BUCKLANDIA SAHNII SP. NOV. FROM THE JURASSIC OF THE RAJMAHAL HILLS, BIHAR

M. N. BOSE

Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

The description of this new species of *Bucklandia* is based on specimens from Amarjola, Amrapara, Rajmahal Hills, India.

The stem is covered with persistent leaf-bases which are very variable in shape and size. Pith wide, surrounded by a broad zone of xylem, phloem and bark. The importance of this stem lies mainly on the secondary wood which is compact with sharply marked growth rings. Medullary rays are very conspicuous by their number and crowded occurrence. Most of the rays are uniseriate, but biseriate ones also occur frequently. The tracheids of the early wood have mainly scalariform pitting. The early wood shows various types of pitting, varying from scalariform to multiseriate. Pits seen on the radial walls of the rays are bordered. The number of bordered pits in a cross-field varies from 1 to 6 or more. Primary xylem is endarch.

B. Sahnii differs from *B. indica* in having tracheids with scalariform as well as multiseriate bordered pits; no scalariform pitting was observed in *B. indica*. Comparisons have been made with the fossil Cycadeoidean stems and *Homoxylon rajmahalense*. The secondary wood of *B. Sahnii* has been found to be very similar to that of *H. rajmahalense* and now *H. rajmahalense* has been said to be a Bennettitalean wood.

INTRODUCTION

WHILE investigating the detailed structure of *Homoxylon rajmahalense*, from the collection made by Professor Sahni and party from Amarjola in the Rajmahal Hills, I thought it worth while to compare this fossil with the specimens of *Bucklandia* collected from the same locality. So a few sections were prepared from a piece of *Bucklandia* and these showed a surprising resemblance with *Homoxylon*. I, therefore, decided to make a complete study of the genus *Bucklandia*. So I went to Amarjola in November 1950 and collected a large number of *Bucklandia*, together with *Ptilophyllum*, *Williamsonia* flowers and fruits and other fossil plants found there. In May 1951 this collection was further supplemented with specimens of *Bucklandia* and other plant remains from the same locality. More than fifty pieces of stems were collected and out of these the anatomy of about thirty specimens has been studied. The anatomy of these specimens is essentially the same. Wherever a certain character of minor importance is missing in a stem, no attempt has been made to form a new species on that basis, for this slight difference may be due to bad preservation or due to extra transparency of the slides which makes it impossible to study the anatomy in detail. The description of the specimens referred to below does not include such stems.

Our knowledge of the Indian fossil Cycadean stems dates back to 1841 (MORRIS). Oldham and Morris described and figured in 1863 a few specimens of Cycadean stems from the Rajmahal Hills, Bihar. Feistmantel reported few stems of *Williamsonia* in 1877. Seward (1900) was probably the first to study the anatomy of the Indian specimen. A fuller investigation was made by Bancroft in 1913 on two stems of *Williamsonia* type. Seward in 1917 reviewed the earlier works and re-described the original specimen (1900) under the name of *Bucklandia indica*, the specimen which differed from the English and American *Bucklandia* stems in having compact wood, uniseriate medullary rays and tracheids with multiseriate bordered pits on their radial walls. No scalariform tracheids were seen as found in the majority of *Cycadeoidea* stems. Sahni (1932), in his paper on *Williamsonia Sewardiana*, compared this stem (*B. indica*) with the peduncle of *W. Sewardiana* and reconstructed the whole plant, of which he thought *Bucklandia indica* was the stem, *Ptilophyllum* cf. *cutchense* the foliage and *W. Sewardiana* the flowers. Jacob and Aiyengar (1942) mentioned a *Cycadeoidea* from Trichinopoly which is of Cretaceous age. From Onthea, Rajmahal Hills, Ganju (1946) described two Cycadean stem impressions.

The present stem in some respects resembles *B. indica*, and in others it shows similarity with *Cycadeoidea* stems, and at the same time it presents some features which are entirely new. I have, therefore, thought that it deserves to be described in detail.

MATERIAL AND METHODS

The specimens are crumbly and brittle and, therefore, it is very difficult to cut them with a wire bow. All the specimens before sectioning were kept in dilute solution of Canada balsam overnight. They were then boiled in balsam over a low flame for about 3 to 4 hours. When the specimens cooled down, they could be easily cut with a wire bow. The more delicate material, after boiling in balsam, was embedded in " Marco resin ". The material then could be cut even with a cutting wheel.

On account of extreme silicification of the tissues staining was difficult. But in some cases safranin was used successfully to bring out the details. Slides were mounted in unheated balsam, for even with the slightest pressure the thin sections would break into pieces.

In some cases it was observed that when the section had been mounted in balsam, it became so transparent that investigation of the finer anatomical details was absolutely impossible. So, as a precautionary measure some of the photographs and drawings were made before mounting in balsam. These photographs were usually taken after mounting the slides in water.

DESCRIPTION

(a) External Characters

Trunks of various sizes have been collected (Pl. 1, Figs. 1-13). The largest piece measures 7·5 cm. in length and 2·8 cm. in diameter, the smallest being 0·7 cm. in length and 1 cm. in diameter. The diameter is variable from 0·6 to 3·5 cm. and is not uniform throughout the length. The stems are almost cylindrical, very rarely slightly oval in cross-section (Pl. 1, Fig. 5).

The stems are covered with an armour of leaf-bases of variable shape and size. No trace of lateral fructification as in *Cycadeoidea* is visible on the trunk. Leaf-bases are spirally arranged around the trunk in two orders of rows, running right to left and left to right, making different angles with the axis of the trunk. Phyllotaxy could not be determined with certainty owing to bad preservation of the leaf-bases. Size of the leaf-bases is very variable; even in the same specimen they differ from each other in shape and size (Pl. 1, Fig. 1). They measure from 0·5 to 2·1 cm. by 0·6 to 1·5 cm. Some of the leaf-bases are concave and elongated (Pl. 1, Fig. 4), while others are flat. Most of the leaf-bases are rhomboidal in shape but some are lozenge-shaped. This variability of shape in the leaf-bases may be due to the fact that the entire leaf does not fall off, but like some of the modern cycads and palms, the leaf bends down at first and then decays to a point a little above the leaf-base, the position of the abscission layer probably not being constant. The leaf then falls off from that point and a small portion of the leaf-base and petiole remain attached to the trunk. After some time the petiole gets finally detached from the trunk, leaving the trunk with the leaf-base only. The point from where the petiole falls off is also probably not constant. Not only this, in some cases even the leaf-bases fall off, leaving a hollow rhomboidal mark on the trunk (Pl. 1, Fig. 5). While making collection of the material I have come across a number of such detached leaf-bases (Pl. 7, Figs. 40, 41) and petioles, and it was surprising that none of the leaves (*Ptilophyllum*) collected was complete with a leaf-base.

At the top of each leaf-base the scar of the fallen leaf can be seen. The leaf-scars exhibit a few small marks of vascular bundles (Pl. 1, Figs. 2, 3). These are generally five in number, one ventral, two laterals and two dorsals, the laterals and dorsals forming an arc parallel to the lower surface of the leaf-base. This arrangement is not constant; sometimes seven marks are seen, two ventrals, two laterals and three dorsals. The number of such marks may vary even in the different leaf-bases of the same stem.

