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SOME MORE FOSSIL WOODS FROM THE TERTIARY OF BURMA

U. PRAKASH & M. B. BANDE
Birbal Sahni Institute of Palaeobotany, Lucknow-226 007, India

ABSTRACT

Fossil woods comparable to *Shorea ovata* of Dipterocarpaceae, *Swintonia floribunda* of Anacardiaceae, *Albizia lebbek* of Leguminosae, *Careya arborea* of Lecythidaceae, *Lagerstroemia venusta* of Lythraceae and *Araucaria-Agathis* of Araucariaceae have been described here from the Neogene of Burma. One more petrified wood *Dipterocarpoxylon holdeni* Gupta (1935) has been reinvestigated and found to belong to *Cynometroxylon* Chowdhury & Ghosh (1946) of the family Leguminosae. All these species except *Araucaria-Agathis* occur in the present day flora of Burma and nearby areas indicating a somewhat similar climate and vegetation in this region since the Neogene.

Key-words — Fossil woods, Xylotomy, Neogene (Burma).

सारांश

बर्मा के टरशरी कल्प से कुछ और काष्ठाश्म — उत्तम प्रकाश एवं मोहन बलवंत बाँडे

यहाँ बर्मा के निओजीन कल्प से डिप्टेरोकारपेसी कुल का **शोरिया ओवेटा**, ऐनाकार्डिएसी कुल का **स्विन्टोनिया फ्लोरीबंडा**, लेग्यूमिनोसी कुल का **एल्बिज़िया लेबेक**, लैसीथिडेसी कुल का **कैरिया आरबोरिया**, लायथ्रेसी कुल **लेजरस्ट्रोमिया वीनुस्टा** तथा अॅराकेरियेसी कुल के **अॅराकेरिया-ऐगेथिस** से तुलनीय काष्ठाश्मों का वर्णन किया गया है। एक और अश्मीभूत काष्ठ, **डिप्टेरोकारपॉक्सीलॉन होल्डेनाई** गुप्ता (1935) पुनः अन्वेषित की गई है तथा लेग्यूमिनोसी कुल के **सायनोमेट्रॉक्सोलॉन** चौधरी एवं घोष (1946) से सजातीय पाई गई है। **अॅराकेरिया-ऐगेथिस** के अतिरिक्त ये सब जातियाँ बर्मा और उसके आस-पास के क्षेत्रों के वनस्पति-जात में मिलती हैं तथा निओजीन काल से अब तक इस क्षेत्र में लगभग वैसी ही जलवायु और वनस्पति का संकेत करती हैं।

INTRODUCTION

RECENTLY a number of petrified dicotyledonous woods were described by one of us (Prakash, 1973) from the Tertiary of Burma. The present study of some more fossil woods from this region forms a further contribution to our knowledge of the Tertiary flora of Burma. This is based on an old collection of fossil woods, mostly belonging to dicotyledons. According to our Museum records these fossil woods belong to the Tertiary of Burma, but no other details are available regarding their precise age and locality. However, these fossil woods bear sender's numbers in red ink, viz., P.228, P.146, etc., which give an indication that this material is a part of the fossil collection received by Professor Birbal Sahni from Professor H. L. Chhibber, then of the Geology Department, University College, Rangoon, because similar numbers in the same red ink, viz., P.63, P.277, P.432 and P.365, are found on the fossil palm woods described by Prof. Sahni in his monograph entitled, "Revision of Indian Fossil Plants. Part III-Monocotyledons" (Sahni, 1964, pp. 41, 42, 43, 44). These fossil palm woods, sent to him by Prof. Chhibber, were collected from the Tertiary of Mount Popa area, Myingyan District, Upper Burma. The horizon is said to be either at the base of the Irrawaddy Series or at the top of the Pegu Series, which is Mio-Pliocene in age. Another point which supports this age is their close similarity with the modern species growing in this region. A detailed anatomical study of these woods has helped us to assign them to modern genera and in some cases even

to nearest modern species found in the present day flora of Burma and nearby areas. Such a close similarity can only be visualized in the Late Tertiary floras. As the fossil woods are known only from the Eocene of Tilin and Pondaung sandstones and the Mio-Pliocene of Pegu and Irrawaddy series, in the Tertiary of Burma, their close similarity with the modern plants indicates the possibility of these fossils belonging to the Mio-Pliocene age, rather than the Eocene.

Although Pegu-Irrawaddy series of Burma are said to be very rich in fossil woods, not much work has so far been done on these woods. The earlier record consists of woods belonging to *Dipterocarpus*, *Shorea-Pentacme*, *Sterculia*, *Gluta - Melanorrhoea*, *Acacia*, *Afzelia-Intsia*, *Cynometra*, *Cassia*, *Lagerstroemia* (Prakash, 1973), *Terminalia* (Chowdhury & Tandon, 1964), palms (Sahni, 1964) and some unidentified legumes (Gupta, 1936; Prakash, 1973). This paper describes in detail some more fossil dicotyledonous woods belonging to *Shorea*, *Swintonia*, *Albizia*, *Careya* and *Lagerstroemia*, besides a gymnospermous wood of Araucariaceae. One more wood, wrongly identified and named as *Dipterocarpoxylon holdeni* Gupta (1935) from the Irrawaddy series of Burma, has been reinvestigated and identified with *Cynometra*.

Family — Araucariaceae

Genus — *Araucarioxylon* Kraus, 1870

Pl. 1, figs 1-3; Text-fig. 1

1. *Araucarioxylon* sp.

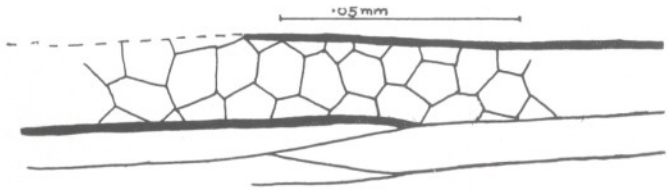
The present description is based on a piece of secondary wood about 5 cm in length and 2 cm in diameter. The fossil is somewhat twisted due to pressure during fossilization making the anatomical details obscure at some places.

Growth rings distinct, delimited by a band of late wood tracheids. Transition from early wood to late wood abrupt (Pl. 1, figs 1, 2). *Late wood* zone usually much less but sometimes almost equal in width to the early wood, about 300-1200 μ in width; cellular details of late wood could not be observed due to bad preservation. *Early wood* usually much more in width than late wood, 450-3600 μ in width, consisting of radial rows of thin-walled, rounded to squarish, radially elongated or rarely tangentially flattened tracheids with big lumen (Pl. 1, fig. 2). Early wood *tracheids* 20-45 μ in radial diameter and 15-40 μ in tangential diameter. Tangential walls of the tracheids smooth but radial walls are pitted at some places. *Parenchyma* absent. *Tracheid pits* 1-2 seriate, contiguous, alternate when biseriate (Text-fig. 1), hexagonal in shape, 8-10 μ in diameter with circular to oval orifices. *Bars of Sanio* absent. *Xylem rays* homogeneous, evenly distributed, 10-12 per mm, usually uniseriate, partly biseriate at one place, 2-12 cells high, made up of elongated, barrel-shaped cells as seen in tangential section (Pl. 1, fig. 3). *Cross-field pits* could not be seen.

Affinities — Anatomical characters of the fossil wood such as presence of growth rings, predominantly uniseriate xylem rays and tracheids with alternate, hexagonal, bordered pits on their radial walls indicate its affinities with the family Araucariaceae. Consequently, it has been placed under the organ genus *Araucarioxylon* Kraus (1870) instituted to include the fossil woods of the family Araucariaceae. Because a number of anatomical details of specific nature could not be ascertained definitely in the present fossil wood due to bad preservation, it has not been possible to compare this fossil with the known species of *Araucarioxylon*. Hence, it is being described here as *Araucarioxylon* sp. without assigning it to any species.

As far as the authors are aware of, no fossil wood showing affinities to the woods of Araucariaceae has so far been described from the Tertiary of Burma and this seems to be the first record of a wood of *Araucaria-Agathis* from this region.

Although fossil records of Araucariaceae are known from both the hemispheres (Florin, 1963, figs 14, 15), this family is exclusively southern in distribution in the present day flora. The genus *Agathis* belongs to the Malay Archipelago and the Pacific islands to the New Zealand, whereas *Araucaria* occurs not only in the Australasian region but also in South America (Coulter & Chamberlain, 1955, p. 302). The present record of fossil wood of Araucariaceae in the Mio-Pliocene of Irrawaddy series of southern Burma indicates that the members of this family were present farther



TEXT-FIG. 1 — *Araucarioxylon* sp.— Radial tracheid pits.

north of Malay Peninsula during the Late Tertiary times. Their disappearance may primarily be due to changes in the environmental conditions of this region.

