FOSSIL WOODS FROM THE LOWER SIWALIK BEDS OF UTTAR PRADESH, INDIA

U. PRAKASH

Birbal Sahni Institute of Palaeobotany, Lucknow-226007, India

ABSTRACT

The present paper deals with a detailed study of the petrified woods belonging to *Polyalthia, Anisoptera, Dipterocarpus, Cynometra, Cassia* and *Diospyros* collected from the Lower Siwalik beds of Kalagarh, district Bijnor in Uttar Pradesh. These are *Polyalthioxylon indicum* sp. nov., *Anisopteroxylon kalagarhensis* sp. nov., *Dipterocarpoxylon parabaudii* sp. nov., *Cynometroxylon* sp. cf. *C. indicum* Chowdhury & Ghosh, *Cassinium borooahii* (Prakash) Prakash, and *Ebenoxylon miocenicum* sp. nov. Present distribution of the modern equivalents of these fossil species indicates a more humid climate in this region during the Lower Siwalik period.

INTRODUCTION

EXTENSIVE areas of Northern India in the foot hills of Himalayas are covered with deposits of sandstones, grits, conglomerates, pseudo-conglomerates, clays and silts. These are known as the Siwalik beds and contain within them a rich and varied assemblages of fauna and flora, the latter specially abounding in angiospermous leaf impressions and petrified woods exposed at a number of localities in Himachal Pradesh and Uttar Pradesh. The present study is, however, based on a collection of fossil woods from the Lower Siwalik beds of Kalagarh, district Bijnor, Uttar Pradesh first brought by Dr Ashok Sahni of Geology Department, Lucknow University who gave these to the author for investigation. Subsequently, the author also visited this locality in April, 1976 and made a rich collection of fossil woods. The town of Kalagarh lies at a distance of about 40 km north-east of Dhampur railway station on Northern Railway. The vertebrate fauna associated with the rocks where the woods have been found also indicate a late Lower Siwalik age for these woods. (Ashok Sahni — personal communication).

Most of the fossil woods are black in colour and show satisfactory preservation. These have been sectioned in transverse, tangential and radial planes and a number of thin sections prepared for the study of their anatomical details. Six of these woods have been identified to the modern genera belonging to *Polyalthia* of Anonaceae, *Anisoptera* and *Dipterocarpus* of Dipterocarpaceae, *Cassia* and *Cynometra* of Leguminosae and *Diospyros* of Ebenaceae and are included in the present communication. Although, this forms the first detailed study of the fossil woods from this locality, a brief note without illustrations has recently appeared describing a fossil wood said to belong to *Dysoxylum* of the family Meliaceae (Trivedi & Misra, 1977).

Another detailed study on petrified woods of the Lower Siwalik beds was recently made by Prakash (1975), who described fossil woods of *Dipterocarpoxylon sivalicus, D. nalagarhense, D. premacrocarpum* of Dipterocarpaceae, *Albizinium eolebbekianum, Cassinium prefistulai, Cynometroxylon indicum, Millettioxylon pongamiensis* of Leguminosae and *Dryoxylon nahanai* tentatively referred to Meliaceae from Nalagarh in Himachal Pradesh. In addition to these, only a few other records of fossil woods are known from the Siwalik beds (Prakash, 1975, pp. 192-193).

SYSTEMATIC DESCRIPTION

Family — ANONACEAE

Genus — *Polyalthioxylon* Bande, 1973 syn. *Polyalthioxylon* Kramer, 1974

1. *Polyalthioxylon indicum* sp. nov.

Pl. 1, figs. 1-5

This species is based on a piece of decorticated secondary wood measuring about

6 cm in length and 4 cm in diameter. It is black in colour.

Topography — Wood diffuse-porous (Pl. 1, fig. 1). *Growth rings* distinct, demarcated by smaller vessels and denser fibrous tissue. *Vessels* small to medium-sized, solitary and usually in radial multiples of 2-(3), rarely 4 cells (Pl. 1, figs. 1, 2), 6-11 per sq mm, mostly open, a few plugged with brownish black gummy deposits; tyloses wanting. *Parenchyma* apotracheal in numerous, closely spaced, sometimes somewhat undulating, concentric tangential lines, usually uniseriate, sometimes 2 cells wide, forming a net work with the rays (Pl. 1, figs. 1, 2). *Xylem rays* typically wide and high, with few uniseriates, usually 6-10 cells broad (Pl. 1, figs. 3, 5), sometimes with evidence of dissection into smaller units, 4-6 per mm, 15-150 μ broad, 7-140 cells and 132-2475 μ high; ray tissue weakly heterogeneous with broader rays composed almost of procumbent cells or with upright cells at one or both the ends, usually arranged in 1 to few rows of cells; uniseriate rays usually composed of both upright and procumbent cells. *Fibres* almost arranged in radial rows of cells.

Elements — Vessels thin-walled, solitary vessels t.d. 60-150 μ, r.d. 75-195 μ, round to oval and elliptical or irregular in shape and variously crowded due to twisting of the woody tissues; vessel-members 150-750 μ long with truncate or slightly tapered ends; perforations simple; intervessel pit-pairs bordered (Pl. 1, fig. 4), alternate, small, 4-6 μ in diameter with linear apertures. *Parenchyma cells* thin-walled, 16-20 μ in diameter, 40-44 μ in height, nonstoried and noncrystalliferous. *Ray cells* thin-walled, procumbent cells 16-32 μ in tangential height and 36-80 μ in radial length; upright cells 20-24 μ in tangential height and 12-16 μ in radial length; cells often very irregular in size as seen in tangential section with occasional large cells interspersed among the smaller procumbent cells. *Fibres* semi-libriform to libriform, polygonal in cross section, non-septate, thick-walled, often with big lumina, 12-16 μ in diameter; interfibre pits could not be seen. *Secretory cells* — big oil or mucilage cells are commonly present in some of the xylem rays; these usually contain dark brown contents.

Affinities — Structural features of the fossil wood indicate after extensive comparison that its closest affinities are with the modern genus *Polyalthia* of the family Anonaceae, in which it shows a close resemblance with *Polyalthia simiarum* Benth. & Hk.f., and *P. lateriflora* (Blume) King, but more so with the former. However, a superficial resemblance can also be seen with the woods of the families Sapotaceae, Lecythidaceae and Ebenaceae, specially in the presence of narrow tangential lines of parenchyma. Yet, all these can be easily distinguished from the present fossil wood in the absence of very broad xylem as seen in the fossil wood. The xylem rays are narrow to moderately broad in the woods of Sapotaceae and Lecythidaceae where the ray tissue is strongly heterogeneous. The sapotaceous woods also possess tracheids which are absent in the present fossil. In Ebenaceae, the xylem rays are very narrow, quite distinct from the present fossil wood. Because the wood anatomy of the family Anonaceae is very uniform, and the genera, with the exception of *Asimina*, are not easily distinguishable, the fossil wood also exhibits a somewhat near resemblance to the wood structure of *Miliusa velutina* (F.R.I., slide no. B3113), *Mitrephora maingyi* (F.R.I., slide nos. A 2646, B 5568), *Saccopetalum tomentosum* and *Sageraea elliptica* of the same family. However, in *Miliusa velutina* the xylem rays are somewhat narrower and the vessel multiples are bigger and different than those of the fossil wood. *Mitrephora maingyi* also differs in having longer rays, bigger vessel multiples (upto 6 cells) and widely spaced parenchyma lines. In *Saccopetalum tomentosum* the vessels are somewhat widely spaced. Widely spaced lines of xylem parenchyma and slightly narrower rays, only upto 8 cells broad and more frequent vessels of *Sageraea elliptica* also differentiate it from this fossil wood.

