"The fossil floras of Kachchh. IV—Tertiary palynostratigraphy" by Ranajit K. Kar (1985) : A critique on dinoflagellate cysts

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The Tertiary dinoflagellate cyst assemblages described from Kutch (Kar, 1985) have been critically re-evaluated. All available figured specimens of Early Eocene, Oligocene and Miocene assemblages have been restudied, most of these are rephotographed and reproduced herein, discussing morphological features for their proper taxonomic assessment and reallocation. The four new species, viz., *Areoligera digitata, Cleistosphaeridium cephalum, Operculodinium paucispinosum,* and *O. robustum,* proposed therein have been rejected. Two new combinations, viz., *Apteodinium unicornum* (Kar) and *Operculodinium ornamentum* (Jain & Tandon) and a new species *Glaphyrocysta indica* are proposed. An assessment of various palynozonation schemes revealed major lacunae in the presentation of stratigraphic and palynological data as well as several inconsistencies in the given charts, histograms and their descriptions in the text. It has been recommended that these zonation schemes should be used with caution for comparison and correlation purposes. The status of systematic descriptions of Middle Eocene and Oligocene dinoflagellate cyst taxa transcribed by Kar (1985) from Jain and Tandon (1981) and Jain (1980) has been discussed exemplifying several unexpected errors, inconsistencies and ambiguities. It is recommended that the readers should consult original papers of reproduced versions for correct citations and understanding.

Key-words—Dinoflagellate cysts, Early Eocene, Middle Eocene, Oligocene and Miocene, Kutch Basin (India).

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सारांश

कच्छ के अश्मित वनस्पतिजात-4. तृतीयक युगीन परागाणुस्तरविन्यास (कर, 1985): घूर्णीकशाभ पुटीयों पर एक समालोचना

कृष्ण प्रसाद जैन एवं राहुल गर्ग

कच्छ से वर्णित तृतीयक युगीन घूर्णीकशाभ पुटी समुच्चयों (कर, 1985) का विस्तृत पुनर्अध्ययन किया गया है। प्रारम्भिक आदिनूतन, पश्चनूतन एवं मध्यनूतन कालीन समुच्चयों से उपलब्ध सभी चित्रित प्रादर्शों का भी पुनः अध्ययन किया गया है जिनमें से अधिकतर का पुनः छायाचित्रण किया गया। इनकी यथार्थ वर्गीकरणिक स्थिति स्पष्ट करने हेतु इनके आकारिकीय लक्षणों की विवेचना की गई है। उक्त शोध-पत्र में प्रस्तावित चार जातियाँ अर्थात् **एरिओलिजेरा डिजिटाटा, क्लिस्टोस्फ़ेयरीडियम सिफ़ेलम, ओपर्कुलोडीनियम पोसीस्पाइनोसम** एवं **ओ० रोबस्टम** समाप्त कर दी गई हैं। **ऐप्टिओडीनियम यूनिकॉर्नम** (कर) एवं **ओपर्कुलोडीनियम ओर्नामेन्टम** (जैन व टंडन) नामक दो नव संयोजन तथा **ग्लेफ़ायरोसिस्टा इंडिका** नामक एक नव जाति प्रस्तावित की गई हैं। उक्त शोध-पत्र में प्रकाशित विभिन्न परागाणविक मंडलों के अध्ययन में स्तरिकीय एवं परागाणविक आँकड़ों के प्रस्तुतीकरण में भारी त्रुटियाँ पाई गई हैं। इसके अतिरिक्त अन्य रेखाचित्र आदि तथा मुख्य पाठ्य सामग्री में भी कई असंगतियां पाई गई हैं। इस शोध-पत्र में यह प्रस्तावित किया गया है कि अन्य मंडलों से तुलना एवं सहसम्बन्ध अन्वेषित करते समय कर (1985) द्वारा प्रस्तावित मंडलों का उपयोग अत्यन्त सावधानी से करना चाहिये। इसके अतिरिक्त जैन एवं टन्डन (1981) तथा जैन (1980) द्वारा प्रकाशित शोध-पत्रों से कर (1985) द्वारा लिये गये मध्य आदिनूतन एवं पश्चनूतन कालीन घूर्णीकशाभ पुटी वर्गकों की वर्गीकरणिक स्थिति की विवेचना की गई है तथा कई त्रुटियों अथवा असंगतियों की ओर ध्यानाकर्षित किया गया है। यह भी प्रस्तावित किया गया है कि सही सन्दर्भों हेतु मूल शोध-पत्रों का ही उपयोग करना चाहिये।

A VOLUMINOUS paper on Tertiary palynostratigraphy of Kutch (Kachchh), western India, has been published by Kar (1985). It contains 280 pages and 50 plates dealing with taxonomy, morphology and biostratigraphy of spores, pollen and dinoflagellate cysts of subcrop and outcrop sections ranging in age from Palaeocene to Pliocene. In this account, he claims to have reassessed the earlier works incorporating some new information also (Kar, 1985, p. 1; abstract).

The dinoflagellate cysts are described and illustrated from the following sequences:

1. Lakhpat bore core nos. 1 and 2 — Lower Eocene
2. Jhadwa-Baranda section — Middle Eocene
3. Rataria bore core no. 27 — Middle Eocene
4. Barkhana nala cutting section near the village Sarangwara — Oligocene
5. Section exposed at the junction of Fulai-Ramania and Goela-Walasar cart track — Oligocene
6. Nala cutting section near the village Ber Mota — Oligocene
7. Maniyara Fort section — Oligocene
8. Khari River section near Aida Village — Miocene

Except for the Early Eocene and Miocene dinoflagellate cyst data, the remaining systematic account in Kar (1985) is entirely a reproduction and compilation from the publications of Jain and Tandon (1981) and Kar and Saxena (1981) for the Middle Eocene, and Kar (1979) and Jain (1980) for the Oligocene. Out of total 98 dinoflagellate cyst and acritarch species documented therein, the systematic descriptions of 90 species are adopted from various sources. Only eight species, including six new, have been described originally by him.

Initially we wanted to update the taxonomy of Early Eocene and Miocene dinoflagellate cysts, as the identifications and morphologic descriptions of several species appeared incompatible with the illustrated specimens. However, a careful scrutiny of all the reproduced descriptions/diagnoses, remarks, measurements, etc. of the dinoflagellate cyst taxa, as well as the details of the lithologs, frequency diagrams and various palynozonation schemes, revealed many unexpected errors and inconsistencies which compelled us to write this critique on dinoflagellate cysts and the related data.

GENERAL REMARKS

A. Lower Eocene dinoflagellate cyst Assemblage

Kar (1985, p. 180-185) described dinoflagellate cysts from subsurface sequence of Lakhpat bore-core no. 1. Besides, he reported the occurrence of 'algal microplankton/phytoplankton' alongwith a rich spore-pollen assemblage from Lakhpat bore-core no. 2, Akri Village section and Panandhro open cast lignite quarry. These sequences have been considered to be Lower Eocene in age. A careful analysis of his Lower Eocene field data and the account of dinoflagellate cysts revealed several ambiguities; a few of these are enumerated below.

1. The explanation of Text-figure 5 (Kar, 1985, p. 63, 64) indicates the location of different bore cores studied around Panandhro, but a perusal of the text shows that it also includes three outcrop sections exposed in Panandhro open cast lignite quarry, Gajra Dam and Akri Village. Further, it is noted that only three lithologs (Bore cores 13 & 15 and Gajra Dam section) are marked with sample positions but without any numbers. However, in case of Akri and Panandhro, the sample numbers are mentioned in pollen frequency diagrams (e.g. text-figs 6, 12), but their stratigraphic positions in the respective lithologs are not provided. A reader is thus unable to use this data purposefully.
2. The bore core depth and number of samples marked for bore core 13 and bore core 15 (text-fig. 5) do not tally with their descriptions in the text (p. 95-96). On careful comparison it was discovered that the bore core numbers are wrongly cited in text-figure 5 and should be interchanged.
3. Kar (1985, p. 102-110; text-fig. 17) discussed at length the palynological zonation of Lower Eocene (Naredi Formation) of Kutch, proposing two cenozones, viz., *Lakiapollis ovatus* and *Lygodiumsporites lakiensis*. This discussion dwells more upon palaeoecological aspects (p. 102-107) of the palynomorphs rather on their biostratigraphic significance. However, details of the zonation scheme given in the text are strikingly different from its diagrammatic representation in text-figure 17. The type section of *Lakiapollis ovatus* Cenozone is proposed in Lakhpat bore core no. 1, while the litholog drawn against this cenozone in text-figure 17 has been related to Panandhro section (Kar 1985, p. 107). Unfortunately, this lithologic sequence does not bear any similarity with Panandhro or Lakhpat bore core no. 1 or any other documented section (see text-fig. 5). Similarly the litholog of Akri sequence, the type section of *Lygodiumsporites lakiensis* Cenozone, is also markedly different as plotted at two places (compare text-figs 5 and 17). The lower contact of this cenozone is stated to overlie unconformably the trap derivatives and laterites in Akri sequence (ref. p. 109), but in text-figure 17 it is placed conformably over Panandhro sequence.
4. It may be pointed out that no vertical scale for thickness of the litholog and percentage bar scale for species frequency distribution are provided in the zonation scheme (text-fig. 17). Though approximate thicknesses of the three subzones are mentioned in the text (p. 108-109), these cannot sensibly be correlated with their

diagramatic representation in the above text-figure, which entirely depicts different relative thicknesses of the proposed subzones. Incidentally, the name of *Tricolpites reticulatus* subzone has been inadvertently replaced by *Proxapertites microreticulatus* Cenozone in text-figure 17. The latter is actually a Middle Eocene Cenozone proposed by Kar (1978, p. 174; 1985, p. 109, 130).

Further, Kar (1985, p. 109) has separately outlined "significant" and "restricted" species occurring in various palynozones. However, all the 10 species listed as "restricted within *Tricolpites reticulatus* subzone" are missing in the zonation chart (see *Proxapertites microreticulatus* subzone in text-fig. 17). On the contrary, three species, viz., *Tricolpites brevis, Cheilanthoidspora enigmata* and *Seniasporites verrucosus* are shown to be restricted within this subzone in text-figure 17 which find a place only under "Significant species of the subzone" on p. 109. The upper contact of *Tricolpites reticulatus* subzone has been defined in the type "Panandhro section of text-figure 5" by yellowish, nummulitic, weathered limestone; this lithology has not been described in Panandhro or any other section, leaving the upper contact quite ambiguous. It is also astonishing to find "algal phytoplankton" listed as a species both under "Significant species" and "Species restricted", under *Inapertusporites kedvesii* subzone.

Another remarkable feature of this palynozonation scheme is seen in the distribution/frequency diagrams. In text-figure 17 the "microplankton" (obviously referring to dinoflagellate cysts) are shown to be abundant throughout, while in the histograms of studied sequences of Lakhpat bore core 1, 2 and Panandhro lignite quarry section (text-figs 6, 14, 15 respectively), the vertical distribution of "microplankton" is shown to be extremely variable with total absence or very low representation at many levels in these sequences (incidentally no horizontal scale is provided for percentage count in any of the histograms).

In view of the above ambiguities and inconsistencies the very purpose of this palynological zonation scheme is defeated and it should, therefore be used with caution for biostratigraphic analysis.

It is interesting to note that two different bore cores have been superimposed to interpret results through the histograms (text-figs 14, 15) without any explanation for their exact correlatibility; moreover, the lithologic sequences of the two bore cores are entirely different from each other (text-fig. 13). In his own words, "The two bore-cores were consolidated and represented in one..." (Kar, 1985, p. 103-104). It is against any stratigraphic norm.

5. In the systematic part 13 taxa are described, including two new species, viz., *Areoligera digitata* and *Cleistosphaeridium cephalum* (Kar, 1985, p. 180-184). It is intriguing to note that while documenting the remaining species, Kar (1985) has transcribed the original diagnosis of every species, including even the holotype and type locality details, mostly from Davey *et al.* (1966). In some of the cases, broken or badly preserved unidentifiable specimens are identified even up to subspecies level (e.g. *Heterosphaeridium heteracanthum* subsp. *sparsiprocessum*), while in majority of other cases identifications are wrong (Table 1), thus rendering the given diagnoses absolutely irrelevant and unconnected with the illustrated Kutch specimens.
6. The 'diagnosis' of *Glaphyrocysta pastielsi* (Deflandre & Cookson) Stover & Evitt 1978, quoted by Kar (1985, p. 182) "after Sarjeant (1966)", is actually an abridged version of a part of the discussion of London Clay specimens assigned to *Cyclonephelium pastielsi* by Williams and Downie. (1966, p. 227) as demonstrated below.

In Kar (1985, p. 182)—"*Diagnosis* (after Sarjeant, 1966)—Archaeopyle apical in position with zig-zag margin. Prominent sulcal notch lies to the right of the mid-ventral line. Numerous, solid taeniate processes complexly united along their length and distally. Proximally processes arise singly or in groups of twos or threes. Distally interconnecting trabeculae may be perforated up to 5-6 μm in width. Unconnected short, slender, acuminate or bifid spines often arise from the trabeculae. Occasional simple acuminate processes occur on central body".

In Williams and Downie (1966, p. 277)—"Discussion. Specimens of *C. pastielsi* from the London Clay almost invariably possess an archaeopyle, apical in position and with a zig-zag margin. The prominent sulcal notch lies to the right of the mid ventral line. Only rarely is a complete individual, with the apex in place, encountered. The numerous, solid taeniate processes are complexly united along their length and distally. They are frequently arranged in linear complexes. Proximally the processes arise singly or in groups of twos or

Table 1—Comparative check list of Lower Eocene dinoflagellate cysts from Lakhpat bore core 1, Kutch Basin

Sl. No.	Dinoflagellate cyst species (Taxonomy after Kar, 1985)	Illustrations	Slide/specimen Nos.
1.	*Cleistosphaeridium cephalum* sp. nov.	pl. 40, fig. 1	8274/1 (Holotype)
2.	*C. cephalum* sp. nov.	pl. 40, fig. 2	8275/2
3.	*Areoligera digitata* sp. nov.	pl. 40, fig. 3	8276/6
4.	*Cleistosphaeridium diversispinosum* Davey *et al.* 1966	pl. 40, fig. 4	8277/3
5.	*C. diversispinosum* Davey *et al.* 1966	pl. 40, fig. 5	8278/4
6.	*Cordosphaeridium gracilis* (Eisenack) Davey & Williams 1966	pl. 40, fig. 6	8279/15
7.	*Glaphyrocysta pastielsii* (Deflandre & Cookson) Stover & Evitt 1978	pl. 40, fig. 7	8280/1
8.	*G. pastielsii* (Deflandre & Cookson) Stover & Evitt 1978	pl. 40, fig. 8	8281/2
9.	*Heterosphaeridium heteracanthum* sub sp. *sparciprocessum* (Verma & Dangwal) Eisenack & Kjellström 1971	pl. 40, fig. 9	8282/1
10.	*Litosphaeridium siphoniphorum* (Cookson & Eisenack) Davey & Williams 1966	pl. 40, fig. 10	8283/2
11.	*Nematosphaeropsis densiradiata* (Cookson & Eisenack) Stover & Evitt 1978	pl. 40, fig. 11	8282/2
12.	*N. densiradiata* (Cookson & Eisenack) Stover & Evitt 1978	pl. 40, fig. 12	8283/1
13.	*Cleistosphaeridium cephalum* sp. nov.	pl. 41, fig. 1	8286/2
14.	*Areoligera digitata* sp. nov.	pl. 41, fig. 2	8286/2 (Holotype)
15.	*A. digitata* sp. nov.	pl. 41, fig. 3	8276/7
16.	*Cordosphaeridium exilimurum* Davey & Williams 1966	pl. 41, fig. 4	8288/1
17.	*C. exilimurum* Davey & Williams 1966	pl. 41, fig. 5	8289/1
18.	*Heterosphaeridium heteracanthum* (Deflandre & Cookson) Eisenack & Kjellström 1971	pl. 41, fig. 6	8290/1
19.	*Homotryblium tenuispinosum* Davey & Williams 1966	pl. 41, fig. 7	8291/1
20.	*H. pallidum* Davey & Williams 1966	pl. 41, fig. 8	8277/5
21.	*H. pallidum* Davey & Williams 1966	pl. 41, fig. 9	8293/1
22.	*H. pallidum* Davey & Williams 1966	pl. 41, fig. 10	8289/3
23.	*Hystrichosphaeridium salpingophorum* (Deflandre) Davey & Williams 1966	pl. 41, fig. 11	8276/4
24.	*H. salpingophorum* (Deflandre) Davey & Williams 1966	pl. 41, fig. 12	8297/3

threes. Distally the interconnecting trabeculae may be perforate, up to 5 to 6 μ in width. Unconnected short, slender, acuminate or bifid spines often arise from the trabeculae. Occasional simple acuminate processes occur on the central body".

