FASCISVARIOXYLON MEHTAE GEN. ET SP. NOV., A NEW PETRIFIED CYCADEAN WOOD FROM THE RAJMAHAL HILLS, BIHAR, INDIA

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ABSTRACT

A new petrified stem from the Rajmahal Hills, Bihar, is described and named *Fascisvarioxylon mehtae* gen. et sp. nov. This wood is compared with the members of the extant family Cycadaceae in having external armour of foliage and scale-leaf bases, parenchymatous internal tissues, broad pith with medullary bundles, single normal vascular ring surrounding the pith and cortex with leaf traces. It is also compared with some Palaeozoic woods especially, the *Medullosa* and *Lyginopteris*, in its mesarch condition of vascular bundles and a tendency to form groups of xylem elements. The Mesozoic cycadophytic genera *Cycadeoidea, Bucklandia, Sahnioxylon* and *Michelilloa* have also been compared.

INTRODUCTION

OUR knowledge of the fossil cycadophytic stems dates back to 1841 (MORRIS, cited in OLDHAM & MORRIS, 1863, p. 11). The history of these stems occurring in the Indian Mesozoic beds has already been reviewed by Bose (1953). It is interesting to note that in spite of a rich occurrence of cycadophytes in the Rajmahal Hills, only bennettitalean woods like *Bucklandia* and *Sahnioxylon* are known but no cycadean wood has so far been reported except for *Sewardioxylon sahnii* Gupta (1960). The only other well known fossil cycad where the anatomical details are known from outside India is *Michelilloa* which has been very recently described by Archangelsky & Brett (1963) from the Triassic beds of Argentina.

The present material is a piece of delicate petrified stem collected by Professor K. R. Mehta from Amarjola, in the Rajmahal Hills, Bihar.

Derivation of Generic and Specific Names — The generic name is derived from Latin words 'Fascis' and 'Varius' which means 'Bundle variable', the last word 'Xylon' is derived from the Greek language meaning 'A piece of wood'. The specific name is given after Prof. K. R. Mehta former Professor of Botany, Banaras Hindu University, Varanasi, who collected the material.

Fascisvarioxylon gen. nov.

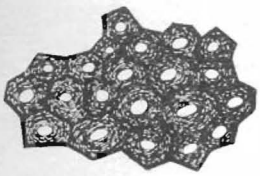
Type Species — *Fascisvarioxylon mehtae* gen. et sp. nov.

Generic Diagnosis — Stem externally covered with an armour of foliage and scale-leaf bases. Pith broad, heterogeneous, cells parenchymatous with thick walled sclerotic nests and collateral to concentric secondary medullary bundles. Orientation of medullary bundles variable from one end to the other. Pith surrounded by a single xylem cylinder made up of segments of mesarch bundles. Centripetal and centrifugal xylem well developed. Segments of xylem traversed on both the sides by pith-like cells. Tracheids tangentially curved and forming an anastomosing system, pits on the radial walls bordered to scalariform. Bordered pits 1-3 seriate, contiguous, alternate or opposite. Medullary rays simple, one to several cells broad and high. Cortex broad, leaf trace bundles collateral and endarch, irregularly distributed throughout the cortex. Mucilage canals absent.

Fascisvarioxylon mehtae sp. nov.

Pls. 1-2, Figs. 1-14; Text-figs 1-4.

Diagnosis — Wood 5·5 cm. long and 2·3 cm. in diameter. Foliage leaf-bases rhomboidal, 7×2 mm. in size; scale-leaves not very well preserved. Medulla 11 mm. in diameter, pith cells heterogeneous with concentric to collateral arcs of secondary vascular bundles, tracheids 10 μ to 20 μ in diameter, radial walls pitted with almost circular bordered pits, uni- or biseriate. Pith surrounded by a single 2 mm. broad ring of normal vascular cylinder, xylem mesarch, primary xylem elements mostly contain annular thickening, only one or two tracheids show spiral thickening.



TEXT-FIG. 1 — A group of sclerotic cells. × 125.

Radial walls of both primary and secondary wood tracheids ranges from 15 μ to 25 μ in diameter, pitted with uni- or biseriate circular to oval, contiguous, alternate, bordered pits. Medullary rays uni- to multiseriate, 1-30 cells high, cells 35 μ × 10 μ in size. Cortex 3 mm. broad with irregularly distributed, trough shaped leaf-traces.

