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SOME MORE DICOTYLEDONOUS WOODS FROM THE TERTIARY OF DEOMALI, ARUNACHAL PRADESH, INDIA

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ABSTRACT

Nine species belonging to six dicotyledonous families have been described here from an assemblage of petrified woods collected from the Mio-Pliocene of Namsang beds near Deomali. They are *Sterculioxylon varmahii* sp. nov., *Heritieroxylon arunachalensis* gen. et sp. nov. of Sterculiaceae; *Burseroxylon garugoides* sp. nov. of Burseraceae; *Mangiferoxylon assamicum* Prakash & Tripathi of Anacardiaceae; *Albizinium eolebbekianum* Prakash and *Millettioxylon palaeopulchra* sp. nov. of Leguminosae; *Lagerstroemioxylon deomaliensis* sp. nov. of Lythraceae; and *Laurinoxylon namsangensis* sp. nov. and *L. deomaliensis* sp. nov. of Lauraceae. Modern comparable forms of these fossils still occur in and around the tropical evergreen to deciduous forests of Arunachal Pradesh, indicating the continuation of somewhat similar kind of vegetation and climatic conditions in this region from the Neogene to the present day.

Key-words — Fossil dicot woods, Xylotomy, Namsang beds, Tertiary, India.

सारांश

अरुणाचल प्रदेश (भारत) में देवमाली के टरशरी कल्प से कुछ और द्विबीजपत्रीय काष्ठ—राजेन्द्रनाथ लखनपाल उत्तम प्रकाश एवं नीलाम्बर अवस्थी

देवमाली के समीपस्थ नामसाँग की मायो-प्लायोसीन कालीन संस्तरों से एकत्रित 6 द्विबीजपत्रीय कुलों की 9 जातियों का वर्णन किया गया है। ये स्टरकुलिएसी कुल की **स्टरकुलिऑक्सोलॉन वर्माही** न० जा०, **हेरिटियरॉक्सीलॉन अरुणाचलेन्सिस** नव वंश व नव जाति; बर्सेरेसी की **बर्सेरॉक्सीलॉन गारूगॉयडिस** न० जा०; एनाकार्डिएसी की **मेंजिफेरॉक्सीलॉन असमिकम** प्रकाश एवं त्रिपाठी; लेग्युमिनोसी की **एल्बिज़िनियम् ईओलेबेकियैनम** प्रकाश तथा **मिलेट्टिऑक्सीलॉन पेलियोपुल्च्रा** न० जा०; लायथ्रेसी की **लेजरस्ट्रोयमिऑक्सोलॉन देवमालियेन्सिस** न० जा०; तथा लॉरेसी कुल की **लॉरिनॉक्सीलॉन नामसाँगेन्सिस** न० जा० एवं **लॉ० देवमालियेन्सिस** न० जा० हैं। इन काष्ठाश्मों के वर्तमान तुलनीय प्रादर्श आज भी अरुणाचल प्रदेश के उष्णकटिबंधीय सदाहरित से लेकर पर्णपाती वनों में तथा इनके आस-पास पाये जाते हैं जिससे इस क्षेत्र में निम्नोजीन से आज तक कुछ-कुछ वैसी ही वनस्पति एवं जलवायु का अनुवर्तन प्रदर्शित होता है।

INTRODUCTION

PETRIFIED woods are known to occur abundantly in the Namsang River bed near Deomali, the headquarters of Khonsa Forest Division in Arunachal Pradesh. These come from the Namsang beds of Dupitila Series and are Mio-Pliocene in age. Based on their earlier studies, a variety of forms consisting of *Ebenoxylon indicum* Ghosh & Kazmi (1958), *Calophylloxylon eoinophyllum* Prakash (1966), *Pahudioxylon deomaliense* Prakash (1965a), *P. sahnii* Ghosh & Kazmi (Prakash, 1966), *Cynometroxylon indicum* Chowdhury & Ghosh (Prakash & Awasthi, 1971), *Terminalioxylon tertiarum* Prakash (1966), *T. coriaceum* Prakash & Awasthi (1971), *Siderinium deomaliense* Prakash & Awasthi (1970) and *Shoreoxylon deomaliense* Prakash & Awasthi (1971) were already described. A rich collection of fossil woods was further made from these beds near Deomali, Northeastern India during 1972 and 1975. Their investigations revealed quite a number of new forms resembling the extant genera,

Sterculia, *Heritiera*, *Garuga*, *Mangifera*, *Albizia*, *Millettia*, *Lagerstreomia*, and those of Lauraceae. These are being dealt with in the present paper.

SYSTEMATIC DESCRIPTION

FAMILY — STERCULIACEAE

Genus — *Sterculioxylon* Kräusel, 1939

1. *Sterculioxylon varmahii* sp. nov.

Pl. 1, figs 1-4

Material — Single piece of petrified wood, measuring 7 cm in length and 3 cm in diameter. The preservation is fairly good.

Topography — Wood diffuse-porous. *Growth rings* not seen. *Vessels* visible to naked eye as small dots, medium-sized to large, mostly medium-sized, majority solitary, sometimes in radial multiples of 2-3 (Pl. 1, fig. 1), evenly distributed, about 2-4 vessels per sq mm; perforations simple; tyloses not seen, vessels filled with dark orange to brown crystalliferous contents. *Parenchyma* aliform-confluent and banded (Pl. 1, figs 1, 4); parenchyma bands alternating with broad fibre bands, completely or incompletely enclosing the vessels, regular or irregular, straight or wavy, sometimes broken, thin to thick, 5-16 cells and 60-160 μm wide and 3-7 per mm. *Xylem rays* of two distinct sizes, fine and broad (Pl. 1, figs 2, 3), 10-13 rays per mm; fine rays 1-3 seriate (Pl. 1, fig. 3), mostly uniseriate, composed of procumbent cells, 2-15 cells in height; broad rays up to 11-seriate and 28-180 μm wide (Pl. 1, fig. 2), up to 50 cells in height, homocellular to heterocellular, consisting of procumbent through the median portion and upright cells at the ends; sheath cells present on the flanks (Pl. 1, fig. 2); fine and low rays storied with parenchyma strands and vessel members (Pl. 1, fig. 3). *Fibres* in broader bands alternating with the thinner bands of parenchyma. *Gum canals* absent.

Elements — Vessels circular to oval, mostly oval, t.d. 120-225 μm, r.d. 210-345 μm, thin-walled; vessel-members truncate or slightly inclined, about 225-750 μm in length; intervessel pits small, 4-6 μm in diameter, alternate with coalescent apertures. *Parenchyma cells* 4-5 per strand, strands about 400 μm in length, storied, cells rectangular or squarish up to 40 μm in diameter, infiltration dark orange or brown. *Ray cells* upright and procumbent; upright cells 40-80 μm in tangential height and 20-60 μm in radial length; procumbent cells 12-40 μm in tangential height and 60-180 μm in radial length; crystals not seen; infiltration dark. *Fibres* angular, mostly hexagonal, t.d. 16-40 μm, r.d. 16-36 μm, nonseptate, moderately thick-walled; pits not seen.

Affinities — The most important features of the fossil wood are banded parenchyma, fine to broad xylem rays with sheath cells and low rays storied with the parenchyma strands and the vessel members. These features together with the other details described above indicate the affinities of the fossil wood with *Sterculia* of the family Sterculiaceae. In 1937, Chattaway divided the woods of the genus *Sterculia* into 2 groups A and B, based on parenchyma distribution. In group A she included those Sterculias which consist of metatracheal parenchyma (now classified under apotracheal), predominantly in uniseriate lines, while in B were included only those Sterculias which have mostly broad bands of parenchyma. Since our fossil wood possesses banded parenchyma, it would fall in group B. According to Chattaway (1937, p. 358) the modern species pertaining to group B are *Sterculia appendiculata* K. Schum. ex. Engl., *S. blancoi* Rolfe, *S. blumei* G. Don, *S. cinerea* A. Rich., *S. coccinea* Roxb., *S. elegantiflora* Hutch. & Dalz., *S. oblonga* Mast., *S. pallens* Wall., *S. rhinopetala* K. Schum. and *S. urens* Roxb. Besides these, *Sterculia alata* Roxb., *S. fulgens* Wall., *S. populifolia* Roxb., and *S. colorata* Roxb. may also be added to this group (Chowdhury & Ghosh, 1958, pl. 27, figs 159, 161, 162, pp. 211, 217, 218). An examination of thin sections of the woods of *Sterculia coccinea* Roxb., *S. oblonga* Mast., *S. rhinopetala* K. Schum., *S. urens* Roxb., and *S. alata* Roxb. available at the Forest Research Institute, Dehradun, and a survey of published anatomical description and photographs of *Sterculia blancoi* Rolfe (Metcalfe & Chalk, 1950), *Sterculia* spp. (Desch, 1954, pp. 581-583), *S. urens*

Roxb. (Pearson & Brown, 1932; Desch, 1954; Henderson, 1953), *S. oblonga* (Henderson, 1953; Kribs, 1959; Brazier & Franklin, 1961) indicate that the fossil wood resembles the modern woods of *Sterulia alata* Roxb.