Our survey included the study of thin sections of ten species of the genus *Polyalthia* and published description of these and one other species. Thin sections were examined from the woods of *Polyalthia andamanica* Kurz, *P. cerasoides* (Roxb.) Bedd., *P. fragrans* (Dalz.) Bedd., *P. lateriflora* (Blume) King, *P. longifolia* Benth. & Hk.f., *P. simiarum* Benth. & Hk.f., *P. suberosa* Benth. & Hk.f., *P. congesta*, *P. oblongifolia* Robinson and *P. suaveolens* Engl. et Diels, while published description

and figures of these and *Polyalthia oliveri* Engl., were also consulted for detailed comparison (Normand, 1950, p. 82, pl. 16; Pearson & Brown, 1932, pp. 23-27, figs. 9, 10; Lebacq, 1955, pl. 19; Chowdhury & Ghosh, 1958, pp. 22-25, pl. 4, figs. 22-24, pl. 5, fig. 25). The present fossil wood resembles the modern wood of *Polyalthia simiarum* (F.R.I., slide no. A 3244/B 6376) in the size and distribution pattern of the vessels, in the perforation plates and intervascular pit-pairs, in parenchyma distribution and the fibre and ray structure. However, in some specimens of *P. simiarum* (F.R.I., slide no. A 3245/B 7523) the rays are somewhat narrower, 1-8-9 seriate in width, while in some they are sometimes more than 10-seriate. Some bigger cells are also present in the xylem rays of the modern wood of *P. simiarum* like those of the fossil wood which may represent the oil or mucilage cells.

As the fossil wood closely resembles the modern wood of *Polyalthia simiarum*, it is being assigned to the organ genus *Polyalthioxylon* Bande, 1973 syn. *Polyalthioxylon* Kramer, 1974.

In 1973, Bande instituted the organ genus *Polyalthioxylon* for a fossil wood resembling the modern wood of *Polyalthia* from the Deccan Intertrappean beds of Central India. Subsequently, Kramer (1974) not knowing that an organ genus already existed for the fossil woods resembling *Polyalthia*, established another genus *Polyalthioxylon* to include his fossil woods from South-east Asia. However, besides *Polyalthia*, he also included the genera *Platymitra*, *Stelechocarpus* and other anatomically similar forms under his genus *Polyalthioxylon*. In view of the fact that most of the woods belonging to different genera of the family Anonaceae are difficult to separate, it seems more appropriate to include anatomically similar genera under *Polyalthioxylon* as suggested by Kramer (1974, p. 105). But because *Polyalthioxylon* Bande (1973) is published earlier than *Polyalthioxylon* Kramer (1974), *Polyalthioxylon* Bande (1973) has the priority and is a valid name, while *Polyalthioxylon* Kramer (1974) becomes its homonym. As Bande's (1973, p. 45) generic diagnosis for *Polyalthioxylon* is somewhat incomplete and does not include even the characters of all the species of *Polyalthia* especially the nature and width of xylem rays, fibre structure, and the vessel size and intervascular pitting, it is advisable to adopt a more comprehensive generic diagnosis as given by Kramer (1974, pp. 105, 106) for his genus *Polyalthioxylon* which includes the secondary wood structures of the genera *Polyalthia*, *Platymitra*, *Stelechocarpus* and anatomically similar forms of the family Anonaceae.

So far only three fossil woods showing resemblance with *Polyalthia* have been described. These are *Polyalthioxylon parapaniense* Bande (1973) from the Deccan Intertrappean beds of India, *Polyalthioxylon platymitroides* Kramer (1974) and *Polyalthioxylon stelechocarpoides* Kramer (1974) from the Tertiary of South-east Asia. In 1911, Schuster also described a fossil wood as *Polyalthia lateriflora* King from the Pithecanthropus beds of Middle Java. However, its identity is doubtful. All these are quite different from the present fossil wood. Thus, *P. parapaniense* differs from the present fossil wood in having somewhat narrower, 1-9 (mostly 3-6) seriate, homogeneous xylem rays and non-libriform fibres. In the present fossil wood, the xylem rays are 1-10 (usually 6-10) seriate and weakly heterogeneous and the fibres are semi-libriform to libriform.

Polyalthioxylon platymitroides, which resembles the modern woods of *Polyalthia hypoleuca* and *Platymitra macrocarpa*, is quite distinct from the present fossil wood in having somewhat narrower, 1-8 (mostly 4-5) seriate, almost homogeneous xylem rays, in the absence of secretory cells in the xylem rays and in possessing usually 1-2, rarely 3 seriate, concentric tangential bands of parenchyma. However, the fine parenchyma bands are 1-2, usually one cell wide and the secretory cells are quite common in the xylem rays of the present fossil wood. Similarly, *Polyalthioxylon stelechocarpoides*, although somewhat nearly resembling this fossil wood, also differs from it in possessing usually smaller vessels [t. 75-80 (50-95) μ], short xylem rays and mostly 2 cells wide parenchyma bands. This fossil wood from Java resembles the modern woods of *Polyalthia celebica* and *Stelechocarpus burahol*.

The fossil wood described as *Polyalthia lateriflora* by Schuster (1911) from the Pithecanthropus beds of Middle Java does not seem to belong either to the genus

Polyalthia or to the family Anonaceae. Here the parenchyma bands are quite short and irregular unlike those in the family Anonaceae and the xylem rays are usually low and narrow devoid of secretory cells so commonly seen in the rays of *Polyalthia lateriflora*.

As the present fossil wood is quite different from all the other known species of *Polyalthioxylon* Bande (1973), it is assigned to a new species, *Polyalthioxylon indicum*, the specific name is after India, from where it is being reported. Although, quite a few leaves of the family Anonaceae are known (Schuster, 1911; Kräusel, 1929; Posthumus, 1931; Lemoigne, Beuchamp & Samuel, 1974), those resembling *Polyalthia* and *Mitrephora* are known from the Pithecanthropus beds of Java.

Polyalthia includes about 50 species of trees and shrubs which are widely distributed from tropical Africa and Madagaskar through tropical Asia to Australia but most numerous in South-east Asia. In the Indian region the genus is represented by about ten species. *Polyalthia simiarum* Benth & Hk.f., with which the present fossil resembles most, is a tall rather slender tree found in the moist forests of Orissa, Mayurbhanj and in lower hill forests of North Bengal, Assam, Chittagong hill tracts, and Burma (Pearson & Brown, 1932, pp. 23, 24; Chowdhury & Ghosh, 1958, pp. 22, 23).

Generic Diagnosis

As for *Polyalthioxylon* Kramer (1974, pp. 105, 106).

Specific Diagnosis

Polyalthioxylon indicum sp. nov.

Wood diffuse-porous. *Growth rings* distinct, demarcated by smaller vessels and denser fibrous tissue. *Vessels* small to medium-sized, t.d. 60-150 μ, r.d. 75-195 μ, solitary and usually in radial multiples of 2-(3)-4, round to oval and elliptical, 6-11 per sq mm; tyloses wanting; vessel members 150-750 μ in length, usually with truncate ends; perforations simple; intervessel pitpairs bordered, alternate, small, 4-6 μ in diameter with linear apertures. *Parenchyma* in numerous, closely spaced, 1-2 (mostly 1) seriate, somewhat undulating, concentric bands. *Xylem rays* very broad and high, with fewer uniseriates, 1-10 (usually 6-10) cells broad, 15-150 μ wide and 132-2475 μ high, 4-6 per mm; ray tissue weakly heterogeneous with homocellular to heterocellular rays composed either completely of procumbent cells or both procumbent and upright cells. *Fibres* semi-libriform to libriform, thick-walled, polygonal in cross section, nonseptate, 12-16 μ in diameter. *Oil* or *mucilage cells* quite common in xylem rays, round to oval in shape and sometimes filled with dark brown deposits.

