FOSSIL WOODS FROM THE TIPAM SANDSTONES NEAR HAILAKANDI, ASSAM

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ABSTRACT

Fossil woods resembling those of *Diospyros-Maba* and *Anisoptera* are described here from the Tipam sandstones near the town of Hailakandi, district Cachar, Assam. These woods are noteworthy owing to their fine structural preservation and from the standpoint of their palaeogeographical distribution. Although *Diospyros-Maba* is presently found in the region of Assam, no *Anisoptera* now grows in India proper.

INTRODUCTION

THE present study is concerned with the description and interpretation of fossil woods resembling *Diospyros-Maba* and *Anisoptera* belonging to the families Ebenaceae and Dipterocarpaceae. These woods were collected by the second author in March, 1966, from the newly discovered localities of Kartikcherra (24° 20′N; 92°31′E) and Sultanicherra (24°18′N; 92°33′E) near the town of Hailakandi, district Cachar, Assam. Besides these, fossil woods of *Adenanthera*, *Swintonia* (PRAKASH & TRIPATHI, 1969a) and *Gluta-Melanorrhoea* (PRAKASH & TRIPATHI, 1969b) are some more forms recently known from near the town of Hailakandi.

The age of the fossil woods is Upper Miocene being derived from the Tipam sandstones exposed at the fossil localities of Kartikcherra and Sultanicherra in Rath Tila (EVANS, 1932).

The preservation of the structural details of the fossil woods is fairly good.

SYSTEMATIC DESCRIPTION

Family — EBENACEAE

Genus — *Ebenoxylon* Felix, 1882

1. *Ebenoxylon kartikcherrense* sp. nov.

Topography — Wood diffuse-porous (PL. 1, FIG. 1). *Growth rings* indistinct. *Vessels* visible to the naked eye, moderately small to moderately large, majority solitary and in short radial rows of 2-5 (mostly 2-3) (PL. 1, FIG. 1), 5-7 per sq. mm., tylosed, sometimes with black deposits probably of gum. *Parenchyma* paratracheal and apotracheal (PL. 1 FIG. 1); paratracheal parenchyma scanty, occurring as few cells adjacent to some of the vessels; apotracheal parenchyma in irregular, concentric, somewhat close, 1-2 (mostly 1) seriate lines, occasionally forking or ending blindly; 5-7 bands per mm. *Xylem rays* not visible to the naked eye, distinct under the microscope, fine, 1-3 (mostly 1) seriate (PL. 1, FIG. 3), rarely triseriate and 12-50 μ in width, 3-30 cells and 80-980 μ high; 15-20 rays per mm.; ray tissue heterogeneous (PL. 2, FIG. 5); rays heterocellular consisting of procumbent cells in the middle part and upright cells at one or both ends. *Fibres* distinctly aligned in radial rows.

Elements — Vessels thin walled, the walls 5-6 μ thick, t.d. 80-180 μ, r.d. 92-240 μ, round to oval when solitary and well preserved, sometimes irregular in shape due to pressure during fossilization, those in radial multiples generally flattened at the places of contact; vessel-members medium sized, 100-600 μ long, with truncated or abruptly tailed ends; perforations simple; intervessel pit-pairs small, 5-6 μ in diameter, alternate, orbicular to oval, with broad border and short, lenticular orifices (PL. 2, FIG. 6); vessel-ray and vessel-parenchyma pits not preserved. *Parenchyma cells* thin-walled, 8-10 μ in diameter and 20-30 μ in length. *Ray cells* thin-walled, tangential height of procumbent cells 10-18 μ, radial length 44-96 μ; upright cells 30-40 μ in tangential height and 14-22 μ in radial length; ray cells crystalliferous. *Fibres* libriform with small lumen, the walls 3-4 μ thick, non-septate, angular in shape, 20-32 μ in diameter, 1000-1620 μ in length; inter fibre pits not preserved.

AFFINITIES AND DISCUSSION

Comparison with Modern Woods — In the present fossil wood, the parenchyma is

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scanty paratracheal and in fine, 1-2 (mostly 1) seriate, close, concentric lines, occasionally forking or ending blindly. Taking this feature into consideration, the fossil wood shows resemblance with the modern woods of some genera of the families Annonaceae, Apocynaceae, Euphorbiaceae, Ebenaceae, Crypteroniaceae, Malvaceae, Sterculiaceae, Tiliaceae, Rubiaceae, and Sapotaceae (PEARSON & BROWN, 1932; METCALFE & CHALK, 1950).

