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EARLY EOCENE ARECOID PALM WOOD, *PALMOXYLON VASTANENSIS* N. SP. FROM VASTAN LIGNITE, GUJARAT, INDIA: ITS PALAEOENVIRONMENTAL IMPLICATIONS

M. PRASAD [1], H. SINGH [1], S. K. SINGH [1], DEBI MUKHERJEE [2] and EMILIO ESTRADA RUIZ[3]

1.BIRBAL SAHNI INSTITUTE OF PALAEOBOTANY, 53, UNIVERSITY ROAD, LUCKNOW- 226007, INDIA.
2. CENTRE OF ADVANCE STUDY IN GEOLOGY, LUCKNOW UNIVERSITY, LUCKNOW, 226007, U.P. INDIA.
3.UNITED ACADEMICAEN CIENCIASDELA TIERRAUNIVERSITDAD AUTONOMADE GUERRERO EX HACIENDA DE SAN JUAN BAUSTINA, 40323, TAXCO EL VIEJO, MEXICO.
Corresponding author: **E-mails**: [1]mahesh_bsip@yahoo.com, [2] Debi_Dutta@Yahoo.com

ABSTRACT

A new species of fossil palm wood, *Palmoxylon vastanensis* is reported and described from the Vastan Lignite Mine, Surat, Gujarat, India. The fossil wood is characterized by highly lacunar ground tissue with very large air spaces indicating that plants were growing in an aquatic or the marshy environment. A detailed anatomical study revealed its affinities with the extant arecoid taxa belonging to the family Arecaceae. Among them, it closely resembles *Areca catechu* as both fossil and living species possess similar anatomical features such as highly lacunar ground tissue, reniform, dorsal sclerenchymatous sheath of the fibrovascular bundles with the frequency of 30-35 per cm². Based on the anatomical characters of the fossil and present day ecology of its modern equivalent, the palaeoenvironmental implications have been discussed.

Keywords: *Palmoxylon vastanensis* n. sp., Arecaceae, anatomy, palaeoenvironment, Vastan Lignite, Lower Eocene, Gujarat, India

INTRODUCTION

The subsurface beds of the Lower Cambay Shale exposed in an opencast lignite mine at Vastan in the southern part of the basin, include a large number of different types of fossils such as foraminifers, ostracods, molluscs, fishes and mammals reported by several workers (e.g. Garg *et al*., 2008; Bajpai *et al*., 2005; Punekar and Saraswati, 2010; Rana *et al*., 2004). The Palaeogene sediments in the Cambay Basin are exposed in the form of the strips along the Saurashtra coast and to the east of the Gulf of Cambay (Fig.1). The Vastan opencast lignite mine is situated about 29 km NE of Surat. The lignite, together with the associated sediments containing pollen assemblage, was reported by Samant and Tapaswi (2000, 2001); Samant and Bajpai (2001); Rana *et al.* (2004). The marine ostracods from these sediments were recovered by Bhandari *et al*. (2005). Evidence of marine fish remains and mammalian fossils was reported by Sahni *et al.* (2004); Nolf *et al*.(2006); Rana *et al*. (2005a,b), while Rose *et al.* (2006) provided information related

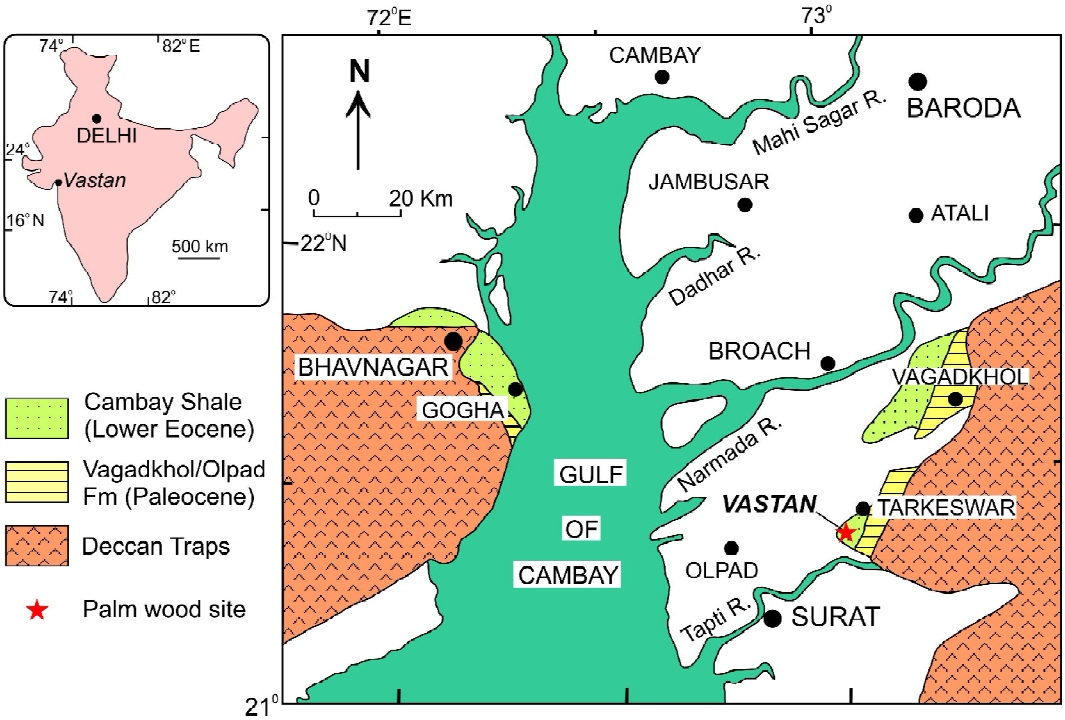


Fig. 1. Geological map of the area showing site of palm wood occurrence. Inset shows position of the study area in India.

to depositional environment and sedimentation in the Palaeogene lignite-rich succession at Surat, Gujarat. Later, these views were also supported by Tom McCann (2010) and Kishor *et al*.(2011).

