The Palaeobotanist, **26**(3): 279-296, 1980.

PALYNOLOGY OF THE MATANOMADH FORMATION IN TYPE AREA, NORTH WESTERN KUTCH, INDIA (PART-3)— DISCUSSION

R. K. SAXENA

Birbal Sahni Institute of Palaeobotany, Lucknow-226 007, India

ABSTRACT

The analysis and interpretation of the palynofloral assemblage from the Matanomadh Formation have been discussed. The assemblage consists of 65 genera and 113 species. Of these, 10 genera and 13 species are of algal remains, 10 genera and 14 species of fungal remains, 14 genera and 27 species of pteridophytic spores, 3 genera and 3 species of gymnospermous pollen grains and 28 genera and 56 species of angiospermous pollen grains. Among the angiosperms, 6 genera and 16 species belong to monocotyledonous pollen while 22 genera and 40 species are of dicotyledonous pollen.

A comparison of the Matanomadh assemblage with the known Palaeocene-Lower Eocene assemblages from the various sedimentary basins in the Indian subcontinent has been made and it is deduced that the Matanomadh Formation is contemporaneous to the Cherra Formation of Shillong Plateau, Tura Formation of Garo Hills and Dandot lignite of Pakistan and is Palaeocene in age. The evidences derived from the order of superposition and palaeontology also support the Palaeocene dating of this formation.

On the basis of palynomorphs representation, the palaeoclimate during the deposition of the Matanomadh Formation has been deduced as tropical-subtropical. The environment of deposition for this formation is interpreted as ranging from fluviatile to estuarine.

Key-words — Palaeopalynology, Matanomadh Formation, Palaeocene, North-western Kutch (India).

साराँश

उत्तर-पश्चिमी कच्छ, भारत में मातानोमढ़ शैल-समूह के प्ररूप क्षेत्र का परागाणविक अध्ययन (भाग-3) विवेचन — रमेश कुमार सक्सेना

मातानोमढ़ शैल-समूह से परागाणविक-वनस्पति जातीय समुच्चय के विश्लेषण तथा निर्वचन विवेचित किये गये हैं। समुच्चय में 65 प्रजातियाँ व 113 जातियाँ विद्यमान हैं। उनमें से 10 प्रजातियाँ व 13 जातियाँ शैवालीय अवशेषों की, 10 प्रजातियाँ व 14 जातियाँ कवक अवशेषों की, 14 प्रजातियाँ व 27 जातियाँ टेरिडोफ़ाइटी बीजाणुओं की, 3 प्रजातियाँ व 3 जातियाँ अनावृतबीजी परागकणों की तथा 28 प्रजातियाँ व 56 जातियाँ आवृतबीजी परागकणों की हैं। आवृतबीजीयों में 6 प्रजातियाँ व 16 जातियाँ एकबीजपत्रीय हैं जबकि 22 प्रजातियाँ व 40 जातियाँ द्विबीजपत्रीय हैं।

भारतीय उपमहाद्वीप में विभिन्न अवसादी बेसिनों से ज्ञात पेलियोसीन-अधर ईओसीन समुच्चयों की तुलना मातानोमढ़ समुच्चय से की गई है तथा यह उपकलित किया गया है कि मातानोमढ़ शैल-समूह शिलौंग पठार के चेरा शैल-समूह, गारो पहाड़ियों के तूरा शैल-समूह तथा पाकिस्तान के डन्डोत लिग्नाइट के समकालीन है और पेलियोसीन युग का है। अध्यारोपणक्रम तथा जीवाश्मविज्ञान के प्रमाण भी इस शैल-समूह के पेलियोसीन कालीन होने की पुष्टि करते हैं।

परागाणविकरूपकों के निरूपण के आधार पर मातानोमढ़ शैल-समूह के निक्षेपण काल की पुराजलवायु उष्णकटिबंधीयउपोष्ण उपकलित की गई है। इसके निक्षेपण का वातावरण नदीय से ज्वारनदमुखीय तक निर्वचित किया गया है।

INTRODUCTION

THE term Matanomadh Formation was instituted by Biswas and Raju (1971, 1973) for the basal lithostratigraphic unit of the Tertiary succession of Kutch. In the type area, this formation conformably overlies the Deccan Trap Formation and is conformably overlain by the Naredi Formation. On lithological ground, Saxena (1977b) divided this formation into 2 members, viz., Laterite Member and Clastic Member. The Laterite Member is composed of white-mottled kaolinitic clays and pink, grey, pale-red and variegated bauxitic laterites; while the Clastic Member is made up of ferruginous and gritty sandstones, tuffaceous and carbonaceous shales, alum shales, bentonitic and ferruginous clays, volcanic ash, tuff and lignitic shales etc. The contact between these two members is unconformable (Text-fig. 1).

Mathur (1966), for the first time, described fossil palynomorphs including pteridophytic spores and gymnospermous and angiospermous pollen grains from the Matanomadh Formation (= Supratrappeans) of Kutch. On the basis of the palynomorphs recovered, he assigned a Palaeocene age to these sediments and concluded the prevalence of tropical-subtropical climate and subaquatic to terrestrial environment of deposition.

Systematic palynology of the Matanomadh Formation has been reinvestigated which revealed the presence of a rich palynoflora consisting of algal and fungal remains, pteridophytic spores and gymnospermous and angiospermous pollen grains (Kar & Saxena, 1976; Saxena, 1978, 1979).

In the present paper, the qualitative and quantitative analyses of the Matanomadh palynoflora, its comparison with other known Palaeocene-Lower Eocene assemblages from Indian subcontinent, age, palaeoclimate and depositional environment of the Matanomadh Formation are discussed.

PALYNOFLORAL ASSEMBLAGE

ALGAE

Botryococcus palanaensis Sah & Kar, *Tetraporina apora* Sah & Kar, *Cephalia globata* Sah & Kar, *Octaplata rotunda* Sah & Kar, *Palanaea granulosa* Sah & Kar, *P. laevigata* Sah & Kar, *Cryptosphaera valvata* Sah & Kar, *Cornplanktona unicorna* Sah & Kar, *Leioplanktona madhensis* Kar & Saxena, *L. verrucosa* Kar & Saxena, *Spinasphaera robusta* Kar & Saxena, *Matanomadhia indica* Kar & Saxena, *M. ovata* Kar & Saxena, *Matanomadhia* sp., Microplankton types 1-4.

FUNGI

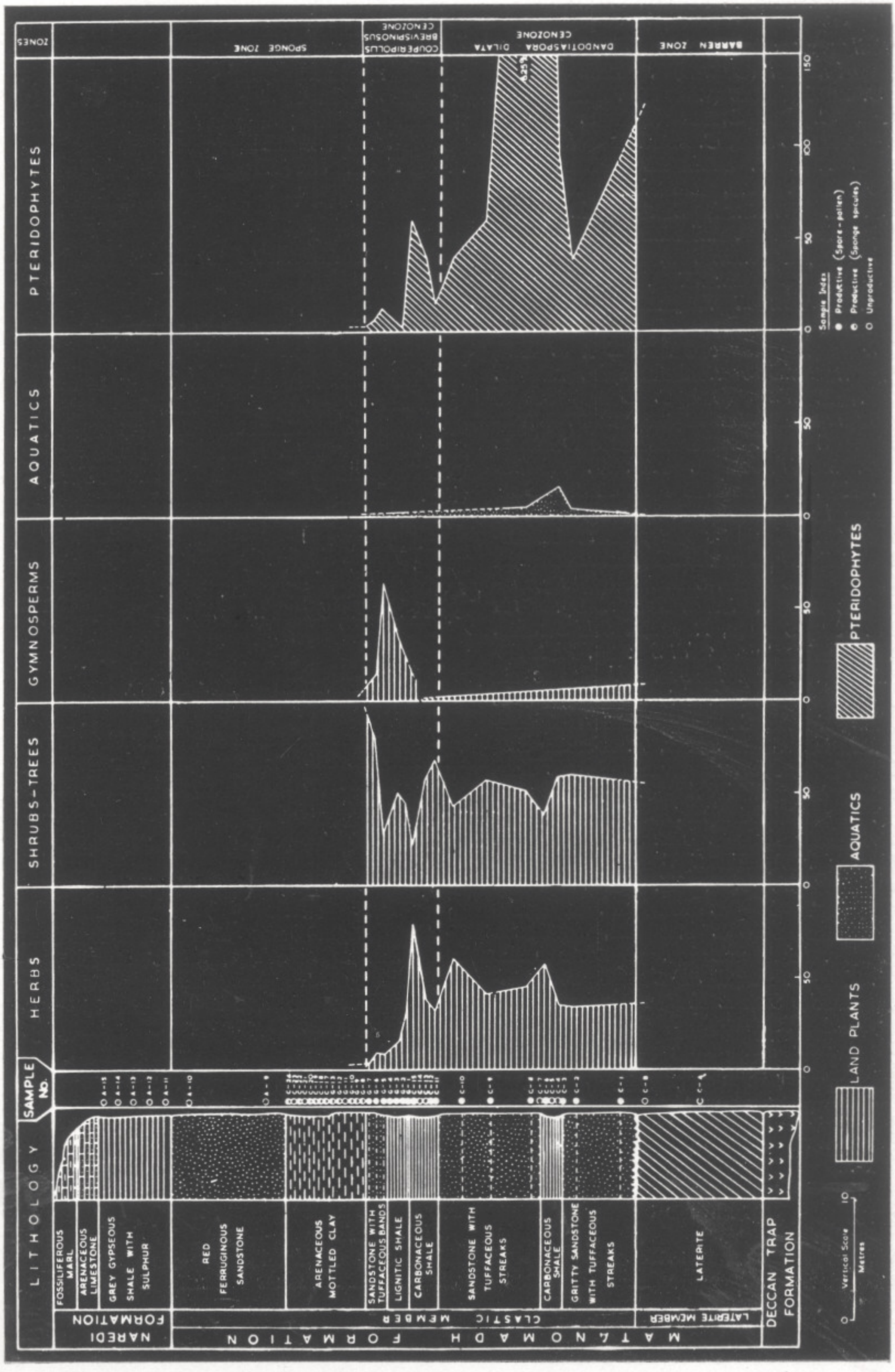
Phragmothyrites eocaenica (Edwards) Kar & Saxena, *Notothyrites setiferus* Cookson, *N. amorphus* Kar & Saxena, *Notothyrites* sp. cf. *N. amorphus* Kar & Saxena, cf. *Notothyrites* sp., *Inapertisporites kedvesii* Elsik, *Inapertisporites* sp., *Pluricellaesporites planus* Trivedi & Verma, *Dicellaesporites popovii* Elsik, *D. minutus* Kar & Saxena, *Multicellaesporites elsikii* Kar & Saxena, *Monoporisporites stoverii* Elsik, *Diporisporites elongatus* van der Hammen, *D. ankleshwarensis* (varma & Rawat) Elsik, *Diporicellaesporites stacyi* Elsik, *D. pluricellus* Kar & Saxena, *Involutisporonites kutchensis* Kar & Saxena.

