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Species Guide to Selected Members of Deflandreoideae (Dinoflagellata)

S.M.S. McLachlan and M. Bringué

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Species guide to selected members of Deflandreoideae (Dinoflagellata)

Sandy M. S. McLachlan and Manuel Bringué

Introduction

The data compiled in this file was extracted from the original works and subsequent published emendations pertaining to 327 dinoflagellate species across thirteen genera currently recognized within the peridiniacean subfamily Deflandreoideae: *Alterbidinium*, *Cerodinium*, *Chatangiella*, *Deflandrea*, *Diconodinium*, *Ibaidinium*, *Isabelidinium*, *Laciniadinium*, *Manumiella*, *Senegalinium*, *Spinidinium*, *Trithyrodinium*, and *Vozzhennikovia* (Fensome et al. 1993). All credit for the original taxonomic descriptions, emendations and illustrations goes to the original authors as cited in the text and illustration captions.

The objective of this work is to serve as a reference guide for the identification of taxa and a basis for future work toward the resolution of taxonomic problems related to the group. The best illustrations of type specimens available to the present authors are included herein. Morphological features for each genus have been tabulated in Appendix 1. Synonymy has been incorporated from Fensome & Williams (2019). Symbols follow those in Fensome et al. (2019), viz. * = type species; + = taxonomic senior synonym of the species name containing the nomenclatural type of the genus; and ? = species of questionable assignment.

Approximately 29% of the literature items (188 papers) provided original descriptions and emendations for species in languages other than English—Chinese (12), French (11), German (14), Romanian (1), Russian (10), Spanish (6), and Ukrainian (1). Where translations where not provided in original publications or by subsequent workers, Adobe Acrobat 9 Pro Extended (version 9.0.0) software was employed using the optical character recognition function, and the text was selected and entered into Google Translate, with subsequent refinement. The reader is referred to the original publications for the citations referenced in quoted entries. Where applicable, revised ages have been provided for each species in light of recent interpretations for their type sections and parent geological formations. The layout of some figured images and illustrations has been modified from the original plates on which they appeared for optimal presentation. Remarks included are largely excerpts of those relating to comparative descriptions and species morphology.

Genus ***ALTERBIDINIUM*** Lentin & Williams, 1985

1967 *Albertia* Vozzhennikova: 150, 151 (illegitimate name).
1976 *Alterbia* Lentin & Williams: 47, 48 (illegitimate name).
1985 *Alterbidinium* Lentin & Williams: 14.
1991 *Alterbidinium* Lentin & Williams emend. Khowaja-Ateequzzaman et al.: 38.
2016 *Alterbidinium* Lentin & Williams emend. Fensome et al.: 24.

+Alterbidinium acutulum (Wilson, 1967b) Lentin & Williams, 1985. Emendation: Khowaja-Ateequzzaman et al., 1991, p. 41, 42.

Description: "Test narrow, bi-layered. comprising smooth outer cyst tapering at poles, and small inner cyst. Apical horn long (*l* = 22–32 μ), bluntly terminated. Right antapical horn long (*l* = 14–36 μ), pointed. Left antapical horn absent, but position represented by minor angularity in margin of outer cyst. Archeopyle long, narrow, intercalary, situated on dorsal epitheca; operculum hinged to shell by posterior margin. Spiral transverse girdle represented by a folding of outer cyst." — Wilson (1967b, p. 225, 226)

Dimensions: "Holotype: *l* = 83 μ, *b* = 44 μ, inner cyst 44 × 36 μ. Two other measured specimens: SM 621: *l* = 116 μ, *b* = 47 μ. Inner cyst 47 × 39 μ; SM 602: *l* = 94 μ, *b* = 50 μ, inner cyst 44 × 41 μ." — Wilson (1967b, p. 226)

Remarks and affinities: "The species is uncommon, six specimens only having been observed. *D. acutula* shares certain features with several Antarctic species of *Deflandrea* described recently by the author (Wilson, 1967). In particular, the archeopyle resembles that of *D. asymmetrica* and *D. distincta*, although it is much narrower. All three species possess a narrow flat-tipped apical horn. *D. acutula* is distinguished from the two Antarctic species by its different shell outline, greater development of the right antapical horn, and the absence of a left antapical horn." — Wilson (1967b, p. 226)

Emended diagnosis: "Cyst proximate, dorsoventrally compressed, circumcavate; pericyst ambitus pentagonal with an apical and two symmetrically placed unequal antapical horns, right antapical horn reduced; periphragm thin, smooth, endocyst subpentagonal, endophragm thicker than periphragm, smooth, periparacingulum present, annulate; paratabulation indicated by archaeopyle and periparacingulum only; archaeopyle intercalary, independently developed on periphragm and endophragm; periarchaeopyle hexa 2a, iso-deltaform, perioperculum adnate; endoarchaeopyle hexa 2a, eury-deltaform, endoperculum acinate." — Khowaja-Ateequzzaman et al. (1991, p. 43)

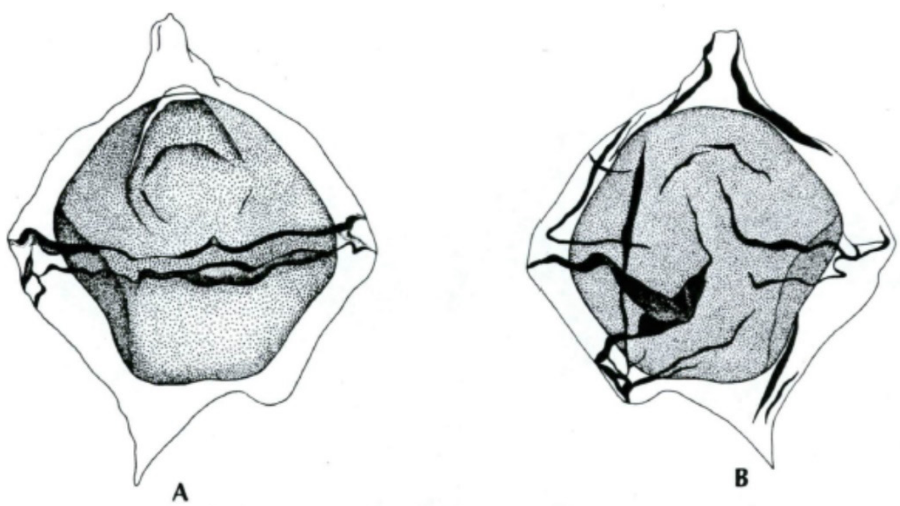
Description: "Shape: Cyst proximate, dorso-ventrally compressed; pericyst ambitus pentagonal with a broad-based apical horn and two symmetrically placed unequal antapical horns, right antapical horn reduced; endocyst subpentagonal. Wall relationship: Apical and antapical pericoels connected through ambital pericoel (circumcavate); endocyst shifted more towards dorsal side where the periphragm and endophragm are appressed in precingular and postcingular areas. Wall features: No parasutural features; periphragm and endophragm thin but endophragm thicker than periphragm; periparacingulum, annulate running high over endocyst, marked by two parallel ridges and a furrow in between; periparasulcus marked by a depression. Paratabulation: indicated by archaeopyle and periparacingulum only. Archaeopyle: Intercalary, independently developed on periphragm and endophragm; periarchaeopyle hexa 2a, iso-deltaform, perioperculum adnate (adnation along adcingular margin); endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate (adnation along adcingular margin)." — Khowaja-Ateequzzaman et al. (1991, p. 41, 42)

Dimensions: "Holotype: Pericyst: 66 × 55 μm, range: 62–70 × 52–57 μm. Endocyst: 42 × 42 μm, 40–45 × 38–42 μm. Periarchaeopyle Transverse Archaeopyle Index (TAl) 0.40, Longitudinal Archaeopyle Index (IAI) 0.66, Archaeopyle Ratio (AR) l.0, Archaeopyle Signum (AS) 3.6; Endoarchaeopyle Transverse

Archaeopyle Index (TAl) 0.35, Longitudinal Archaeopyle Index (IAI) 0.29, Archaeopyle Ratio (AR) l.7, Archaeopyle Signum (AS) 1.5." — Khowaja-Ateequzzaman et al. (1991, p. 42)

Remarks: "The emendation of the species is based on the study of the specimens recovered from Trichinopoly Formation, Cauvery Basin, India and on the face value of the holotype specimen documented by Wilson (1967) and the specimens illustrated by Vozzhennikova (1967) for *Albertia recticornis* Wilson (1967, p. 225) is of the opinion that the right antapical horn is long and the left antapical horn is absent, but its position is marked by a minor angularity on the margin of the pericyst. Wilson (personal communication, 7 May, 1990) now considers that the right antapical horn is reduced following the currently accepted procedure to determine the left and right antapical horns.
Recently, Harker and Sarjeant (In: Harker et al., 1990; p. 103, 104) awarded individual status to *Alterbidinium recticornis* and *A. acutulum* on a very imprecise ground that the attenuated hexagonal peripyle is 'narrower' in the latter. Further, the 'narrower' peripyle is not supported by any comparative dimensions met within the holotypes of these two species and the specimens of *A. acutulum* studied by them. This could be a case of size variation within the species and therefore their proposal is not acceptable." — Khowaja-Ateequzzaman et al. (1991, p. 42)

Age: ?Teurian (Paleocene); holotype of Wilson (1967b, p. 225) later designated as ?Maastrichtian by Wilson (1972, p. 184).



Text-figure 4A, B, Khowaja-Ateequzzaman et al. (1991).

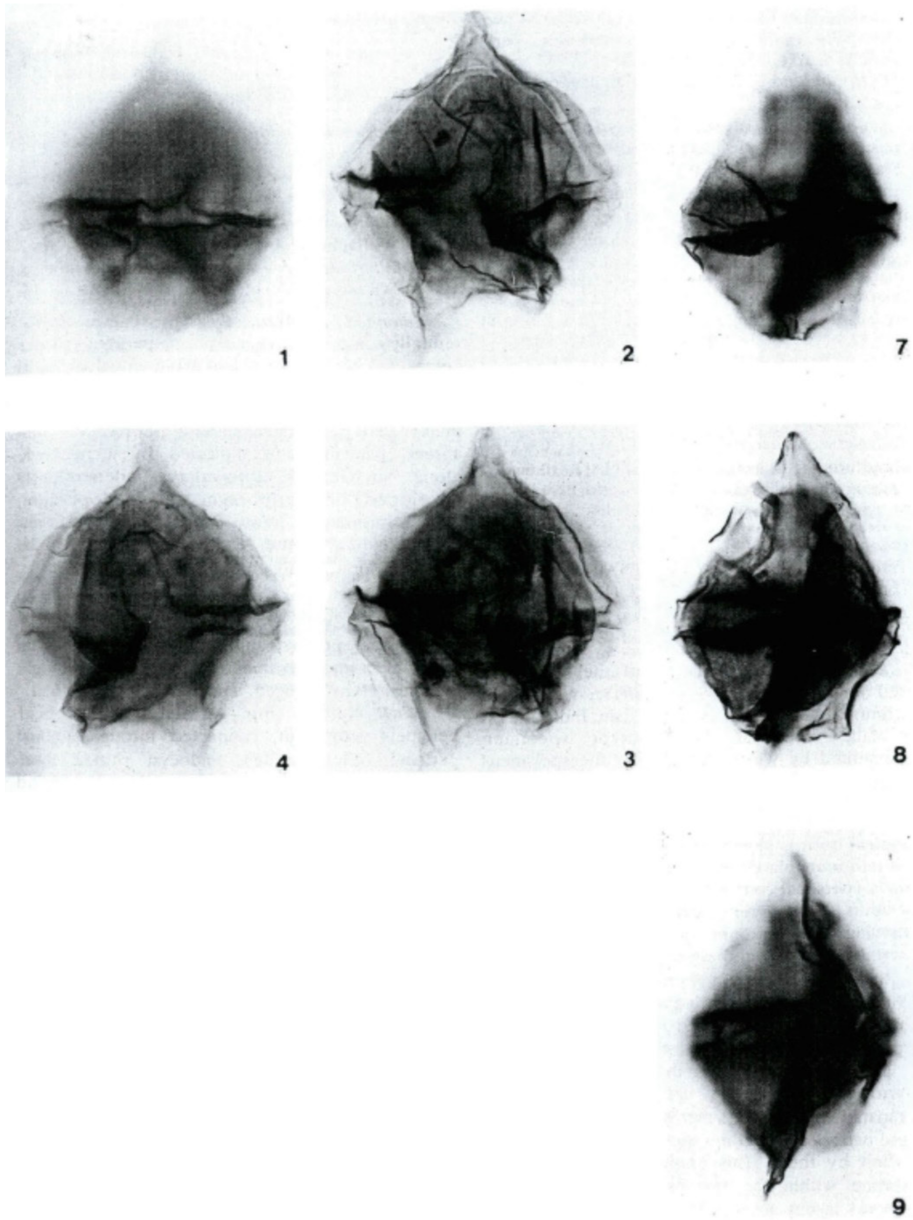
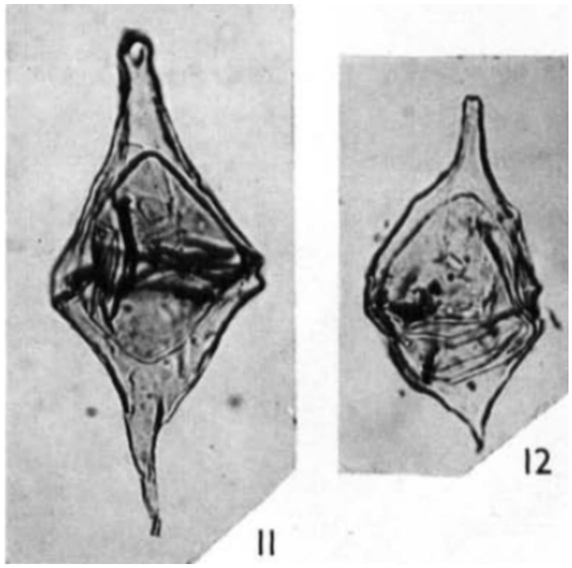


Plate 2, figures 1–4, 7–9, Khowaja-Ateequzzaman et al. (1991).



Figures 11, 12, Wilson (1967b).

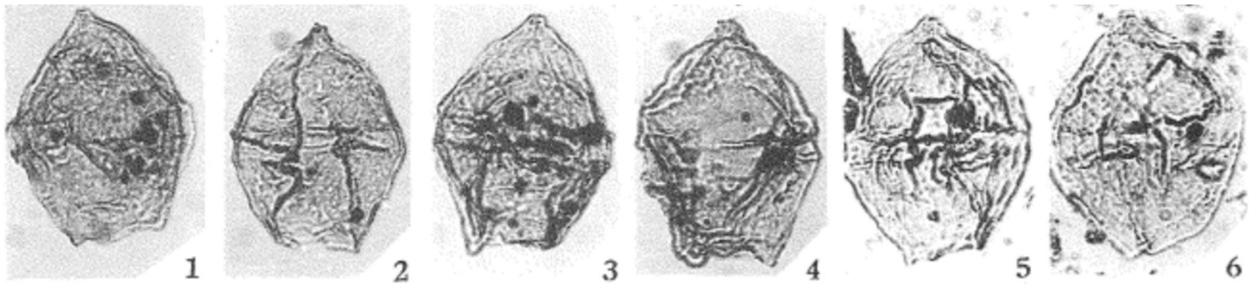
Alterbidinium ambiguum (He Chengquan, 1991) Lentin & Williams, 1993

Description: “It is said that the venter and back of the cyst are flat, and the outline of the outer wall is elongated and pentagonal, which is divided into two parts of nearly equal size by transverse grooves. Epitheca round. Conical, sides straight to slightly convex, with a short apical angle, nipple-shaped, usually concave at the apex, hypotheca inverted trapezoidal, with different caudal angles. Degree of horn development, one of which is more obvious, blunt conical, 3–4.5 μm long, the other convex or broad, rounded. Transverse groove equatorial, flattened, ring-shaped, 6–7.5 μm wide, with thin ridges on the edges, often with granules on the ridges. The longitudinal groove is limited to the lower cyst, sometimes lacking. The surface of the outer wall is fine-grained; some granules are slightly negative on the contour line, and some specimens have more developed local granules, sticking out of the contour line. The inner body is subovoidal in outline, usually indistinct (due to erosion), and perhaps cuffed; it is widely separated from the outer wall. When the archeopyle existed, it was trapezoidal, the height was greater than the width, and there was a front part reflecting the plate. The movement of the film is related. The flap is kept in place.” — Translated from He Chengquan (1991, p. 72, 73).

Dimensions: “The cyst length is 56–62 μm, the width is 45–47.5 μm, the inner body is 38–42 μm long, and the width is about 36 μm (6 specimens measured); the holotype is 60 μm long and 45 μm wide, the inner body is 38 μm long and 35 μm wide, the transverse groove is 7.5 μm wide, and the antapical horn is about 4 μm long.” — Translated from He Chengquan (1991, p. 73).

Discussion: “The inner body of such specimens is often obscure, so that it is quite difficult to affirm or deny its attribution. This may be related to the thin wall and corrosion of the inner body. On better preserved specimens (such as the holotype), the endosomes are clearer. This new species is similar to *Alterbia psilata* (Yu et Zhang) comb. nov. (Yu Jingxian et al., 1980, p. 108, plate 2, figure 19), but the inner body of the latter is obviously elongated.” — Translated from He Chengquan (1991, p. 73).

Age: Late Cretaceous (early Turonian); holotype from lower Wuyitake Formation translated from He Chengquan (1991, p. 226). Based on the range chart and translated from “top of the Kukebai Formation to bottom of the Wuyitake Formation” from He Chengquan (1991, p. 16, 226, fig. 4) and the corresponding age of the upper Kukebai and lower Wuyitake formations given as early Turonian by Mingzhen Zhang et al. (2022, fig. 2), which interestingly did not reference He Chengquan (1991) or report the presence of any deflandreoid species in its survey of dinocyst taxa.



Plates 29, figures 1–6, He Chengquan (1991).

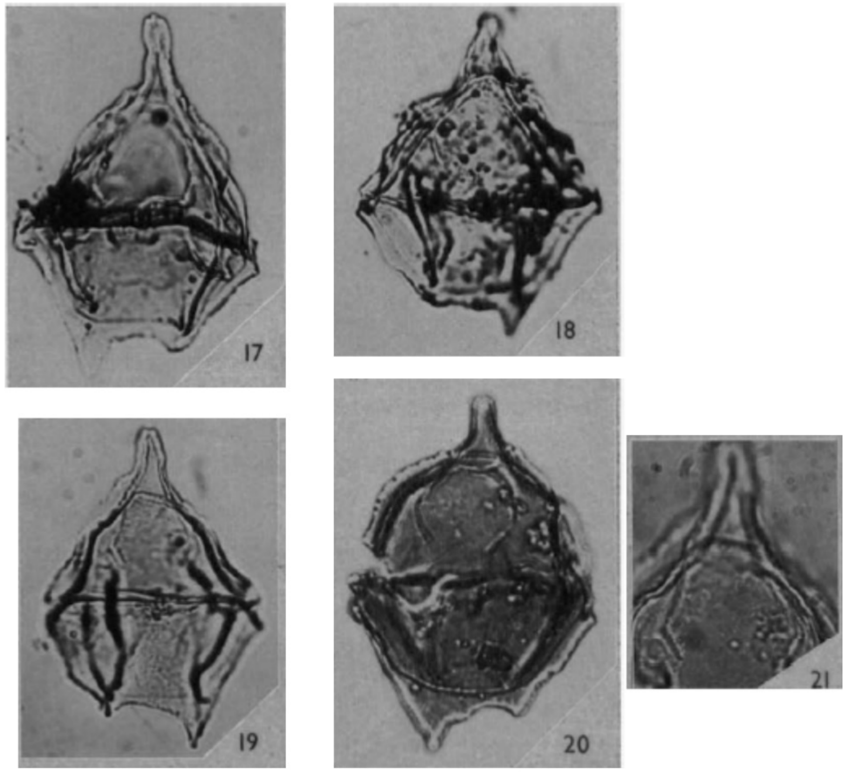
Alterbidinium asymmetricum (Wilson, 1967a) Levy & Harwood, 2000

Description: "Test bi-layered, dorso-ventrally flattened, angular, bilaterally asymmetric; margin often finely serrated in part. Inner layer differentiated into thin-walled smooth inner cyst of sub-angular or subcircular outline. Outer cyst smooth with very distinctive smooth keel-like folds or ridges roughly parallel to the test margin on both dorsal and ventral epithecae; a further two ridges, more centrally located, extend on the ventral surface from each antapical horn to the transverse girdle; a depressed area between the two ridges indicates a large longitudinal furrow. Spiral transverse girdle represented by a low smooth or finely serrated ridge on the dorsal surface. Apical horn relatively long (l = 14–22 μm), rectangular, blunt-ended; right antapical horn prominent, pointed (l = 7–12 μm); left antapical horn very small (l = 2–4 μm). Archeopyle sub-hexagonal or hoof-shaped, intercalary, located on dorsal epitheca. Operculum hinged to test by posterior margin (Fig. 21). Atabulate." — Wilson (1967a, p. 63).

Dimensions: "Holotype 1 = 80 μm, b = 55 μm, dimensions of inner cyst (50 × 47) μm. Range l = 50(84)99 μm. b = 43(58)66 μm (9 specimens)." — Wilson (1967a, p. 63).

Discussion: "*Deflandrea asymmetrica* belongs to the group of asymmetric *Deflandrea* species possessing hinged archeopyle opercula. There is some similarity to *D. ventriosa* Alberti (Alberti. 1959). However. The surface ornamentation differs. A comparison of *Deflandrea asymmetrica*, *D. macmurdoensis*, and *D. distincta* is given below (see under discussion of *D. distincta*). *D. asymmetrica* was recorded as *Deflandrea* spp. indet. in the preliminary species list of McIntyre and Wilson (1966. table 2). *Deflandrea asymmetrica* is fairly common in the Minna Bluff assemblage, though rare in all Black Island samples." — Wilson (1967a, p. 63).

Age: ?Eocene (erratic); holotype of Wilson (1967a, p. 58, 63).



Figures 17–21, Wilson (1967a).

Alterbidinium austrinum Roncaglia & Schiøler, 1999

Diagnosis: "Large, circumcavate, dorso-ventrally compressed, peridinioid cyst, with subpentagonal outline, and two lateral and two or three antapical horns. One or two projections/horns usually occur at the apex. The pericyst is thin-walled and smooth. The endocyst is located centrally, circular to subcircular in shape, smooth, and very thin-walled. The paracingulum is partially indicated on the lateral horns by short, transverse folds in the periphragm. The archeopyle is intercalary, type I(2a), steno- to iso-deltaform; the operculum is attached posteriorly. The paratabulation is indicated by paracingulum and archeopyle only." — Roncaglia & Schiøler (1999, p. 124)

Description: "Cyst large, circumcavate, dorso-ventrally compressed, subpentagonal in outline. The epicyst and hypocyst are approximately equal in size. The pericyst is smooth and thin-walled; it bears two lateral and two or three antapical horns. Usually, one or two apical projections occur on the pericyst. The length of the apical projections is highly variable (3–38.5 μm). When single, the apical projection consists of a long (15–38.5 μm) hollow subconical horn with rounded, truncate or involute tip (Fig. 3A, B, E); when two apical projections are present, they consist of short solid bulges (Fig. 3C, F). A wart-like 3 μm long apical structure surrounded by concentric rings occurs centrally between the bulges, on the ventral side of the cyst (Plate II, 5). In some specimens, the apex may be truncate, and apical projections absent; however, the wart-like apical structure is still present on these specimens (Fig. 3D; Plate I, 6). The left antapical horn is well developed, subconical, with acuminate, rounded or truncate termination; the right antapical horn is usually reduced in size and has a sharp to rounded termination. A third horn may occur between the left and right antapical horns, on the dorsal side of the cyst: it is shorter than the left antapical horn, hollow and with rounded or truncate termination (Fig. 3C; Plate II, 2, 4). The periphragm bears two lateral horns; they are hollow, subconical, distally rounded to truncate. Short transverse folds in the periphragm occur distally on the lateral horns. In the holotype and in a few more specimens, the left lateral horn terminates with a hook-shaped rounded tip. Generally, the left lateral horn is longer than the right [length range of the left lateral horn: 15 (24) 38 μm; length range of the right lateral horn: 11 (19) 34 μm]. A small number of specimens with only a single left lateral and left antapical horn were encountered in the studied population (Plate I, 7; Plate II, 3, 6). The endocyst is located centrally, and is circular to subcircular in shape; it is smooth and very thin-walled, usually barely visible (Fig. 3A–F). The paracingulum is indicated by the transverse folds in the periphragm on the two lateral horns. Generally, the parasulcus is not expressed; however, it may be indicated by an axial invagination on the lower ventral side of the periphragm. A steno- to iso-deltaform intercalary archeopyle, type I(2a), is usually present; archeopyle index: 0.34 (0.41) 0.46. The operculum is attached posteriorly. The paratabulation pattern is indicated by the paracingulum and archeopyle only." — Roncaglia & Schiøler (1999, p. 124, 125, 127)

<u>Dimensions</u>: "Pericyst (35 specimens measured); overall length: 125 (186) 250, holotype: 211; overall width: 95 (137) 182, holotype: 148. Endocyst (6 specimens measured), length: 49 (57) 68, holotype: 68; width: 49 (62) 76, holotype: 76." — Roncaglia & Schiøler (1999, p. 127)

<u>Discussion</u>: "*Alterbidinium austrinum* differs from *Alterbidinium*? *distinctum* (Wilson, 1967) Lentin et Williams, 1985 and *Alterbidinium dictyotum* Harker & Sarjeant in Harker et al. (1990) in being larger, in having two lateral horns, and in lacking clear indication of a parasulcus. It differs further from *A.*? *distinctum* in having a very thin, transparent endophragm, and from *A. dictyotum* in being circumcavate and in having a smooth periphragm. The new species differs from *Alterbidinium*? *pentaradiatum* (Cookson & Eisenack, 1965) Lentin & Williams, 1985 in having a smaller, thin-walled, and transparent endocyst, in having a reduced right antapical horn, and in lacking clear indication of a parasulcus. *Alterbidinium austrinum* resembles the informal taxon '*Alterbidinium* l*ongicornutum*' Roncaglia & Schiøler, 1997 (pl. 2, 1–3), in size and archeopyle shape, but differs in having a subpentagonal outline, in having a smaller, smooth-walled, transparent endocyst, and in possessing two or three antapical horns.