Since the fossil wood compares closely with the modern woods of *Sterculia*, it is assigned to the organ genus *Sterculioxylon* Kräusel (1939). Eight species of the genus *Sterculioxylon* are so far known from all over the world. These are *Sterculioxylon rhenanum* Müller-Stoll & Müller-Stoll (1949) from the Eocene of South-West Germany; *S. giarabubense* (Chiarugi) Kräusel (1939) from the Lower Oligocene to Lower Miocene of Somaliland, North Africa; *S. aegyptiacum* (Ung.) Kräusel (1939) from the Tertiary of Egypt and the Post Eocene of Tibesti in Sahara (Boureau, 1949); *S. freulonii* Boureau (1957) from the Tertiary of Sahara; *S. dattai* Prakash & Tripathi (1974) from the Late Miocene of Tipam Series in Assam; *S. foetidense* Prakash (1973) from the Mio-Pliocene of Irrawaddy Series of Burma; *S. kalagarhense* Trivedi & Ahuja (1978) from the Siwalik beds of Kalagarh, U.P.; and *S. deccanensis* Lakhanpal *et al.* (1979) from the Deccan Intertrappean beds near Mohgaon in Mandla District, M.P. Out of these only two species of *Sterculioxylon*, *S. freulonii* and *S. kalagarhense* possess banded parenchyma somewhat similar to our fossil wood. However, these also differ quite distinctly from our fossil wood. Thus *Sterculioxylon freulonii* is distinct in having somewhat smaller vessels (t.d. 120-200 μm, r.d. 200-300 μm), in the absence of paratracheal parenchyma, and in possessing less broader, 1-6 seriate xylem rays. Similarly *S. kalagarhense* can also be distinguished in possessing vertical traumatic gum canals, relatively broader (1-16) seriate xylem rays and in the presence of narrow (5-7 cells wide) bands of apotracheal parenchyma.

As the present fossil wood is quite distinct from all the species of *Sterculioxylon* Kräusel (1939) known so far, it is described here as a new species, *Sterculioxylon varmahii*. The species is named after Mr J. C. Varmah, President, Forest Research Institute, Dehradun (then Chief Conservator of Forests, Arunachal Pradesh).

Sterculia L. consists of 300 species (Willis, 1973, p. 1103), distributed throughout the Tropics, and reaches its best development in Tropical Asia (Pearson & Brown, 1932, p. 145). The species *Sterculia alata* Roxb. is found in the evergreen forests of North-east India and in the Western Ghats from North Kanara to Kerala up to 900 m but reaches its best development in Chittagong, Burma and the Andamans.

Specific Diagnosis

Sterculioxylon varmahii sp. nov.

Wood — diffuse-porous. *Growth rings* not seen. *Vessels* medium to large, t.d. 120-225 μm, r.d. 210-345 μm, mostly solitary, sometimes in radial multiples of 2-3, circular to oval in cross-section, 2-4 per sq mm; perforations simple; vessel members truncate or slightly inclined, 225-750 μm in length; intervessel pit-pairs small, 4-6 μm in diameter, alternate, with coalescent apertures. *Parenchyma* aliform-confluent to mostly banded; bands completely or incompletely enclosing the vessels, regular or irregular, straight or wavy, sometimes broken, 5-16 cells wide and 3-7 per mm. *Xylem rays* fine and broad, 10-13 per mm; fine rays low, storied with parenchyma strands, 1-3 (mostly 1) seriate and composed of procumbent cells; broad rays up to 11-seriate, homocellular to heterocellular with sheath cells on the flanks. *Fibres* moderately thick-walled, mostly hexagonal and nonseptate. *Gum canals* absent.

Holotype — B.S.I.P. Museum no. 35325.

Genus — *Heritieroxylon* gen. nov.

2. *Heritieroxylon arunachalensis* sp. nov.

Pl. 1, figs 6, 7, Pl. 2, figs 8-10

Material — Two pieces of well-preserved silicified wood. The bigger one measuring 10 cm in length and 6 cm in diameter.

Topography — Wood diffuse-porous. *Growth rings* indistinct. *Vessels* small to large, solitary and in radial multiples of 2-4, sometimes more, forming short radial chain (Pl. 1, fig. 6; Pl. 2, fig. 8), evenly distributed, about 8-14 per sq mm; tyloses not seen. *Parenchyma* abundant, apotracheal, diffuse, as scattered cells (Pl. 1, fig. 7), often occurring as fine, closely spaced

lines forming a net-like pattern. *Xylem rays* 1-5 (mostly 1-4) seriate (Pl. 2, fig. 10), 5-40 cells in height, somewhat closely spaced, about 4-6 rays per mm; ray tissue heterogeneous, rays heterocellular, consisting of procumbent cells in the middle portion and 1-2 marginal rows of upright cells at both the ends; sheath cells present on the flanks. *Fibres* aligned in radial rows between two consecutive xylem rays. *Gum canals* vertical, traumatic (Pl. 2, fig. 8), arranged in concentric rings.

Elements — Vessels circular to oval, those in radial multiples flattened at places of contact, t.d. 60-240 μm, r.d. 40-240 μm; perforations simple, horizontal to oblique; vessel-members 150-750 μm in length; intervessel pits almost circular, alternate (Pl. 2, fig. 9), bordered, small, about 3-4 μm in diameter with small circular or slit-like orifices. *Parenchyma cells* round, about 20-40 μm in diameter. *Ray cells* both upright and procumbent; upright cells about 30-64 μm in tangential height, 20-40 μm in radial length; procumbent cells about 16-32 μm in tangential height and 40-160 μm in radial length. *Fibres* moderately thick-walled, circular or angular, small, about 16-28 μm in diameter, nonseptate; pits not seen. *Gum canals* irregular in shape, 60-440 μm in tangential diameter and 120-320 μm in radial diameter.

Affinities — Occurrence of vertical, traumatic gum canals arranged in concentric rings, apotracheal parenchyma in fine, 1-seriate, closely spaced lines, 1-5 seriate xylem rays with occasional sheath cells and small, bordered intervessel pits are the most characteristic features of this fossil wood. In these features it shows close resemblance with the modern woods of *Heritiera* Dryand of the family *Sterculiaceae*. A survey of thin sections of *Heritiera fomes* Buch. (*H. minor* Lam.), *H. littoralis* Dryand., *H. macrophylla* Wall. and *H. simplicifolia* (Mast.) Kosterm, indicates that there is a close resemblance of the fossil with *H. fomes* in almost all the features, especially in having similar traumatic gum canals.

The present fossil is the first record of *Heritiera* from the Tertiary of India and elsewhere. Therefore it has been placed under a new genus *Heritieroxylon* and named as *Heritieroxylon arunachalensis* indicating its occurrence in Arunachal Pradesh. The genus *Heritiera* Dryand consists of 35 species, distributed in the tropical regions of West Africa, Indo-Malaya, Australia and Pacific Islands (Willis, 1973, p. 549). In the Indian sub-continent there are at least five species, of which *Heritiera fomes* Buch. (*H. minor* Lam.) and *H. littoralis* Dryand are littoral and the rest inland (Chowdhury & Ghosh, 1958, p. 200). *H. fomes* is found gregariously in the Sundarbans and along Chittagong coast, but reaches its best development in Burma where it occurs throughout the tidal forests, from Arakan to Tenasserim.

Generic Diagnosis

Heritieroxylon gen. nov.

Wood diffuse porous. *Growth rings* indistinct to distinct, wherever distinct delimited by a zone of denser fibres. *Vessels* small to large, solitary and in radial multiples, sometimes forming chains; perforations simple; intervessel pits alternate, bordered, small with small circular or slit-like orifices. *Parenchyma* apotracheal, diffuse or in closely spaced uniseriate lines, forming reticulum with rays. *Xylem rays* 1-10 seriate; ray tissue heterogeneous; rays heterocellular, consisting of marginal rows of upright cells and procumbent cells through the median portion; sheath cells often present. *Fibres* moderately thick-walled, nonseptate. *Gum canals* traumatic, present or absent. *Ripple marks* indistinctly present due to storied arrangement of low rays and parenchyma strands.

Genotype — Heritieroxylon arunachalensis sp. nov.

Specific Diagnosis

Heritieroxylon arunachalensis sp. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* small to large, t.d. 60-240 μm, r.d. 40-240 μm, solitary and in radial multiples of 2-4, sometimes up to 10, circular to oval in shape, about 8-14 per sq mm; perforations simple; intervessel pits alternate, bordered, small, 3-5 μm in

diameter with circular or slit-like orifices. *Parenchyma* apotracheal in uniseriate lines, forming reticulum with rays. *Xylem rays* 1-5 (mostly 1-4) seriate, about 5-50 cells in height; ray tissue heterogeneous; rays heterocellular, consisting of 1-2 marginal rows of upright cells and procumbent cells in the middle part; sheath cells often present on the flanks. *Fibres* moderately thick-walled, angular or round, small, 16-28 μm in diameter, nonseptate. *Gum canals* present in concentric rings, t.d. 60-440 μm, r.d. 120-320 μm. *Ripple marks* not clearly seen due to lack of preservation.

Holotype — B.S.I.P. Museum no. 35326.

FAMILY — BURSERACEAE

Genus — *Burseroxylon* Prakash & Tripathi, 1975 emend.

3. *Burseroxylon garugoides* sp. nov.

Pl. 2, figs 11-15

Material — Two small pieces of fairly well-preserved silicified wood. The bigger one measuring about 6 cm in length and 4 cm in diameter.

Topography — Wood diffuse-porous. *Growth rings* not clearly seen. *Vessels* visible to the naked eye, mostly large, a few small to medium, solitary (Pl. 2, figs 11, 12) as well as in radial multiples of mostly 2-4, rarely up to 8, evenly distributed, about 5-10 vessels per sq mm, profusely occluded with tyloses. *Parenchyma* scanty paratracheal (Pl. 2, fig. 12), occasional cells associated with vessels, rarely forming 1-2 seriate sheath. *Xylem rays* 1-5 (mostly 2-4) seriate (Pl. 2, fig. 13) and 6-18 cells in height, about 10-15 rays per mm; ray tissue heterogeneous, rays heterocellular (Pl. 2, fig. 14), consisting of procumbent cells in the middle part and upright cells at both the ends. *Fibres* aligned in radial rows between two consecutive xylem rays.