Locality — Amarjola, Amrapara, Rajmahal Hills, Bihar.

Horizon — Rajmahal Series (Jurassic).

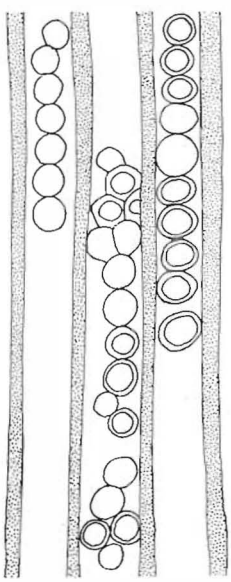
Collection — Holotype No. 32788 of Birbal Sahni Institute of Palaeobotany, Lucknow.

Description — External characters — The specimen is a portion of petrified stem measuring 5·5 cm. in length and 1·8 to 2·3 cm. in diameter, with bulgings and constrictions at intervals of about 2 cm. each. The bulged portion remains covered with an armour of rhomboidal petiole bases, 7 × 2 mm. in size and appears to be spirally arranged. Towards the upper end the elongated petiole bases give an appearance of wrinkled and fissured cork (as in *Cycas circinalis*, SEWARD, 1917). Features on the constricted area not well preserved except to show a small branch scar and wrinkles which may be representing the scale-leaves (PL. 1, FIG. 1).

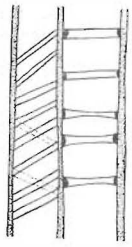
Internal Anatomy — In a transverse section it shows three broad zones, pith, vascular cylinder and cortex (PL. 1, FIG. 2).

Pith — In transverse section it occupies the major central portion, large, 11 mm. in diameter, heterogeneous, composed of oblong to angular parenchymatous cells, groups of sclarenchymatous cells or sclerotic nests (TEXT-FIG. 1) which are more regularly arranged on the outer limit of the pith forming the base of the centripetal xylem of the normal vascular cylinder. Most characteristic feature of pith is the presence of collateral and concentric medullary vascular bundles (PL. 1, FIG. 3). These when seen from top to bottom in a transverse section show all sort of orientations. They are oblique or transverse showing that they do not run as isolated bundles perpendicularly through the tissues of the pith but their course lies in almost every direction, owing to the fact that they form a part of an anastomosing system whose different branches traverse the length and breadth of the pith (PL. 1, FIG. 6). Mucilage canals absent. Tracheids of these secondary bundles, compact, small, rectangular, in transverse plane. Radial walls 10 μ to 20 μ in diameter, pitted, pits bordered, uni- or biseriate, contiguous. Pits in single row longer than broad, 6 μ to 8 μ in size, when in two rows alternate or opposite with rounded angles. No protoxylem elements could be seen. Phloem cells of the bundles not preserved.

Normal Vascular Cylinder — 2 mm. broad, lies in between the pith and the cortex, made up of segments or groups of mesarch bundles, interrupted by broad ray like extentions of pith tissue (PL. 1, FIG. 4). Both centripetal and centrifugal xylem alike, converge in the middle, connected by smaller elements and parenchymatous cells. These connecting tissues are primary in nature having spiral, annular to scalariform pitting on their radial walls. Tracheids showing spiral thickenings are only one or two, otherwise mostly with annular thickenings. The mesarch condition at the top, when traced downwards show that both the centripetal and centrifugal xylem



TEXT-FIG. 2 — A portion of tracheids in radial plane showing bordered pits. × 500.

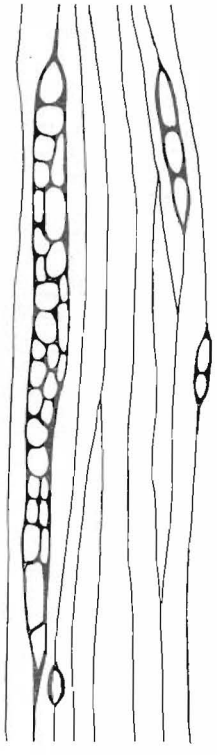


TEXT-FIG. 3 — A portion of primary tracheids in radial plane showing spiral and annular thickenings. × 500.