In continuation of the above, the 2nd para of this discussion has been completely left out by Kar but a part of the last para is adopted as "Remarks".

Further, it may be noted that the same diagnosis (with some more modifications) for this species when reproduced again in the Middle Eocene account, is credited to Williams and Downie, 1969 (Kar, 1985, p. 189)!

B. Middle Eocene dinoflagellate cyst assemblages

Kar (1985, p. 185-199) reproduced the systematic account of Middle Eocene dinoflagellate cysts from the publications of Jain and Tandon (1981) and Kar and Saxena (1981) dealing with outcrop Jhadwa-Baranda section, south-western Kutch and subsurface sequence of Rataria bore core no. 27, respectively.

Out of 52 taxa of dinoflagellate cysts and acritarchs documented by Jain and Tandon (1981), only 46 have been reproduced and the systematic descriptions of 22 taxa have been copied out verbatim, though in many instances the source is not referred. Similarly, in majority of cases the measurements, comparisons and remarks are reproduced from Jain and Tandon (1981) without quoting their reference.

For the other remaining 24 species original diagnoses from different sources have been adopted. In many cases, the original version of diagnoses/descriptions, have partially been omitted or altered. In some instances, the generic description/diagnosis has been reproduced as the description/diagnosis of the species.

A few such examples are enumerated below:

1. The reproduced diagnoses of *Araneosphaera consociata* Jain & Tandon (1981, p. 7-8) and *Glaphyrocysta kachchhensis* Jain & Tandon (1981, p. 9) by Kar (1985, p. 186, 188, 189) does not include significant parts of the original diagnoses (italicised below) making

Table 1—Contd.

Taxonomic reallocations (Present study)				
Sl. No.	Dinoflagellate cyst species	Illustrations	BSIP Slide nos.	Stage coordinates (Vanox AH_2,Olympus Microscope)
1.	*Operculodinium israelianum* (Rossignol) Wall 1967	pl. 1, figs. 8-9	8274	150.0 × 3.6
2.	*O. israelianum* (Rossignol) Wall 1967	pl. 1, fig. 15	8275	163.7 × 18.0
3.	*Homotryblium plectilum* Drugg & Loeblich 1967	pl. 1, figs 1, 2	8276	128 × 15.7
4.	*Polysphaeridium subtile* Davey & Williams emend. Bujak *et al.* 1980	Not illustrated	8277	156.1 × 14.3
5.	*P. subtile* Davey & Williams emend. Bujak *et al.* 1980	pl. 1, fig. 6	8278	151.4 × 16.6
6.	*Homotryblium pallidum* Davey & Williams 1966	pl. 1, fig. 13	8279	132.8 × 20.2
7.	*Adnatosphaeridium multispinosum* Williams & Downie 1966	Not illustrated	8280	150.0 × 5.7
8.	*A. multispinosum* Williams & Downie 1966	pl. 1, fig. 7	8281	144.9 × 15.6
9.	Forma A	Not illustrated	8282	133.1 × 17.7
10.	*Cordosphaeridium robustum* (Gocht) Sarjeant 1981	pl. 1, fig. 14	8283	155.5 × 9.2
11.	*Adnatosphaeridium multispinosum* Williams & Downie 1966	Not illustrated	8284	142.0 × 18.4
12.	*A. multispinosum* Williams & Downie 1966	Not illustrated	8285	159.1 × 9.0
13.	*Operculodinium israelianum* (Rossignol) Wall 1967	pl. 1, fig. 17	8286	156.1 × 12.5
14.	*Homotryblium plectilum* Drugg & Loeblich 1967	pl. 1, figs 4, 5	8287	130.6 × 8.7
15.	*H. plectilum* Drugg & Loeblich 1967	pl. 1, fig. 3	8288	133.9 × 10.1
16.	? *Cordosphaeridium* sp. A	Not illustrated	8289	132.6 × 10.4
17.	? *Cordosphaeridium* sp. A	Not illustrated	8290	130.1 × 9.8
18.	? *Areosphaeridium* sp. A	pl. 1, fig. 12	8291	162.2 × 21.7
19.	*Homotryblium abbreviatum* Eaton 1976	pl. 1, figs 10, 11	8292	131.9 × 16.0
20.	*H. tenuispinosum* Davey & Williams 1966	Not illustrated	8293	154.6 × 8.1
21.	*H. tenuispinosum* Davey & Williams 1966	Not illustrated	8294	139 × 22.8
22.	*H. pallidum* Davey & Williams 1966	Not illustrated	8295	141.9 × 13.5
23.	*H. abbreviatum* Eaton 1976	Not illustrated	8296	141.8 × 23.0
24.	*H. abbreviatum* Eaton 1976	Not illustrated	8297	143.2 × 10.8

morphological description of these species quite ambiguous as follows:

i) Original diagnosis of *Araneosphaera consociata* Jain & Tandon (1981, p. 7) : "Cyst body spherical, surface fibroreticulate; paracingulum raised, equally divides cyst body. Periphragm gives rise to fibrous apical, precingular, postcingular and antapical processes only. Cingular processes absent. Apical and precingular processes usually short, distally united by fenestrate membrane. *Postcingular and antapical processes usually longer than apical and precingular ones, distally united by fibrous, fenestrate membrane.* Paratabulation that of genus; archaeopyle broader than long, precingular (3″)".

Reproduced version of the above in Kar (1985, p. 186) :

> "*Diagnosis (after Jain & Tandon, 1981)*— Cyst body spherical, surface fibroreticulate; paracingulum raised, equally divided cyst body. Periphragm gives rise to fibrous apical, precingular, postcingular and antapical processes only. Cingular processes absent. Apical and precingular processes usually short, distally united by fenestrate membrane. Paratabulation that of genus; archaeopyle broader than long, precingular (3″)".

ii) Original diagnosis of *Glaphyrocysta kachchhensis* Jain & Tandon (1981, p. 9) : "Cyst dorso-ventrally flattened, double layered, periphragm coarsely granulate, gives rise to two types of processes along peripheral zone; on one side short, stout, broad, variously branched, proximal fenestration distinct, some distally *united and a few remain free; on other side processes long, thin, stem of single process branched several times, distally* not united with each other, arcuate process complexes distinct. Archaeopyle apical with zig-zag margin".

Reproduced version of the above in Kar (1985, p. 188-189) :

> "*Diagnosis (after Jain & Tandon, 1981)*— Cysts dorsoventrally flattened, double layered, periphragm coarsely granulate having two types of processes along peripheral zone; on one side short, stout broad, variously branched proximal

fenestration distinct, some distally not united with each other, arcuate process complexes distinct. Archaeopyle apical with zig-zag margin".

2. The specific description of *Eatonicysta ursulae* (Morgenroth) Stover & Evitt 1978 cited by Kar (1985, p. 188) after Stover and Evitt (1978) is in fact verbatim reproduction of the original diagnosis of the genus *Eatonicysta* Stover & Evitt (1978, p. 41) and not of the species. Further, the dimensions are reproduced from Jain and Tandon (1981, p. 9) without quoting their reference.
3. In the case of *Polysphaeridium ornamentum* Jain & Tandon (1981, p. 13), Kar (1985, p. 194) referred the size of the central body to be 66 × 50 μm which actually belongs to the specimens described as *Muratodinium* sp. B (Jain & Tandon, 1981, p. 12). It should have been 70-90 × 90-110 μm.
4. The specific description of *Glaphyrocysta exuberans* (Deflandre & Cookson) Stover & Evitt 1978 given by Kar (1985, p. 189) needs specific attention as discussed below:

"*Description* (after Williams & Downie, 1969)—Chorate cysts with central body flattened, dorso-ventrally and apparently concavo-convex, outline circular to slightly oval. Diameter of central body 56-85 μm, length of processes up to 46 μm. Prominent sulcal notch lies to the right of the mid-ventral line. Surface of central body commonly granular. Archaeopyle apical, tetratabular. Wall layers not distinguished".

The reference of Williams and Downie (1969) in the above context does not exist in the literature and the description is possibly extracted by Kar from Williams and Downie (1966). Surprisingly, the above description appears to have been fabricated using excerpts from three different sources of that publication as quoted below :

— "Chorate cysts with central body flattened dorso-ventrally and apparently concavo-convex, outline circular to slightly oval" (*a part of Emended Diagnosis* of the genus *Cyclonephelium* Deflandre & Cookson in Williams and Downie 1966, p. 223).
— "Diameter of central body 56-85 μm, length of processes up to 46 μ" (*a part of Dimensions* of London Clay specimens assigned to *C. exuberans*, in Williams and Downie, 1966, p. 225).
— "The prominent sulcal notch lies to the right of mid-ventral line. The surface of the central body is commonly granular" (*a part of Discussion* of London Clay specimens assigned to *C. exuberans* in Williams and Downie, 1966, p. 225).
— "Archaeopyle apical tetratabular. Wall layers not distinguished" (*a part of Emended Diagnosis* of the genus *Cyclonephelium* in Williams and Downie, 1966, p. 223).

Further, the remarks on Kutch specimens of *G. exuberans* have been reproduced as such from Jain and Tandon (1981, p. 9) omitting their reference.

→

PLATE 1

(All photomicrographs are in differential interference contrast and magnified × 500; Stage coordinates refer to Olympus Vanox AH-2 microscope)

1,2. *Homotryblium plectilum* Drugg & Loeblich 1967; BSIP Slide no. 8276, Coordinates: 128.7 × 15.7; 1. antapical view of hypocyst; 2. apical view of hypocyst showing epicystal archaeopyle.
3. *Homotryblium plectilum* Drugg & Loeblich 1967; BSIP Slide no. 8276, Coordinates: 133.9 × 10.1; hypocyst only.
4,5. *Homotryblium plectilum* Drugg & Loeblich 1967; BSIP Slide no. 8286, Coordinates: 130.6 × 8.7; broken hypocyst in two foci; 4. showing epicystal archaeopyle; 5. upper focus showing tubular branched processes (Holotype of *Areoligera digitata* Kar 1985).
6. *Polysphaeridium subtile* Davey & Williams emend. Bujak *et al.* 1980; BSIP Slide no. 8278, Coordinates: 151.4 × 16.6; complete specimen in apical-antapical view.
7. *Adnatosphaeridium multispinosum* Williams & Downie 1966; BSIP Slide nos. 8281, Coordinates: 144.9 × 15.6.
8,9. *Operculodinium israelianum* (Rossignol) Wall 1967; BSIP Slide no. 8274, Coordinates: 150 × 3.6; same specimen in two foci.
10,11. *Homotryblium abbreviatum* Eaton 1976; BSIP Slide no. 8291, Coordinates: 131.9 × 16.0; 10. antapical view of hypocyst; 11. hypocyst showing epicystal archaeopyle.
12. ? *Areosphaeridium* sp. A; BSIP Slide no. 8290, Coordinates: 162.2 × 21.7.
13. *Homotryblium pallidum* Davey & Williams 1966; BSIP Slide no. 8279, Coordinates: 132.8 × 20.2.
14. *Cordosphaeridium robustum* (Gocht) Sarjeant 1981; BSIP Slide no. 8283, Coordinates: 155.5 × 9.2.
15. *Operculodinium israelianum* (Rossignol) Wall 1967; BSIP Slide no. 8275, Coordinates: 163.7 × 18.0.
16. *Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967; BSIP Slide no. 5117, Coordinates: 155.0 × 2.6.
17. *Operculodinium israelianum* (Rossignol) Wall 1967; BSIP Slide no. 8286, Coordinates: 156.1 × 12.5.
18,19. *Polysphaeridium congregatum* (Stover) Bujak *et al.* 1980; BSIP Slide no 5116, Coordinates: 153.9 × 12.6; same specimen in two foci; 18. showing proximally joint groups of processes on antapical surface, 19. showing epicystal archaeopyle.
20. *Operculodinium placitum* Drugg & Loeblich 1967; BSIP Slide no. 5118, Coordinates: 153.7 × 15.3. (Holotype of *Polysphaeridium cephalum* Kar 1979).