Holotype — B.S.I.P. Museum no. 35297.

Family — Dipterocarpaceae

Genus — *Anisopteroxylon* Ghosh & Kazmi, 1958

2. *Anisopteroxylon kalagarhensis* sp. nov.

Pl. 2, figs. 6-8

The present fossil wood measures 13 cm in length and 8 cm in diameter. It is dark brown in colour and shows well preserved anatomical details.

Topography — *Wood* diffuse-porous. *Growth rings* absent. *Vessels* large to medium-sized (Pl. 2, fig. 7), majority solitary, occasionally paired, 7-9 per sq mm with rays contiguous on one or both the sides, usually tylosed sometimes with black deposits. *Vasicentric tracheids* paratracheal, sparse, associated with the vessels. *Parenchyma* mostly apotracheal, the paratracheal being scanty; apotracheal parenchyma (Pl. 2, figs. 6, 7) diffuse to diffuse-in-aggregate forming lines of parenchyma in a close irregular pattern in the fibrous tracts in between the xylem rays; sometimes with several rows of parenchyma cells surrounding the gum ducts (Pl. 2, fig. 6). *Xylem rays* fine to medium, 1-5 seriate, mostly 4-5 seriate (Pl. 2, fig. 8), 3-55 cells or 150-1725 μ high, closely spaced, 8-9 per mm; ray tissue heterogeneous with rays composed of both upright and procumbent cells; uniseriate rays consisting only of upright cells or both upright and procumbent cells; broad rays with upright cells at one or both the ends and procumbent cells in the middle, usually with continuous row of sheath cells (Pl. 2, fig. 8)

present on the flanks of the rays. *Fibres* well-preserved, irregularly arranged in between the consecutive xylem rays. *Gum canals* vertical, scanty, usually solitary, scattered among the fibres, round to oval in shape, small, 75-105 μ in diameter.

Elements — *Vessels* thin-walled, t.d. 105-255 μ, r.d. 150-390 μ, mostly solitary, oval to elliptical in shape; vessel members 144-450 μ long, usually with truncate ends; perforations simple; intervessel pit-pairs could not be seen. *Parenchyma cells* thin-walled, t.d. 15-22 μ, height 105-180 μ. *Ray cells* thin-walled, procumbent cells 20-36 μ in tangential height, 60-120 μ in radial length; upright cells 40-60 μ in tangential height, 20-32 μ in radial length. *Fibres* libriform, polygonal in cross section, nonseptate, 16-20 μ in diameter and 750-1200 μ in length. *Gum canals* vertical, scanty, small, 75-105 μ in diameter, round to oval in shape, encircled by parenchymatous sheath.

Affinities — The presence of vertical gum canals along with vasicentric tracheids, heterogeneous xylem rays and diffuse to diffuse-in-aggregate parenchyma indicates the nearest affinity of this fossil wood with the members of the family Dipterocarpaceae. Besides this, small, scanty, usually solitary gum ducts, abundant diffuse to diffuse-in-aggregate parenchyma, moderately large, mostly solitary pores and heterogeneous xylem rays often with continuous row of sheath cells on the flanks further show its resemblance with the modern wood of *Anisoptera*. A detailed examination of thin sections of the modern woods of *Anisoptera oblonga* Dyer., *Anisoptera scaphula* Pierre syn. *A. glabra* Kurz, *A. aurea* Foxw., and *A. brunnea* Foxw. was made besides studying the published description and photographs of a number of species of *Anisoptera* (Kanehira, 1924, p. 5; Metcalfe & Chalk, 1950, pp. 217, 218, fig. 54G; Henderson, 1953, p. 21, fig. 83; Desch, 1957, p. 102, pl. 19, figs. 1, 2, pl. 20, figs. 1, 2; Chowdhury & Ghosh, 1958, pp. 109-111, pl. 15, figs. 86-89; Kribs, 1959, p. 53, fig. 14; Brazier & Franklin, 1961, p. 31). This study showed a close resemblance of the present fossil wood with the modern wood of *Anisoptera scaphula* syn. *A. glabra* (F.R.I., slide no. A 2376/B 6935). The fossil wood *Anisopteroxylon kalagarhensis* resembles the modern wood of *Anisoptera scaphula* syn. *A. glabra* in the size and distributional pattern of the vessels, in parenchyma distribution and the fibre, and ray structure. The small scanty canals are similarly distributed in both and the xylem rays are 1-5 seriate in this section examined at the Forest Research Institute, Dehra Dun. However, in other slides/wood specimens of the same species, the rays are broader, 1-8 or more seriate and spindle-shaped and the gum canals are sometimes present in long tangential rows as is usually seen in the wood of *Anisoptera oblonga*.

Only a few fossil woods belonging to *Anisoptera* are known (Prakash & Tripathi, 1970, table 2). These are *Anisopteroxylon bengalensis* Ghosh & Kazmi (1958b) from the Holocene of West Bengal, *A. jawalamukhi* Ghosh & Ghosh (1958) from the Middle Siwalik beds of Khundian near Jawalamukhi in East Punjab, and *A. garoense* (Chowdhury) Prakash & Tripathi (1970) from the Middle Tertiary beds near Hailakandi and Damalgiri in Assam. In 1963, Navale described a fossil wood as *Anisopteroxylon coromandelense* from the Cuddalore sandstones of South India. This fossil wood is so badly preserved that it is not possible to say anything definite about the presence of gum canals and the parenchyma pattern. As such, its affinities with *Anisoptera* or even with the family Dipterocarpaceae may be regarded highly doubtful. All these species differ markedly from the present fossil wood (Prakash & Tripathi, 1970, table 2). However, the species *Anisopteroxylon bengalensis* is the closest but it also differs from the present Siwalik wood in having slightly broader, 1-6 seriate xylem rays and in somewhat lesser parenchyma in the ground tissue (Ghosh & Kazmi, 1958b, figs. 1, 2). The xylem rays are only 1-5 seriate and the diffuse to diffuse-in-aggregate parenchyma is quite abundant in the present fossil wood (Pl. 2, figs. 6, 7). Similarly, *Anisopteroxylon jawalamukhi* and *A. garoense* also differ from *A. kalagarhensis* in possessing somewhat broader xylem rays which are 1-7 seriate in the former, and 1-8 seriate in the latter. The size of the vessels is also more in *A. jawalamukhi* (t.d. 154-300 μ, r.d. 196-492 μ) as compared to our fossil wood, where the vessels are about 105-255 μ in t.d. and 150-390 μ in r.d. Further, the parenchyma appears to be somewhat less abundant in *A. jawalamukhi* (Ghosh & Ghosh, 1958, figs. 1, 2), than in the

present fossil wood from Kalagarh (Pl. 2, figs. 6, 7).

Since the present fossil wood compares very closely with the modern wood of *Anisoptera* and is quite distinct from all the known species of *Anisopteroxylon* Ghosh & Kazmi (1958b), it is described here as new species, *Anisopteroxylon kalagarhensis*. The specific name indicates its presence in the vicinity of the town Kalagarh.

The genus *Anisoptera* consists of about 32 species which are widely distributed from Chittagong in Bangla Desh on the west spreading upto New Guinea in the Pacific. The largest number of species, however, occurs in Malay Peninsula, Sumatra and Borneo. The two species, *Anisoptera oblonga* and *A. scaphula* syn. *A. glabra* now growing near the eastern part of India, are confined to Chittagong and Burma. The nearest comparable species of the present fossil, *Anisoptera scaphula* syn. *A. glabra* presently occurs in evergreen and semi-evergreen forests upto 600 m above sea level, from Chittagong southwards, lower Burma, and Thailand to Malay Peninsula (Chowdhury & Ghosh, 1958, pp. 108, 109).