PTERIDOPHYTIC SPORES

Cyathidites australis Couper, *C. minor* Couper, *Lygodiumsporites eocenicus* Dutta & Sah, *L. lakiensis* Sah & Kar, *L. pachyexinus* Saxena, *Todisporites major* Couper, *T. minor* Couper, *T. kutchensis* Sah & Kar, *Dandotiaspora dilata* (Mathur) Sah, Kar & Singh, *D. plicata* (Sah & Kar) Sah, Kar & Singh, *D. telonata* Sah, Kar & Singh, *D. pseudoauriculata* Sah, Kar & Singh, *Dictyophyllidites granulatus* Saxena, *Intrapunctisporis intrapunctis* Krutzsch, *I. apunctis* Krutzsch, *Osmundacidites minutus* Sah & Jain, *O. cephalus* Saxena, *Leptolepidites major* Couper, *Foveosporites* sp., *Lycopodiumsporites bellus* Sah & Kar, *L. umstewensis* Dutta & Sah, *Cicatricosisporites australiensis* (Cookson) Potonié, *C. pseudotripartitus* (Bolkhovitina) Dettmann, *Cicatricosisporites* sp., *Gleicheniidites senonicus* Ross, *Polypodiaceaesporites levis* Sah, *P. major* Saxena, *Polypodiaceaesporites* sp., *Polypodiisporites repandus* Takahashi, *P. mawkmaensis* Dutta & Sah, *Polypodiisporites* sp.

GYMNOSPERMOUS POLLEN GRAINS

Podocarpidites ellipticus (Cookson) Potonié, *Laricoidites punctatus* Saxena, *Laricoidites* sp., *Araucariacites australis* Cookson,



TEXT-FIG. 1 — Showing the percentage of various plant groups expressed in terms of land plants.

Angiospermous Pollen Grains

Retipilonapites cenozoicus Sah, *Couperipollis wodehousei* (Biswas) Venkatachala & Kar, *C. brevispinosus* (Biswas) Venkatachala & Kar, *C. rarispinosus* (Sah & Dutta) Venkatachala & Kar, *C. kutchensis* Venkatachala & Kar, *C. achinatus* Sah & Kar, *C. robustus* Saxena, *Liliacidites maximus* Saxena, *L. kutchensis* Saxena, *L. matanomadhensis* Saxena, *Liliacidites* cf. *L. maximus* Saxena, *Palmidites maximus* Couper, *Palmaepollenites kutchensis* Venkatachala & Kar, *P. nadhamunii* Venkatachala & Kar, *P. ovatus* Sah & Kar, *P. plicatus* Sah & Kar, *Dracaenoipollis circularis* Sah & Kar, *Proxapertites microreticulatus* Jain, Kar & Sah, *P. assamicus* (Sah & Dutta) Singh, *Tricolpites reticulatus* Cookson, *T. parvireticulatus* Sah, *T. crassireticulatus* Dutta & Sah, *T. brevis* Sah & Kar, *T. minutus* Sah & Kar, *T. baculatus* Jain, Kar & Sah, *T. retibaculatus* Saxena, *T. matanomadhensis* Saxena, *Verrutricolpites perverrucatus* Ramanujam, *Psilastephanocolpites guaduensis* (van der Hammen) Saxena, *Ghoshiacolpites globatus* Sah & Kar, *Retistephanocolpites flavatus* (Sah & Kar) Saxena, *R. kutchensis* Saxena, *Granustephanocolpites sahii* Saxena, *Platoniapollenites* sp., *Lakiapollis ovatus* Venkatachala & Kar, *L. matanomadhensis* Venkatachala & Kar, *L. spinosus* Saxena, *Paleosantalaceaepites ellipticus* Sah & Kar, *P. minutus* Sah & Kar, *Verrucolporites verrucus* Sah & Kar, *Striacolporites cephalus* Sah & Kar, *S. ovatus* Sah & Kar, *Favitricolporites retiformis* Sah, *Palaeocoprosmadites arcotense* Ramanujam, *Meliapollis ramanujamii* Sah & Kar, *M. navalei* Sah & Kar, *M. quadrangularis* (Ramanujam) Sah & Kar, *M. melioides* (Ramanujam) Sah & Kar, *M. triangulus* Saxena, cf. *Meliapollis* sp., *Triorites bellus* Sah & Kar, *T. triradiatus* Saxena, *Proteacidites protrudus* Sah & Kar, *Triporopollenites minutiformis* (Ramanujam) Saxena, *Trilatiporites cooksonii* Ramanujam, *T. kutchensis* Venkatachala & Kar, *Sonneratioipollis bellus* Venkatachala & Kar, *Pseudonothofagidites kutchensis* Venkatachala & Kar, *Kielmeyerapollenites eocenicus* Sah & Kar, pollen types 1-3.

DISCUSSION

Pteridophytic spores and angiospermous pollen grains are the dominant constituents of the Matanomadh assemblage while gymnospermous elements are comparatively poorly represented. Algal and fungal remains are also present whereas bryophytic elements seem to be totally absent. The qualitative and quantitative analysis of the palynofloral assemblage from the Matanomadh Formation has been discussed below.

QUALITATIVE ANALYSIS

Division — Thallophyta

Algal and fungal remains comprising algal filament, microplanktons, fungal spores and epiphyllous microthyriaceous fungi were recovered from almost all the levels of the Clastic Member of the Matanomadh Formation. The algal remains are represented by 10 genera and 13 species while fungal remains are represented by 10 genera and 14 species. Their systematic description and discussion have already been published by Kar and Saxena (1976).

Division — Bryophyta

There is no conclusive evidence that might indicate the presence of bryophytic elements throughout the deposition of the Matanomadh Formation.

Division — Pteridophyta

Pteridophytic spores are richly represented in the Matanomadh Formation. From spore morphology and comparison with their nearest living relatives it appears that they might be related to the following 7 families:

(i) *Lycopodiaceae* — The spores referred to *Lycopodiumsporites bellus* Sah & Kar, *L. umstewensis* Dutta & Sah and *Foveosporites* sp. show definite affinity with this family. The family is found both in tropical and temperate climate and generally favours moist and shady places.

(ii) *Osmundaceae* — The following 5 species show close relationship with this family, viz., *Osmundacidites minutus* Sah & Jain, *O. cephalus* Saxena, *Todisporites major* Couper, *T. minor* Couper and *T. kutchensis* Sah & Kar. It is quite likely that all of them might represent this family. Members of this family are found both in tropical and temperate region. Their preferred habitat is, however, damp woods and thickets.

(iii) *Schizaeaceae*— Spores described under *Cicatricosisporites australiensis* (Cookson) Potonié, *C. pseudotripartitus* (Bolkhovitina) Dettmann, *Cicatricosisporites* sp., *Leptolepidites major* Couper, *Lygodiumsporites lakiensis* Sah & Kar, *L. eocenicus* Dutta & Sah and *L. pachyexinus* Saxena are of schizaeaceous origin, while the spores described under *Intrapunctisporis intrapunctis* Krutzsch and *I. apunctis* Krutzsch may doubtfully be referred to this family. This family, especially the genus *Lygodiumsporites* (Potonié, Thomson & Thiergart) Potonié, is well represented in the Matanomadh assemblage. The present day distribution of this family is restricted to tropical and subtropical region.

(iv) *Gleicheniaceae* — This family is very poorly represented in the Matanomadh assemblage. The only species of *Gleicheniidites*, viz., *G. senonicus* Ross appears to have an affinity with this family. The family chiefly grows in tropical habitat.

(v) *Cyatheaceae* — The two species referred to *Cyathidites*, viz., *C. australis* Couper and *C. minor* Couper, seem to be definitely related to Cyatheaceae and hence its representation in the assemblage is certain. The present day distribution of this family is restricted to tropical-subtropical climatic belt.

(vi) *Polypodiaceae* — *Polypodiaceaesporites levis* Sah, *P. major* Saxena, *Polypodiaceaesporites* sp., *Polypodiisporites repandus* Takahashi, *P. mawkmaensis* Dutta & Sah and *Polypodiisporites* sp. are most probably related to the family Polypodiaceae. This family is cosmopolitan in distribution but rarely occurs in dry region.

(vii) *Matoniaceae* — The specimens described under *Dictyophyllidites granulatus* Saxena seem to be closely related to this family, while the affinity of *Dandotiaspora dilata* (Mathur) Sah, Kar & Singh, *D. plicata* (Sah & Kar) Sah, Kar & Singh, *D. telonata* Sah, Kar & Singh and *D. pseudoauriculata* Sah, Kar & Singh to this family is doubtful. This family is chiefly distributed in tropical region.

DIVISION — SPERMATOPHYTA

SUBDIVISION — GYMNOSPERMAE

Although gymnospermous pollen grains are not richly represented in the Matanomadh assemblage, still they contribute as a significant group in some levels. Pollen morphology and comparison with living pollen grains indicate that gymnospermous pollen grains in the Matanomadh assemblage might be related to the following two families:

(i) *Podocarpaceae* — The only species referred to *Podocarpidites*, viz., *P. ellipticus* (Cookson) Potonié has close affinity with Podocarpaceae and in all likelihood represents this family. The family grows in tropical as well as in temperate region.

(ii) *Araucariaceae* — This family is represented in the Matanomadh palynoflora by *Laricoidites punctatus* Saxena, *Laricoidites* sp. and *Araucariacites australis* Cookson. The present day distribution of this family is in both tropical and temperate regions.

SUBDIVISION — ANGIOSPERMAE

The angiospermous pollen form the most dominant group in the Matanomadh palynoflora, being represented by far and largest number of genera and species, indicating that the angiosperms played a significant role in the vegetational ecology of this region.