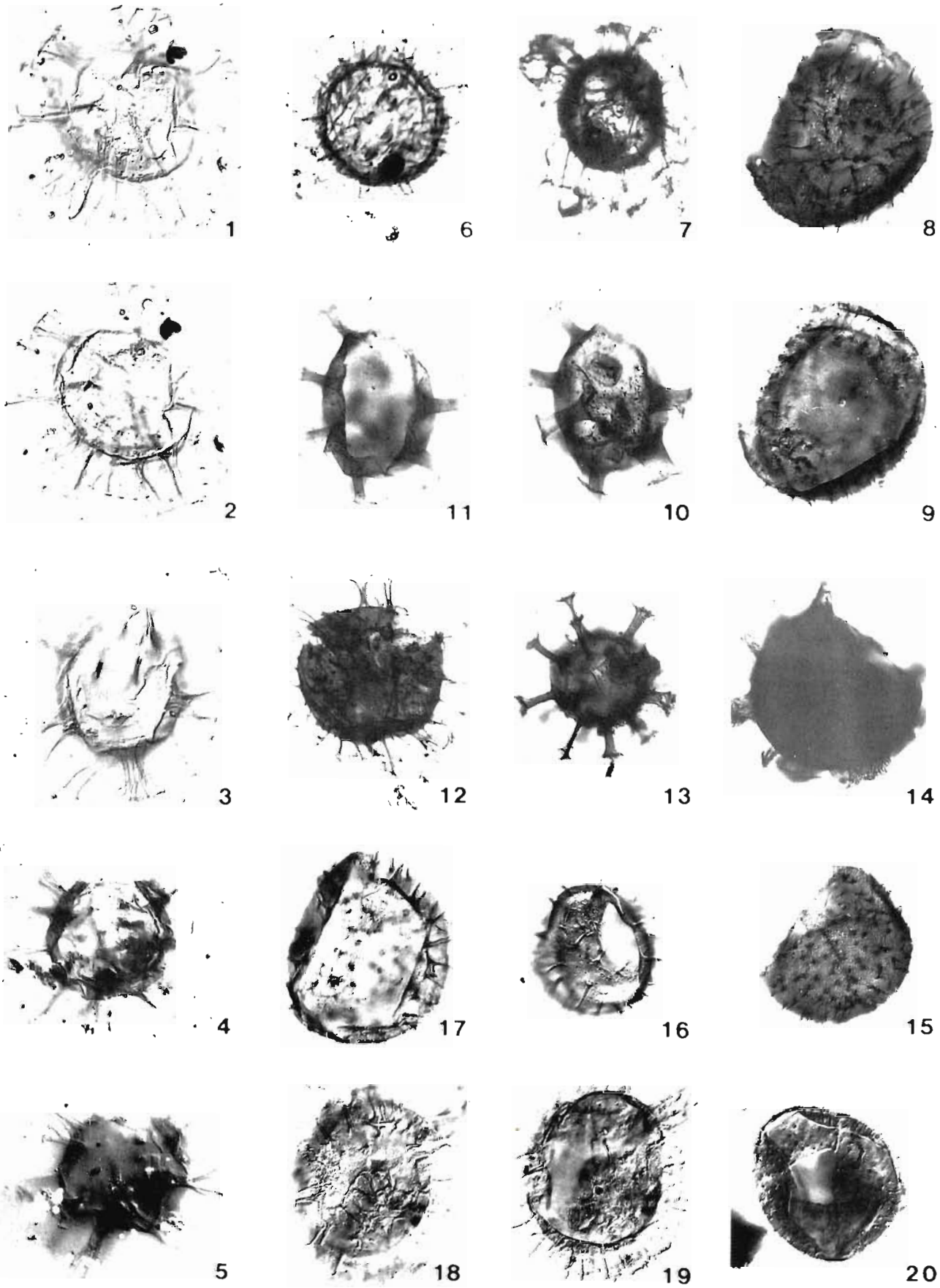


PLATE 1

5. The description of *Glaphyrocysta intricata* (Eaton) Stover & Evitt 1978 reproduced by Kar (1985, p. 189) is actually the generic diagnosis/synopsis of the genus *Glaphyrocysta* proposed by Stover and Evitt (1978, p. 49) and not of *G. intricata*.
6. The description of *Hemicystodinium zoharyi* (Rossignol) Wall (1987) reproduced by Kar (1985, p. 190) from Wall (1967, p. 110) has been extended at personal preference to include a part of the remarks also which is quoted in italics below :

Original version of Wall (1967) :

"*Description* : Test hemispherical, the mid-ventral point marked by a small subrectangular projection and displacement of the rim. Test smooth to microreticulate, spine bases weakly striate. Spines numerous, length variable, all but a few simple and capitate, the others bifurcate.

Remarks—The parallel alignment of spines in the equatorial region reflects the position of girdle and the mid-ventral projection or sulcal notch probably indicates the former position of the anterior limit of the longitudinal furrow. This is a common species in the Yucatan Basin and Cariaco Trench where both varieties described by Rossignol (1964, p. 88) are represented abundantly".

Reproduced version of the above in Kar (1985, p. 190) :

"*Description (after Wall, 1967)*—Test hemispherical, mid-ventral point marked by a small subrectangular projection and displacement of rim. Test smooth to microreticulate, spine bases weakly striate. Spines numerous, length variable, all but a few simple and capitate, others bifurcate. Parallel alignment of spines in equatorial region reflect the position of a girdle and mid-ventral projection or sulcal notch probably indicates former position of the anterior limit of the longitudinal furrow".

7. In the case of reproduction of the systematic description, measurements and remarks of *Hystrichokolpoma* sp. cf. *granulata* Eaton (1976) from Jain and Tandon (1981, p. 10), Kar (1985, p. 192) erroneously copied out the measurements and remarks of *Hystrichokolpoma* sp. B given on the facing page (Jain & Tandon, 1981, p. 11). Thus he has inadvertently omitted the systematic descriptions of the following four taxa, described on the intervening pages, viz., *H. rigaudae, H. rigaudae granulosa, Hystrichokolpoma* sp. A and *Hystrichokolpoma* sp. B. Obviously, these four species are amongst the six species which were left out by Kar while reproducing the taxonomical details from Jain and Tandon (1981).
8. Kar (1985, p. 196) reproduced the details of *Systematophora placacantha* (Deflandre & Cookson) Davey *et al.* (1969) emend. May (1980) in verbatim from Jain and Tandon (1981, p. 13) without referring any illustration, although he wrongly included one of the illustrations of *S. placacantha* given by Jain and Tandon (1981, pl. 1, fig. 14) under *Cordosphaeridium fibrospinosum* (Kar, 1985, p. 187; pl. 43, fig. 8). It is also worth noting that the two specimens (pl. 43, fig. 8; pl. 44, fig. 9) assigned to *C. fibrospinosum* by Kar (1985, p. 187) have been attributed the same slide no. and coordinates (Slide no. 6424, Stage coordinates : 125.2 × 22.7) which should have been Slide no. 6430, Stage coordinates : 125.5 × 12.6 for pl. 43, fig. 8.
9. Apart from the taxonomic imbroglio, Kar (1985, pls. 42-44) has relaid the plates of Jain and Tandon (1981, pls. I-IV) picking only 31 out of 72 illustrated specimens of the original work without citing the source. This reproduction appears to be from the original negatives of Jain and Tandon (1981) deposited alongwith the Figured Slides in the museum of Birbal Sahni Institute of Palaeobotany, Lucknow. However, in many cases Kar (1985), unfortunately, did not maintain proper orientation (pl. 42, fig. 2) and correct magnification (pl. 43, fig. 8) of the cysts. In the explanation of plates too, the details of slide nos. and coordinates of the illustrated specimens have been incorporated as such from Jain and Tandon (1981), omitting their reference.

Kar has obviously plagiarised this data as nowhere he has mentioned to have restudied the type and figured slides of Jain and Tandon (1981). Instead, from the perusal of the following statement, it appears as if he has investigated new material of Jhadwa-Baranda section, although he has reproduced the dinoflagellate cyst data entirely from their publication.

Kar (1985, p. 17) states that "The slides deposited earlier in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow by Venkatachala and Kar (1969a, 1969b, 1969c), Sah and Kar (1969, 1970), Kar and Saxena (1976, 1982), Kar (1977, 1979) and Saxena (1978, 1980) were restudied. Besides, the slides were also prepared from fresh collection from the different Tertiary type localities of Kachchh to verify the previous observations. Many bore-cores supplied by the Directorate of Geology and Mining, Government of Gujarat

from the Naredi Formation were also studied".

10. The other Middle Eocene dinoflagellate cyst assemblage is from Rataria bore core no. 27. It is reproduced by Kar (1985) from Kar and Saxena (1981). Recently this assemblage has been completely revised and commented upon by us (Jain & Garg, 1990, p. 76-78). It includes *Homotryblium plectilum* and *H. oceanicum* as the main constituents with rare occurrence of *Operculodinium centrocarpum*.

    Further, we may point out that the diagnosis, holotype and type locality details reproduced for *Hystrichokolpoma eisenacki* Williams & Downie 1966 by Kar (1985, p. 199) actually belong to *H. eisenacki* var. *turgidum* Williams & Downie (1966, p. 178-179).

11. Another case of an unexpected error, causing utter confusion, could be seen in the palynozonation scheme proposed by Kar (1985, p. 129; text-fig. 19) which according to its explanation should show the names of Middle Eocene palynological zones and quantitative representation of palynomorphs. However, the names of palynological taxa, viz., *Cheilanthoidspora enigmata* and *Proxapertites microreticulatus* are replaced by "*Rataria Bore core*" and "*Harudi Formation*" and instead of putting black bars in accordance with the given percentage scale, single rule lines have been drawn making it difficult for the reader to understand and interpret the data, thus, defeating the very purpose of the text-figure.

C. Oligocene dinoflagellate cyst assemblage

The dinoflagellate cyst taxonomy presented by Kar (1985, p. 199-201) is, as a matter of fact, a verbatim reproduction from Jain (1980) who had made taxonomic revisions of all the dinoflagellate cyst taxa earlier described by Kar (1979). However, a perusal of Kar's (1985) account gives an impression that the taxonomical transfers are effected by him, as nowhere he has mentioned to have reproduced the data from Jain (1980). Though most of the systematic descriptions and remarks, except for *Operculodinium* sp., are referred after Jain (1980), it does not necessarily indicate that the taxonomic revisions followed therein are after Jain (1980). Kar has thus deprived the readers of correct reference for his reproduced account. He has included new specimens under the revised taxa which need further reallocations. Most of the slides of the new material bearing numbers of GW and S series are not available. In fact, in a document submitted alongwith the type and figured slides of the paper under review, in the Museum of Birbal Sahni Institute of Palaeobotany, Kar has certified that slides bearing numbers of P and CW series referred in his paper belong to Mathur and Mathur (1969) dealing with Pliocene spores and pollen from Kutch and are deposited in KDM IPE, ONGC, Dehradun. The palynological details of that paper have also been reproduced as such in that paper (Kar, 1985, p. 158-163, pls. 37-38) properly quoting Mathur and Mathur (1969). However, only the slides carrying the numbers of P series are mentioned in that paper The slides of GW and S series are untraceable and thus the taxonomic and stratigraphic status of the illustrated specimens could not be commented upon (Table 2).

It is important to note that Kar (1985, p. 139-140) has reproduced as such the discussion on palynological zonation of Oligocene sequences earlier proposed by him (Kar, 1979, p. 36, 39). The only difference between the original and reproduced versions is in the names of the dinoflagellate cysts that have apparently been replaced in view of the taxonomic reallocations proposed by Jain (1980). However, these changes have been indiscriminately introduced by Kar (1985). Thus, *Polysphaeridium*, *Membranilarnacia* and *Homotryblium* are replaced by *Operculodinium*, *Tuberculodinium* and *Cordosphaeridium* respectively. Surprisingly, their percentage distribution remained the same despite the fact that *Polysphaeridium* species described by Kar (1979) have been transferred to *Operculodinium* and *Hemicystodinium* and three specimens described under *Membranilarnacia* species have been reallocated each to three different genera, viz., *Operculodinium*, *Hemicystodinium* and *Tuberculodinium* (Jain, 1980).

Kar (1985, p. 139-140; text-fig. 20) discussed the Oligocene palynological zones in the light of taxonomic revisions proposed by Jain (1980) changing the name of *Polysphaeridium microtriainum* Cenozone to *Operculodinium centrocarpum* Cenozone. He made some clarifications with reference to quantitative representation of *Membranilarnacia*, and remarked that *Tuberculodinium vancampoae* is present in all the three cenozones and not only in *Trisyncolpites ramanujamii* Cenozone.

Kar (1979, p. 35-36) had earlier described *Tuberculodinium vancampoae* (as *Membranilarnacia* sp.) from Barkhana nala sequence only, exposed near the village Sarangwara which is the reference locality of his *Trisyncolpites ramanujamii* Cenozone. Based on this information, Jain (1982, p. 55) opined that "The two Cenozones, viz., "*Polysphaeridium microtriainum*" and

Table 2—Comparative check list of Oligocene dinoflagellate cysts from Maniyara Fort Formation, Kutch Basin (read in sequence from A—D)

A. Taxonomy after Kar (1979)

Sl. No.	Dinoflagellate cyst species	Illustrations	Slide/specimen no.
1.	*Polysphaeridium (Hystrichosphaeridium) microtriainum* (Klumpp) *comb. nov.*	pl. 4, figs 63a-63b	5116/2
2.	*Polysphaeridium (Hystrichosphaeridium) microtriainum* (Klumpp) *comb. nov.*	pl. 4, fig. 64	5117/1
3.	*Polysphaeridium (Hystrichosphaeridium) microtriainum* (Klumpp) *comb. nov.*	pl. 4, fig. 65	5116/5
4.	*Polysphaeridium cephalum* sp. nov.	pl. 4, figs 66a-66b	5118/1 (Holotype)
5.	*Polysphaeridium cephalum* sp. nov.	pl. 4, fig. 67	5119/2
6.	*Polysphaeridium* sp.	pl. 4, fig. 68	5100/2
7.	*Spiniferites ramosus* cf. var. *multibrevis* (Davey & Williams) Sarjeant 1970	pl. 4, fig. 69	5086/8
8.	*Membranilarnacia delicata* sp. nov.	pl. 4, fig. 70	5120/3 (Holotype)
9.	*Membranilarnacia delicata* sp. nov.	pl. 4, fig. 71	5121/6
10.	*Membranilarnacia* sp.	pl. 4, fig. 72	5087/2
11.	*Homotryblium* sp.	pl. 4, fig. 73	5122/5
12.	?Epitractal archaeopyle of *Homotryblium*	pl. 4, fig. 74	5075/1
13.	*Fromea pachyderma* sp. nov.	pl. 4, fig. 75	5077/3 (Holotype)
14.	*Cleistosphaeridium heteracanthum* (Deflandre & Cookson) Davey *et al.* 1969	Not documented	—

B. Taxonomic reallocations after Jain (1980)

Sl. No.	Dinoflagellate cyst species	Illustrations	Stage coordinates of Carl ziess Zena Microscope
1	*Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967	pl. 1, figs 2-3	117.7 × 11.8
2.	*O. centrocarpum* (Deflandre & Cookson) Wall 1967	pl. 1, figs 4-5	124.0 × 5.0
3.	*Hemicystodinium* sp. cf. *H. congregatum* Stover 1977	pl. 1, figs 10	133.0 × 14.6
4.	? *Sumatradinium* sp.	pl. 1, fig. 8	123.0 × 17.0
5.	*Operculodinium* sp.	Not documented	—
6.	Forma A	Not documented	—
7	*Spiniferites ramosus* subsp. *granosus* (Davey & Williams) Lentin & Williams 1973	pl. 1, fig. 9	—
8.	*Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967	pl. 1, figs 11-12	138.0 × 12.8
9.	*Hemicystodinium* sp.	pl. 1, fig. 6	135.0 × 18.5
10.	*Tuberculodinium vancampoae* (Rossignol) Wall 1967	pl. 1, fig. 1	104.6 × 17.7
11.	*Cordosphaeridium* sp.	pl. 1, fig. 7	128.6 × 14.0
12.	No comments	—	—
13.	Pteridophytic spore Type 1	pl. 1, figs 13-14	122.4 × 14.8
14.	No comments	—	—

C. Reproduced and modified taxonomic account in Kar (1985) from Jain (1980)

Sl. No.	Dinoflagellate cyst species	Illustrations	Slide/Specimen no.
1.	*Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967	pl. 47, figs 9-10	GW/1/2*
2.	*O. centrocarpum* (Deflandre & Cookson) Wall 1967	—	—
3.	*Hemicystodinium* sp. cf. *H. congregatum* Stover 1977	not illustrated	
4.	? *Sumatradinium* sp.	pl. 46, fig. 8	5118/1, 5119/2
		pl. 47, figs 4-6, 8	5083/1*, S2/1/4*, S2/2/9*
5.	*Operculodinium* sp.	pl. 47, fig. 16	5123/2*
6.	—	—	—
7.	*Spiniferites ramosus* subsp. *granosus* (Davey & Williams) Lentin & Williams 1973	pl. 47, figs 1-3	5086/8, 53/4/2*, 8273/2*

†8.	*Operculodinium* sp. cf. *centrocarpum* (Deflandre & Cookson) Wall 1967	pl. 47, figs 1-15	GW/6/4*, GW/6/1*, 5116/1*, 5116/5*, 5120/3
9.	*Hemicystodinium* sp.	Not illustrated	—
10.	*Tuberculodinium vancampoae* (Rossignol) Wall 1967	pl. 46, fig. 7	5087/2
11.	*Cordosphaeridium* sp.	pl. 46, figs 9-11	GW/2/6*, 5087/6*, GW/7/1*
†12.	Epitractal archaeopyle of *Homotryblium*	pl. 47, fig. 7	5075/1
†13.	Broken Trilete spore	pl. 46, fig. 6	5077/3
14.	*Cleistosphaeridium heteracanthum* (Deflandre & Cookson) Davey *et al.* 1969	Not illustrated	—

*Additional specimens documented by Kar (1985) have not been commented upon.
†Listed in plate legend only.

