PALYNOOSTRATIGRAPHY OF THE NAREDI (LOWER EOCENE) 
AND THE HARUDI (MIDDLE EOCENE) FORMATIONS IN THE 
DISTRICT OF KUTCH, INDIA 

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INTRODUCTION


The Eocene rocks in Kutch, in the opinion of Biswas and Raju (1971, 1973), can be divided into three lithostratigraphic units, viz., Naredi Formation, Harudi Formation, and Fulra Limestone. The Naredi Formation is called after the village Naredi (23° 34'30"; 68°39'00") and is on the side of Nalia — Narayansarовар Road. This formation is well exposed in the cliffs along the river Kakdi and is divisible into three members. The lower Gypseous Shale Member of the Naredi Formation is about 25 m thick and consists of grey-brown clay and shale occasionally with bands of lignite. The gypsum is found occasionally as thin layers in these shales. Besides, calcareous concretions are also frequently met with in this member. The middle Assilina Limestone Member is approximately 6 m thick and is very rich in Assilina. The upper Ferruginous Claystone Member is about 11 m thick and is characterized by grey-brown claystone with gypseous layers and ferruginous liminae. The various microfauna reported from this formation favour a Lower Eocene age (Ypresian) (Map 1).

The Harudi Formation is not more than 15 m thick and is named after the village Harudi (23°30'30"; 68°41'10"). This formation is exposed to the north-west of the village about 2 km north-west on the Nalia-Narayansarовар Road. The formation comprises grey shale with yellow limonitic partings in the lower part. Occasional thin lignitic layers are also found within it. The upper part consists of calcareous claystone and siltstone with occasional layers of gypsum. In the opinion of Biswas and Raju (1971, 1973) a ferruginous, gypseous clayey marlite studded with Nummulites is the marker bed of this formation. Planktonic foraminifera have been worked out by Mohan and Soddan (1970) from these rocks and they have ascribed a Middle Eocene age (Lutetian) to this formation.
Fulra Limestone is well observed in the southern scarp of Babia Hill about 1.7 km south-west of Fulra (23°42′30″; 68°47′12″). The entire formation is made up of yellow to dirty white foraminiferal limestone. This formation is full of macro- and microfauna which indicate a Middle Eocene (Upper Lutetian) age.

MATERIAL AND METHOD

The surface samples from Naredi Formation were collected for number of years from Akri, Panandho, Matanomad, Naredi, Jhulrai, Baranda, Wagapethar and Umarsar in the district of Kutch. Besides, number of bore-hole cores were also studied belonging to the lower Gypseous Shale Member of this formation drilled around Matanomad, Baranda, Jhulrai, Panandho and Akri villages. These samples were kindly supplied by the Directorate of Geology and Mining, Government of Gujarat. The samples were macerated from all the three members of this formation but only the Gypseous Shale Member proved productive. The samples from Harudi Formation were collected from the escarpment beside a nala about 2 km north-west of Harudi — the type locality of this formation. The limonitic partings with occasional very thin lignitic layers in the lower part only yielded palynological fossils. All the slides have been deposited to the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

The following 65 spore-pollen genera and 92 species have been encountered in the different exposures and subsurface samples from the Naredi Formation:

*Cyathidites minor* Couper, 1953; *Cyathidites* cf. *C. minor* Couper, 1953; *Alsophili-
The spores-pollen genera and species recovered from the Harudi Formation have been systematically described as follows.

**SYSTEMATIC PALYNOLOGY**

Anteurgum — Sporites H. Potonié, 1893

Turma — Triletes (Reinsch) Potonié & Kremp, 1954

Subturma — Azonotriletes Luber, 1935
Infraturma — *Laevigati* (Bennie & Kids-ton) Potonie, 1956

**Genus — Cyathidites Couper, 1953**

*Type Species — Cyathidites australis Couper, 1953.*

*Cyathidites australis* Couper, 1953

Pl. 1, figs. 1-2

**Remarks** — The specimens assigned to this species in the present material are generally infected by some bacteria or fungi providing various pseudo-ornamental pattern. One type is very minute in size, looks like a pin head and when closely placed seems cursorily to be punctate (Pl. 1, fig. 1). Another type is more or less subcircular in shape and looks like blotches on the surface (Pl. 1, fig. 2). It may be mentioned here that Dettmann (1963) also noted some bacteria/fungi on the exine of some spores (Dettmann, 1963, pl. 1, fig. 3) assigned to *Cyathidites australis* Couper (1953) from the Upper Mesozoic sediments of South-eastern Australia. She, however, thought this was due to corrosion of the exine.

