

PALMOXYLON CORDATUM, A NEW SPECIES OF PETRIFIED PALM STEMS FROM THE DECCAN INTERTRAPPEAN SERIES OF INDIA

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ABSTRACT

A new species of *Palmoxylon*, *P. cordatum* from the Deccan Intertrappean Series is described here. In this species the dermal region is clearly distinguishable into outer crowded and inner less crowded regions. Elongated parenchyma is present on the ventral side of fibrovascular bundles of the less crowded dermal region. Median sinus of bundles is cordate. Fibrous bundles and stigmata are present. In the roots, fibrous and medullary bundles are absent. It is comparable to *P. surangei* Lakhanpal and *P. sclerodermum* Sahni & Shukla, of the sub-group cordata.

INTRODUCTION

IN December 1965 one of us (B.S.T.) paid a visit to Mohgaon Kalan and collected a large number of petrified specimens; quite a few of these were palms, some of them well preserved. From Mohgaon Kalan only a few species of palm stems have been described. In our collection many species have been found to be distinct from those already known. One of them is described below.

DESCRIPTION

Genus — *Palmoxylon*

SUB-GROUP — CORDATA

Palmoxylon cordatum sp. nov.

Pl. 1, Figs. 1-6; Text-figs. 1-9

In the main the terminology used here is the same as the one suggested by Sahni (1943, 1964).

External Characters — The specimen is a small brownish stump, which before sectioning measured 4.5 cm. in length and 1.5 cm. in diameter at the base. A thick mantle of adventitious roots surrounds the stump.

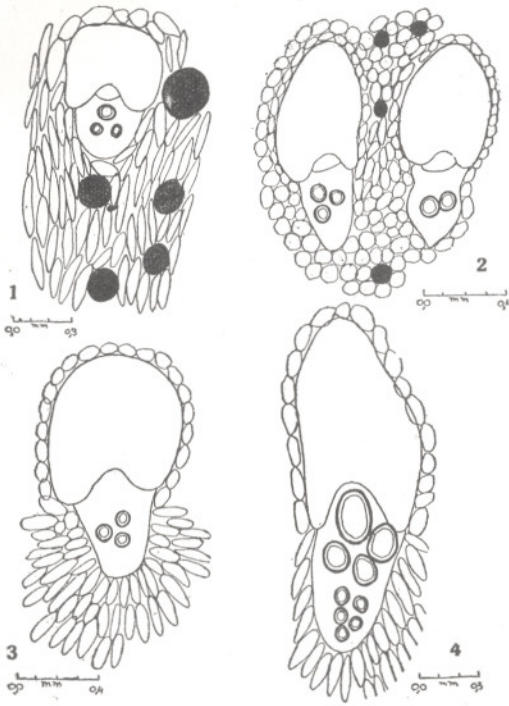
Cortex — (TEXT-FIG. 1). It is 0.5 cm. thick. Only a few fibrovascular bundles are present in the cortex and these are sparsely distributed; hardly 3 or 4 can be seen in the section. They measure $416 \mu \times 272 \mu$. The

base of the sclerenchyma is cordate. f/v ratio is 2/1 to 3/1. The fibrous bundles are usually circular to slightly oval in cross-section measuring about $272 \mu \times 214 \mu$. The ground tissue is made up of parenchymatous cells which are generally tangentially elongated and loosely arranged (TEXT-FIG. 1).

Dermal Zone — (TEXT-FIGS. 2, 3). It is about 1 cm. in radius. The fibrovascular bundles are densely crowded towards the outer dermal becoming less so in the inner dermal region (TEXT-FIG. 2). The distribution of bundles is 55-60 per cm.² in the inner dermal region but in the outer dermal region it is as much as 80-90 per cm.². In cross-section the bundles are elongate-elliptical in the outer dermal region, becoming ovate and bigger towards the inner dermal region. An average bundle measures about $1050 \mu \times 608 \mu$. All of them are normally oriented. The f/v ratio is 5/1 in the outer dermal region and increases to 8/1 in the inner dermal region. The median sinus is round cordate. On the ventral side of bundles ground parenchyma cells are elongated tangentially in a spreading manner (TEXT-FIG. 3). These cells are found only around bundles of internal, less crowded dermal region. In the outer dermal region, however, they are replaced by the usual polygonal parenchyma cells. Fibrous bundles are present only in the outer dermal region. They are about $371 \mu \times 304 \mu$ in diameter. Stigmata arranged in longitudinal rows are present in fibres (TEXT-FIG. 8-st.). Leaf traces are present.