Elements — Vessels thin-walled, circular to oval, those in radial multiples flattened at the places of contact, t.d. 105-345 μm, r.d. 75-420 μm, those in multiples of 6-8 usually small in size and about 45 μm in minimum diameter; perforations simple, nearly horizontal to oblique; vessel-members mostly truncate or slightly inclined, about 225-675 μm in length; intervessel pits large (Pl. 2, fig. 15), alternate, bordered, 8-12 μm in diameter, angular or elliptical in shape with lenticular apertures; vessel-ray and vessel-parenchyma pits not clearly seen. *Parenchyma cells* oval or orbicular in cross section, those occurring in the immediate vicinity of vessels 20-32 μm in diameter and 44-64 μm in length. *Upright ray cells* 44-80 μm in tangential height, 30-60 μm in radial length; procumbent cells 16-20 μm in tangential height and 20-120 μm in radial length; upright cells crystalliferous, containing solitary crystal in each cell. *Fibres* moderately thick-walled, rectangular to squarish in cross section, 8-28 μm in tangential diameter, 12-28 μm in radial diameter, septate, septa more than two in each fibre; interfibre pits not seen. *Gum canals* not seen in the xylem rays.

Affinities — There is a close agreement in almost all structural details of the present fossil wood with the wood of the modern genus *Garuga* of the family Burseraceae, although it also shows a superficial resemblance with the mature secondary xylem of *Boswellia*, *Bursera* and *Lannea*. The wood of *Boswellia* can be distinguished from the fossil as in the former crystals are absent in the end cells of the rays. Moreover, in *Boswellia* the horizontal gum canals are frequently present while in *Garuga* they have been seen occasionally. *Lannea* also differs from this fossil wood in the absence of crystalliferous enlarged end cells in the rays, and in having somewhat smaller vessels and longer xylem rays. Similarly *Bursera* is also distinct from this fossil wood in possessing somewhat smaller vessels. In fact, the most outstanding anatomical difference between *Garuga* and *Bursera* is the presence of usually large to very large vessels in *Garuga* as against mostly small to medium-sized vessels in *Bursera* (Metcalfe & Chalk, 1950) otherwise the two genera are anatomically very close and sometimes may be confused with each other. However, it is with the wood structure of *Garuga pinnata* that the fossil wood shows closest resemblance except in the presence of gum canals in the xylem rays. These horizontal gum canals are reported to be occasionally present in some specimens of *G. pinnata* (Pearson & Brown, 1932, p. 223). Thin sections of the woods of *Garuga*, viz., *Garuga pinnata* Roxb., *G.*

gamblei King, *G. floribunda* Decaisne var. *gamblei* (King) Ex Smith Kalkan, *Garuga* spp. were examined at the Forest Research Institute, Dehradun, besides the published description and photographs of *Garuga pinnata* Roxb. and *G. gamblei* King (Pearson & Brown, 1932, pp. 222, 223, fig. 82; Anonymous, 1963, p. 78, pls 38, 39, figs 228-230). As the woods of *Garuga* and *Bursera* are nearly similar and can only be distinguished by somewhat larger vessels, which are more frequent in *Garuga* than in *Bursera*, it is quite likely that they may sometimes be confused with each other and cannot be distinguished with certainty. It is, therefore, suggested that the fossil woods of *Garuga* may also be included under the organ genus *Burseroxylon* Prakash & Tripathi (1975) originally instituted for *Bursera*. The generic diagnosis of *Burseroxylon* Prakash & Tripathi (1975) is being amended accordingly. Because the present fossil wood resembles the modern wood of *Garuga pinnata*, it is specifically named as *Burseroxylon garugoides* sp. nov., the specific name indicating its slightly closer resemblance with *Garuga*.

Garuga is a small genus of about 4 species of medium-sized to large trees, distributed in Madagascar, India, South-east Asia, north-western Australia and the Pacific islands (Willis, 1973, p. 478). Two species are indigenous to India (Pearson & Brown, 1932, p. 221; Anonymous, 1963, pp. 76, 77). *Garuga pinnata*, which resembles our fossil wood, is widely distributed all over India from Siwalik Hills eastwards to Assam, often mixed with Sal. It is a common tree in all dry forests of Madhya Pradesh, Andhra Pradesh, Mysore and extends into the moist zone of Western Ghats and Satpuras, ascending up to 1,150 m. It is also found in Andaman islands. In Bangla Desh, it occurs in Chittagong and in Burma in mixed forests (Anonymous, 1963, pp. 77, 78).

Emended Generic Diagnosis

Burseroxylon Prakash & Tripathi, 1975 emend.

Wood diffuse-porous. *Growth rings* distinct or indistinct. *Vessels* small to large or very large, solitary and in short radial multiples; perforations simple; intervessel pit-pairs large, bordered, alternate, with linear to lenticular apertures. *Parenchyma* paratracheal, scanty, to narrow vasicentric. *Xylem rays* fine to medium, 1-5 seriate or more, ray tissue heterogeneous; upright ray cells crystalliferous. *Fibres* thin to moderately thick-walled, septate. Horizontal *gum canals* present or absent.

Specific Diagnosis

Burseroxylon garugoides sp. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* mostly large to very large, sometimes medium-sized, t.d. 105-345 μm, r.d. 75-420 μm, circular to oval in shape, solitary as well as in radial multiples of 2-4, rarely up to 8 vessels, 5-10 vessels per sq mm, heavily tylosed; vessel members 225-675 μm in length with mostly truncate ends; perforations simple; intervessel pit-pairs large, 8-12 μm in diameter, alternate, bordered, angular or elliptical in shape with lenticular apertures. *Parenchyma* scanty paratracheal to narrow vasicentric, forming 1-2 seriate sheath around the vessels. *Xylem rays* 1-5 (mostly 2-4) seriate and 6-28 cells in height, about 10-15 rays per mm; ray tissue heterogeneous; rays heterocellular, consisting of procumbent cells in the middle part and upright cells at both the ends; end cells crystalliferous. *Fibres* moderately thick-walled, septate, rectangular to squarish in cross section, 8-28 μm in diameter; interfibre pits not seen. *Gum canals* not seen in the xylem rays.

Holotype — B.S.I.P. Museum no. 35328.

Family — Anacardiaceae

Genus — *Mangiferoxylon* Awasthi, 1966

4. *Mangiferoxylon assamicum* Prakash & Tripathi, 1970

Pl. 3, figs 16, 17

Material — A small piece of well-preserved silicified wood.

Topography — Wood diffuse-porous. *Growth rings* present, delimited by terminal parenchyma. *Vessels* small to large (Pl. 3, fig. 16), solitary and in radial multiples of

2-6, sometimes in double rows, evenly distributed, about 2-5 vessels per sq mm; tyloses present, sometimes completely occluding the vessels. *Parenchyma* paratracheal and apotracheal (Pl. 3, fig. 17); paratracheal parenchyma scanty to vasicentric, forming 1-2 rarely 3-seriate sheath around the vessels, sometimes aliform, rarely enclosing the neighbouring vessels; apotracheal parenchyma represented by terminal lines delimiting the growth rings besides short, 2-6 seriate, irregular bands of parenchyma. *Xylem rays* fine, uniseriate, occasionally biseriate due to pairing of procumbent cells through the median portion (Pl. 3, fig. 17), about 2-20 cells in height, 9-12 rays per mm, each separated by 1-12 tangential rows of fibres; ray tissue heterogeneous; rays homocellular to heterocellular, consisting of procumbent cells and 1-2 marginal rows of upright cells at one or both the ends. *Fibres* aligned in distinct radial rows between two consecutive rays.

Elements — Vessels circular to oval, those in radial multiples tangentially flattened, t.d. 40-240 μm, r.d. 40-200 μm, walls about 8-10 μm in thickness; perforations simple; vessel-members 180-750 μm in length with truncated or tailed ends; intervessel pits large, 8-12 μm in diameter, bordered, alternate with lenticular orifices; pits leading to parenchyma and ray cells slightly bigger than intervessel pits. *Parenchyma cells* rectangular or squarish, those confined to immediate vicinity of vessels peripherally flattened, about 20-32 μm in diameter; infiltration dark. *Ray cells* upright and procumbent; upright cells 60-96 μm in tangential height, 40-48 μm in radial length; procumbent cells 20-40 μm in tangential height, 40-160 μm in radial length; infiltration dark; crystals occasionally present, mostly confined to upright cells. *Fibres* angular, tangentially flattened, thin-walled, walls 2-3 μm in thickness, nonseptate, t.d. 8-28 μm, r.d. 8-32 μm; interfibre pits not seen.

Affinities — The above anatomical features of the fossil indicate its affinities with the wood of the genus *Mangifera* of the family Anacardiaceae. Detailed comparison with a number of available species of *Mangifera* has revealed that the present fossil is very similar to that of *Mangifera indica* L.

Among the fossil species, a petrified wood resembling *Mangifera indica* is already known as *Mangiferoxylon assamicum* Prakash & Tripathi (1970) from the Tipam Series near Hailakandi, Assam. The present fossil resembles it in almost all the features except that the xylem rays in the former are uniseriate, while in *Mangiferoxylon assamicum* they are 1-3 (mostly 2-3) seriate. As pointed out by Prakash and Tripathi (1970, p. 24) the xylem rays in *Mangifera indica* are quite variable in width, which may be uniseriate (or occasionally 2-seriate due to pairing of procumbent cells) to frequently 2- or 3-seriate, varying from specimen to specimen. Keeping this in view the present fossil has been regarded as another specimen of *Mangiferoxylon assamicum* having predominantly uniseriate rays.

Specimen — B.S.I.P. Museum no. 35329.

Family — Leguminosae

Genus — *Albizinium* Prakash, 1975

5. *Albizinium eolebbekianum* Prakash, 1975

Pl. 3, figs 18, 19

Material — A single piece of silicified wood measuring 15 cm in length and 7 cm in width. The preservation is fairly good.

Topography — Wood diffuse-porous. *Growth rings* present, delimited by thin lines of terminal parenchyma. *Vessels* visible to the naked eye as dots, small to large, mostly medium to large (Pl. 3, fig. 18), solitary and in radial multiples of 2-4, evenly distributed, about 4-9 vessels per sq mm; tyloses absent, vessels filled with dark contents. *Parenchyma* paratracheal and apotracheal (Pl. 3, fig. 18); terminal parenchyma forming a narrow, somewhat undulating, mostly 1-3 seriate lines delimiting the growth rings. *Xylem rays* fine to medium, 1-4 (mostly 2-3) seriate (Pl. 3, fig. 19), short, 6-14 cells in height, 6-9 rays per mm; ray tissue homogeneous; rays homocellular, composed wholly of procumbent cells. *Fibres* aligned in almost radial rows between the two consecutive xylem rays.