Mode of branching — Some of the stems furnish evidence of the branching habit of this plant (Pl. 1, Figs. 6-8, 10, 13). The majority of such pieces indicates that the stem generally dichotomized and the flowers were borne at the point of bifurcation. This is shown in one of the stems where three scars are clearly seen (Pl. 1, Fig. 13B); here the two lateral branches *a* and *b* show a broad protruding zone of wood encircling a pith (Pl. 1, Figs. 13, 13A, 13B) whereas the terminal portion *c* at the point of bifurcation is hollow and disc-shaped and shows signs of a detached strobilus. The transverse section at *a* and *b* (Pl. 1, Figs. 13, 13A, 13B) confirms the axillary nature of these parts, while on the other hand, at *c* the wood is very narrow encircling a comparatively much wider pith, a condition which is generally found in the peduncles of *Williamsonia* flowers. Evidently the stem ended in a flower and two opposite lateral branches were put forth below the top. Incidentally cross-sections at the basal region of the main stem and at the three branching regions show this stem to be only one year old.

My observations are again strengthened on the basis of the epidermal characters at two places which are quite different. These were studied from another specimen (PL. 1, FIG. 8). Under a strong reflected light the epidermal cells of the leaf-bases at *b*, *c* and *d* (PL. 1, FIG. 8) are much elongated and are devoid of stomata. These cells are exactly similar to those found on the leaf-bases of the other specimens (PL. 1, FIG. 1 and PL. 7, FIG. 42). But at *a* (PL. 1, FIG. 8 and PL. 7, FIG. 47) the epidermis consists of small rectangular cells with stomata transversely orientated. These epidermal characters have been found on the bracts of one of the *Williamsonia* flowers collected from the same locality (PL. 7, FIGS. 45, 46). It, therefore, shows that there was a flower at the point *a*. The age of this piece is also one year.

In all the specimens at the point of branching the node is very wide, narrowing below. It is quite probable that the branching of *B. Sahnii* may have been similar to that of *Wielandiella angustifolia* Nathorst. But it is difficult to say whether the branching was as profuse as that of *W. angustifolia* reconstructed by Nathorst.

Further, it is seen that the branching of *B. Sahnii* was quite different from the plant *Williamsonia Sewardiana* as has been reconstructed by Sahni. *W. Sewardiana* has been shown to be a small tree with a more or less erect columnar trunk bearing a crown of *Ptilophyllum* leaves at the top with the flowering shoots projecting laterally from the trunk and on the whole giving an appearance somewhat of a living unbranched *Cycas*. Seward in *W. scotica* noticed a branched axis. This was also seen in the flower of *W. Sewardiana* by Sahni where there was unequal branching of the axis. Seward was of the view that there was sympodial branching in these plants, but Sahni in his flower found and unequal dichotomy. *B. Sahnii* shows dichotomy.

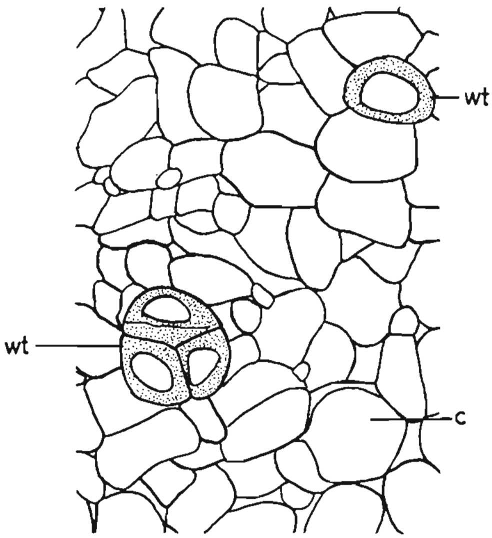
(b) INTERNAL ANATOMY

A transverse section (PL. 2, FIG. 14) of the stem shows a big central pith surrounded by a broad zone of xylem, phloem and bark with persistent leaf-bases.

Leaf-base — In cross-section of a leaf-base, the epidermis is seen lined on its outer side by a layer of cuticle. Under strong reflected light the surface of the leaf-bases shows epidermal cells, which are many times longer than broad (PL. 7, FIG. 42). The original form of the epidermis cells in cross-section is rectangular, but the inner wall is angular on account of the contact with the thick-walled hypodermis cells. They are generally of equal size with length approximately twice the height. A fairly broad hypodermal zone of sclerenchyma follows the epidermis (PL. 2, FIG. 15 *h*). Its cells are either hexagonal or pentagonal. The inner ground mass of parenchyma is thin-walled. There are usually five collateral vascular bundles (PL. 3, FIG. 24), two adaxial and three abaxial ones forming an arc following the outline of the lower surface of the leaf-base. Sometimes even seven vascular bundles are seen (PL. 3, FIG. 23). This variation in the number of bundles was also noticed by Bancroft in her *Williamsonia* type of stems. The xylem is directed inwards. The radial section shows the tracheids having spiral thickening.

Stem — On the outer side of the cortex the cork cambium is seen, the cells of which are rectangular. The cork cambium is from 4 to 9 cells in thickness. The cortex of the stem is quite well developed and is fairly wide (PL. 2, FIGS. 14, 16, 17). It is composed mainly of parenchymatous tissues. In the cortex there are also many irregularly distributed thick-walled cells which occur either singly or in groups of 2 to 3 cells (TEXT-FIG. 1). These cells are mostly empty but sometimes they have some dark contents.

Here and there in the cortex leaf-traces are also seen, but the number of cross-sections which show leaf-traces is not sufficient to determine clearly the minute details of their course. It appears that each leaf-trace arises as a single bundle in the form of an arc (PL. 3, FIG. 20) which gradually takes the form of a U-shaped strand. For some distance it pursues a straight course and then shows signs of breaking into different strands (PL. 3, FIG. 21). Finally it breaks up into five or seven strands arranged close to each other (PL. 3, FIG. 22).

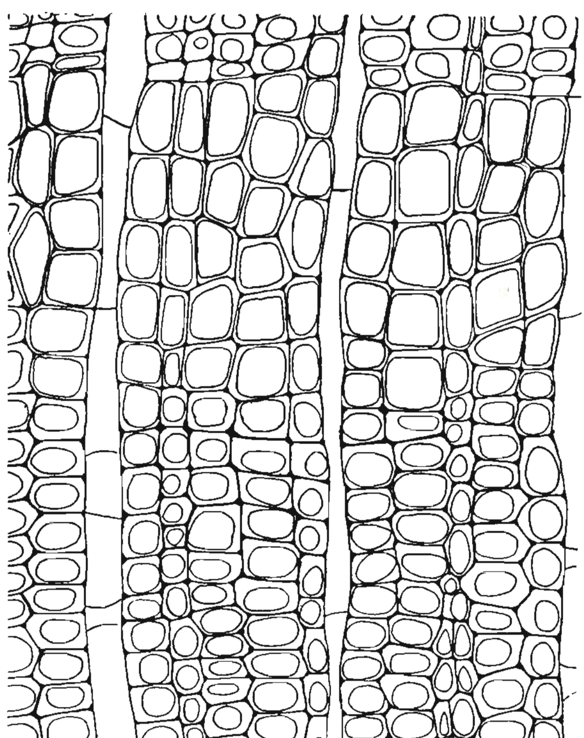


TEXT-FIG. 1 — Transverse section of cortex, showing the cortical cells (*c*) and the thick-walled cells (*wt*). × 115.

On the inner side of the cortex the pericycle can be distinguished; it consists of a few layers of polygonal cells. The phloem ring is marked by radially extended alternate bands of rays and phloem. Ray cells are mostly poorly preserved, leaving big cavities alternating with the bands of phloem (PL. 2, FIG. 17-19). Ray cells are thin-walled and irregularly packed together (PL. 2, FIG. 18). Rows of thick-walled elements of the phloem regularly alternate with thin-walled ones in the tangential direction.