The parenchymatous ground tissue is scanty and compact. The cells are smaller and are isodiametric to slightly rectangular in shape.

Sub-dermal Zone (TEXT-FIG. 5) — This zone is nearly 1.5 cm. in thickness. There are 45-50 bundles per cm.². They are oval in cross-section and measure $1360 \mu \times 784 \mu$. The f/v ratio of an average bundle is 6/1 to 7/1. The sclerenchyma is round to angular, the xylem is narrow and points towards the



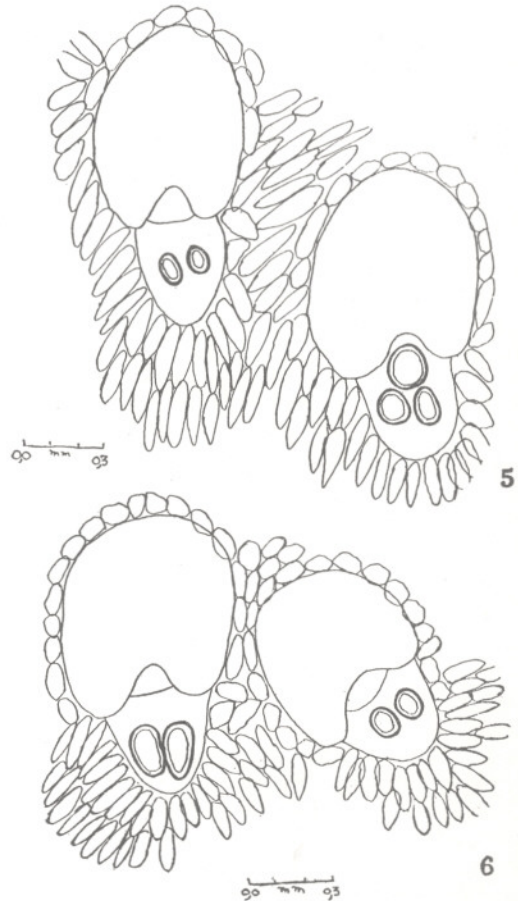
TEXT-FIGS. 1-4 — 1. Cortex and a fibrovascular bundle in cross-section. Note the presence of fibrous bundles and elongated ground tissue cells. 2. Two fibrovascular bundles from the peripheral crowded dermal zone and ground parenchyma cells, 4 fibrous bundles are also seen. 3. A fibrovascular bundle from the less crowded inner dermal zone. Note the presence of radiating elongated ground parenchyma cells on the ventral side of fibrovascular bundle. 4. A leaf trace bundle from the sub-dermal zone.

centre. Auricular lobes are round. Auricular sinuses are obtuse. Tabular parenchyma is present. Phloem is wedged between the xylem and the median sinus and is very poorly preserved, generally it is disorganized. The xylem usually consists of 2-3 vessels which are excluded. Leaf trace bundles occur in the sub-dermal zone. In these bundles the xylem is greatly developed, and in cross-section projects like a tongue (TEXT-FIG. 4). Fibrous bundles are absent. Stegmata are seen in the fibres of fibrovascular bundles.

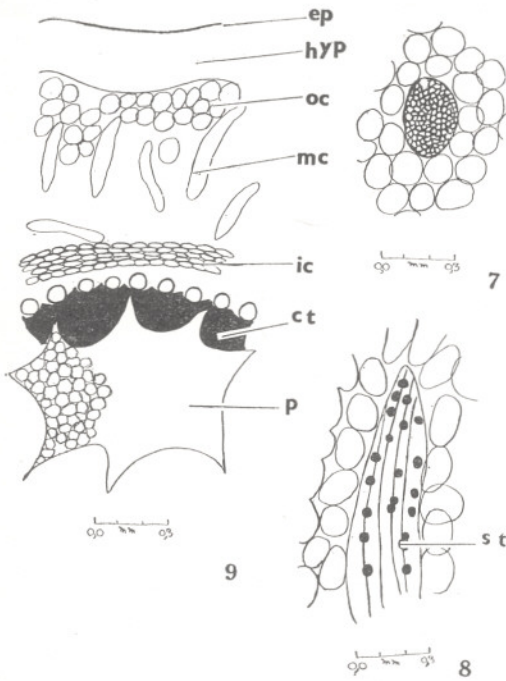
The ground tissue is loosely arranged and consists of big round and elongated parenchyma cells on ventral side of fibrovascular bundles (TEXT-FIG. 5). These cells measure 272μ in length and 100μ in width.