Elements — Vessels more or less circular, those in radial multiples somewhat flattened, t.d. 60-300 μm, r.d. 60-270 μm; perforations simple, horizontal to oblique; vessel-members truncate or slightly inclined, about

150-900 μm in length; intervessel pits alternate, medium to large, orbicular to oval, 6-8 μm in diameter, vestured, with linear-lenticular apertures; pits leading to parenchyma and ray cells similar to intervessel pits. *Parenchyma cells* angular or round in cross section, those occurring in the immediate vicinity of pores peripherally flattened, 16-40 μm in diameter; infiltration dark, outermost cells of aliform-confluent parenchyma crystalliferous with solitary crystals in each locule. *Ray cells* procumbent, 16-24 μm in tangential height and 24-140 μm in radial length; infiltration dark, crystals not seen. *Fibres* nonlibriform, moderately thick-walled, angular or round in cross section, 16-28 μm in diameter, septate; interfibre pits not seen.

Affinities — Because of the presence of anatomical features, such as medium to large vessels, vestured intervessel pit pairs, vasicentric, mostly aliform to aliform-confluent and terminal parenchyma, 1-4 seriate homogeneous xylem rays and septate fibres, it is obvious that the fossil wood belongs to the family Leguminosae wherein it shows close resemblance with the modern wood of *Albizia lebbek* Benth. As the present specimen is similar to *Albizinium eolebbekianum* Prakash (1975) in almost all the anatomical details, it is being assigned to it. This species was known from the Lower Siwalik beds near Nalagarh in Himachal Pradesh (Prakash, (1975). *Albizia lebbek* Benth., with which the present fossil wood resembles closely, grows throughout India from the Indus eastwards along the sub-Himalayas to Assam, and in Burma and the Andamans (Pearson & Brown, 1932, pp. 554, 555).

Specimen — B.S.I.P. Museum no. 35330.

Genus — *Millettioxylon* Awasthi, 1967

6. *Millettioxylon palaeopulchra* sp. nov.

Pl. 3, figs 20-23; Pl. 4, fig. 24

Material — A single piece of silicified wood measuring 7·5 cm in length and 6·5 cm in width. The preservation is fairly good.

Topography — Wood diffuse-porous. *Growth rings* not clearly seen. *Vessels* medium to large (Pl. 3, figs 20, 21), mostly large, rarely small, solitary and in radial multiples of 2-5 (mostly 2-3), about 3-5 vessels per sq mm; tyloses not seen but tyloses-like contents with crystals seen in some vessels. *Parenchyma* banded (Pl. 3, figs 20, 21), bands often touching the vessels and running in regular concentric lines alternating with the fibre bands; bands wavy, sometimes anastomosing (Pl. 3, figs 20, 21); mostly narrower than the fibre bands, each 3-5 seriate (mostly 4-seriate), rarely 6-seriate, about 5-8 per mm. *Xylem rays* mostly 2-seriate, 1-seriate and 3-seriate rarely seen (Pl. 3, fig. 23; Pl. 4, fig. 24) 7-12 (mostly 10) cells in height, and 10-14 rays per mm; ray tissue homogeneous, rays homocellular, consisting wholly of procumbent cells (Pl. 3, fig. 22). *Fibres* banded, bands broader than those of parenchyma (Pl. 3, figs 20, 21), about 6-16 cells in width; cells aligned in radial rows between two consecutive xylem rays. *Ripple marks* present due to storied arrangement of xylem rays, parenchyma strands and vessel members (Pl. 3, fig. 23).

Elements — Vessels circular to oval, t.d. 80-280 μm, r.d. 100-280 μm, usually thin-walled; perforations simple, horizontal to nearly oblique; vessel-members truncate, 300-400 μm in length, storied; intervessel pits alternate, bordered, large, about 8-10 μm in diameter, with circular to lenticular apertures. *Parenchyma strands* storied, 225-350 μm in height, mostly 4 cells per strand; cells circular to rectangular, 16-40 μm in diameter; crystalliferous strands divided into several locules, each containing solitary crystal. *Ray cells* procumbent, 16-28 μm in tangential height, 32-160 μm in radial length. *Fibres* small, angular or squarish in cross section, thick-walled, 8-20 μm in diameter, nonseptate, nonstoried; interfibre pits not seen.

Affinities — Among the dicotyledonous woods such anatomical features as medium to large vessels, banded parenchyma, biseriate xylem rays and ripple marks due to storied arrangement of vessel-members, parenchyma strands and xylem rays are found in the woods of the family Leguminosae. In this family the above features are known to occur in the woods of *Millettia*, *Pongamia*, *Dialium*, *Craibia*, some species of *Swartzia*, *Lonchocarpus*, *Cynometra* (*C. alexandrii*), *Erythrina*, *Bauhinia*, *Dalbergia*, etc. Of these, *Lonchocarpus* and

Erythrina can be easily differentiated from the present fossil in having broader parenchyma bands and xylem rays. Some species of *Bauhinia* although resembling the fossil in gross features, also differ quite markedly in usually having irregular bands of aliform-confluent parenchyma. Besides, the rays in *Bauhinia* are 1-2 (mostly 1) seriate and tall and the parenchyma is non-storied. Similarly, *Swartzia* also differs in having 1-2 seriate xylem rays. The African species of *Cynometra*, *C. alaxandrii*, can be differentiated from the present fossil in having crowded vessels and distinctly heterocellular xylem rays consisting of 1-2 marginal rows of upright cells. *Dialium* resembles the present fossil in quite a number of features except that in the former the parenchyma bands are comparatively thinner and widely placed and the rays are taller.

Among the woods of *Dalbergia*, *D. cana*, *D. cultrata*, *D. fusca*, *D. kurzii*. *D. oliveri* and *D. paniculata* show gross resemblance with our fossil in having parenchyma bands and ripple marks. However, closer examination of the woods of the above species has revealed that the parenchyma is aliform-confluent, often connecting adjacent vessels tangentially giving rise to distinct bands which are mostly thinner. Moreover, in the present fossil the parenchyma bands are apotracheal in nature. Besides, the fibres in *Dalbergia* are also storied.

After critical examination of thin sections of quite a large number of species of *Millettia* and *Pongamia* it was found that the fossil wood shows closest resemblance with *Millettia pulchra* Benth. The present fossil and *Millettia pulchra* both possess medium to mostly large vessels, thinner and comparatively closely spaced parenchyma bands and biseriate, homocellular xylem rays. However, the other species of *Millettia* differ from the fossil wood in having aliform-confluent to broader parenchyma bands, and usually 3-4 seriate xylem rays.

The fossil woods resembling *Millettia* and *Pongamia* are already known from the Neogene of India. They are *Millettioxylon indicum* Awasthi (1967, 1975) from the Cuddalore Series near Pondicherry and *M. pongamiensis* Prakash (1975) from the Lower Siwalik beds of Nalagarh, Himachal Pradesh. Both these fossils show similarity with our fossil wood in a number of anatomical features. However, it differs from these in having thinner parenchyma bands which are mostly 3-4 seriate, rarely 5 or 6 seriate as against 2-9 seriate in *Millettioxylon indicum* and 2-7 seriate in *M. pongamiensis*. Further, the xylem rays are usually 2-seriate (1-seriate and 3-seriate being very rare) in the present fossil wood, whereas 1-4 (mostly 2-3) seriate in *Millettioxylon indicum* and *M. pongamiensis*.

From the above comparison it is apparent that the present fossil is quite distinct from the already known species of *Millettioxylon*. It is, therefore, described as a new species, *Millettioxylon palaeopulchra*, the specific name indicating its antiquity and a close similarity with *Millettia pulchra* Benth. The species *M. pulchra* Benth. is an erect tree found in Khasi Hills of Assam and in Upper Burma up to 1200 m (Ramesh Rao & Purkayastha, 1972, p. 117).

Specific Diagnosis

Millettioxylon palaeopulchra sp. nov.

Wood diffuse-porous. *Growth rings* not clearly seen. *Vessels* mostly medium to large, solitary and in radial multiples of 2-5 (mostly 2-3), t.d. 80-280 μm, r.d. 100-280 μm; tyloses-like contents seen in some vessels; perforations simple; vessel-members truncate, 300-400 μm in length, storied along with parenchyma strands and xylem rays; intervessel pits large, 8-10 μm in diameter, alternate, bordered, vestured, with circular to lenticular apertures. *Parenchyma* banded, bands completely enclosing the vessels and running in concentric lines alternating with fibre bands, wavy, sometimes anastomosing, mostly narrower than fibre bands, about 5-8 per mm, each mostly 3-4 seriate, rarely up to 5 or 6 seriate; strands storied. *Xylem rays* usually 2-seriate, 1-seriate and 3-seriate very rare, 7-12 (mostly 10) cells in height, 10-14 per mm; ray tissue homogeneous, rays homocellular, consisting wholly of procumbent cells. *Fibres* small, 8-20 μm in diameter, thick-walled, nonseptate, nonstoried. *Ripple marks* present due to storied arrangement of vessel-members, parenchyma strands and xylem rays.

Holotype — B.S.I.P. Museum no. 35331.

FAMILY — LYTHRACEAE

Genus — *Lagerstroemioxylon* Mädler, 1939

7. *Lagerstroemioxylon deomaliensis* sp. nov.

Pl. 4, figs 25, 26, 29, 30

Material — A small piece of silicified wood measuring 7 cm in length and 4 cm in width.