Specific Diagnosis

Anisopteroxylon kalagarhensis sp. nov.

Wood diffuse-porous. *Growth rings* absent. *Vessels* large to medium-sized, t.d. 105-255 μ, r.d. 150-390 μ, mostly solitary, oval to elliptical in shape, 7-9 per sq mm, usually tylosed; vessel members 144-450 μ long usually with truncate ends; perforations simple; intervessel pits could not be seen. *Vasicentric tracheids* paratracheal, sparse, associated with the vessels. *Parenchyma* mostly apotracheal, very profuse, present as diffuse to diffuse-in-aggregate forming close, irregular lines in the fibrous tracts and as several rows of cells surrounding the gum ducts; paratracheal parenchyma scanty. *Xylem rays* 1-5 (mostly 4-5) seriate, 8-9 per mm; ray tissue heterogeneous, rays heterocellular; multiseriate rays usually with continuous row of sheath cells on the flanks. *Fibres* libriform, thick-walled, polygonal in cross section, nonseptate, 16-20 μ in diameter, and 750-1200 μ in length. *Gum canals* scanty, vertical, usually solitary, small, 75-105 μ in diameter and round to oval in shape.

Holotype — B.S.I.P. Museum no. 35298.

Genus — *Dipterocarpoxylon* Holden emend. Den Berger, 1927

3. *Dipterocarpoxylon paralaudii* sp. nov.

Pl. 2, figs. 9-11

The fossil wood is represented by a small piece of secondary xylem measuring 8·5 cm in length and 11 cm in diameter. It is very well preserved.

Topography — Wood diffuse-porous. *Growth rings* absent. *Vessels* large to medium-sized, almost always solitary (Pl. 2, fig. 10), 4-7 per sq mm, with rays contiguous on one or both the sides; tyloses present. *Vasicentric tracheids* scanty paratracheal associated with the vessels; bordered pits multiseriate. *Parenchyma* both paratracheal and apotracheal (Pl. 2, figs. 9, 10); paratracheal parenchyma quite scanty often partially touching the vessels; apotracheal parenchyma usually in thick layers of cells surrounding the gum canals (Pl. 2, fig. 10), sometimes also occurring as diffuse, solitary cells or 2-3 cells aggregated together in the fibrous ground tissue. *Xylem rays* fine to broad (Pl. 2, fig. 11), 1-4-(5) (usually 3-4) seriate, 15-90 μ wide and 8-53 cells or 375-1425 μ high, closely spaced, 7-9 per mm; ray tissue heterogeneous with uniseriates quite common composed of both upright and procumbent cells; multiseriates composed of procumbent cells in the middle region with 1-2-(3-4) or sometimes more rows of upright cells at one or both the ends; sheath cells quite common on the flanks of the rays but do not usually form a continuous sheath. *Fibres* well preserved somewhat regularly arranged in between consecutive xylem rays. *Gum canals* abundant, vertical, solitary or mostly in pairs and in short tangential rows of 3-5 ducts.

Elements — Vessels thin-walled, t.d. 165-330 μ, r.d. 135-405 μ, round to oval, usually irregular due to pressure during fossilization; vessel members 270-570 μ long, usually with truncate ends; perforations simple; intervessel pit-pairs could not be seen. *Parenchyma cells* thin-walled, 20-28 μ in diameter, 40-92 μ in height. *Ray cells* thin-walled,

procumbent cells with tangential height 20-28 μ, radial length 40-72 μ; upright cells with tangential height 44-60 μ, radial length 28-40 μ. *Fibres* libriform with small lumen, polygonal in cross section, nonseptate, 12-16 μ in diameter, 795-1245 μ in length; interfibre pits could not be seen. *Gum canals* uniformly distributed, small, 75-165 μ in diameter, round to oval in shape, enclosed in thick parenchymatous sheath.

Affinities — structural features of the present fossil wood, viz., presence of vertical gum canals, usually in pairs or in short tangential rows, vasicentric tracheids, heterogeneous xylem rays with sheath cells and very little diffuse to diffuse-in-aggregate parenchyma, at once indicate, after extensive comparison, that the closest affinities of this fossil wood are with the modern genus *Dipterocarpus* in which a near resemblance can be seen with the species *Dipterocarpus baudii* Korth syn. *D. duperreanus* Pierre, *D. scortichinii* King. However, a superficial resemblance is also seen with *Dipterocarpus indicus* Bedd., but both of them differ in the parenchyma pattern and the xylem rays. Although, both the fossil and the living species *Dipterocarpus baudii* resemble in shape, size and distribution pattern of the vessels and the fibre and ray structure, there is slight observable difference in parenchyma distribution. The vasicentric parenchyma sometimes appears to be little more in the modern wood of *Dipterocarpus baudii* in comparison to the fossil where the paratracheal parenchyma is scanty vasicentric.

Although, most of the fossil woods belonging to *Dipterocarpus* have already been listed (Prakash, 1973, table 1, p. 51; Awasthi, 1974, p. 343), those described afterwards are not many and belong to Miocene-Pliocene of India. These are *Dipterocarpoxylon pondicherriense* Awasthi (1974) from the Cuddalore sandstones of South India and *D. sivalicus*, *D. nalagarhense* and *D. premacrocarpum* from the Lower Siwalik beds of Himachal Pradesh (Prakash, 1975). Of all the Indian species, *Dipterocarpoxylon pondicherriense* Awasthi (1974), *D. premacrocarpum* Prakash (1975) and *D. sivalicus* Prakash (1975) are the closest but they also differ distinctly from this Siwalik fossil wood. Thus, *D. pondicherriense* differs from the present fossil in having vasicentric to occasionally aliform paratracheal parenchyma and in somewhat shorter xylem rays with occasional sheath cells. However, the parenchyma associated with the vessels is very scanty and the sheath cells are quite frequent in the xylem rays of the present fossil wood. Besides, diffuse parenchyma cells are occasional in *D. pondicherriense* but they are somewhat more and sometimes aggregated into 2-3 cells in the present fossil wood. *D. premacrocarpum* Prakash (1975) also differs from this Siwalik wood in having slightly smaller vessels (t.d. 150-270 μ, r.d. 180-330 μ), in slightly more diffuse to diffuse-in-aggregate parenchyma and in somewhat broader, frequently 5-seriate xylem rays with more frequent sheath cells. The vessels are moderately large to medium-sized (t.d. 165-330 μ, r.d. 135-405 μ), the xylem rays are usually 3-4 seriate, rarely 5 cells broad and the diffuse to diffuse-in-aggregate parenchyma is moderately scanty occurring usually as solitary cells in *Dipterocarpoxylon parabaudii*. Similarly, *D. sivalicus* Prakash (1975), although somewhat nearly resembling the present fossil wood, also differs from it in having slightly broader, 1-6 seriate xylem rays, more diffuse to diffuse-in-aggregate parenchyma and in smaller gum canals.

Dipterocarpoxylon chowdhurii Ghosh (1956), *D. malavii* Ghosh & Ghosh (1959), *D. tertiarum* Prakash (1965, 1973) and *D. nalagarhense* Prakash (1975) also differ from the present species in possessing abundant, diffuse to diffuse-in-aggregate parenchyma and in somewhat broader, 1-6 seriate xylem rays in *D. chowdhurii* and 1-9-(10) seriate xylem rays in *D. nalagarhense*. The paratracheal parenchyma is always present as narrow, 1-3 seriate sheath around the vessels (vasicentric type) in *D. malavii* as against scanty paratracheal parenchyma in the present fossil wood. The xylem rays are spindle-shaped and broad, 1-9 seriate in *D. tertiarum* as against long and narrow, 1-5 seriate rays in the present species.

