CASTANOXYLON GEN. NOV. FROM TERTIARY BEDS OF THE CUDDALORE SERIES NEAR PONDICHERRY, INDIA

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ABSTRACT

The paper deals with the anatomical studies of the two new fossil dicotyledonous woods resembling the modern woods of *Castanopsis*. But the woods of *Castanea*, some species of *Lithocarpus* and *Quercus* also show similar combination of anatomical characters like the woods of *Castanopsis*. Therefore, a new genus *Castanoxylon* has been created to accommodate the present fossil and for fossils showing similar anatomical characters like the woods of *Castanopsis*, *Castanea*, some species of *Lithocarpus* and *Quercus*.

INTRODUCTION

STUDIES in the Tertiary flora near Pondicherry have shown a rich variety of fossil dicotyledonous woods (RAMANUJAM, 1953-1960; NAVALE, 1955-1960). The material under investigation is also from the fossiliferous localities near Pondicherry. The geological formation of the area is known as Cuddalore series (KRISHNAN, 1949; WADIA, 1953). The age of the formation is believed to be Eocene to Miocene.

DESCRIPTION

Castanoxylon gen. nov.

Castanoxylon indicum sp. nov.

Wood Anatomy

The fossil woods are dark grey in colour and fairly well preserved.

The fossil specimen is a diffuse-porous wood.

Growth rings are not seen in the fossil wood.

Vessels are well preserved and appear as small pores to the naked eye. They are small to medium in size and more or less oval in shape (PL. 1, FIG. 1; TEXT-FIG. 1). The vessels are arranged characteristically in oblique pattern, appearing as flame-shaped structure even to the naked eye (PL. 1, FIG. 1; TEXT-FIG. 1). Vessels are usually solitary, sometimes in radial groups of two, sparsely distributed, and filled with deposits (PL. 1, FIG. 4; TEXT-FIG. 1). They are diffused in the ground mass of the wood (PL. 1, FIG. 1). Incipient tracheids are usually seen near the vessels having a few faint circular cells (PL. 1, FIG. 4). Vessel segments are short, truncate and thin-walled (TEXT-FIG. 3). The intervessel pits are minute, alternate and polygonal in shape (PL. 1, FIG. 3; TEXT-FIG. 2). Vessel-ray and parenchyma pits are indistinct.

Parenchyma is abundant and distinctly apotracheal (PL. 1, FIG. 4; TEXT-FIG. 1). The apotracheal parenchyma is diffuse and scattered irregularly (PL. 1, FIG. 4; TEXT-FIG. 1). The cells of the parenchyma are very small, round and filled with crystals (PL. 1, FIG. 4). Paratracheal parenchyma is very scanty. Only one or two cells are seen near the vessels.

