

A NEW SPECIES OF PETRIFIED PALM STEM FROM THE DECCAN INTERTRAPPEAN SERIES

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ABSTRACT

A silicified palm stem with roots attached to it collected from Mohgaon Kalan, Madhya Pradesh, is described here in detail. The anatomy of the stem shows that it does not fully agree with any of the Indian species of palm stems described so far, although in minor features it shows some resemblances with *Palmoxylon sclerodermum* Sahni (1943), *P. surangei* Lakhanpal (1955) and *P. raoi* Menon (MS). However, it also differs from these in important characters like the frequency, dimensions, form and structure of the fibrovascular bundles and in some other minor features. It has, therefore, been described under a new specific name, *Palmoxylon kraeuselii*. The specimen can be referred to the *Cocos-like* palms according to the classification given by Sahni (1943).

INTRODUCTION

THE specimen described in this paper is one of the numerous fragments of silicified palm woods collected by the Junior author from Mohgaon Kalan in Madhya Pradesh. It has a number of roots attached to it which indicate that this is probably a part of the basal portion of a stem. Judged by the structural details of the roots and stem of this specimen, it appears to be different from other palm stems described so far from India.

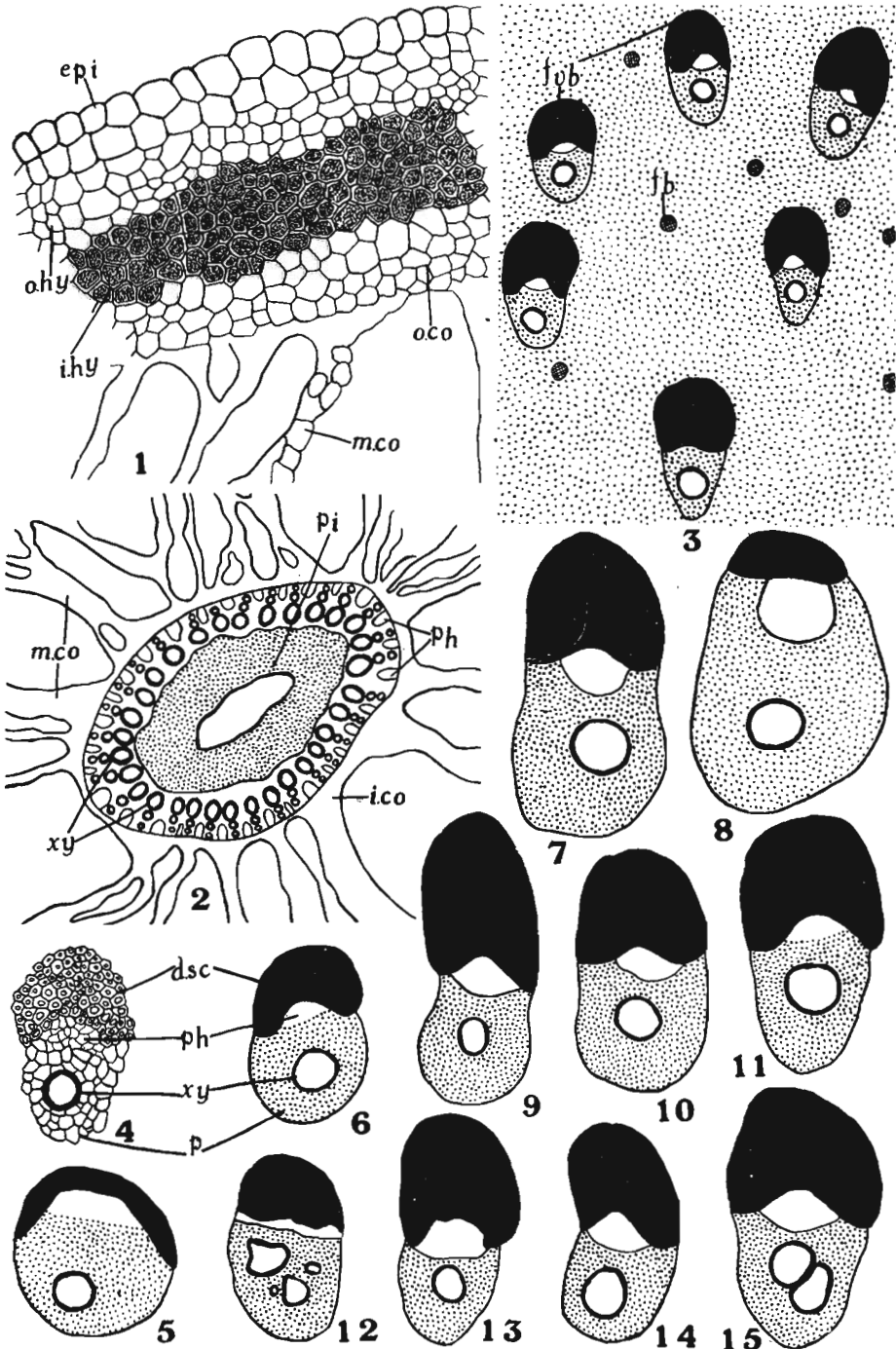
DESCRIPTION

The specimen is a small piece of wood measuring 6 cm. long, and 9 cm. broad; PL. 1, FIG. 1). The root zone is preserved on only one side and even this became separated from the stem after a few sections of the whole block were taken. The stem itself is not complete in transverse section, but the different zones like, cortical, dermal and sub-dermal, (PL. 1, FIG. 2) are preserved in parts. The central zone is not preserved. The colour of the specimen is blackish brown. The root zone consists of small as well as big roots. The preservation is not very good, however, full structural details could be studied from different roots.

Staining the sections in aqueous safranin was helpful.

ANATOMY OF THE ROOT

The root zone consists of numerous roots crowded together. They are usually deformed and pressed in various forms by crowding (PL. 1, FIG. 1). But some of them retain their original circular form in transverse sections (PL. 1, FIG. 3). The outermost layer—the epidermis (TEXT-FIG. 1), which is designated as the 'epiblemma' by Mahabale & Udwardia (1960), and 'limiting layer' by Drabble (1904), is not very clearly preserved. But in some roots it