Alterbidinium austrinum resembles species of the genus *Satyrodinium* Lentin & Manum, 1986 in size, archeopyle shape and, occasionally, in the morphology of the apical and antapical areas. Some specimens of *A. austrinum* conform with the general diagnosis of *Satyrodinium* in having (1) an intercalary, type I(2a), iso-deltaform archeopyle, (2) a mid-apical wart-like structure between two apical bulges on the ventral surface (Fig. 3C, D, F; Plate I, 6–7; Plate II, 2, 3, 5), and (3) a median, reduced, third antapical horn developed between the two antapical horns (Fig. 3C; Plate II, 2, 4). However, the new species is readily distinguishable from the genus *Satyrodinium* in being circumcavate, in having a subpentagonal outline, in having two paracingular lateral horns, and in possessing clear indication of paracingulum. Furthermore, many specimens of *A. austrinum* have a single apical horn.

Alterbidinium austrinum resembles *Manumiella* n. sp. 2 of Askin (1988, fig. 9, 4–5) in size and archeopyle shape, but lacks the readily discernible endophragm that characterises the latter taxon. The new species differs from other species of the genus *Manumiella* in its subpentagonal outline, its two paracingular lateral horns, and its steno- to isodeltaform peri-archeopyle.

Despite the high morphologic variability observed in the apical, antapical and lateral regions of *A. austrinum*, its large size, its subpentagonal outline, and the very thin-walled endocyst, are invariable features that facilitate its identification. *Alterbidinium austrinum* is figured by Roncaglia & al. (1999, figs. 13.7 and 17.6) as 'dinocyst sp. 1'." — Roncaglia & Schiøler (1999, p. 127, 128)

<u>Age</u>: Late Cretaceous (middle–late Campanian); holotype of Roncaglia & Schiøler (1999, p. 124).

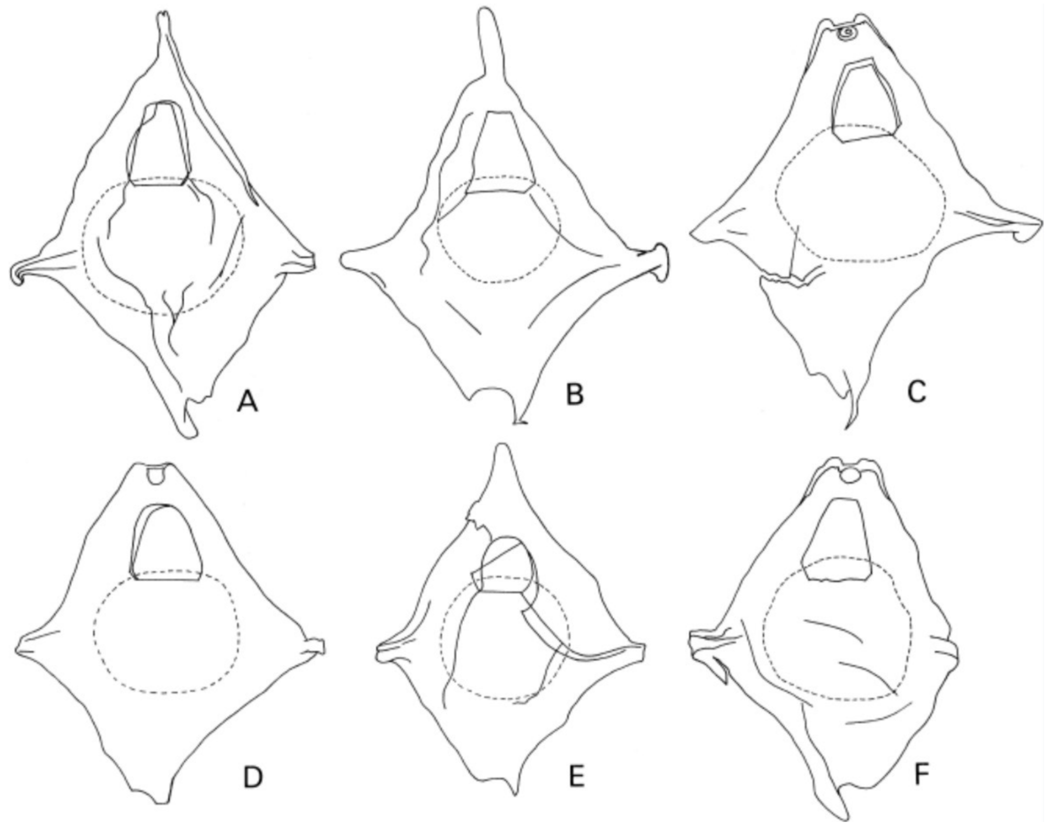


Figure 3A–F, Roncaglia & Schiøler (1999).

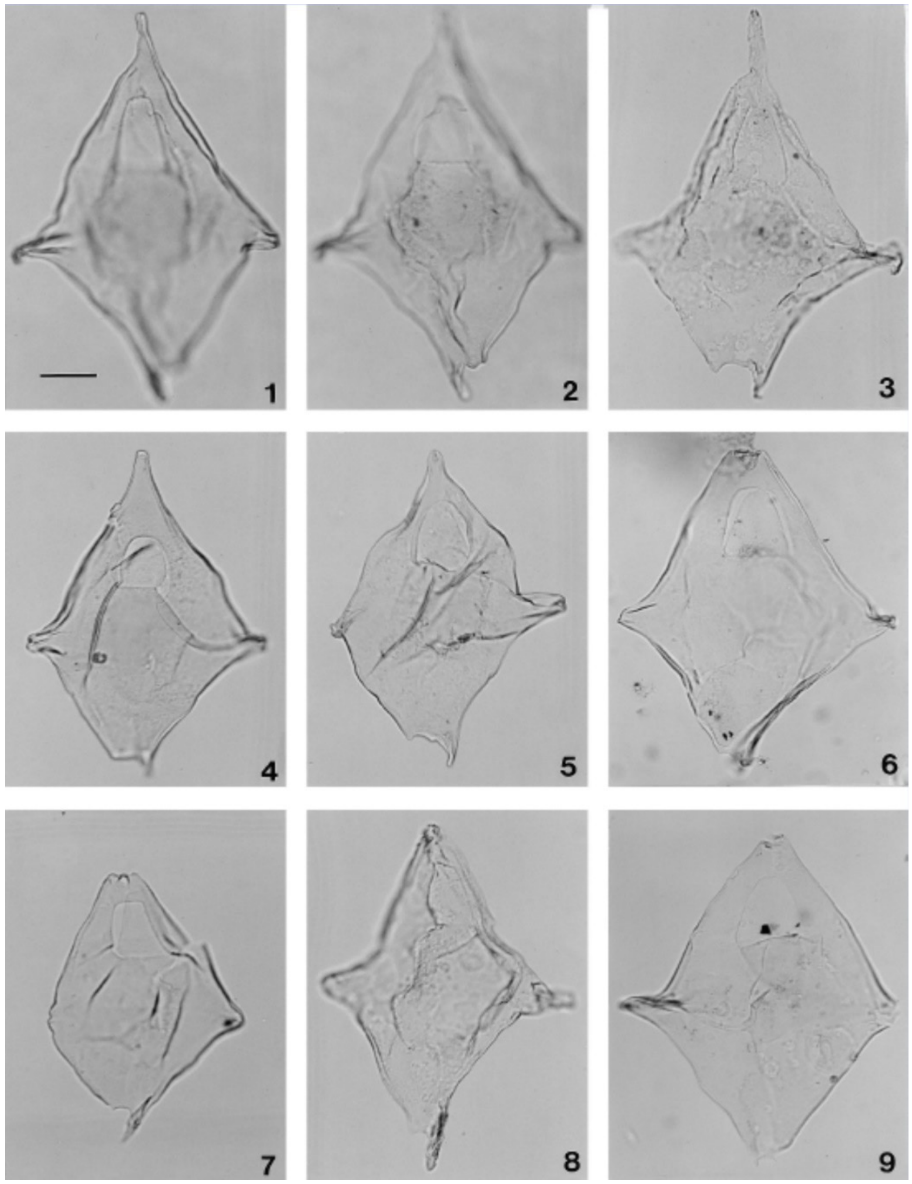


Plate 1, figures 1–9, Roncaglia & Schiøler (1999). Scale bar = 30 μm.

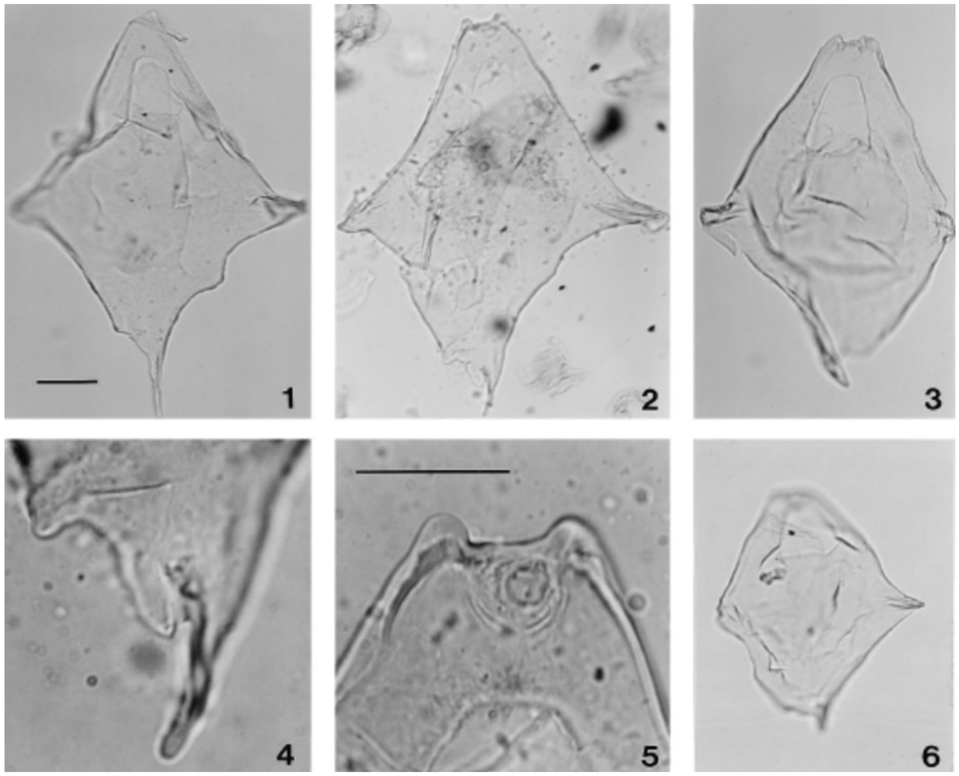


Plate 2, figures 1–6, Roncaglia & Schiøler (1999).
Figures 1–3, 6, scale bar = 30 µm; figures 4, 5, scale bar = 20 µm.

Alterbidinium bellulum (He Chengquan, 1991) Lentin & Williams, 1993

Description: "The venter and back of the cyst are flat, the outline is pentagonal, the sides are straight, and the length is slightly longer than the width. Divided into nearly equal or slightly larger by transverse grooves. Two parts of unequal size: upper cyst triangular, with a conical small apex, apex obtuse; lower cyst slightly larger, inverted trapezoidal, with two caudal angles being quite degraded, only one of them displays. The transverse groove is slightly inclined to the upper cyst, shallow flat, ring-shaped, about 8 µm wide, with fine grains on the edge. Granular ridges are marked. The longitudinal groove is unknown. The surface of the outer wall is finely granular. The inner body is elliptical in outline, the wall is thin and wrinkled on the surface. No significant ornamentation; wide separation between it and outer wall. The archeopyle is obvious, the front style. The operculum is detached." — Translated from He Chengquan (1991, p. 73).

Dimensions: "The length of the cyst is 62 µm and the width is 51 µm, and the length of the inner body is 45 µm and 37 µm." — Translated from He Chengquan (1991, p. 73).

Comparison: "Comparing this new species with a cyst that is not significantly elongated differs from *Alterbia ambigua* in that it is well-defined, five-sided. The shape (straight sides) is different from *A. ovalis*." — Translated from He Chengquan (1991, p. 73).

Age: Late Cretaceous (early Turonian); holotype from the lower Wuyitake Formation translated from He Chengquan (1991, p. 226). Range: Late Cretaceous (early Turonian)–early Oligocene. The early Turonian range base is derived from the range chart and translated from "Wuyitake Formation" from He Chengquan (1991, p. 16, 226, fig. 4) and the corresponding age of the Wuyitake Formation given as early Turonian by Mingzhen Zhang et al. (2022, fig. 2). The early Oligocene range top is based on the Translated from "upper part of the fourth member of Shahejie Formation" from He Chengquan (1991, p. 73) in light of the corresponding age of this interval given by Kashif et al. (2020, fig. 2).


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Plate 29, figure 12, He Chengquan (1991).

Alterbidium biaperturum (McIntyre, 1975) Fensome et al., 2016

Description: "Cyst cavate, dorsoventrally flattened, more or less spherical in dorsoventral view except for apical and antapical horns, and is divided into equal epitract and hypotract by a simple cingulum. Apical horn 10–30 µm long and usually rounded at the end. Left antapical horn 15–30 µm long, narrow, and pointed; right antapical horn normally appears only as an angular bulge. Cingulum about 7 µm wide and bordered on both edges by slightly raised irregular ridges. A large wide sulcus is present on the ventral surface. The large intercalary (2a) archeopyle is rounded hexagonal and the operculum is often attached at the posterior margin. There is no sign of an archeopyle in the endoblast. A large circular opening (antapical archeopyle?) is usually present in the periblast between the antapical horns (Pl. 3, fig. 5, 6). Endoblast large, spherical, normally not folded, and usually closely appressed to periblast laterally, especially in hypotract. Apical and antapical pericoels are present. Endophragm about l µm thick and finely scabrate to finely granulate, especially on anterior and posterior ends. Periphragm less than l µm thick and smooth to finely scabrate. It is often wrinkled and has a somewhat striate appearance (Pl. 3, fig. 7)." — McIntyre (1975, p. 66).

Dimensions: "Holotype, 136 µm long, 78 µm wide; endoblast, 60 µm long; range, 94–145 µm long, 60–92 µm wide; endoblast 41–78 µm long." — McIntyre (1975, p. 66).

Remarks: "*D. biapertura* is abundant in Division H3 in Section CR16B and is recorded as *D.* sp. 5 in McIntyre (1974). A similar form was illustrated by Wilson (1971) as *Deflandrea* aff. *sverdrupiana*. *D. biapertura* is similar to *D. sverdrupiana* in shape and also possesses a relatively large endoblast, but it is larger and lacks the tabulation features of *D. sverdrupiana*. *D. magna* Davey (1970) has a tapering epitract and less well-developed apical and antapical horns. Apparently, it also has a smooth endoblast, and the cyst is smaller than that of *D. biapertura*. There appear to be no other species of *Deflandrea* known that have the antapical opening typical of *D. biapertura*. An antapical opening with an attached operculum has been noted in *Ovoidinium ostium* by Davey (1970)." — McIntyre (1975, p. 66).

Age: Late Cretaceous (Maastrichtian); holotype of McIntyre (1975, p. 66). Range: Late Cretaceous (late Campanian–middle-upper Maastrichtian) (McIntyre, 1975, text-fig. 2).

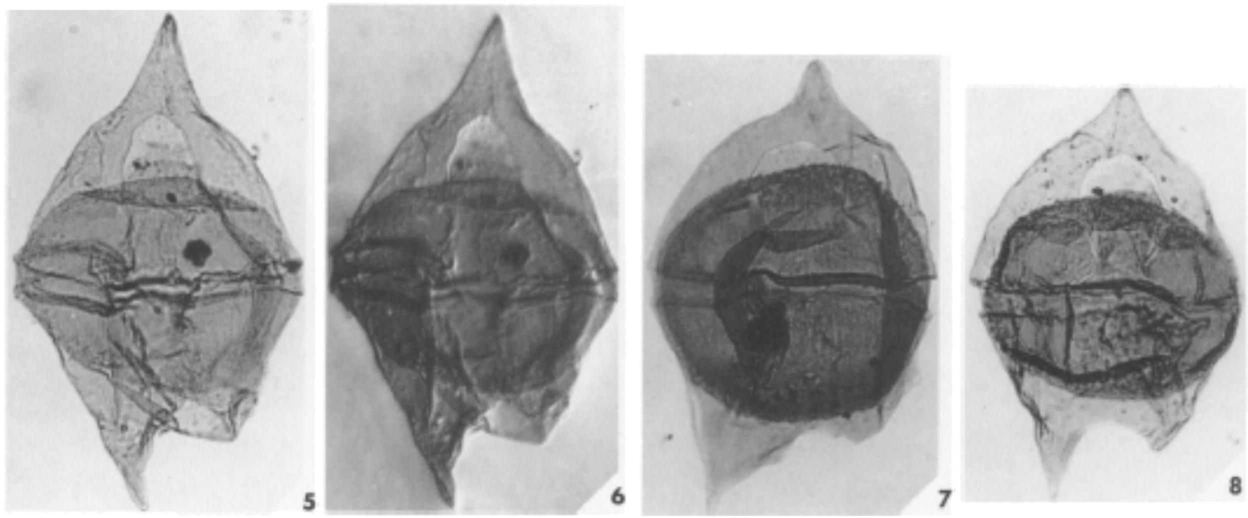


Plate 3, figures 5–8, McIntyre (1975).

?*Alterbidinium bicellulum* (Islam, 1983a) Lentin & Williams, 1985

Diagnosis: “Pericyst dorsoventrally compressed peridinioid with short, conical apical horn commonly having rounded tip, broadening proximally to merge to epipericyst ambitus, and two unequal antapical horns, the left broad-based and conical with pointed tip and more or less equal in length to the apical horn, the right reduced, with a rounded tip; endocyst subspherical and oblate; proximate and bicavate; both phragma thin, chagrinate and sometimes wrinkled; folds in periphragm always defining paracingulum, which may be slightly helicoidal and sunken; parasulcus sometimes indicated by slight depression; archeopyle intercalary type I/I with standard hexa style, operculum attached; epipericoel with or without communication to exterior.” — Islam (1983a, p. 336)

Dimensions: “Holotype: pericyst 54 × 47 μm, endocyst 36 × 46 μm, archeopyle index 0.49. Range: pericyst length 60(54)48 μm, breadth 54(49)43 μm; endocyst length 45(39)31 μm, breadth 53(47)42 μm; archeopyle index 0.60(0.53)0.49 (9 specimens). Specimens measured: 13.” — Islam (1983a, p. 336)

Remarks: “The generic assignment of the species is based on general morphology, but questioned because the epipericoel is not always communicative to the exterior, and its degree of cavation and the archeopyle index do not match those prescribed for the genus. The degree of cavation and the archeopyle index of this species also do not match those of other peridinioid genera that are differentiated on the basis of these features by Lentin and Williams (1976). These features serve to differentiate it from other species of the genus.

The problem was discussed by Stover and Evitt (1978) who met with ‘greatest difficulties’ in drawing generic limits of their Peridiniacean genera of Subcategory 3D which includes *Alterbia*. They also noted that species attributed to the genera of this subcategory ‘exhibit shades of difference and degree of morphologic overlap that leave many uncertainties [sic] about what criteria should be applied’. In view of these difficulties, tentative allocation of the species to *Alterbia* is preferred to creating a new genus to accommodate it.” — Islam (1983a, p. 336)

Age: middle Eocene; holotype of Islam (1983a, p. 336).

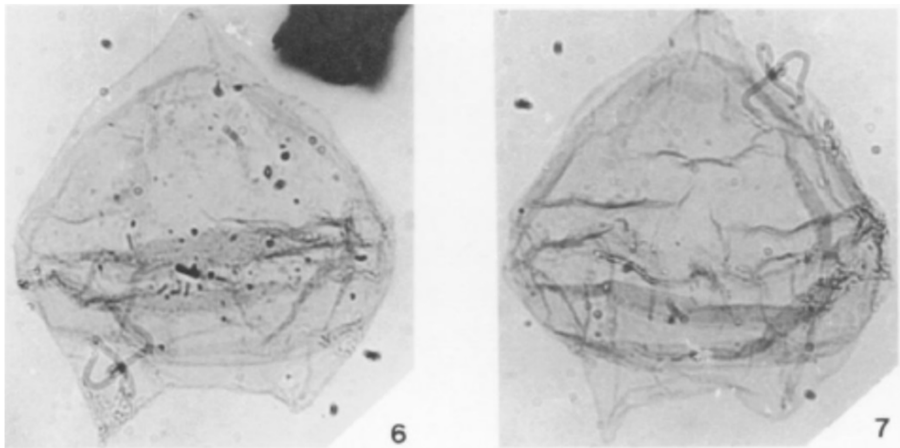


Plate 1, figures 6, 7, Islam (1983a).