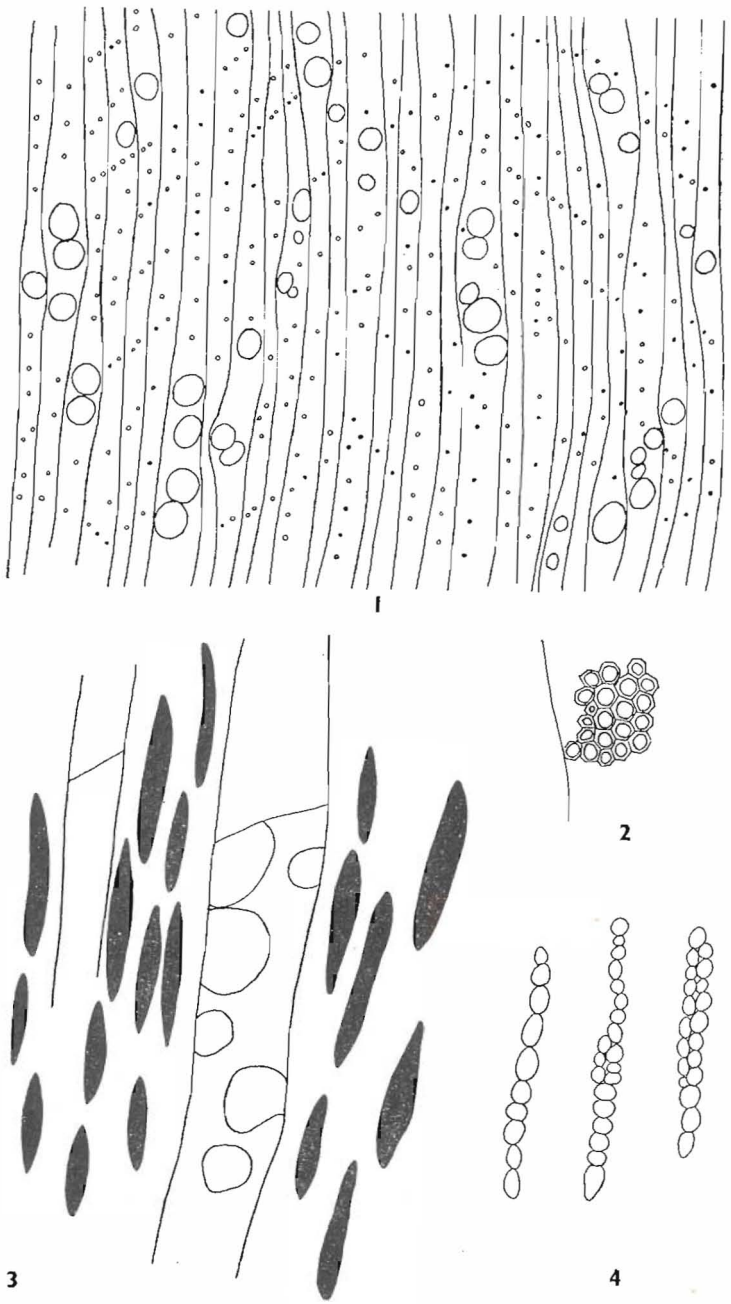
Rays are abundant, uniform in distribution and the cells contain deposits (PL. 1, FIG. 5; TEXT-FIG. 3). Uniseriate rays are abundant, usually made up of vertical cells and homogeneous in nature (PL. 1, FIG. 5; TEXT-FIG. 4). Biseriate rays are also common with homogeneous cells or with few upright cells in the end region (PL. 1, FIGS. 2 & 5; TEXT-FIG. 4). They are often contiguous with vessels (PL. 1, FIG. 4). Cells are usually not well preserved.

Fibres are non-libriform, non-septate and medium in size (PL. 1, FIG. 5). Fibre cells are very small, thin-walled, more or less round in shape and arranged radially in cross-section (PL. 1, FIG. 4).

Tracheids are not abundant, always seen in the vicinity of vessels (PL. 1, FIG. 4). They are small in size and difficult to differentiate from the fibre cells.

Affinities and Discussion

The above structural details of the fossil wood bring out certain typical diagnostic characters which help in the identification.



Castanoxylon indicum gen. et sp. nov.

TEXT-FIGS. 1-4 — 1. Cross-section of the wood showing the distribution of vessels and parenchyma. × *ca.* 75. 2. Tangential section showing the intervessel pits. × *ca.* 240. 3. Tangential section showing the distribution of rays and vessel segments. × *ca.* 150. 4. Rays and their nature. × *ca.* 240.

Considering the nature and the arrangement of vessels, it can be seen that they are usually solitary, medium in size and typically arranged in characteristic oblique radial rows showing flame-shaped arrangement. The parenchyma is distinctly apotracheal, diffuse, punctate and scattered in the wood with occasional, thin, irregular strands. Rays are uniseriate to biseriate having homogeneous or weakly heterogeneous composition. Tracheids are always present in the vicinity of the vessels. These characters limit the comparison to the families of Rutaceae, Rhamnaceae, Myrtaceae, Sapotaceae, Ebenaceae and Fagaceae (METCALFE & CHALK, 1950; PEARSON & BROWN, 1932; GAMBLE, 1902).

Some species of the woods of Rutaceae, Rhamnaceae and Myrtaceae although show oblique arrangement of pores and limited rays like the fossil, yet they differ in many other characters.

The woods of *Diospyros* and Maba of Ebenaceae agree with my fossil specimen in some anatomical characters. They also show apotracheal nature of parenchyma, uniseriate to biseriate rays and small to medium-sized vessels with somewhat radial arrangement. However, a close comparison of these woods with the fossil reveals many differences such as the vessels in these woods are usually small to very small, in groups of 3 to 5, parenchyma distinct, uniseriate, arranged in apotracheal bands and the tracheids are absent.

