Palynology of subsurface Palaeocene-Eocene sediments near Kapurdi, Barmer District, Rajasthan, India

S.K.M. Tripathi

Tripathi SKM 1995. Palynology of subsurface Palaeocene-Eocene sediments near Kapurdi, Barmer District, Rajasthan, India. *Palaeobotanist* **43** (1) : 45-53.

Palynological study on subsurface samples from four Well Sections drilled near Kapurdi, Barmer District, Rajasthan has been carried out. Recorded palynoflora is rich and diversified being represented by dinoflagellate cysts, fungal remains, pteridophytic spores and angiospermic pollen grains and closely resemble those recorded from Palaeocene-Eocene sediments of Kutch and Rajasthan. Most of the palynotaxa present in the assemblage are presently confined to tropical to subtropical areas. Abundance of pteridophytic spores and epiphyllous microthyriaceous fungi in the assemblage indicates that vicinity of the area where investigated sediments were deposited experienced plenty of rainfall. It is also inferred that sediments under study were deposited in a coastal environment.

Key-words — Palynology, Pteridophytic spores, Angiospermic pollen grains, Palaeocene-Eocene, Rajasthan (India).

S.K.M. Tripathi, Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.

सारॉंश

राजस्थान (भारत) में बाड़मेर जनपद में कपूड़ी के समीप उपसतही पुरानूतन-आदिनूतन अवसादों का परागाणविक अध्ययन

सूर्यकान्तमणि त्रिपाठी

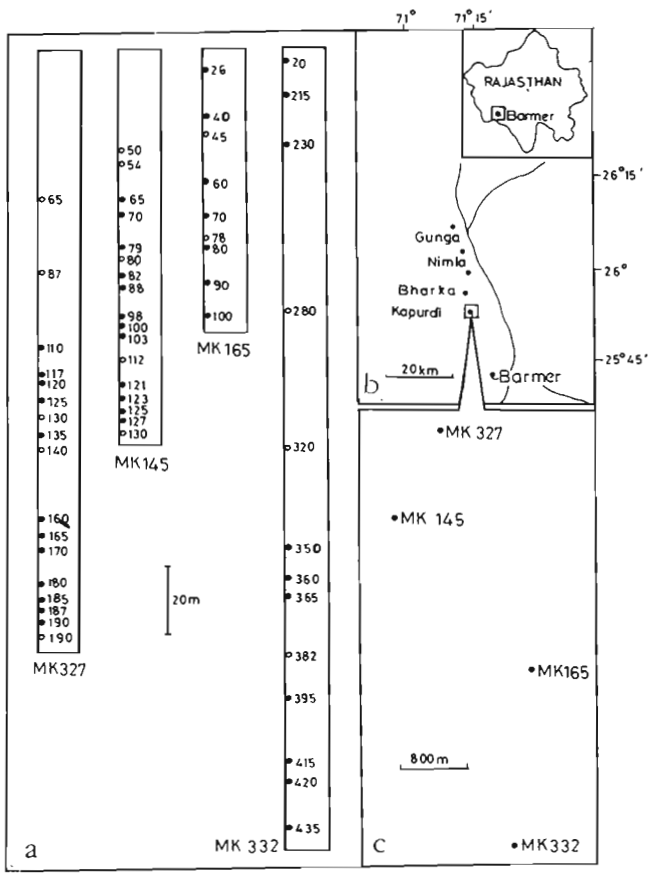
राजस्थान (भारत) में बाड़मेर जनपद में कपूड़ी के निकट ड्रिल किये गये चार कुओं के खण्डों से एकत्रित उपसतही नमूनों का परागाणविक अध्ययन किया गया है। उपलब्ध परागाणुवनस्पतिजात घूर्णीकशाभपुटीयों, कवकीय अवशेषों, टेरीडोफाइटी बीजाणुओं एवं आवृतबीजी परागकणों से भरपूर है तथा कच्छ एवं राजस्थान के पुरानूतन-आदिनूतन कालीन अवसादों से प्राप्त परागाणविकरूपकों से घनिष्ठ समानता व्यक्त करते हैं। समुच्चय से प्राप्त परागाणुवर्गकों में बहुत से वर्तमान उष्णकटिबन्धीय से उपोष्णकटिबन्धीय क्षेत्रों से सम्बद्ध हैं। इस समुच्चय में विद्यमान टेरीडोफाइटी बीजाणुओं एवं एपिफिली सूक्ष्म-थाइरियेसीय कवकों की प्रचुरता से व्यक्त होता है कि इस क्षेत्र के अवसादों का निक्षेपण अत्यधिक वर्षा के समय हुआ था। साथ ही साथ यह भी इंगित होता है कि ये अवसाद तटीय वातावरण में निक्षेपित हुए थे।

PALYNOLOGICAL informations from the Tertiary exposures of Rajasthan are meagre. The only available reports are from Barmer Sandstone, Barmer (Bose, 1952; Jain *et al.*, 1973), Manhera Tibba Structure, Jaisalmer (Lukose, 1974), Bikaner District (Singh & Dogra, 1988), Palana beds (Rao & Vimal, 1950, 1952; Sah & Kar, 1974) and Akli Lignite, Barmer (Naskar & Baksi, 1978) due to which the palynosuccession and palynofloral composition in Rajasthan is less known.