Holotype — Birbal Sahni Institute of Palaeobotany Museum no. 1464.

FAMILY — DIPTEROCARPACEAE

Genus — *Shoreoxylon* Den Berger, 1923

2. *Shoreoxylon irrawaddiensis* sp. nov.

Pl. 1, figs 4, 5; Pl. 2, fig. 6

The fossil consists of a well preserved piece of secondary wood about 8 cm in length and 4 cm in diameter.

Topography—Wood diffuse-porous. *Growth rings* absent; concentric tangential rows of resin canals sometime appear as growth rings to the naked eye (Pl. 1, fig. 5). *Vessels* mostly large and solitary, sometimes in radial pairs, the larger vessels visible to the naked eye as pin holes on the cross surface, evenly distributed, 6-8 per sq mm, usually with rays contiguous on one or both the sides; tyloses and gummy infiltrations present (Pl. 1, fig. 5). *Vasicentric tracheids* sparse. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma occurring round the vessels (Pl. 1, fig. 5); apotracheal parenchyma abundant, usually in 1-2 rarely 3-(4) seriate, continuous or interrupted tangential lines forming a close reticulum with the xylem rays and also occurring as 10-16 seriate, continuous, tangential bands enclosing the resin canals (Pl. 1, fig. 5). *Xylem rays* visible to the naked eye as light coloured lines running radially on the cross surface, 5-8 per mm (Pl. 1, fig. 5), fine to broad, 1-6-(7) (mostly 3-5) seriate, with rare uni-and biseriates, 40-120 μ wide and up to 50 cells or 1200 μ high (Pl. 2, fig. 6); ray tissue homogeneous to weakly heterogeneous with rays mostly made up of procumbent cells, occasionally with a row of upright cells at one or both the ends (Pl. 1, fig. 4; Pl. 2, fig. 6). *Fibres* aligned in radial rows. *Gum canals* vertical, arranged in concentric rows at irregular intervals (Pl. 1, fig. 5).

Elements — Vessels circular to oval when solitary, with flat contact walls when in groups, t.d. 90-300 μ, r.d. 90-380 μ; vessel members 100-650 μ long with horizontal to oblique ends; perforations simple; intervessel pit-pairs not frequent, 4-7 μ in diameter, oval to polygonal through crowding, alternate, bordered, with linear to lenticular apertures. *Parenchyma cells* thin-walled, 25-30 μ in width and 80-120 μ in height (Pl. 2, fig. 6). *Ray cells* slightly thick-walled, procumbent cells oval to polygonal in tangential section, 20-25 μ in tangential height and 40-60 μ in radial length; upright-cells squarish, 40-50 μ in tangential height and 40-50 μ in radial length (Pl. 1, fig. 4). *Fibres* libriform, nonseptate, polygonal in cross section, 15-20 μ in diameter and 600-700 μ in length. *Gum canals* circular to oval in shape, up to 140 μ in diameter, filled with black contents (Pl. 1, fig. 5).

Affinities — The important anatomical characters of the fossil wood such as the presence of gum canals and vasicentric tracheids, mostly solitary, large to medium-sized vessels, usually diffuse-in-aggregate parenchyma, multiseriate, heterocellular xylem rays and the libriform fibres indicate that the fossil belongs to the family Dipterocarpaceae. As the gum canals are arranged in concentric tangential rows, it is quite apparent that the fossil resembles the taxa belonging to the tribe Dryobalanopseae consisting of the genus *Dryobalanops* and the tribe Shoreae including the genera *Shorea*, *Doona*, *Hopea*, *Parashorea*, *Pentacme* and *Balanocarpus*. Woods of Shoreae are characterized by solitary as well as radial multiples of vessels and the fibres are with simple pits, while those of Dryobalanopseae (*Dryobalanops*) possess almost exclusively solitary

vessels and the fibres are with bordered pits (Prakash, 1973, p. 54). Although the nature of fibre pits could not be ascertained, the vessels of the present fossil wood are solitary as well as in radial multiples. Therefore, it falls under the tribe Shoreae.

A detailed anatomical study of all the available species of the genera belonging to Shoreae indicates that the fossil wood belongs to the genus *Shorea*. About three dozen species of *Shorea* were studied at the Wood Anatomy Branch of the Forest Research Institute, Dehra Dun. The fossil wood shows nearest affinity to the modern wood of *Shorea ovata* Dyer (F.R.I. slide no. F. 1339/3090). The similarity can be seen in vessel distribution, parenchyma pattern, and the structure of xylem rays and fibres. However, the number of upright cells at the ends in the xylem rays of *Shorea ovata* is slightly more as compared to our fossil wood. As the present fossil is similar to the modern genus *Shorea*, it has been placed under the organ genus *Shoreoxylon* Den Berger (1923).

Fossil woods assigned to *Shoreoxylon* Den Berger have been listed by Prakash (1973) and Awasthi (1974). To this list three more species may be added, viz., *Shoreoxylon burmense* (Prakash, 1965, 1973) from the Tertiary of Burma and *Shoreoxylon indicum* and *S. arcotense* (Awasthi, 1974) from the Cuddalore series of South India. Of all the eleven species so far known from outside the Indian subcontinent and confined to the Tertiary of south-east Asia (Den Berger, 1923, 1927; Schweitzer, 1958), none is closely comparable to the present fossil wood. They differ quite markedly from this fossil particularly in the distributional pattern of the parenchyma. In none of these species the apotracheal parenchyma is so abundant as in our fossil wood where it is usually in 1-2 rarely 3-(4) seriate, continuous or interrupted tangential lines forming a close reticulum with the xylem rays and also occurring as 10-16 seriate continuous, tangential bands enclosing the gum canals. The xylem rays are narrower in most of these species than in our fossil wood. However, the rays are slightly broader, 1-9 seriate in *Shoreoxylon asiaticum* (Schweitzer, 1958), whereas they are 1-7 seriate in our fossil wood.

So far only seven species of *Shoreoxylon* have been recorded from India. These are *Shoreoxylon speciosum* Navale (1963), *S. evidens* Eyde (1963), *S. krauseli* Ramanujam & Raghu Rama Rao (1969), *S. tipamense* Prakash & Awasthi (1970), *S. deomaliense* Prakash & Awasthi (1971), *S. indicum* (Awasthi, 1974) and *S. arcotense* Awasthi (1974). All these species also differ from our fossil particularly in the distributional pattern of the parenchyma. In all these species except *Shoreoxylon arcotense*, the parenchyma is vasicentric to aliform-confluent, diffuse and also associated with the tangential rows of gum canals. In *S. arcotense*, the paratracheal parenchyma is sparse, occurring as few cells associated with the vessels. However, in none of these species, the apotracheal parenchyma forms 1-4 seriate tangential lines in the form of a net work as in the present fossil. The xylem rays are narrow in most of these species except in *S. deomaliense*. The rays are 1-4 seriate in *S. arcotense*, 1-5 seriate in *S. krauseli*, *S. evidens* and *S. tipamense*, and 1-6 seriate in *S. indicum* and *S. speciosum* as against 1-7 seriate found in our fossil wood which are quite similar to the rays in *S. deomaliense*.

The only other species of *Shoreoxylon* known from the Tertiary of Burma is *S. burmense* Prakash (1973). This also differs from the present fossil wood in a number of important anatomical features. Thus the vessels in *S. burmense* are solitary and often in radial multiples of 2-3, while in the present species they are mostly solitary and infrequently in radial pairs. The parenchyma in *S. burmense* is vasicentric to aliform-confluent and diffuse and forms short, irregular lines besides occurring as tangential bands embedding the gum canals. However, it does not form a reticulum with the xylem rays, a feature quite characteristic in our fossil wood. Lastly, the xylem rays of *S. burmense* are also narrower (1-5 seriate) than in the present fossil where they are 1-7 seriate. As the present fossil wood differs markedly from all the known species of *Shoreoxylon* Den Berger, it is described here as a new species, *Shoreoxylon irrawaddiensis*, indicating its occurrence in the Irrawaddy series of Burma.

Shorea ovata Dyer with which the fossil shows a near resemblance occurs throughout Malay Peninsula at an elevation of 2000 ft but it descends much lower near the coast in Penang (Desch, 1941).

SPECIFIC DIAGNOSIS

Shoreoxylon irrawaddiensis sp. nov.

