

TWO PETRIFIED PALM WOODS FROM THE DECCAN INTERTRAPPEAN BEDS OF MANDLA DISTRICT, MADHYA PRADESH

R. N. LAKHANPAL, U. PRAKASH & K. AMBWANI
Birbal Sahni Institute of Palaeobotanist, Lucknow-226 007, India

ABSTRACT

The present paper deals with the anatomy of two new species of *Palmoxylon*, *P. parapaniensis* and *P. mandlaensis*, collected from the Deccan Intertrappean beds of Parapani and Mohgaon in Mandla District, Madhya Pradesh. *Palmoxylon parapaniensis* shows a prominent lacunar ground tissue throughout the wood and belongs to *Cocos*-like forms, whereas the ground tissue is compact in *P. mandlaensis*; this belongs to *Corypha*-like forms.

Key-words — Petrified palm woods, Xylotomy, Palmae, Deccan Intertrappean Series, (India).

सारांश

माँडला जनपद, मध्य प्रदेश के दक्खिन अंतरट्रेपी संस्तरों से ताड़ के दो काष्ठाश्म - राजेन्द्रनाथ लखनपाल, उत्तम प्रकाश एवं कृष्ण अम्बवानी

प्रस्तुत शोध-पत्र में मध्य प्रदेश के माँडला जनपद में स्थित पारापानी एवं मोहगांव के दक्खिन अंतरट्रेपी संस्तरों से प्राप्त पामाक्सिलॉन की दो नई जातियों, पा० पारापानीयेन्सिस तथा पा० माँडलायेन्सिस, की शारीर का वर्णन है। पामाक्सिलॉन पारापानीयेन्सिस सम्पूर्ण काष्ठ में सुस्पष्ट गतिकाभरण-ऊति प्रदर्शित करता है तथा कोर्कोस-सदृश प्ररूपों से संबंध रखता है, इसके विपरीत पा० माँडलायेन्सिस में भरण-ऊति संहृत है और यह कोराइफ़ा-सदृश प्ररूपों से संबंधित है।

INTRODUCTION

DURING December 1972, a large number of palm woods were collected by one of us (U. Prakash) from the Deccan Intertrappean beds of Parapani and Mohgaon in Mandla District of Madhya Pradesh. The village Parapani is situated near Chabi (22°49': 80°42') at a distance of 56 km north-east of Mandla, while Mohgaon is about 15 km north-east of Nainpur (22°26': 80°10'). This Mohgaon is, however, different from the well known locality of Mohgaon Kalan of Chhindwara District. The two palm woods described in this paper belong to these localities; one with a prominent lacunar ground tissue comes from Parapani and the other is from Mohgaon.

So far only a few fossil woods have been described from Mandla District but none of them belongs to palms. Bande (1973, 1974) has described *Polyalthioxylon parapaniense*, *Homalioxylon mandlaense* and *Bischofinium deccanii* from Parapani, while Ingle (1972, 1973) has recorded *Vitexoxylon indicum* and *Syzygioxylon mandlaense* from Samnapur near Mohgaon.

SYSTEMATIC DESCRIPTION

Family — PALMAE

Genus — *Palmoxylon* Schenk, 1882

1. *Palmoxylon parapaniensis* sp. nov.

The present specimen is a large rusty brown stump complete in cross section

measuring about 50 cm in length and 25 cm in diameter (Pl. 1, fig. 1). It shows well preserved structural details from the centre to the periphery of the stem with a distinct lacunar ground tissue throughout.

In the majority of fossil palms, the cross section of the stem consists of three more or less clearly marked regions. These are dermal, subdermal and central zones. (Sahni, 1943, text-fig. 1). In the present palm wood, however, there is no clear differentiation in the above mentioned zones as the fibrovascular bundles are almost uniformly distributed and somewhat similar in size and structure throughout the wood.

Outer Region — The fibrovascular bundles of this region are widely spaced and usually regularly oriented, sometimes showing slight irregular arrangement (Pl. 1, fig. 2). However, they are somewhat more irregular in distribution towards the inner side (Pl. 1, fig. 3). They are small, circular to oval in shape measuring about 500-1000 μ in diameter. Although, the size of the fibrovascular bundles increases from the periphery towards the centre; there is a slight decrease in the frequency of these bundles which range from 112-100 per cm^2 in the peripheral part (Pl. 1, figs 2, 3) of this zone. The fibrovascular bundles show a massive dorsal sclerenchymatous sheath while ventral sclerenchymatous sheath is absent in all the fibrovascular bundles. The dorsal sclerenchyma is usually reniform, rarely lunate in shape (Pl. 1, figs 5, 6). The fibrovascular ratio is 1/1 to 1/3 but it may sometimes become as low as 1/4-1/5 in some bundles. (Pl. 1, figs 2, 3, 5, 6). The auricular lobes of the bundles are rounded to sometimes roundly pointed with a concave median sinus (Pl. 1, figs 5, 6). Auricular sinus as well as both tabular and radiating parenchyma are absent. Each fibrovascular bundle generally contains two bigger metaxylem vessels (Pl. 1, figs 5, 6) but rarely 3-4 vessels are also seen. These are completely excluded. Leaf-trace bundles are sometimes present. Small fibrous and fibrovascular bundles are present throughout this region and the ground tissue is lacunar. Stegmata are present both in the fibrous (Pl. 2, fig. 8) and fibrovascular bundles. Phloem is too poorly preserved to reveal any structural details.

