SOME FOSSIL WOODS FROM THE JURASSIC OF RAJMAHAL HILLS, BIHAR, INDIA

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ABSTRACT

The present paper deals with four new species of *Dadoxylon* based on secondary woods. They are *D. amraparense, D. mandroense, D. bindrabunense,* and *D. santalense.*

INTRODUCTION

OUR knowledge of fossil woods in the Jurassic flora of the Rajmahal Hills is still meagre in spite of the rich occurrences of well preserved petrified woods in its several localities. The Rajmahal flora includes several genera of fossil gymnospermous woods, most of which cannot be reasonably classified under any of the present day coniferous groups. This is chiefly because of the scanty, but more often the entire absence of preservation of the primary xylem, pith or bark region which leaves a rather large anatomical gap when it comes to the question of affinities. However, with the gradual accumulation of data from time to time, the relationships of the various genera may be better accessed, if not completely established. On the contrary, if these woods are left undescribed till complete specimens are found, then it is more likely that no data may be coming forth from most of the localities. This will naturally impede the process of correlation and thus may seriously hinder the chances of establishing their relationships and affinities. Therefore, in order to avoid this situation it becomes necessary to describe even the fragmentary woods as the information collected from them may ultimately prove to be of some value.

The petrified fossil gymnospermous woods described till now from the Rajmahal Hills, include seven genera and nine species. In 1931 Prof. Sahni for the first time recorded a species of *Dadoxylon, D. rajmahalense* from Banchapa, south of Mirzachowki railway station. Later Bose (1952) described *Brachyphyllum spiroxylum* from Amarjola, followed by Bhardwaj (1952-53) with four species, one each of *Taxoxylon, Dadoxylon, Cupressinoxylon* and *Mesembrioxylon* from Kulkipara and Amarjola. In 1957 Sah assigned some specimens from Amarjola to *Coniferocaulon* Fliche on the basis of their external and anatomical characters. Recently Kräusel & Jain (1964) have reported a new coniferous genus *Circoporoxylon,* and one species of *Dadoxylon* from Amarjola and Mandro.

The present collection includes a large number of petrified woods from several localities in the Rajmahal Hills. Only a few showing distinct and well preserved characters have been taken up for the present study. Most of these were collected from Mandro (previously known as Murruro) about 9 miles south of Mirzachowki railway station. Others were collected from Bindrabun (near Tinpahar) and from Amrapara. Apart from one species of *Sahnixylon* (SAHNI) Bose & Sah (1954), all the woods collected and studied by us from Mandro show araucarian pitting of the *Dadoxylon type.*

Identification and Classification — Fossil woods, as other fossil plants, have certain distinct characters which can be fruitfully utilized for identifying unknown plants. With fossil material this task is usually beset with considerable difficulties, more especially when xylotomists have to work on comparatively very fragmentary and imperfectly preserved material. In such cases also, only a single character might be preserved which may prove sufficient to identify them in terms of genera or species. But on the contrary, classifying them according to the natural system, considering their phylogenetic relationships, evidences of other characters are also equally essential, for that one character which may identify the species might prove to be ineffectual in determining its relationship.

From a perusal of the vast literature on fossil woods, it becomes evident that their classification and nomenclature by various

workers fall into two main categories within the artificial system:

(a) *Purely Artificial* — by assigning to a form-genus without indicating their relationships.

(b) *Comparative System* — by comparing and naming an organ or a form-genus or species with the present day forms.

Occasionally the fossil wood xylotomists have been confronted with the problem as to which of these two approaches is more suitable. To answer this question it is, therefore, essential to discuss the problem and find out the practical usefulness of one over the other. Prior to this paper a lot has already been said about the taxonomic considerations of fossil woods. The purpose of going into it once again, therefore, is partly to clarify the position and partly to express our views on the subject. However, it is not intended here to go beyond briefly outlining a few salient points concerning the nomenclature of fossil woods of the *Dadoxylon* type as it would be outside the scope of this paper.

From time to time various workers like Goeppert (1845), Endlicher (1847), Hartig (1848), Kraus (1882) and Caspary & Triebel (1889) have proposed different generic names for fossil woods having anatomical characters similar to the Araucarineae or Cordiateae. Seward (1917,1919) has already discussed at length the use of these different generic terms.

The form-genus *Dadoxylon* proposed by Endlicher (l.c.) for the secondary woods having the anatomical characters of Araucarineae or Cordaiteae, and some of the generic names suggestive of direct affinities, e.g. *Agathoxylon* Hartig (l.c.), *Araucarioxylon* Kraus (l.c.), etc. have been retained till now.

Hartig (l.c., p. 188) instituted the genus *Agathoxylon* for the reception of fossil woods similar to the living genus *Agathis*, and described a wood *A. cordianum* from the German Keuper. Kräusel & Jain (l.c.) while discussing the genus have remarked that Hartig has not given any detail of his specimen. The arrangement of the tracheidal and ray pits agree with *Araucaria*, while the presence of *' Zellfasern '* or xylem parenchyma is the only character which is absent or very rarely found in *Araucaria*. Perhaps these ' Zellfasern ' are the resinous tracheids ?. Moreover, he has not given any figure or particular description which may be taken as its diagnosis.

Similarly the generic name *Araucarioxylon* was used by Kraus (l.c.) for woods showing similarities with the members of the family Araucarineae. Seward (1919, pp. 176-177) discussed at length the feasibility of retaining this generic name and concluded that there was no adequate justification for using the name *Araucarioxylon*. Gothan (1905) also on the basis of his work on the anatomy of living and fossil coniferous woods, included *Araucarioxylon* Kraus, *Cordaioxylon* Felix and *Araucarites* Presl. used by Goeppert for the fossil woods of araucarian type, in the genus *Dadoxylon*, for he found it impossible to distinguish between these genera.

The present day Araucarineae includes two well-known genera *Agathis* and *Araucaria* which are indistinguishable by their wood structure alone. According to Kraus (1864), it is practically impossible to distinguish one from the other. Seward & Ford (1906, p. 339) agreeing with this view point out, " The two genera *Agathis* and *Araucaria* agree so closely with one another that they may be treated as a single anatomical type". Patton (1928, pp. 5-6) states that botanically these two genera are very distinct, but microscopically the timbers are very similar and it has been found impossible to find a single character that will separate the two genera. Phillips (1941, p. 286) is of the opinion that the two constituent genera are of such similar structure that differentiation of microscopical features is not always possible. He further mentions that the two genera *Agathis* and *Araucaria* are distinguished from all other coniferous woods in possessing small alternately arranged bordered pits in the tracheidal walls, but do not appear to be separable from one another on any positive anatomical feature. Greguss (1955, p. 77), while discussing the family Araucariaceae, in his monographic work ' Identification of living gymnosperms on the basis of xylotomy ' clearly states, " Xylotomically the situation is different regarding the differentiation within the family by genera and species. The species included in the genera *Agathis* and *Araucaria* have so many features in common that their separation is not easy at all; one may say it is very difficult and doubtful, almost impossible."