Wood diffuse-porous *Growth rings* absent. *Vessels* mostly large and solitary, t.d. 90-300 μ, r.d. 90-380 μ, circular to oval in shape, 6-8 per sq mm; tyloses and gummy infiltrations present; vessel members 100-650 μ long with oblique ends; perforations simple; intervessel pit-pairs alternate, bordered, 4-7 μ in diameter, oval to angular through crowding with linear to lenticular apertures. *Vasicentric tracheids* sparse. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma occurring around the vessels; apotracheal parenchyma abundant, forming 1-2 rarely 3-(4) seriate, continuous or interrupted tangential lines forming a close reticulum with the xylem rays, also enclosing gum canals in 10-16 seriate tangential bands. *Xylem rays* 1-6-(7) (mostly 3-5) seriate, up to 50 cells or 1200 μ high and 5-8 per mm; ray tissue homogeneous to weakly heterogeneous with occasional upright cells at the ends. *Fibres* libriform, polygonal in cross section, 15-20 μ in diameter, non-septate. *Gum canals* circular to oval in shape, up to 140 μ in diameter, arranged in tangential rows, embedded in apotracheal bands of parenchyma.

Holotype — Birbal Sahni Institute of Palaeobotany Museum no. 1470.

FAMILY — ANACARDIACEAE

Genus — *Swintonioxylon* Prakash & Tripathi, 1969

3. *Swintonioxylon hailakandiense* Prakash & Tripathi, 1969

Pl. 2, figs 7, 8

The fossil described here is a small piece of secondary wood, measuring about 5 cm in length and 3 cm in diameter.

Wood diffuse-porous. *Growth rings* absent (Pl. 2, fig. 7). *Vessels* medium to large, t.d. 140-480 μ, r.d. 140-320 μ, mostly solitary, sometimes in radial multiples of 2-3; vessels 2-4per sq mm, profusely tylosed (Pl. 2, fig. 7); vessel members 200-300 μ long with truncate ends; perforations simple; intervessel pit-pairs bordered, 6-8 μ in diameter, oval to angular through crowding with lenticular apertures. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, sometimes with lateral extensions; apotracheal parenchyma in 1-5 seriate, short or long tangential bands (Pl. 2, fig. 7). *Xylem rays* fine, 1-3 (mostly 2) seriate and 3-23 cells in height, 5-10 rays per mm; ray tissue heterogeneous, rays made up of procumbent cells in the middle region with upright cells at one or both the ends (Pl. 2, fig. 8); ray cells crystalliferous; horizontal gum canals could not be observed. *Fibres* moderately thick-walled with big lumen, angular in cross section, non-septate but sometimes appearing septate due to presence of artifacts (Pl. 2, fig. 8), 15-20 μ in diameter and 600-800 μ in length; inter-fibre pits not seen.

As the present fossil wood is very similar to *Swintonioxylon hailakandiense* Prakash & Tripathi (1969) described from the Tertiary of Assam, it has been assigned to it. The only difference found between the two is the presence of gum canals in the rays of *S. hailakandiense* and their absence in the present fossil wood. As the fossil is represented by a small piece of wood, the gum canals being occasional may not be present in this part of the wood. In *Swintonia floribunda* Griff. which resembles the fossil wood, the gum canals are occasionally present in the xylem rays and are not always seen in all the sections.

Swintonia floribunda, the modern species comparable to the present fossil, grows in Chittagong and in the moist forests of Lower Burma along the coasts of Tavoy and Mergui (Pearson & Brown, 1932; Ghosh & Purkayastha, 1963).

Specimen — Birbal Sahni Institute of Palaeobotany Museum no. 1474—P 151.

FAMILY — LEGUMINOSAE

Genus — *Albizinium* Prakash, 1975

4. *Albizinium eolebbekianum* Prakash, 1975

Pl. 2, figs 9, 10

The present species is based on a well preserved piece of secondary wood 6 cm in length and 3 cm in diameter.

Wood diffuse-porous. *Growth rings* not seen (Pl. 2, fig. 9). *Vessels* small to large, t.d. 40-200 μ, r.d. 90-300 μ, mostly solitary, sometimes in radial multiples of 2-4, uniformly distributed, 6-7 per sq mm; tyloses absent but dark coloured contents present

(Pl. 2, fig. 9); vessel members 300-600 μ long with oblique ends; perforations simple; intervessel pit-pairs alternate, vestured, 4-8 μ in diameter, with horizontal, lenticular apertures. *Parenchyma* abundant forming wide halo around the vessels, sometimes extending laterally and ending blindly or joining similar extensions from nearby vessels (Pl. 2, fig. 9); apotracheal parenchyma sparse, distributed as occasional cells in the fibrous tissue. *Xylem rays* fine, 1-4 (mostly 2-3) seriate, up to 24 cells or 300 μ in height, 8-12 per mm; ray tissue homogeneous, rays made up of procumbent cells only (Pl. 2, fig. 10). *Fibres* moderately thick-walled with big lumen, polygonal in cross section, septate, 10-15 μ in diameter.

The fossil wood is closely comparable to the known species *Albizinium eolebbekianum* Prakash (1975) described from the Lower Siwalik beds near Nalagarh in Himachal Pradesh. This has been compared with the extant species *Albizia lebbek* Benth. The only difference between the Burmese fossil wood and *Albizinium eolebbekianum* from the Siwalik beds is the presence of terminal parenchyma demarcating the growth rings in *A. eolebbekianum* from Nalagarh and its absence in the fossil wood from Burma. This is a variable character in *Albizia lebbek* in which growth rings are absent from a number of wood specimens (F.R.I. slide nos. A 1562/B 5201, A 1560/B 2208) examined at the Forest Research Institute, Dehra Dun.

Albizia lebbek Benth. is found from the Indus eastwards along the sub-Himalayas to Assam, throughout the Indian subcontinent except Sind and Rajasthan, in Burma and in the Andamans (Pearson & Brown, 1932, pp. 454, 455).

Specimen — Birbal Sahni Institute of Palaeobotany Museum no. 1468.

Family — Leguminosae

Genus — *Cynometroxylon* Chowdhury & Ghosh, 1946

5. *Cynometroxylon holdeni* (Gupta) comb. nov.

Pl. 3, figs 11-14

1935 *Dipterocarpoxylon holdeni* Gupta
1946 *Cynometroxylon indicum* Chowdhury & Ghosh
1966 *Cynometroxylon indicum* Chowdhury & Ghosh in Ramanujam & Raghu Rama Rao
1967 *Cynometroxylon* cf. *Cynometroxylon indicum* Chowdhury & Ghosh in Prakash
1967 *Cynometroxylon schlagintweitii* Müller-Stoll & Mädel
1971 *Cynometroxylon indicum* Chowdhury & Ghosh in Prakash & Awasthi
1973 *Cynometroxylon indicum* Chowdhury & Ghosh in Prakash
1975 *Cynometroxylon indicum* Chowdhury & Ghosh in Prakash
1978 *Cynometroxylon siwalicus* Trivedi & Ahuja
1978 *Cynometroxylon* sp. cf. *C. indicum* Chowdhury & Ghosh in Prakash

In 1935, Gupta described a fossil wood from the Mio-Pliocene of Burma and named it *Dipterocarpoxylon holdeni* suggesting its affinities with the family Dipterocarpaceae. However, the presence of thick tangential bands of parenchyma and the absence of vertical gum canals and vasicentric tracheids in *Dipterocarpoxylon holdeni* created doubt regarding its resemblance with the woods of Dipterocarpaceae. Though Chowdhury (1938) had questioned the validity of placing this fossil under *Dipterocarpoxylon* yet Chowdhury and Ghosh (1946) failed to notice the marked resemblance between this and the fossil wood of *Cynometroxylon indicum* described by them from Assam. Consequently, the present authors during the course of this investigation examined the type slides as well as original material of *Dipterocarpoxylon holdeni* Gupta from which some more sections were prepared for study. A critical examination of this material revealed that *Dipterocarpoxylon holdeni* does not belong to the family Dipterocarpaceae but exhibits closer similarity with *Cynometroxylon indicum* Chowdhury & Ghosh (1946). While describing *Dipterocarpoxylon holdeni*, Gupta (1935) did not give details regarding the vessel size and the intervascular pitting. Besides, the width of the tangential parenchyma bands and the xylem rays were also wrongly given. It is, therefore, proposed to describe below this fossil wood again before tracing its exact affinities.

