A FURTHER INVESTIGATION OF THE LIGNEOUS FOSSILS OF COMBRETACEAE FROM SOUTH INDIA

C. G. K. RAMANUJAM
Department of Botany, Osmania University, Hyderabad

ABSTRACT

The paper deals with a study of three new species of silicified woods of *Terminalioxylon* recently collected from the Cuddalore sandstones near Pondicherry in South India. These are viz., *T. grandiporosum* sp. nov., *T traumaticum* sp. nov., and *T. coromandelinum* sp. nov. With these the rocks of Cuddalore series have so far yielded altogether seven species of *Terminalioxylon*. Based upon the known palaeobotanical data, the past and present distributional pattern of *Terminalia* has been briefly discussed.

A key for the identification of the known species of *Terminalioxylon* has been provided.

INTRODUCTION

THE occurrence of the ligneous fossils of Combretaceae in the Cuddalore sandstone series of South India was first recognized by the author (RAMANUJAM, 1956). Because of their striking xylotomical resemblances with the modern *Terminalia* these fossils have been placed in the genus *Terminalioxylon* Schönfeld (1947). So far four species of this genus are known from the Cuddalore sandstones (RAMANUJAM, 1956; NAVALE, 1955). It may be interesting to note that this genus has also been recorded recently from the Tertiary of Assam (PRAKASH & NAVALE, 1962). *Anogeissusoxylon* is yet another Combretaceous member reported again from the Cuddalore series (NAVALE, 1962).

During a visit (summer of 1962) to the now well known petrified forest area near Pondicherry in South India, the author has made a fairly extensive collection of silicified woods from Mortandra, Tiruchhitambalam, and Kasikoppam. A critical study of a part of this collection has brought to light three more new species of *Terminalioxylon*, which form the subject matter of the present contribution.