repeatedly separate and again join forming exarch and endarch (PL. 2, FIG. 13) or mesarch bundle rings at different lengths. Segments at places show a tendency to form concentric groups of tracheids (PL. 2, FIG. 12). Centripetal xylem development unequal from top to bottom, towards the base it is almost absent. Stone cells occur on both inner and outer margins of vascular segments. Segments 2 to 20 tracheids wide. Radial walls 15 μ to 25 μ in diameter (including both primary and secondary tracheids) showing one to two tracheids with spiral thickenings but mostly annular and bordered pits as traced towards the secondary tracheids. Bordered pits uni- or biseriate, contiguous, ± alternate, angles rounded (somewhat different from the typical araucarian pitting) (PL. 2, FIG. 8). Pits in the field not preserved. The most characteristic feature of the vascular cylinder is to form a complicated anastomosing system which is clearly seen in the tangential plane (PL. 2, FIG. 14). Medullary rays simple, uni- to multiseriate, 1 to 30 cells high, cells longer than broad, 35 μ × 10 μ in size (PL. 2, FIG. 14; TEXT-FIG. 4).

Cortex — 3 mm. wide, made up of pith like parenchymatous cells. The occurrence of irregularly distributed, trough shaped, collateral endarch bundles supplying the leaf-bases is a characteristic feature (PL. 1, FIG. 5). Leaf-traces in a radial longitudinal section show that a single bundle depart from the normal cylinder and traverses some distance through the cortex and then bends to enter the base of the petiole. They could not be further traced due to lack of material and preservation. At one place two uniting bundles are seen (PL. 1, FIG. 7). A two or three celled, pericycle like layer separates the cortex from the cork. Cork cells are found mixed with sclerotic nests. The sclerotic cells very dense and compact near the base of the wood piece.

Comparison with Living Forms — Among the living gymnosperms the Rajmahal specimen approaches nearest to the members of the present day Cycadaceae. Following main features of the fossil undoubtedly suggest its affinities with the cycads, e.g. an armour of foliage and scale-leaf bases formed alternately on the stem, parenchymatous nature of internal tissues, large pith with medullary bundles. Worsdell (1906, p. 131) has stated, " In all species of the genus *Encephalartos*, and in certain species only of *Macrozamia* there occurs a system of medullary bundles scattered in great numbers throughout the pith. Each is always accompanied on the side of the phloem by a mucilage canal. These bundles are orientated in every conceivable direction as seen in a transverse section, and are collateral in structure ". The occurrence of



TEXT-FIG. 4 — Tangential section showing uni- to multiseriate medullary rays. × 125.

these bundles in every direction has also been seen near the lower region of the wood piece. But it is distinguished from these living genera and species only in the absence of canal and phloem, but this may be due to the bad preservation of specimen. The medullary bundles also remind us of peduncular bundles of the pith as found in *Ceratozamia mexicana* Brongn. (WORSDELL, 1898, p. 454) but the bundles in the present specimen are not wedge shaped and moreover their course is also not like the living one as passing through the medullary rays into the cortex. The anastomosing system and concentric nature of medullary bundles have also been reported in *Encephalartos* and *Macrozamia* (WORSDELL, 1896). Other characters indicating the cycadean nature are monostelic and manoxylic wood formed by groups of bundles and their tangentially curved course of tracheids. The monostelic condition occurs in *Stangeria, Zamia, Ceratozamia* and *Dioon* but with collateral bundles in contrast to the mesarch condition in the fossil specimen, though a tendency towards the formation of endarch collateral ring at places is also not uncommon in the present fossil. It is quite interesting to note that among the recent cycads typically mesarch bundles have only been found in the leaves of cycadaceae and not in the mature stems. But Scott (1897, p. 400) showed that both male and female peduncles of *Stangeria, Bowenia* and some species of *Zamia* and *Ceratozamia* possess mesarch type of vascular bundles. It is even more comparable with *Stangeria paradoxa* where also these bundles fuse and separate again repeatedly forming collectively a hollow net work with long meshes (SCOTT, l.c. p. 407) and irregularly orientated component bundles near the base (WORSDELL, 1906, p. 137). The limitation of centripetal xylem only to the principal bundle further strengthens the comparison which is a rule in the male and female peduncles of *Stangeria paradoxa* (SCOTT, l.c. p. 406). Broad cortex with numerous leaf traces or cortical bundles indicate cycadean feature (*Stangeria paradoxa* stem, Marsh, 1914, p. 20). The occurrence of scattered stone cells or sclerotic nests throughout the stem and the apparent resemblance of medullary and cortical bundles are the features seen in *Macrozamia* (WORSDELL, 1896).

