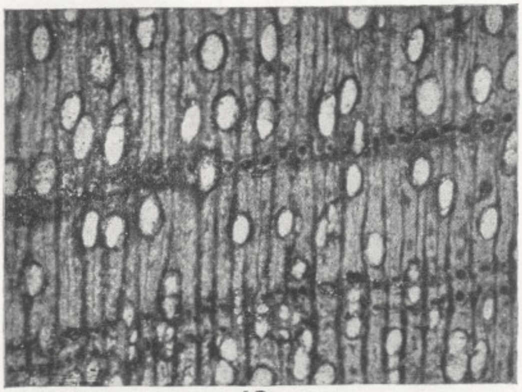

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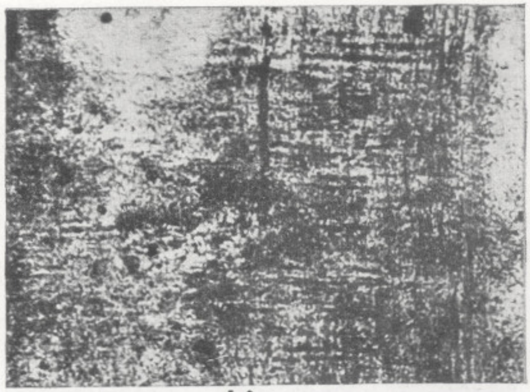

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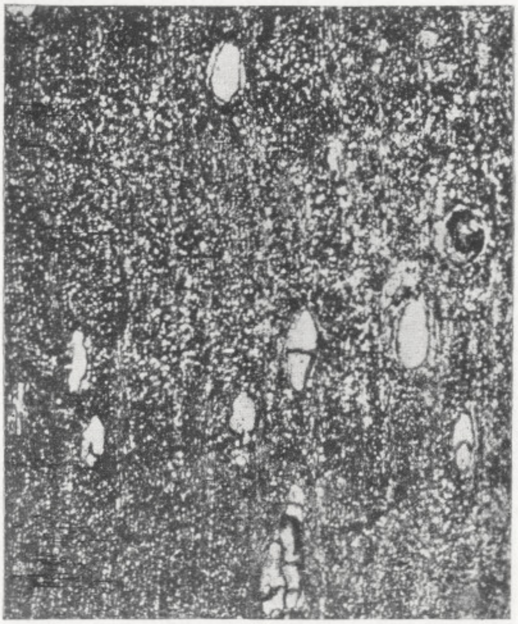

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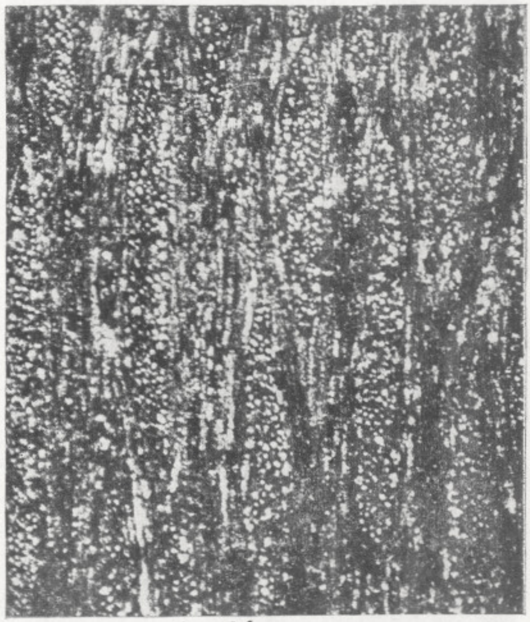

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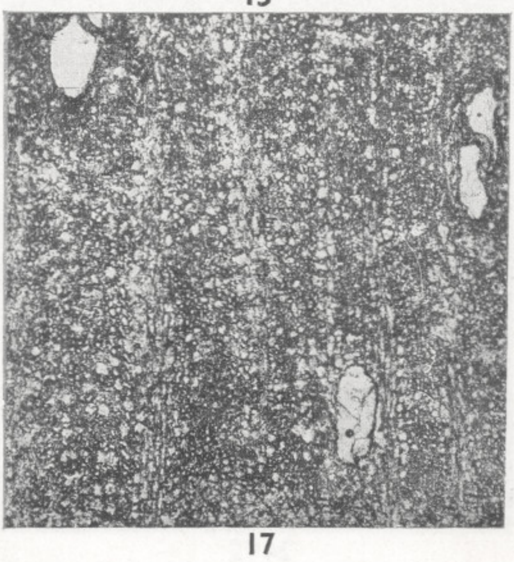