Wood diffuse-porous. *Growth rings* not observed. *Vessels* solitary as well as in radial multiples of 2-4, rarely in clusters, evenly distributed, 3-4 per sq mm, medium

TABLE 1

S. No.	Name of the species	Vessels	Parenchyma	Xylem Rays	Fibres
1.	*Cynometroxylon holdeni* (Gupta) comb. nov.	Solitary and in radial multiples of 2-4, t.d. 105-225 μ, r.d. 150-240 μ; perforations simple; intervessel pit-pairs alternate, vestured with linear-lenticular apertures.	Apotracheal bands 2-9 (mostly 3-6) seriate	1-4 (mostly 2-3) seriate, heterogeneous	Libriform, non-septate
2.	*Cynometroxylon indicum* Chowdhury & Ghosh (1946)	Solitary and in radial multiples of 2-5, t.d. 125±6 μ, r.d. 148±8 μ; perforations simple; intervessel pits alternate, bordered, with lenticular-linear apertures.	Apotracheal bands 3-9 cells in thickness	1-3 (mostly 1-2) seriate, heterogeneous	Libriform, non-septate
3.	*Cynometroxylon indicum* Chowdhury & Ghosh (Ramanujam & Raghu Rama Rao, 1965)	Commonly solitary, often in radial multiples of 2 or 3, t.d. 170-230 μ; perforations simple; intervessel pits alternate or opposite, bordered, with lenticular apertures.	Apotracheal bands 4-10 cells thick	1-4 (mostly 1-3) seriate, heterogeneous	Libriform, non-septate
4.	*Cynometroxylon indicum* Chowdhury & Ghosh (Prakash & Awasthi, 1971)	Solitary as well as in radial multiples of 2-4; intervessel pits vestured.	Apotracheal bands 4-6 cells in width	1-3 seriate, heterogeneous	Thick walled, non-septate
5.	*Cynometroxylon indicum* Chowdhury & Ghosh (Prakash, 1973)	Solitary as well as in radial multiples of 2-3, 90-200 μ in diameter; perforations simple; intervessel pit-pairs vestured.	Apotracheal bands 3-9 cells in thickness	1-3 (mostly 2) seriate, heterogeneous	Thick walled, non-septate
6.	*Cynometroxylon* sp. cf. *Cynometroxylon indicum* Chowdhury & Ghosh (Prakash, 1967)	Mostly solitary, sometimes in radial multiples of 2-3 or 4-5 cells, t.d. 60-175 μ, r.d. 75-225 μ; perforations simple; intervessel pit-pairs alternate, bordered with linear apertures, sometimes vestured.	Apotracheal bands 4-12 cells thick	1-2 (mostly 2) seriate, heterogeneous	Thick walled
7.	*Cynometroxylon schlagintweitii* Müller-Stoll & Mädel (1967)	Mostly solitary, sometimes in radial multiples of 2-3, t.d. 50-170 μ, r.d. 65-250 μ; perforations simple; intervessel pit-pairs small, alternate.	Banded, bands 2-5 cells broad	1-2 (-3) (mostly 1-2) seriate, ?homogeneous	Libriform, non-septate
8.	*Cynometroxylon indicum* Chowdhury & Ghosh (Prakash, 1975)	Solitary as well as in radial multiples of 2-4, t.d. 100-210 μ, r.d. 100-225 μ; perforations simple; intervessel pit-pairs alternate, bordered with linear apertures.	Apotracheal bands 2-10, mostly 3-7 cells in thickness	1-3 (mostly 2-3) seriate, heterogeneous	Thick walled, non-septate
9.	*Cynometroxylon siwalicus* Trivedi & Ahuja (1978)	Solitary as well as in radial multiples of 2-4, t.d. 70-120 μ, r.d. 130-175 μ; perforations simple; intervessel pit-pairs alternate, bordered and polygonal.	Paratracheal and apotracheal; paratracheal vasicentric forming 2-3 seriate sheath; apotracheal banded and diffuse.	1-2 (mostly 2) seriate, heterogeneous	Libriform, non-septate
10.	*Cynometroxylon* sp. cf. *Cynometroxylon indicum* Chowdhury & Ghosh (Prakash, 1978)	Solitary as well as in radial multiples of 2-3 or more, t.d. 75-165 μ, r.d. 90-210 μ; perforations simple; intervessel pit-pairs small, alternate, bordered with linear-lenticular apertures, vestured.	Apotracheal bands 2-7 (usually 3-5) cells thick	1-2 seriate, heterogeneous	Libriform, non-septate
11.	*Cynometra polyandra* Roxb.	Solitary as well as in radial multiples of 2-5, sometimes in clusters; perforations simple; intervessel pit-pairs alternate, bordered with linear-lenticular apertures, vestured.	Apotracheal bands 2-13 (mostly (6-9) cells in thickness	1-4 (mostly 2-3) seriate, heterogeneous	Thick walled, non-septate
12.	*Cynometra ramiflora* Linn.	Solitary as well as in radial multiples of 2-5, rarely in clusters; perforations simple; intervessel pit-pairs alternate, bordered with linear-lenticular apertures, vestured.	Apotracheal bands 2-14 (mostly 6-9) cells in thickness	1-4 (mostly 2-3) seriate, rarely partly 5 seriate, heterogeneous	Thick walled, non-septate

to large, t.d. 105-225 μ, r.d. 150-240 μ (Pl. 3, fig. 11); perforations simple; inter-vessel pit-pairs vestured, alternate, hexagonal due to pressure, 4-6 μ in diameter, with linear-lenticular apertures (Pl. 3, fig. 12). *Parenchyma* vasicentric and apotracheal; apotracheal parenchyma in the form of 2-9 (mostly 3-6) seriate, continuous, tangential bands enclosing most of the vessels (Pl. 3, fig. 11), the bands bifurcating at places and joining with similar bands on their upper and lower side. *Xylem rays* 1-4 (mostly 2-3) seriate and up to 85 cells in height; ray tissue heterogeneous, rays made up of both procumbent and upright cells (Pl. 3, figs 13, 14). *Fibres* libriform and non-septate arranged in tangential bands alternating with the bands of parenchyma (Pl. 3, fig. 11).

Structural features of this fossil wood, after extensive comparison, indicate that its closest affinities are with the modern genus *Cynometra* of Leguminosae in which it shows nearest approach to the woods of *Cynometra polyandra* Roxb. and *Cynometra ramiflora* Linn. The similarity can be observed in the important anatomical characters such as diffuse-porous nature of the wood, absence of growth rings, shape, size and distributional pattern of the vessels, broad tangential bands of parenchyma alternating with the bands of fibres of almost same width, 1-4 (mostly 2-3) seriate, heterogeneous xylem rays and thick-walled, non-septate fibres.

Because the fossil wood *Dipterocarpoxylon holdeni* Gupta actually belongs to *Cynometra* and has no resemblance with *Dipterocarpus*, it is desirable that it should be named accordingly. As the organ genus *Cynometroxylon* Chowdhury & Ghosh (1946) is already known which includes the fossil woods of *Cynometra*, it is proposed to transfer the present fossil wood to this genus and name it as *Cynometroxylon holdeni* (Gupta) comb. nov. This now forms the first record of this genus and automatically becomes the genotype.

A survey of the anatomical characters of all the fossil woods referred to *Cynometroxylon indicum* indicates that the woods described by Chowdhury and Ghosh (1946), Prakash and Awasthi (1971), and Prakash (1973, 1975) primarily differ from *Cynometroxylon holdeni* in having only 1-3 seriate xylem rays as against 1-3 rarely 4 seriate xylem rays in the latter (Table 1). Besides, the parenchyma bands as described by Prakash and Awasthi (1971) in their specimen from near Deomali are somewhat thinner, only 4-6 cells in width, as against 2-9 (mostly 3-6) seriate in *Cynometroxylon holdeni* (Gupta). The fossil woods, *Cynometroxylon* sp. cf. *Cynometroxylon indicum* described by Prakash (1967, 1978) from the Tipam sandstones in Assam and the Lower Siwalik beds of Uttar Pradesh, *Cynometroxylon schlagintweitii* Müller-Stoll & Mädel (1967) from Jaipur in Assam and *Cynometroxylon siwalicus* Trivedi & Ahuja (1978) from Kalagarh in the Siwaliks also differ mainly in having 1-2 seriate xylem rays as against 1-3 rarely 4 seriate xylem rays in *Cynometroxylon holdeni* (Gupta) comb. nov. The xylem rays described as homogeneous in *Cynometroxylon schlagintweitii* (Müller-Stoll & Mädel, 1967, p. 131) appear to be heterogeneous in nature as seen in the photograph (Müller-Stoll & Mädel, 1967, pl. 34, fig. 62), of its tangential section. Because the little differences mentioned above in width of the parenchyma bands and the xylem rays and even in the size of the vessels are variable features usually met within the modern woods of the same species, it is proposed to include these woods under a single species *Cynometroxylon holdeni* (Gupta) comb. nov., which has the priority. A detailed study of the anatomical characters in the modern woods of *Cynometra polyandra* and *C. ramiflora* also confirms this observation. It is observed that although the width of the xylem rays in these two species is usually 2-3 seriate, it varies from 1 to 4 seriate and in rare cases it goes even up to 5-seriate. In one wood specimen of *Cynometra polyandra* (F.R.I. slide no. A 5880/8039), the rays are only 1-2 seriate. Similarly, the parenchyma bands which are usually 6-9 cells thick may range from 2-14 cells in thickness.