*Cyathidites minor* Couper, 1953

**Remarks** — This species is well-known in Jurassic and Cretaceous sediments of the world. In Palaeogene, it is also quite common in India. Sah and Kar (1969) reported this species from Naredi Formation (Lower Eocene) of Kutch while Kar (1978) referred some specimens comparable to this species from Oligocene of Kutch. Dutta and Sah (1970) described the same species from Palaeocene-Lower Eocene of Assam.

**Genus — Dandotiaspora Sah, Kar & Singh, 1971**

*Type Species — Dandotiaspora dilata (Mathur) Sah, Kar & Singh, 1971.*

*Intrapunctisporis harudiensis* sp. nov.

Holotype — Pl. 1, fig. 3, size 44 μ. Slide no. 3254/7.

**Type Locality** — Harudi, Harudi Formation (Middle Eocene), Kutch, India.

**Diagnosis** — Spores triangular, 41-64 μ. Trilete, rays well-developed, extending mostly up to equator. Exine 1-2.5 μ thick, intrapunctate, apices rounded, interapical margin generally convex.

**Comparison** — *Intrapunctisporis* described by Kar (1978) from the Oligocene of Kutch is distinguished from the present species by its bigger size range and narrow apices. *Intrapunctisporis harudiensis* Krutzsch (1959) is bigger in size range and is more intrapunctate than the present species.

**Genus — Lygodiumsporites (Potonie, Thomson & Thiergart) Potonie, 1956**

*Type Species — Lygodiumsporites adriensis (Potonie & Gelletich) Potonie, Thomson & Thiergart, 1950.*

**Remarks** — Potonie, Thomson and Thiergart (1950) instituted *Lygodiumsporites* to accommodate, trilete, triangular spores with laevigate and intrastuctured exine. The rays in this genus do not extend more than half of the radius. They selected *Punctatisporites adriensis* Potonie & Gelletich (1933) as the type species of the genus.

the opinion of Potonie (1956), *Lygodiumsporites* can be distinguished from *Deltiodospora* (Miner) Potonie (1956), *Cyathidites* Couper (1953) and *Gleicheniidites* (Ross) Delcourt & Sprumont (1955) by its distinctly shorter haptotypic mark. By its mostly intrapunctate structure of the exine *Lygodiumsporites* also comes close to *Intrapunctisporis* Krutzsch (1959) but the former is again demarcated by its shorter trilete rays.

*Lygodiumsporites lakiensis* Sah & Kar, 1969

**Genus — Todisporites** Couper, 1958

**Type Species** — *Todisporites major* Couper, 1958.

*Todisporites kutchensis* Sah & Kar, 1969

**Infraturma — Apiculati** (Bennie & Kistston) Potonie, 1956

**Genus — Osmundacidites** Couper, 1953

**Type Species** — *Osmundacidites wellmanii* Couper, 1953.

*Osmundacidites kutchensis* Sah & Kar, 1969

**Genus — Scantigranulites** gen. nov.

**Type Species** — *Scantigranulites triangulus* sp. nov.

**Generic Diagnosis** — Spores triangular—subtriangular. Trilete, rays extending half of radius to equator. Exine generally thick, granulose, grana sparsely placed, scattered all over spore coat.

**Description** — Spores generally triangular with bluntly rounded apices and straight—convex interapical margin. Trilete distinct, rays narrow, uniformly broad; commissure well recognizable, sometimes folds found in association with trilete rays. Exine 1-3 μ high, sparsely placed, intergranular space laevigate.