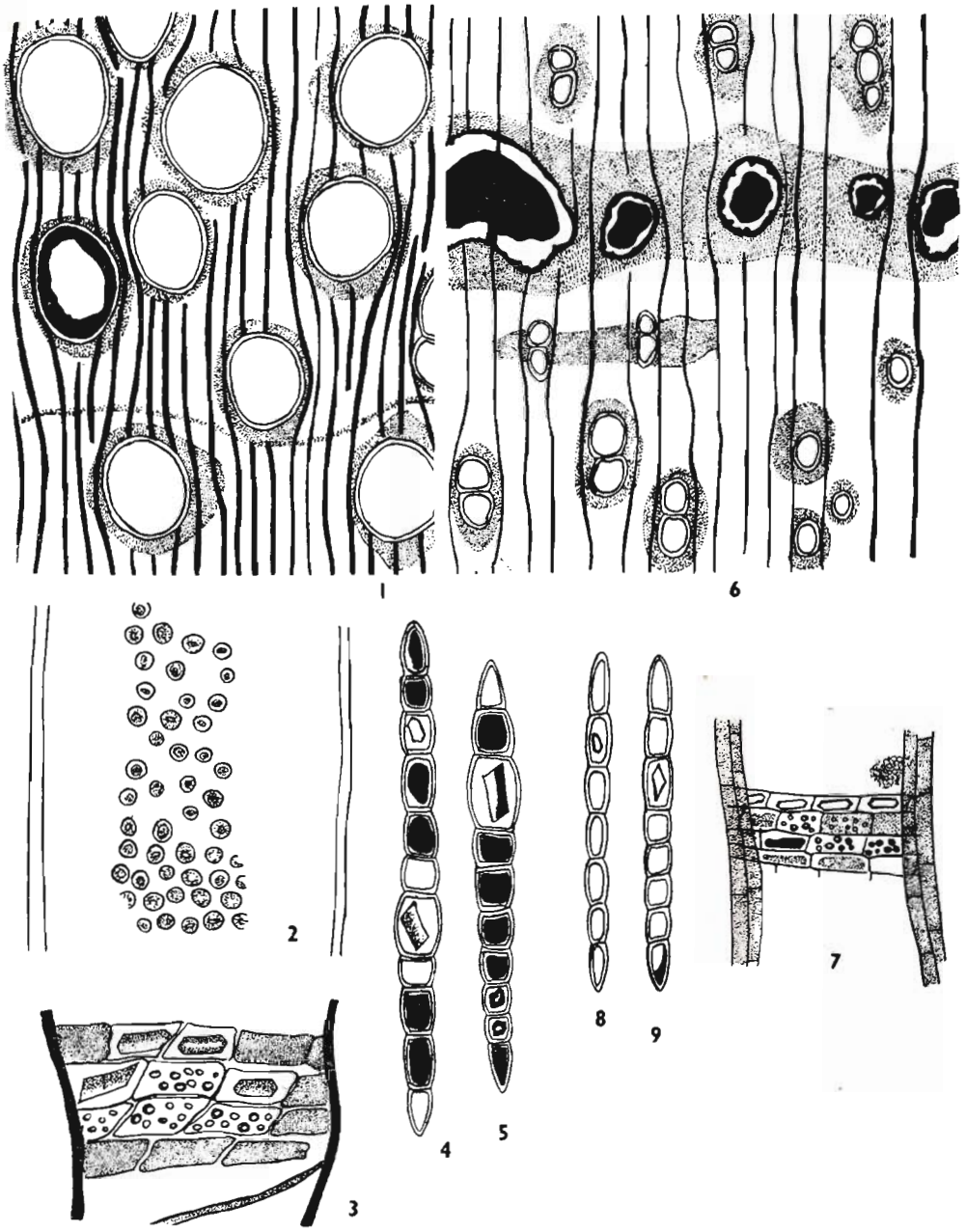
DESCRIPTION

Terminalioxylon Schönfeld 1947

1. *Terminalioxylon grandiporosum* sp. nov.
Pl. 1, Figs. 1-5; Text-figs. 1-5

The fossil shows fairly clear growth rings distinguishable by the smaller vessels and the more compactly placed late wood fibres in the outer portion of the ring, and also by the narrow terminal bands of the xylem parenchyma (PL. 1, FIG. 1). The wood is diffuse porous. The vessels are medium to very large and seen distinctly with the naked eye. The vessels in the bulk of the growth ring representing the spring wood portion are large to very large grading gradually into relatively smaller ones in the outer most portion of the growth ring representing the late wood zone (PL. 1, FIG. 1). The former are usually 300-385 μ in tangential diameter, while the latter 175-200 μ. The vessels are predominantly solitary, oval to rounded and somewhat thin-walled. Radial pairs are occasionally met with and radial groups of three are seen very rarely. When in radial groups the vessels are flattened at places of contact. Because of their very large size, the vessels are few per sq. mm., being usually only 2-5. The large size of the vessels is a conspicuous feature of the transverse facets of the fossil. The majority of the vessels are open and only locally do they contain some dark deposits often in the form of a thick parietal layer. The vessels are commonly with contiguous rays on one or both sides, and deflect them, often prominently. No tyloses are met with in the vessels. The vessel-members are medium and usually truncate or abruptly tailed. Perforations are simple and oblique. Intervessel pits are alternate or opposite, and vestured; they are fairly large (10-13 μ) rounded, or angular with lenticular apertures (PL. 1, FIG. 3; TEXT-FIG. 2). Vessel-ray pits are many per cell, large, oval to rounded narrowly bordered or simple and in one or two series (PL. 1; FIG. 4; TEXT-FIG. 3). Vessel-parenchyma pits are not preserved.

Xylem parenchyma is very much limited and represented by thin vasicentric sheaths, 1-3 cells thick, and uniseriate undulate or ragged bands of terminal parenchyma delimiting the successive growth rings (PL. 1, FIGS. 1, 2; TEXT-FIG. 1). The terminal bands locally are two cells thick. The vasicentric parenchyma consists of tangentially



TEXT-FIGS. 1-5 — *Terminalioxylon grandiporosum* sp. nov., 1, Cross-section showing the distribution of the vessels and parenchyma (stippled). × 45. 2, Intervessel pits. × 205. 3, Vessel-ray pits. × 205. 4, 5, Xylem rays. Note the crystalliferous cells. × 150. 6-9.—*Terminalioxylon traumaticum* sp. nov. 6, cross-section showing the distribution of the vessels, traumatic gum ducts and parenchyma (stippled). × 45. 7, Vessel-ray pitting. × 205. 8, 9, Xylem rays. Note the single crystals. × 150.

tially flattened or round to oval cells and the terminal type, of tengentially flattened cells only. In general the parenchymatous cells are plugged profusely with some dark contents, the nature of which is unknown, but which might have been originally gumiferous. Pits to the parenchyma cells are seen only here and there, particularly on their radial walls; the pits are simple and rounded. The parenchyma is not crystalliferous.

Next to the vessels the fibres constitute the prominent elements of the fossil, forming extensive tracts between the vessels. They are squarish to polygonal in cross section and more or less aligned in regular radial seriations (PL. 1, FIG. 2). They are fairly large, 18-25 μ in diameter and with conspicuous lumina. In the outer most part of the growth ring, however, the fibres are smaller (14-18 μ), thicker walled, tangentially flattened and compactly placed. This narrow zone obviously represents the late wood. The fibres usually are empty but sometimes filled up with a dark substance; they are often crystalliferous. They are non-libriform, medium to long and commonly non-septate. Pits to the fibres are not preserved.

The xylem rays are separated by 4-10 rows of fibres, usually by 4-7 rows; at some places, however, the rays are very closely placed, being separated by only 2-4 rows of fibres. The rays are fine being only one or two seriate (PL. 1, FIG. 5). The uniseriate rays are more common than the biseriates. The height of the rays varies from 4-20 cells. The ray cells are large (30-45 μ in diameter) and thus despite the narrowness of the rays they appear to be fairly conspicuous in the tangential sections. As a rule, the rays are homogeneous (KRIBS' 1935, HOMOGENEOUS TYPE III), consisting entirely of procumbent cells, mostly round to oval or elliptical in the tangential sections (TEXT-FIGS. 4, 5). The ray cells usually are filled up with abundant dark contents, but there are a few cells in each ray which are crystalliferous, each such cell containing a single large crystal. The position of the crystalliferous cells within each ray does not seem to be of any specific nature; the crystalliferous cells are either at the margins or any where in the centre of the ray. Many of the crystalliferous cells are considerably larger and hence more conspicuous than the cells without crystals.

The fossil does not possess any gum ducts either normal or traumatic.

AFFINITIES AND COMPARISON

The above combination of characters indicates the general affinities of the fossil with the woods of Anacardiaceae, Leguminosae, Sapindaceae, Combretaceae and Lythraceae (GAMBLE, 1902; HENDERSON, 1953; KANEHIRA, 1924; METCALFE & CHALK, 1950; PEARSON & BROWN, 1932). The possession of large to very large mostly solitary vessels, large, vestured intervessel pitting, the vasicentric and terminal parenchyma, the non-septate fibres, the uniseriate homogeneous rays with cells containing single crystals, all constitute a characteristic assemblage of characters resembling particularly the modern woods of Combretaceae. Among Combretaceae, it is with the xylotomy of the species of *Terminalia* that the fossil agrees most. The fossil accordingly is placed in the genus *Terminalioxylon* Schönfeld (1947).

The fossil has been compared with various species of *Terminalioxylon* (BOUREAU, 1950, 1955, 1958; NAVALE, 1955; PRAKASH & NAVALE, 1962; RAMANUJAM, 1956; SCHÖNFELD, 1947). With *T. felixi* (RAMANUJAM, 1956) and *T. mortandranse* (NAVALE, 1955) the present fossil resembles in the possession of limited xylem parenchyma but differs in other respects. In the possession of very large vessels, the South Indian fossil is easily distinguished from all the other species of *Terminalioxylon*. It is, therefore, named here as — *Terminalioxylon grandiporosum* sp. nov., the specific name being indicative of the large size of the vessels.

DIAGNOSIS

Terminalioxylon grandiporosum sp. nov.

Wood diffuse porous

Growth rings fairly clear.