Central Zone (TEXT-FIG. 6) — It is 0.3 to 0.5 cm. in thickness. Fibrovascular bundles are broadly ovate in cross section and measure $1248 \mu \times 774 \mu$. Approximately 18-20 bundles occur per cm^2 . The average f/v ratio is 3/1 to 4.5/1. The sclerenchyma is broad with rounded cordate base. The xylem has two vessels and is better developed than in the sub-dermal zone, with obtuse auricular sinuses.

The fibrous bundles are absent. The structure of the ground tissue is essentially the same as that of the sub-dermal zone. However, because of more space between the fibrovascular bundles, the cells become



TEXT-FIGS. 5-6 — 5. Two sub-dermal fibrovascular bundles in cross section, and elongated ground parenchyma cells. 6. Two fibrovascular bundles from the central zone and elongated ground tissue. Note that the bundles are irregularly oriented.



TEXT-FIGS. 7-9—7, 8. Cross section and longitudinal section respectively of the fibrous bundles. Stegmata—*st* are visible on the surface in Fig. 8. 9. A sector of a root in cross-section showing epiderma—*ep*, hypodermis—*hyp* outer cortex—*oc*, middle cortex with air cavities,—*mc*, inner cortex—*ic*, conjunctive tissue—*ct* and pith *p*.

broader and more rounded. Elongated cells are also present. Leaf traces as seen in dermal and sub-dermal zones are also seen in this zone.

Roots (TEXT-FIG. 9)—The roots are closely packed, usually deformed by crowding together. They measure on an average about 1.5 mm. in diameter.

Seen in cross-section, the outermost layers (about 6-8 layers) constitute the epiderma and the hypodermis. Next to this is the cortex which can be distinguished into 3 parts—outer, middle and inner. The outer cortex is 2-4 layered. The cells here are parenchymatous and are compactly arranged. The middle cortex contains air cavities. The roots are young and the air cavities are not seen clearly. The inner cortex is 2-3 layered and is made up of compactly arranged parenchyma cells. Endodermis and pericycle are not visible. Stele is made up of about 15-20 xylem and phloem bundles which alternate with each

other. The vessels are oval in cross-section. The phloem bundles are not well preserved. Conjunctive parenchyma has thick walls and is polygonal in shape. Parenchymatous pith is present in the centre without medullary bundles or accessory metaxylem strands.

DISCUSSION

So far there is no available system for the natural classification of petrified palm stems which are all grouped under a single form genus *Palmoxylo*n. Kaul (1935) indicated that palm stems could be identified by the structure of their ground tissue. It was a good approach to this vexed problem but as the work has not yet been published in full, its value remains to be ascertained. At present, the only course open is to classify the genus artificially. For this purpose Sahni's scheme (1943, pp. 218-219) based jointly on the classifications of Von Mohl (1845) and Stenzel (1904) is the best available. According to this scheme *P. cordatum* falls under the sub-group cordata.

Of the already described *Palmoxylo*na from India only *P. surangei* Lakhnupal, *P. sclerodermum* Sahni, *P. prismaticum* Sahni, *P. intertrappeum* Sahni, *P. compactum* Sahni and *P. geometricum* Sahni fall within the sub-group cordata. Our species comes closest to *P. surangei* and *P. sclerodermum* with which it is compared in detail.

P. surangei (LAKHANPAL, 1955) resembles *P. cordatum* in the (1) general shape, orientation and distribution of fibrovascular bundles (2) in the presence of fibrous bundles and stigmata and (3) in the general form of leaf trace bundles which have a tongue-like vascular process with a ventral sclerenchymatous arc. In a number of other characters, however, the two species are distinct. The fibrovascular bundles are more in number in the cortex of *P. surangei* than in that of *P. cordatum*. F/v ratio in cortical bundles of *P. surangei* is 5/1 to 10/1 whereas in *P. cordatum* it is 2/1 to 3/1. The dermal zone is 2 cm. thick in *P. surangei*, and the distribution of vascular bundles in the crowded outer dermal region is 140 per cm.² and 90-95 per cm.² in the inner dermal region. In *P. cordatum* dermal zone is 1 cm. thick, the distribution of bundles in outer dermal region is 80-90 per cm.² and 55-60 per cm.² in the inner dermal region. F/v ratio of the dermal bundles is 7/8 in outer dermal region and 7/1 in inner dermal region

