

PALMOXYLON SURANGEI, A NEW SPECIES OF PETRIFIED PALMS FROM THE DECCAN INTERTRAPPEAN SERIES

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ABSTRACT

A new species of *Palmoxylon*, *P. surangei* sp. nov., is described from the Deccan Intertrappean series. The specimen was collected from Keria, a village about two miles south of Mohgaon Kalan, District Chhindwara, Madhya Pradesh. The species belongs to the subgroup *Cordata* of petrified palm stems.

INTRODUCTION

IN February 1951 Dr. K. R. Surange and I went to Madhya Pradesh (formerly known as Central Provinces) to make collections of the Deccan Intertrappean flora. While working at Mohgaon Kalan, the famous locality of this flora, we learnt that approximately two miles south there was another village called Keria where fossil plants could be collected in plenty. On investigation we found that the actual locality lay about 500 yards to the north of Keria and was very rich in fossil woods. Amongst the specimens collected here was a large piece of a petrified palm comprising the basal portion of a stem with roots attached. After detailed investigation it is found to be a new species of *Palmoxylon*.

I have great pleasure in naming the species after Dr. Surange who first spotted this fossil in the field and thus has the credit of discovering it.

DESCRIPTION

In the main the descriptive terminology used here is the same as suggested by Professor B. Sahni (1943) in his paper on *Palmoxylon sclerodermum*.

External Characters

The specimen is a large rusty brown stump which, before cutting, measured 37 cm. in length and 46 cm. in diameter at the base, narrowing to about 33 cm. at the top. A thick mantle of adventitious roots surrounds the lower 15 cm. of the stump. In the

upper part the mantle of roots is replaced by a cortical zone measuring about 4 cm. in thickness. Next to the cortex inwards are the three zones, dermal, subdermal and central.