However, the families Malvaceae, Sterculiaceae, Tiliaceae, and Annonaceae can be distinguished from the present fossil wood in possessing generally broader xylem rays, besides having semi-ring to ring-porous wood structure (METCALFE & CHALK, 1950, p. 1350). The families Rubiaceae, Apocynaceae, Euphorbiaceae, and Crypteroniaceae differ also from the present fossil wood in having vestured intervessel pit-pairs. The family Sapotaceae can also be discarded as it possesses vasicentric tracheids, which are not to be seen in the present fossil wood. Now, it is with the family Ebenanceae that the present fossil wood shows resemblance. Considering all the other important features of the fossil wood, viz. vessels moderately small to moderately large; perforations simple; inter vessel pit-pairs small, 5-6 μ in diameter, alternate with broad border and short, lenticular apertures; xylem rays 1-3 (mostly 1) seriate, heterocellular with ray cells crystalliferous; and fibres libriform, and non-septate, it shows close resemblance with the modern woods of the genera *Diospyros* and *Maba* of the family Ebenaceae (PEARSON & BROWN, 1932, pp. 689-708; METCALFE & CHALK, 1950, pp. 880-885; DESCH, 1957, pp. 148-152).

Thin sections of 40 species of *Diospyros* and 3 species of *Maba* were studied in detail at the Forest Research Institute, Dehra Dun, in order to find out the nearest comparable species within these genera. Besides, the present fossil wood was also compared with the published description and photographs of a number of species of *Diospyros* (KANEHIRA, 1924, pp. 41-42, FIG. 10; LECOMTE, 1926, PL. 61; PEARSON & BROWN, 1932, pp. 693-697, 700-708, FIGS. 224-225, 227-229; CHOWDHURY, 1945, PL. 29; METCALFE & CHALK, 1950, pp. 883-885, FIGS. 204ABGEFH; HENDERSON, 1953, p. 24, FIGS. 98A, 98B, 98C, 99; DESCH, 1957, pp. 150-151, PL. 46, FIG. 1, TABLE 25; KRIBS, 1959, pp. 37-38, FIGS. 127-129, 358; NORMAND, 1960, PL. 143-145; BRAZIER & FRANKLIN, 1961, pp. 34, 38, 39, FIG. 359) and with a single species of *Maba*, *M. buxifolia* Persoon (KANEHIRA, 1924, pp. 40-41).

From the above study, it is seen that the genera *Diospyros* and *Maba* are so similar in their anatomical features that it is rather difficult to separate them. However, the present fossil wood shows closest resemblance with the wood of *Diospyros ehretioides* Wall. with which it resembles in almost all the anatomical features. The only observable difference between the two is in the frequency of the biseriate rays which is slightly more in the modern species than in the present fossil wood.

Comparison with the Fossil Woods

There are only 15 species of fossil woods belonging to the family Ebenaceae, most of which have been compared with the genera *Diospyros* and *Maba*. Most of these have been described under the form genus *Ebenoxylon* Felix (1882) and are as shown in Table 1.

From the study of the published description and photographs of the above species, it is concluded that the present fossil wood differs from all these known species of fossil woods showing affinities with the woods of *Diospyros* and *Maba*. The only similar species *Ebenoxylon indicum* Ghosh & Kazmi (1958b) from the Tirap Frontier Division, NEFA, in India, also differs from the present fossil wood in having large vessels (t.d. 82-225 μ, r.d. 164-328 μ) and in homogeneous xylem ray tissue. Here, it may be pointed out that because of the homogeneous ray tissue in *Ebenoxylon indicum*, the affinities of this species are not with the family Ebenaceae, but should be searched among other dicotyledonous families.

As the present fossil wood differs from all the known fossil species enumerated above, it is being placed under a new species of *Ebenoxylon* Felix (1882) and specifically named as *Ebenoxylon kartikcherrense* sp. nov., the specific name indicating its place of occurrence in Assam.

Present Distribution of *Diospyros* Linn. & *Maba* Forst.

The genus *Diospyros* Linn. consists of about 500 species (WILLIS, 1966, p. 360)

TABLE 1

Name of species	*Age*	*Locality*	*Modern Equivalents*
1. *Ebenoxylon ebenoides* Schenk, 1880	Upper Cretaceous	Libyan desert	*Royena*
2. *E.diospyroides* Felix, 1882	Tertiary	Antigua	*Diospyros discolor* & *D. virginiana*
3. *E.tenax* Beck, 1886	Oligocene	Saxony	*Diospyros ebenum*
4. *E.tunetanum* (Fliche) Edwards, 1931	Pliocene	Tunisia	*Royena*
5. *Ebenoxylon* sp. Flische, 1898	Tertiary	Myrtilene (Orthymnos)	*Royena*
6. *E.boreale* Platen, 1908	Tertiary (Oligocene)	Alaska	—
7. *E.speciosum* Platen, 1908	Tertiary	California	*Diospyros*
8. *E.aegyptiacum* Krausel, 1939	Tertiary	Egypt	*Diospyros* & *Maba*
9. *E.knollii* Hofmann, 1944	Oligocene	—	*Diospyros ebenum*
10. *E.hofmannae* Greguss, 1956	Oligocene	—	—
11. *E.indicum* Ghosh & Kazmi, 1958a	Tertiary	Namsang river in Tirap Frontier Division, NEFA	*Diospyros* and *Maba*
12. *Diospyros* sp. (Schonfeld, 1925)	Tertiary	Germany	—
13. *Diospyros* sp. (Slijper, 1932)	Pliocene	Holland	*Diospyros*
14. *D.washingtoniana* Prakash & Barghoorn, 1961	Miocene	Columbia Basalts of Central Washington	*Diospyros virginiana*
15. *Diospyroxylon* cf. *ebenaster* (Greguss, 1967)	Miocene	Ipolytarnoc, Hungary,	*Diospyros ebenaster*