TABLE 1 — SHOWING THE CHARACTERS OF THE VARIOUS SPECIES OF PALMOXYLON IN THE SUB-GROUP CORDATA

NAME OF THE SPECIES	PARTS AVAILABLE	FIBRE BUNDLES AND STEGMATA	F/V RATIO	MEDIAN SINUS	AURICULAR SINUSES; AURICULAR LOBES	VASCULAR PART OF FVB AND THEIR NUMBER	DISTRIBUTION OF FIBROVASCULAR BUNDLES PER CM ²	GROUND TISSUE			LOCALITY AND HORIZON
								General parenchyma	Tabular parenchyma	Radiate parenchyma	
<i>Palmoxylon cordatum</i> sp. nov.	Complete specimen with attached roots. Dermal, subdermal and central zones present	Both present	5/1 exterior Dermal zone 8/1 interior Dermal zone 6/1 to 7/1 Subdermal zone 3/1 to 4.5/1 Central zone	Cordate	Obtuse; lobes round	Excluded; usually 2-3 large vessels	80-90 outer dermal zone 55-60 inner dermal zone 45-50 subdermal zone 18-20 central zone	Round to elongated cells compact	Present round the fibrovascular bundles	On ventral side of fibrovascular bundles	Mohgaon kalan, Deccan Intertrappean series
<i>P. surangei</i> Lakhanpal	Complete specimen with roots attached	Both present	7/8 outer dermal zone 7/1 inner dermal zone 5/1 to 6/1 subdermal zone 4/1 central zone	Rounded cordate	Obtuse; lobes round	Excluded; 1-4 normally 2-3 vessels	140 outer dermal zone 90-95 inner dermal zone 45-50 subdermal zone 25 central zone	Isodiametric to rectangular	Present	Present	Keria, Chhindwara district M.P. Deccan Intertrappean series
<i>P. scleroderium</i> Sahni	Dermal and part of subdermal	Present no stigmata	12/1 to 15/1 dermal zone	Obtuse-angled	Lobes broadly rounded	Scarcely exerted; One large vessel	108 or 192-200 crowded dermal zone 55-60 less crowded dermal zone	Compact	Absent	Absent	Seoni, M.P. Deccan Intertrappean series
<i>P. prismaticum</i> Sahni	Dermal, subdermal and central; roots attached	Both present	5/1 to 6/1 dermal zone 4.5/1 to 5/1 central zone	Stems small, angular or slightly rounded	Absent, lobes rounded	Exserted; usually 2 large vessels	71-85 dermal zone 37-41 subdermal zone 30-34 central zone	Compact in dermal region, palisade like in subdermal irregular in central	2-3 layers round the entire bundles in dermal region	Present round the xylem of subdermal bundles	Unknown
<i>P. intertrappeum</i> Sahni	Complete basal part of trunk, with leaf scars but not roots	Present without stigmata	32-16/1 dermal zone 10/1 subdermal zone	Stems small, angular	: Lobes rounded	Univessel in dermal Bivessel in subdermal	140 dermal zone 19-21 subdermal zone	Compact in dermal region, lacunar in subdermal with rod like to variously shaped cells	—	—	Sindhi Vihira, Wardha district, M.P. Deccan Intertrappean series
<i>P. compactum</i> Sahni	Subdermal	Absent	12/1 subdermal zone	Right-angled	Present; Lobes rounded	Exserted, large vessels 1-3, usually one with long diameter horizontal	12-34 subdermal zone	Compact, cells variously shaped	2-3 layers, not well-marked	Absent	Burma, Tertiary
<i>P. geometricum</i> Sahni	Central	Absent	8/1 or more Central zone	Rounded or angular	: Lobes angular	Usually one large vessel	22 central zone	Very lacunar, cells of various geometric shapes	1-2 layers over sclerenchyma but interrupted by air spaces	Absent	Sind, Tertiary

of *P. surangei* while it is 5/1 in outer and 8/1 in inner dermal regions of *P. cordatum*. Ground parenchyma cells round the bundles are radially elongated in *P. surangei* whereas in *P. cordatum* they are tangentially elongated. Fibrous bundles are present in the subdermal zone of *P. surangei* whereas they are absent in *P. cordatum*. The ground parenchyma cells of subdermal zone in *P. surangei* measure 150 μ long and 60 μ wide whereas in *P. cordatum* they are more elongated (272 μ long and 100 μ wide).

In the roots of *P. surangei* fibrous bundles are present in the middle cortex whereas in *P. cordatum* there are no fibre bundles in roots. In *P. surangei* air cavities are prominently seen in roots while in *P. cordatum* the air cavities are not at all so prominent. In *P. surangei* the roots possess medullary bundles whereas in *P. cordatum* medullary bundles are absent.