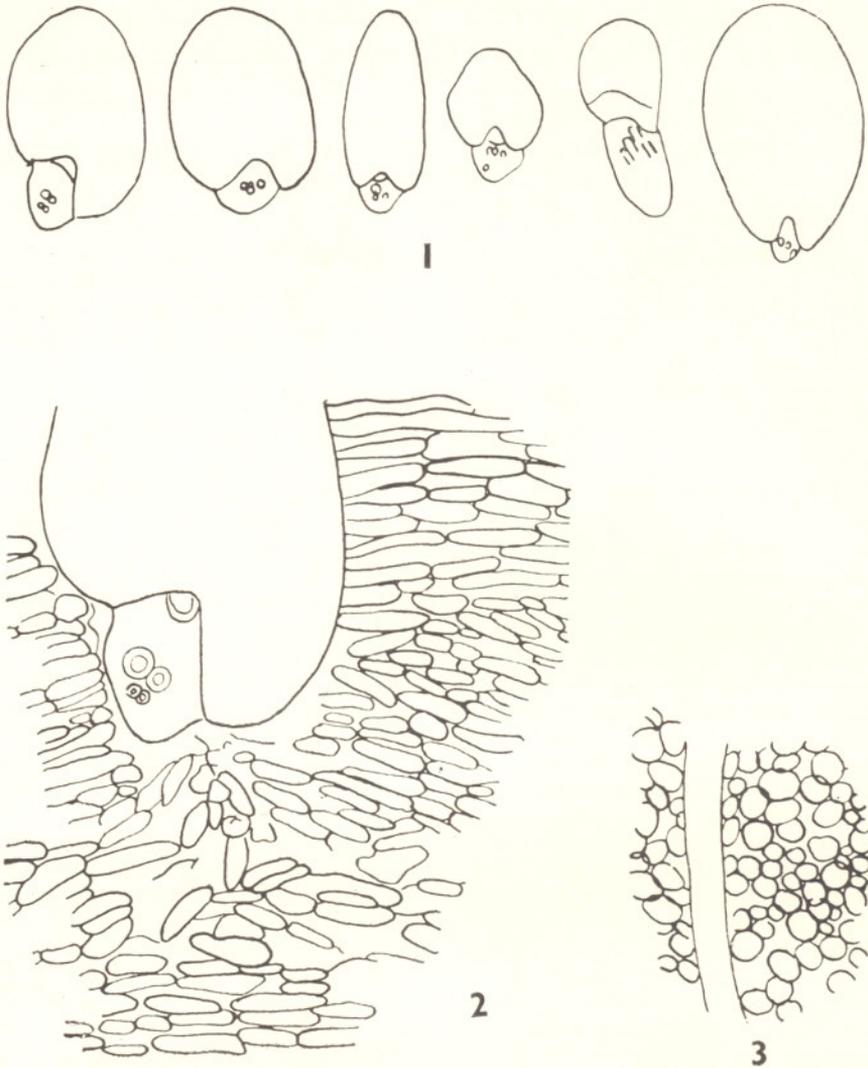
Anatomy

Cortex—The fibrovascular bundles are scattered in the outer part, becoming gradually crowded towards the dermal zone. They are of various shapes and sizes as shown in Text-fig. 1. An average bundle is oval in cross-section and measures about 0.95×0.45 mm. The base of the sclerenchyma is cordate. There are 2-4 vessels in the xylem. The f/v ratio varies from 5/1 to 10/1, the average being 6/1.

The fibrous bundles are usually circular to slightly oval in cross-section, measuring about 80μ in diameter and consisting of about 20 fibres. Stegmata are present around the fibres. There are some structures which in section look like fibrous bundles but are devoid of any cellular structure within. These may be sclereids or mucilage canals.

The ground tissue is made up of parenchymatous cells which are generally tangentially elongated (TEXT-FIGS. 2, 3) except at the distal and proximal ends of fibrovascular bundles where they are radially elongated. Generally the cells are fairly closely packed but sometimes the intercellular spaces increase to form lacunae.

Dermal Zone—It is about 2 cm. thick. The fibrovascular bundles are densely crowded towards the periphery, becoming less so towards the centre (PL. 1, FIG. 1). The average frequency is 90-95 per cm.² but in the outer region it is as much as 140 per cm.². In cross-section the bundles are elongate elliptical in the outer region, becoming broadly ovate towards the interior. But generally the normal shape of the bundles in the crowded exterior region is deformed due to pressure against each other. An average bundle measures about 1×0.5 mm.