It has been observed by one of the authors (H. Singh) that occurrence of plant megfossils (especially leaves) was restricted in the uppermost thin layer of lignite in contact with the shale bed (Fig.2). A few fragmentary wood specimens were found associated with the sandy shale bed. In addition, reports of microfossils from the Vastan lignites have been published by Tripathi and Srivastava (2006); Samant and Tapaswi (2008); Guleria *et al.* (2008): Mandal and Guleria (2006); Garg *et al.* (2008). Recently, Singh *et al.* (2010) reported the occurrence of plant megafossils (fruits) referable to *Ziziphus, Combretum, Terminalia* and *Lagerstromia* belonging to the dicotyledonous famlies Rhamnaceae, Combretaceae and Lythraceae.

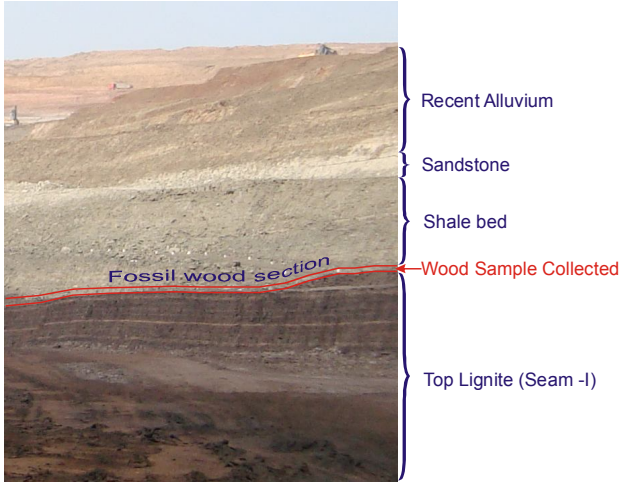


Fig. 2. Field photograph showing the lignite layer from where sample was collected.

GEOLOGICAL SETTING

The vastan lignite mine is situated about 29 km north east of Surat town (Lat 21º 25? 47?N Long. 73º 7? 30?) in Gujarat, western India. The shale referable to the Cambay Shale Formation is variable in thickness (20-145m), consisting of lignite bands of various thicknesses alternating with carbonaceous and grey shales (Fig.2).There are two main lignite seams in this mine; lignite seam-1 lies at the top and lignite sean-2 at the bottom of the mine (Rana *et al*., 2008). The Cambay Formation overlies the Palaeocene-Lower Eocene Vagadkhol Formation and is overlain by the upper Eocene Nummulitic limestone and marl which denotes the Amravati Formation (Sudhakar and Basu,1973) (Table 1). The foraminifer, *Nummulites burdigalensis* occurs as an indicator of Shallow Benthic Zone of middle Ypresian (Early Eocene) age, about 18-20 m above the rodent-bearing horizon (Sahni *et al*., 2006); Berggren and Pearson, 2006). The succession, in turn, is overlain by the recent alluvium. According to Sahni *et al*. (2006) the sediments of lower half of the Vastan lignite mine were deposited in an estuarine to lagoonal environment, whereas those of the upper half were deposited under the shallow marine conditions.

MATERIAL AND METHODS

The material was collected by one of the authors (HS) from the sediments of Lignite seam 1 exposed at the Vastan Lignite Mine. It is a small piece, black in colour measuring 4x2 cm in size, apparently showing fibrovascular bundles scattered in the matrix. The specimen was cut into thin sections (TS and LS). To observe the anatomical characters, these sections were ground to thin slices and polished by standard method for preparation of permanent slides. The important characters were studied under low and high magnifications under the optical microscope and the photomicrographs for important anatomical features were prepared.

Table 1: (Generalised stratigraphy of the Vastan lignite mine (after Bhandari *et al.*, 2005).

Formation	Lithology	Age
Alluvium/ Black soil Amrawati	Soil and Recent alluvium Nummulitic limestone and marl	Recent and Sub Recent
	Calcareous bentonitic variegated Clay, unfossiliferous	Late Eocene
Cambay Shale	Greenish grey, whitish clay and brown fissile shale, clay and marl with carbonaceous zone including lignite seam with vertebrate, plant, pollen and spore fossils	Early Eocene
Vagadkhol	Variegated clay	Palaeocene-Early Eocene
Deccan Trap	Basalt	Late Cretaceous

SYSTEMATIC DESCRIPTION

Family **Arecaceae** Schultz,1832

Genus ***Palmoxylon*** Schenk, 1882

Type species: ***Palmoxylon blanfordi*** Schenk, 1882

Palmoxylon vastanensis n. sp.

(Pl. I, figs.a-k; Pl. II, figs.a-c)

Type specimen (Holotype): *Palmoxylon vatsanensis* n. sp; BSIP Museum No.39901.

Type locality: Vastan lignite mine, Gujarat, India.

Horizon and Age: Cambay Shale Formation; Lowe Eocene.

Parts available: Sub-Dermal and Central zones.

Derivation of name: The specific name is based on the locality, Vastan, from where the specimen was recovered.