Vessels medium to very large, 175-385 μ in tangential diameter, larger vessels (300-385 μ) in the bulk of the growth ring, relatively smaller ones (175-200 μ) in the outer most part of the growth ring, predominantly solitary (85 per cent), oval to rounded, radial pairs occassional; 2-5 per sq. mm; vessel-members medium, 400-650 μ long; perforations simple; intervessel pits 10-13 μ in diameter, alternate or opposite, vestured, rounded or angular; vessel-ray pits 8-12 μ

in diameter, oval to round, narrowly bordered or simple.

Xylem parenchyma very much limited, in 1-3 cells thick vasicentric sheaths, and uniseriate terminal bands, pits simple, rounded. Cells round to oval or flattened, 32-42 μ in diameter.

Fibres squarish to polygonal in cross section, aligned in radial rows, 18-25 μ in diameter, non-libriform, 950-1700 μ long, commonly non-septate.

Rays 8-12 per mm., 1-2 seriate or 30-45 μ broad, uniseriates more common, 4-20 cells or 150-650 μ long, homogeneous, cells with single crystals or abundant dark contents. Crystalliferous cells larger and prominent.

Locality — Mortandra near Pondicherry, S. India.

Age — Cuddalore sandtone series (U. Miocene-Pliocene)

Type specimen — No. S.A. 10, in the author's collection at the Dept. of Botany, Osmania University, Hyderabad.

2. *Terminalioxylon traumaticum* sp. nov.

Pl. 2, Figs. 6-10; Text-figs. 6-9

The fossil shows very faint growth rings, demarcated locally by the tangential bands of traumatic gum ducts.

The vessels are diffuse and medium (100-135 μ in tangential diameter). They are solitary or in radial groups of 2-4. The radial groups of vessels, particularly the radial pairs are more common than the solitary ones (Pl. 2, Figs. 6-8). The solitary pores are oval to elliptical and those in radial groups are often flattened at places of contact. The vessels are either empty or filled up with some dark contents; tyloses are not seen. The vessel-members are medium and truncate. The perforations are simple and inclined. Intervessel pits are numerous, alternate and vestured. The pits are rounded or angular, with more or less lenticular apertures. Vessel-ray pits are many per cell, narrowly bordered and rounded or tangentially flattened (Text-fig. 7).

The parenchyma is of two types viz., paratracheal and apotracheal; the former is vasicentric and confluent (Pl. 2, Fig. 8; Text-fig. 6). The vasicentric sheaths are 2-4 cells thick and seen more commonly than the confluent bands. The confluent bands are also 2-4 cells thick, local and rather short. The parenchyma cells are rounded and usually open or with light brown contents; they are non-crystalliferous. In addition to these types, there are at infrequent intervals broad apotracheal often discontinous bands containing very large traumatic gum ducts (Pl. 2, Figs. 6, 7; Text-fig. 6). Pits to the parenchyma cells are not preserved.

The fibres forming extensive tracts between the vessels are angular and variable in size in cross sections. They are generally aligned in more or less irregular rows. The fibres are empty, medium, libriform and commonly septate. Interfibre pits are not preserved.

The xylem rays are numerous and separated usually by 3-6 rows of fibres. They are predominantly uniseriate with some biseriates seen only locally. The rays are 3-15 cells high and homogeneous consisting entirely of procumbent cells which are oval to elliptical in the tangential sections (Pl. 3, Figs. 9, 10; Text-figs. 8, 9). Many of the ray cells are empty, but here and there, are crystalliferous, each such cell containing a single crystal. The crystalliferous cells and the rest are more or less of the same size.

The vertical traumatic gum ducts are seen in uniseriate tangential rows at infrequent intervals. These bands demarcate the faint growth rings. The gum ducts are always placed in thick tangential bands of apotracheal parenchyma which themselves are interrupted and discontinuous (Pl. 2, Figs. 6, 7; Text-fig. 6). The gum ducts are of irregular shapes and sizes; they are usually much larger than the vessels, being 200-320 μ in diameter and plugged with dark contents.

AFFINITIES AND COMPARISON

The diffuse porous nature, vestured intervessel pits, vasicentric and confluent parenchyma in addition to thick discontinuous apotracheal bands, uniseriate tangential rows of vertical traumatic gum ducts, and lastly the predominantly uniseriate, homogeneous rays with single crystals constitute the important characters of the fossil under investigation. The following is a list of dicotyledonous families showing the occasional presence of vertical traumatic secretory canals (Metcalfe & Chalk, 1950).

Ampelidaceae	Caesalpiniaceae
Bombacaceae	Combretaceae
Boraginaceae	Elaeagnaceae
Burseraceae	Elaeocarpaceae

Euphorbiaceae
Hamamelidaceae
Lecythidaceae
Malvaceae
Meliaceae
Mimosaceae
Moringaceae
Myrtaceae
Papilionaceae
Proteaceae
Rosaceae
Rutaceae
Sapindaceae
Simarubaceae
Sterculiaceae
Styraceae
Vochysiaceae.

Of these it is with the woods of Sapindaceae and Combretaceae that the fossil shows the majority of its similarities. In Sapindaceae, however, the vessels are small to very small, the xylem parenchyma scanty, and the intervessel pits are not vestured. In Combretaceae the predominantly uniseriate rays are seen in species of *Anogeissus, Buchenavia, Conocarpus, Combretum, Laguncularis, Lumnitzera*, and *Terminalia*. Among these, traumatic gum ducts have been recorded in *Anogeissus, Buchenavia* and *Terminalia* (PEARSON & BROWN, 1932; BOUREAU, 1950). The nature of the xylem parenchyma of the fossil particularly indicates its affinities with the woods of *Anogeissus* and *Terminalia*. Xylotomically the species of *Anogeissus* and *Terminalia* are very similar to each other. The vessels in *Anogeissus*, however, are consistantly small to very small and the rays heterogeneous. It would thus appear that the fossil under study is very much closer to *Terminalia* than to *Anogeissus*. It is, therefore, placed in the genus *Terminalioxylon*.