In view of the extreme xylotomical similarities between these two living genera, it appears that referring fragmentary fossil

woods either to the genus *Agathoxylon* or *Araucarioxylon* will be misleading.

Seward (1919, pp. 203-206) created a form-genus *Mesembrioxylon* to embrace Gothan's two genera *Podocarpoxylon* and *Phyllocladoxylon*. He pointed out that the distinction between these two genera rests on a variable character and moreover, when there is no adequate evidence of affinity with a particular living genus, e.g., *Podocarpus* rather than *Phyllocladus* it is preferable to adopt a name free from any such implication. He also emphasized, "The anatomical characters do not enable us to assign fossil species to a position within the Coniferales sufficiently definite to be denoted by the use of name implying close relationship to a particular genus as distinct from a group of allied types."

The International Code of Botanical Nomenclature (1961, p. 21; Art. 20, Recomm. 20 C) also definitely forbids the naming of an organ-genus or a form-genus of fossil plants of uncertain nature or affinities, to a name suggesting definite relationship with a recent plant. Hence the use of such terms as *Araucarioxylon* or *Agathoxylon* etc., implying relationship should as far as possible be avoided.

From the foregoing brief account of the nomenclatural review of some of the fossil woods, it becomes evident that a completely artificial nomenclature would be more suitable for describing the fragmentary fossil woods till more comprehensive data is available. For, the bestowal of names suggesting direct relationship may nullify their usefulness, because the appearance of ever increasing suggestive names would bring about a state where systematization might not only become difficult but almost impracticable.

In view of the above considerations, all the present woods from the Rajmahal Hills, Bihar are referred to the form-genus *Dadoxylon* Endl.

DESCRIPTION

Genus — *Dadoxylon* Endlicher

1. *Dadoxylon amraparense* n. sp.

Pl. 1, Figs. 1-7; Text-figs. 1-6

Decorticated secondary wood, measuring 13 × 20 cm. in size.

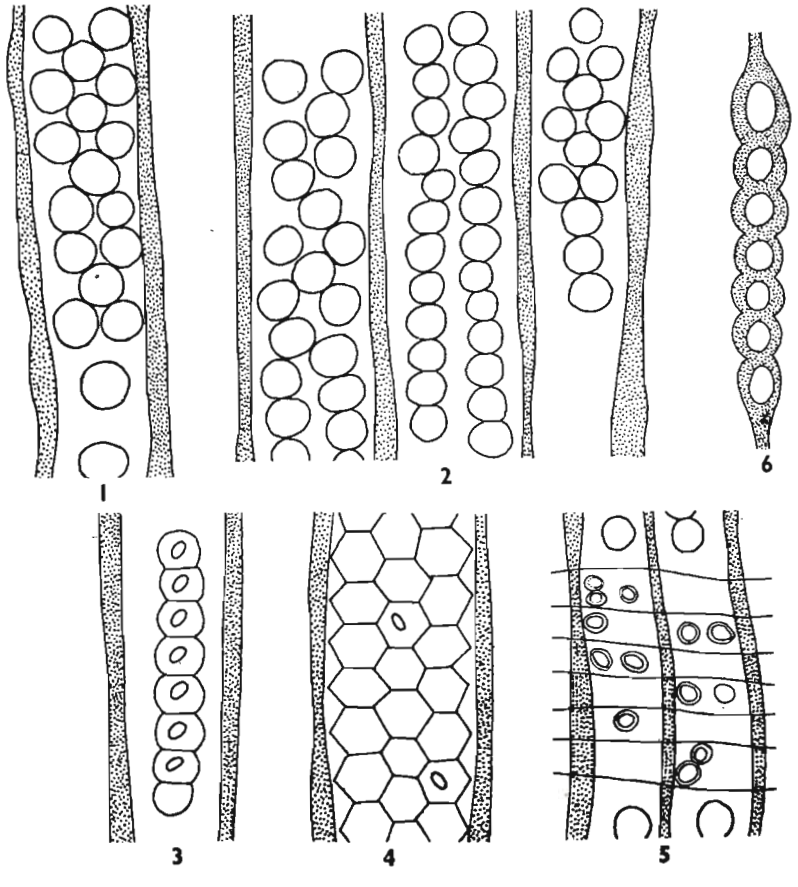
Growth Rings — Distinct, regular, 40 to 70 tracheids wide, transition from early to late wood gradual (Pl. 1, Fig. 1). Tracheids in cross section 28 μ × 44 μ to 8 μ × 16 μ in size, more or less oval in shape, with almost oval to sometimes oblong lumen. Wood compact; xylem parenchyma absent. Resin tracheids abundant near the medullary rays.

Tracheids — Broad, radial diameter 8 μ to 38 μ, only radial walls pitted, pits sometimes single, commonly uni- to tri-seriate. Uni-seriate pits oval or circular, contiguous or separate, tangentially flattened; line of contact straight, free portions usually arching (Text-fig. 3). Pits occupy central part of the tracheid width, aperture broad, oval and inclined; 4 μ × 6 μ in size. Bi- to tri-seriate pits mostly contiguous, rarely separate, alternate, hexagonal with oblique pores (Pl. 1, Figs. 4, 5), or sometimes in two parallel rows, with circular pits, touching each other tangentially (Pl. 1, Fig. 6; Text-fig. 2); opposite or sub-opposite (Pl. 1, Figs. 2, 3; Text-figs. 1, 2), or arranged in an irregular manner e.g. 1-2-1-1-2-2 etc. (Text-fig. 1).

Cross-field Pits — Not very well preserved, seen at places, 2-4, bordered, circular, contiguous, 8 μ in diameter having broadly elliptical pores; pores 4 μ × 6 μ in size (Text-fig. 5).

Medullary Rays — Simple, uniseriate, short, 1-15 cells high (average 6 cells in 32 counts). Cells longer than broad, 8 μ × 12 μ in size (Pl. 1, Fig. 7; Text-fig. 6).