Traces of cambium can be seen below the phloem; the tabular cells are very much crushed and mostly ill-defined. Generally they form a thin black line all round the secondary xylem.

The wood is quite compact with sharply marked growth rings. In a transverse section, this pycnoxylic wood at first sight gives the impression of a conifer type. So far the maximum number of growth rings counted in these specimens is eleven. The tracheids are mostly quadrangular and compactly arranged in radial rows (PL. 3, FIG. 25; TEXT-FIG. 2). The only other elements present along with the tracheids are those of the medullary rays. The tracheids of the early wood have a large diameter and have a thinner wall than those of

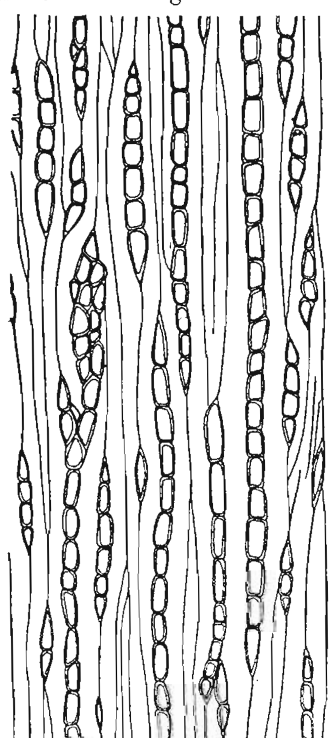


TEXT-FIG. 2 — Transverse section of secondary wood. × 235.

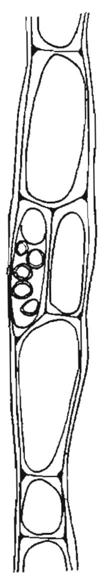
the late wood. The late wood shows a remarkable development as compared to the early wood and occupies about two-thirds of the whole growth ring. The medullary rays are uni- to biseriate, and rarely triseriate.

Pl. 4, Fig. 26 and Text-fig. 3 show a part of the secondary xylem in tangential section. The tracheids reach a length of about 0·2 cm. There are no pits visible on the tangential walls. The medullary rays are conspicuous by their number and crowded occurrence. The majority of the rays are uniseriate but biseriate ones occur frequently and a few triseriate ones are also found. The height of the rays varies from 1 to 48 cells or even more. The cells are slightly higher than broad. The marginal cells are usually bigger than the rest. A number of bordered pits have been observed in the tangential walls of the ray cells (TEXT-FIG. 4). Generally they are not well preserved. Sometimes only pit cavities are seen.

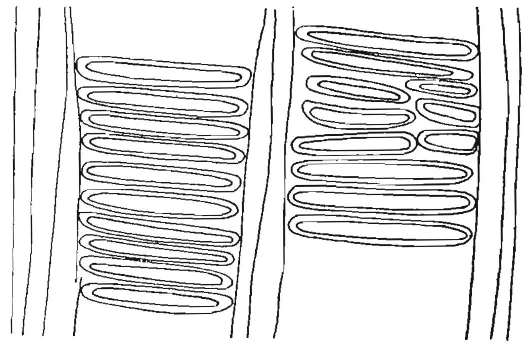
The radial section of the secondary wood is most interesting. The details of the structure of the tracheids and medullary rays can be seen clearly. The pitting is best preserved in the early wood and in the tracheids of the late wood next to it. The pitting on the walls of the tracheids exhibits an extraordinary range of variation both in shape



TEXT-FIG. 3—Tangential section of secondary wood. ×115.



TEXT-FIG. 4—Ray cells in tangential section, showing bordered pits on the tangential wall. × 505.



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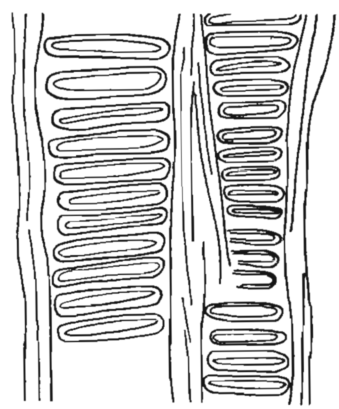

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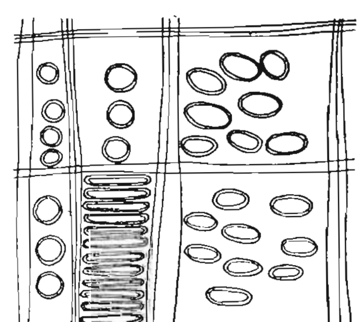

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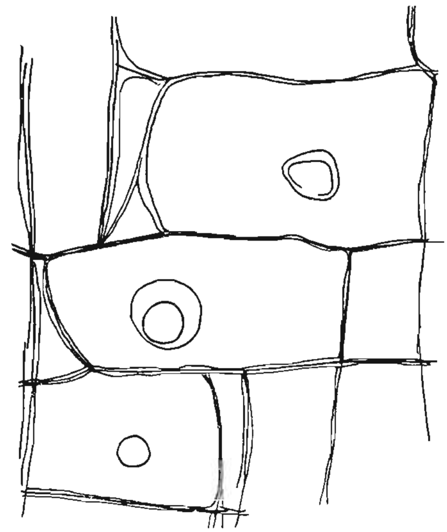
TEXT-FIGS. 5-7 — Parts of early wood in radial sections, showing various types of pitting occurring on the walls of tracheids. × 505.

and arrangement. In the late wood the pits are generally not preserved, but the early wood shows various types of pitting ranging from scalariform to multiseriate pits, on the radial surfaces of tracheids (PL. 4, FIG. 27 and PL. 5, FIGS. 30, 31; TEXT-FIGS. 5-7) and on the whole scalariform tracheids are more common. The slender tracheids of the early wood have often scalariform thickening while the wider ones have multiseriate bordered pits ranging from horizontally elongated to circular. The circular pits are 2-4 seriate (PL. 5, FIG. 31). The transitional stages between the round bordered pits and scalariform thickenings are also clearly exhibited (PL. 5, FIG. 30) as shown by the occurrence of the rounded and the horizontally elongated pits on the same tracheid wall mixed with scalariform thickenings. The pore of the bordered pits appears to be circular.

In the late wood the pitting is not so variable. The pits when preserved are mostly uniseriate, circular and bordered, very rarely scalariform.

The ray cells in radial view are rectangular, much wider than high (PL. 4, FIG. 27). The cells are sometimes vertically elongated. The ' pits in the field ' are bordered, but usually the bordered pits are not well preserved. In many places the preservation is so deceptive that the pits give the impression of being simple. Size of the pits is very variable. The number of bordered pits in a cross-field varies from one to six or more (PL. 5, FIG. 30; TEXT-FIGS. 8-11). The pits in the field are oval or circular. When there is a single pit, it is generally placed in the centre of the field (TEXT-FIG. 9) and is very large.