**Comparison** — *Granulatisporites* (Ibrahim) Potonie & Kremp (1954) compares well with the present genus in possessing triangular shape and granulose ornamentation. But the former genus is easily distinguished by its closely placed grana hardly leaving any intergranular space in between them. *Intertriletes* Anderson (1960) has triangular shape but is ornamented with fine reticulum on the contact area. *Nevesisporites* de Jersey & Paten (1964) is variously sculptured on the proximal side and is also cingulate. *Osmundacidites* Couper (1953) is sparsely granulose but is distinguished from the present genus by its circular—subcircular shape. *Eximispora* Saluja, Kindra & Rehman (1972) is generally triangular—subtriangular shape but is conspicuous by its presence of large tubercles. *Scantigranulites* proposed here is differentiated from all the trilete genera by its triangular—subtriangular shape and sparsely placed grana, uniformly distributed all over the surface.

*Scantigranulites triangulus* sp. nov.

**Pl. 1, figs. 6-7**

**Holotype** — Pl. 1, fig. 6, size 65 μ. Slide no. 3260/3.

**Type Locality** — Harudi, Harudi Formation (Middle Eocene), Kutch, India.

**Diagnosis** — Spores mostly subtriangular, with bluntly rounded apices and convex interapical margin; 59-74 μ. Trilete distinct, rays extending up to three-fourths radius. Exine 2-3 μ thick, granulose, grana 1 μ high, sparsely placed, uniformly distributed.

*Scantigranulites sparsus* sp. nov.

**Pl. 1, figs. 8-11**

**Holotype** — Pl. 1, fig. 8, size 44 μ. Slide no. 3262/2.

**Type Locality** — Harudi, Harudi Formation (Middle Eocene), Kutch, India.

**Diagnosis** — Spores triangular with straight—convex interapical margin, 35-55 μ. Trilete distinct, rays extending up to three-fourths radius. Exine 1-2.5 μ thick, granulose, grana scantily spread.

**Comparison** — *Scantigranulites triangulus* resembles the present species in shape and ornamental pattern but the former is distinguished by its bigger size range.

**Turma — Monoletes** Ibrahim, 1933

**Subturma — Azonomonoletes** Luber, 1935

**Infraturma — Psilosmonoleti** van der Hammen, 1955
Genus — *Laevigatosporites* (Ibrahim) Schopf, Wilson & Bentall, 1944

*Type Species* — *Laevigatosporites vulgaris* Ibrahim, 1933.

*Laevigatosporites cognatus* Sah & Kar, 1969

*Remarks* — The specimens assignable to *Laevigatosporites* is very rare in the present material.

Genus — *Seniasporites* Sah & Kar, 1969

*Type Species* — *Seniasporites verrucosus* Sah & Kar, 1969.

*Seniasporites verrucosus* Sah & Kar, 1969

*Remarks* — Specimens have mostly globular verrucae. They are well-developed and closely placed only on the distal side of the exine providing pseudoreticulate ornamentation in surface view.

Genus — *Polypodiisporites* Potonié, 1934

*Type Species* — *Polypodiisporites favus* Potonié, 1934.

*Polypodiisporites constrictus* Kar, 1978

*Remarks* — The specimens studied here are not much constricted. The verrucae are well-developed on both sides and they have flattened base and pointed tip.

Genus — *Schizaeoisporites* Potonié, 1951

*Type Species* — *Schizaeoisporites phaseolus* Delcourt & Sprumort, 1955.

*Schizaeoisporites sp.*

*Pl. 1, fig. 14*

*Description* — Spore elliptical, 65 x 40 μ. Monolete distinct, straight, extending up to three-fourths radius. Costae prominent, parallel to each other, intercostate exine laevigate.

*Comparison* — The present species comes near to *Schizaeoisporites phaseolus* Sah & Kar (1974) reported from the Palana lignites (Lower Eocene) of Rajasthan by its shape and general organization but is separated by its larger size. *Schizaeoisporites pusilla* Pursh: Ghosh, Jacob & Lukose (1964) has punctate exine. *S. crassimurus* Dutta & Sah (1970) has very stout costae and is mostly subcircular in shape. *S. eocaenicus* (Selling) Potonié (1956) described by Dutta and Sah (1970) is more broad than the present specimen.

Infraturma — *Sphaerozonisulcates* Venkatachala & Kar, 1969

Genus — *Proxapertites* (van der Hammen) van der Hammen, 1956

*Type Species* — *Proxapertites operculatus* (van der Hammen) van der Hammen, 1956.