Inner Region — This part is also well preserved and fibrovascular bundles are

irregularly oriented (Pl. 1, fig. 4), slightly bigger in size, 800-1200 μ in diameter, more widely spaced in the ground tissue, about 35-40 per cm^2 (Pl. 1, fig. 4). They are round to oval in shape, usually with reniform dorsal sclerenchyma. Their fibrovascular ratio is 1/3-1/5. Auricular lobes are rounded and the auricular sinus is generally absent. Median sinus is rounded to concave, and radiating parenchyma is absent (Pl. 1, figs 4, 7). Each fibrovascular bundle generally contains two metaxylem vessels (Pl. 1, fig. 7). The xylem is exerted. Leaf-trace bundles are commonly seen in this region and the small fibrovascular and fibrous bundles are also frequent (Pl. 1, fig. 4).

Ground Tissue — It is uniformly lacunar throughout the wood, composed of parenchymatous cells which are usually Y-shaped (Pl. 1, figs 2-4). About 5-6 individual cells unite together to form circular to oval lacunae which increase in size from periphery to the centre (Pl. 1, figs 5-7). In longitudinal section (Pl. 2, fig. 8), the cells are small, usually tangentially elongated with somewhat rounded ends enclosing the air spaces. They are usually arranged in tiers.

Fibrous Bundles are 100-140 μ in diameter and uniformly scattered throughout the wood. Each fibrous bundle is made up of 20-50 thick-walled cells (Pl. 1, figs 5-7).

Diminutive Fibrovascular Bundles — These bundles are seen throughout the ground tissue (Pl. 1, figs 4, 6). They are very small in size measuring 300 μ in diameter and are similar in structure to that of the large fibrovascular bundles. However, they usually show only one xylem vessel.

Leaf-trace Bundles — These are present throughout the wood but are best seen and quite common in the inner region. They are easily recognized by their protruded tongue-like vascular part with a number of small vessels. The pitting of the metaxylem is of scalariform type while the protoxylem shows annular to spiral thickenings.

DISCUSSION

An artificial classification of fossil palm stems was suggested by Stenzel (1904). Sahni (1943, pp. 218, 219) further gave a classification combining Von Mohl's (1849) and Stenzel's schemes based on the distributional pattern of fibrovascular bundles,

their fibrovascular ratio and the form of sclerenchyma. Kaul (1935, 1938) emphasized that it is possible to classify different genera on the character of ground tissue alone, as the different species of a particular genus show one type of ground tissue with minute variations. Mahabale (1959) further investigated the structure of vessel members of modern palms belonging to different tribes, genera and species and suggested that this character, if taken along with the nature of ground tissue and shape of the fibrovascular bundles, might help in resolving the fossil forms included under the genus *Palmoxylon* Schenk.

In the present state of our knowledge, however, only the artificial classification of fossil palms is feasible because sufficient published data as well as collection of thin sections of modern palm woods are not available so as to enable us to compare our fossil palms with the modern taxa and assign them to some modern genus or tribe. Consequently, the present species is assigned to *Palmoxylon* Schenk.

Comparison with Indian Palmoxyla — As the present fossil palm wood possesses markedly lacunar ground tissue, it is compared only with those Indian *Palmoxyla* which show lacunar ground tissue. These are *Palmoxylon hislopi* (Rode, 1933), *P. dakshinense*, *P. chindwarensense* (Prakash, 1959), *P. eocenum* (Prakash, 1962), *P. deccanense* (Sahni, 1964), *P. wadii* (Sahni, 1931, 1964), *P. burmense* (Sahni, 1931, 1964), *P. mathuri* (Sahni, 1931, 1964), *P. kamalam* (Rode, 1933; Shukla, 1939; Sahni, 1964; Mahabale & Kulkarni, 1973), *P. jammuense* (Sahni, 1931, 1964), *P. blanfordi* (Schenk, 1882; Sahni, 1931, 1964), *P. trabeculosum* (Sahni, 1964), *P. parthasarathyi* (Rao & Menon, 1964), *P. feistmanteli* (Rao & Achuthan, 1969), *P. keriansense* (Trivedi & Verma, 1971a) and *P. superbum* (Trivedi & Verma, 1971b). Of these, only *Palmoxylon parthasarathyi* and *P. superbum* are closely comparable to the present fossil palm wood (Table 1).

Although both in *Palmoxylon superbum* and the present species fibrous bundles and stigmata are commonly present and the ground tissue is lacunar, they differ from each other in a number of features. Whereas dermal, subdermal and central zones can be demarcated in *Palmoxylon superbum*, there is no clear differentiation of these zones in the present species. The fibrovascular bun-

dles are small, 330-602 μ in size, with cordate to reniform dorsal sclerenchyma in *P. superbum*, while they are slightly bigger, about 500-1200 μ in size, with reniform to lunate dorsal sclerenchyma in the present fossil palm wood.