Of the diverse species of *Terminalioxylon*, *T. annamense*, *T. edengense*, and *T. fezzanense* (BOUREAU, 1950, 1955, 1958) are characterized by the possession of traumatic secretory canals and, therefore, particularly comparable with the present fossil. In *T. annamense*, however, the vessels are mostly solitary, 150-300 μ in diameter and 2-6 per sq. mm., while in the South Indian fossil the vessels are commonly in radial groups (pairs), only 100-135 μ in diameter, and 8-15 per sq. mm. *T. edengense* differs from the present species in possessing higher rays (up to 40 cells high) with non-crystalliferous cells, and the scanty distribution of its vessels (2-3 per sq. mm.). Further in *T. edengense*, the broad bands of parenchyma containing resin canals are always associated with 1-3 narrow concentric bands of apotracheal parenchyma. Such parenchyma bands are not seen in the South Indian fossil. There is a closer agreement in many xylotomical features between the South Indian species and *T. fezzanense* (BOUREAU, 1958). The vessels in the present species, however, are commonly in radial groups while in *T. fezzanense* they are mostly solitary. Further, short bands of confluent parenchyma seen locally in the present fossil are not found in *T. fezzanense*.

The fossil is named as *Terminalioxylon traumaticum* sp. nov.

DIAGNOSIS

Terminalioxylon traumaticum sp. nov.

Wood diffuse porous

Growth rings faint.

Vessels medium, 100-135 μ in tangential diameter, more commonly in radial groups of 2-4 (70 per cent), solitary ones 30 per cent, oval to elliptical, 8-15 per sq. mm.; vessel-members 350-700 μ long, truncate; perforations simple, inclined; intervessel pits 8-10 μ in diameter, alternate, vestured, rounded or angular; vessel-ray pits narrowly bordered, rounded or tangentially flattened.

Parenchyma paratracheal and apotracheal, fairly abundant. Paratracheal commonly vasicentric, locally confluent, 2-4 cells thick. Apotracheal type as considerably thick, discontinuous tangential bands containing gum ducts. Cells rounded, 28-35 μ in diameter.

Fibres angular in cross section, aligned in irregular radial rows, 15-22 μ in diameter, libriform, 900-1250 μ long, commonly septate.

Rays numerous, 12-16 per mm., predominantly uniseriate or 20-25 μ broad, locally biseriate, 3-15 cells or 50-550 μ long, homogeneous with oval to elliptical procumbent cells; single crystals present, crystalliferous cells of the same size as others.

Locality — Kasikoppam village near Pondicherry, S. India.

Age — Cuddalore sandstone series (U. Miocene-Pliocene)

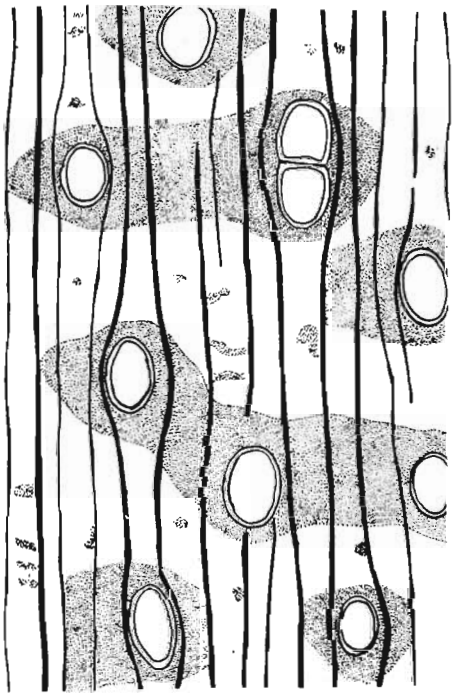
Type specimen — No. S.A. 11, in the author's collection, at the Dept. of Botany, Osmania University, Hyderabad.

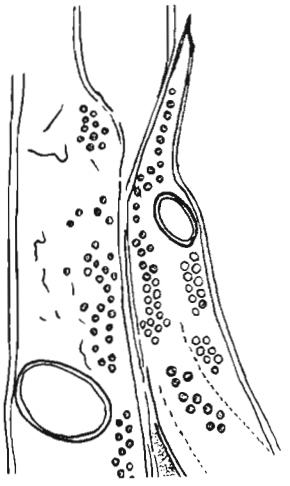
3. *Terminalioxylon coromandelinum* sp. nov

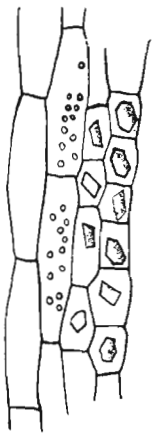
Pl. 3, Figs. 11-15; Text-figs. 10-16

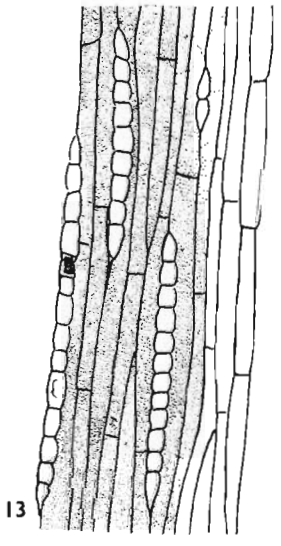
The fossil has no growth rings.

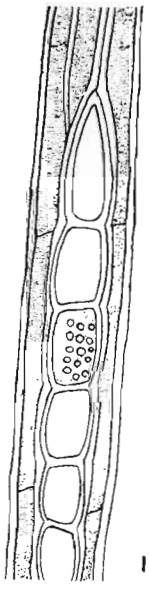
It is dffuse porous. The vessels are medium to large, solitary or in radial groups of 2 or 3, the former being more common, and rounded to oval. They are 160-240 μ











TEXT-FIGS. 10-16 — *Terminalioxylon coromandelinum* sp. nov., 10, Cross-section showing the distribution of vessels and parenchyma (stippled). × 45. 11, Intervessel pits. × 150. 12, Tangential section showing the chambered crystals in the parenchyma, and interparenchyma pits × 150. 13, Tangential section showing the fibres and rays. × 75. 14, 15, Xylem rays. Note the single crystals. 16, A xylem ray showing pits on the tangential walls × 205.

in tangential diameter, fairly thick walled and sparsely distributed being only 4-8 per sq. mm. A brownish red or dark brown substance usually fills up the vessels. There are no tylosic ingrowths. Vessel-members are medium to long and either truncate or attenuately tailed. Perforations are simple and inclined. Intervessel pits are numerous, fairly large, 10-12 μ in diameter, rounded or angular when contiguous and distinctly vestured. (PL. 3, FIG. 13). The vessel-ray pits are many per cell, rounded and simple or narrowly bordered. The vessel-parenchyma pits are similar to the vessel-ray pits.

