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A Monograph of Fossil Peridinioid Dinoflagellate Cysts

J. K. Lentin and G. L. Williams

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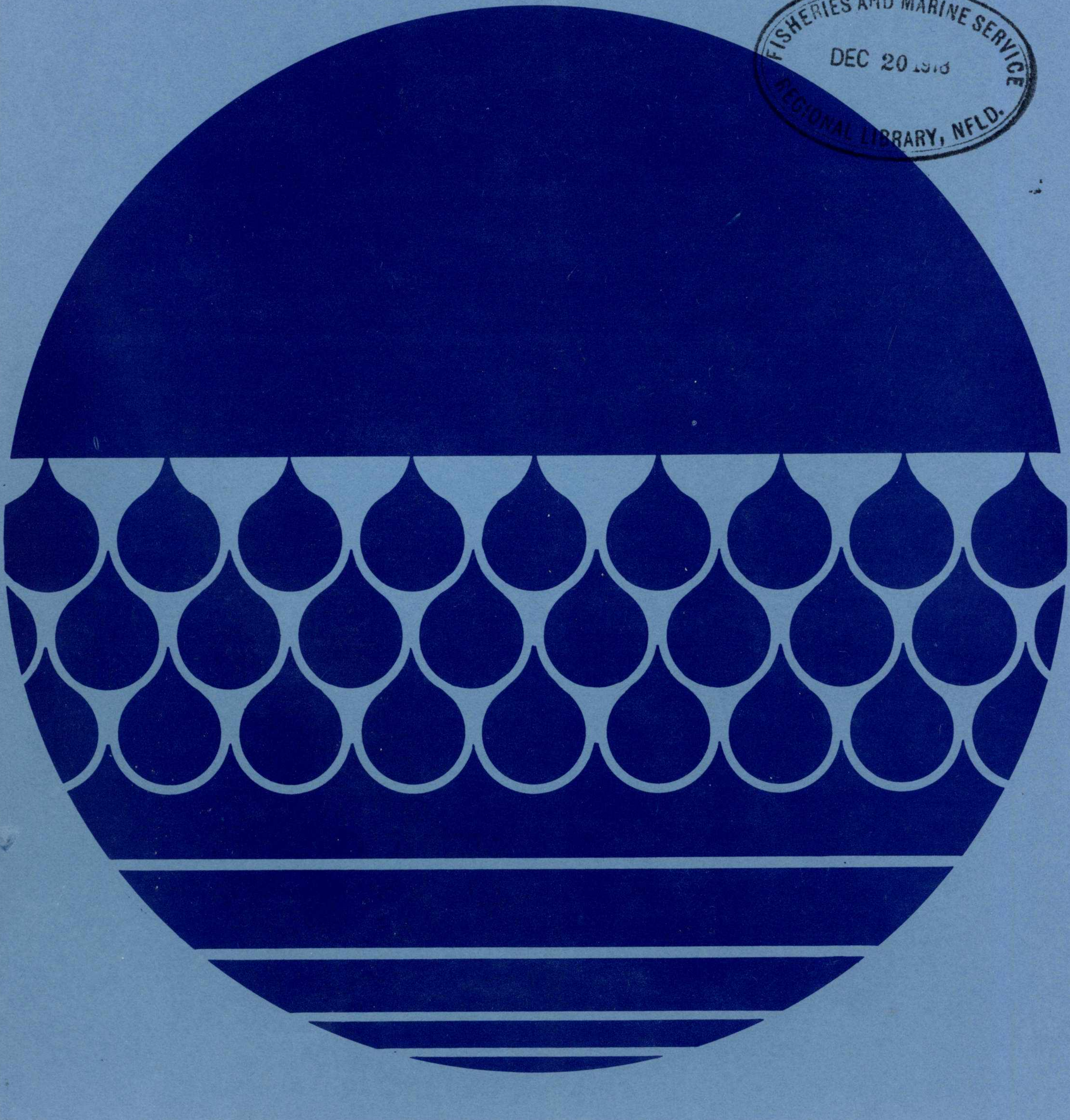

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BEDFORD INSTITUTE OF OCEANOGRAPHY

Dartmouth, Nova Scotia
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A MONOGRAPH OF FOSSIL PERIDINIOID DINOFLAGELLATE CYSTS

by

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ABSTRACT

The fossil peridinioid dinoflagellates have a paratabulation formula of 4', 3a, 7", 5"', 2"". They are predominantly cavate cysts with a distinctive pericyst and endocyst. The archeopyle is either intercalary or combination, when it always involves the intercalaries. The only known exception is *Inversidinium* McLean which appears to have an antapical archeopyle. The simple intercalary archeopyle resulting from the loss of paraplate 2a can be subdivided according to shape. This makes it possible to define *Deflandrea* and related genera more precisely. Fifty-one genera are discussed in this study. Four new genera *Isabelia, Sumatradinium, Vozzhennikovia,* and *Wilsonidium* are erected, and thirteen considered to be superfluous.

SOMMAIRE

Les dinoflagellés péridinioides fossiles ont une formule de paratabulation de 4', 3a, 7", 5"', 2"". Ce sont surtout des kystes cavés avec périkyste et endokyste distinctifs. L'archéopyle peut être soit intercalaire, soit combiné; il comprend toujours les intercalaires. La seule exception connue est l'*Inversidinium* McLean, qui paraît avoir un archéopyle antapical. L'archéopyle intercalaire simple qui résulte de la perte de la paraplaque 2a peut être divisé selon les formes. Ceci permet d'identifier de façon plus précise le *Deflandrea* et les genres voisins. Cinquante et un genres sont analysés dans cette étude. On annonce quatre genres noveaux: *Isabelia, Sumatradinium, Vozzhennikovia* et *Wilsonidium;* treize genres sont jugés superflus.

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We are indebted to W.R. Evitt for reading the draft of the manuscript and pointing out the errors of some of our original concepts. Several of the ideas expressed in the Monograph were first expounded by Professor Evitt. We are grateful to W.R. Evitt, M.E. Millioud and L.E. Stover for the treatment of the generic diagnosis which is a modification of their generic format. Thanks go to Maisie Trapnell and Olive Ross for willingly typing the several versions of the manuscript. Especial thanks to Jan Jansonius for serving as a critical reader and whose recommendations resulted in considerable improvement to the final manuscript. We are also very grateful for having had the opportunity to view some of Cookson and Eisenack's type material. This has been achieved through the courtesy of Robin Helby, who with Roger Morgan and Alan Partridge, is reviewing most of the Mesozoic species of Cookson and Eisenack. The findings of Helby *et al.* will be published in the near future.

Dedicated to W.R. Evitt and T.F. Vozzhennikova whose publications and theories have provided the foundation for this Monograph.

INTRODUCTION

Fossil 'peridinioid' dinoflagellates were first observed by Ehrenberg in 1838 who illustrated the species *Peridinium pyrophorum* [now *Palaeoperidinium pyrophorum* (Ehrenberg) Sarjeant] and other species of dinoflagellates from the Late Cretaceous of Germany. Nothing of significance was added to the study of fossil dinoflagellates until the nineteen thirties when interest was rekindled by the studies of O. Wetzel (1933a, 1933b). Deflandre (1935) erected the genus *Palaeoperidinium* for fossil species with the appearance of *Peridinium* but whose paratabulation was indeterminate. *Deflandrea* and *Wetzeliella* came into existence in 1938 when Eisenack described *Deflandrea phosphoritica, Wetzeliella articulata* and *W. clathrata* from the Eocene-Oligocene of the USSR. No further peridinioid genera were erected until 1955 when Gocht described *Dracodinium* and *Rhombodinium.* Cookson and Eisenack (1958) in the first of their numerous joint publications erected the genus *Broomea.* Subsequently throughout the sixties and to the present, the works of these authors and others, notably Vozzhennikova (1963, 1967), Jain and Millepied (1973), and Harris (1973), have added over forty new genera several of which, as demonstrated later, are junior synonyms. The accumulated data of these authors plus the works of Evitt (1961, 1963, 1967) and Wall and Dale (1968) now permit a more concise understanding of the fossil peridinioid dinoflagellates.

The extant genus *Peridinium* Ehrenberg, 1832, includes over 600 species, most of which have the tabulation formula 4', 7", 5"', 2"". Variations in plate number may occur in any of the prime series with the exception of the postcingular series. Species differentiation is commonly based on variations in the number and arrangement of cingular, sulcal or anterior intercalary plates. Particularly important are the variations in shape of the first apical plate (1') and the second anterior intercalary plate (2a). The first apical (1') may be four-sided, five-sided, or six-sided when it is termed respectively *'ortho,' 'meta,'* and *'para.'* Jörgensen (1912) recognized the subgenera *Metaperidinium* and *Orthoperidinium.* Within *Metaperidinium* he recognized the section *Paraperidinium.* While the subgenera are no longer in use the terms 'ortho,' meta,' and 'para' remain in common usage.

The second anterior intercalary plate (2a) may be four-sided, five-sided, or six-sided when it is respectively termed *'quadra,' 'penta,'* or *'hexa.'* The variation in its shape is reflected in the shape and size of adjacent plates. When 2a is penta, the fourth precingular plate is five-sided. This morphologic type has not been found in fossil peridinioid dinoflagellates. When 2a is quadra, the fourth precingular is six-sided and considerably wider than 2a while the first and third anterior intercalaries (1a and 3a) are six-sided. When 2a is hexa, the fourth precingular is four-sided and not as wide as 2a, while the first and third anterior intercalaries (1a and 3a) are five-sided. Both quadra and hexa 2a paraplates exist in fossil peridinioid dinoflagellates.

The fossil peridinioid dinoflagellates are herein regarded as those taxa with a paratabulation formula of 4', 3a, 7", 5"', 2"", which may or may not be visible. They are predominantly cavate cysts, with a distinctive pericyst and endocyst respectively. The outline of the pericyst is commonly peridinioid, that is with a pointed apex or apical horn and two antapical horns, pentagonal, ellipsoidal or circular, and dorso-ventrally compressed. Rarely are all aspects of the paratabulation discernible. Commonly, only the character of the archeopyle permits assignment to this group. The archeopyle of peridinioid dinoflagellate cysts is either intercalary, or combination, when it always involves the intercalaries. The only known exception is *Inversidinium* McLean, 1973, which appears to have an antapical archeopyle.

The presence of only three intercalaries excludes from this Monograph the genera which may have less than or more than three anterior intercalaries and which are provisionally designated herein as constituting the protoperidinioid lineage. Such genera include *Imbatodinium* Vozzhennikova, 1967, *Netrelytron* Sarjeant, 1961a, *Pareodinia* Deflandre, 1947c, and *Pluriarvalium* Sarjeant, 1962b, which are discussed in detail by Wiggins (1975), and *Shublikodinium* Wiggins, 1973. *Broomea* Cookson and Eisenack, 1958, and *Moesiodinium* Antonescu, 1974, both have an intercalary archeopyle resulting from the loss of a single intercalary paraplate of distinctive shape, and probably belong to the protoperidinioid lineage. They are included, however, in this Monograph because of their simple I (intercalary) archeopyle and their exclusion from the treatment of this group by Wiggins (1975). A full listing of the genera examined in this study is given in Table 1.

Fossil peridinioid genera have in the past been classified into suprageneric groups by several workers. The most significant are Eisenack (1964), Sarjeant and Downie (1966, 1974), and Vozzhennikova (1967). Eisenack (1964) recognized the order Peridiniales within which he included five suborders. The familial designation of the peridinioid genera as given by Eisenack is presented in Table 2, with the exception of *Palaeocystodinium* Alberti, 1961. This genus he placed in the Family Dinococcaceae of the Order Dinoccales. The suprageneric classification into cyst families proposed by Sarjeant and Downie (1966) (Table 3) did not represent a significant improvement on Eisenack. Vozzhennikova (1967) (Table 4) proposed a detailed suprageneric classification, which groups fossil cysts and Recent motile stages together, and places little or no emphasis on archeopyle formation. Her classification has several peculiarities such as the placing of *Cooksoniella* Vozzhennikova, 1967, in a separate cyst family to *Australiella* Vozzhennikova, 1967, and *Chatangiella* Vozzhennikova, 1967, which genera are in turn separated at the familial level from Deflandreaceae. All three genera are here considered synonymous. The placing of *Ceratiopsis* Vozzhennikova, 1963, which is herein regarded as a junior synonym of *Deflandrea,* in the Odontochitineaceae is also inexplicable. Sarjeant and Downie (1974) propose that the term cyst-family be replaced with family. They present a very detailed suprageneric classification which lists 30 of the genera included in this Monograph (Table 5). In this they place *Hexagonifera* Cookson and Eisenack, 1961a, and *Deflandrea* in separate families even though the archeopyle is similar, *Spinidinium* Cookson and Eisenack, 1962b, in the Apteodiniaceae which are characterized by a precingular archeopyle, and are uncertain as to the precise position of *Ginginodinium* Cookson and Eisenack, 1960a, and *Lejeunia* Gerlach, 1961. The value of suprageneric classifications at this stage in our knowledge is questionable. It would seem preferable to list all dinoflagellate genera alphabetically in publications. This would remove the necessity for a suprageneric classification and permit ready location of genera. It would also remove the implications of affinity inherent in a suprageneric classification. If there is a necessity for suprageneric characterization it seems more logical to use the groupings, peridiniacean, gonyaulacean, and ceratiacean, or their derivatives. In this Monograph we impose no suprageneric classification but leave such designations to the discretion of the individual specialist. However, the genera are not arranged alphabetically in this work but according to morphological affinity and archeopyle type. This resulted not from design, but from the constant re-assessment of data resulting from new publications, discussions with experts, emendations of generic concepts to be more encompassing or restrictive and the beneficial effects of exposure of the manuscript to critical readers. To overcome the difficulty of locating the individual genera, an alphabetic listing is provided.

The generic diagnoses within this monograph are presented in a standardized format, with subheadings for distinctive morphologic features. We are grateful to W.R. Evitt, M.E. Millioud and L.E. Stover for the layout, which is a modification of their generic format. The original diagnosis and any subsequent emendations are given for each genus, followed by the emended or expanded diagnosis in the new format. The major subheadings are shape, phragma, paratabulation, archeopyle and dimensions. Within each subheading the pertinent features of the pericyst and endocyst are discussed respectively, where applicable. The terminology is primarily taken from Evitt *et al.*, in press, with a few additions. A separate Glossary hopefully clarifies this terminology. In the Discussion the genus is compared and contrasted with other genera of similar morphology. The stratigraphic range and species included completes the section on each genus.

Fifty-one genera are included in this monograph. These are *Alterbia nom. nov., nom. subst. pro Albertia* Vozzhennikova, 1967; emend (non *Albertia* Schimper, 1837): *Amphidiadema* Cookson and Eisenack, 1960a; *"Andalusiella"* Riegel, 1974; *Ascodinium* Cookson and Eisenack, 1960a; *"Astrocysta"* Davey, 1970; *"Australiella"* Vozzhennikova, 1967; *Broomea* Cookson and Eisenack, 1958; *Bulbodinium* O. Wetzel, 1960; *"Ceratiopsis"* Vozzhennikova, 1963; *"Cerodinium"* Vozzhennikova, 1963; *Chatangiella* Vozzhennikova, 1967; *"Cooksoniella"* Vozzhennikova, 1967; *"Craspedodinium"* Cookson and Eisenack, 1974; *Deflandrea* Eisenack, 1938; *"Dracodinium"* Gocht, 1955; *"Evittodinium"* Deflandre, 1964; *Geiselodinium* Krutzsch, 1962; *Ginginodinium* Cookson and Eisenack, 1960a; *Hexagonifera* Cookson and Eisenack, 1961a; *Inversidinium* McLean, 1973; *Isabelia gen. nov.*; *Kisselevia* Vozzhennikova, 1963; *Laciniadinium* McIntyre, 1975; *Lejeunia* Gerlach, 1961; *Maduradinium* Cookson and Eisenack, 1970a; *Moesiodinium* Antonescu, 1974; *"Morkallacysta"* Harris, 1973; *Nelsoniella* Cookson and Eisenack, 1960a; *Ovoidinium* Davey, 1970; *Palaeocystodinium* Alberti, 1961; *Palaeoperidinium* Deflandre, 1935; *"Pentagonum"* Vozzhennikova, 1967; *Phthanoperidinium* Drugg and Loeblich, 1967; *Pocockia* Lentin and Williams, 1973; *Pseudodeflandrea* Alberti, 1959a; *Rhombodinium* Gocht, 1955; *Saeptodinium* Harris, 1973; *Selenopemphix* Benedek, 1972; *"Senegalinium"* Jain and Millepied, 1973; *Smolenskiella* Vozzhennikova, 1967; *"Soaniella"* Vozzhennikova, 1967; *Spinidinium* Cookson and Eisenack, 1962b; *Subtilisphaera* Jain and Millepied, 1973; *Sumatradinium gen. nov.*; *Svalbardella* Manum, 1960; *Teneridinium* Krutzsch, 1962; *Trithyrodinium* Drugg, 1967; *Uvatodinium* Vozzhennikova, 1963; *Vozzhennikovia, gen. nov.*; *Wetzeliella* Eisenack, 1938; *Wilsonidium gen. nov.* Twelve of these genera, *Andalusiella, Astrocysta, Australiella, Ceratiopsis, Cerodinium, Cooksoniella, Craspedodinium, Dracodinium, Morkallacysta, Pentagonum, Pocockia,* and *Senegalinium,* are considered to be junior synonyms. *Evittodinium* is considered a *nomen dubium* and it is strongly recommended that no further species be included in this genus. *Soaniella* is considered a *nomen ambiguum* on the basis that Vozzhennikova designated two holotype specimens, neither of which is consistent with the generic diagnosis.

Four new genera, *Isabelia, Sumatradinium, Vozzhennikovia* and *Wilsonidium,* are erected. The position of *Smolenskiella* is debatable. The following genera are emended: *Alterbia, Amphidiadema, Broomea, Chatangiella, Deflandrea, Ginginodinium, Kisselevia, Lejeunia, Ovoidinium, Selenopemphix, Spinidinium, Subtilisphaera, Trithyrodinium,* and *Wetzeliella.*

No new species are erected in the monograph although there are numerous transfers. A line drawing of the holotype of each species considered validly published is presented in the accompanying Plates 1-21. Where species are transferred or considered junior synonyms, a brief statement outlines the reasons. The species are in generic groupings but not necessarily illustrated in alphabetical order.

The most significant changes proposed in this monograph are in the *Deflandrea* and *Wetzeliella* complexes. All taxa assigned to these complexes have a simple intercalary periarcheopyle and/or endoarcheopyle resulting from the loss of anterior intercalary paraplate 2a. *Deflandrea* is now restricted to species with two more or less equal antapical horns and a broad hexa intercalary archeopyle. As such it has a stratigraphic range of Maastrichtian-Oligocene. *Ceratiopsis* and *Cerodinium* are herein considered to be junior synonyms of *Deflandrea*. *Geiselodinium*, *Pseudodeflandrea* and *Teneridinium* may also be junior synonyms of *Deflandrea* although it appears more probable that *Geiselodinium* and *Teneridinium* will be shown to have combination $\overline{A_{3}, 3I3P_{3''-5''}}$ archeopyles. Species formerly included in *Deflandrea* which do not have a broad hexa archeopyle and possess antapical horns of unequal length and are common throughout the Cretaceous, are placed elsewhere. The Early Cretaceous members of the *Deflandrea* complex have now been shown to have either a transapical excystment suture or no apparent excystment opening. These are now placed in the genus *Subtilisphaera*. Late Cretaceous members of the *Deflandrea* complex are usually assignable to one of three genera, *Alterbia*, *Chatangiella* or *Isabelia*. *Alterbia* has a well developed pericingulum and an attenuated hexa to standard hexa intercalary archeopyle. *Andalusiella*, *Maduradinium* and *Senegalinium* are herein considered junior synonyms of *Alterbia*. *Chatangiella* is characterized by the distinctive shape of the epipericyst in ambital view, the partite pericingulum, the frequent occurrence of penetabular ornamentation and the omegaform periarcheopyle. *Australiella* and *Isabelia* are herein considered to be junior synonyms of *Chatangiella*, which may be a junior synonym of *Bulbodinium*; however, pending re-examination of *Bulbodinium seitzi*, the type of the genus, *Chatangiella*, is retained. The closely related *Evittodinium* is considered a *nomen dubium*. *Isabelia* lacks a pericingulum but possesses an omegaform archeopyle. It never develops penetabular ornamentation.

Late Cretaceous genera closely related to *Alterbia* and *Isabelia* include *Amphidiadema*, *Hexagonifera*, *Nelsoniella*, *Spinidinium* and *Trithyrodinium*. *Amphidiadema*, *Hexagonifera*, *Nelsoniella* and *Spinidinium* all have standard and/or attenuated hexa intercalary archeopyles resulting from the partial or complete detachment of the anterior intercalary paraplate 2a. *Amphidiadema* is characterized by the rectangular outline of the pericyst in ambital view, the prominent equatorial bulge and the presence of a large apical and a large antapical pericoel. *Hexagonifera* may or may not have a periphragm, which even when present does not form a distinctive pericyst. *Nelsoniella* has a rounded antapex, a very large apical or anterior pericoel and no antapical pericoel. *Spinidinium* has intratabular, sometimes penetabular, echinae or processes, a small apical and one or two small antapical pericoels. *Spinidinium* is now known to extend into the Paleocene in Grand Banks sediments. *Uvatodinium* has only been recorded from the Paleocene and lacks antapical horns. *Trithyrodinium* is characterized by a 3I intercalary archeopyle resulting from the partial or complete detachment of all three anterior intercalaries, 1-3a.

Other genera with a simple intercalary archeopyle resulting from the partial or complete detachment of anterior intercalary paraplate 2a are *Lejeunia*, *Palaeocystodinium*, *Phthanoperidinium*, *Selenopemphix*, *Sumatradinium*, *Svalbardella* and *Vozzhennikovia*. *Lejeunia* is known from the Campanian-Miocene and has a dorso-and ventrally compressed, typically peridinioid pericyst outline with one apical and two antapical horns, a very small apical and very small antapical pericoels where observable, and a large archeopyle. *Selenopemphix* differs from *Lejeunia* in being compressed apically-antapically. The morphologically similar genera *Palaeocystodinium* and *Svalbardella* have a fusiform pericyst with a single antapical horn. *Phthanoperidinium* always shows paratabulation and has no, or very reduced, horns. *Sumatradinium* bears nontabular processes particularly on the ambitus and lacks horns having a rounded apex and rounded antapex. *Vozzhennikovia* has nontabular ornamentation, an apical horn and a rounded antapex, or one antapical horn.

The *Wetzeliella* complex embraces the genera *Kisselevia, Rhombodinium, Wetzeliella* and *Wilsonidium*. The pericyst of these genera is always rhomboidal to peridinioid pentagonal in ambital outline and usually has two well developed periparacingular horns. The archeopyle is always quadra intercalary resulting from the partial or complete detachment of the second anterior intercalary paraplate 2a. When the operculum remains attached it is always along the anterior parasuture. *Rhombodinium* is devoid of processes and lacks parasutural ornamentation. *Wilsonidium* possesses parasutural ornamentation which may range from granules to processes. *Wetzeliella* and *Kisselevia* always have processes; in the former genus they are nontabular, in *Kisselevia* they are penetabular or form simulate complexes and clearly delineate the paratabulation.

Broomea and *Moesiodinium* have a hexa intercalary archeopyle resulting from the partial or complete detachment of a single anterior intercalary paraplate. In these genera, however, the archeopyle is oriented so that the lateral margins are flat and the posterior margin represents two parasutures which meet at an angle. These genera, although treated in this monograph, probably belong to the protoperidinioid lineage.

Fossil peridinioid genera with a combination archeopyle are not so readily categorized. *Ascodinium* and *Ovoidinium* possess archeopyles formed from the loss of both apical and anterior intercalary paraplates. In *Ovoidinium* all the apicals and all the anterior intercalaries are included in the operculum. In *Ascodinium* only one apical and the 2a intercalary are involved, or possibly all the anterior intercalaries are lost. *Ginginodinium* has a combination $3I3P_{3''-5''}$ archeopyle in which the intercalaries are partially or completely detached, and the three precingulars, 3", 4" and 5" always remain attached along the posterior margin. It is one of the very distinctive peridinioid taxa having combination archeopyles that seem to characterize the Albian.

The *Palaeoperidinium* complex includes all the peridinioid genera with $A_3 \cdot 3I3P_{3''-5''}$ archeopyles in which the operculum represents most of the dorsal epipericyst. Occasionally there are intermediate forms to *Ginginodinium* in which the archeopyle is $3I3P_{3''-5''}$. Other genera besides *Palaeoperidinium* placed in this complex are *Saeptodinium* and possibly *Subtilisphaera*. *Palaeoperidinium* is characterized by having a pericyst with rhomboidal to pentagonal ambital outline, usually observable paratabulation, plus one apical and one or two antapical horns. *Morkallacysta* and *Pentagonum* are herein considered junior synonyms of *Palaeoperidinium*. *Subtilisphaera* has a pericyst which has a very reduced right antapical horn, lacks paratabulation apart from having a pericingulum and usually has a clearly delineated endocyst. Not all species of *Subtilisphaera* are known to have an excystment opening. *Saeptodinium* is distinguished from *Palaeoperidinium* by the absence of antapical horns. Both *Palaeoperidinium* and *Saeptodinium* are common in Tertiary nonmarine sediments. *Subtilisphaera* is known only from the Early Cretaceous.

Morphological features which appear of importance in permitting separation of the genera are ambital outline of the pericyst, particularly with regard to the nature and number of horns present, paratabulation including presence or absence of the pericingulum, endocyst pericyst relationship and the location and size of the pericoels and the archeopyle. Some thought has been given to the statistical approach to studies of the peridinioid genera. Sellberg and Kjellström

(1974) have placed considerable emphasis on the measurement of five variables which are taken to characterize the geometrical outline of the endocyst and pericyst of nine species of *Deflandrea*. Text-Figure 1 illustrates the lines of measurement and the mathematical formulae which define the variables. Sellberg and Kjellström measured the holotypes only, of the nine species. This is not surprising in view of the considerable amount of work involved in determination of the variables x, y, z, u, and v. They make the basic assumption that the differentiation in the geometry of the pericyst and endocyst of respective dinoflagellates is clearly demonstrated by the differentiation in the numerical values of respective variables, The letter x indicates the size of the apical horn, y the size of the antapical pericoel, z the length of the antapical horn, u the distance between the periphragm and endophragm presumably equating with the width of the ambital pericoel, and v the width of the epipericyst below the apical horn. It is unfortunate that the measurements were based on the holotypes only. This diminishes the significance of the results since specimens of the same species show considerable variation in the pericyst-endocyst relationship, pericoel size and length of the respective horns. Such an approach is of questionable value unless applied to several specimens, and then it becomes debatable as to whether the time involved yields meaningful data to the working palynologist. The technique seems commendable but somewhat too precise for once-living organisms that show such variation. Also the importance of correct orientation should be stressed in any such method. If the species selected by Sellberg and Kjellström are any guide other more easily perceived morphological features can be used to separate them. *Deflandrea diebeli* Alberti, 1959b, and *D. pentaradiata* Cookson and Eisenack, 1965c, are easily distinguished from each other. The data would be much more significant if it permitted separation of twenty or so species of very similar morphology. However, Sellberg and Kjellström's work should not be overlooked and their hypothesis should be tested on other species. The validity of Sellberg and Kjellström's findings for separation at the generic level is more questionable.

Riegel (1974; Text-Fig. 6A) has produced a scatter diagram of the total length and width for 57 specimens of *Andalusiella mauthei* Riegel, and in Text-Figure 6B a total length and length of body without horns. These indicate that the length of the horns is proportional to the length of the pericyst minus horns, rather than its width. This seems a more logical statistical approach since it is based on several specimens, measures easily observable parameters, and provides meaningful data readily.

In the present study, although dimensions are given, the statistical approach has not been adopted. Only the length:breadth ratio of the pericyst and the transverse archeopyle index and transverse archeopyle ratio, as applied to an intercalary archeopyle resulting from the loss of the second anterior intercalary paraplate only, have been utilized at the generic level. The transverse archeopyle index and transverse archeopyle ratio are defined in the section on archeopyles.

Several of the holotypes of the type species of genera erected by Cookson and Eisenack have been examined by the present authors. For this privilege we are indebted to Dr. Robin Helby who transported the slides from Australia to Calgary, specifically for our benefit. This permitted emendation of the genera *Ginginodinium* and *Hexagonifera*.

The papers written by Vozzhennikova in 1963 and 1967 are two of the few taxonomic treatments in which the fossil peridinioid dinoflagellate cysts are not lumped into one of the three complexes, *Deflandrea, Wetzeliella* and *Palaeoperidinium.* Vozzhennikova separated Cretaceous species formerly included in *Deflandrea,* which she placed into one or other of the genera *Albertia, "Australiella," Chatangiella* and *"Cooksoniella."* Maastrichtian-Tertiary taxa she placed into one of the genera *"Ceratiopsis," "Cerodinium"* and *Deflandrea.* She also recognized other genera in the *Wetzeliella* complex, erecting *Kisselevia* and elevating *Rhombodinium* to generic rank again. Other peridinioid genera erected in Vozzhennikova (1967) were *"Soaniella," "Pentagonum," Uvatodinium* and *Smolenskiella.* Unfortunately, Vozzhennikova placed little or no emphasis on the archeopyle so that she included within *Soaniella* taxa which have different archeopyles (see Discussion under *Soaniella*).

Harris (1973) in a paper on Tertiary nonmarine dinoflagellates from Australia described the genera *"Morkallacysta"* and *Saeptodinium.* Jain and Millepied (1973) erected the genera *"Senegalinium"* and *Subtilisphaera,* the latter including most of the Early Cretaceous peridinioid cysts up to the Albian. Other genera are being erected with increasing rapidity and with some overlap. It is hoped that this monograph will help to elucidate some of the genera now in the literature and provide a basis for re-examination of several others.

GENUS AND AUTHOR	EMENDATION	STATUS IN THIS PAPER
"Albertia" Vozz., 1967		*jr hom.* of *Albertia* Schimper, 1837
Alterbia nom. nov.		*nom. subst. pro Albertia* Vozz., 1967, emend. (*non Albertia* Schimper, 1837)
Amphidiadema Cook. & Eis., 1960a	this paper	valid genus
"Andalusiella" Rieg., 1974		*jr syn.* of *Alterbia*
Ascodinium Cook. & Eis., 1960a		valid genus
"Astrocysta" Davey, 1970		*jr syn.* of *Palaeoperidinium*
"Australiella" Vozz., 1967		*jr syn.* of *Chatangiella*
Broomea Cook. & Eis., 1958	this paper	valid genus
Bulbodinium O. Wet., 1960		valid genus, needs reexamination
"Ceratiopsis" Vozz., 1963		*jr syn.* of *Deflandrea*
"Cerodinium" Vozz., 1963		*jr syn.* of *Deflandrea*
Chatangiella Vozz., 1967	this paper	valid genus
"Cooksoniella" Vozz., 1967		*jr syn.* of *Chatangiella*
Craspedodinium Cook. & Eis., 1974		*jr syn.* of *Ovoidinium*
Deflandrea Eis., 1938	Wills. & Down., 1966c this paper	valid genus
"Dracodinium" Gocht, 1955		*jr syn.* of *Wetzeliella*
"Evittodinium" Defl., 1964		considered a *nomen dubium*
Geiselodinium Krut., 1962		needs reexamination
Gingінodinium Cook. & Eis., 1960a	this paper	valid genus
Hexagonifera Cook. & Eis., 1961a		valid genus
Inversidinium McLean, 1973		valid genus
Isabelia gen. nov.		valid genus
Kisselevia Vozz., 1973	this paper	valid genus
Laciniadinium McInt., 1975		valid genus
Lejeunia Ger., 1961	Kjell., 1972 this paper	valid genus
Maduradinium Cook. & Eis., 1970		valid genus
Moesiodinium Ant., 1974		valid genus
"Morkallacysta" Har., 1973		*jr syn.* of *Palaeoperidinium*
Nelsoniella Cook. & Eis., 1960a		valid genus
Ovoidinium Davey, 1970	this paper	valid genus
Palaeocystodinium Alb., 1961		valid genus
Palaeoperidinium Defl., 1935	Sarj., 1967	valid genus

..../CONT'D

CONT'D

GENUS AND AUTHOR	EMENDATION	STATUS IN THIS PAPER
"*Pentagonum*" Vozz., 1967		*jr syn.* of *Palaeoperidinium*
Phthanoperidinium Drugg & Loeb., 1967		valid genus
Pseudodeflandrea Alb., 1959a		needs reexamination
Rhombodinium Gocht, 1955		valid genus
Saeptodinium Har., 1973		valid genus
Selenopemphix Ben., 1972	this paper	valid genus
"*Senegalinium*" Jain & Mill., 1973		*jr syn.* of *Alterbia*
Smolenskiella Vozz., 1967		needs reexamination
"*Soaniella*" Vozz., 1967	*nomen ambiguum*	invalid genus
Spinidinium Cook. & Eis., 1962b	this paper	valid genus
Subtilisphaera Jain & Mill., 1973	this paper	valid genus
Sumatradinium gen. nov.		valid genus
Svalbardella Manum, 1960		valid genus
Teneridinium Krut., 1962		needs reexamination
Trithyrodinium Drugg, 1967	this paper	valid genus
Uvatodinium Vozz., 1963		valid genus
Vozzhennikova gen. nov.		valid genus
Wetzeliella Eis., 1938	Wills. & Down., 1966b this paper	valid genus
Wilsonidium gen. nov.		valid genus

TABLE 1 PERIDINIOID GENERA COVERED IN PRESENT STUDY.

SUBORDER	FAMILY	PERIDINIOID GENERA INCLUDED
Gymnodinineae	Gymnodiniaceae	*Lejeunia*
Peridiniineae	Podolampaceae	*Broomea*
Deflandreineae	Deflandreaceae	*Amphidiadema* *Ascodinium* *Bulbodinium* *Deflandrea* *"Dracodinium"* *Geiselodinium* *Ginginodinium* *Pseudodeflandrea* *Rhombodinium* *Spinidinium* *Svalbardella* *Teneridinium* *Wetzeliella*
	Nelsoniellaceae	*Nelsoniella*

TABLE 2 CLASSIFICATION OF THE ORDER PERIDINIALES (From Eisenack, 1964). Only *"Peridinioid"* genera are included.

CYST FAMILY	PERIDINIOID GENERA INCLUDED
Canningiaceae	*Broomea*
Deflandreaceae	(?)*Cerodinium* *Deflandrea* (?)*Evittodinium* (?)*Geiselodinium* (?)*Kisselevia* *Palaeocystodinium* (?)*Pseudodeflandrea* *Svalbardella* (?)*Uvatodinium* *Wetzeliella*
Hexagoniferaceae	*Ascodinium* *Hexagonifera*
Nelsoniellaceae	*Amphidiadema* *Nelsoniella*
Pareodiniaceae	*Spinidinium*
Pseudoceratiaceae	(?)*Ceratiopsis*
Proximate Cysts Cyst-Family Unknown	*Ginginodinium* *Lejeunia*

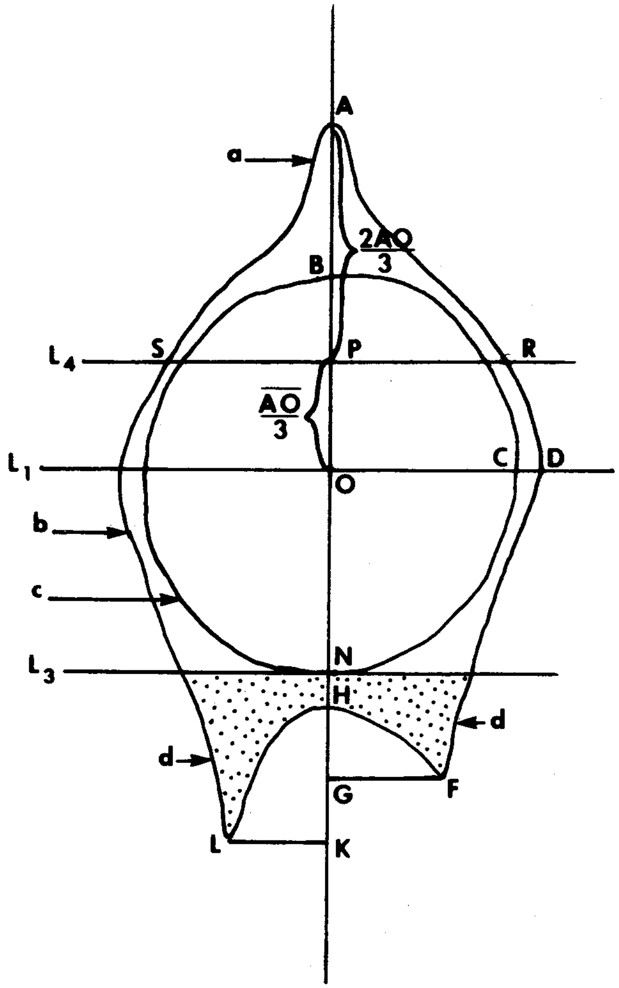
TABLE 3 CLASSIFICATION OF THE CLASS DINOPHYCEAE
(From Sarjeant and Downie, 1966). Only "Peridinioid" genera are included.

SUBCLASS	ORDER	FAMILY	PERIDINIOID GENERA INCLUDED
Dinoflagellatophycidae	Gymnodiniales	Gymnodiniaceae	*Uvatodinium*
	Palaeoperidiniales	Palaeoperidiniaceae	*Gingìnodinium* *Kisselevia* *Lejeunia* *Palaeoperidinium* *Pentagonum*
		Pseudoceratiaceae	*Broomea*
Endoflagellatophycidea	Deflandreales	Chatangiellaceae	*Australiella* *Chatangiella*
		Deflandreaceae	*Albertia* *Amphidiadema* *Ascodinium* *Cerodinium* *Deflandrea* *Palaeocystodinium* *Pseudodeflandrea* *Spinidinium* *Svalbardella*
		Hexagoniferaceae	*Hexagonifera*
		Odontochitineaceae	*Ceratiopsis*
		Wetzeliellaceae	*Dracodinium* *Rhombodinium* *Wetzeliella*
	Endoscriniales	Cooksoniellaceae	*Cooksoniella*
		Endoscriniaceae	*Smolenskiella*

TABLE 4 CLASSIFICATION OF THE CLASS PERIDINOPHYCEAE
(From Vozzhennikova, 1967). Only "Peridinioid" genera are included.

FAMILY	PERIDINIOID GENERA INCLUDED
APTEODINIACEAE	*Soaniella* *Spinidinium*
Broomeaceae	*Broomea*
Deflandreaceae	*Albertia* *"Astrocysta"* *"Australiella"* *Bulbodinium* (?)*"Ceratiopsis"* *"Cerodinium"* *Chatangiella* *"Cooksoniella"* *Deflandrea* *Evittodinium* *Geiselodinium* *Kisselevia* *Palaeocystodinium* (?)*Pseudodeflandrea* *Svalbardella* *Trithyrodinium* (?)*Uvatodinium* *Wetzeliella*
Endoscriniaceae	*Smolenskiella*
Hexagoniferaceae	*Ascodinium* *Hexagonifera*
Nelsoniellaceae	*Amphidiadema* *Nelsoniella*
Palaeoperidiniaceae	*Palaeoperidinium*
Phthanoperidiniaceae	*Phthanoperidinium*
Family Uncertain	*Ginginodinium*

TABLE 5 CLASSIFICATION OF THE ORDER PERIDINIALES
(From Sarjeant and Downie, 1974). Only "Peridinioid" genera are included.



A = upper point of the apical horn (a)
B = upper point of the central capsule (c)
C = point of intersection between L 1 and central capsule
D = point of intersection between L 1 and periphragm (b)
F = lower point of left antapical horn (d)
G = projection of F on L 2
H = upper point of the periphragm between the antapical horns
K = projection of L on L 2
L = lower point of right antapical horn (d)
M = magnification of specimen
N = lower point of central capsule
O = point of symmetry of central capsule
P = point on L 2 dividing $\overline{AO}$ into the ratio of 2/1
R, S = { point of intersection between periphragm and transversal parallel to DO through P
T = dashed area

We now define the five variables x, y, z, u, and v as follows:

$x = \overline{AO}/\overline{BO}$

$y = \frac{T}{M}\ (mm^2)$

$z = (\overline{HK} + \overline{HG})/\sqrt{M}\ (mm)$

$u = \overline{DO}/\overline{CO}$

$v = \overline{RS}/\sqrt{M}\ (mm)$

where $\overline{AO}$, $\overline{BO}$, etc. mean the length of AO, BO, etc.

TEXT-FIG. 1 NOTATIONS USED FOR AN ARBITRARY *DEFLANDREA* BY SELLBERG AND KJELLSTRÖM, 1974.
(This is an inverted reproduction of their Fig. 1.)

ARCHEOPYLE MORPHOLOGY

Introduction

The term archeopyle was proposed by W.R. Evitt (1961, p. 389), who defined it as, "the opening in a fossil dinoflagellate (either its motile or encysted stage) formed by the release of a single plate or group of plates." Evitt (1967, p. 6) more succinctly defined the archeopyle as, "... an excystment aperture in the wall of a dinoflagellate cyst." In this paper Evitt introduced the concept of the archeopyle formula, an alphanumeric representation of the paraplate series and numbers (which together constitute the operculum) lost in formation of the archeopyle. The archeopyle formula also permits distinction between free and attached opercula, the latter remaining partially attached to the rest of the cyst, and simple or compound opercula. In a compound operculum, there are two or more opercular pieces; in a simple operculum, there is one opercular piece.

Archeopyle Formula

Evitt (1967, p. 22) meticulously explains the archeopyle formula. The capital letters A, I, and P represent the apical, anterior intercalary and precingular paraplate series respectively. A bar over one of these letters indicates that two or more paraplates of that series are present in a simple operculum, or single opercular piece (e.g., $\overline{A}$). An operculum or single opercular piece including paraplates of two series is expressed thus, $\overline{AI}$; when there are three series involved the formula would be $\overline{AIP}$. A plus sign between letters indicates that there are accessory archeopyle sutures developed, so that $\overline{A}$ + P indicates separation of the precingulars from the apicals giving two opercular pieces. A numeral before a letter designates the number of opercular pieces so that 2A + 6P indicates eight opercular pieces, two apical and six precingular. An attached operculum is indicated by a lower case a, so that $\overline{A}$a indicates an attached apical operculum. Where a periarcheopyle and endoarcheopyle can be distinguished the periarcheopyle formula is given to the left, and the endoarcheopyle to the right, of an oblique line. Thus I/3I indicates an intercalary periarcheopyle resulting from the loss of paraplate 2a only, and an endoarcheopyle resulting from the loss of all three anterior intercalaries or 1a-3a.

The value of an archeopyle formula is that it synthesizes the data. Evitt's simple alphanumeric system has some restrictions however. It does not indicate the number of paraplates of a series included in the operculum or opercular piece and it lays undue stress on the number of opercular pieces. In the present monograph the capital letter designations are retained. The meaning and significance of the bar over the letters is changed so that its presence simply denotes that the paraplates of the operculum are not separated by accessory sutures. The number preceding the capital letter denotes the number of paraplates included in the operculum or opercular piece of that particular series. Thus $\overline{4A}$ indicates there are four apicals in the operculum. $3\overline{I}$ indicates three anterior intercalaries which are removed as one opercular piece. 3I simply means three anterior intercalaries lost separately. To further clarify the specific paraplates involved each paraplate of a particular series included in the operculum follows the capital letter. Thus $\overline{A_{3},3I3P_{3''-5''}}$ indicates that the single opercular piece or operculum consists of the third apical paraplate, all three anterior intercalary paraplates and the third, fourth and fifth precingular paraplates. $\overline{A_3'3I3Pa_3''_{-5}''}$ indicates that the operculum remains attached to the cyst along the posterior parasuture of the third, fourth and fifth precingulars. $A_3'3I3P_3''_{-5}''$ without the bar indicates that the operculum disintegrates along paraplate sutures into separate opercular pieces. No attempt is made to designate the number of opercular pieces other than by retaining the plus sign since no formula can be all-embracing. Following the system devised by Evitt, the archeopyle formula of *Palaeoperidinium* given above as $\overline{A_3'3I3P_3''_{-5}''}$, or even shortened thus A_33I3P_{3-5}, would be $\overline{AIP}$. Thus the detailed nature of the archeopyle remains obscure. Evitt's method for differentiating the periarcheopyle and endoarcheopyle is retained.

Archeopyle Types in the Peridinioid Genera

Correct interpretation of the archeopyle type and composition in a species is fundamental to the classification of dinoflagellates. The archeopyle permits orientation of a specimen, clarifies the paratabulation and is commonly the basis for separation at the generic level. The relatively recent development of the archeopyle concept and its clarification of paratabulation means that many genera and species are inadequately described in the literature. This is particularly true of the published peridinioid genera, a list of which is given in Table 1. Fortunately, it is possible to recognize the archeopyle in the illustrations of the type species of several genera. Where we could not interpret the archeopyle type from such illustrations, requests were made for permission to view slides. We express thanks to C. Felix, S. Manum, and G. Wilson for responding positively to our requests. The examination of the type material has proved invaluable in our studies.

The archeopyle in all fossil peridinioid genera, except *Inversidinium,* is restricted to the epicyst and involves the partial or complete detachment of one, or more than one, of the anterior intercalaries. It is possible to recognize several archeopyle types in this group, depending on the series and number of paraplates, in the operculum and the shape of the archeopyle margin.

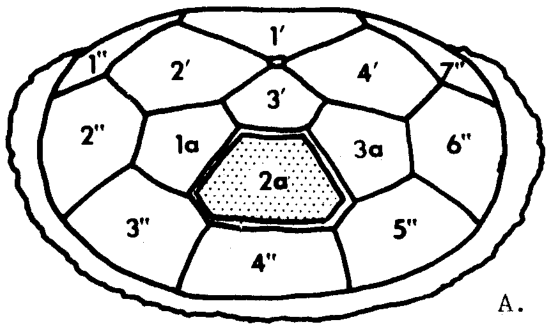
Type I Archeopyle

Not necessarily the simplest, but the most easily recognizable, archeopyle type is Type I of Evitt (1967). This results from the partial or complete detachment of the second anterior intercalary paraplate in the pericyst and/or endocyst.

The Type I archeopyle and primarily the periarcheopyle can be subdivided according to shape of the operculum or archeopyle margin and the outline of surrounding paraplates, particularly the fourth precingular. The basic shape of the 2a paraplate may be hexa or quadra (Text-Fig. 2A and 2B).

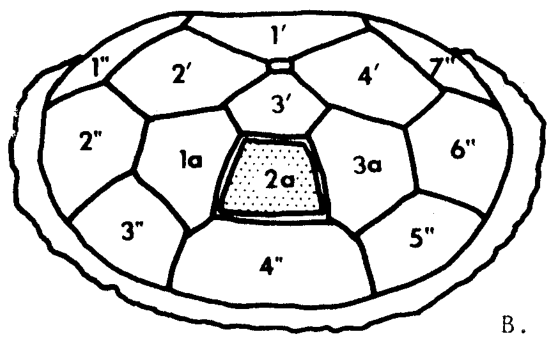
Quadra 2a

When anterior intercalary paraplate 2a is quadra it has four sides (for the alphanumeric designation of the sides of 2a which are also the archeopyle sutures, see Text-Fig. 3A): the anterior or Q1(3'-2a) where it abuts against the third apical, two lateral, the left lateral Q2(1a-2a) where it abuts against the first anterior intercalary and the right lateral Q4(2a-3a) where it abuts against



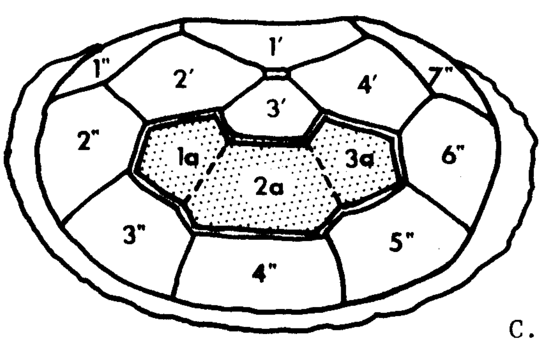
A.

Type I/I with six-sided 2a, herein referred to as an hexa 2a. Paraplates 1a and 3a and 3" and 5" are five-sided. Paraplate 4" is four-sided and not as wide as 2a. Variations in the shape of 2a resulting from differences in relative lengths of the six archeopyle sutures permit the recognition of four groups as shown in text-fig. 2. The archeopyle results from the loss of 2a only.



B.

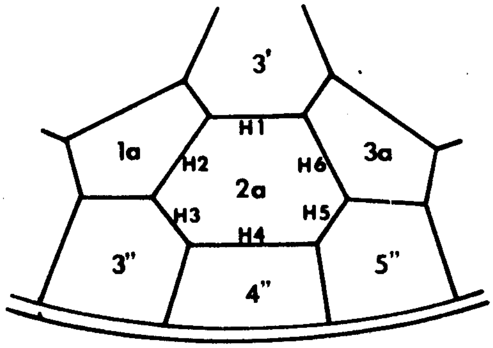
Type I/I with four-sided 2a, herein referred to as a quadra 2a. Paraplates 1a and 3a are six-sided, 2" and 5" are four-sided. Paraplate 4" is six-sided and wider than 2a. The archeopyle results from the loss of 2a only. Present only in the genera *Kisselevia, Rhombodinium, Wetzeliella* and *Wilsonidium*.



C.

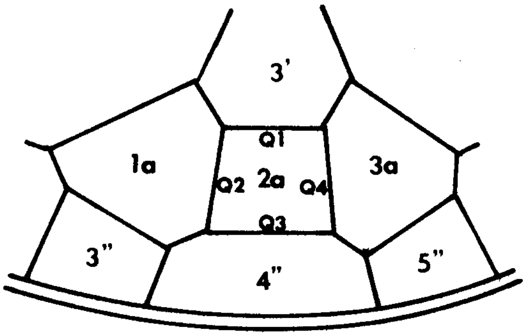
Type 3I/3I with hexa 2a. The archeopyle results from the loss of all three anterior intercalary paraplates, 1a-3a. The operculum may be simple or compound when it separates into the three paraplates. The 3I archeopyle is characteristic of the genus *Trithyrodinium*.

TEXT-FIG. 2 INTERCALARY ARCHEOPYLES.



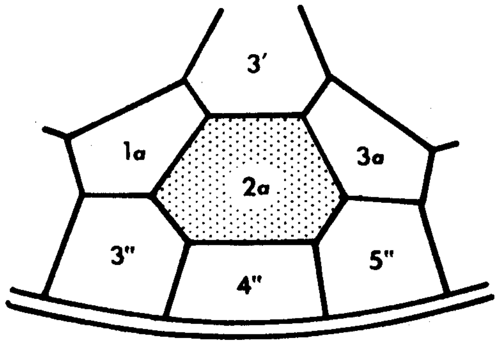
H1 = side 3'-2a = Anterior side or suture
H2 = side 1a-2a = Left anterior lateral side or suture
H3 = side 3"-2a = Left posterior lateral side or suture
H4 = side 4"-2a = Posterior side or suture
H5 = side 5"-2a = Right posterior lateral side or suture
H6 = side 3a-2a = Right anterior lateral side or suture

TEXT-FIG. 3A ALPHANUMERIC CONNOTATION FOR THE SIDES OF THE HEXA 2a PARAPLATE.

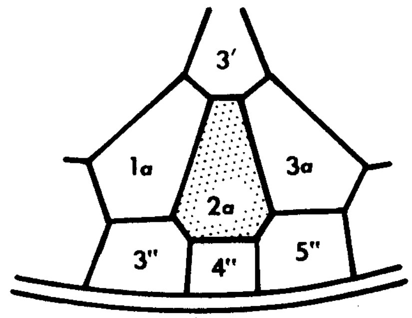


Q1 = side 3'-2a = Anterior side or suture
Q2 = side 1a-2a = Left lateral side or suture
Q3 = side 4"-2a = Posterior side or suture
Q4 = side 3a-2a = Right lateral side or suture

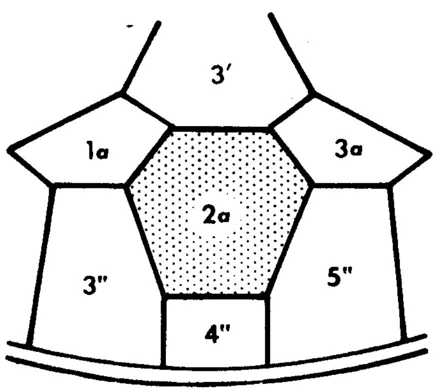
TEXT-FIG. 3B ALPHANUMERIC CONNOTATION FOR THE SIDES OF THE QUADRA 2a PARAPLATE.



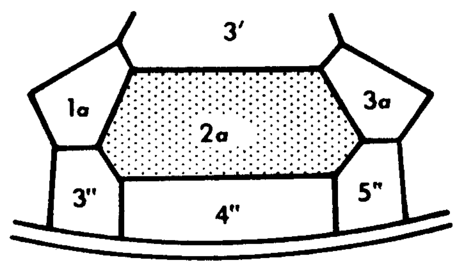
A. Standard hexa 2a



B. Attenuated hexa 2a



C. Omegaform hexa 2a



D. Broad hexa 2a

TEXT-FIG. 4 SHAPE VARIATION IN THE HEXA 2a ARCHEOPYLE.

the third anterior intercalary, and the posterior Q3(2a-4") where it abuts against the fourth precingular. When 2a is quadra, the fourth precingular (4") is considerably wider than 2a and shares parasutures with the first anterior intercalary (1a) and third anterior intercalary (3a) respectively. This influences the shape of 1a and 3a, and also 4", all of which are six-sided; 3" and 5" are five-sided. The quadra 2a is found in species of *Kisselevia, Rhombodinium, Wetzeliella* and *Wilsonidium.* It appears to be restricted to the Paleogene.

Hexa 2a

The hexa 2a archeopyle has six sides (for the alphanumeric designation of the sides of 2a which are also the archeopyle sutures, see Text-Fig. 3B). The archeopyle sutures are sometimes poorly delineated due to obscuring of the angularity. The six sides or sutures in the hexa 2a are: the anterior suture H1 (3'-2a) where it abuts against the third apical, the left anterior lateral suture H2 (1a-2a) where it abuts against the first anterior intercalary, the left posterior lateral suture H3 (2a-3') where it abuts against the third precingular, the posterior suture H4 (2a-4") where it abuts against the fourth precingular, the right posterior lateral suture H5 (2a-5") where it abuts against the fifth precingular, and the right anterior lateral suture H6 (2a-3a) where it abuts against the third anterior intercalary. Thus there are four lateral sides in the hexa 2a. This is reflected in the shape of the surrounding paraplates. The anterior intercalary paraplates 1a and 3a are five-sided. The third (3") and fifth (5") precingulars are four-sided. The fourth precingular (4") is four-sided. It is also not as wide laterally as the second anterior intercalary paraplate 2a. It is stressed here that the hexa 2a can sometimes only be differentiated from the quadra 2a on the shape and size of the fourth precingular paraplate. Thus even when the archeopyle appears circular its hexa 2a origin is evidenced from the four-sided, narrower fourth precingular, and the abutment of the archeopyle margin against the third and fourth precingulars respectively.

The hexa 2a shows variations in shape which permit further subdivision. In this monograph the four types of hexa 2a archeopyle are (a) *standard hexa,* (b) *attenuated hexa,* (c) *omegaform hexa* and (d) *broad hexa* (Text-Fig. 4). These four types of hexa 2a archeopyles appear to exhibit evolutionary trends and consequently are stratigraphically useful.

Standard Hexa Archeopyle

The standard hexa archeopyle (Text-Fig. 4A) is one in which six-sided paraplate 2a has relatively longer anterior lateral H2 and H6 sutures and correspondingly reduced posterior lateral H3 and H5 sutures. The height:width ratio is generally < 1. The standard hexa 2a archeopyle is found in species of *Alterbia, Amphidiadema, Hexagonifera, Lejeunia, Nelsoniella, Phthanoperidinium Selenopemphix, Spinidinium* and *Uvatodinium.* The term 'standard' is not meant to imply that this is the predominant type of the hexa 2a archeopyle categories. It is, however, the shape most associated with peridinioid cysts having a hexa 2a archeopyle as illustrated in the literature. The standard hexa 2a archeopyle ranges throughout the Late Cretaceous. It is relatively uncommon in the Paleogene. The Style A archeopyle recognized by Stover (1973) in species of *"Deflandrea"* is the standard hexa type.

Attenuated Hexa Archeopyle

The attenuated hexa archeopyle (Text-Fig. 4B) is one in which the six-sided 2a paraplate has considerably longer H2 and H6 sutures and very reduced H3 and H5 sutures. The anterior suture H1 and posterior suture H4 are also reduced. The greatest width of paraplate 2a is therefore below its median line. The height:width ratio is greater than 1.25. Such modification in shape of the 2a paraplate is reflected in the third apical (3') and fourth precingular (4") which are considerably narrower than their equivalents, in the epicyst of the standard hexa 2a type.

The attenuated hexa 2a archeopyle is present in *Palaeocystodinium*, *Svalbardella* and some species of *Alterbia* and *Spinidinium*. The ambital outline of such species reflects to some extent the presence of the attenuated 2a, being more elongate and narrower than species with the standard hexa 2a archeopyle.

Stratigraphically the attenuated hexa archeopyle first appears in the Albian and extends throughout the Late Cretaceous and Paleogene into the Miocene. The number of species with this archeopyle type is low. However, it is readily recognizable and characteristic of certain species, so is retained as a subdivision of the hexa 2a archeopyle.

Omegaform Hexa Archeopyle

The omegaform hexa archeopyle (Text-Fig. 4C) is one in which the six-sided 2a paraplate has reduced H2 and H6 sutures and considerably longer H3 and H5 sutures. The anterior suture H1 is lengthened and posterior suture H4 is reduced. The greatest width of paraplate 2a is therefore above its median line, the height:width ratio is approximately 1. This modification of the shape of paraplate 2a is reflected in the precingular paraplates 3" and 5" which are lengthened in the antero-posterior direction; 4", however, remains reduced. The broad anterior intercalary paraplates 1a and 3a modify the ambital outline of the epipericyst to produce the 'square shouldered' appearance.

The omegaform periarcheopyle normally remains attached posteriorly along suture H4. Specimens in which the operculum is free may be damaged.

Species described as having an omegaform hexa 2a archeopyle always have an omegaform hexa 2a periarcheopyle. The endoarcheopyle may, however, be 3I, resulting from the partial or complete detachment of all three anterior intercalary paraplates. The operculum is compound, there being separation into the individual paraplates. The endocyst paraplate 2a is standard to omegaform. The archeopyle formula for such species is I/3I (or 2a/1a-3a). This is common in *Chatangiella*. With the exception of forms from the Arctic Hassel Formation species with the I/3I archeopyle in which the periarcheopyle is omegaform are known only from the Santonian-Campanian.

Taxa with the omegaform archeopyle are included in *Chatangiella* or *Isabelia*. They are known from the Coniacian-Paleocene, attaining their peak in the Santonian-Campanian.

Broad Hexa Archeopyle

In the broad hexa archeopyle (Text-Fig. 4D) the six-sided paraplate 2a has considerably longer H1 and H4 sutures. The anterior lateral sutures H2 and H6 are relatively longer than the posterior lateral sutures H3 and H5 respectively. The height:width ratio is *ca.* 0.5. The 2a paraplate is therefore very broad compared to the two other anterior intercalaries 1a and 3a. This modification in size and shape of the 2a paraplate is reflected in the third apical (3') and fourth precingular (4") which are considerably wider than their equivalents in the epicyst of the standard hexa 2a type. In taxa with a broad hexa 2a periarcheopyle, the endoarcheopyle often appears to be apical due to the orientation. It is in fact also the broad hexa type.

The Style B archeopyle recognized by Stover (1973) in species of *Deflandrea* is the broad hexa type. The broad hexa archeopyle is characteristic for species of *Deflandrea*. It often appears quadra in outline, when it is termed pseudoquadra. It has a known stratigraphic range of Maastrichtian-Oligocene with the maximum number of species being in the Eocene.

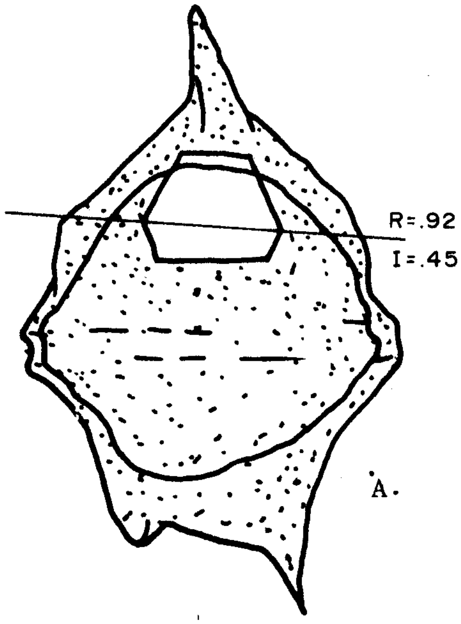
Transverse Archeopyle Index and Transverse Archeopyle Ratio

The transverse archeopyle index and transverse archeopyle ratio have been devised as a means of differentiating the four types of hexa 2a archeopyles defined in this study. The transverse archeopyle index results from dividing the width of the hexa 2a archeopyle at its widest point in ambital view, by the width of the epicyst in the same plane (Text-Fig. 5). It can be determined for both the periarcheopyle and the endoarcheopyle, although it is more common to give a value for the periarcheopyle only. The transverse archeopyle ratio results from dividing the width of the hexa 2a archeopyle at the widest point in ambital view, by the width of the epicyst less the archeopyle width in the same plane (Text-Fig. 5). This is also usually determined for the periarcheopyle alone.

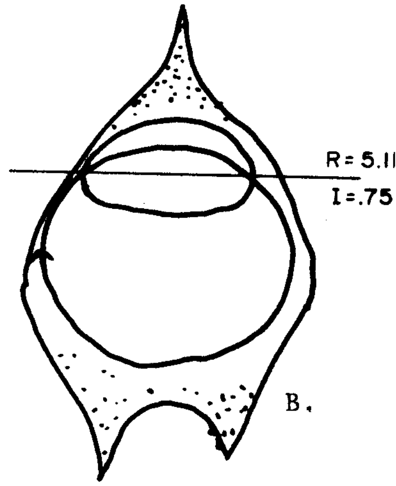
Text-Figure 5 gives the respective values for the transverse archeopyle index (TAI) and transverse archeopyle ratio (TAR) in four taxa representing the four types of hexa 2a archeopyles. The relatively slight variation in the TAI and TAR values between the standard hexa 2a and attenuated hexa 2a is due to reduction in the epipericyst width being proportional to the reduction in the archeopyle width. The separation of the broad and omegaform hexa archeopyle types from the standard hexa and attenuated hexa archeopyle types can be readily effected. Separation of the broad from the omegaform hexa archeopyle type is also relatively simple using the difference in the TAI and TAR. The TAI and TAR for eight genera are given in Table 6 and plotted in relationship to one another in Table 7. Application of these principles to the quadra 2a or types of archeopyles involving more than one anterior intercalary paraplate, or paraplates of another series, may yield meaningful data. This line of research has yet to be investigated, however.