looks as though it is composed of slightly thick-walled cells. Below the epidermis is seen a band of thin-walled parenchymatous cells, which can be referred to as the outer layer of hypodermis (TEXT-FIG. 1; PL. 1, FIG. 4). The inner hypodermis consists of thick-walled cells with yellow contents (TEXT-FIG. 1; FIG. 4). Below the hypodermis lies the cortex divisible into, the outer, middle and inner cortex. The outer cortex forms 2-4 layers of parenchymatous cells compactly arranged (TEXT-FIG. 1; PL. 1, FIG. 4). The inner cortex which is just outside the endodermis has compact layers of thin-walled cells. In between the outer and inner cortex occurs the middle cortex including a number of large and small air spaces (FIGS. 3, 4), which are separated by radial layers of parenchymatous cells. These layers are mostly single celled, sometimes 2-4 celled in thickness. There are no fibrous bundles in the cortex. The endodermis and pericycle are single layered. There are 26 to 33 exarch xylem strands in the roots (TEXT-FIG. 2; PL. 1, FIGS. 3, 5). Phloem patches occur in between the xylem strands. The conjunctive parenchyma is thin-walled. The well preserved peripheral part of the parenchymatous pith contains a few isolated thick-walled cells scattered amidst the thin-walled cells which contain dark contents. This is responsible for the dark colour of the pith region in Figs. 3 and 5.



TEXT-FIGS. 1-15 — 1 A portion of the Transverse section of the root showing epidermis, hypodermis and outer cortex. $\times 175$. 2. Transverse section of the root showing the stelar portion. $\times 40$. 3. Diagrammatic representation of the distribution of fibrovascular and fibrous bundles in the dermal zone. $\times 40$. 4-15. Different types of fibrovascular bundles from the dermal zone. $\times 75$. (d.sc.—dorsal sclerenchyma; epi.—epidermis; fb.—fibrous bundle; fvb — fibrovascular bundle; i.co.—inner cortex; i.hy.—inner hypodermis; m.co.—middle cortex; o.co.—outer cortex; o.hy.—outer hypodermis; p.—parenchyma; ph.—phloem; pi.—pith; xy.—xylem.)

The central part of the pith is not preserved.

ANATOMY OF THE STEM

The stem region is divided into three zones the cortical, dermal and subderma (PL. 1, FIG. 2). The *cortical zone* is clearly marked from the root zone and contains numerous fibrous bundles of different sizes distributed irregularly. The fibrovascular bundles are very rarely seen. The longitudinally cut roots are also seen in the cortex of the stem. Most of the fibrous bundles are obliquely cut here. Ground tissue cells are not well preserved.