Members of the Sapotaceae, namely *Plaquium, Bassia* and *Mimusopsis* are comparable in some respects. But these woods differ from the fossil in one to many characters. In *Plaquium,* the vessels are usually in multiples of many, the parenchyma apotracheal but differs in having very regular bands of two to three rows. Woods of *Bassia* differ as the vessels are usually in multiples without any particular pattern, parenchyma is in tangential bands of one or two layers and the rays are high and heterogeneous. Genus *Mimusopsis* differs in having radially arranged multiples of very small vessels and wide and heterogeneous rays.

In Fagaceae, woods of *Castanopsis, Castanea,* some species of *Quercus* and *Lithocarpus* deserve close comparison. They all show more or less similar characters to that of the fossil under investigation in having medium-sized to large, usually solitary vessels with characteristic flame-shaped arrangement; diffuse, scattered apotracheal parenchyma; limited rays and the presence of tracheids. Woods of *Quercus,* in general markedly differ from the fossil in the nature of rays which are distinctly of two types, namely the uniseriate rays and the broad multiseriate compound rays. But in some species of *Quercus* only one type of rays are seen. In *Castanopsis, Castanea* and some species of *Lithocarpus* as well, only one type of rays are seen as is the case in the present fossil. A number of wood sections of modern species of *Castanopsis, Castanea, Lithocarpus* and some species of *Quercus* when examined, and the details available in references consulted (METCALFE & CHALK, 1950; PEARSON & BROWN, 1932; GAMBLE, 1902; MOLL & JANSSONIUS, 1908), indicate that out of these, the woods of *Castanopsis* compare well with my fossil in anatomical details.

There is no record of fossil woods from India resembling the fossil under consideration. However, it can be compared with *Ebenoxylon indicum* (GHOSH & KAZMI, 1958). It shows agreement in over all characters of vessels, parenchyma and rays but detailed comparison shows many differences. In *E. indicum* vessels are small in size, usually in multiples of two to four, parenchyma forms distinct tangential line of one or two cells in regular rows, and the tracheids are absent unlike the fossil.

Fossils of somewhat similar structure as the present specimen described from outside India are *Ebenoxylon aegyptiacum* comparable to *Diospyros,* and *E. knollii* (HOFMANN, 1944) and *E. hofmannae* (GREGUSS, 1956) belonging to Ebenaceae. But they all differ totally as they have very small multiple vessels, highly heterogeneous rays and lack the tracheids. Comparing with the known fossil woods of Fagaceae described as species of *Fegonium, Fagoxylon, Nothofagoxylon, Quercinium* and *Quercoxylon* (FELIX, 1894; VATER, 1884; STOPES, 1910; HOFMANN, 1952; GOTHAN, 1908; UNGER, 1847; SCHLEIDEN, 1883; FELIX, 1883; KRÄUSEL, MÜLLER-STOLL & ERIKA MÄDEL, 1959) with the present specimen, one can easily eliminate all of them as they have distinct compound rays and growth rings. Only two records of fossil woods of *Castanopsis*-type are known from outside this country. One is from the Tertiary of Nagano (*Ogura,* 1949) and the other is an

incomplete description by Schönfeld (1925). As compared to the fossil wood *Castanopsis makinoi* (OGURA, 1949), the present fossil differs in many details. In Ogura's specimen vessels are large, distinctly ring-porous type and rays are exclusively uniseriate and homogeneous. The present fossil wood could not be compared with Schönfeld's specimen as he has not given any anatomical description.

The detailed anatomical studies of the present fossil indicate its similarities with the woods of *Castanopsis*. Ogura (1949) described a fossil wood resembling *Castanopsis* and included it in that as *C. makinoi*. The present fossil specimen also agrees in most of the structural details with the genus *Castanopsis* and so this could also be included in the genus *Castanopsis*. But the living woods of *Castanopsis* are anatomically very similar to those of the genera *Castanea* and some species of *Lithocarpus* and *Quercus*. They commonly share ring-porous form, obliquely radially arranged vessels, uniseriate to biseriate and diffuse parenchyma. There are no clear border line between the above mentioned genera and, therefore, it is not possible in many species to differentiate from the anatomical key given by Müller-Stoll and Mädel, (1957). As opposed to this in Fagaceae the woods of *Fagus, Nothofagus, Quercus* and others are characterized by the prevalence of two types of rays — uniseriate and wide multiseriate rays. Among these, further subgrouping is possible anatomically on the character of flame-shaped arrangement of pores which is absent in *Fagus* and *Nothofagus* but present in *Quercus, Lithocarpus*, etc. It is apparent that the woods of Fagaceae anatomically fall into three groups, viz.