Frequency of the fibrovascular bundles and their f/v ratio is also different in the two. In *P. superbum* the frequency of fibrovascular bundles ranges from 40-130 per cm^2 and the f/v ratio is 1.5/1-1.7/1, while in our fossil, the frequency is about 35-112 per cm^2 and the f/v ratio is 1/1-1/5. The tabular parenchyma is present and diminutive fibrovascular bundles are absent in *P. superbum*, whereas diminutive bundles are present and the tabular parenchyma is absent in our specimen. Lastly, the ground tissue is rather compact in the dermal zone of *P. superbum* becoming extremely lacunar towards the centre, while it is highly lacunar throughout the wood in the present species. Similarly, *P. parthasarathyi* also differs from the present fossil palm wood in having smaller fibrovascular bundles (90-620 μ in size) and in possessing only reniform dorsal sclerenchyma; these are more crowded, about 60-380 per cm^2 and exhibit a somewhat lower fibrovascular ratio, 0.2/1-0.3/1. This species is also characterized by the absence of diminutive fibrovascular bundles and the stigmata.

Comparison with Foreign Palmoxyla — Of the foreign known species, only *Palmoxylon lacunosum* (Unger) and *Palmoxylon vasculosum* (Stenzel) described in detail by Stenzel (1904) can be compared to some extent with the present fossil. Both of them show lacunar ground tissue with numerous fibrous bundles similar to our fossil wood. However, they also differ from the present species in some important characters. The fibrovascular bundles of *P. lacunosum* has a typical flat median sinus and the fibrous part is much more than the vascular part. In *P. vasculosum* the dorsal sclerenchyma of the fibrovascular bundles is generally reniform, the fibrous part of the bundles is less than the vascular part and more than two vessels are usually present in the fibrovascular bundles. However, the dorsal sclerenchyma is reniform to lunate, the fibrous part is mostly less than the vascular part and usually two vessels are present in the fibrovascular bundles of the present fossil wood,

In view of the distinctness of the present fossil palm it is being described as a new species, *Palmoxylon parapaniensis*, naming it after the village Parapani from where it has been collected.

SPECIFIC DIAGNOSIS

Palmoxylon parapaniensis sp. nov.

Stem large rusty brown stump, complete in cross section, about 50 cm in length and 25 cm in diameter. Fibrovascular bundles of outer region circular to oval, 500 to 1000 μ in diameter, 85-112/cm², regularly to somewhat irregularly oriented with two excluded metaxylem vessels; f/v ratio 1/1-1/5; dorsal sclerenchymatous sheath reniform to lunate with median sinus concave and auricular lobes rounded to roundly pointed. Fibrovascular bundles in inner region irregularly oriented, round to oval, 800-1200 μ in size, sparsely placed, 35-40 per cm², usually with two exserted, metaxylem vessels; dorsal sclerenchymatous sheath usually reniform with median sinus concave; f/v ratio 1/3-1/5. Diminutive fibrovascular bundles and fibrous bundles present throughout the stem; stegmata present both in fibrous and fibrovascular bundles. Ground tissue lacunar throughout, composed of Y-shaped, parenchymatous cells. Leaf-traces rare in outer, common in inner region.

Holotype — B.S.I.P. Museum no. 35275.

Locality — Parapani near Chabi, 56 km north-east of Mandla, Madhya Pradesh.

2. *Palmoxylon mandlaensis* sp. nov.

This fossil wood consists of a part of palm stem complete in cross section about 27 cm in length and 23 cm in diameter (Pl. 2, fig. 10). It shows well-preserved vascular bundles regularly to irregularly distributed in a compact ground tissue. The cross section consists of the following three clearly marked regions.

Dermal Zone — The fibrovascular bundles of this region are closely placed, 135-150 per cm² and show regular arrangement with xylem facing towards the centre. They are 285-760 μ in size and more or less elongated in shape with a prominent dorsal sclerenchymatous sheath usually with a sagittate, sometimes cordate base (Pl. 2, fig. 11). The f/v ratio of the fibrovascular bundles

varies from 3/1-6/1. The auricular sinus is absent while the median sinus is concave and the auricular lobes are pointed to round. Each fibrovascular bundle generally shows a single large xylem vessel, which is partly excluded. Although radiating parenchyma is altogether absent, one to two layers of tabular parenchyma are present around the fibrous part of the fibrovascular bundles. Fibrous bundles are also rarely seen in the ground tissue. Stegmata are present both in the fibrovascular and fibrous bundles. Leaf-trace bundles can sometimes be seen. Diminutive fibrovascular bundles are occasionally present. Phloem is badly preserved.