*Proxapertites microreticulatus* Jain, Kar & Sah, 1973

*Pl. 1, figs. 15-16*

*Remarks* — This species is quite common in the present material. The overall shape of the specimens is mostly subcircular with a pronounced suture at the margin; completely detached specimens are, however, rare. The microreticulation is mostly well-developed and the exine is, sometimes, irregularly folded.

Infraturma — *Plicates* (Naumova) Potonié, 1960

Subinfraturma — *Monocolpates* Iversen & Troels-Smith, 1950
Genus — *Palmaepollenites* Potonié, 1951  

*Type Species* — *Palmaepollenites tranquillus* (Potonié) Potonié, 1951.  

*Remarks* — *Palmaepollenites* is well represented in the assemblage. The pollen grains are generally elliptical and their size range varies from 26-51 \( \times \) 18-40 \( \mu \). The following species are generally met with.  

*Palmaepollenites kutchensis* Venkatachala & Kar, 1969a  

*P. ovatus* Sah & Kar, 1970  

*P. plicatus* Sah & Kar, 1970  

Genus — *Dracaenoipollis* Sah & Kar, 1970  

*Type Species* — *Dracaenoipollis circularis* Sah & Kar, 1970.  

*Dracaenoipollis circularis* Sah & Kar, 1970  

*Remarks* — The size range of the specimens studied is almost same as has been observed by Sah and Kar (1970) from the Lower Eocene sediments of Kutch. The operculum is distinct and the exine is weakly granulose.  

Besides *Dracaena*, some of the modern genera of Palmae, particularly *Cocos* also resembles *Dracaenoipollis*.  

Genus — *Arecipites* Wodehouse, 1933  

*Type Species* — *Arecipites punctatus* Wodehouse, 1933.  

*Remarks* — *Arecipites* was instituted by Wodehouse (1933) to accommodate monocarpate, elliptical pollen with puncta. He assumed that this genus shows close affinity to the extant pollen grains of *Phoenix dactylifera* of the family Palmae. Besides *Phoenix*, it seems that this genus also shows similarity to the pollen grains of *Calamus* also of Palmae.  

*Arecipites bellus* Sah & Kar, 1970  

*Remarks* — This species is very rare. The colpus is distinct and extends from one end to the other. The puncta is distinct, closely placed and provides pseudo-reticulate ornamentation in surface view.  

Genus — *Couperipollis* Venkatachala & Kar, 1969a  

*Type Species* — *Couperipollis perspinosus* (Couper) Venkatachala & Kar, 1969a.  

*Couperipollis brevispinosus* (Biswas) Venkatachala & Kar, 1969a  

*Remarks* — The colpus is indistinct and even hardly traceable in some specimens. Interspinal exine is distinctly intrapunctate. This structure is also visible at the base of the bulbous spines.  

*Couperipollis kutchensis* Venkatachala & Kar, 1969a  

Pl. 1, fig. 17  

*Remarks* — The colpus is indistinct and even hardly traceable in some specimens. The spines are closely placed, interspinal exine is intrapunctate.  

Subturma — *Triptyches* (Naumova) Potonié, 1960  

Genus — *Tricolpites* (Erdtman) Potonié, 1960  

*Type Species* — *Tricolpites reticulatus* Cookson, 1947.  

*Tricolpites levis* Sah & Dutta, 1966  

*Remarks* — The specimens are subcircular in polar view. Three colpi are distinct and extending almost from pole to pole.  

*Tricolpites sp.* cf. *T. matauraensis* Couper, 1953  

Pl. 1, fig. 18  

*Description* — Pollen grains mostly found in polar view, 32-36 \( \mu \), colpi distinct, broad. Exine upto 4 \( \mu \) thick, retipilate, lumen broad.
Remarks — The specimens are distinguished from *T. matauraensis* Couper (1953) by its broadly retipilate nature; other characters closely resemble each other.

*Tricolpites* sp.

Pl. 1, fig. 19

**Description** — Pollen grains subcircular, 56-63 µ. Tricolpate, colpi distinct. Exine 4-6 µ thick, sexine much thicker than nexine, retipilate.

**Comparison** — The present species is distinguished from *Tricolpites levis* Sah & Dutta (1966) by its well-developed retipilate ornamentation. *T. reticulatus* Cookson (1947) is distinctly reticulate.