Alterbidinium circulum (Heilmann-Clausen, 1985) Lentin & Williams, 1989

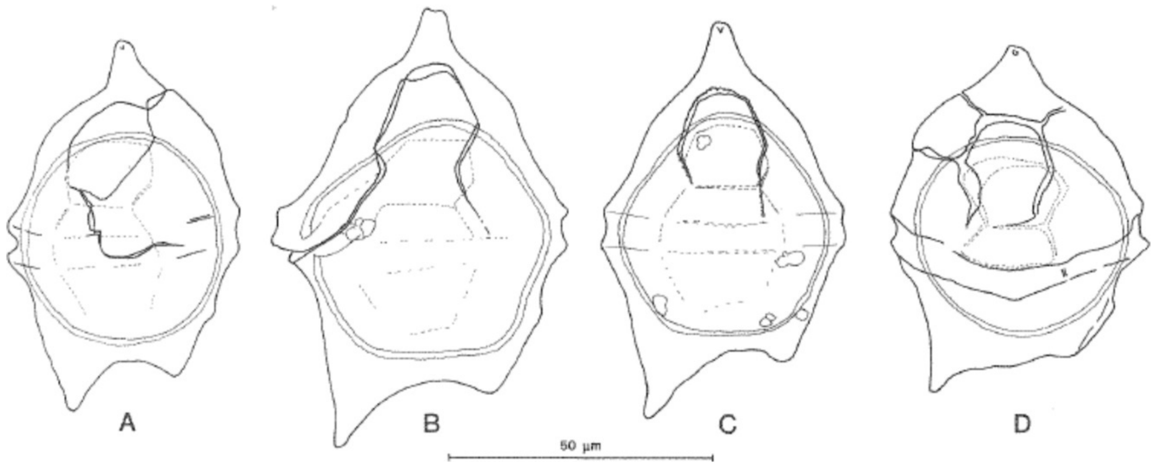
Diagnosis: “A species of *Alterbia* Lentin & Williams 1976, with the following specific characters: The cyst is circumcavate. The smooth pericyst has convex lateral margins of the epicyst. The right antapical horn is reduced, but not completely absent. The peri-archaeopyle is intercalary, or an intercalary-precingular combination type. The shape of paraplate 2a is steno to isodeltaform to thetaform. The endocyst is almost circular in ambitus and shows a faint paratabulation mid-dorsally. The endo-archaeopyle is intercalary. The endophragm is thicker than the periphragm.” — Heilmann-Clausen (1985, p. 16)

Description: “A circumcavate peridiniacean cyst. The pericyst is smooth-walled, and the outline is peridinioid. The epicyst has convex lateral margins, ‘shoulders’, and an apical horn of moderate length with a truncated apex. The left antapical horn is longer than the right one which may be almost absent. The paracingulum is clearly marked laterally by indentations of the periphragm, but otherwise is not expressed, or is only indicated by faint parasutural lines. The parasulcus is only indicated as an indentation of the ventral surface of the hypocyst. The peri-archaeopyle is intercalary or is an intercalary-precingular combination type. The variation of the archaeopyle includes the types Ia(2a) (fig. 5C, D), l(2a) (fig. 5A) and IPa(2a, 4'') (fig. 5B). The shape of plate 2a is steno to iso- deltaform to thetaform. The endocyst is thick-walled (about 1 µm) and finely granular, occasionally bearing a few large verrucae. The outline in dorsoventral view is almost perfectly circular to sub-pentagonal. Paratabulation is expressed mid-dorsally as a hex a I(2a) archaeopyle, and additionally as fine parasutural lines showing the paraplates 4'', 3c and 3''', or parts of these paraplates (fig. 5).” — Heilmann-Clausen (1985, p. 16, 17)

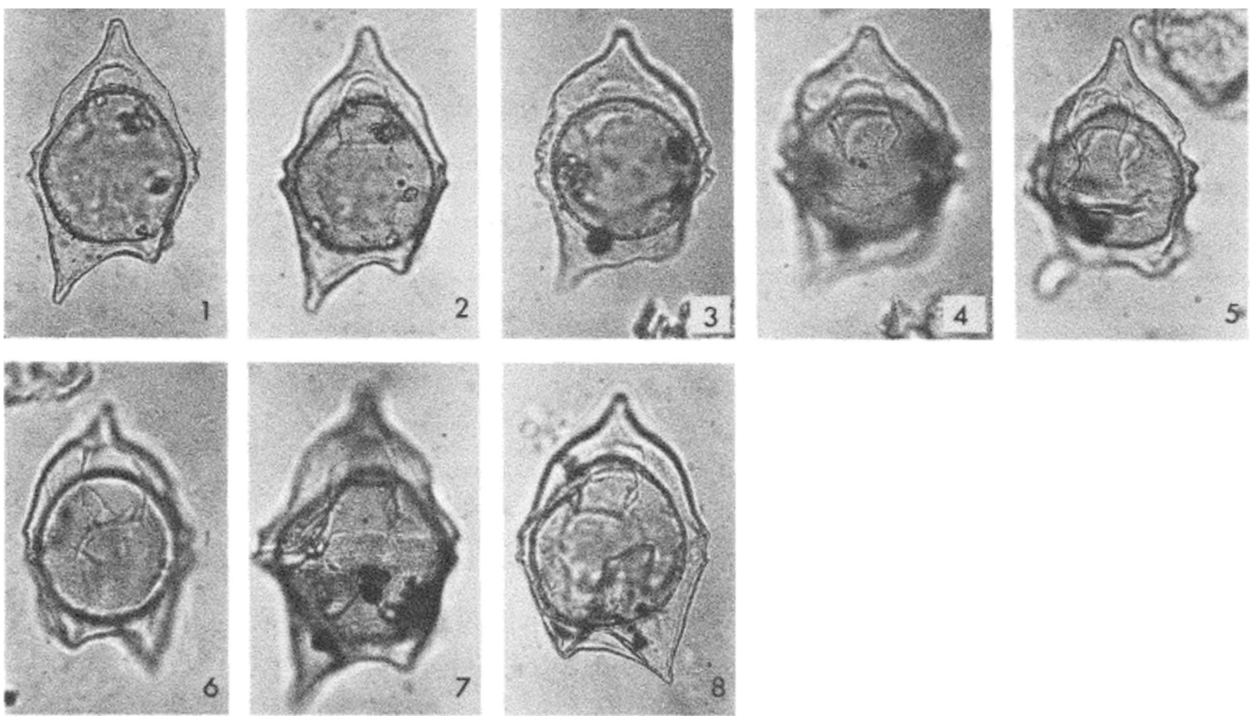
Dimensions: “Pericyst length, max., (mean), min.: 83, (73), 66 µm, width: 53, (46), 41 µm. Endocyst length: 46, (42), 37 µm, width: 45, (40), 35 µm. (10 specimens measured). Holotype: pericyst length 75 µm, width 46 µm; endocyst length 43 µm, width 40 µm.” — Heilmann-Clausen (1985, p. 17)

Remarks: *A. circula* bears some resemblance to, and may be a descendant of, *Alterbia acutula* (Wilson) Lentin & Williams 1976. *A. acutula* is widely distributed in Upper Cretaceous deposits. *A. circula* differs from *A. acutula* in the almost circular, partially tabulated endocyst, in having ‘shoulders’ and a shorter apical horn. The right antapical horn is better developed in *A. circula* and the shape of the second intercalary tends to be more thetaform whereas it is distinctly deltaform in *A. acutula*.” — Heilmann-Clausen (1985, p. 17)

Age: early Paleocene (Danian); holotype of Heilmann-Clausen (1985, p. 17). Range: early-?middle Paleocene (Danian–?Selandian, re-worked?) (Heilmann-Clausen, 1985, p. 17).



Text-figure 5A–D, Heilmann-Clausen (1985).



Plates 1, figures 1–8, Heilmann-Clausen (1985).

Alterbidinium compactum (Vasilyeva in Andreeva-Grigorovich et al., 2011) Williams & Fensome, 2016

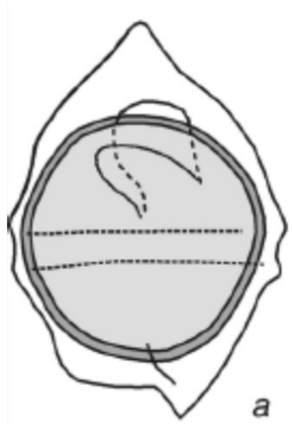
Diagnosis. “Peridinioid circumcavate oval-pentagonal small-sized cyst. Apical horn weakly prominent, sharpened. Left antapical horn well developed, right one almost reduced. Endocyst round. Periphragm thin, transparent. Endophragm quite dense, thin, smooth or weakly scabrate. Periarcheopyle wide, hexagonal, intercalary. Perioperculum attached. Paracingulum distinct, prominent. Parasulcus indistinguishable.” — Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 40)

Description: “Pericyst oval-pentagonal. Epicyst greater than or equal to hypocyst. The ‘shoulders’ are smoothly rounded. Apical horn protrudes slightly; the top of it is retracted and pointed. Hypocyst trapezoidal, asymmetric; the sides are smoothly tapering. Left (usually) antapical horn well developed, pointed, right practically reduced or slightly protruding, rounded. Endocyst coarse, usually round, less often wide. The periphragm is thin, transparent, dense, smooth. Endophragm dense, smooth or indistinct bulging, slightly thicker and darker than the periphragm. On the endophragm commonly encountered inclusion of an organic material in the form of large grains and bumps. The ambitus is well defined, sometimes narrowing asymmetrically in the area of cingulum on one side of the cyst. Epitheca and hypotheca expands slightly. Periarcheopyle round-hexagonal, intercalary type (plates 1a or 2a). Attached is the periphragm. Paracingulum clear, protruding in the form of a fairly wide range furrow, indicated by a fold (sometimes double) on the periphragm. Parasulcus is indistinguishable.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 40, 41)

Dimensions: “(μm). Holotype: pericyst length, 61; pericyst width, 53; endocyst diameter, 48. Other specimens (3 specimens): pericyst length, 62–55; pericyst width, 53–50; endocyst diameter, 49–48.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 41)

Comparisons: “Comparable with the species *Alterbidinium rugulum*, but significantly smaller in size; characterized by a smooth periphragm, less distinguished cingulum, structure of antapical horns, and has another stratigraphic distribution.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 41, 42)

Age: early-middle Paleocene (Danian–Selandian); holotype as translated from Andreeva-Grigorovich et al. (2011, p. 100, text-fig. 18a, pl. 11, fig. 1) by subsequent designation of Williams & Fensome (2016, p. 138). How Williams & Fensome (2016, p. 138) were able to make the distinction of Selandian is unclear when the series of figured specimens (Andreeva-Grigorovich et al. (2011, text-fig. 18a, pl. 11, fig. 1–4) are attributed to the Danian–Selandian interval. Range: early-middle Paleocene (Danian–Selandian) based on the translation from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 41, 100).



Text-figure 18a, Vasilyeva in Andreeva-Grigorovich et al. (2011).

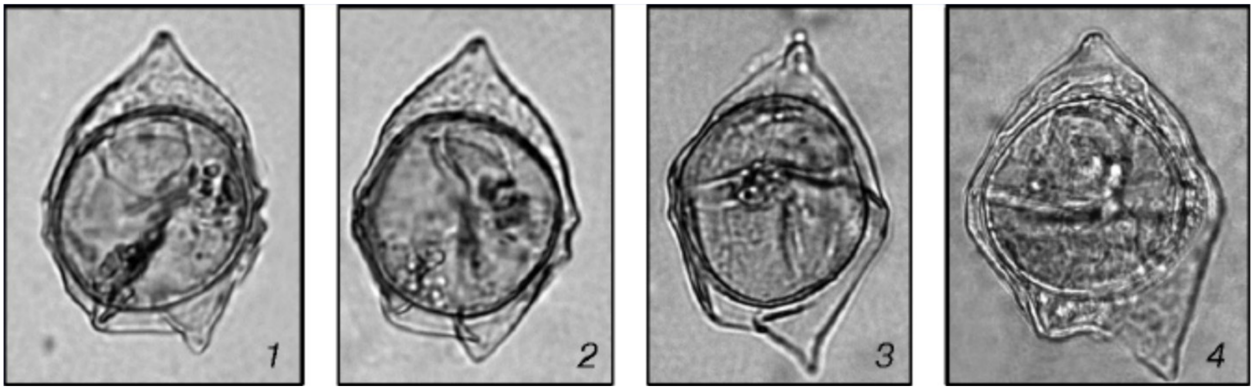


Plate 11, figures 1–4, Vasilyeva in Andreeva-Grigorovich et al. (2011).

Alterbidinium dictyotum Harker & Sarjeant in Harker et al., 1990

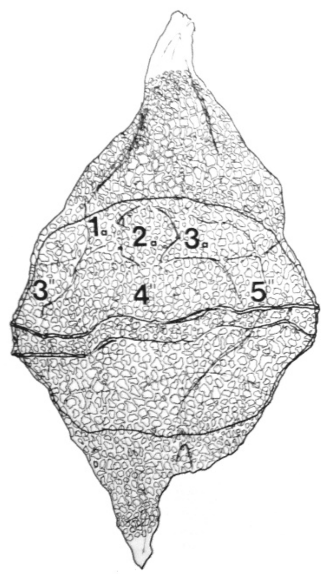
Diagnosis: "Bicavate cysts having a subpentagonal ambitus. Apical pericoel larger than antapical; ambital pericoel meagerly developed or lacking. Periblast thin-walled, reticulate, prolonged into a single long, tapering apical horn and two unequal antapical horns (a long tapering left and a very short, rounded right horn). Greatest width in the cingular region; epitract slightly larger than hypotract. Endoblast ovoidal, thin-walled, smooth to finely granular, breadth slightly greater than length. A narrow, slightly laevorotatory cingulum is indicated by low, narrow thickenings of the periphragm; very low, dorsal parasutural crests (delimiting paraplates 1a, 2a, 3a, 3'', 4'', 5'') are developed on the epitracts of some specimens. Peripyle intercalary (I, 2a), standard hexagonal shape, the operculum usually remining in place." — Harker & Sarjeant in Harker et al. (1990, p. 105)

Description: "The reticulation of the periphragm is the most distinctive feature of this species; it is present all over the periblast except on the distal two-thirds of the apical horn and the distal one-third of the left antapical horn, where the periphragm is laevigate. The lumina are rounded to polygonal, 0.5–2.0 µm in diameter; the muri are 0.2–0.5 µm wide, 0.2 µm high. Both endophragm and periphragm are thin (less than 0.5 µm) and specimens do not take stain readily. The tapering apical horn has a blunt or indented distal termination. The left antapical horn is sharply conical, though frequently folded against the main body of the cyst (Pl. 8, fig. 3), whereas the right is merely a small, rounded outbulge. The endoblast is generally ovoidal in shape, though sometimes developing slight protuberances at apes and antapex. Parasutural ridges are best developed on the dorsal surface of the epitract, but can be seen clearly only in scanning electron microscope examination (Pl. 8, fig. 2); they consist of low, narrow thickenings of the periphragm outlining the dorsal intercalary and precingular paraplates (1a, 2a, 3a, 3'', 4'', 5''). The cingulum is well defined by two low, parallel ridges; it is only slightly laevorotatory, sulcal displacement being less than half the cingulum's width. The peripyle is formed by opening of the second anterior intercalary paraplate (2a), which usually remains in place and indeed is markedly displaced in only one specimen discovered (Pl. 8, fig. 4)." — Harker & Sarjeant in Harker et al. (1990, p. 105)

Remarks: "*A. dictyotum* is similar in general features to *Alterbidinium*? *distinctum* (Wilson 1967a) Lentin & Williams 1985, but differs from it, and from all other species of *Alterbidinium,* in having a reticulate periphragm." — Harker & Sarjeant in Harker et al. (1990, p. 105)

Dimensions: "Holotype: overall length 111 µm, breadth 68 µm, endoblast length 52 µm, breadth 61 µm, length of apical horn 12 µm, left antapical horn 19 µm, right antapical horn 1 µm, cingulum width 5 µm, transverse peripyle index 0.36, transverse peripyle ratio 0.56. Range of 53 measurable specimens: periblast length 55–111 µm, mean 84 µm; breadth 32–69 µm, mean 58 µm; endoblast length 35–52 µm, mean 44 µm; breadth 33–65 µm, mean 54 µm; length of apical horn 9–12 µm, mean 10 µm; left antapical horn 5–19 µm, mean 12; right antapical horn 0.5–5 µm, mean 2 µm; cingulum width 4–7 µm, mean 6 µm; transverse peripyle index 0.26–0.48, mean 0.37; transverse peripyle ratio 0.36–0.93, mean 0.58. 91 specimens were counted." — Harker & Sarjeant in Harker et al. (1990, p. 106)

Age: Late Cretaceous (early Campanian); holotype of Harker & Sarjeant in Harker et al. (1990, p. 105; text fig. 26) as correlated with the zones M2 and M3 corresponding to the Pembina Member of the Pierre Formation (Harker & Sarjeant in Harker et al., 1990, text-fig. 30). Range: Late Cretaceous (early Campanian) (Harker & Sarjeant in Harker et al., 1990, text-fig. 26).



Text-figure 21, Harker et al. (1990).

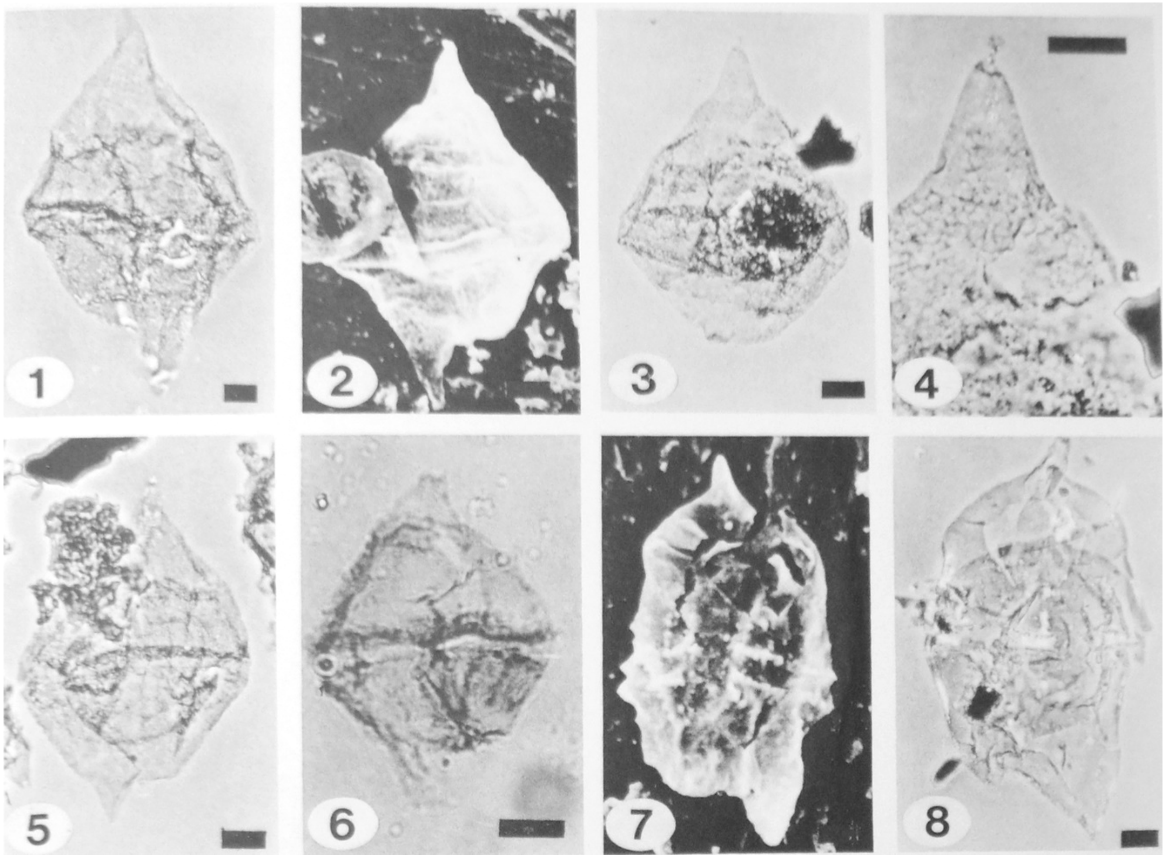


Plate 8, figures 1–5, Harker et al. (1990). Scale bars = 10 μm.

?*Alterbidinium distinctum* (Wilson, 1967a) Lentin & Williams, 1985

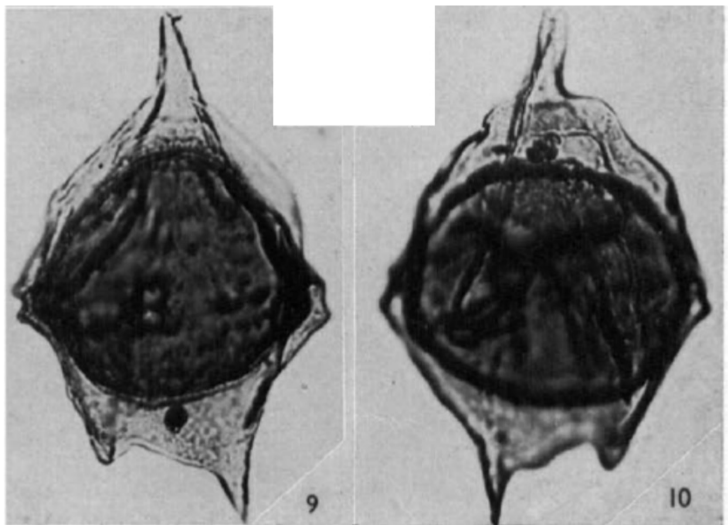
Description: "Test bi-layered, dorso-ventrally flattened, elongate, bilaterally asymmetric. Inner layer radially contracted forming fairly thick-walled, dense, smooth, circular internal cyst. Outer layer conspicuously folded, especially on the ventral surface; the linear folds extend from the apex to each antapical horn; surface of outer cyst finely granulate and epithecal margin forms membranous shoulder-like flange. Prominent blunt-ended apical horn wide at base and narrow at top (l = 27–33 μm) and well developed pointed right antapical horn (l = 16–20 μm); left antapical horn small (l = 5–8 μm). Laevorotatory transverse girdle present. Depressed area between longitudinal folds on ventral hypotheca indicative of longitudinal furrow. Archeopyle more or less trapezium-shaped, intercalary, dorsal; operculum fixed by posterior margin to shell. Atabulate." — Wilson (1967a, p. 63, 64)

Dimensions: "Holotype l = 118 μ, b = 61 μ, dimensions of inner cyst (58 × 63) μ. Range l = 96(106)118 μ, b = 58(64)77 μ (7 specimens)." — Wilson (1967a, p. 64)

Discussion: "*Deflandrea distincta* shares certain features with *D. macmurdoensis* and *D. asymmetrica*, especially the pronounced bilateral asymmetry, the blunt apical horn, and the unusual type of archeopyle. However, in *Deflandrea macmurdoensis* the surface of the outer cyst is adorned with spines or spiny ridges, whereas the only forms of ornamentation of the other two species are the conspicuous folds, especially prominent on the ventral surface. *D. distincta* differs from *D. asymmetrica* in having a much larger outer cyst, relatively narrower and more pointed horns, finely granulate sculpturing, more angular archeopyle and a relatively smaller and thicker-walled inner cyst. The species was recorded as *Deflandrea* aff. *pirnaensis* in the preliminary species list of McIntyre and Wilson (1966, table 2).

A somewhat similar type of archeopyle has been illustrated by Evitt in an unnamed species of *Deflandrea* (Evitt 1961, plates 1 and 2, figs. 1–4). *D. distincta* is fairly abundant in the Minna Bluff material, but does not occur in any of the Black Island samples." — Wilson (1967a, p. 64)

Age: early Tertiary (erratic); holotype of Wilson (1967a, p. 63).



Figures 9, 10, Wilson (1967a).

?*Alterbidinium earnleyense* (Islam, 1983a) Lentin & Williams, 1985

Diagnosis: "Pericyst dorsoventrally compressed peridinioid with short, conical apical horn having pointed or rounded tip, broadening proximally to merge with epipericyst ambitus, and only left antapical horn which is similarly conical, broad-based and equally long with pointed or rounded tip; right antapical horn, if present, vestigial; endocyst oblate and subspherical; both phragma thin and chagrinate, sometimes wrinkled; proximate and cornucavate to narrowly bicavate; folding in periphragm always defining paracingulum, which is slightly helicoidal and sometimes sunken; parasulcus sometimes indicated by slight depression; archeopyle intercalary type I/I with standard hexa style, operculum attached or free; epipericoel may or may not be in communication to exterior. " — Islam (1983a, p. 336)

Dimensions: "Holotype: pericyst 54 × 44 µm, endocyst 37 × 43 µm, archeopyle index 0.51. Range: pericyst length 58(53)49 µm, breadth 52(48)44 µm; endocyst length 48(39)31 µm, breadth 51(47)43 µm; archeopyle index 0.59(0.52)0.49 (5 specimens). Specimens measured: 11." — Islam (1983a, p. 336)

Remarks: "The remarks made on the generic assignment of ?*A. bicellula* n. sp. are also relevant to this species. The holotype of ?*A. earnleyense* n. sp. (pl. 1, fig. 10) vaguely indicates the presence of accessory sutures adjacent to the archeopyle, implying possible involvement of other adjacent paraplates in archeopyle formation. But this could not be conclusively determined, as most of the specimens did not indicate an archeopyle.

?*Alterbia earnleyense* n. sp. differs from ?*A. bicellula* n. sp. in possessing one antapical horn. This distinction may possibly be argued to be infraspecific, but the two species are distinguished because of their relative stratigraphic significance. ?*Alterbia earnleyense* n. sp. is stratigraphically younger." — Islam (1983a, p. 336)

Age: middle Eocene; holotype of Islam (1983a, p. 336).

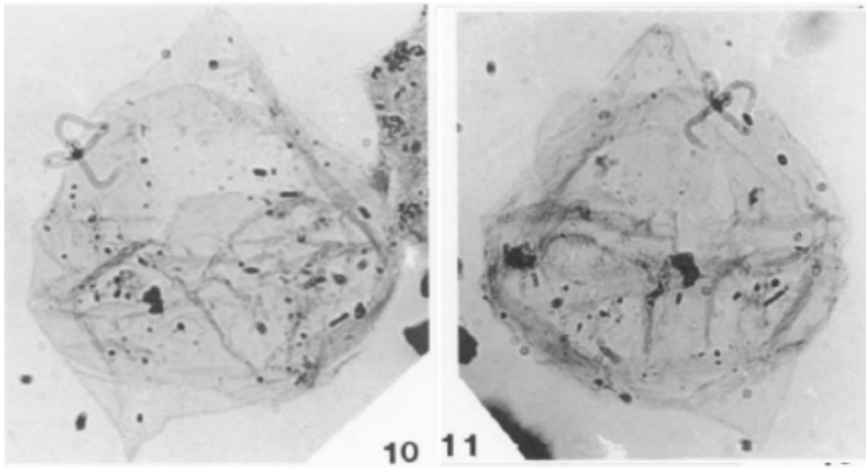


Plate 1, figures 10, 11, Islam (1983a).