1. Uniseriate and broad multiseriate rays without flame-shaped arrangement of vessels — *Fagus, Nothofagus* (except few species of *Nothofagus*).
2. Uniseriate and broad multiseriate rays with flame-shaped arrangement of vessels — *Quercus, Lithocarpus* (except some species of *Quercus* and *Lithocarpus*).
3. Uniseriate to biseriate rays with flame-shaped arrangement of pores — *Castanea, Castanopsis* (with some species of *Quercus, Lithocarpus*).

Among the fossil woods of Fagaceae, those woods showing similarity of anatomical organization with the woods of *Fagus* have been described under *Fegonium* (FELIX, 1894) or *Fagoxylon* (STOPES & FUJII, 1910), those with woods of *Nothofagus* under *Nothofagoxylon* Gothan (1908) and those similar as *Quercinium* (UNGER, 1847) and *Quercoxylon* (KRÄUSEL, 1939). The only species of fossil wood belonging to group 3 above has been described as a species of the living genus *Castanopsis* itself. However, with the realization of the fact that anatomically, *Castanea* and few species of *Lithocarpus* and *Quercus* from a homogeneous group with *Castanopsis*, I consider it prudent to create a new genus as *Castanoxylon* to include fossil woods showing characters of group 3 above.

Castanoxylon gen. nov.

Diagnosis

General — A diffuse-porous or ring-porous wood.

Growth Rings — May or may not be present.

Vessels — Visible to the naked eye, medium to large, usually solitary, diffuse, characteristically arranged in wide obliquely radial rows; vessel segments short to medium, truncate; intervessel pits small, distinct, alternate to opposite.

Parenchyma — Paratracheal and apotracheal; paratracheal scanty; apotracheal abundant, distinct, diffuse, and scattered irregularly, chambered crystals may or may not be present in parenchyma cells.

Rays — Frequent, closely placed, thin, short, uniseriate or biseriate, homogeneous or weakly heterogeneous.

Fibres — Forming the ground mass of the wood, more or less angular in cross-section, arranged in radial rows, non-libriform, non-septate.

Tracheids — Always in the vicinity of vessels, inconspicuous, incipient, often difficult to differentiate from the fibre cells.

Genotype — *Castanoxylon indicum* sp. nov.

Other species —

1. *Castanoxylon makinoi* (Ogura) comb. nov.

2. *Castanoxylon indicum* sp. nov.

Diagnosis

General — A diffuse-porous wood.

Growth Rings — Not recognizable.

Vessels — Limited, diffuse, small to medium, 120-150 μ in diameter, solitary,

rarely radial, oval in shape, arranged in conspicuous flame-shaped pattern; vessel segments short, 300-480 μ in length, truncate vessel-ray pits not recognizable.

Parenchyma — Abundantly apotracheal, diffuse, closely distributed, often in uniseriate lines; parenchyma cells 24 μ broad, thin, and contain crystals.

Rays — Poorly preserved, closely placed, uniseriate or biseriate, 10-20 cells high, mostly homogeneous with few upright cells in the ray ends.

Fibres — Small, more or less round, 10 μ in diameter, arranged radially in cross-section, non-libriform, non-septate and medium in height.

Tracheids — Very sparse, always in the vicinity of vessels, minute, 12 μ in diameter, thick-walled, slightly bigger than the fibres.

Holotype — No. 26418, Museum, Birbal Sahni Institute of Palaeobotany.

Locality — Usteri, near Pondicherry, South India.

Horizon — Tertiary.

3. *Castanoxylon tertiarum* sp. nov.

Wood Anatomy

The fossil specimen is light brown to dark grey in colour. The details of the wood structure is fairly clear to indicate the affinities of the fossil specimen.

Growth rings are indistinct, scarcely visible to the naked eye or to the microscope. However faint growth differentiation can be seen in the ground tissue due to the darker bands of the fibre cells and larger vessels (TEXT-FIG 5).