The xylem parenchyma is very abundant and constitutes the most conspicuous of the various tissues. It is of two types viz., paratracheal and apotracheal, the former being the most predominant one (PL. 3, FIGS. 11, 12; TEXT-FIG. 10). The paratracheal parenchyma is profusely aliform-confluent and only locally typically vasicentric. The aliform sheaths are diamond shaped and the aliform-confluent sheaths are often fairly long. These sheaths are not of uniform thickness and often irregularly aligned. The aliform-confluent sheaths seen distinctly as light coloured patches against the darker background with the naked eye, are 5-10 cells thick. The cells immediately surrounding the vessels are tabular conforming to the contour of the vessels, and the rest rounded to oval. The apotracheal parenchyma is of diffuse type consisting of many individual cells or small groups of cells, among the fibres (PL. 3, FIG. 12; TEXT-FIG. 10). The diffuse parenchyma cells are rounded to oval and easily distinguishable from the surrounding fibres by their larger size and thinner walls. Some of the parenchyma cells are filled with brownish or brownish red contents, others are profusely crystalliferous, with many chambered crystals. The presence of chambered crystals constitutes an important character of the fossil (TEXT-FIG. 12). Pits to the parenchyma cells are seen only occassionally; they are simple, rounded and many per cell.

The fibres are rounded to slightly angular in cross sections and placed in radial rows interrupted at many places by the extensive tracts of the xylem parenchyma. They are libriform, and possess extremely small, simple slit-like and rather obliquely oriented pits in a linear seriation. The fibres are non-septate or septate, and medium to long; they are usually filled up with some brownish red contents (TEXT-FIG. 13).

The rays are numerous, closely placed and constitute the most conspicuous tissue of the tangential sections. They are very fine and are almost exclusively uniseriate and 5-45 cells high (average 18 cells). They are commonly heterogeneous, consisting of a few marginal rows of vertical cells. In tangential sections the vertical cells are very much elongated and the procumbent cells are rounded to oval (PL. 3, FIGS. 14, 15; TEXT-FIGS. 14, 15). They belong to Kribs (1935) Heterogeneous Type III. The ray cells are large and very commonly crystalliferous, there being a single large crystal in each cell. The cells with single crystals are usually larger than the rest. Ray cells without crystals are mostly empty. Pits to the tangential walls of the ray cells are often preserved; they are small, simple, rounded and many per cell (TEXT-FIG. 16).

The fossil does not possess any gum ducts either normal or traumatic.

AFFINITIES AND COMPARISON

The above combination of characters clearly indicates the affinities of the fossil with the woods of *Terminalia*. The fossil is, therefore, placed in the genus *Terminalioxylon*.

The present silicification is particularly comparable with *Terminalioxylon naranjo*, *T. porosum* (SCHÖNFELD, 1947), *T. sahnii* (NAVALE, 1955), *T. speciosum* (RAMANUJAM, 1956), and *Terminalia tomentosa* (CHOWDHURY & TANDON, 1964) in the possession of abundant aliform-confluent parenchyma and in the absence of traumatic gum ducts. It, however, differs from both *T. naranjo* and *T. speciosum* in its higher rays (up to 45 cells high). Further *T. naranjo* is distinguishable in the possession of many short tangential strips of apotracheal parenchyma and *T. speciosum* in its heavily tylosed vessels. It may also be mentioned that in both these species no chambered crystals are found. *T. sahnii* is distinguishable from the present fossil in the possession of smaller vessels (100-140 μ) and homogeneous rays. *T. porosum* can be differentiated from the South Indian species in its commonly radial groups of vessels, homogeneous rays and in lacking chambered crystals in the parenchyma. The fossil wood of *Terminalia tomentosa* recently discovered from

the Tertiary of Burma in its possession of initial parenchyma and clear growth rings, is easily distinguishable from the present fossil.

The fossil is named as *Terminalioxylon coromandelinum* sp. nov. The specific name is after the Coromandel coast, a name that is commonly used for the east coast of India.

DIAGNOSIS

Terminalioxylon coromandelinum sp. nov.

Wood diffuse porous

Growth rings wanting.

Vessels medium to large, 160-240 μ in tangential diameter, 4-8 per sq. mm., more commonly solitary (70 per cent), sometimes in radial groups of 2 or 3 (30 per cent), rounded to oval; vessel-members 350-850 μ long, truncate or attenuately tailed; perforations simple, inclined; intervessel-pits 10-12 μ in diameter, alternate, vestured, rounded or angular; vessel-ray pits 8-12 μ in diameter, rounded, simple, or narrowly bordered.

Parenchyma very abundant, paratracheal and apotracheal. Paratracheal aliform-confluent, 5-10 cells thick, cells large, flattened or rounded to oval, 40-52 μ in diameter; apotracheal, diffuse. Chambered crystals common in parenchyma. Interparenchyma pits simple, rounded and many per cell.

Fibres rounded to slightly angular in cross sections, aligned in radial rows, 18-24 μ in diameter, libriform, septate or non-septate, 965-1800 μ long. Pits extremely small, simple, slit-like, placed in a linear row.

Rays numerous, 10-15 per mm., almost exclusively uniseriate or 30-40 μ broad, 5-45 cells or 150-1300 μ long, commonly heterogeneous; single crystals abundant; crystalliferous cells larger and conspicuous.

Locality — Mortandra near Pondicherry, S. India.

Age — Cuddalore sandstone series (U. Miocene-Pliocene).

Type specimen — No. S.A. 12, in the author's collection at the Dept. of Botany, Osmania University, Hyderabad.

The following is the key for the identification of the various species of *Terminalioxylon*.

