KAYEOXYLON ASSAMICUM, GEN. ET SP. NOV., A FOSSIL DICOTYLEDONOUS WOOD FROM ASSAM.

(Specimen F.R.I. Fossil Type No. 35.)

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ABSTRACT.

A fossil dicotyledonous wood from Assam has been studied and its identification is reported here. Geologically the locality is known to be Upper Miocene. The fossil wood shows greatest affinity with the living *Kayea* of the family *Guttifereae*. It appears to be the first fossil wood of *Kayea* that has so far been recorded and it is named as *Kayeoxylon assamicum*.

INTRODUCTION.

In 1936, Mr. K. B. Mohan Lal of the Indian Forest Service, Assam, sent some fossil wood specimens to the Forest Research Institute, Dehra Dun, for identification. These specimens he collected from the bed of Thailangthu Nadi near the 8th milestone on the Dhansiri-Manglumakh cart-road. The exact location of the place is Long. 93° 43′ and Lat. 26° 32′. One of these fossil specimens bears F.R.I. fossil type number 35 and is reported here.

The specimen is about 10 cm. long and 6 cm. thick. It is made of moderately coarse ferruginous sandstone. Due to uneven and incomplete preservation, considerable difficulty was experienced in preparing microscope slides from this fossil. Grinding of sections to the usual thinness often led to loss of anatomical details. Many sections had to be prepared. Some of them were left fairly thick with a view to getting a general impression of the anatomical features, while others were ground down to usual thinness to obtain a clear idea of the minute structure like pits.

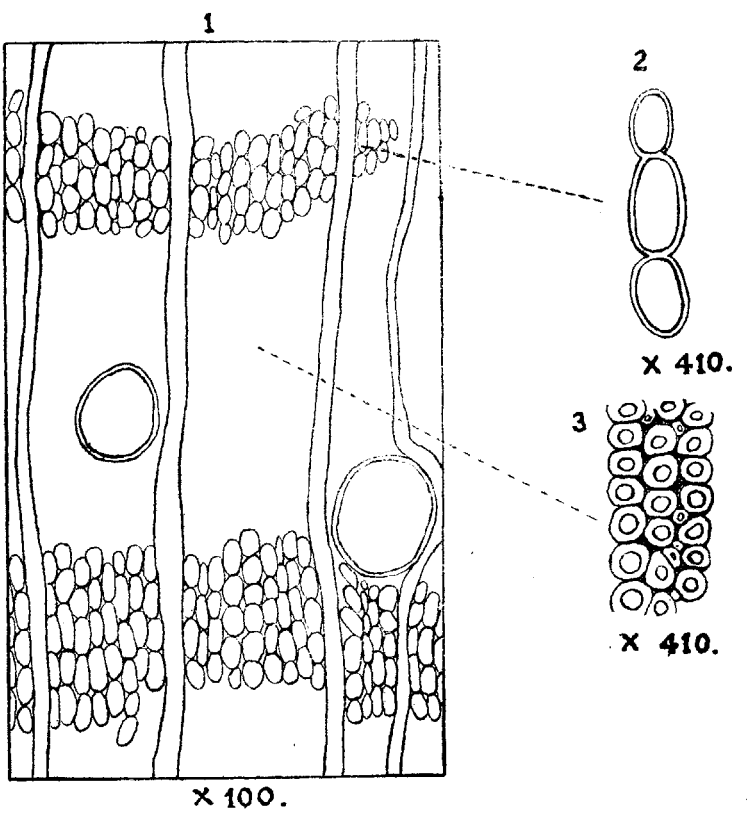
Geologically, the locality is known to be the Tipam stage of the Assam series (Evans, 1932). The Geological Survey of India has recently supplied us with up-to-date information by saying: 'The strata in the locality are Tertiary and probably belong to the Tipam series which correspond to Murree-Lower Siwaliks sequence of Northern India and the Burdigalian and Vindobonian stages of the Miocene of the European stratigraphical scale.'

ANATOMY OF F.R.I. FOSSIL TYPE NO. 35 AND ITS COMPARISON WITH THE LIVING DICOTYLEDONS.

The fossil shows the structure of a diffuse-porous wood.

Growth rings are difficult to determine. The concentric bands of parenchyma cells occurring at somewhat equal intervals give the impression of growth marks but whether they are true growth marks or not, it is not possible to say with certainty. Early wood and late wood are not well marked. Nor do the size, shape and distribution of cell elements help in determining the growth rings (Pl. V, Figs. 2, 3 and 4).