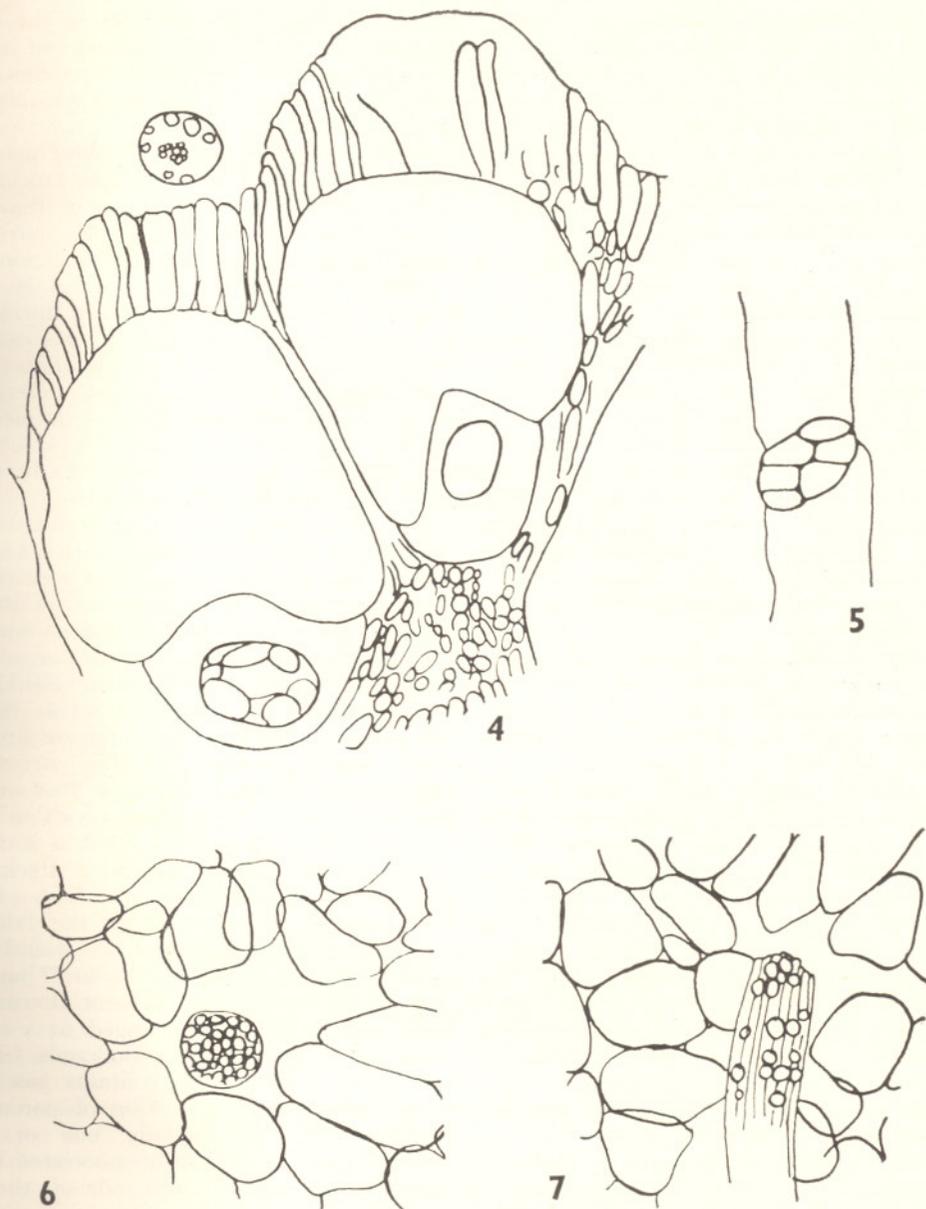
TEXT-FIGS. 1-3 — 1, outlines of some fibrovascular bundles from the cortical zone. $\times 31$. 2, ground tissue cells of the cortex in cross-section. $\times 70$. 3, the same in longitudinal section. $\times 70$.

All of them are normally orientated. The f/v ratio is less in the exterior region, being in some cases only about 7/8, and increases towards the interior to about 7/1. The fibrous part is usually pyriform. The median sinus is rounded cordate. The vessels in the xylem number 1-4, normally 2-3, and are excluded. On the distal side, along the sclerenchyma the bundles are surrounded by elongated parenchymatous cells arranged radially (TEXT-FIG. 4). These cells are found only around the bundles of the external

crowded region; in the inner region they are replaced by the usual tabular parenchyma.

In the less crowded region fibrous bundles may occur sporadically. They are about 110-120 μ in diameter. The stegmata are present in longitudinal rows on the fibrous bundles (TEXT-FIGS. 6, 7) as well as on the sclerenchyma of the fibrovascular bundles.

The parenchymatous ground tissue is scanty and compact. The cells are smaller than those of the cortex. They are isodiametric to slightly rectangular in the outer



TEXT-FIGS. 4-7 — 4, two fibrovascular bundles from the dermal zone showing the radially elongated parenchymatous cells on the distal side. $\times 70$. 5, end wall of a large vessel. $\times 115$. 6, 7, cross-section and longitudinal section respectively of the fibrous bundles. Stegmata are visible on the surface in Fig. 7. Both $\times 115$.

region, becoming longer and bigger towards the interior. At places some of the longer cells arrange themselves in wavy horizontal rows as seen in transverse section.

Subdermal Zone—This zone is nearly 4 cm. in thickness. There are 45-50 fibro-

vascular bundles per cm.². They are broadly oval to slightly ovate in cross-section (PL. 1, FIG. 3). Their normal size is 0.95×0.65 mm. The f/v ratio in average bundles is 5/1 to 6/1. The sclerenchyma is broadly round, pyriform to orbicular and the xylem

is narrower, pointing towards the centre. Auricular lobes are round. Auricular sinuses are obtuse, being less prominent in broader bundles. The tabular parenchyma is present. The phloem which is wedged in between the xylem and the median sinus is very poorly preserved, generally disorganized. The xylem usually consists of 2-3 vessels, excluded. The pitting of the metaxylem is scalariform in the narrow elements and reticulate in the wider ones. The protoxylem has spiral thickening. The end walls of the vessels are slightly oblique and have scalariform or reticulate thickening with nearly half a dozen broad rounded meshes (PL. 2, FIG. 7; TEXT-FIG. 5).