P. sclerodermum (SAHNI, 1943; SHUKLA, 1946) resembles our species in the shape, orientation and distribution of bundles as also in the presence of fibrous bundles and stigmata and in the shape of leaf trace bundles. But in other respects these two species are quite distinct as shown below.

Fibrovascular bundles are bigger, crowded and their f/v ratio is 12/1 to 15/1 in *P. sclerodermum* while in *P. cordatum* the bundles are smaller and their f/v ratio is 5/1 to 8/1. In *P. sclerodermum* most of the bundles possess one large median vessel whereas in *P. cordatum* bundles have 2-3 vessels. The distribution of bundles per cm.² in *P. sclerodermum* is 108 or even up to 192-200 in crowded region and 55-60 in less crowded region, whereas in *P. cordatum* it is 80-90 per cm.² in outer dermal region and 55-60 in inner dermal region. Ground tissue cells of the cortex in *P. sclerodermum* are radially elongated and often occur in layers whereas in *P. cordatum* they are tangentially elongated. They are small lobed and isodiametric in *P. sclerodermum* but are elongated in *P. cordatum*. Auricular sinuses

are almost absent in *P. sclerodermum* while in *P. cordatum* they are present. In *P. sclerodermum* the vascular bundles have no elongated parenchyma cells whereas in *P. cordatum* they are surrounded ventrally by elongated cells.

In the roots of *P. sclerodermum* there are 3-4 vessels placed end to end in radial direction while in *P. cordatum* there is usually one big vessel. The rest of the species have been compared and are shown in a tabular form (Table 1).

Diagnosis — Stem in type specimen about 4.5 cm. in diameter near the base, cortex fairly thick, composed of thin-walled parenchymatous cells, elongated tangentially and containing few fibrovascular bundles and numerous fibrous bundles. Dermal bundles 55-60 per cm.², f/v ratio 5/1 to 8/1. Inner dermal bundles surrounded by tangentially elongated ground parenchyma on ventral sides. Outer dermal bundles possess polygonal parenchyma. Median sinus cordate. Number of vessels in the xylem usually 1-3, excluded. Subdermal bundles 45-50 per cm.², f/v ratio 6/1 to 7/1. Auricular sinuses round. Xylem usually with 2-3 vessels. Ground tissue of loosely arranged elongated parenchyma cells. In central zones approximately 18-20 bundles occur per cm.². f/v ratio 3/1 to 4.5/1. Fibrous bundles absent. Ground tissue of loosely arranged elongated and round parenchyma cells. Leaf traces radially stretched with well-developed xylem projecting as a tongue-like process.

Roots closely packed, 1.5 mm. in diameter. Cortex made up of three zones, middle cortex with air cavities. Fibrous bundles absent. The stele consists of about 15-20 xylem bundles which alternate with phloem. Xylem of each bundle consisting of one large vessel. Pith composed of thin walled cells without medullary bundles.

Locality — Mohgaon Kalan.

Horizon — Deccan Intertrappean series.

Collection — B. S. Trivedi. Specimen No. 13 with (B.S.T.) Department of Botany, Lucknow University.

REFERENCES

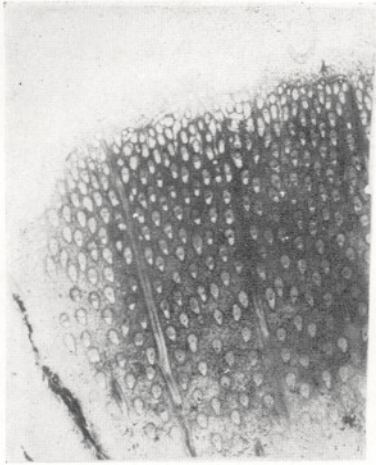
- KAUL, K. N. (1935). A classification of palms based upon the ground tissue of the stem. *Proc. 22nd Indian Sci. Cong.*: 285-186.
- LAKHANPAL, R. N. (1955). *Palmoxyton surangei*, a new species of petrified palm stems from the Deccan Intertrappean Series. *Palaeobotanist*. **4**: 15-21.
- MOHL, HUGO VON (1845). Über den Bau des palmenstammes. Vermischte schriften botanischen inhalts: 129-185. *Tubingen*.