Palynological studies on subsurface samples drilled near Kapurdi, Barmer District, Rajasthan have been conducted and results obtained from four Well Sections, viz., MK-327, MK-165, MK 145 and MK 332 (Text-figure 1) have been presented in this paper. Palynofloras recorded from these Well sections are rich and diversified being represented by dinoflagellate cysts, fungal remains, pteridophytic spores and angiospermic pollen.

GENERAL GEOLOGY AND LITHOSUCCESSION IN BARMER BASIN

The sedimentary tracts in Rajasthan, geologically forming a part of western Rajasthan Shelf, are subdivided into four basins covering an area of about 1,20,000 sq km. Barmer Basin is predominantly in-



Text-figure 1 a. — Location of samples in diagrametically represented Well-sections, **b.** Location of area, **c.** Location of Well sections.

tracratonic type and is comprised of Middle Jurassic to Early Eocene sediments. It is north-south trending graben (Dasgupta, 1977).

The Early Tertiary rocks in Rajasthan are exposed at distant places in Barmer, Bikaner and Jaisalmer districts. Relation of these sediments is not very clear due to intervening desert and alluvium. These lithounits are called by different names in different areas.

Tertiary rocks in Rajasthan basin overlie the Early Cretaceous Habur Formation and have been divided into a lower clastic unit of Palaeocene-Early Eocene age and an upper unit of Middle Eocene age (Nagappa, 1959). Palaeocene sediments in Rajasthan were identified by Sigal *et al.* (1971) in a deep well and was further confirmed by Singh (1976, 1984).

Lithostratigraphy of Tertiary sediments in Barmer Basin is discussed briefly. Palaeocene-Eocene rocks in this basin are represented by Fategarh, Barmer, Akli, Mataji Ka Dungar and Kapurdi formations. Fategarh Formation is made up of sandstone mixed with clay bands. On the basis of lithological similarity this formation has been correlated with nonmarine sandstone member of the subsurface Sanu Formation of Jaisalmer Basin. Its lower part is represented by fluviatile sediments, whereas the upper part is shallow marine in nature. Palynologically, lower part of this formation has been assigned a Palaeocene age (Sah & Kar, 1974).

Akli Formation unconformably overlies the Barmer Formation. Lower part of this formation is a sandstone-lignite sequence while the upper part is a volcanogenic bentonite sequence. Overlying Mataji Ka Dungar Formation is dominantly made up of ferruginous, coarse sandstone with pisolite and pebbly sandstone. The Kapurdi Formation, next in the order of stratigraphy, is made up of Fuller's Earth deposits interbedded with marine bioclastic limestone. The Fuller's Earth deposits indicate lacustrine conditions during deposition.

PALYNOLOGY

Samples on which the present study is based were drilled by Mineral Exploration Corporation Limited. Rock samples from four well sections drilled near Kapurdi have yielded good suits of palynomorphs. Sample positions in studied well sections are given in Text-figure 1. Dinoflagellate cysts have not been included in this communication and thus shall be dealtwith separately. A list of remaining palynotaxa is as follows:

Pteridophytic spores

Lygodiumsporites eocenicus Dutta & Sah 1970
L. lakiensis Sah & Kar 1969
L. pachyexinous Saxena 1978
Todisporites kutchensis Sah & Kar 1969
T. major Couper 1958
T. flavatus Sah & Kar 1969
Dandotiaspora dilata (Mathur) Sah, Kar & Singh 1971
D. telonata Sah, Kar & Singh 1971
D. pseudoauriculata Sah, Kar & Singh 1971
Osmundacidites cephalus Saxena 1978
O. kutchensis Sah & Kar 1969
Lycopodiumsporites palaeocenicus Dutta & Sah 1970

L. umstewensis Dutta & Saḥ 1970
Scantigranulites sparsus Kar 1978
S. triangulus Kar 1978
Monolites mawkmaensis Sah & Dutta 1970
Laevigatosporites lakiensis Sah & Kar 1969