Occasionally leaf trace bundles (PL. 1, FIG. 4) also occur in the dermal as well as the subdermal zone. In these bundles the xylem is greatly developed, almost double that of the fibrovascular bundles, and in cross-section projects like a tongue. There is an arc of sclerenchymatous cells on the ventral border.

Fibrous bundles occur sporadically, each consisting of about 20 fibres and measuring approximately 80 μ in diameter. Stegmata are present as in the dermal zone. Idioblasts are not seen.

The ground tissue is quite compact and consists of fairly big parenchymatous cells which in cross-section appear elongated with round edges. Wavy horizontal rows of longer cells are seen in the outer region. In wider areas between the fibrovascular bundles the cells tend to become broader, some attaining almost circular outline. An average cell is 150 μ long and 60 μ wide. The round ones average about 80 μ across. In longitudinal section the cells are round, isodiametric to slightly elongated.

Central Zone — This is the widest part of the stem with a radius of about 6.5 cm. The fibrovascular bundles are irregularly orientated (PL. 1, FIG. 5), broadly ovate in cross-section, measuring about 0.95 \times 0.8 mm. Approximately 25 bundles occur per cm.². The average f/v ratio is 4/1. The sclerenchyma is broad and orbicular with broad rounded cordate base (PL. 1, FIG. 6), sometimes appearing as reniform. The xylem is better developed than in the subdermal zone, with obtuse auricular sinuses. There are usually 3-4 vessels in the xylem.

The fibrous bundles and stegmata are present (PL. 2, FIG. 9) as in the subdermal zone. The structure of the ground tissue

also is essentially the same as in the subdermal zone. However, because of more space between the fibrovascular bundles, the cells become broader and more rounded as they approach the centre.

Roots — The roots are closely packed, usually deformed by crowding together. They measure 5-7 mm. in diameter, the ones coming from the periphery being narrower than those arising from the central region.

Seen in cross-section (PL. 2, FIGS. 10, 11) the outermost layer, about 30 μ in thickness, is indistinguishable. Next to this is the cortex which can be distinguished into three parts — outer, middle and inner. The outer cortex, about 0.5 mm. thick, is formed of compact rows of thick-walled, dark-coloured, rounded cells, approximately 25 \times 30 μ in size. The middle cortex is about 1 mm. thick. It is composed of round, thin-walled cells, about 35 μ in diameter, rather loosely packed and with air cavities between them. In this region also occur a number of fibrous bundles appearing almost circular in outline. They are slightly bigger than those of the stem region, usually measuring 110-120 μ in diameter, while some may be as big as 160 μ across. Stegmata are present around these bundles. Some of the structures looking like fibrous bundles in cross-section but having no cellular structure within may be sclereids. The inner cortex is a more compact zone, about 0.2 mm. in thickness. Next to the cortical region inwards is a layer of rectangular cells constituting the endodermis. Next are two layers of thin-walled cells of the pericycle. There are about 22 bundles each of the xylem and phloem alternating with each other and arranged in a circle concentric with the endodermis. Each xylem bundle usually contains one big vessel surrounded by a ring of parenchymatous cells. Occasionally one or two smaller vessels may also be associated with, and situated on the outer side of, the big vessel. The vessels are oval in cross-section, measuring about 140-190 μ in radial and 80-115 μ in tangential direction. The phloem bundles are not well preserved and occur as light patches alternating with and a little outward of the xylem vessels. On the inner side the vascular bundles are embraced by thick-walled polygonal cells of the conjunctive parenchyma which extends by about 0.2 mm. beyond the vascular row towards the centre where it meets the central core of the pith composed of thin-walled cells.