Diagnosis: Wood blackish in colour; comprising sub-dermal and central size 4x2.6cm, fibro-vascular bundles in sub-*dermal zone* irregularly oriented with one metaxylem vessel sometimes two may be present; size of the bundles ranges from 440x500-700-800µm; dorsal sclerenchymatous sheath reniform; cells of this sheath generally not preserved. A layer of tabular parenchyma present around the fibrous part of the bundle; auricular lobes round, auricular sinus absent; diminutive fibrovascular bundles rare, fibrous bundles absent, leaf-trace bundles rare. Fibrovascular bundles of *central zone* irregularly dispersed in ground tissue, bigger in size as compared to sub-dermal zone; 1000x900-1200x1000µm; the sclerenchymatous sheath reniform, cells of this sheath partly preserved; frequency of the fibrovascular bundles is 30-35 cm² and the f/v ratio varies 4/1-5/1; tabular parenchyma present; stegmata absent. Ground tissue highly lacunar; cells rod to cylindrical and variously shaped forming large air spaces; secretory cells present in the ground tissue; diminutive fibro-

vascular bundles rare; leaf trace bundles present.

Description: The silicified specimen is black in colour due to association of lignite beds; it measures 4xcm in length and 2.6cm broad. The fibrovascular bundles are irregularly dispersed throughout the specimen as seen in cross section (Pl.I, fig.a). Based on the consistency, orientation of the fibro-vascular bundles and the nature of ground tissue, anatomically it is divisible into sub-dermal and central zones, while the outermost part (dermal zone) is missing .The distinction between sub-dermal and central zones can be made by the concentration of the fibro-vascular per cm²; ground tissue being highly lacunar with larger air spaces in the central zone (Pl. I, figs. f-k; Pl. II, figs a,b).

Sub-dermal Zone: The fibro-vascular bundles in this zone are sparsely placed. Their size varies from 440x500 to700x800µm, generally round to oval in shape having reniform dorsal fibrous sheath; bundles generally with one metaxylem vessel, rarely two vessels can be present (Pl. I, figs.b,d,g). The cells of fibrous sheath generally are decayed off possibly due to unsuitable ecological conditions for its preservation; however, the outer most layer (tabular parenchyma) are present around fibrous part, these cells are cylindrical, oval to elongated in shape, their size varies from 200-250µm. Radiating parenchyma around vascular part of the bundles are present (Pl. I, fig.e,f).The frequency of fibro-vascular bundles varies from 35-40 per cm²; the f/v ratio ranges from 4/1 to 6/1. Phloem cells are not preserved; fibrous bundles are absent; sometimes a few diminutive fibro-vascular bundles are observed in this zone. The ground tissues made up of parenchyma of variable shapes; oval to elongated and triangular cells provide moderately large air spaces to the matrix (Pl.I, fig.h, j).

Central Zone: This zone is about 2cm thick having larger fibro-vascular bundles as compared to the sub-dermal zone, they measure1000x900-1200x1000µm with a layer of peripherally elongated tabular parenchyma (Pl.I, figs.d,g). The sclerenchymatous sheath of the fibro-vascular bundles is reniform**;** the cells of this part are disintegrated to reveal their exact nature (Pl. II, fig.a). However, a few sclerenchymatous cells can be observed, they are polygonal in shape with larger lumen and thin cell wall. The auricular sinus is indistinct; each fibro-vascular bundle has generally one metaxylem vessel, rarely two may be present. The frequency of fibro-vascular bundles vary from 30- 35 per cm². The fibro-vascular ratio ranges 4/1-5/1.The fibrous bundles and stegmata are absent in this zone; are absent. Radiating parenchyma present around the vascular part of the bundles and anastomos with the parenchyma cells of the ground tissue (Pl.I, figs.e,g,h). The ground tissue is highly lacunar with very large air spaces formed by union of cylindrical parenchyma of various shapes (50 x100-410x250µm size) (Pl. I, fig. k). Leaf-trace bundles are sometimes present in this zone. At places, secretory glands are also present in this zone (Pl. I, fig.i; Pl. II, fig.a).

DiminutiveFibro-vascular Bundles: These are small-sized fibrovascular bundles, rarely seen in this zone, irregularly arranged in the ground tissue, measuring less than 250-300µm in size. Their structure is almost similar to that of normal, fibro-vascular bundles (Pl. I, fig.c).

*Leaf-Trace Bundles***:** Leaf trace bundles are very rarely seen in the stem and can be distinguished by protruded vascular part with many smaller xylem vessels. They are slightly larger in size than the normal fibro-vascular bundles and extend from 1 to 1.4mm (Pl. I, fig.a).