Topography — Wood diffuse porous to slightly semi-ring porous (Pl. 4, fig. 25), *Growth rings* present, delimited by larger vessels and bands of parenchyma appearing as dark zone at the inception of spring wood (Pl. 4, fig. 26). *Vessels* small to medium, large at the beginning of annual rings and grading into smaller ones towards the close of the rings (Pl. 4, figs 25, 26), solitary and in radial multiples of mostly 2-3, usually crowded at the inception of spring wood, about 12-36 vessels per sq mm; tyloses present. *Parenchyma* paratracheal, vasicentric to aliform, aliform-confluent, joining neighbouring vessels tangentially as well as radially (Pl. 4, fig. 26); confluent parenchyma bands narrow or wide and wavy, occurring at the beginning of annual rings enclosing vessels completely or incompletely. *Fibres* aligned in distinct rows between two consecutive xylem rays. *Xylem rays* fine, predominantly uniseriate (Pl. 4, fig. 29), rarely with paired cells and 2-30 cells in height and about 15-22 rays per mm; ray tissue homogeneous, rays homocellular, composed wholly of procumbent cells (Pl. 4, fig. 30).

Elements — Vessels circular to oval, those in radial multiples flattened at the places of contact, t.d. 60-280 μm, r.d. 40-320 μm; perforations simple, horizontal to oblique; vessel members 150-750 μm in length, truncate or slightly tailed; intervessel pit-pairs bordered, large, about 8-10 μm in diameter, vestured, with linear to lenticular, horizontal orifices. *Parenchyma cells* 16-32 μm in diameter those occurring in the immediate vicinity of vessels flattened. *Ray cells* procumbent, 20-40 μm in vertical height, 40-160 μm in radial length, filled with dark contents. *Fibres* thin to thick-walled, angular in cross-section, small, 12-24 μm in diameter, septate, crystalliferous divided into several locules containing solitary crystals (Pl. 4, fig. 29); pits not seen.

Affinities — The characteristic features of this fossil wood are semi-ring porous in nature with comparatively bigger vessels at the inception of spring wood and smaller vessels towards the close of the rings, vasicentric to aliform and aliform-confluent as well as banded parenchyma, occurring at the beginning of the annual ring, uniseriate, homocellular xylem rays consisting of procumbent cells and septate fibres quite often with crystals in small locules. These features indicate its similarity with the modern woods of *Lagerstroemia* of the family Lythraceae.

In order to find out the nearest modern equivalent of the present fossil wood, thin sections of a large number of modern woods of *Lagerstroemia* were examined. Among the species consulted, *Lagerstroemia calyculata* Kurz, *L. floribunda* Jack, *L. flosreginae* Retz., *L. hypoleuca* Kurz, *L. lanceolata* Wall., *L. macrocarpa* Kurz, *L. parviflora* Roxb., *L. tomentosa* Presl., and *L. venusta* Wall. appear to be quite different from the present fossil in having more parenchyma as the confluent parenchyma bands are frequently present besides the usual ones occurring at the inception of the spring wood. However, it shows near resemblance with that of *Lagerstroemia villosa* Wall., except the vessels in our fossil are comparatively smaller and crowded than in the modern wood of *L. villosa* Wall.

Comparison with the Fossil Woods of Lagerstroemia — There are only four species of the fossil woods of *Lagerstroemia*, viz., *Lagerstroemioxylon durum* Mädler (1939) from the Tertiary of Frankfurt, West Germany, *L. parenchymatosum* Prakash (1965b, 1973) from the Tertiary of Burma, *L. eoflosreginum* Prakash & Tripathi (1970) from the Tertiary of Hailakandi, Assam, and the Mio-Pliocene of South-west Asia (Kramer, 1974), and *L. irrawaddiensis* Prakash & Bande (1979) from the Tertiary of Burma. Of these, *Lagerstroemioxylon durum* Mädler differs from the present fossil in having 1-2 (rarely 3) seriate and 50-60 cells high rays. In our fossil wood the rays are predominantly uniseriate with rare occurrence of biseriate rays due to pairing of procumbent cells through the median portion and only up to 30 cells in height. Similarly our fossil differs from *L. parenchymatosum*, *L. eoflosreginum* and *L. irrawaddiensis* in the size and frequency of

vessels and the amount of parenchyma. In all these fossil woods the vessels are comparatively bigger and the parenchyma is more than in our fossil. Thus *L. parenchymatosum* differs from our fossil wood in having long bands in the outer part of the late wood and in possessing solitary or groups of cells in the ground tissue. Similarly, *L. eoflosreginum* also differs in having diffuse parenchyma and long and short bands in the late wood. *L. eoflosreginum* and *L. irrawaddiensis* can be further differentiated from the present fossil in possessing a distinctly ring-porous wood. In view of these differences from the known species of *Lagerstroemioxylon*, the present fossil wood is assigned to a new species, *L. deomaliense*.

The genus *Lagerstroemia* consists of 53 species, distributed in the tropical forests of Asia to North Australia (Willis, 1973, p. 630). In the Indian subcontinent about 11 species are found growing in the deciduous forests of India, Burma, Bangla Desh and Sri Lanka. *Lagerstroemia villosa* Wall., the nearest modern equivalent of the fossil wood, is found in the tropical forests of Pegu, Martaban and Upper Burma.

Specific Diagnosis

Lagerstroemioxylon deomaliense sp. nov.

Wood diffuse-porous to slightly semi-ring porous. *Growth-rings* present, delimited by larger vessels at the inception of spring wood. *Vessels* small to medium, large at the beginning of annual rings, solitary and in radial multiples of 2-3, about 12-36 vessels per sq mm, t.d. 60-280 μm, r.d. 40-320 μm; perforations simple; intervessel pits vestured, large, 8-10 μm in diameter, with linear to lenticular, horizontal orifices. *Parenchyma* paratracheal, vasicentric to aliform and aliform-confluent; confluent parenchyma bands narrow to wide and wavy, present at the beginning of annual rings enclosing several vessels. *Xylem rays* fine, 1-seriate, rarely biseriate due to paired cells, about 2-30 cells in height, homocellular, composed wholly of procumbent cells. *Fibres* thick-walled, small, 12-24 μm in diameter, septate; crystalliferous fibres present, divided into several locules each containing solitary crystal.

Holotype — B.S.I.P. Museum no. 35332.

Family — Lauraceae

Genus — *Laurinoxylon* Felix, 1883

8. *Laurinoxylon namsangensis* sp. nov.

Pl. 5, figs 31-33

Material — A single piece of silicified wood measuring 16 cm length and 8 cm in width. The preservation is fairly good.

Topography — Wood diffuse-porous. *Growth rings* not seen. *Vessels* seen with naked eye as pin holes, medium to large and small (Pl. 5, fig. 31), laterally compressed due to pressure during fossilization, solitary and in radial multiples of 2-5 (mostly 2-3), uniformly distributed, 8-10 vessels per sq mm, plugged with tyloses. *Parenchyma* scanty paratracheal, only a few cells associated with the vessels, rarely forming uniseriate sheath (Pl. 5, fig. 31). *Xylem rays* fine (Pl. 5, fig. 32), 2-seriate, rarely 3-seriate, 5-22 cells in height, 6-9 per mm; ray tissue heterogeneous; rays homocellular to heterocellular, the latter consisting of procumbent cells through the median portion and usually a single row of marginal upright or square cells (Pl. 5, fig. 33). *Fibres* aligned in distinct radial rows between two consecutive xylem rays. *Oil cells* associated with the xylem rays (Pl. 5, figs 32, 33).

Elements — Vessels thin-walled, circular to oval, t.d. 75-300 μm, r.d. 75-405 μm; vessel members 225-750 μm in length with truncate or slightly inclined ends; perforations simple, nearly horizontal; intervessel pits large, 8-12 μm in diameter, alternate to subopposite with wide border and linear to lenticular apertures; pits leading to parenchyma and ray cells large, 20-28 μm in diameter, orbicular to oval with narrow border and wide orifice. *Parenchyma cells* occurring in the immediate vicinity of vessels, 28-40 μm in diameter. *Ray cells* upright and procumbent; upright cells 40-100 μm in tangential height, 32-80 μm in radial length; procumbent cells 16-24 μm in tangential height, 40-160 μm radial length; crystals not seen. *Fibres* thick-walled, angular, 16-32 μm in diameter, septate; pits not seen.

Affinities — Presence of oil cells in the rays is the most important and diagnostic feature of the present fossil wood. The oil

cells occur profusely in the rays and parenchyma among the woods of Lauraceae to which the present fossil wood is closely comparable. The woods of this family have received considerable attention by the wood anatomists. Macbride (1931) pointed out that morphologically and anatomically species within a genus of this family often differ from each other more than do the genera from each other. Dadswell and Eckersley (1940) also noted that the anatomical differences between genera are not clear cut and it is difficult to list features by which the various genera in each group may be readily classified. According to Metcalfe and Chalk (1950) Lauraceae is a remarkably uniform family throughout in its wood structure. Similarly, Stern (1954) and Desch (1957) after studying the modern woods of a large number of species of this family have also indicated that the individual genera cannot be distinguished. The authors also support this contention and include their fossil wood under the comprehensive organ genus *Laurinoxylon* Felix (1883). Among the woods of Lauraceae examined in order to find out the nearest modern equivalent of the present fossil wood, *Phoebe attenuata* and *P. goalparense* appear to be somewhat similar to our fossil. Consequently, the genus *Phoebe* can be considered as one of the probable modern equivalents of the present fossil.

A large number of fossil woods belonging to Lauraceae are known from all over the world. These have recently been listed by Prakash and Tripathi (1974, pp. 313, 314). So far only one species, *Laurinoxylon tertiarum* Prakash & Tripathi (1974) is known from the Indian subcontinent which has been recorded from the Tipam sandstones near Hailakandi in Cachar District of Assam. All these differ quite distinctly from the present fossil wood. Thus *Laurinoxylon tertiarum* is markedly different from the fossil in having both scalariform and simple perforations in smaller vessels (t.d. 60-152 μm, r.d. 80-200 μm), oil cells both in the rays and parenchyma and 1-3 (mostly 2) seriate xylem rays. However, the vessels are bigger (t.d. 75-300 μm, r.d. 75-405 μm), perforations simple, and the oil cells are associated only with xylem rays, rays 2-seriate, very rarely 3-seriate in our fossil wood. Because the present fossil is quite distinct from all the species of *Laurinoxylon* so far known, it is described as a new species, *L. namsangensis*, the specific name is after the river Namsang from whose bed this fossil wood has been collected.