Dermal Zone is not very well preserved. The fibrovascular bundles are regularly orientated. They are crowded but not confluent (TEXT-FIG. 3; PL. 2, FIG. 6). The frequency of the fibrovascular bundles could not be counted as the dermal zone is a very narrow portion of the stem (FIG. 2). The fibrous part is mostly smaller than the vascular part (TEXT-FIGS. 4-8, 10-12, 14-16), but in some of the bundles they are more or less equal in amount (TEXT-FIGS. 9 & 13). The f/v ratio of the vascular bundles is 0.2/1.1/1. They are of different sizes and mostly oval to elongated in shape (TEXT-FIGS. 4-16). Their diameter being 0.18-0.3 mm. The dorsal sclerenchyma has cordate to reniform base. The median sinus is concave, sometimes it is flat as in Text-fig. 12 or deep as in Text-fig. 16. The auricular lobes are generally rounded. Phloem cells are not preserved, but the phloem patch is seen quite clearly. The xylem usually consists of one, rarely 2 or 3 vessels. It is surrounded on the ventral side by parenchyma only and the ventral sclerenchyma is completely absent. Stigmata around the fibrous part of the fibro-vascular and fibrous bundles could not be recognized in transverse sections, but something like them could be noticed in longitudinal sections (FIG. 7) as in *P. sclerodermum* Sahni (1943). Fibrous bundles are distributed in between the fibrovascular bundles. The ground parenchyma cells adjacent to the vascular part of the bundles are seen, radiating from them (TEXT-FIG. 17; PL. 2, FIG. 8). Tabular parenchyma is totally absent. Loosely arranged ground parenchyma consists of thin-walled elongated cells.

Subdermal Zone—The fibrovascular bundles of different forms (FIGS. 19-24)

are widely placed and more or less regular in distribution (TEXT-FIG. 18; PL. 2, FIG. 9). Their frequency is 50-55/cm². The fibrous part is smaller than the vascular part (TEXT-FIGS. 19, 21-24, PL. 2, FIG. 10) in most of the bundles, except in a few in which they are more or less equal (TEXT-FIG. 20). Their f/v ratio is 0.4/1.1/1. The bundles are bigger than the bundles of the dermal zone, their diameter being 0.27-0.4 mm. The dorsal sclerenchyma is reniform in shape. The median sinus is flat to concave and the auricular lobes are rounded. The xylem vessels are one to two, sometimes more. Protoxylem is surrounded by parenchyma only (PL. 2, FIG. 10). Fibrous bundles occur in between the fibrovascular bundles. Smaller fibrovascular bundles are scattered here and there (PL. 2, FIG. 9). The ground parenchyma is very loose and composed of elongated cells distributed somewhat in a scattered manner (TEXT-FIG. 25).

Longitudinal sections of the stem show scalariform pitting of the metaxylem vessels (FIG. 11) and spiral thickenings of the protoxylem vessels.