Subdermal Zone — The fibrovascular bundles (Pl. 2, fig. 12) are slightly bigger in size, sparsely placed, 85-100 per cm² and usually show a regular orientation in the ground tissue. They are oval to slightly elongated in shape and measure 570-1050 μ in diameter. The dorsal sclerenchyma is reniform to cordate in shape with the median sinus concave and the auricular lobes pointed. The auricular sinus is absent. The fibrovascular ratio varies from 2.5/1-5/1. Generally two xylem vessels are present in each fibrovascular bundle; these are excluded to partly included. Tabular parenchyma is present in 1-2 layers of cells around the fibrous part of the fibrovascular bundles, while the radiating parenchyma is absent. Leaf-trace bundles and the fibrous bundles are sometimes present. Stegmata are present both in the fibrovascular as well as in fibrous bundles. Diminutive fibrovascular bundles are also rarely seen. Phloem is badly preserved.

Central Zone — The fibrovascular bundles (Pl. 2, fig. 13) of this zone are irregularly oriented and widely placed, about 40-50 per cm². They are oval to circular in shape and measure 570-1350 μ in diameter. The f/v ratio varies from 3/1-3.5/1. Each fibrovascular bundle possesses a very well developed reniform to cordate dorsal sclerenchymatous sheath, and 2-3 excluded to partly included xylem vessels. Median sinus is concave and the auricular lobes are rounded, while the auricular sinus is absent (Pl. 2, fig. 14). Tabular parenchyma is present in 1-2 layers around the fibrous part of each fibrovascular bundle. Leaf-traces are sometimes seen. Fibrous bundles are frequently present in the ground tissue. Stegmata are present in the fibrous as well as

TABLE 1

FOSSIL SPECIES	STENZEL'S CLASSIFICATION	FIBROUS BUNDLES; STEGMATA	F/V RATIO	DISTRIBUTION OF FIBROVASCULAR BUNDLES PER cm ²	MEDIAN SINUS	AURICULAR SINUS; AURICULAR LOBES	VASCULAR PART OF FIBROVASCULAR BUNDLES WITH NUMBER OF VESSELS	GROUND TISSUE			ANY SPECIAL PECULIARITY	LOCALITY	REFERENCES
								GENERAL PARENCHYMA	TABULAR PARENCHYMA	RADIATING PARENCHYMA			
1. <i>Palmoxyton superbum</i> Trivedi & Verma	Cordata	Both present; Stegmata spherical	D. 9/1-12/1 SD. 10/1-17/1 C. 1.5/1-2/1	D. 100-130 SD. 60-70 C. 40-45	Concave	Lobes rounded	Mostly excluded; D. 1-2 SD. 2 C. 2-3	Extremely lacunar	Present	Absent	—	Keria, Chhindwara District, Madhya Pradesh	Trivedi & Verma, 1971b
2. <i>Palmoxyton parthasarathyi</i> Rao & Menon	Reniformia	Fibrous bundles present; stigmata absent	D. 0.2/1-0.8/1 SD. 0.2/1-0.6/1 C. 0.3/1-0.4/1	D. 350-380 SD. 90-110 C. 60-66	Concave	—	D. 1-3 SD. 2-6 C. 2-3	Highly lacunar	—	Absent	—	Mohgaon Kalan, Chhindwara District, Madhya Pradesh	Rao & Menon, 1964
3. <i>Palmoxyton parapaniensis</i> sp. nov.	Reniformia-Lunaria	Both present	O. 1/1-1/5 I. 1/3-1/5	O. 85-112 I. 35-40	Generally concave	Lobes generally rounded sometimes pointed; sinus absent	Excluded; generally 2 vessels	Highly lacunar throughout consisting of Y-shaped cells forming circular to oval air chambers	Absent	Absent	Diminutive fibrovascular bundles present	Parapani, Mandla District, Madhya Pradesh	

O — Outer, I — Inner.

TABLE 2

FOSSIL SPECIES	STENZEL'S CLASSIFICATION	FIBROUS BUNDLES; STEGMATA	F/V RATIO	DISTRIBUTION OF FIBROVASCULAR BUNDLES PER cm ²	MEDIAN SINUS	AURICULAR SINUS; AURICULAR LOBES	VASCULAR PART OF FIBROVASCULAR BUNDLES WITH NUMBER OF VESSELS	GROUND TISSUE			ANY SPECIAL PECULIARITY	LOCALITY	REFERENCES
								GENERAL PARENCHYMA	TABULAR PARENCHYMA	RADIATING PARENCHYMA			
<i>Palmoxyton scleroderum</i> Sahni	Cordata	Both present	D. 9/1-18/1 SD. 15/1-25/1 C. 23/1	D. 105-108 SD. 65-85 C. 65-70	Cordate	Sinus obsolete to acute angled; lobes rounded	Excluded; 1-2 or 3-4 vessels	Compact composed of isodiametric, thin walled cells	Present	Generally absent, present only around the leaf-trace bundles	Diminutive fibrovascular bundles and idioblasts present in the ground tissue	Seoni, Chhindwara District and Nawar-gaon, Wardha District, Madhya Pradesh	Sahni, 1943; Shukla, 1946
<i>Palmoxyton surangei</i> Lakhanpal	Cordata	Both present	D. 9/2 SD. 5/1-6/1 C. 4/1	D. 90-95 SD. 45-50 C. 25	Cordate to reniform	Sinus obtuse; lobes rounded	Excluded; usually 2-3 vessels in dermal and subdermal, 3-4 in central	Generally compact, slightly loose in subdermal and central regions	Present	Absent	Wavy horizontal rows of longer parenchymatous cells	Keria, Chhindwara District, Madhya Pradesh	Lakhanpal, 1958
<i>Palmoxyton mandlaensis</i> sp. nov.	Cordata, Sagittata, sometimes Reniformia	Both present	D. 3/1-6/1 SD. 2.5/1-5/1 C. 3/1-3.5/1	D. 135-150 SD. 85-100 C. 40-50	Concave	Sinus insignificant; lobes rounded to pointed	Excluded; 1-2 vessels	Generally compact, somewhat loose in central region, composed of round to oval cells	Present	Absent	Diminutive fibrovascular bundles	Mohgaon, Mandla District Madhya, Pradesh	