Angiospermic pollen

Arecipites bellus Sah & Kar 1970
Palmidites plicatus Singh in Sah & Singh 1974
P. naviculus Kar & Saxena 1981
P. excellens Kar & Kumar 1986
Palmaepollenites eocenicus (Biswas) Sah & Dutta 1966
P. kutchensis Venkatachala & Kar 1969
P. nadhamunu Venkatachala & Kar 1969
Spinizonocolpites echinatus Muller 1968
Matanomadhiasulcites baculatus (Venkatachala & Kar) Kar 1985
M. kutchensis (Saxena) Kar 1985
M. maximus (Saxena) Kar 1985
M. microreticulatus (Dutta & Sah) Kar & Kumar 1986
Liliacidites major Singh in Sah & Singh 1974
L. magnus Jain, Kar & Sah 1973
L. reticulatus Sah & Kar 1974
Neocouperipollis achinatus (Sah & Kar) Kar & Kumar 1987
N. magnus (Dutta & Sah) Kar & Kumar 1987
N. rarispinosus (Sah & Dutta) Singh 1990
Assamialetes emendatus Singh emend. Singh & Tripathi 1986
Proxapertites assamicus (Sah & Dutta) Singh 1975
P. cursus van Hoeken-Klinkenberg 1966
P. microreticulatus Jain, Kar & Sah 1973
Kapurdipollenites baculatus Tripathi 1994
K. gemmatus Tripathi 1994
Retiverrumonosulcites barmerensis Tripathi 1994
Tricolpites baculatus Jain, Kar & Sah 1973
T. crassireticulatus Dutta & Sah 1970
T. matanomadhensis Saxena 1979
T. levis Sah & Dutta 1966
Retitricolpites robustus Sah & Kar 1970
Margocolporites sahnii Ramanujam 1966
M. sitholeyi Ramanujam 1966
M. tsukadae Ramanujam 1966
Foveotricolporites reticuloidus Kar 1985
Tricolporopollis globosa Dutta & Sah 1970
T. rubra Dutta & Sah 1970
T. matanomadhensis (Venkatachala & Kar) Tripathi & Singh 1985
Proteacidites protrudus Sah & Kar 1970
Caprifoliipites subglobosus Sah & Kar 1974
Palaeocaesalpiniaceaepites eocenica Biswas 1962
Triangulorites bellus (Sah & Kar) Kar 1985
T. pachyexinous Kar & Kumar 1986
Kielmeyerapollenites eocenicus Sah & Kar 1974
Psilastephanocolporites psilatus Kar & Kumar 1986
Retistephanocolpites williamsii Germeraad, Hopping & Muller 1968
Granustephanocolpites sahnii Saxena 1979

Fungal remains and acritarchs

Callimothallus pertusus Dilcher 1965
Phragmothyrites eocenica Edwards 1922
Dicellaesporites popovii Elsik 1968
D. minutus Kar & Saxena 1976
Diporicellaesporites pluricellus Kar & Saxena 1976
D. stacyi Elsik 1968
Diporisporites elongatus van der Hammen 1954
Collumosphaera fruticosa Jain in Dutta & Jain 1980

In addition to the above mentioned palynotaxa, some following forms were also recorded which could not be assigned to any genus or species.

Assamialetes sp.

Pl. 1, figs 18, 19

Description – Pollen grains ovoidal in shape, 100 x 110 µm in size. Monocolpate, colpus long, running along the equator. Exine 12-18 µm thick, sexine much thicker than nexine, sexine reticulate, muri 2-3 µm thick, lumina 1-1.5 µm across.

Occurrence – Well-327 (depth 20 m), Kapurdi, Barmer District, Rajasthan.

Remarks – Present form resembles living pollen of *Eugeissona* (Arecaceae) except that exine in the former is very thick.

Tricolpites sp.

Pl. 1, fig. 12

Description – Pollen grain spheroidal in shape, 68 µm in size. Tricolpate, colpi short, widely open at the equator. Exine 1 µm thick, spinose, spines up to 2 µm long, about 1 µm wide at the base and 2-3 µm apart, interspinal area smooth.

Occurrence– Well MK-327 (depth 165 m), Kapurdi, Barmer District, Rajasthan.

Tricolporopollis sp.

Pl. 1, fig. 9

Description– Pollen grain spherical in shape, 60 µm in size, tricolporate, brevicolpate, apertures subeqatorially placed. Exine about 3 µm thick, retipilate. Muri of the reticulum 1 µm thick, lumen 1.5-2 µm across.

Remarks– The present form differs from other species of the genus in having retipilate exine.

Occurrence– Well MK - 327 (depth 125 m), Kapurdi, Barmer District, Rajasthan.

Fungal Body Type-1

Pl. 1, fig. 20

Description– Fruiting body ovoidal in shape, 100 x 110 µm in size, hyphae forming pseudoparenchymatous cells, no ostiole visible. Rounded spores of 8-10 µm in size, visible inside the fruiting body.

Occurrence– Well - 332 (depth 20 m), Kapurdi, Barmer District, Rajasthan.

PALYNOFLORAL COMPOSITION

Botanical affinities of the recorded palynotaxa and present day distribution of their extant counterparts have been given in Table 1. In the palynoflora, pteridophytic spores are represented by 8 genera and 17 species referable to the families — Lycopodiaceae, Matoniaceae, Polypodiaceae, Osmundaceae and Schizaeaceae. Angiosperms are represented by 26 genera and 46 species attributable to the families Arecaceae, Bombacaceae, Caesalpiniaceae, Caprifoliaceae, Guttiferae, Liliaceae Oleaceae, Onagraceae, Proteaceae and Rubiaceae. Fungal remains are common in the assemblage and include fruiting bodies of epiphyllous fungi and spores.

PALAEOCLIMATE, PALAEOECOLOGY AND ENVIRONMENT OF DEPOSITION

Most of the palynotaxa recorded from four studied Well Sections drilled near Kapurdi appear to be related to families presently confined to tropical-subtropical areas. These are : Schizaeaceae, Arecaceae, Oleaceae, Caesalpiniaceae, Bombacaceae, Rubiaceae and Guttiferae. Other families marking their presence in the assemblage are cosmopolitan in distribution. Temperate elements are completely missing in the assemblage.