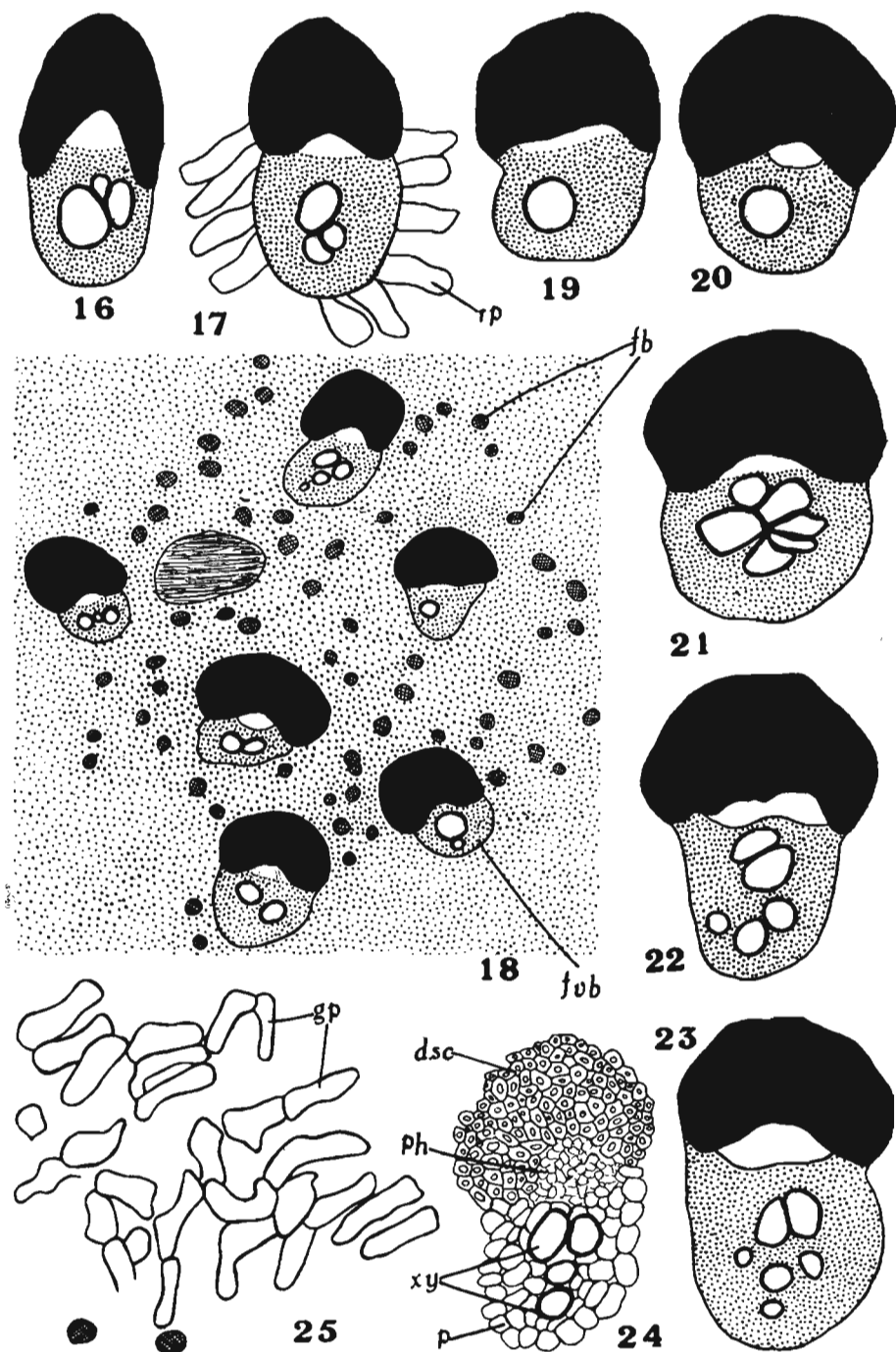
DISCUSSION

A number of *Palmoxylon* species have been described from India by various workers (see RAO & MENON, 1963, 1964; MENON, 1964; † SAHNI, 1964). After comparing the present species with all these Indian species we find that a detailed comparison is possible only with *Palmoxylon sclerodermum* (SAHNI, 1943; SHUKLA, 1946), *P. surangei* Lakhanpal (1955) and *P. raoi* Menon (MS). Among the foreign species of *Palmoxylon*, *P. maedae* Ogura (1952) and *P. anchorus* Stevens (1912) are the ones with which a comparison is also possible. The points involved in the comparison are incorporated in Table 1. A careful study of the table shows that the present species does not agree with any of the Indian species shown in the accompanying table in important characters like, (1) the number of xylem bundles in the root, (2) the frequency of the bundles in the various zones of the stem, (3) the f/v ratio, (4) the diameter of the bundles, (5) the relative extent of the dorsal sheath, and (6) the proportion of the dorsal sclerenchyma to the ventral. It, however, agrees with *P. maedae* Ogura in many of these points. But at the same time it differs from *P. maedae* in the frequency of the bundles and