Another fossil wood, *Cynometroxylon dakshinense* Navale (1959) described from the Cuddalore series near Pondicherry in South India, although possesses 1-2 seriate, heterogeneous xylem rays and 3-6 seriate, concentric parenchyma bands similar to the modern wood of *Cynometra polyandra* but the type slides of this species show on examination a storied structure in the rays not mentioned by the author. This might indicate its resemblance with *Millettia*, *Pongamia* or other anatomically allied genera.

Holotype — Birbal Sahni Institute of Palaeobotany Museum no. 29785.

FAMILY — LECYTHIDACEAE

Genus — *Careyoxylon* Awasthi, 1970

6. *Careyoxylon pondicherriense* Awasthi, 1970

Pl. 3, figs 15, 16

The fossil wood consists of a piece of secondary xylem measuring 6 cm in length and 4 cm in diameter.

Wood diffuse-porous. *Growth rings* not seen. *Vessels* small to large, t.d. 60-200 μ, r.d. 80-300 μ, mostly in radial multiples of 2-5, sometimes in small clusters, 8-10 per sq mm; tyloses present (Pl. 3, fig. 15); perforations simple; intervessel pits large, 10-12 μ in diameter with linear to lenticular apertures. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma scanty as few cells associated with the vessels; apotracheal parenchyma abundant, narrow, mostly uniseriate lines forming a reticulum with the rays (Pl. 3, fig. 15). *Xylem rays* 1-3-(4) seriate with uniseriates rare, up to 50 cells in height; ray tissue heterogeneous with multiseriate rays consisting of procumbent cells through the median thickened portion and 1-several marginal rows of upright cells at the ends (Pl. 3, fig. 16); end to end rayfusion common. *Fibres* thick-walled, nonseptate, 15-20 μ in diameter and 700-1000 μ in length.

As the fossil wood is similar to *Careyoxylon pondicherriense* Awasthi (1970) described from the Cuddalore series of India, it is being assigned to it. *C. pondicherriense* resembles the modern wood of *Careya arborea* Roxb. which occurs wild almost throughout India from Kangra District eastwards, throughout Indian Peninsula and the lower hill forests of Burma (Pearson & Brown, 1932).

Specimen — Birbal Sahni Institute of Palaeobotany Museum no. 1473—P 406.

FAMILY — LYTHRACEAE

Genus — *Lagerstroemioxylon* Mädler, 1939

7. *Lagerstroemioxylon irrawaddiensis* sp. nov.

Pl. 4, figs 17-21

The present species is based on a piece of secondary wood about 10 cm in length and 5 cm in diameter.

Topography — Wood ring-porous (Pl. 4, figs 17, 18). *Growth rings* distinct, demarcated by large spring wood vessels enclosed in parenchymatous tissue (Pl. 4, figs 17, 18). *Vessels* large to small in size, large vessels in the early wood, usually solitary, forming a conspicuous band, 3-(4) pores in width, 3-4 per sq mm, profusely tylosed (Pl. 4, figs 17, 18), abruptly becoming smaller in the late wood, somewhat graded towards the outer portion of the ring (Pl. 4, figs 17, 18). Late wood vessels solitary and in radial multiples of 2-3, usually open, 15-25 per sq mm (Pl. 4, figs 17, 18). *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma well-developed, forming 1-several layered sheath around the vessels in the late wood, often extending laterally to form continuous or interrupted, somewhat wavy, tangential bands up to 6 seriate in width (Pl. 4, figs 17, 18). The bands becoming very broad, 15-20 cells thick, near the beginning of the ring enclosing large spring wood vessels (Pl. 4, fig. 18); apotracheal parenchyma diffuse, present as small groups of cells scattered in the fibrous tissue (Pl. 4, fig. 18). *Xylem rays* fine, 1-2 (mostly 1) seriate (4-seriate at one place), and 2-35 cells or 35-720 μ in height, closely spaced and evenly distributed, 15-20 per mm (Pl. 4, fig. 19); ray tissue homogeneous, rays homocellular, made up of procumbent cells only (Pl. 4, figs 19, 20). *Fibres* aligned in radial rows in between the rays

Elements — Early wood vessels thick-walled, round to oval in cross section when solitary, t.d. 150-350 μ, r.d. 320-480 μ, *late wood vessels* thin-walled, round to oval, t.d. 40-100 μ; r.d. 45-150 μ; vessel members up to 450 μ in length with truncate ends; perforations simple; intervessel pit-pairs vestured, alternate to subopposite, 6-8 μ in diameter, with lenticular apertures (Pl. 4, fig. 21). *Parenchyma cells* thin-walled, rectangular, about 20 μ in diameter, 60 μ in height (Pl. 4, fig. 19); cells crystalliferous. *Ray cells* with beaded appearance in tangential section (Pl 4, fig 19); vertical height of procumbent cells 20-25 μ, radial length 50-100 μ (Pl. 4, fig. 20). *Fibres* semi-libriform with large lumen, septate, polygonal in cross section, 25-30 μ in diameter and 300-600 μ in length; cells crystalliferous.

Affinities — Important anatomical features of the fossil wood indicate its affinities

with the modern wood of *Lagerstroemia* of the family Lythraceae (Metcalfe & Chalk, 1950; Pearson & Brown, 1932; Kribs, 1959). The fossil wood was compared with 13 species of *Lagerstroemia*, viz., *L. villosa* Wall. ex Kurz, *L. tomentosa* Presl, *L. parvifolia* Roxb., *L. lanceolata* Wall., *L. speciosa* (L.) Persl, *L. calyculata* Kurz, *L. gilletii* Wildem., *L. floribunda* Jack, *L. flosregineae* Retz., *L. hypoleuca* Kurz., *L. macrocarpa* Kurz and *L. venusta* Wall. and photographs and published description of some of these and *L. ovalifolia* Teysen. et Binn., *L. piniformis* Koehnne, and *L. subcostata* Koehnne (Lecomte, 1926, pl. 51; Chowdhury, 1932, pl. 5, 1945, p. 12, pl. 1; Pearson & Brown, 1932, pp. 575-597, figs 190-196; Metcalfe & Chalk, 1950, pp. 652-654, fig. 147A, B; Desch, 1957, pp. 307-308, pl. 67, fig. 2; Brazier & Franklin, 1961, p. 51; Kribs, 1959, p. 104, figs 233, 234; Moll & Janssonius, 1914, pp. 585-593, fig. 207; Henderson, 1953, fig. 2(10). The above study revealed that the fossil wood shows closest resemblance with *Lagerstroemia venusta* Wall. The similarity can be observed in almost all the anatomical features. Thus both in the living and fossil wood a distinct ring porosity is present with the growth rings demarcated by tangential bands of large spring wood vessels enclosed in the parenchymatous tissue, vessels are profusely tylosed and the intervessel pit-pairs are vestured. The distribution of parenchyma appears to be almost identical in both as is the structure of fibres. Lastly, the xylem rays in both living as well as fossil species are homogeneous, 1-2 (mostly 1) seriate and about 35 cells in height.

As the fossil wood closely resembles modern wood of *Lagerstroemia*, it has been assigned to the organ genus *Lagerstroemioxylon* Mädler (1939). So far three species of *Lagerstroemioxylon* Mädler are known from India and abroad. These are *Lagerstroemioxylon durum* Mädler (1939) from the Pliocene of Frankfurt in Germany, *L. eoflosreginium* Prakash & Tripathi (1970) from the Tipam sandstones of Assam and the Mio-Pliocene of south-east Asia (Kramer, 1974) and *L. parenchymatosum* Prakash (1965, 1973) from the Tertiary of Burma. All these species are quite different from the present fossil wood in a number of characters. *Lagerstroemioxylon durum* is diffuse-porous, *L. parenchymatosum* is graded porous and *L. eoflosreginium* is ring-porous to semi-ring-porous, while a distinct ring-porous condition is seen in our fossil. The vessels are comparatively smaller in *Lagerstroemioxylon durum* (t.d. 30-170 μ, r.d. 19-170 μ), *L. parenchymatosum* (t.d. 105-270 μ, r.d. 105-370 μ), and *L. eoflosreginium* (t.d. 52-200 μ, r.d. 52-260 μ) than in the fossil wood (t.d. 50-300 μ, r.d. 55-480 μ). Lastly, there is also a remarkable difference in the parenchyma distribution of the fossil wood and the other species of *Lagerstroemioxylon*. Thus, tangential bands of parenchyma are absent in *Lagerstroemioxylon durum* and *L. parenchymatosum*. Such bands are present only in the late wood of *L. eoflosreginium*. However, in the present fossil paratracheal parenchyma forms up to 6 seriate continuous tangential bands in the region of late wood and the bands become very wide, up to 15-20 cells in the region of early wood enclosing large spring wood vessels.