The primary xylem is endarch and not easily recognizable in transverse section. They occur either in groups (PL. 6, FIG. 36) or scattered (PL. 6, FIG. 35). Occasionally some groups of small polygonal cells, about 20-30 in number, are situated next to the inner margin of the secondary xylem wedges. When scattered, the rows of primary xylem cells, as seen in transverse section, are uniseriate to biseriate, about 4 to 8 cells or more in height. Walls of the primary xylem cells are rather thin compared to the secondary xylem. Longitudinal section (PL. 6, FIG. 37) shows that the innermost part of the xylem ring is composed of 4 to 8 layers of slender tracheids with spiral thickenings on their walls. The next elements further out are



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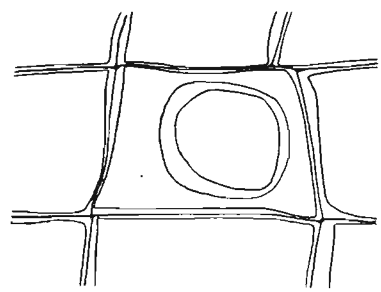

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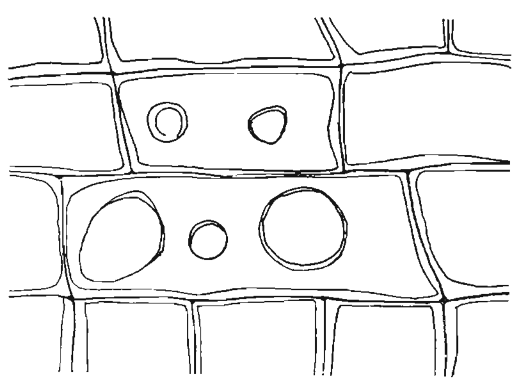

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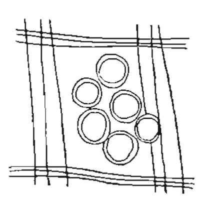

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TEXT-FIGS. 8-11 — Parts of secondary wood in radial section, showing pits in the field. × 505.

the bordered scalariform tracheids, forming part of the secondary xylem.

The pith is very wide; in younger stems it is wider than in older stems. It consists mainly of parenchymatous cells (PL. 6, FIG. 38) with hundreds of irregularly scattered thick-walled cells which are exactly like those found in the cortex. In cross-section the parenchymatous cells are iso-diametric with well-developed intercellular spaces. Pl. 6, Fig. 39 shows longitudinal section of pith cells; these are rectangular. Longitudinal sections of the thick-walled cells show that they are elongated cells of various calibres. Sometimes they are forked and become γ-shaped.

In two of the specimens a few layers of rectangular cells have been noticed in the pith (PL. 5, FIGS. 33, 34). These cells are arranged in the form of an arc, the convexity being towards the centre of the pith. These structures are evidently the result of some cambial activity, but their exact nature could not be determined with certainty.

COMPARISONS AND DISCUSSION

As is evident from the description above our knowledge of the structure of the stem is fairly complete. The compact secondary wood like that of conifers, growth rings with late wood more developed than the early wood and peculiar tracheids, which exhibit various types of pitting on their radial surfaces including more commonly found scalariform and multiseriate pitting, are the chief points of interest in this species. Anatomically the stem shows a close resemblance with the other Bucklandias, *Wielandiella*, Cycadeoideas, and the recent Cycads. More noteworthy, however, is the apparent resemblance with the secondary wood of *Homoxylon rajmahalense*.

Comparison with Bucklandia and Williamsonia Sewardiana — One of the important stem genera belonging to Bennettitales is *Bucklandia*. Most of the species of *Bucklandia* are known from casts. Their trunks are slender and longer than that of *Cycadeoidea* and are covered with persistent leaf-bases, which are less uniform in size and assume various forms. There are growth rings in the secondary xylem. *B. Sahnii* shows these generic characters, but it differs markedly from all other Bucklandias, of which anatomy is known, in having scalariform tracheids. *B. Sahnii* has persistent leaf-bases which are not uniform in size and shape. This character is very well seen in *B. indica* as well, as has been described by Seward. In *B. indica* there is also indication of alternation of large and small leaf-bases but in *B. Sahnii* only in few specimens such alternation of large and small leaf-bases has been noticed. In *B. Sahnii* ramental hairs have not been seen so far, whereas in *B. indica* they are present. In *B. Sahnii* as in *B. indica* secondary wood is more compact with well-defined growth rings but in the former medullary rays are uniseriate, biseriate and rarely triseriate and tracheids show from multiseriate to scalariform pitting, whereas in *B. indica* medullary rays are uniseriate and tracheids have only multiseriate bordered pits.

According to Sahni (1932) *B. indica* was the stem of *Williamsonia Sewardiana*. In his reconstruction of *W. Sewardiana* he has shown this plant to be a small tree with an erect columnar trunk bearing a crown of leaves (*Ptilophyllum* cf. *cutchense*) at the top and the flowering shoots projecting laterally from the trunk. In *B. Sahnii*, however, the stem had branches which were forked and the flowers were borne at the point of bifurcation, a condition which is quite different from *B. indica* which possessed an unbranched stem very similar in general appearance to a living unbranched *Cycas*.

I have studied the original slides of *Williamsonia Sewardiana* and have also studied the flowers of *Williamsonia* collected by me from Amarjola. The peduncles of these flowers show a surprising resemblance with the young stem of *B. Sahnii*. In both species the wood is compact with mostly uniseriate medullary rays but bi- and triseriate ones also occur; the secondary tracheids are all scalariform; field pits are bordered and are 1 to 4 in number. *B. indica* which is said to be the stem of *W. Sewardiana* does not show these characters.

Again the anatomy of the leaf-bases of *B. Sahnii* is similar to that seen in the cross-sections of the bracts of *W. Sewardiana*; in both hypodermal cells and ground tissue are similar and the xylem is on the inner side. However, in *B. Sahnii* the vascular bundles in the leaf-bases are mostly five in number although sometimes there are seven. The number of bundles in *W. Sewardiana* is generally seven but this number is not constant as even up to eleven have been met with. Most probably the number of vascular bundles present depends on at what level the section is cut.

Now the question arises whether *B. indica* is really the stem of the plant *W. Sewardiana* as suggested by Sahni. As stated above *B. Sahnii* shows a closer resemblance with the peduncle of the flower of *W. Sewardiana.* My opinion is that *W. Sewardiana* flowers must have been borne on stems of the type of *B. Sahnii*, if not on *B. Sahnii* itself. A definite conclusion can only be reached after a complete study of these flowers have been made.

B. Sahnii also shows resemblance with *Bucklandia Yatesii* and *B. buzzardensis* in having growth rings in the xylem. In *B. Yatesii* there are two concentric growth rings; tracheids occur in single rows and the circular bordered pits are uniseriate or in two alternate series. *B. buzzardensis* has several growth rings, the maximum number being eight. *B. Sahnii* differs from both these species in having scalariform as well as multiseriate bordered pits on the tracheids.

Comparison with Wielandiella angustifolia— In its branching habit *B. Sahnii* is very close to *Wielandiella angustifolia* Nathorst and differs widely from all other members of Bennettitales. *W. angustifolia* has a slender stem, repeatedly branched as a dichasial system with a fertile shoot in the forks formed by widely divergent branches; similarly in *B. Sahnii* the stem has forking branches bearing the flowers at the point of bifurcation, but whether *B. Sahnii* also branched repeatedly like *W. angustifolia* is not known so far.

Comparison with Cycadeoideas — The wood of *Cycadeoidea* shows some points of similarity with *B. Sahnii* in having a wide cortex, a broad zone of phloem with alternation of thick-walled elements with thin-walled cells, and a secondary xylem mainly composed of scalariform tracheids. Some of the species of *Cycadeoidea* shows a close resemblance with *B. Sahnii*. For example, *C. Jenneyana* like *B. Sahnii* shows signs of rings in the xylem and has narrow medullary rays, which are 1 to 2 cells in thickness. *C. micromyela*, an exceptional type, shows bordered pits on its tracheids ranging in shape from the circular to the scalariform even on the same tracheid; medullary rays in this species are uniseriate and 7 to 20 cells deep. *C. Dartoni* shows similar combination of pitting. Wieland has found in *Raumeria Reichenbachiana* secondary xylem consisting of scalariform tracheids, but with a stronger tendency to form pitted wood than other species of *Cycadeoidea.* Similar combination of scalariform pits along with transitional stages between the round bordered and scalariform pitting is also found in some of the Japanese Cycadeoideas described by Endo (1925).