D. Taxonomic reallocations (Present study)

Sl. No.	Dinoflagellate cyst species	Illustrations	BSIP Slide nos.	Stage coordinates (Vanox AH$_2$ Olympus microscope)
1.	*Operculodinium* sp. A	pl. 4, figs 9-10	5116	148.5 × 10.1
2.	*Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967	pl. 1, fig 16	5117	155.0 × 2.6
3.	*Polysphaeridium congregatum* (Stover) Bujak *et al.* 1980	pl. 1, figs 18-19	5116	153.9 × 12.6
4.	*Operculodinium placitum* Drugg & Loeblich 1967	pl. 1, fig. 20	5118	153.7 × 15.3
5.	*Operculodinium placitum* Drugg & Loeblich 1970	pl. 4, fig. 5	5119	139.0 × 7.7
6.	Forma A	Not illustrated	—	—
7.	*Spiniferites ramosus* subsp. *granosus* (Davey & Williams) Lentin & Williams 1973	Not illustrated	—	—
8.	*Polysphaeridium zoharyi* (Rossignol) Bujak *et al.* 1980	pl. 2, figs 3-4	5120	168.0 × 7.8
9.	*Polysphaeridium zoharyi* (Rossignol) Bujak *et al.* 1980	pl. 2, figs 1-2	5121	165.6 × 16.8
10.	*Tuberculodinium vancampoae* (Rossignol) Wall 1967	Not illustrated	—	—
11.	*Operculodinium uncinispinosum* (De Coninck) Islam 1983	pl. 2, fig. 13	5122	159.1 × 12.1
12.	Broken fragment of ? *Operculodinium*	Not illustrated	—	—
13.	Pteridophytic spore Type 1	Not illustrated	—	—
14.	No comments	—	—	—

Aplanosporites robustus exhibit similar lithology, microfloral contents (except for fungal form which may be a very localised phenomenon) and the presence of *Nummulites* at the base. This may possibly suggest contemporaneous extension of a single cenozone representing the Lower Oligocene".

Further, we may add that if the occurrence of *T. vancampoae* throughout the sequence as documented by Kar (1985) is taken to be authentic, the entire sequence should not be older than Upper Oligocene. However, Kar (1979) has mentioned to have made collections from Lower Oligocene sequences as well, which casts doubt over the sampling as well as microplankton data.

In view of the above ambiguities created in the palynostratigraphic data and also in the absence of precise sample details, the credibility of palynozonation scheme proposed by Kar (1979, 1985) is totally lost.

A perusal of the text further revealed the following unexpected errors :

1. *Polysphaeridium (Hystrichosphaeridium) microtriainum* (Klumpp) Kar (1979, p. 33, pl. 4, fig. 70) has been included in the synonymy of *O. centrocarpum* by Kar (1985, p. 199). The citation of pl. 4, fig. 70 is wrong as it refers to the holotype of *Membranilarnacia delicata* Kar 1979. This should have been pl. 4, figs 63a-b, 64 (vide Jain, 1980).
2. Following the revision of Jain (1980), Kar (1985, p. 199) placed a specimen of *Polysphaeridium cephalum* Kar (1979, p. 34, pl. 4, fig. 67) under the synonymy of *Operculodinium* sp. However, the same specimen is also described and illustrated under ?*Sumatradinium* sp. (Kar, 1985, p. 200, pl. 47, fig. 4), thus created utter taxonomic confusion.
3. The holotype of *Membranilarnacia delicata* Kar (1979, pl. 4, fig. 70) was transferred to *Operculodinium centrocarpum* by Jain (1980, pl 1, figs 11, 12). But Kar (1985, p. 230, pl. 47, fig. 15) only illustrated the holotype as *Operculodinium* sp. cf. *centrocarpum* in the plate legend without discussing its taxonomic transfer.

D. Miocene dinoflagellate cyst assemblage

Kar (1985, p 202-210) recorded 24 species of dinoflagellate cysts from Khari Nadi Formation (Miocene). Four species, viz., *Millioudodinium unicornum*, *Operculodinium delicatum*, *O. paucispinosum* and *O. robustum* have been proposed to be new. Out of the remaining 20 species, systematic descriptions/diagnosis/holotype and type locality details for 18 species have been reproduced from the earlier publications. There are, however, some discrepancies in the systematic and palynostratigraphic account as outlined below :

1. The "diagnosis" of *Operculodinium israelianum* credited to Wall (1967) by Kar (1985, p. 206) is actually the reproduction of the "Remarks" of the Caribbean and Mediterranean specimens and not the diagnosis given by Wall (1967, p. 111).
2. The extensive remarks made by Kar (1985, p. 208-209) on the genus *Spiniferites* have entirely been reproduced from Stover and Evitt (1978, p. 283-284, Appendix-I on *Spiniferites* Complex). A careful comparison of the two publications reveals that a part of "Remarks" in Kar (1985) has been referred to Stover and Evitt (1978), while the remaining text is either verbatim reproduction without quoting original authors or some parts have been rewritten, often resulting in alteration of the views of the original authors. Thus, it gives an impression that the views expressed are original of Kar. Furthermore, the statement on the generic distinction between *Spiniferites* and *Achomosphaera* has become confusing and misleading as significant part of the original statement adopted from Appendix-I of Stover and Evitt (1978) has been omitted.
3. The description of *Tuberculodinium vancampoae* provided by Kar (1985, p. 210) is in fact a verbatim reproduction of *modified description* of the genus *Tuberculodinium* from Stover and Evitt (1978, p. 240), although they have not been quoted.
4. Kar (1985, p. 154-157, text-fig. 22) proposed three "Palynological Cenozones" for Miocene sediments of Kutch belonging to Khari Nadi Formation with their type sections exposed in Khari River section near Aida Village. These Cenozones, viz., *Cordosphaeridium cantharellum* Cenozone, *Striatriletes susannae* Cenozone and *Operculodinium israelianum* Cenozone, are wrongly stated to be in ascending order (p. 155), as these are actually in descending order.
5. From a review of text-figure 22, one gets an impression that the entire sequence is rich in palynomorphs, although there are only 7 productive samples confined mainly to four levels plotted on the litholog without providing any vertical scale. It is rather difficult to ascertain the stratigraphic position of the productive levels as thickness of the studied sequence or of the Formation is also not provided. However, Kar (1985, p. 156) has at one place indicated the thickness of the lowermost *Operculodinium israelianum* Cenozone to be approximately 10 m, and if we take this into consideration, the thickness of the lithological column in text-fig. 22 should be about 30 m, which will apparently represent the entire thickness of Khari Nadi

→

PLATE 2

(All photomicrographs are in differential interference contrast and magnified × 500; Stage coordinates refer to Olympus Vanox AH-2 microscope)

1,2. *Polysphaeridium zoharyi* (Rossignol) Bujak *et al.* 1980; BSIP Slide no. 5121, Coordinates: 165.6 × 16.8; broken specimen in two foci; 1. showing epicystal archaeopyle, 2. showing distribution of processes on antapical surface.

3,4. *Polysphaeridium zoharyi* (Rossignol) Bujak *et al.* 1980; BSIP Slide no. 5120, Coordinates: 168.0 × 7.8; broken specimen in two foci; 3. showing distribution of processes on antapical surface; 4. showing epicystal archaeopyle (Holotype of *Membranilarnacia delicata* Kar 1979).

5. *Spiniferites mirabilis* (Rossignol) Sarjeant 1970; BSIP Slide no. 6633, Coordinates: 151.4 × 5.5.

6,7 *Apteodinium unicornum* (Kar) comb. nov. emend.; BSIP Slide no. 6634, Coordinates: 142.3 × 21.8; same specimen in two foci (an additional specimen from Khari Nadi Formation, Miocene; Paratype).

8. *Apteodinium unicornum* (Kar) comb. nov. emend.; BSIP Slide no. 6634, Coordinates: 140.2 × 4.9 (an additional specimen from Khari Nadi Formation, Miocene).

9. *Achomosphaera alcicornu* (Eisenack) Davey & Williams 1966; BSIP Slide no. 8268, Coordinates: 149.5 × 3.8.

10. *Thalassiphora pelagica* (Eisenack) Eisenack & Gocht 1960 emend. Benedek & Gocht 1981; BSIP Slide no. 8272, Coordinates: 141 × 13.1.

11. *Thalassiphora* sp. cf. *T. patula* (Williams & Downie) Stover & Evitt 1978; BSIP Slide no. 8279, Coordinates: 139.7 × 5.5 (an additional specimen from Lakhpat bore core 2).

12. *Operculodinium ornamentum* (Jain & Tandon) comb. nov.; BSIP Slide no. 8268, Coordinates: 141.4 × 8.3.

13. *Operculodinium uncinispinosum* (De Coninck) Islam 1983; BSIP Slide no. 5122, Coordinates: 159.1 × 12.1.

14. *Achomosphaera alcicornu* (Eisenack) Davey & Williams 1966; BSIP Slide no. 8268, Coordinates: 148.8 × 7.4.

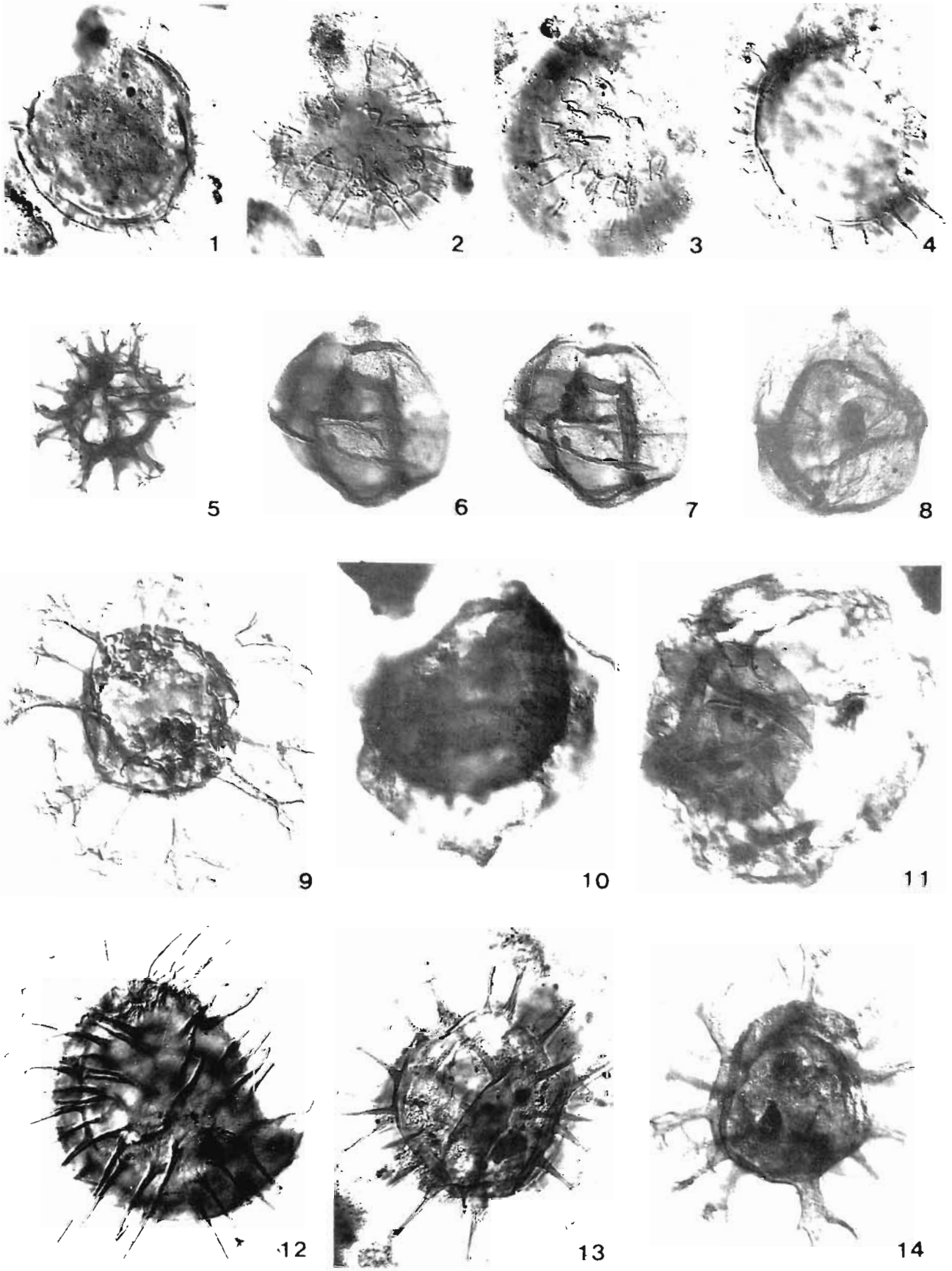


PLATE 2

Table 3—Comparative check list of Miocene dinoflagellate cysts from Khari Nadi Formation, Kutch Basin

Sl. No.	Dinoflagellate cyst species (Taxonomy after Kar (1985))	Illustrations	Slide/specimen nos.
1.	*Achomosphaera ramulifera* (Deflandre) Evitt 1963	pl. 48, fig. 1	6634/17
2.	*Cordosphaeridium cantharellum* (Brosius) Gocht 1969	pl. 48, fig. 2	8268/9
3.	*C. cantharellum* (Brosius) Gocht 1969	pl. 48, fig. 3	6634/20
4.	*C. exilimurum* Davey & Williams 1966	pl. 48, fig. 4	8268/10
5.	*C. cracenospinosum* Davey & Williams 1966	pl. 48, fig. 5	6632/4
6.	*C. cracenospinosum* Davey & Williams 1966	pl. 48, fig. 6	6632/15
7.	*Hystrichokolpoma rigaudae* Deflandre & Cookson 1955	pl. 48, fig. 7	8269/5
8.	*H. rigaudae* Deflandre & Cookson 1955	pl. 48, fig. 8	6634/8
9.	*Spiniferites mirabilis* (Rossignol) Sarjeant 1970	pl. 48, fig. 9	6633/10
10.	*Operculodinium placitum* Drugg & Loeblich 1967	pl. 48, fig. 10	6633/9
11.	*Hystrichokolpoma poculum* Maier 1959	pl. 49, fig. 1	6632/8
12.	*H. unispinum* Williams & Downie 1966	pl. 49, fig. 2	6632/4
13.	*Lingulodinium machaerophorum* (Deflandre & Cookson) Wall 1967	pl. 49, fig. 3	6634/1
14.	*L. machaerophorum* (Deflandre & Cookson) Wall 1967	pl. 49, fig. 4	6633/4
15.	*Cordosphaeridium gracilis* Eisenack emend Davey & Williams 1966	pl. 49, fig. 5	8268/12
16.	*C. fibrospinosum* Davey & Williams 1966	pl. 49, fig. 6	8268/15
17	*Cordosphaeridium* sp.	pl. 49, fig. 7	8270/1
18.	*Millioudodinium unicornum* sp. nov.	pl. 49, fig. 8	6634/12
19.	*Spiniferites hyperacanthus* (Deflandre & Cookson) Cookson & Eisenack 1974	pl. 49, fig. 9	8270/1
20.	*Tuberculodinium vancampoae* (Rossignol) Wall & Dale 1971	pl. 49, fig. 10	6633/13
21.	*T. vancampoae* (Rossignol) Wall & Dale 1971	pl. 49, fig. 11	6632/16
22.	*Spiniferites bulloideus* (Deflandre & Cookson) Sarjeant 1970	pl. 50, fig. 1	6633/9
23.	*S. bulloideus* (Deflandre & Cookson) Sarjeant 1970	pl. 50, fig. 2	6634/29
24.	*S. mirabilis* Rossignol 1962	pl. 50, fig. 3	6633/12
25.	*S. mirabilis* Rossignol 1962	pl. 50, fig. 4	6634/23
26.	*Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967	pl. 50, fig. 5	8268/7
27.	*O. paucispinosum* sp. nov.	pl. 50, fig. 6	8269/3 (Holotype)
28.	*O. delicatum* sp. nov.	pl. 50, fig. 7	8270/2 (Holotype)
29.	*O. robustum* sp. nov.	pl. 50, fig. 8	8271/2 (Holotype)
30.	*Operculodinium* sp.	pl. 50, fig. 9	8268/12
31.	*Thalassiphora pelagica* (Eisenack) Eisenack & Gocht 1960	pl. 50, fig. 10	8272/2
32.	*Operculodintum israelianum* (Rossignol) Wall 1967	Not illustrated	—

Formation. Biswas and Raju (1971, 1973), whose lithostratigraphic scheme has been followed by Kar, measured a thickness of about 240 ft (ca. 73 m) for this formation. In all probabilities the sequence investigated by Kar for palynozonation represents only a part of the Miocene succession of Kutch.