Thus the present fossil is quite distinct from all the species of *Lagerstroemioxylon* and is described here as a new species, *L. irrawaddiensis*, the specific name is after the Irrawaddy Series of Burma which abounds in fossil woods.

The genus *Lagerstroemia* is confined to the Old World and consists of over 50 species of trees and shrubs. The centre of distribution is in south-east Asia, but the genus extends from Madagascar through south-east Asia and East Indies to tropical eastern Australia, China and Japan (Pearson & Brown, 1932, p. 573). Eighteen species occur in south-east Asia, extending to Australia, Burma being the distribution centre of the genus (Hooker, 1879, p. 575). The species *L. venusta* Wall. with which the fossil wood shows maximum resemblance is a rare species of Burma reported from Mellon on the Irrawaddy near Thayet Myoo (Gamble, 1902, p. 371; Hooker, 1879, p. 576).

SPECIFIC DIAGNOSIS

Lagerstroemioxylon irrawaddiensis sp. nov.

Wood ring porous. *Growth rings* distinct, delimited by parenchyma and the large spring wood vessels. *Vessels* large to small, large in the early wood, round to oval, t.d. 150-350 μ, r.d. 320-480 μ, usually

solitary, forming conspicuous bands 3-(4) pores in width, 3-4 per sq mm, heavily tylosed; late wood vessels solitary and in radial multiples of 2-3, round to oval, t.d. 40-100 μ, r.d. 45-150 μ, 15-20 per sq mm; vessel members up to 450 μ in length with truncate ends; perforations simple; intervessel pit-pairs vestured, alternate to subopposite, 6-8 μ in diameter, polygonal in shape with lenticular apertures. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma forming 1-several layered sheath around the vessels, extending laterally to form continuous or interrupted, somewhat wavy tangential bands up to 6 seriate in width in the late wood; bands becoming very broad, 15-20 cells thick near the beginning of the ring enclosing large spring wood vessels; apotracheal parenchyma diffuse, present as small groups of cells scattered in the fibrous tissue; parenchyma cells thin-walled, about 20 μ in diameter and 60 μ in height. *Xylem rays* 1-2 (mostly 1) seriate, 2-35 cells or 35-720 μ in height, 15-20 per mm; ray tissue homogeneous, rays made up of procumbent cells only. *Fibres* polygonal in cross section, semilibriform with large lumen, septate, 25-30 μ in diameter and 300-600 μ in length; cells crystalliferous.

Holotype — Birbal Sahni Institute of Palaeobotany Museum no. 1475-P 350 A.

REFERENCES

AWASTHI, N. (1970). On the occurrence of two new fossil woods belonging to the family Lecythidaceae in the Tertiary rocks of South India. *Palaeobotanist*, **18** (1): 67-74.

AWASTHI, N. (1974). Occurrence of some dipterocarpaceous woods in the Cuddalore Series of South India. *Palaeobotanist*, **21** (3): 339-351.

BRAZIER, J. D. & FRANKLIN, G. L. (1961). Identification of hard woods. A microscope key. *Forest Prod. Res. Bull.*, **46**: 1-96.

CHOWDHURY, K. A. (1932). The identification of important Indian sleeper woods. *Forest Bull. Econ. Series, Calcutta*, **77**: 1-18.

CHOWDHURY, K. A. (1938). Two fossil dicotyledonous woods from the Garo Hills, Assam. *Rec. geol. Surv. India*, **73**: 247-266.

CHOWDHURY, K. A. & GHOSH, S. S. (1946). On the anatomy of *Cynometroxylon indicum* gen. et sp. nov., a fossil dicotyledonous wood from Nailalung, Assam. *Proc. Natn. Inst. Sci. India*, **12** (8): 435-447.

CHOWDHURY, K. A. & GHOSH, S. S. (1958). *Indian Woods, Their Identifications Properties and Uses*. Delhi.

CHOWDHURY, K. A. & TANDON, K. N. (1964). A fossil wood of *Terminalia tomentosa* W. & A. from the Tertiary of Burma. *Ann. Bot. N.S.*, **28** (111): 445-450.

COULTER, J. M. & CHAMBERLAIN, C. J. (1955). *Morphology of Gymnosperms*. Allahabad.

DEN BERGER, L. G. (1923). Fossiele houtsoorten uit het Tertiar van Zuid-Sumatra. *Verh. geol Mijnb. Gen. Ned.*, **7**: 143-148.

DEN BERGER, L. G. (1927). Unterscheidungsmerk male von rezenten und fossilen Dipterocarpaceen gattungen. *Bull. Jard. bot. Buitenz.*, Ser. 3, **8**: 495-498.

DESCH, H. E. (1941). Dipterocarp timbers of the Malay Peninsula. *Malay. Forest Rec.*, **14**: 1-171.

DESCH, H. E. (1957). Manual of Malayan timbers. I. *Malay. Forest Rec.*, **15**: 1-328.

EYDE, R. H. (1963). A *Shoreoxylon* and two other Tertiary woods from the Garo Hills, Assam. *Palaeobotanist*, **11** (1-2): 115-121.

FLORIN (1963). The distribution of conifer and taxad genera in time and space. *Acta Hort. Bergiani*, **20** (4): 121-312.

GAMBLE, J. S. (1902). *A Manual of Indian Timbers*. London.

GHOSH, S. S. & PURKAYASTHA, S. K. (1963). Family Anacardiaceae, in: *Indian Woods*, **2**: 264-323. Dehra Dun.

GUPTA, K. M. (1935). A review of the genus *Dipterocarpoxylon* of Holden, with description of a new species *D. holdeni* from the Irrawady System of Burma. *Proc. Indian Acad. Sci.*, **1** (10): 633-639.

GUPTA, K. M. (1936). *Leguminoxylon burmense* gen. et sp. nov.— a dicotyledonous wood from the Tertiary of Burma. *Proc. 23rd Ind. Sci. Congress, Indore*, **4**: 304-305.

HENDERSON, F. Y. (1953). An atlas of end grain photomicrographs for the identification of hard woods. *Forest Prod. Res. Bull.*, **26**. London.

HOOKER, J. D. (1879). *The Flora of British India*, Vol. **2**. London.

KRAMER, K. (1974). The Tertiary woods of Southeast Asia (Dipterocarpaceae excluded). Part 1. *Palaeontographica*, **144B**: 45-81.

KRAUS, G. (In SCHIMPER, W. PH.) (1870). Triate de Paleontologie vegetable Ou La Flore du monde primitif dans ses rapports avec les formations geologiques et la flore du monde actuel — Paris, *J. B. Bailliere et Fils, Paris*

KRIBS, D. A. (1959). *Commercial Foreign Woods of the American Market*. Pennsylvania.

LECOMTE, H. (1926). *Les bois de L'Indochine*. Paris.

MÄDLER, K. (1939). Die Pliozane flora von Frankfurt am Main. *Abh. Senckenb. naturforsch. Ges.*, **446**: 1-202.

METCALFE, C. R. & CHALK, L. (1950). *Anatomy of the Dicotyledons*. Vols **1** & **2**. Oxford.

MOLL, J. W. & JANSSONIUS, H. H. (1914). *Mikrographie des holzes der auf Java vorkommenden Baumarten*. Vol. **3**. Leiden.

MÜLLER-STOLL, W. R. & MÄDEL, E. (1967). Die fossilen Legumonosen-Hölzer. Eine Revision der mit Leguminosen verglichenen fossilen hölzer und

beschreibungen älterer und neur arten. *Palaeontographica*, **119B**: 95-174.

NAVALE, G. K. B. (1959). Occurrence of fossil *Cynometra* from the Cuddalore Series near Pondichery, India. *Palaeobotanist*, **7** (1): 6-11.

NAVALE, G. K. B. (1963). Some silicified dipterocarpaceous woods from Tertiary beds of the Cuddalore Series near Pondicherry, India. *Palaeobotanist*, **11** (1-2): 66-81.

PEARSON, R. S. & BROWN, H. P. (1932). *Commercial Timbers of India*. Vols **1** & **2**. Calcutta.

PRAKASH, U. (1965a). Fossil wood of Dipterocarpaceae from the Tertiary of Burma. *Curr. Sci.*, **34** (8): 254-255.