In *Dipterocarpoxylon kalaicharparense* Eyde (1963) the paratracheal parenchyma is vasicentric, forming 1-3 seriate sheath around the pores, the uniseriate extensions of several cells in height are not uncommon in the xylem rays and the gum canals are large, mostly solitary and occasionally in pairs. The gum canals of *D. parabaudii*

are sometimes solitary but usually in pairs as well as in short tangential rows of 3-5. *Dipterocarpoxylon* sp. Rawat (1964) is also quite distinct from this fossil wood especially in possessing large gum canals.

As regards the species of *Dipterocarpoxylon* known from outside the Indian region, *Dipterocarpoxylon goepperti* (Kräusel, 1926) and *D. porosum* (Kräusel, 1922) differ from the present species in possessing broader xylem rays, while the ray tissue of *D. kraeuseli, D. gracile, D. resiniferum* and *D. javanicum* is homogeneous in nature (Schweitzer, 1958). Lastly, *D. schenki* (Schweitzer, 1958) can also be differentiated from the present fossil wood in having smaller vessels and in the distributional pattern of gum ducts.

Since the present fossil wood differs from all the species of *Dipterocarpoxylon* so far known from India and abroad, and compares very well with the modern wood of *Dipterocarpus baudii*, it is assigned to the organ genus *Dipterocarpoxylon* Holden emend. Den Berger (1927) and described here as a new species, *Dipterocarpoxylon parabaudii*.

The genus *Dipterocarpus* includes about 80 species, which grow mainly in the Indo-Malayan region, having maximum development in Borneo, Malay Peninsula and Sumatra. The species *Dipterocarpus baudii* Korth, which resembles the present fossil wood, grows in the evergreen forests of Burma, specially Bassein, Insein, Tavoy and Mergui. It also occurs in Sumatra, Thailand, Malay Peninsula, Combodia and Cochin-china (Chowdhury & Ghosh, 1958, pp. 114, 115).

Specific Diagnosis

Dipterocarpoxylon parabaudii sp. nov.

Wood diffuse-porous. *Growth rings* absent. *Vessels* large to medium-sized, t.d. 165-330 μ, r.d. 135-405 μ, almost always solitary, round to oval, 4-7 per sq mm; tyloses present; vessel members 270-570 μ, usually with truncate ends; perforations simple; intervessel pit-pairs could not be seen. *Vasicentric tracheids* sparse, intermingled with paratracheal parenchyma. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma quite scanty often partly encircling the vessels; apotracheal parenchyma associated with the gum canals, sometimes also occurring as diffuse, solitary cells or 2-3 cells aggregated together. *Xylem rays* 1-5 (usually 3-4) seriate, 7-9 per mm; ray tissue heterogeneous with heterocellular rays; sheath cells quite common. *Fibres* libriform, thick-walled, polygonal in cross section, nonseptate, 12-16 μ in diameter and 795-1245 μ in length; inter-fibre pits not preserved. *Gum canals* frequent, vertical, usually in pairs or tangential rows of 3-5 ducts, sometimes solitary, round to oval in shape, small, 75-165 μ in diameter.

Holotype — B.S.I.P. Museum no. 35299.

Family — Leguminosae

Genus — *Cynometroxylon* Chowdhury & Ghosh, 1946

4. *Cynometroxylon* sp. *Cynometroxylon indicum* Chowdhury & Ghosh, 1946

Pl. 3, figs. 12-14

The present fossil wood is a small piece of decorticated secondary wood 11 cm in length and 5 cm in diameter. It is black in colour and shows satisfactory preservation.

Topography — Wood diffuse-porous. *Growth rings* indistinct. *Vessels* small to medium-sized, solitary and in radial multiples of 2-3 or sometimes of more cells (Pl. 2, fig. 12), irregular clusters are also seen, 4-7 per sq mm, almost always empty, sometimes plugged with black deposits. *Parenchyma* apotracheal in thick concentric bands (Pl. 2, fig. 12) alternating with the fibres and partially or wholly encircling the vessels, usually undulating and occasionally forking, generally somewhat thinner than the fibre bands; parenchyma bands 4-5 per mm, and 2-7 (usually 3-5) cells thick. *Xylem rays* fine, 1-2 seriate (Pl. 3, fig. 13), 20-52 μ wide, usually tall, 7-44 cells or 195-1245 μ high and 10-11 per mm; uniseriates quite frequent in one section, whereas in other section the biseriates are commonly present, sometimes with long uniseriate extensions; ray tissue heterogeneous with rays composed of both upright and procumbent cells; upright cells occurring in 1-2 rows at one or both the ends of the rays; end to end ray fusion quite common. *Fibres* not aligned in distinct radial rows,

Elements — *Vessels* thick-walled, t.d. of solitary vessels 75-165 μ, r.d. 90-210 μ, round to oval in shape, those in radial multiples flattened at the places of contact; vessel segments 225-600 μ in length, usually with truncate ends; perforations simple; intervessel pit-pairs small, 4-6 μ in diameter, vestured, bordered, alternate, with linear-lenticular apertures (Pl. 3, fig. 14). *Parenchyma cells* thin-walled, 16-24 μ in diameter, 76-120 μ in length. *Ray cells* thick-walled, procumbent cells 20-35 μ in tangential height, 40-60 μ in radial length; upright cells 44-56 μ in tangential height and 20-35 μ in radial length. *Fibres* libriform, thick-walled with small lumen, nonseptate, polygonal in cross section, 8-16 μ in diameter; interfibre pits not seen.

Affinities — The fossil wood most closely resembles the modern wood of *Cynometra* of the family Leguminosae, although it also shows a superficial resemblance with the mature secondary xylem of *Cassia auriculata* of Leguminosae and some species of *Chisocheton* (*C. grandiflorus, C. paniculatus*) and *Dysoxylum* (*D. binectariferum, D. fraseranum, D. muelleri*) of the family Meliaceae. However, *Cassia auriculata* differs from the present fossil wood in having mostly uniseriate, somewhat shorter xylem rays and comparatively smaller vessels. Similarly, modern woods of *Chisocheton* and *Dysoxylum* also differ in having profusely septate fibres unlike the present fossil wood where the fibres are nonseptate. Besides, some species of *Dysoxylum* are further differentiated by the presence of terminal and scanty paratracheal parenchyma (*Dysoxylum malabaricum, D. loureiri*) and almost homogeneous xylem rays (*Dysoxylum fraseranum, D. hamiltonii, D. muelleri, D. malabaricum, D. pettigrewianum, D. euphlebium*).

This fossil wood exhibits a near resemblance to *Cynometroxylon indicum* Chowdhury & Ghosh (1946), although there are some differences between the two which may be due to anatomical variations occurring in a single individual or in different individuals of the same species. It resembles *Cynometroxylon indicum* in vessel distribution, parenchyma pattern and the fibre structure; the differences are mainly in having longer xylem rays which are only 1-2 seriate in the present fossil wood as against 1-3 (mostly 1-2) seriate in *Cynometroxylon indicum*. Besides the variation in vessel size and in the thickness of parenchyma bands, such variations in the width of xylem rays from 1-2 seriate to 1-4 (mostly 2-3) seriate have been seen in different modern wood specimens of *Cynometra polyandra*. Considering the extent of such variations and the occurrence of *Cynometroxylon indicum* in the Lower Siwalik beds of Nalagarh in Himachal Pradesh (Prakash, 1975), it is most likely that the same species may also be found in the Lower Siwalik beds of Kalagarh in Uttar Pradesh situated in the south-east of Nalagarh. As such the present fossil wood is described here as *Cynometroxylon* sp. cf. *Cynometroxylon indicum* Chowdhury & Ghosh, indicating the structural differences which may probably be due to the nearness of the pith region.

Specimen — B.S.I.P. Museum no. 35300.