Other Hexa Archeopyles

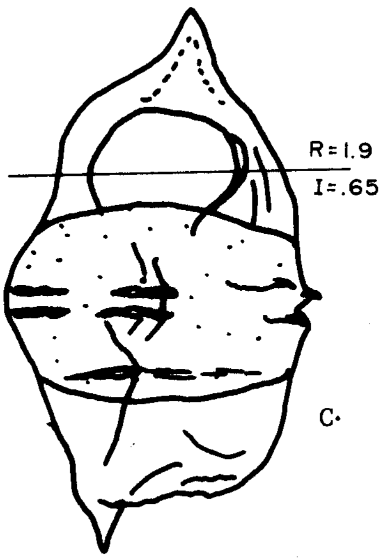
The hexa intercalary archeopyle as found in *Broomea* and *Moesiodinium* results from the partial or complete detachment of a single anterior intercalary



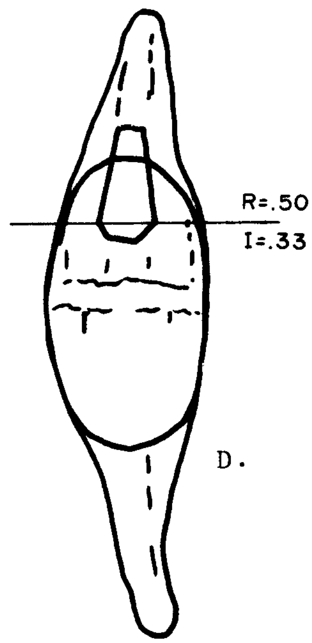
Alterbia distincta



Deflandrea phosphoritica subsp. *australis*



Chatangiella ditissima



Svalbardella cooksoniae

A. standard hexa, B. broad hexa, C. omegaform hexa, D. attenuated hexa

TEXT-FIG. 5 ARCHEOPYLE INDEX AND RATIO IN FOUR SPECIES, REPRESENTING THE FOUR TYPES OF HEXA 2a ARCHEOPYLES.

GENUS	AVERAGE	RANGE
Alterbia	I. = .33 R. = .57	I. = .16 - .46 R. = .20 - .88
Amphidiadema	I. = .62 R. = 1.75	I. = .54 - .69 R. = 1.20 - 2.25
Chatangiella	I. = .49 R. = 1.02	I. = .33 - .64 R. = .44 - 1.81
Deflandrea	I. = .68 R. = 2.58	I. = .51 - .86 R. = 1.02 - 6.25
Isabelia	I. = .43 R. = .78	I. = .33 - .55 R. = .50 - 1.25
Lejeunia	I. = .41 R. = .73	I. = .36 - .47 R. = .58 - .88
Palaeocystodinium	I. = .39 R. = .64	I. = .33 - .44 R. = .50 - .80
Spinidinium	I. = .35 R. = .57	I. = .26 - .42 R. = .35 - .75
Svalbardella	I. = .33 R. = .50	Only one species
Vozzhennikovia	I. = .43 R. = .78	I. = .33 - .50 R. = .50 - 1.0

TABLE 6 TRANSVERSE ARCHEOPYLE INDEX AND TRANSVERSE ARCHEOPYLE RATIO AVERAGES AND AVERAGES AND RANGES FOR GENERA WITH 2a ARCHEOPYLES.

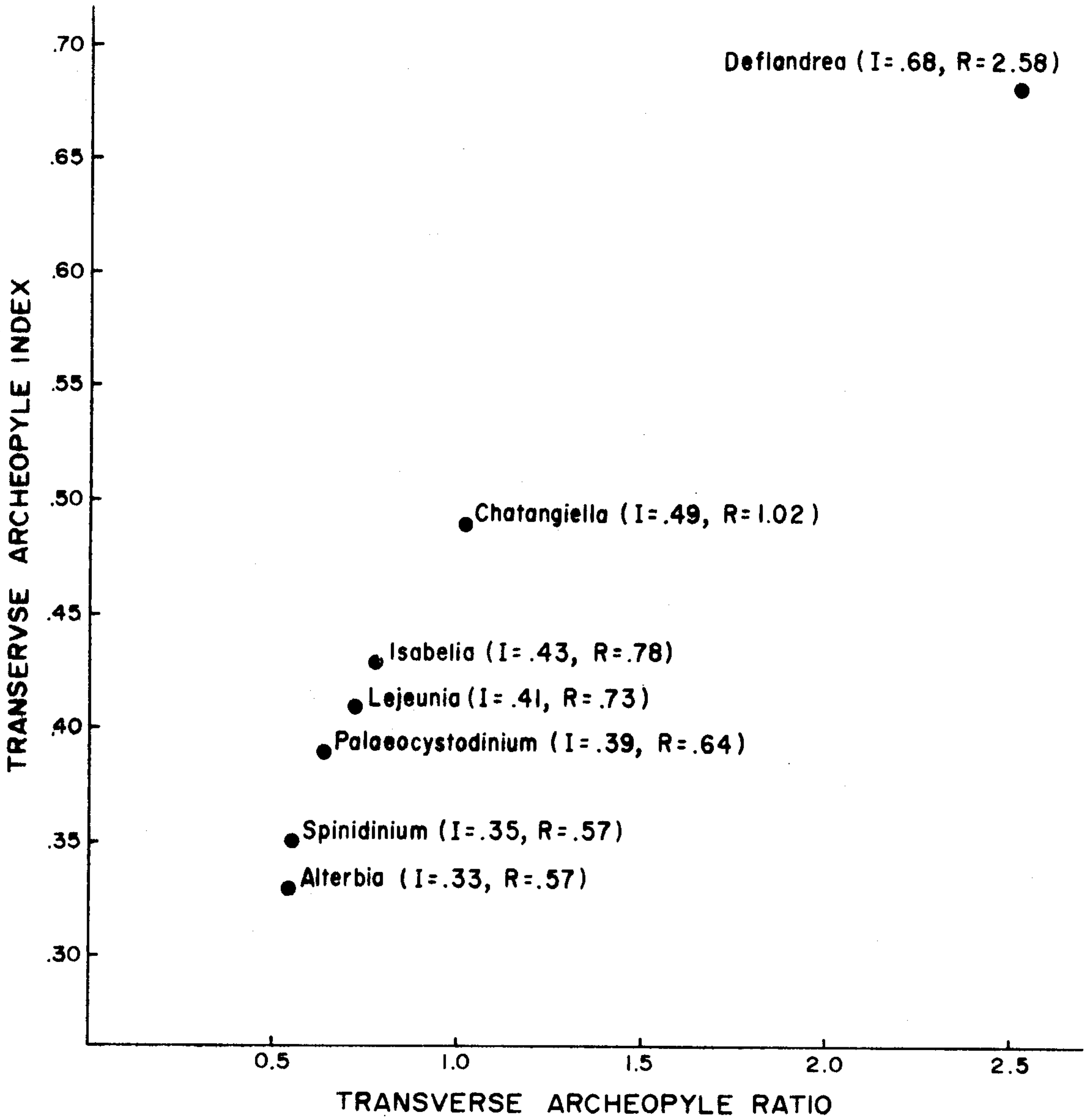


TABLE 7 TRANSVERSE ARCHEOPYLE INDEX (X AXIS) AND TRANSVERSE ARCHEOPYLE RATIO (Y AXIS) PLOTS FOR FOSSIL PERIDINIOID GENERA WITH THE HEXA 2a INTERCALARY ARCHEOPYLE.

paraplate. The orientation for the 2a paraplate differs from that in members of the 'peridinioid group.' The two parallel sutures are H2(a-a) and H5(a-a) as opposed to H1 and H4 in the peridinioid group. The resulting symmetrical apical and precingular angulations indicate that the intercalary paraplate lost in archeopyle formation anteriorly and posteriorly lay between two apicals and two precingulars respectively, rather than in the same vertical plane as in the peridinioid group. This is assumed to indicate the existence of two or more than three intercalaries in *Broomea* and *Moesiodinium* and is regarded as a primitive feature. This type of I archeopyle has not been assigned a name.

Intercalary Archeopyles of the 3I/3I Type

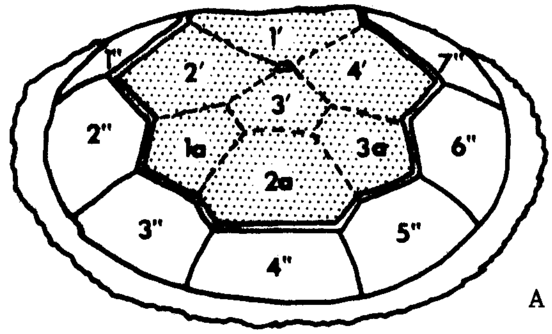
The intercalary archeopyle resulting from the partial or complete loss of all three anterior intercalary paraplates in both the pericyst and the endocyst is designated as a 3I/3I type (Text-Fig. 2C). Whether both pericyst and endocyst have a 3I archeopyle is often difficult to observe. It is present in the type of the genus *Trithyrodinium, T. evittii* according to Drugg (pers. comm.). Davey (1970, p. 10) believes that the endoarcheopyle is 3I and the periarcheopyle, which admittedly he had not observed, is I(2a). Evitt (pers. comm.) also believes that the periarcheopyle in *Trithyrodinium* is not always 3I. Species of *Chatangiella* and *Isabelia,* as discussed previously, may have an I/3I archeopyle. Resolution of this problem, however, is rarely possible with the light microscope. The 3I/3I archeopyles occur in species of Senonian-Paleocene age. Its relationship to the I/3I archeopyle is presently uncertain.

Combination Archeopyles

a. Involving Apicals and Intercalary Paraplates Only

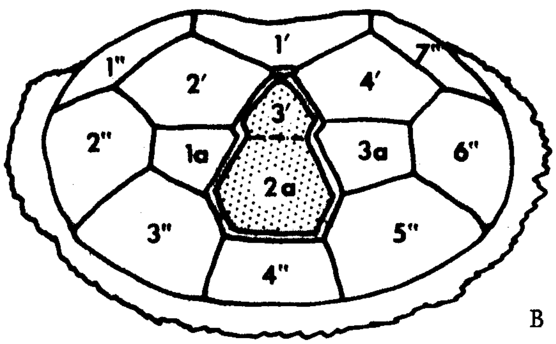
Combination archeopyles involving apical and intercalary paraplates occur in only two genera included in the peridinioid group. These are *Ascodinium* and *Ovoidinium.* The type species of *Ascodinium, A. acrophorum* has a distinctive circular archeopyle located on the dorsal surface of the epipericyst immediately below the apex (Cookson and Eisenack, 1960a, pl. 1, Fig. 19, 20). Evitt (1967, p. 50) suggested that it represents an AI (or 4A3I) archeopyle with rounded angles, thus explaining the dorsal extension towards the pericingulum. The archeopyle in *Ascodinium* alternatively could result from the loss of a single apical paraplate 3' plus one (2a) or all the anterior intercalaries, 1a-3a (Text-Fig. 6B). This might be a more reasonable interpretation than one assuming all four apicals plus the three anterior intercalaries were involved. If the operculum is composed of paraplates 3' and 2a it would remain partially attached, along parasutures 2'-3' and 3'-4'. *Ascodinium* is known only from the Albian-Cenomanian.

Ovoidinium was erected by Davey (1970) who interpreted the archeopyle as apical. The type species *O. verrucosum* and the species *O. scabrosum* had originally been included in *Ascodinium.* Evitt (1967, p. 45) superbly demonstrated that a taxon he designated as *Ascodinium cf. verrucosum* had a combination 4A3I archeopyle, thus explaining the irregularities in the archeopyle margin. *O. verrucosum* also has a 4A3I archeopyle (Text-Fig. 6A). In the species included in *Ovoidinium* the perioperculum and endoperculum are removed as one piece, so that effectively there is a single operculum. *Ovoidinium* is known only from the



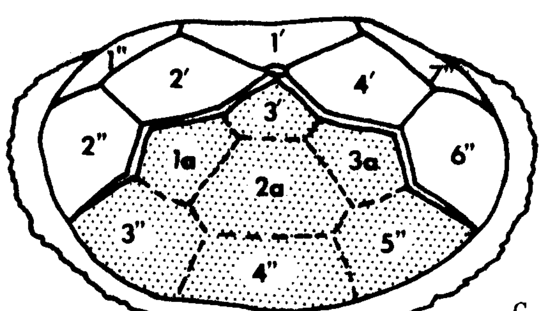
A

Type $\overline{4A3I}/\overline{4A3I}$ with hexa 2a. The archeopyle results from the loss of all four apical and all three anterior intercalary paraplates. The operculum is simple and may be free or remain attached along archeopyle suture 1'-as. The $\overline{4A3I}$ archeopyle is characteristic of the genus *Ovoidinium*.



B

Type $\overline{?A_3,I_{2a}}$ with questionably hexa 2a. The archeopyle, which has a subcircular outline may result from the loss of the third apical paraplate 3' plus the second anterior intercalary paraplate 2a. The operculum is simple and usually remains attached apically. The $\overline{?A_3,I_{2a}}$ archeopyle is characteristic of the genus *Ascodinium*.



C

Type $\overline{A_3,3I3P_{3''-5''}}$ with hexa 2a. The archeopyle results from the loss of the third apical (3'), all three anterior intercalary (1a-3a), and three precingular (3"-5") paraplates. The archeopyle suture or transapical suture is the sum of the sutures between paraplate 2"-3", 2"-1a, 2'-1a, 2'-3', 3'-4', 3a-4', 3a-6", and 5"-6". The operculum is simple and may be free or remain attached along the posterior margin. The $\overline{A_3,3I3P}$ archeopyle is characteristic of the genera *Palaeoperidinium* and *Saeptodinium*.

TEXT-FIG. 6 COMBINATION ARCHEOPYLES RESULTING FROM THE LOSS OF APICAL AND ANTERIOR INTERCALARY PARAPLATES, OR THE APICAL, ANTERIOR INTERCALARY AND PRECINGULAR PARAPLATES.

Albian-Cenomanian, the $\overline{4A3I}$ archeopyle therefore having a restricted stratigraphic range.

b. Involving Apicals, Intercalary and Precingular Paraplates

Genera herein assigned to the *Palaeoperidinium* complex are characterized by having an excystment opening resulting from separation along a transapical suture. This transapical suture is sequentially composed of the sutures 2"-3", 2"-1a, 2'-1a, 2'-3', 3'-4', 3a-4', 3a-6", and 5"-6" plus possibly those between the precingulars and cingulars. The archeopyle formula is $\overline{AIP}$ (or $\overline{A_{3'}3I3P_{3''-5''}}$) as demonstrated by Evitt (1974, 1975). The operculum may remain attached along the posterior margin, that is along the parasutures between the precingulars and the pericingulum. If, as usually happens, the operculum falls back into place after excystment, recognition of this archeopyle type depends solely on discerning the course of the transapical suture. Probably the most useful characteristic to use in determining the presence of the transapical suture are the small shoulders created immediately below the apex by the second and fourth apical paraplates. On separation along the transapical suture these two paraplates, instead of extending onto the dorsal surface at the point where they intersect 3' and 1a and 3a and 3' respectively, are free to unfold and stand out.

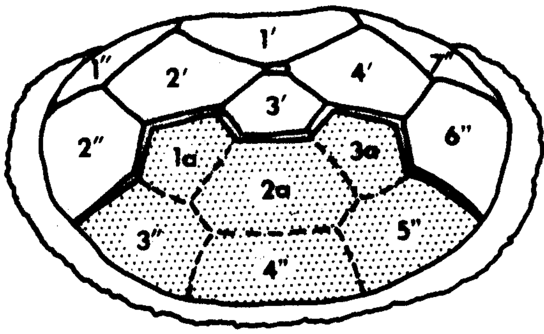
The *Palaeoperidinium* complex includes *Palaeoperidinium, Saeptodinium* and some species of *Subtilisphaera*. All have the $\overline{A_{3'}3I3P_{3''-5''}}$ archeopyle which is present in both the pericyst and endocyst (Text-Fig. 6C). This archeopyle type has a known stratigraphic range of Early Cretaceous to Recent.

c. Involving Intercalary and Precingular Paraplates Only

In peridinioid cysts possessing a combination archeopyle resulting from the loss of both anterior intercalary and precingular paraplates, all three anterior intercalaries and the three precingulars 3", 4" and 5" are always partially or completely detached either as a single operculum or two or more opercular pieces. The archeopyle formulas are $\overline{3I3P_{3''-5''}}$, $3I3P_{3''-5''}$ $\overline{3I3Pa_{3''-5''}}$, and $3I3Pa_{3''-5''}$. The complexity and variability of this archeopyle type has only recently been appreciated. The archeopyle suture is sequentially composed of the sutures 2"-3", 2"-1a, 2'-1a, 3'-1a, 3'-2a, 3'-3a, 3a-4', 3a-6", 5"-6" plus possibly those between the precingulars and cingulars, although rarely are all of them separated along their entire length. In this type of archeopyle the 3' is not lost as in the *Palaeoperidinium* complex, thus considerably influencing the anterior outline of the archeopyle, which is not pointed but indented. McIntyre (1975) has erected the genus *Laciniadinium* for species with a $\overline{3I3Pa_{3''-5''}}$ archeopyle in which the single operculum remains attached only along the posterior margin (Fig. 6A). This type of archeopyle is restricted to the Campanian.

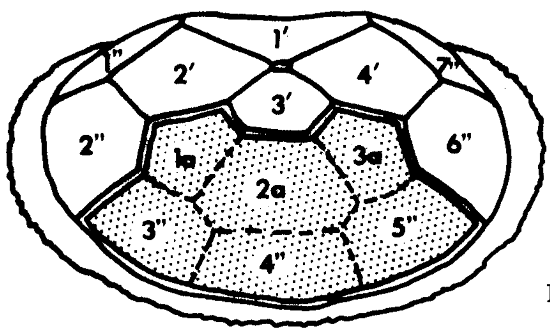
The $\overline{3I3P_{3''-5''}}$ archeopyle (Text-Fig. 7A) differs from that of *Laciniadinium* in that the operculum is completely detached or free. The nature of the archeopyle is easily determined from the tongue-like projection of 3', which is all that remains of the dorsal epicyst. As Evitt (1975, p. 79) has demonstrated, the species described as *Scriniodinium eurypylum* Manum and Cookson, 1964, by both Brideaux (1971), and Singh (1971), possesses this archeopyle type (Text-Fig. 7B). The known stratigraphic range of this archeopyle is Middle Albian-Cenomanian.

In the $3I{+}3Pa_{3''-5''}$ archeopyle (Text-Fig. 7C) accessory archeopyle sutures separate all the paraplates, so that the three anterior intercalary and three precingular paraplates are discrete units. The three precingulars 3", 4", and



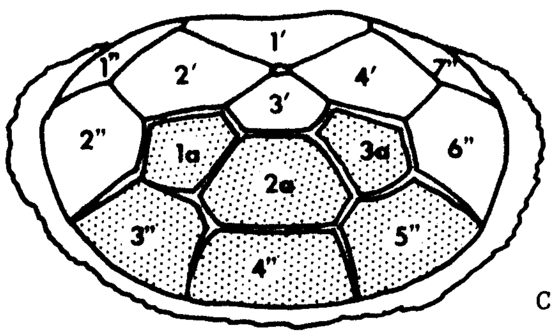
A

Type $\overline{\text{3I3Pa}}$ with hexa 2a. The archeopyle results form the loss of all three anterior intercalary (1a-3a) and three precingular (3"-5") paraplates. The operculum is simple and remains attached posteriorly. The $\overline{\text{3I3Pa}}$ archeopyle is characteristic of *Laciniadinium*.



B

Type $\overline{\text{3I3P}}$ with hexa 2a. The archeopyle results from the loss of all three anterior intercalary (1a-3a) and three precingular (3"-5") paraplates. The operculum is simple and free. The 3I3P archeopyle is characteristic of a new genus by Brideaux and McIntyre (in press).



C

Type 3I+3Pa/3I+3Pa. The archeopyle results from the loss of all three anterior intercalary (1a-3a) and three precingular (3"-5") paraplates. The operculum is compound with the three precingulars remaining attached posteriorly. The 3I+3Pa/3I+3Pa archeopyle is characteristic of *Ginginodinium*.

TEXT-FIG. 7 COMBINATION ARCHEOPYLES RESULTING FROM THE LOSS OF THE ANTERIOR INTERCALARY AND PRECINGULAR PARAPLATES.

5", however, remain attached along their posterior parasutures, or where they abut against the cingulars. Variability in this archeopyle is considerable. Sometimes the archeopyle appears to be simply of the 3I type when the sutures separating the precingulars, 2"-3", 3"-4", 4"-5", and 5"-6" are only partially developed. Occasionally 1a and 3a will remain attached to 3" and 5" forming two flaps, one on each side of the missing 2a and attached 4". Alternatively, the second anterior intercalary remains attached to the fourth precingular. In yet another variation, 1a and 3a remain attached to the rest of the epicyst, 1a is removed and the precingulars 3", 4", and 5" remain attached only along the posterior margin. More than one of the above variations have been observed in one taxon on the same slide so that it is felt undesirable at this stage to erect a new genus for each variable. Taxa with a $3I3Pa_{3''-5''}$ archeopyle are placed in the genus *Ginginodinium*. With the exception of the Maastrichtian aged *Ginginodinium ornatum* Felix and Burbridge, 1973, species with this archeopyle appear to be restricted to the Albian-Cenomanian.

Hypocystal Archeopyle

Inversidinium McLean, 1973, is interpreted as having an antapical opening in both the pericyst and endocyst. No other genus included in the peridinioid group has an antapical archeopyle although *Ovoidinium verrucosum* (Cookson and Hughes) Davey, 1970, can have an opening in the sulcal region of the pericyst. The significance of this opening is not known.

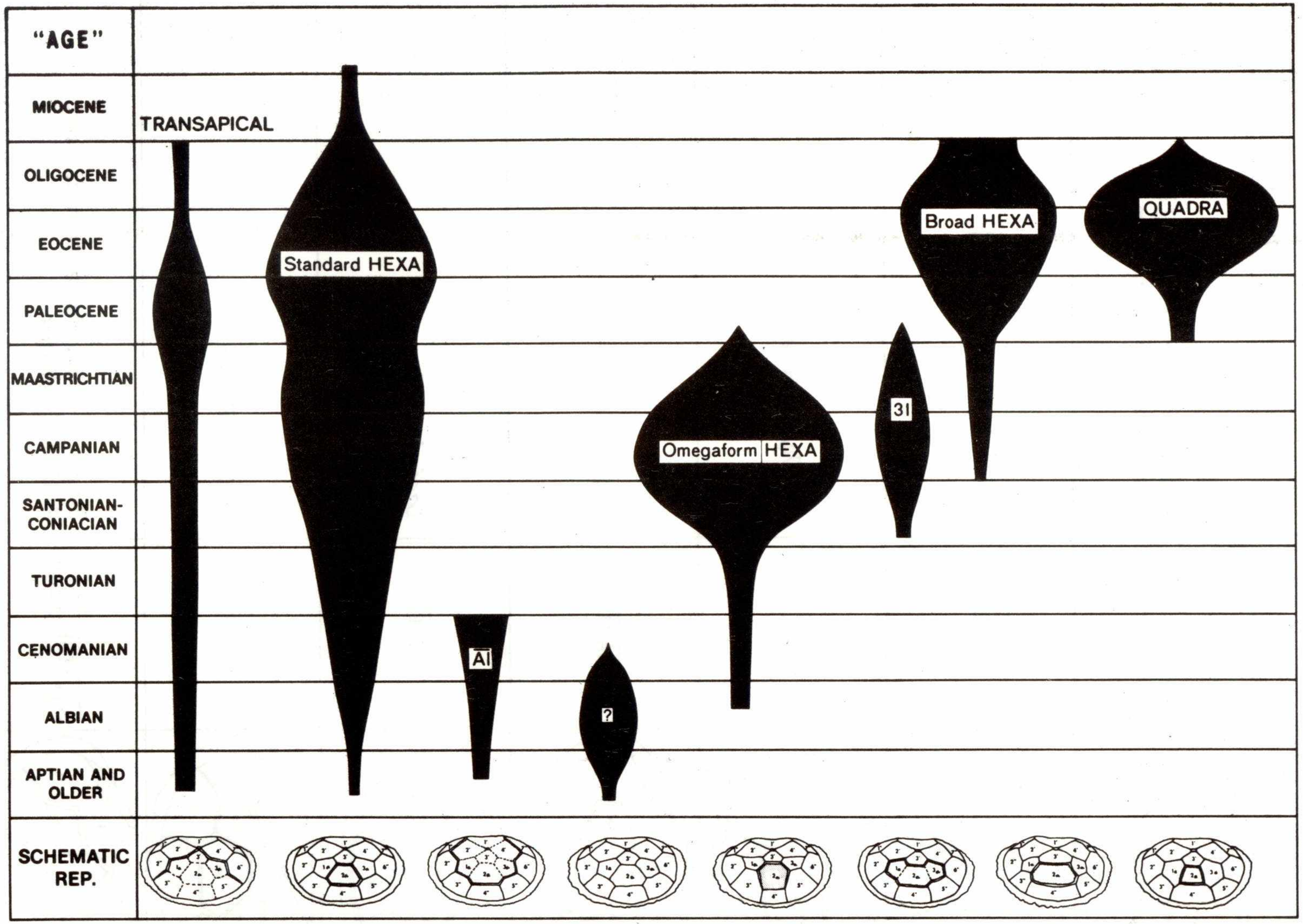
Stratigraphic Significance

The known stratigraphic ranges of the various archeopyle types recognized in the peridinioid dinocysts has been plotted (Text-Fig. 8). The width of the column represents the number of species. It can be seen that there is some stratigraphic sequence to the types. The *Broomea, Moesiodinium* hexa intercalary archeopyle is known only from the Jurassic. The $\overline{A_3 , 3I3Pa_{3''-5''}}$ archeopyles appear in the Neocomian and are long ranging. In the Albian the $\overline{4A3I}$, $\overline{A_3 , I}$? and $3I+3Pa_{3''-5''}$ in all its variations evolved, to almost immediately die out in the Cenomanian. The $\overline{3I3Pa_{3''-5''}}$ archeopyle which may represent homeomorphy to the morphologically similar 3I+3Pa is known only from the Campanian.

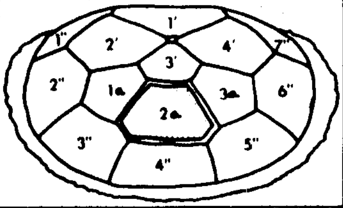
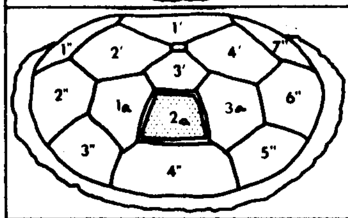
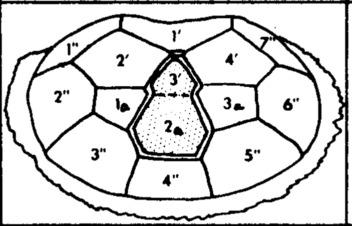
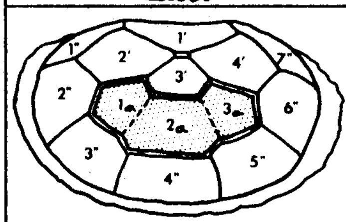
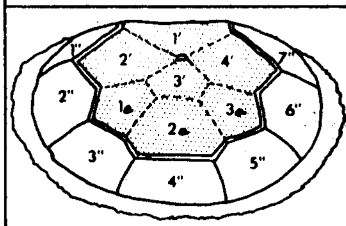
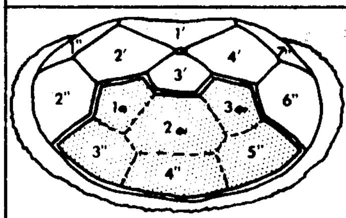
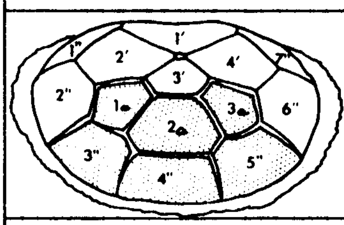
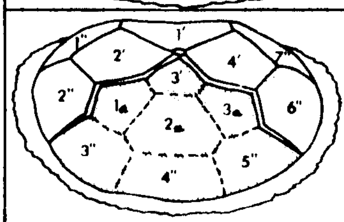
In the Late Cretaceous the standard hexa I and omegaform hexa I attain their peak in number of species and number of individuals. The Paleogene, peridinioid dinocysts are predominantly forms with a broad hexa or quadra I archeopyle. Surviving into the Neogene are the attenuated hexa, the standard hexa as in *Sumatradinium* and the $\overline{A_3 , 3I3P_{3''-5''}}$, the latter two surviving into the Quaternary.

Conclusions

The basic archeopyle types found in the fossil peridinioid dinoflagellates together with included genera are shown in Text-Figure 9. This demonstrates the dominance of the hexa 2a intercalary type, which is present in 18 genera. The other archeopyle types may be of more common occurrence than is presently realized, since their complexity is easily overlooked.



TEXT-FIG. 8. STRATIGRAPHIC RANGES OF THE MAJOR ARCHEOPYLE TYPES IN FOSSIL PERIDINIOID DINOFLAGELLATES.

	I Hexa	*Deflandrea, Chatangiella, Alterbia, Isabelia, Bulbodinium, Amphidiadema, Nelsoniella, Palaeocystodinium, Svalbardella, Spinidinium, Lejeunia, Phthanoperidinium, Hexagonifera, Vozzhennikovia, Maduradinium, Selenopemphix*
	I Quadra	*Rhombodinium, Wetzeliella, Kisselevia, Wilsonidium*
	$\overline{A_3{'}I_{2a}}$?	*Ascodinium*
	3I	*Trithyrodinium*
	$\overline{4A3I}$	*Ovoidinium*
	$\overline{3I3Pa}$	*Laciniadinium*
	3I+3Pa	*Ginginodinium*
	$\overline{A_3{'}3I3P_{3''-5''}}$	*Saeptodinium, Palaeoperidinium, ?Subtilisphaera*

TEXT-FIG. 9 ARCHEOPYLE TYPES IN THE FOSSIL PERIDINIOID GENERA.

VALID GENERA

DEFLANDREA Eisenack, 1938, emend.
[Fig. 1-54]

TYPE SPECIES: *Deflandrea phosphoritica* Eisenack, 1938, p. 187, Text-Fig. 6. Late Eocene-Early Oligocene.

DIAGNOSIS: Eisenack, 1938, p. 187 (translation): "*Deflandrea phosphoritica* n.g. is recognizable through its circular apical view, oval inner body in cross section, furnished with a transverse band within its characteristically three-pointed, compressed outer shell."

Eisenack, 1954, p. 52 (translation): "Shell elongate pentagonal, with apical horn and two antapical horns, without tabulation, smooth (without spines), with a broad but very shallow horizontal transverse furrow, which is developed only on the front (dorsal) surface; a longitudinal furrow is absent. Flagellar pore on the back (ventral) surface between the antapical horns. With a spherical inner body."

Williams and Downie, 1966c, p. 231: "Cavate cysts with periphragm forming elongate pentagonal (also often somewhat rounded to rhomboidal) outer shell. Lateral walls usually convex. One apical and two antapical horns, more or less reduced. Tabulation, when decipherable, peridinioid. Periphragm smooth or granular. Cingulum circular longitudinal furrow, if observable, restricted to hypotract. Inner capsule circular to ovoidal in outline. Endophragm of variable thickness. Archeopyle intercalary."

EMENDED DIAGNOSIS:

Shape

Pericyst: Ambitus ovoidal to pentagonal, elongated in an antero-posterior direction. Pericyst prolonged into one apical and two, more or less equal, symmetrically placed antapical horns, the right antapical horn sometimes being slightly reduced. This is the typical peridinioid outline. Compression dorso-ventral.

Endocyst: Ambitus circular to ovoidal, may be occasionally elongate or peridinioid. May be in contact with pericyst in precingular, cingular and postcingular regions.

Pericoels: An apical and an antapical pericoel invariably present. They may be united by an ambital pericoel.

Periphragm: Usually of a constant thickness. Surface laevigate, scabrate, granulate, minutely echinate or minutely rugulate.

Phragma

Endophragm: Less than 1 µ to several microns and commonly of variable thickness. Surface rarely laevigate, frequently scabrate, granulate, verrucate or tuberculate; the ornamentation can be localized or uniformly distributed.

Paratabulation

Pericyst: The penetabular spines of *D. spinulosa* and the parasutures visible in *D. phosphoritica*, particularly under the SEM, denote a peridinioid paratabulation of 4', 3a, 7", 5"', 2"". 1' is a broad rhomboidal paraplate reaching almost to the pericingulum; 2' and 4' are elongate antero-posteriorly and narrow; 3' is considerably shorter. Of the anterior intercalaries, 1a and 3a are of similar size and shape; 2a is considerably larger and is pseudoquadra to hexa. It is usually broader than paraplate 4". Of the precingulars 2" and 6" are elongate five-sided; 3" and 5" are shorter, narrow and five-sided; 4" is quadrate. Of the postcingulars, 3"' is broad pentagonal; 1"', 2"', 4"', and 5"' are approximately equal in size and essentially four-sided. The antapicals 1"" and 2"" are of equal size and possess the same shape. Pandasutural striae are visible on several specimens of *D. phosphoritica* under the SEM.

Pericingulum: Always present, commonly indented, planar or very slightly helicoidal and composed of an unknown number of paraplates. Parasutures commonly as raised ridges or borders with smooth or denticulate margins.

Perisulcus: When visible of restricted width on the posterior epipericyst, gradually widening on the hypopericyst and extending almost to the antapex. Sulcal paraplates and flagellar scar may be visible.

Endocyst: Paratabulation not observed.

Archeopyle

Periarcheopyle: Broad hexa to pseudoquadra intercalary, resulting from the loss of the second anterior intercalary paraplate, 2a. When the outline of 2a appears quadra detailed examination often reveals greatly reduced H3 and H5 parasutures. Perioperculum free. Transverse periarcheopyle index is 0.51-0.86. Transverse periarcheopyle ratio is 1.02-6.25.

Endoarcheopyle: Broad hexa to pseudoquadra intercalary, resulting from the loss of the second anterior intercalary paraplate, 2a. Endoperculum usually free.

Archeopyle Formula: I/I (2a/2a)

Dimensions

Pericyst: Length 46-210 μ, breadth 34-158 μ.
Endocyst: Length 20-92 μ, Breadth 31-96 μ.

DISCUSSION:

The *Deflandrea* pericyst is characterized by a peridinioid outline, the absence of pericingular horns, the presence of two antapical horns, more or less equal in length, a broad pseudoquadra to broad hexa intercalary archeopyle resulting from the loss of the second anterior intercalary paraplate 2a and a distinct endocyst. The transverse archeopyle index is *ca.* 0.75.

The genus as herein defined is restricted to forms which have a broad hexa archeopyle as in *Deflandrea phosphoritica* Eisenack, 1938, emend., the type of the genus. All other taxa previously included in *Deflandrea,* and possessing an archeopyle which cannot be classed as the broad hexa type, are included in the species list together with their new generic assignment. The species formerly included in *Deflandrea* and with a pericingulum, an attenuated or standard hexa 2a intercalary archeopyle, a transverse archeopyle index of 0.3-0.5 and almost invariably a reduced right antapical horn are herein transferred to the genus *Alterbia nom. nov.* Species formerly included in *Deflandrea* and having a partite pericingulum and omegaform hexa 2a intercalary archeopyle with the operculum remaining attached posteriorly, a transverse archeopyle index of 0.3-0.6 and a reduced right antapical horn are herein transferred to the genus *Chatangiella* Vozzhennikova, 1967. Penetabular ornamentation is commonly present in *Chatangiella.* Species formerly included in *Deflandrea* and having an omegaform hexa 2a intercalary archeopyle, a transverse archeopyle index of 0.3-0.5, and a reduced right antapical horn, and lacking a pericingulum are placed in *Isabelia gen. nov.* Species previously assigned to *Deflandrea* in which an archeopyle has not been observed or in which excystment is effected by separation along a transapical suture giving an $\overline{A_{3'}3I3P_{3''-5''}}$ operculum, are transferred to the genus *Subtilisphaera* Jain and Millepied, 1973.

The morphological separation of species formerly assigned to *Deflandrea* that is proposed in this monograph also appears to have stratigraphic significance. *Subtilisphaera* is dominant in the Early Cretaceous. *Alterbia, Chatangiella* and *Isabelia* are common in the Late Cretaceous with very few species occurring in the Paleogene. *Deflandrea* Eisenack, 1838, emend. appears in the Maastrichtian, is common in the Paleogene and dies out in the Miocene. Whether all the genera originate from a common stock is not known.

Ceratiopsis Vozzhennikova, 1963, according to the original diagnosis has a precingular archeopyle. Vozzhennikova, 1967, p. 158, includes three species in *Ceratiopsis, C. diebeli* (Alberti, 1959b), the type species *C. leptoderma* Vozzhennikova, 1963, and *C. markovi* Vozzhennikova, 1967. All three species have a broad hexa intercalary archeopyle resulting from the loss of paraplate 2a. The relatively long apical and two antapical horns of the pericyst and the elongate endocyst in *C. diebeli* are characteristic of the genus. However, the illustrations for *C. leptoderma* (Vozzhennikova, 1967, pl. 118, fig. 6) and *C. markovi* (Vozzhennikova, 1967, pl. 120, fig. 1-4) are morphologically similar to several species of *Deflandrea,* including *D. speciosa* Alberti, 1959b. It is herein considered that since such transitional forms are common, that *Ceratiopsis* be regarded as a *jr syn.* of *Deflandrea.* The three species of *Ceratiopsis* are accordingly transferred to *Deflandrea.*

Cerodinium Vozzhennikova, 1963, includes two species, *C. balticum* and the type of the genus *C. sibiricum.* Vozzhennikova, 1967, p. 153, stated that *Cerodinium* is distinguished from other genera by the shape of the pericyst and endocyst and the presence of a bent apical horn. The accompanying illustrations of *C. sibiricum* (pl. 117, fig. 1a-b) show a typical *Deflandrea* with a well developed apical horn, broad hexa intercalary archeopyle resulting from the loss of anterior paraplate 2a, a large endocyst and two widely divergent antapical horns. There is close similarity to *Deflandrea oebisfeldensis* Alberti, 1959b, which is one of several species of *Deflandrea* with widely divergent antapical horns. The so-called 'bent' apical horn is not uncommon in species of *Deflandrea* where the horn has a certain degree of flexibility. This often results in bending or even breaking of the apical horn during preparation of palynology slides. *Cerodinium* is accordingly here considered a *jr syn.* of *Deflandrea* and the species contained therein are transferred to *Deflandrea.*

STRATIGRAPHIC RANGE: Maastrichtian-Miocene

SPECIES OF *Deflandrea*

"acribes" (Davey and Verdier, 1971). Now *Alterbia.*

"acuminata" (Cookson and Eisenack, 1958). Now *Alterbia.*

"acutula" (Wilson, 1967b). Now *Alterbia.*

albertii Corradini, 1973, p. 174-175, pl.27, fig. 7a-b, 8; pl. 28, fig. 2. Late Cretaceous-Paleocene [Fig. 36].

"amphiata" (McIntyre, 1975). Now *?Isabelia.*

andromiensis Vozzhennikova, 1967, p. 142-143, pl. 71, fig. 3-4; pl. 72, fig. 1-2. Eocene [Fig. 12].

antarctica Wilson, 1967a, p. 58, 60, fig. 23-24, 26-27. Erratics, probably Eocene [Fig. 2].

arcuata Vozzhennikova, 1967, p. 143-144, pl. 66, fig. 1; pl. 68, fig. 3a-b. Late Eocene-Early Oligocene [Fig. 1].

"armata" (Cookson and Eisenack, 1970a). Now *Chatangiella.*

"asymmetrica" (Wilson, 1967a). Now *Alterbia.*

"asymmetrica" (Davey and Verdier, 1971). Now *Subtilisphaera asymmetrica.*

"bakeri" (Deflandre and Cookson, 1955). Now *Isabelia.*

"balcattensis" (Cookson and Eisenack, 1969). Now *Subtilisphaera.*

"balmei" (Cookson and Eisenack, 1962b). Now *Alterbia.*

baltica (Vozzhennikova, 1967) *comb. nov.*
1967 *Cerodinium balticum* Vozzhennikova, p. 154, pl. 11, fig. 2a-b. Eocene [Fig. 13].

"belfastensis" (Cookson and Eisenack, 1961a). Now *Isabelia.*

"biapertura" (McIntyre, 1975). Now *?Chatangiella.*

boloniensis Riegel, 1974, p. 354-356, pl. 1, fig. 6-10; text-fig. 3. ?Senonian [Fig. 50].

"campbellensis" (Wilson, 1967b). Now *Chatangiella.*

"cincta" (Cookson and Eisenack, 1958). Now *Ovoidinium.*

"conica" Vozzhennikova, 1960, *nom. nud.* No description.

"conorata" (Stover, 1973). Now *Isabelia.*

"cooksoniae" (Alberti, 1959b). Now *Isabelia.*

"coronata" (McIntyre, 1975). Now *Chatangiella.*

"cretacea" (Cookson, 1956). Now *Isabelia.*

cygniformis de Baldis, 1966, p. 222, pl. 2, fig. C. Early Tertiary [Fig. 54].

"dakotaensis" (Stanley, 1965). Now *Isabelia.*

danica Lange, 1969, p. 114-115, pl. 1, fig. 6. Danian [Fig. 43].

dartmooria Cookson and Eisenack, 1965b, p. 133-134, pl. 16, fig. 1-2, text-fig. 1. Paleocene [Fig. 6].
subsp. *medcalfii* (Stover, 1973) *comb. nov., stat. nov.*
1973 *Deflandrea medcalfii* Stover, p. 175-176, pl. 3, fig. 3a-c. Middle Paleocene. The differences between *D. dartmooria* and *D. medcalfii* as defined by Stover, 1973, are not considered to be of specific rank [Fig. 7].

"daveyi" (Lentin and Williams, 1973). This name, designated as a *nom. subst.* for *Deflandrea asymmetrica* Davey and Verdier, 1971, is a *jr syn.* of *D. deformans* Davey and Verdier, 1973. The species is now in the genus *Subtilisphaera* and reverts to the name *asymmetrica.*

"decorosa" (McIntyre, 1975). Now *Chatangiella.*

"deformans". Now *Subtilisphaera asymmetrica.*

"delicata" (Baltes ex Lentin and Williams, 1973). Now *Isabelia.*

delineata Cookson and Eisenack, 1965c, p. 140-141, pl. 18, fig. 3-5; text-fig. 1. Paleocene [Fig. 4].

denticulata Alberti, 1959b, p. 102-103, text-fig. 1. Paleocene-Early Eocene [Fig. 5].
subsp. *minor* (De Coninck, 1969, p. 16, pl. 1, fig. 16-17; pl. 2, fig. 1-2) Lentin and Williams, 1973, pl. 40. Early Eocene [Fig. 9].

depressa Morgenroth, 1966a, p. 8, pl. 1, fig. 2. Farly Eocene [Fig. 48].

diebeli Alberti, 1959b, p. 99, pl. 9, fig. 18-21. Late Senonian-Paleocene [Fig. 3].

"dilwynensis" (Cookson and Eisenack, 1965c). Now *Alterbia.*

dissoluta Vozzhennikova, 1967, p. 144, pl. 73, fig. 1-4. Eocene [Fig. 46].

"distincta" (Wilson, 1967a). Now *Alterbia.*

"ditissima" (McIntyre, 1975). Now *Chatangiella.*

"druggii" (Stover, 1973). Now *Isabelia.*

?dubia (Jain and Millepied, 1973) *comb. nov.*
1973 *Senegalinium dubium* Jain and Millepied, p. 25, pl. 2, fig. 12-13. Maastrichtian [Fig. 8].

"echinoidea" (Cookson and Eisenack, 1960a). Now *Spinidinium.*

"ectorugosa" (Archangelsky, 1969b). Now *Alterbia.*

endopapillata Archangelsky, 1969b, p. 192-193, pl. 1, fig. 8-9. Late Eocene [Fig. 44].

eocenica Baltes ex Lentin and Williams, 1973, p. 40. (Baltes, 1969, p. 34, pl. 5, fig. 8-9). Early Eocene [Fig. 51].

"extensa" (Stover, 1973). Now *Vozzhennikovia.*

"extrema" (Cookson and Eisenack, 1974, p. 48, pl. 20, fig. 4) is here questionably transferred to *?Spongodinium,* as *?S. extremum comb. nov.*

"euthema" (Davey and Verdier, 1971). Now *?Subtilisphaera.*

"eyrensis" (Cookson and Eisenack, 1971). Now *Alterbia.*

"?filigrana" (Benedek, 1972). Now *?Vozzhennikovia.*

flounderensis Stover, 1973, p. 174-175, pl. 3, fig. 1a-c, 2. Early Eocene [Fig. 11].

"foliacea" (Eisenack and Cookson, 1960). Now *Alterbia.*

fuegiensis Menendez, 1965, p. 8-9, pl. 1, fig. 1-3, pl. 3, fig. 16. Late Cretaceous [Fig. 53].

gaditana Riegel, 1974, p. 356-357, pl. 2, fig. 8-9; pl. 3, fig. 1-2. ?Senonian. This species is transitional to *Lejeunia* [Fig. 10].

galeata (Lejeune-Carpentier, 1942, p. 186-188, fig. 15-20. Lentin and Williams, 1973, p. 41. Senonian [Fig. 45].

"gallia" (Davey and Verdier, 1973). Now *Spinidinium.*

"gambangensis" (Cookson and Eisenack, 1970a). Now *Isabelia.*

"glabra" (Cookson and Eisenack, 1969). Now *Isabelia.*

"globosa" (Davey, 1970). Now *Isabelia.*

"glomerata" (Davey, 1970). Now *Isabelia.*

granulata Menendez, 1965, p. 9-10, pl. 1, fig. 4. Eocene-Oligocene [Fig. 41].

"granulifera" (Manum, 1963). Now *Chatangiella.*

granulosa Cookson and Eisenack, 1965a, p. 122, pl. 11, fig. 8-9. Late Eocene [Fig. 29].

granulostriata (Jain and Millepied, 1973) *comb. nov.*
1973 *Senegalinium granulostriatum* Jain and Millepied, p. 24-25, pl. 1, fig. 7-11; pl. 2, fig. 18; pl. 3, fig. 29. Maastrichtian [Fig. 47].

heterophlycta Deflandre and Cookson, 1955, p. 249, pl. 5, fig. 6; text-fig. 5. Late Eocene [Fig. 34].
subsp. *"pusulosa"* (Rozen, 1965, p. 293-294, pl. 1, fig. 3-4; text-fig. 2). Lentin and Williams, 1973, p. 41. Late Eocene. This subspecies which is based on one specimen is considered to be a *jr syn.* of *Deflandrea phosphoritica.*

hialina Baltes ex Lentin and Williams, 1973, p. 41. (Baltes, 1969, p. 34, pl. 1, fig. 3-4). Oligocene-Early Miocene [Fig. 30].

"ingrami" (Cookson and Eisenack, 1970a). Now *Alterbia.*

"irmoechinata" (Heisecke, 1970, p. 230, pl. 1, fig. 3; pl. 2, fig. 2-3) is here questionably transferred to *?Gonyaulacysta,* as *?G. irmoechinata comb. nov.*

"?kansana" (Tasch, 1964). Now *?Ovoidinium.*

"korojonensis" (Cookson and Eisenack, 1958). Now *Isabelia.*

"lata" (Cookson and Eisenack, 1968). Now *Isabelia.*

"laevigata" (Malloy, 1972). Now *Lejeunia.*

leptoderma (Vozzhennikova, 1963) *comb. nov.*
1963 *Ceratiopsis leptoderma* Vozzhennikova, p. 180, text-fig. 8. Paleocene [Fig. 42].

leptodermata Cookson and Eisenack, 1965a, p. 121-122, pl. 11, fig. 6-7. Late Eocene [Fig. 31].

"limpida" Singh, 1971, p. 359-361, pl. 61, fig. 1-12; text-fig. 62. This name was considered a *jr syn.* of *Spinidinium vestitum* Brideaux, 1971, p. 99-101, by Lentin and Williams, 1973, p. 43.

"longispinosa" (Wilson, 1968). Now *Wetzeliella.*

"macmurdoensis" (Wilson, 1967a). Now *Spinidinium.*

"macrocysta" (Cookson and Eisenack, 1960a). Now *Alterbia.*

"madurensis" (Cookson and Eisenack, 1970a). Now *Isabelia.*

"magna" (Davey, 1970). Now *Chatangiella.*

"magnifica" (Stanley, 1965). Now *Lejeunia.*

"manumi" (Cookson and Eisenack, 1970a). Now *Chatangiella madura.*

markovii (Vozzhennikova, 1967) *comb. nov.*
1967 *Ceratiopsis markovi* Vozzhennikova, p. 159, pl. 119, fig. 5, 7; pl. 120, fig. 1-4. Paleocene-Eocene [Fig. 37].

"medcalfii" (Stover, 1973). Now *Deflandrea dartmooria* subsp. *medcalfii.*

"menendezi" (de Baldis, 1966, p. 223, pl. 2, fig. A). This species, which is based on the observation of one specimen, is considered to be a *jr syn.* of *Deflandrea phosphoritica.*

"micracantha" (Cookson and Eisenack, 1960a). Now *Chatangiella.*

"microarma" (McIntyre, 1975). Now *Isabelia.*

"microganulata" (Stanley, 1965). Now *Alterbia.*

micropoda Cookson and Eisenack, 1974, p. 49, pl. 47, fig. 11. Late Eocene [Fig. 52].

"minor" (Alberti, 1959b). Now *Alterbia.*

"minor" (Cookson and Eisenack, 1960a) *jr hom.* of *D. minor* Alberti, 1959b. Now *Alterbia balmei.*

"multispinosa" (Cookson and Eisenack, 1970a). Now *Chatangiella.*

"nucula" (Cookson and Eisenack, 1962b). Now *Amphidiadema.*

obliquipes Deflandre and Cookson, 1955, p. 252, pl. 4, fig. 6. Middle Paleocene-Early Eocene [Fig. 33].

"obscura" (Drugg, 1967). Now *Albertia.*

oebisfeldensis Alberti, 1959b, p. 95-96, pl. 8, fig. 10-13. Paleocene-Early Eocene [Fig. 40].
subsp. *angustata* (Vozzhennikova, 1967, p. 146-147, pl. 72, fig. 3-4) Lentin and Williams, 1973, p. 43. Eocene [Fig. 38].
subsp. *oebisfeldensis* Alberti, 1959b, p. 95-96, pl. 8, fig. 10-13 [Fig. 40].
subsp. *ovalis* (Vozzhennikova, 1967, p. 146, pl. 71, fig. 2). Lentin and Williams, 1973, p. 43. Eocene [Fig. 39].

pachyceros Deflandre and Cookson, 1955, p. 252, pl. 4, fig. 7. Late Paleocene-Early Eocene [Fig. 32].

pannucea Stanley, 1965, p. 220, pl. 22, fig. 1-4, 8-10. Paleocene [Fig. 17].

"*parva*" (Cookson and Eisenack, 1958). Now *Ascodinium*.

"*pellucida*" (Deflandre and Cookson, 1955). Now *Isabelia*.

"*pentagonalis*" (Corradini, 1973). Now *Lejeunia*.

"*pentaradiata*" (Cookson and Eisenack, 1965c). Now *?Alterbia*.

"*perlucida*" (Alberti, 1959b). Now *Subtilisphaera*.

**phosphoritica* Eisenack, 1938, p. 187, text-fig. 6. Late Eocene-Early Oligocene [Fig. 16]. *Deflandrea menendezi* (de Baldis, 1966) which is based on one specimen is herein considered to be a *jr syn.* of *D. phosphoritica*.

subsp. *australis* Cookson and Eisenack, 1961b, p. 39-40, pl. 1, fig. 2-3. Eocene [Fig. 25].

var. *lata* (Vozzhennikova, 1967, p. 142, pl. 69, fig. 5-6) Lentin and Williams, 1973, p. 44. Eocene-Early Oligocene [Fig. 20].

subsp. *phosphoritica* Eisenack, 1938, p. 187, text-fig. 6 [Fig. 16].

var. *attenuata* (Vozzhennikova, 1967, p. 140-141, pl. 65, fig. 2-4, pl. 67, fig. 2-4; pl. 69, fig. 4; pl. 70, fig. 1, 4, 6-10) Lentin and Williams, 1973, p. 44. Eocene-Early Oligocene [Fig. 15].

var. *phosphoritica* Eisenack, 1938, p. 187, text-fig. 6 [Fig. 16].

subsp. *vozzhennikovae* Grigorovich, 1972, p. 66, fig. 3. Early Miocene. This subspecies of *Deflandrea phosphoritica* is the only taxon within the genus in which the holotype is reported from post-Oligocene sediments. The sample from which the holotype was recovered is from a bore hole and has been dated as Early Miocene. It is therefore possible that the age of the sample is somehwat older than that given [Fig. 22].

"*pilosa*" (Davey, 1969b). Now *Alterbia*.

"*pirnaensis*" (Alberti, 1959b). Now *Subtilisphaera*.

"*?plea*" (Tasch, 1964, p. 196, pl. 1, fig. 15) is here questionably transferred to the genus *?Gonyaulacysta*, as *?G. plea comb. nov.*

"*pontis-mariae*" (Deflandre, 1936b). Now *Subtilisphaera*.

"*raijae*" (Kjellström, 1973). Now *Alterbia*.

"*rectangularis*" (Cookson and Eisenack, 1962b). Now *Amphidiadema*.

"*rhombica*" (Cookson and Eisenack, 1974). Now *Spinidinium echinoideum* subsp. *rhombicum*.

"*rhombovalis*" (Cookson and Eisenack, 1970a). Now *Isabelia*.

robusta Deflandre and Cookson, 1955, p. 250, pl. 4, fig. 9. Eocene [Fig. 19].

"rotundata" (Eisenack and Cookson, 1960). Now *Subtilisphaera.*

"sagittula" (Drugg, 1970b). Now *Spinidinium.*

"scheii" (Manum, 1963). Now *?Chatangiella.*

"serratula" (Cookson and Eisenack, 1958). Now *Chatangiella.*

sibirica (Vozzhennikova, 1963) *comb. nov.*
1963 *Cerodinium sibiricum* Vozzhennikova, p. 181, text-fig. 9-10. Paleocene-Eocene. This species was the type of the genus *Cerodinium* Vozzhennikova, 1963, which is now considered to be a *jr syn.* of *Deflandrea* and is therefore superfluous [Fig. 26].

speciosa Alberti, 1959b, p. 97, pl. 9, fig. 12-13. Late Paleocene [Fig. 21].
subsp. *glabra* Gocht, 1969, p. 10, text-fig. 12-13. Late Paleocene [Fig. 14].

"spectabilis" (Alberti, 1959b). Now *Chatangiella.*

"spinosissima" (Cookson and Eisenack, 1970a). Now *?Isabelia.*

spinulosa Alberti, 1959b, p. 95, pl. 8, fig. 8-9. Middle-Late Oligocene [Fig. 18].

stagonoides (Benedek, 1972) *comb. nov.*
1972 *Ascodinium stagonoides* Benedek, p. 10, pl. 2, fig. 12; text-fig. 5. Late Oligocene. Although text-fig. 5, of Benedek, 1972, indicates an apical archeopyle for this species, the photograph (pl. 2, fig. 12) shows a broad hexa archeopyle with a tear in the periphragm which allows the apical region to collapse. The species was based on the observation of three specimens [Fig. 28].

striata Drugg, 1967, p. 18, pl. 2, fig. 13-14. Danian [Fig. 23].

subquadra Corradini, 1973, p. 175-176, pl. 28, fig. 1. Senonian [Fig. 35].

"sverdrupiana" (Manum, 1963). Now *Spinidinium.*

"?tenera" (Krutzsch, 1962). Now *Vozzhennikovia.*

"terrula" (Davey, 1974). Now *?Subtilisphaera.*

"thomasi" (Cookson and Eisenack, 1961a). Now *Isabelia.*

"tripartita" (Cookson and Eisenack, 1960a). Now *Chatangiella.*

truncata Stover, 1973, p. 176-177, pl. 5, fig. 2, 3a-c. Early Eocene [Fig. 49].

"ventriosa" (Alberti, 1959b). Now *Subtilisphaera.*

"verrucosa" (Manum, 1963). Now *Chatangiella*.

"vestita" (Brideaux, 1971). The transfer of this species from *Spinidinium* to the genus *Deflandrea* by Sverdlove and Habib, 1973, p. 59, is herein rejected.

"victoriensis" (Cookson and Manum, 1964). Now *Chatangiella*.

wardenensis Williams and Downie, 1966c, p. 233, pl. 26, fig. 5. Early Eocene [Fig. 24].

"?wellingtoniana" (Tasch, 1963, p. 336, pl. 1, fig. 9). This species is here transferred to *Nannoceratopsiella*, as *N. wellingtoniana comb. nov.*

wetzelii Morgenroth, 1966a, p. 9, pl. 1, fig. 4-5. Early Eocene [Fig. 27].

ALTERBIA nom. nov., nom. subst. pro Albertia
Vozzhennikova, 1967, emend (non *Albertia* Schimper, 1837)

TYPE SPECIES: *Alterbia recticornis* (Vozzhennikova, 1967) *comb. nov.* 1967 *Albertia recticornis* Vozzhennikova, p. 151-152, pl. 77, fig. 1-4; pl. 78, fig. 1-3; pl. 79, fig. 1-2. Turonian.

DIAGNOSIS: Vozzhennikova, 1967, p. 150-151 (translation): "Theca is pentagonal, rhombic, divided into almost equal parts. Epitheca is bell-shaped, triangular, with a small apical horn. Hypotheca has one or two antapical horns of unequal size. Transverse furrow is equatorial and circular. Longitudinal furrow is located on the hypotheca and reaches to the antapex. Inner body follows the outline of the theca. Pylome is triangular and rounded at the angles, or bluntly truncated and becoming trapezoidal."

EMENDED DIAGNOSIS:

Shape

Pericyst: Ambitus rhomboidal to subpentagonal, elongated in an antero-posterior direction. Pericyst prolonged into one apical and two symmetrically placed antapical horns, the right antapical generally reduced or vestigial. The pericyst attains its greatest width in the region of the pericingulum. Compression dorso-ventral.

Endocyst: Ambitus circular to ovoidal to rhomboidal. Frequently there is a slight apical protuberance. May be in contact with pericyst in precingular, cingular and postcingular regions.

Pericoels: Apical pericoel always present, antapical pericoel commonly present. The apical and antapical pericoels may be united by an ambital pericoel.

Phragma

Periphragm: Thickness variable but usually *ca.* 1 μ. Surface generally laevigate, occasionally scabrate, granulate, or verrucate.

Endophragm: Rarely exceeding 1 μ and of constant thickness. Surface generally laevigate, may be granulate or striate.

Paratabulation

Pericyst: Paratabulation indeterminate except in the vicinity of the archeopyle.

Pericingulum: Frequently well developed, planar or slightly helicoidal, with anterior parasuture only, or anterior and posterior parasuture as a slightly raised ridge or border, with smooth or denticulate margins.

Perisulcus: Rarely determinable; when visible largely restricted to the hypopericyst. Occasionally flagellar scar visible.

Endocyst: No observable paratabulation, other than in the vicinity of the endoarcheopyle.

Archeopyle

Periarcheopyle: Attenuated hexa to standard hexa intercalary resulting from the loss of the second anterior intercalary paraplate, 2a. Perioperculum free or remaining attached along parasuture H4. The attenuated hexa archeopyle usually has a free operculum, the standard archeopyle is usually an attached operculum. Transverse periarcheopyle index 0.16-0.46. Transverse periarcheopyle ratio 0.20-0.88.

Endoarcheopyle: Often difficult to discern. When observed is intercalary resulting from the loss of the second anterior intercalary paraplate (2a).

Archeopyle Formula: I/I (2a/2a)

Dimensions

Pericyst: Length 23-192 μ, breadth 19-152 μ.
Endocyst: Length ?22-118 μ, breadth ?18-118 μ.

DISCUSSION:

Fossil dinoflagellate species which are included in *Alterbia* differ from species of *Deflandrea* in possessing an attenuated hexa to standard hexa 2a intercalary archeopyle, an archeopyle index of 0.3-0.5, and almost invariably a reduced right antapical horn. The presence in the species *Alterbia distincta* (Wilson, 1967a) and *A. dilwynensis* (Cookson and Eisenack, 1965c) of such *Deflandrea*-like features as a thicker endophragm and larger overall size suggest that they constitute a morphogenetic lineage from which some of the ancestral species of *Deflandrea* evolved.

STRATIGRAPHIC RANGE: Albian-Eocene

SPECIES OF *Alterbia*

acribes (Davey and Verdier, 1971) *comb. nov.*
1971 *Deflandrea acribes* Davey and Verdier, p. 38-39, pl. 2, fig. 10, 12. Early Albian [Fig. 56].

acuminata (Cookson and Eisenack, 1958) *comb nov.*
1958 *Deflandrea acuminata* Cookson and Eisenack, p. 27, pl. 4, fig. 5-8. Cenomanian-Early Turonian [Fig. 57].

acutula (Wilson, 1967b) *comb. nov.*
1967 *Deflandrea acutula* Wilson, p. 225-226, fig. 11-12. ?Paleocene [Fig. 69].

asymmetrica (Wilson, 1967a) *comb. nov.*
1967 *Deflandrea asymmetrica* Wilson p. 62-63, fig. 17-21. Erratics, probably Eocene [Fig. 59].

balmei (Cookson and Eisenack, 1962b) *comb. nov.*
1962b *Deflandrea balmei* Cookson and Eisenack, p. 486, *nom. subst. pro. Deflandrea minor* Cookson and Eisenack, 1960a, p. 2, pl. 1, fig. 1-3. Turonian-Middle Senonian [Fig. 60].

bicavata (Jain and Millepied, 1973) *comb. nov.*
1973 *Senegalinium bicavatum* Jain and Millepied, p. 23, pl. 1, fig. 1-4; text-fig. 1b. Campanian-Maastrichtian. This species was the type of the genus *Senegalinium* which is herein considered superfluous [Fig. 68].

curvicornis Vozzhennikova, 1967, p. 151, pl. 74, fig. 1-3. Campanian [Fig. 75].

dilwynensis (Cookson and Eisenack, 1965c) *comb. nov.*
1965c *Deflandrea dilwynensis* Cookson and Eisenack, p. 141, pl. 18, fig. 6-9. Paleocene [Fig. 63].

distincta (Wilson, 1967a) *comb. nov.*
1967 *Deflandrea distincta* Wilson, p. 63-64, fig. 9-10. Erratics. Early Tertiary [Fig. 73].

ectorugosa (Archangelsky, 1969b) *comb. nov.*
1969b *Deflandrea ectorugosa* Archangelsky, p. 192, pl. 1, fig. 5-7. Late Eocene [Fig. 61].