Vessels are clearly seen without the help of the hand lens. They are medium-sized to small, solitary, also radial and often filled with contents (PL. 2, FIG. 8; TEXT-FIG. 5). The vessels are diffuse, abundant, arranged in obliquely radial strings sometimes simulating flame-shaped appearance (PL. 2, FIGS. 6 & 7; TEXT-FIG. 5). Vessels are usually accompanied by scanty vasicentric tracheids and frequently with contiguous rays on either side (PL. 2, FIG. 8; TEXT-FIG. 5). Vessel segments are thin-walled, truncate or tailed (PL. 2, FIG. 9; TEXT-FIG. 6). The intervessel pits are small, distinct and alternate to opposite (PL. 2, FIG. 9). Pits in the ray and wood parenchyma are faintly recognizable.

Parenchyma is dominantly apotracheal type. The paratracheal parenchyma is almost absent or rarely confined to one or two cells near the vessels (PL. 2, FIGS. 7 & 8; TEXT-FIG. 5). The apotracheal parenchyma is distinct and scattered, appearing as small, pores in the wood (PL. 2, FIGS. 7, 8; TEXT-FIG. 5). Cells of the parenchyma are small, circular in shape, diffused and scattered in the ground mass of the wood.

Rays are not visible to the naked eye. Rays are very close and uniform in distribution. Rays are uniseriate and biseriate (PL. 2, FIG. 10; TEXT-FIGS. 6,7). Ray cells are homogeneous to heterogeneous with few marginal rows of upright cells (PL. 2, FIGS. 10, 11; TEXT-FIG. 7). Ray cells are usually poorly preserved.

Fibres form the ground mass of the wood. They are more or less angular in cross-section and arranged in radial rows (PL. 2, FIG. 8). Fibres are non-libriform, non-septate and medium in height (PL. 2, FIG. 10). Pits in the fibre cells are hardly visible due to the poor preservation.

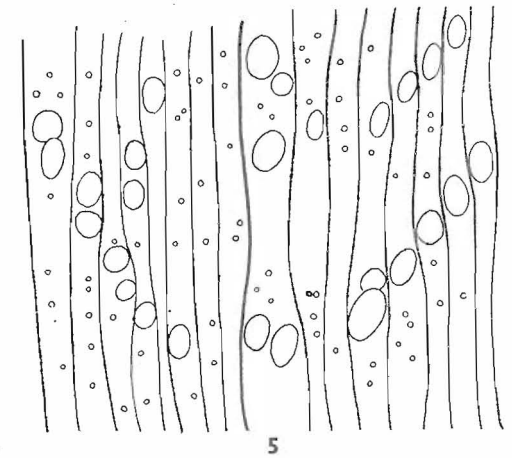
Tracheids are always found in the vicinity of the vessels. They are scanty and often difficult to differentiate from the fibres. They are vasicentric, slightly larger than the fibre cells and more or less round in cross-section (PL. 2, FIG. 8).

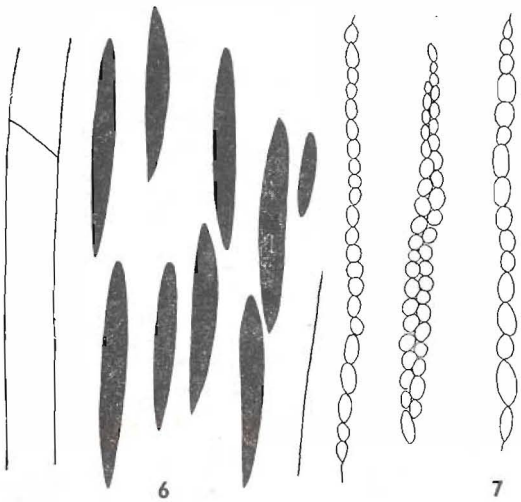
Comparisons

The fossil under investigation more or less shows the same anatomical diagnostic features as shown by the previous fossil and therefore placed under *Castanoxylon* gen. nov.

The closely comparable fossil wood to the present specimen is *Castanoxylon indicum* descibed earlier. The detailed comparison between the two shows large number of characters in agreement, however certain typical differences separate them specifically. Vessels in the present wood are larger, having close distribution, and less widely oblique in arrangement pattern. The parenchyma cells are bigger, less abundant and mostly scattered. Rays are mostly uniseriate.