in fibrovascular bundles. Phloem is badly preserved and is represented usually by a cavity (Pl. 2, fig. 14). Diminutive fibrovascular bundles are also seen.

Ground Tissue—The ground tissue consists of almost round to oval parenchymatous cells which are compact in the dermal and subdermal zones (Pl. 2, figs 11, 12). It is slightly spongy with small intercellular spaces in the central region (Pl. 2, figs 13, 14). The size of the parenchymatous cells is about 90-110 μ in longitudinal section, and the cells are again round to oval in shape (Pl. 2, fig. 9).

Fibrous Bundles—The fibrous bundles are present throughout the ground tissue but they are rare in dermal as well as in subdermal zones, while their frequency increases in the central region. Each fibrous bundle consists of 10-20 fibrous cells. Stegmata are present around these fibrous bundles.

Diminutive Fibrovascular Bundles—These bundles are present throughout the ground tissue of the wood, but they are not common. They are small in size, measuring 400-500 μ in diameter and similar in structure to the large fibrovascular bundles. They possess only one xylem vessel.

Leaf-trace Bundles—These are present throughout the wood. They are quite commonly seen in the central region where they are recognized by their protruded tongue-like vascular part (Pl. 2, fig. 13) with a number of small vessels. The pitting of the metaxylem vessels is scalariform, while the protoxylem vessels show annular to spiral thickenings.

DISCUSSION

Comparison with Indian Palmoxyla—Out of a number of Indian fossil palm woods possessing compact ground tissue, the present palm wood resembles closely *Palmoxylon sclerodermum* Sahni (Sahni, 1943; Shukla, 1946) and *P. surangei* Lakhanpal (1955). However, it also differs from them in a number of characters (Table 2). In both *P. sclerodermum* and the present species, the ground tissue is compact, the tabular parenchyma is present around the dorsal sclerenchymatous sheath of the fibrovascular bundles and the diminutive fibrovascular bundles, fibrous bundles and the stegmata are present. However, *P. sclerodermum*

differs from the present species in having slightly smaller fibrovascular bundles with a higher fibrovascular ratio and somewhat lower frequency in the dermal and subdermal regions. In *P. sclerodermum* the fibrovascular bundles are 300-1000 μ in size, while in the present species they are 285-1350 μ in size. The frequency of fibrovascular bundles in the dermal and subdermal regions of *P. sclerodermum* is 65-108 per cm^2 , while it is 40-150 per cm^2 in the present species. Lastly, the radiating parenchyma is generally seen around the leaf-trace bundles of *P. sclerodermum* whereas it is absent in the present species.

Palmoxylon surangei also shows similarities with the present species in having fibrous bundles and the stegmata, in the presence of tabular parenchyma around the fibrovascular bundles and in the cordate dorsal sclerenchymatous sheath. However, it also differs from this species in the frequency of the fibrovascular bundles which is comparatively low in *P. surangei* ranging from 25-95 per cm^2 . Another important feature of *P. surangei* is the presence of wavy, horizontal rows of longer parenchymatous cells in the outer region of the stem; these are absent in *P. mandlaensis*. The diminutive fibrovascular bundles are absent in *P. surangei*, but they are quite common in the present fossil wood.

Comparison with Foreign Palmoxyla—Among the known fossil palm species from outside India, *Palmoxylon speciosum* (Stenzel) Schenk described in detail by Stenzel (1904) and *P. rutherfordi* Stockmans and Williere (1943) are to some extent comparable to the present species.

Palmoxylon speciosum resembles *P. mandlaensis* in general shape of the fibrovascular bundles, in the sagittate to cordate dorsal sclerenchymatous sheath and in the presence of tabular parenchyma, fibrous bundles and the stegmata. However, it also differs from the present species in the frequency of the fibrovascular bundles which is much lower in *P. speciosum* than in the present species. The auricular sinus is acute and majority of the fibrovascular bundles possess one vessel in *P. speciosum* whereas the auricular sinus is insignificant and there are usually two vessels in the fibrovascular bundles of the present species. Although, the fibrous bundles are quite frequent in both the species, they are somewhat smaller

(100-160 μ) in *P. speciosum* than in the present fossil wood (40-190 μ). Besides, the ground tissue cells are larger (166-250 μ) in length and 40-60 μ in width in *P. speciosum* than in *P. mandlaensis* (30-75 μ in diameter). Lastly, the diminutive fibrovascular bundles are present in *P. mandlaensis* but absent in *P. speciosum*.