?eyrensis (Cookson and Eisenack, 1971) *comb. nov.*
1971 *Deflandrea eyrensis* Cookson and Eisenack, p. 217-218, pl. 7, fig. 2-3. Albian-Cenomanian [Fig. 77].

foliacea (Eisenack and Cookson, 1960) *comb. nov.*
1960 *Deflandrea foliacea* Eisenack and Cookson, p. 2, pl. 2, fig. 3. Turonian-Middle Senonian [Fig. 72].

ingramii (Cookson and Eisenack, 1970a) *comb. nov.*
1970a *Deflandrea ingrami* Cookson and Eisenack, p. 143, pl. 12, fig. 7-9. Senonian [Fig. 67].

macrocysta (Cookson and Eisenack, 1960a) *comb. nov.*
1960a *Deflandrea macrocysta* Cookson and Eisenack, p. 3, pl. 1, fig. 7-8. Campanian [Fig. 76].

microgranulata (Stanley, 1965) *comb. nov.*
1965 *Deflandrea microgranulata* Stanley, p. 219, pl. 19, fig. 4-6. Paleocene [Fig. 71].

minor (Alberti, 1959b) *comb. nov.*
1959b *Deflandrea minor* Alberti, p. 98, pl. 9, fig. 9-11. Late Senonian [Fig. 70].

obscura (Drugg, 1967) *comb. nov.*
1967 *Deflandrea obscura* Drugg, p. 17, p 2, fig. 8-9; pl. 9, fig. 5. Maastrichtian-Danian [Fig. 66].

?pentaradiata (Cookson and Eisenack, 1965c) *comb. nov.*
1965c *Deflandrea pentaradiata* Cookson and Eisenack, p. 139-140, pl. 18, fig. 1-2. Paleocene. This species is questionably included in the genus *Alterbia*. The distinctive outline of the pericyst suggests it may be better placed in the genus *Rhombodinium;* however, the distinctively hexa archeopyle excludes it from that genus. *Alterbia pentaradiata* subsp. *preceda* conforms more closely to the generic concept of *Alterbia* [Fig. 58].

subsp. *preceda* (Cookson and Eisenack, 1974) *comb. nov.*
1974 *Deflandrea pentaradiata* subsp. *preceda* Cookson and Eisenack, p. 49, pl. 20, fig. 1-2. Paleocene [Fig. 55].

pilosa (Davey, 1969b) *comb. nov.*
1969b *Deflandrea pilosa* Davey, p. 9, pl. 3, fig. 2-5. Campanian-Maastrichtian [Fig. 64].

polymorpha (Malloy, 1972) *comb. nov.*
1972 *Svalbardella polymorpha* Malloy, p. 63-64, pl. 1, fig. 8-16, 21. Maastrichtian.
Andalusiella mauthei (Riegel, 1974, p. 357-360, pl. 2, fig. 1-7; text-fig. 5-6), the type of the monospecific genus *Andalusiella* is considered to be a *jr syn.* of *Alterbia polymorpha.* The genus *Andalusiella* is therefore considered to be superfluous. The species *Palaeocystodinium microgranulatum* (Jain and Millepied, 1973, p. 29, pl. 2, fig. 23-24; pl. 3, fig. 30), *Palaeocystodinium punctatum* (Jain and Millepied, 1973, p. 29, pl. 3, fig. 26-28), and *Senegalinium trisinum* (Jain and Millepied, 1973, p. 25, pl. 2, fig. 16) are considered to be *jr syn.* of *Alterbia polymorpha* [Fig. 62].

raijae (Kjellström, 1973) *comb. nov.*
1973 *Deflandrea raijae* Kjellström, p. 20-22, fig. 16. Middle-Late Maastrichtian [Fig. 65].

**recticornis* Vozzhennikova, 1967, p. 151-152, pl. 77, fig. 1-4; pl. 78, fig. 1-3; pl. 79, fig. 1-2. Turonian [Fig. 74].

CHATANGIELLA Vozzhennikova, 1967, emend.
(Fig. 78-100]

TYPE SPECIES: *Chatangiella niiga* Vozzhennikova, 1967, p. 129, pl. 56, fig. 1-4; pl. 57, fig. 1-4; pl. 58, fig. 1-4. Senonian.

DIAGNOSIS: Vozzhennikova, 1967, p. 129 (translation): "Theca is elongate with strongly or slightly convexo-concave lateral sides and divided into almost equal parts; it has a short apical and two short antapical horns. Transverse furrow is equatorial and slightly spiral. Longitudinal furrow is located on the hypotheca and reaches to the antapex. Inner body is oval in outline and compressed along the longitudinal axis; its convex sides tightly abut the thin, lateral sides of the theca. Surface of the theca is sculptured. Pylome is large and polygonal."

EMENDED DIAGNOSIS:

Shape

Pericyst: Ambitus elongate rectangular with a convex pericingular region. Produced into a broad distally acuminate or rounded apical horn and two symmetrically placed antapical horns, of which the left is always the larger, the right being reduced or vestigial. The epipericyst is of more or less constant width, with concave sides, or widens towards the apex with prominent shoulders immediately below the apical horn. There is sometimes an antapical opening in the hypopericyst. Epipericyst and hypopericyst of approximately the same size. Compression dorso-ventral.

Endocyst: Ambitus subcircular in contact with, or almost touching, the pericyst in the precingular, cingular and postcingular regions. Compression dorso-ventral.

Pericoels: A well developed apical and antapical pericoel.

Phragma

Periphragm: Surface laevigate or with nontabular or penetabular ornamentation as grana, verrucae, tubercles, echinae or spines.

Endophragm: Generally in excess of 1 µ. Surface rarely laevigate, frequently scabrate, granulate or verrucate.

Paratabulation

Pericyst: The penetabular ornamentation denotes the peridinioid paratabulation of 4', 3a, 7", 5"', 2"". Paraplates 1', 2', and 4' are elongate antero-posteriorly, 3' is short and broad. Paraplate 2a is omegaform and wider than 4". The 3"' appears to be the largest of the postcingulars.

Pericingulum: Always present and slightly helicoidal; frequently the only observable evidence of paratabulation. The anterior and posterior parasutures are discontinuous, and represent the posterior penetabular ridges of the precingulars, and the anterior penetabular ridges of the postcingulars, respectively. The resultant partite pericingulum therefore should have seven anterior and five posterior ridges. The ridges, or borders, have smooth or denticulate margins.

Perisulcus; Largely restricted to the hypopericyst and widening towards the antapex.

Endocyst: Paratabulation not known other than three anterior intercalaries.

Archeopyle

Periarcheopyle: Omegaform intercalary resulting from the complete or partial detachment of paraplate 2a. Perioperculum free or remaining attached along parasuture H4. The shape of the perioperculum seems to reflect the epipericyst and is widest anteriorly. Transverse periarcheopyle index is 0.33-0.64. Transverse archeopyle ratio is 0.44-1.81.

Endoarcheopyle: Where observable is intercalary resulting from the complete or partial detachment of one (2a) or all three anterior intercalary paraplates 1a, 2a, and 3a. Commonly 1a and 3a are completely detached while 2a remains attached along the H4 (2a-4") parasuture.

Archeopyle Formula: I/I (2a/2a) or I/3I (2a/1-3a)

Dimensions

Pericyst: Length 62-190 μ, breadth 38-125 μ
Endocyst: Length 30-110 μ, breadth 38-109 μ

DISCUSSION:

Chatangiella is characterized by the distinctive shape of the epipericyst in ambital view, the hepta/pentapartite pericingulum and the omegaform periarcheopyle, the operculum of which commonly remains attached along parasuture H4. *Chatangiella* can be readily distinguished from *Alterbia* by its partite pericingulum and omegaform archeopyle; and from *Isabelia* by its partite pericingulum and frequently developed penetabular ornamentation.

Vozzhennikova (1967) in the generic diagnosis of *Chatangiella* did not draw attention to the hepta/pentapartite pericingulum and termed the archeopyle polygonal. She included in the genus one species only, *Chatangiella niigi*. Study of some of the illustrations in Vozzhennikova (1967) shows that *C. niigi* has a partite pericingulum (pl. 56, fig. 4; pl. 57, fig. 1; and pl. 58, fig. 1) and an omegaform periarcheopyle (pl. 56, fig. 1-4; pl. 57, fig. 1-4; and pl. 58, fig. 1 and 3). Other genera possessing a partite pericingulum and omegaform periarcheopyle are *Australiella* Vozzhennikova, 1967, and *Cooksoniella* Vozzhennikova, 1967. In the generic diagnosis of *Australiella* Vozzhennikova, 1967, p. 129-130, stated that the pericingulum was fringed with low continuous or discontinuous projections, and that the archeopyle was shaped like a horseshoe or was roundly hexagonal. Vozzhennikova designated as type of the genus *Australiella, A. tripartita* (Cookson and Eisenack, 1960a) Vozzhennikova, 1967, which has an omegaform periarcheopyle (Cookson and Eisenack, 1960a, pl. 1, fig. 10). The species *Australiella bondarenki* Vozzhennikova, 1967, has a partite pericingulum and omegaform periarcheopyle (Vozzhennikova, 1967, pl. 59, fig. 1a-b), as do all the other species assigned to *Australiella* by Vozzhennikova (1967), and Lentin and Williams (1973) respectively. Vozzhennikova included in her genus *Cooksoniella, C. manumi* and the type species *C. vnigri.* Lentin and Williams (1973, p. 31) included three more species, *C. damasii* (Lejeune-Carpentier, 1942), *C. paleocenica* (Cookson and Eisenack, 1965c) and *C. scheii* (Manum, 1963). According to Vozzhennikova (1967, p. 129) *Chatangiella* is differentiated from *Cooksoniella* on its polygonal archeopyle and poorly developed antapical horns. *Cooksoniella manumi* (Vozzhennikova, 1967, pl. 108, fig. 1-4) and *Cooksoniella vnigri* (Vozzhennikova, 1967, pl. 59, fig. 2; pl. 107, fig. 1; pl. 109, fig. 1-2; and pl. 110, fig. 2-3) unquestionably possess a partite pericingulum and omegaform periarcheopyle. *Chatangiella, Australiella* and *Cooksoniella* are therefore generally indistinguishable and must be regarded as synonymous. Since the description of *Chatangiella* precedes those of *Australiella* and *Cooksoniella* in Vozzhennikova (1967), the generic name *Chatangiella* has been retained and *Australiella* and *Cooksoniella* made superfluous.

The genera *Bulbodinium* O. Wetzel, 1960, and *Evittodinium* Deflandre, 1964, appear to be closely related, if not identical, to *Chatangiella.* Unfortunately, the nature of the pericingulum cannot be determined from the generic diagnosis or illustrations of the species of *Bulbodinium.* Pending examination of the topotype material containing *Bulbodinium, Chatangiella* must be retained. The monospecific genus *Evittodinium* Deflandre, 1964, possesses a pericingulum, according to the generic diagnosis, but the details of its structure are lacking. Further elucidation of the genus is impossible since the holotype of *Evittodinium giselae* is a damaged specimen, in which the entire epidorsal surface is missing (W.R. Evitt, pers. comm.). Thus the nature of the archeopyle cannot be determined so that no additional species should be assigned to *Evittodinium.*

STRATIGRAPHIC RANGE:

SPECIES OF *Chatangiella*

armata (Cookson and Eisenack, 1970a) *comb. nov.*
1970a *Deflandrea armata* Cookson and Eisenack, p. 142-143, pl. 13, fig. 9. Senonian [Fig. 97].

?biapertura (McIntyre, 1975) *comb. nov.*
1975 *Deflandrea biapertura* McIntyre, p. 66, pl. 3, fig. 5-8. Campanian [Fig. 89].

bondarenkii (Vozzhennikova, 1967) *comb. nov.*
1967 *Australiella bondarenki* Vozzhennikova, p. 130-131, pl. 59, fig. 1a-b; pl. 60, fig. 2. Santonian [Fig. 82].

campbellensis (Wilson, 1967b) *comb. nov.*
1967b *Deflandrea campbellensis* Wilson, p. 225, fig. 2-3. Paleocene [Fig. 92].

chetiensis (Vozzhennikova, 1967) *comb. nov.*
1967 *Australiella chetiensis* Vozzhennikova, p. 131, pl. 60, fig. 1a-b. Santonian [Fig. 79].

coronata (McIntyre, 1975) *comb. nov.*
1975 *Deflandrea coronata* McIntyre, p. 64-65, pl. 3, fig. 1-4. Campanian [Fig. 86].

decorosa (McIntyre, 1975) *comb. nov.*
1975 *Deflandrea decorosa* McIntyre, p. 63-64, pl. 2, fig. 1-4. Campanian [Fig. 84].

ditissima (McIntyre, 1975) *comb. nov.*
1975 *Deflandrea ditissima* McIntyre, p. 62-63, pl. 1, fig. 1-4. Campanian [Fig. 81].

granulifera (Manum, 1963) *comb. nov.*
1963 *Deflandrea granulifera* Manum, p. 61, pl. 3, fig. 5-9. Senonian [Fig. 80].
subsp. *tenuis* (Davey, 1970) *comb. nov.*
1970 *Deflandrea granulifera* var. *tenuis* Davey, p. 340-341, pl. 2, fig. 1. Albian. This variety was raised to the subspecies level by Lentin and Williams (1973, p. 18) [Fig. 99].

madura nom. nov., nom. subst. pro. Chatangiella manumii Cookson and Eisenack, 1970a, *comb. nov.* (non-*Chatangiella manumii* Vozzhennikova, 1967, *comb. nov.*)
1970a *Deflandrea manumii* Cookson and Eisenack, p. 141-142, pl. 11, fig. 10-11. Senonian [Fig. 88].

magna (Davey, 1970) *comb. nov.*
1970 *Deflandrea magna* Davey, p. 342-343, pl. 2, fig. 6-8. Cenomanian [Fig. 95].

manumii (Vozzhennikova, 1967) *comb. nov.*
1967 *Cooksoniella manumi* Vozzhennikova, p. 184-185, pl. 107, fig. 1-4. Turonian-Campanian [Fig. 100].

micracantha (Cookson and Eisenack, 1960a) *comb. nov.*
1960 *Deflandrea micracantha* Cookson and Eisenack, p. 3, pl. 1, fig. 9. Campanian [Fig. 93].

multispinosa (Cookson and Eisenack, 1970a) *comb. nov.*
1970a *Deflandrea multispinosa* Cookson and Eisenack, p. 141, pl. 11, fig. 7-9. Albian-Cenomanian [Fig. 90].

**niiga* Vozzhennikova, 1967, p. 129, pl. 56, fig. 1-4; pl. 57, fig. 1-4; pl. 58, fig. 1-4. Santonian [Fig. 87].

?scheii (Manum, 1963) *comb. nov.*
1963 *Deflandrea scheii* Manum, p. 56-58, pl. 1, fig. 1-16; text-fig. 1. Middle Cretaceous. This species is tentatively placed in the genus *Chatangiella* due to the unique parasutural ridges which occur on this species and are not a character of the genus *Chatangiella* [Fig. 98].

serratula (Cookson and Eisenack, 1958) *comb. nov.*
1958 *Deflandrea serratula* Cookson and Eisenack, p. 28, pl. 4, fig. 4. Campanian-Early Maastrichtian [Fig. 94].

spectabilis (Alberti, 1959b) *comb. nov.*
1959 *Deflandrea spectabilis* Alberti, p. 99, pl. 9, fig. 7-8. Late Senonian [Fig. 83].

tripartita (Cookson and Eisenack, 1960a) *comb. nov.*
1960a *Deflandrea tripartita* Cookson and Eisenack, p. 2, pl. 1, fig. 10. Senonian. This species was transferred to the now superfluous genus *Australiella* as the type of the genus by Vozzhennikova (1967). [Fig. 96].

verrucosa (Manum, 1963) *comb. nov.*
1963 *Deflandrea verrucosa* Manum, p. 60, pl. 3, fig. 1-4. Middle Cretaceous [Fig. 91].

victoriensis (Cookson and Manum, 1964) *comb. nov.*
1964 *Deflandrea victoriensis* Cookson and Manum, p. 522, pl. 76, fig. 3-8. Senonian [Fig. 78].

vnigri (Vozzhennikova, 1967) *comb. nov.*
1967 *Cooksoniella vnigri* Vozzhennikova, p. 185, pl. 59, fig. 2; pl. 79, fig. 3; pl. 107, fig. 1; pl. 109, fig. 1-2; pl. 110, fig. 2-3. Turonian-Santonian. This species was the type of the now superfluous genus *Cooksoniella* Vozzhennikova, 1967, p. 183 [Fig. 85].

ISABELIA gen. nov.
[Fig. 101-121 and 306]

TYPE SPECIES: *Isabelia korojonensis* (Cookson and Eisenack, 1958) *comb. nov.* 1958 *Deflandrea korojonensis* Cookson and Eisenack, p. 27-28, pl. 4, fig. 10-11. Campanian-Early Maastrichtian.

DIAGNOSIS:

Shape

Pericyst: Ambitus commonly pentagonal, elongated in an antero-posterior direction, rarely rhomboidal or rectangular. Apex prolonged into a broad short apical horn which may merge imperceptibly into the epipericyst, or be developed into shoulders. Antapex produced into two symmetrically located short antapical horns, usually of unequal length. The left antapical horn is always the longer, the right is reduced or vestigial. The apical and two antapical horns sometimes reduced. There is usually a slight to prominent equatorial bulge in ambital view. Compression dorso-ventral.

Endocyst: Ambitus ovoidal with longest axis equatorially aligned to circular, to elongate ovoidal. May be equatorially in contact with endocyst.

Pericoels: When endocyst and pericyst are appressed in precingular, cingular and postcingular regions, they are separated apically and antapically by a large apical and a large antapical pericoel respectively. Alternatively the apical and antapical pericoels may be united by an ambital pericoel. Compression dorso-ventral, may be negligible.

Phragma

Periphragm: Usually of constant thickness. Surface laevigate, scabrate, granulate or verrucate. Ornamentation nontabular.

Endophragm: Surface laevigate to scabrate to granulate.

Paratabulation

Pericyst: Paratabulation indeterminate other than in the vicinity of the periarcheopyle.

Pericingulum: Almost always absent or rudimentary and never complete, occasionally visible on the ambitus as an indentation.

Perisulcus: Not observed.

Endocyst: Paratabulation unknown.

Archeopyle

Periarcheopyle: Omegaform intercalary resulting from the partial detachment of the second anterior intercalary paraplate, 2a, with perioperculum usually remaining attached along parasuture H4. Transverse periarcheopyle index is 0.33-0.55. Transverse archeopyle ratio is 0.50-1.25.

Endoarcheopyle: Where observable appears to result from the loss of the second anterior intercalary paraplate (2a), or all three anterior intercalaries.

Archeopyle Formula: I/I (2a/2a) or I/3I (2a/1-3a).

Dimensions — Pericyst: Length 46-162 μ, breadth 36-124 μ
Endocyst: Length 28-112 μ, breadth ?33-114 μ

DISCUSSION: *Isabelia* closely resembles *Chatangiella* in possessing an omega-form periarcheopyle which seems to be related to the outline of the epipericyst, which in such taxa is commonly widest in the vicinity of the archeopyle. However, *Chatangiella* has a hepta/pentapartite pericingulum and frequently penetabular ornamentation. *Alterbia* differs in possessing a pericingulum and a standard to attenuated hexa periarcheopyle. The apical horn and left antapical horn also tend to be more prominent in *Alterbia*. *Amphidiadema* which lacks a pericingulum differs from *Isabelia* in having a standard hexa or attenuated hexa periarcheopyle, and apical and antapical regions devoid of horns. *Trithyrodinium* has the distinctive 3I (1-3a) periarcheopyle.

STRATIGRAPHIC RANGE:

SPECIES OF *Isabelia*

?amphiata (McIntyre, 1975) *comb. nov.*
1975 *Deflandrea amphiata* McIntyre, p. 65-66, pl. 2, fig. 5-8. Campanian. The transverse archeopyle index of 0.65 and the transverse archeopyle ratio of 2.14 do not conform with the mean for this genus [Fig. 105].

bakeri (Deflandre and Cookson, 1955) *comb. nov.*
1955 *Deflandrea bakeri* Deflandre and Cookson, p. 251, pl. 4, fig. 1-2, 4. Paleocene-Early Eocene [Fig. 117].

belfastensis (Cookson and Eisenack, 1961a) *comb. nov.*
1961a *Deflandrea belfastensis* Cookson and Eisenack, p. 71, pl. 11, fig. 4-6. Senonian [Fig. 112).

conorata (Stover, 1973) *comb. nov.*
1973 *Deflandrea conorata* Stover, p. 171-172, pl. 1, fig. 8a-b. Early-Middle Paleocene [Fig. 111].

cooksoniae (Alberti, 1959b) *comb. nov.*
1959b *Deflandrea cooksoni* Alberti, p. 97, pl. 9, fig. 1-6. Late Senonian [Fig. 110].

cretacea (Cookson, 1956) *comb. nov.*
1956 *Deflandrea cretacea* Cookson, p. 184-185, pl. 1, fig. 1-5 (non 6-7, which are now *Nelsoniella aceras*). Late Cretaceous [Fig. 113].

dakotaensis (Stanley, 1965) *comb. nov.*
1965 *Deflandrea dakotaensis* Stanley, p. 217-218, pl. 19, fig. 1-3. Paleocene. This species possesses a 3I endoarcheopyle from the illustrations accompanying Stanley [Fig. 119].

delicata (Baltes ex Lentin and Williams, 1973) *comb. nov.*
1973 *Deflandrea delicata* Baltes ex Lentin and Williams, p. 40 (Baltes, 1969, p. 34, pl. 1, fig. 7). Early Eocene [Fig. 115].

druggii (Stover, 1973) *comb. nov.*
1973 *Deflandrea druggi* Stover, p. 171, pl. 1, fig. 3a-b, 4. Early-Middle Paleocene [Fig. 121].

gambangensis (Cookson and Eisenack, 1970a) *comb. nov.*
1970a *Deflandrea gambangensis* Cookson and Eisenack, p. 140, pl. 11, fig. 1-2. Senonian [Fig. 114].

glabra (Cookson and Eisenack, 1969) *comb. nov.*
1969 *Deflandrea glabra* Cookson and Eisenack, p. 3, fig. 1a. Albian-Cenomanian [Fig. 102].

?globosa (Davey, 1970) *comb. nov.*
1970 *Deflandrea globosa* Davey, p. 344, pl. 2, fig. 3. Cenomanian. This form is tentatively placed in *Isabelia* although it may represent only an endocyst [Fig. 106].

glomerata (Davey, 1970) *comb. nov.*
1970 *Deflandrea glomerata* Davey, p. 343-344, pl. 1, fig. 7-9. Cenomanian [Fig. 103].

**korojonensis* (Cookson and Eisenack, 1958, p. 27-28, pl. 4, fig. 10-11) Lentin and Williams, *comb. nov.* (above) Campanian-Early Maastrichtian [Fig. 104].

lata (Cookson and Eisenack, 1968) *comb. nov.*
1968 *Deflandrea lata* Cookson and Eisenack, p. 110, text-fig. 1a-c. ?Santonian-Earliest Campanian [Fig. 120].

madurensis (Cookson and Eisenack, 1970a) *comb. nov.*
1970a *Deflandrea madurensis* (Cookson and Eisenack, p. 140, pl. 11, fig. 3-4. Senonian [Fig. 116].

microarma (McIntyre, 1975) *comb. nov.*
1975 *Deflandrea microarma* McIntyre, p. 65, pl. 1, fig. 5-8. Campanian [Fig. 107].

pellucida (Deflandre and Cookson, 1955) *comb. nov.*
1955 *Deflandrea bakeri* forma *pellucida* Deflandre and Cookson, p. 251, pl. 4, fig. 3. Paleocene-Early Eocene. This form was raised to the species level by Cookson and Eisenack, 1958, p. 27 [Fig. 101].

rhombovalis (Cookson and Eisenack, 1970a) *comb. nov.*
1970a *Deflandrea rhombovalis* Cookson and Eisenack, p. 143, pl. 12, fig. 10-11. Late Albian-Senonian [Fig. 109].

seelandica (Lange, 1969) *comb. nov.*
1969 *Broomea seelandica* Lange, p. 113-114, pl. 2, fig. 10; pl. 3, fig. 3. Danian. The paratype (pl. 2, fig. 10) clearly possesses an omegaform hexa 2a archeopyle. [Fig. 306].

spinosissima (Cookson and Eisenack, 1970a) *comb. nov.*
1970 *Deflandrea spinossisima* Cookson and Eisenack, p. 141, pl. 11, fig. 5-6. Senonian. The sometimes clearly delineated pericingulum is not characteristic for the genus *Isabelia* [Fig. 108].

thomasii (Cookson and Eisenack, 1961a) *comb. nov.*
1961a *Deflandrea thomasi* Cookson and Eisenack, p. 71-72, pl. 11, fig. 7-10. Senonian [Fig. 118].

AMPHIDIADEMA Cookson and Eisenack, 1960a, emend.
[Fig. 122-125]

TYPE SPECIES: *Amphidiadema denticulata* Cookson and Eisenack, 1960a, p. 4, pl. 1, fig. 11. Senonian.

DIAGNOSIS: Cookson and Eisenack, 1960a, p. 4: "Shell elongate, without girdle, furrow and horn, differentiated into a swollen middle portion containing a capsule which opens apically, and two smaller terminal portions, in the apical one of which a large dorsal pylome is developed."

EMENDED DIAGNOSIS:

Shape

Pericyst: Ambitus rectangular, elongated in an antero-posterior direction. Apex concave, flat or rounded with occasionally the suggestion of an apical horn. Antapex concave, flat or rounded, commonly with one, or two, symmetrically located more or less equal antapical bulges which may represent antapical horns. Possessing an equatorial bulge which is slight to prominent and determined by the size of the endocyst, being located where the endophragm and periphragm are appressed. Compression dorso-ventral.

Endocyst: Ambitus ovoidal with longest axis equatorially aligned, to circular, to longitudinally ovoidal. In contact with pericyst in precingular, cingular and postcingular regions. Compression dorso-ventral, often negligible.

Pericoels: Endocyst and pericyst separated apically and antapically by large apical and large antapical pericoel.

Phragma

Periphragm: Usually of constant thickness. Surface laevigate, granulate verrucate or denticulate.

Endophragm: Usually thicker than periphragm. Surface laevigate to scabrate to granulate.

Paratabulation

Pericyst: Paratabulation not observed.
Pericingulum: Absent
Perisulcus: Absent
Endocyst: Paratabulation not observed.

Archeopyle

Periarcheopyle: Attenuated hexa or standard hexa intercalary resulting from the partial or complete detachment of the anterior intercalary paraplate (2a); periarcheopyle opening primarily into the apical pericoel. When partially detached, the operculum remains attached along parasuture H4. Transverse periarcheopyle index is 0.54-0.69. Transverse archeopyle ratio is 1.20-2.25.

Endoarcheopyle: Where observable appears to result from the loss of the second anterior intercalary paraplate (2a).

Archeopyle Formula: I/I (2a/2a)

Dimensions — Pericyst: Length 52-140 μ, breadth 43-64 μ
Endocyst: Length 40-48 μ, breadth ?42-60 μ

DISCUSSION: *Amphidiadema* is characterized by the rectangular ambital outline of the pericyst, the prominent equatorial bulge determined by the shape and size of the endocyst, being located where periphragm and endophragm are appressed, and the presence of a large apical and a large antapical pericoel. *Isabelia* differs in having an omegaform periarcheopyle, and apical and antapical horns.

STRATIGRAPHIC RANGE: Late Turonian-Maastrichtian

SPECIES OF *Amphidiadema*

**denticulata* Cookson and Eisenack, 1960a, p. 4, pl. 1, fig. 11 Senonian [Fig. 122].

nucula (Cookson and Eisenack, 1962b) *comb. nov.*
1962b ***Deflandrea nucula*** Cookson and Eisenack, p. 486, pl. 1, fig. 13. Senonian [Fig. 125].

rectangularis (Cookson and Eisenack, 1962b) *comb. nov.*
1962b *Deflandrea rectangularis* Cookson and Eisenack, p. 486, pl. 1, fig. 14-15. Late Turonian-Middle Senonian [Fig. 123].
subsp. *samuelsonii* (Kjellström, 1973) *comb. nov. stat. nov.*
1973 *Deflandrea rectangularis* var *samuelsonii* Kjellström, p. 22, fig. 18. Maastrichtian [Fig. 124].

SPINIDINIUM Cookson & Eisenack, 1962b, emend.
[Fig. 126-138]

TYPE SPECIES: *Spinidinium styloniferum* Cookson and Eisenack, 1962b, p. 489, pl. 1, fig. 1-5. Aptian-?Albian.

DIAGNOSIS: Cookson and Eisenack, 1962b, p. 489: "Shell longer than broad, concavo-convex, with straight or slightly convex slanting sides. Epitheca horned, hypotheca with a small projection on one side. Girdle equatorial circular; longitudinal furrow more or less well developed. Wall of shell two layered, the outer layer of which is covered with small spines, forming the apical horn and antapical projection. A pylome may develop on the dorsal surface of the epitheca."

EMENDED DIAGNOSIS:

Shape

Pericyst: Ambitus rhomboidal to pentagonal (peridinioid) to elongate pentagonal. Apex occasionally rounded, more commonly with an apical horn. Antapex with two symmetrically located antapical horns, which may be equal in length, or unequal when the right antapical horn is reduced, or vestigial, or with only one eccentrically located horn. Epipericyst and hypopericyst of more or less equal size. Compression dorso-ventral, often extreme.

Endocyst: Ambitus ovoidal to rhomboidal, usually appressed against pericyst but not extending into the horns. Usually difficult to delineate. Compression dorso-ventral, often extreme.

Pericoels: Small apical pericoel in the vicinity of the apical horn. One, or two, small antapical pericoels in the vicinity of the single, or the two, antapical horns. The apical and antapical pericoels may be united by an ambital pericoel.

Phragma

Periphragm: Surface ornamented with intratabular, sometimes penetabular, echinae or processes up to several microns long. Processes may be distally acuminate, oblate or evexate. Pericingulum usually delineated by parasutural processes anteriorly and posteriorly.

Endophragm: Laevigate. Usually very thin and difficult to delineate.

Paratabulation

Pericyst: Paratabulation always partially or completely determinable. Penetabular processes often form simulate complexes indicating a typical peridinioid paratabulation of 4', 3a, 7", 5"', and ?2"". The paraplate boundaries are generally devoid of ornamentation.

Pericingulum: Always present; commonly indented; planar, slightly or strongly helicoidal. Parasutures delineated by echinae or processes.

Perisulcus: Extending into the epipericyst but considerably longer and wider on the hypopericyst where it reaches almost to the antapex.

Endocyst: Paratabulation not observed.

Archeopyle

Attenuated hexa or standard hexa intercalary resulting from the partial or complete detachment of the anterior intercalary paraplate 2a. When partially detached, the operculum remains attached along parasuture H4 and accessory archeopyle sutures may develop between precingular paraplates 3"-4" and 4"-5". Since the endophragm and periphragm are appressed in the vicinity of the archeopyle, there is no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum. Transverse archeopyle index is 0.26-0.42. Transverse archeopyle ratio is 0.35-0.75.

Archeopyle Formula: I/I (2a/2a)

Dimensions

Pericyst: Length 34-103 μ, breadth 20-80 μ
Endocyst: Insufficient data.

DISCUSSION:

Specimens of *Spinidinium echinoideum* (Cookson and Eisenack, 1960a) from the Senonian of the Scotian Shelf clearly demonstrate the peridinioid paratabulation of 4', 3a, 7", 5"', and ?2"". The apical paraplate 1' is rhombic, elongate antero-posteriorly. 3" is reduced in length antero-posteriorly. Of the anterior intercalaries 2a is hexagonal, attenuated hexa. The seven precingulars include the quadrate 4", the almost identical antero-posteriorly reduced 3" and 5", the elongate more or less similar 2" and 6", and 1" and 7" slightly dissimilar in size but of the same shape. The shape of the postcingulars is difficult to determine other than 3"' is pentagonal. The two antapicals have not been positively identified. Further study of other species assigned to this genus will probably demonstrate considerable variation in the individual paraplate outlines.

Other genera within the fossil peridinioid group possessing penetabular echinae or processes are *Chatangiella, Gingінodinium* and *Kisselevia*. *Chatangiella* differs from *Spinidinium* in having an easily discernible endocyst, well developed apical and antapical pericoels, a hepta/pentapartite pericingulum, and an omegaform hexa 2a archeopyle. *Ginginodinium* has an intercalary archeopyle in which all three intercalaries are removed, or a combination archeopyle in which all three intercalaries are removed, and accessory archeopyle sutures tend to be developed between precingulars 2"-3", 3"-4", 4"-5" and 5"-6". *Kisselevia* has lateral horns and a quadra intercalary archeopyle resulting from the loss of the second anterior intercalary paraplate 2a.

STRATIGRAPHIC RANGE: (?)Aptian-Paleocene

SPECIES OF *Spinidinium*

"aperturum" (Wilson, 1967a). Now *Vozzhennikovia.*

clavum Harland, 1973, p. 674-675, pl. 84, fig. 5-6, 10; text-fig. 9. Late Campanian [Fig. 129].

densispinatum Stanley, 1965, p. 226-227, pl. 21, fig. 1-5. Paleocene [Fig. 138].

echinoideum (Cookson and Eisenack, 1960a) *comb. nov.*
1960a *Deflandrea echinoidea* Cookson and Eisenack, p. 2, pl. 1, fig. 5-6. Santonian-Campanian [Fig. 132].
subsp. *rhombicum* (Cookson and Eisenack, 1974) *comb. nov., stat. nov.*
1974 *Deflandrea rhombica* Cookson and Eisenack, p. 49-50, pl. 20, fig. 5-9. Albian-Cenomanian. This taxon is lowered to the subspecies level because it is separated from *S. echinoideum,* only by the reduced number of spines on *S. echinoideum* subsp. *rhombicum* [Fig. 137].

essoi Cookson and Eisenack, 1967a, p. 135, pl. 19, fig. 1-8. Paleocene [Fig. 127].

gallium (Davey and Verdier, 1973) *comb. nov.*
1973 *Deflandrea gallia* Davey and Verdier, p. 196-197, pl. 3, fig. 1-4. Late Albian [Fig. 135].

lanterna Cookson and Eisenack, 1970a, p. 144-145, pl. 12, fig. 1-3. Senonian [Fig. 131].

macmurdoense (Wilson, 1967a) *comb. nov.*
1967a *Deflandrea macmurdoensis* Wilson, p. 60-62, fig. 11-16, 22; text-fig. 2a. Erratics. Early Tertiary [Fig. 133].

"microceratum" (Stanley, 1965, p. 227-228, pl. 22, fig. 5-6). Considered to be a *jr syn.* of *S. densispinatum* by Stone, 1973, p. 53-54.

rallum Heisecke, 1970, p. 226-228, pl. 1, fig. 1-2; pl. 2, fig. 1. Danian [Fig. 134].

"rotundum" (Wilson, 1967a). Now *Vozzhennikovia.*

sagittulum (Drugg, 1970b) *comb. nov.*
1970b *Deflandrea sagittula* Drugg, p. 809-810, fig. 1a-c. Early Eocene [Fig. 128].

**styloniferum* Cookson and Eisenack, 1962b, p. 489, pl. 1, fig. 1-5. Aptian-?Albian [Fig. 130].

sverdrupianum (Manum, 1963) *comb. nov.*
1963 *Deflandrea sverdrupiana* Manum, p. 59-60, pl. 2, fig. 6-15; text-fig. 3. Cenomanian [Fig. 126].

vestitum Brideaux, 1971, p. 99-101, pl. 29, fig. 99-103; text-fig. 10a, d. Late Albian-Early Cenomanian [Fig. 136].

VOZZHENNIKOVIA gen. nov.
[Fig. 139-144]

TYPE SPECIES: *Vozzhennikovia apertura* (Wilson, 1967a) *comb. nov.*
1967a *Spinidinium aperturum* Wilson, p. 64-65, fig. 3-5, 8.
Paleocene-Oligocene.

DIAGNOSIS:

Shape

Pericyst: Ambitus rounded to ovoidal. Apex occasionally rounded, more frequently produced into a short apical horn which distally may be acuminate, oblate or invaginated. Antapex rounded or commonly with one eccentrically located left antapical horn. Rarely there are two symmetrically located antapical horns which are unequal in length, the right antapical horn being reduced or vestigial. Epipericyst and hypopericyst of more or less equal size or epipericyst somewhat larger. Ambital outline widest in pericingular region. Compression dorso-ventral, moderate to extreme.

Endocyst: Ambitus rounded to ovoidal, almost always appressed against pericyst apart from in the vicinity of the horns. Usually difficult to delineate. Compression dorso-ventral, often extreme.

Pericoels: A small apical pericoel in the vicinity of the apical horn. If an antapical horn is present there may be a small antapical pericoel.

Phragma

Periphragm: Epipericyst and hypopericyst ornamented with non-tabular echinae or processes rarely exceeding 10 µ in length. The processes may be distally acuminate, oblate or evexate. Processes often orientated in pericingular or perisulcal regions only.

Endophragm: Laevigate. Usually thin and difficult to delineate.

Paratabulation

Pericyst: Paratabulation never discernible other than in the vicinity of the periarcheopyle.

Pericingulum: Generally present and indented. Planar or slightly helicoidal. Anterior and posterior parasutures delineated by a continuous or discontinuous row of echinae or processes. Area of pericingulum within parasutures is devoid of a surface ornamentation.

Perisulcus: Commonly delineated by absence of ornamentation. Indented. Extending onto epipericyst but considerably longer and wider on the hypopericyst reaching almost to the antapex.

Endocyst: Paratabulation not observed.

Archeopyle — Standard hexa or broad hexa intercalary resulting from the partial or complete detachment of the anterior intercalary paraplate 2a. The operculum may be free or remain attached along parasuture H4. Since the endophragm and periphragm are appressed in the vicinity of the archeopyle, there is no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum. Transverse archeopyle index is 0.33-0.50. Transverse archeopyle ratio is 0.50-1.0.

Archeopyle Formula: I

Dimensions — Pericyst: Length 40-85 μ, breadth 41-66 μ

DISCUSSION: *Vozzhennikovia* is characterized by having a pericyst ornamented with nontabular echinae or processes and with a rounded to ovoidal ambital outline. There is usually a short apical horn and a short eccentrically located antapical horn, both of which may be absent. The genus is unusual in including species with a standard hexa 2a archeopyle [*Vozzhennikovia aperturum* (Wilson, 1967a) and *V. rotundum* (Wilson, 1967a)] and a species with a broad hexa 2a archeopyle [*V. extensa* (Stover, 1973)]. The nature of the archeopyle in *?Vozzhennikovia tenella* (Morgenroth, 1966b) is not known. This species is questionably included in *Vozzhennikovia* because of having two more or less equal antapical horns.

Vozzhennikovia differs from *Spinidinium* in having nontabular, rather than intratabular and specifically penetabular ornamentation. Other genera within the fossil peridinioid group possessing echinae or processes are *Chatangiella, Ginginodinium, Kisselevia, Phthanoperidinium, Sumatradinium, Wetzeliella* and *Wilsonidium*. *Chatangiells* differs from *Vozzhennikovia* in having an easily discernible endocyst, well developed apical and antapical pericoels, an omegaform hexa 2a archeopyle and echinae or processes that when present are penetabular. *Ginginodinium* has an intercalary archeopyle in which all three intercalaries are removed, or a combination archeopyle in which all three intercalaries are removed, and accessory archeopyle sutures tend to be developed between precingular paraplates 2"-3", 3"-4", 4"-5", and 5"-6". The pericyst of *Kisselevia* has discernible paratabulation delineated by penetabular processes or simulate process complexes, lateral horns and a quadra intercalary archeopyle resulting from the loss of the second anterior intercalary paraplate 2a. *Phthanoperidinium* has echinae or processes that are parasutural or penetabular and a hexa intercalary archeopyle resulting from the loss of the second anterior intercalary paraplate 2a. *Sumatradinium* has a pericyst which lacks horns, and has relatively long processes, usually exceeding 10 μ in length. *Wetzeliella,* like *Vozzhennikovia,* has nontabular processes but also possesses lateral (pericingular) horns and a quadra intercalary archeopyle resulting from the loss of the second anterior intercalary paraplate 2a. *Wilsonidium* has a pericyst with parasutural ornamentation, lateral (pericingular) horns and a quadra intercalary archeopyle resulting from the loss of the second anterior intercalary paraplate 2a.

STRATIGRAPHIC RANGE: Paleocene-Oligocene

SPECIES OF *Vozzhennikovia*

**apertura* (Wilson, 1967a, p. 64-65, fig. 3-5, 8) Lentin and Williams, *comb. nov.*
(above) Paleocene-Oligocene [Fig. 139].

?extensa (Stover, 1973) *comb. nov.*
1973 *Deflandrea extensa* Stover, p. 178-179, pl. 5, fig. 4a-c, 5a-d, 6. Middle-Late Eocene. This species, which has a broad hexa 2a archeopyle, is questionably included in *Vozzhennikovia*. Stover (1973, p. 178) stated that the processes are fairly evenly spaced. He later observed (p. 179) that the paratabulation is commonly obscure although the outlines of some precingular and postcingular paraplates can be identified by the alignment of the processes, particularly on the dorsal surface of the epicyst. This is confirmed by the accompanying illustrations (pl. 5, fig. 4a and 5a). *Deflandrea extensa* appears to represent a distinct morphotype. For the present, however, it is questionably included in *Vozzhennikovia* [Fig. 140].

?filigrana (Benedek, 1972) *comb. nov.*
1972 *?Deflandrea filigrana* Benedek, p. 12-13, pl. 4, fig. 3. Middle Oligocene. This species which has a broad hexa 2a archeopyle is questionably included in *Vozzhennikovia* [Fig. 143].

rotunda (Wilson, 1967a) *comb. nov.*
1967a *Spinidinium rotundum* Wilson, p. 65-66, fig. 6-7. Eocene [Fig. 141].

tenella (Morgenroth, 1966b) *comb. nov.*
1966b *Lejeunia tenella* Morgenroth, p. 4-5, pl. 1, fig. 8-9. Early Oligocene. This species does not conform to the generic diagnosis of *Vozzhennikovia* in that it possesses two antapical horns of more or less equal length [Fig. 144].

tenera (Krutzsch, 1962) *comb. nov.*
1962 *?Deflandrea tenera* Krutzsch, p. 44, pl. 11, fig. 20-22; text-fig. 1e. Middle Eocene [Fig. 142].

LEJEUNIA Gerlach, 1961, emend. Kjellström, 1972, emend.
[Fig. 145-154]

TYPE SPECIES: *Lejeunia hyalina* Gerlach, 1961, p. 169, pl. 26, fig. 10-11, emend. Kjellström, 1972, p. 469. Late Oligocene.

DIAGNOSIS: Gerlach, 1961, p. 169 (translation): "Theca bilaterally symmetrical-pentagonal, with apical horn and two antapical horns, without tabulation. Course of transverse furrow spiral, longitudinal furrow suggested."

Kjellström, 1972, p. 267: "Proximate dinoflagellate cysts, pentagonal in shape, more or less well defined apical horn and two antapical horns. Cingulum present or absent. Sulcus weakly defined or absent. No tabulation. Archaeopyle precingular."

EMENDED DIAGNOSIS:

Shape — Pericyst: Ambitus rhomboidal to peridinioid, pentagonal, usually elongated in an anterio-posterior direction. Apex rounded or prolonged into an apical horn of variable length, which usually merges imperceptibly with the anterior epipericyst. Antapex with two unequal symmetrically located antapical lobes separated by a concavity, or with two more or less equal symmetrically located antapical horns. These usually merge imperceptibly with the posterior hypopericyst. The right antapical horn is sometimes reduced. Epipericyst and hypopericyst of more or less equal size. Length to breadth ratio generally > 1. Compression dorso-ventral, often extreme.

Endocyst: Not always observable. In some taxa appears to be appressed to pericyst throughout.

Pericoels: May be present as small cavities at the tips of the apical and antapical horns.

Phragma — Usually of constant thickness and rarely separable into periphragm and endophragm. Surface laevigate or striate.

Paratabulation — Pericyst: Paratabulation indeterminate other than in the vicinity of the archeopyle.

Pericingulum: Present or absent. When present may be delineated by folding, by one parasuture only, or by anterior and posterior parasutures. The parasutures may be raised with entire or denticulate margins. Commonly indented. Planar or helicoidal.

Perisulcus: Extending onto epipericyst but considerably larger on the hypopericyst. Widening posteriorly.

Endocyst: Paratabulation indeterminate.

Archeopyle — When observable standard hexa resulting from the partial or complete detachment of the second anterior intercalary paraplate 2a. This paraplate extends almost to the pericingulum in several specimens. Operculum free or remaining attached along parasuture H4. Since the endophragm and periphragm are appressed in the vicinity of the archeopyle, there is no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum. Transverse archeopyle index is 0.36-0.47. Transverse archeopyle ratio is 0.58-0.88.

Archeopyle Formula: I/I (2a/2a).

Dimensions — Pericyst: Length 45-148 μ, breadth 51-115 μ
Endocyst: Insufficient data

DISCUSSION: *Lejeunia* is characterized by its generally peridinioid outline, a standard hexa intercalary 2a archeopyle and a smooth or striate periphragm.

Kjellström (1972) stated that the archeopyle in *Lejeunia* is precingular. The specimen illustrated in Figure 1 (Fig. 153, herein) and which Kjellström places in the type species *Lejeunia hyalina* can be more accurately interpreted as having an intercalary archeopyle resulting from the loss of the second anterior intercalary, 2a. Other species of *Lejeunia* also possess a 2a archeopyle. *Lejeunia* cf. *tricuspis* Gorka, 1963 (pl. 5, fig. 2) and *Lejeunia psilodora,* Benedek, 1972 (pl. 6, fig. 5) both possess a hexagonal archeopyle whose size and location conforms with the second anterior intercalary paraplate, if the paratabulation of this genus is peridinioid. The peridinioid ambital outline, dorso-ventral compression, bilateral symmetry, often equal antapical horns and shape of the archeopyle clearly indicate a close affinity with *Peridinium.* Therefore Kjellström's assumption that the archeopyle results from the loss of a precingular paraplate appears to be at variance with the evidence, particularly since this type of archeopyle is unknown in peridinioid forms.

Lejeunia was regarded by Gerlach (1961) as a nontabulate *Palaeoperidinium.* Deflandre (1934) stated that *Palaeoperidinium* included fossil dinoflagellates like *Peridinium* which possessed an indeterminate paratabulation. Sarjeant (1967, p. 246) emended the genus *Palaeoperidinium* to include fossil peridinioid forms with a paratabulation of 4', 3a, 7", 5-?7c, 5"', and 2"" and an epicystal (epitractal) archeopyle. His accompanying illustrations of topotype specimens of the type species of the genus *Palaeoperidinium, P. pyrophorum,* clearly show an archeopyle suture running immediately anterior to the paracingulum on the dorsal surface. Figure 6 also shows a detached hypocyst. Specimens of *Palaeoperidinium pyrophorum* from the Paleocene of the Scotian Shelf demonstrably possess an A_3'3I3P_3"-5" archeopyle. Study of specimens of the species *Palaeoperidinium basilium* Drugg, 1967 (pl. 1, fig. 10) show separation of the epicyst from the rest of the cyst immediately anterior to the anterior parasuture of the paracingulum. *P. basilium,* as Evitt

(1975) has also demonstrated, obviously has an $\overline{A_{3'}3I3P_{3''-5''}}$ archeopyle identical to that in *P. pyrophorum*. *Lejeunia* can therefore be distinguished from *Palaeoperidinium* by the nature of the archeopyle and the absence of pandasutural zones.

The genus *Pentagonum* Vozzhennikova, 1963, was differentiated from *Lejeunia* by Vozzhennikova (1967, p. 106) in having a planar rather than laevorotatory paracingulum and being strongly compressed dorso-ventrally. Both conditions are present in *Lejeunia*. Two species are included in *Pentagonum*, *P. marginatum* and the type species *P. sibiricum*. One of the specimens figured as *P. marginatum* by Vozzhennikova (1967, pl. 46, fig. 3) has lost the dorsal epipericyst as can be seen from the extremely thin transparent remaining ventral epipericyst. The specimen of the same species in pl. 46, fig. 4, shows development of the transapical suture and partial attachment of the operculum along its posterior margin. Thus the archeopyle is the $A_{3'}3I3P_{3''-5''}$ type as found in *Palaeoperidinium*. *Pentagonum* is herein regarded as a *jr syn.* of *Palaeoperidinium*.

Davey (1970, p. 359) when erecting the genus *Astrocysta* stated that the archeopyle when visible is intercalary. The holotype of the type species, *A. cretacea* figured by Pocock (1962), and the specimen figured by Davey (pl. 1, fig. 4) have the $A_{3'}3I3P_{3''-5''}$ archeopyle found in *Palaeoperidinium* and resulting from the partial or complete loss of paraplates 3', 1-3a, and 3"-5". Norris and Hedlund (1972) in a detailed study of *A. cretacea* confirm the presence of a transapical archeopyle suture. *Astrocysta* is herein considered a *jr syn.* of *Palaeoperidinium*.

The genus *Maduradinium* Cookson and Eisenack, 1970a, p. 150, is defined as having a circular to pentagonal autocyst with an apical horn and one or two antapical lobes. The archeopyle is large, six-sided and allegedly precingular. Cookson and Eisenack's accompanying illustrations (pl. 10, fig. 13 through 16) show a standard hexa intercalary archeopyle resulting from the loss of anterior intercalary paraplate 2a. Cookson and Eisenack (1974, pl. 20, fig. 10, 11) illustrated specimens of *Maduradinium pentagonum* with a well developed endocyst although where mention of this is made in the text it is referred to as a conglomeration of nodules of up to 2 μ diameter. *Maduradinium* is differentiated from *Lejeunia* by the presence of ornamentation on the periphragm and the absence of two antapical horns. The specimens illustrated by Cookson and Eisenack (1974) and named *Maduradinium pentagonum* are assignable to *Alterbia*.

The genus *Selenopemphix* Benedek, 1972, differs from *Lejeunia*, in always being compressed apically, antapically, and not dorso-ventrally as in the latter genus. *Vozzhennikovia gen. nov.* which also has a 2a archeopyle always possesses processes, which are randomly orientated.

STRATIGRAPHIC RANGE: Senonian-Late Oligocene

SPECIES OF *Lejeunia*

"aechmophora" (Benedek, 1972). Now *?Wilsonidium.*

"cretacea" (Pocock, 1962). Now *Palaeoperidinium.*

fallax Morgenroth, 1966b, p. 2-3, pl. 1, fig. 6-7. Middle Oligocene [Fig. 146].

**hyalina* Gerlach, 1961, p. 169-171, pl. 26, fig. 10-11. Late Oligocene [Fig. 145 and 153].

kozlowskii Gorka, 1963, p. 41, pl. 5, fig. 4. Late Maastrichtian [Fig. 149].

laevigata (Malloy, 1972) *comb. nov.*
1972 *Deflandrea laevigata* Malloy, p. 64, pl. 1, fig. 1-7. Senonian. The species *Senegalinium psilatum* (Jain and Millepied, 1973, p. 23-24, pl. 1, fig. 5-6) is considered to show the variety of morphological characteristics described by Malloy (1972) as typical of the species *Lejeunia laevigata* (Malloy, 1972) *comb. nov.* and is considered to be a junior synonym [Fig. 147].

magnifica (Stanley, 1965) *comb. nov.*
1965 *Deflandrea magnifica* Stanley, p. 218-219, pl. 20, fig. 1-6. Paleocene [Fig. 150].

paratenella Benedek, 1972, p. 41-42, pl. 5, fig. 8; text-fig. 18. Late Oligocene [Fig. 151].

pentagonalis (Corradini, 1973) *comb. nov.*
1973 *Deflandrea pentagonalis* Corradini, p. 175, pl. 28, fig. 3 [Fig. 148].

psilodora Benedek, 1972, p. 42, pl. 6, fig. 5. Middle Oligocene [Fig. 154].

"spatiosa" (Morgenroth, 1966b). Now *Maduradinium.*

"tenella" (Morgenroth, 1966b). Now *Vozzhennikovia.*

tricuspia (O. Wetzel, 1933a, p. 166, pl. 2, fig. 14) Gorka, 1963, p. 40. Senonian [Fig. 152].

MADURADINIUM Cookson and Eisenack, 1970a
Fig. 155-156

TYPE SPECIES: *Maduradinium pentagonum* Cookson and Eisenack, 1970a, p. 150, pl. 10, fig. 13-17.

DIAGNOSIS: Cookson and Eisenack, 1970a, p. 150: "Shell five-sided to nearly circular in outline with a readily detachable apical horn and one or two antapical projections. Girdle relatively wide, circular in outline with more or less strongly developed borders and a wide ventral furrow. The archeopyle is relatively large, precingular, six-sided with a straight to somewhat rounded outline.

Surface of shell finely granular, typically with scattered patches of more or less strongly developed, closely arranged thickenings, especially in the vicinity of the apex, antapex and girdle."

EXPANDED DIAGNOSIS:

Shape — Pericyst: Ambitus rhomboidal to pentagonal. Apex rounded or prolonged into an apical horn, which may merge imperceptibly with the anterior epipericyst or be sharply differentiated. Antapex with one eccentrically located antapical lobe or horn, invariably the left, or two more or less equal symmetrically located antapical lobes. Epipericyst and hypopericyst of more or less equal size. Length:breadth ratio commonly < 1. Compression dorso-ventral, often extreme.

Phragma — Autophragm: Thin. Surface granulate to verrucate to pustulate. Ornamentation uniformly distributed or concentrated in apical, antapical and autocingular regions, with individual granules decreasing in size away from these regions. Separation into periphragm and endophragm not observed.

Paratabulation — Autocyst: Not observable other than in the vicinity of the archeopyle.

Autocingulum: Present or absent. When present delineated by folding or with anterior and posterior parasutures represented by ridges. Autocingulum wide, planar or possibly slightly helicoidal. May be indented.

Autosulcus: Extending onto epiautocyst; more fully developed on the hypoautocyst and broadening antapically.

Autoarcheopyle: Hexa intercalary archeopyle resulting from the partial or complete detachment of the second anterior intercalary paraplate 2a. Autooperculum free or remaining attached along parasuture H4. Orientation of specimens prevents determination of transverse archeopyle index or ratio.

Archeopyle Formula: I

Dimensions — Autocyst: Length 80-103 μ, breadth 78-110 μ

DISCUSSION: *Maduradinium* is characterized by being an autocyst, its peridinioid outline in ambital view, the development of one antapical lobe or horn or two antapical lobes, the hexa 2a intercalary archeopyle and the ornamented phragma, the ornamentation often being unequally distributed. The distribution of the ornamentation is similar to that commonly present in the endocyst of *Wetzeliella* Eisenack. *Lejeunia* differs in having a laevigate periphragm and two antapical horns. Cookson and Eisenack (1974, pl. 20, fig. 10, 11) have illustrated specimens which they place in *Maduradinium pentagonum* and which possess a well developed granulate endocyst, although where mention of this is made in the text (P. 54), it is referred to as a conglomeration of small nodules of up to 2 μ in diameter. It is the present authors' opinion that the specimens illustrated are not *Maduradinium*, differing in the distinct differentiation into endocyst and pericyst, the apparently narrower 2a archeopyle and the general absence of ornamentation on the pericyst. These specimens should be included in *Alterbia*.

STRATIGRAPHIC RANGE: Senonian-Early Oligocene

SPECIES OF *Maduradinium*

**pentagonum* Cookson and Eisenack, 1970a, p. 150, pl. 10, fig. 13-17. Senonian [Fig. 156].

spatiosum (Morgenroth, 1966b) *comb. nov.*
1966b *Lejeunia spatiosa* Morgenroth, 1966b, p. 3-4, pl. 1, fig. 5. Early Oligocene [Fig. 155].

PHTHANOPERIDINIUM Drugg and Lobelich, 1967
[Fig. 157-165]

TYPE SPECIES: *P. amoenum* Drugg and Lobelich, 1967, p. 182, pl. 1, fig. 1-5; text-fig. la-e. Oligocene.

DIAGNOSIS: Drugg and Loeblich, 1967, p. 182: "Proximate fossil cysts, more or less ovoidal in shape, with a short apical projection. Tabulation 4', 3a, 7", 5"', 2"". Additional furrow platelets may be present. The archeopyle is formed by the removal of intercalary plate 2a. Sutures delineated by low ridges, crests, or lines of spines."

EXPANDED DIAGNOSIS:

Shape — Pericyst: Ambitus ovoidal to ellipsoidal, with or without a short apical horn. The single short, slightly offset antapical horn, when present, is presumably the left. Epipericyst and hypopericyst more or less equal or unequal when the epipericyst is the larger. Compressicn tends to be dorso-ventral.

Endocyst: Ambitus ovoidal to ellipsoidal, a reflection of the outline of the pericyst, to which it is appressed apart from in the vicinity of the apical and antapical horn, if these are present.

Pericoels: Small apical and antapical pericoels present in specimens with an apical and an antapical horn.

Phragma — Periphragm: Thin. Surface laevigate, scabrate, granulate vermiculate or reticulate. With parasutural ridges, septa or processes, and with pandasutural zones delineated by penetabular and intratabular ornamentation. The processes which may be parasutural or penetabular are acuminate, oblate, bifid, bifurcate, trifurcate or multifurcate distally and are up to 20 μ in length.

Endophragm: Of equal or greater thickness than the periphragm and may be dense. Appressed to periphragm except in the vicinity of the horns.

Paratabulation — Pericyst: Typical peridinioid and indicated either by parasutural ridges, septa or processes, and/or pandasutural zones which are delineated by penetabular and intratabular ornamentation. Paratabulation formula 4', 3a, 7", 5c, 5"', 2"" and up to 5s. In specimens of *Phthanoperidinium* sp. examined from the Oligocene of the Grand Banks the paraplates are as follows:
Apical paraplate 1', rhombic elongate and whose posterior parasuture forms anterior margin of parasulcus; 2'and 4' are more or less identical pentagonal; 3' is pentagonal, reduced in length antero-posteriorly and pcsteriorly abutting against anterior intercalary 2a. 2a is standard hexa. la and 3a are more or less equal size and are being

pentagonal and considerably smaller than 2a. Of the seven precingulars 1" and 7" are more or less of similar size and shape being pentagonal; 2", 3", 5" and 6" are pentagonal; 2" and 6" are similar in size and shape as are also the smaller 3" and 5"; 4" is quadrate with the longest axis lying parallel to the paracingulum, whilst its antero-posterior axis is of a shorter length than those of other precingulars.

The cingular paraplates appear to be five in number. The five postcingular paraplates consist of the similar 1"' and 5"' and the identical 2"' and 4"' all of which are quadrate and the pentagonal 3"'. Paraplates 1"" and 2"" are pentagonal and of similar size and largely confined to the dorsal surface. Of the sulcal paraplates, the pentagonal posterior is very large, the others are reduced.

Pericingulum: Clearly delineated with anterior and posterior, parallel parasutural ridges which may bear processes. Pericingulum planar or slightly helicoid. Apparently composed of five paraplates.

Perisulcus: Clearly delineated, extends onto the epipericyst but considerably larger and usually depressed on the hypopericyst and extending to the antapex. Commonly the individual paraplates are discernible, the most prominent being the posterior.

Endocyst: Paratabulation not discernible.

Archeopyle — Standard hexa intercalary resulting from the detachment of the anterior intercalary paraplate 2a. Operculum usually free. Since the endophragm and periphragm are appressed in the vicinity of the archeopyle, there is no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum. Transverse archeopyle index is 0.36-0.60. Transverse archeopyle ratio is 0.57-1.54.

Archeopyle Formula: I/I (2a/2a).

Dimensions — Pericyst: Length 33-66 μ, breadth ?20-48 μ

DISCUSSION: *Phthanoperidinium* possesses peridinioid paratabulation which is delineated by parasutural ridges, septa or processes, and pandasutural zones bordered by penetabular ridges septa or processes. The pandasutural zones are relatively narrow. *Phthanoperidinium* is also characterized by the presence of a standard hexa 2a intercalary archeopyle, only one, or commonly no antapical horn, and its relatively small overall size. It differs from *Spinidinium* in the nature of the ornamentation and its location which always delineates the paratabulation, and from *Ginginodinium* in having a 2a archeopyle.

STRATIGRAPHIC RANGE: Senonian-Early Pliocene

SPECIES OF *Phthanoperidinium*

**amoenum* Drugg and Loeblich, 1967, p. 182, pl. 1, fig. 1-5; text-fig. 1a-e. Oligocene [Fig. 163].

campoense Caro, 1973, p. 359-360, pl. 4, fig. 7. Early Eocene [Fig. 165].

comatum (Morgenroth, 1966b, p. 1-2, pl. 1., fig. 1-2). Eisenack and Kjellström, 1971a, p. 907. Early Oligocene [Fig. 160].

coreoideum (Benedek, 1972) *comb. nov.*
1972 *Hystrichogonyaulax coreoides* Benedek, p. 20, pl. 9, fig. 4.
Middle Oligocene [Fig. 161].

"diamantum" (Churchill and Sarjeant, 1963, p. 34-36, pl. 1, fig. 19; text-fig. 3). This species is here transferred to the genus *Gonyaulacysta* as *G. diamanta comb. nov.*

?eocenicum (Cookson and Eisenack, 1965a, p. 119-120, pl. 11, fig. 1-5) Lentin and Williams, 1973, p. 113. Late Eocene [Fig. 159].

?illustrans (O. Wetzel, 1933a, p. 167, pl. 2, fig. 15) Lentin and Williams, 1973, p. 113. Senonian [Fig. 164].

lambdoideum (Nagy, 1966, p. 39, pl. 1, fig. 1-3; text-fig. 1a-b) Eisenack and Kjellström, 1971a, p. 909. Early Pliocene [Fig. 162].

?polytrix (Benedek, 1972) *comb. nov.*
1972 *Hystrichogonyaulax polytrix* Benedek, p. 20, pl. 6, fig. 1.
Middle Oligocene [Fig. 158].

resistente (Morgenroth, 1966a, p. 5, pl. 2, fig. 1-2) Eisenack and Kjellström, 1971a, p. 911. Early Eocene [Fig. 157].

SUMATRADINIUM gen. nov.
[Fig. 166]

TYPE SPECIES: *Sumatradinium hispidum* (Drugg, 1970a) *comb. nov.*
1970a *Xenicodinium hispidum* Drugg, p. 120-121, fig. 12-15.
Middle Miocene-Pliocene.

DIAGNOSIS:

Shape

Pericyst: Ambitus rounded to ovoidal to pentagonal, widest in the pericingular region. Apex rounded, apical horn absent. Antapex rounded, flattened or with very weakly developed symmetrically located antapical lobes. Epipericyst and hypopericyst of approximately equal size. Length:breadth ratio *ca.* 1. Compression dorso-ventral, usually extreme.

Endocyst: Not always observable. In some specimens appears to be appressed to pericyst throughout.

Pericoels: Absent.

Phragma

Periphragm: Surface rarely laevigate, generally scabrate to granulate, reticulate or rugulate, the rugulae often developed into a hieroglyphic ornamentation. Generally nontabular, occasionally penetabular, processes of varying length are always present. They may be uniformly distributed or concentrated along the ambitus. The processes are hollow, slender, distally acuminate, oblate or bifid. Occasionally they are separated along their length by septa.

Endophragm: Where observed, very thin and laevigate.

Paratabulation

Pericyst: Some processes appear to be penetabular but the paratabulation is obscure, although it must be peridinioid from the nature of the archeopyle. The 2a paraplate is very large, extending almost to the pericingulum, from which it is separated by a very narrow 4" paraplate.

Pericingulum: May be partially delineated by penetabular processes. Planar or slightly helicoidal.

Perisulcus: Rarely determinable; when visible appears to be largely restricted to hypopericyst.