CLASS — MONOCOTYLEDONAE

Although this group exhibits less variety than the dicotyledons, the high percentage of pollen grains referable to the family Palmae makes it very significant. The monocotyledons are represented by the following three families:

(i) *Palmae* — The rich representation of all the six species of *Couperipollis*, viz., *C. wodehousei* (Biswas) Venkatachala & Kar, *C. brevispinosus* (Biswas) Venkatachala & Kar, *C. rarispinosus* (Sah & Dutta) Venkatachala & Kar, *C. kutchensis* Venkatachala & Kar, *C. achinatus* Sah & Kar and *C. robustus* Saxena clearly testifies that this family constituted one of the principal elements in the Matanomadh assemblage. Besides, *Palmidites maximus* Couper, *Palmaepollenites nadhamunii* Venkatachala & Kar, *P. kutchensis* Venkatachala & Kar, *P. ovatus* Sah & Kar and *P. plicatus* Sah & Kar also have definite affinity with this family. The geological record of this family dates back to the late Cretaceous. The present distribution of this family is restricted to tropical and subtropical region.

(ii) *Potamogetonaceae* — This characteristically fresh-water family is represented in the assemblage by a single species, viz., *Retipilonapites cenozoicus* Sah. This family is cosmopolitan in distribution and is exclusively aquatic.

(iii) *Liliaceae*— The presence of this family in the Matanomadh assemblage is evidenced by the presence of pollen referred to *Liliacidites maximus* Saxena, *L. matanomadhensis* Saxena, *L. kutchensis* Saxena and *Dracaenoipollis circularis* Sah & Kar. Plants belonging to this family are mostly ubiquitous in distribution.

CLASS — DICOTYLEDONAE

The dicotyledonous pollen grains form the most dominant group and are referable to the following 19 families:

(i) *Juglandaceae* — This family is doubtfully represented by *Triporopollenites minutiformis* (Ramanujam) Saxena, *Trilatiporites cooksoni* Ramanujam and *T. kutchensis* Venkatachala & Kar. Conclusive evidence indicating their affinity to the family Juglandaceae is lacking. However, close morphological similarity brings these species closest to this family, which is found world over.

(ii) *Fagaceae* — The representation of this family in the Matanomadh miofloral assemblage is doubtful. Only a single species, *Pseudonothofagidites kutchensis* Venkatachala & Kar may doubtfully be related to this family. This family is distributed throughout the world.

(iii) *Proteaceae* — It is represented by the pollen grains referred to *Proteacidites protrudus* Sah & Kar. In eastern Asia, this family has a tropical distribution.

(iv) *Nymphaeaceae* — The morphological characters of the two species, viz., *Proxapertites microreticulatus* Jain, Kar & Sah and *P. assamicus* (Sah & Dutta) Singh suggest their close relationship to Nymphaeaceae and, in all probability, they belong to this family. The family has a long geological history dating back to Cretaceous. The family is chiefly tropical and favours fresh-water and marshy places.

(v) *Cruciferae* — Definite evidence for the presence of this family is lacking. However, *Tricolpites minutus* Sah & Kar, *T. brevis* Sah & Kar, *T. baculatus* Jain, Kar & Sah and *T. parvireticulatus* Sah might doubtfully be referred to Cruciferae. The family is cosmopolitan and grows in diverse condition.

(vi) *Leguminosae* — The presence of this family is evidenced by *Tricolpites crassireticulatus* Dutta & Sah. This family has a long geological history dating back to the late Cretaceous and generally grows in tropical to subtropical region.

(vii) *Meliaceae* — Five species of *Meliapollis*, viz., *M. ramanujamii* Sah & Kar, *M. navalei* Sah & Kar, *M. quadrangularis* (Ramanujam) Sah & Kar, *M. melioides* (Ramanujam) Sah & Kar and *M. triangulus* Saxena indicate the presence of this family. Fossil pollen grains of Meliaceae are so far known from Eocene to Miocene strata of India. This family has a tropical to subtropical distribution.

(viii) *Euphorbiaceae* — Three species of *Lakiapollis*, viz., *L. ovatus* Venkatachala & Kar, *L. matanomadhensis* Venkatachala & Kar and *L. spinosus* Saxena indicate the presence of this family. The family is cosmopolitan and is found in varied climate, except in arctic region.

(ix) *Vitaceae* — Pollen grains referred to *Favitricolporites retiformis* Sah might, doubtfully, be related to the family Vitaceae. The geological history of this family dates back to late Cretaceous. The family is principally tropical to subtropical in distribution.

(x) *Guttiferae* — The family is represented by pollen grains referred to *Kielmeyerapollenites eocenicus* Sah & Kar and *Platoniapollenites* sp. Both these species show close affinity with the family Guttiferae. Fossil leaves ascribed to *Mesua* sp. and *Garcinia* sp. of the family Guttiferae have also been recorded by Lakhanpal and Bose (1951) from the Eocene rocks of Barmer, Rajasthan.

(xi) *Sonneratiaceae* — Morphological characters of pollen grains referred to *Sonneratioipollis bellus* Venkatachala & Kar indicate definite affinity with this family. It is distributed in tropical to subtropical region.

(xii) *Rhizophoraceae* — Pollen grains of *Paleosantalaceaepites minutus* Sah & Kar and *P. ellipticus* Sah & Kar strongly indicate the presence of this family. The family has a tropical distribution and is an important element of the mangrove vegetation, hence a significant ecological marker.

(xiii) *Onagraceae* — The presence of this family is evidenced by the representation of *Triorites bellus* Sah & Kar and *T. triradiatus* Saxena. Fossil pollen record of this family dates back to the early Tertiary sediments. It grows in both tropical and temperate regions.

(xiv) *Oleaceae* — The presence of this family is indicated by the pollen of *Tricolpites retibaculatus* Saxena and *T. matanomadhensis* Saxena. Fossil pollen of Oleaceae have been recorded from the Eocene sediments. The present day geographical distribution of this family ranges from tropical to warm-temperate zone.

(xv) *Labiatae* —The presence of this family is probably indicated by *Psilastephanocolpites guaduensis* (van der Hammen) Saxena, *Retistephanocolpites kutchensis* Saxena, *R. flavatus* (Sah & Kar) Saxena and *Tricolpites reticulatus* Cookson. The present day dis ribution of this family is ubiquitous.

(xvi) *Solanaceae* — This family is undoubtedly represented by two species of *Striacolporites*, viz., *S. cephalus* Sah & Kar and *S. ovatus* Sah & Kar. The family generally grows in tropical-temperate region.

(xvii) *Lentibulariaceae* — *Granustephanocolpites sahii* Saxena and *Ghoshiacolpites globatus* Sah & Kar indicate the presence of this family. The family has a cosmopolitan distribution but generally prefers plenty of water or moist and shady places.

(xviii) *Rubiaceae* — The presence of the family is evidenced by the recovery of pollen grains of *Palaeocoprosmadites arcotense* Ramanujam. The family mostly grows in tropical region.

QUANTITATIVE ANALYSIS

The study of the Matanomadh palynoflora reveals that it is populated by 65 genera and 113 species of algal and fungal remains, pteridophytic spores and gymnospermous and angiospermous pollen grains. The quantitative analysis of the assemblage (excluding algal and fungal remains) has been done on the basis of the frequency of a species in a count of 200 specimens per sample which indicates that the pteridophytic spores represented by 14 genera and 27 species, constitute 33 per cent of the assemblage. In the lower part of the Clastic Member, the pteridophytic spores are predominant while they start declining in the middle levels. Among the pteridophytic elements, trilete spores constitute the major part while monolete spores remain insignificant and do not come in percentage count. *Dandotiaspora* Sah, Kar & Singh remains the most common pteridophytic genus, especially in the lower levels of the Clastic Member where it constitutes about 35 per cent of the total assemblage. In some samples its frequency reaches up to 60 per cent or even more. Other pteridophytic genera in order of their abundance are *Lygodiumsporites* (Potonié, Thomson & Thiergart) Potonié, *Todisporites* Couper and *Lycopodiumsporites* Thiergart.

The gymnospermous pollen grains are represented by 3 genera and 3 species and their overall percentage comes to about 11 per cent. These pollen are insignificant in the lower part of the Clastic Member (= *Dandotiaspora dilata* Cenozone) but gradually start coming up in the middle levels (Text-fig. 1). The gymnospermous pollen are of bisaccate (*Podocarpidites* (Cookson) Potonié) and inaperturate [*Laricoidites* (Potonié, Thomson & Thiergart) Potonié; *Araucariacites* (Cookson) Couper] types. Of these, inaperturate pollen grains are most common, owing to the high frequency (about 13 per cent) of *Laricoidites* in the middle part of the Clastic Member (*Couperipollis brevispinosus* Cenozone). However, in general, the gymnospermous pollen remain comparatively in minor community in the overall assemblage.

The angiospermous pollen grains are represented by 56 species belonging to 28 genera. Of these, 6 genera and 16 species belong to the monocotyledons while 22 genera and 40 species belong to the dicotyledons. Obviously, the dicotyledonous pollen grains dominate over those of monocotyledons. The angiospermous pollen grains, as a whole, constitute about 56 per cent of the entire Matanomadh spore-pollen assemblage. Among monocotyledonous pollen grains, *Couperipollis* Venkatachala & Kar is most common (average 32 per cent), especially in middle levels of the Clastic Member, followed by *Palmaepollenites*

Potonié and *Retipilonapites* Ramanujam. On the other hand, among dicotyledonous pollen grains *Tricolpites* (Erdtman) Potonié, *Lakiapollis* Venkatachala & Kar, *Paleosantalaceaepites* (Biswas) Dutta & Sah, *Trilatiporites* Ramanujam, *Favitricolporites* Sah and *Proxapertites* (van der Hammen) Singh are the major constituents.

A survey of overall composition and distribution of the Matanomadh palynoflora, as shown in Text-fig. 1, clearly indicates that the vegetational pattern during the deposition of the Matanomadh Formation witnessed sharp changes of stratigraphic importance. In the lower part of the Clastic Member, the pteridophytes and the land angiosperms dominate, while gymnosperms and aquatics are comparatively poorly represented. In the middle part of the profile, the pteridophytes become rare, whereas gymnosperms and angiosperms show increased frequency. The aquatic plants also correspondingly show decrease in frequency in the middle levels. The herb and shrub-tree percentages remain more or less uniform throughout the sequence except in the middle part where the shrub-tree percentage shows increased frequency with corresponding decrease in the percentage of herbaceous plants (the frequencies of 'herbs' and 'shrubs-trees' plotted in Text-fig. 1 are tentative and give only a broad picture of the floral organisation).