A rich and diversified palynoassemblage allows identification of three types of plants which constituted the vegetation at the time of deposition. These are: (i) low-land elements, (ii) fresh-water swamp and water-edge elements, and (iii) coastal elements.

Low-land elements are represented by the

PLATE 1

(All photographs are magnified ca. x 500. Coordinates of specimens in slides refer to stage of Leitz Laborlux microscope no. 513547).

1,2. *Margocolporites sahnii* Ramanujam, Slide nos. BSIP 11218 and 11225; Coordinates : 51.7 x 104.3 and 46.3 x 99.4 respectively.

3. *Tricolpites crassireticulatus* Dutta & Sah, Slide no. BSIP 11224; Coordinates : 52.3 x 109.3.

4. *Tricolpites levis* Sah & Dutta, Slide no. BSIP 11214; Coordinates : 51.2 x 101.3.

5. *Paleocaesalpiniaceaepites eocenica* Biswas, Slide no. BSIP 11220; Coordinates : 47.3 x 103.6.

6. *Collumosphaera fruticosa* Jain in Dutta & Jain, Slide no. BSIP 11202; Coordinates: 52.6 x 103.2.

7. *Trioolporopollis matanomadhensis* (Venkatachala & Kar) Tripathi & Singh, Slide no. BSIP 11222; Coordinates : 48.3 x 98.6.

8. *Caprifolipites subglobosus* Sah & Kar, Slide no. BSIP 11203; Coordinates : 53.4 x 103.7.

9. *Tricolporopollis* sp., Slide no. BSIP 11204; Coordinates : 51.3 x 104.5.

10. *Psilastephanocolporites psilatus* Kar & Kumar, Slide no. BSIP 11205; Coordinates : 48.3 x 106.4.

11 *Kapurdipollenites gemmatus* Tripathi, Slide no. BSIP 10895; Coordinates : 70.5 x 110.4.

12. *Tricolpites* sp., Slide no. BSIP 11209; Coordinates : 48.7 x 98.3.

13. *Kapurdipollenites baculatus* Tripathi, Slide no. BSIP 10893; Coordinates: 51.4 x 102.6.

14. *Retistephanocolpites williamsii* Germeraad, Hopping & Muller, Slide no. BSIP 11217; Coordinates: 53.6 x 104.3.

15, 16. *Triangulorites bellus* (Sah & Kar) Kar, Slide no. BSIP 11206 and 11228; Coordinates : 54.5 x 102.3 and 49.4 x 98.6 respectively.

17. *Proteacidites protrudus* Sah & Kar, Slide no. BSIP 11207; Coordinates : 53.6 x 102.7.

18, 19. *Assamialetes* sp., Slide no. BSIP 11216; Coordinates: 48.6 x 104.6 and 60.2 x 104.6 respectively.