Comparison with Living Woods — The radial pitting in this fossil wood is typically araucarioid type, except that at some places the radial pits show a marked tendency towards arranging themselves in opposite, circular pairs. This feature is not uncommon amongst the Araucarineae. Greguss (1955; Pl. 21) figures similar combination of characters in *Araucaria columnaris* (Forster) Hook. His drawings of *Agathis alba* (Rumphius) Warb. (Pl. 3; Text-fig. a) also shows a similar distribution at the end portions of the tracheids. As there is no clear anatomical distinction between the two living genera *Agathis* and *Araucaria*, we can only say at the present moment that our fossil wood shows anatomical relations similar to those of the araucarineae. Bailey (1933, p. 148) pointed out that an admixture of pinaceous and araucarian radial pitting occurs in *Ketelerria* and also in some other living representatives of the Pinaceae.



TEXT.FIGS. 1-6 — *Dadoxylon amraparense* n. sp. 1, part of a single tracheid in radial plane showing circular, opposite pits with their irregular arrangement. × 400. 2, part of radial section showing pits in pairs and in parallel rows. × 400. 3 & 4, parts of tracheids showing uni- and tri-seriate contiguous pits respectively. × 400. 5, radial section showing cross-field pits. × 400. 6, medullary ray in tangential view. × 400.

Comparison with Fossil Forms — Many of the Palaeozoic gymnospermous woods show similar type of mixed radial pitting. Kräusel (1956, pp. 411-426) on the basis of pith characters has placed such woods to different genera, e.g. *Kakoxylon, Megaporoxylon*, etc. The pith is not preserved in our woods, and therefore they cannot be assigned to any one of these Palaeozoic genera.

Some Mesozoic transitional genera, e.g. *Xenoxylon* Gothan, *Araucariopitys* Jeffrey and *Brachyoxylon* Hollick & Jeffrey show mixed type of radial pitting. In *Cedroxylon transiens* Gothan (Seward, 1919, p. 214) and *Piceoxylon thomsoni* Bannan & Fry (1957, p. 336) this type of mixed radial pitting has also been observed. Kräusel (1949, p. 152) proposed a new name *Palaeopiceoxylon* to include coniferous woods in which the radial pitting is of mixed type and other characters being as in *Piceoxylon* Gothan. But as all these fossil wood genera show abietinean characters, and so are excluded from the present comparison.

In its overall features the present specimen approaches nearest to the genus *Dadoxylon* Endl. Amongst the many known species of the genus, only *Dadoxylon* sp. (Holden) Seward, *Araucarioxylon jeholense* Ogura, *Dadoxylon* (*Araucarioxylon*) *japonicum*

Shimakura, and *Dadoxylon* (*Araucarioxylon*) *sidugawaense* Shimakura are comparable to our specimen in one or the other character.

All these species resemble our wood in having mixed type of radial tracheidal pits. *Dadoxylon* sp. differs in having bars of Sanio, but other characters are not known, its further comparison with the Rajmahal wood is not possible. *Araucarioxylon jeholense* is characterized by the absence of growth rings and also differs in having mostly circular or elliptical pits. *Dadoxylon* (*Araucarioxylon*) *japonicum* distinguishes itself by the presence of bordered pits on the tangential walls of the tracheids. *Dadoxylon* (*Araucarioxylon*) *sidugawaense* differs in having pits in the tangential walls of the tracheids and apparently simple pits in the cross-field, the pith is not known in our wood.

The three Indian Tertiary species, *Dadoxylon eocenum* Chitaley, *Dadoxylon resinosum* Shukla and *Dadoxylon deccani* Shukla also show some comparison with the present wood. Chitaley's species differs in having 1-2-seriate pits in the tangential walls of the tracheids. Similarly the other two species differ from our wood in having 1-4-seriate pits in the radial walls and 1-2-seriate pits in the tangential walls of the tracheids. The pits in the field are also greater in number, while the medullary rays are considerably higher than encountered in the present species.

So far, as can be ascertained, none of the many *Dadoxylon* species show closer relation to the Rajmahal wood, hence a new specific name *Dadoxylon amraparense* is proposed. The specific name is after the locality " Amrapara ".

Diagnosis — Decorticated secondary wood, growth rings distinct, only radial walls of the tracheids pitted, pits uni- to tri-seriate, alternate or opposite, contiguous or separate, hexagonal to circular, with broadly elliptical apertures. Pits mostly incontact with each other, line of contact always present. Cross-field pits not very well preserved, 2-4, contiguous circular with broad apertures. Rays simple, uniseriate, 1-15 cells high. Xylem parenchyma absent. Resin tracheids abundant.

Type Specimen No. — 4511, B.S.I.P. Museum.

Locality — Amrapara, Rajmahal Hills, Bihar.

Horizon — Rajmahal Stage (Jurassic).

2. *Dadoxylon mandroense* n. sp.

Pl. 1, Fig. 8; Pl. 2, Figs. 9-10; Pl. 3, Figs. 19-21; Text-figs. 7-8

Large petrified, decorticated secondary wood, measuring 10 in. in length and 16 in. in diameter.

Growth Rings — Distinct, transition from early to late wood gradual. Elements angular with rounded to oblong lumen, varying from 20 to 50 μ in diameter, compact. No xylem parenchyma or resin tracheids (PL. 2, FIG. 9).

Tracheids — Broad, radial diameter 20 μ to 50 μ, only radial walls pitted. Pits in the spring wood uni- to tri-seriate. Uniseriate pits tangentially compressed, forming a horizontal line of contact, free ends arching, tangentially broadly oval, inclined, 4 μ to 8 μ in size (PL. 1, FIG. 8). When in two or three rows, pits alternate, contiguous and hexagonal. Sometimes occurring in groups (PL. 1, FIG. 8). In late wood, pits only uni- to partially bi-seriate, circular, touching each other, opposite when in pairs (PL. 2, FIG. 10; TEXT-FIG. 7) 12 μ to 16 μ in diameter, apertures more or less circular, 4 μ in diameter.

Cross-field Pits — In early wood 4-12, circular, contiguous, 12 μ in diameter; pit pores inclined, 3 μ × 12 μ in size (PL. 3, FIG. 19). In late wood 2-6 (usually 3 or 4), circular, separate, 8 μ in diameter; pit pores broadly elliptical, 4 μ × 6 μ in size (PL. 3, FIG. 20; TEXT-FIG. 8).

Medullary Rays — Simple, uniseriate, distantly placed, 1-15 cells high (average 3-4 cells in 32 counts), cells slightly higher than broad (PL. 3, FIG. 21).