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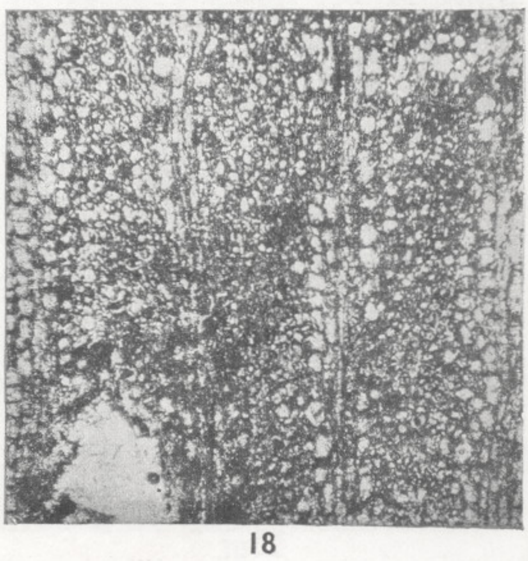

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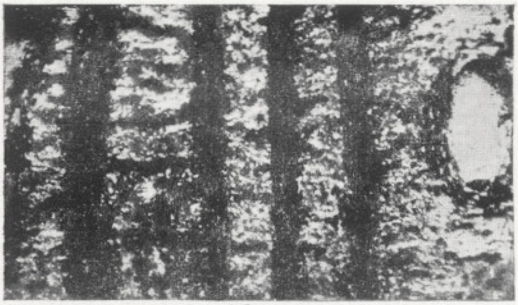

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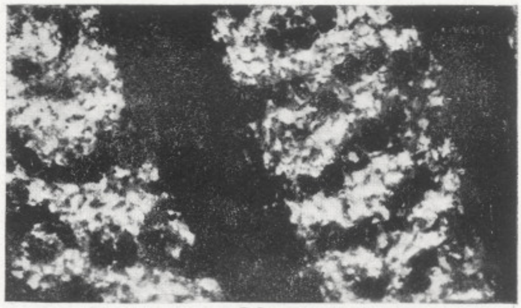

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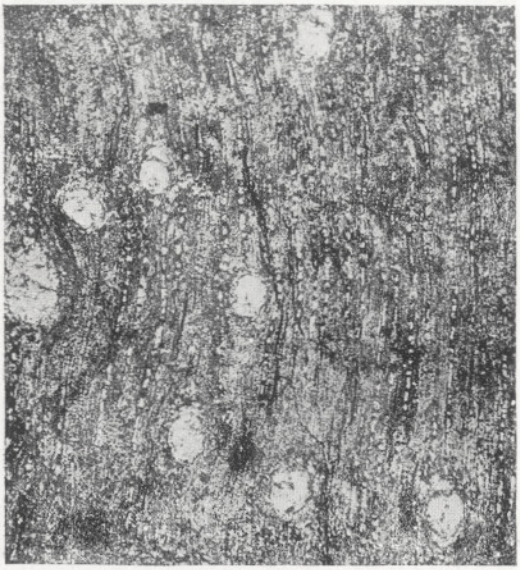

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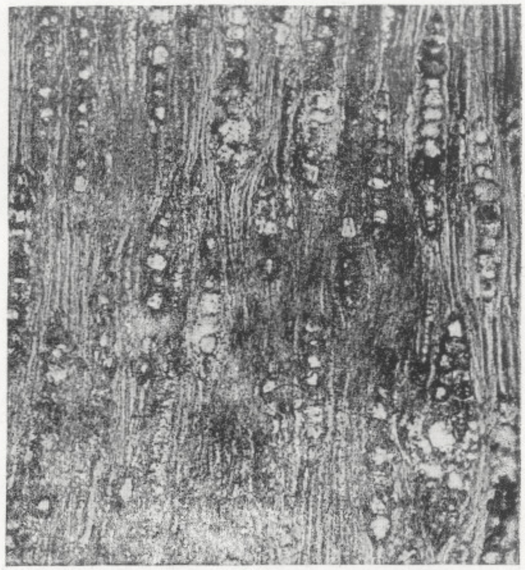