The inner boundary of the conjunctive tissue is irregularly sinuous. The cells in the pith are round, measuring about 20-25 μ in diameter. In the pith region there may be 1-4 medullary bundles each consisting of a vessel encircled by a ring of thick-walled cells.

DISCUSSION

So far there is no available system for the natural classification of petrified palm stems which are all grouped under the form genus *Palmoxylon*. In 1935, based on an extensive study of modern palms, Kaul had announced that palm stems could be identified by the structure of their ground tissue. But this work has not yet been published in full. At present the only course open is to classify the genus artificially. For this purpose Professor Sahni's scheme (1943, pp. 218-219) based jointly on the classifications of von Mohl (1845) and Stenzel (1904) is very convenient and suitable. According to this scheme *P. surangei* falls under the subgroup *Cordata*.

Comparison with Indian Palmoxyla — Of the already described *Palmoxyla* from India, only *P. sclerodermum* (SAHNI, 1943; SHUKLA, 1946) belongs to *Cordata*. It resembles our species in (i) the general appearance, orientation and distribution of fibrovascular bundles, (ii) the sculpturing of the xylem elements (with some difference with regard to the end walls of the vessels), (iii) the presence of fibrous bundles and stegmata, and (iv) the general form of the leaf-trace bundles, having a tongue-like vascular process with ventral sclerenchymatous arc.

In a number of other characters, however, the two species are distinctly separate. The ground tissue cells of the cortex are radially elongated and often occur in layers in *P. sclerodermum* while they are tangentially elongated in *P. surangei*. The fibrovascular bundles are bigger and more crowded, and their f/v ratio is higher in *P. sclerodermum* than in *P. surangei*. Auricular sinuses are almost absent in *P. sclerodermum* while they are usually present and obtuse in *P. surangei*. The end walls of the broad xylem vessels in *P. sclerodermum* are very oblique and have scalariform thickening. In *P. surangei* they are less oblique and generally with reticulate thickening. In *P. surangei* the sclerenchyma of a few outer rows of the dermal bundles is externally surrounded by radially elongated parenchymatous cells. This character is not met with in *P. sclerodermum*. The frequency

of fibrous bundles is higher in *P. surangei* than in *P. sclerodermum*. The ground tissue cells in *P. sclerodermum* are smaller (0.08 \times 0.06 mm.) and roughly isodiametric while in *P. surangei* they are bigger (0.15 \times 0.06 mm.), oval, oblong and elongated. The more rounded cells of the latter species average about 0.08 mm. in diameter. The cells in *P. sclerodermum* are lobed while this tendency is not prevalent in *P. surangei*.

In the roots of *P. surangei*, fibrous bundles are found in the middle cortex while no such fibrous bundles occur in *P. sclerodermum*. The structure of the xylem bundles is different in the two species. While in *P. sclerodermum* there are 3-4 vessels placed end to end in radial direction, in *P. surangei* there is usually only one big vessel. Another important difference is the presence of medullary bundles in the pith region of *P. surangei*. Such bundles have not been recorded in *P. sclerodermum*.

Comparison with Foreign Palmoxyla — Of the foreign known species only *P. densum* (UNGER) Schenk and *P. speciosum* (STENZEL) Schenk described by Stenzel (1904) can, to some extent, be compared with the present species.

P. densum is known only by the outer parts of the stem. This species resembles *P. surangei* in having roughly comparable shape of the fibrovascular bundles, increasing distance between the bundles and decreasing f/v ratio as we go inwards, the presence of fibrous bundles and stegmata, and the general form of the leaf trace bundles. However, there are a number of differences which distinguish it from *P. surangei*. The frequency of fibrovascular bundles in *P. densum* is higher than in *P. surangei*. In *P. densum* the auricular lobes are very prominent, the auricular sinuses being acute. In *P. surangei* the auricular sinuses are obtuse and not so prominent. The median sinus is reniform in *P. densum* and cordate in *P. surangei*. No stegmata have been reported from the fibrous part of the fibrovascular bundles of *P. densum* while they are present in *P. surangei*. The ground tissue is quite different in the two species. The cells are smaller (about 50-70 μ in diameter), more rounded and often arranged in vertical rows in *P. densum*. In *P. surangei* they are bigger and elongated. Their arrangement is different and not in vertical rows. Some of the cells are polygonal in *P. densum* while no polygonal cells are seen in *P. surangei*.