Castanoxylon makinoi (Ogura) comb. nov., although agreeing in most of the features yet show some differences well marked to separate them. *C. makinoi* conspicuously possesses ring porous vessels, the size of which is very large and the rays are exclusively uniseriate.





Castanoxylon tertiarum sp. nov.

TEXT FIGS. 5-7 — 5. Cross-section of the wood showing the distribution of vessels and parenchyma. × *ca.* 75. 6. Tangential section showing the distribution of rays and vessel segment × *ca.* 150. 7. Rays and their nature. × *ca.* 240.

The present fossil wood has been referred to a new species of *Castanoxylon* as it differs from the known species of this genus.

Diagnosis

General — Diffuse-porous wood.

Growth Rings — Scarcely visible; often with faint growth differentiation in the ground mass due to darker bands of fibre cells and larger vessels.

Vessels — Medium to large, 140-200 μ in diameter, solitary also rarely radial in groups of two, often with tyloses and other contents, diffused, showing flame-shaped arrangement; vessel-segments 380-800 μ in length, thin-walled, intervessel pits small, circular, alternate to opposite and distinct.

Parenchyma — Distinctly apotracheal, abundant, scattered, parenchyma cells 36 μ broad, round to oval in shape.

Rays — Abundantly uniseriate, also biseriate, homogeneous, also heterogeneous, 3 to 4 upright cells in the end region, 20 cells high, filled with brown deposits.

Fibres — Abundant, more or less angular and 12 μ broad in cross-section, thin-walled, non-libriform and non-septate.

Tracheids — limited, vasicentric, cells 20 μ broad, fairly thick-walled.

Holotype — No. 26393, Museum, Birbal Sahni Institute of Palaeobotany.

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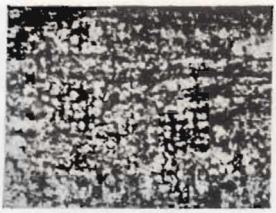

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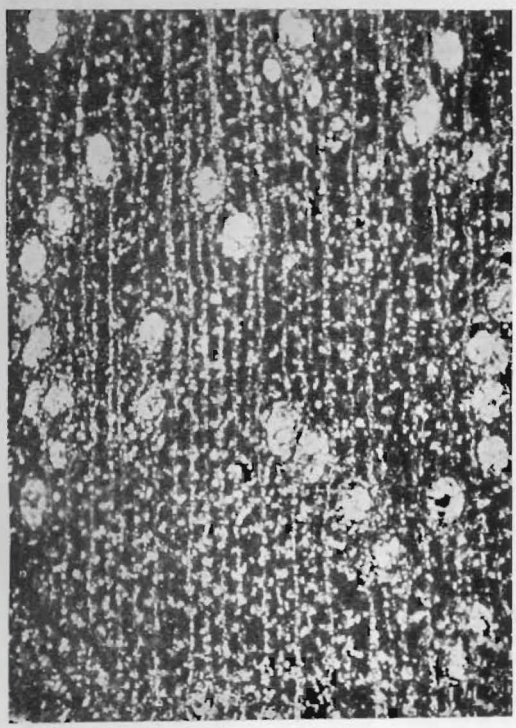

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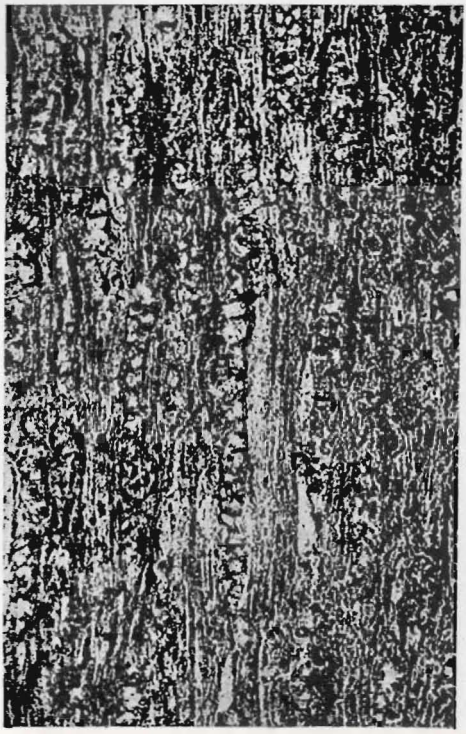