Alterbidinium ellentonense Lucas-Clark, 2006

Diagnosis: "Medium sized pale peridinioid. Bicavate or apically cavate in the epicyst and cornucavate in the hypocyst. Distinguished by pronounced apical cavation and variable archeopyle. Ovoidal in shape with unequal antapical horns. Archeopyle either 2a with sutures around 4" or combination of 2a and 4". Tabulation shown only by archeopyle and weak folds indicating the cingulum." — Lucas-Clark (2006, p. 189)

Description: "Medium size, proximate peridiniacean cysts, bicavate or cornucavate in the hypocyst and apically cavate in the epicyst, with a short, wide apical horn and two short antapical horns. Left antapical horn longer and better developed than right, which is greatly reduced. Endocyst ovoidal to pear-shaped in outline; endophragm smooth, about equal in thickness to periphragm, the two walls appressed around the archeopyle and the cingulum, and on the hypocyst except beneath horns. Pericyst outline peridinioid, usually wider in hypocystal area; lateral margins convex; antapical margin straight to slightly convex except for horns. Periphragm thin, surface smooth or with tiny, randomly scattered granules. Tabulation indicated by archeopyle and cingulum only. Cingulum indicated by weak folding. Archeopyle type variable: I+P (2a and 4") or type I, sometimes with accessory archeopyle sutures on either side of plate 4". Plate 2a is hexagonal, eurythetaform. If archeopyle is type I + P, the operculum is adnate along the posterior margin of 4". If the archeopyle is type I, the operculum is free. The archeopyle appears to penetrate both cyst walls, but the exact relationship of endoarcheopyle and periarcheopyle is uncertain. Cingulum weakly indicated by folds in the periphragm. Sulcus not indicated. Accumulation bodies sometimes present." — Lucas-Clark (2006, p. 189, 190)

Dimensions: "Length, 90–120 μm; width, 60–70 μm (4 specimens measured)." — Lucas-Clark (2006, p. 190)

Remarks: "Unusual features of *Alterbidinium ellentonense* sp. nov. in terms of this genus include bicavation or cornucavation, rather than circumcavation. They also include a somewhat more rectangular/ovoidal shape, and only a moderate difference between the development of antapical horns. *Alterbidinium ellentonense* sp. nov. could be assigned to *Senegalinium*, except that it consistently has unequal antapical horns. This species is slightly larger than most small peridiniacean species here. It is distinguished by an apical pericoel, a smooth exterior, and a variable archeopyle. A case for two species based on the different types of archeopyle could be made, but otherwise the specimens appear virtually identical, and other species of dinoflagellate cysts exhibit variable archeopyle types." — Lucas-Clark (2006, p. 190)

Comparison: "*Alterbidinium ellentonense* sp. nov. is similar to *Senegalinium obscurum*. However, it has unequal antapical horns (as in the generic distinction), is larger, more elongate, has a longer apical horn and a more prominent apical pericoel, has no traces of tabulation other than the archeopyle and faint cingulum, and has a more eurythetaform archeopyle with frequent accessory sutures on either side of plate 4''. Other species of *Alterbidinium* are usually circumcavate or cornucavate. They have different overall shapes and have species level distinctions (such as spines, granules or lineations) from *Alterbidinium ellentonense* sp. nov." — Lucas-Clark (2006, p. 190)

Age: Paleocene (early Danian–early Thanetian); age of holotype stratal position at 132 m in core P21 of Savannah River Site not provided (Lucas-Clark, 2006, p. 190). Range: Paleocene (early Danian–early Thanetian) (Lucas-Clark, 2006, text-fig. 2).

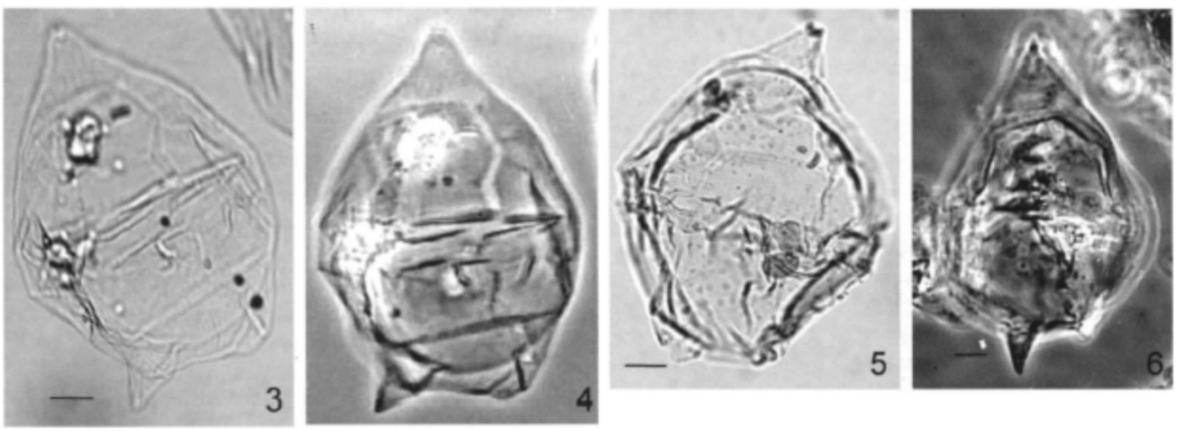


Plate 1, figures 3–6, Lucas-Clark (2006). Scale bar = 10 μm.

Alterbidinium emulatum Mao Shaozhi & Norris, 1988

Diagnosis: "Cyst proximate, circumcavate, elongated pentagonal with straight or convex sides. Both apical and left antapical horns short with broad bases. Endoblast subspherical to oval, relatively large, close to periphragm laterally, resulting typically in two narrow ambital pericoels. Archeopyle intercalary, type (I), attenuated hexa 2a. Transverse archeopyle index (AI) 0.35 to 0.47." — Mao Shaozhi & Norris (1988, p. 41)

Description: "Cyst laterally asymmetrical, ambitus biconical. Apical horn short, bluntly pointed, formed by tapering of two sides of epitract; a small circular thickening, about 2 to 3 μm in diameter, usually at top. Left antapical horn pointed with very broad base; right one either poorly developed or, more often, undeveloped. Shape of endoblast approximately paralleling that of periblast (see Text-Fig. 12); sometimes endoblast protruding to base of apical and left antapical horns. Periphragm thin and granulate, endophragm smooth. Cingulum usually present, 4 to 6 μm wide, slightly levorotatory, delineated by wavy folds or low denticulate ridges. Sulcus restricted to hypotract. Archeopyle on periphragm attenuated hexa, with hexagonal 2a, relatively longer anterior lateral sides (H2 and He), and reduced posterior lateral sides (H3 and H5); the anterior margin (Hi) much shorter than posterior margin (H4), giving hexagonal archeopyle a superficially triangular shape. Archeopyle on endophragm not clearly discernible." — Mao Shaozhi & Norris (1988, p. 41)

Dimensions: "Overall: length 61 to 80 μm (holotype 75 μm), width 40 to 50 μm (holotype 46 μm); endoblast: length 36 to 60 μm (holotype 50 μm), width 30 to 45 μm (holotype 42 μm); 15 specimens measured." — Mao Shaozhi & Norris (1988, p. 41)

Discussion: "*Alterbidinium emulatum* resembles *A. acutulum* and *Isabelidinium acuminatum*. It differs from *A. acutulum* in having a cyst that is plump, with two sides of the epitract straight or convex, and apical and left antapical horns that are much shorter. *I. acuminatum* differs from *A. emulatum* in possessing (1) an endoblast of smaller size, located more centrally in the cyst, and a circular ambitus slightly pointed towards the apex and (2) a relatively wide pericoel between the endophragm and periphragm. *A. emulatum* also shows some similarity to *Deflandrea psilala*, but the latter is smaller (48 to 50 μm) and has two weakly developed antapical horns; the former typically has only the left antapical horn developed. *A. emulatum* is also comparable to *A. montanaense*, but the latter species is much smaller (only 18.75 to 36.25 μm long, 8.75 to 25 μm wide), has two sides of the epitract concave rather than straight or convex, and has a long and prominent apical horn." — Mao Shaozhi & Norris (1988, p. 41, 42)

Age: Late Cretaceous (early Turonian) for the holotype following a general age of Late Cretaceous given by Mao Shaozhi & Norris (1988, p. 41) for the Kukebai Formation. However, the age of the formation has since been refined to early Turonian by Mingzhen Zhang et al. (2022, fig. 2). Range: Late Cretaceous (early Turonian–Campanian) based on a range from the upper Kukebai Formation to the top of Yigezia Formation (Mao Shaozhi & Norris (1988, table 2) as the former unit has been shown to be early Turonian (Mingzhen Zhang et al., 2022, fig. 2) with the top of the latter corresponding approximately to the Campanian (Tibert et al. 2003, p. 211).

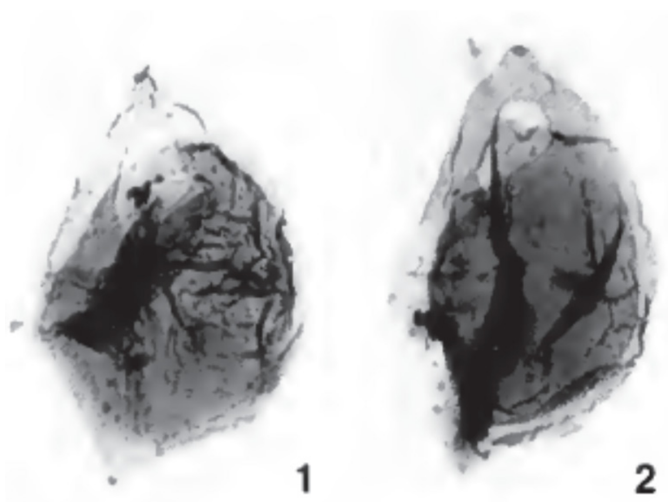


Plate 9, figures 1, 2, Mao Shaozhi & Norris (1988).

Alterbidinium ioannidesii Pearce, 2010

Diagnosis: "A species of *Alterbidinium* possessing a well-developed parasutural paratabulation on the periphragm." — Pearce (2000, p. 66)

Description: "Medium-sized peridinioid, cornucavate to circumcavate dinoflagellate cyst. The wall is two-layered composed of a smooth endophragm and a finely reticulate to striate periphragm that forms low parasutural ridges with no accessories. The pericyst is elongate ellipsoid to biconical and forms a well-developed apical and left antapical horn (right antapical horn much reduced or absent). The endocyst is sub-spherical to ovoidal and lacks horns, follows the general shape of the pericyst and lacks supporting processes. The paratabulation is indicated by well-developed parasutural crests indicating the formula: 4', 3a, 7', ?c, 5''', 2''''. The paracingulum is indicated by parallel horizontal crests, and undifferentiated, except perhaps by the most posterior paraplate in contact with the right sulcal boundary. The parasulcus is indicated by a deep longitudinal depression. The periarchaeopyle is intercalary (Type I, operculum detached) and formed by the loss of a steno-deltaform 2a paraplate. The endo-archaeopyle type has not been identified." — Pearce (2010, p. 67)

Dimensions: "Holotype, overall (w/l) 42 × 61 µm; range, overall (w/l) 40(54.3)62 × 54(64.6)74 µm. 15 specimens measured. As recorded by Ioannides (1986), overall (w/l) 50–64 × 70–98 µm, 14 specimens measured." — Pearce (2010, p. 67)

Remarks: "*Alterbidinium ioannidesii* is comparable in width to Dinoflagellate type E Ioannides, 1986 but shorter in overall length by 10–20 µm. Dinoflagellate type E has been recorded from Arctic Canada (questionably from the Maastrichtian, but no detailed occurrence data were provided) and extensively in the Norwegian Sea (pers. obs.) from the upper Santonian? to lower Campanian, often forming a common or even abundant component of the palynoflora. It is a feature of many peridinioid genera to reach a particularly large size in high (northern) latitudes (Lentin & Williams, 1980), which are otherwise smaller elsewhere, and this may account for the slightly smaller size at Trunch." — Pearce (2010, p. 67)

Comparison: "Differs from other species of *Alterbidinium* by possessing clearly developed parasutural crests on the periphragm." — Pearce (2010, p. 67)

Age: Late Cretaceous (early Campanian); holotype of Pearce (2010, p. 66). Range: Late Cretaceous (early Campanian) (Pearce, 2010, fig. 2).

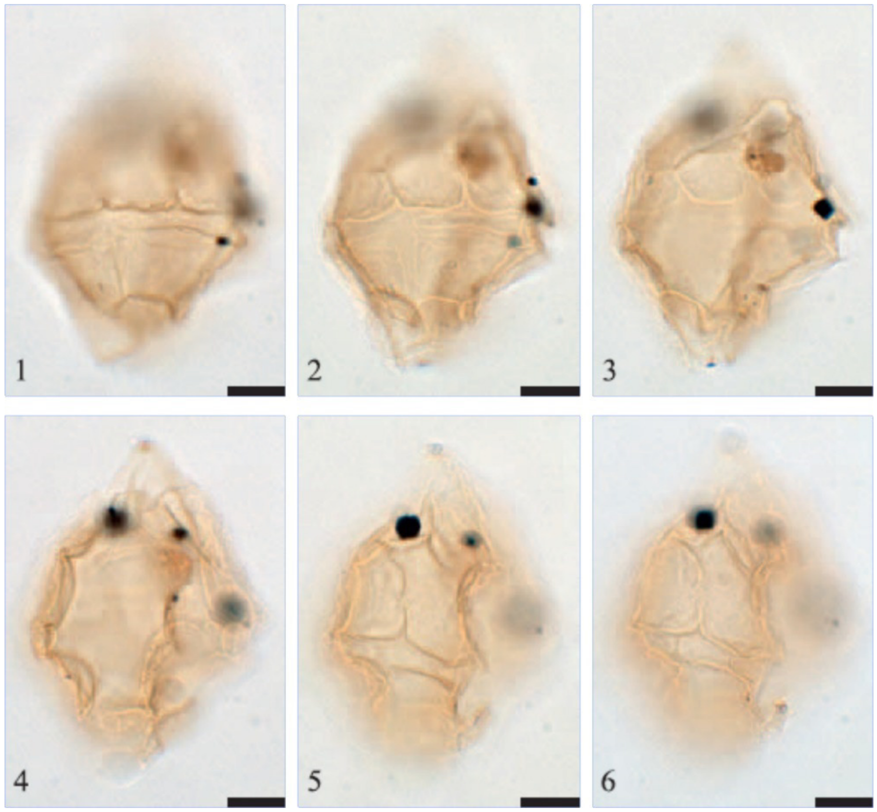


Plate 1, figures. 1–6, Pearce (2010). Scale bar = 10 µm.

Alterbidinium kirschii Slimani, 1994

Diagnosis: "Cyst proximate, circumcavate, pentagonal to rhomboid in shape; the smooth endocyst is spheroidal to ellipsoidal, the pericyst is typically granulated and forms an apical horn and two unequal antapical horns. The paracingulum is relatively broad, the parasulcus is marked by a longitudinal depression which extends from the apex towards the antapex widening posteriorly. The archeopyle is intercalary type (I)a with an operculum attached to the posterior edge." — Translated from Slimani (1994, p. 89).

Dimensions: "Holotype: pericyst, length: 54 µm, width: 40 µm; endocyst, length: 40 µm, width: 33 µm. Variations: pericyst, length: 38–60 µm, width: 34–40 µm; endocyst, length: 30–40, width: 30–36 µm. Apical horn length: 2–7 µm. Length of the left antapical horn: 2–7 µm. Number of specimens measured: 12." — Translated from Slimani (1994, p. 89).

Description: "The endophragm, about 0.5 µm thick, is thinner than the periphragm, which is about 0.75 µm thick. The apical horn is short and truncate to slightly rounded, the left antapical horn is short, while the right one is very reduced or absent. The broad paracingulum (6 to 10 µm) is slightly laevorotatory; it is constantly present and often indicated by two transverse lines of fused granules. The archeopyle is stenodeltaform, the operculum is formed of a single paraplate 2a." — Translated from Slimani (1994, p. 89, 90).

Comparison: "This species corresponds to the specimens called *Alterbidinium* sp. A by Kirsch (1991: p. 99, text-fig. 48, pl. 19, fig. 12), it is probably similar to the cyst in figure 15 determined as *Deflandria minor* by Kjellström (1973); but it is distinguished from *A. minus* (Alberti, 1959b) Lentin & Williams (1985), especially by its periphragm typically granulated and by its wider paracingulum. ?*Manumiella* *hemoorensis* Marheinecke (1992) is represented by a cyst whose periphragm is provided with a more complex ornamentation, and a paracingulum very weakly indicated. Two other species look like *A. kirschii* sp. nov. both by the shape of the pericyst and by its grainy ornamentation; these are *Deflandrea raijae* Kjellström (1973) and *Deflandrea* cf. *acutula* May (1980: p. 73, pl. 8, fig. 2, pl. 13, fig. 1) but they are distinguished respectively by the pentagonal shape of the endocyst and by the probable presence of a single wall. *A. acutulum* (Wilson, 1967b) Lentin & Williams (1985) and particularly the forms found by Whitney (1979 p. 125, 126, pl. 1, fig. 1–12), has a cyst which may be covered by a granulation, but it differs from *A. kirschii* by its longer horns and pentagonal outline endocyst. Specimens of *Alterbia* sp. figured by Vozzhennikova (1967: pl. 79, fig. 4–6) resemble *A. kirschii* in the shape of the cyst, but probably differ by the absence of clear granulation on the surface of the pericyst." — Translated from Slimani (1994, p. 90).

Age: Late Cretaceous (late-early Maastrichtian); holotype as translated from Slimani (1994, p. 89). Range: Late Cretaceous (late-early Maastrichtian) (translated from Slimani, 1994, p. 90).

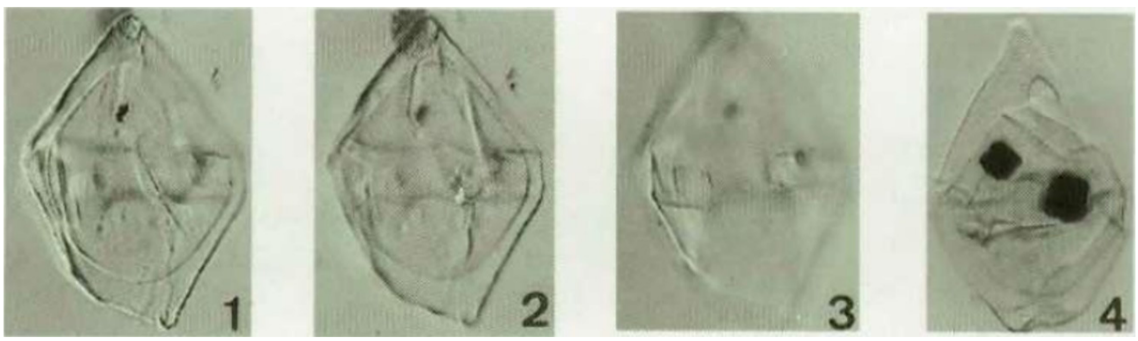


Plate 14, figures 1–4, Slimani (1994).

Alterbidinium longicornutum Roncaglia et al., 1999

Diagnosis: "Large, circumcavate, elongate peridinioid cyst, with one long apical horn and one long antapical horn. The periphragm is thin, smooth to finely granulate. The endocyst is centrally located, subcircular to oval, thin-walled and scabrate. The paracingulum is indicated by lateral projections and folds of the periphragm. The archeopyle is intercalary, type I(2a); operculum attached posteriorly. The paratabulation pattern is indicated by paracingulum and archeopyle only." — Roncaglia et al. (1999, p. 297)

Description: "Cyst large, circumcavate, elongate to nearly biconical. The pericyst bears one apical and one left antapical horn; sometimes a very reduced right antapical horn is present. The apical and left antapical horns are long (apical horn 25–50 μm; antapical horn 13–30 μm), conical, and terminate with acuminate to truncate tips. The periphragm is thin, transparent, and smooth to finely granulate. The endocyst is centrally located, subcircular to oval in ambital view, thin-walled, and scabrate; it is always clearly visible. The paracingulum is indicated by lateral projections of the periphragm and by low, transverse equatorial folds (Figure 15.2). The lateral projections of the periphragm vary from faintly marked to very well developed. The parasulcus is not indicated. An intercalary, steno-deltaform archeopyle, type I(2a), is always present; the operculum is attached posteriorly." — Roncaglia et al. (1999, p. 297, 299)

Dimensions: "(in μm, 15 specimens measured). Overall length, holotype 192.6, range, 118 (158) 200; overall width, holotype 106.7, range, 70 (89) 107; length of endocyst, holotype 76.2, range, 57 (73) 85; width of endocyst, holotype 91.4, range, 58 (75) 92." — Roncaglia et al. (1999, p. 299)

Discussion: "*Alterbidinium longicornutum* differs from *A. acutulum* in having paracingular lateral projections and being much bigger than the latter. However, one paratype of *A. acutulum* figured by Wilson (1967, fig. 11) closely resembles the new species, and it may be conspecific with *A. longicornutum*. The new species differs from *A. circulum* and *A. emulatum* in having longer apical and antapical horns, bearing paracingular lateral projections, and being two to three times bigger. Furthermore, it differs from *A. circulum* in lacking indications of paratabulation on the dorsal surface. *Alterbidinium longicornutum* differs from *A. dictyotum* in lacking a reticulate periphragm and being larger. It differs from *A.*? *distinctum* in lacking longitudinal folds in the periphragm between the apical and antapical horns, in lacking indication of parasulcus, and in being larger. *Alterbidinium longicornutum* differs from *A. montanaense* and *A. pilosum* in being circumcavate and bigger; it differs further from *A. montanaense* in lacking indications of paratabulation, and from *A. pilosum* in lacking paracingular spines. *Alterbidinium longicornutum* resembles *A.*? *pentaradiatum* in size and archeopyle shape, but lacks a well-developed right antapical horn, striate periphragm, low and parallel paracingular ridges, and indication of parasulcus." — Roncaglia et al. (1999, p. 299)

Age: Late Cretaceous (late Maastrichtian); holotype of Roncaglia et al. (1999, p. 297, fig. 9) based on the position of Sample WSB28 from the Loburn Mudstone. Range: Late Cretaceous (late early–late Maastrichtian) (Roncaglia et al., 1999, p. 297, fig. 9).

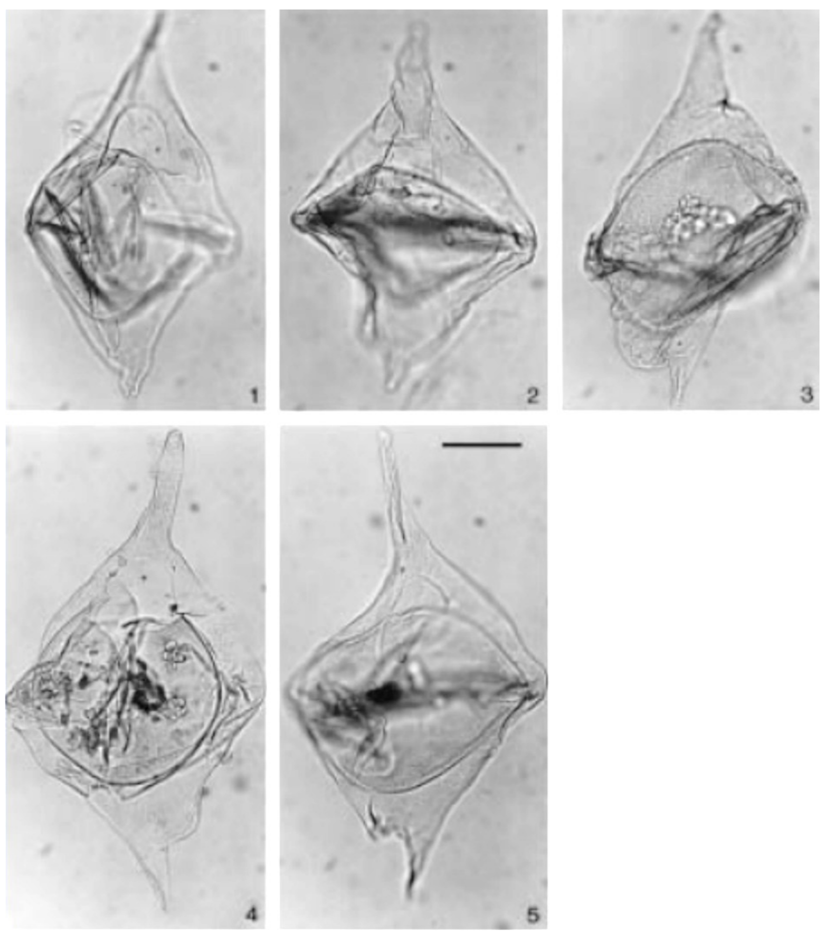


Figure 15, nos. 1–5, Roncaglia et al. (1999). Scale bar = 30 μm.