PRAKASH, U. 1965b). Fossil wood of *Lagerstroemia* from the Tertiary of Burma. *Curr. Sci.*, **34** (16): 484-485.

PRAKASH, U. (1967). Fossil woods of *Cassia* and *Cynometra* from the Tertiary beds of Mikir Hills, Assam. *Pub. Cent. Adv. study geol.*, **3**: 93-100. Panjab Univ., Chandigarh.

PRAKASH, U. (1973). Fossil woods from the Tertiary of Burma. *Palaeobotanist*, **20** (1): 48-70.

PRAKASH, U. (1975). Fossil woods from the Lower Siwalik beds of Himachal Pradesh, India. *Palaeobotanist*. **22** (3): 192-210.

PRAKASH, U. (1978). Fossil woods from the Lower Siwalik beds of Uttar Pradesh, India. *Palaeobotanist*, **25**: 376-392.

PRAKASH, U. & AWASTHI, N. (1970). Fossil woods from the Tertiary of eastern India. 1. *Palaeobotanist*, **18** (1): 32-44.

PRAKASH, U. & AWASTHI, N. (1971). Fossil woods from the Tertiary of eastern India. 11. *Palaeobotanist*, **18** (3): 219-225.

PRAKASH, U. & TRIPATHI, P. P. (1969). Fossil woods of Leguminosae and Anacardiaceae from the Tertiary of Assam. *Palaeobotanist*, **17** (1): 22-32.

PRAKASH, U. & TRIPATHI, P. P. (1970). Fossil woods from the Tertiary of Hailakandi, Assam. *Palaeobotanist*, **18** (1): 20-31.

RAMANUJAM, C. G. K. & RAO, M. R. R. (1966). On the occurrence of *Cynometroxylon indicum* Chowdhury & Ghosh from the Cuddalore sandstone series. *Curr. Sci.*, **35** (6): 158-159.

RAMANUJAM, C. G. K. & RAO, M. R. R. (1967). A new species of *Shoreoxylon*, *S. krauseli* sp. nov., from the Tertiary of South India. *Curr. Sci.*, **36** (6): 439-441.

RAMANUJAM, C. G. K. & RAO, M. R. R. (1969). *Shoreoxylon kraeuseli* sp. nov. a new dipterocarpaceous wood from the Cuddalore Series of South India. *J. Sen. Memorial Volume*. Bot. Soc. Beng. Calcutta: 253-258.

SAHNI, B. (1964). *Revision of Indian Fossil Plants* — Pt. III. *Monocotyledons*. Birbal Sahni Institute of Palaeobotany, Lucknow.

SCHWITZER, H. J. (1958). Die fossilen Dipterocarpaceen-Holzer. *Palaeontographica*, **105B**: 1-66.

TRIVEDI, B. S. & AHUJA, M. (1978). *Cynometroxylon siwalicus* n. sp. from the Siwalik range. *Curr. Sci.*, **47** (17): 638-639.

EXPLANATION OF PLATES

PLATE 1

1. *Araucarioxylon* sp. — Cross section showing sharply distinguished late wood and early wood zone. × 30. Slide no. 5530.
2. *Araucarioxylon* sp.— Cross section magnified to show early wood tracheids and the xylem rays. × 65. Slide no. 5530.
3. *Araucarioxylon* sp.— Tangential longitudinal section showing uniseriate, homogeneous xylem rays. × 100. Slide no. 5532.
4. *Shoreoxylon irrawaddiensis* sp. nov.— Radial longitudinal section showing structure of the xylem rays. × 70. Slide no. 5533.
5. *Shoreoxylon irrawaddiensis* sp. nov.— Cross section showing shape, size and distribution of the vessels, paratracheal and apotracheal parenchyma, xylem rays and tangential rows of gum canals. Note short tangential lines of apotracheal parenchyma. × 30. Slide no. 5534.

PLATE 2

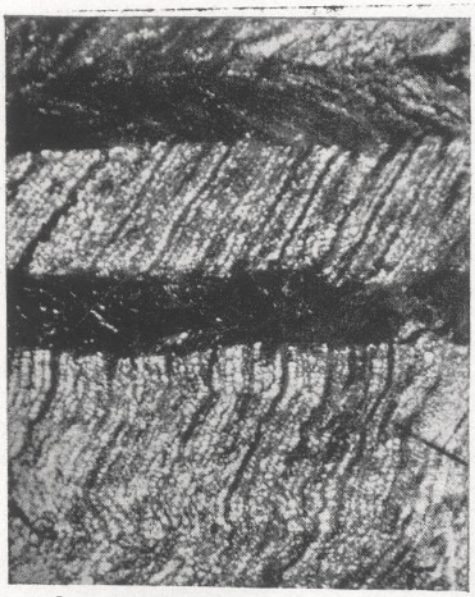
6. *Shoreoxylon irrawaddiensis* sp. nov.— Tangential longitudinal section showing weakly heterogeneous xylem rays and parenchyma. × 55. Slide no. 5535.
7. *Swintonioxylon hailakandiense* Prakash & Tripathi — Cross section showing shape, size and distribution of the vessels, paratracheal and apotracheal parenchyma. × 45. Slide no. 5536.
8. *Swintonioxylon hailakandiense* Prakash & Tripathi — Tangential longitudinal section to show the xylem rays. × 100. Slide no. 5537.
9. *Albizinium eolebbekianum* Prakash — Cross section showing shape, size and distribution of the vessels and aliform parenchyma. × 30. Slide no. 5538.
10. *Albizinium eolebbekianum* Prakash — Tangential longitudinal section showing short, homogeneous xylem rays. × 90. Slide no. 5539.

PLATE 3

11. *Cynometroxylon holdeni* (Gupta) comb. nov.— Cross section showing shape, size and distribution of vessels and alternate, tangential bands of parenchyma and fibres. × 30. Slide no. 5540.
12. *Cynometroxylon holdeni* (Gupta) comb. nov. — Intervessel pit-pairs. × 215. Slide no. 5541.
13. *Cynometroxylon holdeni* (Gupta) comb. nov. — Tangential longitudinal section showing xylem rays. × 100. Slide no. 5541.
14. *Cynometroxylon holdeni* (Gupta) comb. nov.— Radial longitudinal section. × 90. Slide no. 5542.
15. *Careyoxylon pondicherriense* Awasthi — Cross section showing shape, size and distribution of vessels and lines of apotracheal parenchyma. × 30. Slide no. 5543.
16. *Careyoxylon pondicherriense* Awasthi — Tangential longitudinal section showing xylem rays. × 65. Slide no. 5544.

PLATE 4

17. *Lagerstroemioxylon irrawaddiensis* sp. nov.— Cross section showing ring-porous nature of the fossil wood. Note the difference in the size of the early wood vessels and the late wood vessels. × 17. Slide no. 5545.
18. *Lagerstroemioxylon irrawaddiensis* sp. nov.— Cross section magnified to show large early wood vessels and small late wood vessels as well as paratracheal and apotracheal parenchyma. × 30. Slide no. 5545.
19. *Lagerstroemioxylon irrawaddiensis* sp. nov.— Tangential longitudinal section showing uniseriate, homogeneous xylem rays and parenchyma. ×125. Slide no. 5546.
20. *Lagerstroemioxylon irrawaddiensis* sp. nov.— Radial longitudinal section showing homogeneous xylem rays. × 100. Slide no. 5547.
21. *Lagerstroemioxylon irrawaddiensis* sp. nov.— Intervessel pit-pairs. × 400. Slide no. 5546.