Comparison with Fossil Forms — Among the fossil plants so far known, the mesarch type of vascular bundles of the normal wood cylinder in the stems are quite widely spread which not only occur in Medulloseae or other Pteridosperms but also found in the leaves of the Cordaiteae. The Cordaitalean stem possesses normal cycadean stem type of bundles. But it is interesting that certain other Palaeozoic forms possess typical mesarch bundles in their stems.

Recently Kräusel *et al.* (1961) have reviewed the gymnospermous woods with primary structure from the Gondwana land, showing that they can be grouped under two main categories, one with endarch protoxylem and the other with mesarch protoxylem. Under the latter category are placed several genera, e.g. *Phyllocladopitys* Kräusel, *Taxopitys* Kräusel, *Abietopitys* Kräusel, *Taeniopitys* Kräusel, *Solenopitys* Kräusel and *Medullopitys* Kräusel. The affinities of these genera are not very clearly known except that they are gymnospermous. These genera differ from my wood in their alround features especially in the absence of medullary bundles along with sclerotic cells. *Taxopitys alves-pintoi* Kräusel & Dolianiti, shows the presence of some pith tracheids but of doubtful nature.

The two other Palaeozoic forms with which *F. mehtae* may be compared are *Lyginopteris* and *Medullosa*.

Lyginopteris oldhamia resembles my specimen in having spirally arranged leaves, large parenchymatous pith with sclerotic nests and a ring of separate mesarch wood around the pith. But differs mainly in the absence of medullary bundles, equally developed centripetal and centrifugal xylem and in the presence of well developed secondary xylem. But according to Bancroft (1914, pp. 45-46) the specimens of *Lyginopteris* type also show occasional anamolies in anatomical structure, e.g. the formation of secondary vascular tissues with inverted orientation in the pith immediately within the normal ring.

It is quite interesting to note that the present fossil shows a very striking feature of *Medullosa*, the formation of separate steles in the main cylinder of wood near the base (PL. 2, FIG. 12). The medullary system of vascular bundles is also not uncommon amongst the Medulloseae. The polystelic structure of *Medullosa* distinguishes them from the recent and Mesozoic cycadophytes which are regarded as monostelic. Though in some species of *Medullosa*

e.g. *M. porosa* a reduction of concentric bundle is seen.

The Mesozoic cycadophytes are mainly represented by the *Cycadeoidea* type of stems having large pith surrounded by a thin zone of wood which is interrupted by large ray like extentions of pith tissues. They are distinguished mainly in their endarch protoxylem structure and peculiar C-shaped leaf traces. The two well known bennettitalean genera *Bucklandia* and *Sahnioxylon* represented in India needs no comparison as they are quite distinct in their own features especially in having picnoxylic wood, well developed secondary xylem, growth rings, their peculiar radial pitting and medullary ray system. *Sewardioxylon sahnii* Gupta (1960) needs only a reference here as it cannot be compared due to the lack of desirable description and moreover, the genus is invalidly published because it does not contain any photograph or diagnosis.

Recently a fossil cycad wood *Michelilloa waltonii* has been reported by Archangelsky and Brett (1963) from the Triassic of Argentina. The authors have compared this fossil wood with the living *Dioon spinulosum* in its leaf gap structure. This wood shows resemblance with the Rajmahal specimen only in having broad medulla, single normal ring of vascular bundle and cortex with leaf traces but differs mainly in the absence of medullary bundles, stones cells, curved nature of tracheids of medulla and normal vascular ring forming an anastomosing system, and especially the mesarch xylem condition.

In view of the above comparison, it is quite evident that *F. mehtae* is closest to the Cycadales than any other known group as far as stem anatomy is concerned.