Alterbidinium mcmillanii Willumsen, 2012

<u>Diagnosis</u>: “Medium-sized, circumcavate, elongated peridinoid cyst, with one apical horn and two antapical horns of unequal size. In ventral view, the left antapical horn is much reduced compared to the right antapical horn. Periphragm is covered by a baculate to echinate surface ornamentation. Endocyst is centrally located, subcircular to oval shape and covered by a dense irregular pilate to clavate surface ornamentation. The paracingulum is indicated by latterly folds of the periphragm. Archeopyle is intercalary, type I(2a). Paratabulation is indicated by paracingulum and archeopyle only.” — Willumsen (2012, p. 58)

<u>Description</u>. “Intermediate, circumcavate peridinoid cyst with an elongated shape. The pericyst bears one apical horn and two antapical horns. In ventral view the left antapical horn is much reduced compared to the right. The apical horn is 18–20 μm long, conical and terminates in a rounded tip. The right antapical horn is 20–25 μm long, pointed and has an acuminate to truncate tip. The periphragm is c. 1 μm thick, transparent and covered by numerous evenly distributed echinae or baculae with a height of 1–2 μm. The density of spines and bacula on the periphragm differs within an assemblage recorded at the same stratigraphic level. The endocyst is subcircular to oval in shape and located centrally and is covered by a pilate to clavate surface ornamentation (Plate 2, figures 10–12) up to 2–3 μm high in the apical and antapical parts of cyst. The endocyst is 1 μm thick and always visible. Paracingulum is indicated by lateral projections of the periphragm and by low transverse folds (Plate 1, figure 18; Plate 2, figure 7). The parasulcus is not indicated. An intercalary, steno-deltaform archeopyle is always visible (Plate 1, figures 16–18). Operculum is often in place, attached along the posterior margin.” — Willumsen (2012, p. 58)

<u>Dimensions</u>: “Specimens measured 10, total length 77(98)108 μm; total width 55(62)70 μm.” — Willumsen (2012, p. 58)

<u>Discussion</u>: “*Alterbidinium mcmillanii* sp. nov. differs from the type species *A. aculutum* (Wilson 1967) and *A. papillatum* (Khowaja-Ateequzzaman et al. 1991) by having surface ornamentation on both the endo- and periphragm. It differs from *A. longicornutum* (Roncaglia et al. 1999) by being half the size, having a less prominent apical horn and baculate ornamentation. *A. pentaradiatum* (Cookson and Eisenack 1965) is a much larger cyst compared to *A. mcmillanii* sp. nov. and also has a smooth hyaline periphragm. *Alterbidinium mcmillanii* sp. nov. differs from *A. pilosum* (Davey 1969) by having surface ornamentation on both the endophragm and periphragm and having no indication of a sulcus.” — Willumsen (2012, p. 58)

<u>Age</u>: early Paleocene (early Danian); holotype of Willumsen (2012, p. 58, fig. 4) following the position of sample series 144/f334. Range: Late Cretaceous–early Paleocene (late Maastrichtian–early Danian) (Willumsen, 2012, fig. 4).

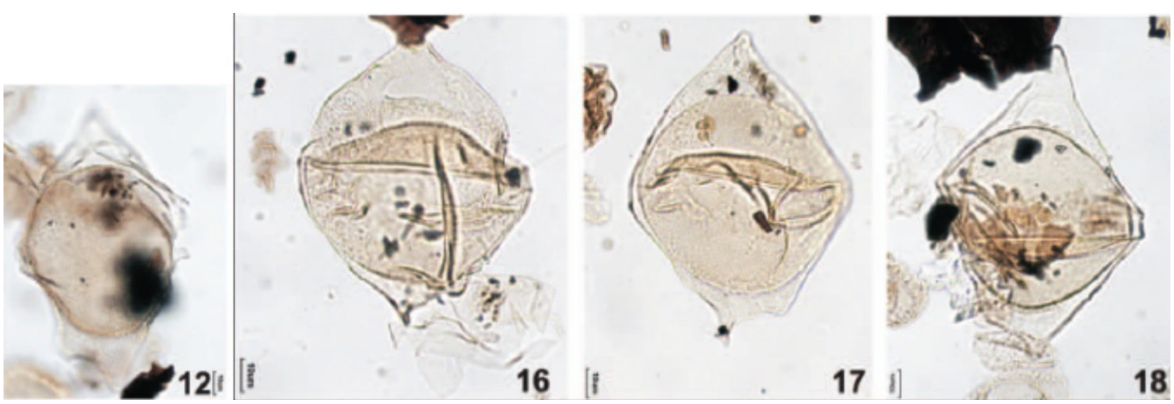


Plate 1, figures 12, 16–18, Willumsen (2012).

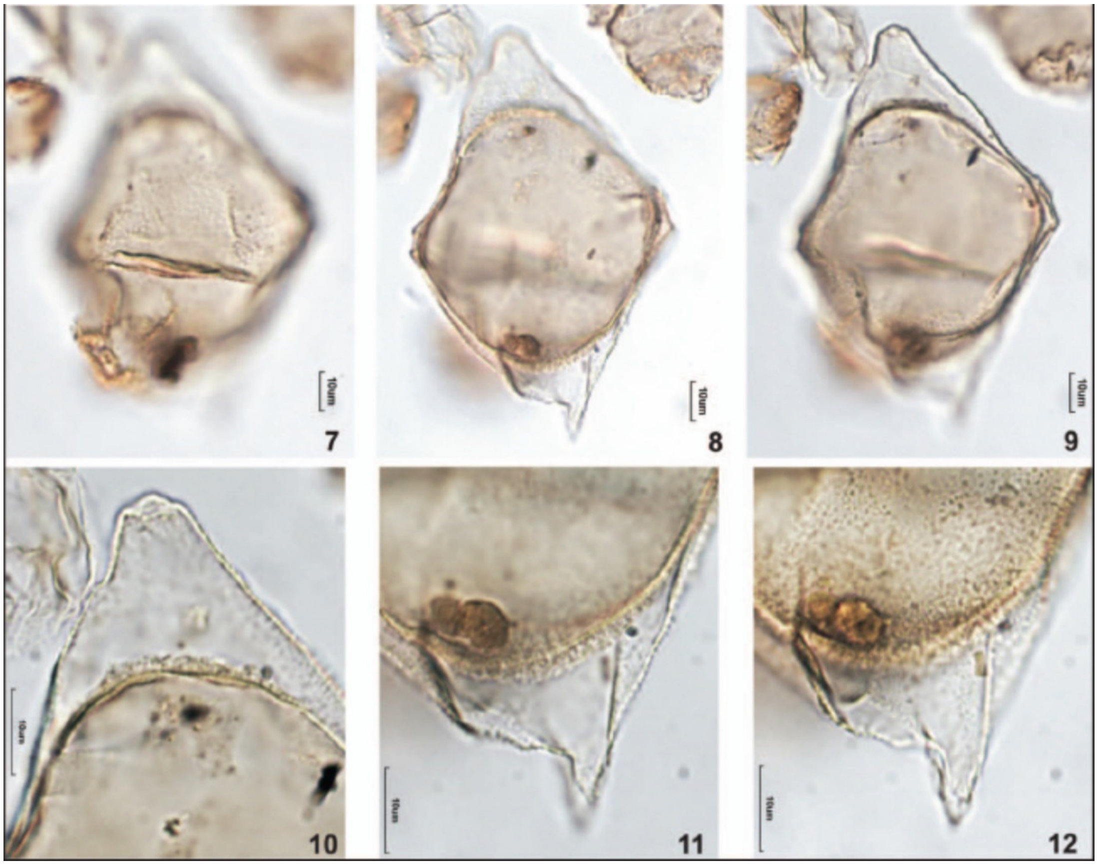


Plate 2, figures 7–12, Willumsen (2012).

Alterbidinium microverrusum (Yu Jingxian & Zhang Wangping, 1980) He Chengquan et al., 2009

<u>Dimensions</u>: “The length of the cyst is 41.4–46.0 microns, holotype length 43.7 microns, width 39.1–43.7 microns, holotype width 43.7 microns. Vertex length 4.6–6.9 microns. The antapical horn is about 3.0–4.0 microns.” — Translated from Yu Jingxian & Zhang Wangping (1980, p. 109)

<u>Description</u>: “The dorsal abdomen of the cyst is flat, and the outline is nearly round to oblong. Consists of two membranes, the outer membrane surrounds the centrosome, and the apical horn is small, triangular, slightly concave at the end wall thickness, forming a small round opening to communicate with the outside. Basal corners slightly developed, two unequal horns. The central body nearly fills the entire outer body, and the surface is densely covered with small nodules. The transverse groove is narrow, about 3 microns, and the edge of the groove is small, jagged, with a polygonal intermediate hole.” — Translated from Yu Jingxian & Zhang Wangping (1980, p. 109)

<u>Comparison</u>: “The new species is of similar cyst shape, outline, and contours described by Stanley for *D. microgranulata*. However, the ornamentation of this new species is rougher and nodule-like, the ends of the top corners are concave, and the walls are thicker to distinguish them.” — Translated from Yu Jingxian & Zhang Wangping (1980, p. 109)

<u>Age</u>: Late Cretaceous (Santonian–Campanian); holotype originated from the Yigezia Formation as translated from Yu Jingxian & Zhang Wangping (1980, p. 118). The Yigezia Formation is of approximately to the Santonian–Campanian (Tibert et al. 2003, p. 211). It is unclear how Fensome et al. (2019, p. 69) established the age as Campanian–early Maastrichtian. Range: presumed Late Cretaceous (Santonian–Campanian).

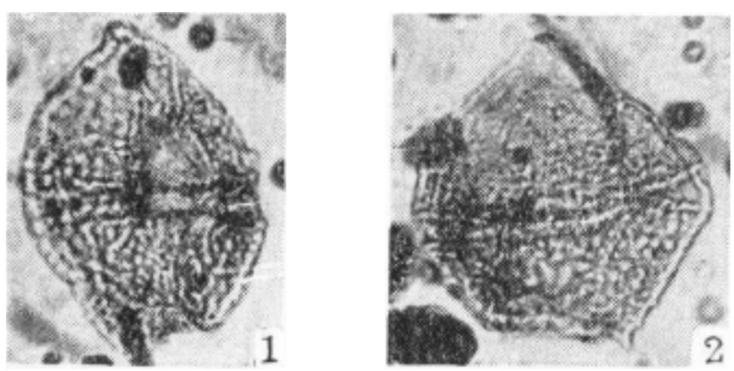


Plate 3, figures 1–2, Yu Jingxian & Zhang Wangping (1980).

Alterbidinium minus (Alberti, 1959) Lentin & Williams, 1985

<u>Diagnosis</u>: “Cyst flattened, its outline elongated pentagonal to almost rhombic, lateral edges often convex. The epitheca, forming an approximately right-angled triangle, is almost as large as the hypotheca and extended into a small ± offset apical horn. Transverse furrow mostly absent, if present shallowly indented. Usually only one small, pointed antapical horn developed, rarely the second indicated (Fig. 10). With a delicate inner body that does not always fit the outer edge of the cyst. It and the cyst's surface is finely dotted.” — Translated from Alberti (1959, p. 98)

<u>Additions</u>: “The apical horn is slightly blunted at its free end. A few specimens also have the 'second antapical horn' in the form of a small protrusion. The cyst is sometimes notched at the level of the

completely reduced side horns. A rounded-hexagonal hatch lies just below the apex." — Translated from Alberti (1959, p. 98)

Differential diagnosis: "The species is characterized by its small dimensions compared to most members of the genus from *Defl. parva* Cookson & Eisenack, it differs in the outline of the carapace, the lack of a transverse furrow and the shape of the inner body." — Translated from Alberti (1959, p. 98)

Dimensions: "Holotype: length 52 µm, width 36 µm. In other specimens, the length varies between 44 µm and 68 µm and the width between 29 µm and 46 µm." — Translated from Alberti (1959, p. 98)

Emended diagnosis: "Cyst proximate, dorsoventrally compressed, circumcavate, pericyst ambitus pentagonal with an apical and two unequal antapical horns, right antapical horn reduced; periphragm thin, smooth; endocyst subpentagonal, endophragm thicker than periphragm, smooth; periparacingulum absent, paratabulation indicated by archaeopyle alone; archaeopyle intercalary, independently developed on periphragm and endophragm, periarchaeopyle hexa 2a, steno-deltaform, perioperculum adnate, endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate." — Khowaja-Ateequzzaman et al. (1991, p. 44)

Description: "Shape: cyst proximate, dorsoventrally compressed; pericyst ambitus pentagonal with an apical horn and two unequal antapical horns, right antapical horn reduced; endocyst subpentagonal. Wall relationship: apical and antapical pericoels prominent, connected through ambital pericoel (circumcavate); endocyst shifted more towards dorsal side where periphragm and endophragm appressed in the precingular and postcingular areas. Wall features: no parasutural features; periphragm thin, smooth; endophragm relatively thick, smooth, at times a short apicular process present (sensu Wiggins, 1975, p. 98), paracingulum absent. Paratabulation indicated by archaeopyle alone. Archaeopyle: intercalary, independently developed on periphragm and endophragm; periarchaeopyle hexa 2a, steno-deltaforrn, perioperculum adnate (adnation along adcingular margin); endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate (adnation along adcingular margin)." — Khowaja-Ateequzzaman et al. (1991, p. 44)

Dimensions: "Pericyst: 60–65 × 45–50 µm; Endocyst: 40–45 × 40–45 µm; Periarchaeopyle, Transverse Archaeopyle Index (TAI) 0.34, Longitudinal Archaeopyle Index (LAI) 0.44, Archaeopyle Ratio (AR) 1.2, Archaeopyle Signum (AS) 2.3; Endoarchaeopyle, Transverse Archaeopyle Index (TAI) 0.33, Longitudinal Archaeopyle Index (LAI) 0.42, Archaeopyle Ratio (AR) 0.52, Archaeopyle Signum (AS) 1.6." — Khowaja-Ateequzzaman et al. (1991, p. 45)

Remarks: "The emendation of the species is based on the study of specimens recovered from the Trichinopoly Formation, Cauvery Basin, India as well as on the face value of the holotype specimens documented by Alberti (1959, p. 98, pl. 9, figs 9–11)." — Khowaja-Ateequzzaman et al. (1991, p. 45)

Age: Late Cretaceous (late Senonian); holotype as translated from Alberti (1959, p. 98).

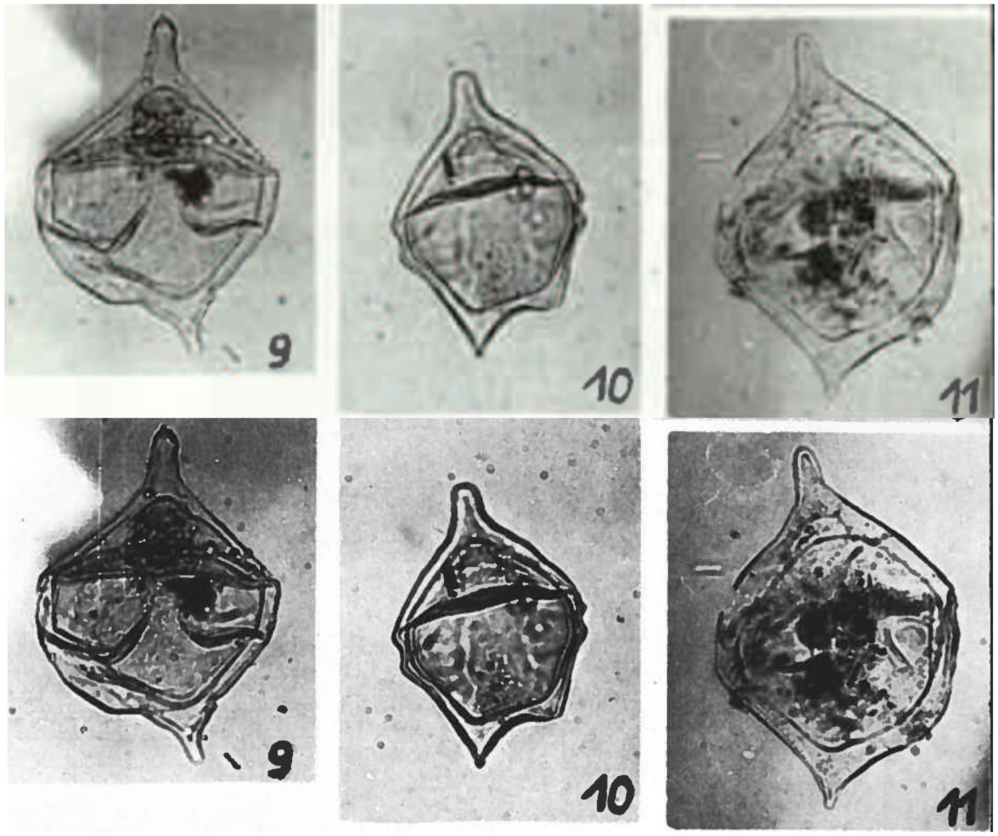


Plate 9, figures 9–11, Alberti (1959).

Alterbidinium montanaense (Harland, 1977) Lentin & Williams, 1985

Diagnosis: "Cavate cyst, epitract conical, hypotract hemispheroidal with an asymmetrical 'skirt' and horn. Endoblast elongated apically and hemisplieroidal antapically. Wall layers smooth. Apex surmounted by a bifid tip; the larger antapical horn acuminate. Tabulation discernible but not usually recognizable, delimited by low, smooth, or poorly denticulate ridges. Cingulum planar, may or may not be slightly indented; sulcus large and broad, widening towards the antapex. Archeopyle intercalary in periphragm and endophragm; commonly attached Ia/Ia (Evitt 1967), and apically/antapically elongate hexagonal in shape." — Harland (1977, p. 184)

Description: "A diamond-shaped to elongate fusiform cyst made up of the two wall layers that are only adpressed in the cingular region and on the upper part of the hypotract. The epitractal periphragm is drawn out into an apical horn which carries a dorso-ventrally flattened, bifid tip. The antapical 'skirt' and horn sometimes carry small, poorly developed, irregular spines, especially on the margin of the 'skirt'. The tabulation is variously developed but difficult to decipher, it is probably ?4', 1a, ?7'', 6c, ?''', ?2''''. The cingulum is divided into six well-defined cingular plates. Archeopyle is formed by a single opening through the periphragm and endophragm and the operculum appears to remain attached (Pl. 25, fig. 10), type Ia/Ia of Evitt (1967)." — Harland (1977, p. 185)

Dimensions: "Holotype: length 35.0 μ, breadth 16.25 μ. Range: length 18.75 (27.50) 36.25 μ, breadth 8.75 (17.0)25.00 μ. Twelve specimens were measured from a studied population of twenty-five." — Harland (1977, p. 185)

Remarks: “This cyst is closely comparable to *Spinidinium clavum* Harland, 1973 (see below for further comments), and it is possible that a full range of variation exists between the two forms. This was not seen to be the case, however, in either the present assemblage or in southern Alberta (Harland 1973), and therefore it is regarded as a distinct and separate species. It occurs throughout the studied section.” — Harland (1977, p. 185)

Comparisons: “This cyst is closely comparable to *D. minor* Alberti, 1959 from which it differs in over-all shape, *D. minor* being more rhomboidal and having a condensed endoblast, and in possessing a tabulation. It is also comparable with *D. balmei* Cookson and Eisenack, 1962 which again differs in form, in the amount of endoblastic ‘contraction’ and in possessing spines. It is closest to *S. clavum* Harland, 1973 but differs in not possessing high, denticulate, sutural crests and in being much smaller, i.e. nearly half the size. It may be an evolutionary descendant of that species. It is also closely comparable to *S. rallum* Heisecke, 1970, *D. irmoechinata* Heisecke, 1970, and *D. rhombica* Cookson and Eisenack, 1974, all of which, however, differ in possessing numerous well-developed spines.” — Harland (1977, p. 185)

Age: Late Cretaceous (late Campanian–?early Maastrichtian); holotype of Harland (1977, p. 184, text-fig. 3). Range: Late Cretaceous (late Campanian–Maastrichtian); holotype of Harland (1977, p. 184, text-fig. 3).

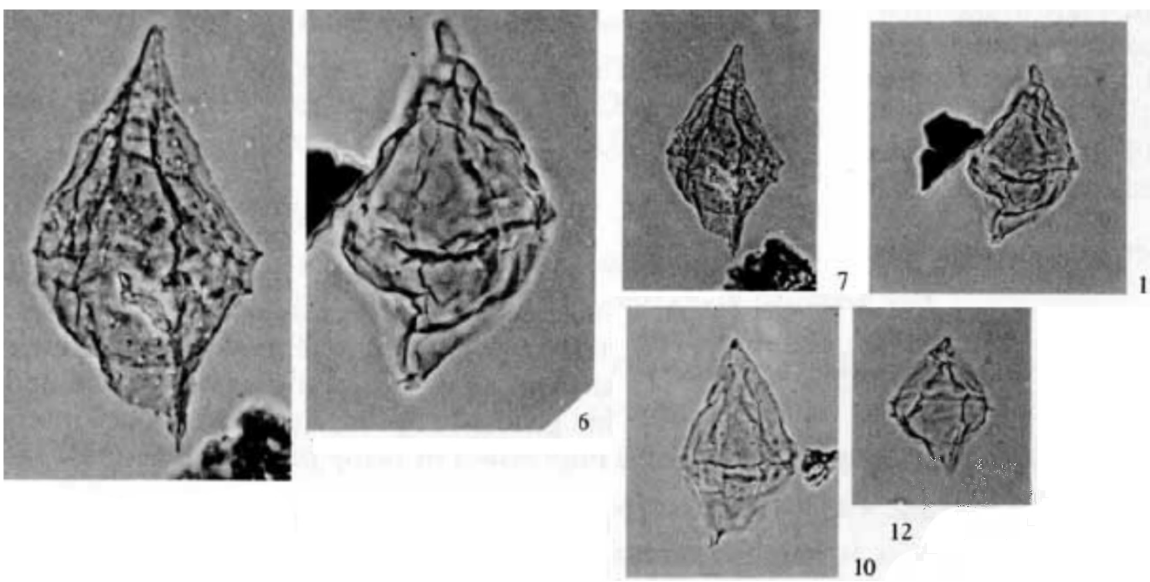


Plate 25, figures 4, 6, 7, 10–12, Harland (1977).

?*Alterbidinium novozealandicum* Schiøler et al., 2001

Diagnosis: “Large, smooth, almost fusiform peridinioid cyst with long tapering apical and left antapical horns and strongly reduced right antapical horn. Endocyst not clearly defined, or absent. The apical part of the cyst has two folds on the dorsal side. The folds start close to the cyst margin on both sides of the archeopyle, run sub-parallel to the cyst margin, and converge towards the apex where they meet. The archeopyle is intercalary, type 1(2a), steno-deltaform, the operculum is attached posteriorly. Parasulcus and paracingulum not indicated.” — Schiøler et al. (2001, p. 148)

Description: “Large, fusiform, dorso-ventrally compressed peridinioid cyst without clearly defined endocyst. The phragm is relatively thick (1–2 µm), hyaline and smooth to shagreenate; it has a long tapering apical horn, a long tapering left antapical horn and a very reduced right antapical horn which, on almost all specimens observed, is only indicated by a more or less pronounced bulge on the side of the left antapical horn (figs 4, A, C, D, E; 5, A, B, D). On a few specimens, the right antapical horn is developed into a small spur-like projection on the side of the left horn (Fig. 4, E). On some specimens, a third antapical horn is indicated by a small bulge on the phragm between the left and right antapical horns (figs 4, D; 5, E). Due to the dominance of the left antapical horn over the right antapical horn, the cyst appears fusiform, with a shape resembling that typical of species of the genus *Palaeocystodinium*. The apical part of the cyst has two folds on the dorsal side. The folds start close to the cyst margin on both the sides of the archeopyle, run sub-parallel to the ambitus, and converge towards the apex (see e.g. figs 4, B, D, E; 5, B, D–G). A clearly defined endophragm was not observed in any of the specimens studied. However, on a few specimens minute amorphous particles (diameter 0.5–1.5 μm), or larger aggregates of those particles, were observed occupying a sub-circular to oval area located centrally, assumingly within the cyst, or outlining parts of a sub-circular to oval perimeter (figs 4, D, E; 5, D). The archeopyle is intercalary, type I(2a), steno-deltaform. On some specimens, the archeopyle margin is rounded with a straight posterior margin. On other specimens the shape of the archeopyle margin clearly indicates adjacent edges of one or more of the paraplates 3'', 4'', 5'', la, 3a and 3' (see e.g. Fig. 4, B, C). The transverse archeopyle index is between 0.27 and 0.45, with an average value of 0.38 (holotype: 0.32). The operculum is attached posteriorly on all specimens observed. The paracingulum and parasulcus are not indicated. Paratabulation is only indicated by the archeopyle margin." — Schiøler et al. (2001, p. 148)

Dimensions: "Length: holotype, 180, range: 163(181)201; width: holotype, 69, range: 41(59)79. Number or specimens measured: 20."— Schiøler et al. (2001, p. 149)

Discussion: "Some specimens of *Alterbidinium austrinum* Roncaglia & Schiøler (1999) resemble the new species in general appearance and size, in having a long apical and antapical horn, in lacking a clearly visible endocyst, and in having indication of a third antapical horn. However, *A. austrinum* differs markedly from *A.*? *novozealandicum* in bearing two lateral horns. Some specimens of *A. austrinum* (including the holotype) have indications of folds in the phragm on both sides of the archeopyle, roughly similar to those on *A.*? *novozealandicum* (see Roncaglia & Schiøler 1999, plates I, 1,4; II, 1). Those specimens have been restudied in connection with the present work. The folds on the phragm of those specimens are either random folds, optical phenomena or regular folds that run from the apex to the tip of the lateral horns close to the edge of the specimen, and thus differ from the folds on the apical horn of *A.*? *novozealandicum*. Khowaja-Ateequzzaman et al. (1991) emended the genus *Alterbidinium* to accommodate proximate, dorso-ventrally compressed, circumcavate cysts, with one apical and two unequal antapical horns, indication of paracingulum, and an intercalary, steno-/iso-deltaform periarcheopyle. The archeopyle shape and the reduction of the right antapical horn in the new species would suggest affiliation with *Alterbidinium*. However, as the new taxon appears to be lacking both a clearly defined endocyst and indications of paracingulum, the allocation of the new species within the genus *Alterbidinium* is done with hesitation.