To sum up, some inferences can be drawn out of the pollen analytical data. Text-fig. 1 shows that the *Dandotiaspora dilata* Cenozone (lower part of the Clastic Member) is characterized by the dominance of pteridophytes and land angiosperms (the herb and shrub-tree remain almost uniform throughout this interval) together with the paucity of the gymnosperms and aquatic elements. This zone unconformably overlies the Barren Zone (= Laterite Member). The overlying *Couperipollis brevispinosus* Cenozone, i.e. the middle part of the Clastic Member, on the other hand, is poor in pteridophytic elements while gymnosperms rise in percentage. The percentage of angiosperms remains consistent but shrub-tree elements show significantly increased frequency over the herbs. Aquatic elements are very poor and insignificantly represented in the middle levels. This zone is overlain by Sponge Zone. This frequency pattern remains uniform in all the sections studied. Thus, the lateral persistence of these biozones can be usefully applied in the recognition of the stratigraphic levels of the Matanomadh Formation in the Kutch sedimentary basin.

PALAEOCLIMATE

Qualitative and quantitative analyses of the Matanomadh assemblage make it possible to interpret and provide some information concerning the palaeoclimate which prevailed during Matanomadh sedimentation.

The Matanomadh assemblage, as a whole, is very rich and diversified. It consists of algal and fungal remains in considerable amount. The pteridophytic spores related to Lycopodiaceae, Osmundaceae, Cyatheaceae, Polypodiaceae, Gleicheniaceae, Schizaeaceae and Matoniaceae are richly represented in the lower levels of the Clastic Member of Matanomadh Formation.

In the middle part of the Matanomadh succession the frequency of fungal and pteridophytic elements decreases as compared to that of the lower level (= *Dandotiaspora dilata* Cenozone). Such a change may be related to a change in climatic conditions from a moist humid to a drier phase.

The gymnospermous group represented by pollen grains related to Araucariaceae and Podocarpaceae shows a more or less insignificant representation in the lower levels while their frequency increases progressively in the middle levels (Text-fig. 1). The paucity of gymnosperms in the lower levels of Matanomadh Formation and their increased frequency in the middle part (i.e. *Couperipollis brevispinosus* Cenozone) also tends to support a change from humid to a comparatively drier phase.

The angiospermous pollen grains have an overall dominance, both in number and variety. From comparative morphological studies, it has been noted that the Matanomadh assemblage comprises palynomorphs having affinities with the following families (according to their relative abundance in descending order), viz., Palmae, Cruciferae, Meliaceae, Oleaceae, Onagraceae, Euphorbiaceae, Rhizophoraceae, Lentibulariaceae, Labiatae, Juglandaceae, Liliaceae, Potamogetonaceae, Nymphaeaceae, Sonneratiaceae, Leguminosae, Fagaceae, Proteaceae, Vitaceae, Guttiferae, Rubiaceae and Solanaceae. Of these,

TABLE 1

TROPICAL-SUBTROPICAL	COSMOPOLITAN (TROPICAL-TEMPERATE)	HABITAT OF COSMOPOLITAN FAMILIES
1. Schizaeaceae	1. Lycopodiaceae	Humid shady habitat
2. Gleicheniaceae	2. Osmundaceae	Shady places or swamps
3. Cyatheaceae	3. Polypodiaceae	
4. Matoniaceae	4. Podocarpaceae	Montane rain-forest zone
5. Palmae	5. Araucariaceae	
6. Leguminosae	6. Potamogetonaceae	Aquatic
7. Meliaceae	7. Liliaceae	
8. Vitaceae	8. Juglandaceae	
9. Guttiferae	9. Fagaceae	
10. Sonneratiaceae	10. Proteaceae	
11. Rhizophoraceae	11. Nymphaeaceae	Aquatic, chiefly tropical
12. Rubiaceae	12. Cruciferae	Grows in diverse situation
	13. Euphorbiaceae	
	14. Onagraceae	
	15. Oleaceae	Chiefly tropical-subtropical
	16. Labiatae	
	17. Solanaceae	
	18. Lentibulariaceae	

nine families are restricted to the tropical-subtropical region while the remaining families are cosmopolitan in distribution. The present day distribution of the various families represented in the Matanomadh assemblage is given in Table 1.

The prevalence of tropical-subtropical climate during Matanomadh sedimentation is evident from the composition of the assemblage and the present day distribution of their nearest living relatives. This is also supported by the occurrence of a number of palm leaf impressions in the tuffaceous shale beds of the Matanomadh Formation.

ENVIRONMENT OF DEPOSITION

The qualitative analysis of the Matanomadh assemblage reveals that it contains a mixture of land, aquatic and brackish-water elements.

Pollen grains related to the families Nymphaeaceae and Potamogetonaceae, although scantily represented, are exclusively aquatic. On the other hand, pollen grains belonging to Rhizophoraceae, Sonneratiaceae and Palmae (the last being richly represented) indicate close proximity to the shore line. The presence of microplanktons indicates brackish-water environments.

From Text-fig. 1 it is apparent that aquatic elements are represented mainly in the lower levels of the Clastic Member while in middle biozone, their representation is negligible. On the other hand, the coastal elements (Palmae etc.) are richly represented in the middle levels, whereas in lower levels, they are insignificant. Such a composition is only possible if the lower part of the Matanomadh Formation was deposited in continental water but in close proximity and perhaps having some connection with the sea to receive minor amount of mangrove elements and phytoplanktons. The middle level is characterized by an abundance of pollen related to Palmae together with increasing frequency of mangrove elements and brackish-water microplanktons. This clearly indicates that during the deposition of these levels, the basin of deposition saw some subsidence resulting in the transgression of sea and a change from fresh water to deltaic or estuarine conditions. Only such conditions could have brought about a mixture of coastal (Palmae-Rhizophoraceae-Sonneratiaceae), brackish-water microplanktons and continental elements (Sah & Kar, 1971). The aquatic elements and fern spores might have been brought down through water transport.

Besides, in the uppermost levels of this formation (= Sponge Zone) the sponge spicules occur in profusion, which also indicate the influence of marine conditions over the area of deposition.

PALYNOFLORAL COMPARISON

A comparison of the Matanomadh assemblage with the known Palaeocene-Lower Eocene assemblages from different sedimentary basins of the Indian subcontinent is discussed below:

Rajasthan — The Lower Eocene (Palana lignite) palynoflora from Palana, Rajasthan has been described by Rao and Vimal (1952) and Sah and Kar (1974). The Palana assemblage consists of 44 genera and 67 species. Of these, 9 genera and 16 species are of algal remains, 3 genera and 4 species are of fungal remains, 8 genera and 11 species are of pteridophytic spores and 24 genera and 36 species are of angiospermous pollen grains. Species common to both the assemblages are: *Botryococcus palanaensis* Sah & Kar, *Tetraporina apora* Sah & Kar, *Cephalia globata* Sah & Kar, *Octaplata rotunda* Sah & Kar, *Palanaea granulosa* Sah & Kar, *P. laevigata* Sah & Kar, *Cryptosphaera valvata* Sah & Kar, *Cornplanktona unicorna* Sah & Kar, *Inapertisporites kedvesii* Elsik, *Dandotiaspora plicata* (Sah & Kar) Sah, Kar & Singh, *Palmaepollenites nadhamunii* Venkatachala & Kar, *Couperipollis brevispinosus* (Biswas) Venkatachala & Kar, *C. rarispinosus* (Sah & Dutta) Venkatachala & Kar, *C. kutchensis*, Venkatachala & Kar, *Tricolpites reticulatus* Cookson, *Lakiapollis ovatus* Venkatachala & Kar, *L. matanamadhensis* Venkatachala & Kar, *Verrucolporites verrucus* Sah & Kar, *Kielmeyerapollenites eocenicus* Sah & Kar, *Meliapollis ramanujamii* Sah & Kar, *Retistephanocolpites flavatus* (Sah & Kar) Saxena, *Granustephanocolpites sahii* Saxena, *Pseudonothofagidites kutchensis* Venkatachala & Kar, *Trilatiporites kutchensis* Venkatachala & Kar and *Proteacidites protrudus* Sah & Kar.

Comparison of the Matanomadh and Palana assemblages shows that 25 species are common to both the assemblages while 42 species are found only in the Palana assemblage and 88 species only in the Matanomadh assemblage. The comparison also makes it clear that the Palana assemblage is more closely related to Naredi (= Laki) assemblage than to the Matanomadh assemblage. Sah and Kar (1974, p. 184) also suggested the homotaxiality of Palana and Naredi assemblages.

Palynological assemblages from Barmer Sandstone of Barmer, Rajasthan has been described by Bose (1952) and Jain, Kar and Sah (1973). A comparison of this assemblage with the Matanomadh assemblage shows that out of 41 genera and 23 recognizable species reported from the Barmer Sandstone only 14 genera and 8 species are common to both the assemblages. The common species are, however, not much of stratigraphic importance.

Lukose (1974) recorded palynofloral assemblage from the subsurface Ranikot Formation in the Jaisalmer basin. He recorded 26 genera of spores and pollen grains. Of these, 13 genera are also found in the Matanomadh assemblage. Since the palynomorphs are not described in detail, a close comparison is not possible.

Himachal Pradesh — The palynofloral assemblage from the Subathu Formation of Himachal Pradesh has been recorded by Mathur (1963, 1964) and Salujha, Srivastava and Rawat (1969). The assemblages comprise 30 genera and 48 species. Palynofossils described therein are extremely ill-preserved and preclude a more precise comparison. However, the following forms appear to be common to both the assemblages: *Lygodiumsporites lakiensis* Sah & Kar (= *Psilatriletes lobatus* Salujha, Srivastava & Rawat, pl. 3, fig. 7), *Osmundacidites cephalus* Saxena (= *Verrutriletes* sp., pl. 3, fig. 17), *Laricoidites punctatus* Saxena ($\pm$ = *Psilainaperturites* sp., pl. 3, fig. 25), *Palmidites maximus* Couper ($\pm$ = *Retimonocolpites* sp., pl. 3, fig. 38).