6. The distribution of species in different cenozones plotted in text-fig. 22 and that listed in the description of cenozones is quite inconsistent. Besides, the percentage distribution of various spore, pollen and dinoflagellate cyst taxa as depicted in palynozonation scheme (text-fig. 22) and the bar diagram (text-fig. 21) are also strikingly inconsistent. Further, the statements regarding the occurrence of palynomorphs in the uppermost *Cordosphaeridium cantharellum* Cenozone referred at two places are contradictory to each other. On page 155, the author reports the two samples (viz., AB1 & AB2), belonging to this zone, to be rich in microplankton with negligible percentage of spores and pollen, while on page 168 he mentions both microplankton and spore-pollen to be well represented in the same zone (erroneously named as *Operculodinium centrocarpum* Cenozone; for clarification please see his text-fig. 22). Not only this, he (Kar 1985, p. 168) even considers this Cenozone to be "Close to Pandua (Malta) assemblage of Bengal Basin by the good representation of bisaccate pollen".

All these ambiguities/discrepancies and departure from established norms of biostratigraphic and taxonomic procedures mentioned above, leave the reader in a quandary as soon as one attempts to use sensibly the dinoflagellate based palynological

Taxonomic reallocations (Present study)				
Sl. No.	Dinoflagellate cyst species	Illustrations	BSIP Slide nos.	Stage coordinates (Vanox AH_2 Olympus microscope
1.	*Achomosphaera ramulifera* (Deflandre) Evitt 1963	Not illustrated	6634	144.3 × 3.2
2.	*Achomosphaera alcicornu* (Eisenack) Davey & Williams 1966	Pl. 2, fig. 9	8268	149.5 × 3.8
3.	*Glaphyrocysta indica* sp. nov.	Pl. 4, figs 7-8	6634	144.0 × 20.3
4.	*Achomosphaera alcicornu* (Eisenack) Davey & Williams 1966	Pl. 2, fig. 14	8268	148.8 × 7.4
5.	*Glaphyrocysta indica* sp. nov.	Pl. 4, figs 14-16	6632	133.5 × 4.6
6.	*Glaphyrocysta indica* sp. nov.	Pl. 4, figs 1-2	6632	158.9 × 9.4
7	Badly preserved specimen	Not illustrated	8269	142.0 × 22.4
8.	*Hystrichokolpoma ?rigaudae* Deflandre & Cookson 1955	Pl. 3, fig. 12	6634	135.6 × 10.9
9.	*Spiniferites mirabilis* (Rossignol) Sarjeant 1970	Not illustrated	6633	147.2 × 15.7
10.	*? Lingulodinium* sp.	Pl. 3, fig. 7	6633	148.6 × 14.5
11	*Hystrichokolpoma poculum* Maier 1959	Not illustrated	6632	148.2 × 4.9
12.	*Hystrichokolpoma ?unispinum* Williams & Downie 1986	Pl. 3, figs 1-2	6632	159.9 × 6.5
13.	*Lingulodinium machaerophorum* (Defl. & Cooks.) Wall 1967	Not illustrated	—	Specimen not traceable
14.	*L. machaerophorum* (Defl. & Cooks.) Wall 1967	Not illustrated	6633	139.0 × 14.4
15.	*Cordosphaeridium gracilis* (Eisenack) Davey & Williams 1966	Not illustrated	8268	161.0 × 10.8
16.	*C. fibrospinosum* Davey & Williams 1966	Not illustrated	8268	165.9 × 5.0
17	*Glaphyrocysta indica* sp. nov.	Pl. 4, fig. 3	8270	135.2 × 17.8
18.	*Apteodinium unicornum* (Kar) comb. nov. emend.	Pl. 3, fig. 3	6634	135.0 × 21.0
19.	*Spiniferites hyperacanthum* (Deflandre & Cookson) Cookson & Eisenack 1974	Not illustrated	8270	133.5 × 18.2
20.	*Tuberculodinium vancampoae* (Rossignol) Wall 1967	Pl. 3, figs 8-9	6633	153.2 × 9.0
21	*T. vancampoae* (Rossignol) Wall 1967	Not illustrated	6632	147.7 × 10.0
22.	*Spiniferites ramosus* subsp. *multibrevis* Davey & Williams 1966	Pl. 4, fig. 6	6633	147.5 × 14.2
23.	*S. bulloideus* (Deflandre & Cookson) Sarjeant 1970	Pl. 4, fig. 12	6634	154.3 × 6.6
24.	*S. mirabilis* (Rossignol) Sarjeant 1970	Pl. 2, figs 5	6633	151.4 × 5.5
25.	*S. mirabilis* (Rossignol) Sarjeant 1970	Pl. 3, fig. 6	6634	149.7 × 21.9
26.	*Operculodinium ornamentum* (Jain & Tandon) comb. nov.	Pl. 2, fig. 12	8268	141.4 × 8.3
27	*Operculodinium microtriainum* (Klumpp) Islam 1983	Pl. 3, fig. 11	8269	145.6 × 11.9
28.	*? Operculodinium delicatum* Kar 1985	Pl. 3, fig. 5	8270	138.7 × 15.4
29.	*Operculodinium microtriainum* (Klumpp) Islam 1983	Pl. 3, fig. 10	8271	140.8 × 6.4
30.	Fragmentary specimen, unidentifiable	Not illustrated	8268	161.3 × 9.5
31.	*Thalassiphora pelagica* (Eisenack) Eisenack & Gocht 1960 emend. Benedek & Gocht 1981	Pl. 2, fig. 10	8272	141.8 × 13.1
32.	No comments	—		—

cenozones and related data presented by Kar (1985).

TAXONOMIC COMMENTS

The taxonomic assessments made in this account are primarily based on the restudy of the type and figured slides of Kar (1985) available in the Museum of Birbal Sahni Institute of Palaeobotany, Lucknow. All the specimen of his referred taxa from Early Eocene (total 24), Oligocene (total 14) and Miocene (total 32) have been tabulated in different parts of each table (Tables 1, 2, 3), that refers to their original taxonomic status followed by subsequent revision, if any (Jain, 1980, for Oligocene assemblage), adoption or reproduction, if any (Kar, 1985, for Oligocene assemblage from Jain, 1980) and our own views, facilitating direct comparison. Most of these specimens have been rephotographed and are illustrated herein for morphologic justification and understanding. Those, not illustrated are either the different specimens of the same taxon or are badly preserved ones. A few well-preserved specimens encountered in the slides while scanning, have also been illustrated for record (e.g. *Heteraulacacysta pustulosa*, pl. 3, fig. 4; *Thalassiphora* sp. cf. *T. patula*, pl. 2, fig. 11). Apart from these, some taxa are illustrated but not commented upon as these are self explanatory and need no morphologic reinterpretations (Tables 1, 2, 3).

Genus—*Achomosphaera* Evitt 1963

Achomosphaera alcicornu (Eisenack) Davey & Williams 1966
Pl. 2, figs 9, 14

1985 *Cordosphaeridium cantharellum* (Brosius) Gocht 1969, *in* Kar, p. 203; pl. 48, fig. 2.
1985 *Cordosphaeridium exilimurum* Davey & Williams 1966, *in* Kar, p. 203; pl. 48, fig. 4.

Remarks—Kar (1985, pl. 48, figs 2, 3) assigned two morphologically entirely dissimilar specimens to *Cordosphaeridium cantharellum*. One of these specimens (Kar, 1985; pl. 48, fig. 2) discussed here, is a spherical to subspherical, skolochorate thick-walled cyst with a granular periphragm and non-fibrous, hollow, long, tubular processes which are distally open and expanded having typically broad recurved trifurcate distal terminations ending into finely bifid extremities. A couple of processes are branched. Processes are more than one per paraplate area and often found to be linearly arranged. Archaeopyle is indiscernible due to partly broken dorsal surface of the cyst.

Another specimen identified as *Cordosphaeridium exilimurum* by Kar (1985, pl. 48, fig. 4) is identical to the one discussed above and displays a single paraplate precingular archaeopyle. The characteristically broadly trifurcate, tubular processes without proximal ridges or connections and precingular archaeopyle suggest placement of Kutch specimens under *Achomosphaera alcicornu* (Eisenack) Davey & Williams 1966. We have observed several other well-preserved specimens of this species in the figured slides of Kar (1985).

Dimensions:

Body diameter	60-66 μm
Process length	25-45 μm

Genus—*Adnatosphaeridium* Williams & Downie 1966

Adnatosphaeridium multispinosum Williams & Downie 1966
Pl. 1, fig. 7

1985 *Glaphyrocysta pastielsii* (Deflandre & Cookson) Stover & Evitt 1978, *in* Kar, p. 182; pl. 40, figs 7, 8.
1985 *Nematosphaeropsis densiradiata* (Cookson & Eisenack) Stover & Evitt 1978; *in* Kar, p. 184-185; pl. 40, figs 11, 12.

Remarks—Our re-examination of the specimens described as *Glaphyrocysta pastielsii* by Kar (1985) revealed that the cysts are subspherical with thin, finely granular autophragm having numerous slender, solid processes, apparently more than one per paraplate area. The processes are distally irregularly branched and are connected by a thin ribbon-like trabeculae bearing short, unconnected acuminate spines. The archaeopyle is apical with a distinctive zig-zag margin. Further, processes do not form complexes and the mid-dorsal and mid-ventral areas of the cyst are not free of processes. In view of above morphological features, this form is reallocated to *Adnatosphaeridium multispinosum*.

Kar (1985, p. 184-185; pl. 40, figs 11, 12) illustrated two specimens under *Nematosphaeropsis densiradiata* (Cookson & Eisenack) Stover & Evitt 1978, which appear to be similar to the one described above. However, both the specimens are badly preserved, incomplete cysts making it impossible to discern the body shape or archaeopyle type with confidence. Nevertheless, nature and distribution of processes and the occurrence of short unconnected acuminate spines on the thin distal trabeculae in both the specimens is quite similar to *A. multispinosum* documented above. These forms are, therefore, tentatively included here under *A. multispinosum*.

Dimensions:

Body size	42-48 × 36-45 μm
Length of processes	20-30 μm

Genus—*Apteodinium* Eisenack emend. Sarjeant 1985 emend. Lucas-Clark 1987

Apteodinium unicornum (Kar) comb. nov. emend.
Pl. 2, figs 6, 7, 8; Pl. 3, fig. 3; Pl. 4, fig. 4

1985 *Millioudodinium unicornum* Kar, p. 206; pl. 49, fig. 8 (Holotype); Miocene; *Palaeobotanist* **34** : 1-280 (Basionym).

Emended Diagnosis—Cyst proximate, acavate, subspherical to ellipsoidal in shape with a short, tapering, truncate apical horn. Cyst wall thin, apparently consists of autophragm only which is finely microgranulate. The wall appears to be differentiated with an inner microgranular layer and an outer discontinuous, very thin, smooth, faintly pitted to spongy, shagreenate layer. The latter is discernible only at a few places on the cyst specially at the apical horn, equatorial parasutural ridges along the paracingulum and/or antapical region; when present, this secondary layer is incipiently separated from the autophragm. However, it can also be interpreted as a thin loosely appressed periphragm (or ?ectophragm) but for its discontinuous and somewhat spongy nature which does not suggest distinct pericoel development.

Parasutural features commonly expressed only by low but prominent, parallel equatorial ridges along the paracingulum; in some specimens additional faint parasutures are seen dividing the paracingulum into six paraplates, and a few are very faintly visible on the ventral side along the apical

horn and parasulcal region. Paratabulation is typically indicated by archaeopyle, paracingulum and narrow parasulcus only; in few specimens the paracingulum is divided indicating presence of six paraplates; the other faint parasutural ridges do not clearly express distinct paratabulation. Paracingulum is distinct, expressed by strongly helicoid, shallow, transverse equatorial depression.

Parasulcus is distinctly marked by prominently offset ends of the paracingulum and a slight depression characterised by relatively faint ornamentation, in some specimens a faint parasutural ridge forming a loop delimits the posterior parasulcal region Archaeopyle is single plate precingular, type P (3″), usually broad with rounded adapical margin, operculum free but often found in place.

Dimensions:

	Holotype	Range
Cyst size	66 × 66 μm	66-80 × 63-66 μm
Length of apical horn	03 μm	03-07 μm

Comparison—A. granulatum Eisenack emend. Lucas-Clarks 1987 has a much thicker and more differentiated wall and longer apical horn than *A. unicornum*. In wall structure it comes closer to *A. maculatum* Eisenack & Cookson 1960, but differs due to its differentiated wall having inner granular and outer shagreenate layers. *A. maculatum* has densely granulate to irregularly verrucate wall and almost spherical shape with a circular ambitus having a more prominent apical horn.

The wall structure in this species conforms to the views of Lucas-Clark (1987). The prominently granular autophragm with a very thin, smooth to pitted (?spongy) outer layer, a short but prominent apical horn formed mainly by outer autophragm layer, limited paratabulation and parasutural features, distinguish it from the other known *Apteodinium* species.

Remarks—For the holotype of *M. unicornum*, Kar (1985, p. 206, 230) quoted two different slide nos. 8267/12 and 6634/12, the latter slide no. refers to the holotype specimen.

Genus—*Areosphaeridium* Eaton 1971

? *Areosphaeridium* sp. A
Pl. 1, fig. 12

1985 *Heterosphaeridium heteracanthum* (Deflandre & Cookson) Eisenack & Kjellström 1971, *in* Kar, p. 182-183; pl. 41, fig. 6.