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EXPLANATION OF PLATES

PLATE 1

1. Original specimen showing external characters. No. 32788. × 1.

2. Transverse section. Sl. No. 32788/1. × 4.

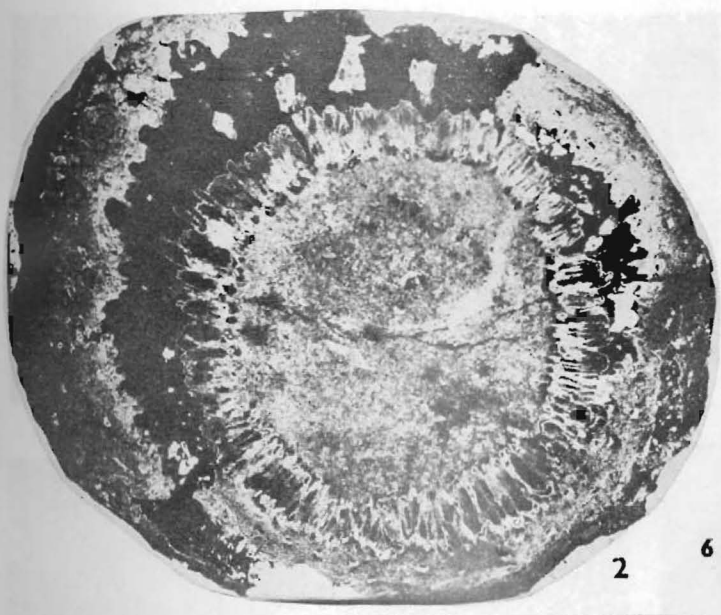
3. Magnified view of pith showing concentric and collateral medullary bundles. Sl. No. 32788/2. × 30.

4. A portion of normal vascular bundles showing centripetal and centrifugal xylem forming a mesarch condition with pith like cells traversing on both sides. Sl. No. 32788/2. × 120.

5. Leaf-trace. Sl. No. 32788/2. × 90.

6. Radial section through the pith showing the anastomosing system of medullary bundles. Sl. No. 32788/7. × 90.

7. Double leaf trace in transverse section. Sl. No. 32788/2. × 90.



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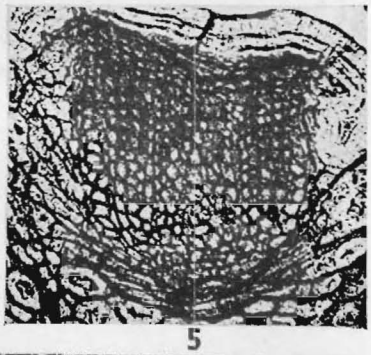

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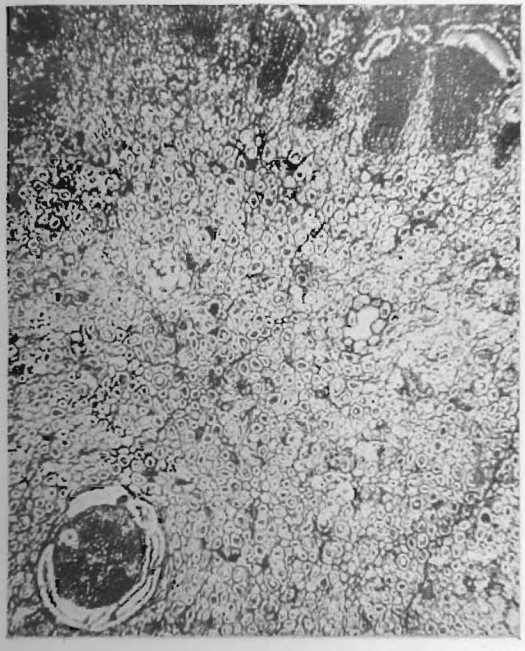

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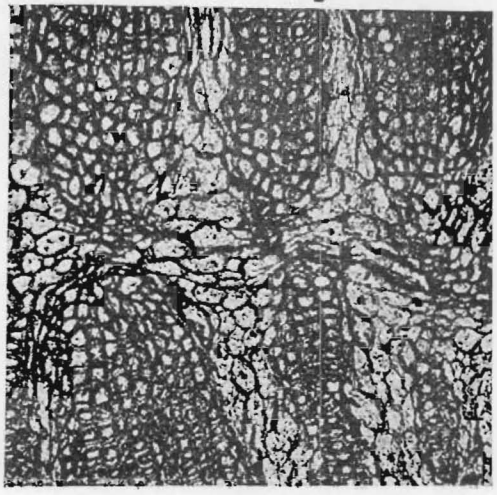

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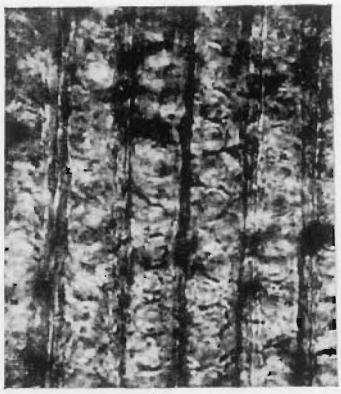