In the general shape of the bundles, presence of fibrous bundles with stigmata, and the ground tissue consisting of elongated cells, *P. surangei* also resembles *P. speciosum*. But, as enumerated below, there are a number of differences between the two species. In *P. speciosum* the fibrovascular bundles are bigger (1.1-2.5 mm. across) and more sparsely distributed (15-21 per cm.² in the subdermal region). In cross-section although the fibrous part of some bundles of *P. speciosum* does seem cordate as in *P. surangei*, in majority of them it is sagittate. The f/v ratio is higher in *P. speciosum*, especially in the outer region. The auricular sinuses are acute in *P. speciosum* and obtuse in *P. surangei*. While a large number of bundles in *P. speciosum* have only one big vessel, those in *P. surangei* have 2-3. Fibrous bundles are more numerous and bigger (100-166 μ in diameter) in *P. speciosum*. The ground tissue cells are longer in *P. speciosum* (166-250 μ in length and 40-60 μ in width). The arrangement of these cells is also different in the two. In *P. speciosum* there is usually one short polygonal cell at places where the long cells from all the directions meet. Such an arrangement is not seen in *P. surangei*.

DIAGNOSIS

Genus — *Palmoxylon*

Sub-group — *Cordata*

Palmoxylon surangei sp. nov.

Plates 1, 2, Text-figs. 1-7

Stem thick (in type specimen about 33 cm. in diameter near the base). Cortex fairly thick, composed of thin-walled parenchymatous cells elongated horizontally and containing scattered fibrovascular and fibrous bundles. Dermal and subdermal zones fairly well developed, central zone quite broad. Fibrovascular bundles in the dermal, subdermal and central zones almost of the same size, becoming slightly bigger towards the centre. Dermal bundles 90-95 per cm.²; f/v ratio 9/2; external bundles with radially

elongated parenchymatous cells on the dorsal side; inner bundles having tabular parenchyma; median sinus cordate; number of vessels in the xylem usually 2-3, excluded. Subdermal bundles 45-50 per cm.² measuring ca. 0.95 \times 0.65 mm.; f/v ratio 5/1-6/1; tabular parenchyma present; auricular sinus obtuse; xylem usually consisting of 2-3 vessels, excluded; thickening of the metaxylem scalariform to reticulate; end walls of the vessels slightly oblique with scalariform or reticulate thickenings with wide perforations between them. Central bundles far apart, about 25 per cm.², broad, looking almost orbicular in cross-section, 0.95 \times 0.8 mm. in size; f/v ratio 4/1; median sinus broad, almost reniform; xylem usually with 3-4 vessels. Fibrous bundles present in all the zones, measuring about 80 μ in diameter. Stigmata present on fibrous as well as the fibrovascular bundles. Leaf trace bundles in the dermal and subdermal zones radially stretched with well-developed xylem projecting as a tongue-like process. Ground tissue composed of thin-walled, elongated, oval-oblong cells with rounded corners, arranged horizontally; more compact in the dermal zone and rather loose in the subdermal and central zones; average subdermal cell measuring 150 \times 60 μ in size; in wider areas between the fibrovascular bundles the cells tend to become broader, some attaining almost circular outline in cross-section.

Roots running downwards, closely packed, 5-7 mm. in diameter. Cortex made of 3 zones; middle cortex with aerenchyma containing fibrous bundles. The stele consisting of about 22 xylem bundles alternating with phloem; the xylem of each bundle usually consisting of one large vessel and rarely one or two small ones. Pith composed of thin-walled cells, often with 1-4 medullary bundles.

Locality — About 500 yards to the north of the village Keria in Chhindwara district, Madhya Pradesh.

Horizon — Deccan Intertrappean series.

Collection — Holotype, specimen No. 17426 of the Birbal Sahni Institute of Palaeobotany Museum.