Vessels are indistinct to the eye but clearly visible with a lens. They are moderately numerous, more or less evenly distributed, occasionally with a tendency to form obliquely radial chains (Pl. V, Figs. 3 and 4). They are mostly single, round to oval and frequently without tyloses. Some vessels are embedded entirely in fibrous tract, while others in parenchyma bands. There are still others which are partially surrounded by parenchyma and partially by fibres (Pl. V, Figs. 2, 3 and 4). Vessel lines are inconspicuous. Perforation plates are horizontal to slightly oblique. Vessels being mostly single, inter-vessel pits are naturally scanty. In spite of careful searching it was not possible to detect inter-vessel pits in any of the longitudinal sections that were prepared by us. Pits between vessels and fibres are,

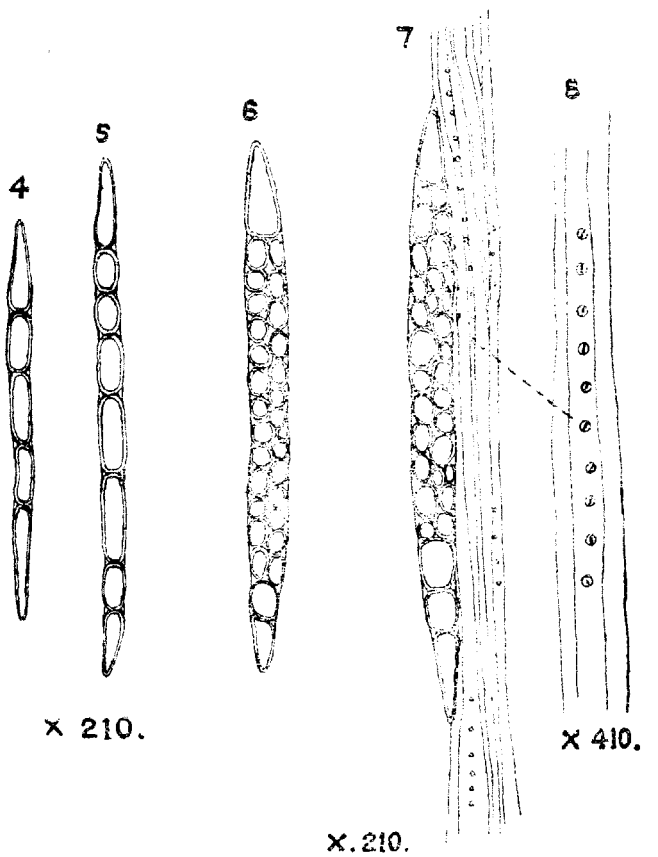


TEXT-FIGS. 1–3.—*Kayeoxylon assamicum* Gen. et sp. nov. (semi-diagrammatic camera lucida drawings).

Fig. 1.—Cross-section showing alternate bands of apotracheal parenchyma and fibre (×100).
Fig. 2.—Individual parenchyma under high magnification; note their size and shape (×410).
Fig. 3.—Fibres under high magnification; note their alignment, size and shape (×410).

however, frequent. They are alternate, moderate sized and widely spaced. The borders are round to oval and the apertures are slit-like to lenticular with longer axis vertical or oblique. Vessel-ray and vessel-parenchyma pits were difficult to observe due to bad preservation of the fossil.

Fibres are mostly in thick bands alternating with parenchyma bands (Pl. V, Figs. 2 and 3, Text-Fig. 1). Sometimes fibre bands may be wider than parenchyma bands. As a rule, the fibres are not well preserved and it is difficult to detect their detailed microscopic structure. In some portion of the fossil preservation is fairly good and it has been possible to see here the size and shape of the fibres in some detail. They are arranged in distinctly radial rows and are semi-libriform to libriform. In transverse section they are round to oval with fairly thick walls (Pl. VI, Fig. 5, Text-Fig. 3). Individual fibres show rather gradual tapering at both ends and they are non-septate (Pl. VI, Fig. 9). Inter-fibre pits are fairly abundant both on the radial and tangential walls. There appears to be a tendency for the pits on the tangential walls to show up conspicuously. They are fairly large with round border and vertical or oblique orifice (Pl. VI, Fig. 10, Text-Fig. 8).



TEXT-FIGS. 4–8.—*Kayeoxylon assamicum* Gen. et sp. nov. (semi-diagrammatic camera lucida drawings).