In both *Palmoxylon rutherfordi* and the present species, the shape of the fibrovascular bundles is somewhat similar and the fibrous bundles are present. However, *P. rutherfordi* differs from *P. mandlaensis* in having slightly smaller fibrovascular bundles which are more crowded (388 per cm^2) in the dermal zone and in the absence of tabular parenchyma and diminutive fibrovascular bundles. The ground tissue cells are oval to elongated in *P. rutherfordi* but they are circular to oval in the present species. The frequency of the fibrovascular bundles of the dermal zone is 135-150 per cm^2 in *Palmoxylon mandlaensis*.

SPECIFIC DIAGNOSIS

Palmoxylon mandlaensis sp. nov.

Stem large brown stump, complete in cross section about 27 cm long and 23 cm in diameter exhibiting three well-defined zones, viz., dermal, subdermal and central. Fibrovascular bundles of dermal and subdermal regions usually regularly oriented and generally with 1-2 partly excluded metaxylem vessels; these bundles become irregularly oriented in central zone with

two to three excluded to partly included metaxylem vessels. Dermal bundles more or less elongated in shape, 285-760 μ in size and 135-150 per cm^2 ; fibrovascular ratio 3/1-6/1; median sinus concave and auricular lobes round to pointed; tabular parenchyma present around dorsal sclerenchymatous sheath. Fibrous bundles and stegmata present. Subdermal bundles circular to oval in shape, 570-1050 μ in diameter, 85-100 per cm^2 with reniform to cordate dorsal sclerenchyma and f/v ratio 2.5/1-5/1; median sinus concave and auricular lobes round to pointed; tabular parenchyma present around the dorsal sclerenchyma; fibrous bundles and stegmata present. Central bundles sparsely placed, 40-50 per cm^2 , mostly circular rarely oval, 570-1350 μ in diameter; and with reniform to cordate dorsal sclerenchymatous sheath; f/v ratio 3/1 to 3.5/1; median sinus concave with rounded auricular lobes; tabular parenchyma present. Fibrous bundles and stegmata present. Diminutive bundles present throughout the wood. Ground tissue compact in dermal and subdermal zones, slightly spongy in central zone, made up of round to oval cells. Leaf-traces rare in dermal and subdermal zones but commonly present in central zone; metaxylem vessels show scalariform to reticulate thickenings.

Holotype — B.S.I.P. Museum no. 35276.

Locality — Mohgaon in Mandla District, Madhya Pradesh.

The specific name is after the District from where the fossil was collected.

REFERENCES

- BANDE, M. B. (1974). A petrified dicotyledonous wood from the Deccan Intertrappean beds of Mandla District, Madhya Pradesh. *Botanique*, 4 (1): 41-48.
- BANDE, M. B. (1974). Two fossil woods from the Deccan Intertrappean beds of Mandla District, Madhya Pradesh. *Geophytology*, 4 (2): 189-195.
- INGLE, S. R. (1972). A new fossil dicotyledonous wood of Verbenaceae from Mandla District of Madhya Pradesh. *Botanique*, 3 (1): 7-12.
- INGLE, S. R. (1973). *Syzygioxylon mandlaense* gen. et sp. nov. a fossil dicotyledonous wood from Mandla District of Madhya Pradesh, India. *Botanique*, 4 (1): 71-76.
- KAUL, K. N. (1935). A classification of palms based upon the ground tissue of the stem. *Proc. 22nd Indian Sci. Congr.*, Calcutta: 285-286.
- KAUL, K. N. (1938). An analysis of the artificial genus *Palmoxylon* into natural genera. *Proc. 25th Indian Sci. Congr.*, Calcutta, 3:1 49-150.
- LAKHANPAL, R. N. (1955). *Palmoxylon surangei*, a new species of petrified palms from the Deccan Intertrappean Series. *Palaeobotanist*, 4: 15-21.
- MOHL, HUGO VON (1849). *On the structure of the palm stem*. Ray society Reports and Papers on Botany, London.
- MAHABALE, T. S. (1959). Resolution of the artificial genus *Palmoxylon*—a new approach. *Palaeobotanist*, 7 (1): 76-84.
- MAHABALE, T. S. & KULKARNI, K. M. (1973). *Palmoxylon kamalam* Rode from Kandhali, district Nagpur, M.S. and its resemblance with other palms. *Palaeobotanist*, 22 (2): 170-178.