Description—Cyst lenticular, subcircular in outline with a prominent antapical lobe, autophragm granular, processes numerous, non-tabular to apparently intra-tabular, confined primarily along the peripheral zone but sparsely distributed in mid-dorsal and mid-ventral areas, these are thin, slender, solid, short, about one fourth of average cyst diameter, with often bifid or branched stems, distally expanded or ramified into arcuate or recurved terminations with dentate margins, a few joined distally by thin ribbon-like delicate trabeculae. Archaeopyle apical with offset sulcal notch.

Dimensions:

Body size	52 × 52 μm
Length of processes	14-16 μm

Remarks—This form is only tentatively placed under *Areosphaeridium* due to the greater number of thin, slender, solid processes having arcuate to recurved distal terminations with dentate margins and presence of occasional distal trabeculae.

Genus—*Cordosphaeridium* Eisenack emend. Davey 1969

Cordosphaeridium robustum (Gocht) Sarjeant 1981
Pl. 1, fig. 14

1985 *Litosphaeridium siphoniphorum* (Cookson & Eisenack) Davey & Williams 1966, *in* Kar, p. 184; pl. 40, fig. 10.

Remarks—The form identified as *Litosphaeridium siphoniphorum* by Kar (1985, p. 184; pl. 40, fig. 10) does not possess the characteristic features of the genus *Litosphaeridium*, viz., an apical archaeopyle, intratabular non-fibrous, conical processes and process-free paracingular region. Re-examination of this well-preserved specimen revealed that the cyst is almost spherical in shape and has a two-layered wall with highly fibrous and thin periphragm giving rise to fibrous, intratabular processes reflecting gonyaulacacean paratabulation, and a single paraplate (3″) precingular archaeopyle. These features clearly suggest its placement under *Cordosphaeridium*. The fibrous processes are characteristically short and broad having elliptical to subcircular shape in cross-section, and width of the processes often exceeds their length and is considerably variable. A few precingular and post cingular processes are somewhat conical, distally slightly narrower and open. These features suggest its closest comparison with *Cordosphaeridium robustum*.

Dimensions:

Body size	60 × 60 μm

Length of processes 10–15 μm

? *Cordosphaeridium* sp. A

1985 *Cordosphaeridium exilimurum* Davey & Williams 1966, *in* Kar, p. 182; pl. 41, figs 4, 5.

Remarks—Our re-examination of the two specimens assigned to *Cordosphaeridium exilimurum* by Kar (1985, p. 182; pl. 41, figs 4, 5) revealed that the cysts are thick-walled with fibrous periphragm and intratabular, fibrous, tubular processes with variable digitate or foliate distal margins. The length of the processes is about one-third of the cyst size. Both the specimens are damaged making it difficult to discern the type of archaeopyle; occurrence of precingular archaeopyle is only tentatively suggested in one of the specimens (Kar, 1985; pl. 41, fig. 5). These forms are, therefore, doubtfully assigned to *Cordosphaeridium*. The thick-walled nature of tubular processes suggests its comparison with *Cordosphaeridium inodes*.

Glaphyrocysta indica sp. nov.
Pl. 4, figs 1, 2, 3, 7, 8, 13, 14, 15, 16

1985 *Cordosphaeridium cracenospinosum* Davey & Williams 1966, *in* Kar, p. 203-204; pl. 48, figs 5, 6.

1985 *Cordosphaeridium cantharellum* (Brosius) Gocht 1969, *in* Kar, p. 203; pl. 48, fig. 3.

1985 *Cordosphaeridium* sp., *in* Kar, p. 204; pl. 49, fig. 7.

Holotype—Pl. 4, figs 14-16; Slide no. BSIP 6632; coordinates: 133.5 × 4.6.

Type locality—Aida, Laiyari, Khari Nadi Formation, Kutch (after Kar, 1985, p. 204); Miocene.

Diagnosis—Cyst skolochorate, dorso-ventrally compressed, ambitus circular to oval; autophragm thin, differentially ornamented, smooth to pitted. Process complexes confined along peripheral zone; mid-dorsal and mid-ventral areas free of processes; individual processes thin, slender, solid, distally commonly branched and joined by petulate to recurved, thin, net-like perforate membrane and thin trabecular strands. Some adjacent process complexes joined by discontinuous perforate membraneous ectophragm. Archaeopyle apical; paratabulation gonyaulacacean expressed by 4′, 6″, ?0-3C, 5-6‴, 1p, ? 1ps, 1⁗.

Description—Cyst skolochorate, body lenticular, dorsoventrally compressed, circular to oval in out line, autophragm thin, differentially ornamented, smooth along periphery, gradually become dense and unequally pitted to spongy in mid-dorsal and mid-ventral areas. Autophragm gives rise to process complexes which are confined primarily along the marginal areas of the cyst; mid-dorsal and mid-ventral areas are free of processes; processes commonly occur in annulate to arcuate or often linear, intratabular to penitabular complexes with simple or complexly branched stem but a few may occur isolated. Processes typically thin, slender and solid but a few may be broad, flattened, solid and fibrous with fenestrate stem; proximally the processes may be joined by a low ridge in some groups but are generally isolated. Processes characteristically have slightly expanded proximal bases and more expanded distal ends terminating into a few to several branched stems which are joined distally by patulate to recurved, thin, net-like perforate membrane and also through slender, smooth, arched, ribbon-like trabecular strands; some of the adjacent process complexes joined with thin, perforate, membranous or slender trabecular discontinuous ectophragm. Development of ectophragm is more commonly found along marginal zone in precingular and postcingular regions.

→

PLATE 3

(All photomicrographs are in differential interference contrast and magnified × 500; Stage coordinates refer to Olympus Vanox AH-2 microscope)

1,2. *Hystrichokolpoma ?unispinum* Williams & Downie 1966 BSIP Slide no. 6632, Coordinates: 159.9 × 6.5; same specimen in two foci.

3. *Apteodinium unicornum* (Kar) comb. nov. emend.; BSIP Slide no. 6634, Coordinates: 135.0 × 21.0 (Holotype of *Millioudodinium unicornum* Kar 1985).

4. *Heteraulacacysta pustulata* Jan du chêne & Adediran 1985; BSIP Slide no. 6632, Coordinates: 148.7 × 11.8 (an additional specimen from Khari Nadi Formation, Miocene).

5. ? *Operculodinium delicatum* Kar 1985; BSIP Slide no. 8270, Coordinates: 138.7 × 15.4.

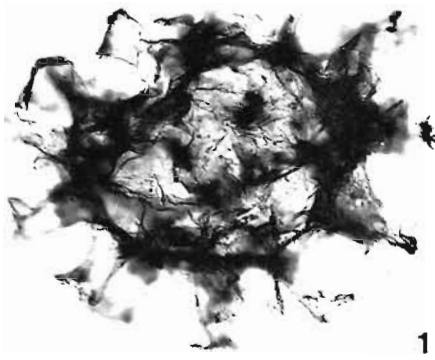
6. *Spiniferites mirabilis* (Rossignol) Sarjeant 1970; BSIP Slide no. 6634, Coordinates: 149.7 × 21.9.

7. ? *Lingulodinium* sp., BSIP Slide no. 6633, Coordinates: 148.6 × 14.5.

8,9. *Tuberculodinium vancampoae* (Rossignol) Wall 1967; BSIP Slide no. 6633, Coordinates: 153.2 × 9.0; same specimen in two foci showing antapical archaeopyle.

10,11. *Operculodinium microtriainum* (Klumpp) Islam 1983; BSIP Slide nos. 8271 and 8269, Coordinates: 140.8 × 6.4 and 145.6 × 11.9 respectively.

12. *Hystrichokolpoma rigaudae* Deflandre & Cookson 1955; BSIP Slide no. 6634, Coordinates: 135.6 × 10.9.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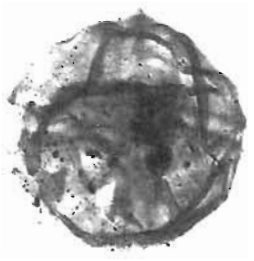
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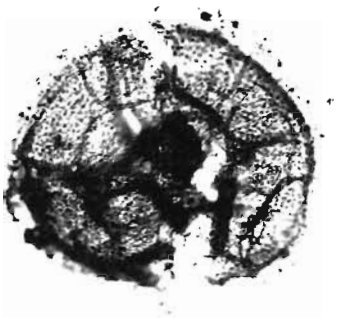
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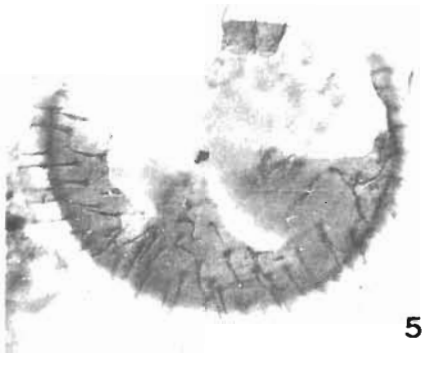
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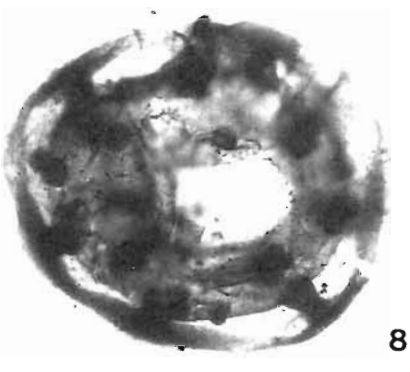
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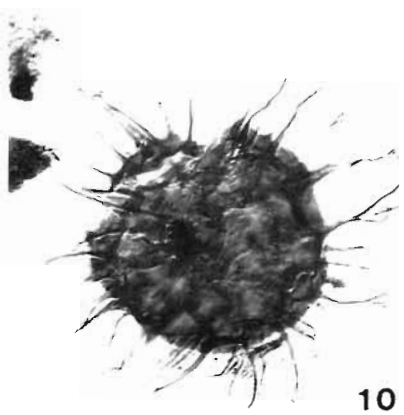
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PLATE 3

Parasutural features absent. Archaeopyle apical, type (tA), principal archaeopyle sutures angular, zig-zag with a prominent offset parasulcal notch and corresponding parasulcal tab, faint accessory archaeopyle sutures extending into apical paraplates often visible; operculum free but commonly remains in place.

Paracingulum not clearly indicated, probably expressed by few slender processes. Parasulcus generally indicated by process free area posterior to parasulcal notch; its antapical end is often marked by a slender process in extreme posterior sulcal region.

Paratabulation indicated by archaeopyle and intratabular to penitabular process complexes. Clarity of paratabulation is somewhat obliterated by more complexly branched and distally joined process complexes along the marginal zone in precingular and postcingular regions; paratabulation gonyaulacacean, expressed by 4′, 6″, ? 0-3C, 5-6‴, 1p, ? 1ps, 1⁗. Apical process complexes annulate to arcuate, those reflecting paraplates 1′ and 4′ are always smaller having shorter processes than process complexes reflecting 2′ and 3′. Process complexes in pre-and post-cingular paraplates often less clearly demarcated due to extensive branching and distal trabecular net work but are discernible in some specimens; those reflecting paraplates 3″ and 6″ are typically reduced. Processes representing paracingular, ? 1‴ and 1p paraplate are typically slender, isolated and least branched.

Dimensions:

	Holotype	Range
Cyst size with with process complex	118 × 104 μm	84-118 × 90-104 μm
Body size	74 × 66 μm	60-74 × 55-66 μm
Length of process complexes	15 to 30 μm	10 to 30 μm

Comparison—*Glaphyrocysta indica* sp. nov. differs from all the known species of the genus in its well defined process complexes each of which is typically joined by perforate membrane but with reduced trabecular ectophragm between adjacent process complexes and differentially ornamented autophragm.

Genus—*Homotryblium* Davey & Williams 1966

Homotryblium abbreviatum Eaton 1976
Pl. 1, figs 10, 11

1985 *Homotryblium tenuispinosum* Davey & Williams 1966, *in* Kar, p. 183, pl 41, fig. 7.

1985 *Hystrichosphaeridium salpingophorum* (Deflandre) Davey & Williams 1966, *in* Kar, p. 184; pl. 41, figs 11, 12

Remarks—The three specimens documented by Kar (1985) as *Hystrichosphaeridium salpingophorum* (pl. 41, figs 11, 12) and *Homotryblium tenuispinosum* (pl 41, fig. 7) represent the hypocyst parts only. These cysts are skolochorate, thin-walled, two-layered with finely granular periphragm giving rise to about 15 to 16 intratabular, hollow, tubular, typically short processes of variable width which are up to only one-third of the mean cyst diameter in length. Processes are slightly expanded distally with finely denticulate to aculeate distal margins. Proximally a circular to subcircular mark is evident at the base of processes. These forms, in view of the above characters, are here re-attributed to *Homotryblium abbreviatum* Eaton. One of these specimens resembles *H. pallidum* due to the occurrence of few slightly longer processes but has not been assigned to it due to more regularly and finely denticulate distal margins and length of processes being less than half of the mean cyst diameter.

Dimensions:

Diameter of hypocyst	42-58 μm
Length of processes	14-20 μm

Homotryblium pallidum Davey & Williams 1966
Pl 1, fig. 13

1985 *Cordosphaeridium gracilis* (Eisenack) Davey & Williams 1966; *in* Kar, p. 181; pl. 40, fig. 6.

1985 *Homotryblium pallidum* Davey & Williams 1966, *in* Kar, p. 183, pl 41, fig. 10.

Remarks—Our restudy of the dinoflagellate cysts assigned to *Cordosphaeridium gracilis* by Kar (1985, p. 183; pl. 40, fig. 6) indicates that it does not possess precingular archaeopyle and fibrous intratabular processes characteristic of the genus *Cordosphaeridium*. Instead, the cyst is subspherical, skolochorate showing distinct indications of combination (epicystal) archaeopyle and intratabular, non-fibrous, hollow tubular processes, about 23 in number, typical of the genus *Homotryblium*. Further, the cyst is thin-walled, two layered with faintly granular periphragm. Processes are distally expanded and open with irregular distal margins; some of the processes form a distinct proximal circle at the point of emergence. The above features clearly suggest placement of this specimen under *Homotryblium pallidum*.

Kar (1985, p. 183; pl. 41, figs 8-10) described and figured three specimens under *H. pallidum*. However, a restudy of these specimens revealed that only one of these (pl. 41, fig. 10) belongs to *H. pallidum* while the remaining two specimens should be assigned to *Homotryblium tenuispinosum* as discussed else where.

Dimensions:

Diameter of cyst	38 μm
Process length	14 μm

Homotryblium plectilum Drugg & Loeblich 1967
Pl. 1, figs 1-5

1985 *Areoligera digitata* Kar, p. 180-181; pl. 40, fig. 3; pl. 41, figs 2, 3; Lower Eocene, Kutch Basin.

Remarks—Kar (1985, p. 180-181) proposed the following diagnosis for *Areoligera digitata* "Subcircular chorate cysts with convex dorsal side and flat ventral side. Processes arranged in circular fashion distally, intratabular. Size of body 42-54 × 36-52 μm, processes 38-55 μm, branched, finger-like from middle, body as well as processes granulose, processes on ventral side generally not highly branched. Archaeopyle apical".