1. Maximum tangential diameter of vessels up to 385 μ.
   Growth rings fairly distinct, parenchyma vasicentric and terminal. *T. grandiporosum* sp. nov.
1. Maximum tangential diameter of vessels up to 300 μ.
2. Traumatic gum ducts present.
3. Vessels mostly solitary, paratracheal parenchyma aliform.
   Vessels 150-300μ in diam., 2-6 per sq. mm., rays 3-20 cells high, homo to heterogeneous, crystalliferous. *T. annamense.*
   Vessels 71-189 μ in diam., 2-3 per sq. mm., rays 8-40 cells high, heterogeneous, noncrystalliferous. *T. edengense.*
   Vessels 100-200 μ in diam., 5-13 per sq. mm., paratracheal parenchyma in incomplete sheaths, rays 3-26 cells high, homo to heterogeneous, crystalliferous. *T. fezzanense.*
3. Vessels commonly in radial groups, 100-135 μ in diam., parenchyma vasicentric and locally confluent. *T. traumaticum* sp. nov.
2. Traumatic gum ducts absent.
4. Maximum height of rays up to 25 cells.
5. Parenchyma abundant, aliform, confluent
6. Rays homogeneous.
   Terminal bands of parenchyma present *T. chowdhurii*
   Terminal bands absent, tangential strips of apotracheal parenchyma present. *T. naranjo.*
6. Rays heterogeneous, fibres non-septate, vessels tylosed. *T. speciosum.*
5. Parenchyma little, vasicentric to aliform.
   Initial bands present, vessels 130-250 μ in diam., fibres non-septate. *T. felixi*
   Initial bands absent, vessels 140-170 μ in diam., fibres septate. *T. mortandranse.*
4. Maximum height of rays up to 40 cells (or even above)
   Vessels 100-140 μ in diam., mostly solitary. *T. sahnii.*
   Vessels 150-300 μ in diam., commonly in radial groups of 2-9, rays homogeneous. *T. porosum.*
   Vessels 160-240 μ in diam., commonly solitary, rays heterogeneous, chambered crystals present. *T. coroman delinum* sp. nov.

DISCUSSION

The genus *Terminalioxylon* so far is known from the Tertiary strata of Colombia, S. America (SCHÖNFELD, 1947), Indochina (BOUREAU, 1950), Sudan (BOUREAU, 1955), Libya (BOUREAU, 1958), and India (NAVALE, 1955, RAMANUJAM, 1956; PRAKASH & NAVALE, 1962). From the Pliocene to Miocene of Burma (Irrawady system) Chowdhury & Tandon (1964) recently recorded

a fossil wood of *Terminalia tomentosa*. The other ligneous fossil of Combretaceae viz., *Anogeissusoxylon* is known only from the Tertiary of S. India. Of the 13 species of *Terminalioxylon* recorded, two are known from Colombia, one each from Indochina, Sudan and Libya, and eight from India (seven from the Cuddalore series including the present three and one from Assam Tertiary). From the xylotomical studies of the Indian Tertiary fossils during the recent years it is becoming increasingly evident that Combretaceae constituted one of the dominant elements of the flora of the Cuddalore sandstone series (RAMANUJAM, 1960).

The occurrence of the fossil woods referable to the modern woods of *Terminalia* from the Tertiary strata of such far off localities as Colombia in S. America, Sudan and Libya in Africa, and Burma, India and Indochina in the South East Asia would point out the extensive geographical distribution of this genus during this period. This incidentally seems to be quite in conformity with the present day phytogeography of *Terminalia*. The genus *Terminalia*, represented by more than 200 species is widely distributed throughout the tropical and subtropical regions of both the hemispheres (PEARSON & BROWN, 1932). Within India itself *Terminalia* is very widely distributed covering almost the entire subcontinent. The occurrence of silicified woods resembling *Terminalia* from the middle to upper Tertiary of Assam and South India would probably indicate its equally wide distribution even during the bygone ages of this country.

ACKNOWLEDGEMENTS

I am thankful to Mrs. Savitri Sahni, President, Governing Body of Birbal Sahni Institute of Palaeobotany, for kindly inviting me to participate in this Special Session of Palaeobotany, and to the Director-General of the Geological Survey of India, Calcutta for his help in getting the sections of the petrifactions prepared and for library facilities during the summer of 1963. To Prof. M. R. Suxena, Head of the Department of Botany, Osmania University, Hyderabad, I am thankful for his kind interest and encouragement.

REFERENCES

BOUREAU, E. (1950). Contribution a l'etude Palaeoxylologique de l'Indochina (III). *Terminalioxylon annamense* n. sp., Combretaceae des argiles neogenes du Sud de L'Annam central. IV Presence du *Sapindoxylon pleiKuense* n. sp., daus les argiles neogenes du su l'Annam. *Bull. Serv. Geol. Indochine.* **29**(4): 5-22.

Idem (1955) Etude Palaeoxylologique du Sahara (XXI): Sur un *Terminalioxylon edengense* n. sp. de la pente sud de Edeng, Au Sud-Ouest De 1' Adrar Tiguirirt (Sahara Soudanais). *Bull. du Mus.* **27**(3): 247-254.

Idem (1958). Etude Palaeoxylologique du Sahara (XXIV): Sur le *Terminalioxylon fezzanense* n. sp. Combretaceae fossile du desert du Calancho (Fezzan oriental). *Ibid.* **30**(3): 321-327.

CHOWDHURY, K. A. & TANDON, K. N. (1964). A fossil wood of *Terminalia tomentosa* W. & A. from the Tertiary of Burma. *Ann. Bot. Lond.* N S. **28**: 446-450.

GAMBLE, J S. (1902). A manual of Indian timbers. *London.*

HENDERSON, F Y (1953). An atlas of end-grain photomicrographs for the identification of hard woods. *Bull. For. Prod. Res. Lond.* **26** 1-87.

KANEHIRA, R. (1924). Anatomical notes on Indian woods. *Govt. Res. Taihoku, Formosa. Bull.* **4**: 1-40.

KRIBS, D. A. (1935). Salient lines of structural specialization in the wood rays of Dicotyledons. *Bot. Gaz.* **96**: 547-557

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

NAVALE, G. K. B. (1955). On two new species of *Terminalioxylon* Schönfeld from the Tertiary beds of South India. *Palaeobotanist.* **4**: 35-39.