Lentin & Williams (1976) defined the genus *lsabelidinium* (as '*lsabelia*') for bicavate to circumcavate, elongate, peridinioid cysts, with one apical and two antapical horns, without paratabulation apart from the archeopyle, or with paratabulation indicated by archeopyle and paracingulum only, and with intercalary, omegafonn periarcheopyle. Marshall (1988) emended that genus to accommodate elongate peridinioid cysts with a deltaform to thetaform periarcheopyle and with a weakly defined paratabulation, hereunder a weakly defined cingulum with a partite structure. The new taxon resembles species of the genus *lsabelidinium* as emended by Marshall (1988), but it also clearly differs in having a dominant left antapical horn and in lacking a clearly defined endocyst.

Alterbidinium? *novozealandicum* resembles species of the genus *Satyrodinium* Lentin & Manum, 1986 in general appearance, size and archeopyle shape, and in lacking indication of paratabulation apart from the archeopyle. However, the original diagnosis of the genus *Satyrodinium* (Lentin & Manum, 1986, p.112) implies the presence of at least 2 apical horns. The new taxon has only one apical horn; thus it cannot be included in the genus *Satyrodinium*.

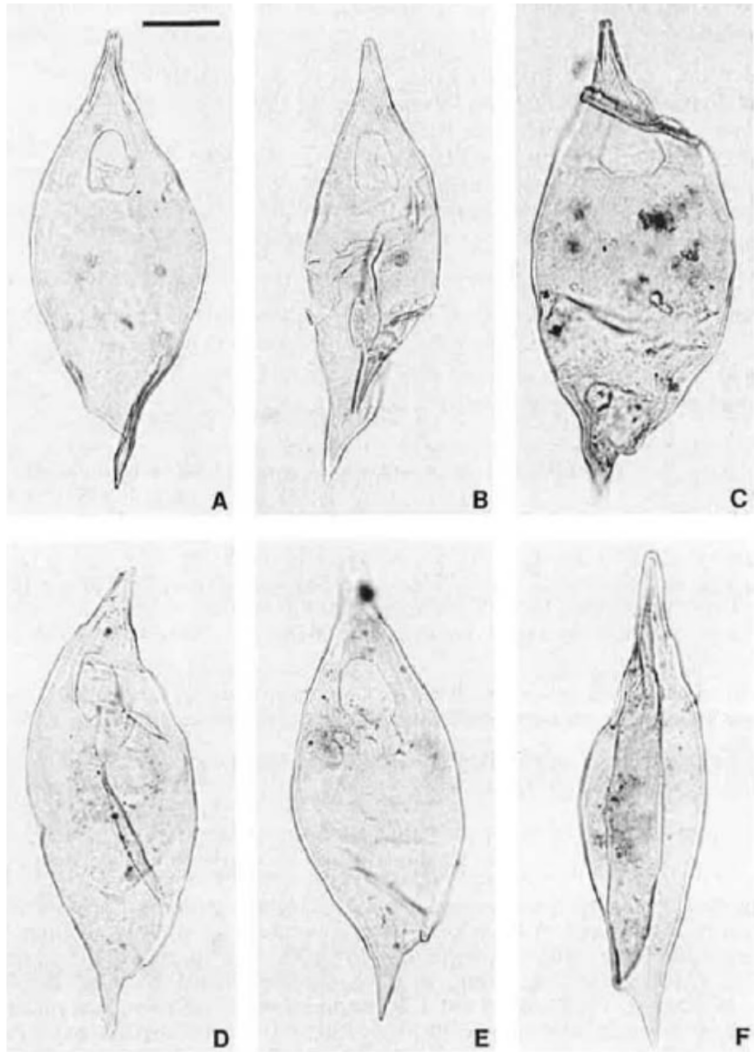
The species *Isabelidinium marshallii* Roncaglia (2000) was encountered in the *I. korojonense* Zone at Haumuri Bluff and Conway River (southern Marlborough, New Zealand); it was previously illustrated and discussed as *Satyrodinium*? sp. 1 by Roncaglia et al. 1999. The species resembles *A*.? *novozealandicum* in size, in having a reduced right antapical horn, in archeopyle shape, and in having two longitudinal folds on the dorsal side of the apical horn. However, *I. marshallii* differs from the new species in having a rhomboid shape instead of a fusiform, and in having a well defined (albeit thin-walled) endocyst and in having indications of a parasulcus and, occasionally, a paracingulum.

The genus *Palaeocystodinium* Alberti, 1961 accommodates fusiform cornu- to circumcavate peridinioid cysts without paratabulation and with a steno-deltaform periarcheopyle. Species of that genus always have an endocyst. A few species have a spur on the left antapical horn indicating the presence of a right antapical horn. The new species superficially resembles species of *Palaeocystodinium* in 1) being fusiform, 2) lacking paratabulation other than the archeopyle, 3) having a steno-deltaform archeopyle. However, the new species lacks a well defined endocyst and normally has the right antapical hom indicated by a bulge; thus it cannot be included in *Palaeocystodinium*.

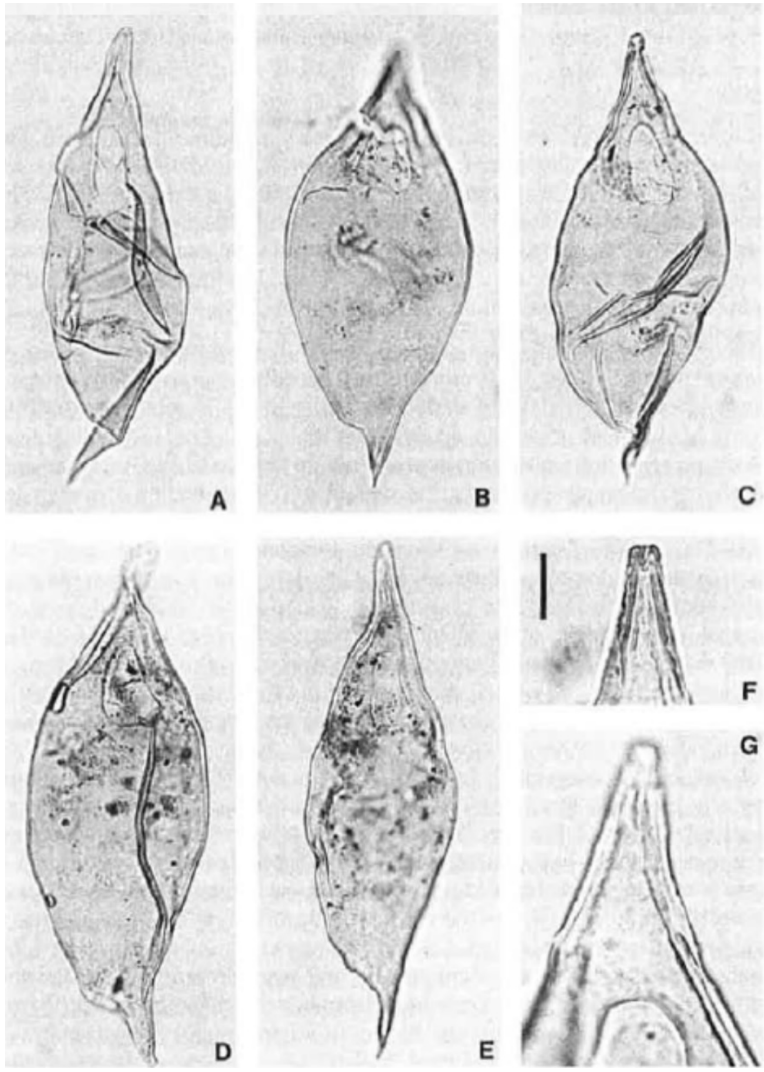
The new species resembles *Manumiella seymourensis* Askin, 1999 in having an indistinct endocyst, and in lacking clear signs of paratabulation apart from the archeopyle. However, it differs in being bigger and in having a fusiform shape instead of the ovoid to rounded shape which characterizes *M. seymourensis*.

Although somewhat smaller, *Fusiformacysta salasii* Morgan, 1975 is roughly similar in shape to *A*.? *novozealandicum* and also lacks an endocyst, but the former species differs markedly in having a precingular archeopyle. An option would be to establish a new genus to accommodate the new species, possibly together with the closely related species *A. austrinum* and *I. marshallii*. However, until more taxonomic work has been done on the Australasian dinoflagellate assemblages, we hesitate to take that step." — Schiøler et al. (2001, p. 149, 150)

<u>Age</u>: Late Cretaceous (middle–late Campanian); holotype of Schiøler et al. (2001, p. 148). Range: Late Cretaceous (middle–late Campanian) narrow constraint based on two samples (see: Schiøler et al., 2001, fig. 3).



Figures 4A–F, Schiøler et al. (2001). Scale bar = 30 μm.



Figures 5A–G, Schiøler et al. (2001). Scale bar = 10 µm.

Alterbidinium nuculum (Vasilyeva in Andreeva-Grigorovich et al., 2011) Williams & Fensome, 2016

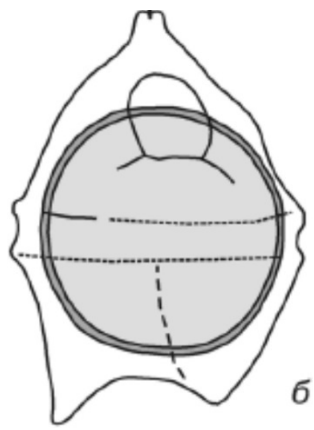
Diagnosis: "Peridinioid, oval-pentagonal, widely ellipsoidal cyst of intermediate size. Left antapical horn developed. Right antapical horn considerably reduced. Epicyst helmet-shaped with a small cut off apical horn. Hipocyst [sic] trapeziform asymmetrical. Endocyst rounded, circular-pentagonal. Periphragm dense, granular, coarse granular. Endophragm thick, bilayered, coarse granular, scabrate. Periarcheopyle wide, round-pentagonal. Perioperculum attached. Parasulcus marked by two folds of periphragm on hypocyst ventral side." — Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 42)

Description: "The pericyst of the peridinoidal type is oval-pentagonal with one apical and two antapical unequal horns. Epicyst a little more hypocritical. Epicyst is helmet-shaped, spherical, sometimes with pronounced shoulders, truncated apex. Hypocyst trapezoidal with two well-expressed non-linear, pointed antapical horns; the right one is somewhat longer than the left one. Endocyst round, sometimes slightly pentagonal. The ambitus is well defined, narrowing in the area of cingulum. The epitheca is helmet-shaped, voluminous. The hypotheca is significantly narrower. The periphragm is transparent, slightly grainy, dense, hard, good dry form. Endophragm thick, bilayer; the outer layer is tuberculate. The endophragm is coarse-grained, with streakiness visible. The surface of the endophragm should include the inclusion of an organic material in see dark round spots. The consequence of the structure of the endophragm of the endocyst looks like a dense nut. Parasulcus well expressed in the form of a groove with raised edges. Periarcheopyle round-hexagonal, elongated, intercalary in position. Periarcheopyle significantly larger than endoarchaeopyle. The operculum is attached. Paratabulation is fuzzy, designated archeopyle and cingulum. Parasulcus is not clear." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 42)

Dimensions: "(µm) Holotype: pericyst length, 56.1; pericyst width, 42.9; endocyst length, 35.0. Other specimens (7 specimens): perimeter length, 61.1–55.0; pericyst width, 44.0–41.2; endocyst length, 37.2–36.0; endocyst width, 36–35". — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 42)

Comparison: "This species is comparable with *Alterbidinium rugulum* Iakovleva et Kulkova, 2001, but differs from the latter in a more convex, spiky epicyst shape, unequal in antapical horn length and thick, dense, bumpy, usually dark endophragm. *Alterbidinium nuculum* differs from the species *Alterbidinium saltanovae* more broadly in the proportions of the cyst, with a round, and not elongated endocyst." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 42, 43)

Age: late Paleocene (Thanetian); holotype as translated from Andreeva-Grigorovich et al. (2011, p. 100, text-fig. 18b, pl. 11, figs. 5, 6) by subsequent designation of Williams & Fensome (2016, p. 138). Range: late Paleocene (Thanetian)–early Eocene (Ypresian) (translated from Vasilyeva in Andreeva-Grigorovich et al., 2011, p. 43).



Text-figure 18b, Vasilyeva in Andreeva-Grigorovich et al. (2011).

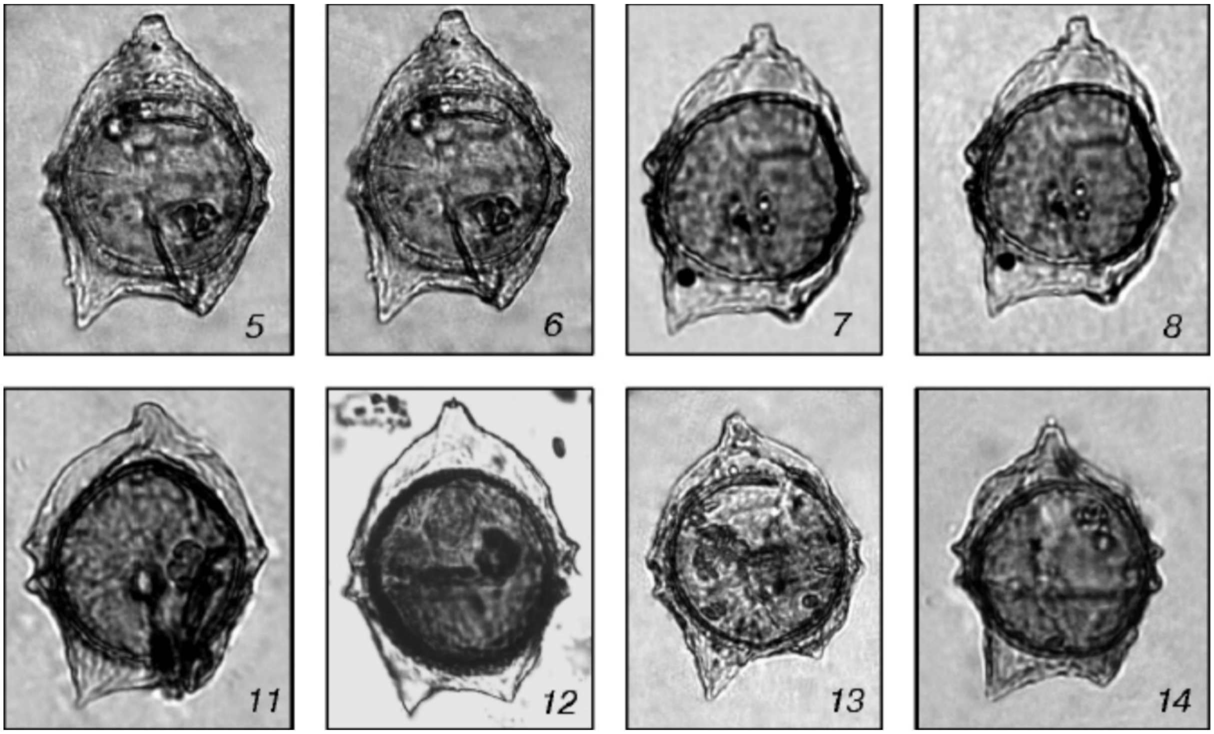


Plate 11, figures 5–8, 11–14, Vasilyeva in Andreeva-Grigorovich et al. (2011).

Alterbidinium nummuliforme (Vasilyeva in Andreeva-Grigorovich et al., 2011) Williams & Fensome, 2016

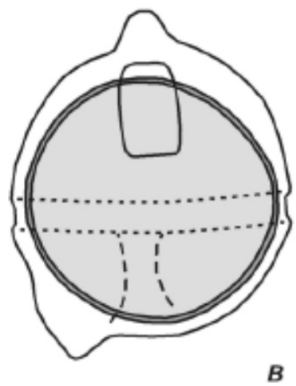
Diagnosis. "Peridinioid circumcavate almost round cyst of intermediate size. Endocyst circular. Periphragm thin, smooth, light, transparent. Endophragm dense, coarse granular. Periarcheopyle elongate, hexagonal, intercalary. Perioperculum attached. Paracingulum weakly expressed by wide furrow. Parasulcus marked by thin semicircular folds of periphragm on hypocyst ventral side." —Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 43)

Description: "The pericyst is almost round. Epicyst and hypocyst of equal length. Apical horn protrudes slightly above the surface of the cyst wide truncated triangle. Usually, the apical horn is slightly inclined, which gives the epicyst an asymmetric shape. Hypotheca, as a rule, asymmetric. Developed left antapical horn (pointed), right reduced. There are specimens with antapical horns of almost the same length. Endocyst of almost regular round shape, occupies most of the pericyst. The periphragm is thin, light, transparent, smooth. Endophragm dense, two-layered, more thick, coarse-grained or indistinctly lumpy. On the endophragm, in the center of the endocyst, the inclusion of an organizational substance is almost always observed in the form of large mounds. The pericelum is pronounced, very narrow. Epitheca several times extended. The hypotheca expands only in the region of the antapical horns. The paracingulum is weakly expressed: the wide flat sulcus and thin cord-like folds on the periphragm. Periarcheopyle elongated round-hexagonal, difficult to distinguish, intercalary type. Attached is the periphragm. Parasulcus is indicated by thin, rounded folds of the periphragm on the hypocyst." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 43)

Dimensions: "(µm) Holotype: pericyst length, 46.1; pericyst width, 36.3; endocyst diameter, 33.3; endophragm thickness, 1.5; paracinglum width, 5. Other specimens (3 specimens): pericyst length, 56.1; pericyst width, 41.3; endocyst diameter, 36.3." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 43)

Comparison: “The overall structure, dimensions, and ratio of the apical and antapical horns resemble a representative of the genus *Senegalinium*, however the species differs in being typical for the genus *Alterbidinium* with the structure of the archeopyle and antapical horns.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 43)

Age: late Paleocene (Thanetian); holotype as translated from Andreeva-Grigorovich et al. (2011, p. 100, text-fig. 18c, pl. 11, fig. 15) by subsequent designation of Williams & Fensome (2016, p. 138). Range: late Paleocene (Thanetian)–early Eocene (Ypresian) (translated from Vasilyeva in Andreeva-Grigorovich et al., 2011, p. 43).



Text-figure 18c, Vasilyeva in Andreeva-Grigorovich et al. (2011).

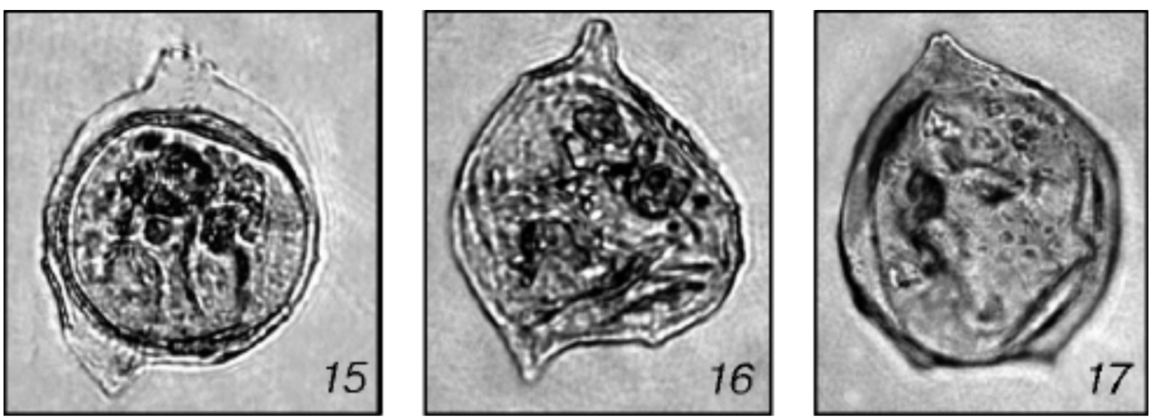


Plate 11, figures 15–17, Vasilyeva in Andreeva-Grigorovich et al. (2011).

Alterbidinium ovale (He Chengquan, 1991) Lentin & Williams, 1993

Description: “The outline of the outer wall is oval or round and pentagonal, the sides of the waist are smooth and obviously convex, and the length and width are nearly equal or with a slightly larger width. The epitheca and hypotheca are nearly equal in size. Epitheca triangular, laterally convex, apical horn slightly or almost absent, occasionally apically crested. Hypotheca inverted trapezoidal, with nearly straight and slightly convex sides, with degenerated antapical horns, or only one of them protruding slightly from the contour line, the end blunt. The equatorial position of the cingulum is shallow and flat, ring-shaped, 6–7 μm wide, and its edge is bounded by granular ridges. The longitudinal groove is blurred. Outside the surface of the wall is finely granular. The outline of the inner body is nearly round, the wall is thin, and there is no obvious decoration on the surface. It is widely separated from the outer wall. The archeopyle is small, more obvious, with an anterior style, indicated by the main crack of the archeopyle. The operculum is kept in place.” — Translated from He Chengquan (1991, p. 73).

Dimensions: “Cyst length 50–60 μm, width 45–52.5 μm, inner body length 32–43 μm, width 36–45 μm (4 specimens measured). The [holotype?] specimen is 52.5 μm long and 52.5 μm wide, the endosome is 43 μm long and 45 μm wide, and the transverse groove is 7.5 μm wide.” — Translated from He Chengquan (1991, p. 73).

Age: Late Cretaceous (early Turonian); holotype of He Chengquan (1991, p. 226). Based on the range chart and Translated from “top of the Kukebai Formation to bottom of the Wuyitake Formation” from He Chengquan (1991, p. 16, 266, fig. 4) and the corresponding age of the upper Kukebai and lower Wuyitake formations given as early Turonian by Mingzhen Zhang et al. (2022, fig. 2), which interestingly did not reference He Chengquan (1991) or report the presence of any deflandreoid species in its survey of dinocyst taxa.

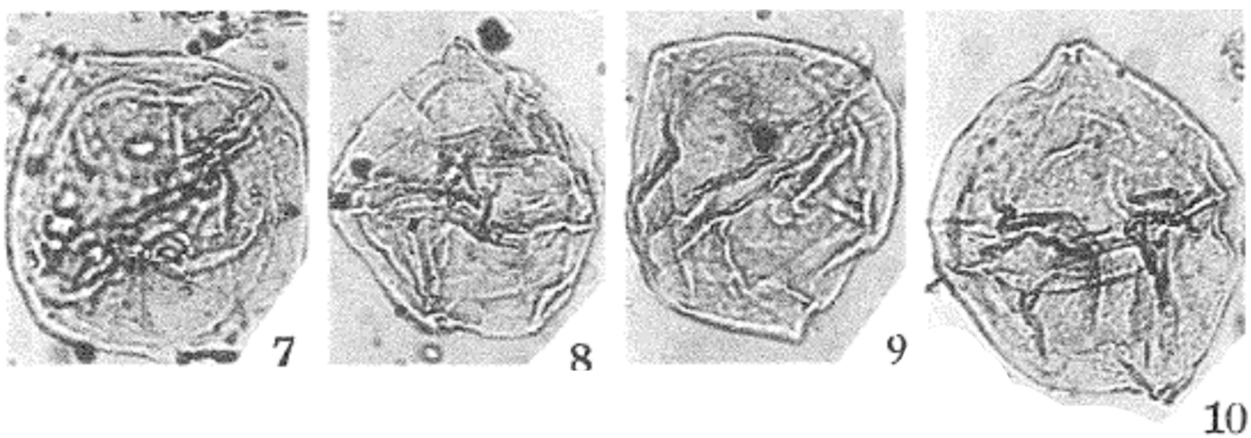


Plate 29, figure 7–10, He Chengquan (1991).