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EXPLANATION OF PLATES

PLATE 1

Palmoxylon surangei sp. nov.

1. Part of cross-section through the dermal zone. Wavy horizontal rows of long parenchymatous cells are clearly visible. $\times 7\frac{1}{2}$.

2. Part of cross-section through the subdermal zone. $\times 7\frac{1}{2}$.

3. A subdermal fibrovascular bundle seen in cross-section. $\times 50$.

4. A leaf-trace bundle from the subdermal zone seen in cross-section. $\times 50$.

5. Part of cross-section through the central zone showing irregular orientation of the bundles. $7\frac{1}{2}$.

6. A central fibrovascular bundle seen in cross-section. $\times 50$.

PLATE 2

Palmoxylon surangei sp. nov.

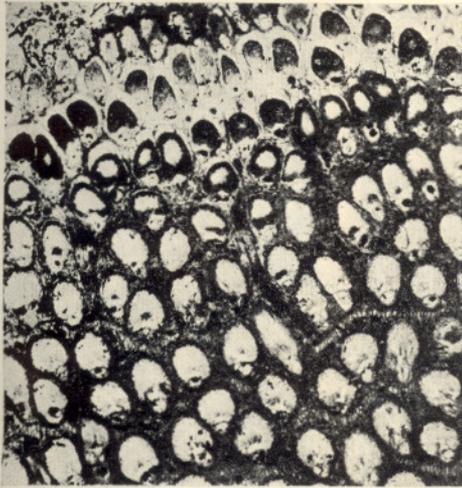
7. Longitudinal section through a fibrovascular bundle with the vessel showing the end walls. $\times 50$.

8. Surface view of a vessel showing mixed scalariform and reticulate thickenings. $\times 270$.

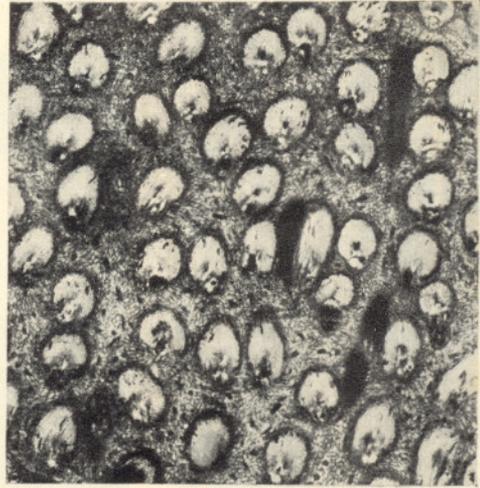
9. Longitudinal section through the central zone showing stegmata (s) on the fibrous cells.

10. Transverse section through a root. oc, outer cortex; mc, middle cortex; ic, inner cortex; fb, fibrous bundle; st, stele; p, pith. $\times 23$.

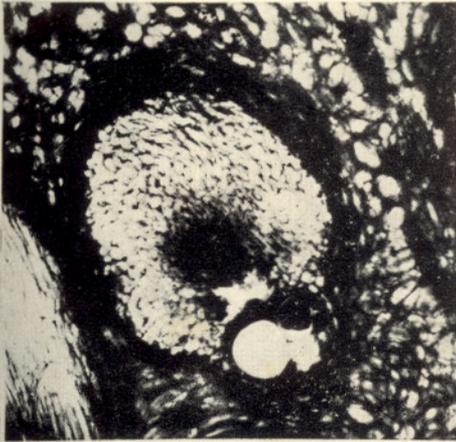
11. Magnified view of a part of the T.S. through a root. mc, middle cortex; ic, inner cortex; fb, fibrous bundle; ph, phloem bundle; x, xylem bundle; mb, medullary bundle. $\times 50$.