TABLE 1

CHARACTERS	<i>Palmoxylon sclerodermum</i> SAHNI	<i>P. surangei</i> LAKHANPAL	<i>P. raoi</i> MENON	<i>P. maedae</i> OGURA	<i>P. kraueselii</i>	<i>P. anchorus</i> STEVENS
Roots						
Epidermis	Not clear	Not clear	Not clear	Unknown	Somewhat thick walled	
Hypodermis	—	—	Outer—Thin walled, 2-3 layers Inner—Thick walled, 2-3 layers	Unknown	Outer—thin walled, 2-4 layers Inner—thick walled, 2-3 layers	Outer limiting layer consists of cells with cuticularized, comparatively thin walls
Cortex	Outer—Thick walled Middle—Peripheral cells compact with some cells containing black contents; other portions loose with air spaces.	Outer—Thick walled; cells with dark contents; other portions loose with air cavities separated by layers of parenchyma Inner—compact cells	Outer—Thin walled 2-3 layers Middle—loose with large air spaces separated by layers of parenchyma cells. Inner—parenchymatous cells	Outer—not preserved Middle—Large radially extending intercellular spaces separated by 3 layers of parenchyma Inner—Compact cells	Outer—Thin walled compact cells Middle—loose large air spaces. Sometimes 2-3 layers of air spaces, separated by parenchymatous cells Inner—Compact; cells thin walled	Outer—several layers of elongated, lignified cells with thick walls and small lumen Middle—Radially arranged longer air spaces separated by 1-6 layers of parenchyma cells Inner—Thin walled lignified cells shorter in proportion to their length
Endodermis	Single layered; capsarian strips evident	Single layered	Single layered with lignified lateral and inner walls	Single layered	Single layered	Single layered
Pericycle	1-2 layered; cells thin walled	2 layered, thin walled cells	One layered; cells thin walled	—	One layered	One to two layered
Xylem bundles	24, 3-4 cells end to end	22 arches of xylem	8-12, 2 to 3 end to end, l-shaped or v-shaped	39 arches in big roots; 27 arches in small roots	26-33 arches, 2-3 vessels end to end	50 or more in bigger roots
Pith	Sclerenchymatous	Parenchymatous with medullary bundles	Parenchymatous, some times sclerenchymatous	Peripheral cells where the xylem bundles are embedded are sclerenchymatous and the central part thin walled parenchymatous	Thin walled parenchymatous	The cells surrounding the xylem bundles are sclerenchymatous. Inner region consists of lignified parenchyma with air spaces. Central vessels surrounded by sclerenchyma are present
Fibrous bundles	—	Present in the cortex	Scattered cells with dark contents present in the cortex	—	—	—
Stem						
Distribution of fvb. in different zones	CO—Regular D—Regular SD—Regular C—Irregular	CO—Regular D—Regular SD—Regular C—Irregular	CO—Irregular D—Regular SD—Irregular	Distribution of bundles similar in outer and inner parts. Mostly they are regular but some are irregular	CO— D—Regular SD—Regular C—	Distribution of bundles similar in outer and inner parts
Frequency of fvb. per cm. ²	Sahni D—108 SD—65 C—	Shukla 105 85 65-70	D—90-95 SD—45-50 C—25	D—120-130 SD—44-55 C—	D— SD—50-55 C—	Not mentioned
F/v ratio of fvb.	Sahni D—10/1-15/1 SD—15/1-25/1 C—	Shukla 9/1-18/1 20/1 23/1	D—0.37/1-1.1/1 SD—0.56/1-0.9/1 C—	Not mentioned. The fibrous sheath is very large	D—0.2/1-1.1/1 SD—0.4/1-1/1 C—	Not mentioned
Diameter of fvb. in mm.	Sahni D—0.3-0.5 SD—1 C—	Shukla 0.4 1 1	D—0.36-0.73 SD—0.26-0.67 C—	Not mentioned	D—0.18-0.3 SD—0.27-0.4	Not mentioned
Sclerenchyma of the fvb.	Dsc—bigger, cordate base Vsc—smaller, only in leaf-trace bundles	Dsc—bigger, cordate base Vsc—smaller only in leaf-trace bundles	Both Dsc and Vsc joined together surrounding the vascular elements. Vsc many times bigger than Dsc.	Dsc—very large Vsc. Absent	Dsc—Present smaller than vascular part Vsc—Absent	Dsc—very large Vsc—Absent
Xylem vessels	D—one SD—2, side by side C—2, side by side	D—2-3, side by side SD—2-3, side by side C—2-4, side by side	Xylem vessels more, arranged in crescentic manner.	Xylem vessels 2-3,	D—one SD—2-3, side by side	2, side by side, smaller vessels present
Fibrous bundles	Present	Present	Absent	Present	Present	—
Stegmata	Present	Present	Absent	—	Present ?	—
Radiating and tabular parenchyma	Radiating parenchyma present	Tabular parenchyma present	Radiating parenchyma present	—	Radiating parenchyma present	—
Ground tissue	Compact; cells thin walled, isodiametric	Compact; cells thin walled	Compact; cells thin walled angular	Porous consisting of parenchyma including large intercellular spaces	Elongated thin walled loose cells	—

NOTE: C—Central zone, CO—cortical zone, D—dermal zone, Dsc—dorsal sclerenchyma, fvb—fibrovascular bundles, SD—Sub-dermal zone, Vsc—ventral sclerenchyma.