- PRAKASH, U. (1959). Study in the Deccan Intertrappean Flora: Two palm woods from Mohgaon Kalan. *Palaeobotanist*, **7** (2): 136-142.
- PRAKASH, U. (1962). *Palmoxylon eocenum* sp. nov. from the Deccan Intertrappean beds of Mahurzari. *Palaeobotanist*, **10** (1): 6-9.
- RAO, A. R. & MENON, V. K. (1964). *Palmoxylon parthasarathyi* sp. nov. a petrified palm stem from Mohgaon Kalan. *Palaeobotanist*, **12** (1): 1-6.
- RAO, A. R. & ACHUTHAN, V. (1969). Two new species of petrified palms from the Deccan Intertrappean beds of Mohgaon Kalan (M.P.), India, pp. 319-329 in: *J. Sen. Memorial. Volume*, Santapau, H. *et al.* (Eds). Bot. Soc. Bengal, Calcutta.
- RODE, K. P. (1933). Petrified palms from the Deccan Intertrappean beds. II. *Q. Jl geol. Min. metall. Soc. India*, **5** (3): 75-83.
- SAHNI, B. (1931). Materials for a monograph of the Indian petrified palms. *Proc. Acad. Sci. U.P.*, **1**: 40-144.
- SAHNI, B. (1943). A new species of petrified palm stem *Palmoxylon sclerodermum* sp. nov. from the Deccan Intertrappean Series. *J. Indian bot. Soc.*, **22** (2-4): 209-224.
- SAHNI, B. (1946). A silicified *Cocos*-like palm stem *Palmoxylon (Cocos) sundaram* from the Deccan Intertrappean beds. *Proc. Acad. Sci. India (M. O. P. Iyenger Commemoration Volume)*: 361-374.
- SAHNI, B. (1964). *Revision of Indian Fossil Plants. III. Monocotyledons*. Monograph No. 1. Birbal Sahni Institute of Palaeobotany, Lucknow.
- SCHENK, A. (1882). Die von den Gebrüdern Schlagintweit in Indien gesammelten fossilen Hölzer. *Bot. Jahrb.*, **3**: 353-358.
- SHUKLA, V. B. (1939). On *Palmoxylon kamalam* Rode, from the Deccan Intertrappean Series with special reference to the importance of ground tissue in the classification of palms. *Rec. geol. Surv. India*, **74** (4): 492-503.
- SHUKLA, V. B. (1946). *Palmoxylon sclerodermum* Sahni from the Eocene beds of Nawargaon, Wardha District, C. P. *J. Indian bot. Soc.*, **25** (1): 106-116.
- STENZEL, K. G. (1904). Fossile Palmenholzer. *Beitr. Palaont. Geol. Ost. Ung.*, **16**: 107-287.
- STOCKMANS, F. & WILLIERE, Y. (1943). *Palmoxylons paniseliens de la Belgique. Mém. Mus. r. Hist. nat. Belg.*, **100**: 5-75.
- TRIVEDI, B. S. & VERMA, C. L. (1971a). A new petrified palm stem *Palmoxylon keriensis* sp. nov. from Keria, Deccan Intertrappean beds of M.P., India. *Proc. natn. Acad. Sci. India*, **37B** (2): 61-67.
- TRIVEDI, B. S. & VERMA, C. L. (1971b). A petrified palm stem *Palmoxylon superbum* sp. nov. from Keria, Deccan Intertrappean Series in Chhindwara District, M.P. *Palaeobotanist*, **18** (3): 270-279.

EXPLANATION OF PLATES

PLATE 1

Palmoxylon parapaniensis sp. nov.

1. Fossil palm wood specimen. $\times 1/5$; Specimen no. 35275.
2. Cross section of outer portion showing mostly regular arrangement of fibrovascular bundles. $\times 7$; Slide no. 5182/35275.
3. Cross section of inner part of outer region, where fibrovascular bundles are sparsely placed and show slight increase in size. Note the presence of leaf-trace bundles. $\times 7$; Slide No. 5183/35275.
4. Cross section of inner region of the fossil wood showing irregular orientation of fibrovascular bundles. $\times 7$; Slide no. 5183/35275.
5. Cross section of outer portion highly magnified to show fibrovascular bundles. Note fibrovascular and fibrous bundles in the lacunar ground tissue. $\times 45$; Slide no. 5183/35275.
6. Cross section of inner part of outer region magnified to show fibrovascular bundles and fibrous bundles. Also note a diminutive fibrovascular bundle in the lacunar ground tissue. $\times 45$; Slide no. 5183/35275.
7. Cross section of inner region of the stem highly magnified to show fibrovascular bundles. Also note the lacunar ground parenchyma. $\times 45$; Slide no. 5183/35275.

PLATE 2

Palmoxylon parapaniensis sp. nov.

8. Longitudinal section of the fossil wood showing loosely arranged parenchyma cells in the lacunar ground tissue. Note rows of stigmata on the fibrous part of the bundle. $\times 60$; Slide no. 5184/35275.

Palmoxylon mandalaensis sp. nov.