20. Fungal body Type-1., Slide no. BSIP 11217; Coordinates: 52.4 x 102.3.

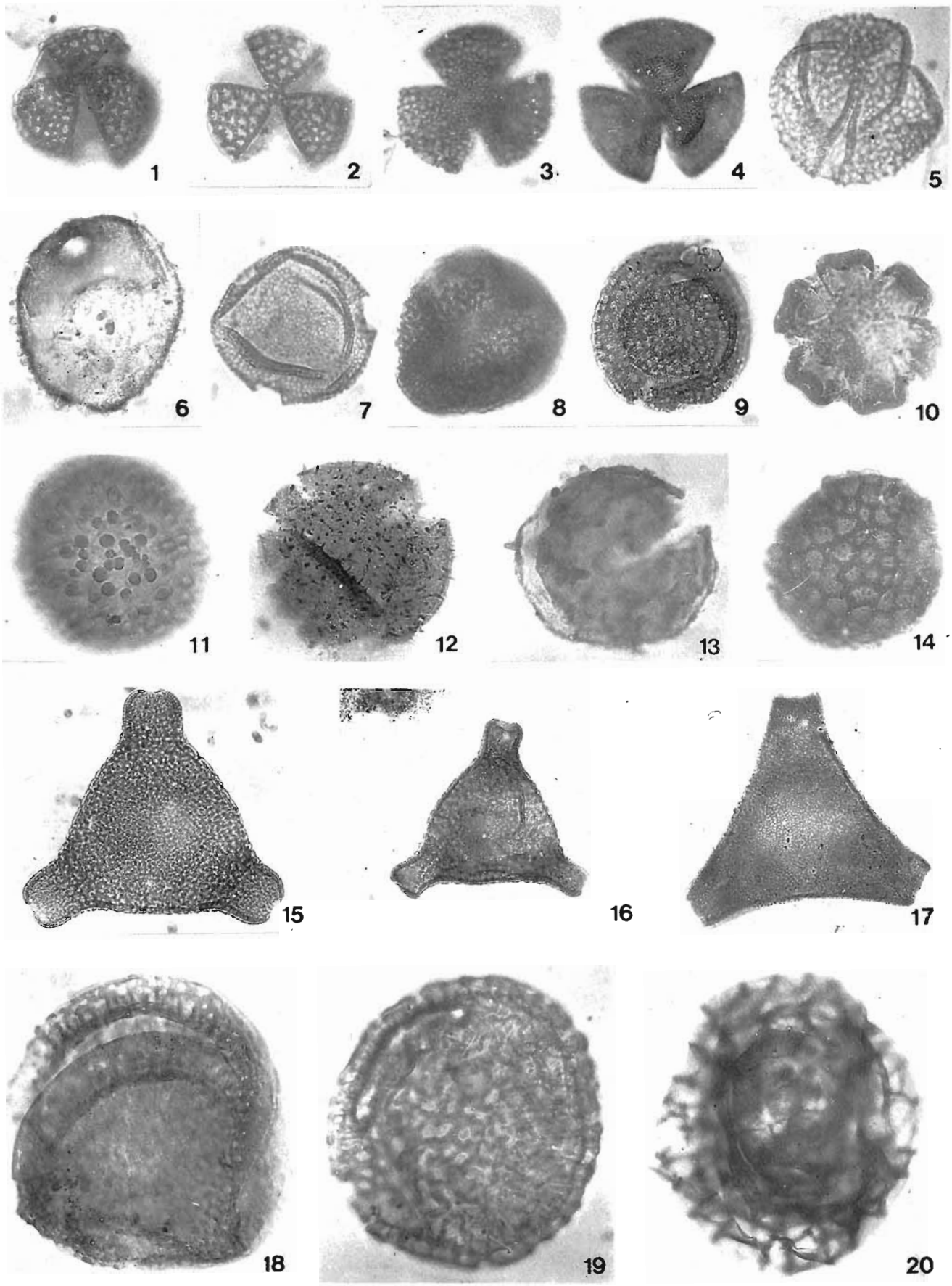


PLATE 1

families Rubiaceae and Bombacaceae. The family Bombacaceae is profusely represented by different species of the genus *Tricolporopollis*. Fresh-water swamp and water-edge elements constitute a major part of the palynoflora. This group is represented by pteridophytic spores and angiospermic pollen belonging to families Schizaeaceae, Polypodiaceae, Liliaceae and Caesalpiniaceae. A coastal vegetation thriving near the area of deposition is indicated by the presence of variety of palynofossils related to the family Arecaceae. This group is also richly represented in the flora.

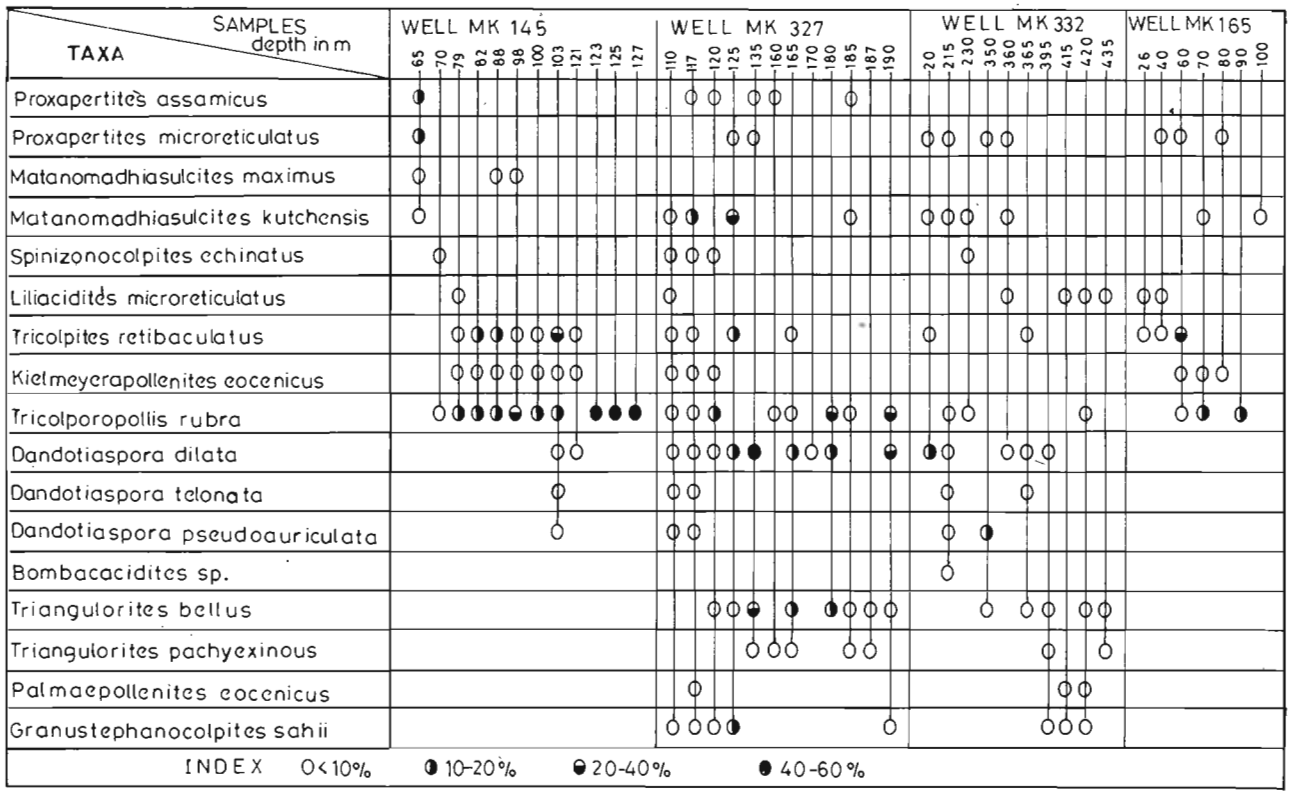
Abundance of pteridophytic spores and epiphyllous microthyriaceous fungi indicates a tropical climate with plenty of rainfall. Environment of deposition of investigated samples from Well sections, as indicated by the present studies, was coastal.