Endocyst: Paratabulation unknown, other than presumably in the vicinity of the endoarcheopyle.

Archeopylew

Large, broad hexa intercalary resulting from the partial or complete detachment of the second anterior intercalary paraplate 2a. Operculum free or remaining attached along parasuture H4. Since the endophragm and periphragm are appressed in the vicinity of the archeopyle, there is no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum. Transverse archeopyle index is 0.45. Transverse archeopyle ratio is 1.8.

Archeopyle Formula: I/I (2a/2a?)

Dimensions — Pericyst: Length 78-97 μ, breadth 72-87 μ

DISCUSSION: *Sumatradinium gen. nov.* is characterized by the absence of apical and antapical horns and pericoels, the large 2a intercalary archeopyle, and the presence of processes. *Spinidinium* differs in possessing both an apical and one or two antapical horns. *Chatangiella* differs in having a well developed apical and two unequally developed antapical horns, an omegaform archeopyle, an hexa/pentapartite pericingulum and pericoels. *Sumatradinium* superficially resembles *Wetzeliella,* the latter genus differs, however, in having pericingular horns and a quadra 2a archeopyle. The diagnosis for the genus *Sumatradinium* is based on the diagnosis for *Sumatradinium hispidum* given by Drugg (1970, p. 120-121) and the personal observation of several specimens from the Neogene of the Grand Banks and Scotian Shelf.

STRATIGRAPHIC RANGE: Miocene-Pliocene

SPECIES OF *Sumatradinium*

**hispidum* (Drugg, 1970a) *comb. nov.*
above; Middle Miocene-Pliocene [Fig. 166].

UVATODINIUM Vozzhennikova, 1963
[Fig. 167-168]

TYPE SPECIES: *Uvatodinium nasutum* Vozzhennikova, 1963, p. 182, text-fig. 13a-b. Paleocene.

DIAGNOSIS: Vozzhennikova, 1963, p. 182 (translation): "Cells spherical or roundly ovoidal with well developed anterior or apical horn. Antapical or posterior horns are absent. In their places are sometimes developed crest-like protrusions or other structures. Transverse furrow circular and located in the middle of the cell or slightly lower in which case it divides the cell into two uneven parts. Longitudinal furrow is located on the hypovalve. Membrane hyaline, dense cellular. Spines and denticles of varying size may be present at the junctions."

EXPANDED DIAGNOSIS:

Shape

Pericyst: Ambitus ovoidal, widest in the precingular region. Apex prolonged into a well developed apical horn, which is sharply delineated from the rest of the epipericyst. Antapex rounded. Sometimes there is a slight pericingular bulge. Epipericyst and hypopericyst more or less equal or unequal when the epipericyst is the larger. Compression dorso-ventral.

Endocyst: Ambitus ovoidal, sometimes with apical protuberance. Appressed to pericyst except in vicinity of apical horn.

Pericoels: Small apical pericoel. Occasionally there is also developed an antapical pericoel.

Phragma

Periphragm: Surface reticulate, granulate, echinate or bearing spines at the intersection of the muri.

Endophragm: Details unknown.

Paratabulation

Pericyst: Paratabulation unknown other than in the vicinity of the archeopyle. Presumably peridinioid.

Pericingulum: Present but often difficult to delineate, apart from where it crosses the ambitus. Appears to be planar or slightly helicoidal.

Perisulcus: Faintly developed and broader on the hypopericyst.

Endocyst: Paratabulation unknown, other than in the vicinity of the archeopyle.

Archeopyle

Standard hexa intercalary resulting from the partial or complete detachment of the second anterior intercalary paraplate 2a. Since the endophragm and periphragm are appressed in the vicinity of the archeopyle, there is no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum. Orientation of specimens prevents determination of transverse archeopyle index or ratio.

Archeopyle Formula: I/I (2a/2a)

Dimensions — Pericyst: Length 97-179 μ, width 78-140 μ

DISCUSSION: *Uvatodinium* is characterized by having an ovoidal outline, a well developed apical horn, a rounded antapex, and an anterior intercalary 2a archeopyle. It lacks antapical horns. The nature of the archeopyle is clearly shown in Vozzhennikova (1967, pl. 8, fig. 4) which is an illustration of the type of the genus *Uvatodinium, U. nasutum*. *Uvatodinium* is distinguished from *Nelsoniella* by the absence of a large apical pericoel and the nature of the ornament. *Deflandrea* differs in having antapical horns and a broad hexa archeopyle. *Spongodinium* has a similar ambital outline and periphragm ornamentation but possesses a large precingular archeopyle resulting from the loss of paraplate 3".

STRATIGRAPHIC RANGE: Paleocene

SPECIES OF *Uvatodinium*

marginatum Vozzhennikova, 1967, p. 51-52, pl. 8, fig. 1-2. Paleocene [Fig. 168].

**nasutum* Vozzhennikova, 1963, p. 182, text-fig. 13a-b. Paleocene [Fig. 167].

NELSONIELLA Cookson and Eisenack, 1960a
[Fig. 169-171]

TYPE SPECIES: *Nelsoniella aceras* Cookson and Eisenack, 1960a, p. 5, pl. 1, fig. 12-13. Santonian-Campanian.

DIAGNOSIS: Cookson and Eisenack, 1960a, p. 4: "Shell circular in outline, epithecal and hypothecal regions distinctly differentiated, not delimited by a girdle but by the anterior limit of the large capsule, which completely fills the hypotheca and causes the shell to bulge considerably on the ventral surface; the dorsal surface, marked by a prominent pylome, is slightly convex. The epitheca is variously sculptured and may or may not be provided with an apical horn. The wall of the hypotheca is smooth.

"*Nelsoniella* is closely related to the genus *Deflandrea* but is readily distinguished from it by the convex form of the hypotheca, the absence of antapical horns and the fact that the capsule completely fills the cavity of the hypotheca."

EXPANDED DIAGNOSIS:

Shape

Pericyst: Ambitus circular to subcircular to ovoidal to rhomboidal, commonly with an equatorial bulge. Apex rounded with sometimes a slight concavity, or with a short, usually oblate apical horn. Antapex rounded or indented. Compression dorso-ventral.

Endocyst: Commonly folded, circular to ovoidal when not folded, and only partially filling the epipericyst. Endocyst and pericyst appressed in the hypocyst.

Pericoels: One large apical pericoel always occupying the apical and, sometimes, the intercalary and precingular regions.

Phragma

Periphragm: Usually of uniform thickness. Generally laevigate on the hypopericyst; laevigate, scabrate, granulate, verrucate or reticulate on the epipericyst.

Endophragm: Surface laevigate to scabrate.

Paratabulation

Pericyst: Paratabulation indeterminate other than in the vicinity of the archeopyle.

Pericingulum: Not indicated.

Perisulcus: Not indicated.

Endocyst: Paratabulation indeterminate.

Archeopyle — Periarcheopyle: Attenuated hexa to standard hexa intercalary resulting from the partial or complete detachment of the second anterior intercalary paraplate 2a. When partially detached the operculum remains attached along parasuture H4. Transverse archeopyle index is 0.43-0.53. Transverse archeopyle ratio is 0.77-1.30.

Endoarcheopyle: Appears to be standard hexa from the visible posterior margin of the endoperculum.

Archeopyle Formula: I/I (2a/2a)

Dimensions — Pericyst: Length 64-123 μ, breadth 62-108 μ
Endocyst: Dimensions not given.

DISCUSSION: *Nelsoniella* is characterized by its rounded antapex, the presence of a large anterior or apical pericoel and absence of an antapical pericoel, and its intercalary archeopyle. Cookson and Eisenack (1960a, p. 4) placed considerable emphasis on the endocyst completely filling the hypopericyst. This together with the large apical pericoel appear to be consistent features which permit ready recognition of this genus. *Nelsoniella* differs from *Isabelia* in not having an antapical pericoel or antapical horns. *Amphidiadema* has a large antapical pericoel, always lacks an apical horn and has a more pronounced bulge which extends from the precingular to cingular to postcingular regions. *Deflandrea* has a pseudoquadra to broad hexa archeopyle, well developed antapical horns and generally possesses a pericingulum.

STRATIGRAPHIC RANGE: Santonian-Campanian

SPECIES OF *Nelsoniella*

**aceras* Cookson and Eisenack, 1960a, p. 4, pl. 1, fig. 12-13. Santonian-Campanian [Fig. 171].

semireticulata Cookson and Eisenack, 1960a, p. 4-5, pl. 1, fig. 15. Santonian-Campanian [Fig. 169].

tuberculata Cookson and Eisenack, 1960a, p. 4, pl. 1, fig. 14. Santonian-Campanian [Fig. 170].

HEXAGONIFERA Cookson and Eisenack, 1961a
[Fig. 172-173]

TYPE SPECIES: *Hexagonifera glabra* Cookson and Eisenack, 1961a, p. 74, pl. 12, fig. 9-13. Senonian.

DIAGNOSIS: Cookson and Eisenack, 1961a, p. 73: "Shell oval, wall of variable thickness, smooth or ornamented. Pylome formed by the removal of a six-sided lid at one pole."

Cookson and Eisenack, 1962b, p. 495: "Shell oval, either without or partially or completely enclosed in a thin, transparent, detachable membrane, wall of variable thickness, smooth or variously sculptured. Pylome formed by the removal of a six-sided portion of the shell at one end."

EXPANDED DIAGNOSIS:

Shape

Pericyst: Present or absent. When present outline is shapeless, determined by endocyst or circular to ovoidal in ambital view.

Endocyst: Ambitus ovoidal to ellipsoidal, rounded at the apex and antapex.

Pericoels: There may be a prominent ambital pericoel or a large apical and a large antapical pericoel or numerous small and haphazardly distributed and orientated pericoels.

Phragma

Periphragm: May be appressed to endophragm or separated. Thin, commonly fragmentary and not always uniformly present over the endophragm.

Endophragm: Thick walled. Surface laevigate, scabrate, granulate or otherwise ornamented.

Paratabulation

Pericyst: Paratabulation indeterminate.

Pericingulum: Not discernible.

Perisulcus: Not discernible.

Endocyst: Paratabulation clearly delineated on the holotype of *H. glabra*. Peridinioid.

Endocingulum: Clearly delineated on the holotype of *H. glabra*, broad. Slightly helicoidal.

Endosulcus: Well developed on the hypoendocyst.

Archeopyle

Standard hexa intercalary resulting from the detachment of the anterior intercalary paraplate 2a. Operculum usually free.

When the endophragm and periphragm are appressed in the vicinity of the archeopyle, there appears to be no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum. Orientation of specimens prevents determination of transverse archeopyle index or ratio.

Archeopyle Formula: I/I (2a/2a)

Dimensions (Based on *H. chlamydata* and *H. glabra* only)
Pericyst: Length 68-75 μ, breadth 42-66 μ?
Endocyst: Length 56-77 μ, breadth 42-65 μ

DISCUSSION: The genus *Hexagonifera* was erected by Cookson and Eisenack (1961a, p. 73) and initially included two species, *H. glabra* the type of the genus and *H. vermiculata*. *Hexagonifera glabra* conforms to the generic diagnosis in having an hexa 2a archeopyle as can be seen in Cookson and Eisenack (1961a, pl. 12, fig. 10-11). This has been confirmed by the present authors in a microscopic examination of the holotype which was seen by courtesy of Dr. Robin Helby. *Hexagonifera vermiculata* and the species *H. suspecta* subsequently included in this genus, have a 3I intercalary archeopyle as can be seen in Cookson and Eisenack (1961a, pl. 12, fig. 7-8, *H. vermiculata*) and Manum and Cookson (1964, pl. 1, fig. 10-13, *H. suspecta*). Accordingly these two species are herein transferred to *Trithyrodinium*. The species remaining in *Hexagonifera* are *H. chlamydata* Cookson and Eisenack 1962b, *H. jurassica* Gitmez and Sarjeant, 1972, and *H. laticaudata* Vozzhennikova, 1967. *Hexagonifera chlamydata* appears to have an apical archeopyle (Cookson and Eisenack, 1962b, pl. 7, fig. 1-3, 6, 8), but is questionably retained in *Hexagonifera* pending re-examination of the type material. *Hexagonifera jurassica* has an apical archeopyle as stated in the diagnosis by Gitmez and Sarjeant (1972, p. 240, pl. 14, fig. 5 and 7). It is herein transferred to *Senoniasphaera* Clarke and Verdier. *Hexagonifera laticaudata* opens apically according to Vozzhennikova (1967, p. 125). This cannot be confirmed, however, in her accompanying illustration (pl. 54, fig. 1). The species is therefore questionably retained in *Hexagonifera*.

Hexagonifera is characterized by a standard hexa archeopyle and the absence of apical and antapical horns. It differs from *Phthanoperidinium* in lacking periphragm ornamentation which delineates the paratabulation and from *Spinidinium* in the absence of spines or echinae.

STRATIGRAPHIC RANGE: Albian-Senonian

SPECIES OF *Hexagonifera*

?chlamydata Cookson and Eisenack, 1962b, p. 496, pl. 7, fig. 1-3, 5-8. Albian-Cenomanian [Fig. 173].

"cylindrica" (Habib, 1970, p. 374, pl. 10, fig. 2). The transfer of this species from *Prismatocystis* to *Hexagonifera* by Habib (1972, p. 378) is here rejected.

"defloccata" (Davey and Verdier, 1973, p. 198, pl. 3, fig. 6, 8). This species is here transferred to *Thalassiphora* as *T. defloccata comb. nov.*, since the morphology of the holotype of the species (pl. 3, fig. 8) is more consistent with the genus *Thalassiphora*.

**glabra* Cookson and Eisenack, 1961a, p. 74, pl. 12, fig. 9-13. Senonian [Fig. 172].

"jurassica" (Gitmez and Sarjeant, 1972, p. 240-241, pl. 14, fig. 5, 8). This species is here transferred to *Senoniasphaera*, as *S. jurassica comb. nov.*

?laticaudata Vozzhennikova, 1967, p. 125-126, pl. 54, fig. 1. Santonian. This species is left in the genus *Hexagonifera* with the recommendation that the name not be used because of the extremely poor illustration of the holotype which renders morphological elucidation impossible. It is not figured on the enclosed plates.

"suspecta" (Manum and Cookson, 1964). Now *Trithyrodinium*.

"vermiculata" (Cookson and Eisenack, 1961a). Now *Trithyrodinium*.

SVALBARDELLA Manum, 1960
[Fig. 174]

TYPE SPECIES: *Svalbardella cooksoniae* Manum, 1960, p. 21-22, pl. 1, fig. 1-3; text-fig. 2. Late Paleocene-Eocene.

DIAGNOSIS: Manum, 1960, p. 21: "Shells of planktonic micro-organisms. Shape fusiform with somewhat swollen middle part and blunt ends. No appendages. Girdle approximately equatorial. Middle part of shell entirely filled by a thin-walled ellipsoid body.

"In addition to the characters given above there are indications of plates and a longitudinal furrow in the type species. The internal body and the shell possess a more or less irregular opening dorsally towards the apical end."

EXPANDED DIAGNOSIS:

Shape

Pericyst: Fusiform, prolonged into one apical and one antapical horn of more or less equal length and which merge almost imperceptibly into the posterior part of the epipericyst and the anterior part of the hypopericyst respectively. Both horns centrally located, subcylindrical, broad and distally oblate. Epipericyst and hypopericyst of more or less equal size. Compression random and negligible.

Endocyst: Elongate ovoidal, in contact with pericyst except apically and antapically. Compression random and negligible.

Pericoels: Endocyst separated from pericyst apically and antapically in the vicinity of the horns. The large apical and antapical pericoels are therefore restricted to the horns.

Phragma

Periphragm: Laevigate, scabrate, granulate or reticulate. Intratabular, commonly penetabular.

Endophragm: Laevigate.

Paratabulation

Pericyst: Peridinioid paratabulation, details not known although the intratabular ornamentation delineates the paraplates of the precingular and postcingular series.

Pericingulum: Planar or slightly helicoidal, interrupted, never deeply indented.

Perisutures: May be delineated by denticles.

Endocyst: Paratabulation unknown.

Archeopyle

Attenuated hexa intercalary resulting from the detachment of the anterior intercalary paraplate 2a. Since the endophragm and periphragm are appressed in the vicinity of the archeopyle, there is no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum. Transverse archeopyle index is 0.33. Transverse archeopyle ratio is 0.50.

Dimensions — Pericyst: Length 150-172 μ, breadth 35-42 μ
Endocyst: Dimensions not given.

DISCUSSION: *Svalbardella* is morphologically similar to *Palaeocystodinium* Alberti, 1961, which genus also has a fusiform pericyst, produced into an apical and antapical horn respectively, an elongate endocyst and an hexa intercalary archeopyle resulting from the loss of the anterior intercalary paraplate 2a. Evitt (1967, p. 37) considered *Palaeocystodinium* to be a *jr syn.* of *Svalbardella*. However, the horns of *Palaeocystodinium* invariably taper and are acuminate distally and since transitional taxa are unknown it is the present authors' opinions that *Svalbardella* and *Palaeocystodinium* should be retained as two separate genera, distinguished on the nature of the horns. Also determinable paratabulation has not as yet been observed in *Palaeocystodinium*. The species "*Svalbardella australina*" (Cookson, 1965b, p. 140) which has tapered acuminate horns is herein transferred to *Palaeocystodinium*.

Other genera with a fusiform pericyst and elongate endocyst are *Ceratocystidiopsis* Deflandre, 1937; *Diplofusa* Cookson and Eisenack, 1960a; *Korojonia* Cookson and Eisenack, 1958, and *Wallodinium* Loeblich and Loeblich, 1968. Paratabulation or an archeopyle have not been observed in *Ceratocystidiopsis, Diplofusa* or *Korojonia*. The remaining genus *Wallodinium* possesses an apical archeopyle with attached operculum and lacks horns.

STRATIGRAPHIC RANGE: Late Paleocene-Eocene

SPECIES OF *Svalbardella*

"*australina*" (Cookson, 1965b). Now *Palaeocystodinium*.

**cooksoniae* Manum, 1960, p. 21-22, pl. 1, fig. 1-3; text-fig. 2. Late Paleocene-Eocene [Fig. 174].

"*granulata*" (Wilson, 1967b). Now *Palaeocystodinium*.

"*polymorpha*" (Malloy, 1972). Now *Alterbia*.

PALAEOCYSTODINIUM Alberti, 1961
[Fig. 175-187]

TYPE SPECIES: *Palaeocystodinium golzowense* Alberti, 1961, p. 20, pl. 7, fig. 10-12; pl. 12, fig. 16. Late Eocene-Late Oligocene.

DIAGNOSIS: Alberti, 1961, p. 20 (translation): "Body fusiform, more or less flattened dorso-ventrally. Always with a horn-shaped process at both ends; these taper towards their free ends. With rounded-trapezoidal pylome below the apex. A roundish to ellipsoidal inner body is closely appressed against the outer shell."

EXPANDED DIAGNOSIS:

Shape

Pericyst: Fusiform usually prolonged into slender apical and slender antapical horn of more or less equal length. The junction between the apical horn and remainder of the epipericyst and between antapical horn and remainder of the hypopericyst respectively is usually sharp and readily discernible. Both horns are centrally located, tapering and distally acuminate. The antapical horn may possess a short secondary spine along its length. A vestigial or greatly reduced right antapical horn is sometimes present.

Endocyst: Elongate, ovoidal, in contact with the pericyst, except apically and antapically.

Pericoels: Endocyst separated from pericyst apically and antapically in the vicinity of the horns. Apical and antapical pericoels therefore are restricted to the horns.

Phragma

Periphragm: Laevigate, granulate, echinate or small spines. Granules, echinae or spines often concentrated on, or restricted to the horns. May be parasutural.

Endophragm: Laevigate to scabrate. Usually thicker than periphragm.

Paratabulation

Pericyst: Precise paratabulation unknown although some taxa have parasutural ornamentation.

Pericingulum: Present or absent. When present is generally weakly indicated. Never deeply indented. Parasutures may be raised with smooth or ornamented margins.

Perisulcus: When present is faint. Extends onto epipericyst.

Endocyst: Paratabulation unknown.

Archeopyle

Attenuated hexa to standard hexa resulting from the detachment of the second anterior intercalary paraplate 2a. Since the endophragm and periphragm are appressed in the vicinity of the archeopyle, there is no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum. Transverse archeopyle index is 0.33-0.44. Transverse archeopyle ratio is 0.50-0.80.

Archeopyle Formula: I/I (2a/2a).

Dimensions — Pericyst: Length 95-302 μ, breadth 20-74 μ
Endocyst: Length 69-169 μ, Breadth 20-74 μ

DISCUSSION: Evitt(1967, p. 37) considered *Palaeocystodinium* to be a *jr syn.* of *Svalbardella* Manum, 1960. However, the difference in the horns distally and where they merge with the epipericyst and hypopericyst respectively, and the presence of paratabulation in *Svalbardella* we feel justify their separation at the generic level.

STRATIGRAPHIC RANGE: Turonian-Late Oligocene

SPECIES OF *Palaeocystodinium*

australinum (Cookson, 1965b) *comb. nov.*
1965b *Svalbardella australina* Cookson, p. 140, pl. 25, fig. 1-4. This species was emended by Malloy 1972, p. 63. Paleocene [Fig. 177].

benjaminii Drugg, 1967, p. 31, pl. 3, fig. 1; pl. 9, fig. 3. Maastrichtian-Danian [Fig. 186].

?deflandrei Gruas-Cavagnetto, 1968, p. 92-93, pl. 13, fig. 15-19. Late Paleocene [Fig. 187].

denticulatum Alberti, 1961, p. 20-21, pl. 7, fig. 9. Turonian [Fig. 178].

**golzowense* Alberti, 1961, p. 20, pl. 7, fig. 10-12; pl. 12, fig. 16. Late Eocene-Late Oligocene [Fig. 175].

granulatum (Wilson, 1967b) *comb. nov.*
1967b *Svalbardella granulata* Wilson, p. 226-227, fig. 7-9. Paleocene [Fig. 179].

hyperxanthum (Vozzhennikova, 1963, p. 185, fig. 20) Vozzhennikova, 1967, pl. 152-153. Paleocene [Fig. 176].

lidiae (Gorka, 1963, p. 37, pl. 5, fig. 6) Davey, 1969b, p. 12-13. Maastrichtian [Fig. 180].

"microgranulatum" Jain and Millepied, 1973, p. 29, pl. 2, fig. 23; pl. 3, fig. 30. Maastrichtian. This species is herein considered to be a *jr syn.* of *Alterbia polymorpha* (Malloy, 1972).

"punctatum" Jain and Millepied, 1973, p. 29, pl. 2, fig. 24; pl. 3, fig. 26-28. Maastrichtian. This species is herein considered to be a *jr syn.* of *Alterbia polymorpha* (Malloy, 1972).

rhomboideum (O. Wetzel, 1933a, p. 168, pl. 2, fig. 17) Lentin and Williams, 1973, p. 103. Senonian [Fig. 185].

subsp. *filosum* (O. Wetzel, 1933a, p. 169, pl. 2, fig. 20) Lentin and Williams, 1973, p. 103. Senonian [Fig. 184].

subsp. *incertum* Deflandre, 1936a, p. 40, pl. 10, fig. 8-9). Lentin and Williams, 1973, p. 103. Senonian [Fig. 182].

subsp. *nodosum* (O. Wetzel, 1933a, p. 169, pl. 2, fig. 19). Lentin and Williams, 1973, p. 104. Senonian [Fig. 181].

subsp. *ovatum* (O. Wetzel, 1933a, p. 168-169, pl. 2, fig. 18) Lentin and Williams, 1973, p. 104. Senonian [Fig. 183].

SELENOPEMPHIX Benedek, 1972
[Fig. 188-189]

TYPE SPECIES: *Selenopemphix nephroides* Benedek, 1972, p. 47-48, pl. 11, fig. 13; pl. 16, fig. 1-4. Middle-Late Oligocene.

DIAGNOSIS: Benedek, 1972, p. 47 (translation): "Thin-walled dorso-ventrally flattened shell without apical process but with two antapical prominences. The outer wall of the shell is weakly granular and generally somewhat folded. A trapezoidal opening pierces the apical area laterally."

EXPANDED DIAGNOSIS:

Shape

Pericyst: In apical antapical view outline rounded to ovoidal with a moderate to deep indentation on the ventral surface which denotes the position of the perisulcus. Apex rounded or prolonged into apical horn. Antapex prolonged into two symmetrically located antapical lobes or horns. Compression apical antapical, moderate to extreme.

Endocyst: Commonly obscure. When visible is appressed to pericyst throughout. Compression apical antapical.

Pericoels: None observed other than very small haphazardly arranged pericoels.

Phragma

Periphragm: Thin, laevigate to granulate. Commonly folded.

Endophragm: Thin, but commonly thicker than periphragm, laevigate to scabrate.

Paratabulation

Pericyst: Paratabulation unknown other than in the vicinity of the archeopyle.

Pericingulum: Present. Runs around the periphery in apical antapical view. Parasutures denoted by ridges, commonly raised and distally entire or with echinate, denticulate or spinate margin. Appears to be slightly helicoidal.

Perisulcus: Present. Moderately to deeply depressed forming a concave depression on the ventral surface. Broader on the hypopericyst.

Endocyst: Paratabulation unknown other than in the vicinity of the archeopyle.

Archeopyle

Hexa intercalary resulting from the partial or complete detachment of the second anterior intercalary paraplate 2a. Operculum free or remaining attached along one parasuture, presumably the posterior. Since the endophragm and periphragm are appressed in the vicinity of the archeopyle, there is no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum. Orientation of specimens prevents determination of transverse archeopyle index and ratio.

Archeopyle Formula: I/I (2a/2a).

Dimensions Pericyst: Width dorso-ventrally 42-60 μ, laterally 43-76 μ

DISCUSSION: Benedek erected the genus *Selenopemphix* for dorso-ventrally flattened taxa without an apical projection but with two antapical prominences, and a subapical archeopyle. Study of Benedek's illustrations of the two species placed in the genus, *S. nephroides* the type of the genus (pl. 11, fig. 13) and *S. selenoides* (pl. 11, fig. 15, text-fig. 22) and other material, has demonstrated to the present authors that Benedek's assumptions concerning orientation are incorrect. *Selenopemphix* is not dorso-ventrally compressed, but apically antapically compressed. Thus the two 'antapical' prominences are in fact the left and right extremities of the pericingulum, with the indentation marking the position of the perisulcus. In the diagnosis for *S. selenoides* Benedek stated that the antapical horns are joined laterally by a sharp edge set with spines and that the marginal regions of the shell are thickened and have spine-like prominences. These spines in fact represent the parasutural ornamentation of the pericingulum. Realization of the correct orientation of the genus permits interpretation of the archeopyle as an intercalary 2a type. It does not however, negate the significance of the genus. *Selenopemphix* is characterized by being compressed apically, antapically, having a 2a intercalary archeopyle. It has an apical and two antapical lobes or horns. The paratabulation is presumably peridinioid. *Lejeunia* is distinguished from *Selenopemphix* by being dorso-ventrally compressed. *Palaeoperidinium* is dorso-ventrally compressed and has a combination AIP archeopyle.

STRATIGRAPHIC RANGE: Middle-Late Oligocene

SPECIES OF *Selenopemphix*

**nephroides* Benedek, 1972, p. 47-48, pl. 11, fig. 13; pl. 16, fig. 1-4. Middle-Late Oligocene [Fig. 188].

selenoides Benedek, 1972, p. 48, pl. 11, fig. 15: pl. 16, fig. 5-8; text-fig. 22. Middle-Late Oligocene [Fig. 189].

BULBODINIUM O. Wetzel, 1960
[Fig. 190-192]

TYPE SPECIES: *Bulbodinium seitzi* O. Wetzel, 1960, p. 82-83, pl. 1, fig. 1-2, 4, 8, 10-13. Senonian.

DIAGNOSIS: O. Wetzel, 1960, p. 82 (translation): "Outline of shell on the whole somewhat elongate-pentagonal with rounded corners. Equatorial region (middle body) as a rule broadly standing out, often in the centre swollen up in a more or less bulbous fashion or at least bounded above and below always by a darker transverse band (boundary bands), by which means the impression is given of a tripartite shell. A true transverse furrow is only to be perceived with difficulty and piece by piece [an angular connection itself with two boundary bands is not definitely established (thus no clear spiral form of the transverse furrow, as e.g. in *Gyrodinium*)], principally on both sides of the equatorial zone always by means of a pair of fine, more or less pointed projections (lateral horns) of the shell surface sloping towards one another on opposite sides. The longitudinal furrow forms a long, relatively deep hollow. Epitheca towards the top drawn out in cone, helmet, or bill form. Hypotheca rectangular to rounded trapezoidal in outline, frequently with shallow-arched sloping lower margin, and at its projecting angle terminating in an antapical horn. Some large, somewhat rectangular windows in the girdle region as well as a larger rounded deepening above them not infrequent. A constantly developed, clear arrangement of plates is lacking; certainly however it usually shows an indication of large fields through darker undulating lines or an extensive cover of numerous, small net-meshes, which are in part ordered in rows and marginally bear fine pores or humps, which form a rough-granular surface. The shell wall of the equatorial region often seems coarsely wrinkled through the pad-like projections of thicker mesh edges."

O. Wetzel, 1961, p. 341 (description based on the 1960 German diagnosis): "In contrast to all other fossil and extant microorganisms (so far as I am aware) that have been described to date (i.e., through 1959) and referred to the Dinoflagellata, this form has the body clearly divided into three rather than two segments. However, when some of my specimens were isolated chemically from the flintstone matrix, the very flat girdle of the equatorial region became distinct, or at least some parts of it. This structure seems to replace the transverse furrow characteristic of the typical dinoflagellates (peridinians) separating their epitheca and hypotheca from one another. Instead of a regular arrangement of plates, the wall of the typical *Bulbodinium* shell is more or less granular or areolar and has, at most, some wide fields with indistinct borders. The central portion of the body, which may be a highly inflated, block-shaped capsule, extends outward, and the epitheca may also extend outward, but less so, below the apical point, which is often blunted. The hypotheca has a square outline and may be prolonged into a horn at one of the terminal edges.

"The type species of *Bulbodinium* appears to be closely similar to *Deflandrea tripartita* Cookson and Eisenack (1960), but it differs in the distinct transverse delimitation of the central portion from both external segments, which are longer than the corresponding ones in the new Australian form and all previously described species of *Deflandrea* that I have seen. In addition, there are other species of *Bulbodinium* with forms that are even more slender than the type species and do not resemble the true *Deflandrea* species."

Dimensions Pericyst: Length 112-135 , breadth 40-65 , based on six specimens
Endocyst: Dimensions not given.

DISCUSSION: Klement (1961) criticized the genus *Bulbodinium* and concluded that *B. seitzi* and *B. altipetax* were assignable to *Deflandrea* and *B. oistoides* was possibly a species of *Scriniodinium* Klement. He did not however, effect any formal transfers. Study of some of the illustrations in Wetzel (1961) show that *B. seitzi* (pl. 2, fig. 7) has an intercalary archeopyle resulting from the loss of anterior intercalary paraplate 2a. It therefore appears that *Bulbodinium* is a senior synonym of *Chatangiella*. Unfortunately the hepta/pentapartite nature of the pericingulum cannot be determined so that until examination of the topotype material *Bulbodinium* must be treated separately from *Chatangiella*.

STRATIGRAPHIC RANGE: Senonian

SPECIES OF *Bulbodinium*

altipetax O. Wetzel, 1960, p. 83, pl. 1, fig. 3, 5, 9. Senonian [Fig. 191].

oistoides O. Wetzel, 1960, p. 83-84, pl. 1, fig. 6-7. Senonian [Fig. 192].

**seitzi* O. Wetzel, 1960, p. 82-83, pl. 1, fig. 1-2, 4, 8, 10-13. Senonian [Fig. 190].

GINGINODINIUM Cookson and Eisenack, 1960a emend
[Fig. 192-194]

TYPE SPECIES: *Ginginodinium spinulosum* Cookson and Eisenack, 1960a, p. 7, pl. 2, fig. 9. Late Albian-Cenomanian.

DIAGNOSIS: Cookson and Eisenack, 1960a, p. 7: "Shell somewhat flat, with convex ventral and dorsal surfaces, a pentagonal outline, and an apical and two antapical horns and without tabulation and capsule. Girdle broad, helicoid; longitudinal furrow broad and deep, restricted to the hypotheca."

Cookson and Eisenack, 1965c, p. 143: "We propose, therefore, following the custom for the genus *Deflandrea,* to enlarge the genus *Ginginodinium* to include forms with or without tabulation."

EMENDED DIAGNOSIS:

<u>Shape</u>

<u>Pericyst</u>: Ambitus, ovoidal to rhomboidal to pentagonal to elongate pentagonal. Apex rounded or produced into a short apical horn. Antapex produced into two symmetrically located unequal antapical horns, the right antapical horn may be reduced or vestigial. Compression moderate to extreme dorso-ventral.

<u>Endocyst</u>: Reflects the outline of the pericyst to which it is appressed other than in the vicinity of the horns.

<u>Pericoels</u>: A single small apical pericoel and one or two small antapical pericoels.

<u>Phragma</u>

<u>Periphragm</u>: Thin, with laevigate to granulate pandasutural bands and penetabular and intratabular ornamentation, which may be granules, echinae, tubercles or processes. Processes may be acuminate, oblate, or bifid distally.

<u>Endophragm</u>: Thin, laevigate.

<u>Paratabulation</u>

<u>Pericyst</u>: The pandasutural bands and penetabular ornamentation delineate a peridinioid paratabulation of 4', 3a, 7", ?0c, 5"', 2"". Paraplates 2' and 4' are slender and difficult to determine.

<u>Pericingulum</u>: Prominent and delineated by anterior and posterior parasutural ridges which may be denticulate or bear processes. Sometimes partite. Pericingulum helicoidal.

<u>Perisulcus</u>: Usually strongly delineated on both the epipericyst and hypopericyst. Considerably larger on the hypopericyst and posteriorly extending to the antapex.

<u>Endocyst</u>: Presumably identical to that of the pericyst.

Archeopyle — Combination archeopyle with the formula $3I+3Pa_{3''-5''}$. Compound operculum with paraplates 1a, 2a and 3a being removed separately. 2a may be removed with 1a and 3a sometimes remaining attached to the 3" and 5" paraplates respectively. Alternatively 1a and 3a are detached while 2a remains attached along parasuture H4. Accessory archeopyle sutures may be partially or completely developed between the precingular paraplates 2"-3", 3"-4", 4"-5" and 5"-6". The precingulars always remain attached along the posterior margin. When the three anterior intercalaries are lost and the accessory archeopyle sutures between the precingulars are not developed, the archeopyle appears to be 3I. Since the endophragm and periphragm are appressed in the vicinity of the archeopyle, there is no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum.

Archeopyle Formula: $3I_{1a-3a}+3Pa_{3''-5''}$

Dimensions — Pericyst: Length 62-84 μ, breadth 54-69 μ

DISCUSSION: When Cookson and Eisenack, 1960a, p. 7, erected *Ginginodinium* they included only one species, *G. spinulosum*. Through the courtesy of Dr. Robin Helby the holotype of *Ginginodinium spinulosum* has been examined by the present authors. In this specimen the archeopyle sutures separating the three anterior intercalaries are visible. Paraplate 2a remains attached along parasuture H4 to the precingular 4". Separation along the accessory archeopyle parasutures is only weakly indicated. However other taxa assigned to this genus and closely related to *Ginginodinium spinulosum*, if not identical, forcibly demonstrate these accessory sutures. The complexity of this type of archeopyle and the degree of development varies within the same species. We therefore propose to emend the diagnosis of *Ginginodinium* to include all the observed variations.

Ginginodinium is characterized by having a peridinioid outline, an apical horn, one or two antapical horns, a combination $3I+3Pa_{3''-5''}$ archeopyle and periphragm ornamentation. A genus with a peridinioid paratabulation and $3I_{1-3a}3P_{3''-5''}$ archeopyle, in which the operculum may be simple or compound has been described by Brideaux and McIntyre (in press). *Ginginodinium* differs in having a compound operculum in which the precingulars 3", 4" and 5" always remain attached to the remainder of the cyst along the posterior margins, and in the periphragm ornamentation. *Laciniadinium* McIntyre, 1975, has a $\overline{3I3Pa_{3''-5''}}$ archeopyle with an operculum that remains attached posteriorly. The operculum is always simple, however, in *Laciniadinium*. *Palaeoperidinium* also has a combination archeopyle involving the loss of three anterior intercalaries and three precingulars, but also including paraplate 3'. *Palaeoperidinium* always has a simple operculum with no separation into individual paraplates.

STRATIGRAPHIC RANGE: Late Albian-Maastrichtian

SPECIES OF *Ginginodinium*

ornatum (Felix and Burbridge, 1973) *comb. nov.*
1973 *Trithyrodinium ornatum* Felix and Burbridge, p. 23-24, pl. 4, fig. 12. Maastrichtian [Fig. 194].

**spinulosum* Cookson and Eisenack, 1960a, p. 7, pl. 2, fig. 9. Late Albian-Cenomanian [Fig. 193].

"*tabulatum*" (Cookson and Eisenack, 1965c). Now *Palaeoperidinium*.

TRITHYRODINIUM Drugg, 1967 emend.
[Fig. 195-199]

TYPE SPECIES: *Trithyrodinium evittii* Drugg, 1967, p. 20, pl. 3, fig. 2-3; pl. 9, fig. 2. Danian.

DIAGNOSIS: Drugg, 1967, p. 20: "The same as for the genus *Deflandrea* Eisenack, 1938, except that the archeopyle is formed by the removal of three intercalary plates rather than one plate as in *Deflandrea*. The three plates forming the operculum are removed as a unit."

Davey, 1969b, p. 10: "Cavate cysts consisting of a two-layered inner body surrounded by a single-layered outer wall which is produced into an apical and two antapical horns. Inner body subspherical, with opening formed by the removal of three intercalary plate-areas. Tabulation may be present. Archeopyle dorsal intercalary (2a)."

Davey goes on to say in his remarks: "The diagnosis is amended to point out that the three intercalary plate-areas are lost from the inner body, not the outer wall, and therefore do not strictly constitute an archeopyle. The genus is also now not restricted to species which lose the three plate-areas as a unit, since whether this is so or not is extremely difficult to determine unless detached opercula are studied. That the plate areas may be lost as a unit or as separate plates does not appear to be of generic importance. This is undoubtedly due to the fineness of this wall which is often apparently absent or damaged to some extent."

EMENDED DIAGNOSIS:

Shape

Pericyst: Ambitus ovoidal to pentagonal to elongate. Apex prolonged into a short apical horn with acuminate to rounded tip. Antapex produced into one eccentrically located antapical horn, the left, or two symmetrically located antapical horns, which may be equal, or unequal when the right is always the shorter. Pericyst widest in the pericingular region. Epipericyst and hypopericyst of more or less equal size. Compression dorso-ventral.

Endocyst: Ambitus circular ovoidal or elliptical. Appressed to pericyst in precingular, cingular and postcingular regions. Isolated endocysts are not uncommon.

Pericoels: A small apical and one or two small antapical pericoels.

Phragma

Periphragm: Thin. Surface laevigate.

Mesophragm: Present in some specimens when it is appressed to the endophragm.

Endophragm: Up to several microns thick. Surface laevigate, punctate, granulate, tuberculate or vermiculate.

Paratabulation

Pericyst: Paratabulation indeterminate other than in the vicinity of the periarcheopyle when visible. The three anterior intercalaries indicate peridinioid paratabulation. Paraplates 1a and 3a are pentagonal in outline. 2a is a standard hexa.

Pericingulum: Generally present but weakly indicated by raised anterior and posterior parasutures. Planar or slightly helicoidal.

Perisulcus: Weakly indicated on the hypopericyst.

Endocyst: Paratabulation indeterminate other than in the vicinity of the endoarcheopyle. The three anterior intercalaries indicate peridinioid paratabulation. Paraplates 1a and 3a are pentagonal in outline, 2a is a standard hexa.

Archeopyle

Periarcheopyle: Frequently indeterminate. When visible is 3I intercalary resulting from the loss of all three anterior intercalary paraplates, 1a, 2a and 3a; 2a is standard hexa. The perioperculum may be simple or compound, when it is separated into the three individual paraplates.

Endoarcheopyle: 3I intercalary resulting from the loss of all three anterior intercalary paraplates, 1a, 2a and 3a; 2a is standard hexa. The endoperculum may be simple or compound, when it is separated into the three individual paraplates. Endoperculum often remains in place.

Archeopyle Formula: 3I/3I

Dimensions

Pericyst: Length 56-130 μ, breadth 47-80 μ
Endocyst: Length 41-81 μ

DISCUSSION:

Trithyrodinium is characterized by a short apical horn and one or two short antapical horns, a 3I intercalary archeopyle in both the pericyst and endocyst, a pericingulum, and an absence of ornamentation on the pericyst. Drugg (1967, p. 20) erected *Trithyrodinium* for *Deflandrea* like taxa with a 3I archeopyle, in which the three plates forming the operculum are removed as a unit. Only the type of the genus, *T. evittii,* was initially included in the genus. The present authors have seen several specimens of *Trithyrodinium* in which the endoperculum has separated into discrete individual paraplates. The diagnosis has therefore been emended to include such forms. Davey (1969b, p. 10) contended that the archeopyle was not present in the pericyst. Although it is difficult to perceive the periarcheopyle in most specimens, where observable it is a 3I archeopyle. Thus the generic diagnosis is emended to include the specifics of the periarcheopyle. Species in which only the endocyst is known, and that possess a 3I endoarcheopyle, should be included in *Trithyrodinium*.

The genus *Ginginodinium* Cookson and Eisenack, 1960a, also has an archeopyle in which the three anterior intercalaries are lost. It differs however in the variable development of accessory archeopyle sutures between the precingulars 2"-3", 3"-4", 4"-5", and 5"-6", and in having an ornamented periphragm. Several species in *Chatangiella* and *Isabelia* have an I/3I (2a/1-3a) archeopyle. Such species are *Chatangiella granulifera* Manum, 1963, *C. verrucosa* Manum, 1963, and *Isabelia dakotaensis* Stanley, 1965. *Chatangiella,* however, has a hepta/pentapartite pericingulum, omegaform periarcheopyle and large apical and antapical pericoels. *Isabelia* never possesses a prominent pericingulum or a 3I periarcheopyle, and always has unequal antapical horns. The species *Hexagonifera suspecta* Manum and Cookson, 1964, and the species *Hexagonifera vermiculata* Cookson and Eisenack, 1961a, are herein transferred to *Trithyrodinium* since they possess a 3I archeopyle.

STRATIGRAPHIC RANGE: Cenomanian-Danian

SPECIES OF *Trithyrodinium*

druggii Stone, 1973, p. 54-55, pl. 5, fig. 18-19a. Late Campanian [Fig. 199].

**evittii* Drugg, 1967, p. 20, pl. 3, fig. 2-3; pl. 9, fig. 2. Danian [Fig. 196].

fragile Davey, 1969b, p. 11, pl. 3, fig. 3, 6, 9. ?Danian [Fig. 195].

"ornata" (Felix and Burbridge, 1973). Now *Ginginodinium*.

suspectum (Manum and Cookson, 1964, p. 9-10, pl. 1, fig. 9-13) Davey, 1969b, p. 12. Cenomanian [Fig. 198].

vermiculatum (Cookson and Eisenack, 1961a) *comb. nov.*
1961a *Hexagonifera vermiculata* Cookson and Eisenack, p. 74, pl. 12, fig. 6-8. Senonian [Fig. 197].

ASCODINIUM Cookson and Eisenack, 1960a
[Fig. 200-202]

TYPE SPECIES: *Ascodinium acrophorum* Cookson and Eisenack, 1960a, p. 5, pl. 1, fig. 19-20. Late Albian-Cenomanian.

DIAGNOSIS: Cookson and Eisenack, 1960a, p. 5: "Shell rather flat, oval to rhomboidal in outline, with or without apical and antapical horns and girdle, and containing an ovoidal, spheroidal or rhomboidal capsule. Pylome formed on the dorsal surface by the detachment of a circular part of the apical region including the apex itself, and part of the ventral wall."

EXPANDED DIAGNOSIS:

Shape

Pericyst: Ambitus circular to ovoidal to rhomboidal. Rounded at the apex or prolonged into a short, acuminate apical horn. Possessing one eccentrically located, short, acuminate antapical horn, the left. The right antapical horn is absent. Compression dorso-ventral.

Endocyst: Ambitus circular to ovoidal. May be in contact with the pericyst in the precingular, cingular and postcingular regions, or completely detached in ambital view.

Pericoels: Apical and antapical pericoel always present, commonly united by an ambital pericoel.

Phragma

Periphragm: Rarely exceeding 1 μ in thickness. Surface laevigate, may be serrate antapically.

Endophragm: Usually thicker than periphragm. Surface laevigate to scabrate.

Paratabulation

Pericyst: Paratabulation not discernible.

Pericingulum: Present or absent. May be indicated in ambital view as an indentation, or weakly delineated on the dorsal surface. Appears to be interrupted.

Perisulcus: Not delineated.

Endocyst: No observable paratabulation.

Archeopyle

Periarcheopyle: According to Evitt (1967, p. 50), the periarchepyle in *Ascodinium* is a circular opening occupying an eccentrically apical position, extending further towards the pericingulum dorsally then ventrally. The rounded perioperculum appears to be attached on the ventral side of the apex. Evitt suggested it represents an AI archeopyle with rounded angles, this explaining the dorsal extension towards the pericingulum.

Endoarcheopyle: Smaller than periarcheopyle. Endoarcheopyle appears to be detached.

Archeopyle Formula: Unknown. Possibly $\overline{AIa}/\overline{AIa}$ (3' + 2a/3' + 2a or 3' + 1a-3a/3' + 1a-3a).

Dimensions

Pericyst: Length 48-76 μ, breadth 33-65 μ
Endocyst: Length 38-45 μ (three specimens), width 30-46 μ (three specimens)

DISCUSSION: *Ascodinium* is the only genus known which has a circular eccentrically located apical periarcheopyle. In this respect it is easily distinguished from *Isabelia gen. nov.* which has an omega-form hexa, *Alterbia* Vozzhennikova, 1967, *Amphidiadema* Cookson and Eisenack, 1960a, and *Nelsoniella* Cookson and Eisenack, 1960a, all of which have an attenuated hexa to standard hexa intercalary archeopyle, and *Ovoidinium* which has a combination $\overline{4A3I}$ archeopyle in which all the apical and all the intercalary paraplates are lost and the archeopyle margin is not rounded.

STRATIGRAPHIC RANGE: Late Albian-Cenomanian

SPECIES OF *Ascodinium*

**acrophorum* Cookson and Eisenack, 1960a, p. 5, pl. 1, fig. 19-20. Late Albian-Cenomanian [Fig. 201].

"*hialinum*" Baltes, 1963, p. 585, *nom. nud.* (holotype not designated by Baltes).

"*lordi*" (Cookson and Eisenack, 1968, p. 112, fig. 1, I-K. This species is herein transferred to the genus *Senoniasphaera,* as *S. lordi comb. nov.*

"*ovalis*" (Cookson and Eisenack, 1970a). Now *Ovoidinium.*

parvum (Cookson and Eisenack, 1958, p. 28, pl. 4, fig. 12-13) Cookson and Eisenack, 1960a, p. 5. Late Albian-Cenomanian [Fig. 202].

"*pontis-mariae*" (Deflandre, 1936b). Now *Subtilisphaera.*

"*scabrosum*" (Cookson and Hughes, 1964). Now *Ovoidinium.*

serratum Cookson and Eisenack, 1960a, p. 5, pl. 1, fig. 21-22. Cenomanian [Fig. 200].

"*stagonoides*" (Benedek, 1972). Now *Deflandrea.*

"*trendalli*" (Cookson and Eisenack, 1970a). Now *Subtilisphaera.*

"*verrucosum*" (Cookson and Hughes, 1964). Now *Ovoidinium.*

OVOIDINIUM Davey, 1970, emend.
[Fig. 203-209]

TYPE SPECIES: *Ovoidinium verrucosum (=Ascodinium verrucosum,* Cookson and Hughes, 1964, p. 41, pl. 5, fig. 4-7) Davey, 1970, p. 351-352. Cenomanian.

DIAGNOSIS: Davey 1970, p. 351: "Bicavate dinoflagellate cysts, possessing one or two antapical horns and typically an apical horn. Periphragm smooth or granular, forming sulcus. Tabulation absent. Archeopyle apical with slightly angular margin."

EMENDED DIAGNOSIS:

Shape

Pericyst: Ambitus ovoidal to elongate pentagonal, produced into a short acuminate to rounded apical horn and one eccentrically located or two symmetrically located unequal antapical horns. When there are two antapical horns, the right is either reduced or vestigial. Maximum width in vicinity of pericingulum. Epipericyst and hypopericyst of more or less equal size.

Endocyst: Ambitus circular to ovoidal. In contact with the pericyst, except apically and antapically.

Pericoels: An apical and an antapical pericoel.

Phragma

Periphragm: Surface laevigate, scabrate, granulate, verrucate, rugulate or tuberculate.

Endophragm: Surface laevigate, scabrate, granulate or verrucate.

Paratabulation

Pericyst: Paratabulation indeterminate other than three anterior intercalaries present.

Pericingulum: Generally present, may be delineated by a raised anterior and posterior parasuture. Planar or slightly helicoidal. Not always visible.

Perisulcus: Rarely discernible, more developed on the hypocyst than on the epicyst.

Endocyst: Paratabulation unknown.

Archeopyle

Combination simple archeopyle including all the apical and all the anterior intercalary paraplates. The operculum may be completely detached or remain attached along parasuture 1' - anterior sulcal. The endophragm and periphragm are appressed in the vicinity of the archeopyle other than immediately below the apical horn. There is no separation of the endoperculum and perioperculum so that effectively there is one archeopyle and one operculum.

Archeopyle Formula: $\overline{4A3I}$ $\overline{(1'-4' + 1a-3a)}$

Hypopericyst Opening: A second opening with attached 'operculum' may be present in the perisulcal or ventral posterior region of the hypopericyst. The opening appears to result from separation along the antapical parasuture of the perisulcus, the flap or 'operculum' remaining attached along the anterior margin. The function of this opening is unknown. There is no observable ventral opening in the hypoendocyst.

Dimensions

Pericyst: Length 52-118 μ, breadth 32-96 μ
Endocyst: Length 28-66 μ, breadth 31-57 μ

DISCUSSION: *Ovoidinium* is characterized by the presence of one apical, and one or two antapical horns, apical and antapical pericoels and the distinctive combination $\overline{4A3I}$ archeopyle, which has been superbly elucidated by Evitt (1967, p. 45-46) (for *"Ascodinium* cf. *verrucosum"*). *Ovoidinium* can be readily distinguished from *Ascodinium,* which according to Evitt (1967, p. 50) possesses a periarcheopyle which is a circular opening occupying an eccentrically apical position, extending farther towards the pericingulum dorsally than ventrally. *Senoniasphaera* Clarke and Verdier, 1967, differs in having the endocyst separated from the pericyst laterally and possesses an apical archeopyle. Pocock (1972, p. 93) erected the genus *Evittia* for cavate peridinioid cysts with an apical archeopyle, which includes the three anterior intercalary paraplates. *Evittia* Pocock is a junior homonym of the acritarch genus *Evittia* Brito, 1967, p. 477. Lentin and Williams (1973, p. 114) therefore erected *Pocockia* as a *nom. subst. pro Evittia* Pocock, 1972, *non Evittia* Brito, 1967. Included in Pocockia are two species, the type of the genus, *P. cincta* and *P. waltonii. P. cincta* was included in *Ovoidinium* by Davey (1970, p. 354). *P. cincta* obviously has 4A3I archeopyle as is clearly demonstrated in Cookson and Eisenack (1958, pl. 4, fig. 1). This is synonymous with the 4AeI archeopyle of *Ovoidinium.* Since *Pocockia cincta* conforms in all respects with the diagnosis of *Ovoidinium,* it is transferred to that genus. This, by removal of the type species, makes *Pocockia* a superfluous genus. *Pocockia* is herein regarded as a *jr syn.* of *Ovoidinium.* The remaining species *Pocockia waltonii* which also appears to have a $\overline{4A3I}$ archeopyle (Pocock, 1972, pl. 22, fig. 14) is likewise transferred to *Ovoidinium. Craspedodinium* Cookson and Eisenack, 1974, is herein considered a *jr syn.* of *Ovoidinium.*

STRATIGRAPHIC RANGE: ?Early Jurassic-Cenomanian

SPECIES OF *Ovoidinium*

cinctum (Cookson and Eisenack, 1958, p. 26, pl. 4, fig. 1-3) Davey 1970, p. 354. Late Neocomian or Early Aptian. This species was chosen by Pocock (1972) as the type of the genus *Evittia* (non Brito, 1967). The name *Pocockia* was chosen by Lentin and Williams (1973, p. 114) as a *nomen subst.* for *Evittia* Pocock, 1972. However, *Pocockia nom. subst. pro Evittia* Pocock, 1972 (non Brito, 1967) is now considered to be a *jr syn.* of *Ovoidinium* [Fig. 203].

?indistinctum (Cookson and Eisenack, 1974) *comb. nov.*
1974 *Craspedodinium indistinctum* Cookson and Eisenack, p. 76, pl. 25, fig. 6-8. Aptian-?Albian [Fig. 207].

?kansanum (Tasch, 1964) *comb. nov.*
1964 *Peridinium kansanum* Tasch, p. 196, pl. 1, fig. 1. Albian. This form is questionably included in *Ovoidinium* because of uncertainty as to its archeopyle.

ovale (Cookson and Eisenack, 1970a) *comb. nov.*
1970 *Ascodinium ovalis* Cookson and Eisenack, p. 145, pl. 13, fig. 8. Albian-Cenomanian [Fig. 205].

scabrosum (Cookson and Hughes, 1964, p. 40, pl. 5, fig. 1-3) Davey, 1970, p. 352. Albian-Early Cenomanian [Fig. 204].

**verrucosum* (Cookson and Hughes, 1964, p. 41, pl. 5, fig. 4-7) Davey, 1970, p. 351-352. Cenomanian [Fig. 209].
subsp. *ostium* (Davey, 1970, p. 353, pl. 4, fig. 5-6; text-fig. 16) Davey and Verdier, 1973, p. 198. Albian-Early Cenomanian [Fig. 206].

waltoni (Pocock, 1972) *comb. nov.*
1972 *Evittia waltonii* Pocock, p. 93, pl. 22, fig. 13-14. Early Jurassic [Fig. 208].

PALAEOPERIDINIUM Deflandre, 1934 emend. Sarjeant, 1967
[Fig. 210-225]

TYPE SPECIES: *Palaeoperidinium pyrophorum* (=*Peridinium pyrophorum* Ehrenberg, 1838, pl. 1, fig. 1, 4) Deflandre, 1935, p. 227 emend. Sarjeant, 1967, p. 146-147. Late Cretaceous.

DIAGNOSIS: Deflandre, 1935, p. 227 (translation): "All the dinoflagellates of the flint, with the physiognomy of *Peridinium,* whose tabulation whilst present cannot be studied in detail. I think moreover that it is a mistake to employ the name of an extant species as long as one is not absolutely certain of the identity between it and the fossil form."

Sarjeant, 1967, p. 246: "Proximate cysts, ovoidal or polygonal to subpolygonal in outline, with apical horn and two antapical horns. Reflected tabulation 4', 3a, 7" 5-?7c, 5"', 2"" sutures with or without raised crests. Archeopyle epitractal."

EXPANDED DIAGNOSIS:

Shape

Pericyst: Ambitus rhomboidal to peridinioid or pentagonal, generally prolonged into one apical and two symmetrically placed antapical horns, more or less equal in length or with the right antapical reduced. The apical horn, when developed, is conical, broad, with rounded or oblate distal extremity, and merges almost imperceptibly into the anterior epipericyst. Antapical horns commonly acuminate distally. Pericyst widest in the pericingular region in ambital view. Epipericyst and hypopericyst of approximately equal size. Compression dorso-ventral, moderate to extreme.

Endocyst: Commonly obscure. May be present and appressed to pericyst throughout, or rhomboidal, ovoidal or circular in ambital view, and separated from the pericyst. Compression dorso-ventral, moderate to extreme.

Pericoels: The endocyst may be separated from the pericyst by an ambital pericoel.

Phragma

Periphragm: Usually less than 2 μ thick, and of constant thickness. Surface laevigate, granulate, verrucate, rugulate or reticulate, commonly with smoothly granulate or transversely striate, pandasutural zones lying between paraplates. Ornamentation intratabular.

Endophragm: Surface laevigate to scabrate.

Paratabulation

Pericyst: Paratabulation when observable typical peridinioid with paratabulation formula 4', 3a, 7", 5-?7c, 5"', 2"". The paratabulation is usually determinable from the pandasutural zones or intratabular ornamentation. Where the paraplate outlines are discernible apical 1' is rhombic, 2' and 4' are narrow elongate, and 3' is shortened where it abuts against the anterior intercalaries. The anterior intercalary 2a is standard hexa; 1a and 3a are elongate pentagonal. Of the precingulars 4" is quadrate with its longest axis parallel to the pericingulum. 1" and 7" are of more or less similar size and rhomboidal. The postcingular paraplate 3"' is pentagonal with its longest axis lying parallel to the pericingulum. 1"" and 2"" are of similar size and shape and located primarily on the dorsal surface.

Pericingulum: Present, usually indented, planar, or slightly or strongly helicoidal. Parasutures raised, distally entire or denticulate.

Perisulcus: Extending onto the peipericyst but more fully developed on the hypopericyst and reaching to the antapex.

Endocyst: No observable paratabulation.

Archeopyle

Periarcheopyle: Combination $\overline{A_{3'}3I3P_{3''-5''}}$ type resulting from the partial or complete detachment of a simple perioperculum composed of paraplates 3', 1a-3a, 3"-5", i.e., most or all of the dorsal epipericyst. The archeopyle suture has been termed the transapical epitractal suture by Wall and Dale (1968, p. 279). Subsequent authors have shortened the term to transapical suture. Accessory archeopyle sutures not developed. The perioperculum may be detached or remain attached along the parasutures 3"-c, 4"-c, and 5"-c.

Endoarcheopyle: Identical to periarcheopyle when the endocyst reflects the outline of the pericyst. Otherwise unknown.

Archeopyle Formula: $\overline{A_{3'}3I3P_{3''-5''}}/\overline{A_{3'}3I3P_{3''-5''}}$

Dimensions

Pericyst: Length 34-154 μ, breadth 25-124 μ
Endocyst: Insufficient data

DISCUSSION:

Palaeoperidinium is characterized by its usually discernible peridinioid paratabulation, apical and antapical horns, and its combination AIP archeopyle. Evitt (1974) gives an extremely thorough treatment of the morphology of *Palaeoperidinium hansonianum* (Traverse, 1955) Lentin and Williams, 1973, and fully details the nature of the periarcheopyle and endoarcheopyle. Evitt (1975) also demonstrates conclusively that the archeopyle in *Palaeoperidinium basilium* (Drugg) Drugg is $\overline{A_{3'}3I3P_{3''-5''}}$. This species he considers is probably a *jr syn.* of the type of the genus *Palaeoperidinium, P. pyrophorum.* Evitt (1975, p. 81) believes that the archeopyle in *P. pyrophorum* is not epitractal as stated by Sarjeant (1967, p. 246) in his re-examination of Ehrenberg's type material, but results from separation along a transapical suture, with the operculum remaining attached along its posterior margin.

The type of the genus *Astrocysta, A. cretacea* which was shown by Norris and Hedlund (1972) to have an $\overline{A_{3'}3I3P_{3''-5''}}$ archeopyle conforms to the diagnosis of *Palaeoperidinium.* Therefore, the genus *Astrocysta* is a *jr syn.* of *Palaeoperidinium*. *Palaeoperidinium deflandrei* subsp. *larjakiensis* (Vozzhennikova, 1967) Lentin and Williams 1973 appears to have a 2a archeopyle. Vozzhennikova's illustrations, however, show certain inconsistencies. In plate 16, figure 2b, the striae in the pandasutural zones are aligned parallel to the parasutures and not perpendicular as in other species. Vozzhennikova's interpretation may therefore be incorrect.

The ambital outline of the pericyst of *Pentagonum* Vozzhennikova, 1963, is identical to *Palaeoperidinium pyrophorum* (Ehrenberg, 1838) Deflandre, 1935, emend. Sarjeant, 1967. Two species are included in the genus, *Pentagonum marginatum,* and the type species *P. sibiricum.* One of the specimens figures as *P. marginatum* by Vozzhennikova (1967, pl. 46, fig. 3) has lost the dorsal epipericyst as can be seen from the extremely thin, transparent remaining ventral epipericyst. The specimen of the same species in plate 46, figure 4, shows development of the transapical suture and partial attachment of the operculum along its posterior margin. Thus the archeopyle is the $\overline{A_3{}'3I3P_3{}''{}_{-5}{}''}$ type as found in *Palaeoperidinium.* In the specific diagnosis of *Pentagonum marginatum* Vozzhennikova states that the lateral sides of the theca have a border with transverse parallel striae. These are obviously equivalent to the striate pandasutural zones in *Palaeoperidinium pyrophorum.* Both species of *Pentagonum* are large (from *ca.* 100-125 μ in length) and occur in Paleocene sediments. *Pentagonum marginatum* and *P. sibiricum* are herein transferred to *Palaeoperidinium* and retained as separate species pending re-examination. *Pentagonum* is therefore a *jr syn.* of *Palaeoperidinium.* Vozzhennikova (1967, p. 106) compared *Pentagonum* to *Lejeunia* from which genus she distinguished *Pentagonum* by its dorso-ventrally compressed cyst and its planar rather than helicoidal pericingulum. These alleged differences reflect a misinterpretation of the morphology of the genus. *Lejeunia* is dorso-ventrally compressed but has a hexa 2a archeopyle. For some inexplicable reason Vozzhennikova did not compare *Pentagonum* with *Palaeoperidinium.*

McIntyre (1975) has erected the genus *Laciniadinium* to accommodate peridinioid taxa with a $\overline{3I+3Pa_3{}''{}_{-5}{}''}$ archeopyle with the operculum remaining attached along the posterior margin. Brideaux and McIntyre (in press) are proposing a genus to accommodate peridinioid taxa having a simple $\overline{3I3P_3{}''{}_{-5}{}''}$ archeopyle with a free operculum.