Genus — *Cassinium* Prakash, 1975

5. *Cassinium borooahii* (Prakash) Prakash, 1975

Pl. 3, figs. 15, 17

The fossil wood consists of a small piece of secondary xylem 9 cm in length and 5 cm in diameter. It shows the following anatomical features.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* large to medium-sized, 120-380 μ in diameter, mostly solitary, sometimes in radial multiples of 2-3, circular to oval in shape; perforations simple; intervessel pit-pairs vestured, alternate to sub-opposite, 4-7 μ in diameter. *Parenchyma* usually banded, sometimes aliform to confluent; concentric parenchyma bands alternating with the fibre bands of nearly same thickness, about 4-8 cells in width. *Xylem rays* 1-3 (mostly 2) seriate, rarely uniseriate, short; ray tissue homogeneous with rays composed of procumbent cells. *Fibres* moderately thick-walled, nonseptate, polygonal in cross section, 16-28 μ in diameter; inter-fibre pits not preserved.

As the present fossil wood is identical to *Cassinium borooahii* (Prakash) Prakash (1975), it is assigned to it. However, it shows slight variation in vessel size and in the frequency of triseriate xylem rays which are only sometimes present in this fossil wood as against their common occur-

rence in the wood of the type material known from the Tipam sandstones on Dimapur-Diphu Road in Assam (Prakash, 1967). The fossil wood shows near resemblance with the modern wood of *Cassia siamea* Lam., which is a moderate sized tree, common in the jungles at the south of the Madras Presidency, mixed and dry forests of Burma from Chittagong down; low country of Ceylon upto 2000 ft, largely planted in suitable places all over India (Gamble, 1902).

Specimen — B.S.I.P. Museum no. 35301.

Family — EBENACEAE

Genus — *Ebenoxylon* Felix, 1882

6. *Ebenoxylon miocenicum* sp. nov.

Pl. 4, figs. 19-23

The fossil wood is a small twisted piece measuring 8 cm in length and 7 cm in diameter. The preservation of the fossil wood is fairly satisfactory.

Topography — Wood diffuse-porous. *Growth rings* indistinct. *Vessels* small to medium-sized (Pl. 4, fig. 19), solitary as well as in radial multiples of 2-4-(6), 10-15 per sq mm, plugged with dark gummy deposits. *Parenchyma* apotracheal and paratracheal; paratracheal parenchyma scanty associated with the vessels; apotracheal parenchyma (Pl. 4, figs. 19, 20) in regular, concentric, slightly wavy, somewhat close, 1-2 (mostly 1) seriate lines, about 9-11 per mm. *Xylem rays* fine usually uniseriate (Pl. 4, fig. 21), occasionally partly biseriate and 12-16 μ in width, 4-17 cells and 60-570 μ in height, 16-24 rays per mm; ray tissue heterogeneous (Pl. 4, fig. 23) with rays composed of both upright and procumbent cells. *Fibres* somewhat aligned in radial rows.

Elements — Vessels thin-walled, t.d. 45-120 μ, r.d. 75-180 μ, round to oval when solitary, those in radial multiples generally flattened at the places of contact; vessel members 150-375 μ in length, usually with truncate ends, sometimes tailed; perforations simple; intervessel pit-pairs (Pl. 4, fig. 22) small, 3-5 μ in diameter, alternate, orbicular to oval in shape with linear-lenticular apertures; vessel-ray and vessel-parenchyma pits not preserved. *Parenchyma cells* thin-walled, 12-16 μ in diameter and 40-52 μ in length. *Ray cells* slightly thicker-walled, tangential height of procumbent cells 20-24 μ, radial length 40-48 μ; upright cells 36-40 μ in tangential height and 20-24 μ in radial length; ray cells crystalliferous. *Fibres* semilibriform, moderately thick-walled, nonseptate, polygonal in cross section, 12-16 μ in diameter.

Affinities — The present fossil wood most closely resembles the structural features of the ebenaceous genus *Diospyros* Linn. (= *Maba* Forst.). A survey of all available woods of the genus *Diospyros* (= *Maba*) indicates that the nearest affinity of the fossil is with *Diospyros kurzii* Hiern. Our survey included the study of thin sections of the woods of 40 species of *Diospyros* and three species of *Maba* available at the Forest Research Institute, Dehra Dun. Besides, the present fossil wood was also compared with the published anatomical description and figures of several species of *Diospyros* and *Maba* (Kanehira, 1924, pp. 40-42, fig. 10; Lecomte, 1926, pl. 61; Pearson & Brown 1932, pp. 693-697, 700-708, figs. 224-225, 227-229; Chowdhury, 1945, pl. 29; Metcalfe & Chalk, 1950, pp. 883-885, figs. 204 A,B,E,F,G,H; Henderson, 1953, p. 24, figs. 98 A,B,C, 99; Desch, 1957, pp. 150-151, pl. 46, fig. 1, table 25; Kribs, 1959, pp. 37-38, figs. 127-129, 358; Normand, 1960, pls. 143-145; Brazier & Franklin, 1961, pp. 34, 38, 39, fig. 359).

The fossil wood of *Ebenoxylon miocenicum* resembles the modern wood of *Diospyros kurzii* (F.R.I., slide no. A 5079/B 521) in the size and distribution pattern of the vessels plugged with black gummy deposits, in the perforation plates and intervascular pit-pairs, in parenchyma distribution with uniseriate to sometimes biseriate, concentric, somewhat closely placed bands, in moderately thick-walled fibres and usually uniseriate rays with frequent upright cells.

In view of its closest resemblance with the woods of *Diospyros*, it is assigned to the organ genus *Ebenoxylon* Felix (1882). Fossil woods showing affinities with the modern woods of *Diospyros* and *Maba* have already been listed by Prakash and Tripathi (1970, p. 185, table 1). Those not included in this list are *Ebenoxylon kartikcherrense* Prakash & Tripathi (1970) from the Tipam sandstones of Assam, *E. arcotense*

Awasthi (1970) from the Cuddalore sandstones of South India, *E. bavaricum* Selmeier (1976) and *Ebenoxylon* sp. from the Tertiary sediments of Bavaria and a wood tissue resembling *Diospyros* and *Maba* from the Neyveli lignite of South India (Navale, 1968). All these species differ quite distinctly from the present fossil wood. Thus, *Ebenoxylon indicum* Ghosh & Kazmi (1958a) from the Tirap Frontier Division, Arunachal Pradesh differs from the present fossil in having large vessels (t.d. 82-225 μ, r.d. 164-328 μ) and homogeneous xylem rays. However, the vessels are somewhat smaller (t.d. 45-120 μ, r.d. 75-180 μ) and the xylem rays are mostly uniseriate and heterocellular in the present fossil wood. Similarly, *Ebenoxylon kartikcherrense* also differs from this Siwalik wood in possessing 1-3 seriate xylem rays and slightly larger vessels (t.d. 80-180 μ, r.d. 92-240 μ). Lastly, *Ebenoxylon arcotense* although showing somewhat near resemblance with *E. miocenicum* also differs from it in the xylem rays with only 1-2 marginal rows of upright cells at one or both the ends and in the width of the parenchyma bands. The xylem rays of the present fossil wood are usually long and the upright cells are frequent. Besides, the apotracheal parenchyma bands are uniseriate in *E. arcotense*, whereas they are 1-2 seriate in the Siwalik wood.

As the present fossil wood differs quite distinctly from all the species of *Ebenoxylon* Felix, it is described here as a new species, *Ebenoxylon miocenicum*.

The genus *Diospyros* (= *Maba*) consists of about 500 species of trees and shrubs, widely distributed throughout the tropical and subtropical regions of the World (Willis, 1966). In the Indian region, there are nearly 100 species, chiefly occurring in South India, Ceylon, Burma, Eastern Bengal, and a few extending to North India (Gamble, 1902). The species *Diospyros kurzii* with which the present fossil wood shows nearest resemblance is an evergreen tree and grows in tropical and moister upper mixed forests of the Andamans (Gamble, 1902, p. 458).