Table 1 — Botanical affinities of recorded palynotaxa and present day distribution of their extant counterparts

FAMILIES	PALYNOTAXA	PRESENT DAY DISTRIBUTION
Osmundaceae	*Todisporites kutchensis, T. major, T. flavatus, Osmundacidites cephalus, O. kutchensis*	Cosmopolitan
Matoniaceae	*Dandotiaspora dilata, D. telonata, D. pseudoauriculata*	Cosmopolitan
Polypodiaceae	*Monolites mawkmaensis, Laevigatosporites lakiensis*	Cosmopolitan
Lycopodiaceae	*Lycopodiumsporites palaeocenicus, L. umstewensis*	Cosmopolitan
Schizaeaceae	*Lygodiumsporites eocenicus L. lakiensis, L. pachyexinous*	Tropical-subtropical
Arecaceae	*Neocouperipollis achinatus, N. magnus, N. rarispinosus, Proxapertites assamicus, P. cursus, P. microreticulatus, Kapurdipollenites baculatus, K. gemmatus, Retiverrumonosulcites barmerensis, Spinizonocolpites echinatus, Arecipites bellus, Palmaepollenites eocenicus, P. kutchensis, Tropical-subtropical P. nadhamunii, Palmidites plicatus, P. naviculatus, P. excellensus*	Tropical-subtropical
Liliaceae	*Liliacidites major, L. magnus, L. reticulatus, Matanomadhiasulcites baculatus, M. kutchensis, M. maximus, M. microreticulatus*	Cosmopolitan
Oleaceae	*Tricolpites baculatus, T. crassireticulatus, T. matanomadhensis, T. levis, Retitricolpites robustus*	Cosmopolitan (Chiefly tropical)
Caesalpiniaceae	*Margocolporites tsukadae, M. sitholeyi, M. sahnii, Palaeocaesalpiniaceaepites eocenica*	Tropical-subtropical
Bombacaceae	*Tricolporopollis rubra, T. globosa, T. matanomadhensis*	Tropical-subtropical
Proteaceae	*Proteacidites protrudus*	Tropical-subtropical
Rubiaceae	*Foveotricolporites reticuloides*	Tropical-subtropical
Onagraceae	*Triangulorites bellus, T. pachyexinous*	Cosmopolitan
Caprifoliaceae	*Caprifoliipites subglobosus*	Cosmopolitan
Guttiferae	*Kielmeyerapollenites eocenicus*	Tropical

QUANTITATIVE ANALYSIS

Frequency and distribution of stratigraphically significant palynotaxa in the samples of four studied Well sections have been given in Text-figure 2. Two Well sections, viz., MK - 145 and MK - 165 exhibit almost similar patterns with regard to distribution and frequency of different palynotaxa. Dominance of angiospermic pollen over pteridophytic spores is



Text-figure 2 — Frequency and distribution of significant palynotaxa in Well Sections.

noticed in these two Wells. *Proxapertites assamicus, P. microreticulatus, T. retibaculatus, Tricolporopollis rubra* and *Kielmeyerapollenites eocenicus* are the most common pollen encountered in MK - 145 Well Section. Different species of *Tricolporopollis, Matanomadhiasulcites* and *Dandotiaspora* register a high frequency in MK-327 and MK- 332 Wells.

PALYNOFLORAL COMPARISON AND AGE

Present palynofloral assemblage is closely comparable with those recorded from Palaeocene-Eocene sediments of Kutch (Kar, 1978, 1985; Saxena, 1978) and Rajasthan (Jain *et al.*, 1973; Sah & Kar, 1974; Naskar & Baksi, 1978; Singh & Dogra, 1988).

Miofloral resemblance between the present assemblage and that recorded from Matanomadh Formation is striking. Forms common between *Dandotiaspora dilata* Cenozone (Saxena, 1981) and *Neocouperipollis brevispinosus* Cenozone (Saxena, 1981) of Matanomadh Formation, Kutch and the palynological assemblage from Kapurdi Well sections are : *Dandotiaspora dilata, D. telonata, Lygodiumsporites eocenicus, L. lakiensis, Todisporites major, Palmaepollenites nadhamunii, P. kutchensis, Neocouperipollis rarispinosus, N. achinatus, Tricolporopollis matanomadhensis* and *Kielmeyerapollenites eocenicus*. Forms recorded in the two above mentioned cenozones of Matanomadh Formation and absent in the present assemblage are : *Retipilonapites cenozoicus, Tricolpites minutus, Trilatiporites kutchensis, Sonneratioipollis bellus* and *Lakiapollis ovatus*.