**Genus — Marginipollis** Clarke & Frederiksen, 1968

**Type Species** — *Marginipollis concinnus* Clarke & Frederiksen.

**Marginipollis kutchensis** (Venkatachala & Kar) comb. nov.

Pl. 1, fig. 26

1968 *Rostriapollenites kutchensis* Venkatachala & Kar, p. 336, pl. 1, figs. 9-11.

1969a *Rostriapollenites kutchensis* Venkatachala & Kar; Venkatachala & Kar, p. 161, pl. 1, figs. 19-21a-c.

**Remarks** — Venkatachala and Kar (1968) instituted *Rostriapollenites* to accommodate fossil *Barringtonia* type of pollen grains from the Lower Eocene of Kutch. But Clarke and Frederiksen (1968) also published *Marginipollis* to accommodate the same. Since *Marginipollis* has been published earlier, it has got nomenclatural priority over *Rostriapollenites*.

*Marginipollis kutchensis* is distinguished from *M. concinnus* Clarke & Frederiksen (1968) by its tegillate sexine with irregular thickenings of the tegillum providing areoloidate appearance. Besides, *M. concinnus* is also granulose whereas *M. kutchensis* is laevigate.

**Genus — Parumbelliferoipollis** gen. nov.

**Type Species** — *Parumbelliferoipollis dulcis* sp. nov.

**Generic Diagnosis** — Pollen grains elliptical in equatorial view. Tricolpate, colpi distinct to indistinct. Exine thick, rugulate to scrobiculate; sexine as thick as nexine at poles, but much thicker than nexine at equator.

**Description** — Pollen grains always found in equatorial view, known size range 38-49 × 20-30 µ. Colpi generally narrow, sometimes hardly discernible, extending up to three-fourths along longitudinal axis. Exine 2-5 µ broad at poles, thickened up to 10 µ at equator. Pila closely placed, 6-10 µ long, mostly fused together to form rugulate to scrobiculate structure. Sexine in some specimens considerably thickened at equator forming a pseudocolpate appearance in surface view.

**Comparison** — The present genus is closely comparable to *Umbelliferoipollenites* Venkatachala and Kar (1969a) described from the Lower Eocene sediments of Kutch in general organization but the latter is dicolporate and usually constricted at equator. *Ailanthipites* Wodehouse (1933) resembles *Parumbelliferoipollis* in elliptical shape and ornamental pattern but differs in being distinctly tricolpate. *Caprifoliipites* Wodehouse (1933), *Cupuliferopollenites* Potonié (1951) and *Castaneoidites* Potonié, Thomson & Thiergart (1950) are also tricolporate. *Cornaceopollenites* Potonié (1950), *Platanoidites* Potonié, Thomson & Thiergart (1950) and *Tricolpites* (Erdtman) Couper (1953) approximate *Parumbelliferoipollis* in tricolpate condition but the latter is easily distinguished by its much thicker sexine at equator.

**Remarks** — *Parumbelliferoipollis* instituted here resembles the extant pollen grains of Umbelliferae worked out by Cerceaul-Larrival (1959, 1962, 1965), Ting (1961), Rossingnol (1962), Maurizio and Louveaux (1964), Joshi and Raghuvansi (1966) and others in overall shape, size range, ornamental pattern and much thickened sexine at equator. But the pollen grains of Umbelliferae are either di- or tricolporate and generally they are constricted at the equator in equatorial view. In none of the specimens studied here, has colporate condition and thus they are easily separated
from the known modern pollen of Umbelliferae.

Some of pollen grains of Araliaceae also resemble *Parumbelliferoipollis* in overall shape and general organization but in the former, the pollen grains are mostly tricolporate and the nexine is much thicker than sexine at equator in some of the species.

The pollen grains of *Heliotropium* of the family Boraginaceae described by Gupta (1972) also somewhat resemble the present genus in elliptical shape without any marked constriction at the equator. But the eight species described by him are generally colporate or colporoidate. *Heliotropium zeylanicum* Lam. in the opinion of Gupta (1972), is tricolpate but the exine is almost psilate.

Pollen grains of Cornaceae are also usually tricolporate and the pore is quite distinct in most of the species.

The present genus proposed here is not exactly comparable to any of the families but it comes closer to the pollen grains of Umbelliferae in general shape, size range and peculiar thickened sexine at equatorial region.