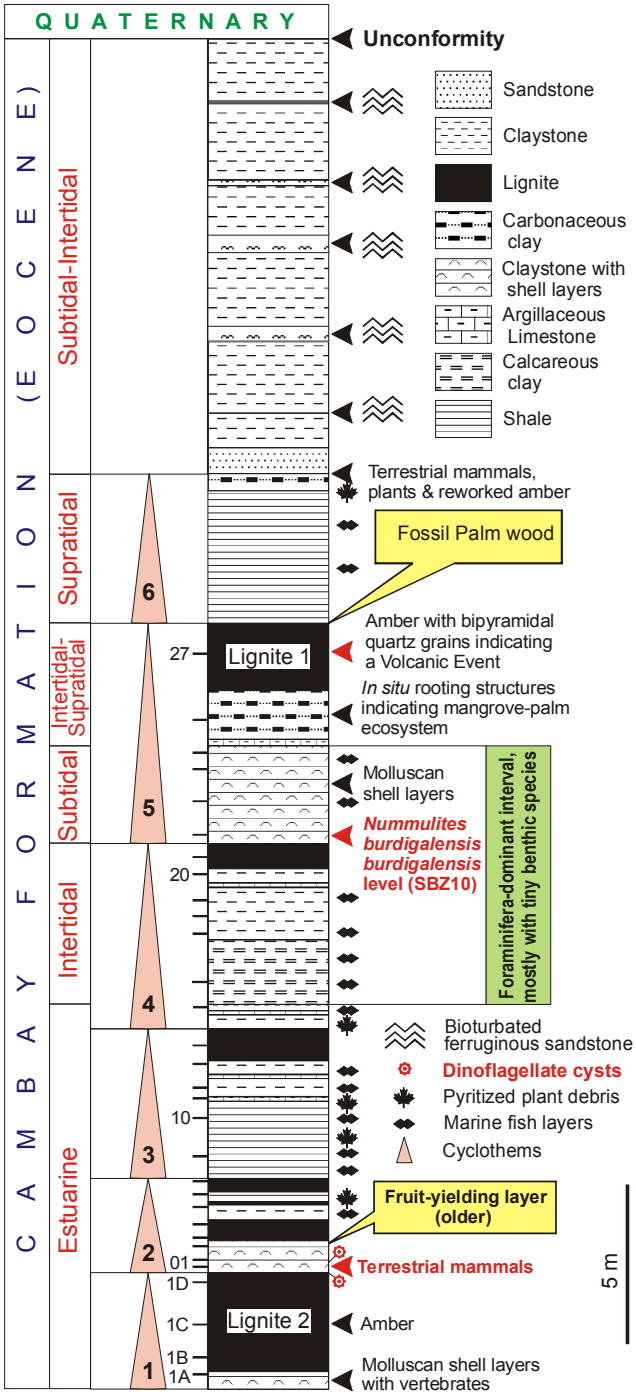
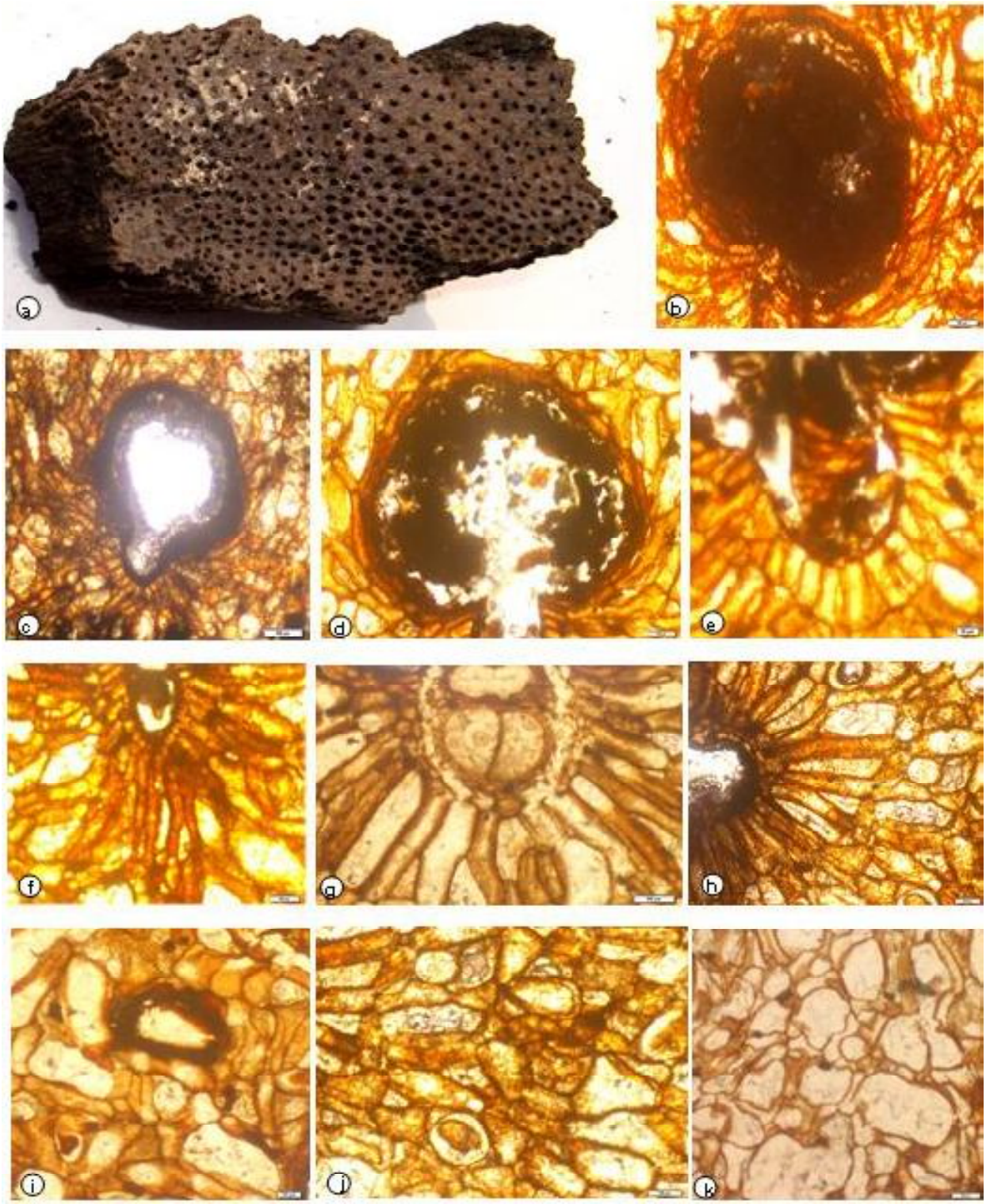


Fig. 3. Lithostratigraphic column of Vastan Lignite Mine showing position of fossil palm wood in the Vastan sequence (after Sahni *et al.*, 2006.).