Comparison — This fossil wood is also characterized by possessing typical araucarian pitting in the early wood tracheids along with oppositely placed circular bordered pits in the late wood. *Dadoxylon amraparense* n. sp. differs from the present species firstly in having mixed type of radial pitting restricted only in the early wood tracheids and secondly in having lesser number of cross-field pits. This wood is closely comparable to *Dadoxylon* (*Araucarioxylon*) *japonicum* Shimakura in possessing distinct growth rings, almost similar type of radial pitting and in the absence of xylem parenchyma. But *D.* (*Arau.*) *japonicum* differs in the presence of bordered pits on the tangential walls of the tracheids and also in having greater

number of pits in the cross-field. *Dadoxylon* (*Araucarioxylon*) *rajmahalense* Sahni (*see* also SURYANARAYANA, 1955, p. 89) differs from the present species in having typically 2-3 seriate radial pitting in the early wood tracheids and only uniseriate in the late wood. The cross-field pits are not preserved in Sahni's specimen, therefore its further comparison is not possible. *Dadoxylon eocenum* Chitaley differs in having lesser number of cross-field pits (not differentiated in early and late woods) and pits in the tangential walls of the tracheids. Other known species are not comparable to our species (see TABLE 1), and hence described under a new specific name *Dadoxylon mandroense*. The specific name is after the locality 'Mandro' from where the specimen was collected.

Diagnosis — Secondary wood, growth rings distinct, only radial walls of the tracheids pitted. Pits in the early wood tracheids uni- to tri-seriate, contiguous, tangentially flattened, alternate and hexagonal with broadly oval pit apertures. In the late wood tracheids, pits uni- to partially biseriate, circular, usually touching each other, very rarely separate, pairing occurs in biseriate condition. 4-12 cross-field pits in the early wood; pits circular, contiguous with elliptical and inclined apertures. In the late wood 2-6, usually 3 or 4 pits in the field; pits circular, separate with rounded or broadly oval pit pores. Medullary rays simple, uniseriate, 1-15 cells high (average 3-4 cells). Xylem parenchyma absent.

Type specimen No. — 2611, B.S.I.P. Museum.

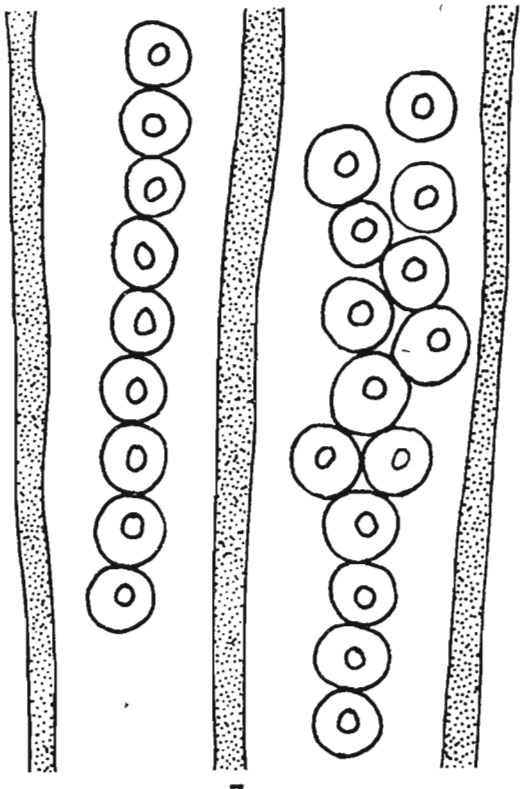
Locality — Mandro, Rajmahal Hills, Bihar.

Horizon — Rajmahal Stage (Jurassic).

3. *Dadoxylon bindrabunense* n. sp.

Pl. 2, Figs. 12-14; Pl. 3, Fig. 22

Only secondary wood preserved, measuring 8 × 18 cm. in size.



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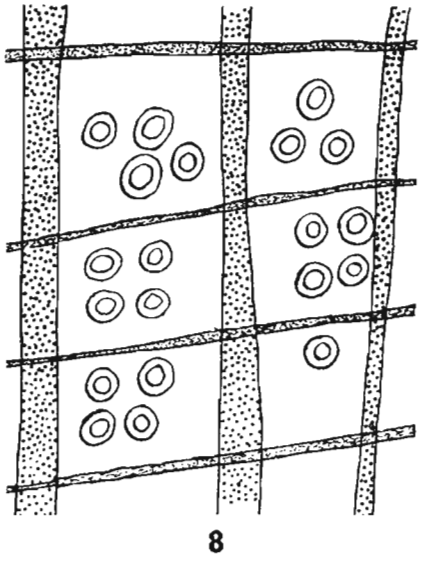

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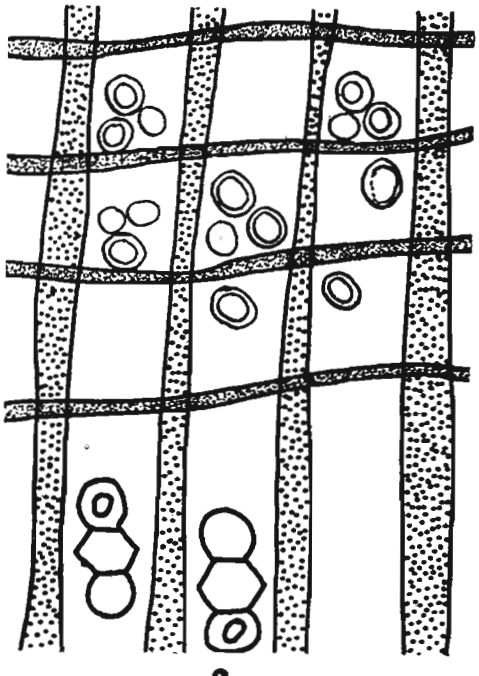
TEXT-FIGS. 7, 8 — *Dadoxylon mandroense* n. sp. 7, part of radial section through late wood showing uni- and bi-seriate pitting, and circular oppositely placed pit pairs. × 800. 8, same showing cross-field pits. × 800.