Our restudy of the holotype and other figured specimens revealed that these subspherical skolochorate cysts display a combination (epicystal) archaeopyle and intratabular tubular processes typical of the genus *Homotryblium*. All the three specimens are hypocysts only Except for one paratype (Kar, 1985; pl. 40, fig. 3), the remaining two specimens including the holotype, are partly broken. The cyst is two layered with thin, smooth endophragm and finely granular periphragm closely appressed between intratabular processes. The processes are typically striate, hollow, tubular to taeniate, distally expanded and branched or digitate, terminating into 2 to 6 slender tubular ramifications. The tubular branching at the distal terminations of the processes is quite variable. It may be restricted almost to the distal margin or may extend almost up to the base of process shafts. Processes in the paracingular region are relatively broader and taeniate, while postcingular ones are tubular and variously branched. A few single tube slender processes also occur possibly in the sulcal region. The parasulcal tab is not distinctly marked due to the state of preservation as the archaeopyle margin is partly folded but a single tube slender process along the margin indicates its position on the hypocyst.

The tubular distal branching of the intratabular processes bring these specimens close to *H. plectilum* but the occurrence of taeniate processes with similar branching suggests their comparison with *H. vallum* Stover 1976. However, *H. vallum* is distinguished by relatively shorter processes and rossette-like pattern at the base.

We opine that the branched processes with deeply incised shafts may be considered within the range of specific variation. We therefore, treat *Areoligera digitata* Kar 1985, a junior synonym of *H. plectilum*.

Dimensions:

Diameter of cyst	40-60 μm
Length of processes	20-30 μm

Homotryblium tenuispinosum Davey & Williams 1966

1985 *Homotryblium pallidum* Davey & Williams 1966, *in* Kar, p. 183-184; pl. 41, figs 8, 9.

Remarks—The figured specimen assigned to *H. pallidum* by Kar (1985; pl. 41, fig. 8) is represented by a complete hypocyst showing combination (epicystal) archaeopyle, but the other one (pl. 41, fig. 9) is a broken part of the hypocyst. Both these specimens have a strongly granular periphragm and intratabular, slender, hollow, tubular processes which are distally slightly expanded and open with aculeate or serrate distal margins. In the complete hypocyst, there are about 16 processes which also have a very finely granular surface. These features suggest the placement of the studied specimens under *Homotryblium tenuispinosum* rather than *H. pallidum*.

Genus—*Lingulodinium* Wall 1967 emend. Wall & Dale 1973

?Lingulodinium sp.
Pl. 3, fig. 7

1985 *Operculodinium placitum* Drugg & Loeblich 1967, *in* Kar, p. 207; pl. 48, fig. 10.

Remarks—This particular cyst is seen with broken opercular pieces suggesting the presence of probably an epicystal archaeopyle. The cyst is broken. The surface is ornamented with small, hollow, distally closed, finger-like non-tabular processes having rounded to somewhat pointed distal tips. These features suggest closest affinities with *Lingulodinium*. This conclusion is further supplemented by the fact that the figured slide contains abundance of *Lingulodinium* specimens belonging to at least three different species including *L. machaerophorum*.

Genus—*Operculodinium* Wall 1967

Operculodinium centrocarpum (Deflandre & Cookson) Wall 1967
Pl. 1, fig. 16

1979 *Polysphaeridium (Hystrichosphaeridium) microtriainum* (Klumpp) Kar, p. 33-34; pl. 4, fig. 64.

1980 *Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967, *in* Jain, p. 140; pl. 1, figs 4-5.

1985 *Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967, *in* Kar, p. 199; non pl. 47, figs 9-10.

Remarks—Kar (1985, p. 199) maintained the transfer of *Polysphaeridium microtriainum* (Klumpp) Kar (1979, pl. 4, fig. 64; documented herein) to *O. centrocarpum* proposed by Jain (1980) but illustrated some other specimens which could not be traced (see Table 2).

Dimensions:

Body size	48 × 48 μm
Length of processes	10-12 μm

?*Operculodinium delicatum* Kar 1985
Pl. 3, fig. 5

1985 *Operculodinium delicatum* Kar, p. 207; pl. 50, fig. 7 (Holotype); Miocene, Kutch Basin.

1989 *Operculodinium delicatum* Kar 1985, *in* Lentin & Williams, p. 267.

Remarks—The holotype of *Operculodinium delicatum* Kar (1985; pl. 50, fig. 7) is an extremely fragmentary and incomplete specimen and appears in all probabilities to be the only specimen of its kind on which a new species has been established. The few characters that could be observed in this damaged cyst are the finely granular ornamentation of its phragma and numerous, short, slender spine-like non-tabular processes. The processes bear faint striations at the base and are slightly tapering distally with aculeate tips with tiny, 2-5 thread-like distal hooklets. Archaeopyle, although mentioned by Kar (1985) to be probably precingular in position, cannot be determined. This specimen is questionably placed under *Operculodinium* due to the resemblance of its processes with those of *O. centrocarpum* (Deflandre & Cookson) Wall 1967. As *O. delicatum* Kar is based only on a single badly-preserved and damaged specimen and no paratypes or other specimens are documented by him we therefore recommend that the name should be restricted to the holotype alone.

Operculodinium israelianum (Rossignol) Wall 1967
Pl. 1, figs 8, 9, 15, 17

1985 *Cleistosphaeridium cephalum* Kar, p. 181; pl. 40, figs 1, 2; pl. 41, fig. 1; Lower Eocene, Kutch Basin.

Remarks—The re-examination of the holotype and other illustrated specimens of *Cleistosphaeridium cephalum* Kar 1985 revealed that the cysts are spherical to subspherical in shape having two layered phragma with finely granular periphragm that remains appressed between numerous, non-tabular, solid spines of similar size and shape. The spines are short, less than one tenth of the cyst diameter, broader at the base having fine striations and faintly capitate tips, often bearing short, delicate

→

PLATE 4

(All photomicrographs are in differential interference contrast and magnified × 500; Stage coordinates refer to Olympus Vanox AH-2 microscope)

1,2. *Glaphyrocysta indica* sp. nov.; BSIP Slide no. 6632, Coordinates: 158.9 × 9.4; 1. ventral side showing faintly developed sutures of apical archaeopyle; 2. dorsal side (Paratype).

3. *Glaphyrocysta indica* sp. nov.; BSIP Slide no. 8270, Coordinates: 135.2 × 17.8.

4. *Apteodinium unicornum* (Kar) comb. nov. emend., BSIP Slide no. 6634, Coordinates: 143.7 × 20.3 (an additional specimen from Khari Nadi Formation, Miocene).

5. *Operculodinium placitum* Drugg & Loeblich 1967; BSIP Slide no. 5119, Coordinates: 139.0 × 7.7.

6. *Spiniferites ramosus* subsp. *multibrevis* Davey & Williams, 1966; BSIP Slide no. 6633, Coordinates: 147.5 × 14.2.

7,8. *Glaphyrocysta indica* sp. nov.; BSIP Slide no. 6634, Coordinates: 144.0 × 20.3; same specimen in two foci.

9,10. *Operculodinium* sp. A; BSIP Slide no. 5116, Coordinates: 148.5 × 10.1.

11. *Lingulodinium machaerophorum* (Deflandre & Cookson) Wall 1967; BSIP Slide no. 6632, Coordinates: 149.7 × 9.5 (an additional specimen from Khari Nadi Formation, Miocene).

12. *Spiniferites bulloideus* (Deflandre & Cookson) Sarjeant 1970; BSIP Slide no. 6634, Coordinates: 154.3 × 6.6.

13. *Glaphyrocysta indica* sp. nov.; BSIP Slide no. 6632, Coordinates: 147.6 × 4.9. Dorsal side showing broad fenestrate solitary process (an additional specimen from Khari Nadi Formation, Miocene).

14,15,16. *Glaphyrocysta indica* sp. nov.; BSIP Slide no. 6632, Coordinates: 133.5 × 4.6; same specimen in different foci (Holotype).

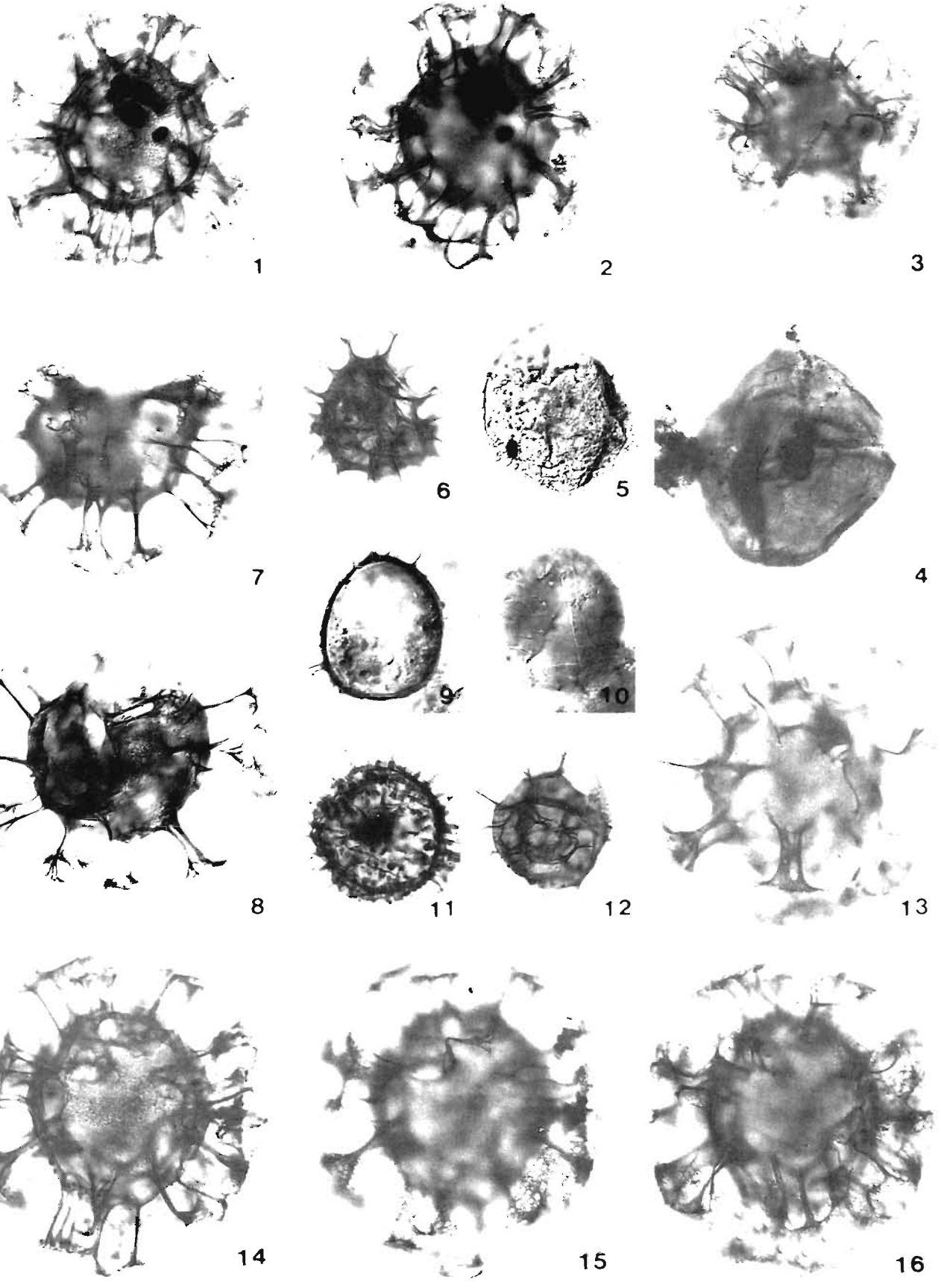

PLATE 4

distal hooklets; along the paracingular region, the spines occur in transverse alignment. The archaeopyle is typically precingular (3″) and is not apical as described by Kar (1985, p. 181).

In view of the presence of precingular archaeopyle and process features, it is apparent that these forms belong to *Operculodinium israelianum* (Rossignol) Wall 1967. We therefore, consider *Cleistosphaeridium cephalum* Kar 1985, a junior synonym of *O. israelianum*.

Dimensions:

Body size	56-72 × 56-70 μm
Length of processes	5–10 μm

Operculodinium microtriainum (Klumpp) Islam 1983
Pl. 3, figs 10, 11

1985 *Operculodinium paucispinosum* Kar, p. 207; pl. 50, fig. 6 (Holotype); Miocene, Kutch Basin.

1985 *Operculodinium robustum* Kar, p. 207-208; pl. 50, fig. 8 (Holotype); Miocene, Kutch Basin.

1986 *Achomosphaera microtriaina* (Klumpp) Sarjeant 1989, *in* Jain & Garg, p. 106-107; pl. 3, fig. 11; pl. 5, fig. 11.

1989 *Operculodinium paucispinosum* Kar, *in* Lentin & Williams, p. 268.

Remarks—Kar (1985, p. 207-208) proposed two new species, viz., *Operculodinium paucispinosum* and *O. robustum* and noted close similarity between these in having long, robustly built processes, but differentiated *O. paucispinosum* only in that the tips of the processes are divided more than three times. However, the processes in *O. robustum* are also stated to have "pointed tips dividing at ends" (Kar, 1985, p. 207), although the number of divisions in this case is not given. Further, the processes in both these species are mentioned by Kar to be between 20-35 μm long and are approximately one third size of the cyst diameter, but the given cyst size differs greatly. In both the species the measurements are given for the holotype only and no size ranges are provided. The cyst body of *O. paucispinosum* is apparently much larger (90 μm) than that of *O. robustum* (58 μm) (Kar, 1985, p. 207-208). However, the larger size of *O. paucispinosum* is due to the splitting of the specimen that does not represent the original size of the cyst, otherwise closely corresponds to the size of *O. robustum*.

Re examination of holotypes of *O. paucispinosum* and *O. robustum* demonstrates that both the cysts have a two-layered wall with pitted, shagreenate periphragm giving rise to numerous, non-tabular, long processes which are nearly half of the cyst diameter in length. The processes are more than 40-45 in number, slender, tapering, solid with aculeate distal tips bearing 2 to 3, rarely up to 4 to 5, commonly recurved, tiny hooklets. Proximally the processes are slightly broader with striate base, often the fine striations extend up to nearly one-third or half the length of process shafts. Presence of precingular archaeopyle could be observed only in the holotype of *O. robustum* while in the holotype of *O. paucispinosum* precingular archaeopyle could only be doubtfully marked.

Our observations thus clearly suggest that *O. paucispinosum* and *O. robustum* are conspecific and display morphological similarity typical of *O. microtriainum* (Klumpp) Islam 1983. Both are thus the junior synonyms of *O. microtriainum*. Sarjeant (1981) transferred *Hystrichosphaeridium microtriaina* Klumpp to *Achomosphaera* in view of bifid or trifid nature and gonal/intergonal distribution of the processes. In view of the above observations of Sarjeant (1981), Jain and Garg (1986, p. 106-107; pl. 3, fig. 11; pl. 5, fig. 9) described the Late Palaeocene specimens from Cauvery Basin as *Achomosphaera microtriaina* and interpretted that the process tips were briefly bifid or trifid which deceptively appeared as aculae. However, our study of several other specimens from Kutch and Cauvery basins and South Shillong Plateau under DIC, clearly demonstrated that the process shafts proximally exhibit distinctive root-like striations which may be extremely short being confined to the base of the processes or may extend up to half or more. Distally the processes are closed with aculeate or orthogonal tips commonly characterised by 2 to 3 or rarely more, very short, fine hooklet-like aculae. In fact, common occurrence of 2 or 3 aculae deceptively suggested briefly bifid or trifid condition. In the absence of any other parasutural features, the linear arrangement of some processes (e.g. along archaeopyle margin), was taken to be presumably gonal/intergonal in position. In view of our present observations we endorse the view of Islam (1983a, p. 240; 1983b, p. 341).