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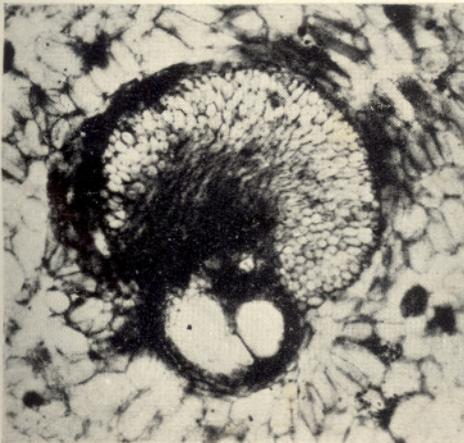
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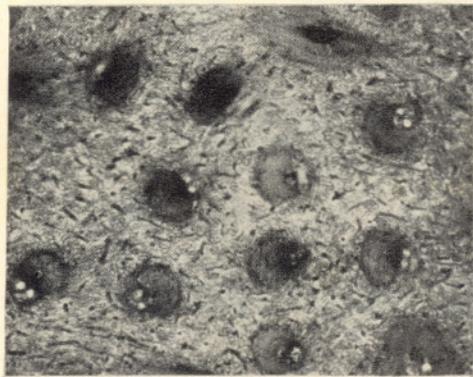
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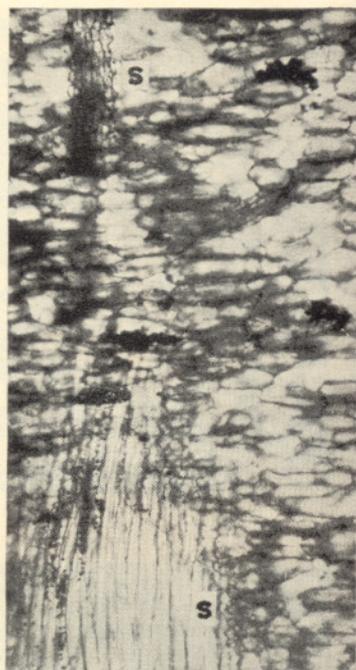
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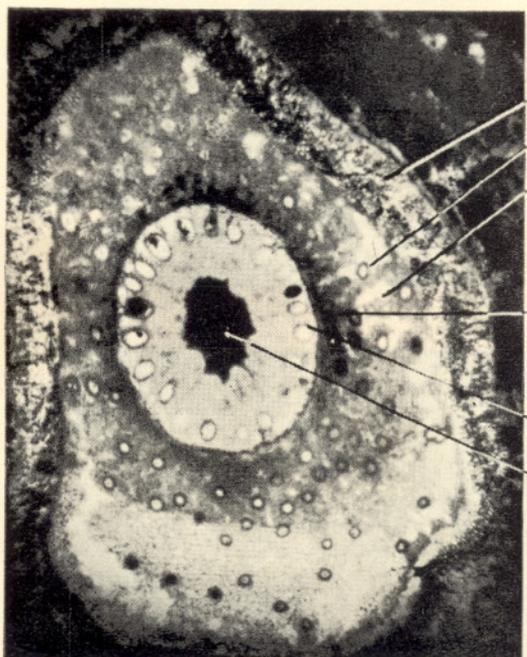
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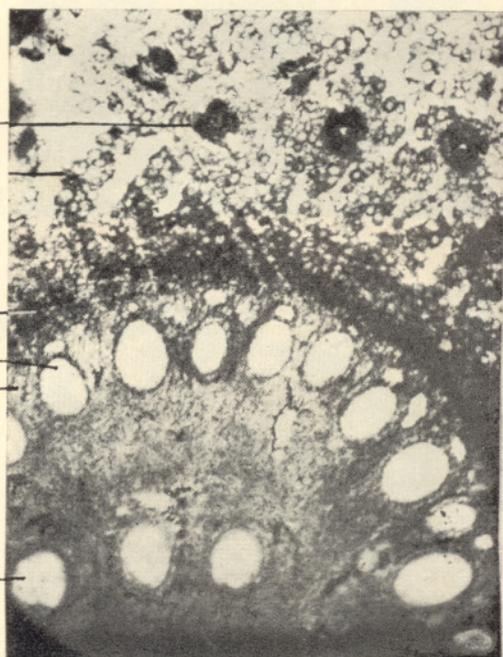
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9



10



11

- oc
- fb
- mc
- ic
- x
- ph
- st
- p
- mb