TEXT-FIGS. 16-25 — 16. One fibrovascular bundle from the dermal zone showing deep median sinus. $\times 75$. 17. A fibrovascular bundle from the dermal zone showing radiating parenchyma. $\times 75$. 18. Diagrammatic representation of the distribution of fibrovascular and fibrous bundles in the sub-dermal zone. $\times 40$. 19-24. Different types of fibrovascular bundles from the sub-dermal zone. $\times 75$. 25. A portion of the ground tissue showing elongated lacunar cells. $\times 75$. (d.sc.— dorsal sclerenchyma; fb.— fibrous bundle; fvb.— fibrovascular bundle; gp.— ground parenchyma; p.— parenchyma; ph.— phloem; rp.— radiating parenchyma; xy.— xylem vessel).

in the dorsal sclerenchyma being much more than the vascular part. It thus appears that our specimen cannot be fully compared to any of the Indian or foreign species.

It will, therefore, have to be described as a new species of petrified palm stem. Unfortunately the specimen does not bear any prominent distinctive feature on which the specific name can be based. We, therefore, designate it as *Palmoxyton kraeuselii*, after the distinguished German palaeobotanist, Prof. R. Kräusel from whom we have received kindness and courtesy.

The present species can be referred to the *Cocos-like* palms according to Sahni's classification which is based upon the combined classifications of Stenzel (1904) and Von Mohl (1845 & 1849). It is difficult to compare this incomplete and badly preserved specimen with any of the living palms. Without making any serious comparison we would like to point out that the roots in specimen No. V86 are very similar to those of *Bactris major* (MAHABALE & UDWADIA, 1960) except that they are lacking the raphide sacs, sclereids and tannin cells, which are present in *B. major*. The specimen also shows some resemblance with the stem of *Bactris major* as described by Tomlinson (1961). The similar characters are, (1) a narrow cortex with fibrous bundles, (2) peripheral zone of congested bundles, (3) central zone of loosely placed bundles, each with a narrow fibrous sheath. The bundle sheath of the peripheral bundles is massive and radially extended in *Bactris*. In the specimen described here, the fibrous sheath is smaller than the vascular part. In *Bactris* the ground parenchyma cells are secondarily expanded and become sclerotic enclosing air spaces, but in our specimen the ground parenchyma cells are elongated, loosely arranged with air spaces. In view of this it is not possible to compare the specimen fully with *Bactris major*. Further compa-

parison with either *Bactris* or other palms is not possible as their anatomy is not known.

DIAGNOSIS

Root Region — Roots crowded; epidermis slightly thick-walled; hypodermis — thin-walled parenchymatous outer layer, thick-walled inner layer; thin-walled compact outer and inner cortex; lacunar middle cortex; endodermis and pericycle single layered; 26-33 exarch xylem strands, with phloem in between the xylem strands; thin-walled parenchymatous pith.

Stem Region — *Cortical Zone* — consists of longitudinally cut roots, with few fibrovascular bundles and many fibrous bundles.

Dermal Zone — Fibrovascular bundles regularly orientated, vascular part smaller than fibrous part, f/v ratio 0.2/1.1-1/1, diameter 0.18-0.3 mm., dorsal sclerenchyma cordate to reniform; xylem vessel one; ventral sclerenchyma absent. Radiating parenchyma present. Fibrous bundles in between the fibrovascular bundles. Ground parenchyma of thin-walled elongated cells loosely arranged.

Sub-dermal Zone — Fibrovascular bundles regular in orientation 50-55/cm², f/v ratio 0.4/1.1-1/1, diameter 0.27-0.4 mm.; dorsal sclerenchyma reniform; xylem vessels one to two; all the other characters are same as that of the dermal zone.

Locality — Mohgaon Kalan, Chhindwara district, Madhya Pradesh.