Madhya Pradesh — The Deccan Intertrappean palynoflora from Mohgaon Kalan, Madhya Pradesh has been described by Chitaley (1951, 1957). The assemblage comprises 12 spore-pollen genera and a number of species. Detailed comparison between the Matanomadh and Deccan Intertrappean assemblages is difficult as the latter is not known in detail. However, the following sporomorphs described by Chitaley (1951) seem to be common to both the assemblages: *Polypodiaceaesporites levis* Sah ($\pm$ = *Monolites* spm., pl. 13, fig. 2), *Palmaepollenites nadhamunii* Venkatachala & Kar ($\pm$ = *Monosulcites minima*, pl. 13, fig. 9; *M. media*, pl. 13, fig. 10; *Monosulcites* spm., pl. 13, fig. 12), *Couperipollis achinatus* Sah & Kar (= *Monosulcites spinosa*, pl. 13, fig. 11), *Tricolpites minutus* Sah & Kar ($\pm$ = *Tricolpites* spm., pl. 13, figs 13B, 14), *Paleosantalaceaepites minutus* Sah & Kar ($\pm$ = *Tricolpites* spm., pl. 14, figs 19, 20).

The following taxa described by Chitaley (1957) also appear to be common to the Matanomadh assemblage: *Palmaepollenites nadhamunii* Venkatachala & Kar ($\pm$ = *Monosulcites* spm., text-fig. 2H), *Tricolpites minutus* Sah & Kar ($\pm$ = *Tricolpites* spm., text-fig. 2M), *Paleosantalaceaepites minutus* Sah & Kar ($\pm$ = *Tricolpites* spm., text-fig. 2O), *Paleosantalaceaepites ellipticus* Sah & Kar ($\pm$ = *Tricolpites* spm., text-fig. 2Q).

From the above data it appears that the two palynological assemblages have some common elements. However, it will be rather too premature to draw any specific conclusion on the basis of such scanty data.

Bengal Basin — Baksi (1972) published a paper on the palynostratigraphy of the subsurface Upper Cretaceous to Plio-Pleistocene sediments of Bengal Basin. He mentioned that the Jalangi Formation (Palaeocene-Lower Eocene) of Bengal Basin is characterized by the frequent occurrence of *Assamialetes emendatus* (Sah & Dutta) Singh, *Proxapertites crassimurus* (Sah & Dutta) Singh, *Spinozonocolpites baculatus* Muller and restricted occurrence of *Granulatisporites* spp., *Leiotriletes* sp., *Proteacidites* sp., etc. A comparison of this assemblage with the Matanomadh assemblage shows that important taxa of Jalangi assemblage, viz., *Assamialetes emendatus* and *Proxapertites crassimurus* are absent from Matanomadh assemblage while important elements of the Matanomadh assemblage, viz., *Dandotiaspora* spp., *Lygodiumsporites* spp., *Couperipollis* spp., *Lakiapollis* spp., *Tricolpites* spp. and *Laricoidites punctatus* Saxena are absent from the Jalangi assemblage.

Meghalaya — The palynofloral assemblage from the Cherra Formation has been recorded by Biswas (1962), Sah and Dutta (1966, 1968, 1974), Dutta and Sah (1970) and Salujha, Kindra and Rehman (1974). The Cherra assemblage consists of 49 genera and 103 species. Of these, 18 genera and 34 species are of pteridophytic spores, 2 genera and 2 species belong to gymnospermous pollen grains and 29 genera and 67 species are of angiospermous pollen grains. The following species are common to both Cherra and Matanomadh assemblages: *Cyathidites minor* Couper, *Lygodiumsporites eocenicus* Dutta & Sah, *Lycopodiumsporites umstewensis* Dutta & Sah, *Dandotiaspora dilata* Sah, Kar & Singh (= *Biretisporites triglobosus* Sah & Dutta), *D. plicata* (Sah & Kar) Sah, Kar & Singh, *Polypodiisporites repandus* Takahashi, *P. mawkmaensis* Dutta & Sah, *Retipilonapites cenozoicus* Sah, *Couperipollis brevispinosus* (Biswas) Venkatachala & Kar, *C. wodehousei* (Biswas) Venkatachala & Kar, *C. rarispinosus* (Sah & Dutta) Venkatachala & Kar, *Proxapertites assamicus* (Sah & Dutta) Singh, *Tricolpites crassireticulatus* Dutta & Sah.

The lateral equivalent of Cherra Formation, in Garo Hills, is known as Tura Formation. A rich palynoflora has been described from this formation by Biswas (1962), Banerjee (1964), Salujha, Kindra and Rehman (1972) and Singh (1977). A comparison of the Tura assemblage with the Matanomadh assemblage shows the common occurrence of following species: *Cyathidites minor* Couper, *Lygodiumsporites eocenicus* Dutta & Sah, *Dandotiaspora dilata* (Mathur) Sah, Kar & Singh, *D. plicata* (Sah & Kar) Sah, Kar & Singh, *D. telonata* Sah, Kar & Singh, *D. pseudoauriculata* Sah, Kar & Singh, *Couperipollis brevispinosus* (Biswas) Venkatachala & Kar, *C. rarispinosus* (Sah & Dutta) Venkatachala & Kar, *Palmidites maximus* Couper, *Lakiapollis ovatus* Venkatachala & Kar, *L. matanamadhensis* Venkatachala & Kar, *Verrucolporites verrucus* Sah & Kar, *Meliapollis ramanujamii* Sah & Kar, *Triorites bellus* Sah & Kar, *Pseudonothofagidites kutchensis* Venkatachala & Kar.

A comparative analysis makes it clear that although Matanomadh assemblage is not closely related to that of Cherra and Tura assemblages, there are certain important marker species which are common to them. The representation and occurrence of common marker species suggest their homotaxiality. Sah and Kar (1972, p. 263) also suggest that the Cherra, Tura and Matanomadh formations are synchronous.

Cauvery Basin — The Palaeocene-Lower Eocene palynoflora from Cauvery Basin (Venkatachala & Rawat, 1972) consists of 61 genera and 110 species. A comparison of this assemblage with the Matanomadh assemblage shows that the two assemblages are much different from each other. Only 17 genera and 2 species are common to both the assemblages.

Andaman Islands — A partial palynofloral assemblage from the Port Blair Formation (Palaeogene) of Andaman Islands has been described by Banerjee (1966). The palynoflora consists of 18 spore-pollen genera. Of these, 5 genera, viz., *Polypodiaceaesporites major* Saxena ($\pm$ = *Psilamonoletes* sp., pl. 1, fig. 2), *Polypodiisporites repandus* Takahashi ($\pm$ = *Verrumonoletes* sp., pl. 1, fig. 1), *Lygodiumsporites lakiensis* Sah & Kar ($\pm$ = *Psilatriletes* spp. 1, 3, 4, pl. 1, figs 5-7), *Couperipollis achinatus* Sah & Kar ($\pm$ = *Monosulcites* sp. 2, pl. 1, fig. 13), *Paleosantalaceaepites ellipticus* Sah & Kar ($\pm$ = *Scabratricolpites* sp. 3, pl. 1, fig. 16) are common to both the assemblages. Inspite of these similarities the two palynoflora are distinct and do not seem to be closely related.

Pakistan (*Dandot*) — A partial palynoflora from Dandot lignite of Pakistan has been described by Vimal (1952). The assemblage consists of 30 spore-pollen types referable to 11 genera. The following palynomorphs are common to both Matanomadh and Dandot assemblages: *Cyathidites minor* Couper (=*Trilites* spm. 9, pl. 5, fig. 13; pl. 8, fig. 13), *Lygodiumsporites lakiensis* Sah & Kar (± = *Trilites* spm. 8, pl. 5, fig. 12; pl. 8, fig. 12), *L. eocenicus* Dutta & Sah (± = *Trilites* spm. 4, pl. 5, figs 4-6; pl. 7, figs 4-6), *Dandotiaspora dilata* (Mathur) Sah, Kar & Singh (± = *Trilites* spm. 6, pl. 5, figs 9, 10; pl. 7, figs 9, 10; *Trilites* spm. 7, pl. 5, fig. 11; pl. 7, fig. 11), *D. telonata* Sah, Kar & Singh (± = *Trilites* spm. 5, pl. 5, figs 7, 8; pl. 7, figs 7, 8), *Retipilonapites cenozoicus* Sah (± = *Subpilonapites* spm. 1, pl. 6, fig. 16; pl. 8, fig. 15), *Tricolpites matanomadhensis* Saxena (± = *Tricolpites* spm. 3, pl. 6, fig. 25; pl. 8, fig. 22), *Psilastephanocolpites guaduensis* (van der Hammen) Saxena (± = *Tetracolpites* spm. 1, pl. 6, fig. 30; pl. 8, fig. 26), *Retistephanocolpites kutchensis* Saxena (± = *Hexacolpites* spm. 3, pl. 6, fig. 34; pl. 8, fig. 29), *Granustephanocolpites sahii* Saxena (± = *Septacolpites* spm. 1, pl. 6, fig. 36; pl. 8, fig. 31; *Octacolpites* spm. 1, pl. 6, fig. 37; pl. 8, fig. 32) and *Triporopollenites minutiformis* (Ramanujam) Saxena (± = *Triorites* sp. 2, pl. 6, fig. 39; pl. 8, fig. 34). The representation of these palynomorphs indicate that the Dandot lignite may be palynostratigraphic equivalent of the *Dandotiaspora dilata* Cenozone of the Matanomadh Formation.