Specific Diagnosis

Ebenoxylon miocenicum sp. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* small to medium-sized, round to oval, solitary and in radial multiples of 2-4-(6), t.d. 45-120 μ, r.d. 75-180 μ, 10-15 per sq mm, plugged with dark gummy deposits; vessel segments 150-375 μ in length, usually with truncate, sometimes tailed ends; perforations simple; intervessel pitpairs small, 3-5 μ in diameter, alternate, orbicular to oval with linear-lenticular apertures. *Parenchyma* scanty paratracheal and in 1-2 (mostly 1) seriate, regular, concentric, somewhat close bands, about 9-11 per mm. *Xylem rays* usually uniseriate, 4-17 cells high, 16-24 rays per mm; ray tissue heterogeneous with quite frequent upright cells. *Fibres* semilibriform, moderately thick-walled, nonseptate and 12-16 μ in diameter.

Holotype — B.S.I.P. Museum no. 35302.

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EXPLANATION OF PLATES

PLATE 1

1. *Polyalthioxylon indicum* sp. nov. — Cross section of the fossil wood showing vessel and parenchyma distribution. × 45. Slide no. 5335/35297.

2. *Polyalthioxylon indicum* sp. nov. — Cross section of the fossil wood magnified to show the parenchyma pattern. × 80. Slide no. 5336/35297.

3. *Polyalthioxylon indicum* sp. nov. — Tangential longitudinal section of the fossil showing xylem rays. × 45. Slide no. 5337/35297.

4. *Polyalthioxylon indicum* sp. nov. — Magnified intervessel pit-pairs. × 450. Slide no. 5338/35297.

5. *Polyalthioxylon indicum* sp. nov. — Another tangential longitudinal section showing xylem rays. Note secretory sacs in the rays. × 80. Slide no. 5337/35297.

PLATE 2

6. *Anisopteroxylon kalagarhensis* sp. nov. — Cross section highly magnified to show the parenchyma pattern. × 60. Slide no. 5339/35298.

7. *Anisopteroxylon kalagarhensis* sp. nov. — Cross section of the fossil wood showing vessel and parenchyma distribution. Note profuse parenchyma and a few gum canals. × 30. Slide no. 5340/35298.

8. *Anisopteroxylon kalagarhensis* sp. nov. — Tangential longitudinal section showing xylem rays. Note usually continuous row of sheath cells on the flanks of the rays. × 60. Slide no. 5341/35298.

9. *Dipterocarpoxylon parabaudii* sp. nov. — Cross section magnified to show gum canals and vessels. × 65. Slide no. 5342/35299.

10. *Dipterocarpoxylon parabaudii* sp. nov. — Cross section in low power to show vessel distribution and frequent occurrence of gum canals. × 30. Slide no. 5342/35299.

11. *Dipterocarpoxylon parabaudii* sp. nov.— Tangential longitudinal section of the fossil wood showing heterocellular xylem rays. × 30. Slide no. 5343/35299.

Plate 3

12. *Cynometroxylon* sp. cf. *C. indicum* — Cross section of the fossil wood to show the vessel distri bution and parenchyma bands. × 30. Slide no. 5344/35300.

13. *Cynometroxylon* sp. cf. *C. indicum* — Tangential longitudinal section of the fossil wood showing xylem rays. × 60. Slide no. 5345/35300.

14. *Cynometroxylon* sp. cf. *C. indicum* — Magnified intervessel pit-pairs. × 400. Slide no. 5346/35300.

15. *Cassinium borooahii* (Prakash) Prakash — Cross section of the fossil wood showing shape, size and distribution of vessels and parenchyma pattern. × 30. Slide no. 5347/35301.

16. *Cassia siamea* — Cross section of the modern wood showing similar shape, size and distribution of vessels and parenchyma pattern. × 30.

17. *Cassinium borooahii* (Prakash) Prakash — Tangential longitudinal section of the fossil wood showing xylem rays. × 60. Slide no. 5348/35301.

18. *Cassia siamea* — Tangential longitudinal section of the modern wood showing similar xylem rays. × 60.

Plate 4

19. *Ebenoxylon miocenicum* sp. nov. — Cross section of the fossil wood in low power showing vessel distribution and concentric lines of parenchyma. × 40. Slide no. 5349/35302.

20. *Ebenoxylon miocenicum* sp. nov. — Cross section slightly magnified to show Parenchyma distribution. × 105. Slide no. 5350/35302.

21. *Ebenoxylon miocenicum* sp. nov.— Tangential longitudinal section of the fossil wood showing predominantly uniseriate xylem rays. × 105. Slide no. 5351/35302.

22. *Ebenoxylon miocenicum* sp. nov.— Magnified intervessel pit-pairs. × 400. Slide no. 5352/35302.

23. *Ebenoxylon miocenicum* sp. nov.— Radial longitudinal section of the fossil wood showing heterocellular xylem rays. × 70. Slide no. 5353/35302.

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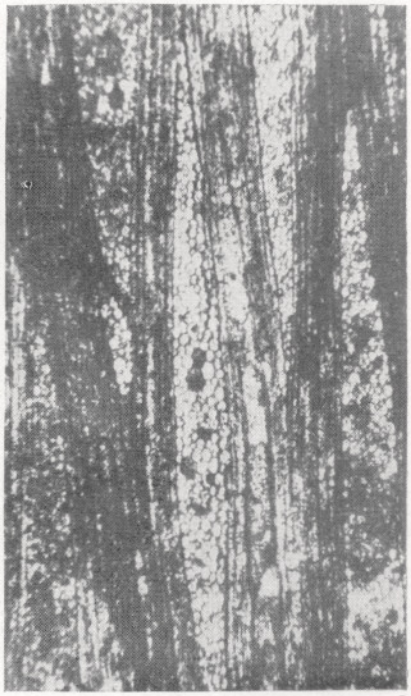

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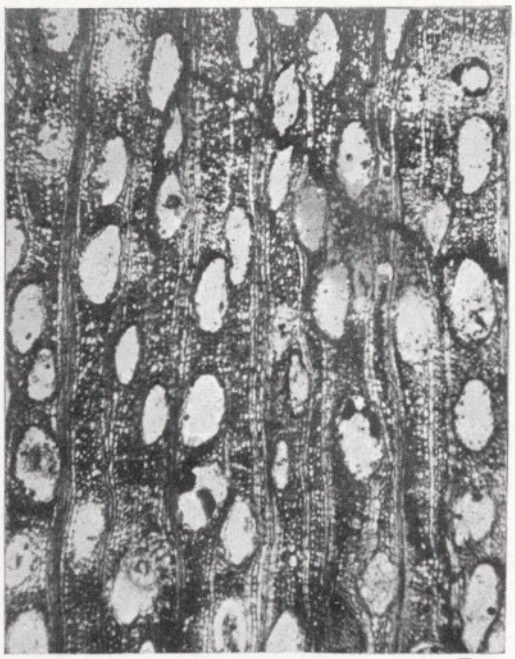

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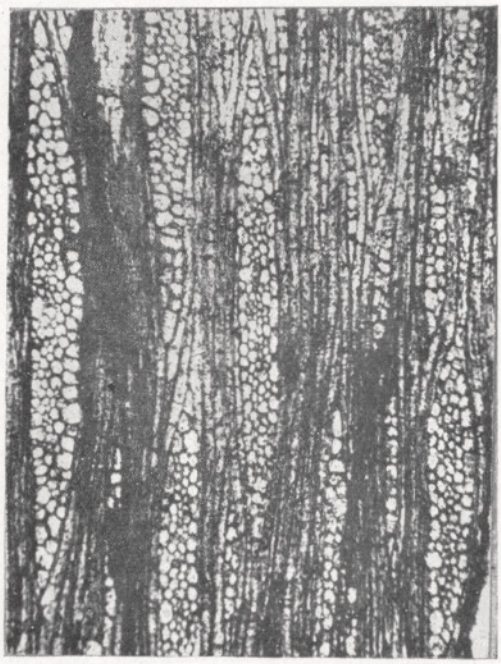