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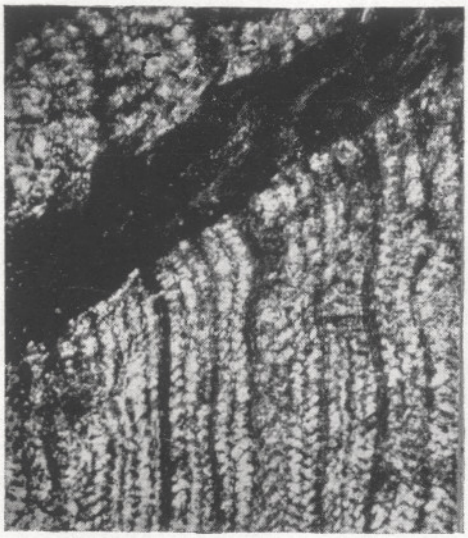

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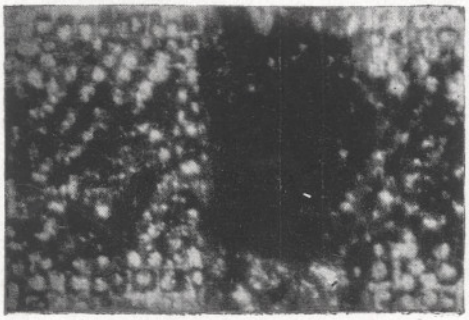

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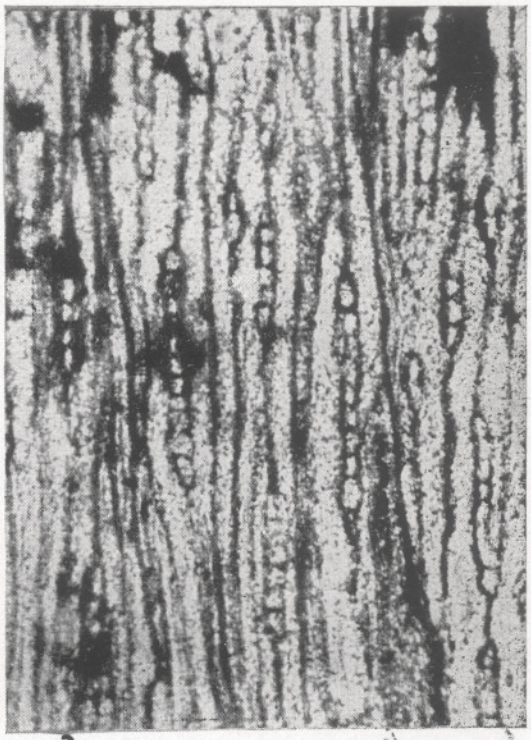

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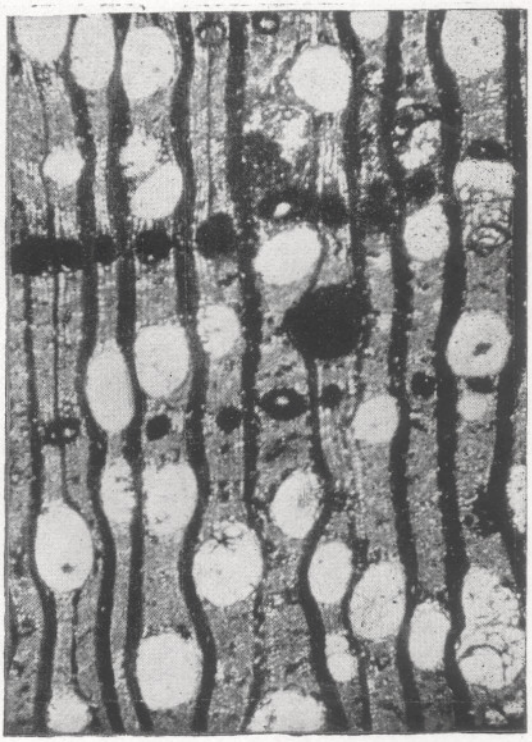

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PLATE 1

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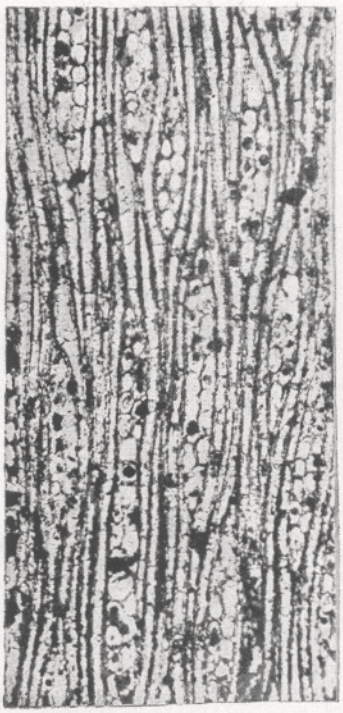

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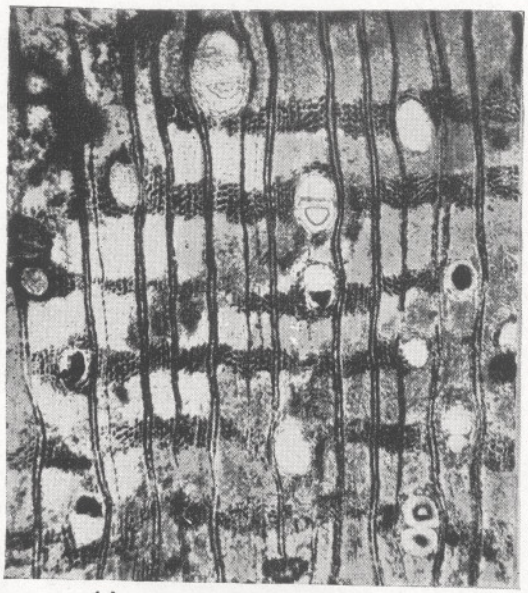
PLATE 2



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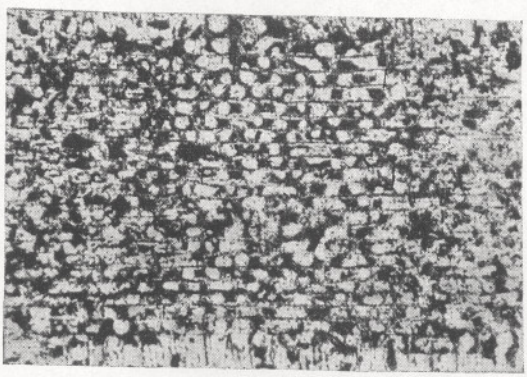

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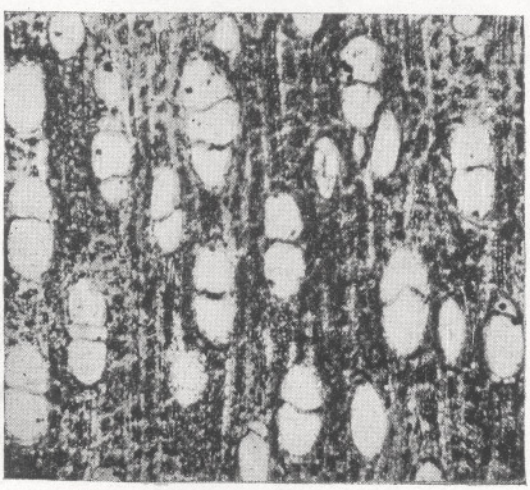

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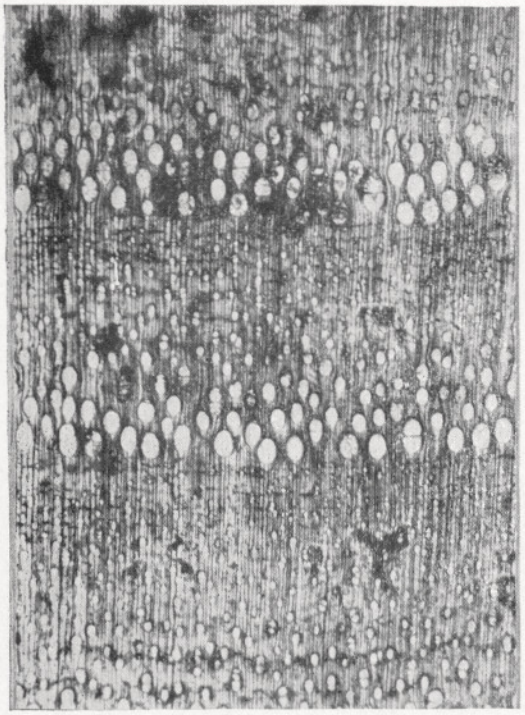
PLATE 3



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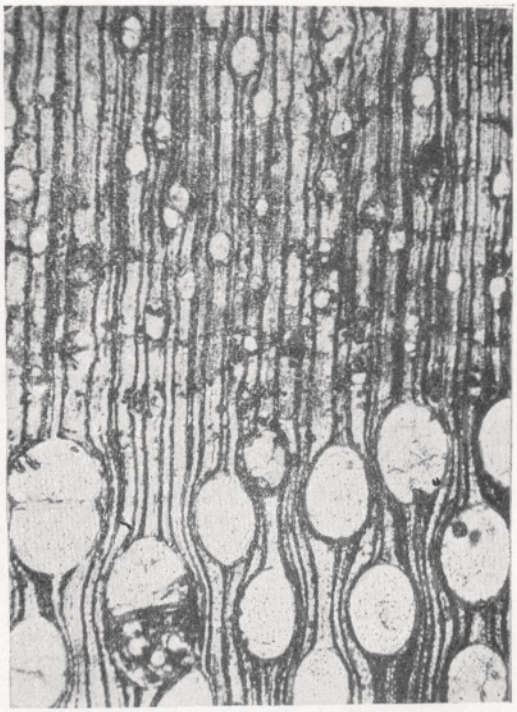

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PLATE 4