COMPARISON OF MATANOMADH AND NAREDI ASSEMBLAGES

Lithostratigraphically, the Matanomadh Formation is underlain by the Deccan Traps and overlain by the Naredi Formation. A comparison of the Matanomadh and Naredi palynofloras is therefore essential to bring out the differences in the composition of the two. The palynoflora from the Naredi (= Laki) Formation has been described by Mathur (1963), Venkatachala and Kar (1968, 1969a, b) and Sah and Kar (1969, 1970). The assemblage consists of 67 genera and 101 species. Of these, 3 genera and 3 species are of fungal remains, 21 genera and 30 species are of pteridophytic spores, 4 genera and 4 species belong to gymnospermous pollen grains and 39 genera and 64 species to angiospermous pollen grains. The taxa common to both Matanomadh and Naredi assemblages are: *Cyathidites minor* Couper, *Todisporites kutchensis* Sah & Kar, *Intrapunctisporis apunctis* Krutzsch, *Dandotiaspora dilata* (Mathur) Sah, Kar & Singh, *D. plicata* (Sah & Kar) Sah, Kar & Singh, *D. pseudoauriculata* Sah, Kar & Singh, *D. telonata* Sah, Kar & Singh, *Lygodiumsporites lakiensis* Sah & Kar, *Lycopodiumsporites bellus* Sah & Kar, *Podocarpidites ellipticus* (Cookson) Potonié, *Araucariacites australis* Cookson, *Couperipollis kutchensis* Venkatachala & Kar, *C. achinatus* Sah & Kar, *Palmaepollenites kutchensis* Venkatachala & Kar, *P. nadhamunii* Venkatachala & Kar, *P. ovatus* Sah & Kar, *P. plicatus* Sah & Kar, *Dracaenoipollis circularis* Sah & Kar, *Tricolpites brevis* Sah & Kar, *T. minutus* Sah & Kar, *Ghoshiacolpites globatus* Sah & Kar, *Retistephanocolpites flavatus* (Sah & Kar) Saxena, *Granustephanocolpites sahii* Saxena, *Lakiapollis ovatus* Venkatachala & Kar, *L. matanamadhensis* Venkatachala & Kar, *Paleosantalaceaepites ellipticus* Sah & Kar, *P. minutus* Sah & Kar, *Verrucolporites verrucus* Sah & Kar, *Striacolporites cephalus* Sah & Kar, *S. ovatus* Sah & Kar, *Palaeocoprosmadites arcotense* Ramanujam, *Meliapollis ramanujamii* Sah & Kar, *M. navalei* Sah & Kar, *M. melioides* (Ramanujam) Sah & Kar, *M. quadrangularis* (Ramanujam) Sah & Kar, *Triorites bellus* Sah & Kar, *Proteacidites protrudus* Sah & Kar, *Trilatiporites kutchensis* Venkatachala & Kar, *Sonneratioipollis bellus* Venkatachala & Kar, *Pseudonothofagidites kutchensis* Venkatachala & Kar.

The following species are restricted to the Matanomadh Formation and do not extend to Naredi Formation: *Botryococcus palanaensis* Sah & Kar, *Tetraporina apora* Sah & Kar, *Cephalia globata* Sah & Kar, *Octaplata rotunda* Sah & Kar, *Palanaea granulosa* Sah & Kar, *P. laevigata* Sah & Kar, *Cryptosphaera valvata* Sah & Kar, *Cornplanktona unicorna* Sah & Kar, *Leioplanktona madhensis* Kar & Saxena, *L. verrucosa* Kar & Saxena, *Spinasphaera robusta* Kar & Saxena, *Matanomadhia indica* Kar & Saxena, *M. ovata* Kar & Saxena, *Phragmothyrites eo-*

caenica (Edwards) Kar & Saxena, *Notothyrites setiferus* Cookson, *N. amorphus* Kar & Saxena, *Inapertisporites kedvesii* Elsik, *Pluricellaesporites planus* Trivedi & Verma, *Dicellaesporites popovii* Elsik, *D. minutus* Kar & Saxena, *Multicellaesporites elsikii* Kar & Saxena, *Monoporisporites stoverii* Elsik, *Diporisporites elongatus* van der Hammen, *D. ankleshwarensis* (Varma & Rawat) Elsik, *Diporicellaesporites stacyi* Elsik, *D. pluricellus* Kar & Saxena, *Involutisporonites kutchensis* Kar & Saxena, *Cyathidites australis* Couper, *Dictyophyllidites granulatus* Saxena, *Todisporites major* Couper, *T. minor* Couper, *Lygodiumsporites eocenicus* Dutta & Sah, *L. pachyexinus* Saxena, *Osmundacidites minutus* Sah & Jain, *O. cephalus* Saxena, *Leptolepidites major* Couper, *Intrapunctisporis intrapunctis* Krutzsch, *Lycopodiumsporites umstewensis* Dutta & Sah, *Cicatricosisporites australiensis* (Cookson) Potonié, *C. pseudotripartitus* (Bolkhovitina) Dettmann, *Gleicheniidites senonicus* Ross, *Polypodiaceaesporites levis* Sah, *P. major* Saxena, *Polypodiisporites repandus* Takahashi, *P. mawkmaensis* Dutta & Sah, *Laricoidites punctatus* Saxena, *Retipilonapites cenozoicus* Sah, *Couperipollis wodehousei* (Biswas) Venkatachala & Kar, *C. brevispinosus* (Biswas) Venkatachala & Kar, *C. rarispinosus* (Sah & Dutta) Venkatachala & Kar, *C. robustus* Saxena, *Liliacidites maximus* Saxena, *L. kutchensis* Saxena, *L. matanomadhensis* Saxena, *Palmidites maximus* Couper, *Proxapertites assamicus* (Sah & Dutta) Singh, *P. microreticulatus* Jain, Kar & Sah, *Tricolpites reticulatus* Cookson, *T. parvireticulatus* Sah, *T. crassireticulatus* Dutta & Sah, *T. baculatus* Jain, Kar & Sah, *T. retibaculatus* Saxena, *T. matanomadhensis* Saxena, *Verrutricolpites perverrucatus* Ramanujam, *Psilastephanocolpites guaduensis* (van der Hammen) Saxena, *Retistephanocolpites kutchensis* Saxena, *Lakiapollis spinosus* Saxena, *Favitricolporites retiformis* Sah, *Meliapollis triangulus* Saxena, *Triorites triradiatus* Saxena, *Triporopollenites minutiformis* (Ramanujam) Saxena, *Trilatiporites cooksonii* Ramanujam and *Kielmeyerapollenites eocenicus* Sah & Kar.

The following species appear only in the Naredi Formation while they are completely absent in the Matanomadh Formation: *Biretisporites bellus* Sah & Kar, *B. convexus* Sah & Kar, *Todisporites flavatus* Sah & Kar, *Osmundacidites kutchensis* Sah & Kar, *Lakiasporites triangulus* Sah & Kar, *Lycopodiumsporites parvireticulatus* Sah & Kar, *Laevigatosporites lakiensis* Sah & Kar, *L. cognatus* Sah & Kar, *Seniasporites verrucosus* Sah & Kar, *S. minutus* Sah & Kar, *Palmaepollenites magnus* Sah & Kar, *Laricoidites kutchensis* Venkatachala, Kar & Raza, *Monosulcites ovatus* Sah & Kar, *Liliacidites ovatus* Venkatachala & Kar, *L. ellipticus* Venkatachala & Kar, *Clavatipollenites cephalus* Sah & Kar, *Arecipites bellus* Sah & Kar, *Marginipollis kutchensis* (Venkatachala & Kar) Venkatachala & Rawat, *Ranunculacidites communis* Sah, *Retitricolpites robustus* Sah & Kar, *Proxapertites marginatus* (Venkatachala & Kar) Singh, *P. flavatus* (Venkatachala & Kar) Singh, *Umbelliferoipollenites ovatus* Venkatachala & Kar, *U. constrictus* Venkatachala & Kar, *Araliaceoipollenites matanamadhensis* Venkatachala & Kar, *Cupuliferoipollenites ovatus* Venkatachala & Kar, *Rhoipites kutchensis* Venkatachala & Kar, *Symplocoipollenites kutchensis* Venkatachala & Kar, *S. minutus* Venkatachala & Kar, *S. constrictus* Sah & Kar, *Nyssapollenites kutchensis* Venkatachala & Kar, *Margocolporites tsukadai* Ramanujam, *M. sitholeyi* Ramanujam, *M. sahnii* Ramanujam, *Sastriipollenites trilobatus* Venkatachala & Kar, *Verrutricolpites triangulus* Sah & Kar, *Pellicieroipollis langenheimii* Sah & Kar, *Granustephanocolpites granulatus* (Venkatachala & Kar) Saxena, *Stephanocolpites nadhamunii* Venkatachala & Kar, *Meliapollis raoi* Sah & Kar, *Striacolporites striatus* Sah & Kar, *Paleosantalaceaepites primitiva* Biswas, *Polybrevicolporites cephalus* Venkatachala & Kar, P. *antiquum* Venkatachala & Kar, *Trilatiporites minutus* Sah & Kar, *Triorites triangulus* Sah & Kar, *T. minutus* Sah & Kar, *T. dermatus* Sah & Kar, *Pseudonothofagidites cerebrus* Venkatachala & Kar, *Cryptopolyporites cryptus* Venkatachala & Kar, *Thymelaepollis crotonoides* Sah & Kar.

The comparison of the Matanomadh and Naredi assemblages reveals that 36 genera and 40 species are common to both the assemblages while 29 genera and 73 species are restricted to the Matanomadh Formation and 31 genera and 61 species are restricted to the Naredi Formation.

The above discussion makes it clear that inspite of some similarities the two assemblages can be easily distinguished. The contact of the Matanomadh Formation with the overlying Naredi Formation is marked by distinct lithologic contrast. Since both Matanomadh and Naredi formations are distinguishable by lithological characteristics as well as by their palynological contents, they can reliably serve as time-stratigraphic units.

AGE OF THE MATANOMADH FORMATION

The age of the Matanomadh Formation has remained a subject of controversy ever since 1872, when Wynne recognized this succession as a separate stratigraphic unit. He named it as Subnummulitic Group and assigned an early Eocene age. Since then various opinions have been given from time to time regarding the age of this formation.

The early Eocene dating for this formation has been supported by Oldham (1893), Tewari (1952, 1957), Nagappa (1959), Poddar (1959, 1963) and Wadia (1968).

Pascoe (1964), for the first time, suggested a probable Palaeocene age for the Subnummulitic Group (= Matanomadh Formation) without producing any evidence in support of this contention. Biswas (1965) described this unit as Madh Series and assigned a Palaeocene age. This dating was based upon the correlation of the overlying Kakdi Stage with the Laki Series (Lower Eocene) of Sind-Baluchistan and also upon palynological evidences. Biswas (1965, p. 3) mentions:

" . . . . . Madh Series overlies the Deccan Traps but underlies the Kakdi Stage which correlates well with the Lower Eocene Laki rocks. Thus, considering the order of superposition these rocks are assigned to the Palaeocene, while the age of the Deccan Traps in Kutch appears to be Upper Cretaceous to Palaeocene. Further, the rocks of the Madh Series from the type area of Matanomadh have yielded *Deltoidospora diaphana*, *Proteacidites palisadus*, *Ginkgo bilobaeformis*, *Schizea penicillata* and *Verrunonacolpites brevicolpatus*. These indicate a probable Palaeocene age for the Madh Series (Y. K. Mathur, ONGC, personal communication) ".