Fig. 4.—Uniseriate ray with entirely upright cells (× 210). **Fig. 5.**—Uniseriate ray with both upright and procumbent cells; note their distribution (× 210). **Fig. 6.**—Biseriate ray showing upright end cells and procumbent cells of varying size and shape (× 210). **Fig. 7.**—Triseriate ray along with some fibres; note distribution of inter-fibre pits (× 210). **Fig. 8.**—Enlarged view of inter-fibre pits (× 410).

Parenchyma cells are mostly in thick apotracheal bands, appearing as whitish lines on the smooth end surface of the fossil (Pl. V, Figs. 2 and 3). By their distribution, size and shape, it is not possible to say whether they have any relation with the initiation or termination of seasonal growth activity of the tree. Under microscope these parenchyma bands appear to be normally composed of 4–9 cells. Where the bands are thin they may be made up of only 3 cells and where the bands are thick they may contain as many as 13 cells. The cells show often a tendency to be flattened tangentially (Text-Fig. 2) and as a result are somewhat oblong in shape (cross-section). These bands usually occur at regular interval and run to a considerable distance. In fact in many slides prepared by us, the apotracheal bands were noticed to run throughout the entire sections. A few short apotracheal bands were, however, noticed in the fibre tracts. As a rule, the latter type run for a short distance and end abruptly. All the cross-sections prepared by us do not show this type of distribution of parenchyma cells but, at the same time, there is no doubt about their presence in some slides. (Pl. V, Fig. 2.) Pits between parenchyma cells are not clear. Gummy deposits are present.

Rays are indistinct to the eye but visible with a lens, rather fine, 1–3 seriate (mostly 1-2), closely spaced (Pl. V, Figs. 2, 3 and 4) and heterogeneous. They can be conveniently described under 2 groups: uniseriate and biseriate. Amongst the uniseriate type, there are two sub-groups. One sub-group contains those which are entirely made up of high cells (Text-Fig. 4) and the other sub-group shows high cells at both ends with procumbent cells in the middle or high cells at extreme ends with interspersed high and procumbent cells (Text-Fig. 5). Thus it will be seen that there is a considerable variation in the uniseriate type. In the biseriate type 1 or 2 or 3 high cells may occupy the extreme ends and the rest are made up of procumbent cells. The procumbent cells again show considerable variation in shape and size when seen on the tangential surface (Pl. VI, Fig. 8, Text-Figs. 6 and 7). Rays also show a considerable variation in their height. A few are as low as 1 cell high while others may be as many as 27 cells high.

Ripple marks are absent.

Gum canals could not be seen.

Pith fleck: Whether pith flecks are present or not, it is difficult to say. In one cross-section of the type specimen there is a suggestion of pith fleck.

In the anatomical details recorded here, there appear to be six characters which might be used with advantage in our attempt to identify the fossil. These characters are:—

(i) Diffuse-porous wood; (ii) Concentric and alternate bands of parenchyma cells and fibres; (iii) Vessels in some places show a tendency to form radial chains; (iv) Some apotracheal parenchyma bands end abruptly; (v) Conspicuous inter-fibre pits on tangential and radial walls; (vi) No ripple marks.

Recently Chowdhury and Ghosh (1946) have discussed in some detail the diffuse-porous woods with concentric and alternate bands of parenchyma cells and fibres. According to their classification, there are 4 main types within this group and the fossil under investigation comes under type (*c*). These workers have also drawn up a list of timbers which show type (*c*) parenchyma distribution and the list includes 16 families with 40 genera. In the course of our present study we have examined once again the wood collection of the Forest Research Institute, Dehra Dun, and we are of opinion that some specimens of *Eleodendron* belonging to *Celastraceae* should be included in the list drawn by Chowdhury and Ghosh. Now before making a comparative study of the fossil under investigation with those timbers belonging to 41 genera of 17 families, it seems advisable to take into consideration the remaining important characters of the fossil. The tendency for the vessels to form radial chains is found only in the genus *Kayea* of *Guttiferae*. No other timber

in the list prepared by Chowdhury and Ghosh (1946) shows this character. Moreover, the occasional abrupt ending of the apotracheal parenchyma bands and the characteristically conspicuous inter-fibre pitting in the fossil are also found in the *Kayea* (Desch, 1941; Gamble, 1922; Moll and Janssonius, 1906–28; Pearson and Brown, 1932; Vestal, 1937). Lastly, neither the fossil nor *Kayea* has got ripple marks. It will, therefore, be seen that the fossil under investigation shows the greatest similarity with the genus *Kayea*.