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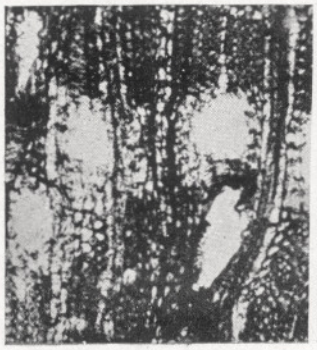

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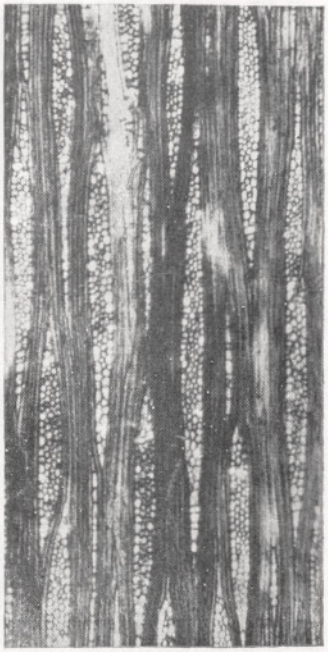

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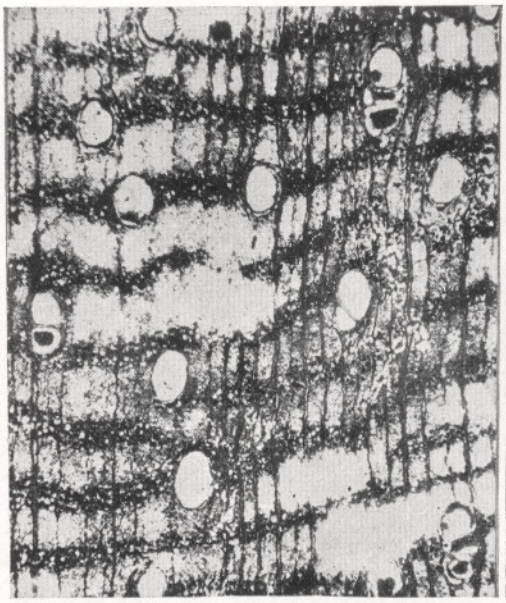

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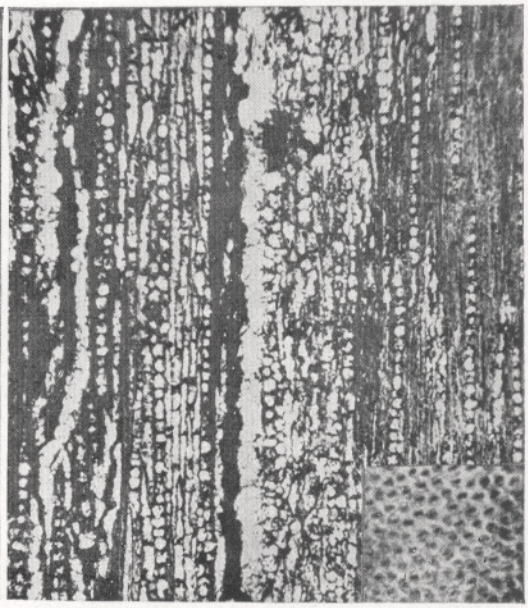

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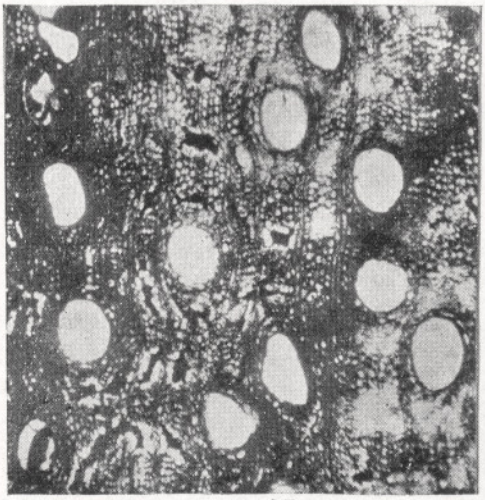

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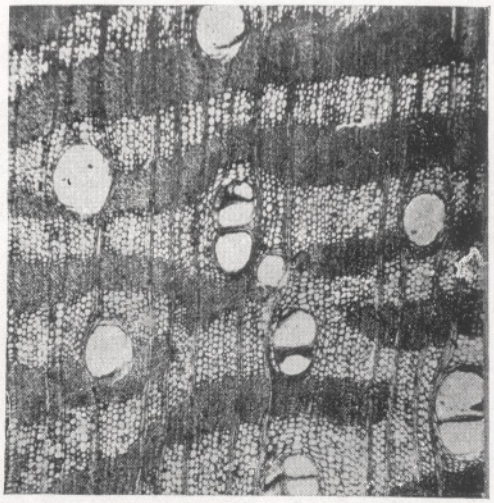

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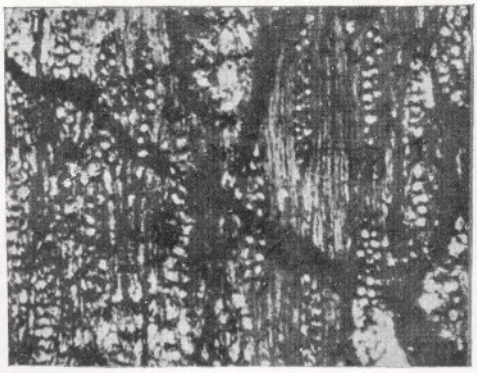

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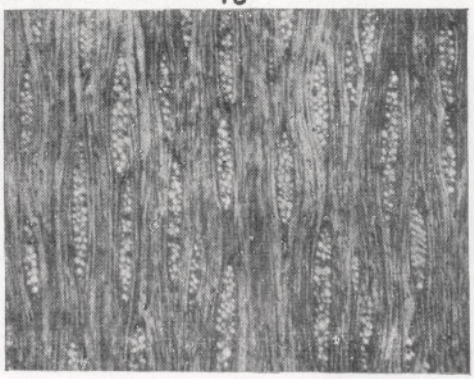

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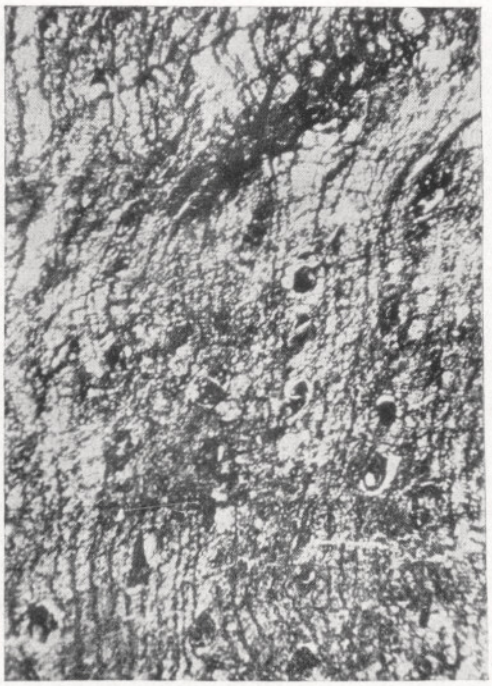

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PLATE 4