TABLE 1 — MICROSCOPICAL STRUCTURES FOR IDENTIFYING DADOXYLON SPECIES

Sl. No.	Name of species	Growth rings	Tracheids		Medullary rays		Cross-field pits	Pith	Xylem parenchyma	Resin Tracheids	Bars of Sanio	Cortex	Horizon
			Radial pitting	Tangential pitting	Seriation	Height							
1	*Dadoxylon amraparense* n. sp.	Distinct	1-3 rows, alternate to opposite, contiguous or separate hexagonal to circular	Absent	Uniseriate	1-15 cells	4-8 contiguous, rounded (poorly preserved)	Absent	Absent	Present	Absent	Absent	Jurassic
2	*D. mandroense* n. sp.	,,	1-3 rows, contiguous alternate hexagonal in early wood. 1-2 rows circular, opposite in pairs in late wood	,,	,,	1-15 cells	4-12 in early wood, 2-6 in late wood (usually 3-4, rounded)	,,	,,	Absent	,,	,,	,,
3	*D. bindrabunense* n. sp.	Indistinct	Mostly only 2-3 rows rarely one row. Contiguous, alternate hexagonal	,,	,,	1-45 cells	4-12, bordered, aperture as big as the border	,,	,,	,,	,,	,,	,,
4	*D. santalense* n. sp.	Macroscopically distinct, but microscopically indistinct	Mostly 1-row, some times 2 rows flattened, contiguous, alternate	,,	,,	1-10 cells	2-6, bordered, circular, separate	,,	,,	Present	,,	,,	,,
5	*D. (Araucarioxylon) jurassicum* Bhardwaj	Faint	1-2 rows, contiguous, alternate, hexagonal	,,	,,	1-11 cells	4-8, pore oblique, border not preserved	Present with stone cells	,,	,,	,,	,,	,,
6	*D. (Araucarioxylon) rajmahalense* Sahni	Well marked	2-3 rows, alternate, hexagonal, rarely circular in early wood. 1-row, flattened pits, somtimes circular in late wood	,,	,,	1-20 cells	Not preserved	Absent	,,	,,	,,	,,	,,
7	*D. deccani* Shukla	,,	1-2 rows, alternate, to opposite, contiguous to separate	,,	,,	2-49 cells	1-6, bordered, pore round or elliptical	,,	,,	,,	,,	,,	Tertiary
8	*D. resinosum* Shukla	,,	1-4 rows, alternate to opposite, contiguous to separate, hexagonal or circular	,,	1-2 seriate	1-39 cells	1-10 (generally 4-6) simple, rounded	,,	,,	,,	,,	,,	,,
9	*D. eocenum* Chitaley	,,	1-3 rows, irregularly arranged, sometimes in groups, hexagonal or circular contiguous or separate, sometimes opposite	Present	1-2 seriate	1-15 cells	1-7 bordered or simple	,,	,,	Absent	,,	,,	,,
10	*D. keuperianum* (Geopp.) Seward.	—	One or more rows, contiguous, flattened	Absent	Uniseriate	2-50 cells	2-4, simple, circular	,,	,,	—	—	,,	Triassic
11	*D. septentrionale* Gothan	Macroscopically distinct but microscopically indistinct	One row, separate or polygonal or two rows alternate, sometimes in stellate clusters	,,	Uniseriate	1-30 cells	2-4, elliptical, oblique	,,	Abundant	—	—	Absent ?	Triassic
12	*D. mahajumbjense* (Fliche) Seward	—	Two rows, alternate, contiguous	,,	,,	8-16 cells	Small circular	,,	Absent	—	—	,,	Liassic
13	*D. divescense* (Lignier) Seward	—	1-4 rows	,,	—	8-11 cells	—	,,	,,	—	—	,,	—
14	*D. (Araucarioxylon) novaezeelandiae* (Stopes) Seward	Well marked	2-rows, alternate, hexagonal	,,	Uniseriate	3-4 cells	5-6 bordered, pore oblique	,,	,,	Abundant	—	,,	Cretaceous
15	*D.* sp. (Holden) Seward	—	Alternate, compressed or near inner edge in opposite rows	—	—	—	—	,,	,,	—	Present	,,	Cretaceous Lignites
16	*D. (Araucarioxylon) breveradiatum* (Lignier) Seward	—	1-3 rows, alternate, not flattened	—	Uniseriate	1-3 rarely 4 celled	8-15	,,	,,	Abundant	—	Present	,,
17	*D. (Araucarioxylon) kerguelense* Seward	Narrow	1-2 rows, contiguous, alternate, flattened	—	—	—	5-8	,,	,,	—	—	Absent	Tertiary
18	*D. (Araucarioxylon) pseudoparenchymatosum* Gothan	Distinct	1-2 rows	—	Uniseriate	2-10 cells	Several, small oblique	,,	,,	—	—	,,	Tertiary or upper Cretaceous
19	*D. (Araucarioxylon) japonicum* Shimakura	Present, but boundaries indistinct	1-2 rows, large, contiguous, alternate and opposite	Present	Uniseriate, rarely biseriate	1-24 cells mostly 3-10 cells	5-14 in early wood, 1-5 (?) in late wood, circular, contiguous bordered	,,	,,	Present	—	,,	Jurassic
20	*D. (Araucarioxylon) sidugawaense* Shimakura	Present	1-2 rows, contiguous, alternate, flattened	With circular alternate pits	Uniseriate	1-14 cells	1-2 large, oval or circular, simple (?)	,,	Present	—	—	Present with vertical mucilage canals	,,



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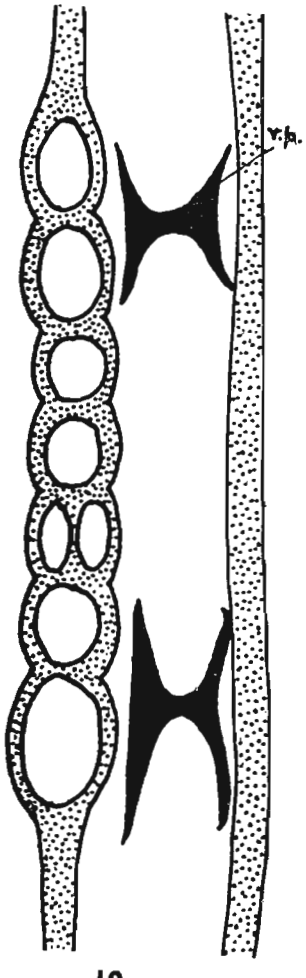

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TEXT-FIGS. 9, 10 — *Dadoxylon santalense* n. sp. 9, radial section showing cross-field pits. × 800. 10, medullary rays in tangential view with resin pluges (r.p.). × 800.

Growth Rings — Indistinct, tracheids thick walled, triangular to squarish in shape with almost angular to rounded lumen (PL. 3, FIG. 12). No xylem parenchyma or resin tracheids. Wood compact.