Ground Tissue: The ground tissue in the present fossil is highly lacunar throughout providing spongy nature to the stem, distinctly consisting of the cells of variable shapes and sizes (100x300 µm). These cells provide the ground matrix with small to very large air spaces. The spongy nature of the ground tissue gradually increases from sub-dermal to central zone (Pl. I, figs.i,j ; Pl. II, fig. b).

Vessel Elements: The number of the xylem vessels in the sub-dermal and central zones is generally one, rarely two per fibro-vascular bundle, they are round to oval in shape and

Plate I



EXPLANATION OF PLATE I

(a). Cross section of ***Palmoxylon vastanensis*** n. sp. Showing general distribution of the fibrovscular bundles. (b) Fibrovascular bundles of sub-dermal zone with small xylem vessel. (c) Diminutive fibrovascular bundle of subdermal zone. (d) Fibrovascular bundle showing elongated tabular parenchyma around the fibrous sheath. (e, f) Part of fibrovascular bundle showing radiating parenchyma around vascular region. (g) Fibrovascular bundle of central zone shows radiating parenchyma and two xylem vessels. (h, j) Part of fibrovascular bundles showing spongy nature of ground tissue in sub-dermal zone and secretory canal. (k) Ground tissue of central zone showing large air spaces.

extruded. Their size ranges from 150-230µm; due to poor preservation the sculpture of these vessels is not seen (Pl. I, figs. d,g ; Pl. II, fig.c).

COMPARISION WITH INDIAN FOSSIL PALMS

The present fossil palm possesses a distinct lacunar ground tissue with very large air spaces throughout (sub-dermal and central parts). Different species of *Palmoxylon* having reniform dorsal sclerenchymatous sheath and lacunar ground tissue, have been taken into account (Table 2) viz. *Palmoxylon hislopi* Rode (1933), *P. dakshinense* and *P. chhindwarense* Prakash (1990), *P. eocenum* Prakash (1962), *P. deccanense* Sahni (1964), *P. wadiai* Sahni (1931, 1964 and El Sadaavi, *et al.,* 2004), *P. kamalam* Rode (Rode, 1933), Shukla (1939), Sahni (1964); Mahabale and Kulkarni (1972), *P. trabeculosum* (Sahni, 1964). *P. jammuensis* Sahni (1931, 1964), *P. blanfordi* Schenk (1882), Sahni (1964), *P. parathsarathyi* Rao and Menon (1964), *P. fiestmentali* Rao and Achutan (1969), *P. superbum* Trivedi and Verma (1971), *P. parapaniensis* Lakhanpal *et al.* (1979), *P. livistonoides* Prakash and Ambwani (1980) and *P. dilacunosum* Ambwani (1984). Further, on close observation, it was found that *Palmoxylon parapaniensis, P. livitonoides* and *P. dilacunosum* having highly lacunar ground tissue and a number of characters such as fibrovascular bundles/cm2, presence/absence of fibrous bundles and stegmata were considered. *Palmoxylon parapaniensis* has greater number of fibrovascular bundles both in outer and inner zones, whereas f/v ratio is almost similar to the present species; both fibrous bundles and stegmata are seen while they are absent in the present fossil, the ground tissue consists of Y-shape parenchyma cells with comparatively smaller air spaces, whereas in *P. vastanensis* these are very large with radiating parenchyma. *P. livistonoides* has greater number of fibrovascular bundles in dermal and sub-dermal zones with higher f/v ratio, fibrous bundles and stegmata are present while they are absent in the present species. The ground tissue is compact in dermal zone and lacunar in sub-dermal zone, thus can not be fully compared with the present species. Lastly, *P. dilacunosum* though has very large air spaces in ground tissue but is compact in the dermal zone, the number of fibrovascular bundles, f/v ratio and presence of fibrous bundles with stegmata does not match with the present species. Considering the above fact, the present fossil reveals characters of difference from above-mentioned species.

Table 2: Comparison of *Palmaxylon vastanensis* with other known species of *Palmaxylon*.