chiefly tropical and widely distributed in both the hemispheres, a few species extending beyond the tropics into eastern North America, eastern Asia, south-western Asia, and Mediterranean region. The genus attains its best development in the Indo-Malayan region (PEARSON & BROWN, 1932, p. 690). The species *Diospyros ehretioides* Wall. with which the present fossil wood shows nearest resemblance, grows in deciduous forests, all over Burma, upto 910 metres (GAMBLE, 1902, p. 457). In relation to the geographic locale of the fossil, the nearest tree species of *Diospyros* are *D. montana* Roxb., *D. toposia* Ham., *D. nigricans* Wall. and *D. pilosula* Wall. which grow in Cachar, Lushai Hills, Sylhet, Sibsagar, Lakhimpur, and Khasi & Jantia Hills.

On the other hand, the genus *Maba* Forst. consists of 8 species (GAMBLE 1902, p. 452). Of these only four species grow in India. *Maba buxifolia* Pres. grows in Orissa, North Circars, Deccan and Carnatic, in dry evergreen forests or along water courses frequently dry; dry region of Ceylon and Upper Tennasserim in Burma. *Maba andamanica* Kurz grows in upper mixed forests of the Andaman Islands. *Maba nigrescens* Dalz. grows in evergreen forests of the Konkan and North Kanara, common near Nilkund and Gairsoppa (GAMBLE, 1902, pp. 452-453). *Maba cacharensis* Das et Kanjilal, grows in Cachar, Khasi Hills and Lakhimpur (KANJILAL, DAS, KANJILAL & DE, 1931, pp. 200-208).

SPECIFIC DIAGNOSIS

Ebenoxylon kartikcherrense sp. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* moderately small to moderately large, t.d. 80-180 μ, r.d. 92-240 μ, round to oval in cross section, majority solitary, and in short radial rows of 2-5 (mostly 2-3); 5-7 vessels per sq. mm., tylosed; vessel-members 100-600 μ in length, with truncated or abruptly tailed ends; perforations simple; intervessel pit-pairs, small, 5-6 μ in diameter, orbicular to oval, with broad border and short, lenticular orifices. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma scanty; apotra-

cheal parenchyma in close, concentric, fine, 1-2 (mostly 1) seriate lines, occasionally forking or ending blindly; 5-7 lines per mm. *Xylem rays* fine, 1-3 (mostly 1) seriate and 12-15 μ in width, 3-30 cells and 80-980 μ high, 15-20 rays per mm.; ray tissue heterogeneous; rays heterocellular consisting of procumbent cells in the median thickened portion and upright cells at one or both the ends; crystals present in both the upright and procumbent cells. *Fibres* libriform, the walls 3-4 μ thick, non-septate, angular in shape, 1000-1620 μ in length; interfibre pits not preserved.

Material — A single piece of mature, secondary xylem measuring 5 cm. in length and 3 cm. in diameter.

Holotype — B.S.I.P. Museum No. 33926.

Locality — Kartikcherra (24°20′N; 92°31′ E) about 38 km. in the south-west of Hailakandi, district Cachar, Assam.

Family — DIPTEROCARPACEAE

Genus — *Anisopteroxylon* Ghosh & Kazmi, 1958a

2. *Anisopteroxylon garoense* (Chowdhury) com. nov.

Topography — Wood diffuse-porous (PL. 2, FIG. 7). *Growth rings* indistinct. *Vessels* visible as minute dots to the naked eye, medium-sized or moderately large, mostly solitary, rarely in short radial rows of 2-3 (PL. 2, FIG. 7), evenly distributed without any definite pattern, 8-12 per sq. mm., occasionally contiguous with the rays on one or both the sides; tyloses sparsely present (PL. 2, FIG. 9). *Tracheids* paratracheal, not clearly distinct in cross section, visible only in longitudinal sections. *Parenchyma* paratracheal and apotracheal (PL. 2, FIGS. 7, 9); paratracheal parenchyma scanty to vasicentric, forming 1-3 (mostly 2) cells thick sheath around the vessels (PL. 2, FIGS. 7, 9), often interrupted by the tracheids; apotracheal parenchyma diffused, sometimes forming distinct lines, occasionally occurring as short bands surrounding the gum ducts (PL. 2, FIGS. 7, 9). *Xylem rays* not visible to the naked eye, distinct with a hand lens on the cross surface of the wood, very fine to moderately broad, 1-8 (mostly 5-6) cells and 16-105 μ broad, 5-12 per mm. (PL. 2, FIG. 10); ray tissue heterogeneous (PL. 2, FIG. 11); uniseriate rays, 2-15 cells and 92-380 μ high, 16-36 μ wide, homocellular, consisting only of upright cells; multiseriate rays, 2-8 seriate, 16-105 μ in width, 6-30 cells and 180-1350 μ in height, heterocellular (PL. 2, FIG. 11), consisting of procumbent cells in the middle thickened portion with frequent sheath cells at the flanks and with 1-8 marginal rows of upright cells at one or both the ends (PL. 2, FIG. 10). *Fibres* irregularly arranged in between two consecutive rays. *Gum ducts* normal, vertical, mostly solitary, rarely in short tangential rows of 2-3 (PL. 2, FIG. 7).