Tracheids — Broad, radial diameter 20 μ to 60 μ, only radial walls pitted, pits mostly biseriate or sometimes triseriate, but very rarely uniseriate. When bi- or tri-seriate, pits contiguous, alternate, and hexagonal, with circular pit-pores, 6 μ in diameter (PL. 2, FIG. 13).

Cross-field Pits — 4-12, usually 4 or 6, bordered, circular or oval, separate, 6 μ to 8 μ in diameter with broad oval apertures, almost as broad as the border (PL. 3, FIG. 22).

Medullary Rays — Simple, uniseriate, very rarely biseriate, 1-45 cells high (average 25 cells in 32 counts). Cells beed-like, longer than broad, 8 μ × 12 μ to 24 μ × 32 μ in size (PL. 2, Fig. 14).

Comparison with Fossil Forms — The distinctly araucarian characters of the present wood clearly distinguishes it from the two

new species *Dadoxylon amraparense* and *Dadoxylon mandroense*. Amongst the other Mesozoic and Tertiary species, it is comparable only with *Dadoxylon rajmahalense* Sahni, *Dadoxylon keuperianum* (GEOPP.) Seward and *Dadoxylon* (*Araucarioxylon*) *jurassicum* Bhardwaj (*see* TABLE 1). *D. rajmahalense* is distinguished in having distinct growth rings. The cross-field pits are not preserved in Sahni's specimen and hence no further comparison is possible. *D. keuperianum* resembles in the radial pitting and high medullary rays, but differs in possessing 2-4 circular simple pits in the cross-field. While Bhardwaj's species differs in having pits in the tangential walls of the tracheids, considerably low medullary rays and circular or oval cross-field pit apertures.

Diagnosis — Decorticated secondary wood, growth rings indistinct, only radial walls of the tracheids pitted. Pits mostly bi- to tri-seriate, (very rarely uniseriate), contiguous, alternate and hexagonal. Cross-field pits 4-12, bordered, oval or rounded, apertures almost as large as the border. Medullary rays simple, 1-45 cells high (average 25 cells), uniseriate. No xylem parenchyma or resin tracheids.

Type Specimen No. — 3656, B.S.I.P. Museum.

Locality — Bindrabun, Rajmahal Hills, Bihar.

Horizon — Rajmahal Stage (Jurassic).

4. *Dadoxylon santalense* n. sp.

Pl. 2, Figs. 11; Pl. 3, Figs. 15-18; Text-figs. 9-10

Decorticated secondary wood, measuring 9 × 11 cm. in size.

Growth Rings — Macroscopically distinct but microscopically indistinct, tracheids angular, thick walled with rounded to oval lumen, compact (PL. 3, FIG. 15). Xylem parenchyma absent. Resin tracheids present at places.

Tracheids — Broad, radial diameter 20 μ to 40 μ, only radial walls pitted, pits mostly uniseriate or sometimes biseriate. Uniseriate pits broad, tangentially flattened, contiguous, 8 μ × 12 μ to 8 μ × 25 μ in size (PL. 3, FIG. 17), sometimes very broad, occupying the whole radial diameter of the tracheid; pit pores circular 4 μ to 6 μ in diameter. Bi-seriate pits hexagonal, alternate and contiguous (PL. 3, FIG. 18).

Cross-field Pits — 2-6, usually 4, bordered, circular, separate, 6 μ in diameter; apertures broad, as big as the border (PL. 3, FIG. 16; TEXT-FIG. 9).

Medullary Rays — Simple, uniseriate or rarely partially biseriate, short, 1-10 cells high (average 4-5 cells in 24 counts), ray cells slightly higher than broad, with end cells comparatively enlarged (PL. 2, FIG. 11; TEXT-FIG. 10).

Comparison with Fossil Forms — In its anatomical characters the present wood is comparable with the following species. *Dadoxylon septentrionale* Gothan resembles in having macroscopically distinct and microscopically indistinct growth rings, 1-2 seriate radial pits and 2-4 pits in the field, but differs chiefly in the presence of xylem parenchyma. *Dadoxylon* (*Araucarioxylon*) *kerguelense* Seward and *Dadoxylon* (*Araucarioxylon*) *pseudoparenchymatosum* Gothan resemble in having similar pitting in the radial walls of the tracheids. The former differs in having 5-8 elliptical pits in each field while the latter in having bars of Sanio. The Indian species *Dadoxylon* (*Araucarioxylon*) *jurassicum* Bhardwaj compares very closely with the present specimen, but differs in the presence of pits in the tangential walls of the tracheids. Pith in *D. jurassicum* is characterized by the sclarotic cells whereas the pith in our specimen is not preserved. Amongst the newly described species it differs in the absence of mixed radial pitting. *Dadoxylon bindrabunense* shows similar pitting but is distinguished by its high medullary rays, mostly 2-3 seriate radial pit and greater number of pits in the field. The new specific name *Dadoxylon santalense* is adopted after the Santal Parganas.

Diagnosis — Secondary wood, growth rings macroscopically distinct, but microscopically indistinguishable, only radial walls of the tracheids pitted, pits mostly uni- sometimes biseriate, tangentially flattened alternate, hexagonal and contiguous. Cross-field pits 2-6, usually 4, bordered, circular, separate; apertures as big as the border. Medullary rays simple, uniseriate, 1-10 cells high (average 4-5 cells in 24 counts). Xylem parenchyma absent. Resin tracheids present at places.

Type Specimen No. — 4506, B.S.I.P. Museum.

Locality — Mandro, Rajmahal Hills, Bihar.

Horizon — Rajmahal Stage (Jurassic).

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EXPLANATION OF PLATES

PLATE 1

Dadoxylon amraparense n. sp.

1. Cross section showing growth ring. × 110.
2, 3. Radial section showing separate or contiguous oppositely placed pit pairs. × 500.
4, 5. Radial section showing bi- and tri-seriate, contiguous, alternate, and hexagonal pits. × 500.
6. Radial section showing parallel rows of pits in the tracheids. × 200.
7. Tangential section showing the height and distribution of medullary rays. × 120.

Dadoxylon mandroense n. sp.

8. Radial section showing uni- and bi-seriate hexagonal, contiguous and alternate pits in the early wood tracheids. × 500.

PLATE 2

Dadoxylon mandroense n. sp.

9. Cross section showing growth ring. × 100.
10. Radial section through the late wood showing uni- and bi-seriate circular pits with opposite pairs. × 500.