Age — Eocene

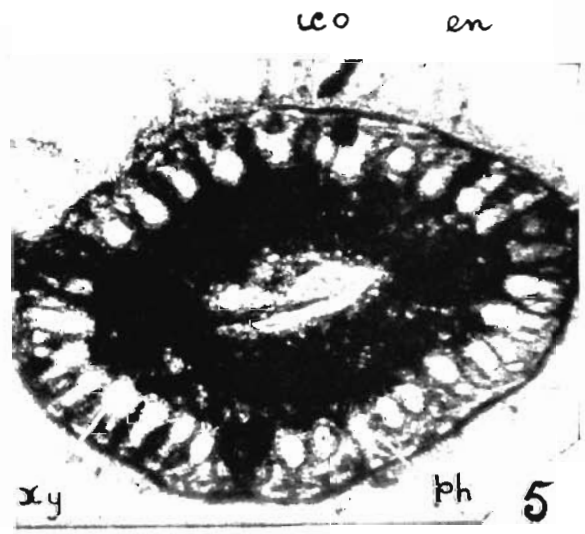
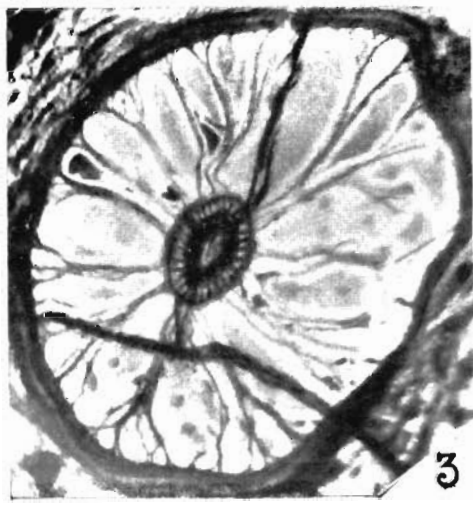
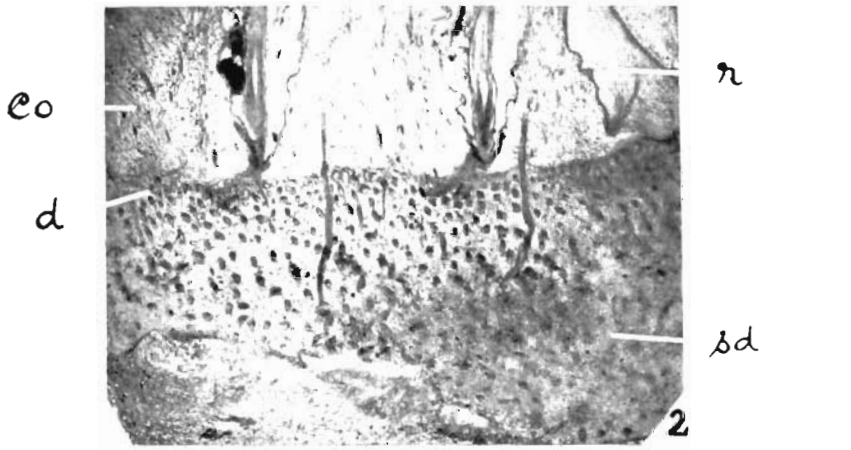
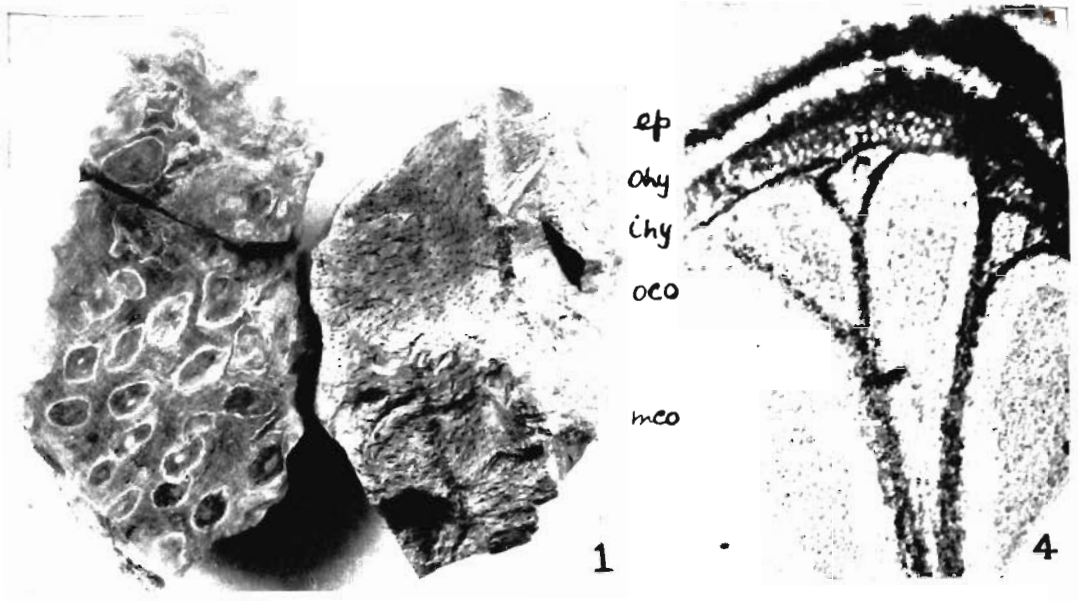
Type Specimen — V86. Department of Botany, University of Lucknow.