At present there are about 12 species of *Kayea* growing in the Indo-Malayan region, of which only 2 species are Indian (Desch, 1941; Kanjilal and Das, 1934). We have had opportunity to study 18 wood specimens belonging to 8 species. All of them show more or less similar anatomical structure. In view of this fact, there seems to be little doubt about the fossil being a *Kayea*.

Comparison of the fossil with the dicotyledonous fossil woods previously reported.

(*a*) *India.*

Amongst the few fossil wood specimens identified in India, only *Cynometroxylon indicum* Chowdhury and Ghosh (1946) shows some similarity with the fossil under investigation. Both have concentric and alternate bands of parenchyma cells and fibres, but they differ in detail structure of rays, vessels and pittings on various types of cells. It can, therefore, be said that F.R.I. Fossil Type No. 35 does not show any similarity with the fossil wood specimens that have so far been reported from India.

(*b*) *Outside India.*

Of the fossil woods that have been reported from outside India, *Dryoxylon symphonoides* Bancroft (1932) is worth considering here. This fossil wood from East Africa has shown the greatest resemblance to 'that of various species of the recent genus *Symphonia* of the *Guttifereae*. But woods of *Symphonia* have got much higher and broader rays than that of our fossil (Bancroft, 1932; Garrat, 1936). Moreover, it was not possible for Bancroft to record the pitting on cell walls of her fossil. We are, therefore, unable to make a comparative study of Bancroft's fossil with our fossil wood and come to a definite conclusion regarding their affinity.

In this connection, the next fossil wood that is worth discussing is *Lecythioxylon bransiliense* Milanez (1935) from the Cretaceous of Brazil. This fossil shows resemblance with F.R.I. Type No. 35 in having concentric and alternate bands of parenchyma cells and fibres. But the photomicrographs of cross-sections of the fossil given by Milanez show parenchyma distribution more like the type (*b*) than type (*c*) described by Chowdhury and Ghosh (1946). Furthermore, the drawing of ray cells given by Milanez, shows no similarity with the rays of the fossil under investigation. In these circumstances, we may be justified in drawing the conclusion that the Brazilian fossil wood shows no affinity with our fossil. Finally it can be said that the F.R.I. Fossil Type No. 35 shows no affinity with the fossil woods that have so far been reported from outside India.

Determination of the Fossil and its Diagnosis.

It has already been shown that the fossil wood under investigation shows the greatest affinity with the present day genus *Kayea* of the family *Guttifereae*. The timbers of the genus *Kayea* show such a uniform and characteristic anatomical structure that it is possible to separate them from those of the remaining genera in the family. In view of this, we propose the generic name *Kayeoxylon* to include all fossil *Kayea*. The F.R.I. Fossil Type No. 35 is specifically named as *Kayeoxylon assamicum*. The generic and specific diagnoses are given:—

Genus: *Kayeoxylon* K. A. Chowdhury and K. N. Tandan.

A diffuse-porous wood.

Growth rings : Indistinct.

Vessels : hardly visible to the eye, moderate sized, mostly single; more or less evenly distributed, occasionally with a tendency to form radial or obliquely radial chains; mostly open, sometimes contain darkish deposit along with tyloses; fairly thick-walled, embedded either wholly or partially in fibrous bands or parenchyma bands; perforation plates single, horizontal to slightly oblique; with or without tails at one or both ends; vessel-fibre pits alternate and moderate sized, the border round to oval and aperture slit-like to lenticular with longer axis vertical or oblique.

Fibres : form dense bands alternating with parenchyma bands. Fibre bands 10–50 (55) cells thick, individual fibres arranged in conspicuous radial rows, semi-libriform to libriform, non-septate. Inter-fibre pits abundant on radial and tangential walls; fairly large with round border and vertical to oblique orifice.

Parenchyma : prominently visible to the eye, in concentric bands alternating with fibre bands, wholly or partially encircle vessels, often run a considerable distance crossing many rays. The bands fairly thick and composed of 5–10 (12) cells. Some apotracheal bands occur in between the concentric bands and end abruptly.

Individual cells usually oblong in the cross-section. Gummy deposit present.

Rays : not visible to the eye but distinct with a lens, fine, fairly close, heterogeneous, 1–3 (mostly 2) seriate. Uniseriate rays about 25%, some made up of entirely high cells, while others with high cells at both ends and procumbent cells in the middle or high cells at extreme ends with procumbent and high cells interspersed in the middle. Biseriate rays with 1 or 2 or 3 high cells at both ends and procumbent cells in the middle. Gummy deposits present.