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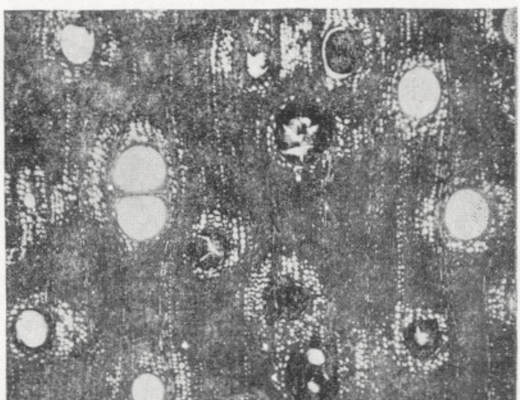

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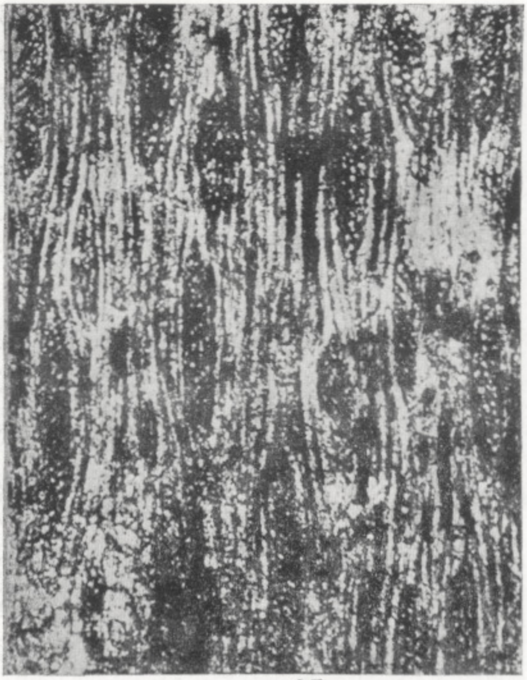

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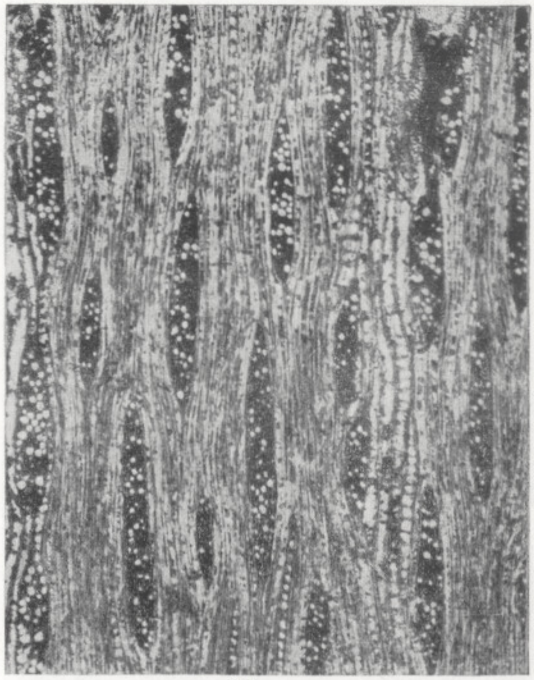

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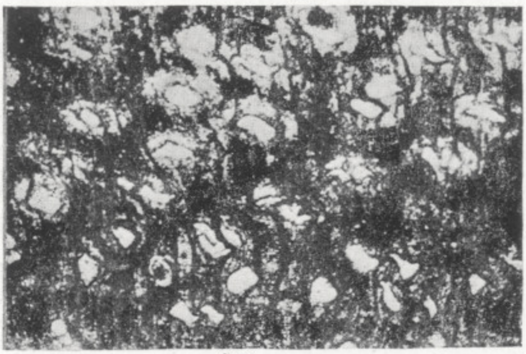