Dadoxylon santalense n. sp.

11. Tangential section showing the height and distribution of medullary rays. × 100.

Dadoxylon bindrabunense n. sp.

12. Cross section. × 130.
13. Radial section showing only biseriate, hexagonal, alternate and contiguous pits. × 500.
14. Tangential section showing mainly the height of the medullary rays. × 100.

PLATE 3

Dadoxylon santalense n. sp.

15. Cross Section. × 130
16. Radial section showing cross-field pits. × 500.
17, 18. Radial section showing uni- and biseriate, contiguous, hexagonal and alternate pits. × 500.

Dadoxylon mandroense n. sp.

19. Radial section through early wood showing cross-field pits. × 500.
20. Radial section through late wood showing cross-field pits. × 500.
21. Tangential section. × 130.

Dadoxylon bindrabunense n. sp.

22. Radial section showing cross-field pits. × 500.

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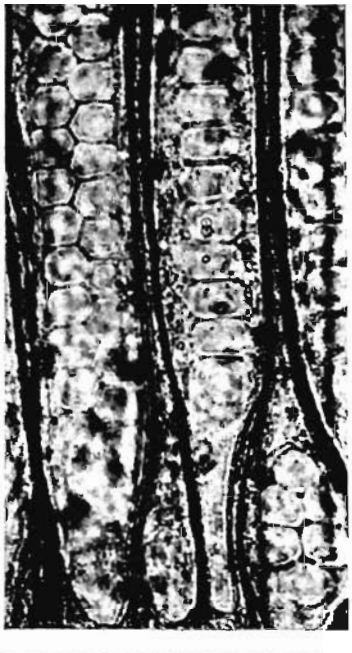

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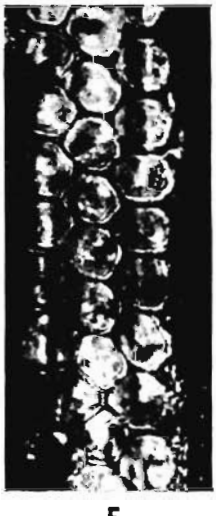

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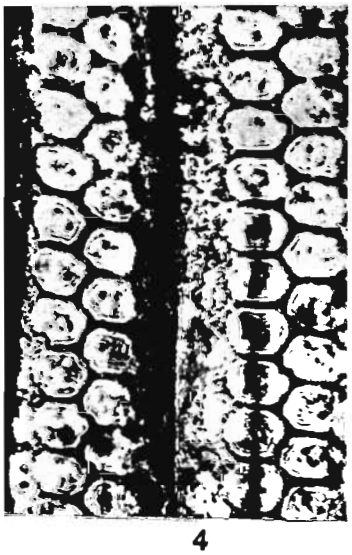

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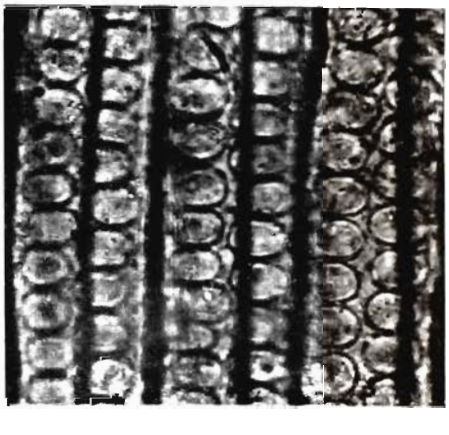

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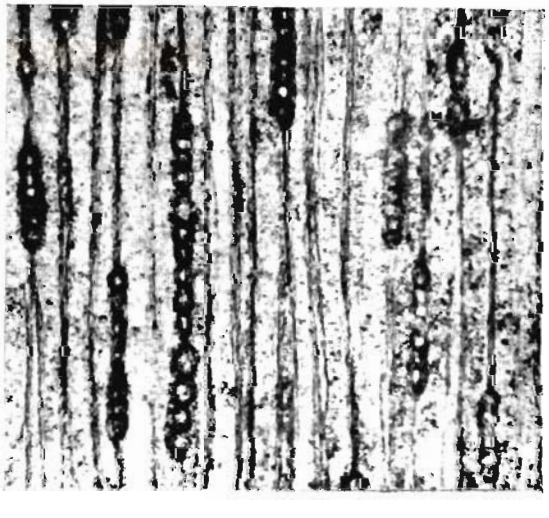

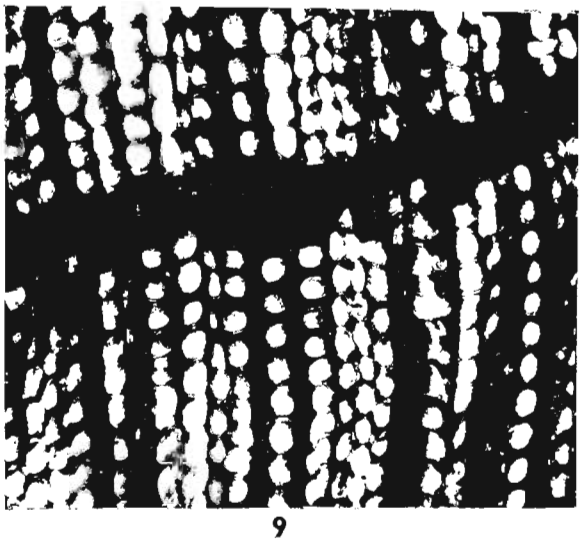

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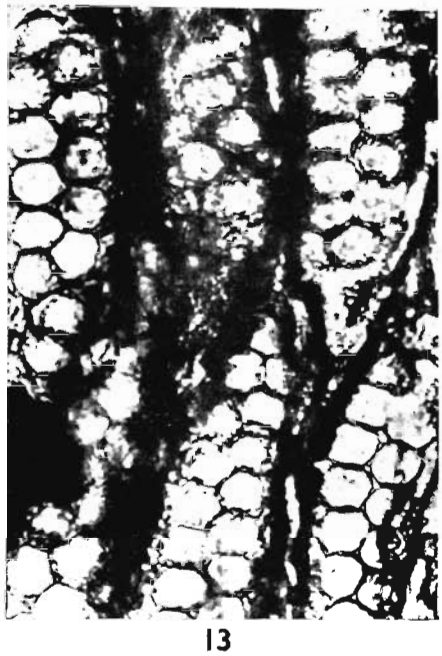