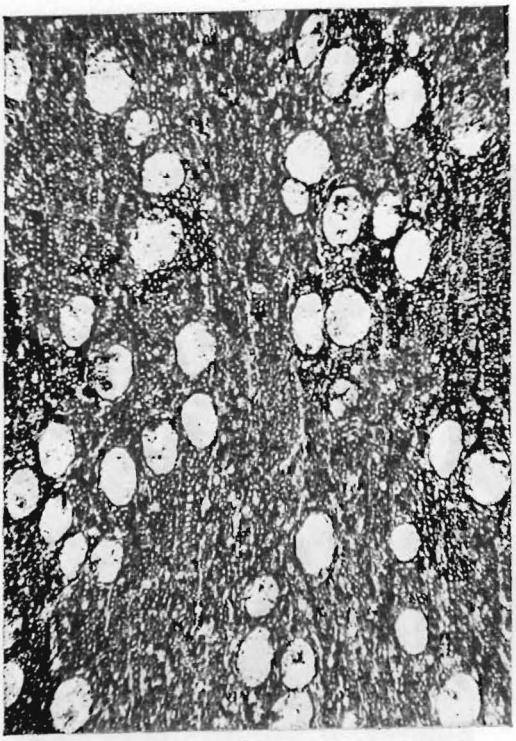

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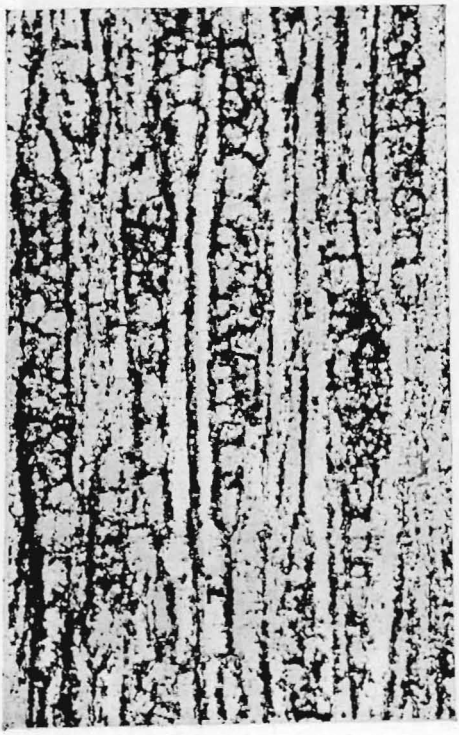

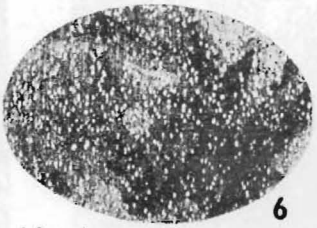

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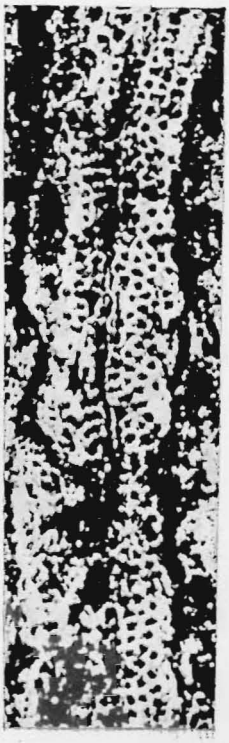

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EXPLANATION OF PLATES

PLATE 1

Castanoxylon indicum gen. et sp. nov.

1. Cross-section of the fossil wood showing the distribution and nature of vessels. Note the distinct oblique arrangement of vessels. × 3.
2. Radial section showing the nature of rays. × 35.
3. Tangential section showing the nature of pits. × 100.
4. Cross-section in high power showing the nature and distribution of parenchyma. × 35
5. Tangential section showing the distribution and nature of rays. × 35.

PLATE 2

Castanoxylon tertiarum sp. nov.

6. Cross-section of the fossil wood in low magnification showing the oblique arrangement of vessels. × 3.
7. Cross-section showing the nature and distribution of vessels and parenchyma. × 35.
8. Another Cross-section highly magnified to show the nature of tracheids, parenchyma cells and vessel contents. × 100.
9. Tangential section showing the intervessel pits. × 100.
10. Another tangential section showing the nature and distribution of rays. × 100.
11. Radial section to show the nature of rays. × 35.