Several palynotaxa recorded in *Meliapollis ramanujamii* Subzone and *Tricolpites reticulatus* subzones (Kar, 1985) of Panandhro Section, Panandhro, Kutch are also present in the present assemblage. These are : *Proxapertites microreticulatus, Palmaepollenites nadhamunii, Neocouperipollis achinatus* and *Lygodiumsporites lakiensis*.

Palynotaxa present in two above mentioned subzones of Panandhro Section but absent in the present assemblage are : *Lakiapollis ovatus, Der-*

matobrevicolporites dermatus, Meliapollis quadrangularis, Pellicieroipollis langenheimii and *Umbelliferoipollenites ovatus.*

Palynofloras recorded from Palaeocene-Eocene sediments of Rajasthan by other workers are very similar to the present assemblage. Forms common between the Palana assemblage (Sah & Kar, 1974), Sp- 4 and Sp- 5 Zone assemblages (Singh & Dogra, 1978), Akli Lignite assemblage (Naskar & Baksi, 1978) and Barmer Assemblage (Jain *et al.*, 1973) and the present assemblage are : *Dandotiaspora dilata, D. telonata,, Liliacidites major, L. magnus, L. reticulatus, Neocouperipollis rarispinosus, Palmaepollenites eocenicus, Proxapertites assamicus, P. microreticulatus, Triangulorites bellus, Tricolporopollis matanomadhensis, Tricolpites baculatus, T. levis* and *Kielmeyerapollenites eocenicus* Based on palynological studies a Palaeocene-Eocene age has been assigned to the studied Well sections.

ACKNOWLEDGEMENT

Author is thankful to Dr R.K. Saxena, Assistant Director, B.S.I.P., Lucknow, for his helpful suggestions.

REFERENCES

Biswas B 1962. Stratigraphy of the Mahadeo, Langpar, Cherra and Tura formations, Assam, India. *Bull. geol. Min. metall. Soc. India* **25** : 1-48.

Bose MN 1952. Plant remains from Barmer District, Rajasthan. *J. scient. industr. Res.* **11B**(5) : 185-190.

Couper C 1958. British Mesozoic miospores and pollen grains : A systematic study. *Palaeontographica* **103 B** : 75-179.

Dasgupta SK 1977. The stratigraphy of the West Rajasthan Shelf. *Proc. 4th Colloq. Indian Micropalaeontol. Stratigr.* : 219- 233.

Dilcher DL 1965. Epiphyllous fungi from Eocene deposits in western Tennessee, U.S.A. *Palaeontographica* **116** : 1- 54.

Dutta SK & Jain KP 1980. Geology and palynology of the area around Lumshnong, Jaintia Hills, Meghalaya, India. *Biol. Mem.* **5**(1) : 56-81.

Dutta SK & Sah SCD 1970. Palynostratigraphy of the Tertiary sedimentary formations of Assam. 5. Stratigraphy and palynology of South Shillong Plateau. *Palaeontographica* **131**: 1- 72.

Edwards WN 1922. An Eocene microthyriaceous fungus from Mull, Scotland. *Trans. Brit. mycol. Soc.* **8** : 66-72.

Elsik WC 1968. Palynology of Palaeocene Rockdale Lignite, Milam County, Texas 1. Morphology and taxonomy. *Pollen Spores* **10**(2) : 263-314.

Germeraad JH, Hopping CA & Muller J 1968. Palynology of Tertiary sediments from tropical areas. *Rev. Palaeobot. Palynol.* **6** (3 & 4) : 189-348.

Hammen T van der 1954. El desarrollo de la Flora Colombiana en los periodos geologicos 1. Maestrichtiano Hasta Terciario mas Inferior. *Boln. geol. Bogota* **11**(1) : 49-106.

Hoeken-Klinkenberg PMJ van 1966. Maestrichtian, Palaeocene and Eocene pollen and spores from Nigeria. *Leids. geol. Medl.* **38**: 37-48.

Jain KP, Kar RK & Sah SCD 1973. A palynological assemblage from Barmer, Rajasthan. *Geophytology* **3**(2) : 150-165.

Kar RK 1978. Palynostratigraphy of the Naredi (Lower Eocene) and Harudi (Middle Eocene) formations in district of Kutch, India. *Palaeobotanist* **25** : 161-178.

Kar RK 1985. The fossil floras of Kachchh- IV Tertiary palynostratigraphy. *Palaeobotanist* **34** : 1-280.

Kar RK & Kumar M 1986. Palaeocene palynostratigraphy of Meghalaya. *Pollen Spores* **28**(2) : 177-218.

Kar RK & Kumar M 1987. *Neocouperipollis*– A new name for *Couperipollis* Venkatachala & Kar. *Palaeobotanist* **35**(2) : 171-174.

Kar RK & Saxena RK 1976. Algal and fungal microfossils from Matanomadh Formation (Palaeocene), Kutch, India. *Palaeobotanist* **23**(1) : 1-15.