Evitt (1975) has observed the *Palaeoperidinium* $\overline{A_3 3I3P_3{}''{}_{-5}{}''}$ archeopyle in *Scriniodinium eurypylum* Manum and Cookson, 1964, and has accordingly transferred this species to *Palaeoperidinium.* *Lejeunia ampla* Harland, 1973, and *Lejeunia parva* Harland, 1973, show distinct features resulting from the possession of a $\overline{A3I3P}$ combination archeopyle and are therefore transferred to *Palaeoperidinium.*

Saeptodinium Harris, 1973, according to the generic diagnosis does not possess an observable archeopyle. Two species

Saeptodinium gravattense the type species, and *S. tasmaniense* are included in the genus. In the description under *S. tasmaniense* Harris stated that the archeopyle was possibly formed by splitting between epicyst and hypocyst. Examination of the accompanying plates conclusively demonstrate separation along a transapical suture on the epicyst. Comparison of *S. tasmaniense* (Harris, 1973, pl. 2, fig. 2 and 5) with *Palaeoperidinium hansonianum* (Evitt, 1974, pl. 1, fig. 8) shows a striking similarity, especially in the nature of the archeopyle. *Saeptodinium tasmaniense* therefore possesses an $\overline{A_{3'}3I3P_{3''-5''}}$ archeopyle. The archeopyle in *Saeptodinium gravattense,* the type species, cannot be determined with certainty although the specimens illustrated (Harris, 1973, pl. 1, fig. 1-4) appear to show a transapical suture suggestive of the $\overline{A_{3'}3I3P_{3''-5''}}$ archeopyle. *Saeptodinium* should, however, be retained, since it differs from *Palaeoperidinium* in lacking apical and antapical horns, or having only a very weak apical horn and antapical bulges rather than horns. The pericingulum, when present in *Saeptodinium,* is only weakly developed. In the generic description of *Saeptodinium* Harris, 1973, p. 162, states "... with weakly developed apical and antapical horns." The diagnosis for the two included species read somewhat differently. According to Harris (1973, p. 162) *Saeptodinium gravattense* has a bulge on the epicyst and two slight subequal bulges at the antapex. *S. tasmaniense* (Harris, 1973, p. 163) has a weakly formed apical horn and two very small antapical bulges. There is no mention of antapical horns. The morphologically similar species *Palaeoperidinium hansonianum* has short but prominent antapical horns (Evitt, 1974, p. 3).

Morkallacysta Harris, 1973, p. 163, has a strongly peridinioid outline in ambital view and a triangular archeopyle with attached operculum. The endocyst is allegedly absent. The type and only species *M. pyramidalis* clearly possesses an $\overline{A_{3'}3I3P_{3''-5''}}$ archeopyle with the operculum remaining attached posteriorly (Harris, 1973, pl. 1, fig. 6, 7) and an endocyst (Harris, 1973, pl. 1, fig. 11). It is therefore herein considered a *jr syn.* of *Palaeoperidinium.* Other than *Saeptodinium* no other genera are known to possess the diagnostic *Palaeoperidinium* archeopyle.

STRATIGRAPHIC RANGE: Barremian-Late Oligocene

SPECIES OF *Palaeoperidinium*

"alatum" (Conrad, 1941, p. 5, pl. 1, fig. C). Following Sarjeant's (1967, p. 248) recommendation this species is transferred to *?Microdinium,* as *?M. alatum comb. nov.*

amplum (Harland, 1973) *comb. nov.*
1973 *Lejeunia ampla* Harland, p. 673-674, pl. 84, fig. 1, 7; text-fig. 8. Late Campanian [Fig. 217].

basilium (Drugg, 1967, p. 13, pl. 1, fig. 9-11; pl. 9, fig. 1a-b) Drugg, 1970b, p. 810. ?Maastrichtian-Danian [Fig. 223].

cretaceum Pocock ex Davey, 1970, p. 359 (Pocock, 1962, p. 80, pl. 14, fig. 219-221). Barremian. This species was the type of the genus *Astrocysta* Davey, 1970, p. 359, which is herein considered to be a *jr syn.* of *Palaeoperidinium* [Fig. 216].

damasii (Lejeune-Carpentier, 1942) *comb. nov.*
1942 *Peridinium damasii* Lejeune-Carpentier, p. 185-186, fig. 10. Senonian [Fig. 222].

deflandrei Lentin and Williams, 1973, p. 105 (for description see *Peridinium conicum* Deflandre, 1936b, p. 174, pl. 4, fig. 4). ?Senonian [Fig. 214].
subsp. *larjakiensis* (Vozzhennikova, 1967, p. 71-72, pl. 16, fig. 1-2). Lentin and Williams, 1973, p. 105. Paleocene [Fig. 215].

"ellipsoideum" (Deflandre, 1936b, p. 178, pl. 6, fig. 5-7). Following Sarjeant's (1967, p. 250) recommendation, this species is transferred to *?Microdinium,* as *?M. ellipsoideum comb. nov.*

eurypylum (Manum and Cookson, 1964, p. 20-21, pl. 4, fig. 7-13). Evitt, 1975, p. 81. Late Cretaceous [Fig. 224].

hansonianum (Traverse, 1955, p. 77-79, pl. 13, fig. 147) Lentin and Williams, 1973, p. 105. Late Oligocene [Fig. 218].

"manumcooksoni" Corradini, 1973, p. 176-177, pl. 28, fig. 4, 6). This species is herein considered a *jr syn.* of *Palaeoperidinium cretacea.*

marginatum (Vozzhennikova, 1967) *comb. nov.*
1967 *Pentagonum marginatum* Vozzhennikova, p. 107, pl. 46, fig. 1, 3-4, 6. Paleocene [Fig. 211].

"mecsekense" (Nagy, 1969, p. 292, pl. 1, fig. 6, 8). This species is here transferred to *?Gonyaulacysta,* as *?G. mecsekensis comb. nov.*

"monacanthum" (Deflandre, 1935, p. 228, pl. 6, fig. 1). Following Sarjeant's (1967, p. 252) recommendation, this species is transferred to *Gonyaulacysta,* as *G. monacantha comb. nov.*

"muriciforme" (Conrad, 1941, p. 7, pl. 1, fig. k). Following Sarjeant's (1967, p. 253) recommendation this species is transferred to *?Palaeohystrichophora,* as *P. muriciformis comb. nov.*

paleocenicum (Cookson and Eisenack, 1965c) *comb. nov.*
1965c *Peridinium paleocenicum* Cookson and Eisenack, p. 142-143, pl. 19, fig. 1-4. Middle Paleocene [Fig. 225].

"pannonium" (Lentin and Williams, 1973, p. 106, *nom. subst. pro Palaeoperidinium nudum* Nagy, 1969, *non P. nudum* Downie, 1957, p. 291, pl. 1, fig. 1) Late Pannonian. This species is according to Nagy (1969, p. 291) most closely comparable to *"Palaeoperidinium nuciforme"* (Deflandre, 1938b) which was transferred to *Gonyaulacysta* by Sarjeant (1968, p. 227). It is here suggested that *"Palaeoperidinium pannonium"* be questionably transferred to *Gonyaulacysta* as *?Gonyaulacysta nuda* (Nagy, 1969) *comb. nov.*

parvum (Harland, 1973) *comb. nov.*
1973 *Lejeunia parva* Harland, p. 672-673, pl. 84, fig. 3, 12-14; text-fig. 7. Late Campanian [Fig. 221].

"piriforme" (Conrad, 1941, p. 9, pl. 1, fig. G). Following Sarjeant's (1967, p. 255) recommendation, this species is transferred to *Gonyaulacysta* as *G. piriformis comb. nov.*

pyramidale (Harris, 1973) *comb. nov.*
1973 *Morkallacysta pyramidalis* Harris, p. 163, pl. 1, fig. 5-11. Paleocene. The monospecific genus *Morkallacysta* is herein considered to be a *jr syn.* of *Palaeoperidinium* [Fig. 212].

**pyrophorum* (Ehrenberg, 1838, pl. 1, fig. 1, 4) Deflandre, 1935, p. 227
l. emend. Sarjeant, 1967, p. 246-247. Late Cretaceous [Fig. 213].

sibiricum (Vozzhennikova, 1963) *comb. nov.*
1963 *Pentagonum sibiricum* Vozzhennikova, p. 183, text-fig. 17a-b. Paleocene. *Pentagonum* Vozzhennikova, 1963, p. 183, is herein considered to be a *jr syn.* of *Palaeoperidinium* and is made a superfluous genus by the transfer of the type species, *P. sibiricum,* and *P. marginatum* to *Palaeoperidinium* [Fig. 210].

?subconicoides (Lejeune-Carpentier, 1942, p. 183-185, text-fig. 1-18). Lentin and Williams, 1973, p. 106. Senonian [Fig. 219].

tabulatum (Cookson and Eisenack, 1965c) *comb. nov.*
1965c *Ginginodinium tabulatum* Cookson and Eisenack, p. 143-144, pl. 19, fig. 5-8; text-fig. 3. Middle Paleocene [Fig. 220].

"velatum" (Conrad, 1941, p. 8-9, pl. 1, fig. A). Following Sarjeant's (1967, p. 256) recommendation this species is transferred to *?Scriniodinium,* as *?S. velatum comb. nov.*

l. *"rhomboidalis"* (Gorka, 1965, p. 301-302, pl. 1, fig. 6). Following Sarjeant's (1967, p. 256) recommendation this species is transferred to *?Trichodinium,* as *T. rhomboidale comb. nov.*

SAEPTODINIUM Harris, 1973
[Fig. 226-227]

TYPE SPECIES: *Saeptodinium gravattense* Harris, 1973, p. 162-163, pl. 1, fig. 1-4. Paleocene.

DIAGNOSIS: Harris, 1973, p. 162: "Cavate dinoflagellate cysts of oval to peridiniod form with weakly developed apical and antapical horns. Endocorpus ovoidal. Pericorpus lacking tabulation and with indistinct trace of cingulum. Archeopyle formation not known. Ornament smooth to finely granulate."

EXPANDED DIAGNOSIS:

Shape

Pericyst: Ambitus circular to ovoidal to weakly pentagonal. Apex rounded or with short broad apical horn which merges imperceptibly into the anterior epipericyst. Commonly the apex is invaginate. Antapex rounded or with one eccentrically located antapical lobe, or with two symmetrically located antapical lobes separated by a concavity. Pericyst in ambital view widest in the precingular or postcingular region. Epipericyst and hypopericyst approximately equal in size. Compression dorso-ventral, moderate.

Endocyst: Ambitus circular to ovoidal, in close proximity to the pericyst except apically, or slightly separate.

Pericoels: Apical pericoel only, or narrow ambital pericoel with partial contact of endocyst and pericyst.

Phragma

Periphragm: Surface laevigate to scabrate to granulate.

Endophragm: Surface laevigate to scabrate to granulate.

Paratabulation

Pericyst: Paratabulation not observed other than in the vicinity of the periarcheopyle. Obviously peridinioid.

Pericingulum: Present or absent. When present is only faintly indicated by raised borders or folds.

Perisulcus: Not always determinable, when visible largely restricted to the hypopericyst.

Endocyst: No observable paratabulation other than in the vicinity of the endoarcheopyle.

Archeopyle

Periarcheopyle: Combination $\overline{A_3'3I3P_3''\text{-}_5''}$ type resulting from the partial detachment of a simple perioperculum composed of paraplates 3', 1a-3a, 3"-5", i.e., most or all of the dorsal epipericyst. The archeopyle suture is of the type commonly termed a transapical suture. Accessory archeopyle sutures not developed. The perioperculum remains attached along the posterior parasuture, i.e. 3"-c, 4"-c, and 5"-c.

Endoarcheopyle: Combination $\overline{A_3'3I3P_3''-5''}$ and identical to periarcheopyle $A_3'3I3P_3''-5''$.

Archeopyle Formula: $\overline{A_3'3I3P_3''-5''}$

Dimensions

Pericyst: Length 45-62 μ, breadth 42-60 μ
Endocyst: Length < 40-55 μ, breadth 37-50 μ

DISCUSSION:

Saeptodinium Harris is characterized by the circular to ovoidal outline of the pericyst, the absence of antapical horns, and the combination $\overline{AIP}$ archeopyle. According to Harris (1973, p. 162) *Saeptodinium* does not possess an observable archeopyle. Two species, *Saeptodinium gravattense,* the type species, and *S. tasmaniense* are included in the genus. In the description under *S. tasmaniense* Harris stated that the archeopyle was possibly formed by splitting between epicyst and hypocyst. Examination of the accompanying plates conclusively demonstrates separation along a transapical suture on the epicyst. Comparison of *S. tasmaniense* (Harris, 1973, pl. 2, fig. 2, 5) with *Palaeoperidinium hansonianum* (Traverse) Lentin and Williams (1973) (*in* Evitt, 1974, pl. 1, fig. 8) shows a striking similarity, especially in the nature of the archeopyle. Evitt (1974) has lucidly outlined the morphology of *P. hansonianum* and convincingly demonstrated its $\overline{AIP}$ archeopyle. *Saeptodinium tasmaniense* therefore possesses an $\overline{A_3'3I3P_3''-5''}$ archeopyle. The archeopyle in *Saeptodinium gravattense,* the type species, cannot be determined with certainty although the specimens illustrated (Harris, 1973, pl. 1, fig. 1-3) appear to show a transapical suture suggestive of the $\overline{A_3'3I3P_3''-5''}$ archeopyle. *Saeptodinium* differs from *Palaeoperidinium* in lacking apical and antapical horns, or having only a very weak apical horn and antapical bulges rather than horns. Also the pericingulum when present in *Saeptodinium* is only weakly developed. In the generic description of *Saeptodinium,* Harris (1973, p. 162) states "... with weakly developed apical and antapical horns." The diagnoses for the two included species read somewhat differently. According to Harris (1973, p. 162) *Saeptodinium gravattense* has an apical bulge on the epicyst and two slight subequal bulges at the antapex. *S. tasmaniense* (Harris, 1973, p. 163) has a weakly formed apical horn and two very small antapical bulges. There is no mention of antapical horns. The morphologically similar *Palaeoperidinium hansonianum* has short but prominent antapical horns. *Saeptodinium* therefore can be readily separated from *Palaeoperidinium* on the absence of antapical horns, although as with all classifications based on form genera there is some overlap. No other known genera possess the diagnostic *Palaeoperidinium* archeopyle.

STRATIGRAPHIC RANGE: Paleocene-Early Miocene

SPECIES OF *Saeptodinium*

**gravattense* Harris, 1973, p. 163-163, pl. 1, fig. 1-4. Paleocene [Fig. 227].

"hansonianum" (Traverse, 1955). The transfer of this species to *Saeptodinium* by Harris, 1973, p. 162, is invalid. The species is retained in *Palaeoperidinium*.

tasmaniense Harris, 1973, p. 163, pl. 1, fig. 12; pl. 2, fig. 1-6. Late Oligocene-Early Miocene [Fig. 226].

LACINIADINIUM
[Fig. 228-229]

TYPE SPECIES: *Laciniadinium orbiculatum* McIntyre, 1975, p. 70-71, pl. 4, fig. 10-13. Campanian.

DIAGNOSIS: McIntyre, 1975, p. 70: Cysts proximate, spherical to rhombic in shape, dorso-ventrally flattened. Apical and antapical horns either present or absent. Wall single-layered except at apex where two layers may be present, smooth to granulate and echinate. Cingulum visible as low ridges, sulcus present but indistinct. Archeopyle combination type, intercalary-precingular ($\overline{3I3Pa}$); operculum attached at cingulum, simple, flap-like, formed of reflected plates 1a, 2a, 3a, 3", 4", 5".

DESCRIPTION:

<u>Shape</u> <u>Autocyst</u>: Ambitus spherical to rhomboidal, generally prolonged into a short apical horn which is usually invaginated. Antapex rounded or produced into a single eccentrically located antapical horn, the left, which is usually acuminate distally. Autocyst widest in the autocingular region in ambital view. Epiautocyst and hypoautocyst of approximately equal size or epiautocyst slightly larger. Compression dorso-ventral extreme.

<u>Phragma</u> <u>Autophragm</u>: Thin. Surface granulate, or with ridges, or spinate. The spines rarely exceed 1 μ. The ornamentation may be arranged in rows giving the autocyst a striate appearance. Ornamentation nontabular.

<u>Paratabulation</u> <u>Autocyst</u>: Paratabulation not discernible other than in the vicinity of the archeopyle. Presumably peridinioid.

<u>Autocingulum</u>: Present and distinct. May be slightly indented. Planar or slightly helicoidal. Parasutures as low laevigate or granulate to spiny ridges or delineated by rows of granules or spines.

<u>Autosulcus</u>: Broad and more fully developed on the hypoautocyst reaching almost to the antapex.

<u>Archeopyle</u> <u>Autoarcheopyle</u>: Combination $\overline{3I3Pa_{3''-5''}}$ type resulting from partial detachment of a simple autooperculum composed of the three anterior intercalaries 1a-3a and three precingular paraplates 3"-5". The autooperculum remains attached along parasutures 3"-c, 4"-c, and 5"-c.

Archeopyle Formula: $\overline{3I3Pa_{3''-5''}}$.

<u>Dimensions</u> Autocyst: Length 55-110 μ, breadth 34-97 μ

DISCUSSION: *Laciniadinium* is characterized by its spherical to rhomboidal ambital outline and the $\overline{3I3Pa}$ archeopyle with the simple operculum remaining attached along its posterior margin. Other genera superficially similar to *Laciniadinium* are *Palaeoperidinium* and *Ginginodinium*. *Palaeoperidinium*, however, has an $\overline{A_3{}'3I3P_3{}''{-}_5{}''}$ archeopyle, the operculum having a characteristic anterior projection which is the third apical paraplate. *Ginginodinium* like *Laciniadinium* has a 3I3P archeopyle, but the operculum is always compound, although the three precingulars remain attached posteriorly. *Ginginodinium* is also characterized by intratabular, and commonly penetabular, ornamentation. Brideaux and McIntyre (in press) erect a genus with a $\overline{3I3P}$ archeopyle which differs from *Laciniadinium* in always having a detached operculum.

STRATIGRAPHIC RANGE: Campanian

SPECIES OF *Laciniadinium*

biconiculum McIntyre, 1975, p. 71, pl. 4, fig. 5-9. Campanian [Fig. 229].

**orbiculatum* McIntyre, 1975, p. 70-71, pl. 4, fig. 10-13. Campanian [Fig. 228].

SUBTILISPHAERA Jain and Millepied, 1973, emend.
[Fig. 230-242]

TYPE SPECIES: *Subtilisphaera senegalensis* Jain and Millepied, 1973, p. 27-28, pl. 3, fig. 31-33. Aptian.

DIAGNOSIS: Jain and Millepied, 1973, p. 27: "Shell pentagonal-ovoid, test cavate to bicavate non-tabulate, asymmetrical; cingulum (girdle) well developed, dividing the shell into almost equal halves. Epitract broadly rounded with pointed to broadly obtuse apical horn; hypotract rounded having one prominent antapical horn and second undeveloped or only as slight projection placed away from median axis (non-axial). Periphragm smooth to granulate, thin delicate. Endophragm well developed, smooth, thin, delicate; capsule circular, filling periphragm completely or leaving a small pericoel. Archaeopyle mostly not seen, if present intercalary."

DESCRIPTION: "Periphragm extents [*sic*] apically to form a single short apical horn; antapically it again extents [*sic*] into one sided antapical horn, the second antapical horn is never completely developed but shows a slight projection at the place of second antapical horn. Single antapical horn never occupies the median axial position opposite to apical."

EMENDED DIAGNOSIS:

<u>Shape</u>

<u>Pericyst</u>: Ambitus ovoidal, to peridinioid, to elongate. Apex rounded or produced into a single apical horn. Antapex produced into one eccentrically located antapical horn, the left, or two unequal symmetrically located antapical horns, the right antapical horn being reduced or vestigial. Epipericyst and hypopericyst of more or less equal size. Compression dorso-ventral, moderate to extreme.

<u>Endocyst</u>: Ovoidal to ellipsoidal in ambital view may be appressed to pericyst in precingular, cingular and postcingular regions along the right ambital, left ambital or both ambital margins.

<u>Pericoels</u>: Usually a small apical and one or two small antapical pericoels. The apical and antapical pericoels may be united by an ambital pericoel, which occasionally may be restricted to the right ambital or left ambital margins. Compression dorso-ventral moderate to extreme.

<u>Phragma</u>

<u>Periphragm</u>: Thin, surface laevigate, scabrate or granulate.

<u>Endophragm</u>: Thin, usually laevigate or scabrate.

Paratabulation Pericyst: Paratabulation indeterminate.

Pericingulum: Present or absent. When present may be indicated only by an indentation on the ambitus, or may be delineated by raised parasutural ridges. Planar or helicoidal.

Perisulcus: Usually weakly indicated by folding on the hypopericyst.

Endocyst: Paratabulation unknown.

Archeopyle Periarcheopyle often indeterminate. When visible is a combination archeopyle ($\overline{?AIP}$) resulting from separation along a transapical suture. The operculum, which may include paraplates 3', 1-3a and 3"-5", remains attached along the posterior parasuture.

Endoarcheopyle: Unknown.

Archeopyle Formula: When determinable $\overline{?AIP/?AIP}$

Dimensions Pericyst: Length 42-106 μ, breadth 24-68 μ
Endocyst: Length 30-48 μ, breadth 30-46 μ

DISCUSSION: Jain and Millepied, 1973, p. 27, stated that the archeopyle was generally not visible, but if present was intercalary, meaning presumably that it resulted from the loss of paraplate 2a. Only two of the species which were included in *Subtilisphaera* have intercalary archeopyles. These are *"Subtilisphaera pirnaensis"* (Alberti, 1959b) and *"Subtilisphaera sverdrupiana"* (Manum, 1963), *"Subtilisphaera cretacea"* (Pocock, 1962) is known to have an $\overline{A3I3P}$ archeopyle (Norris and Hedlund, 1972). However, the species *Subtilisphaera senegalensis* which is the type of the genus *Subtilisphaera* is described as not having an archeopyle. The inclusion in *Subtilisphaera* of such disparate morphological types suggests the need for emendation of the genus. However, the holotype of *S. senegalensis* will not be made available for examination in Canada. The emendation therefore proposed by the present authors cannot exclude the possibility of an archeopyle being absent. Species transferred to *Subtilisphaera* by Jain and Millepied which do not conform to the general morphology of *S. senegalensis* have been accommodated elsewhere. *"S. pirnaensis"* is transferred to *Alterbia*, *"S. sverdrupiana"*, and *"S. cretacea"* to *Palaeoperidinium*.

Specimens assigned to *Subtilisphaera perlucida* by the present authors have an $\overline{A3I3P}$ archeopyle with the operculum remaining attached. It is possible that other species within *Subtilisphaera* may have an $\overline{A3I3P}$ archeopyle. *Subtilisphaera* is characterized by the absence of an archeopyle, or the possession of a combination archeopyle resulting from schism along a transapical suture. There is either one eccentrically located antapical horn, or two symmetrically located but unequal antapical horns. Paratabulation is not observable on the pericyst which is laevigate or ornamented with scabrae or granules only.

Subtilisphaera is distinguished from *Palaeoperidinium* by having an ovoidal pericyst which lacks paratabulation and observable pandasutural bands and on which the right antapical horn is vestigial or absent. The endocyst of *Subtilisphaera* is always clearly delineated. In *Palaeoperidinium* the endocyst is differentiated only in paratabulate species.

STRATIGRAPHIC RANGE: Middle Barremian-?Senonian

SPECIES OF *Subtilisphaera*

asymmetrica (Davey and Verdier, 1971) *comb. nov.*
1971 *Deflandrea asymmetrica* Davey and Verdier, p. 39-40, pl. 2, fig. 4, 6. Middle Albian. With the transfer of this species out of *Deflandrea*, its original name is no longer a *jr hom.*, therefore the *nom. subst. D. deformans* is now superfluous [Fig. 236].

balcattensis (Cookson and Eisenack, 1969) *comb. nov.*
1969 *Deflandrea balcattensis* Cookson and Eisenack, p. 3, 5, fig. 1B-F. Albian-Cenomanian [Fig. 241].

crassigranulosa Jain and Millepied, 1973, p. 28, pl. 2, fig. 25. Aptian [Fig. 233].

"cretacea" (Pocock ex Davey, 1970). Now *Palaeoperidinium.*

?euthema (Davey and Verdier, 1971) *comb. nov.*
1971 *Deflandrea euthema* Davey and Verdier, p. 40, pl. 3, fig. 1-3. Middle-Late Albian. Archeopyle of this species not fully interpreted [Fig. 237].

perlucida (Alberti, 1959b, p. 102, pl. 9, fig. 16-17) Jain and Millepied, 1973, p. 27. Late Barremian [Fig. 234].

pirnaensis (Alberti, 1959b, p. 10C, pl. 8, fig. 1, 5) Jain and Millepied, 1973, p. 27. Middle Turonian [Fig. 232].

pontis-mariae (Deflandre, 1936b) *comb. nov.*
1936b *Gymnodinium pontis-mariae* Deflandre, p. 167, pl. 2, fig. 7-9. ?Senonian [Fig. 235].

rotundata (Eisenack and Cookson, 1960, p. 2, pl. 1, fig. 1-2). Jain and Millepied, 1973, p. 27. Albian. We do not agree with Davey (1974, p. 65) that *S. rotundata* is a *jr syn.* of *S. perlucida* [Fig. 239].

scabrata Jain and Millepied, 1973, p. 28, pl. 3, fig. 36-39. Aptian [Fig. 242].

**senegalensis* Jain and Millepied, 1973, p. 27-28, pl. 3, fig. 31-33. Aptian [Fig. 231].

"sverdrupiana" (Manum, 1963). Now *Spinidinium.*

?terrula (Davey, 1974) *comb. nov.*
1974 *Deflandrea terrula* Davey, p. 65, pl. 8, fig. 4-5. Middle Barremian [Fig. 238].

?trendalli (Cookson and Eisenack, 1970a) *comb. nov.*
1970a *?Ascodinium trendalli* Cookson and Eisenack, p. 145-146, pl. fig. 5-6. Albian-Cenomanian [Fig. 240].

ventriosa (Alberti, 1959b, p. 101, pl. 9, fig. 14-15) Jain and Millepied, 1973, p. 29. Early Aptian [Fig. 230].

GEISELODINIUM Krutzsch, 1962
[Fig. 243 and 303-305]

TYPE SPECIES: *Geiselodinium geiseltalense* Krutzsch, 1962, p. 43, pl. 11, fig. 8-13; text-fig. 1b. Middle Eocene.

DIAGNOSIS: Krutzsch, 1962, p. 42 (translation after Norris and Sarjeant, 1965, p. 29-30): "A genus of the Deflandreidae with a thin central body and thin outer body, that are close together. The single apical and two antapical horns are small. The longitudinal and transverse furrows are preserved as relics, and at times are almost vestigial. The furrows are not in contact or rarely in contact with each other. Outline broadly oval, horns not or only feebly entering into the contour. Pylome absent, or not clear. Both inner and outer bodies weakly granular (pustulate). No tabulation."

EXPANDED DIAGNOSIS:

Shape

Pericyst: Ambitus ovoidal to broadly elliptical. Apex rounded or produced into very broad, conical, distally rounded apical horn which merges imperceptibly with the anterior epipericyst. Antapex flat, rounded, or with two symmetrically located slight antapical lobes separated by a concavity. Pericyst in ambital view widest in the pericingular region.

Endocyst: Ambitus circular to ovoidal, almost filling pericyst except apically and antapically.

Pericoels: Larger apical and smaller antapical pericoels, united by narrow ambital pericoel.

Phragma

Periphragm: Thin laevigate granulate (pustulate), commonly folded.

Endophragm: Thin, laevigate to scabrate.

Paratabulation

Pericyst: Paratabulation not observed.

Pericingulum: Absent or weakly delineated, weakly indented.

Perisulcus: Questionably identifiable by folds.

Endocyst: Paratabulation not observed.

Archeopyle

Apparently absent.

Dimensions

Pericyst: Length 55-75 μ
Endocyst: Diameter 50-60 μ

DISCUSSION: *Geiselodinium* differs from *Teneridinium* Krutzsch in not possessing prominent apical or antapical horns. It bears a close resemblance to *Saeptodinium* which has an $\overline{A_{3'}3I3P_{3''-5''}}$ archeopyle. In the generic diagnosis for *Geiselodinium* Krutzsch stated that a pylome had not been observed. Krutzsch's failure to observe the archeopyle in *Geiselodinium* inidicates that it may be a combination of $\overline{AIP}$ type with attached operculum. Since, however, this is only conjectural it seems advisable to retain *Geiselodinium* as a genus pending re-examination of the type material, and if possible the nature of the archeopyle in the type species *G. geiseltalense*. If the archeopyle is of the *Palaeoperidinium* type, then *Saeptodinium* would be a *jr syn.* of *Geiselodinium*.

STRATIGRAPHIC RANGE: Middle Eocene-Middle Miocene

SPECIES OF *Geiselodinium*

eocenicum Krutzsch, 1962, p. 44, pl. 11, fig. 17-19; text-fig. 1d. Middle Eocene [Fig. 303].

**geiseltalense* Krutzsch, 1962, p. 43, pl. 11, fig. 8-13; text-fig. 1b. Middle Eocene [Fig. 243].

hallense Krutzsch, 1962, p. 44, pl. 11, fig. 14-16, text-fig. 1c. Middle Eocene [Fig. 304].

miocenicum Nagy, 1965, p. 201, pl. 1., fig. 3; pl. 2, fig. 11. Middle Miocene [Fig. 305].

TENERIDINIUM Krutzsch, 1962
[Fig. 244]

TYPE SPECIES: *Teneridinium magnoides* Krutzsch, 1962, p. 42, pl. 10, fig. 1-7; text-fig. 1a. Eocene.

DIAGNOSIS: Krutzsch, 1962, p. 41 (translation after Norris and Sarjeant, 1965, p. 58): "A genus of the Deflandreidae with very thin central body; outer body likewise very thin. Both loose fitting, under 1 μ thick, always with numerous crumpled folds; walls smooth or shagreenate. With clearly delineated long apical horn and two more or less equal antapical horns. Outline elongate pentagonal with concave sides. Equatorial furrow absent, sometimes faintly indicated on the outline; longitudinal furrow likewise more or less completely reduced. No pylome observed. No tabulation."

EXPANDED DIAGNOSIS:

Shape

Pericyst: Ambitus elongate pentagonal (peridinioid), generally with concave sides, pericyst prolonged into one broad apical and two symmetrically placed, more or less equal, broad, antapical horns. Horns rounded distally. Greatest width in the equatorial region.

Endocyst: Ambitus circular to ovoidal, more or less fitting the pericyst except apically and antapically.

Pericoels: Apical and antapical pericoels present, and may be united by a partial or complete ambital pericoel.

Phragma

Periphragm: Thin, surface laevigate to scabrate.

Endophragm: Thin, surface laevigate to /scabrate.

Paratabulation

Pericyst: Paratabulation not observed.

Pericingulum: Absent or faintly indicated on ambitus.

Perisulcus: Unknown.

Endocyst: Paratabulation not observed.

Archeopyle

Apparently absent?

Dimensions

Pericyst: Length 100-130 μ
Endocyst: Diameter *ca.* 80 μ

DISCUSSION: *Teneridinium* differs from *Geiselodinium* Krutzsch in having well-developed apical and antapical horns. Norris and Sarjeant (1965, p. 58) concluded that *Teneridinium* differed from *Deflandrea* only in having thinner periphragm and endophragm. They concluded that this was insufficient grounds for generic separation, although they did not actually designate *Teneridinium* as a *jr syn*.

of *Deflandrea*. In the generic diagnosis for *Teneridinium* Krutzsch stated that a pylome had not been observed. Kurtzsch's failure to observe the archeopyle in *Teneridinium* inidcates that it may be a combination $\overline{\text{AIP}}$ type with attached operculum. Since, however, this is only conjectural it seems advisable to retain *Teneridinium* as a monospecific genus pending re-examination of the holotype of *T. magnoides* and if possible determination of the archeopyle type.

STRATIGRAPHIC RANGE: Eocene

SPECIES OF *Teneridinium*

**magnoides* Krutzsch, 1962, p. 42, pl. 10, fig. 1-7; text-fig. 1a. Eocene [Fig. 244].

PSEUDODEFLANDREA Alberti, 1959a
[Fig. 245]

TYPE SPECIES: *Pseudodeflandrea gigantea* Alberti, 1959a, p. 92, text-fig. 1. Middle Oligocene.

DIAGNOSIS: Alberti, 1959a, p. 91 (translation from Norris and Sarjeant, 1965, p. 52): "Shell flattened, its outline pentagonal to rhomboidal. Epitheca forms an acute angled triangle, at the free end strongly rounded off. Hypotheca shorter than the epitheca, reversed trapezoidal. With two horn-like antapical processes of unequal length which taper to their free ends. Shell unplated, without transverse furrow. Ventral and dorsal sides of the shells give rise to rather robust, flange-like processes whose bases may coalesce with one another. These flanges narrow forward very strongly, their ends are often forked and connected to the ends of other outgrowths by slender trabeculae. Outer edge of shell usually entire, in different places moderately indented. With a large oval, thick-walled inner body, whose surface is ornamented with wart-like elevations."

Dimensions

Pericyst: Length 220 μ, breadth 105 μ
Endocyst: Length 95 μ, breadth 81 μ

DISCUSSION: The monospecific genus *Pseudodeflandrea* Alberti is based on a single complete specimen of *Pseudodeflandrea gigantea*. Alberti also recorded the presence of a hypocyst of another specimen. According to Alberti (1959a, p. 91-92) *Pseudodeflandrea* differs from *Deflandrea* in possessing processes and from *Wetzeliella* in the outline of the pericyst and the presence of interconnecting trabeculae which unite some processes distally. *Pseudodeflandrea* may represent an aberrant form. Alternatively it may be a species of *Odontochitinopsis* Eisenack, 1961, or *Xenascus* Cookson and Eisenack, 1969, the so-called hypocyst of Alberti representing a specimen possessing an apical archeopyle. Unfortunately the genus has not been adequately described or figured. Pending re-examination of the holotype of *P. gigantea* it is recommended by the present authors that no further species be placed in *Pseudodeflandrea*.

STRATIGRAPHIC RANGE: Middle Oligocene

SPECIES OF *Pseudodeflandrea*

**gigantea* Alberti, 1959a, p. 92, text-fig. 1. Middle Oligocene [Fig. 245].

RHOMBODINIUM Gocht, 1955
[Fig. 246-257]

TYPE SPECIES: *Rhombodinium draco* Gocht, 1955, p. 86, text-fig. 1. Middle Oligocene.

DIAGNOSIS: Gocht, 1955, p. 85 (translation): "Dinoflagellate with approximately rhomboidal, kite-shaped or quadrilateral outline, well developed apical and lateral horns and usually reduced antapical horns. Shell not tabulated, smooth, not usually ornamented with spines or setae (distinction from *Wetzeliella*) without distinctly recognizable transverse or longitudinal furrows. The shell always contains an inner capsule (see *Wetzeliella*)."

Alberti, 1961, p. 9: "In the sense of the diagnosis given by Gocht, 1955, with the addition that a transverse furrow can be distinguished. Since direct intermediate between the genera *Wetzeliella* Eisenack and *Rhombodinium* Gocht exist, the separation of *Rhombodinium* Gocht thus appears questionable and it is regarded as a subgenus of *Wetzeliella*."

Vozzhennikova, 1967, p. 167 (translation): "Theca is rhombiform, with well developed apical horn and lateral horns. Antapical horns are small and varied in size, one of them is reduced. Transverse furrow is well or poorly defined and often noticeable only on the lateral horns. Location of the longitudinal furrow is unclear. Inner body is oval or ovally-quadrangular, its surface is sculptured and yellow, light yellow, or light brown in colour. Theca is light-coloured, its surface is smooth or fine grained."

Vozzhennikova, 1967, p. 168 (translation): "This genus possesses morphological similarity to the genus *Wetzeliella* from which it is distinguished by the stronger reduction of antapical horns and the absence of spine-like or hair-like protuberances on the surface of the theca." "... the general similarity of thecal structure of the genera *Rhombodinium* and *Wetzeliella* and their affinity have served Alberti (1961) as a basis for the amalgamation of these two genera into one, the genus *Wetzeliella*, with *Rhombodinium* being regarded as a subgenus. In spite of the morphological similarity and affinity of these genera they possess peculiar structural features (size and shape of horn-like projection, presence or absence of ornamentation and others), which permits their consideration as independent genera."

EXPANDED DIAGNOSIS:

<u>Shape</u> <u>Pericyst</u>: Ambitus rhomboidal to pentagonal. Apex rounded or prolonged into a short apical horn. Two equal pericingular horns usually present but may be reduced or vestigial. Antapex prolonged into two unequal, symmetrically-located antapical horns, of which the left is always the longer, the right being very reduced or vestigial. From the location of the pericingular

horns, the epipericyst and hypopericyst may be equal in size or unequal, when the hypopericyst is the larger. Compression dorso-ventral, extreme.

Endocyst: Ambitus circular, to ovoidal, to rhomboidal, may be in contact with pericyst in the interhorn areas. Occasionally the endocyst outline closely conforms to that of the pericyst. Isolated endocysts are not uncommon.

Pericoel: When the endocyst and pericyst are in contact between the horns, the result is an apical, two cingular and one or two antapical pericoels. Alternatively, the pericoels may be united when the endocyst and pericyst are separated by an ambital pericoel.

Phragma

Periphragm: Thin and usually of constant thickness. Surface ornamentation laevigate, scabrate, granulate, verrucate, tuberculate or perforate. Apparently nontabular, occasionally intratabular including penetabular alignment.

Endophragm: < 1 μ to several microns and occasionally thickening where underlying a horn. Surface laevigate to granulate.

Paratabulation

Pericyst: Paratabulation usually indeterminate other than in the vicinity of the archeopyle. When delineated peridinioid 4', 3a, 7" xc, 5"', 2', ?3s.

Pericingulum: Produced into two pericingular horns. Commonly delineated as an indentation at the distal extremity of the pericingular horns, occasionally seen as a faint thickening in the mid-dorsal region. Slightly helicoidal.

Perisulcus: Rarely discernible. Extends onto the epipericyst but considerably larger on the hypopericyst. Flagellar pore imprints occasionally visible.

Endocyst: Paratabulation indeterminate other than in the vicinity of the archeopyle.

Archeopyle

Periarcheopyle: Quadra intercalary resulting from the partial or complete loss of the second anterior intercalary paraplate 2a. Perioperculum free or attached along the anterior suture Ql.

Endoarcheopyle: Quadra intercalary resulting from the loss of the second anterior intercalary paraplate, often of greater width than the periarcheopyle. In rare specimens all three anterior intercalaries seem to be lost in archeopyle formation. Operculum usually free.

Archeopyle Formula: I/I (2a/2a)

Dimensions

(excluding *?Rhombodinium minusculum*)
Pericyst: Length 76-166 μ, breadth 86-193 μ
Endocyst: Length 56-108 μ, breadth 62-113 μ

DISCUSSION: *Rhombodinium* is characterized by having usually well developed pericingular horns, unequal antapical horns, a periphragm lacking processes, a clearly delineated endocyst and a quadra 2a archeopyle. This type of archeopyle is also present in *Kisselevia, Wetzeliella* and *Wilsonidium*. *Wetzeliella* and *Kisselevia* both differ in having processes. *Wilsonidium* differs in possessing parasutural ornamentation.

STRATIGRAPHIC RANGE: Eocene-Oligocene

SPECIES OF *Rhombodinium*

condylos (Williams and Downie, 1966b) *comb. nov.*
1966b *Wetzeliella condylos* Williams and Downie, p. 193-194, pl. 20, **fig.** 1-2. Early Eocene [Fig. 248].

"coronatum" (Vozzhennikova, 1967). Now *Wetzeliella*.

**draco* Gocht, 1955, p. 86, text-fig. 1. Middle Oligocene [Fig. 247].
subsp. *freienwaldense* (Gocht, 1955, p. 87, text-fig. 2). Lentin and Williams, 1973, p. 120. Middle Oligocene [Fig. 256].

glabrum (Cookson, 1956, p. 186, pl. 2, fig. 1-5) Vozzhennikova, 1967, p. 169. Eocene [Fig. 253].
subsp. *crassithecum* (Vozzhennikova, 1967, p. 170, pl. 91, fig. 1-2, 4-6) Lentin and Williams, 1973, p. 120. Late Eocene-Early Oligocene [Fig. 246].
subsp. *granulatum* (Wilson, 1967c, p. 493, fig. 29-30) Lentin and Williams, 1973, p. 120. Late Eocene [Fig. 251].

intermedium (Cookson and Eisenack, 1961b, p. 40, pl. 1, fig. 5-6) Lentin and Williams, 1973, p. 120. Eocene [Fig. 250].

longimanum Vozzhennikova, 1967, p. 171, pl. 92, fig. 1-3; pl. 93, fig. 1-6; pl. 94, fig. 1-3. Late Eocene [Fig. 252].

?minusculum (Alberti, 1961, p. 10-11, pl. 1, fig. 10; pl. 12, fig. 4) Lentin and Williams, 1973, p. 120. Early Eocene. This species may belong to the genus *Inversidinium* (see McLean, 1973, p. 732) [Fig. 254].

"pentagonum" (Vozzhennikova, 1967). Now *Wetzeliella*.

rhomboideum (Alberti, 1961, p. 10, pl. 1, fig. 1-5; pl. 12, fig. 9) Lentin and Williams, 1973, p. 121. Late Eocene [Fig. 257].

rotundatum Baltes ex Lentin and Williams, 1973, p. 121 (Baltes, 1969, p. 35, pl. 5, fig. 10). Oligocene [Fig. 255].

waipawaense (Wilson, 1967c, p. 493-494, fig. 18, 20). Lentin and Williams, 1973, p. 121. Early Eocene [Fig. 249].

WETZELIELLA Eisenack, 1938b, emend.
[Fig. 258-284]

TYPE SPECIES: *Wetzeliella articulata,* Eisenack, 1938, p. 186, text-fig. 4. Late Eocene-Early Oligocene.

DIAGNOSIS: Eisenack, 1938, p. 187 (translation): "The bristled, integument and strengthened, almost limb-like protrusions of the body are designated as characteristics of the species."

Eisenack, 1954, p. 54 (translation): "Shell more or less flattened, rhomboidal to pentagonal or more or less oval, usually with an apical, a lateral horn on each side and two antapical horns, all of which can be strongly recurved, without tabulation, almost always ornamented with setae spines. Transverse and longitudinal furrows respectively not determinable as a flagellar grove (the first perhaps sometimes indicated). In the interior is an ellipsoidal capsule."

Williams and Downie, 1966b, p. 182: "Body with distinct pericoel and endocoel. Periphragm having a distinctive outline, varying from oval to pentagonal and generally prolonged into an apical horn, two lateral horns and one or two antapical horns. Periphragm may or may not bear intratabular processes. Processes (when present) open proximally, open or closed distally and frequently arranged in process complexes. Endophragm circular to ovoid in outline, in cross section biconvex and separated, by pericoel of variable size from periphragm. Reflected tabulation of 4', 3a, 7", 5"', 2"". 3-4s, ?c not always evident. Cingulum slightly laevo-rotatory, running round maximum width of periphragm. Sulcus wider and longer on hypotract than epitract. Archaeopyle usually present in periphragm and resulting from loss of plate 2a. Endophragm usually with archaeopyle in analogous position."

EMENDED DIAGNOSIS:

<u>Shape</u> <u>Pericyst</u>: Ambitus rhomboidal to pentagonal peridinioid. Apex rounded or more commonly prolonged into a short apical horn, which may be acuminate oblate or rounded distally. Two equal pericingular horns usually present, occasionally reduced or absent. Antapex prolonged into one eccentrically located antapical horn, the left, or commonly, two unequal symmetrically located antapical horns, the left always being the longer, the right being reduced or vestigial. Occasionally in specimens with a single antapical horn, this horn appears to be centrally located. From the position of the pericingular horns, the epipericyst and hypopericyst appear to be closely similar in size. Compression dorso-ventral, usually extreme.

Endocyst: Ambitus circular to ovoidal to ellipsoidal. Rarely may be completely appressed to the pericyst when it then has the same shape. Generally only partially in contact with the pericyst, and then usually in the interhorn areas. Compression dorso-ventral, moderate to extreme. Isolated endocysts not uncommon.

Pericoels: When the endocyst and pericyst are in contact in the interhorn areas there result an apical, two cingular and one or two antapical pericoels. Alternatively the pericoels may be united when the endocyst and pericyst are separated by a single ambital pericoel.

Phragma

Periphragm: Thin (usually less than 2 μ) and of a constant thickness. Produced into numerous nontabular simple or occasionally branched processes which are open proximally, and may be open or closed distally. Process length often reduced proportionately towards the horns and rarely exceeding 20 μ. Distally the processes may be acuminate, oblate, bifid, bifurcate or aculeate.

Endophragm: $<$ 1 μ to several microns thick. Often thicker where underlying a horn. Outer surface laevigate, to granulate to verrucate; ornamentation tends to be concentrated in the vicinity of the horns.

Paratabulation

Pericyst: Paratabulation usually indeterminate other than in the vicinity of the archeopyle. Where determinate is the typical peridinioid. Paratabulation of 4', 3a, 7", 5"', 2"" and 3-4s.

Pericingulum: Produced into two pericingular horns. Commonly delineated as an indentation at the distal extremity of the pericingular horns; occasionally indicated by processes alignment.

Perisulcus: Obscured by the processes. Flagellar pore imprints occasionally visible.

Endocyst: Paratabulation indeterminate other than in the vicinity of the archeopyle.

Archeopyle

Periarcheopyle: Quadra intercalary, resulting from the partial or complete detachment of the second anterior intercalary paraplate, 2a. Perioperculum free or attached along the anterior parasuture Ql.

Endoarcheopyle: Quadra intercalary, resulting from the loss of the second anterior intercalary paraplate, 2a. Endoperculum usually free.

Archeopyle Formula: I/I (2a/2a).

Dimensions

Pericyst: Length 42-196 μ, breadth 30-178 μ
Endocyst: Length $<$ 40-120 μ, breadth /28-114 μ

DISCUSSION: *Wetzeliella* is characterized by the rhomboidal to pentagonal outline of the pericyst, the usually well developed pericingular horns, the unequal antapical horns, the usually nontabular processes, and a quadra 2a archeopyle. The quadra 2a archeopyle is also present in *Rhombodinium, Kisselevia* and *Wilsonidium.* Williams and Downie (1966b, p. 182) observed simulate process complexes in a few specimens of *Wetzeliella articulata* Eisenack, *W. homomorpha* Deflandre and Cookson and *W. similis* Eisenack. The paratabulation is peridinioid 4', 3a, 7", 5"', 2"", 3-4s ?c. These are obviously transitional forms to *Kisselevia.* The processes, however, are never interconnected distally or show the pandasutural zones as in *Kisselevia. Wetzeliella* is distinguished from *Rhombodinium* on the presence of processes, from *Kisselevia* in usually lacking orientation of the processes which rarely form simulate complexes or are penetabular and are not united distally and from *Wilsonidium* in lacking parasutural ornamentation.

The genus *Dracodinium* Gocht, 1955, p. 87, differs from *Wetzeliella,* according to Gocht, in lacking an apical horn. Gocht stated that the position of the slip hole (archeopyle) was variable. The type of the genus and sole species *Dracodinium solidum* obviously possesses a quadra 2a intercalary archeopyle from Gocht's accompanying illustrations (text-fig. 3-5). Gocht's contention that some specimens have an apical 'archeopyle' is probably attributable to orientation. Williams and Downie (1966b, p. 182) noted that transitional forms between *D. solidum* and *Wetzeliella similis* Eisenack, a species with an apical horn, were common in samples from the Early Eocene of England. Consequently, these authors (p. 195) transferred *Dracodinium solidum* to *Wetzeliella,* while excluding forms with a so-called apical archeopyle. *Dracodinium* is herein considered a *jr syn.* of *Wetzeliella,* and the specimens of *"Dracondinium solidum"* with an 'apical archeopyle' are also taken to have a quadra 2a archeopyle and as such constitute the same species.

STRATIGRAPHIC RANGE: Paleocene-Oligocene (excluding *W. irregularis*)

<u>SPECIES OF *Wetzeliella*</u>

**articulata* Eisenack, 1938, p. 186, text-fig. 4. Late Eocene-Early Oligocene [Fig. 258].
subsp. *conopia* (Williams and Downie, 1966b, p. 184, pl. 18, fig. 5) Lentin and Williams, 1973, p. 141. Early Eocene [Fig. 259].

"clathrata" (Eisenack, 1938). Now *Kisselevia.*

"coleothrypta" (Williams and Downie, 1966b). Now *Kisselevia.*

"condylos" (Williams and Downie, 1966b). Now *Rhombodinium.*

coronata (Vozzhennikova, 1967) *comb. nov.*
1967 *Rhombodinium coronatum,* p. 170-171, pl. 89, fig. 1-3, 5; pl. 90, fig. 1-5. Late Eocene [Fig. 260].

"echinosuturata" (Wilson, 1967c). Now *Wilsonidium.*

echinulata Vozzhennikova, 1967, p. 164-165. Figured in Vozzhennikova, 1960, pl. 3, fig. 3; descriptior not published until 1967. Eocene [Fig. 284].

edwardsii Wilson, 1967c, p. 477. fig. 8-9. Early Eocene [Fig. 281].

hampdenensis Wilson, 1967c, p. 480-481, fig. 17, 19. Middle Eocene [Fig. 282].

homomorpha Deflandre and Cookson, 1955, p. 254, pl. 5, fig. 7; text-fig. 19. Early Eocene [Fig. 276].
subsp. *quinquelata* (Williams and Downie, 1966b, p. 191-192, pl. 18, fig. 7). Lentin and Williams, 1973, p. 141. Early Eocene [Fig. 278].

hyperacantha Cookson and Eisenack, 1965b, p. 134-135, pl. 16, fig. 3-6. Paleocene [Fig. 273].

"intermedia" (Cookson and Eisenack, 1961b). Now *Rhombodinium.*

irregularis Cookson and Eisenack, 1958, p. 28-29, pl. 10, fig. 1-2. Late Jurassic. The age of this species suggests that it may have been in the sample as a result of contamination [Fig. 272].

irtyschensis Alberti, 1961, p. 8, pl. 1, fig. 11-12; pl. 12, fig. 8. Early Oligocene [Fig. 268].

"lineidentata" (Deflandre and Cookson, 1955). Now *Wilsonidium.*

longispinosa (Wilson, 1968) *comb. nov.*
1968 *Deflandrea longispinosa* Wilson, p. 59-60, fig. 1-10. Early Eocene [Fig. 275].

lunaris Gocht, 1969, p. 13-15, pl. 10, fig. 1-3; text-fig. 6. Early Eocene [Fig. 274].

meckelfeldensis Gocht, 1969, p. 15-16, pl. 10, fig. 12-15. Early Eocene [Fig. 277].

"ornata" (Wilson, 1967c). Now *Wilsonidium.*

ovalis Eisenack, 1954, p. 59, pl. 8, fig. 1-7. Early Oligocene [Fig. 280].

pachyderma Caro, 1973, p. 365, pl. 3, fig. 4-6. Basal Eocene [Fig. 283].

parva Alberti, 1961, p. 8-9, pl. 1, fig. 14-18; pl. 12, fig. 10-11. Eocene [Fig. 279].

pentagona (Vozzhennikova, 1967) *comb. nov.*
1967 *Rhombodinium pentagonum* Vozzhennikova, p. 171-172, pl. 89, fig. 4; pl. 95, fig. 1-5; pl. 96, fig. 1-6. Late Eocene-Early Oligocene [Fig. 263].

?pilata Stanley, 1965, p. 222, pl. 21, fig. 12-16. Paleocene. Archeopyle indeterminate [Fig. 264].

"reticulata" (Williams and Downie). Now *Kisselevia*.

"rugosa" (Stanley, 1965). Now *Wilsonidium*.

samlandica Eisenack, 1954, p. 59, pl. 8, fig. 11-12. Early Oligocene [Fig. 265].

similis Eisenack, 1954, p. 58-59, pl. 8, fig. 8-10. Early Oligocene [Fig. 269].

solida (Gocht, 1955, p. 88, text-fig. 2a-b, 4a-b, 5a) Williams and Downie, 1966b, p. 195. Eocene or Oligocene [Fig. 271].

symmetrica Weiler, 1956, p. 132-135, pl. 11, fig. 1-3; text-fig. 2-5. Middle Oligocene [Fig. 270].
- subsp. *incisa* Gerlach, 1961, p. 156-158, pl. 25, fig. 9. Middle-Late Oligocene [Fig. 267].
- subsp. *lobisca* (Williams and Downie, 1966b, p. 196, pl. 20, fig. 3). Lentin and Williams, 1973, p. 143. Early Eocene [Fig. 266].
- subsp. *symmetrica* Weiler, 1956, p. 132-135, pl. 11, fig. 1-3; text-fig. 2-5. Middle Oligocene [Fig. 270].

"tabulata" (Wilson, 1967c). Now *Wilsonidium*.

"tenuivirgula" (Williams and Downie, 1966b). Now *Kisselevia*.

unicaudalis Caro, 1973, p. 366, 368, pl. 5, fig. 1, 9. Early Eocene [Fig. 261].

varielongituda Williams and Downie, 1966b, p. 196-197, pl. 20, fig. 4, 8. Early Eocene [Fig. 262].

KISSELEVIA Vozzhennikova, 1967 emend.
[Fig. 285-292]

TYPE SPECIES: *Kisselevia ornata* Vozzhennikova, 1967, p. 103-104, pl. 42, fig. 1-3; pl. 43, fig. 1-4; pl. 44, fig. 1-12; pl. 45, fig. 1-3. Eocene.

DIAGNOSIS: Vozzhennikova, 1967, p. 103 (translation): "Armour is regularly pentagonal and dorso-ventrally strongly compressed, with a short apical and two short antapical horns. On the lateral sides of the theca (at the joining points of the epitheca and the hypotheca) there are blunt, slightly drawn-out corners. Transverse furrow is equatorial and circular. Longitudinal furrow is located on the hypotheca. Surface of the theca is reticulate or reticulately spinose. Armour is divided into plates (areas) whose number could not be established. Pylome is trapezoidal to quadrangular. Internal contours of the theca are easily discernible."

Vozzhennikova goes on to remark: "... (Vozzhennikova, 1963) there was mentioned the presence of an inner body, which was mistakenly assumed from the contours of the perivisceral cavity of the cell. As (further) investigations have shown, the inner body is absent in representatives of the genus *Kisselevia.*"

EMENDED DIAGNOSIS:

Shape — Pericyst: Ambitus rhomboidal to pentagonal (peridinioid). Apex rounded or more commonly prolonged into an apical horn, which may be sharply delineated or merge imperceptibly with the anterior epipericyst. Two equal pericingular horns usually present, occasionally reduced or absent. Antapex prolonged into one eccentrically located antapical horn, the left, or two unequal symmetrically located antapical horns, the left always being the longer, the right being reduced or vestigial. Occasionally in specimens with a single antapical horn, this horn appears to be centrally located. From the position of the pericingular horns the epipericyst and hypopericyst appear to be closely similar in size. Compression dorso-ventral, usually extreme.

Endocyst: Ambitus circular to ovoidal to ellipsoidal. Rarely may be completely appressed to the pericyst when it then has the same shape. Generally only partially in contact with the pericyst and then in the interhorn areas. Compression dorso-ventral.

Pericoels: When the endocyst and pericyst are in contact in the interhorn areas there result an apical, two cingular and one or two antapical pericoels. Alternatively the pericoels may be united when the endocyst and pericyst are separated by a single ambital pericoel.

Phragma — Periphragm: Thin (usually less than 2 μ) and of a constant thickness. Surface separated into unornamented pandasutural zones and ornamented intratabular zones with processes arranged in simulate complexes, or penetabular. Processes united distally by a continuous or discontinuous membrane or trabeculae within the same paraplate, rarely between paraplates.

Endophragm: Thin, rarely exceeding 2 μ in thickness. Surface laevigate to granulate.

Paratabulation

Pericyst: The simulate complexes which are separated by unornamented pandasutural zones delineate a typical peridinioid paratabulation of 4', 3a, 7", 5"', 2"", 3-4s. Apical paraplate 1' is rhomboidal and the largest of the apicals; 2' and 4' are narrow elongate; 3' is reduced and roughly triangular. Of the anterior intercalaries 1a and 3a are identical in size and shape and are elongate, antero-posteriorly. 2a is quadrate (quadra type) and posteriorly abuts against 4". Within the precingulars 1" and 7" are rhomboidal and of more or less equal size. Their shortest parasuture is 1"-as and as-7" respectively. 2" and 6" are narrow elongate, 3" and 5" are reduced rhomboidal; 4" appears rectangular with rounded anterior margin. Its longest axis lies parallel to the pericingulum and it is wider than 2a.

Within the postcingulars 1"' and 5"' are large subrhombic and of unequal size, 1"' being slightly larger. 2"' and 4"' are of more or less equal size and the smallest of the series. 3"' is pentagonal and of approximately the same width as 4". The two large antapical paraplates are located primarily on the dorsal surface and are approximately equal in size.

Pericingulum: Produced into two pericingular horns. Delineated by linear process complexes, number of paraplates at least five. Commonly indented as can be seen at the distal extremity of the pericingular horns. Slightly helicoidal.

Perisulcus: Clearly delineated. Large on both epipericyst and hypopericyst. Widening posteriorly and extending onto the antapical horns. Usually contains three or four simulate process complexes, the largest by far of which is the posterior. This posterior sulcal paraplate has a very distinctive outline. Flagellar pore imprints occasionally visible.

Endocyst: Paratabulation indeterminate other than in the vicinity of the endoarcheopyle.

Archeopyle

Periarcheopyle: Quadra intercalary resulting from the partial or complete detachment of the second anterior intercalary paraplate 2a. Perioperculum free or attached along the anterior parasuture Q1.

Endoarcheopyle: Quadra intercalary resulting from the loss of the second anterior intercalary paraplate 2a. Operculum usually free. Often of greater width than the periarcheopyle.

Archeopyle Formula: I/I (2a/2a).

Dimensions — Pericyst: Length 100-182 μ, breadth 95-163 μ
Endocyst: Length 66-144 μ, breadth 62-110 μ

DISCUSSION: *Kisselevia* is characterized by having one apical, two pericingular and one or two unequal antapical horns, pandasutural zones devoid of ornamentation, intratabular processes, which form simulate complexes or are penetabular, and are interconnected distally within the same paraplate, and a quadra 2a archeopyle. *Wetzeliella* differs in not having processes interconnected distally. Also in *Wetzeliella* simulate process complexes are exceedingly rare and pandasutural zones are not delineated. *Rhombodinium* lacks processes. *Wilsonidium* has parasutural ornamentation. Although Vozzhennikova (1967, p. 103) states categorically that an endocyst is lacking in *Kisselevia,* the holotype of *K. ornata* (pl. 44, fig. 6) and several other specimens of this species (e.g. pl. 42, fig. 1, 2, 3) clearly possess one. The absence of an endocyst cannot therefore be retained in the generic diagnosis.

STRATIGRAPHIC RANGE: Early Ecoene-Early Oligocene

SPECIES OF *Kisselevia*

?clathrata (Eisenack, 1938) *comb. nov.*
1938 *Wetzeliella clathrata* Eisenack, pl. 187, text-fig. 5. Late Eocene-Early Oligocene. This species is questionably transferred to *Kisselevia* because the 'lists' or linear process complexes may be parasutural [Fig. 288].
subsp. *fasciata* (Rozen, 1965) *comb. nov.*
1965 *Wetzeliella clathrata* var. *fasciata* Rozen, p. 296-297, pl. 2, fig. 13; text-fig. 4. Late Eocene. Raised to subspecies status by Lentin and Williams (1973, p. 141) [Fig. 291].

coleothrypta (Williams and Downie, 1966b) *comb. nov.*
1966b *Wetzeliella coleothrypta* Williams and Downie, p. 185-186, pl. 18, fig. 8-9; text-fig. 47. Early Eocene [Fig. 287].

"major" (Vozzhennikova, 1960). *nom. nud.*

**ornata* Vozzhennikova, 1967, p. 103-104, pl. 42, fig. 1-3; pl. 43, fig. 1-3; pl. 44, fig. 1-12; pl. 45, fig. 1-3. Eocene [Fig. 285].
subsp. *ornata* (Vozzhennikova, 1967, p. 103-104, pl. 42, fig. 1-3; pl. 43, fig. 1-4; pl. 44, fig. 4-6, 9-12) Lentin and Williams, 1973, p. 84. Eocene [Fig. 285].
subsp. *reticulata* (Vozzhennikova, 1967, p. 104, pl. 44, fig. 1-3, 7-8; pl. 45, fig. 1-3) Lentin and Williams, 1973, p. 84. Eocene [Fig. 290].

reticulata (Williams and Downie, 1966b) *comb. nov.*
1966b *Wetzeliella reticulata* Williams and Downie, p. 187-188, pl. 19, fig. 3, 6; text-fig. 48. Early Eocene [Fig. 286].

tenuivirgula (Williams and Downie, 1966b) *comb. nov.*
1966b *Wetzeliella tenuivirgula* Williams and Downie, p. 188-189, pl. 19, fig. 2, 4; text-fig. 49. Early Eocene [Fig. 289].

subsp. *crassoramosa* (Williams and Downie, 1966) *comb. nov.*
1966b *Wetzeliella tenuivirgula* var. *crassoramosa* Williams and Downie, p. 189-190, pl. 19, fig. 1, 5, 7; text-fig. 50. Raised to subspecies status by Lentin and Williams, 1973, p. 143 [Fig. 292].

WILSONIDIUM gen. nov.
[Fig. 293-298]

TYPE SPECIES: *Wilsonidium tabulatum* (Wilson) *comb. nov. (=Wetzeliella tabulata* Wilson, 1967c, p. 473-474, fig. 2, 4-7, 10-11).

DIAGNOSIS:

Shape

Pericyst: Ambitus rhomboidal to pentagonal (peridinioid). Apex rounded or more commonly prolonged into an apical horn. Two equal precingular horns usually present, occasionally reduced or absent. Antapex prolonged into one eccentrically located antapical horn, the left, or two unequal symmetrically located antapical horns, the left always being the longer, the right being reduced or vestigial. From the position of the pericingular horns, the epipericyst and hypopericyst may be equal in size, or unequal, in which case the hypopericyst is always the larger. Compression dorso-ventral, usually extreme.

Endocyst: Ambitus circular to ovoidal to ellipsoidal. Rarely may be completely appressed to the pericyst when it has the same shape. Generally only partially in contact with the pericyst and then in the interhorn areas. Compression dorso-ventral.

Pericoels: When the endocyst and pericyst are in contact in the interhorn areas, there result an apical, two cingular and one or two antapical pericoels. Alternatively the pericoels may be united when the endocyst and pericyst are separated by a single ambital pericoel.

Phragma

Periphragm: Thin (usually less than 2 μ) and of a constant thickness. Surface ornamented with parasutural granules, septa and/or processes. Intratabular ornamentation reduced or absent.

Endophragm: < 1 μ to several microns thick. Surface laevigate to granulate.

Paratabulation

Pericyst: The parasutures delineate a typical peridinioid paratabulation of 4', 3a, 7", 5"', 2"" plus sulcals. In the apical series, paraplate 1' is pentagonal, 2', 3' and 4' are considerably smaller. The 1a and 3a paraplates appear to be pentagonal and extend closer to the pericingulum than the quadra 2a. Of the precingulars 1" and 7" are rhomboidal with their longest axis parallel to the pericingulum, 2" and 6" are elongate narrow, 3" and 5" are four-sided, and 4" is six-sided with its longest axis parallel to the pericingulum. The width of the 4" is greater than that of 2a.

The postcingular paraplates consist of 1"' and 5"' which are four-sided and of more or less equal size, 2"' and 4"' which are likewise four-sided and of equal size, and the distinctive pentagonal 3"'. The two large antapicals are located primarily on the dorsal surface and are more or less equal in size.

Pericingulum: Produced into two pericingular horns. Delineated by parasutural ornamentation, or apparently penetabular ornamentation as linear features. Commonly indented as can be seen at the distal extremity of the pericingular horns. Slightly helicoidal.

Perisulcus: Clearly delineated. Large on both epipericyst and hypopericyst. Widening posteriorly and extending onto the antapical horns. The largest paraplate is the posterior sulcal. Flagellar pore imprints occasionally visible.