- SAHNI, B. (1943). A new species of petrified palm stems, *Palmoxylon sclerodermum* sp. nov.; from the Deccan Intertrappean series. *J. Indian bot. Soc.* **22**(2-4): 209-224.
- SAHNI, B. (1964). Revisions of Indian fossils plants. Part III. Monocotyledons. *Monogr. Birbal Sahni Inst. Palaeobot. Lucknow.* No. 1.
- SHUKLA, V. B. (1946). *Palmoxylon sclerodermum* Sahni from the Eocene beds of Nawargaon, Wardha district, C.P. *J. Indian bot. Soc.* **25**(3): 105-116.
- STENEEL, K. G. (1904). Fossil Palmenholzer. *Beiträge zur Palaeontologie und Geologie österreich-ungarns und des orientes.* **16**: 107-287.

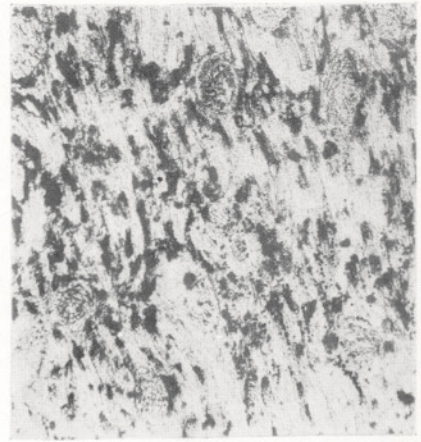
EXPLANATION OF PLATE 1

Palmoxylon cordatum sp. nov.

1. Cross-section of stem showing dermal, sub-dermal and central vascular zones and a part of cortex with roots $\times 2$.
2. Cortex with fibre bundles seen in a cross-section $\times 270$.
3. Cross-section of stem showing outer crowded dermal zone $\times 290$.
4. Cross-section of stem showing inner less crowded dermal zone $\times 290$.
5. Cross-section of stem showing sub-dermal zone $\times 290$.
6. Cross-section of a root, magnified $\times 290$.



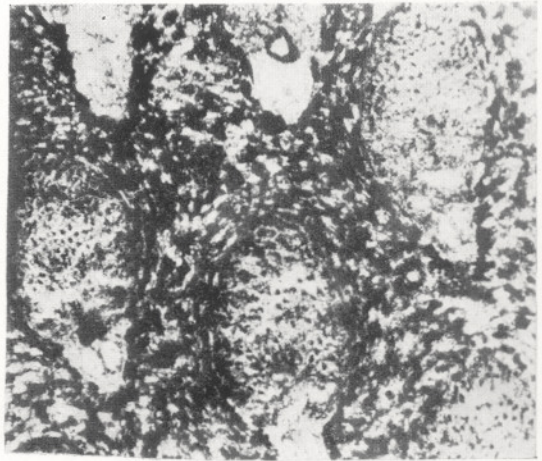
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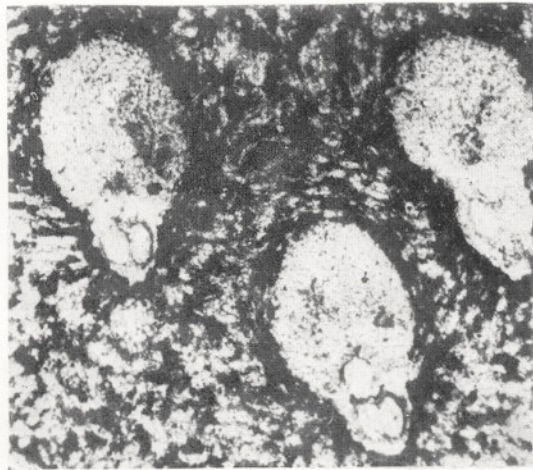
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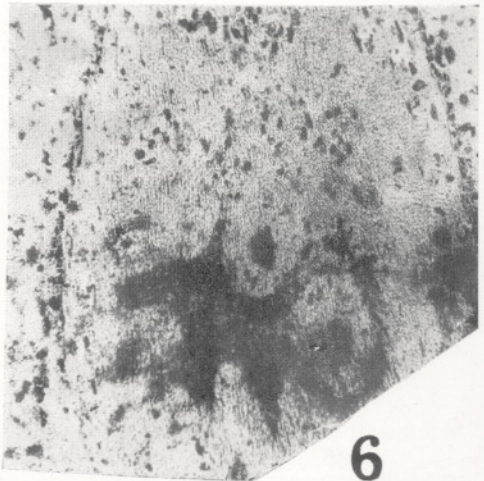
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