*Parumbelliferoipollis dulus* sp. nov.

Pl. 1, figs. 20-24

**Holotype** — Pl. 1, fig. 20, size 42 x 23 μ. Slide no. 3254/13.

**Type Locality** — Harudi, Harudi Formation (Middle Eocene), Kutch, India.

**Diagnosis** — Pollen grains only found in equatorial view, elliptical, without any marked constriction in middle region. Tricolpate, colpi long, distinct to indistinct, extending up to three-fourths along longer axis. Exine 2-5 μ thick at polar region, 6-10 μ broad at equator; sexine as thick as nexine at equator; pila closely placed and fused to form rugulate to scrobiculate structure.

**Remarks** — *Strobilathidites kundavaensis* Sah (1967) described from Neogene of Rusizi Valley resembles the present species in shape and somewhat in size range but is distinctly porate. The apparent presence of colpi in *S. kundavaensis* is due to the alternation of crassiseinous with crassiseinous parts. This is the characteristic feature of the pollen grains of *Strobilanthes* belonging to the family Acanthaceae.

**Genus — Verrucolporites Sah & Kar, 1970**

**Type Species** — *Verrucolporites verrucus* Sah & Kar, 1970.

**Remarks** — Pollen grains are smaller in size range (20-26 μ) than those previously described by Sah and Kar (1970). The pores are ill-defined. Verrucae are well-developed, inter-verrucose exine is granulose.

**Subturma ** — *Polyptyches* (Naumova) Potonić, 1960

**Genus — Stephanocolpites (van der Hammen) Potonić, 1960**

**Type Species** — *Stephanocolpites constatus* van der Hammen, 1954.

*Stephanocolpites globatus* Venkatachala & Kar, 1969a

**Remarks** — This species is rare. The specimens are found only in polar view. Four colpi are short; the exine is about 4 μ thick and seems to be scrobiculate.

**Genus — Polycolpites Couper, 1953**

**Type Species** — *Polycolpites clavatus* Couper, 1953.

*Polycolpites flavatus* Sah & Kar, 1970

**Remarks** — The specimens recovered here have almost similar size range and same ornamentation pattern noted by Sah and Kar (1970) for the Lower Eocene pollen grains from Kutch,
Genus — *Palaeosantalaceaeptes* Biswas, 1962

*Type Species* — *Palaeosantalaceaeptes primitiva* Biswas, 1962.

*Palaeosantalaceaeptes minutas* Sah & Kar, 1970

Remarks — Pollen grains are not so broad in the present material as has been reported by Sah and Kar (1970). The pores are comparatively less developed and the colpi extend more than three-fourths along the longer axis. The exine is not more than 2 \( \mu \) thick and is laevigate.

Genus — *Symplocopollenites* Potonié, 1957

*Type Species* — *Symplocopollenites vestitulum* Potonié, 1957.

*Symplocopollenites minutas* Venkatachala & Kar, 1969a

Remarks — The pollen grains are 5-porate, pore margin is not much thickened and the exine is sparsely granulose.

**Pollen Polyad — Type 1**

Pl. 1, fig. 27

Description — Pollen grains found in polyad, most probably 16 pollen attached together. Aperture not traceable; exine upto 3 \( \mu \) thick, spinose, interspinal space seems to be intrapunctate.

Comparison — *Droseridites* Cookson (1947) resembles the present specimens in the presence of spines but the former is always found in tetrad. *Polyadopollenites* Thomson & Pflug (1953) approximates the present type in possessing 16 pollen clustered together but is distinguished by its granulose exine. *Ericipites* Wodehouse (1933) is always found in tetrad and the exine is laevigate-granulose.

**Microplankton — Type 1**

Pl. 1, fig. 28

Genus — *Diporites* van der Hammen, 1954

*Type Species* — *Diporites grandiporus* van der Hammen, 1954.

*Diporites* sp.

Pl. 1, fig. 25

Description — Pollen grain elliptical, diorate, 38 \( \times \) 30 \( \mu \). Ora distinct, margin thickened. Exine 3 \( \mu \) thick, scrobiculate.

Comparison — *Diporites* ssp. described by Sah and Kar (1970, 1974) are distinguished from the present specimen by their non-thickened pore margin.