9. Longitudinal section of the fossil wood showing compactly arranged parenchyma cells of the ground tissue. $\times 45$; Slide no. 5198/35276.
10. Fossil palm wood specimen. $\times 1/5.5$; Specimen no. 35276.
11. Cross section of dermal region showing regular orientation of fibrovascular bundles. Also note the diminutive fibrovascular bundles. $\times 13$; Slide no. 5199/35276.
12. Cross section of subdermal region showing usually irregular orientation of fibrovascular bundles. Note the leaf-trace bundles. $\times 13$; Slide no. 5199/35276.
13. Cross section of central region showing irregularly arranged fibrovascular bundles. $\times 13$; Slide no. 5199/35276.
14. An enlarged fibrovascular bundle of central region. Note the spongy ground tissue. $\times 75$; Slide no. 5199/35276.

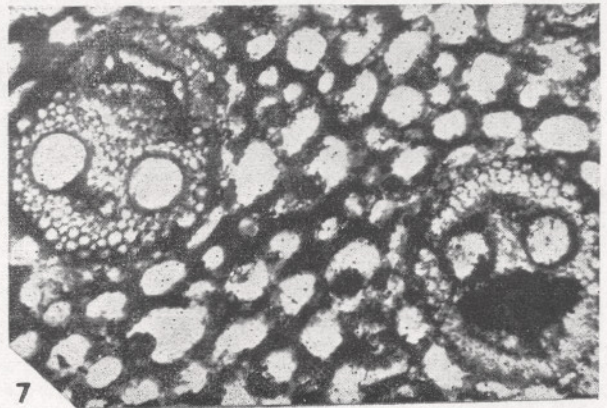
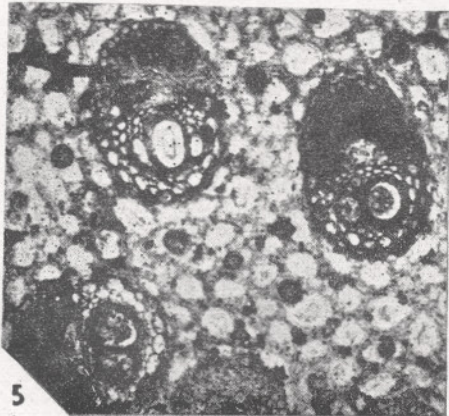
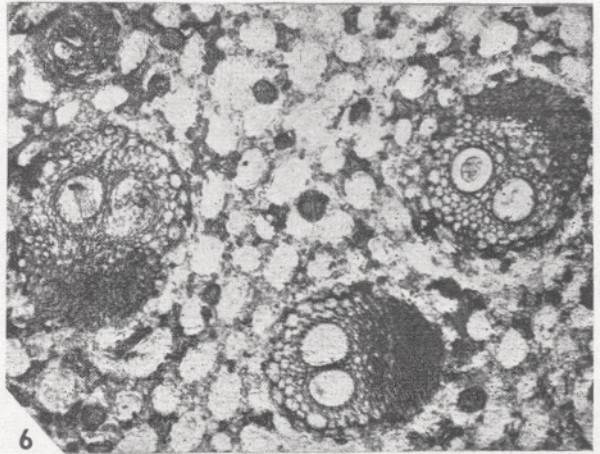
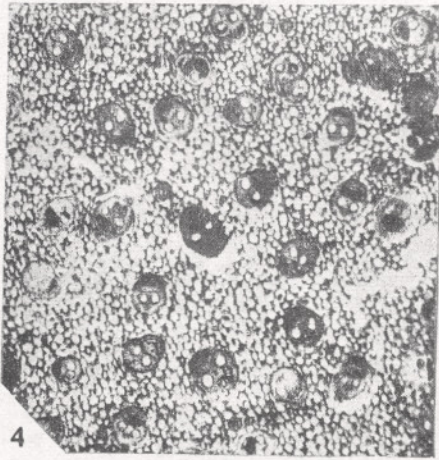
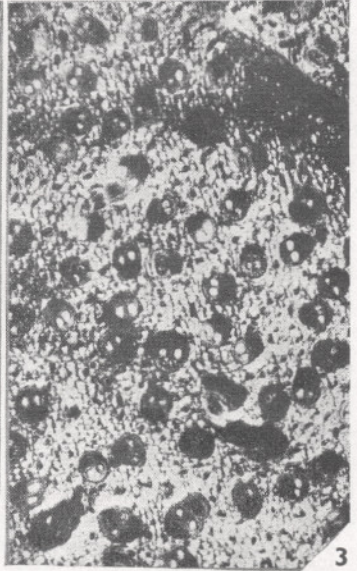
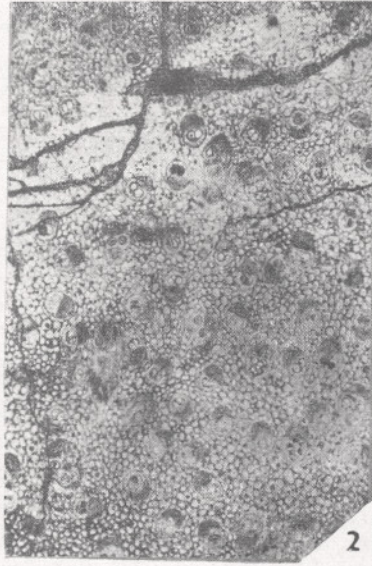


PLATE 1