Dimensions:

Body size	60 × 60 μm
Length of processes	26–30 μm

Operculodinium ornamentum (Jain & Tandon) comb. nov.
Pl. 2, fig. 12

1981 *Polysphaeridium ornamentum* Jain & Tandon, p. 12; pl. II-35; Middle Eocene,

Kutch Basin; *J. Palaeont. Soc. India* **26** : 6-21 (Basionym).

1985 *Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967, *in* Kar, p. 206; pl. 50, fig. 5.

1989 *Polysphaeridium ornamentum* Jain & Tandon 1981, *in* Tripathi, p. 70; pl. 3, fig. 4.

Remarks—Jain and Tandon (1981, p. 12; pl. II-35) established a new species of *Polysphaeridium, P ornamentum*. In view of the current morphologic status of *Polysphaeridium* (Bujak *et al.*, 1980, p. 32, 34), the genus is characterised to have combination archaeopyle (epicystal) rather than precingular which alongwith process features characterise the cysts of *Operculodinium*. In view of the presence of precingular archaeopyle in the holotype of *P. ornamentum* Jain & Tandon 1981, we propose to transfer this species to *Operculodinium*. This species is distinguished from all the known species of *Operculodinium* in having typically fenestrate, fibrous, hollow processes alongwith solid striate (?sulcal) processes and strongly pitted, shagreenate periphragm ornamentation.

Further, re-examination of the specimen, identified and described as *Operculodinium centrocarpum* by Kar (1985; p. 206; pl. 50, fig. 5), demonstrates that the cyst is subspherical, two-layered with a pitted, shagreenate to fibrous periphragm bearing numerous, non-tabular, slender, long, distally tapering, almost acuminate processes. The processes have a striated base with slightly expanded to capitate distal tips terminating into 2 to 5, commonly 3-4, fine thread-like, recurved hooklets or aculae. The processes are of two types: majority of these are hollow, fibrous, irregularly and profusely fenestrate, ramifying with distally open process shafts. On ventral surface, apparently in the sulcal region, some processes are solid with striations or rib-like fibres extending from their base up to the half or little further on the process shafts. These processes are distally closed. Archaeopyle is single plate precingular (3″). The processes appear to be linearly arranged along the paracingulum.

Dimensions:

Body size	90 × 90 μm
Length of processes	25-32 μm

Operculodinium placitum Drugg & Loeblich 1967
Pl. 1, fig. 20; Pl. 4, fig. 5

1979 *Polysphaeridium cephalum* Kar, p. 34; pl. 4, figs 66a-b, 67.

1980 ? *Sumatradinium* sp., *in* Jain, p. 141; pl. 1, fig. 8.

1980 *Operculodinium* sp., *in* Jain, p. 141.

1981 ? *Batiacasphaera cephala* (Kar) Lentin & Williams, p. 25.

1985 ? *Batiacasphaera cephala* (Kar) Lentin & Williams 1981, *in* Lentin & Williams, p. 33.

1985 ? *Sumatradinium* sp., *in* Kar, p. 200; pl. 46, fig. 8.

1989 ? *Batiacasphaera cephala* (Kar) Lentin & Williams 1981, *in* Lentin & Williams, p. 34.

Remarks—Our re-examination of the holotype of *Polysphaeridium cephalum* Kar 1979 demonstrates that the cyst is subspherical to ellipsoidal in shape with finely microgranular periphragm bearing numerous, very short, spine-like non-tabular processes having pointed, less commonly blunt to somewhat capitate distal ends. Archaeopyle is single plate precingular, with free operculum. In view of the above features this specimen is assigned to *O. placitum* Drugg & Loeblich 1967. All earlier transfers of this specimen proposed by Jain (1980) and Lentin and Williams (1981) are herein rejected.

Dimensions:

Body size	50 × 58 μm
Length of processes	2-4 μm

Operculodinium uncinispinosum (De Conick) Islam 1983
Pl. 2, fig. 13

1979 *Homotryblium* sp., *in* Kar, p. 35; pl. 4, fig. 73.

1980 *Cordosphaeridium* sp., *in* Jain, p. 141; pl. 1, fig. 7.

1985 *Cordosphaeridium* sp., *in* Kar, p. 200; pl. 46, figs 9-11.

Remarks—Re-examination of this specimen reveals that the subspherical cyst bears non-tabular, slender, striate to fibrous processes which are slightly tapering and open distally with typically aculeate tips. The aculae are commonly 5-6 in number and are more or less recurved. The cyst is partly broken but outline and position of the opening suggest the presence of a precingular archaeopyle. In view of these characters the Kutch specimen is assigned to *O. uncinispinosum* as discussed by Islam (1983, p. 342) who has indicated that this species closely resembles *O. microtriainum* except for having greater number of aculae at the process tips. Processes in *O. microtriainum* commonly have bifid or trifid tips.

Dimensions:

Body size	60 × 80 μm
Length of processes	18-30 μm

Operculodinium sp. A
Pl. 4, figs 9, 10

1979 *Polysphaeridium (Hystrichosphaeridium) microtriainum* (Klumpp) Kar, p. 33-34; pl. 4, fig. 63a-b.
1980 *Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967, *in* Jain, p. 140; pl. 1, figs 2, 3.

Remarks—Re-examination of this specimen revealed that the cyst has a characteristic thick endophragm and thin microgranular periphragm. The process characters are similar to *O. centrocarpum* discussed earlier.

Jain (1980, p. 140; pl. 1, 2-3) described this specimen as *O. centrocarpum* but in view of its thick endophragm character, we for the time being assign it as *Operculodinium* sp. A.

Dimensions:

Body size	52 × 43 μm
Length of processes	5-7 μm

Genus—*Polysphaeridium* Davey & Williams emend. Bujak *et al.* 1980

Polysphaeridium congregatum (Stover) Bujak *et al.* 1980
Pl. 1, figs 18, 19

1979 *Polysphaeridium (Hystrichosphaeridium) microtriainum* (Klumpp) Kar, p. 33-34; pl. 4, fig. 65.
1980 *Hemicystodinium* sp. cf. *H. congregatum* Stover 1970, *in* Jain, p. 141; pl. 1, fig. 10.

Remarks—While assigning this specimen to *Polysphaeridium*, Kar (1979, p. 33-34) mentioned the presence of an apical archaeopyle with more or less a triangular shape and slender, translucent processes with generally bifurcated tips. However, its restudy by Jain (1980) revealed that the hollow, tapering and distally open processes are arranged in poorly delimited groups due to which he suggested its affinities with *Hemicystodinium congregatum*. Our present observations further reveal that the archaeopyle is epicystal and the short, slender processes are either solitary or commonly joined proximally by low ridges to form rectilinear groups, slightly tapering distally with a broader and distinctly striated base and slightly expanded open tips which may be very finely aculeate. This specimen is, therefore, assigned here to *Polysphaeridium congregatum*.

Dimensions:

Diameter of cyst	70 μm
Length of processes	10-12 μm

Polysphaeridium subtile Davey & Williams emend Bujak *et al.* 1980
Pl. 1, fig. 6

1985 *Cleistosphaeridium diversispinosum* Davey *et al.* 1966, *in* Kar, p. 181; pl. 40, figs 4, 5.

Remarks—The specimens assigned to *Cleistosphaeridium diversispinosum* by Kar (1985; pl. 40, figs 4, 5) on re-examination revealed that the cysts are subspherical, thin-walled with granular periphragm having numerous, non-tabular processes of almost similar size and shape and display a combination (epicystal) archaeopyle. Processes are typically short, slender and hollow, distally open and slightly expanded with finely serrate margins. A few processes are distally tapering, acuminate and probably closed. In view of the above features, both the specimens are re-attributed to *Polysphaeridium subtile*.

Dimensions:

Diameter of cyst	54 μm
Length of processes	15-20 μm

Polysphaeridium zoharyi (Rossignol) Bujak *et al.* 1980
Pl. 2, figs 1-4

1979 *Membranilarnacia delicata* Kar, p. 35; pl. 4, figs 70, 71.
1980 *Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967, *in* Jain, p. 140; pl. 1, figs 11, 12.
1980 *Hemicystodinium* sp., *in* Jain, p. 141; pl. 1, fig. 6.
1981 *Membranilarnacia delicata* Kar 1979, *in* Lentin & Williams, p. 183.
1985 *Operculodinium* sp. cf. *Centrocarpum* (Deflandre & Cookson) Wall 1967, *in* Kar, p. 230; pl. 47, fig. 15.

Remarks—The holotype reference for *Membranilarnacia delicata* given by Kar (1979, p. 35) is erroneous. In the text its location has been mentioned as slide no. 5120/2, pl. 4, fig. 70, while the illustrated specimen is marked as 5120/3 in the explanation of plate. Our re-examination of the BSIP slide no. 5120 reveals that the specimen illustrated as the holotype of *M. delicata* relates to slide no. 5120/3 and the specimen in 5120/2 is the one which has been documented by Jain (1980). Accordingly, *M. delicata* was proposed to be the junior synonym of *O. centrocarpum* by Jain (1980). As a matter of fact, Jain's assignment of the specimen no. 5120/2 as *O. centrocarpum* is correct, but it does not effect a valid transfer. Our present re-study of the holotype

indicates that the specimen is characterised by short, striate slender, tubular to slightly distally tapering non-tabular processes with open ends which are capitate to faintly aculeate and the archaeopyle, though broken, is epicystal. These characters demonstrate that *M. delicata* is a junior synonym of *Polysphaeridium zoharyi*.

Surprisingly, Kar (1985, p. 199) again erroneously cited the holotype of *M. delicata* Kar (1979, pl. 4, fig. 70) for *Polysphaeridium (Hystrichosphaeridium) microtriainum* (Klumpp) Kar 1979, which has been included under the synonymy of *O. centrocarpum*.

Dimensions:

Diameter of hypocyst	68 μm
Length of processes	14–18 μm

Forma A

1985 *Heterosphaeridium heteracanthum* subsp. *sparsiprocessum* (Varma & Dangwal) Eisenack & Kjellstörm 1971, *in* Kar, p. 183; pl. 40, fig. 9.

Remarks—The specimen identified as *H. heteracanthum* subsp. *sparsiprocessum* by Kar (1985, p. 183; pl. 40, fig. 9) is a poorly preserved and incomplete showing only a few sparsely placed solid, slender and distally tapering processes, most of which are broken. A couple of complete processes are slightly distally expanded and closed. The archaeopyle is also indiscernible precluding the possibility to identify even at the generic level. It is documented here as Forma A.

SOME OBSERVATIONS

1. Taxonomic revisions have brought out a new aspect of dinoflagellate cyst assemblages described from Lower Eocene and Miocene sediments by Kar (1985). The documented microfloras are incomplete as evidenced by our re-examination of type and figured slides. However, it was beyond the scope of the present critique to describe the undocumented taxa, though a few additional forms have been included.

2. Kar's compilation indicates that Tertiary sequences of Kutch are quite rich in dinoflagellate cysts. In our opinion a careful and detailed taxonomic and biostratigraphic study is imperative to focus their stratigraphic potential in dating, biozonation and correlation within the Kutch Basin and interbasinal correlation of much wider range

3. Kar (1985, p. 92-110) discussed the stratigraphy of Naredi Formation considering it to be the Lower Eocene in age as suggested by Biswas and Raju (1971). It will not be out of place to point out that the documented dinoflagellate cyst assemblage from this bore core is incomplete and possesses long ranging Palaeogene taxa. We therefore suggest that the question of its age to be Early Eocene must be kept open.

4. Occurrence of *Eatonicysta ursulae* in the Harudi Formation (Jain & Tandon, 1981, Sample J_2b corresponding to *Nummulites beaumonti* zone of Tandon, 1976) suggests Middle Eocene age not younger than Lutetian (up to NP14 and P10 zones; Williams & Bujak, 1985) for lower part of the Harudi succession. Jain and Tandon (1981, p. 16) also indicated Lutetian affinity to the dinoflagellate cyst microflora of microplankton Zone V.

5. Occurrence of *Tuberculodinium vancampoae* in Maniyara Fort Formation is very significant. This species has its FAD in Upper Oligocene (equivalent to P21 and NP24 zones) and may help to demarcate Early and Late Oligocene sequences in Kutch. However, its distribution documented by Kar (1985) is confusing and inconclusive and, therefore, a detailed study of dinocyst distribution within this formation is required for its potential use in stratigraphy.

6. Our re-examination of type and figured slides revealed that the Miocene assemblage recovered from Khari Nadi Formation shows predominance of *Lingulodinium* species, especially *L. machaerophorum*. Its abundant occurrence has palaeoenvironmental significance indicating high salinity conditions (Williams, 1971, p. 237; Williams & Bujak, 1977, p. 231).

7. The foregoing review has brought to light a plethora of errors and ambiguities not only in the identifications and systematic descriptions of dinoflagellate cysts but also in various palynozonation schemes proposed for Tertiary sequences of Kutch by Kar (1985).

8. Only the more glaring inconsistencies in this work have been pointed out. Several minor errors in citations, date of publication and authorship, nomenclature, inconsistent spellings, dimension of specimens and magnification of illustrations, figures depicting histograms, palynozonation schemes and species distribution, etc. have generally not

been pointed out. In some instances, even incompletely prepared text-figs have been published by Kar (1985, text-fig. 19).

9. In his entire systematic account of dinoflagellate cysts, Kar's preference for transcribing the original diagnoses or descriptions of documented taxa has been the most perplexing feature. Besides, in several instances the original and reproduced versions do not tally and identifications of his "Lower Eocene" and Miocene taxa appeared questionable. This queer taxonomic procedure has contributed enormously to the time-consuming, cumbersome and thankless task of comparison of the entire text with original publications besides a thorough morphologic and taxonomic restudy.

10. It is recommended that the readers should consult the original papers of Kar (1979), Jain (1980) and Jain and Tandon (1981) for reproduced versions for correct citations and understanding.

11. As a part of our endeavour to prepare an annotated catalogue of Indian *Fossil Dinoflagellate Cysts*, we had our own compulsions to write this critique. Throughout our engagement with this work, we had been contemplating over the amount of labour in terms of time and energy spent in our attempt to regulate the morphologic, taxonomic and stratigraphic status of Tertiary dinoflagellate cysts described by Kar (1985) from Kutch. In this context, it should be realised that Kar's (1985) monographic compilation was supposed to be a treatise on Palynostratigraphy of Kutch (including dinoflagellate cysts) and any young micropalaeontologist/palynologist venturing to take up the study of dinoflagellate cysts would certainly consult it only to find his initial steps unwarily entrapped in a quagmire. Difference of opinion in taxonomic placement of some specimens is understandable and our present work is also surely open to criticism and revision. Admittedly also, some errors may eventually creep in due to oversight or proof reading in a mammoth research-cum-review paper of nearly 280 pages written by any worker including ourselves, but such numerous errors, ommissions, misquotations and misidentifications leave us in little doubt that a more careful and critical scientific approach would have greatly improved that work and would have made it readily usable. We have been able to go through only the part dealing with dinoflagellate cysts and the remaining major part dealing with spore-pollen is hopefully left to be treated by better equipped and competent palynologists.

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