The main difference between *B. Sahnii* and the typical Cycadeoideas is that Cycadeoideas have mostly tuberous or short, columnar, unbranched trunks covered with closely packed persistent leaf-bases and multicellular hairs, the flowers are partially sunken within the leaf-base layer and are lateral on the trunks. *Cycadeoidea gigantea* is the only exceptional form which differs from the other species of *Cycadeoidea* in the absence of lateral fertile shoots although it is identical with them in habit, in the form and structure of the leaf-bases and in the ramenta. *B. Sahnii* unlike Cycadeoideas is more slender, and branched dichotomously; as in *C. gigantea* there is no evidence of lateral fertile shoots. While the wood in *B. Sahnii* is very compact and has well-defined growth rings, in Cycadeoideas there is mainly a single vascular cylinder in the main stem and in this respect it resembles most of the recent cycads.

Comparison with Living Cycads — In general appearance and external characters, *B. Sahnii* is similar to some recent 'armoured' cycads. However, in the former the wood is compact and has definite growth rings, which is totally different from the loose structure of recent cycads, in which growth rings are missing except in few species, such as *Dioon spinulosum.* In *B. Sahnii* the spiral elements of the protoxylem are followed by a main mass of secondary scalariform wood, but transition towards pitted wood is also noticed rather frequently. On this point it shows a marked difference from some members of Cycadales, and a resemblance with *Stangeria* and *Microcycas calocoma.*

Comparison with Homoxylon rajmahalense— *B. Sahnii* also shows a very close resemblance with *Homoxylon rajmahalense.* The structure of *B. Sahnii*, so far as the cortex and phloem is concerned, perfectly agrees with *H. rajmahalense* described by Hsü and Bose, except that in *H. rajmahalense* no leaf traces have been found in the cortex. In *Homoxvlon* as well as in *B. Sahnii* the medullary rays are uni- to biseriate, triseriate rays are also frequent; in the former the height of the ray is 1 to 42 cells whereas in *B. Sahnii* the height of the ray has been found to be 1 to 48 cells. In the secondary wood of *B. Sahnii* scalariform tracheids are more common and the ray cells sometimes show some big pits occurring singly in the field. In *H. rajmahalense*, circular pits on a tracheid are 3-4 or even 5-seriate, and tend to be so densely arranged that they become hexagonal, while in *B. Sahnii* so far no such hexagonal form of pits has been observed. On the whole, if we had only the secondary wood of *B. Sahnii* and *H. rajmahalense*, we would find it very difficult to distinguish between the two. With the complete description of *B. Sahnii* in front of us the suggested angiospermous affinities of *H. rajmahalense* become more doubtful and I think that the original *H. rajmahalense* is only a part of the secondary wood of a Bennettitalean stem.

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EXPLANATION OF PLATES

Plate 1

Bucklandia Sahnii

(Except Figs. 13a and 13b all are natural size.)

1-13. Some of the pieces of *Bucklandia Sahnii*, showing the variation in size and shape of the leaf-bases.

2, 3. Pieces of stem showing the marks of the vascular bundles (*v*) on the leaf-scars.

6, 8, 10 & 13. These pieces show the branching habit of the plant.

13a. Shows the protruding xylem of one of the lateral branch of the specimen number 13. × 2½.

13b. Shows the three scars (*a*, *b* and *c*) on the stem shown in Fig. 13 (*see* Figs. 43-44). × 2.

Plate 2

Bucklandia Sahnii

14. Transverse section of the stem, showing wide pith and the broad zone of xylem, the phloem ring and the cortex. × 25.

15. Transverse section, showing epidermal cells (*e*) and hypodermal cells (*h*) of the leaf-base. × 150.

16. Part of the cortical cells. × 60.

17. Part of a transverse section of the stem enlarged to show the broad zone of the xylem (*x*), the ring of phloem (*ph*) and the cortex (*c*). × 20.

18. Part of the phloem ring, showing the phloem rays and the thick-walled elements of the phloem. × 55.

19. Part of the phloem ring, showing the thick-walled and the thin-walled elements of the phloem. × 55.

Plate 3

Bucklandia Sahnii

20. Arc-shaped leaf-trace bundle. × 55.

21, 22. Shows the stages in the formation of the vascular bundles supplying the leaf-bases.

23. Part of a leaf-base, showing seven vascular bundles. × 20.

24. Part of a leaf-base, showing five vascular bundles. × 55.

25. Part of transverse section, showing well-marked growth rings with late wood greatly developed as compared to early wood. × 60.

Plate 4

Bucklandia Sahnii

26. Part of secondary xylem in tangential section, showing uni- to triseriate rays. × 90.

27. Part of secondary xylem in radial section, showing scalariform tracheids and ray cells. × 200.

28. Radial section of secondary xylem to show distribution of medullary rays. × 150.

29. Part of secondary xylem in radial section, showing the bordered pits in the walls of ray cells. × 500.

Plate 5

Bucklandia Sahnii

30. Part of secondary xylem in radial section, showing scalariform tracheids, the transitional stages between multiseriate bordered pits and scalariform pits and field pits. × 280.

31. Part of secondary xylem in radial section, showing scalariform (*sp*) and multiseriate pits (*bp*). × 290.

32. Radial section of secondary wood, showing scalariform tracheids. × 400.

33. A part of the pith in transverse section, showing the cambium-like cells (*pc*) in the pith. × 17.

34. Part of the same magnified, showing cambium-like cells (*pc*) and the pith cells (*p*). × 150.

Plate 6

Bucklandia Sahnii

35. Part of primary wood in transverse section showing the scattered nature of the primary xylem (*px*). × 150.

36. Part of primary wood in transverse section, showing group of protoxylem cells. × 150.

37. Part of primary xylem in transverse section, showing the tracheids with spiral thickening. × 500.

38. Part of pith in transverse section, showing the parenchymatous cells (*p*) of the pith and some of the thick-walled cells found in the pith (*wt*). × 25.

39. Pith cells in radial section. × 60.

Plate 7

Bucklandia Sahnii

40, 41. Upper and lower side of a detached leaf-base. × 1.

42. Epidermal cells in surface view from one of the leaf-base of the specimen number 1 (*see* Pl. 1, Fig. 1). × 35.

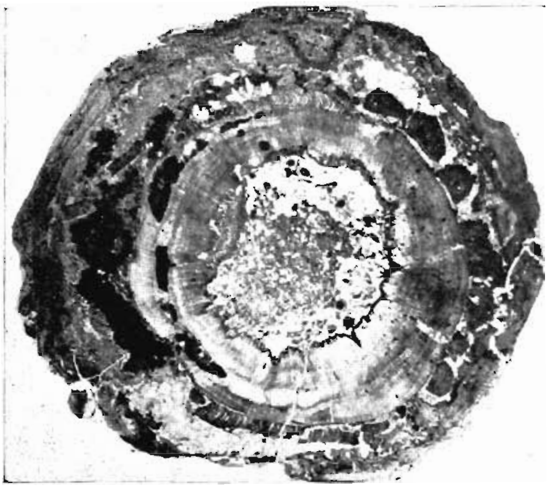
43, 44. Side and basal view of one of the fruits of *Williamsonia* collected from Amarjola, in order to show what type of fertile shoot was probably present at the point (*c*) of the specimen number 13 (*see* Pl. 1, Figs. 13 and 13b). × 1.