Lauraceae is a widely distributed family, occurring throughout the warmer parts of the world but most abundant in tropical and subtropical regions, a few genera extending into Malay Archipelago and the other in the American tropics, chiefly in Brazil, relatively a few species occur in Europe and the African continents (Pearson & Brown, 1932, p. 823).

Specific Diagnosis

Laurinoxylon namsangensis sp. nov.

Wood diffuse-porous. *Growth rings* not seen. *Vessels* medium to large and small, t.d. 75-300 μm, r.d. 75-405 μm, solitary and in radial multiples of 2-5, 8-10 per sq mm; perforations simple; vessel members with truncate or slightly inclined ends; intervessel pits large, 8-12 μm in diameter, alternate to subopposite with linear to lenticular apertures. *Parenchyma* scanty paratracheal, rarely forming uniseriate sheath. *Xylem rays* 2-3 seriate, 5-22 cells in height, 6-9 per mm and heterocellular. *Fibres* thick-walled, angular and septate. *Oil cells* associated with the xylem rays.

Holotype — B.S.I.P. Museum no. 35333.

9. *Laurinoxylon deomaliensis* sp. nov.

Pl. 5, figs 34-36

Material — A piece of silicified, decorticated secondary wood measuring 20 cm in length and 8 cm in width.

Topography — Wood diffuse-porous. *Growth rings* present, delimited by narrow zone of denser fibres and slightly bigger and crowded vessels at the inception of early wood. *Vessels* small to large (Pl. 5, figs 34, 35), crowded at the inception of spring wood and smaller towards the close of annual rings, solitary and in radial multiples of 2-5 (mostly 2-3), occasionally up to 8, uniformly distributed, 12-44 vessels per sq mm; tyloses present. *Parenchyma* not easily recognizable, scanty paratracheal (Pl. 5, fig. 34), limited only to a few cells

in the immediate vicinity of vessels, forming incomplete sheath; diffuse cells not seen. *Xylem rays* fine, 1-3 seriate (Pl. 5, fig. 36), mostly 2-seriate, about 5-30 cells in height, 6-8 rays per mm; ray tissue heterogeneous; rays homocellular to heterocellular, homocellular rays consisting of procumbent cells only; heterocellular rays consisting of single marginal row of upright cells at one or both the ends and procumbent cells through the median portion. *Fibres* aligned in radial rows between two consecutive xylem rays. *Oil* or *secretory cells* abundant, scattered singly among the fibres (Pl. 5, fig. 35), appearing as white dots under low magnification, sometimes difficult to differentiate from smaller solitary vessels.

Elements — *Vessels* circular to oval in cross section, t.d. 60-120 μm, r.d. 40-320 μm; vessel-members about 100-500 μm in length; perforations simple; intervessel pits large, about 8-10 μm, alternate, bordered with lenticular orifices. *Parenchyma cells* round, those in the immediate vicinity of vessels flattened, about 24-40 μm in diameter. *Ray cells* upright or square and procumbent; upright or square cells 24-60 μm in tangential height and about 20-40 μm in radial length; procumbent cells 16-24 μm in tangential height and 24-100 μm in radial length. *Fibres* moderately thick-walled, angular, small, 24-40 μm in diameter, septate; pits not seen. *Oil cells* round to oval in shape, 40-100 μm in diameter.

Affinities — Presence of secretory (oil) cells in the wood is a characteristic feature of the family Lauraceae. The oil cells usually occur either in wood parenchyma or in rays or relatively rarely in both. Sometimes isolated cells scattered among the fibres are also found. In the present fossil the oil cells are scattered among the fibres. It shows near resemblance with quite a number of lauraceous woods. However, considering all the above described features of the fossil collectively, the wood of *Alseodaphne* (*A. owdeni*) and *Actinodaphne* (*A. hookerii*) are among those which show close resemblance with our fossil.

The present lauraceous fossil differs from *Laurinoxylon tertiarum* Prakash & Tripathi in having numerous oil cells scattered among the fibres. The oil cells are also present in *L. tertiarum* but they are confined to parenchyma and rays. Moreover, the vessels are crowded in the present fossil than in *L. tertiarum*. Similarly, there is a marked difference between *L. namsangensis* and the present fossil because the oil cells in the former are found in the rays, while in the latter they are found scattered in the fibres. Besides, the vessels are large and their frequency is 8-10 per sq mm in *L. namsangensis*, whereas the vessels are mostly small to medium and crowded and their frequency is more, about 12-36 per sq mm in the present fossil wood. As the fossil wood is quite distinct from the species known so far, it is assigned to a new species, *Laurinoxylon deomaliensis*, the specific name indicates its occurrence near Deomali in Arunachal Pradesh.

Specific Diagnosis

Laurinoxylon deomaliensis sp. nov.

Wood diffuse-porous. *Growth rings* present. *Vessels* small to large, t.d. 60-120 μm, r.d. 40-320 μm, crowded at the inception of the spring wood, circular to oval in cross section, solitary and in radial multiples of 2-5, occasionally more, 12-44 per sq mm; perforations simple; vessel-members 100-500 μm in length; intervessel pits large, about 8-10 μm, alternate, bordered, with lenticular orifices. *Parenchyma* scanty paratracheal. *Xylem rays* 1-3 seriate, 5-30 cells in height, 6-8 per mm, homocellular to heterocellular. *Fibres* moderately thick-walled, angular and septate. *Oil cells* abundant, scattered singly among the fibres, 40-100 μm in diameter.

Holotype — B.S.I.P. Museum no. 35334.

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EXPLANATION OF PLATES

PLATE 1

Sterculioxylon varmahii sp. nov.

1. Cross section showing the nature and distribution of vessels and parenchyma. × 10. B.S.I.P. Museum slide no. 5952.
2. Tangential longitudinal section showing uniseriate to multiseriate, broad xylem rays. × 60. B.S.I.P. Museum slide no. 5953.
3. Another tangential longitudinal section showing parenchyma strands storied with low rays. × 60. B.S.I.P. Museum slide no. 5954.

4. Cross section magnified to show the type and distribution of vessels and parenchyma bands. × 30. B.S.I.P. Museum slide no. 5952.

Sterculia alata Roxb.

5. Cross section showing similar vessels and parenchyma bands as in fossil shown in fig. 4. × 30.

Heritieroxylon arunachalensis gen. et sp. nov.

6. Cross section showing distribution of vessels, parenchyma and tangential row of gum canals. × 8. B.S.I.P. Museum slide no. 5955.
7. Cross section magnified to show diffuse and uniseriate lines of parenchyma. × 90. B.S.I.P. Museum slide no. 5955.

PLATE 2

Heritieroxylon arunachalensis gen. et sp. nov.

8. Cross section magnified to show the nature and distribution of vessels and vertical gum ducts. × 30. B.S.I.P. Museum slide no. 5955.
9. Intervessel pit-pairs. × 400. B.S.I.P. Museum slide no. 5957.
10. Tangential longitudinal section showing xylem rays. × 90. B.S.I.P. Museum slide no. 5956.

Burseroxylon garugoides sp. nov.

11. Cross section showing nature and distribution of vessels. × 8. B.S.I.P. Museum slide no. 5961.
12. Cross section magnified showing vessels and vasicentric parenchyma. × 30. B.S.I.P. Museum slide no. 5962.
13. Tangential longitudinal section showing rays. × 90. B.S.I.P. Museum slide no. 5963.
14. Radial longitudinal section showing heterocellular ray. × 90. B.S.I.P. Museum slide no. 5964.
15. Intervessel pit-pairs. × 400. B.S.I.P. Museum slide no. 5965.

PLATE 3

Mangiferoxylon assamicum Prakash & Tripathi

16. Cross section showing vessels and paratracheal and apotracheal parenchyma. × 30. B.S.I.P. Museum slide no. 5966.
17. Tangential longitudinal section showing uniseriate rays. × 90. B.S.I.P. Museum slide no. 5967.

Albizinium eolebbekianum Prakash

18. Cross section showing nature and distribution of vessels and parenchyma. × 30. B.S.I.P. Museum slide no. 5968.
19. Tangential longitudinal section showing rays. × 90. B.S.I.P. Museum slide no. 5969.

Millettioxylon palaeopulchra sp. nov.

20. Cross section showing nature and distribution of vessels and parenchyma. × 7. B.S.I.P. Museum slide no. 5970.
21. Cross section magnified showing vessels and parenchyma bands. × 30. B.S.I.P. Museum slide no. 5970.
22. Radial longitudinal section showing homocellular rays. × 100. B.S.I.P. Museum slide no. 5971.
23. Tangential longitudinal section under low magnification showing ripple marks. × 40. B.S.I.P. Museum slide no. 5972.

PLATE 4

Millettioxylon palaeopulchra sp. nov.

24. Another tangential longitudinal section magnified to show storied rays. × 100. B.S.I.P. Museum slide no. 5973.

Lagerstroemioxylon deomaliensis sp. nov.

25. Cross section showing nature and distribution of vessels and growth rings. × 8. B.S.I.P. Museum slide no. 5974.
26. Cross section magnified to show nature and distribution of vessels, parenchyma and growth rings delimited by bigger vessels and broad parenchyma bands. × 45. B.S.I.P. Museum slide no. 5974.

Lagerstroemia villosa Wall.

27. Cross section showing similar vessels, parenchyma and growth rings delimited by comparatively bigger vessels and broad parenchyma band as in fossil shown in fig. 26. × 45.

28. Tangential longitudinal section showing uniseriate rays. × 90.

Lagerstroemioxylon deomaliensis sp. nov.

29. Tangential longitudinal section showing similar rays as in *Lagerstroemia villosa* shown in fig. 28.
30. Radial longitudinal sections showing homocellular rays composed of procumbent cells. × 90. B.S.I.P. Museum slide no. 5976.

PLATE 5

Laurinoxylon namsangensis sp. nov.