Elements — Vessels thick walled, the walls 5-10 μ thick, t.d. 108-255 μ, r.d. 140-360 μ, round to oval, (PL. 2, FIGS. 7, 9), those in radial groups flattened at the places of contact; vessel-members 350-750 μ long and truncated or tailed ends; perforations simple; intervessel pit-pairs could not be seen; vessel-parenchyma and vessel-ray pits not preserved. *Tracheids* 20-25 μ in diameter and 60-100 μ in length; pits arranged in vertical rows (PL. 2, FIG. 8), small, bordered, round to oval with lenticular, horizontal appertures. *Parenchyma cells* thin walled, 8-16 μ in diameter and 20-80 μ in length. *Ray cells* thin walled; procumbent cells oval to round in tangential longitudinal section; tangential height of procumbent cells 16-32 μ, radial length 50-100 μ; upright cells 24-44 μ in tangential height and 13-19 μ in radial length; sheath cells with t.d. 16-20 μ, r.d. 18-24 μ. *Fibres* thick to very thick walled, the walls 8-12 μ thick, non-septate, angular in shape, 20-30 μ in diameter, 700-1600 μ in length; interfibre pits indistinct. *Gum ducts* thick walled, walls 4-6 μ thick, t.d. 40-55 μ, r.d. 51-70 μ.

AFFINITIES AND DISCUSSION

Comparison with the Modern Woods — The presence of normal, vertical gum canals in the fossil wood under investigation, is one of the most important diagnostic features. Among the dicotyledons, 65 families only possess normal, vertical gum canals (METCALFE & CHALK, 1950, pp. 1348-1349 and 1353). Besides the gum canals, the fossil wood is also characterized by the medium-size to large (t.d. 108-255 μ), mostly solitary vessels with simple perforations, vasicentric tracheids, scanty to vasicentric, and diffuse and diffuse-in-aggregate parenchyma, 1-8 seriate, heterocellular xylem rays and thick walled, non-septate fibres. All these