45. One of the flower of *Williamsonia* collected from Amarjola. × 1.

46. Epidermal cells and stomata in surface view from one of the bracts of the above flower. × 40.

47. Epidermal cells and stomata in surface view from one of the leaf-bases at the point *a* in Fig. 8 (*see* Pl. 1, Fig. 8). × 60.


v
1
2
3
4
6 A
7
9
10
a
b
c
d
5
6
8
11
12
a
b
C
13 B
a
d
13
a
13 A



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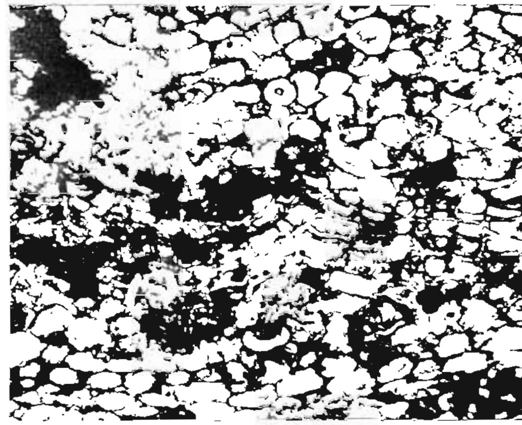

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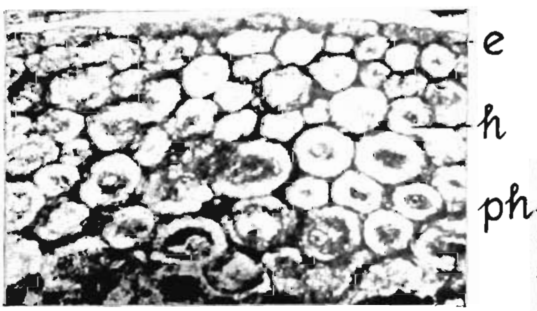

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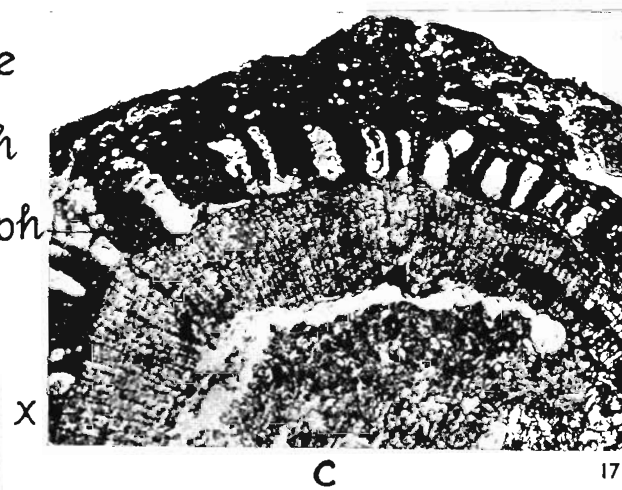

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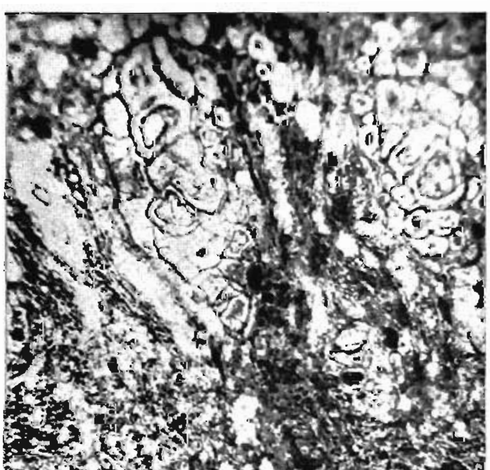

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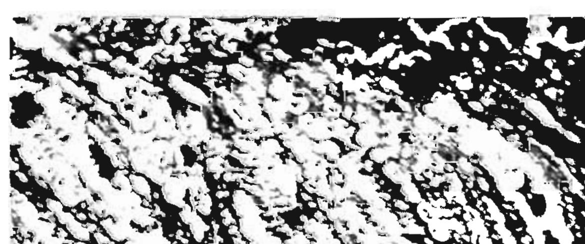

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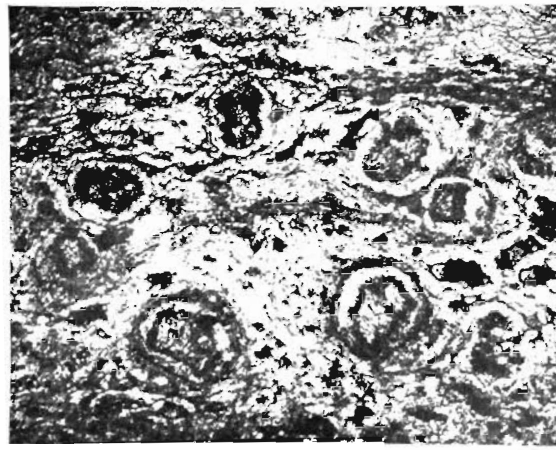

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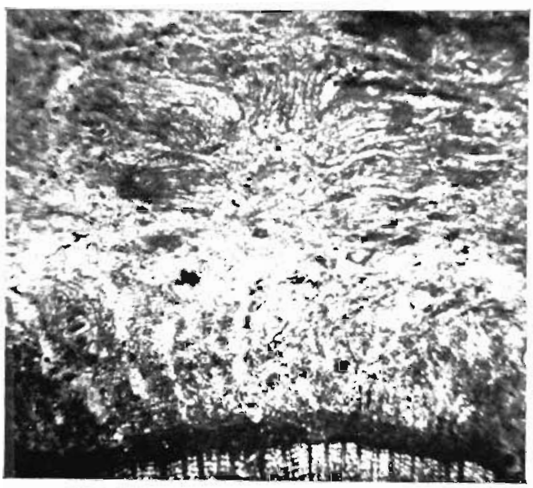

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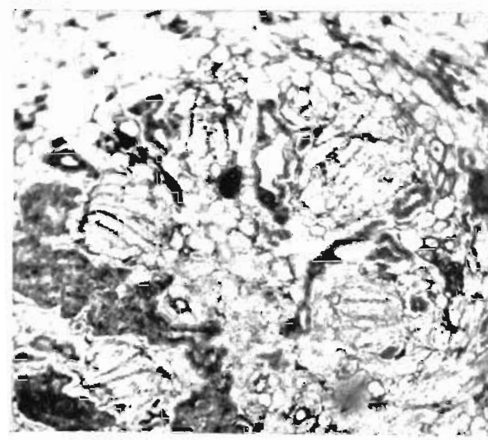

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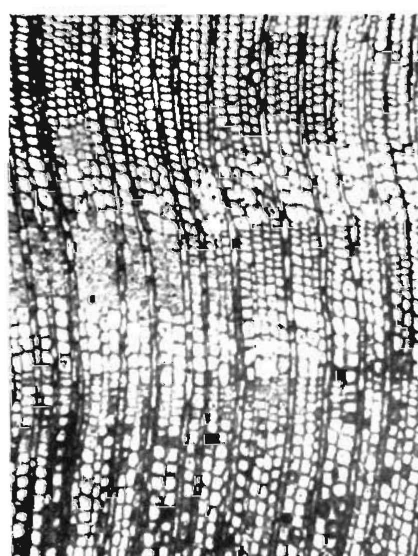