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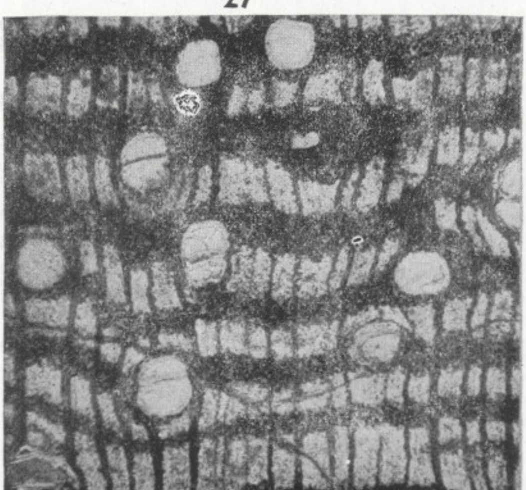

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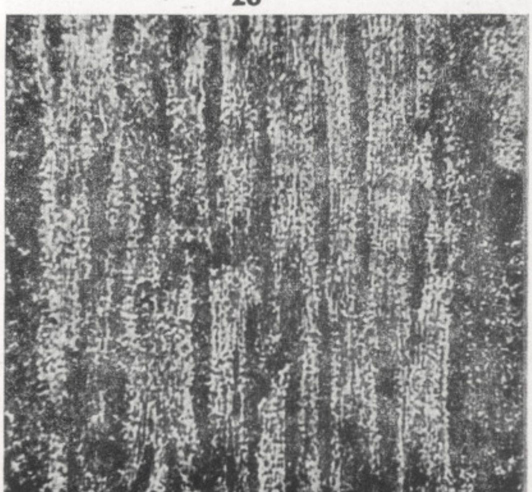