Subsequently, Biswas and Deshpande (1970), Biswas (1971) and Biswas and Raju (1971, 1973) maintained a Palaeocene dating for this formation.

Based on the palynological evidence Mathur (1966), Sah, Kar and Singh (1971), Sah and Kar (1972), Kar (1974) and Saxena (1977a) also supported a Palaeocene dating for the Matanomadh Formation.

Sahni and Kumar (1974) equated the Matanomadh Formation with Upper Ranikot of Sind-Baluchistan, Lower Hill Limestone of Potwar Plateau, Palana lignite of Rajasthan, Upper Therria Sandstone of Assam and basal Subathu Formation of Simla Himalaya. They assigned a late Palaeocene age to this unit without giving any stratigraphical or fossil evidence.

A perusal of the above mentioned publications indicates that the general consensus is in favour of a basal Tertiary age for this formation, i.e. Palaeocene-early Eocene. The age of the Matanomadh Formation, in the light of the evidences derived from order of superposition, palaeontology and in more detail from palynology is discussed ahead.

1. *Evidences Derived from Order of Superposition*— Typical early Eocene foraminifers, viz., *Assilina granulosa*, *A. subspinosa*, *A. leymerie*, *Nummulites atacicus*, *N. thalicus*, *Lockhartia* sp., *Globonomalina wilcoxensis*, *Operculina* sp., *Operculinoides* sp., *Coskinolina* sp. and *Globigerina aquiensis* etc., have been recorded from the gypseous shale and limestone of the Naredi Formation indicating an early Eocene (Ypresian) age (Biswas, 1965, 1971). Palynofloral assemblage recorded from the Naredi Formation (Mathur, 1963; Venkatachala & Kar, 1969a, b; Sah & Kar, 1969, 1970) also suggests an early Eocene age. It is, therefore, reasonable to assume a Palaeocene age for the Matanomadh Formation which conformably underlies the Naredi Formation. Considering the order of superposition, Biswas (1965) also assigned a Palaeocene age to the Matanomadh Formation (= Madh Series).

2. *Evidences Derived from Palaeontology* — The records of animal fossils from the Matanomadh Formation are rare. The only such record from this unit is by Tandon (1971), who reported *Venericordia beaumonti* d'Archiac & Haime and *Venericordia* cf. *V. vredenburgi* Douville from the equivalent rocks exposed in Nareda area. On the basis of these fossils, he suggested a Palaeocene age for the Nareda exposures.

3. *Evidences Derived from Palynology* — The usefulness of palynology in age determination needs no emphasis. Detailed palyno-

logical information from well-dated sedimentary sequences permits the dating of equivalent units whose geological ages have remained a matter of conjecture either due to insufficient field evidences or lack of evidences from other conventional disciplines.

Since the Clastic Member of the Matanomadh Formation yielded a rich palynoflora (Kar & Saxena, 1976; Saxena, 1978, 1979), an attempt is made here to precisely date this formation on palynological basis.

In recent years considerable palynological work on the Palaeocene-early Eocene rock formations of Indian subcontinent has been published. A comparison of the Matanomadh assemblage with the other known Palaeocene-Lower Eocene assemblages from Indian subcontinent has already been discussed. This discussion clearly shows that the Matanomadh assemblage is identical to the other well dated Palaeocene assemblages, i.e. assemblages from Cherra Formation of Shillong Plateau, Tura Formation of Garo Hills and Dandot lignite of Pakistan, while the Lower Eocene assemblages are distinctly different.

A palynostratigraphic evaluation of the Lower Eocene (including Palaeocene) sediments, based upon published work on surface and subsurface samples from the various sedimentary basins and upon unpublished data, has been published by Sah and Kar (1972). They also have concluded that Matanomadh Formation (= Madh Series) is homotaxial to the Cherra Formation of Shillong Plateau, Tura Formation of Garo Hills and Barmer Sandstone of Rajasthan. This dating and correlation is based upon common occurrence of the marker taxa like *Dandotiaspora dilata* (Mathur) Sah, Kar & Singh, *Proxapertites* Complex, *Triorites* (*Epilobium* type), *Polycolpites* and *Proteacidites* types (Sah & Kar, 1972, pp. 263, 265). The above mentioned taxa are characteristic of Palaeocene and do not extend into the Eocene.

On the other hand, the characteristic marker taxa of early Eocene age, as recognized by Sah and Kar (1972, pp. 263, 265) are either absent in the Matanomadh assemblage or occur with low frequencies. The representative early Eocene palynomorphs which are absent in the Matanomadh assemblage are: *Stephanocolpites nadhamunii* Venkatachala & Kar, *Margocolporites tsukadai* Ramanujam, *M. sitholeyi* Ramanujam, *Verrucolporites verrucus* Sah & Kar, *Cheilanthoidspora monoleta* Sah & Kar and *C. enigmata* Sah & Kar. There are still other early Eocene marker taxa which have very low frequencies in the Matanomadh assemblage, e.g. *Palmaepollenites ovatus* Sah & Kar, *P. plicatus* Sah & Kar, *Lakiapollis ovatus* Venkatachala & Kar and *Meliapollis navalei* Sah & Kar (Sah & Kar, 1972, p. 265).

From the foregoing discussion, it appears that the Matanomadh assemblage is definitely older than the known early Eocene assemblages from India. Moreover, it shows similarity with the so far known well-dated Palaeocene assemblages, as far as the marker taxa with limited vertical range are concerned. Therefore, it seems that palynological evidence is also in favour of a Palaeocene age for the Clastic Member of the Matanomadh Formation.

The Laterite Member of the Matanomadh Formation unconformably underlies the Clastic Member and is completely devoid of fossils. For this reason, a precise dating of this member is not possible.

The Laterite Member is formed by the alternation of the upper surface of traps. The age of the laterites should, therefore, be slightly younger than the age of the latest volcanic flow in Kutch. Since the cessation of the volcanic activity in Kutch is believed to be in late Cretaceous to early Palaeocene, it will be reasonable to assume an early Palaeocene age for this member.

CONCLUSION

From the foregoing discussion, the following conclusions have been derived:

1. The Matanomadh assemblage is a mixed assemblage consisting of algal and fungal remains, pteridophytic spores and gymnospermous and angiospermous pollen grains. The bryophytic elements seem to be totally unrepresented.

2. The pteridophytic spores (33 per cent) and angiospermous pollen grains (56 per cent) are the dominant constituents of the Matanomadh assemblage while gymnospermous pollen grains (11 per cent) are comparatively poorly represented. The algal and fungal remains are also present.

3. Qualitative analysis of the assemblage indicates that the pteridophytic spores may

be related to seven families, viz., Lycopodiaceae, Osmundaceae, Schizaeaceae, Gleicheniaceae, Cyatheaceae, Polypodiaceae and Matoniaceae; gymnospermous pollen grains may be referred to two families: Podocarpaceae and Araucariaceae; and angiospermous pollen grains may be related to 21 families (according to their relative abundance in descending order), viz., Palmae, Cruciferae, Meliaceae, Lentibulariaceae, Oleaceae, Onagraceae, Euphorbiaceae, Rhizophoraceae, Labiatae, Juglandaceae, Liliaceae, Potamogetonaceae, Nymphaeaceae, Sonneratiaceae, Leguminosae, Fagaceae, Proteaceae, Vitaceae, Guttiferae, Rubiaceae and Solanaceae.

4. Among the pteridophytic spores, *Dandotiaspora* Sah, Kar & Singh is most common, especially in the lower levels of the Clastic Member (= *Dandotiaspora dilata* Cenozone), where it constitutes about 35 per cent of the assemblage. In some samples its frequency reaches up to 60 per cent or even more. Other important pteridophytic genera are: *Lygodiumsporites* (Potonié, Thomson & Thiergart) Potonié, *Todisporites* Couper and *Lycopodiumsporites* Thiergart.

5. The gymnospermous pollen grains are insignificant in the lower levels of the Clastic Member (= *Dandotiaspora dilata* Cenozone) while in the middle levels (= *Couperipollis brevispinosus* Cenozone) their frequency increases considerably, owing to the common occurrence of *Laricoidites* (Potonié, Thomson & Thiergart) Potonié (13 per cent) and *Araucariacites* (Cookson) Couper (4 per cent) in this part.

6. The angiospermous pollen grains are the dominant constituent of the Matanomadh palynoflora both in number and variety. The dicotyledonous pollen grains dominate over monocotyledonous pollen grains. Among monocotyledonous pollen grains, *Couperipollis* Venkatachala & Kar (32 per cent) is most common especially in the middle levels of the Clastic Member (= *Couperipollis brevispinosus* Cenozone) followed by *Palmaepollenites* Potonié and *Retipilonapites* Ramanujam; while among dicotyledonous pollen grains *Tricolpites* (Erdtman) Potonié, *Lakiapollis* Venkatachala & Kar, *Paleosantalaceaepites* (Biswas) Dutta & Sah, *Trilatiporites* Ramanujam, *Favitricolporites* Sah and *Proxapertites* (van der Hammen) Singh are the major constituents.

7. The palynoflora suggests the prevalence of tropical-subtropical climate during the deposition of Matanomadh Formation.

8. The environment of deposition for the Matanomadh Formation is interpreted as ranging from fluviatile to estuarine.

9. The comparison of the Matanomadh assemblage with known Palaeocene-Lower Eocene assemblages from Indian subcontinent indicates that the Cherra Formation of Shillong Plateau, Tura Formation of Garo Hills and Dandot lignite of Pakistan are contemporaneous or correlative equivalents of the Matanomadh Formation.

10. The evidence derived from order of superposition, palaeontology and palynology unanimously suggest a Palaeocene age for the Matanomadh Formation and as such the possibility of early Eocene age for the Matanomadh Formation, as suggested by few previous workers, is completely ruled out.

11. Comparison of palynofloras from Matanomadh and Naredi formations indicates that the two formations can be identified and differentiated by their distinctly different assemblages.

ACKNOWLEDGEMENT

The author records his sincere thanks to Dr S. C. D. Sah, Director, Wadia Institute of Himalayan Geology, Dehra Dun and to Dr R. K. Kar, Birbal Sahni Institute of Palaeobotany, Lucknow for their supervision and encouragement during the progress of the present study. The author also expresses his deep gratitude to Dr H. P. Singh, Head of the Oil Palynology Department, B.S.I.P., Lucknow for critically going through the manuscript.