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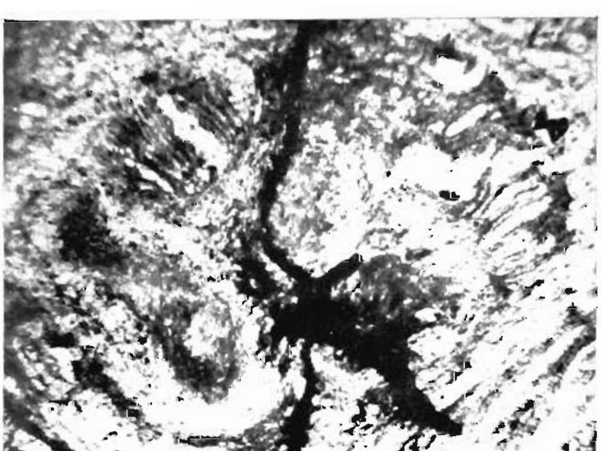

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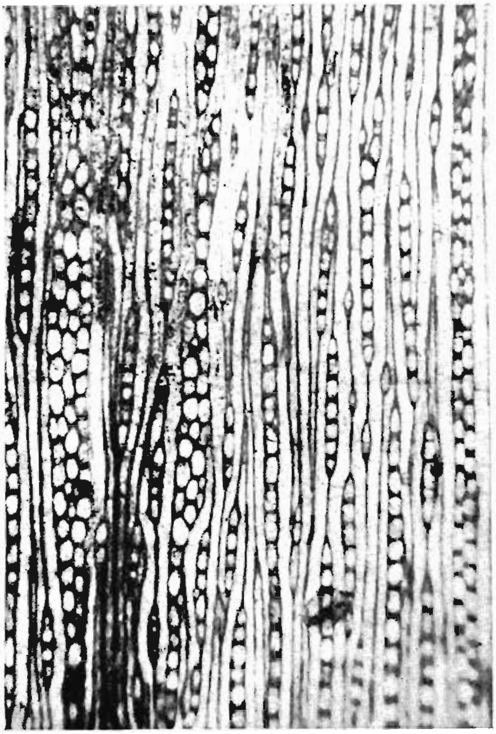

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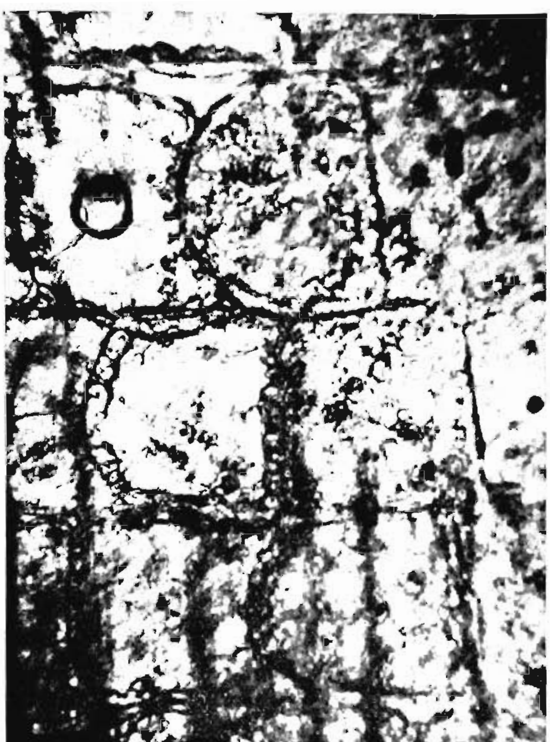

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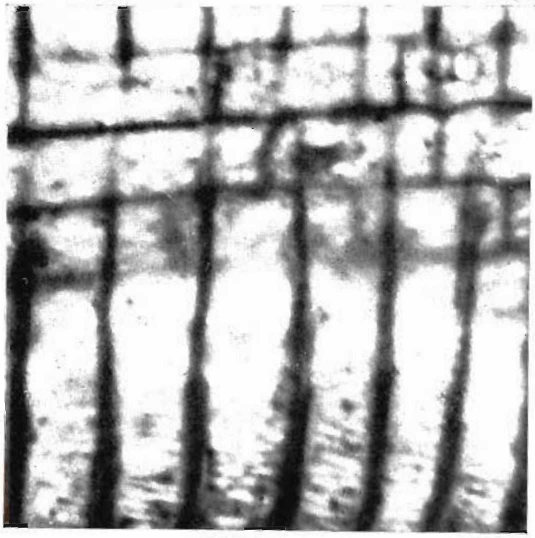

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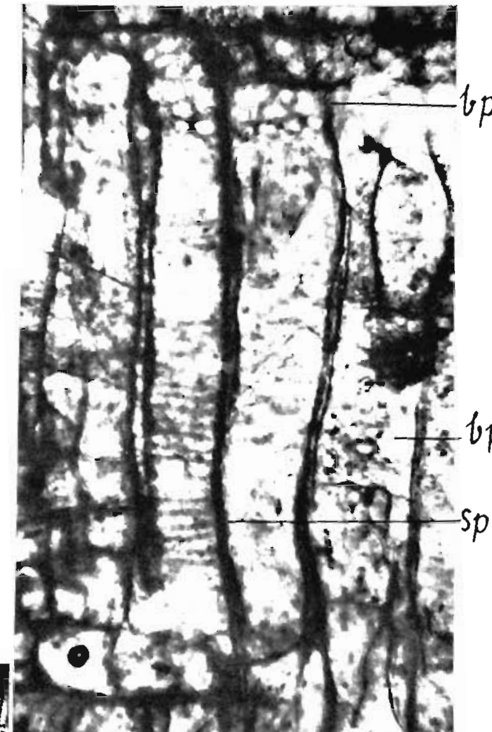

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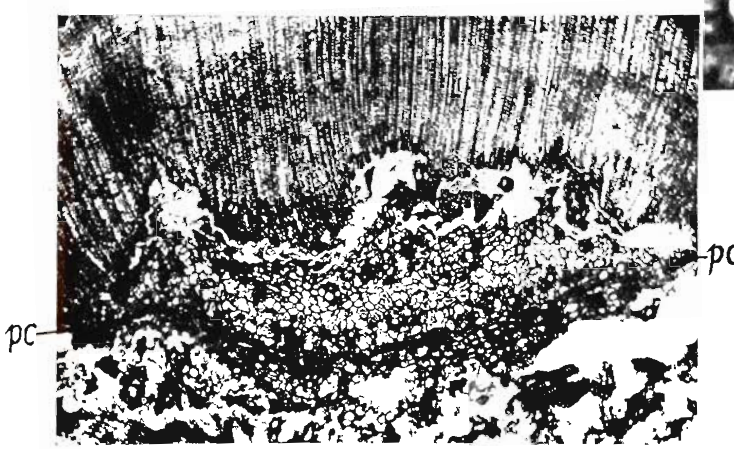

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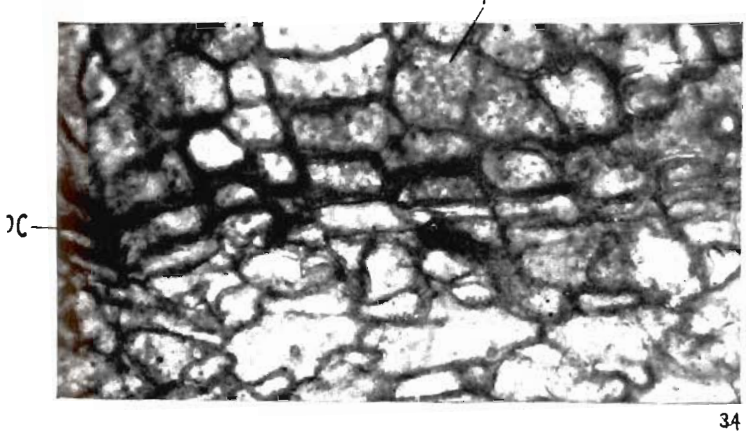