Endocyst: Paratabulation indeterminate other than in the vicinity of the endoarcheopyle.

Archeopyle — Periarcheopyle: Quadra intercalary resulting from the partial or complete detachment of the second anterior intercalary paraplate 2a. Perioperculum free or remaining attached along the anterior parasuture.

Endoarcheopyle: Quadra intercalary resulting from the loss of the second anterior intercalary paraplate 2a. Operculum usually free. May be of greater width than the periarcheopyle.

Dimensions — Pericyst: Length 50-171 μ, breadth 50-156 μ
Endocyst: Length < 50-99 μ, breadth < 50-102 μ

DISCUSSION: *Wilsonidium* is characterized by having one apical, two pericingular and one or two unequal antapical horns, parasutural ornamentation on the pericyst and generally reduced intratabular ornamentation. *Wetzeliella* had nontabular or occasionally intratabular processes. *Kisselevia* has pandasutural zones and intratabular processes which are penetabular or form simulate process complexes. *Rhombodinium* lacks parasutural ornamentation.

STRATIGRAPHIC RANGE: Paleocene-Oligocene

SPECIES OF *Wilsonidium*

?aechmophorum (Benedek, 1972) *comb. nov.*
1972 *Lejeunia aechmophora* Benedek, p. 41, pl. 5, fig. 7, 11; text-fig. 17. Middle-Late Oligocene. The archeopyle in this species may be hexa [Fig. 294].

echinosuturatum (Wilson, 1967c) *comb. nov.*
1967c *Wetzeliella echinosuturata* Wilson, p. 477-479, fig. 3, 22-25. Middle Eocene [Fig. 293].

lineidentatum (Deflandre and Cookson, 1955) *comb. nov.*
1955 *Wetzeliella lineidentata* Deflandre and Cookson, p. 253-254, pl. 5, fig. 5; text-fig. 17-18. Eocene [Fig. 296].

ornatum (Wilson, 1967c) *comb. nov.*
1967c *Wetzeliella ornata* Wilson, p. 481-482, fig. 33-34. Early Eocene [Fig. 298].

?rugosum (Stanley, 1965) *comb. nov.*
1965 *Wetzeliella rugosa* Stanley, p. 222-223, pl. 21, fig. 6-11.
Paleocene [Fig. 297].

**tabulatum* (Wilson, 1967c) *comb. nov.*
1967c *Wetzeliella tabulata* Wilson, p. 473-474, fig. 2, 4-7, 10-11.
Late Eocene [Fig. 295].

MOESIODINIUM Antonescu, 1974
[Fig. 299]

TYPE SPECIES: *Moesiodinium raileanui* Antonescu, 1974, p. 62-63, pl.1, fig. 1-16; text-fig. 1. Middle Jurassic.

DIAGNOSIS: Antonescu, 1974, p. 62 (translation): "Rounded to ovoidal dinoflagellate with a capsule (cavate) and tapering towards the apex. The periphragm shows a tendency to form two small appendices at the antapex. The large rounded or ovoidal capsule occupies most of the theca and is surrounded at a more or less equal distance throughout by the periphragm. Cingulum helicoidal, dextrorotatory, dividing the theca into two almost equal halves; the epitheca is slightly larger than the hypotheca. Longitudinal furrow present, barely visible. Archeopyle dorsal, intercalary, hexagonal (formed by the loss of the second anterior intercalary plate?). No other traces of tabulation - tabulation probably of the peridinian type. Operculum free, simple.

EXPANDED DIAGNOSIS:

Shape

Pericyst: Ambitus rounded to ovoidal. Apex rounded, or with or without 'apical pore,' which when present forms an indentation. Antapex rounded, or produced into two symmetrically located equal or unequal antapical lobes separated by a concavity. Widest in pericingular region. Epipericyst and hypopericyst of more or less equal size, or epipericyst slightly larger. Dorso-ventrally compressed.

Endocyst: Ambitus rounded to ovoidal, sometimes with a slight antapical indentation. In ambital view detached from the pericyst.

Pericoels: A single ambital pericoel of more or less uniform width.

Phragma

Periphragm: Thin, laevigate to possibly granulate.

Endophragm: Thin laevigate to granulate.

Paratabulation

Pericyst: Paratabulation indeterminate other than in the vicinity of the archeopyle.

Pericingulum: Clearly delineated by folds or broad ridges. Dextrorotatory. Forms an indentation on the ambitus of the pericyst.

Perisulcus: When visible only faintly delineated. Present on both epipericyst and hypopericyst. Extending to antapex. Widening posteriorly.

Endocyst: Paratabulation indeterminate other than in the vicinity of the archeopyle.

Archeopyle

Periarcheopyle: Hexagonal, intercalary resulting from the loss of a single intercalary paraplate. The shape of the posterior parasuture indicates that the intercalary paraplate lost in archeopyle formation was located between two precingular paraplates and not directly above 4" as in the Type I archeopyle characteristic of the post-Jurassic. Perioperculum free.

Endoarcheopyle: Appears to be hexagonal intercalary and of identical shape to the periarcheopyle.

Archeopyle Formula: I/I?

Dimensions

Pericyst: Length 30-35 μ, breadth 32 μ
Endocyst: Diameter 25 μ

DISCUSSION:

Moesiodinium is characterized by the rounded to ovoidal pericyst with antapical lobes, the ambital pericoel and the very distinctive hexagonal archeopyle which lacks the straight posterior parasuture of most other peridinioid dinoflagellate cysts, rather having a margin that indicates abutment against two rather than one precingular. This is analogous to the archeopyle in *Broomea ramosa* Cookson and Eisenack. The characteristic outline of the archeopyle readily separates it from other genera with an I archeopyle, apart from *Broomea*.

STRATIGRAPHIC RANGE: Middle Jurassic

SPECIES OF *Moesiodinium*

**raileanui* Antonescu, 1974, p. 62-63, pl. 1, fig. 1-16; text-fig. 1. Middle Jurassic [Fig. 299].

BROOMEA Cookson and Eisenack, 1958, emend.
[Fig. 301-302]

TYPE SPECIES: *Broomea ramosa* Cookson and Eisenack, 1958, p. 41-42, pl. 6, fig. 6-8. Middle-Late Jurassic.

DIAGNOSIS: Cookson and Eisenack, 1958, p. 41: "Test elongate with a longer apical horn and two shorter antapical horns. A shallow 'girdle' situated below the middle of the body may be present. A pylome is developed in the apical region.

EMENDED DIAGNOSIS:

Shape — Pericyst: Ambitus elongate ellipsoidal, prolonged into a long apical horn and two symmetrically located usually unequal antapical horns. The antapical horns may be simple or branched giving rise to several slender, tapered processes on each horn. Pericyst widest in the pericingular region. Epipericyst considerably larger than hypopericyst.

Endocyst: Not observed.

Pericoels: Not applicable.

Phragma — Periphragm: Thin, surface laevigate to granulate.

Endophragm: Not observed.

Paratabulation — Pericyst: Paratabulation weakly indicated by parasutural ornamentation or indeterminate. Precise paratabulation formula unknown. The distinctive hexagonal outline of the archeopyle suggests that there may be more than three anterior intercalaries.

Pericingulum: Present or absent; when present delineated by very low anterior and posterior parasutural ridges. Not indented.

Perisulcus: Not observed.

Endocyst: The endocyst has not been identified.

Archeopyle — Periarcheopyle: Hexagonal intercalary resulting from the partial or complete detachment of a single intercalary paraplate. The operculum is free or remains attached along the parasutures H2 and H6; these are the intercalary parasutures. The shape of the posterior parasuture indicates that the paraplate lost in archeopyle formation was located between two precingular paraplates, and not directly above 4" as in Type I archeopyles from the post-Jurassic. This suggests that there are two or more than three anterior intercalaries.

Endoarcheopyle: Not identified.

Archeopyle Formula: I

<u>Dimensions</u> Pericyst: Length 176-314 μ, breadth 24-38 μ

DISCUSSION: *Broomea* is characterized by having an elongate pericyst produced into a long apical and two short antapical horns and an intercalary archeopyle resulting from the partial or complete detachment of a single anterior intercalary paraplate which is located between two precingular paraplates. When Cookson and Eisenack (1958) erected the genus *Broomea* they included in it two species, the type of the genus *B. ramosa*, and *B. simplex*. *Broomea ramosa* has a distinctive hexagonal intercalary archeopyle resulting from the loss of a single anterior intercalary paraplate. The archeopyle of *B. simplex* is unknown. Wiggins (1975, p. 107) transfers *Broomea ramosa* to *Pareodinia* arguing that the described antapical horns are not true horns but septal outgrowths around the margins of the antapical series and could possibly be associated with the posterior intercalaries. The 'septal outgrowths' or 'horns' are not found in species of *Pareodinia*. Also the intercalary, presumably the 2a, according to Wiggins, is not seven-sided but six-sided. The distinctive antapical morphology and hexa intercalary archeopyle of *Broomea ramosa* we feel demand retention of the genus *Broomea*. Wiggins transfer of *Broomea ramosa* to *Pareodinia* is accordingly rejected.

Alberti (1961) included several species in *Broomea* which have been shown by Evitt (1967, p. 32) to possess apical archeopyles. Consequently Wiggins (1975, p. 111) erected the genus *Necrobroomea* to accommodate species differing from *Broomea* in the possession of an apical archeopyle and designates as the type species *N. longicornuta* (Alberti, 1961). Brideaux (1975, p. 1241) independently erected the genus *Batioladinium* for the same forms; however, he designates the species *B. jaegeri* (Alberti, 1961) as the type of the genus. Which genus has priority has not been established as of going to press.

Broomea shows similarity in archeopyle outline to *Moesiodinium* which is distinctly cavate, and lacks horns. The genera provisionally assigned to the protoperidinioid group in this monograph possess questionably two or more than three anterior intercalary paraplates. Both *Broomea* and *Moesiodinium* would be included in this group. They are included here for completeness. Other genera assigned to the group are discussed extensively by Wiggins (1963, 1975) and Sarjeant (1966b).

STRATIGRAPHIC RANGE: Middle-Late Jurassic

<u>SPECIES OF *Broomea*</u>

"*exigua*" (Alberti, 1961). Now *Necrobroomea*.

"*gochtii*" (Alberti, 1961). Now *Necrobroomea*.

"*jaegeri*" (Alberti, 1961). Now *Necrobroomea*.

"*longicornuta*" (Alberti, 1961). Now *Necrobroomea*.

"micropoda" (Eisenack and Cookson, 1960). Now *Necrobroomea.*

"pellifera" (Alberti, 1961). Considered to be a *jr syn.* of *Necrobroomea micropoda* by Wiggins (1975, p. 111).

**ramosa* Cookson and Eisenack, 1958, p. 41-42, pl. 6, fig. 6-8. Middle to Late Jurassic [Fig. 301].

"seelandica" (Lange, 1969). Now *Isabelia.*

simplex Cookson and Eisenack, 1958, p. 42, pl. 6, fig. 9. Late Jurassic [Fig. 302].

"tricornoides" (Alberti, 1961). Now *?Necrobroomea.*

INVERSIDINIUM McLean, 1973
[Fig. 300]

TYPE SPECIES: *Inversidinium exilimurum* McLean, 1973, p. 730, 732, pl. 90, fig. 1-9. Late Paleocene.

DIAGNOSIS: McLean, 1973, p. 730: "Bi-layered cyst; periblast outline peridinioid with pointed apex and truncated antapex; lacks indications of tabulation; endoblast outline variable. Convex-outward folds of the periblast reflect cingulum and sulcus. Excystment apparatus (=archeopyle?) antapical; forms by rupture of antapical tips of periblast and endoblast. Periphragm and endophragm externally smooth to granulose."

EXPANDED DIAGNOSIS:

Shape

Pericyst: Ambitus rhomboidal to peridinioid with acuminate to rounded apex and flattened or truncated antapex. Narrow convex-outward fold running equatorially on the dorsal surface. A similar fold extends longitudinally on the ventral surface, from the antapex to epipericyst. Compression dorso-ventral.

Endocyst: Ambital outline variable, commonly inverted, rounded triangular with antapical lobes. In apical antapical view elliptical at the widest part, and triangular at the antapex. Endocyst wholly or largely restricted to hypopericyst. In contact with pericyst dorsally and ventrally.

Pericoels: Very large apical pericoel occupying most of the epipericyst. Smaller single antapical pericoel. These are united by a narrow ambital pericoel.

Phragma

Periphragm: Thin, with laevigate to granulate surface.

Endophragm: Thin, with laevigate to granulate surface.

Paratabulation

Pericyst: Paratabulation not observable.

Pericingulum: Presumably indicated by a narrow convex outward fold on the dorsal surface.

Perisulcus: Presumably indicated by a narrow convex outward fold extending longitudinally along the ventral midline from approximately midway between the widest part of the pericyst and the apex to the antapex.

Endocyst: Paratabulation not observable.

Archeopyle

Periarcheopyle: Antapical; formed by irregular rupture of the posterior tip of the pericyst.

Endoarcheopyle: Antapical; formed by rupture of the posterior tip of the endocyst.

Archeopyle Formula: Unknown.

Dimensions — Pericyst: Length 45-60 μ, breadth 32-52 μ

DISCUSSION: *Inversidinium* is characterized by a rhomboidal to peridinioid pericyst with a transverse fold on the dorsal surface and a longitudinal fold on the ventral surface, an endocyst largely confined to the hypopericyst giving rise to a very large apical pericoel and an antapical archeopyle. *Nelsoniella* Cookson and Eisenack also has an endocyst largely confined to the hypopericyst although of somewhat different outline in ambital view. *Nelsoniella,* however, has a hexa 2a intercalary archeopyle and lacks a transverse or longitudinal fold. *Rhombodinium* has a similar pericyst outline in ambital view and also lacks processes but differs in having a quadra 2a archeopyle, one or two antapical horns and an endocyst which extends into the epipericyst.

STRATIGRAPHIC RANGE: Late Paleocene

SPECIES OF *Inversidinium*

**exilimurum* McLean, 1973, p. 730, 732, pl. 90, fig. 1-9. Late Paleocene [Fig. 300].

SMOLENSKIELLA Vozzhennikova, 1967

TYPE SPECIES: *Smolenskiella crassitheca* Vozzhennikova, 1967, p. 182-183, pl. 105, fig. 1-4, 6; pl. 106, fig. 1-4. Late Cretaceous.

DIAGNOSIS: Vozzhennikova, 1967, p. 181 (translation): "Theca is ovally polygonal and divided into unequal parts. Epitheca is larger than hypotheca, hemispherical, and rounded at the apex or with a short apical projection. Hypotheca is roundly trapezoidal; its small base corresponds to the antapex. Theca is tabulate. Plate formula: on the epitheca 4', 3a, 6", on the hypotheca 5"', (?2p), 1"". Transverse furrow is circular or slightly spiral. Longitudinal furrow extends from the first apical plate to the antapex. Inner body is ovoidal, ellipsoidal, and thin-walled. Its surface is smooth. Theca is light coloured, its surface is smooth. Pylome is formed by the ejection of the third intercalary plate."

DISCUSSION: *Smolenskiella* as circumscribed by Vozzhennikova (1967, p. 181-182) is characterized by the rounded ambital outline of the pericyst, the presence of paratabulation, the absence of antapical horns and a standard hexa intercalary archeopyle resulting from the loss of anterior intercalary paraplate 2a. As Vozzhennikova has observed, the type and sole species of *Smolenskiella, S. crassitheca* bears a marked resemblance to *Sirmiodinium,* Alberti, 1961 (as in Vozzhennikova, 1967, pl. 106, fig. 1-2). This is presumably a superficial resemblance. In view of the presence of the three anterior intercalary paraplates and the 2a archeopyle *Smolenskiella* is presumably peridinioid. However, Vozzhennikova (1967, p. 181) states that there are only six precingulars. In the accompanying illustrations (text-fig. 8) there appear to be eight. Dinoflagellate cysts with peridinioid paratabulation have invariable been shown to have seven precingulars. Also Vozzhennikova labels the paraplate immediately posterior to the second anterior intercalary 2a, as 3". In all known cyst genera with peridinioid paratabulation, this is invariably the fourth precingular (4"). There is thus considerable doubt as to the true paratabulation formula of *Smolenskiella* and it is felt advisable to exclude an emendation of the generic diagnosis in the present monograph, pending re-examination of the type material.

STRATIGRAPHIC RANGE: Late Cretaceous

SPECIES OF *Smolenskiella*

**crassitheca* Vozzhennkiova, 1967, p. 182-183, pl. 105, fig. 1-4, 6; pl. 106, fig. 1-4. Late Cretaceous [not figured].

INVALID GENERA

"*ANDALUSIELLA*" Riegel, 1974

TYPE SPECIES: "*Andalusiella mauthei*" Riegel, 1974, p. 357-360, pl. 2, fig. 1-7; text-fig. 5-6.

DIAGNOSIS: Riegel, 1974, p. 357: "Rhomboidal cyst with strong apical and two unequal antapical horns. Antapical horns contiguous or fused at base, left horn short, right horn long. Girdle and sulcus visible, sulcus with flagellar structure, archeopyle intercalary. Thick inner and thin outer wall closely adhering, clearly distinct capsule lacking. Peridinioid tabulation indicated."

DISCUSSION: *Andalusiella* is characterized by having one apical and two unequal antapical horns, a pericingulum and perisulcus and an intercalary archeopyle resulting from the loss of paraplate 2a, and lacking a distinct endocyst. Considerable emphasis is placed on the apparent absence of a distinct endocyst. However, Riegel (1974, p. 359) in the description of the type species *A. mauthei* states, "The cyst wall consists of an inner layer 1 to 2 μ in thickness and distinctly brown in colour, and a very thin outer membrane which is closely fused with the inner layer separating slightly from it only in the horns of most specimens." This is confirmed by the accompanying illustrations of *A. mauthei* (pl. 2, fig. 1 and 4). This is analogous to the morphology observed in several species of *Alterbia*, including *A. polymorpha* (Malloy, 1972). The species *Andalusiella mauthei* is compared with *Alterbia polymorpha* (Malloy) and *Palaeocystodinium australina* (Cookson, 1965b) by Riegel. He concluded that the two latter species differ from *Andalusiella mauthei* only by a larger ratio of length to width, by the shape of the antapical horns and by the general lack of a pericingulum. Malloy (1972) assigned specimens to *Palaeocystodinium australina* (pl. 1, fig. 17 and 20 as *Svalbardella*) which differ markedly from the holotype of *P. australina* and cannot be morphologically separated from *Alterbia polymorpha*. *Andalusiella mauthei* falls within the permissible specific variation of *Alterbia polymorpha*, and is herein regarded as a *jr syn.* of that species.

Species formerly included in "*Andalusiella*".
"*mauthei*" (Reigel, 1974), *jr. syn.* of *Alterbia polymorpha*.

"ASTROCYSTA" Davey, 1970

TYPE SPECIES: *Astrocysta cretacea* (Pocock, 1962, p. 80, pl. 14, fig. 219-221) Davey, 1970, p. 359. Barremian.

DIAGNOSIS: Davey, 1970, p. 359: "Proximate cyst of pentagonal shape, composed of two layers, typically in contact. One apical and two antapical horns. Tabulation lightly marked, peridinioid. Cingulum circular and archaeopyle, when seen, intercalary."

DISCUSSION: Davey, 1970, included three species in the genus *Astrocysta, A. cretacea, A. kozlowskii* (Gorka, 1963) and *A. tricuspis* (O. Wetzel, 1933a). *Astrocysta* has been shown to have an $A_{3'}3I3P_{3''-5''}$ archeopyle by Norris and Hedlund (1972) and not a precingular archeopyle as stated by Davey. *A. cretacea* thus conforms to the diagnosis of *Palaeoperidinium. Astrocysta* is therefore regarded herein as a *jr syn.* of *Palaeoperidinium,* to which the species *"Astrocysta cretacea"* is transferred. For the reasons stated in Lentin and Williams (1973, p. 17) the transfer of *"Astrocysta cretacea"* (as *Palaeoperidinium*) to *Lejeunia,* by Brideaux (1971, p. 86) has been rejected. The two remaining species of *Astrocysta, A. kozlowskii* and *A. tricuspis* which appear to have a hexa 2a intercalary archeopyle are herein transferred to *Lejeunia.*

Species formerly included in *"Astrocysta"*

"cretacea" (Pocock, 1962). Now *Palaeoperidinium.*

"kozlowskii" (Gorka, 1963). Now *Lejeunia.*

"tricuspis" (O. Wetzel, 1933a). Now *Lejeunia.*

"AUSTRALIELLA" Vozzhennikova, 1967

TYPE SPECIES: *Australiella tripartita* (Cookson and Eisenack, 1960a, p. 2, pl. 1, fig. 10) Vozzhennikova, 1967, p. 134-135. Senonian.

DIAGNOSIS: Vozzhennikova, 1967, p. 129-130 (translation): "Theca is elongate-oval in shape, with a large, oval inner body occupying the greater part of the theca. The lateral sides (of the inner body) tightly adjoin the thin, lateral sides of the theca which are strongly or slightly convex. Transverse furrow is equatorial, slightly spiral, and fringed with low, continuous or discontinuous projections; it is sometimes noticeable only on the lateral sides of the theca and divides the latter into equal parts. Longitudinal furrow is located on the hypotheca and reaches to the antapex. Apical horn and antapical horns are small, the latter may or may not be of equal length, and are less frequently absent. Pylome is shaped like a horseshoe or is rounded hexagonal.

DISCUSSION: Vozzhennikova (1967, p. 130) states that the species comprising the genus *Australiella* represent a separate morphological group which was distinguished from species of the genus *Deflandrea* in the outline of the pericyst, the development and location of the horns, the outline of the archeopyle and shape and size of the endocyst. In her generic diagnosis Vozzhennikova noted that the pericingulum was fringed with low continuous or discontinuous projections and that the archeopyle was shaped like a horseshoe or roundly hexagonal. She designated as type of the genus *Australiella, A. tripartita* (Cookson and Eisenack, 1960a) Vozzhennikova, 1967, which has an omegaform periarcheopyle (Cookson and Eisenack, 1960a, pl. 1, fig. 10). The species *Australiella bondarenki* Vozzhennikova, 1967, has a partite pericingulum and omegaform periarcheopyle (Vozzhennikova, 1967, pl. 59, fig. 1a-b), as do all the other species assigned to *Australiella* by Vozzhennikova (1967) and Lentin and Williams (1973) respectively. *Chatangiella* Vozzhennikova, 1967, is characterized by the distinctive shape of the epipericyst in ambital view, the hepta/pentapartite pericingulum and the omegaform periarcheopyle, the operculum of which commonly remains attached along suture H4. These are precisely the generic characteristics of *Australiella*. Vozzhennikova (1967, p. 130) compared the two genera and concluded that although the endocyst location and size and pericyst ambital outline were similar, *Australiella* was distinguished from *Chatangiella* by the oval-hexagonally shaped archeopyle, unevenly developed antapical horns and convex lateral sides of the pericyst. Vozzhennikova's accompanying illustrations of *Chatangiella niigi* (pl. 56, 57 and 58) show specimens with an "oval-hexagonally shaped archeopyle" and unevenly developed antapical horns. The so termed convex lateral sides of the pericyst in *Australiella tripartita* the type of the genus (see Cookson and Eisenack, 1960a, pl. 1, fig. 10) are remarkably similar to those in *Chatangiella niigi* as illustrated in

Vozzhennikova (1967, pl. 56, 57, and 58). Consequently the two genera *Chatangiella* and *Australiella* are herein considered synonymous, with *Australiella* being a *jr syn.* of *Chatangiella.* The majority of species formerly included in *Australiella* are accordingly transferred to *Chatangiella.*

Species formerly included in *Australiella*

"*bondarenki*" (Vozzhennikova, 1967). Now *Chatangiella.*

"*chetiensis*" (Vozzhennikova, 1967). Now *Chatangiella.*

"*cooksoniae*" (Alberti, 1959b). Now *Isabelia.*

"*granulifera*" (Manum, 1963). Now *Chatangiella.*
subsp. "*tenuis*" (Davey, 1970). Now *Chatangiella.*

"*micracantha*" (Cookson and Eisenack, 1960a). Now *Chatangiella.*

"*spectabilis*" (Alberti, 1959b). Now *Chatangiella.*

"**tripartita*" (Cookson and Eisenack, 1960a). Now *Chatangiella.*

"*verrucosa*" (Manum, 1963). Now *Chatangiella.*

"*victoriensis*" (Cookson and Manum, 1964). Now *Chatangiella.*

"CERATIOPSIS" Vozzhennikova, 1963

TYPE SPECIES: *Ceratiopsis leptoderma* Vozzhennikova, 1963, p. 181, text-fig. 8. Paleocene.

DIAGNOSIS: Vozzhennikova, 1963, p. 181 (translation): "Cells elongate or ovoidal with long horns, one apical and two slightly divergent antapical. Girdle annular, running round the equator or displaced slightly forward. Longitudinal furrow not developed on the epivalve but on the hypovalve extending to the antapex. Membrane light yellow, coriaceous, thin, delicate, smooth. Cell cavity occupied by internal body of darker colour than membrane."

Vozzhennikova, 1967, p. 157 (translation): "Theca is elongate-oval in shape, with well developed apical horn and antapical horns whose shape and size vary. Transverse furrow is shallow, circular and equatorial; it divides the theca into almost equal parts. Longitudinal furrow is located on the hypotheca and reaches to the antapex. Inner body is large, ellipsoidal, ovoidal, and light yellow and light brown in colour; its surface is smooth or fine-grained. Theca is light-coloured, thin-walled, delicate, transparent, and tightly abuts the inner body. Pylome is large, roundly trapezoidal and located above the transverse furrow; it corresponds to the location of the third precingular plate. Less frequently the pylome is not defined."

DISCUSSION: Vozzhennikova, 1967, p. 158, includes three species in *Ceratiopsis, C. diebeli* (Alberti, 1959b), *C. leptoderma* Vozzhennikova, 1963, and *C. markovi* Vozzhennikova, 1967. Her interpretation that the archeopyle is precingular is incorrect; all three species have a broad hexa intercalary archeopyle resulting from the loss of paraplate 2a. The relatively long apical and two antapical horns of the pericyst and the elongate endocyst in *C. diebeli* are characteristic of the genus *Ceratiopsis*. The illustration of the holotype of *Ceratiopsis leptoderma* (Vozzhennikova, 1963, pl. 8) and other specimens (Vozzhennikova, 1965, fig. 42H, and Vozzhennikova, 1967, pl. 118, fig. 1, 2, 7) appear to be almost if not identical to *C. diebeli*. However, the illustrations for *C. leptoderma* (Vozzhennikova, 1967, pl. 118, fig. 6) and *C. markovi* (Vozzhennikova, 1967, pl. 120, fig. 1-4) are morphologically similar to several other species of *Deflandrea*, including *D. speciosa* Alberti, 1959b. It is herein considered that since such transitional forms are common, that *Ceratiopsis* be regarded as a *jr syn.* of *Deflandrea*. The species *C. diebeli*, *C. leptoderma* and *C. markovi* are accordingly transferred to *Deflandrea*.

Species formerly included in *"Ceratiopsis"*

"diebeli" (Alberti, 1959b). Now *Deflandrea*.
  subsp. *"brevicornis"* (Vozzhennikova, 1967). *nom. nud.*

**leptoderma* (Vozzhennikova, 1963). Now *Deflandrea*.

"markovi" (Vozzhennikova, 1967). Now *Deflandrea*.

"CERODINIUM" Vozzhennikova, 1963, p. 181

TYPE SPECIES: *Cerodinium sibiricum* Vozzhennikova, 1963, p. 181, text-fig. 9-10. Paleocene-Eocene.

DIAGNOSIS: Vozzhennikova, 1963, p. 181 (translation): "Cells spherical or lenticular, with one apical and two widely spaced antapical horns. Girdle annular; longitudinal furrow present on hypovalve. Width of furrow varies. Membrane thin, delicate, smooth hyaline. Internal body occupies the whole cell cavity, which is darker than the membrane."

Vozzhennikova, 1967, p. 153 (translation): "Theca is ovoidal-elongate in shape, with a straight or bent apical horn, and antapical horns which are widely set apart. Size of the horns varies. Epitheca is somewhat larger than hypotheca. Transverse furrow is circular and equatorial. Longitudinal furrow is located on the hypotheca. Width of the furrows varies. Inner body is spherical, ellipsoidal; its surface is smooth or granular. Theca is light, or bright-yellow in colour; its surface is smooth or sculptured. Pylome is trapezoidal."

DISCUSSION: Vozzhennikova, 1967, p. 153, states that *Cerodinium* is distinguished from other genera by the shape of the pericyst and endocyst, and the presence of a bent apical horn. The accompanying illustrations of the type species *C. sibiricum* (pl. 117, fig. 1a-b) show a typical *Deflandrea* with well developed apical horn, broad hexa intercalary archeopyle resulting from the loss of anterior paraplate 2a, a large endocyst and two widely divergent antapical horns. There is close similarity to *Deflandrea oebisfeldensis* Alberti, 1959b, which is one of the several species of *Deflandrea* with widely divergent antapical horns. The so-called 'bent' apical horn is not uncommon in species of *Deflandrea* where the horn has a certain degree of flexibility. This often results in bending or even breaking of the apical horn during preparation of palynology slides. *Cerodinium* is accordingly herein considered a *jr syn.* of *Deflandrea* and its species transferred to the latter genus.

Species formerly included in *"Cerodinium"*

"balticum" (Vozzhennikova, 1967). Now *Deflandrea.*

"sibiricum" (Vozzhennikova, 1963). Now *Deflandrea.*

"*COOKSONIELLA*" Vozzhennikova, 1967, p. 183

TYPE SPECIES: *Cooksoniella vnigri* Vozzhennikova, 1967, p. 185, pl. 59, fig. 2; pl. 79, fig. 3; pl. 107, fig. 1; pl. 109, fig. 1-2; pl. 110, fig. 2-3. Turonian-Santonian.

DIAGNOSIS: Vozzhennikova, 1967, p. 183 (translation): "Theca is pentagonal, rhombiform, elongated, slightly convex or blunt-angled, and divided into two almost equal parts. Transverse furrow is shallow, equatorial, weakly spiral; its margins and the boundaries of areas are fringed with low ribs or short, acute-angled, conical projections. Tabulation is represented by the formula: on the epitheca 4', 3a, 7"; on the hypotheca 5"', ?"". Apical horn is short, drawn out, and bluntly rounded at the end. Antapical horns are unequal in length; one of them is poorly developed or absent. Inner body is oval or elliptical and occupies the central part of the theca. Pylome is oval-hexagonal in shape.

DISCUSSION: *Cooksoniella* according to Vozzhennikova (1967, p. 184) is distinguished from the genus *Deflandrea* by the presence of paratabulation on, and the outline of, the pericyst and the hexagonal archeopyle. *Chatangiella* Vozzhennikova is differentiated from *Cooksoniella* on the basis of its polygonal archeopyle and poorly developed antapical horns. Vozzhennikova included in her genus *Cooksoniella, C. manumi* and the type species *C. vnigri*. Lentin and Williams (1973, p. 31) transferred three more species to *Cooksoniella, C. damasii* (Lejeune-Carpentier, 1942), *C. paleocenica* (Cookson and Eisenack, 1965c) and *C. scheii* (Manum, 1963). *Cooksoniella manumi* (Vozzhennikova, 1967, pl. 108, fig. 1-4) and *Cooksoniella vnigri* (Vozzhennikova, 1967, pl. 59, fig. 2; pl. 107, fig. 1; pl. 109, fig. 1-2; and pl. 110, fig. 2-3) unquestionably possess a partite pericingulum and omegaform periarcheopyle. The paratabulation is delineated by penetabular ornamentation, in the form of grana, verrucae, tubercles, echinae or spines. In the simplest forms in *Chatangiella* paratabulation is exhibited solely by the penetabular ornamentation on the anterior and posterior margins of the pericingulum, as in *Chatangiella victoriensis* (Cookson and Manum, 1964). Transitional forms ranging from *C. victoriensis* to taxa in which the majority of paraplates are delineated by penetabular ornamentation on the pericyst have been observed in the Late Cretaceous of the Grand Banks and Scotian Shelf. There thus seems no logic in attempting to separate *Chatangiella* and *Cooksoniella* which are herein regarded as synonymous. *Cooksoniella* is regarded a *jr syn.* of *Chatangiella* and the species listed therein by Lentin and Williams (1973, p. 31) are transferred elsewhere as shown below.

Species formerly included in "*Cooksoniella*"

"*?damasii*" (Lejeune-Carpentier, 1942). Now *Palaeoperidinium.*

"*manumi*" (Vozzhennikova, 1967). Now *Chatangiella.*

"*?paleocenica*" (Cookson and Eisenack, 1965c). Now *Palaeoperidinium*.

"*scheii*" (Manum, 1963). Now *?Chatangiella*.

"**vnigri*" (Vozzhennikova, 1967). Now *Chatangiella*.

"CRASPEDODINIUM" Cookson and Eisenack, 1974

TYPE SPECIES: *Craspedodinium indistinctum* Cookson and Eisenack, 1974, p. 76, pl. 25, fig. 7. ?Aptian-Albian.

DIAGNOSIS: Cookson and Eisenack, 1974, p. 75 (translation): "Shell in outline oval to flattened to convex, not indented, with a not very thick walled endophragm and a thin periphragm which projects only slightly beyond the endophragm. This (the periphragm) bears, mostly marginally, a round mesh ornamentation, that is unevenly developed and may be absent over most of the outer shell.

The opening of the shell results from the occasional removal of the apical region and includes both the endo- and periphragm."

DISCUSSION: Cookson and Eisenack (1974, p. 75) believed that the monospecific genus *Craspedodinium* closely resembles *Hexagonifera,* which genus has a standard hexa intercalary archeopyle resulting from the loss of the second anterior intercalary paraplate. Cookson and Eisenack differentiate the two genera on this basis, stating that *Craspedodinium* has an apical archeopyle. Study of the accompanying illustrations (Cookson and Eisenack, 1974, pl. 25, fig. 6-8) suggests that *Craspedodinium indistinctum* has a $\overline{4A3I}$ archeopyle, as found in the genus *Ovoidinium* and conforms to the diagnosis for this genus in all other respects. *Craspedodinium* is therefore regarded herein as a *jr syn.* of *Ovoidinium* and *C. indistinctum* is accordingly transferred.

Species formerly included in *"Craspedodinium":*

"indistinctum" (Cookson and Eisenack, 1974). Now *?Ovoidinium.*

"DRACODINIUM" Gocht, 1955, p. 87

TYPE SPECIES: *"Dracodinium solidum"* Gocht, 1955, p. 88, text-fig. 3-5. Eocene or Oligocene.

DIAGNOSIS: Gocht, 1955, p. 88 (translation from Norris and Sarjeant, 1965, p. 26): "Dinoflagellates with approximately kite-shaped outline, well developed lateral horns and partially reduced antapical horns. Apex more or less rounded, rarely slightly tapered to a point (distinction from *Wetzeliella*); only in exceptional cases a suggestion of an apical angle. Theca without tabulation, copiously provided with bristles; no furrow formation. A circular to roughly ellipsoidal capsule always in the interior.

DISCUSSION: Gocht (1955, p. 87) erected the genus *Dracodinium* for forms differing from *Wetzeliella* in the absence of an apical horn. Gocht stated that the slip hole (archeopyle) was variable. The type of the genus and sole species *Dracodinium solidum* obviously possesses a quadra 2a intercalary archeopyle from Gocht's accompanying illustrations (text-fig. 3-5). Gocht's contention that some specimens have an apical 'archeopyle' is probably attributable to orientiation or damage. Williams and Downie (1966b, p. 182) noted that transitional forms between *D. solidum* and *Wetzeliella similis* Eisenack, a species with an apical horn, were common in samples from the Early Eocene of England. Consequently these authors (p. 195) transferred *Dracodinium solidum* to *Wetzeliella*, while excluding forms with a so-called apical archeopyle. *Dracodinium* is herein considered to be a *jr syn.* of *Wetzeliella* and the specimens of *"Dracodinium solidum"* with an apical archeopyle are also taken to have a quadra 2a archeopyle and as such constitute the same species.

"EVITTODINIUM" Deflandre, 1964, nomen dubium

TYPE SPECIES: *Evittodinium giselae* Deflandre, 1964, p. 5030, fig. 1-5. Senonian.

DIAGNOSIS: Deflandre, 1964, p. 5030 (translation): "Test with an internal body. Epitheca with one horn, hypotheca with two horns. Cingular (equatorial) area ornamented with slightly elevated processes. Genotype: *E. giselae n. sp.* Characteristics of genus. Processes slightly depressed transversely, apparently corresponding to cingular plates. Archeotype [*sic*] indistinct, perhaps related to the median (tubular) structure on the right side of the epitheca (Fig. 1-5) length 77 μ; width 47 μ."

Dimensions

Pericyst: Length 77 μ, breadth 47 μ based on one specimen.
Endocyst: Dimensions not given.

DISCUSSION: Further elucidation of this monospecific genus is impossible due to the fact that it is based on a broken specimen. W.R. Evitt (pers. comm.) reports that the entire epidorsal surface of the holotype of *Evittodinium giselae* is missing. Consequently, one might interpret Article 71 of the ICBN ("A name is to be rejected if it is based on a monstrosity.") as a valid reason to eliminate *Evittodinium*. However, the term 'monstrosity' botanically refers to variation due to genetic damage, rather than to physical damage from external forces. Therefore, we consider *E. giselae* as a *nomen dubium* and strongly recommend that no additional species be assigned to the genus *Evittodinium*.

STRATIGRAPHIC RANGE: Senonian

Species of *Evittodinium*

**giselae* Deflandre, 1964, p. 5030, fig. 1-5. Senonian [no fig.].

"MORKALLACYSTA" Harris, 1973

TYPE SPECIES: *Morkallacysta pyramidalis* Harris, 1973, p. 163, pl. 1, fig. 5-11. Paleocene.

DIAGNOSIS: Harris, 1973, p. 163: "Non-cavate dinoflagellate cysts of strongly peridinioid form with prominent apical and antapical horns. Helicoid girdle strongly marked. Archeopyle triangular with attached operculum. Cyst lacking tabulation and ornamentation."

DISCUSSION: *Morkallacysta* according to Harris has a strongly peridinioid outline with well developed horns and a triangular archeopyle with attached operculum. The endocyst is allegedly absent. The type and only species *M. pyramidalis* clearly possesses an $\overline{A_{3'}3I3P_{3''-5''}}$ archeopyle with the operculum remaining attached posteriorly (Harris, 1973, pl. 1, fig. 6, 7) and an endocyst (Harris, 1973, pl. 1, fig. 11). *Morkallacysta* is therefore considered a *jr syn.* of *Palaeoperidinium* which also has a pericyst with a peridinioid outline and an $\overline{A_{3'}3I3P_{3''-5''}}$ archeopyle.

STRATIGRAPHIC RANGE: Paleocene

Species formerly included in *"Morkallacysta"*

"pyramidalis" (Harris, 1973). Now *Palaeoperidinium.*

"PENTAGONUM" Vozzhennikova, 1963

TYPE SPECIES: *Pentagonum sibiricum* Vozzhennikova, 1963, p. 183, text-fig. 17a-b. Paleocene.

DIAGNOSIS: Vozzhennikova, 1963, p. 183 (translation): "Theca pentagonal, with triangular epitheca, the lateral sides connected almost perpendicularly at the apex and forming a short apical horn. Hypotheca inverted trapezoidal with two widely separated antapical horns. Transverse furrow narrow, longitudinal furrow in some species not reaching the posterior margin of the hypotheca. Theca dense, smooth, unornamented.

DISCUSSION: Vozzhennikova, 1967, p. 106, compares *Pentagonum* to *Lejeunia* from which she distinguished it by its dorso-ventrally compressed cyst and planar as opposed to helicoidal pericingulum. Two species are included in the genus *Pentagonum, P. marginatum* and the type species *P. sibiricum.* The pericyst of both species is identical in ambital outline to that of *Palaeoperidinium pyrophorum* (Ehrenberg, 1838) Sarjeant, 1967. One of the specimens of *Pentagonum marginatum* figured by Vozzhennikova (pl. 46, fig. 3) has lost the dorsal epipericyst as can be seen from the extremely thin, remaining ventral epipericyst. The specimen in pl. 46, fig. 4, shows development of the transapical suture, the operculum being partially attached along its posterior margin. The archeopyle is therefore of the *Palaeoperidinium* $\overline{A_{3'}3I3P_{3''-5''}}$ type, which excludes it from *Lejeunia.*

In the specific diagnosis of *Pentagonum marginatum* Vozzhennikova states that the lateral sides of the theca have a border with transverse parallel striae. These are obviously equivalent to the striate pandasutural zones in *Palaeoperidinium pyrophorum.* Both species of *Pentagonum* are large (from *ca.* 100-125 μ in length) and occur in Paleocene sediments. *Pentagonum marginatum* and *P. sibiricum* for the reasons listed above are herein transferred to *Palaeoperidinium.* The transfer of the two species of the genus *Pentagonum* to *Palaeoperidinium* makes the former genus a *jr syn.* of *Palaeoperidinium.*

Species formerly included in *"Pentagonum"*

"conicoides" Vozzhennikova, 1963, *nom. nud.* no description.

"marginatum" (Vozzhennikova, 1967). Now *Palaeoperidinium.*

"sibiricum" (Vozzhennikova, 1963). Now *Palaeoperidinium.*

"POCOCKIA" Lentin and Williams, 1973
[*nom. subst. pro Evittia* Pocock, 1972, *non Evittia* Brito, 1967]

TYPE SPECIES: *Pocockia cincta* (Cookson and Eisenack, 1958, p. 26, pl. 4, fig. 1-3). Lentin and Williams, 1973, p. 114. Late Neocomian or Early Aptian.

DIAGNOSIS: Pocock, 1972, p. 93: "Elongate amphipolar outline. Capsule distinct, spherical to sub-spherical. No distinct tabulation. Archeopyle apical with operculum that includes three reflected intercalary plates."

DISCUSSION: *Evittia* Pocock, 1972, is a *jr hom.* of the acritarch genus *Evittia* Brito, 1967, p. 477. Lentin and Williams, 1973, p. 114, therefore erected *Pocockia* as a *nom. subst. pro Evittia* Pocock, 1972, *non Evittia* Brito, 1967. Included in *Pocockia* are two species, the type of the genus, *P. cincta,* and *P. waltonii.* Pocock states definitively that *Pocockia* has an apical archeopyle with an operculum that includes the three anterior intercalary paraplates. This is synonymous with the $\overline{4A3I}$ archeopyle of *Ovoidinium. Pocockia cincta* obviously has a $\overline{4A3I}$ archeopyle as is clearly demonstrated in Cookson and Eisenack, 1958, pl. 4, fig. 1. This species is therefore transferred to *Ovoidinium* whose diagnosis it conforms to in all respects. This creates a superfluous genus by removing the type of *Pocockia,* which genus is regarded as a *jr syn.* of *Ovoidinium. Pocockia waltonii* also appears to have a $\overline{4A3I}$ archeopyle (Pocock, 1972, pl. 22, fig. 14) although Pocock (1972, p. 93) refers to it as apical. *P. waltonii* is herein transferred to *Ovoidinium.*

Species formerly included in *Pocockia:*

"cincta" (Cookson and Eisenack, 1958). Now *Ovoidinium.*

"waltonii"(Pocock, 1972). Now *Ovoidinium.*

"SENEGALINIUM" Jain and Millepied, 1973

TYPE SPECIES: *Senegalinium bivacatum* Jain and Millepied, 1973, p. 23, pl. 1, fig. 1-4; text-fig. 1b.

DIAGNOSIS: Jain and Millepied, 1973, p. 22: "Bicavate dinoflagellate cysts, spheriodal [*sic*] or ovoidal to rounded pentagonal, no tabulation; transverse furrow present or absent, circular; sulcus present (restricted to hypotract). Inner body (capsule) well developed, dark in color, circular to rounded pentagonal in outline. Endophragm characteristically ornamented along pericoel areas. Periphragm smooth to ornamented, extending apically and antapically forming one apical and two anapical [*sic*] horns. Some times a third delicate layer enveloping periphragm also present. Archaeopyle well marked, trapezoidal, single plate, pentagonal or hexagonal, intercalary, below apical horn."

DESCRIPTION: "Periphragm remains in close contact with endophragm except at the points of horn formation. Pericoel areas vary from two to three, large or small; periphragm frequently folded. In endophragm localized ornamentation starts as soon as pheriphragm [*sic*] separates from endophragm (text-fig. 1a-b), ornamentation variable, granulose to verrucose or warty, rest surface of endophragm remains smooth to slightly ornamented. In most of the specimens it has been observed that both periphragm and endophragm are involved in the formation of archaeopyle. Archaeopyle limit extends maximum to endophragm margin towards apical horn."

DISCUSSION: Jain and Millepied, 1973, p. 22, erected the genus *Senegalinium* to include bicavate dinoflagellates, with a pericyst prolonged into one apical and two antapical horns, an endocyst, and an intercalary archeopyle. Considerable emphasis was placed on the localized concentration of the endophragm surface ornamentation on the endocyst in the vicinity of the apical and antapical regions. This is a not uncommon feature in peridinioid cysts, being known in individuals included in *Rhombodinium* Gocht emend. Vozzhennikova, *Wetzeliella* Eisenack, *Deflandrea* Eisenack, and *Alterbia* Vozzhennikova. It is so variable that to differentiate on this basis even at the specific level is difficult. Five species were included in *Senegalinium* by Jain and Millepied, *S. bicavatum, S. psilatum, S. granulostriatum, S. trisinum* and *S. dubium*. The type of the genus *S. bicavatum* conforms to the diagnosis of *Alterbia* and is herein transferred to that genus. *S. psilatum* is considered to be a *junior synonym* of *Lejeunia laevigata* (Malloy, 1972) *comb. nov.* In the description for *S. dubium* Jain and Millepied (1973, p. 25) state that the large size of the archeopyle gives an indication of its precingular position. It is, however, an intercalary archeopyle resulting from the loss of anterior intercalary paraplate 2a, as can be seen in Jain and Millepied (1973, pl. 2, fig. 13). This species has a rounded antapex. It has been questionably transferred to the genus *Deflandrea*. *Senegalinium granulostriatum* possesses two more or less equal antapical horns and a broad hexa archeopyle and is herein transferred to *Deflandrea*. *S. trisinum* is here considered to be a *junior synonym* of *Alterbia polymorpha*. Thus *Senegalinium* becomes a superfluous genus, since all five species conform to diagnoses for existing genera.

Species formerly included in *"Senegalinium"*

"bicavatum" (Jain and Millepied, 1973). Now *Alterbia*.

"dubium" (Jain and Millepied, 1973). Now *?Deflandrea*.

"granulostriatum" (Jain and Millepied, 1973). Now *Deflandrea*.

"psilatum" (Jain and Millepied, 1973). Considered to be a *jr syn.* of *Lejeunia laevigata*.

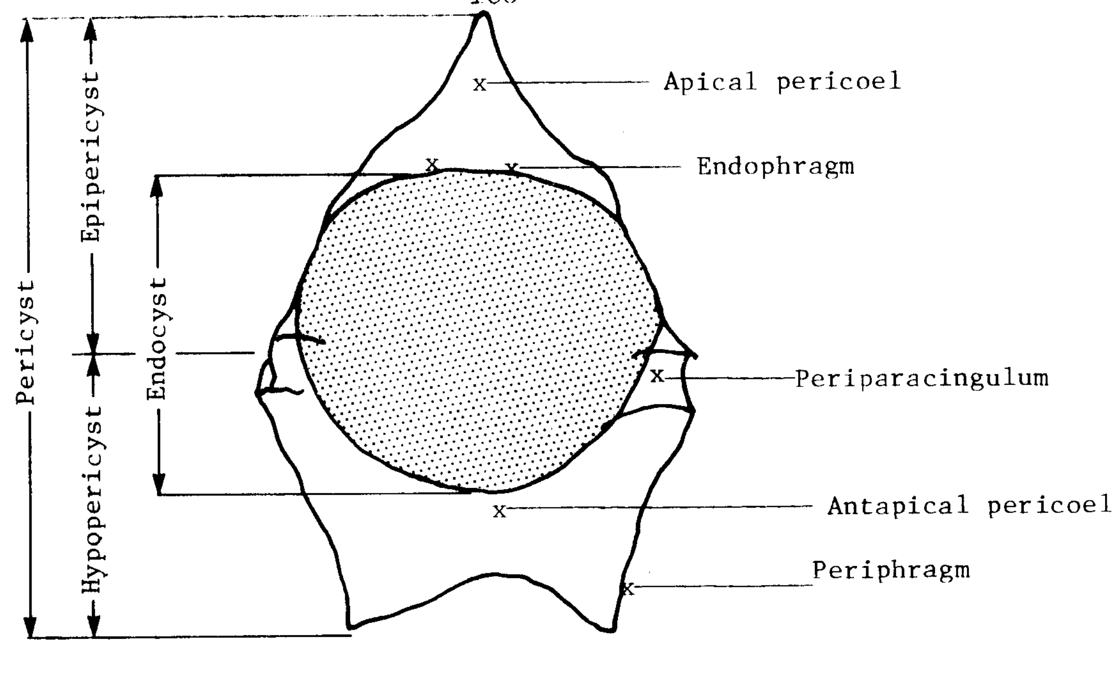
"trisinum" (Jain and Millepied, 1973). Considered to be a *jr syn.* of *Alterbia polymorpha*.

"*SOANIELLA*" (Vozzhennikova, 1967) *nomen ambiguum*

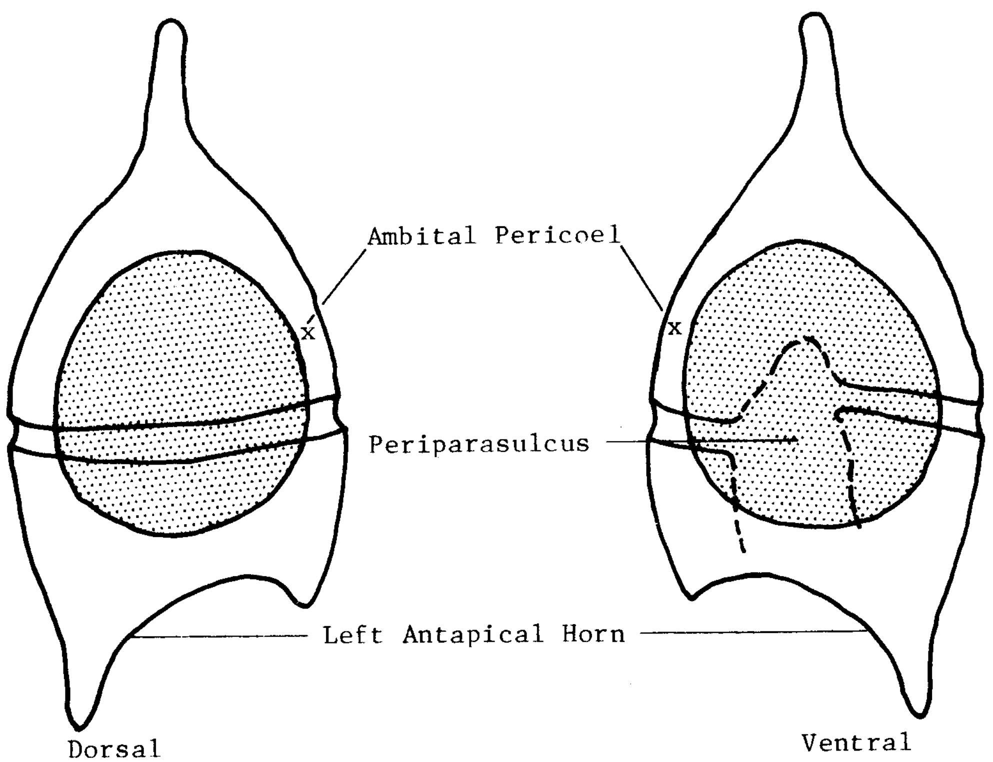
TYPE SPECIES: "*Soaniella granulata*" Vozzhennikova, 1967, p. 108-109, pl. 116, fig. 1-12. Eocene-Early Oligocene.

DESCRIPTION: Theca is oval. Epitheca is dome-shaped with a small apical projection. Hypotheca is trapezoidal with small, sometimes poorly visible antapical projections. Girdle is circular and divides the theca into even or uneven parts. Longitudinal furrow has the form of a depression running from the transverse furrow to the antapex. Theca is thin-walled, its surface smooth or sculptured. Pylome is hexahedral and located above the transverse furrow; it corresponds to the third precingular plate.

DISCUSSION: *Soaniella granulata* is herein designated a *nomen ambiguum* and is rejected in accordance with Article 69 of the I.C.B.N. The name is rejected on the basis that two holotype specimens are designated, neither of which is consistent with the generic diagnosis. The specimen in plate 116, fig. 1, possibly possesses a transapical archeopyle suture while plate 116, fig. 2, shows an intercalary 2a archeopyle. The shape of the two specimens indicates that the small size and general outline are the only consistent features. Because of the poor quality of the specimens in question, it is impossible to arbitrarily choose a type specimen and thus validate the species. Thus the species *Soaniella granulata* Vozzhennikova, 1967, is rejected and the generic name *Soaniella* becomes superfluous.



Specimen with
Equal Antapical Horns



Specimen with
Unequal Antapical Horns

TEXT-FIG. 10 TERMINOLOGY AS APPLIED TO THE MORPHOLOGIC FEAUTURES IN FOSSIL CAVATE PERIDINIOID DINOFLAGELLATE CYSTS.

GLOSSARY

Several of the following terms and definitions are taken from Evitt *et al.* (in press). Text-figure 10 illustrates some of the more common terms.

Accessory archeopyle suture: A suture developed between paraplates which form the archeopyle margin, or within the operculum. Such sutures do not result in complete separation of the paraplates involved.

Acuminate: Pointed.

Ambital pericoel: In dorso-ventral view a pericoel which separates the endocyst from the pericyst.

Ambitus: The cyst outline when viewed from the dorsal or ventral side. Synonymous with outline in dorso-ventral view.

Antapex: In a dinoflagellate cyst, the area at the posterior end of the hypocyst.

Antapical: Adjectival form of antapex.

Antapical archeoyple: An archeopyle formed by the partial or complete loss of a single, some, or all of the antapical paraplates.

Antapical paraplate: The paraplate, or one of the group of paraplates, occupying the antapex of a paratabulate dinoflagellate cyst.

Antapical pericoel: A cavity resulting from the separation of the endocyst and pericyst in the antapical region of a dinoflagellate cyst.

Antapical plate: The plate, or one of the group of plates, occupying the antapex of a tabulate motile dinoflagellate.

Anterior: That part of the dinoflagellate theca or cyst towards the apex.

Anterior intercalary paraplate: The paraplate, or one of the group of paraplates, in a paratabulate dinoflagellate cyst, which lie between the apicals and precingulars, without touching the apex or paracingulum [text-fig. 2].

Anterior intercalary plate: The plate, or one of the group of plates, of a tabulate motile dinoflagellate, which lie between the apicals and precingulars, without touching the apex or cingulum.

Anterior sulcal pore: The pore from which the transverse flagellum arises. Equivalent to flagellar pore imprint in the cyst.

Antero-posterior: Apically-antapically.

Apex: That area of the dinoflagellate cyst at the anterior end of the epicyst.

Apical: Adjectival form of apex.

Apical archeopyle: An archeopyle formed by the partial or complete loss of the single apical, or all the apical paraplates [text-fig. 6a-b].

Apical paraplate: The paraplate, or one of the group of paraplates, occupying the apex of a paratabulate dinoflagellate cyst.

Apical pericoel: A cavity resulting from the separation of the endocyst and pericyst in the apical region of a dinoflagellate cyst.

Apical plate: The plate, or one of the group of plates, occupying the apex of a tabulate motile dinoflagellate.

Archeopyle: The excystment aperture in a dinoflagellate cyst through which the dinoflagellate escapes during excystment.

Archeopyle formula: Alphanumeric representation of the archeopyle of a dinoflagellate cyst.

Archeopyle suture: The suture(s) developed in formation of the archeopyle.

Attached operculum: An operculum that remains partially attached to the cyst.

Attenuated hexa archeopyle: An intercalary type I or I/I archeopyle in which the six-sided 2a paraplate has considerably lengthened anterior lateral H3 and H6 sutures, and very reduced posterior lateral H3 and H5 sutures. The anterior suture H1 and posterior suture H4 are also reduced. The greatest width of paraplate 2a is therefore below the median line. The height:width ratio is greater than 1.25 [text-fig. 4b].

Autoblast: Synonym of autocyst.

Autocoel: The cavity enclosed by the autophragm.

Autocyst: The body formed by the autophragm.

Autophragm: The wall present in dinoflagellate cysts with a single-layered wall.

Broad hexa archeopyle: An intercalary type I or I/I archeopyle in which the six-sided 2a paraplate has considerably lengthened H1 and H4 sutures. The anterior lateral sutures H2 and H6 are relatively longer than the posterior lateral sutures H3 and H5 respectively. The height:width ratio is *ca.* 0.5. Paraplate 2a is therefore very broad compared to the two other anterior intercalaries 1a and 3a [text-fig. 4d].

Cavate: A dinoflagellate cyst in which the endophragm and periphragm are generally not in contact and in which the endocyst and pericyst are therefore separated.

Cingular: Adjectival form of cingulum.

Cingular paraplate: One of the paraplates forming the paracingulum in a paratabulate motile dinoflagellate cyst.

Cingular plate: One of the plates forming the cingulum in a tabulate motile dinoflagellate.

Cingulum: The transverse furrow, occupying a more or less equatorial position in which lies the transverse flagellum in a motile dinoflagellate.

Combination Archeopyle: An archeopyle which results from the loss of paraplates belonging to more than one series; e.g. in some dinoflagellate cysts the archeopyle is formed by the loss of apical and anterior intercalary paraplates [text-fig. 6-7].

Cyst: The resting cyst of a dinoflagellate. All fossil dinoflagellates appear to be cysts.

Echina: Small, distally acuminate spine not exceeding 2-3 μ in length.

Endo-: Prefix denoting morphological features of the endocyst.

Endoarcheopyle: The archeopyle of the endocyst which may or may not conform to the morphology of the periarcheopyle.

Endoparacingulum: The paracingulum on the endocyst. Usually abbreviated to endocingulum.

Endoblast: Synonym of endocyst.

Endocingulum: See endoparacingulum.

Endocyst: The body formed by the endophragm.

Endoparaplate: A paraplate on the endocyst.

Endoparasulcus: The parasulcus on the endocyst. Usually abbreviated to endosulcus.

Endoperculum: The operculum of the endoarcheopyle.

Endophragm: The innermost wall in dinoflagellate cysts with two or more walls.

Endosulcus: See endoparasulcus.

Epicyst: The portion of a dinoflagellate cyst corresponding to the epitheca of a motile dinoflagellate. In paratabulate cysts this is the area anterior to the paracingulum and consisting of the pre-apical, apical, anterior intercalary, if present, and precingular paraplates.

Epicystal archeopyle: An archeopyle involving the loss of the epicyst in which the archeopyle suture runs immediately anterior to the paracingulum.

Epiendocyst: In paratabulate dinoflagellate cysts the portion of the endocyst anterior to the paracingulum and consisting of the pre-apical, if present, apical, anterior intercalary, if present, and precingular endoparaplates.

Epitheca: In a thecate motile dinoflagellate, the portion of the theca which is anterior to the cingulum. It includes the pre-apical, if present, apical, anterior intercalary, if present, and precingular plates.

Epitract: Synonym of epicyst.

Flagellar pore imprint: Cyst expression of the anterior or posterior flagellar pore and located in the parasulcus.

Free operculum: An operculum which is completely detached from the rest of the dinoflagellate cyst.

Girdle: A general term which can be synonymous with either the transverse furrow or cingulum of a motile dinoflagellate or the paracingulum of a dinoflagellate cyst. Its use is not recommended.

Gonyaulacean: Dinoflagellates with the *Gonyaulax* tabulation or dinoflagellate cysts with the *Gonyaulacysta* paratabulation.

Granule: Small rounded protuberance on the surface of the endophragm or periphragm. Width not exceeding height, which is generally less than 2 μ.

Helicoid(al): When the ends of the cingulum in a motile dinoflagellate or the paracingulum in a dinoflagellate cyst do not lie in the same plane on the sulcus or parasulcus, i.e. there is displacement so that one end lies posterior to the other.

Heptapartite: Divided into seven parts.

Hexa archeopyle: An intercalary type I or I/I archeopyle in which the second anterior intercalary paraplate is six-sided. These are the anterior or H1 where it abuts against the third apical, the left anterior lateral H2 where it abuts against the first anterior intercalary, the left posterior lateral H3 where it abuts against the third precingular, the posterior H4 where it abuts against the fourth precingular, the right posterior lateral H5 where it abuts against the fifth precingular, and the right anterior lateral H6 where it abuts against the third anterior intercalary. Thus there are four lateral sides in the hexa 2a. This is reflected in the size and shape of the surrounding paraplates. The anterior intercalary paraplates 1a and 3a are five-sided. The third (3") and fifth (5") precingulars are four-sided. The fourth precingular is also four-sided and is not as wide laterally as the second anterior intercalary paraplate 2a. The hexa 2a archeopyle can be subdivided into the attenuated hexa, broad hexa, omegaform hexa and standard hexa archeopyles [text-fig. 2a].

Hexa paraplate: When the second anterior intercalary paraplate of the theca or cyst in a peridinioid dinoflagellate is six-sided.

Horn: An outbulge or extension of the wall, or of its outer layer in motile dinoflagellates or dinoflagellate cysts. Horns may be apical, lateral or antapical in position.

Horseshoe shaped: Synonymous with omegaform.

Hypocyst: The portion of a dinoflagellate cyst corresponding to the hypotheca of a motile dinoflagellate. In paratabulate cysts this is the area posterior to the paracingulum and consisting of the postcingular, posterior intercalary, if present, and antapical paraplates. Most or all of the parasulcus is located on the hypocyst.

Hypoendocyst: In paratabulate cysts the portion of the endocyst posterior to the endocingulum and consisting of the postcingular, posterior intercalary, if present, and antapical paraplates. Most or all of the endosulcus is located on the hypoendocyst.

Hypopericyst: In paratabulate cysts the portion of the pericyst posterior to the pericingulum and consisting of the postcingular, posterior intercalary, if present, and antapical paraplates. Most or all of the perisulcus is located on the hypopericyst.

Hypotheca: In a thecate motile dinoflagellate, the portion of the theca which is posterior to the cingulum. It includes the postcingular, posterior intercalary, if present, and antapical plates. Most or all of the sulcus is located on the hypotheca.

Hypotract: Synonym of hypocyst.

Inner body: Synonym of endocyst. Its usage is not recommended.

Inner capsule: Synonym of endocyst. Its usage is not recommended.

Intercalary: Located either between the apical and the precingular or between the postcingular and antapical series of plates in the theca, or between the corresponding series of paraplates in the cyst.

Intercalary archeopyle: An archeopyle formed from the loss of one or more of the anterior intercalary paraplates [text-fig. 2].

Intercalary band: The area between adjacent plates in peridinioid dinoflagellate thecae. It is commonly striate. Cyst equivalent term, pandasutural.

Intercalary paraplate: The paraplate, or one of the group of paraplates, occupying the anterior and/or posterior intercalary area of a paratabulate cyst.