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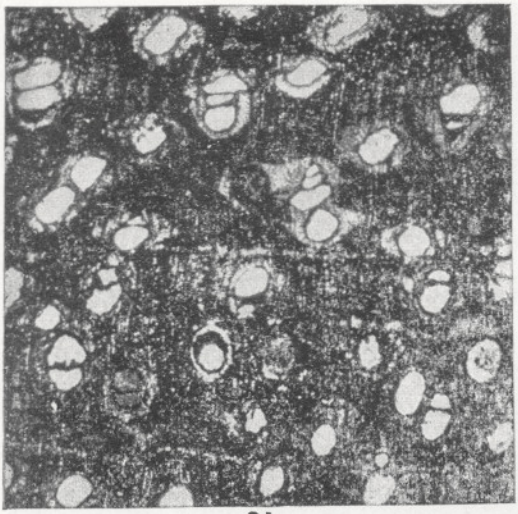
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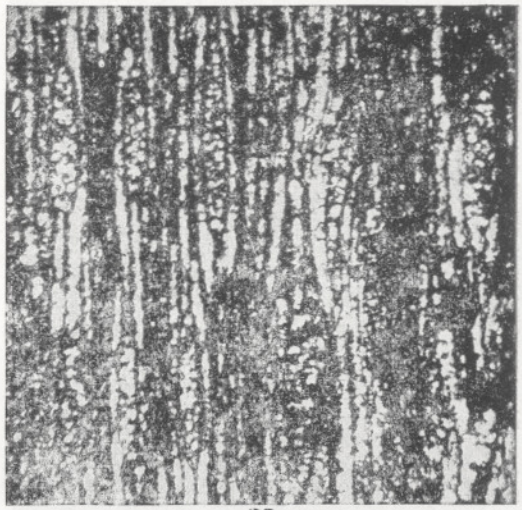
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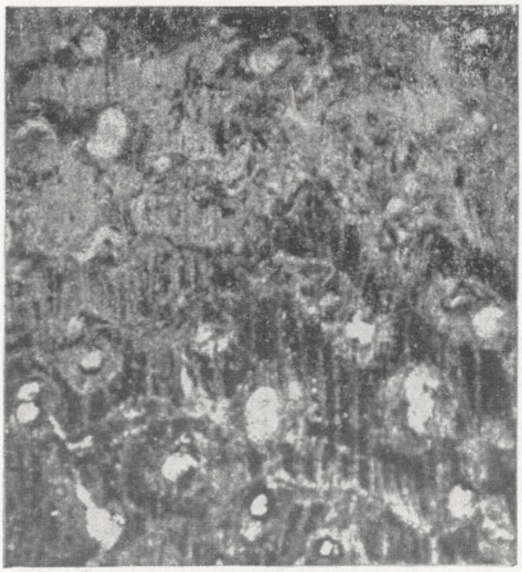
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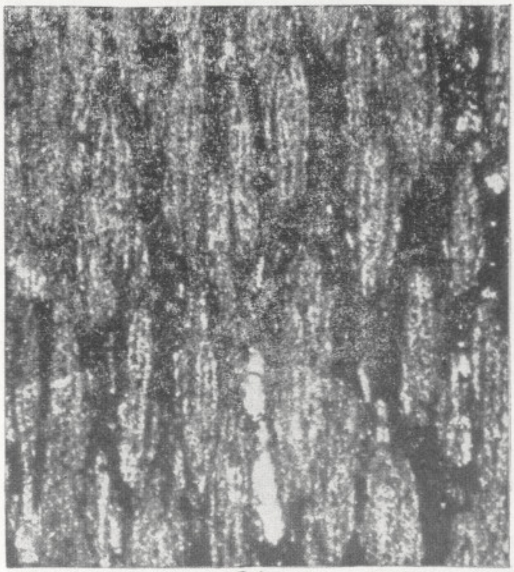
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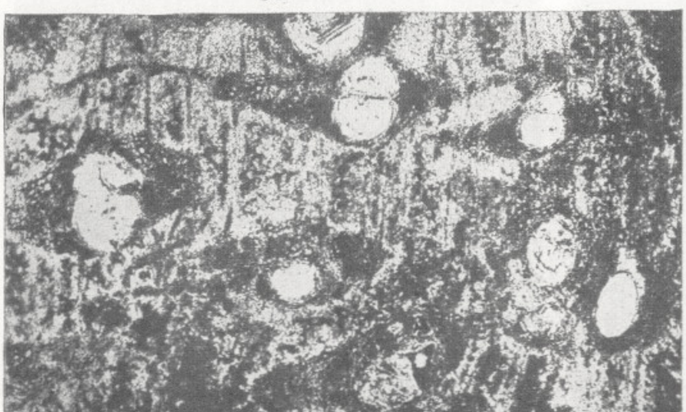
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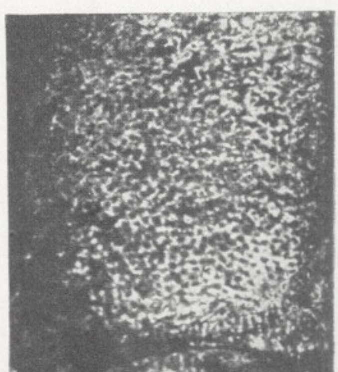
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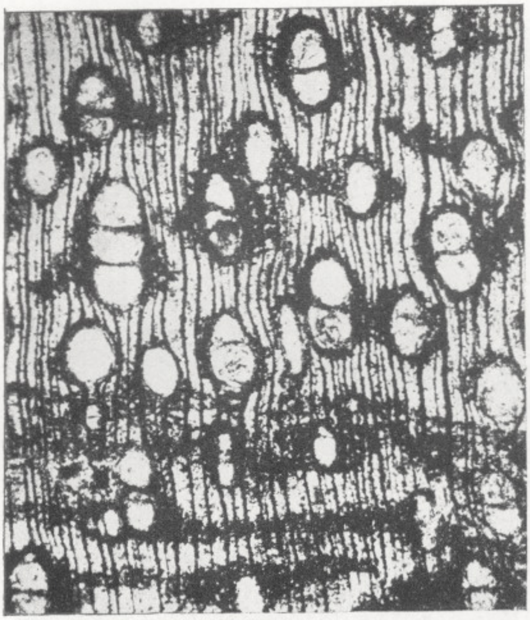