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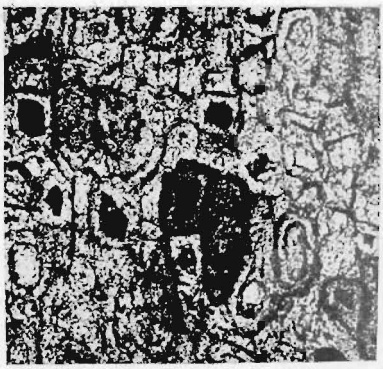

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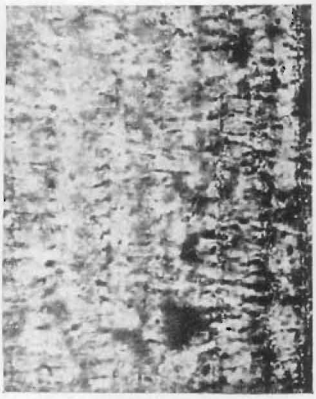

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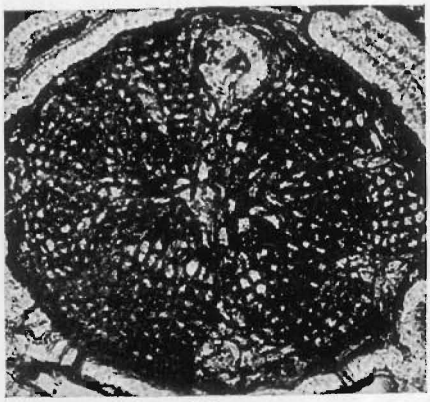

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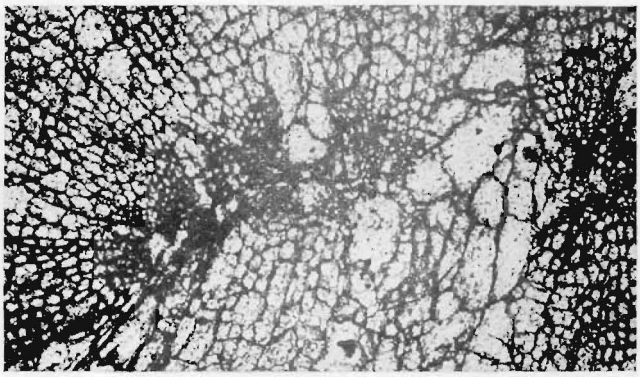

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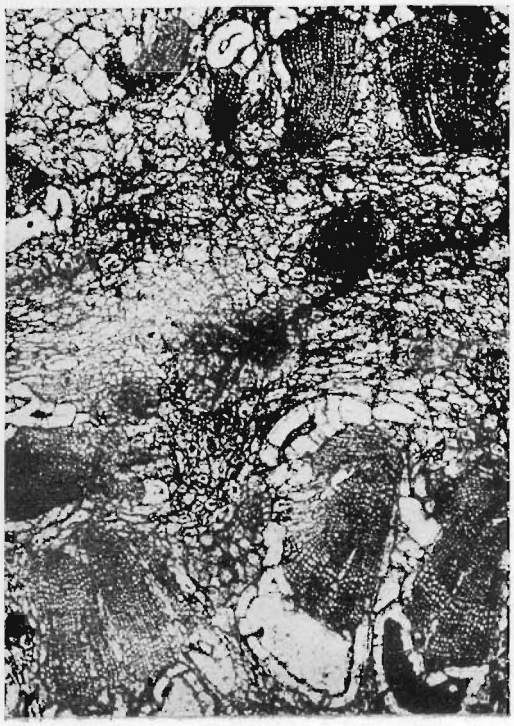

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PLATE 2

8. Tracheids of normal vascular cylinder in radial plane showing bordered pits. Sl. No. 32788/4. × 500.

9. Magnified view of pith cells in radial longitudinal plane. Sl. No. 32788/4. × 90.

10. Primary xylem tracheids of normal vascular cylinder showing annular and scalariform thickenings. Sl. No. 32788/4. × 500.

11. Magnified view of concentric bundle in pith (T.S.). Sl. No. 32788/2. × 120.

12. A portion of normal vascular cylinder showing the formation of group. Sl. No. 32788/2. × 90.

13. A portion of separate centrifugal and centripetal xylem forming the endarch and exarch rings in transverse view near the base of the wood piece. Sl. No. 32788/9. × 31.

14. Tangential section through the normal vascular cylinder showing several cells high and broad medullary rays and anastomosing system of tracheids. Sl. No. 32788/6. × 160.