Idem (1962) *Anogeissusoxylon indicum* gen. et sp. nov. from the Tertiary rocks near Pondicherry, India. *Ibid.* **11**(3): 154-158.

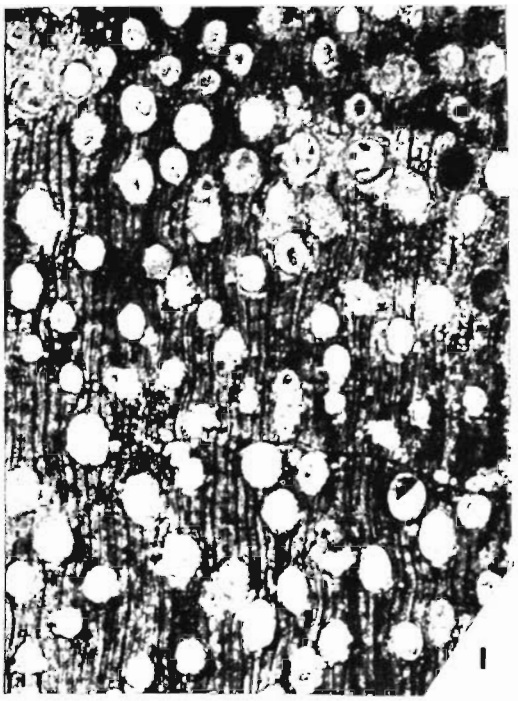
PRAKASH, U & NAVALE, G. K. B. (1962). *Terminalioxylon chowdhurii* sp. nov., a new fossil dicotyledonous wood from the Tertiary rocks of Assam. *Ibid.* 11(1-2): 49-53.

RAMANUJAM, C. G. K. (1956). On two new species of *Terminalioxylon* Schönfeld from the Tertiary of South Arcot district, Madras. *J. Indian bot. Soc.* 35 (1): 103-113.

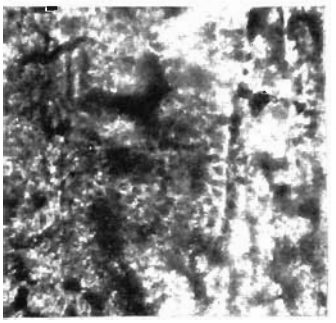
Idem (1960) Silicified woods from the Tertiary rocks of South India. *Palaeontographica.* **106B**: 99-140.

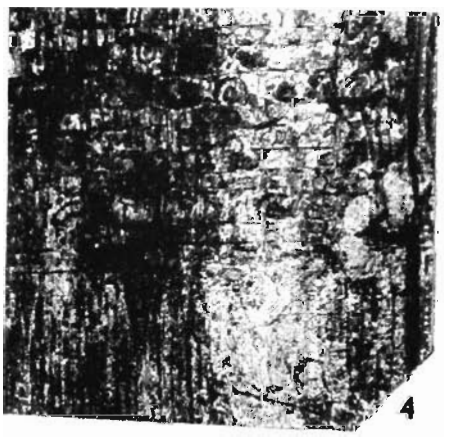
SCHÖNFELD, G. (1947) Hölzer aus dem Tertiär von Kolumbien. *Abh. Senckenb. naturf. Ges.* **475**. 4-48.

ADDENDUM — After the galley proof of this paper was sent to the press, the auther happened to come across the recent publication of Mahabalé & Deshpande (1965 — *Bull. bot. Surv, India,* **7**: 266-275) dealing with a new species of *Terminalioxylon* viz., *T. tomentosum* from the Eccene of Gujarat. The Gujarat species is quite different from the three species described here, and is particularly distinguishable in the possession of very short (5-11 cells high) xylem rays. Incidentally, this record further confirms the wide distribution of *Terminalia*, in the Indian subcontinent during the Tertiary period.