Kar RK & Saxena RK 1981. Palynological investigation of a bore core near Rataria, southern Kutch, Gujarat. *Geophytology* **11**: 103-124.

Lukose NG 1974. Palynology of subsurface sediments of Manhera-Tibba Structure, Jaisalmer, western Rajasthan, India. *Palaeobotanist* **21**(2) : 285-297

Muller J 1968. Palynology of the Pedawan and Plateau Sandstone formations (Cretaceous-Eocene) in Sarawak, Malaysia. *Micropaleontology* **14** : 1-37.

Nagappa Y 1959. Foraminiferal biostratigraphy of the Cretaceous- Eocene succession in India, Pakistan and Burma regions. *Micropaleontology* **5** : 145-192.

Naskar P & Baksi SK 1978. Palynological investigation of Akli lignite, Rajasthan. *Palaeobotanist* **25** 314-329.

Ramanujam CGK 1966. Palynology of the Miocene Lignite from South Arcot District, Madras, India. *Pollen Spores* **8**(1) : 149-203.

Rao AR & Vimal KP 1950. Plant microfossils from Palana Lignite (Eocene), Bikaner. *Curr Sci.* **19** : 82-84.

Rao AR & Vimal KP 1952. Tertiary pollen from lignites of Palana (Eocene), Bikaner. *Proc. natn. Inst. Sci. India* **18**(6) : 595-601.

Sah SCD & Dutta SK 1966. Palynostratigraphy of the sedimentary formations of Assam-1. Stratigraphic position of the Cherra Formation. *Palaeobotanist* **15** (1-2) : 72-86.

Sah SCD & Kar RK 1969. Pteridophytic spores from the Laki Series of Kutch, Gujarat, India. *In* Santapu H *et al.* (Editors) – *J. Sen Memorial Volume* : 109-122. Botanical Society Bengal, Calcutta.

Sah SCD & Kar RK 1970. Palynology of the Laki sediments in Kutch 3. Pollen from the bore-holes around Jhulari, Baranda and Panandhro. *Palaeobotanist* **18**(2) : 127-142.

Sah SCD & Kar RK 1974. Palynology of the Tertiary sediments of Palana, Rajasthan. *Palaeobotanist* **21**(2) : 163-188.

Sah SCD, Kar RK & Singh RY 1971. Stratigraphic ranges of *Dandotiaspora* gen. nov. in the Lower Eocene sediments in India. *Geophytology* **1**(1) : 54-63.

Sah SCD & Singh RY 1974. Palynological biostratigraphy of the Tura Formation in the type area. *In* Sah SCD & Cross AT (Editors) –

Symposium on Stratigraphical Palynology, 1971, Spl. Publ. **3** : 76-98. Birbal Sahni Institute of Palaeobotany, Lucknow.

Saxena RK 1978. Palynology of the Matanomadh Formation in type area, north-western Kutch, India (Part 1). Systematic description of pteridophytic spores. *Palaeobotanist* **25** : 448-456.

Saxena RK 1979. Palynology of the Matanomadh Formation in type area, north-western Kutch, India (Part 2). Systematic description of gymnospermous and angiospermous pollen grains. *Palaeobotanist* **26**(2) : 130-143.

Saxena RK 1981. Stratigraphy of the area around Matanomadh in north-western Kutch with special reference to the Matanomadh Formation. *Palaeobotanist* **27**(3) : 300-313.

Sigal J, Singh NP & Lys M 1971. Palaeocene-Eocene boundary in the Jaisalmer area, India. *J. Foram. Res.* **1** : 190-194.

Singh HP & Tripathi SKM 1986. Observations on some Tertiary zonisulcate pollen grains. *Palaeobotanist* **35**(1) : 48-52.

Singh NP 1976. Micropalaeontological control in subsurface Tertiary sequence of Jaisalmer Basin, western Rajasthan, India. *Proc. 4th Indian Colloq. Micropalaeont. Stratigr., Varanasi* : 256-278.

Singh NP 1984. Addition to the Tertiary biostratigraphy of Jaisalmer Basin. *Petroleum Asia J.* : 106-128.

Singh RY 1975. Morphological study of the *Retialetes* complex from Indian Tertiaries. *Geophytology* **5**(1) : 98-104.

Singh RY & Dogra NN 1988. Palynological zonation of Palaeocene in India with special reference to western Rajasthan. *In* Maheshwari HK (Editor) – *Palaeocene of India : Proceedings of the Symposium on Palaeocene of India : Limits and subdivisions 1986* : 51-64. Indian Association of Palynostratigraphers, Lucknow.

Tripathi SKM 1994. New angiosperm pollen from subsurface Early Palaeogene sediments of Barmer District, Rajasthan, India. *Palaeobotanist* **42**(1) : 61-65.

Tripathi SKM & Singh HP 1985. Palynology of the Jaintia Group (Palaeocene-Eocene) exposed along Jowai-Sonapur Road, Meghalaya, India, Part 1. Systematic palynology. *Geophytology* **15**(2) : 164-184.

Venkatachala BS & Kar RK 1969. Palynology of Tertiary sediments of Kutch-1. Spores and pollen from bore-hole no. 14. *Palaeobotanist* **17**(2) : 157-178.