Intercalary plate: The plate, or one of the group of plates, occupying the anterior and/or posterior intercalary area of a tabulate motile dinoflagellate.

Intratabular: The area of the paraplate excluding the parasutures in a dinoflagellate cyst.

Laevigate: Smooth.

Left antapical horn: The antapical horn located to the left when the motile dinoflagellate or cyst is viewed with dorsal surface uppermost or towards the observer, and ventral view lowermost or away from the observer.

Linear process complex: A series of processes arranged in a straight line, linked or unlinked proximally, along their length, or distally.

Longitudinal furrow: The flagellum which arises from the posterior sulcal pore and is directed backwards along the longitudinal furrow or sulcus in motile dinoflagellates.

Longitudinal furrow: The furrow on the ventral surface of the motile dinoflagellate which houses the longitudinal flagellum. It lies wholly or partially on the hyposome or hypotheca. Synonymous with sulcus.

Mesophragm: The middle wall in dinoflagellate cysts with three walls, in which the outer is the periphragm.

Meta: When the first apical plate in peridinioid thecae or first apical paraplate in peridinioid cysts is five-sided.

Motile dinoflagellate: A dinoflagellate that has not encysted, but is a functional component of the plankton, swimming, feeding and reproducing.

Motile stage: When used for a dinoflagellate is synonymous with motile dinoflagellate.

Motile unicell: When used for a dinoflagellate is synonymous with motile dinoflagellate.

Nontabular: Bearing no observable relationship to paratabulation; apparently haphazardly arranged. Commonly used for random surface ornamentation of the periphragm.

Omegaform hexa: An intercalary type I archeopyle in which the six-sided 2a paraplate has reduced anterior lateral H2 and H6 sutures and correspondingly lengthened posterior lateral H3 and H5 sutures. The anterior suture H1 is lengthened and the posterior suture H4 along which the operculum usually remains attached is reduced. The outline approximates that of a horseshoe. The greatest width of paraplate 2a is therefore above its median line. The height:width ratio is approximately 1 [text-fig. 4c].

Operculum: The paraplate or group of paraplates which are lost or partially detached in archeopyle formation and which are bounded by the principal archeopyle suture.

Ortho: When the first apical plate in peridinioid thecae or first apical paraplate in peridinioid cysts is four-sided.

Outer layer: Synonymous with periphragm.

Pandasutural zone: "Parasutural area also embracing the peripheral area of a paraplate whose ornamentation, or lack of, separates it from the adjacent areas of the paraplate." From Evitt *et al.*, in press. Cyst equivalent to intercalary band in the theca.

Para: When the first apical plate in peridinioid thecae or first apical paraplate in peridinioid cysts is six-sided.

Para-: Prefix, meaning like.

Paracingular: Adjectival form of paracingulum.

Paracingulum: The area on the dinoflagellate cyst analogous to the cingulum of the motile dinoflagellate. Paraplates may or may not be visible.

Paraplate: The cyst equivalent to a plate in the theca. May be delineated by parasutural or penetabular ornamentation or pandasutural zones.

Paraplate formula: Synonym of paratabulation formula or reflected tabulation formula.

Parasulcal: Adjectival form of parasulcus.

Parasulcal notch: The re-entrant angle in the apical archeopyle margin which marks the posterior extension of the first apical paraplate. It is immediately anterior to the parasulcus.

Parasulcus: The area on the cyst analogous to the sulcus or longitudinal furrow of the motile dinoflagellate. Paraplates may or may not be visible.

Parasuture: The junction between adjacent paraplates in the dinoflagellate cyst. Separation normally never occurs along parasutures, apart from along the archeopyle suture(s). It is felt advisable to retain suture where there is visible separation as in archeopyle suture.

Paratabulation: The pattern or arrangement of the constituent paraplates in a dinoflagellate cyst. It is usually expressed as an alphanumeric formula, the paratabulation formula, which indicates the series of paraplates present, and the number of paraplates within each series.

Paratabulation formula: The alphanumeric formula which indicates the series of paraplates present and the number of paraplates within each series in a dinoflagellate cyst.

Partite: Divided.

Penetabular: "Linear features which lie immediately interior to the margin of the paraplate." From Evitt *et al.*, in press.

Pentapartite: Divided into five parts.

Periarcheopyle: The archeopyle of the pericyst.

Periblast: Synonym of pericyst.

Pericingulum: See periparacingulum.

Pericoel: The cavity, or cavities, lying between the endophragm and periphragm, or mesophragm and periphragm.

Pericyst: The body formed by the periphragm.

Peridiniacean: Dinoflagellate thecae and cysts with the *Peridinium* tabulation or paratabulation.

Peridinioid: The characteristic outline of a dinoflagellate of the genus *Peridinium*, with a pointed apex or apical horn and two antapical horns. Also applied to motile dinoflagellates and dinoflagellate cysts with a pentagonal outline, which may or may not be prolonged into one apical, two lateral (paracingular) and one or two antapical horns. Within this monograph the peridinioid dinoflagellates are regarded as those taxa with a paratabulation formula of 4', 3a, 7", 5"', 2"", which may or may not be visible.

Periparacingulum: The paracingulum on the pericyst. Usually abbreviated to pericingulum.

Periparasulcus: The parasulcus on the pericyst. Usually abbreviated to perisulcus.

Periphragm: The outer wall in dinoflagellate cysts with two walls. The outermost wall in dinoflagellate cysts with three walls, of which the middle is the mesophragm.

Perisulcus: See periparasulcus.

Peritabular: Synonym of penetabular.

Phragma: The wall of a dinoflagellate cyst. It can be composed of one, two, or more than two, layers.

Planar: In one plane. Applied to the transverse furrow or cingulum of a motile dinoflagellate, or the paracingulum of a dinoflagellate cyst, whose two ends do not differ in antero-posterior position at the position of contact with the longitudinal furrow (sulcus) or parasulcus.

Plate: One of the constituent and separable units of the theca.

Plate formula: The alphanumeric representation of the plates in a thecate dinoflagellate. It shows the series of plates present, and the number of plates within each series, in an abbreviated formula. Thus 4', 3a, 7", 5c, 5"', 2"" means there are four apical, three anterior intercalary, seven precingular, five cingular, five postcingular and two antapical plates in the taxon whose tabulation is given in the plate formula.

Postcingular: Located between the cingulum and antapex in a motile dinoflagellate, and between the paracingulum and antapex in a dinoflagellate cyst.

Postcingular paraplate: One of the latitudinal series of paraplates lying immediately posterior to the paracingulum in a paratabulate dinoflagellate cyst.

Postcingular plate: One of the latitudinal series of plates lying immediately posterior to the cingulum in a thecate motile dinoflagellate.

Posterior sulcal pore: The pore from which the longitudinal flagellum arises.

Precingular: Located between the apex and cingulum in a motile dinoflagellate, and between the apex and paracingulum in a dinoflagellate cyst.

Precingular paraplate: One of the latitudinal series of paraplates lying immediately anterior to the paracingulum in a paratabulate dinoflagellate cyst.

Precingular plate: One of the latitudinal series of plates lying immediately anterior to the cingulum in a thecate motile dinoflagellate.

Principal archeopyle suture: The suture(s) developed between the operculum or opercular pieces and archeopyle margin.

Process: An essentially columnar or spine-like projection arising from the surface of a dinoflagellate cyst. Processes may be simple or intricately branched and interconnected. Processes are rarely, if ever, found in motile dinoflagellates.

Process complex: The association of three or more adjacent intratabular processes to form a distinctly arranged and aligned group, often united, proximally, along their length and/or distally.

Pseudo-quadra: A broad hexa intercalary type I archeopyle in which the posterior lateral sutures H3 and H5 of the second anterior intercalary paraplate 2a are very reduced. Thus 2a superficially appears to be quadra. That it is not can be determined from the size and shape of the precingular paraplate 4".

Pylome: The circular excystment opening present in many acritarchs. The term has also been used as a synonym of archeopyle in dinoflagellate cysts.

Quadra archeopyle: An intercalary type I or I/I archeopyle in which the second anterior intercalary paraplate is four-sided. These are the anterior or Q1 where it abuts against the third apical, the left lateral, Q2, where it abuts against the first anterior intercalary, the posterior or Q3 where it abuts against the fourth precingular, and the right lateral Q4 where it abuts against the second anterior intercalary. When 2a is quadra, the fourth precingular 4" is considerably wider than 2a and has parasutures with the first anterior intercalary (1a) and third anterior intercalary (3a) respectively. This thus influences the shape of 1a and 3a, and also 4", all of which are six-sided. Paraplates 3" and 5" are five-sided [text-fig. 2b and 3b].

Reflected tabulation: Synonym of paratabulation.

Resting cyst: Synonym of cyst in dinoflagellate usage.

Right antapical horn: The antapical horn located to the right when the motile dinoflagellate or dinoflagellate cyst has the dorsal surface uppermost or towards the observer, and ventral view lowermost or away from the observer.

Rugulate: Elongate raised surface ornamentation with an irregular course.

Scabrate: With sculpturing of projections, no dimension of which equals or exceeds 1 μ.

Septum: A membraneous, linear projection on the wall of a dinoflagellate cyst. Commonly parasutural in position.

Simulate process complex: An arrangement of intratabular processes in the form of a closed polygon, linked or unlinked proximally, along their length, or distally. The complex is developed within, but parallel to the boundaries or parasutures of a paraplate. Partly synonymous with penetabular.

Spine: Synonym of process.

Standard hexa archeopyle: An intercalary type I or I/I archeopyle in which the six-sided 2a paraplate has relatively longer anterior lateral H2 and H6 sutures and correspondingly reduced posterior lateral H3 and H5 sutures. The height:width ratio is generally < 1 [text-fig. 4a].

Sulcal paraplate: A paraplate located within the parasulcus of a dinoflagellate cyst.

Sulcal plate: A plate located within the sulcus of a motile dinoflagellate.

Sulcal pore: One of the two pores located in the sulcus and from which arise either the transverse flagellum or the longitudinal flagellum.

Sulcus: Synonym of longitudinal furrow.

Tabulate: Composed of plates, in reference to motile dinoflagellates.

Tabulation: The pattern or arrangement of the constituent plates in a tabulate motile dinoflagellate. It is usually expressed as an alphanumeric formula which gives the series of plates present, and the number of plates within each series.

Theca: The body formed by the plates of a thecate or tabulate motile dinoflagellate.

Thecate: Composed of plates which together form a theca; or possessing a theca.

Transapical suture: The excystment suture developed in peridinioid dinoflagellate cysts with a transapical excystment aperture.

Transverse archeopyle index: The width of the hexa 2a archeopyle at its widest point in ambital view, divided by the width of the epicyst in the same plane. Usually determined for the pericyst only.

Transverse archeopyle ratio: The width of the hexa 2a archeopyle at its widest point in ambital view, divided by the width of the epicyst, less the archeopyle width, in the same plane. Usually determined for the pericyst only.

Transverse flagellum: The flagellum which arises from the anterior sulcal pore and is directed laterally in an equatorial position along the transverse furrow or cingulum, in a motile dinoflagellate.

Transverse furrow: The equatorially aligned furrow which almost completely encircles the theca and which houses the transverse flagellum. It separates the episome or epitheca from the hyposome of hypotheca. Synonymous with cingulum.

Tubercle: Small knob-like projection, oblate distally, rarely exceeding 3-4 μ.

Ventral: The surface containing the sulcus in the motile dinoflagellate, and the parasulcus in the dinoflagellate cyst.

Ventral notch: Synonymous with parasulcal notch.

Ventral paraplate: Synonymous with sulcal paraplate.

Verrucate: Sculpturing of projections not specially constricted or modified in any way, at least one dimension of which exceeds 1 μ.

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The following figures are tracings of the holotype specimens of the species as figured by the original authors. Some specimens are embellished to include characteristics which are described by the authors but which are not visible on the photograph. The figures are not intended for taxonomic use. They are presented strictly for the purpose of helping to elucidate the generic groupings as herein presented.

PLATE 1

1. *Deflandrea arcuata* Vozz., 1967. 118 μ

2. *D. antartica* Wilson, 1967a. 138 μ

3. *D. diebeli* Alb., 1959b. 180 μ

4. *D. delineata* Cook. & Eis., 1965c. 171 μ

5. *D. denticulata* Alb., 1959b. 119 μ

6. *D. dartmooria* Cook. & Eis., 1965b. 152 μ

7. *D. dartmooria* subsp. *medcalfii* (Stov., 1973) *stat. nov.* 106-140 μ

8. *?D. dubia* (Jain & Mill., 1973) *comb. nov.* 84 μ

9. *D. denticulata* subsp. *minor* (DeCon., 1969) Lent. & Wills., 1973. 85 μ

10. *D. gaditana* Rieg., 1974. 68 μ

11. *D. flounderensis* Stov., 1973. 112-166 μ

12. *D. andromiensis* Vozz., 1967. 135 μ

13. *D. baltica* (Vozz., 1967) *comb. nov.* 148 μ

1-13

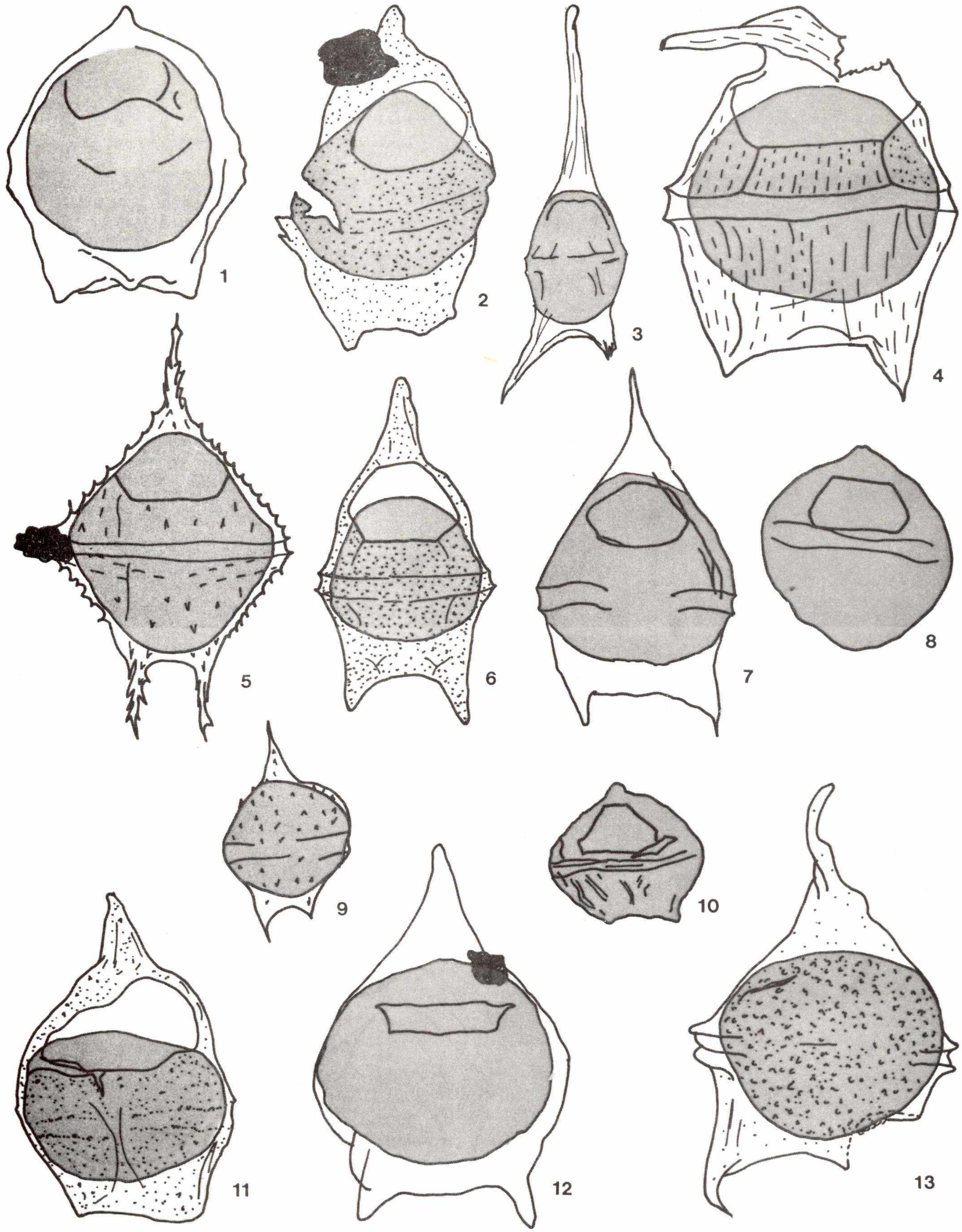

PLATE 2

14. *Deflandrea speciosa* subsp. *glabra* Gocht, 1969. 157 μ

15. *D. phosphoritica* subsp. *phosphoritica* var. *attenuata* (Vozz., 1967) Lent. & Wills., 1973. 126 μ

16. *D. phosphoritica* Eis., 1938. 116 μ

17. *D. pannucea* Stanley, 1965. 100 μ

18. *D. spinulosa* Alb., 1959b. 104 μ

19. *D. robusta* Defl. & Cook., 1955. 123 μ

20. *D. phosphoritica* subsp. *australis* var. *lata* (Vozz., 1967) Lent. & Wills., 1973. 135 μ

21. *D. speciosa* Alb., 1959b. 120 μ

22. *D. phosphoritica* subsp. *vozzhennikovae* Grig., 1972. 100-102 μ

23. *D. striata* Drugg, 1967. 138-168 μ

24. *D. wardenensis* Wills. & Down., 1966c. 57 μ

25. *D. phosphoritica* subsp. *australis* Cook. & Eis., 1961b. 146 μ

26. *D. sibirica* (Vozz., 1967) *comb. nov.* 95 μ

27. *D. wetzelii* Morg., 1966a. 61 μ

28. *D. stagonoides* (Ben., 1972) *comb. nov.* 78 μ

14-28

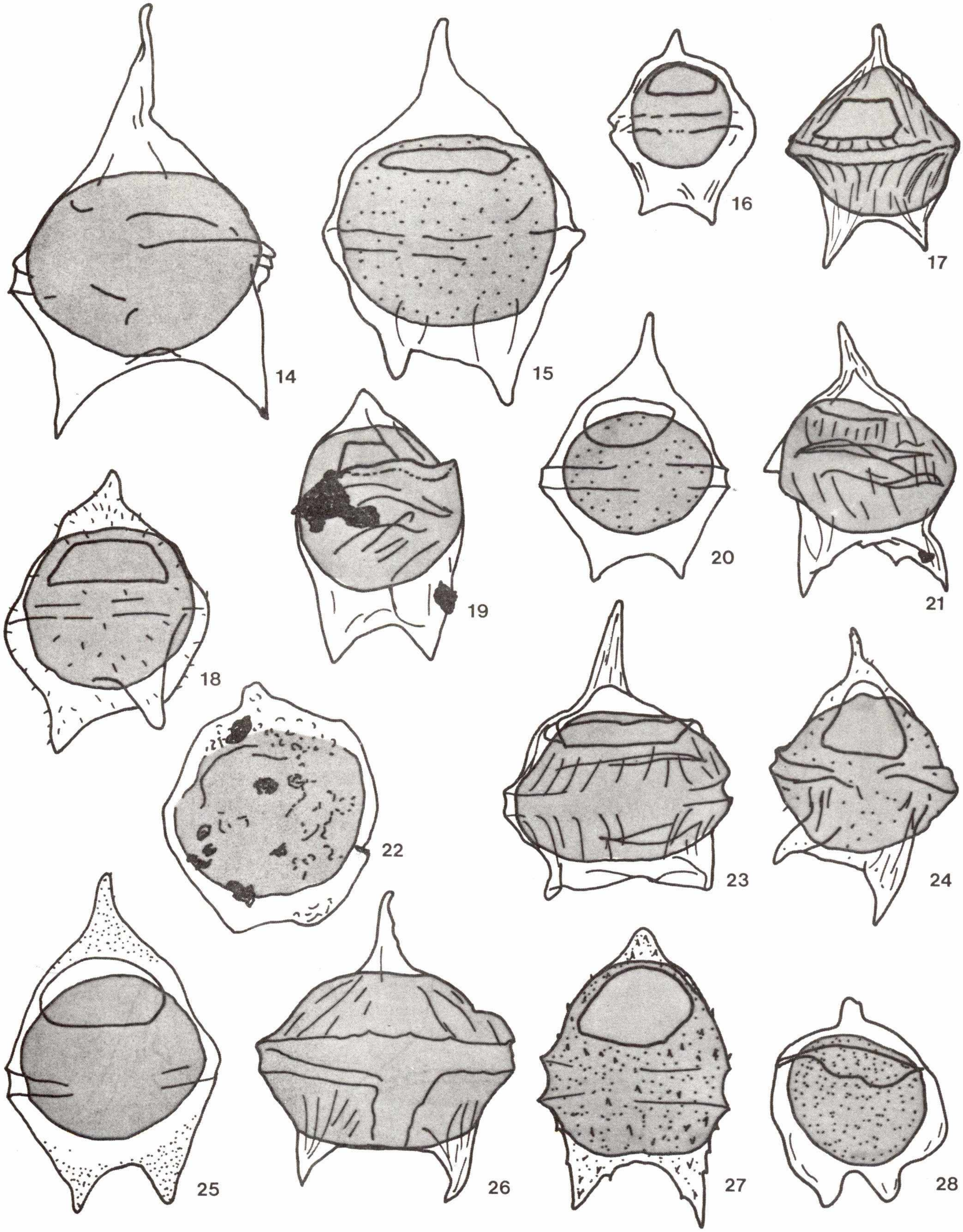

PLATE 3

29. *Deflandrea granulosa* Cook. & Eis., 1965a. 118 μ

30. *D. hialina* Baltes ex Lent. & Wills., 1973. 55-60 μ

31. *D. leptodermata* Cook. & Eis., 1965a. 118 μ

32. *D. pachyceros* Defl. & Cook., 1955. 89 μ

33. *D. obliquipes* Defl. & Cook., 1955. 105 μ

34. *D. heterophlycta* Defl. & Cook., 1955. 115 μ

35. *D. subquadra* Cor., 1973. 143 μ

36. *D. albertii* Cor., 1973. 190 μ

37. *D. markovii* (Vozz., 1967) *comb. nov.* 132 μ

38. *D. oebisfeldensis* subsp. *angustata* (Vozz., 1967) Lent. & Wills., 1973. 162 μ

39. *D. oebisfeldensis* subsp. *ovalis* (Vozz., 1967) Lent. & Wills., 1973. 125 μ

40. *D. oebisfeldensis* Alb., 1959b. 150 μ

29-40

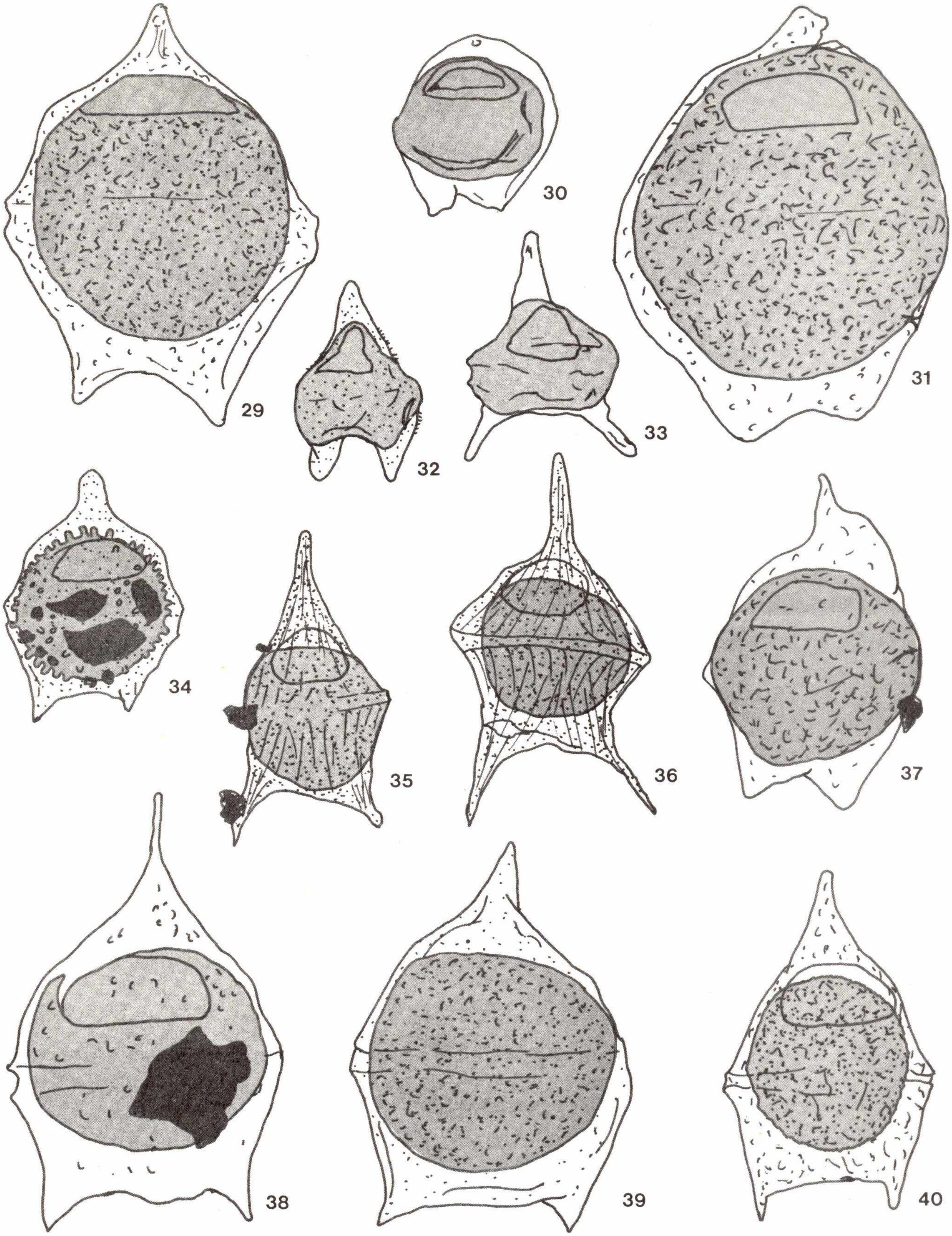

PLATE 4

41. *Deflandrea granulata* Men., 1965. 130 μ

42. *D. leptoderma* (Vozz., 1963) *comb. nov.* 126 μ

43. *D. danica* Lange, 1969. 151 μ

44. *D. endopapillata* Arch., 1969b. 128 μ

45. *D. galeata* (Lej-Carp., 1942) Lent. & Wills., 1973. 95-116 μ

46. *D. dissoluta* Vozz., 1967. 154 μ

47. *D. granulostriata* (Jain & Mill., 1973) *comb. nov.* 104 μ

48. *D. depressa* Morg., 1966a. 80 μ

49. *D. truncata* Stov., 1973. 86-104 μ

50. *D. boloniensis* Rieg., 1974. 144 μ

51. *D. eocenica* Baltes ex Lent. & Wills., 1973 88-92 μ

52. *D. micropoda* Cook. & Eis., 1974. 100 μ

53. *D. fuegiensis* Men., 1965. 112 μ

54. *D. cygniformis* de Bald., 1966. 195 μ

55. *Alterbia pentaradiata* subsp. *preceda* (Cook. & Eis., 1974) *comb. nov.* 192 μ

41-55

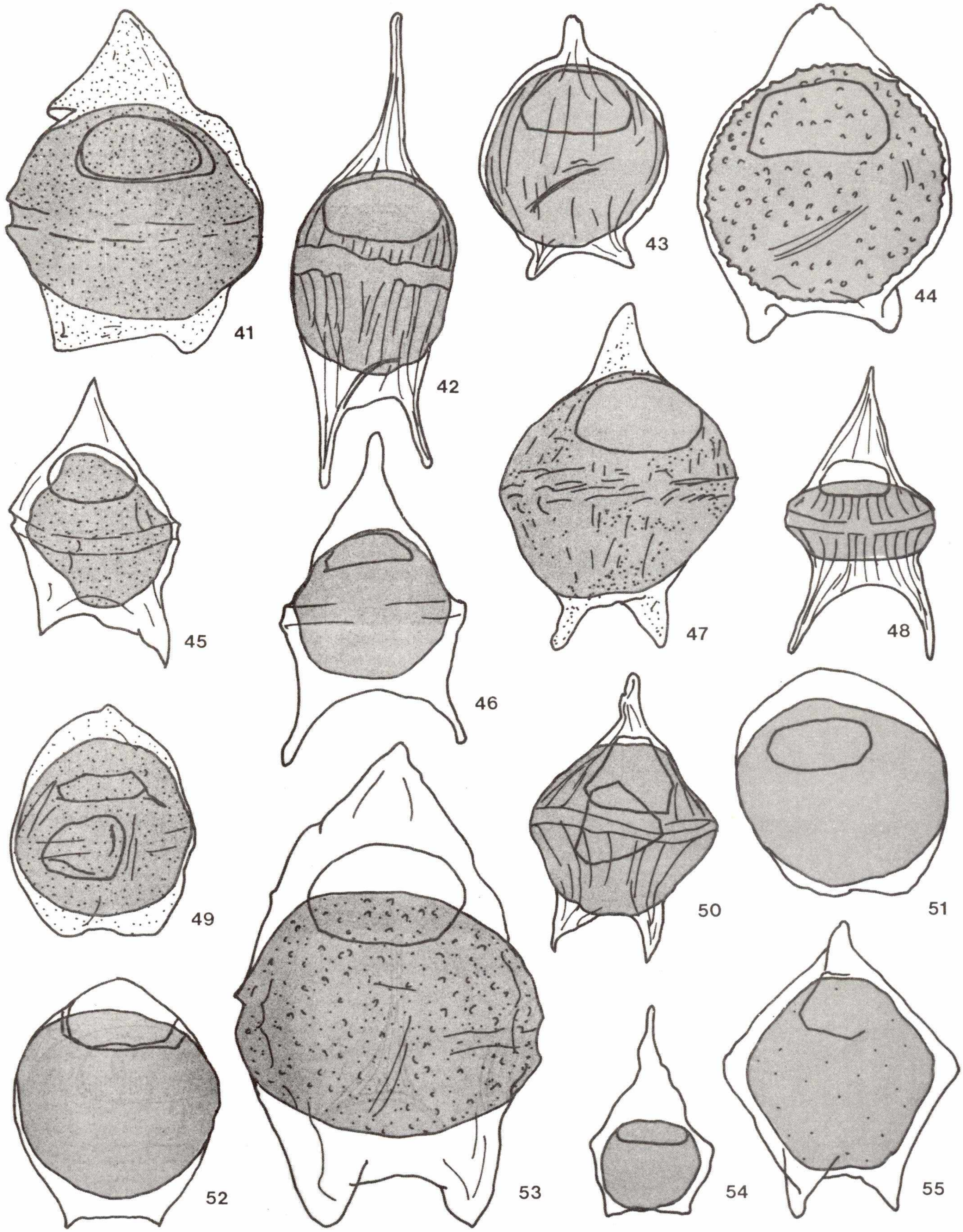

PLATE 5

56. *Alterbia acribes* (Davey & Verd., 1971. *comb. nov.* 27 μ

57. *A. acuminata* (Cook. & Eis., 1958) *comb. nov.* 85 μ

58. ?*A. pentaradiata* (Cook. & Eis., 1965c) *comb. nov.* 182 μ

59. *A. asymmetrica* (Wilson, 1967a) *comb. nov.* 80 μ

60. *A. balmei* (Cook. & Eis., 1962b) *comb. nov.* 52 μ

61. *A. ectorugosa* (Arch., 1969b) *comb. nov.* 78 μ

62. *A. polymorpha* (Malloy, 1972) *comb. nov.* 127 μ

63. *A. dilwynensis* (Cook. & Eis., 1965c) *comb. nov.* 74 μ

64. *A. pilosa* (Davey, 1969b) *comb. nov.* 57 μ

65. *A. raijae* (Kjel., 1973) *comb. nov.* 70 μ

66. *A. obscura* (Drugg, 1967) *comb. nov.* 52 μ

67. *A. ingramii* (Cook. & Eis., 1970a) *comb. nov.* 67 μ

68. *A. bicavata* (Jain & Mill., 1973) *comb. nov.* 100 μ

69. *A. acutula* (Wilson, 1967b) *comb. nov.* 83 μ

70. *A. minor* (Alb., 1959b) *comb. nov.* 52 μ

71. *A. microgranulata* (Stan., 1965) *comb. nov.* 54 μ

72. *A. folicea* (Eis. & Cook., 1960) *comb. nov.* 53 μ

73. *A. distincta* (Wilson, 1967a) *comb. nov.* 118 μ

74. *A. recticornis* Vozz., 1967. 92 μ

56-74

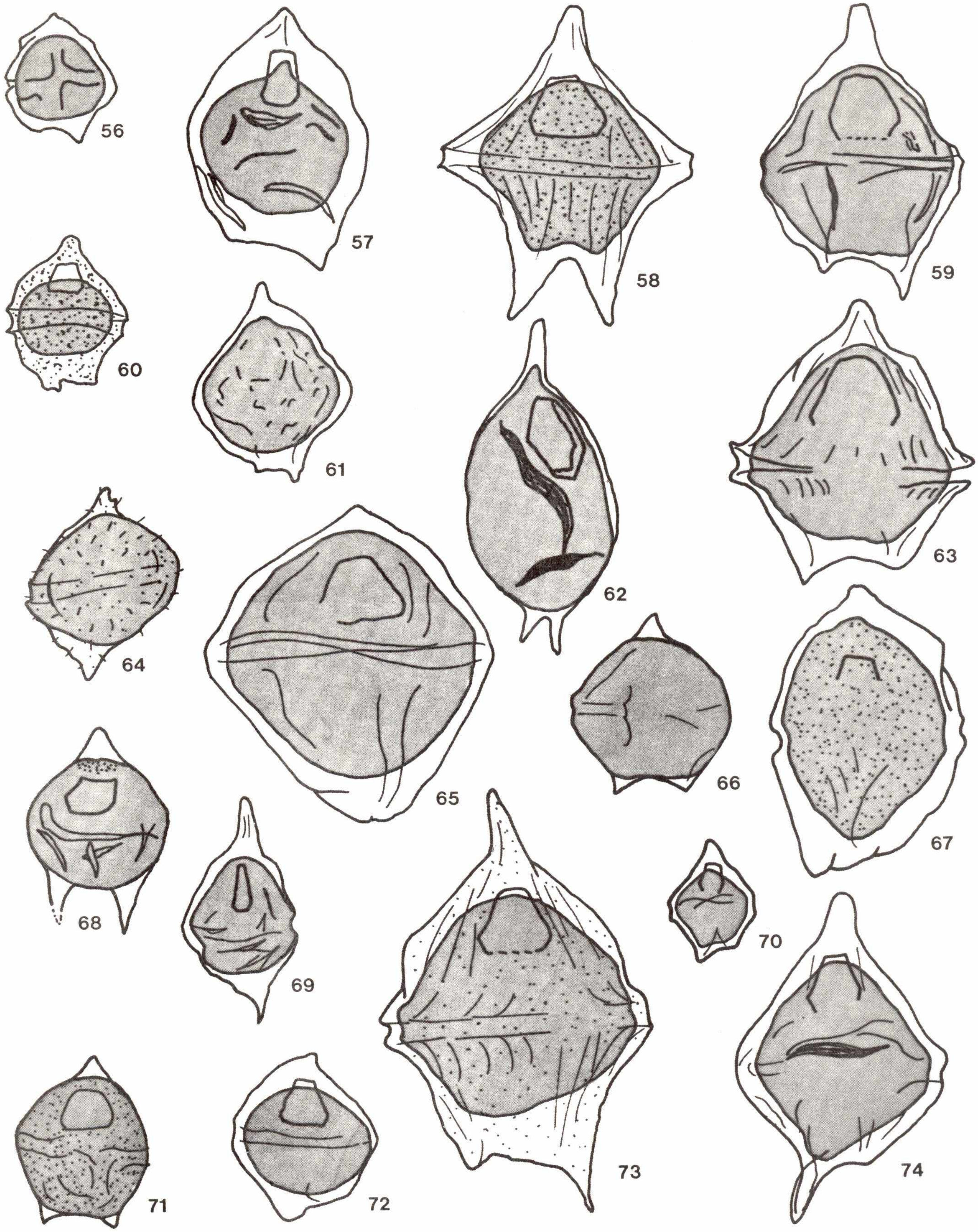

PLATE 6

75. *Alterbia curvicornis* Vozz., 1967. 105 μ

76. *A. macrocysta* (Cook. & Eis., 1960a) *comb. nov.* 94 μ

77. ?*A. eyrensis* (Cook. & Eis., 1971) *comb. nov.* 90 μ

78. *Chatangiella victoriensis* (Cook. & Man., 1964) *comb. nov.* 112 μ

79. *C. chetiensis* (Vozz., 1967) *comb. nov.* 130 μ

80. *C. granulifera* (Manum, 1963) *comb. nov.* 95 μ

81. *C. ditissima* (McInt., 1975) *comb. nov.* 147 μ

82. *C. bondarenkii* (Vozz., 1967) *comb. nov.* 149 μ

83. *C. spectabilis* (Alb., 1959b) *comb. nov.* 104 μ

84. *C. decorosa* (McInt., 1975) *comb. nov.* 156 μ

85. *C. vnigri* (Vozz., 1967) *comb. nov.* 92 μ

86. *C. coronata* (McInt., 1975) *comb. nov.* 168 μ

75-86

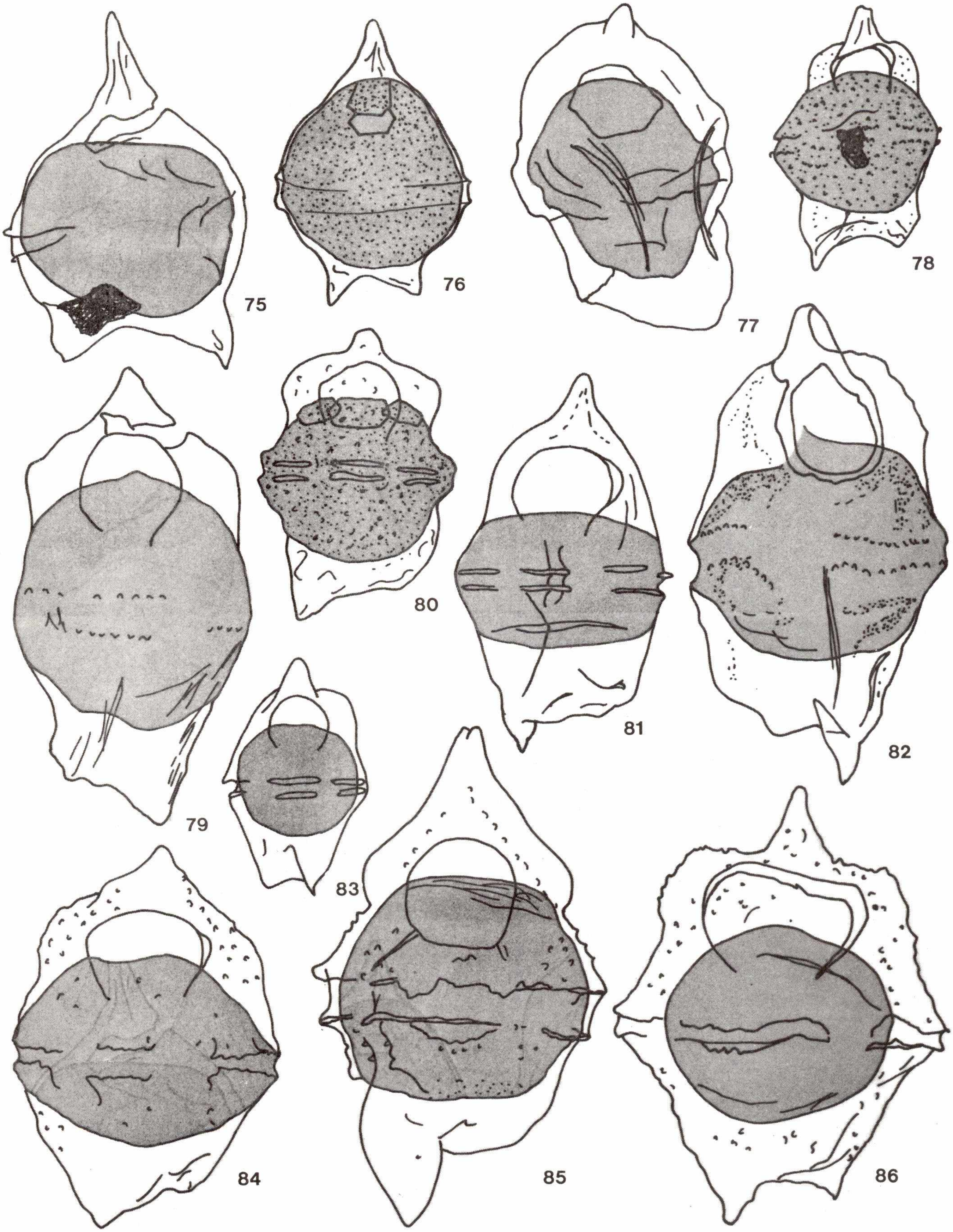

PLATE 7

87. *Chatangiella niiga* Vozz., 1967. 113 μ

88. *C. madura nom. nov. (pro C. manumii* Cook. & Eis., 1970a) *comb. nov.* 102 μ

89. ?*C. biapertura* (McInt., 1975) *comb. nov.* 136 μ

90. *C. multispinosa* (Cook. & Eis., 1970a) *comb. nov.* 96 μ

91. *C. verrucosa* (Manum, 1963) *comb. nov.* 134 μ

92. *C. campbellensis* (Wilson, 1967b) *comb. nov.* 153 μ

93. *C. micracantha* (Cook. & Eis., 1960a) *comb. nov.* 133 μ

94. *C. serratula* (Cook. & Eis., 1958) *comb. nov.* 73 μ

95. *C. magna* (Davey, 1970) *comb. nov.* 102 μ

96. *C. tripartita* (Cook. & Eis., 1960a) *comb. nov.* 100 μ

97. *C. armata* (Cook. & Eis., 1970a) *comb. nov.* 80 μ

98. ?*C. scheii* (Manum, 1963) *comb. nov.* 94 μ

99. *C. granulifera* subsp. *tenuis* (Davey, 1970) *comb. nov.* 85 μ

100. *C. manumii* (Vozz., 1967) *comb. nov.* 68 μ

87-100

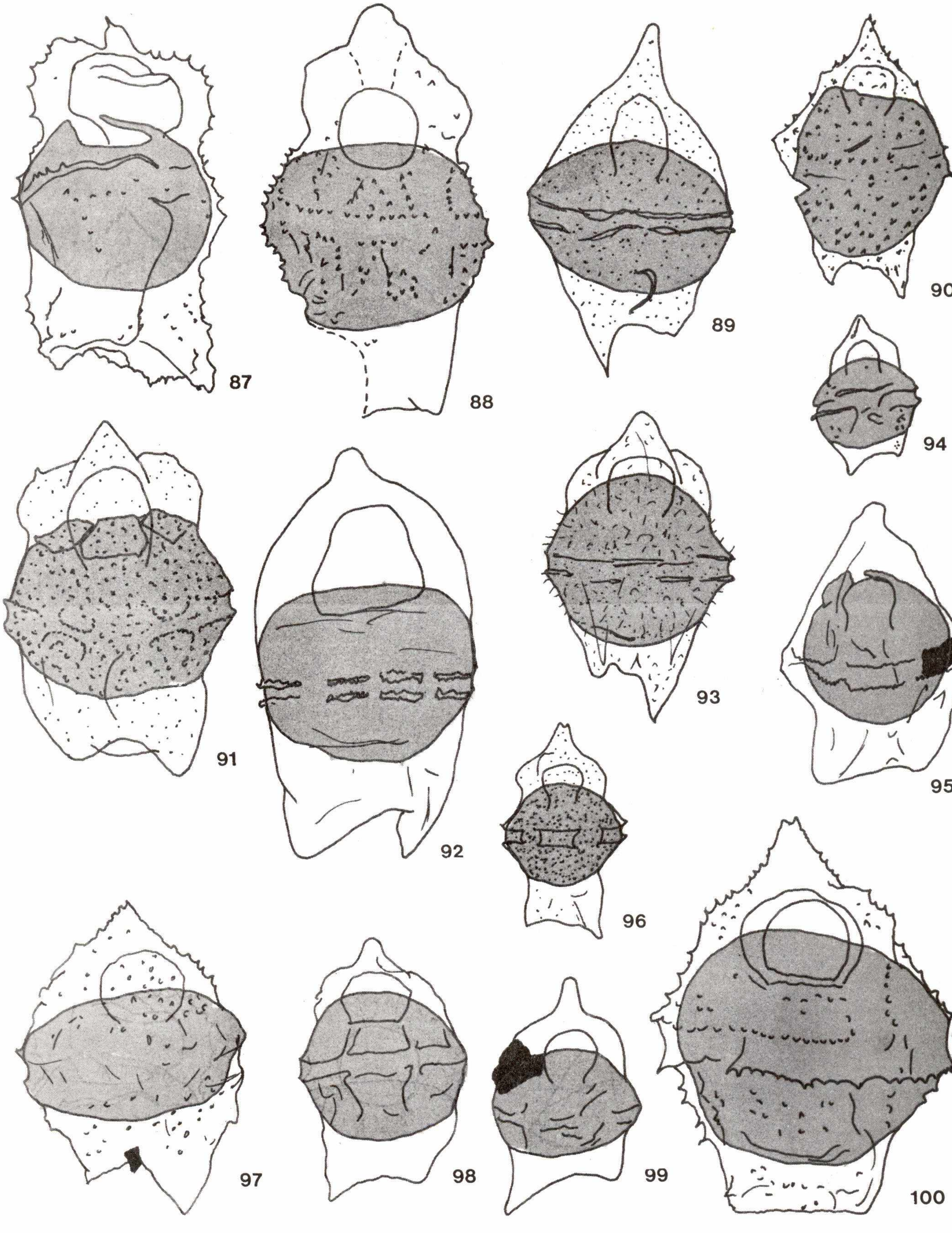

PLATE 8

101. *Isabelia pellucida* (Defl. & Cook., 1955) *comb. nov.* 118 μ

102. *I. glabra* (Cook. & Eis., 1969) *comb. nov.* 75 μ

103. *I. glomerata* (Davey, 1970) *comb. nov.* 97 μ

104. *I. korojonensis* (Cook. & Eis., 1958) *comb. nov.* 71 μ

105. ?*I. amphiata* (McInt., 1975) *comb. nov.* 113 μ

106. ?*I. globosa* (Davey, 1970) *comb. nov.* 69 μ

107. *I. microarma* (McInt., 1975) *comb. nov.* 101 μ

108. ?*I. spinosissima* (Cook. & Eis., 1970a) *comb. nov.* 100 μ

109. *I. rhombovalis* (Cook. & Eis., 1970a) *comb. nov.* 54 μ

110. *I. cooksoniae* (Alb., 1959b) *comb. nov.* 72 μ

111. *I. conorata* (Stov., 1973) *comb. nov.* 140-162 μ

112. *I. belfastensis* (Cook. & Eis., 1961a) *comb. nov.* 109 μ

113. *I. cretacea* (Cook., 1956) *comb. nov.* 55 μ

114. *I. gambangensis* (Cook. & Eis., 1970a) *comb. nov.* 86 μ

115. *I. delicata* (Baltes ex Lent. & Wills., 1973) *comb. nov.* 65-70 μ

116. *I. madurensis* (Cook. & Eis., 1970a) *comb. nov.* 90 μ

101-116

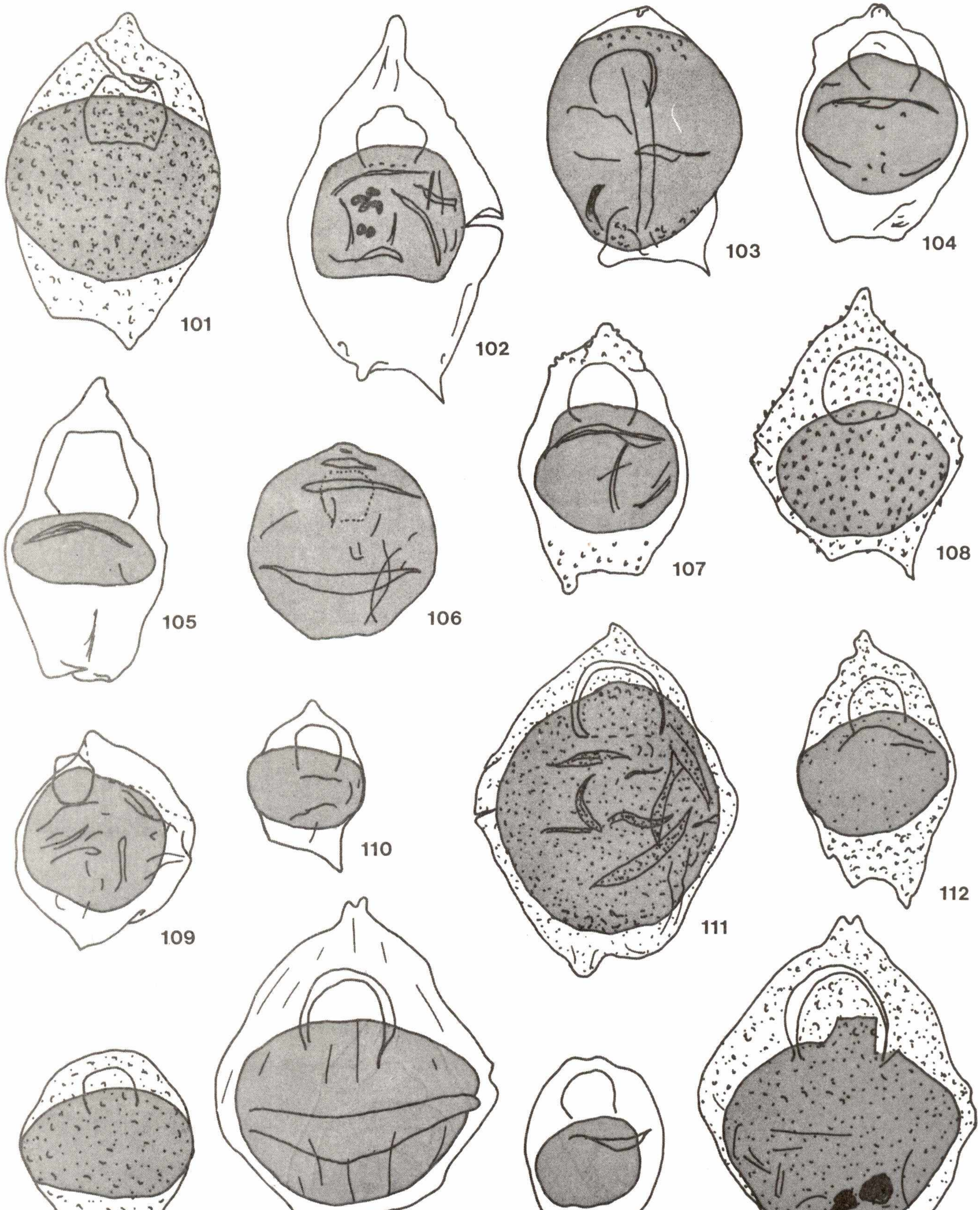

PLATE 9

117. *Isabelia bakeri* (Defl. & Cook., 1955) *comb. nov.* 108 μ

118. *I. thomasii* (Cook. & Eis., 1961a) *comb. nov.* 108 μ

119. *I. dakotaensis* (Stan., 1965) *comb. nov.* 120 μ

120. *I. lata* (Cook. & Eis., 1968) *comb. nov.* 98 μ

121. *I. druggii* (Stov., 1973) *comb. nov.* 104-122 μ

122. *Amphidiadema denticulata* Cook. & Eis., 1960a. 90 μ

123. *A. rectangularis* (Cook. & Eis., 1962b) *comb. nov.* 120 μ

124. *A. rectangularis* subsp. *samuelsonii* (Kjel., 1973) *comb. nov.* 140 μ

125. *A. nucula* (Cook. & Eis., 1962b) *comb. nov.* 67 μ

126. *Spinidinium sverdrupianum* (Manum, 1963) *comb. nov.* 98 μ

127. *S. essoi* Cook. & Eis., 1967a. 60 μ

128. *S. sagittulum* (Drugg, 1970b) *comb. nov.* 81-103 μ

129. *S. clavum* Har., 1973. 51 μ

130. *S. styloniferum* Cook. & Eis., 1962b. 53 μ

131. *S. lanterna* Cook. & Eis., 1970a. 70 μ

132. *S. echinoideum* (Cook. & Eis., 1960a) *comb. nov.* 80 μ

133. *S. macmurdoense* (Wilson, 1967a) *comb. nov.* 99 μ

117-133

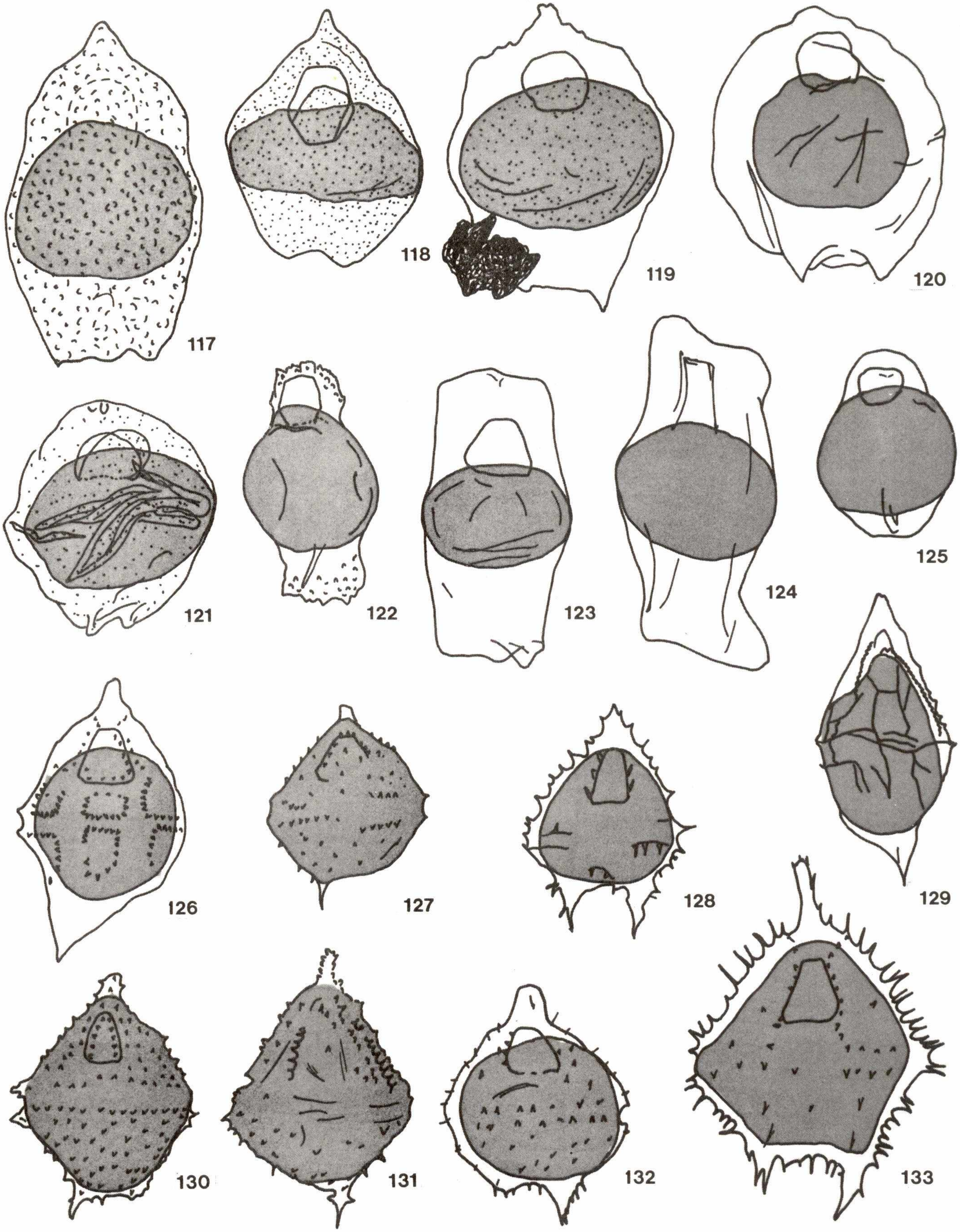
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PLATE 10

134. *Spinidinium rallum* Heis., 1970. 46 μ

135. *S. gallium* (Davey & Verd., 1973) *comb. nov.* 52 μ

136. *S. vestitum* Brid., 1971. 71 μ

137. *S. echinoideum* subsp. *rhombicum* (Cook. & Eis., 1974) *comb. nov.* 72 μ

138. *S. densispinatum* Stan., 1965. 50-65 μ

139. *Vozzhennikovia apertura* (Wilson, 1967a) *comb. nov.* 52 μ

140. ?*V. extensa* (Stov., 1973) *comb. nov.* 66-81 μ

141. *V. rotunda* (Wilson, 1967a) *comb. nov.* 65 μ

142. *V. tenera* (Krut., 1962) *comb. nov.* 50-55 μ

143. ?*V. filigrana* (Ben., 1972) *comb. nov.* 40-50 μ

144. *V. tenella* (Morg., 1966b) *comb. nov.* 63 μ

145. *Lejeunia hyalina* Ger., 1961. 93 μ

146. *L. fallax* Morg., 1966b. 77 μ

147. *L. laevigata* (Malloy, 1972) *comb. nov.* 64 μ

148. *L. pentagonalis* (Cor., 1973) *comb. nov.* 120 μ

149. *L. kozlowskii* Gorka, 1963. 128-148 μ

150. *L. magnifica* (Stan., 1965) *comb. nov.* 126 μ

151. *L. paratenella* Ben., 1972. 54 μ

152. *L. tricuspia* (O. Wet., 1933a) Gorka, 1963. 128-148 μ

153. *L. hyalina* sensu Kjel., 1972. approx. 84 μ

134-153

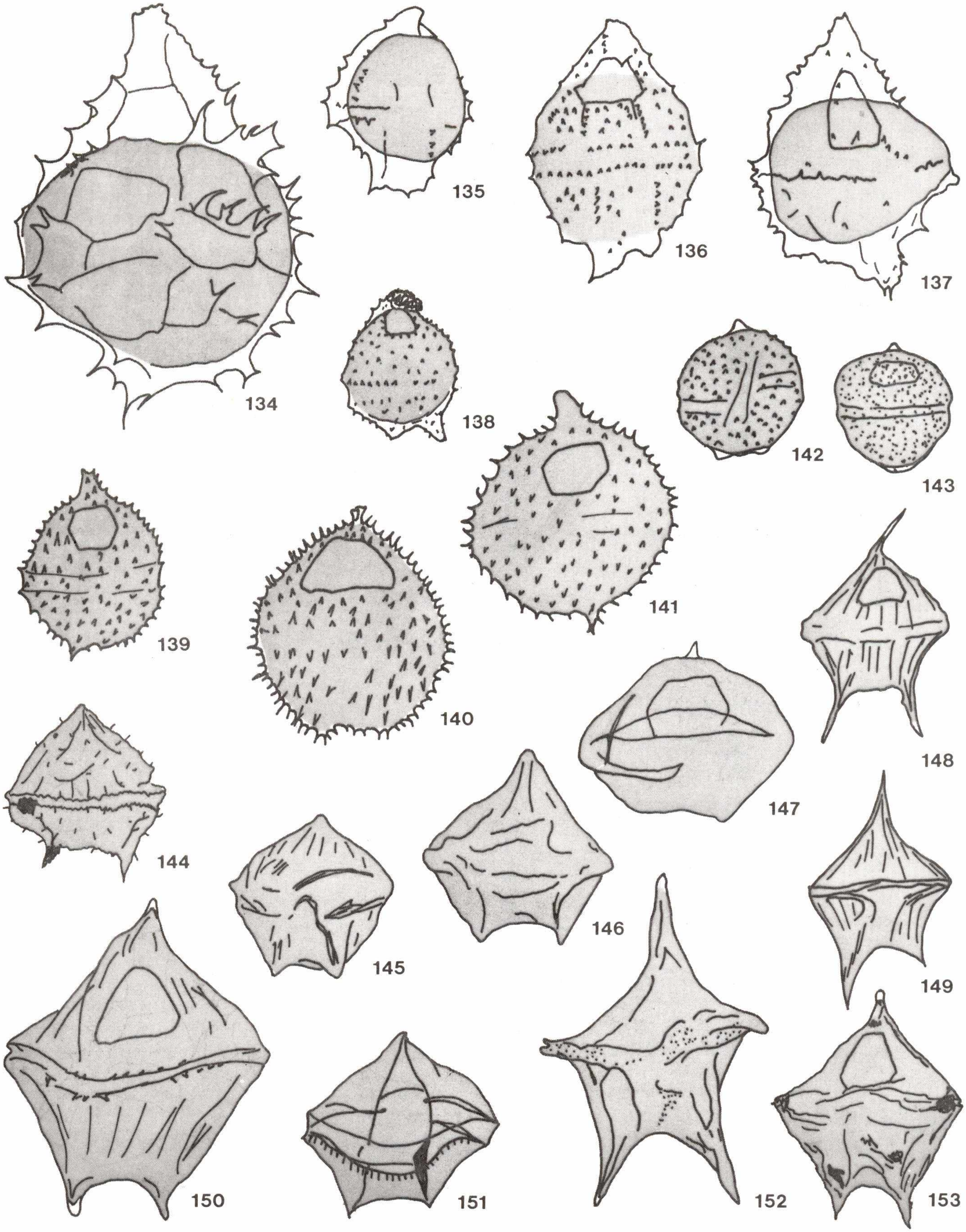
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PLATE 11