31. Cross section showing nature and distribution of vessels and vasicentric parenchyma. × 30. B.S.I.P. Museum slide no. 5977.
32. Tangential longitudinal section showing rays. × 90. B.S.I.P. Museum slide no. 5978.
33. Radial longitudinal section showing rays with a marginal row of oil cells. × 90. B.S.I.P. Museum slide no. 5979.

Laurinoxylon deomaliensis sp. nov.

34. Cross section showing nature and distribution of vessels. × 30. B.S.I.P. Museum slide no. 5980.
35. Another cross section magnified to show vessels and oil cells scattered among the fibres. × 50. B.S.I.P. Museum slide no. 5980.
36. Tangential longitudinal section showing rays. × 90. B.S.I.P. Museum slide no. 5981.

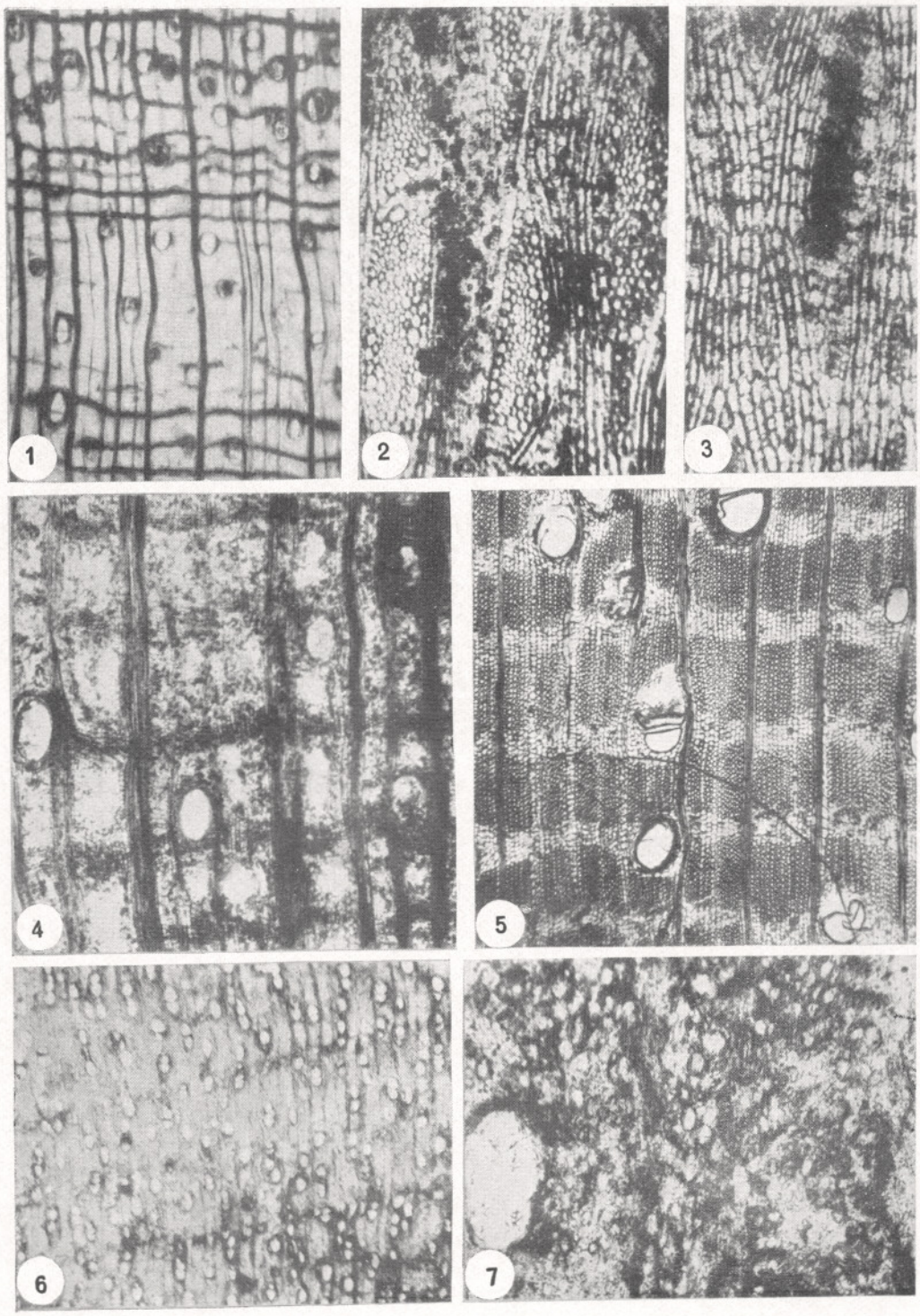
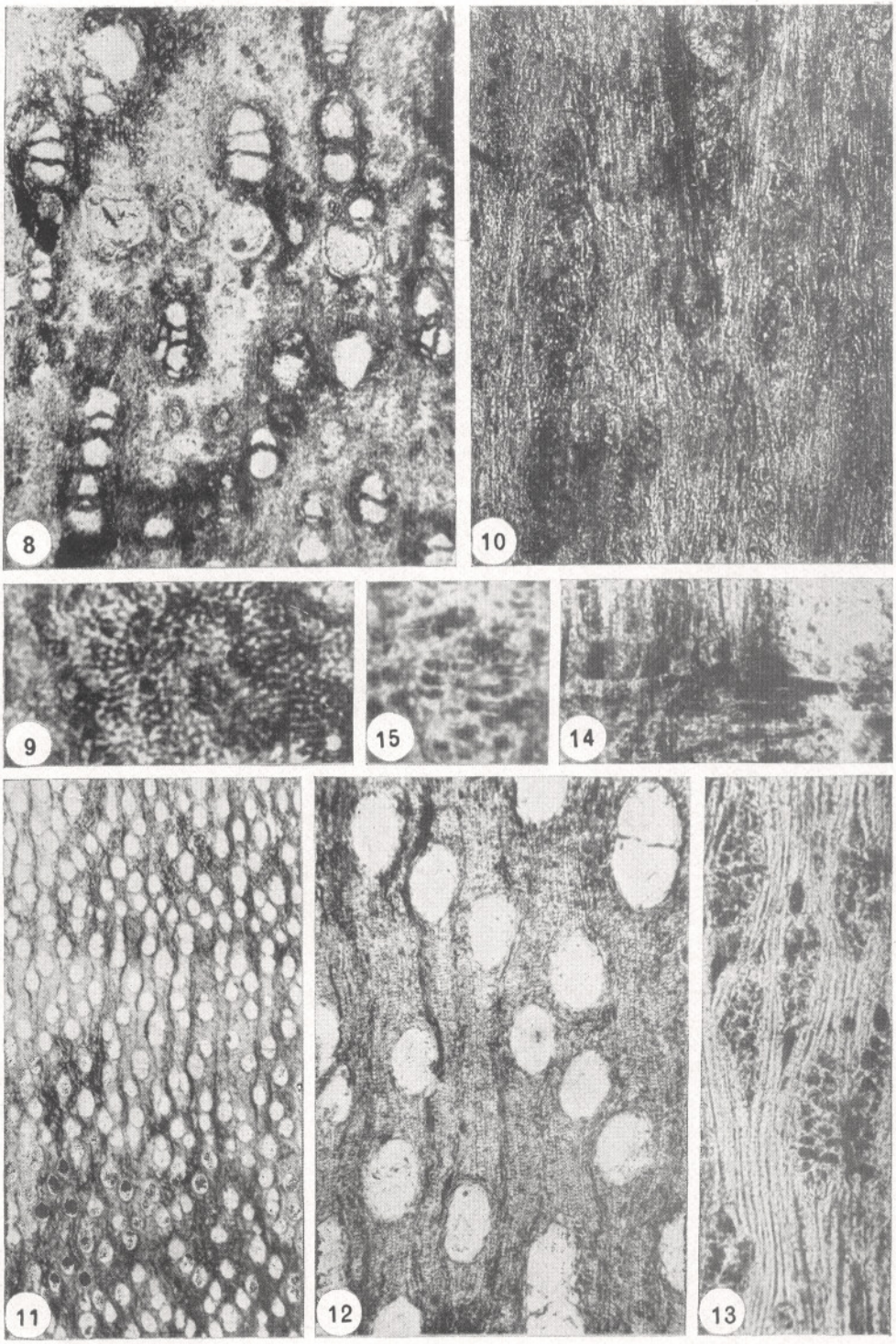


PLATE 1



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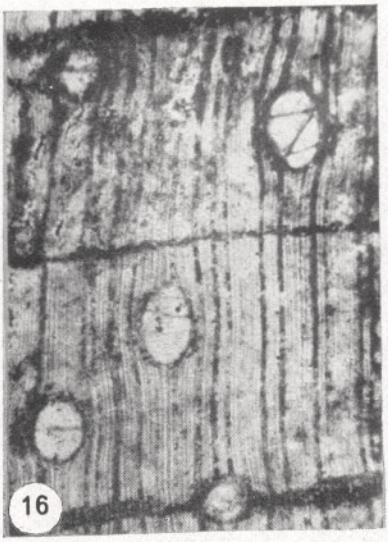