TABLE 2 — SHOWING IMPORTANT ANATOMICAL CHARACTERS OF THE FOSSIL WOODS OF *ANISOPTEROXYLON* GHOSH AND KAZMI

Name of the fossil species	Growth rings	Vessels	Tracheids	Parenchyma	Xylem rays	Fibres	Vertical gum ducts	Locality	Age
1. *Anisopteroxylon bengalensis* Ghosh and Kazmi, 1958b	Absent	Diffuse, medium-sized to large, t.d. 96-210μ, r.d. 210-406μ, mostly solitary, oval in shape, tylosed	Vasicentric	Paratracheal and apotracheal; paratracheal parenchyma scanty to vasicentric in 2-3 rows of cells; apotracheal parenchyma diffuse to diffuse-in-aggregate, forming irregular or broken reticulum in the fibrous ground tissue and also around the gum ducts	1-6 seriate; ray tissue heterogeneous; the uniseriate rays homocellular, consisting mostly of upright cells; the multiseriate rays 4-6 cells and 61-98μ in width, 19-59 cells and 546-1386μ in height, hetero-cellular, consisting of large cells at both the ends and small procumbent cells in the middle with a row of upright or large cells simulating sheath cells also occurring on the flanks of the rays	Non-libriform, nonseptate	Very scanty, distributed irregularly, oval in shape, t.d. 60-77μ, r.d. 126-168μ	Birbhanpur, near Durgapur in Damodar Valley, West Bengal	Tertiary
2. *Anisopteroxylon jawalamukhi* Ghosh & Ghosh, 1958	Absent	Diffuse, moderately large to very large, t.d. 154-300μ, r.d. 196-492μ, usually solitary, occasionally in short radial multiples of 2-3, round to oval in shape, tylosed	Vasicentric	Paratracheal and apotracheal; paratracheal parenchyma vasicentric in narrow 2-3 seriate sheath; apotracheal parenchyma diffuse to diffuse-in-aggregate and also forming multilayered sheath surrounding the gum ducts	1-7 seriate; ray tissue heterogeneous; the uniseriate rays not very common, 4-9 cells and 168-552μ in height, homocellular, consisting of upright cells; the multiseriate rays 2-7 cells and 42-133 μ in width, 15-67 cells and 458-1946μ in height, heterocellular, consisting of large cells at both the ends and small procumbent cells in the middle portion, with sheath like cells on the flanks	Non-libriform, non-septate and round in shape	Scanty, mostly solitary, rarely 2-3 in tangential rows, round to oval in shape, t.d. 98-168μ, r.d. 125-224μ.	Village Khundian north of Jawalamukhi, Kangra district, East Punjab	Tertiary, Middle Sewaliks
3. *Anisopteroxylon coromandelense* Navale,, 1963	Not visible	Diffuse, medium to large, 180-215μ in diameter, solitary, often in radial groups of 2, circular in shape; vessel-segments medium-sized with truncated ends; perforations simple; intervessel pit-pairs small, alternate, bordered	Scanty vasicentric	Paratracheal and apotracheal; paratracheal parenchyma scanty vasicentric; apotracheal parenchyma diffuse to diffuse-in-aggregate and also surrounding groups of resin ducts	1-6 seriate, rarely uniseriate; ray tissue heterogeneous, composed of both upright and procumbent cells, and a row of upright cells simulating sheath cells forming the outer boundary of the rays	Libriform and non-septate	Solitary or in pairs, circular in cross-section, 36-48μ in diameter	Usteri, near Pondicherry, South India	Tertiary (Mio-Pliocene), Cuddalore series
4. *Anisopteroxylon garoense* (Chowdhury) comb. nov.	Indistinct	Diffuse, medium to large, t.d. 108-255μ, r.d. 140-360μ, majority solitary, rarely in short radial rows of 2-3, round to oval, 8-12 per sq. mm., tylosed; vessel-members 350-750μ long, with truncated or tailed ends; perforations simple	Scanty vasicentric	Paratracheal and apotracheal; paratracheal parenchyma scanty to vasicentric forming 1-3 (mostly 2) cells thick sheath around the vessels; apotracheal parenchyma diffuse, sometimes in distinct lines, occasionally forming irregular, narrow bands surrounding the gum ducts	1-8 seriate and 16-105μ broad; ray tissue heterogeneous; uniseriate rays, 2-15 cells and 92-380μ high, 16-36μ wide, homocellular, consisting only of upright cells; multiseriate rays 2-8 seriate, 16-105μ in diameter, 6-30 cells and 180-1350μ high, heterocellular, consisting of procumbent cells in the thickened portion, with sheath cells at the flanks and marginal rows of 1-8 upright cells at one or both the ends	Thick to very thick walled, non-septate, 20-30μ in diameter, 700-1600μ in length	Diffuse, sometimes in short tangential rows of 2-3	Hailakandi, district Cachar and Damalgiri, district Garo Hills, Assam	Tertiary (Miocene)

features clearly indicate the affinity of the present fossil with the woods of family Dipterocarpaceae (PEARSON & BROWN, 1932, pp. 67-131; METCALFE & CHALK, 1950, pp. 215-219; CHOWDHURY & GHOSH, 1958, pp. 98-167; SCHWEITZER, 1958, pp. 1-66). In the family Dipterocarpaceae, the vertical gum canals are found in all the genera except *Marquesia* and *Monotes*. According to the distribution of the gum canals, the genera of this family have been divided into following two groups (DEN BERGER, 1927, pp. 495-498; CHOWDHURY & GHOSH, 1958, pp. 107-108):

Group I — Genera in which gum canals are always present both solitary as well as in short rows all over the wood, e.g. *Anisoptera, Dipterocarpus, Vatica, Vateria, Cotylelobium, Stemonoporous, Pachynocarpus* and *Monoporandra*.

Group II — Genera in which gum canals when present are usually in long, concentric bands rather irregularly distributed, e.g. *Balanocarpus, Hopea, Dioticarpus, Doona, Parashorea, Shorea, Pentacme, Isoptera* and *Dryobalanops*.

Taking into consideration the distribution of the gum canals, the present fossil wood can be placed in the 1st group. The present fossil wood compares very well with the genera *Dipterocarpus* and *Anisoptera* which can be differentiated amongst themselves in the distribution of the gum canals and the structure of the xylem rays. In *Anisoptera* the gum canals are minute, usually solitary, rarely in tangential rows of not more than 2-3 and the xylem rays are frequently with sheath cells at the flanks, whereas in *Dipterocarpus* the resin canals are rarely solitary, mostly in short, tangential groups of 2-8 or more and the xylem rays have comparatively less sheath cells at the flanks (CHOWDHURY & GHOSH, 1958, pp. 107-108; SCHWEITZER, 1958, pp. 2-5). According to these features the present fossil wood shows nearest resemblance with the wood of the modern genus *Anisoptera* Korth.