Species: *Kayeoxylon assamicum* K. A. Chowdhury and K. N. Tandan.[1]

Vessels : Somewhat evenly distributed, usually 135–146 (160) per 3 sq. mm., mostly solitary, about 10% in pairs; moderate sized; tangential diameter of solitary vessel $116 \pm 17\mu$, radial diameter $175 \pm 15\mu$; vessel segments up to 950μ observed.

Fibres : Short $1072 \pm 185\mu$ in length.

Parenchyma : Apotracheal, two types: (*a*) concentric bands, running considerable distance; (*b*) short bands ending abruptly; round to oval in cross-section. Vertical cells of unequal height, often contain gummy deposit.

Rays : Numerous, $14 \pm 2{\cdot}5$ per mm.; 1-2 seriate; uniseriate up to 9 cells high; biseriate 27 cells high, $460 \pm 99\mu$ high and $44 \pm 3\mu$ wide.

SUMMARY.

1. A dicotyledonous fossil wood from the bed of Thailangthu Nadi, Assam, at Long. 93° 43′ and Lat. 26° 32′ is described and recorded. It bears the F.R.I. Fossil Type No. 35.

2. A detailed anatomical study has shown its affinities to the living genus *Kayea* of the *Guttifereae*. Comparison of this fossil with those previously identified from India and outside is made and their possible resemblances are discussed. The F.R.I. Fossil Type No. 35 appears to be the first *Kayeoxylon* so far recorded and it is named as *Kayeoxylon assamicum*.

3. The age of the fossil is known to be Upper Miocene.

ACKNOWLEDGEMENT.

Our acknowledgements are due to Mr. K. B. Mohanlal of the Indian Forest Service, Assam, who collected and sent this fossil wood specimen to the Forest

[1] The standard method of describing a wood by Chattaway (1932) has been followed. Figures included in this description are based on the following counts :—

Vessel distribution, 5 counts; tangential and radial diameter of vessels, 100; vessel length, 10; fibre length, 100; ray distribution, 25; ray height and width, 30.

Research Institute, Dehra Dun, for identification. Dr. H. E. Desch of Malayan Forest Department sent us 9 authentic wood specimens of *Kayea* for our comparative study. His help is gratefully acknowledged here. Our thanks are also due to the Director, Geological Survey of India, for the latest information on the Geology of the locality from which this fossil was collected. It is a great pleasure for us to acknowledge here the kindness of Professor Sir W. Wright Smith, F.R.S., and Mr. M. Y. Orr, Royal Botanic Garden, Edinburgh, for reading through the manuscript.

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EXPLANATION OF PLATES.

(All photomicrographs are from untouched negatives.)

PLATE V.

Kayeoxylon assamicum Gen. et sp. nov., F.R.I. Fossil Type No. 35.

FIG. 1. Photograph of the fossil.

FIG. 2. Transverse section showing general structure; note variation in distribution of parenchyma and fibre bands, specially short apotracheal parenchyma (A.P.) ending abruptly (× 10).

FIG. 3. Another transverse section showing general structure of wood; note alternate apotracheal parenchyma and fibre bands (× 10).

FIG. 4. Another transverse section showing pore-chains (P.C.); note distorted view of the rays (× 35).

PLATE VI.

FIG. 5. Transverse section showing radial alignment of fibre (× 110).

FIG. 6. Tangential section showing general distribution of rays (× 30).

FIG. 7. Tangential section showing uniseriate rays: note size and shape of individual cells (× 110).

FIG. 8. Tangential section showing a triseriate ray (× 110).

FIG. 9. A fibre; note its size and shape (× 50).

FIG. 10. Tangential section showing inter-fibre pits (× 460).

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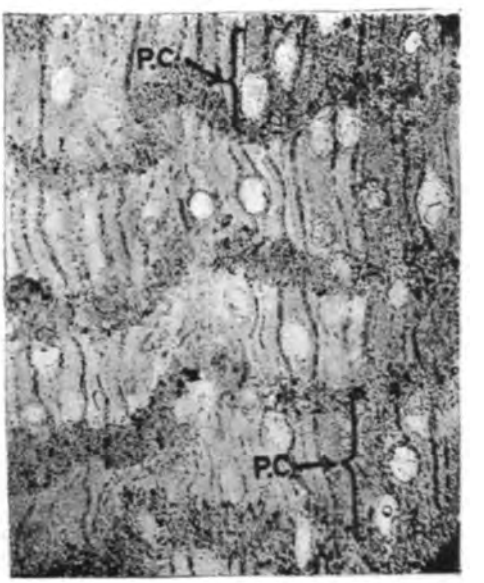

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