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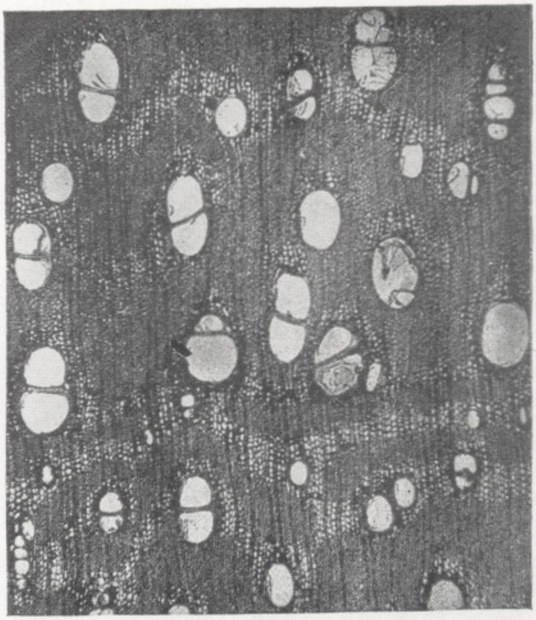

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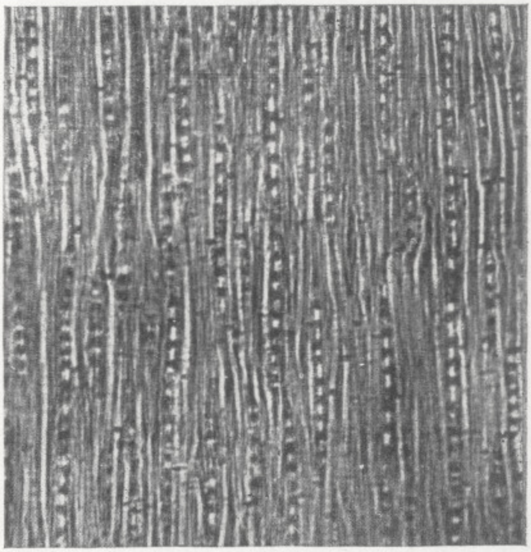

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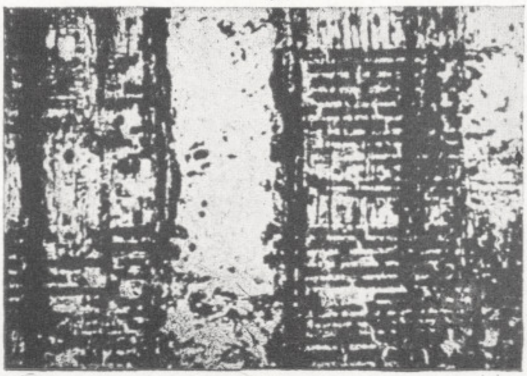

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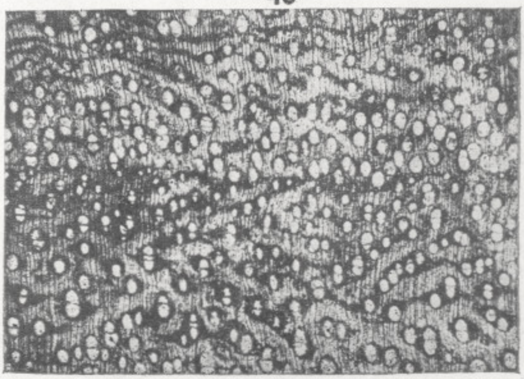

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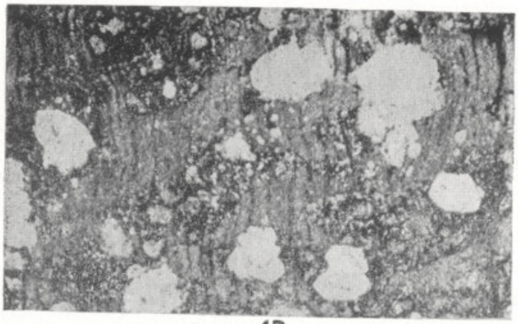
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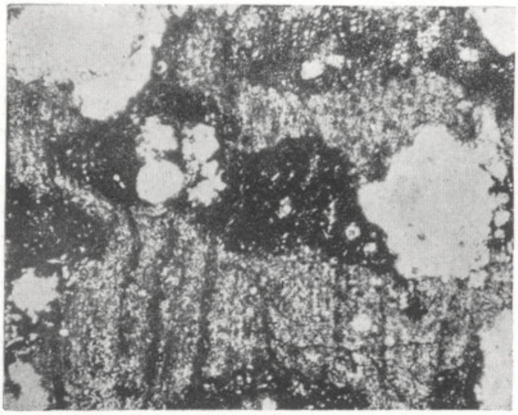
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