Species	Stenzel's Classification	No of FVB/cm²	F/V Ratio	Fibrous bundles& Stegmata	Ground Tissue
P.deccanense Prakash,1960	Reniformia	D. 200-270 SD. 50-90	D. 10/1 SD. 12/1-17/1	Fibrousbundles absent; stegmata present	Slightly lacunar to highly lacunar
P. chhindwarensis Prakash,1960	Reniformia	D. 297-625 SD. 156-250 C. 60-130	D. 4.5/1-8/1 SD. 3/1-5/1 C. 2.5/1-3/1	Both absent	Conspicuously lacunar, air spaces small
P. eocenum Prakash, 1962	Reniformia	D. 300-366 SD. 66-132 C. 30-60	D. 6.5/1-10.5/1 SD. 3/1-6/1 C. 2.5/1-3.5/1	Fibrousbundles present; stegmata absent	Lacunar throughout; cells Y shape
P. parthasarathyi Rao & Menon, 1964	Reniformia	D. 350-380 SD. 90-110 C. 60-66	D. 0.2/1-0.8/1 SD. 0.2/1-0.6/1 C. 0.3/1-0.4/1	Fibrous bundles present; stegmata absent	Highly lacunar
P. khalsa Sahni,1964	Reniformia	NA	!/1-2/1	Absent	Lacunar,cells rod -like
P. trabeculosum Sahni,1964	Reniformia	Very small D. 320 SD. 138	2/1-4/1	Both present	Lacunar,cells isodiametric
P.blanfordi I (Schenk) Sahni,1964	Reniformia / Complanata	Usually 14	2/1-3/1	Absent	Lacunar,cells stellate,radiating
P. kamalam (Rode) Sahni,1964	Complanata	Usually- 70	1.5/1 -2/1	Absent	Lacunar,cells trabecular
P. wadiai Sahni, 1964	Reniformia	SD. 30 C. 20	3/1-4/1	Absent	Lacunar, air spaces small
P. jammuensis Sahni, 1964	Lunaria	10-12	12/1-16/1	Both present	Slightly lacunar
P.caudatum Sahni,1964	Lunaria	D. 32-41 SD. 36-38	D. 12/1- 15/1 SD. 12/1- 15/1	Absent	Very Lacunar
P. sclerodermum Sahni,1964	Cordata	C. 22	8/1	Absent	Very lacunar; cells shape vary
P.superbum Trivedi & Verma, , 1971	Cordata	D.100-130 SD. 60-70 C.40-50	D. 9/1-12/1 SD. 10/1-17/1. C. 1.5/1-1.2/1	Both present	Extremely lacunar
P.parapaniensis Lakhanpal *et al.,* 1979	Reniform-Lunate	O. 85-112 I. 35-40	O. 1/1-5/1 I. I3/1- 5/1	Both present	Highly lacunar Throughout, cells Y- shape, oval
P. livistonoides, Prakash& Ambwani,1980	Reniformia	D. 130-140 SD. 40-60	D. 1/1-6/1 SD. 3/1-7/1	Both present	Compact- lacunar
P. dilacunosum Ambwani, 1984	Reniformia	D. 160-170 SD. 120-130 C. 65-70	D. 4/1-6/1 SD. 2/1-3/1 C. 1/1-2/1	Both present	Compact to Highly lacunar

P. vatsanensis n. sp.	Reniform	SD. 35-40 C. 30-35	SD. 4/1-6/1 C. 4/1-5/1	Both absent	lacunar with very big air spaces
P.lacunosum (Unger) Stenzel, 1904	Reniform Complanata	120	1/5-1/11	Stegmata,absent tabular parenchyma	Lacunar, radiating parenchyma
P.vasculosum (Schenk) Stenzel, 1904	Reniform	70	1/5	Tabular parenchyma, stegmata absent	Slightly lacunar
P. smiperi Tidwell *et al*., 1970	Reniform	10-20	1-1.5/1 - 1/1	Fibrous bundles present; stegmata absent	Generally compact to slightly lacunar
P. pristine Tidwell *et al*., 1970	Reniform	30-40	1.7/1- 2.7/1	Both present	Ground tissue compact
P.enochii Emilio & Cevallos Ferriz, 2009	Reniformia	17-34	6/1-7/1	Both absent	Lacunar cells rod to triangular formig air spaces
Areca catechu Linn.	Reniform	26-40	6/1-8/1	Both present	lacunar, cells rod shape to triangular
Loxococos rupicola H. Wendl. & Drude	Reniform	35-45	5/1-7/1	Both absent	Highly lacunar
Oredoxa(Roystoea regia Cook	Reniform	30-35	7/1—9/1	Both absent	Hig Highly lacunar, cells ribbon shaped

(**D:** dermal zone, **SD.** Sub- dermal zone, **C:** central zone, **I:** inner zone, **O:** outer zone).

COMPARISION WITH FOREIGN FOSSIL PALMS

Cretaceous palm woods described from abroad with lacunar ground tissue by Tidwell (1970) are *Palmoxylon simperi* and *P. pristine* (Table 2*)*; both the species belong to Reniformia group, possess fibro-vascular bundles with one to two xylem vessels and show presence of fibrous bundles as well as stegmata; the f/v ratio varies from 1/1 -1.5/1 but the ground tissue is compact to slightly spongy in nature. The above characters do not fully agree with the anatomical characters of the present specimen. Further, comparison with *P. enochii* Emilio *et al*. (2009), though, show Reniform-type of dorsal sclerenchymatous sheath, the frequency of the fibrovascular bundles ranges from 17-34 per cm². The f/v ratio is slightly higher being 6/1-7/1 while the fibrous bundles and stegmata are present. Ground tissue is lacunar with moderately bigger air spaces; however, it can be compared with the present species only in having nearly similar frequency of the fibro-vascular bundles and lacunar ground tissue. *Palmoxylon vastanensis* was also compared with *P. lacunosum* (Unger) Stenzel (1904) and *P. vasculosum* (Schenk) Stenzel (1904)). These species show similarity to some extent because of lacunar ground tissue and reniform dorsal sclerenchymatous sheath but differ from the present species in containing higher number of fibro-vascular bundles per cm ² and lower f/v ratio. In view of the distinctions of the present fossil palm wood from the above-mentioned fossil species, it is preferred to describe it as a new species.