A detailed study of the thin sections of the modern woods of *Anisoptera scaphula* Pierre, *A. oblonga* Dyer, *A. glabra* Kurz, *A. aurea* Foxw. and *A. brunnea* Foxw. was made besides consulting the published description and photographs of a number of species of *Anisoptera* (KANEHIRA, 1924, p. 5; METCALFE & CHALK, 1950, pp. 217-218, FIG. 54G; HENDERSON, 1953, p. 21, FIG. 83; DESCH, 1957, p. 102, PL. 19, FIGS. 1 & 2 & PL. 20, FIGS. 1 & 2; CHOWDHURY & GHOSH, 1958, pp. 109-111, PL. 15, FIGS. 86-89; KRIBS, 1959, p. 53, FIG. 14; BRAZIER & FRANKLIN, 1961, p. 31). From this detailed study, it is seen that the fossil wood resembles most with the species *Anisoptera scaphula* and *A. oblonga*. The resemblance is in the presence of small to large, mostly solitary or rarely in radial multiples of 2-3, round to oval, tylosed vessels; vasicentric tracheids; scanty to vasicentric paratracheal parenchyma and diffuse, sometimes diffuse-in-aggregate apotracheal parenchyma also forming multi-layered sheath around the gum ducts; 1-8 (mostly 5-6) seriate, heterocellular xylem rays; thick walled, non-septate fibres and in small, diffuse, mostly solitary, normal, vertical gum ducts. However, the modern species *Anisoptera scaphula* and *A. oblonga* slightly differ from the present fossil wood in having somewhat less frequent and slightly smaller vessels.

Comparison with the Fossil Woods — So far only a few fossil woods of *Anisopteroxylon* are known from India. These are *Anisopteroxylon bengalensis* Ghosh & Kazmi (1958b) from Birbhanpur, near Durgapur, in Damodar Valley, West Bengal, *A. jawalamukhi* Ghosh & Ghosh (1958) from the village Khundian north of Jwalamukhi, Kangra district, East Punjab and *A. coromandelense* Navale (1963) from Usteri, near Pondicherry, South India. Ramanujam (1960) also reported *Anisopteroxylon cuddalorense* from the Cuddalore series of South India. However, Awasthi (1965, pp. 35-45) recently revised and merged it as *Dryobalanoxylon holdeni*. The anatomical features of all these species of *Anisopteroxylon* have been listed in the accompanying Table 2. Another fossil wood described as *Dipterocarpoxylon garoense* Chowdhury (1938) from Damalgiri, district Garo Hills, Assam, is said to show affinities with the modern *Anisoptera*. From a close comparison, it is evident that the present fossil is identical with the species *Dipterocarpoxylon garoense* Chowdhury (1938). The present fossil wood resembles *D. garoense* Chowdhury (1938) in all the anatomical features except the size of the vessels. In *D. garoense* vessels are 160-178 μ in tangential diameter and 260-276 μ in radial diameter, while in the present fossil wood the tangential diameter of the vessels is 108-255 μ and the radial diameter is 140-360 μ.

However, the vessel size is a variable feature which differs distinctly from the base to the top and from the centre to the periphery of a tree. As the present fossil wood belongs to *Dipterocarpoxylon garoense* and resembles closely the modern species *Anisoptera scaphula* and *A. oblonga*, it is assigned to the species *D. garoense*, which is transferred here to the form genus *Anisopteroxylon* Ghosh & Kazmi (1958b) and named as *Anisopteroxylon garoense* (Chowdhury) comb. nov. The form genus *Dipterocarpoxylon* Holden was originally meant for the fossil woods of the family Dipterocarpaceae but now Den Berger (1927) used it in a restricted and more precise sense for the fossil woods of *Dipterocarpus*.

Present Distribution of *Anisoptera* Korth.

The genus *Anisoptera* Korth. consists of about 13 species (Willis, 1966, p. 66) which are widely distributed starting from Chittagong, East Pakistan. on the west and spreading up to New Guinea in the Pacific. The largest number of species, however, occur in the Malaya Peninsula, Sumatra and Borneo. The genus consists of moderately to very large sized trees upto 46 m. high found in the evergreen as well as deciduous forests. It grows from sea level to 850 m. elevation. No. *Anisoptera* now grows in India proper. Only two species, *A. scaphula* and *A. oblonga* occur in Chittagong and South Burma respectively (Chowdhury & Ghosh, 1958, p. 108).

SPECIFIC DIAGNOSIS

Anisopteroxylon garoense (Chowdhury) com. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* medium to large, t.d. 108-255 μ, r.d. 140-360 μ, mostly solitary, rarely in short radial rows of 2-3; tyloses present; vessel-members 350-750 μ in length; perforations simple; intervessel pit-pairs large, alternate, bordered, border oval with horizontal apertures; vessel-tracheids pits and vessel-ray pits similar to the intervessel pits. *Tracheids* paratracheal; 20-25 μ in diameter and 60-100 μ in length; pits arranged in vertical rows, small, bordered, border round to oval with lenticular, horizontal apertures. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma scanty to vasicentric, forming 1-3 (mostly 2) cells thick sheath around the vessels; apotracheal parenchyma diffuse and diffuse-in-aggregate forming distinct lines, occasionally with short bands surrounding the gum ducts. *Xylem rays* very fine to moderately broad, 1-8 cells and 16-105 μ broad, 5-12 per mm.; uniseriate rays 2-15 cells and 92-380 μ high, 16-36 μ wide, homocellular, consisting only of upright cells; multiseriate rays 2-8 (mostly 5-6) seriate, 6-30 cells and 180-1350 μ high, 16-105 μ in width, heterocellular, consisting of procumbent cells in the thickened middle portion and 1-8 marginal rows of upright cells at one or both the ends; sheath cells quite frequent at the flanks. *Fibres* thick to very thick walled, the walls about 8-12 μ thick, angular in shape, non-septate, 700-1600 μ in length; inter-fibre pits indistinct. *Gum ducts* normal, vertical, t.d. 40-55 μ, r.d. 51-70 μ, mostly solitary.