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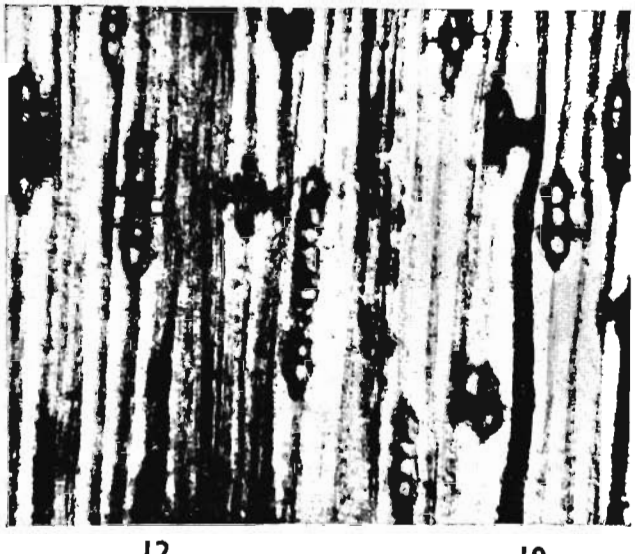

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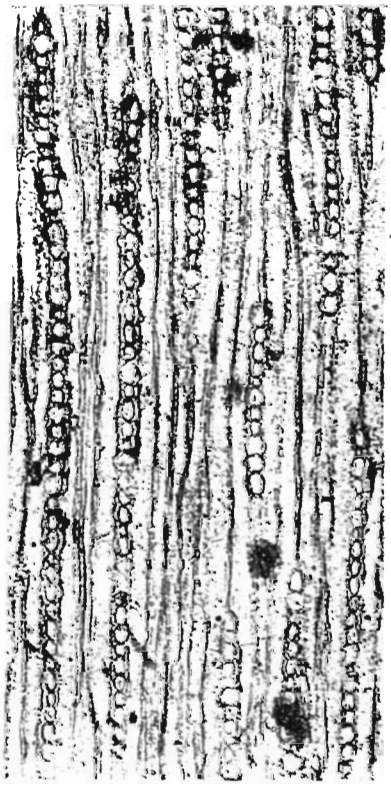

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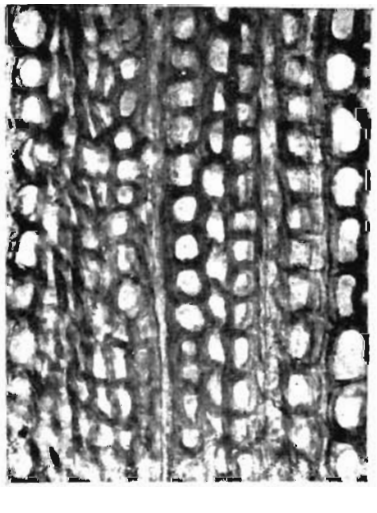

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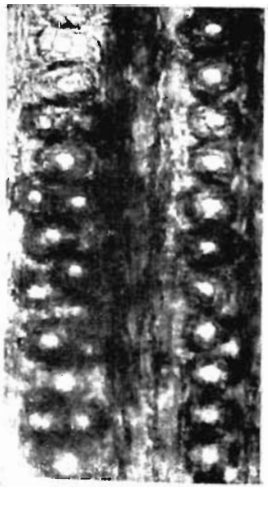

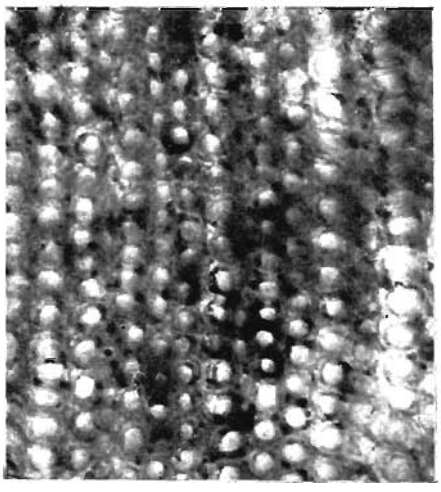

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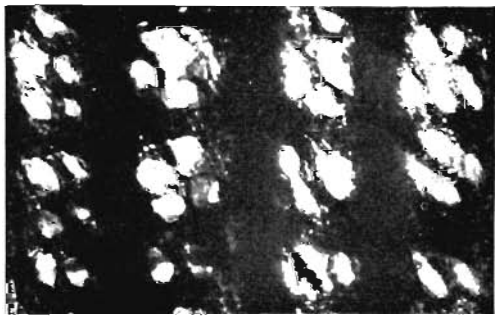

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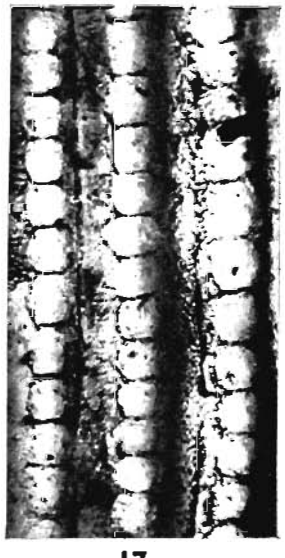

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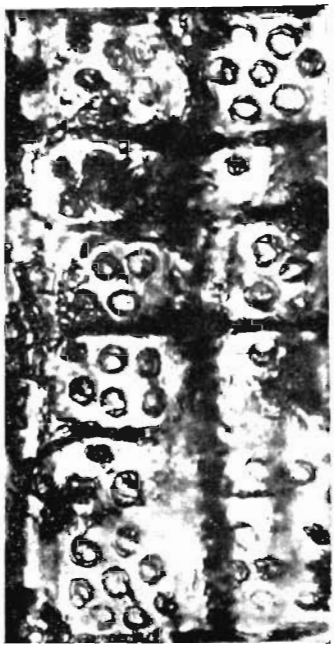

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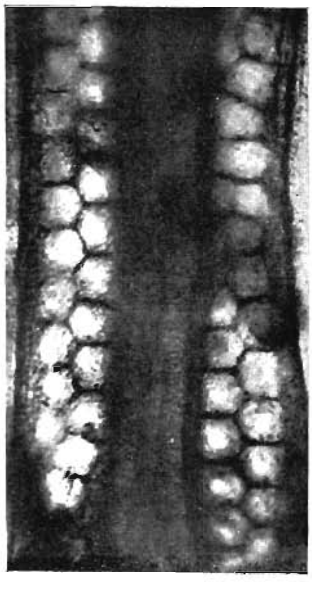

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