154. *Lejeunia psilodora* Ben., 1972. 95 μ

155. *Maduradinium spatiosum* (Morg., 1966b) *comb. nov.* 84 μ

156. *M. pentagonum* Cook. & Eis., 1970a. 85 μ

157. *Phthanoperidinium resistente* (Morg., 1966a) Eis. & Kjel., 1971a. 38 μ

158. ?*P. polytrix* (Ben., 1972) *comb. nov.* 36-50 μ

159. ?*P. eocenicum* (Cook. & Eis., 1965a) Lent. & Wills., 1973. 60 μ

160. *P. comatum* (Morg., 1966b) Eis. & Kjel., 1971a. 39 μ

161. *P. coreoideum* (Ben., 1972) *comb. nov.* 36-38 μ

162. *P. lambdoideum* (Nagy, 1966) Eis. & Kjel., 1971a. 66 μ

163. *P. amoenum* Drugg & Loeb., 1967. 38 μ

164. ?*P. illustrans* (O. Wet., 1933a) Lent. & Wills., 1973. 34 μ

165. *P. campoense* Caro, 1973. 45 μ

166 *Sumatradinium hispidum* (Drugg, 1970a) *comb. nov.* 78-79 μ

167. *Uvatodinium nasutum* Vozz., 1963. 95 μ

168. *U. marginatum* Vozz., 1967. 152 μ

169. *Nelsoniella semireticulata* Cook. & Eis., 1960a. 94 μ

170. *N. tuberculata* Cook. & Eis., 1960a. 92 μ

171. *N. aceras* Cook. & Eis., 1960a. 78 μ

172. *Hexagonifera glabra* Cook. & Eis., 1961a. 66 μ

173. ?*H. chlamydata* Cook. & Eis., 1962b. 75 μ

154-173

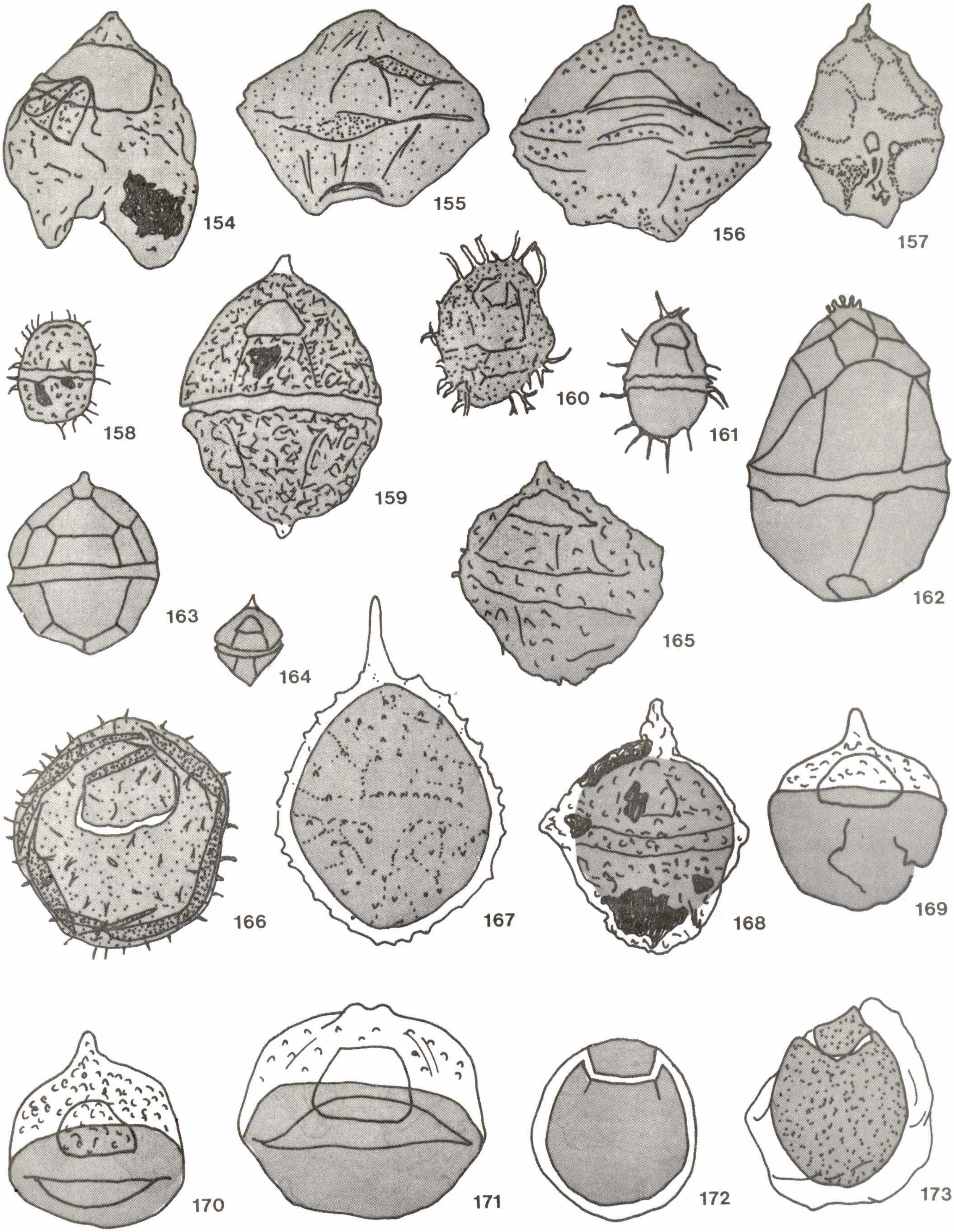
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PLATE 12

174. *Svalbardella cooksoniae* Manum, 1960. 150-172 μ

175. *Palaeocystodinium golzowense* Alb., 1961. 136 μ

176. *P. hyperxanthum* (Vozz., 1963) Vozz., 1967. 150-165 μ

177. *P. australinum* (Cook., 1965b) *comb. nov.* 270 μ

178. *P. denticulatum* Alb., 1961. 236 μ

179. *P. granulatum* (Wilson, 1967b) *comb. nov.* 250 μ

180. *P. lidiae* (Gorka, 1963) Davey, 1969b. 110-210 μ

181. *P. rhomboideum* subsp. *nodosum* (O. Wet., 1933a) Lent. & Wills., 1973. 168 μ

182. *P. rhomboideum* subsp. *incertum* (Defl., 1936a) Lent. & Wills., 1973. 70 μ

183. *P. rhomboideum* subsp. *ovatum* (O. Wet., 1933a) Lent. & Wills., 1973. 106 μ

184. *P. rhomboideum* subsp. *filosum* (O. Wet., 1933a) Lent. & Wills., 1973. 153 μ

185. *P. rhomboideum* (O. Wet., 1933a) Lent. & Wills., 1973. 153 μ

186. *P. benjaminii* Drugg, 1967. 172 μ

187. ?*P. deflandrei* Gruas-Cav., 1968. 95-135 μ

188. *Selenopemphix nephroides* Ben., 1972. 43-76 μ

189. *S. selenoides* Ben., 1972. 42-68 μ

190. *Bulbodinium seitzi* O. Wet., 1960. 128 μ

191. *B. altipetax* O. Wet., 1960. 135 μ

192. *B. oistoides* O. Wet., 1960. 120 μ

193. *Ginginodinium spinulosum* Cook. & Eis., 1960a. 72 μ

194. *G. ornatum* (Fel. & Bur., 1973) *comb. nov.* 72 μ

174-194

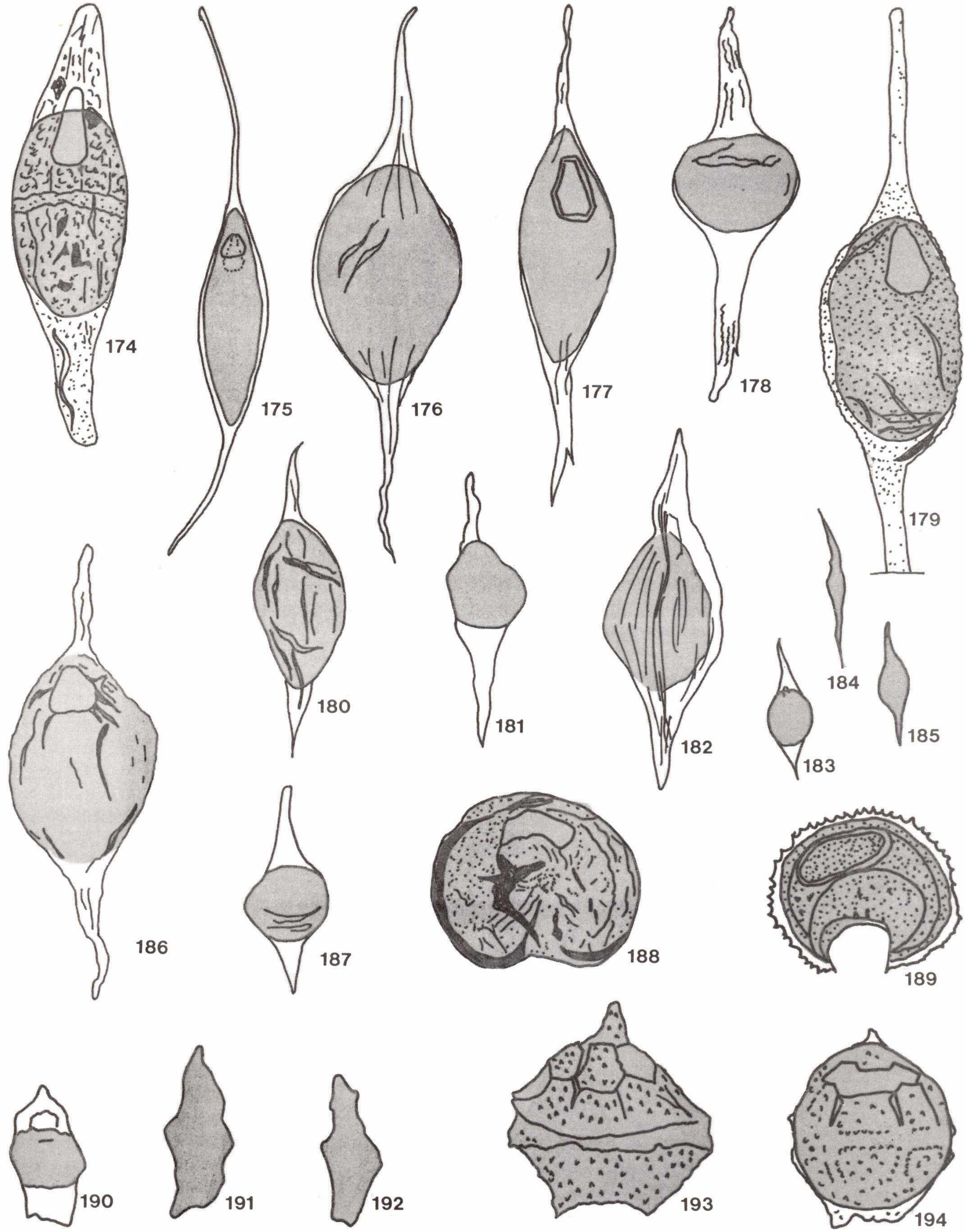
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PLATE 13

195. *Trithyrodinium fragile* Davey, 1969. 45 μ

196. *T. evittii* Drugg, 1967. 75-95 μ

197. *T. vermiculatum* (Cook. & Eis., 1961a) *comb. nov.* 76 μ

198. *T. suspectum* (Man. & Cook., 1964) *comb. nov.* 118 μ

199. *T. druggii* Stone, 1973. 95-130 μ

200. *Ascodinium serratum* Cook. & Eis., 1960a. 63 μ

201. *A. acrophorum* Cook. & Eis., 1960a. 72 μ

202. *A. parvum* (Cook. & Eis., 1958) Cook. & Eis., 1960a. 57 μ

203. *Ovoidinium cinctum* (Cook. & Eis., 1958) Davey, 1970. 88 μ

204. *O. scabrosum* (Cook. & Hughes, 1964) Davey, 1970. 80 μ

205. *O. ovale* (Cook. & Eis., 1970a) *comb. nov.* 65 μ

206. *O. verrucosum* subsp. *ostium* (Davey, 1970) Davey & Verd., 1973. 59 μ

207. *?O. indistinctum* (Cook. & Eis., 1974) *comb. nov.* 103 μ

208. *O. waltonii* (Pocock, 1972) *comb. nov.* 60-73 μ

209. *O. verrucosum* (Cook. & Hughes, 1964) Davey, 1970. 52 μ

210. *Palaeoperidinium sibiricum* (Vozz., 1963) *comb. nov.* 98 μ

211. *P. marginatum* (Vozz., 1967) *comb. nov.* 120-127 μ

212. *P. pyramidale* (Harris, 1973) *comb. nov.* 55-68 μ

195-212

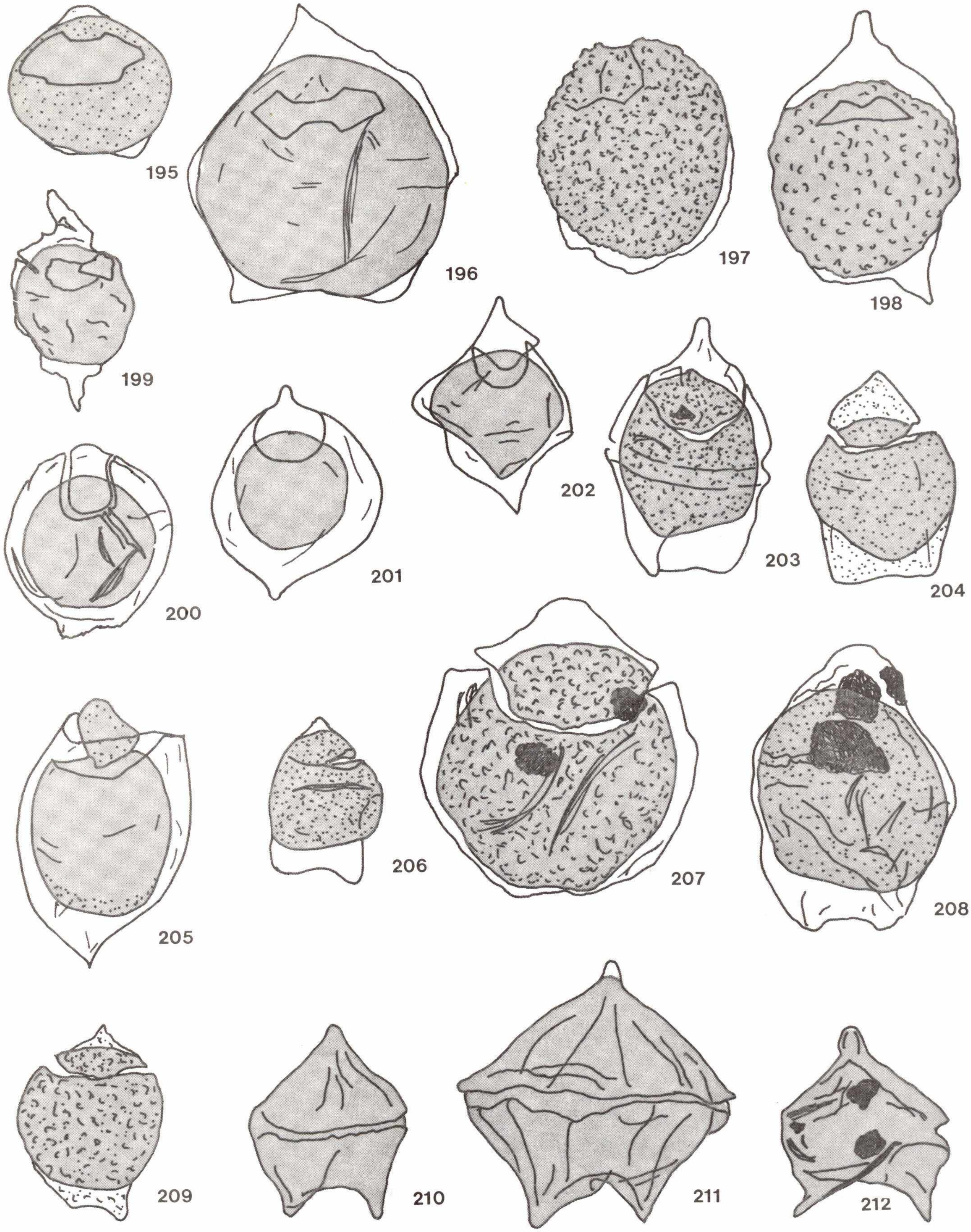
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PLATE 14

213. *Palaeoperidinium pyrophorum* (Ehren., 1838) Sarj., 1967. 92 μ

214. *P. deflandrei* Lent. & Wills., 1973. 70-80 μ

215. *P. deflandrei* subsp. *larjakiensis* (Vozz., 1967) Lent. & Wills., 1973. 148 μ

216. *P. cretaceum* Pocock ex Davey, 1970. 81-95 μ

217. *P. amplum* (Har., 1973) *comb. nov.* 149 μ

218. *P. hansonianum* (Trav., 1955) Lent. & Wills., 1973. 80 μ

219. ?*P. subconicoides* (Lej.-Carp., 1942) Lent. & Wills., 1973. 40-50 μ

220. *P. tabulatum* (Cook. & Eis., 1965c) *comb. nov.* 65 μ

221. *P. parvum* (Har., 1973) *comb. nov.* 45 μ

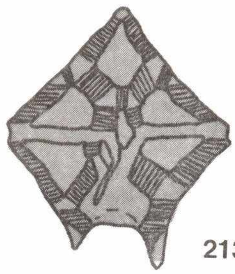
222. *P. damasii* (Lej.-Carp., 1942) *comb. nov.* 78 μ

223. *P. basilium* (Drugg, 1967) Drugg, 1970b. 93 μ

224. *P. eurypylum* (Man. & Cook., 1964) Evitt, 1975. 81 μ

225. *P. paleocenicum* (Cook. & Eis., 1965c) *comb. nov.* 74 μ

213-225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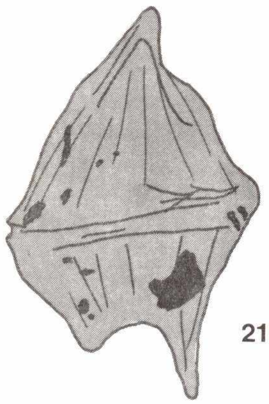
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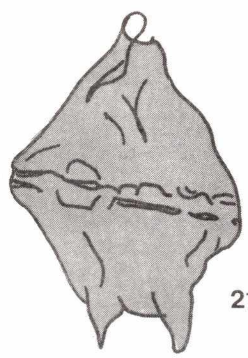
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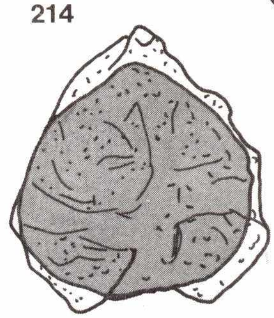
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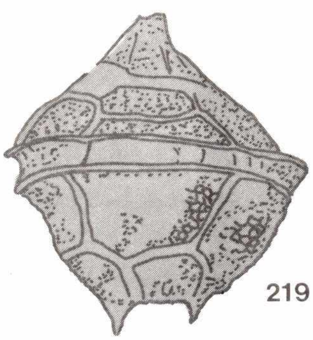
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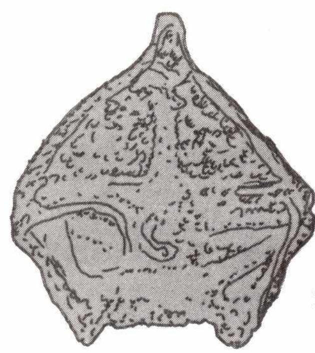
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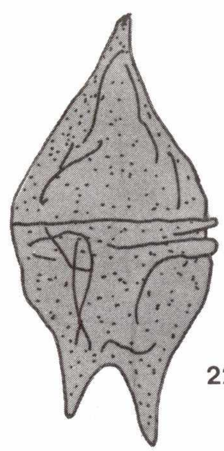
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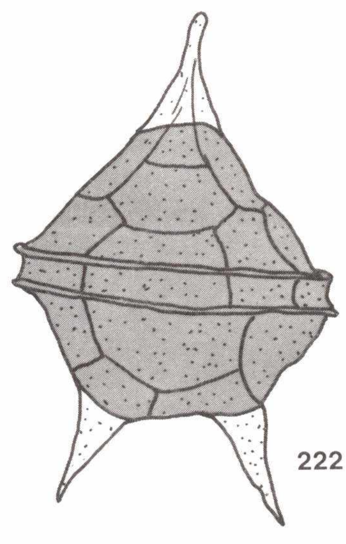
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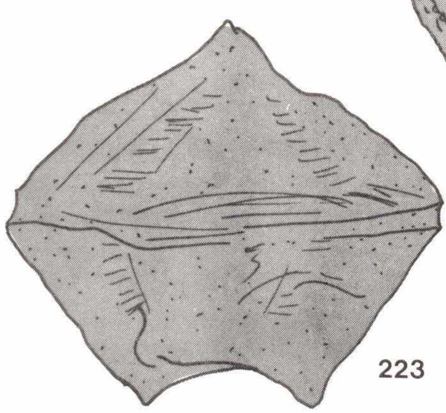
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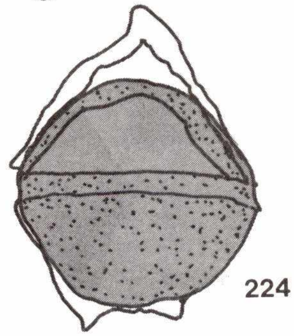
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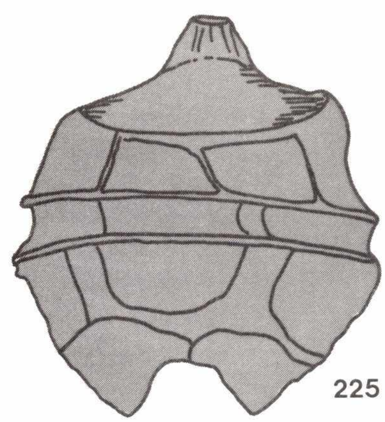
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PLATE 15

226. *Saeptodinium tasmaniense* Harris, 1973. 45-62 μ

227. *S. gravattense* Harris, 1973. 50-62 μ

228. *Laciniadinium orbiculatum* McInt., 1975. 87 μ

229. *L. biconiculum* McInt., 1975. 78 μ

230. *Subtilisphaera ventriosa* (Alb., 1959b) Jain & Mill., 1973. 67 μ

231. *S. senegalensis* Jain & Mill., 1973. 50 μ

232. *S. pirnaensis* (Alb., 1959b) Jain & Mill., 1973. 104 μ

233. *S. crassigranulosa* Jain & Mill., 1973. 54 μ

234. *S. perlucida* (Alb., 1959b) Jain & Mill., 1973. 74 μ

235. *S. pontis-mariae* (Defl., 1936b) *comb. nov.* 42-52 μ

236. *S. asymmetrica* (Davey & Verd., 1971) *comb. nov.* 58 μ

237. ?*S. euthema* (Davey & Verd., 1971) *comb. nov.* 74 μ

238. ?*S. terrula* (Davey, 1974) *comb. nov.* 59 μ

239. *S. rotundata* (Eis. & Cook., 1960) Jain & Mill., 1973. 80 μ

240. ?*S. trendalli* (Cook. & Eis., 1970a) *comb. nov.* 70 μ

241. *S. balcattensis* (Cook. & Eis., 1969) *comb. nov.* 72 μ

242. *S. scabrata* Jain & Mill., 1973. 60 μ

243. *Geiselodinium geiseltalense* Krut., 1962. 65-75 μ

244. *Teneridinium magnoides* Krut., 1962. 100-130 μ

245. *Pseudodeflandrea gigantea* Alb., 1959a. 220 μ

226-245

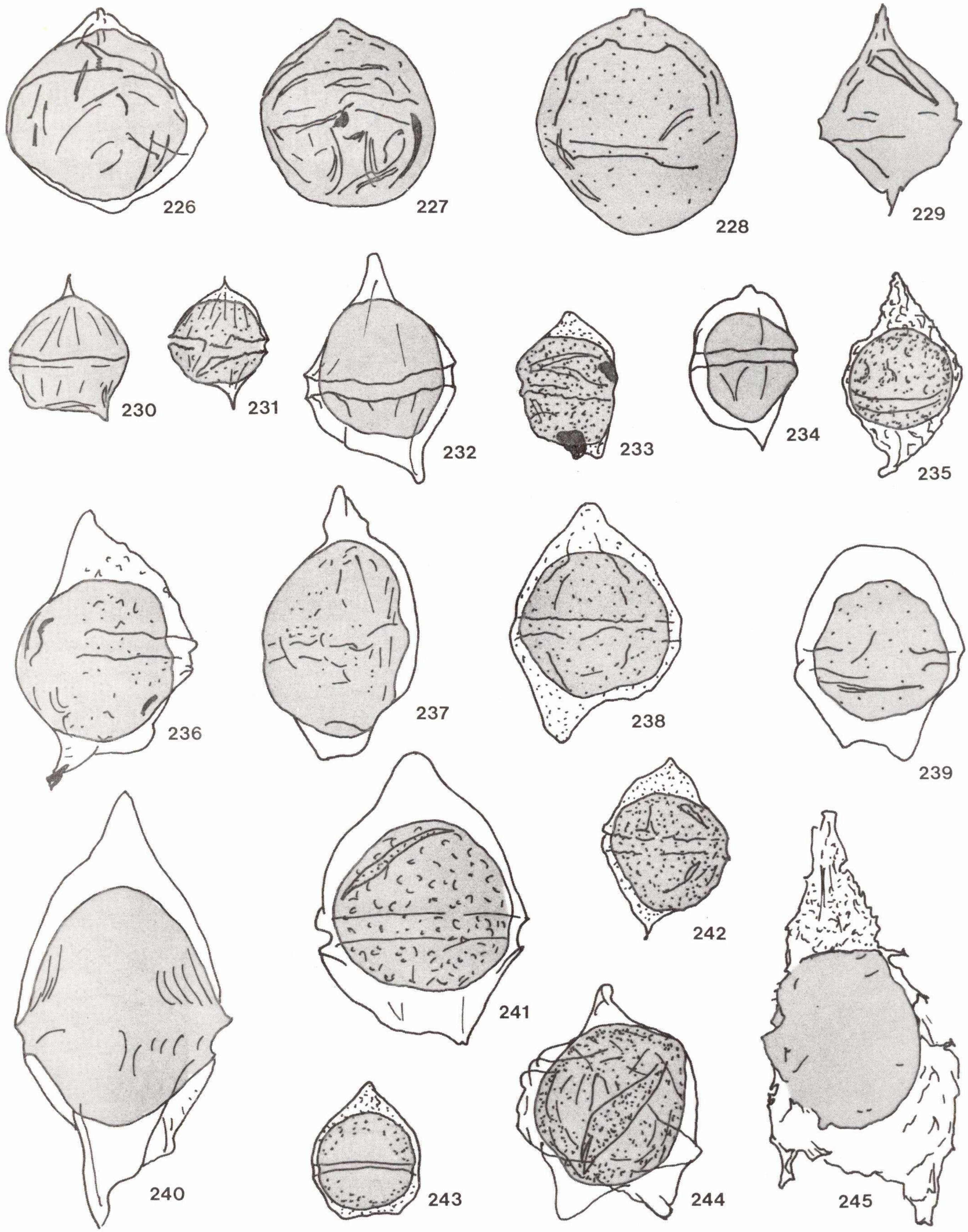
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PLATE 16

246. *Rhombodinium glabrum* subsp. *crassithecum* (Vozz., 1967) Lent. & Wills., 1973. 97-140 μ

247. *R. draco* Gocht, 1955. 158 μ

248. *R. condylos* (Wills. & Down., 1966b) *comb. nov.* 122 μ

249. *R. waipawaense* (Wilson, 1967c) Lent. & Wills., 1973. 102 μ

250. *R. intermedium* (Cook. & Eis., 1961b) Lent. & Wills., 1973. 125 μ

251. *R. glabrum* subsp. *granulatum* (Wilson, 1967c) Lent. & Wills., 1973. 129 μ

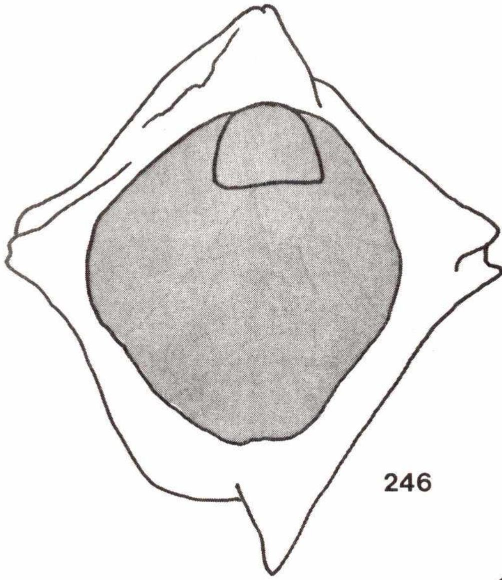
252. *R. longimanum* Vozz., 1967. 121-165 μ

253. *R. glabrum* (Cook., 1956) Vozz., 1967. 137 μ

254. ?*R. minusculum* (Alb., 1961) Lent. & Wills., 1973. 52 μ

255. *R. rotundatum* Baltes ex Lent. & Wills., 1973. 140-160 μ

246-255



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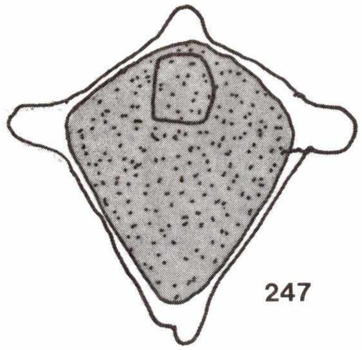

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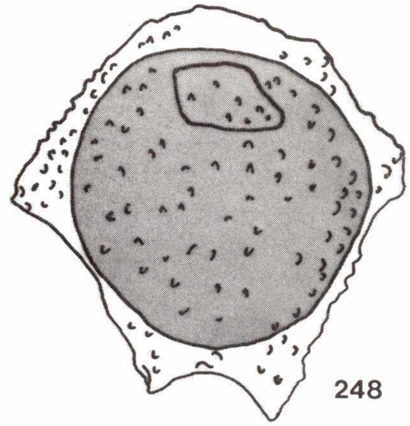

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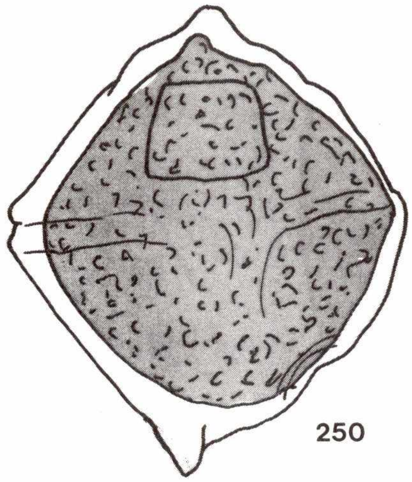

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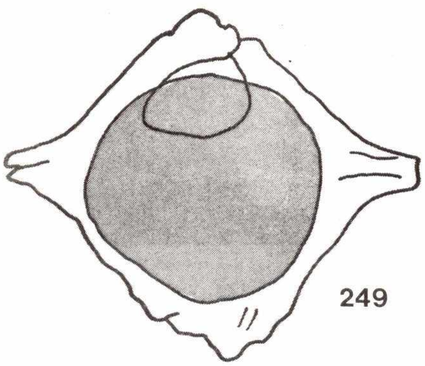

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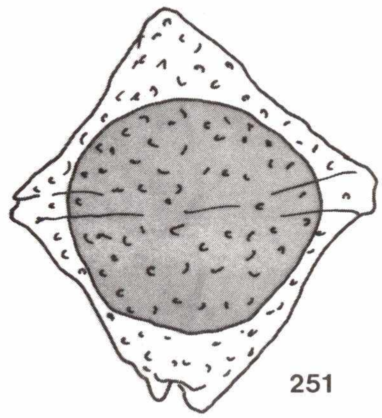

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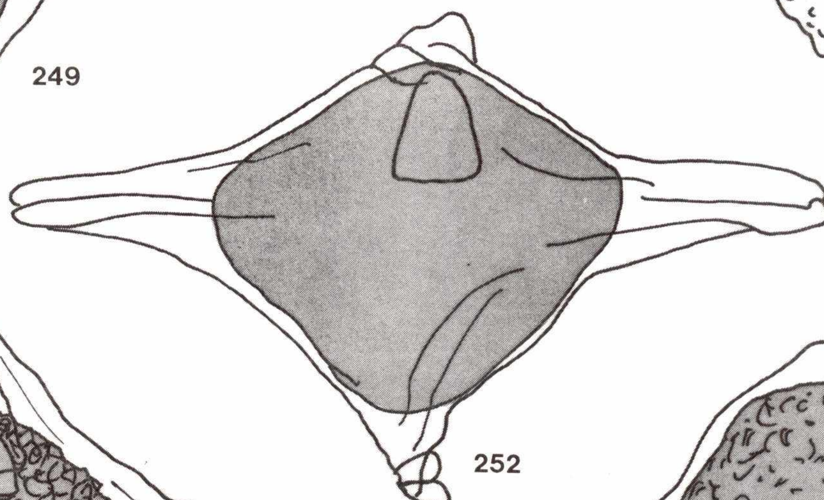

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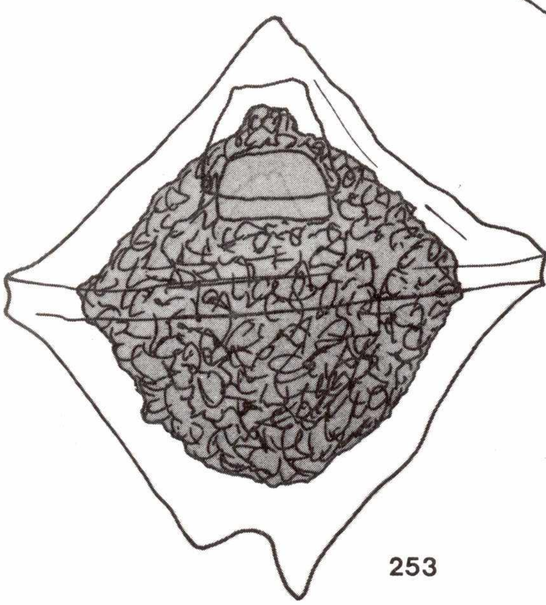

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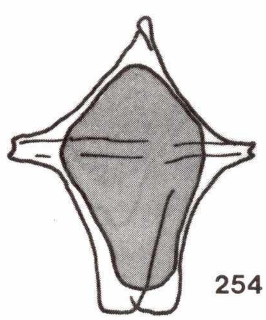

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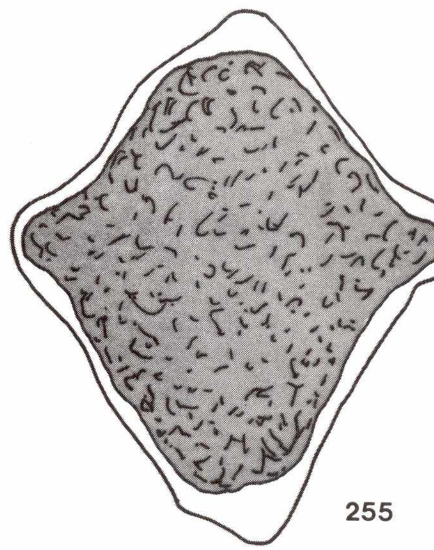

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PLATE 17

256. *Rhombodinium draco* subsp. *freienwaldense* (Gocht, 1955) Lent. & Wills., 1973. 111 μ

257. *R. rhomboideum* (Alb., 1961) Lent. & Wills., 1973. 128 μ

258. *Wetzeliella articulata* Eis., 1938. 167 μ

259. *W. articulata* subsp. *conopia* (Wills. & Down., 1966b) Lent. & Wills., 1973. 132 μ

260. *W. coronata* (Vozz., 1967) *comb. nov.* 145 μ

261. *W. unicaudalis* Caro, 1973. 121 μ

262. *W. varielongituda* Wills. & Down., 1966b. 103 μ

263. *W. pentagona* (Vozz., 1967) *comb. nov.* 162 μ

264. ?*W. pilata* Stanley, 1965. 42-49 μ

265. *W. samlandica* Eis., 1954. 114 μ

266. *W. symmetrica* subsp. *lobisca* (Wills. & Down., 1966b) Lent. & Wills., 1973. 137 μ

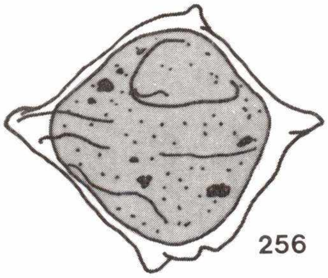
267. *W. symmetrica* subsp. *incisa* Ger., 1961. 118-150 μ

268. *W. irtyschensis* Alb., 1961. 145 μ

269. *W. similis* Eis., 1954. 97 μ

270. *W. symmetrica* Weiler, 1956. 125 μ

256-270



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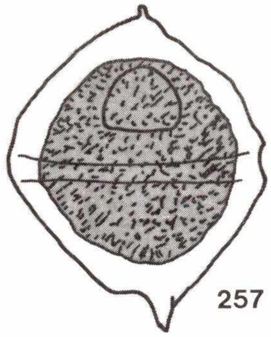

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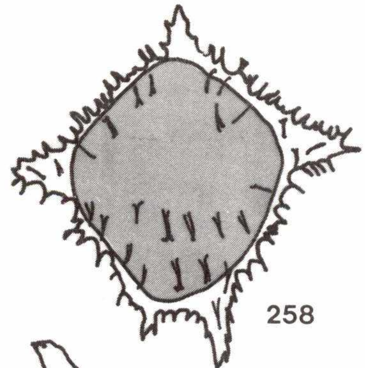

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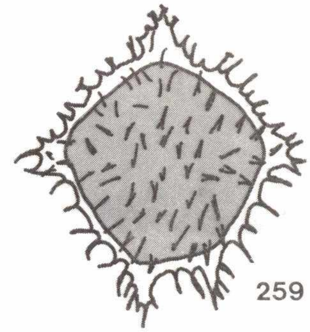

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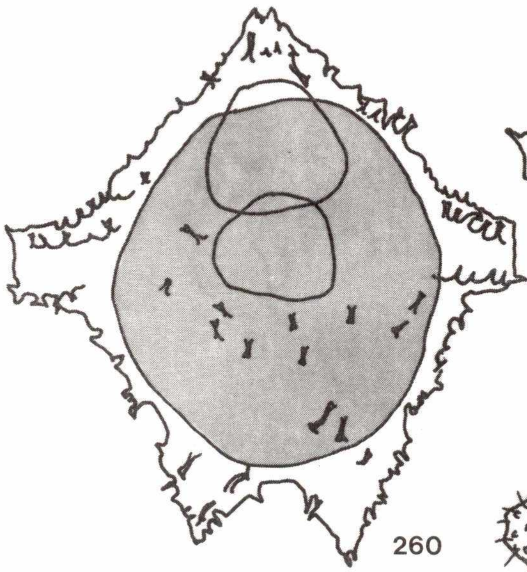

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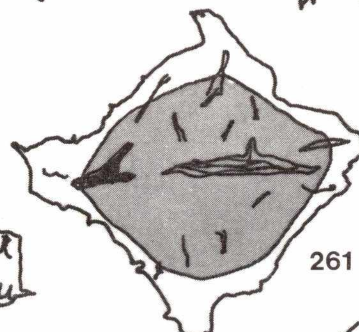

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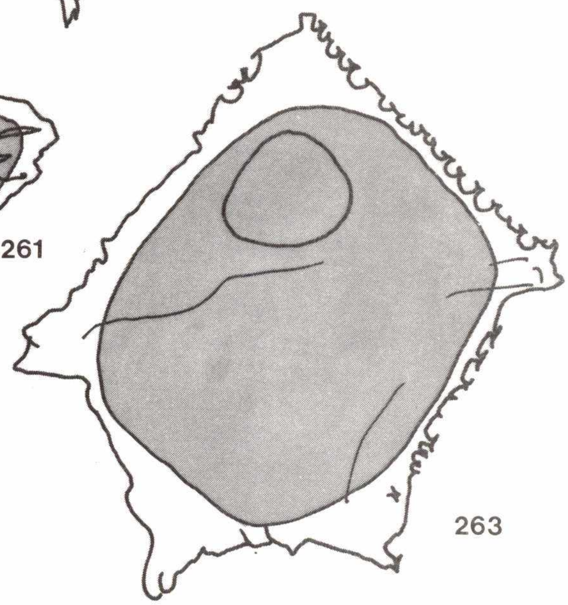

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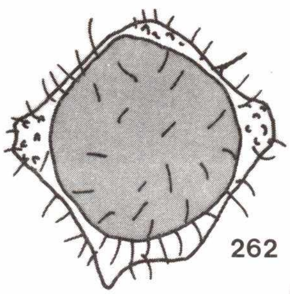

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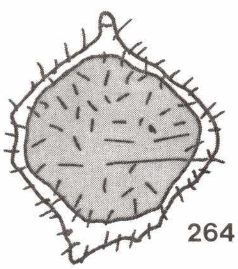

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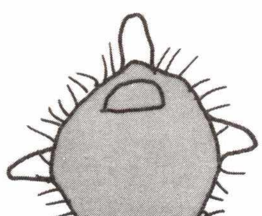

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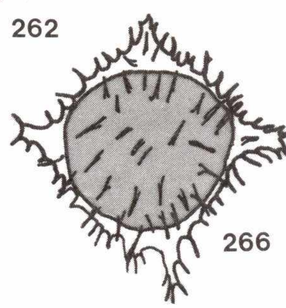

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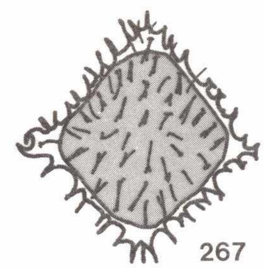

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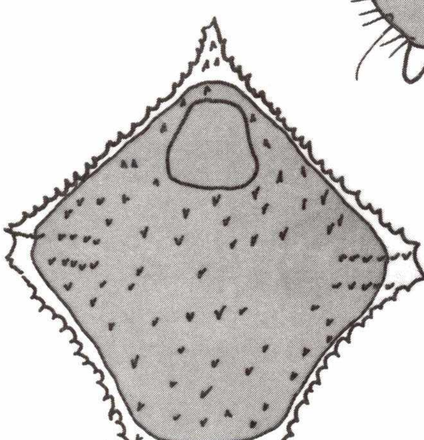

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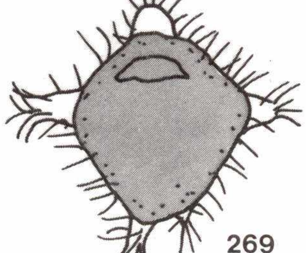

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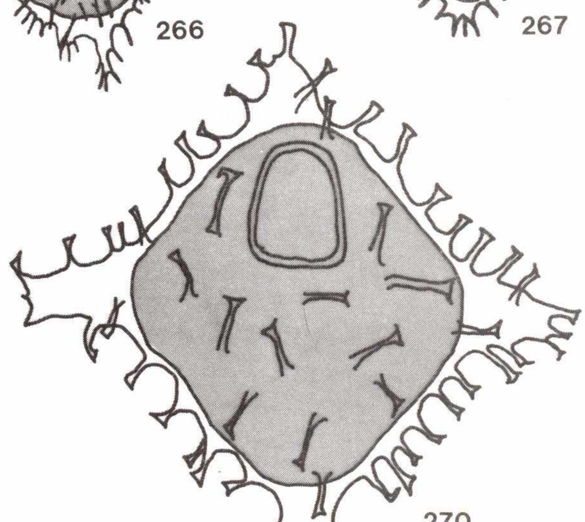

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PLATE 18

271. *Wetzeliella solida* (Gocht, 1955) Wills. & Down., 1966b. 97 μ

272. *W. irregularis* Cook. & Eis., 1958. 133 μ

273. *W. hyperacantha* Cook. & Eis., 1965b. 110 μ

274. *W. lunaris* Gocht, 1969. 155 μ

275. *W. longispinosa* (Wilson, 1968) *comb. nov.* 121 μ

276. *W. homomorpha* Defl. & Cook., 1955. 44-60 μ

277. *W. meckelfeldensis* Gocht, 1969. 151 μ

278. *W. homomorpha* subsp. *quinquelata* (Wills. & Down., 1966b) Lent. & Wills., 1973. 94 μ

279. *W. parva* Alb., 1961. 82 μ

280. *W. ovalis* Eis., 1954. 104 μ

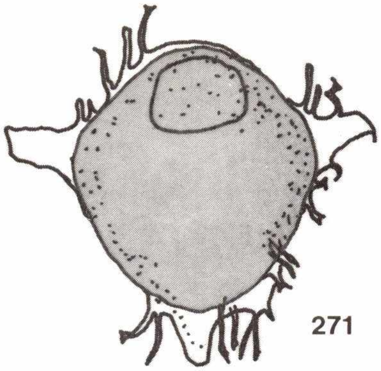
281. *W. edwardsii* Wilson, 1967c. 96 μ

282. *W. hampdenensis* Wilson, 1967c. 132 μ

283. *W. pachyderma* Caro, 1973. 78 μ

284. *W. echinulata* Vozz., 1967. 127 μ

271-284



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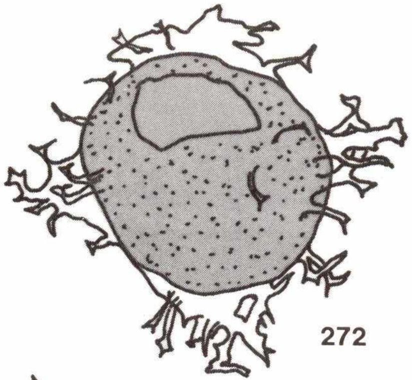

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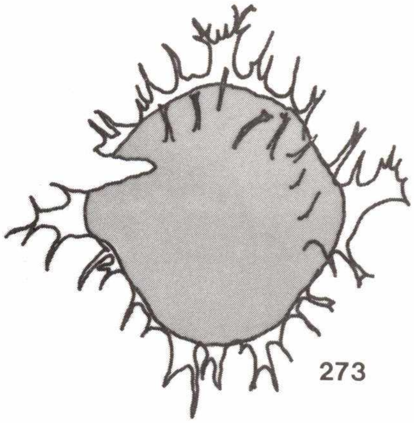

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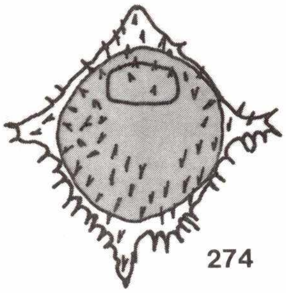

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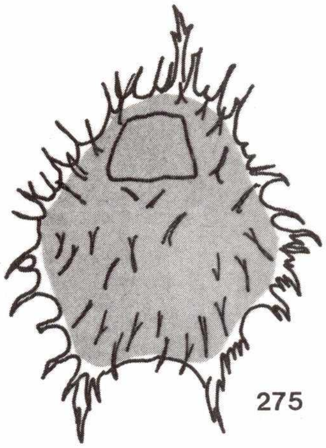

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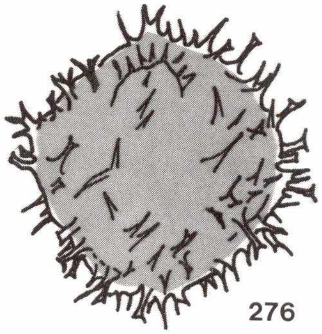

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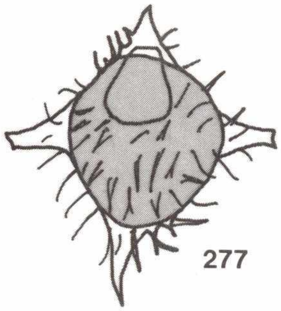

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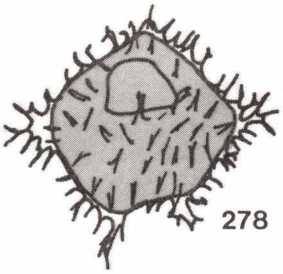

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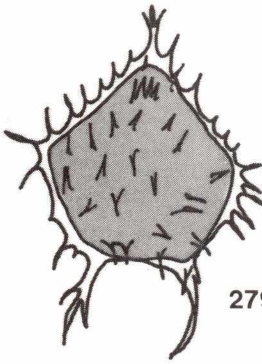

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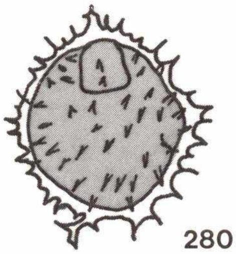

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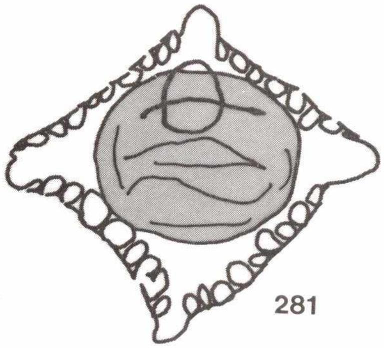

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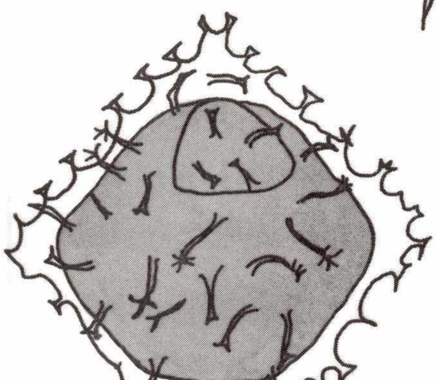

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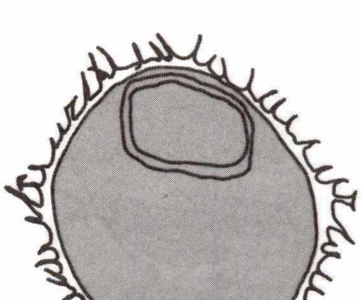

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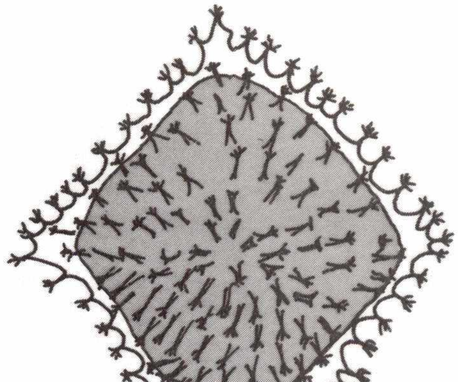

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PLATE 19

285. *Kisselevia ornata* Vozz., 1967. 108 μ

286. *K. reticulata* (Wills. & Down., 1966b) *comb. nov.* 146 μ

287. *K. coleothrypta* (Wills. & Down., 1966b) *comb. nov.* 122 μ

288. *?K. clathrata* (Eis., 1938) *comb. nov.* 160 μ

289. *K. tenuivirgula* (Wills. & Down., 1966b) *comb. nov.* 125-175 μ

290. *K. ornata* subsp. *reticulata* (Vozz., 1967) Lent. & Wills., 1973. 108 μ

291 *?K. clathrata* subsp. *fasciata* (Roz., 1965) *comb. nov.* 143 μ

292. *K. tenuivirgula* subsp. *crassoramosa* (Wills. & Down., 1966b) *comb. nov.* 125 μ

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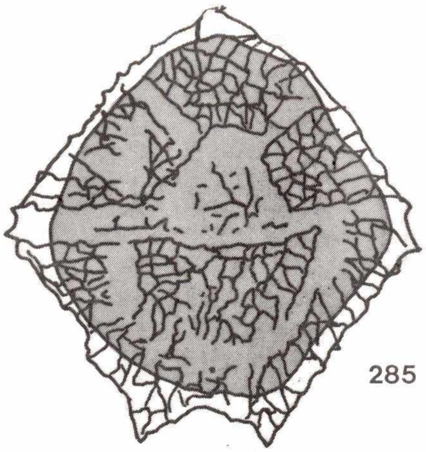

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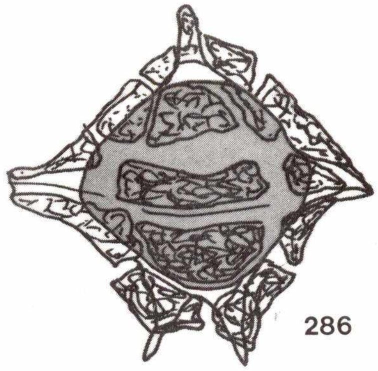

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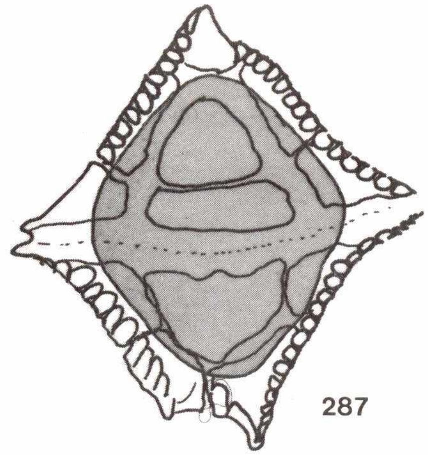

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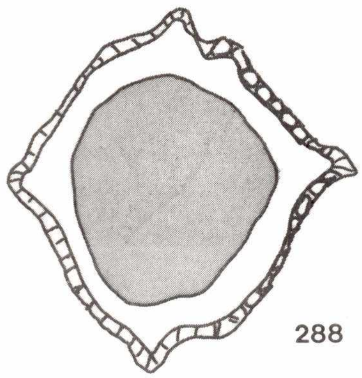

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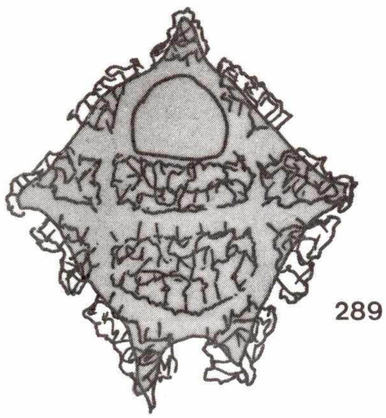

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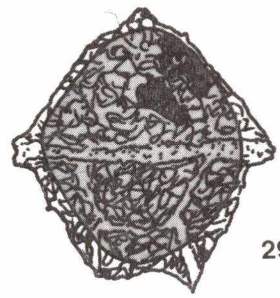

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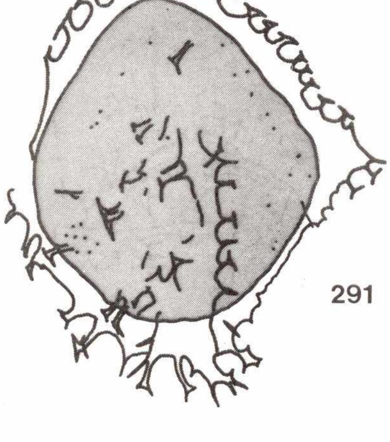

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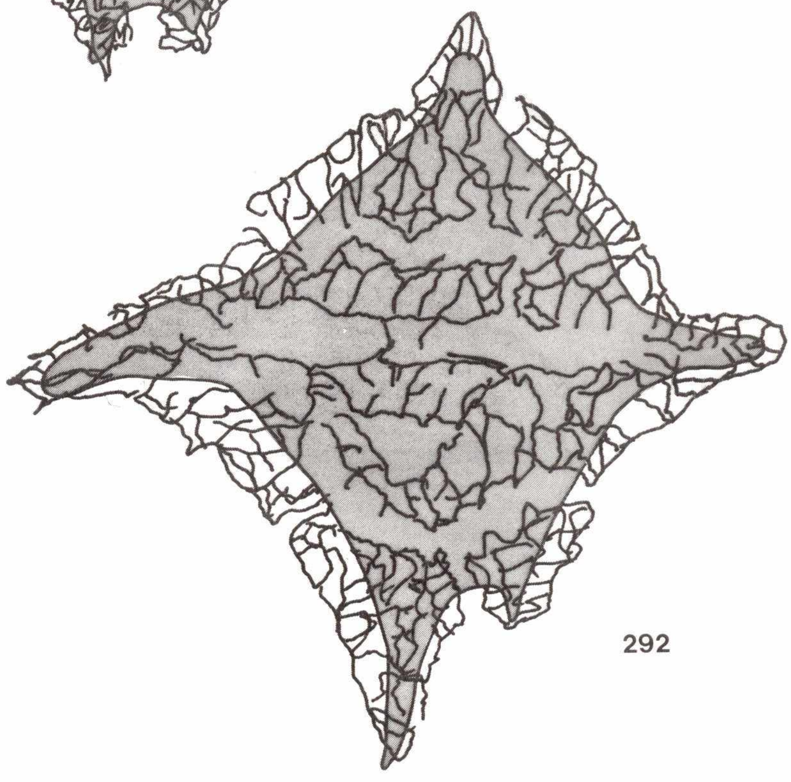

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PLATE 20

293. *Wilsonidium echinosuturatum* (Wilson, 1967c) *comb. nov.* 149 μ

294. ?*W. aechmophorum* (Ben., 1972) *comb. nov.* 66 μ

295. *W. tabulatum* (Wilson, 1967c) *comb. nov.* 149 μ

296. *W. lineidentatum* (Defl. & Cook., 1955) *comb. nov.* 118 μ

297. ?*W. rugosum* (Stanley, 1965) *comb. nov.* 50-60 μ

298. *W. ornatum* (Wilson, 1967c) *comb. nov.* 156 μ

299. *Moesiodinium raileanui* Ant., 1974. 34 μ

300. *Inversidinium exilimurum* McLean, 1973. 50 μ

301. *Broomea ramosa* Cook. & Eis., 1958. 214 μ

302. *B. simplex* Cook. & Eis., 1958. 285 μ

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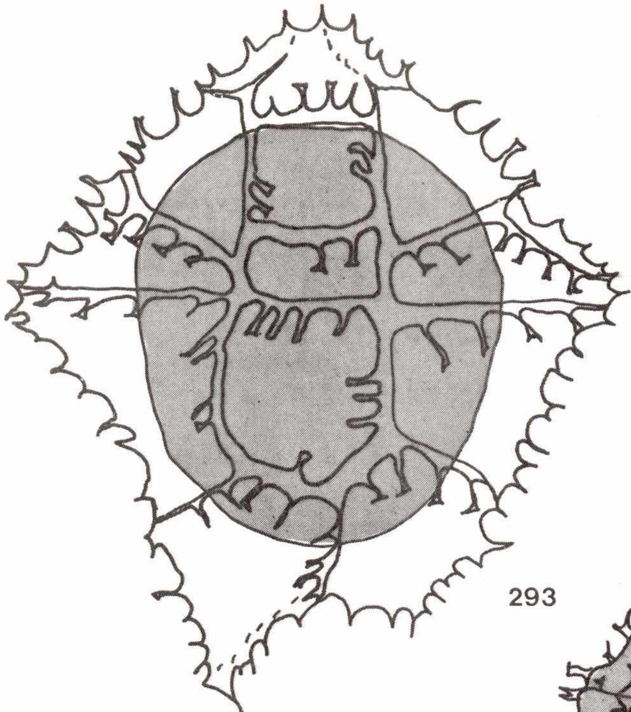

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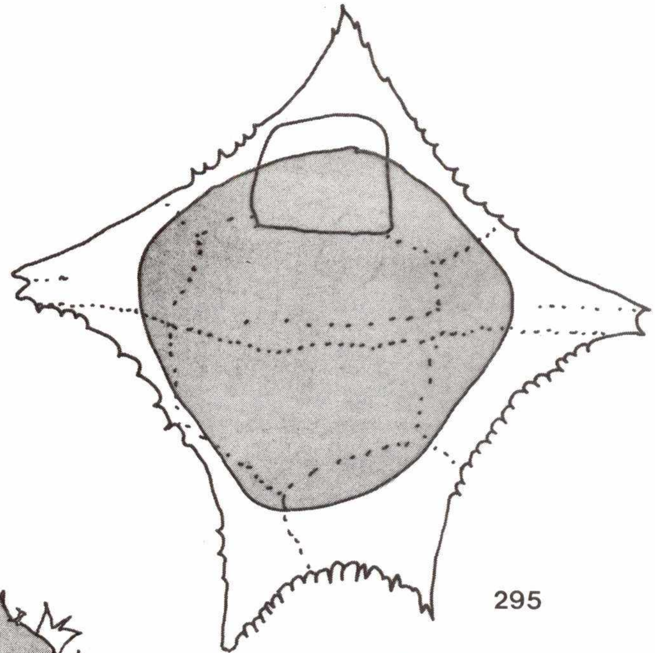

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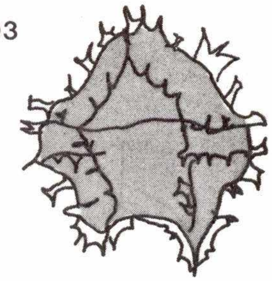

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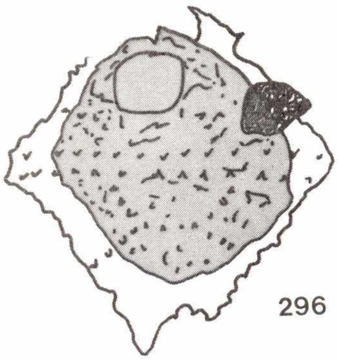

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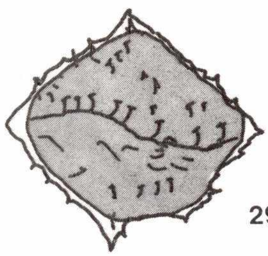

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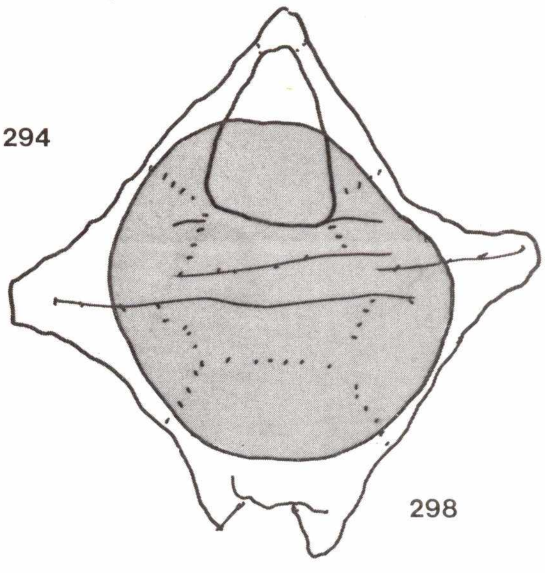

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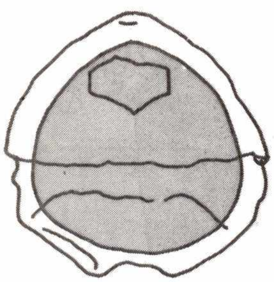

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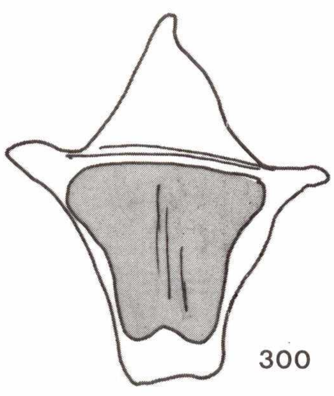

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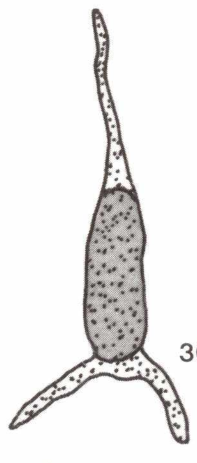

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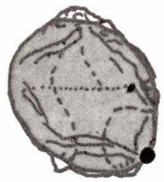
PLATE 21

303. *Geiselodinium eocenicum* Krut., 1962. 55-60 μ

304. *G. hallense* Krut., 1962. 55-70 μ

305. *G. miocenicum* Nagy, 1965. 62 μ

306. *Isabelia seelandica* (Lange, 1969) *comb. nov.* 106 μ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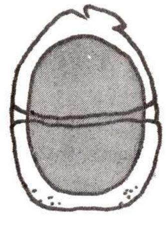
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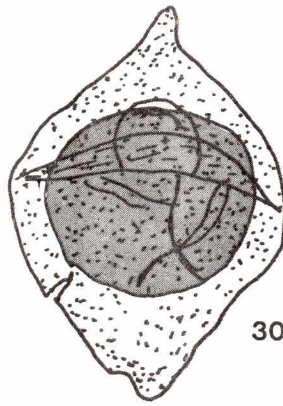
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INDEX OF GENERA AND SPECIES

To facilitate usage of the Monograph, the species name precedes the generic name.

Environment Canada
Environnement Canada

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