Alterbidinium papillatum Khowaja-Ateequzzaman et al., 1991

Diagnosis: “Cyst proximate, dorso-ventrally compressed, circumcavate, pericyst ambitus pentagonal with an apical horn and two symmetrically placed unequal antapical horns, right antapical horn reduced; periphragm thin, papillate, papillae more pronounced on dorsal surface, intratabular; endocyst subpentagonal, endophragm thicker than periphragm, smooth; periparacingulum annulate; paratabulation peridinioid, ?4', 3a, 7'', Xc, 5''', 1p, 2''''; archaeopyle intercalary, independently developed on periphragm and endophragm, periarchaeopyle hexa 2a, steno-deltaform, perioperculum adnate, endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate.” — Khowaja-Ateequzzaman et al. (1991, p. 38, 40)

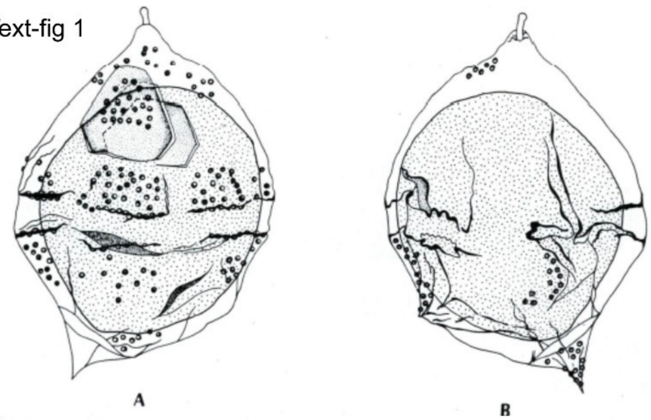
Description: “Shape: cyst proximate, dorsoventrally compressed; pericyst ambitus pentagonal with a broad-based apical horn having a short apicular process at the tip (sensu Wiggins, 1975, p. 98) and two symmetrically placed unequal antapical horns, right antapical horn reduced; endocyst subpentagonal. Wall relationship: apical and antapical pericoels prominent, connected through ambital pericoel (circumcavate), endocyst shifted more towards dorsal side where periphragm and endophragm appressed in the precingular and postcingular areas. Wall features: no parasutural features; periphragm thin, papillate, papillae intratabular, pronounced on perioperculum, precingular, postcingular and antapical paraplate areas on dorsal surface (Text-figs lA, 2A, B); ventral surface bears numerous irregular folds (Text-fig. 1B); periparacingulum marked by two parallel ridges and a furrow running high over endocyst, bearing papillae arranged in two single discontinuous rows on the margins of the ridges, paracingular paraplates indiscernible; endophragm thicker than periphragm, smooth; perisulcus marked by a depression. Paratabulation: peridinioid, incompletely discernible on individual specimens; pericyst paratabulation formula ?4', 3a, 7'', Xc, 5''', 1p, 2'''' (Text-fig. 3A, B). Archaeopyle: intercalary, independently developed on periphragm and endophragm, periarchaeopyle hexa 2a, steno-deltaform, perioperculum adnate (adnation along adcingular margin); endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate (adnation along adcingular margin)." — Khowaja-Ateequzzaman et al. (1992, p. 40, 41)

Dimensions: "Pericyst: holotype 70 × 52 µm, range: 68–75 × 50–58 µm; Endocyst: holotype 46 × 46 µm, range 45–48 × 46–52 µm; Periarchaeopyle: Transverse Archeopyle Index (TAI) 0.33, Longitudinal Archaeopyle Index (LAI) 0.46, Archaeopyle Ratio (AR) 1.1, Archaeopyle Signum (AS) 2.5; Endoarchaeopyle: Transverse Archaeopyle Index (TAl) 0.32, Longitudinal Archaeopyle Index (LAI) 0.44, Archaeopyle Ratio (AR) 0.56, Archaeopyle Signum (AS) 1.8" — Khowaja-Ateequzzaman et al. (1992, p. 41)

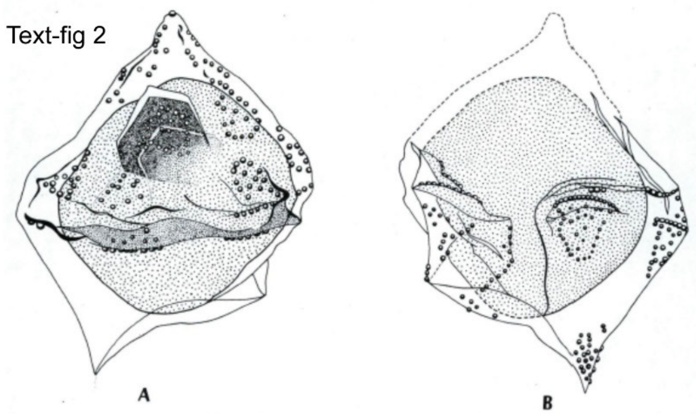
Comparison: "*Alterbidinium papillatum* sp. nov. is characterized mainly in having intratabular papillate ornamentation on pericyst which differentiates it from all the known species of the genus. Manum (1963, p. 58, 59, pl. 2, figs 1–5; text-fig. 2) described some dinoflagellate cysts as *Deflandrea* cf. *scheii* from the Cretaceous of Graham Island, Arctic Canada. These forms resemble the present specimens in having intratabular ornamentation and overall shape but differ mainly in having parasutural ridges." — Khowaja-Ateequzzaman et al. (1992, 41)

Age: Late Cretaceous (Turonian–Santonian); holotype of Khowaja-Ateequzzaman et al. (1992, p. 41)

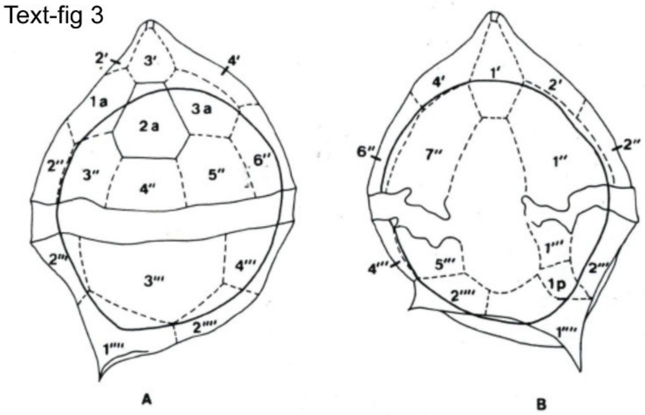
Text-fig 1



Text-fig 2



Text-fig 3



Text-figures 1A, B, 2A, B, 3A, B, Khowaja-Ateequzzaman et al. (1992).

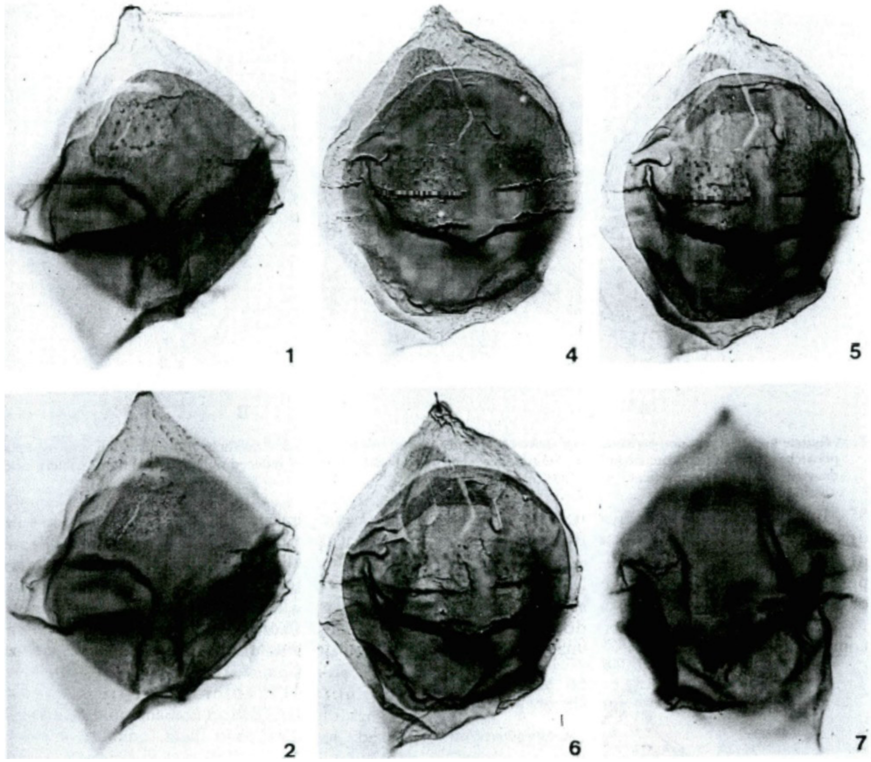


Plate 1, figures 1–7, Khowaja-Ateequzzaman et al. (1992).

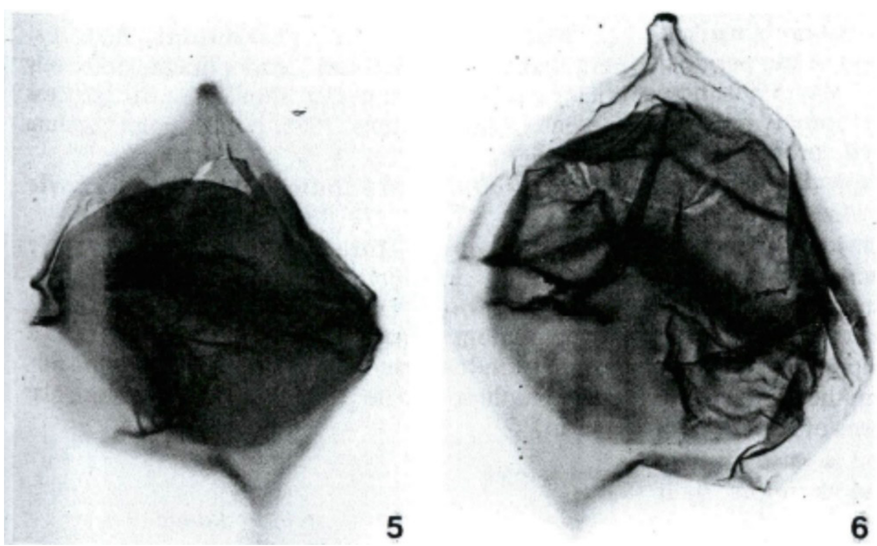


Plate 2, figures 5–6, Khowaja-Ateequzzaman et al. (1992).

Alterbidinium pentangulare (Vasilyeva in Andreeva-Grigorovich et al., 2011) Williams & Fensome, 2016

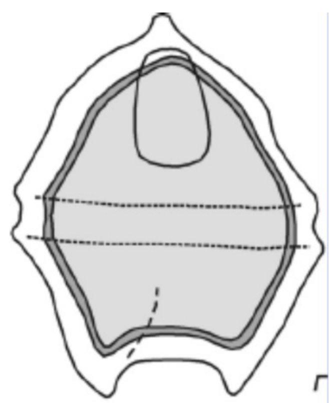
Diagnosis: "Peridinioid circumcavate pentagonal cyst of intermediate size. Endocyst pentagonal, almost duplicates pericyst shape. Periphragm dense, lightly coloured. Periarcheopyle elongate, rounded, hexagonal. Perioperculum attached. Paracingulum clear, wide furrow. Parasulcus marked by weak folds of periphragm on hypocyst ventral side." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 44)

Description: “The pericyst is symmetrical, distinct pentagonal shape. The epicyst is somewhat longer than the hypocyst. Lateral sides of the epicyst almost straight, with pronounced transient ‘shoulders’. Hypocyst symmetrical, with straight lateral sides, and protrusion between antapical horns. Endocyst with a clear pentagonal shape, repeats the shape of the pericyst. The periphragm is dense, granular, transparent. Endophragm dense, thick, darker than the periphragm, with diffuse hillocks. Endophragm surfaces are rare with large inclusions of a boundary material. The ambitus is very narrow, sustained over the entire perimeter of the cyst. Epitheca and hypotheca absent. Paracingulum fuzzy. Archeopyle elongated, hexagonal, intercalary type Ia (2a) or combined intercalary precingular type: 2a, 4''. Parasulcus has just been designated as a pair thin short folds of the periphragm on the ventral side of the hypocyst.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 44)

Dimensions: “(μm). Holotype: pericyst length, 68.2; pericyst width, 55.4; endocyst length, 64.3; endocyst width, 52.6; width paracinglum, 5.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 44)

Comparison: “Distinguished from other representative of the genus *Alterbidinium* by the distinct symmetrical shape of the pericyst, pentagonal endocyst, and narrow retained ambitus.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 44)

Age: early Eocene (Ypresian); holotype as translated from Andreeva-Grigorovich et al. (2011, p. 100, text-fig. 18d, pl. 11, fig. 10) by subsequent designation of Williams & Fensome (2016, p. 138). Range: early Eocene (Ypresian) (translated from Vasilyeva in Andreeva-Grigorovich et al., 2011, p. 44).



Text-figure 18d, Vasilyeva in Andreeva-Grigorovich et al. (2011)

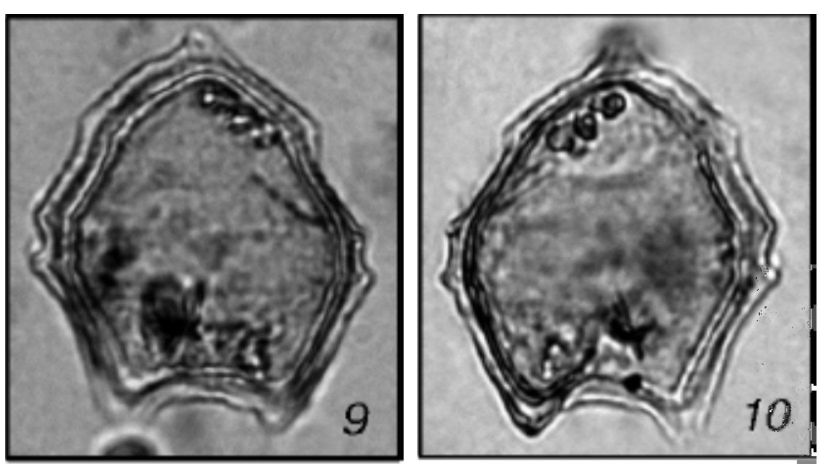


Plate 11, figures 9, 10, Vasilyeva in Andreeva-Grigorovich et al. (2011)

?*Alterbidinium pentaradiatum* subsp. ***pentaradiatum*** (Cookson & Eisenack, 1965c) Lentin & Williams, 1985

Description: "Shell rather flat, somewhat longer than broad, with five ± deeply concave sides. Apical and antapical horns strongly developed; apical horn bluntly pointed; antapical horns parallel to or divergent from one another and sharply pointed. Lateral projections broad and blunt with a faintly developed notch resulting from the girdle. Wall of shell thin, smooth or with fine longitudinal striae, especially in the vicinity of the girdle (Pl. 18, fig. 2), composed of dot-like thickenings. Girdle circular, marked by two low, narrow ridges. Longitudinal furrow relatively broad, bounded by ± clearly marked curved ledges. In the mid-line of the ventral surface slightly below the ends of the girdle a curved slit (Pl. 18, fig. 1) with thickened edges indicative of a flagella-pore is evident in well-preserved specimens. The capsule, while roughly oval in outline, tends to follow the outline of the shell itself; its wall is unthickened and finely, and usually faintly, granular. The archeopyle is trapezoidal with rounded corners and extends from near the girdle to beyond the base of the apical horn." — Cookson & Eisenack (1965c, p. 139, 140)

Dimensions: "Holotype: overall length 162 μ; overall width 128 μ; capsule 86 × 95 μ; Range: overall length 159–171 μ; overall width 116–130 μ; capsule length 76–97 μ, width 82–96 μ." — Cookson & Eisenack (1965c, p. 140)

Age: Paleocene; holotype of Cookson & Eisenack (1965c, p. 139).

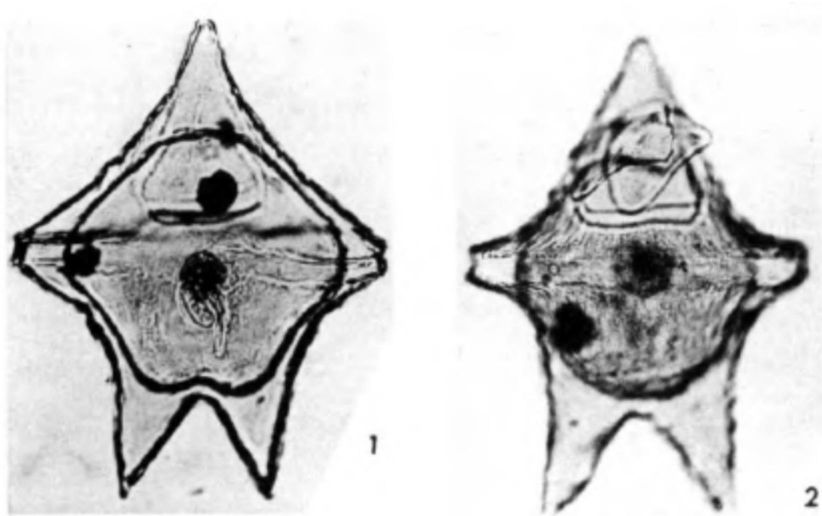


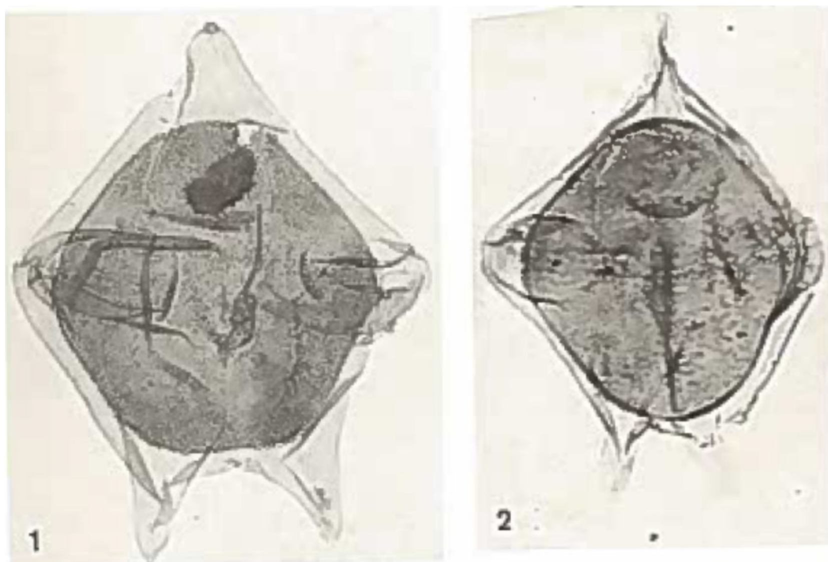
Plate 18, figures 1, 2, Cookson & Eisenack (1965c)

?*Alterbidinium pentaradiatum* subsp. ***precedum*** (Cookson & Eisenack, 1974) Lentin & Williams, 1985

Diagnosis: "Subspecies of *D. pentaradiata* with the following peculiarities: Periphragm thin, smooth, only occasionally (e.g. in the type on the left edge of the picture) finely, hardly noticeably punctured. Apical horn with a small, button-like protuberance, lateral horns less pronounced, rounded, i.e. without indentation. Girdle present, bordered by folds, but more obscure than in *D. pentaradiata*. Antapical horns further apart than there and less pointed. Endophragm, as in the parent species, following the outer involucre at a considerable distance, but thicker than in that, and granulated strongly and densely. Archaeopyle trapezoidal as in *D. pentaradiala*. Flagellar mark as a fine linear gap between the ends of the belt." — Translated from Cookson & Eisenack (1974, p. 49)

Dimensions: "Holotype: periphragm, 192 × 152 µ; endophragm, 118 × 118 µ; archaeopyle: 42 × 47 µ. The other two specimens measure: 173 × 123 µ and 147 × 138 µ." — Translated from Cookson & Eisenack (1974, p. 49)

Age: Paleocene; holotype as translated from Cookson & Eisenack (1974, p. 49).



Plates 20, figures 1, 2, Cookson & Eisenack (1974)

Alterbidinium pilosum (Davey, 1969) Lentin & Williams, 1985

Diagnosis: "Fusiform test having a thin outer wall which bears minute hairs and granules. Apical horn stout, blunt or rounded distally; single antapical horn asymmetrically placed, conical. Inner body large, in contact with the outer wall except in the apical and antapical regions. Cingulum moderately well developed, almost circular, broken by a sulcus which extends to the apex. Archaeopyle intercalary, the operculum typically remaining in position." — Davey (1969, p. 9)

Description: "The minute hairs and granules are not densely arranged and are not aligned. The hairs are often stouter along the borders of the cingulum and may here be termed spines. The operculum is usually attached to the test along its antapical margin and thus remains in position. An interesting feature is that this species is scarcely stained by safranin." — Davey (1969, p. 9)

Dimensions: "Holotype: overall length 57 µ, width 46 µ, inner body 38 by 42 µ. Range: overall length 55(58.4)61 µ, width 38(42.0)45 µ. Number of specimens measured, 10." — Davey (1969, p. 9)

Remarks: "The overall form and the nature of the ornamentation easily distinguish *D. pilosa* sp. nov. from all previously described species." — Davey (1969, p. 9)

Age: Late Cretaceous (Campanian–Maastrichtian); holotype of Davey (1969, p. 9).