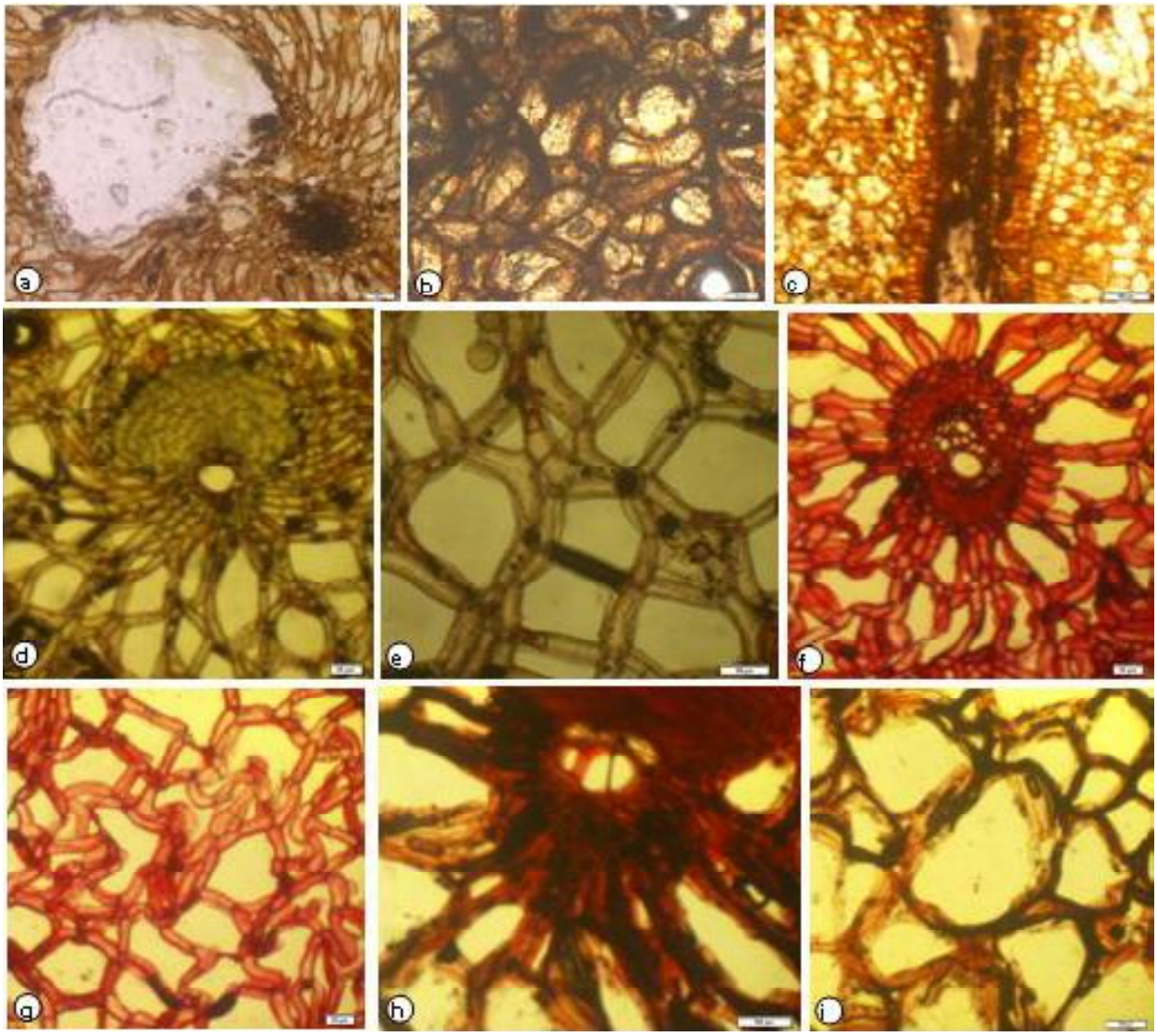
AFFINITIES WITH EXTANT PALMS

The present fossil palm wood has been compared with the modern palms having highly lacunar ground tissue, reniform dorsal sclerenchymatous sheath of the fibrovascular bundles, their frequency per cm², fibrovascular ratio, presence and absence of fibrous bundles and stegmata as well as other cellular details. Of the known anatomy of different genera (as mentioned by Tomlinson,1961), *Areca catechu* Linn. *Oreodoxa* (*Roystonea*) *regia* Cook. and *Loxococos rupicola*. H. Wendle and Drude show anatomical similarities with *Palmoxylon vastanensis* (Table 2). Out of the above mentioned taxa, anatomical characters of *Areca catechu* show closest resemblance to the fossil as both have highly lacunar ground tissue, fibrovascular bundles with one metaxylem vessel, dorsal sclerenchymatous sheath being reniform, secondarily enlarged ground tissue parenchyma with elongated, cylindrical and rod-shaped cells forming very large air spaces and marked by absence of fibrous bundles. However, stegmata are present in *Areca catachu*. It has been observed that the frequency of fibrovascular bundles and presence of radiating parenchyma around the vascular part both in *Areca catachu* and *Palmoxylon vastanensis* is almost similar (Pl. I, fig.k; PL. II, figs d,e). *Oreodoxa* (*Roystonea*) *regia* also shows anatomical similarity to certain extent; the frequency of fibrovascular bundles ranges from 30 to 35 per cm², absence of fibrous bundle and stegmata are recorded both in fossil and living specimens; though the ground tissue is highly lacunar and the parenchyma cells are secondarily expanded, they are ribbon shaped. The fibro-vascular ratio is much higher and presence of two metaxylem vessels are generally seen in *Oreodoxa* (*Roystonea*) *regia* (Pl. II, figs.h,i). Lastly, *Loxococos rupicola* has reniform type of dorsal sclerenchymatous sheath; the frequency of the fibovascular bundles is slightly higher (35-45 per cm²) while the fibrovascular ratio is 5/1-7/1(5/1-6/1 in fossil); Fibrous bundles and stegmata are absent both in fossil and the living species; whereas the ground tissue parenchyma cells are transversely expanded and the air spaces are smaller in the living species, the cells form triangular to polygonal and sometimes rectangular air spaces; absence of radiating parenchyma in *Loxococos rupicola* adds a point of difference between the living and fossil forms (Pl. II, figs.f,g).