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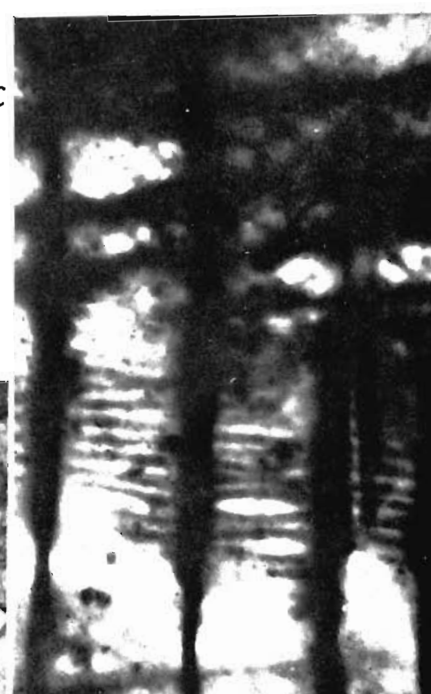

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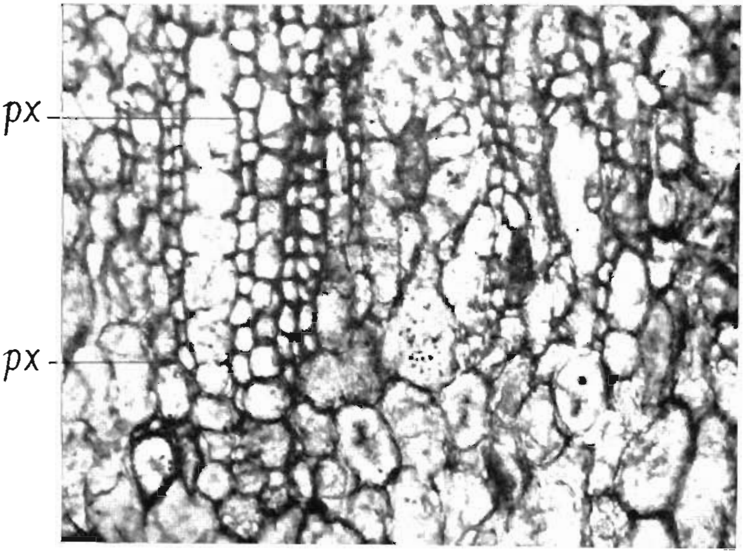

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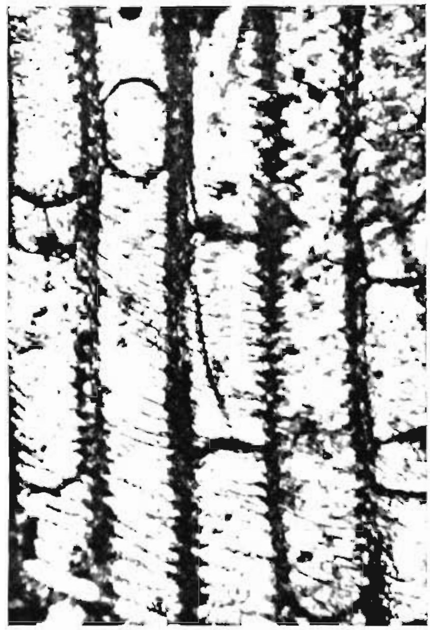

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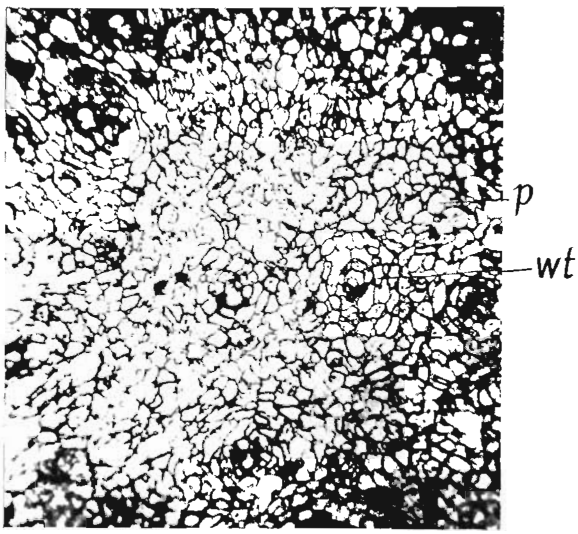

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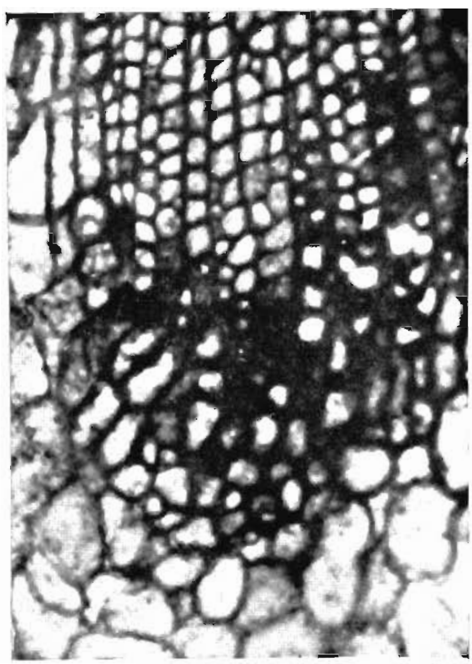

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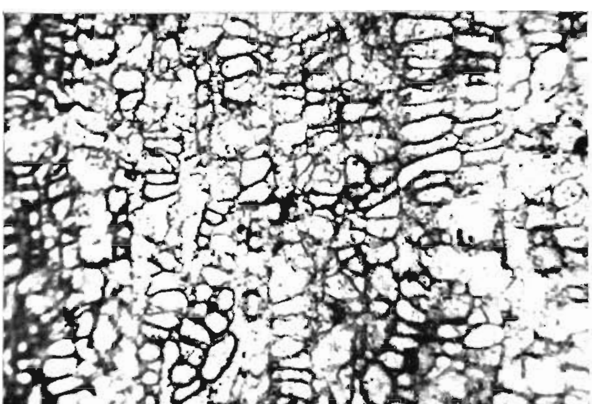

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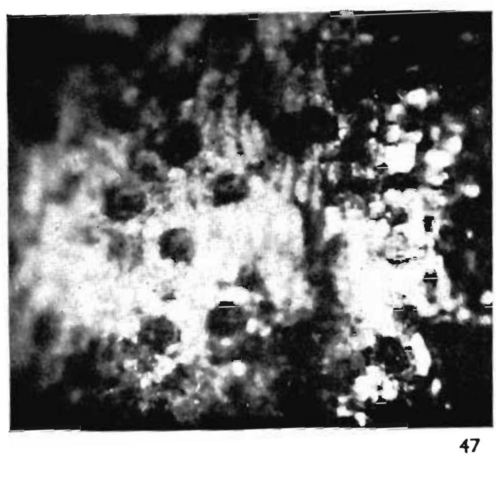

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