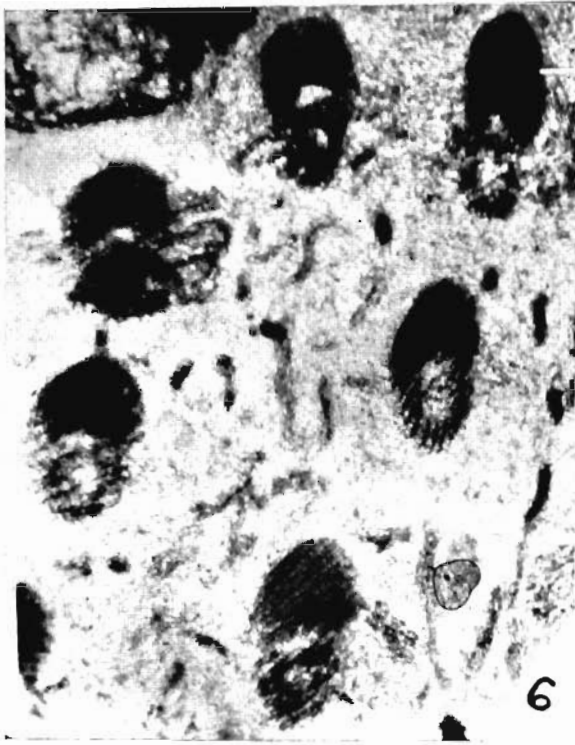
ACKNOWLEDGEMENT

Our grateful thanks are due to the authorities of the Birbal Sahni Institute of Palaeobotany, Lucknow, for permitting us to consult their library.

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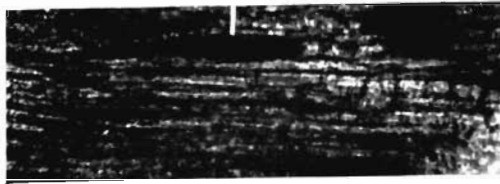




fvb
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6

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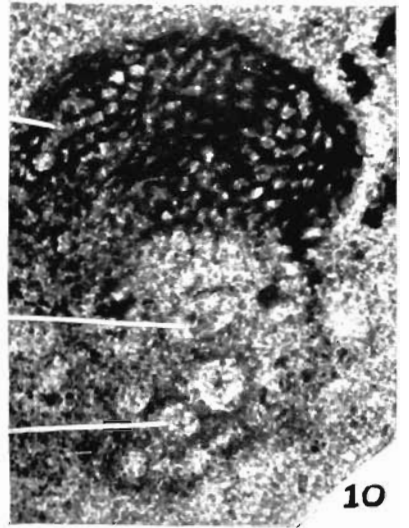


7

mxy
 pxy



8



10

11



fvb
 fb

9



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EXPLANATION OF PLATES

PLATE 1

1. The specimen after cutting showing the root region and stem region. × 1·6
2. Transverse section of the specimen showing cortical, dermal and sub-dermal zones. × 2·6.
3. Transverse section of the root showing all the tissues. × 12·5.
4. An enlarged portion of the root with epidermis, hypodermis and cortex. × 54.
5. Enlarged portion of the stele with clear xylem strands. × 61.
co — cortex; d — dermal zone; epi — epidermis; en — endodermis; i.co — inner cortex; i.hy — inner hypodermis; m.co — middle cortex; o.co — outer cortex; o.hy — outer hypodermis; ph — phloem; pi — pith; sd — sub-dermal zone; xy — xylem.

PLATE 2

6. Distribution of the fibrovascular bundles in the dermal zone. × 51.
7. Longitudinal section of the specimen showing ? stigmata. × 21.
8. One enlarged fibrovascular bundle from the dermal zone showing radiating parenchyma. × 17·6.
9. Distribution of the fibrovascular bundles in the sub-dermal zone. × 50.
10. An enlarged fibrovascular bundle from the sub-dermal zone. × 21.
11. Longitudinal section of the specimen showing multiseriate pitting. × 136.
d.sc — dorsal sclerenchyma; fb — fibrous bundle; fvb — fibrovascular bundle; mxy — metaxylem; p — parenchyma; ph — phloem; pxy — protoxylem; rp — radiating parenchyma; st — ?stigmata; xy — xylem.