REFERENCES

Baksi, S. K. (1972). On the palynological biostratigraphy of Bengal basin. *Proc. Sem. Paleopalynol. Indian Stratigr., Calcutta*: 188-206.

Banerjee, D. (1964). A note on polospores from Tura Formation, Simsang River Section, Assam. *Bull. geol. min. metall. Soc. India*, **32**: 1-4.

Banerjee, D. (1966). A note on Tertiary microflora from Andaman Islands, India. *Pollen Spores*, **8** (1): 205-212.

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

BISWAS, S. K. (1965). A new classification of Tertiary rocks of Kutch, western India. *Bull. geol. min. metall. Soc. India*, **35**: 1-6.

BISWAS, S. K. (1971). Note on the geology of Kutch. *Q. Jl geol. Min. metall. Soc. India*, **43** (4): 223-235.

BISWAS, S. K. & DESHPANDE, S. V. (1970). Geological and tectonic maps of Kutch. *Bull. Oil Nat. Gas Commn*, **7** (2): 115-116.

BISWAS, S. K. & RAJU, D. S. N. (1971). Note on the rock stratigraphic classification of the Tertiary sediments of Kutch. *Q. Jl geol. Min. metall. Soc. India*, **43** (3): 177-180.

BISWAS, S. K. & RAJU, D. S. N. (1973). The rock-stratigraphic classification of the Tertiary sediments of Kutch. *Bull. Oil Nat. Gas Commn.*, **10**: 37-45.

BOSE, M. N. (1952). Plant remains from Barmer District, Rajasthan. *J. Sci. indus. res.*, **11B**: 185-190.

CHITALEY, S. D. (1951). Fossil microflora from the Mohgaon Kalan beds of the Madhya Pradesh, India. *Proc. natn. Inst. Sci. India*, **17** (5): 373-383.

CHITALEY, S. D. (1957). Further report on the fossil microflora from the Mohgaon Kalan beds of the Madhya Pradesh, India. *Proc. natn. Inst. Sci. India*, **23B** (3-4): 69-79.

DUTTA, S. K. & SAH, S. C. D. (1970). Palynostratigraphy of the Tertiary sediments of Assam-5. Stratigraphy and palynology of South Shillong Plateau. *Palaeontographica*, **131B** (1-4): 1-72.

JAIN, K. P., KAR, R. K. & SAH, S. C. D. (1973). A palynological assemblage from Barmer, Rajasthan. *Geophytology*, **3** (2): 150-165.

KAR, R. K. (1974). Palynostratigraphy of western region, pp. 561-568 in *Aspects & Appraisal of Indian Palaeobotany*. Birbal Sahni Institute of Palaeobotany, Lucknow, India.

KAR, R. K. & SAXENA, R. K. (1976). Algal and fungal microfossils from Matanomadh Formation (Palaeocene), Kutch, India. *Palaeobotanist*, **23** (1): 1-15.

LAKHANPAL, R. N. & BOSE, M. N. (1951). Some Tertiary leaves and fruits of the Guttiferae from Rajasthan. *J. Indian bot. Soc.*, **30** (1-4): 132-136.

LUKOSE, N. G. (1974). Palynology of the subsurface sediments of Manhera-Tibba Structure, Jaisalmer, western Rajasthan, India. *Palaeobotanist*, **21** (3): 285-297.

MATHUR, K. (1963). Occurrence of *Pediastrum* in Subathu Formation (Eocene) of Himachal Pradesh, India. *Sci. Cult.*, **29**: 250.

MATHUR, K. (1964). On the occurrence of *Botryococcus* in Subathu Series of Himachal Pradesh, India. *Sci. Cult.*, **30**: 607-608.

MATHUR, Y. K. (1963). Studies in the fossil microflora of Kutch, India-1. On the microflora and hystrichosphaerids in the Gypseous shales (Eocene) of western Kutch, India. *Proc. natn. Inst. Sci. India*, **29B** (3): 356-371.

MATHUR, Y. K. (1966). On the microflora in the supratrappeans of W. Kutch, India. *Q. Jl geol. Min. metall. Soc. India*, **38**: 33-51.

NAGAPPA, Y. (1959). Foraminiferal biostratigraphy of the Cretaceous-Eocene succession in India- Pakistan-Burma region. *Micropaleontology*, **5** (2): 145-192.

OLDHAM, R. D. (1893). *Manual of the Geology of India*: 319-323. 2nd edn, Calcutta.

PASCOE, E. H. (1964). *A Manual of the Geology of India and Burma*, **3**: 1485-1486. 3rd edn, Govt. of India Press, Calcutta.

PODDAR, M. C. (1959). Stratigraphy and oil possibilities in Kutch, western India. *Proc. Ist Symp. Dev. Petrol. Resources of Asia & Far East*, **10**: 146-148.

PODDAR, M. C. (1963). Geology and oil possibilities of Tertiary rocks of western India. *Proc. IInd Symp. Dev. Petrol. Resources of Asia & Far East*, **18** (1): 226-230.

RAO, A. R. & VIMAL, K. P. (1952). Tertiary pollen from lignites from Palana (Eocene), Bikaner. *Proc. natn. Inst. Sci. India*, **18** (6): 595-601.

SAH, S. C. D. & DUTTA, S. K. (1966). Palynostratigraphy of the sedimentary formations of Assam-1. Stratigraphical position of the Cherra Formation. *Palaeobotanist*, **15** (1-2): 72-86.

SAH, S. C. D. & DUTTA, S. K. (1968). Palynostratigraphy of the Tertiary formations of Assam-2. Stratigraphic significance of pollen and spores in Tertiary succession of Assam. *Palaeobotanist*, **16** (2): 177-195.

SAH, S. C. D. & DUTTA, S. K. (1974). Palynostratigraphy of the sedimentary formations of Assam-3. Biostratigraphic zonation of the Cherra Formation of South Shillong Plateau. *Palaeobotanist*, **21** (1): 42-47.

SAH, S. C. D. & KAR, R. K. (1969). Pteridophytic spores from the Laki Series of Kutch, Gujarat, India, pp. 109-121 in Santapau H. *et al.* (Eds)— *J. Sen Mem. Vol*. Bot. Soc Bengal, Calcutta.

SAH, S. C. D. & KAR, R. K. (1970). Palynology of the Laki sediments in Kutch-3. Pollen from bore holes around Jhulrai, Baranda and Panandhro. *Palaeobotanist*, **18** (2): 127-142.

SAH, S. C. D. & KAR, R. K. (1971). Palynological interpretations of palaeoenvironments with reference to India. *Palaeobotanist*, **19** (1): 86-94.

SAH, S. C. D. & KAR, R. K. (1972). Palynostratigraphic evaluation of the Lower Eocene sediments of India. *Proc. Sem. Paleopalynol. Indian Stratigr., Calcutta*: 255-265.

SAH, S. C. D. & KAR, R. K. (1974). Palynology of the Tertiary sediments of Palana, Rajasthan. *Palaeobotanist*, **21** (2): 163-188.

SAH, S. C. D., KAR, R. K. & SINGH, R. Y. (1971). Stratigraphic range of *Dandotiaspora* gen. nov. in the Lower Eocene sediments of India. *Geophytology*, **1** (1): 54-63.

SAHNI, A. & KUMAR, V. (1974). Palaeogene palaeobiogeography of the Indian subcontinent. *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, **15** (3): 209-226.

SALUJHA, S. K., KINDRA, G. S. & REHMAN, K. (1972). Palynology of the South Shillong Front, Part-1: The Palaeogene of Garo Hills. *Proc. Sem. Palaeopalynol. Indian Stratigr., Calcutta*: 265-291.

SALUJHA, S. K., KINDRA, G. S. & REHMAN, K. (1974). Palynology of the South Shillong Front: Part-II. The Palaeogene of Khasi and Jaintia Hills. *Palaeobotanist*, **21** (3): 267-284.

SALUJHA, S. K., SRIVASTAVA, S. C. & RAWAT, S. K. (1969). Microfloral assemblage from Subathu sediments of Simla Hills. *J. palaeont. Soc. India*, **12**: 25-40.

SAXENA, R. K. (1977a). On the stratigraphic status of the Matanomadh Formation, Kutch, India. *Palaeobotanist*, **24** (3): 211-214.

SAXENA, R. K. (1977b). Lithostratigraphy of the Matanomadh Formation, Kutch, India. *Palaeobotanist*, **24** (3): 261-262.

SAXENA, R. K. (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, R. K. (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.

SINGH, R. Y. (1977). Stratigraphy and palynology of the Tura Formation in the type area, Part-II (Descriptive palynology). *Palaeobotanist*, **23** (3): 189-205.

TANDON, K. K. (1971). Occurrence of *Venericardia beaumonti* D'Archiac and Haime from Nareda, South-Western Kutch, India. *Geophytology*, **1** (1): 70-74.

TEWARI, B. S. (1952). Tertiary beds of Vinjhan-Miani area S. W. Kutch, India. *Curr. Sci.*, **21** (8): 217-218.

TEWARI, B. S. (1957). Geology and the stratigraphy of the area between Waghopadar and Cheropadi, Kutch, western India. *J. palaeont. Soc. India*, **2**: 136-148.

VENKATACHALA, B. S. & KAR, R. K. (1968). Fossil pollen comparable to *Barringtonia* from the Laki sediments of Kutch. *Pollen Spores*, **10** (2): 335-339.

VENKATACHALA, B. S. & KAR, R. K. (1969a). Palynology of the Tertiary sediments of Kutch-1. Spores and pollen from bore-hole no. 14. *Palaeobotanist*, **17** (2): 157-178.

VENKATACHALA, B. S. & KAR, R. K. (1969b). Palynology of the Tertiary sediments in Kutch-2. Epiphyllous fungal remains from bore-hole no. 14. *Palaeobotanist*, **17** (2): 179-183.

VENKATACHALA, B. S. & RAWAT, M. S. (1972). Palynology of the Tertiary sediments in the Cauvery basin-1. Palaeocene-Eocene palynoflora from the subsurface. *Proc. Sem. Paleopalynol. Indian Stratigr., Calcutta*: 292-335.

VIMAL, K. P. (1952). Spores and pollen from Tertiary lignites from Dandot, West Punjab (Pakistan). *Proc. Indian Acad. Sci.*, **38** (5), Ser. B: 195-210.

WADIA, D. N. (1968). *Geology of India*. London.

WYNNE, A. B. (1872). Geology of Kutch. *Mem. geol. Surv. India*, **9** (1): 1-289.