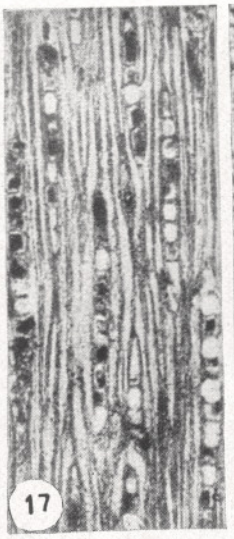

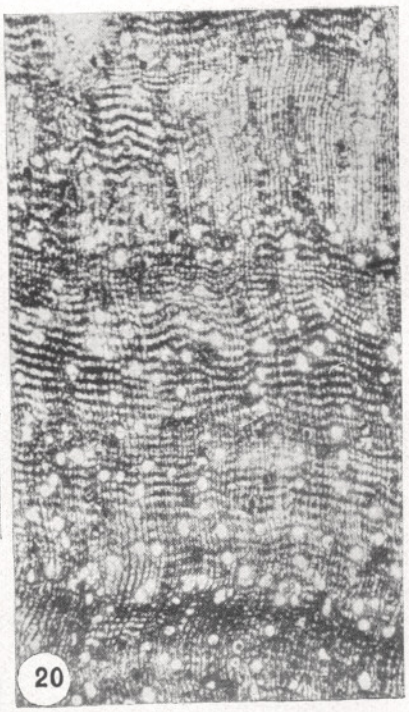

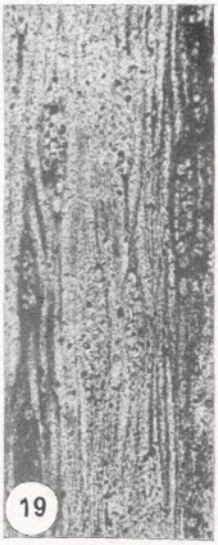

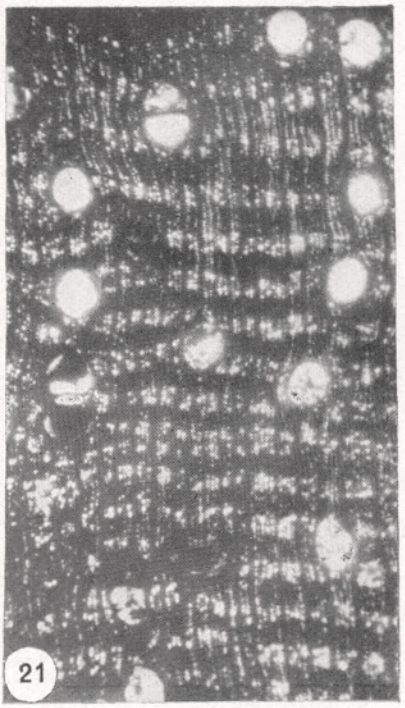

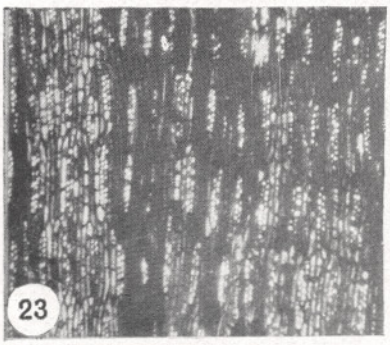

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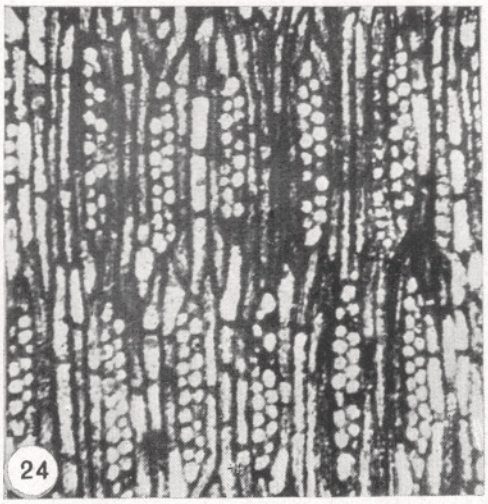

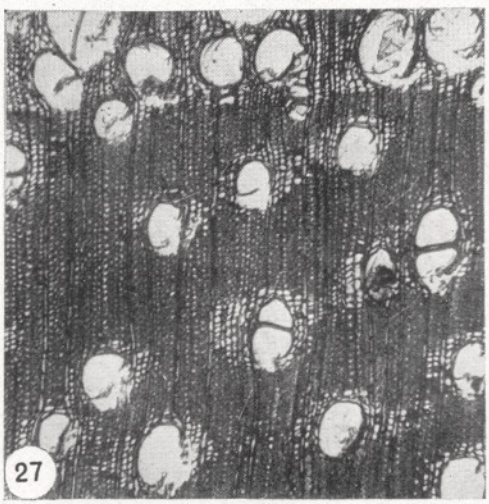

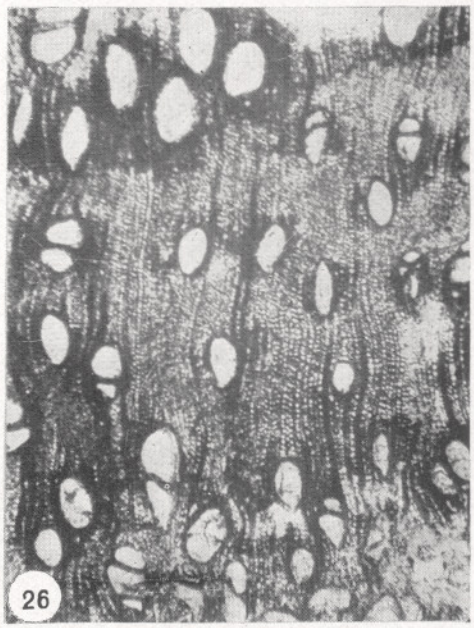

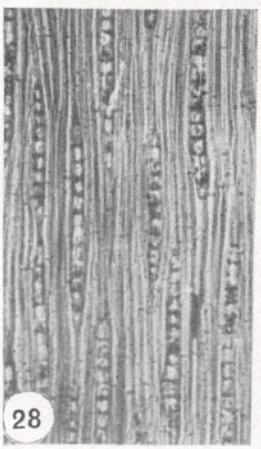

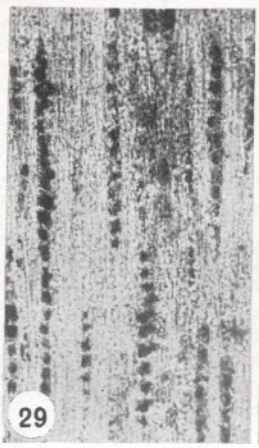

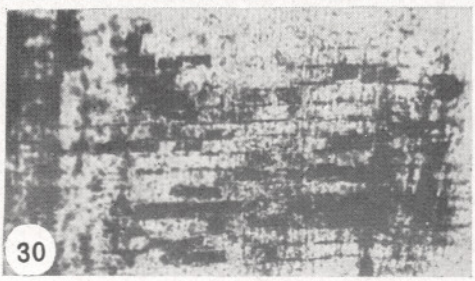

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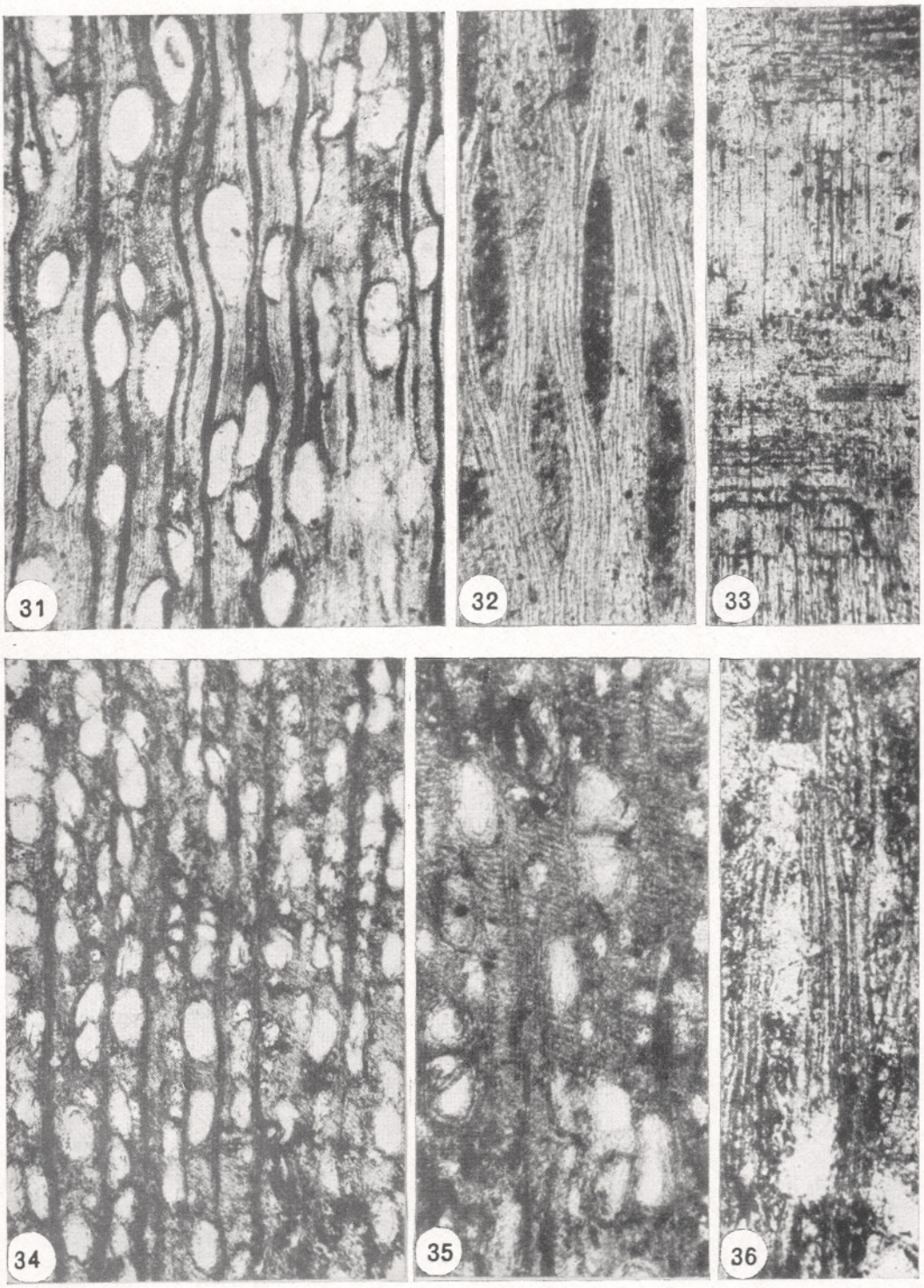

PLATE 5