Subturma — *Polyporines* (Naumova) Potonié, 1960

**Microplankton — Type 2**

Pl. 1, fig. 29

Genus — *Pseudonothofagidites* Venkatachala & Kar, 1969a

*Type Species* — *Pseudonothofagidites kutchensis* Venkatachala & Kar, 1969a.

Remarks — The pollen grains are 5-porate, pore margin is not much thickened and the exine is sparsely granulose.

**Microplankton — Type 2**

Pl. 1, fig. 29

Description — Microplanktons subcircular, 56-70 \( \mu \). Wall upto 2 \( \mu \) thick, wrinkled, granulose-warty. Subcircular operculum present on one side.

Comparison — *Psilosphaera* Sah & Kar (1974) comes close to this type in shape and nature of operculum but is distinguished by its smooth wall.

Genus — *Phragmothyrites* (Edwards) Kar & Saxena, 1976

*Type Species* — *Phragmothyrites eocaenicus* (Edwards) Kar & Saxena, 1976.
PALYNOSTRATIGRAPHIC ZONATION OF EOCENE SEDIMENTS IN KUTCH

Text-fig. 1—Note that the stratigraphic column shown in the Text-figure is not to the scale. Where palynological information is not known, the space against the stratigraphic column has been kept blank.
Phragmothyrites sp.
Pl. 1, fig. 30

Description—Ascrostromata subcircular, 72 μ, non-ostiolate. Radial hyphae well-developed, radiating, transverse hyphae not traceable. Ascrostomata seems to be one-celled thick, pores not observed.

Comparison—Phragmothyrites eocaenica (Edwards) Kar & Saxena (1976) is distinguished from the present species by the possession of well-developed transverse hyphae to form pseudoreticulate appearance in conjunction with the radial ones.

PALYNOCOLOGICAL ZONATION

Naredi Formation—The Gypseous Shale Member is quite rich in spores and pollen grains and in all 65 genera and 92 species have been recovered so far. Out of these, Callialasporites tenticularis (Döring) Dev., 1961; Podocarpidites ellipticus Cookson, 1947; Podocarpidites sp.; Laricoidites kutchensis Venkatachala & Kar, 1969a; K. ovatus, Cyathidites minor, Tricolpites levis, T. brevis, Rhoipites kutchensis, Symplocoipolites constrictus, Meliapollis ovatus, and Nyssapollenites kutchensis Venkatachala & Kar, 1969a; Palaeocoprosmadites arcotense Ramanujam, 1966; Lakiapollis ovatus Venkatachala & Kar, 1969a; Meliapollis ramanujamii Sah & Kar, 1970; Polycopites flavus Sah & Kar, 1970; Trilatiporites kutchensis Venkatachala & Kar, 1969a; T. minutus Sah & Kar, 1970; Triorites triangulus Sah & Kar, 1970; T. minutus Sah & Kar, 1970; Pseudonothofagi­dites kutchensis Venkatachala & Kar, 1969a.

Of all these taxa, Triorites triangulus is most common and so the cenozone is proposed after the name of this species.

Triorites triangulus Cenozone

Reference Localities—Naredi Section, Panandhro and Akri Sections.

Lithology—Grey gypseous shale, brown and grey clay with occasional bands of lignites and carbonaceous shales.

Lower Contact—This member rests unconformably on the trap and its derivatives. At Naredi, it rests on the laterites, at Akri on the altered trap and at Panandhro on the lithomargic clay.

Upper Contact—The Assilina Limestone Member overlies this cenozone.

Characteristic species of the Cenozone—Cupuliferoipolinite ovatus, Trilocpites reticulatus, Lakiapollis ovatus, Cyathidites minor, Trilocpites levis, T. brevis, Rhoipites kutchensis, Symplocoipolinite constrictus, Meliapollis ramanujamii and Pseudonothofagus kutchensis.

Cenozone Indicator—The good percentage of Triorites triangulus is a good indicator for this cenozone.

Harudi Formation—The miospore assemblage consists of 26 genera and 30 species. Out of these, 17 species are found in all the samples within the counted specimens:


Amongst these, 7 species, viz., *Dandotiaspora plicata*, *Cyathidites minor*, *Laevigatosporites cognatus*, *Couperipollis brevispinosus*, *Tricolpites levis*, *Palmaepollenites llutchensis* and *Proxapertites microreticulatus* are also found in the Naredi Formation.