PALAEOENVIRONMENT

The fossil remains of palm are among the safest guides to climatic conditions in the past. It is evident that the temperature by itself is not the main factor governing the distribution of plants of this family. Apart from a few "desert" species such as *Phoenix sylvestris* and *P. dectylefera* which form the prominent exceptions, the existing members of this group demand high temperature and relatively high humidity throughout the year. The area drained by upper Narbada and Godavari rivers (between 18ºN and 23º N), from which at least several species of *Palmoxylon* and fruits have been reported, is by no means rich in plant fossils. The climate in this area during the Intertrappean period would, therefore, seem to have been more humid than at present and comparable to Sri Lanka or parts of

Plate II



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EXPLANATION OF PLATE II

(a) Leaf trace bundle with protruded xylem part with many small vessels. **(b)** Lacunar ground tissue of the central zone showing the large air spaces and cylindrical cells. **(c)** Longitudinal section of ***Palmoxylon vastanensis*** n. sp.. showing degraded xylem vessel sculpture and air spaces in lateral view. **(d)** Cross section of ***Areca catachu*** to show the fibrovascular bundle with a vessel. **(e)** Ground tissue of the same showing cylindrical parenchyma cells and large air spaces. **(f,g)** Cross section of ***Loxococos rupicola*** showing single vessel in the fibro-vascular bundle, rod-shaped parenchyma cells and irregular air spaces**.** **(h,i)** Cross section of stem of ***Oreodoxa (Roystonea) regia*** Cook. to show fibrovascular bundle with two metaxylem vessels and ribbon- shaped parenchyma cells anastomosing to form large air spaces.

Bengal and Assam. The family Arecaceae containing almost unique group of plants known as palms is a large group both in genera (250) and approximately 2000 species; it differs from any other dicot plants and at the same time is very natural one with a most distinctive appearance. Its geographical range is also distinct, being rigidly limited by tropical climatic conditions (Fig.4). They are one of the most exclusive large tropical families. Such climatic limitation is never absolute in family of any size and to Arecaceae, having representation in subtropical and even in the warm temperate regions. However, the tropical character of the family is emphasized.

The more humid and warm conditions during Pre-Eocene period (especially in the Deccan Intertrappean (Trap Country) which became drier later on, are further indicated by the fact that abundance of the genus *Palmoxylon* known in the area; it is now poor in palms. A little west in Rajasthan (Kapurdi) it indicated much higher rainfall and a moist climate in contrast to the desertic and scrub forests of the present day. However, it became drier and warmer after the Miocene in the northern and western India including Vastan. The present report of the plant megafossil (Palm) belonging to monocotyledons constitutes a first report from the Vastan Lignite Mine.

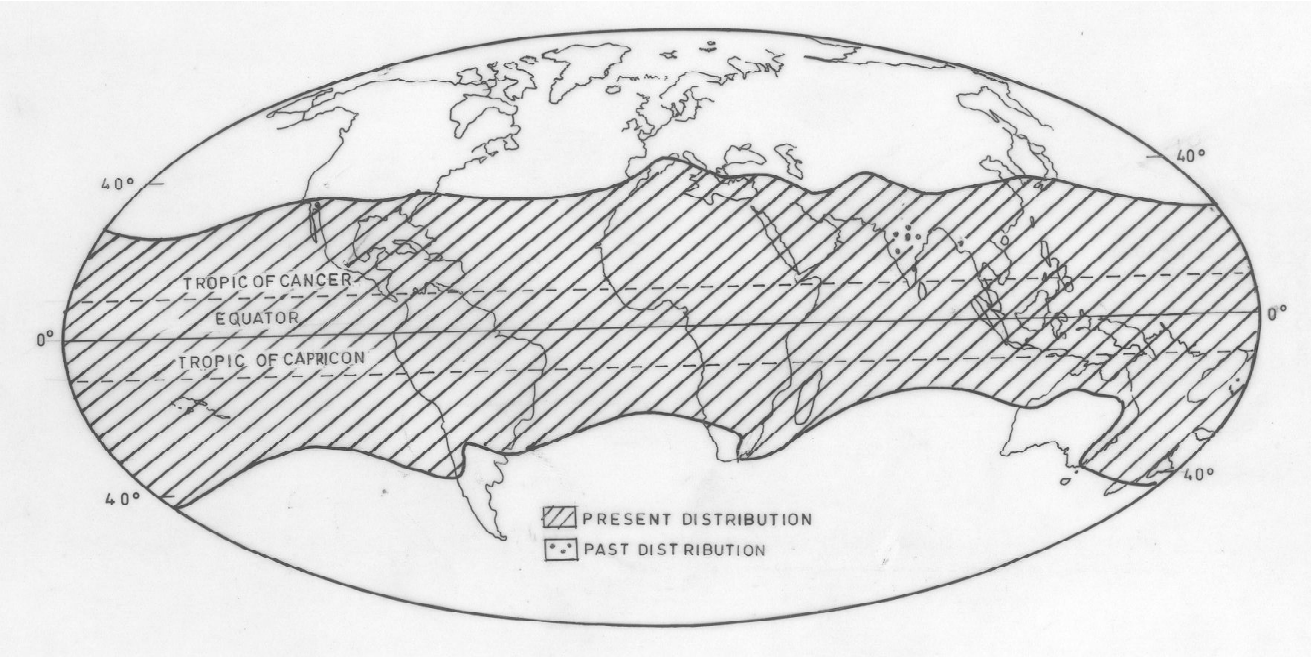

Fig. 4. General latitudinal distribution of family Arecaceaein the world (shaded area).

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