Material — A single specimen of petrified, mature secondary xylem measuring 6 cm. in length and 3 cm. in diameter.

Specimen — B.S.I.P. Museum No. 33911.

Locality — Sultanicherra (24°18′ N; 92° 33′ E) about 48 km. in the south-west of Hailakandi, district Cachar, Assam.

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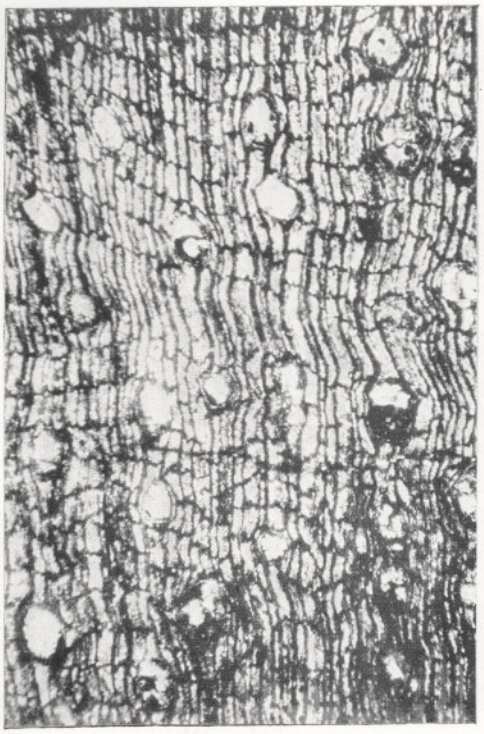

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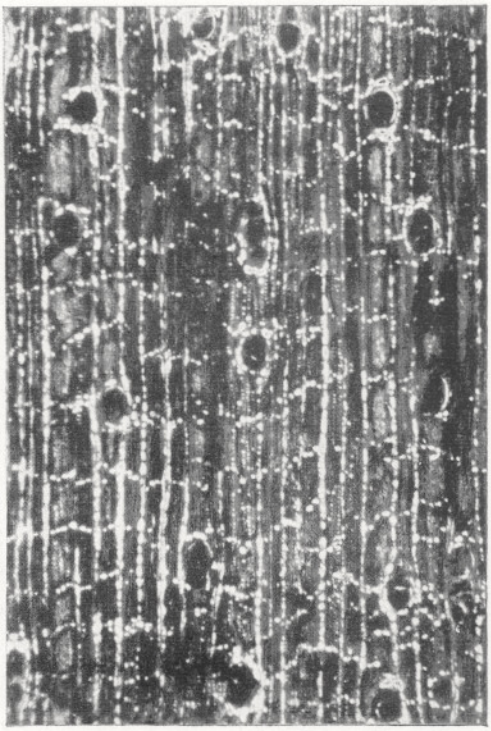

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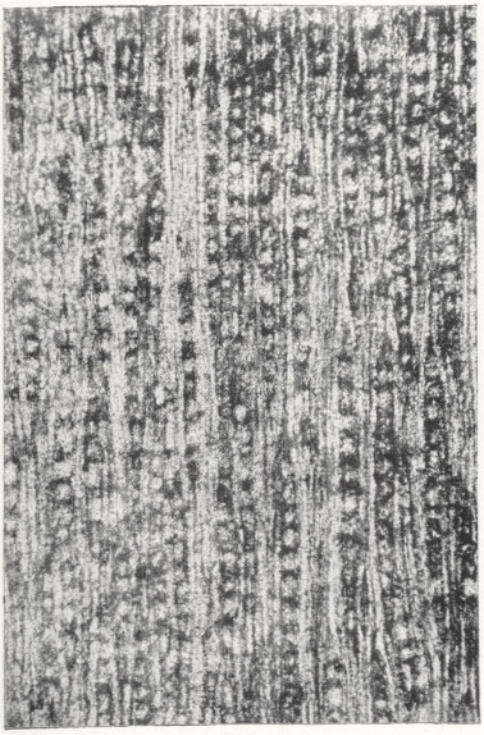