But this formation is well recognized by its good representation of *Proxapertites microreticulatus*, *Couperipollis kutchensis*, *Scantigranulites sparsus* and *Seniasporites verrucosus*. *Proxapertites microreticulatus* which is found only in 1% in the Naredi Formation contributes 26% in the Harudi Formation. For this reason the cenozone is named after this species (Text-fig. 1).

**Proxapertites microreticulatus** Cenozoane

Reference Locality — Exposure about 2 km north-west of the village Harudi.

Lithology — Mostly grey shale with yellow limonitic partings and occasional thin lignitic bands.

Lower Contact — The shales lie unconformably on the laterites.

Upper Contact — This comprises calcareous claystone and siltstone with thin layers of gypsum.

Characteristic species of the Cenozoane — *Palmaepollenites kutchensis*, *Cyathidites minor*, *Couperipollis kutchensis*, *Scantigranulites sparsus*, *Palmaepollenites ovatus*, *Seniasporites verrucosus*, *Laevigatosporites cognatus* and *Tricolpites levis*. The Cenozoane Indicator — The cenozone is well marked by the abundance of *Proxapertites microreticulatus*, *Palmaepollenites kutchensis*, *Couperipollis kutchensis* and *Scantigranulites sparsus*.

**Comparison with other palynological zones**

The Bengal palynological zone II comprising Jalangi Formation (Palaeocene-Lower Eocene) proposed by Baksi (1972) is not much comparable to the *Triorites triangulus* Cenozoane as the former is characterized by the abundance of *Reticulatites* and *Schizosporis* which he thinks should be grouped to *Proxapertites* van der Hammen (1956).

Similarly, *Nymphaeopollis assamicus* Cenozoane proposed by Sah and Singh (1974) for Tura Formation (Lower Eocene) is also quite distinct from the present zone by its presence of *Nymphaeopollis assamicus*, *Cicatricosisporites macrorostatus*, *Stephanocpiles tertiarus* and *Polypodisporites speciosus*. Only *Meliapollis ramanujamii* is common to both the cenozones.

The Lakadong palynological zone proposed by Dutta and Sah (1970) is also easily distinguished by its occurrence of *Reticulatites* and *Biretispores* in good number.

On the other hand *Proxapertites microreticulatus* Cenozoane which has been proposed for Harudi Formation (Middle Eocene) closely resembles the palynological zones described by Baksi (1972) and Sah and Singh (1974) from Lower Eocene of Bengal and Assam respectively by their abundance of *Proxapertites*. As has already been stated, on the basis of *Nummulites* (Biswas & Raju, 1971, 1973) and planktonic foraminifera (Mohan & Soodan, 1970), the Harudi Formation has been dated as Middle Eocene (Lutetian) and so this disparity in age between the Kutch and Assam-Bengal assemblages should be critically examined. The Naredi Formation on the basis of microfauna has also been dated as Lower Eocene (Ypresian) and the Gypseous Shale Member, from which the *Triorites triangulus* Cenozoane has been proposed forms the basal member of this formation. The *Psilodiporites hammenii* and the *Anacolosidites trilobatus* palynological zones proposed by Venkatachala and Rawat (1971) for the Lower and Middle Eocene of Cauvery basin respectively are only broadly comparable to the present cenozones as both *Psilodiporites* and *Anacolosidites* are absent in the samples studied here.

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**EXPLANATION OF PLATE**

(All photomicrographs are enlarged ca. × 500)

**PLATE 1**

1-2. *Cynathidites australis* Couper; Slide nos. 3252/1, 3253/1.

3-5. *Intrapunctisporis harudienisis* sp. nov.; Slide nos. 3254/7, 3255/9, 3256/3.


8-11. *Scantigranulites sparsus* sp. nov.; Slide nos. 3262/2, 3263/1, 3261/9, 3264/11.


17. *Couperipollis brevispinosus* (Biswas) Venkatachala & Kar; Slide no. 3257/10.


25. *Diporites* sp.; Slide no. 3255/5.


27. Pollen polyad—type-1; Slide no. 3261/5.

28. Microplankton—type-1; Slide no. 3255/8.

29. Microplankton—type-2; Slide no. 3257/2.