1


2


3

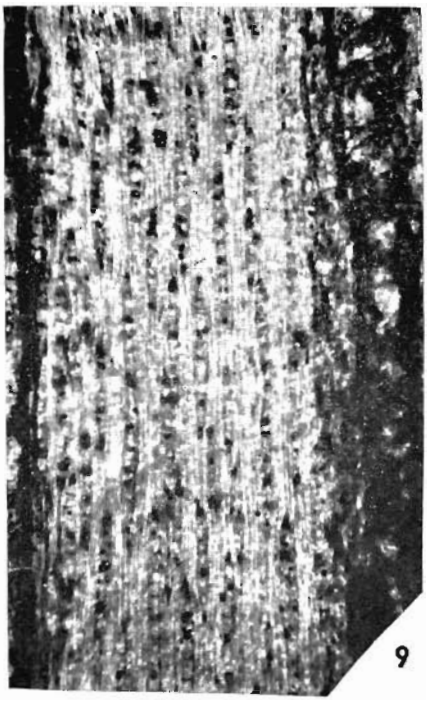

4

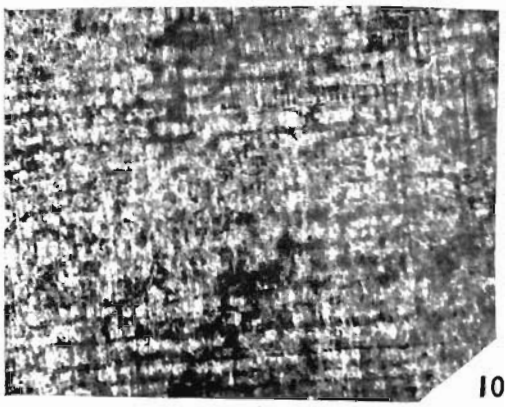

5

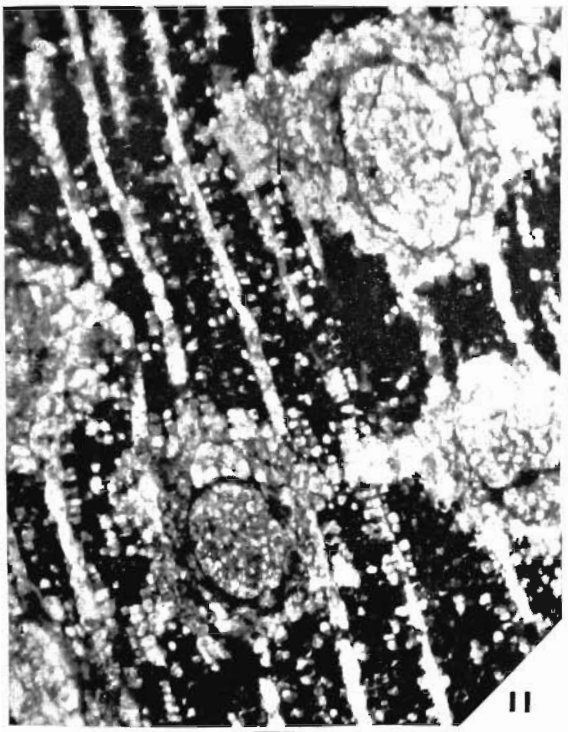

6

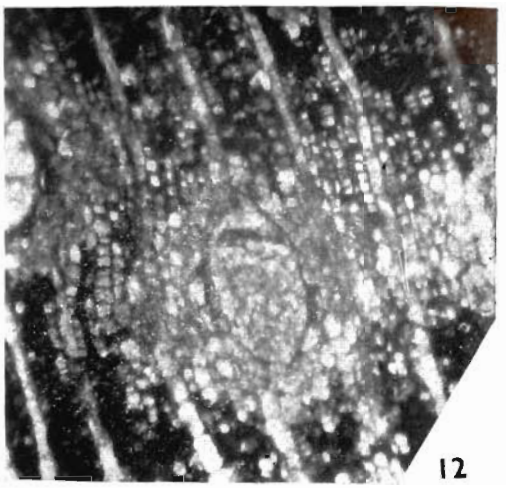

8

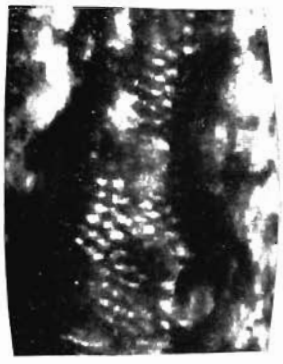

7

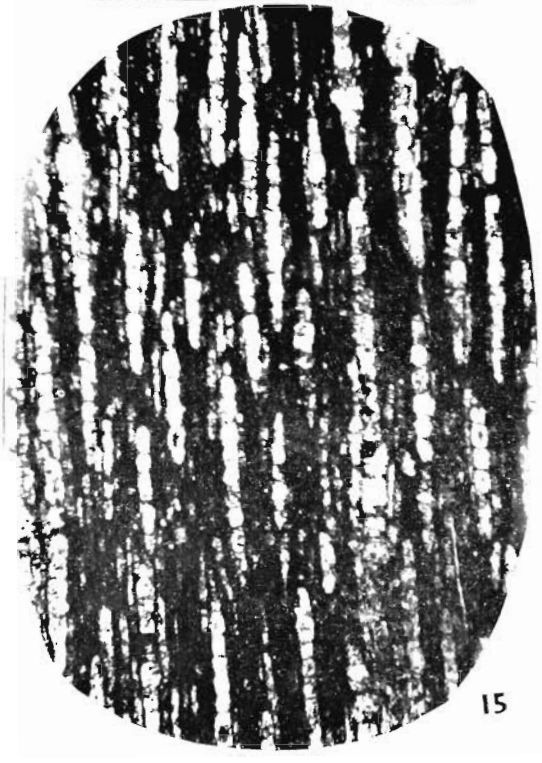

9

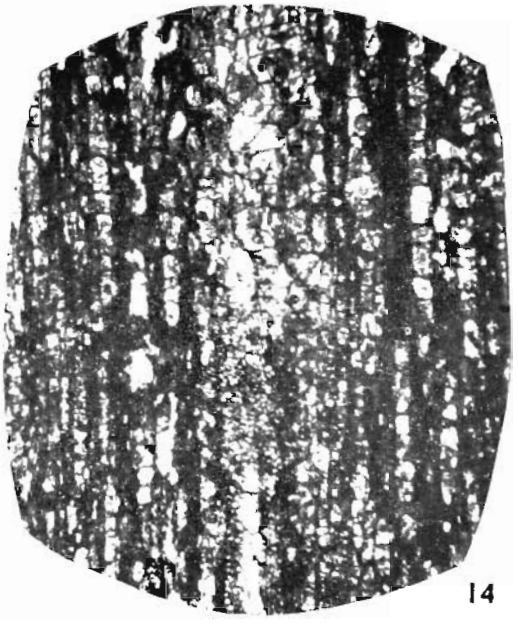

10


11


12


13


15


14

EXPLANATION OF PLATES

PLATE 1

Figs. 1-5, *Terminalioxylon grandiporosum* sp. nov

1. Transverse section under low magnification to show the nature of the growth rings. × 15.
2. Transverse section showing the spring wood vessels, vasicentric and terminal parenchyma and fibres. × 90.
3. Intervessel pitting. × 350.
4. Radial section to show the homogeneous rays with crystalliferous cells. Note the vessel-ray pits. × 90.
5. Tangential section to show the uniseriate rays. Note the crystalliferous cells. × 90.

PLATE 2

Figs. 6-10, *Terminalioxylon traumaticum* sp. nov.

6, 7. Transverse sections showing the tangential rows of traumatic gum ducts. × 75.
8. Transverse section showing the vessels in radial groups and vasicentric parenchyma. × 90.
9. Tangential section showing the uniseriate rays. Note the single crystals. × 90.
10. Radial section showing the homogeneous nature of the rays. × 90.

PLATE 3

Figs. 11-15, *Terminalioxylon coromandelinum* sp. nov.

11 Transverse section showing the nature of the parenchyma and uniseriate rays. × 90.
12. Part of another transverse section showing the aliform-confluent and diffuse parenchyma and fibres. × 90.
13. Intervessel pitting. × 350.
14. Another tangential section. Note the vessel-ray pitting. × 90.
15. Tangential section showing the rays. Note the crystalliferous cells. × 90.