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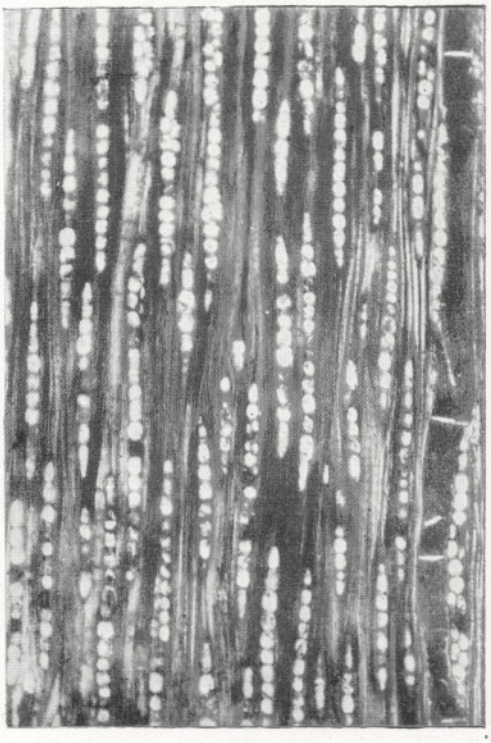

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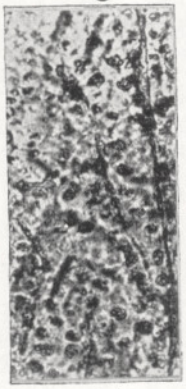

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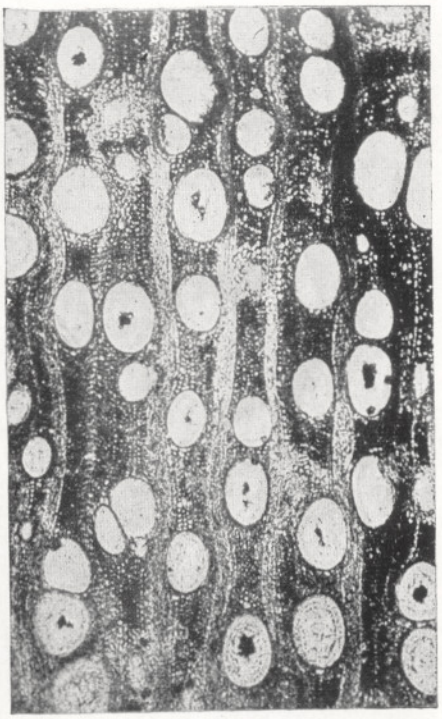

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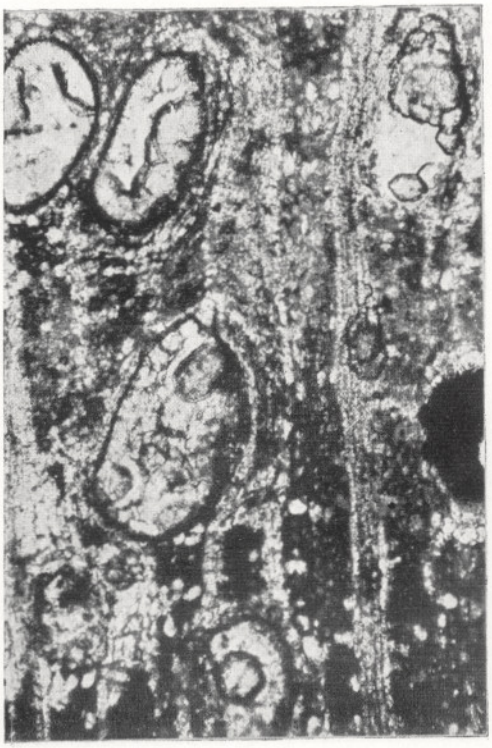

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EXPLANATION OF PLATES

PLATE 1

1. *Ebenoxylon kartikcherrense.* Transverse section of the fossil wood magnified. × 30. Note the vessel and parenchyma distribution. 2. *Diospyros ehretioides.* Transverse section of the modern wood. × 30. Note the close agreement in major structural features with the fossil wood shown in Fig. 1. 3. *Ebenoxylon kartikcherrense.* Tangential section of the wood. × 90. Note the shape and size of the xylem rays similar to the modern wood shown next. 4. *Diospyros ehretioides.* Tangential section of the modern wood. ×90.

PLATE 2

5. *Ebenoxylon kartikcherrense.* Radial longitudinal section of the fossil showing heterocellular xylem rays. × 130. 6. *Ebenoxylon kartikcherrense.* Intervessel pit-pairs magnified. × 700. 7. *Anisopteroxylon garoense.* Vessel-tracheid pitting highly magnified. × 400. 8. *Anisopteroxylon garoense.* Transverse section of the fossil wood in low power showing the distribution of the vessels, parenchyma and the gum canals. × 20. 9. *Anisopteroxylon garoense.* Another transverse section of the fossil highly magnified to show the fibre structure and the parenchyma distribution. × 90. 10. *Anisopteroxylon garoense.* Tangential section showing heterocellular xylem rays with sheath cells at the flanks. × 60.