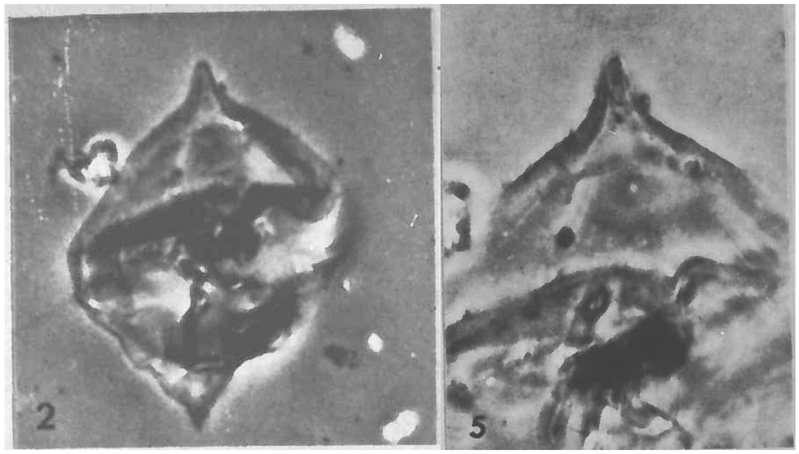


Plate 3, figures 2, 5, Davey (1969)

Alterbidinium prominense (Vasilyeva in Andreeva-Grigorovich et al., 2011) Williams & Fensome, 2016

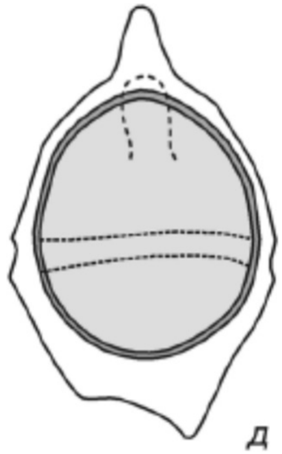
Diagnosis: "Peridiniod circumcavate oval cyst small to intermediate size. Apical horn pyramidal, comparatively prominent, narrow. Left antapical horn well developed, of wide triangular shape. Endocyst rounded-oval. Periphragm smooth, thin, dense, transparent. Endophragm more dense, smooth or weakly scabrate. Periarcheopyle wide-hexagonal, intercalary or intercalary-precingular. Perioperculum attached. Paracingulum expressed by prominent furrow and thin fold of periphragm. Parasulcus not expressed." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 45)

Description: "The pericyst is round-oval in shape. Epicyst in length approximately equal to the hypocyst. Epicyst round shape with protrusion in the form of a pyramid with an apical horn. Sometimes the hypocyst is observed 'shoulders' in the form of an insignificant overhang. Hypocyst asymmetric, trapezoidal shape, with a well-developed left antapical horn, having the shape of a wide triangle. Right antapical horn is significantly reduced, fixed or not expressed. The endocyst is round-oval, round-pentagonal. Paraphrase comparatively dense, smooth or smooth rough. Endophragm dense, hummocky-shaggy. On the surface of the endophragm, the inclusion is observed organic material in the form of separate hillocks. The ambitus is comparatively narrow, expanding only in the area of the hypocyst. Periarcheopyle relatively wide, hexagonal shape, intercalary or intercalary precinct. Participation in the formation of the periarcheopyle plates Ia or 2a. Attached is the periphragm. Paracingulum is represented by double wide sulcus, usually well-raised, sometimes a more smooth, and also thin folded periphragm. Parasulcus is not expressed." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 45)

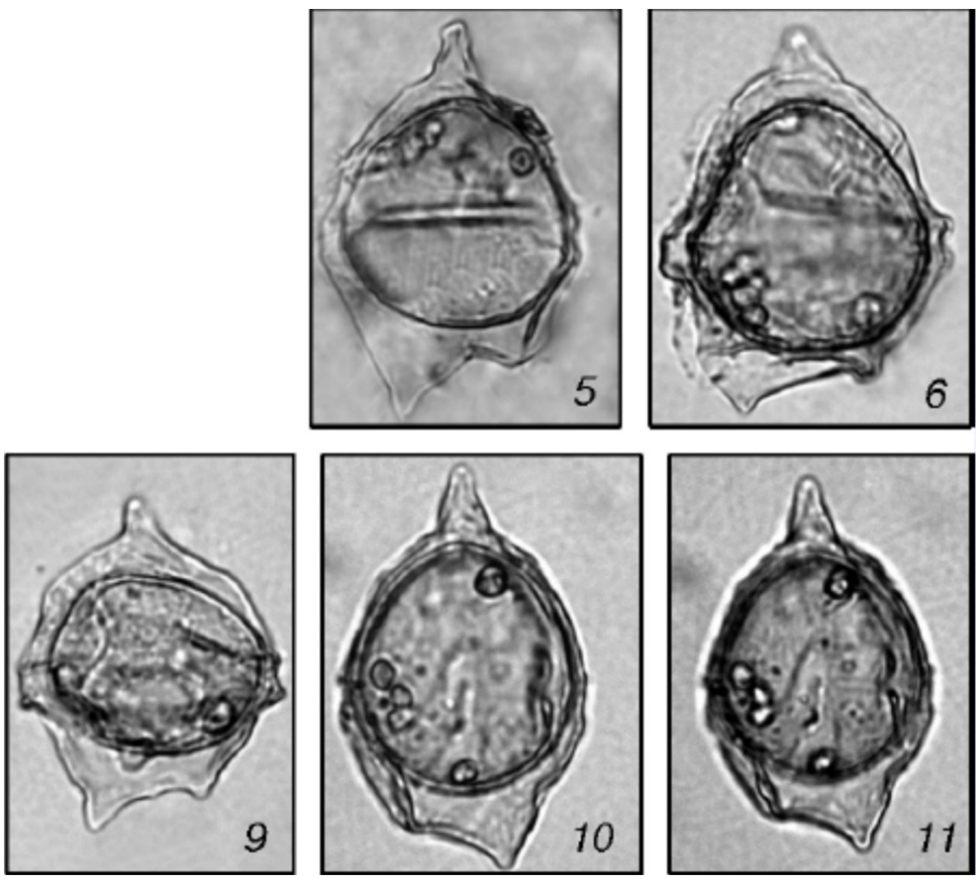
Dimensions: "(μm) Holotype: pericyst length, 58; pericyst width, 56; endocyst diameter ,44. Other specimens (3 specimens): pericyst length, 60–55; pericyst width, 58–55; endocyst length, 50–43; endocyst width, 50–42." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 45)

Comparison: "This species is comparable with *Alterbidinium compactum* sp. nov., but is distinguished by a narrow extruded pericyst, the shape of the apical horn, and structure of the hypocyst." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 45)

Age: early-middle Paleocene (Danian–Selandian); holotype as translated from Andreeva-Grigorovich et al. (2011, p. 102, text-fig. 18e, pl. 12, figs. 10, 11) by subsequent designation of Williams & Fensome (2016, p. 139). Range: early-middle Paleocene (Danian–Selandian) (translated from Vasilyeva in Andreeva-Grigorovich et al., 2011, p. 45)



Text-figure 18e, Vasilyeva in Andreeva-Grigorovich et al. (2011).



Plates 12, figures 5, 6, 9–11, Vasilyeva in Andreeva-Grigorovich et al. (2011).

Alterbidinium pseudocirculum (Vasilyeva in Andreeva-Grigorovich et al., 2011) Williams & Fensome, 2016

Diagnosis: “Peridinioid circumcavate elongate-oval cyst of intermediate to large size. Apical horn conical, top rounded off. Left antapical horn usually well developed, right one reduced. Endocyst rounded to oval. Periphragm thin, smooth, transparent. Endophragm thin, more dense, smooth or lightly scabrate. Periarcheopyle hexagonal of intercalary or intercalary-precingular type. Paracingulum poorly defined by flat furrow and low folds. Parasulcus not indicated.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 46)

Description: “The pericyst is longitudinal-elongated, round-pentagonal. The epicyst is approximately equal in length to the epicyst. Lateral sides of the epicyst slightly convex, without protohorns, ‘shoulders’. Apical horn moderately protruding, the top of it rounded; sometimes with a short spine. Hypocyst with slightly curved sides, asymmetrical. Antapical horns of different lengths; well-developed left antapical horn, sharpened, the right one is significantly reduced. The top of the right horn is smooth, rounded. Endocyst almost round, sometimes round-oval, large, occupies central position in the cage. The periphragm is thin, transparent, smooth, dense, does not crease into folds. Endophragm thin, smooth or vaguely rough, a little more dense and dark than the periphragm. Sometimes on the endophragm, organic material in the form of round grains occurs. The ambitus is well defined, not wide, occasionally narrowing significantly in the region of the cingulum and the side parts of the pericyst, so that the epitheca and hypotheca are practically in contact. The periphragm is slightly protruding, round-hexagonal, of intercalary or combined intercalary precingular type. Attached is the periphragm. Endoarcheopyle is round hexagonal. Endoperculum attached. Parametrically expressed slightly adjoining weakly curved wide sulcus and thin, short sulcus bounded by single or double fold periphragm. Parasulcus is not expressed.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 46)

Dimensions: “(μm). Holotype: pericyst length,71.2; pericyst width, 45; endocyst diameter, 45.0–44.2. Other specimens (3 specimens): pericyst length, 75.2–69.4; pericyst width, 50.0–43.2; endocyst length, 46.2–43.4; endocyst width, 45.2–43.0.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 46)

Comparison: “It differs from the morphologically closely related species *Alterbidinium circulum* Rogov, in the shape of the hypocyst (there is no characteristic for *A. circulum* notch on the side of the shortened antapical horn) and the shape of the epicyst (at *Alterbidinium pseudocirculum* sp. nov. the absence of ‘shoulders’) in being more narrow. In other words, a significantly ill-smoothed form of paracynglum.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 46)

Age: early-middle Paleocene (Danian–Selandian); holotype as translated from Andreeva-Grigorovich et al. (2011, p. 100, text-fig. 18f, pl. 11, figs. 23, 24) by subsequent designation of Williams & Fensome (2016, p. 139). Range: early-middle Paleocene (Danian–Selandian) (translated from Vasilyeva in Andreeva-Grigorovich et al., 2011, p. 46)

Text-figure 18f, Vasilyeva in Andreeva-Grigorovich et al. (2011).

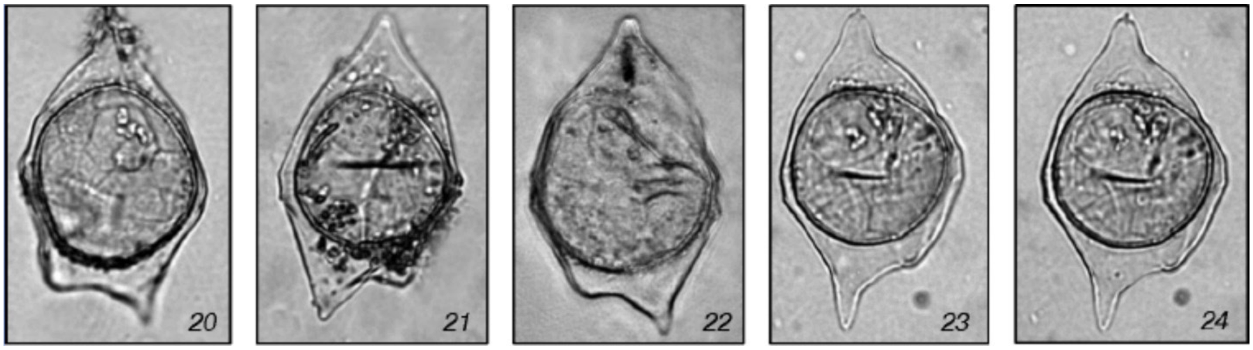


Plate 11, figures 20–24, Vasilyeva in Andreeva-Grigorovich et al. (2011).

Alterbidinium recticorne (Vozzhennikova, 1967) Harker & Sarjeant in Harker et al., 1990

Description: “Epitheca triangular, with straight slightly convex or somewhat concave lateral walls and with a short, slender apical horn bluntly rounded at the tip. Hypotheca trapeziform, with one long and one short antapical horn both of which are acutely pointed. The short horn is often absent and where it would occur the hypotheca is rounded or truncated. Transverse furrow shallow, equatorial, annulate, from its ends the longitudinal furrow runs towards the antapex. Internal body broadly rhomboid or similar in form to the theca, thin walled, with a smooth or finely granular surface. Thecal surface smooth or finely granular. Pilome triangular, its angles [horns] rounded or bluntly truncated.” — Vozzhennikova (1967, p. 245, 246, translation: Lees & Sarjeant, 1971)

Dimensions: “In microns: holotype, length of theca: 91.8, breadth 54.0, width of transverse furrow 5.4, length of internal body 56.7, breadth 45.2. In other specimens: length of theca 65–82, breadth 45–50, width of transverse furrow 5.4, length of internal body 52.0–56.1, breadth 40.0–42.0.” — Vozzhennikova (1967, p. 246, translation: Lees & Sarjeant, 1971)

Comparison: “This species differs from *A. curvicornis* in having a straight acutely pointed long horn and in the shape of its theca.” — Vozzhennikova (1967, p. 246, translation: Lees & Sarjeant, 1971)

Age: Late Cretaceous (Turonian); holotype by implication of Lentin & Vozzhennikova (1990, p. 32, text-fig. 13b).

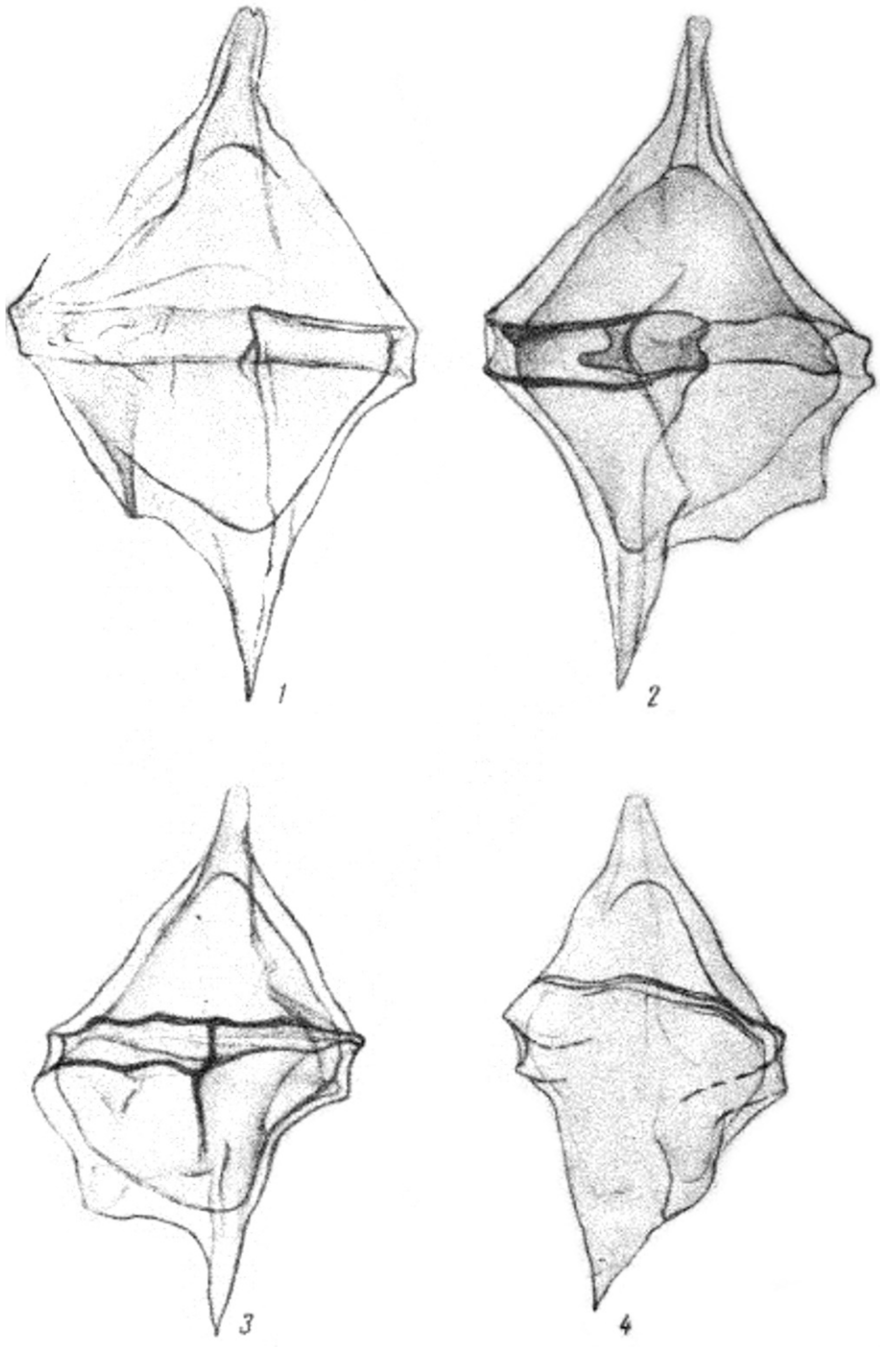


Plate 77, figures 1–4, Vozzhennikova (1967).

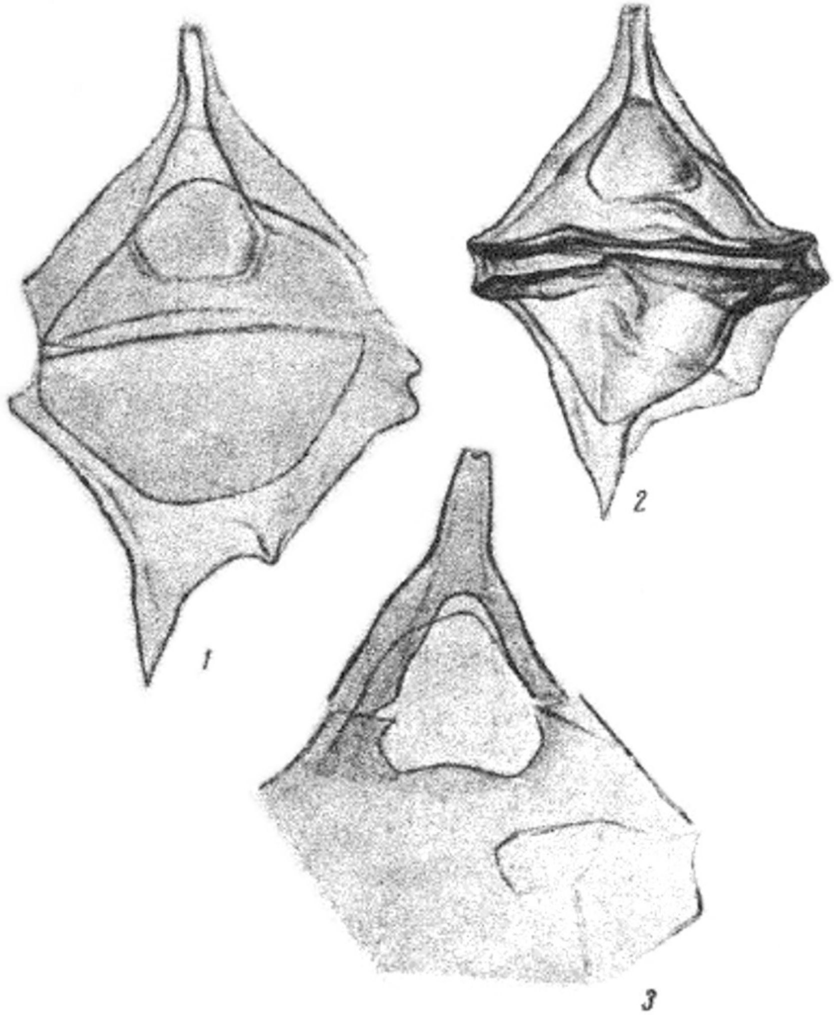


Plate 78, figures 1–3, Vozzhennikova (1967).

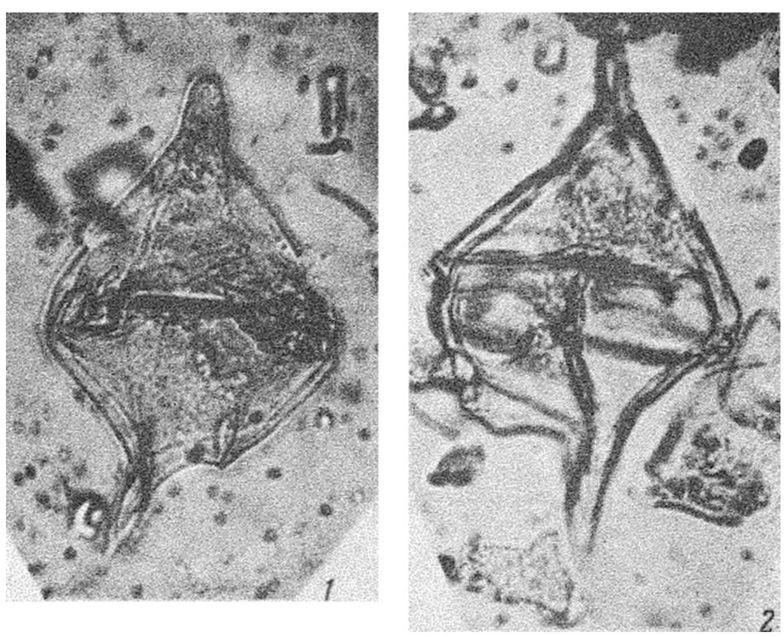


Plate 79, figures 1, 2, Vozzhennikova (1967).

Alterbidinium rugulum Iakovleva & Kulkova, 2001

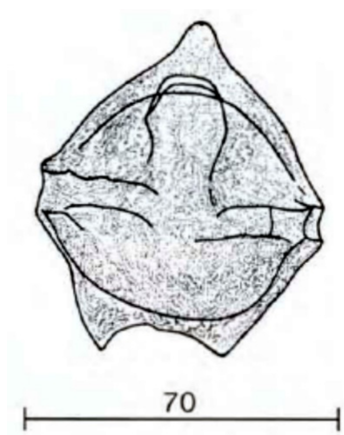
Diagnosis: “A species of *Alterbidinium* Lentin & Williams 1985 which is characterised by rugulate surface of periphragm and endophragm. The cyst is circumcavate. The apical and antapical horns are reduced, and the antapical horns are symmetrical. The peri-archaeopyle is of intercalary-precingular type. The paraplate 2a is hexa-thetaform.” — Iakovleva & Kulkova (2001, p. 16)

Description: “The cysts [sic] is peridiniacean circumcavate: the periphragm and the endophragm are rugulate. The epicyst has a triangular shape: an apical horn is reduced with a truncated apex. The antapical horns are symmetrical and reduced. The paracingulum is clearly visible by elevations of periphragm. The endocyst is oval. The archaeopyle is intercalary-precingular of the type Ia(2a); the shape of pylome is hexa-thetaform.” — Iakovleva & Kulkova (2001, p. 16)

Holotype dimensions: “Length of pericyst: 81.6 μm; width of pericyst: 63.7 μm; length of endocyst 58.7 μm; width of endocyst: 51 μm; width of paracingulum: 7.65 μm.” — Iakovleva & Kulkova (2001, p. 16)

Remarks: “The species *Alterbidinium rugulum* differs from another species of genus *Alterbidinium* (especially *Alrerbidinium circulum*) in the rounded shape, the rugulate surface of the wall and in the symmetry of the antapical horns.” — Iakovleva & Kulkova (2001, p. 16)

Age: earliest Eocene (earliest Ypresian); holotype of Iakovleva & Kulkova is right at the base of the Ypresian at 156 m depth (2001, p. 16, fig. 7). Range: early Eocene (earliest Ypresian) (Iakovleva & Kulkova, 2001, p. 16, fig. 4)



Text-figure 10, Iakovleva & Kulkova (2001).

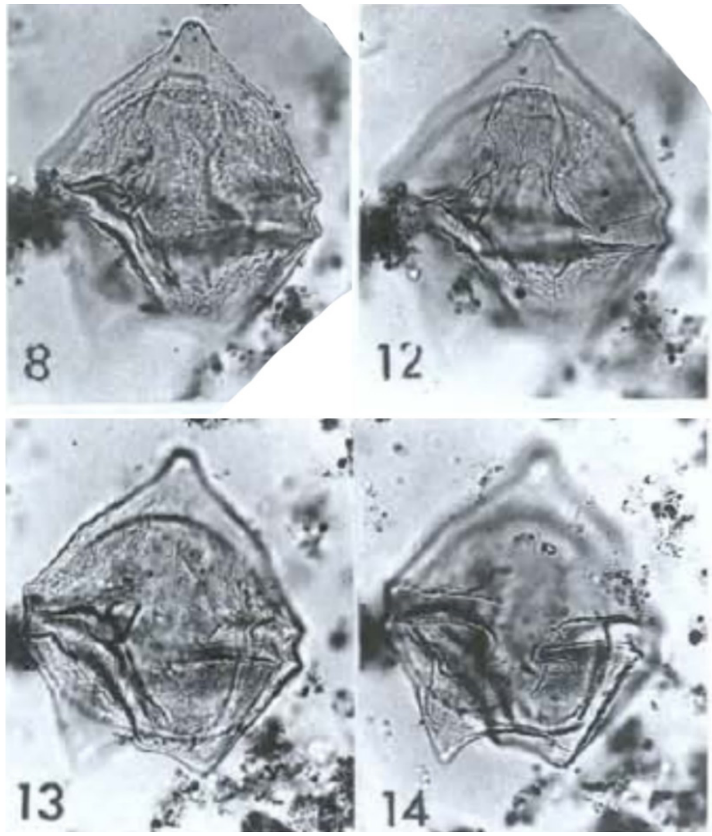


Plate 8, figures 8, 12–14, Iakovleva & Kulkova (2001).

Alterbidinium saltanovae (Vasilyeva in Andreeva-Grigorovich et al., 2011) Williams & Fensome, 2016

Diagnosis: "Peridinioid circumcavate rounded-oval cyst of intermediate to large size. Left antapical horn well developed, right horn reduced. Endocyst large, rounded-pentagonal, oviform, and extends the most part of cyst. Periphragm thin, smooth, transparent. Endophragm dense, thick, coarse granular. Periarcheopyle round hexagonal, intercalary. Perioperculum attached. Parasulcus marked by wide folds." — Andreeva-Grigorovich et al. (2011, p. 47)

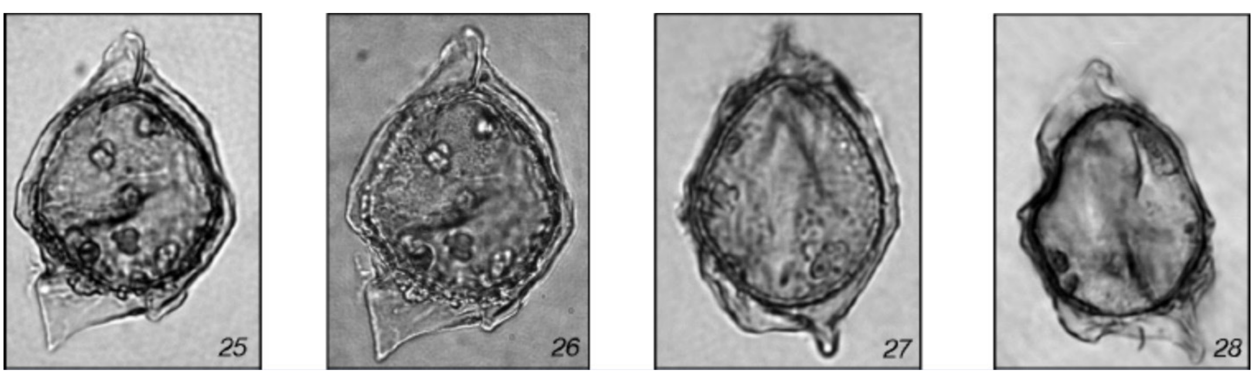
Description: "The pericyst is round-oval, slightly pentagonal in shape. The epicyst is slightly longer or equal to the hypocyst in length. Epicyst has convex sides, barely noticeable bends or 'shoulders'. Apical horn is slightly retracted, rounded, with a short spine at the top. Hypocyst with slightly concave lateral sides, significantly narrowing to the antapical horns. The left antapical horn is well developed, usually drawn out, pointed. Right antapical horn in significant degrees reduced, rounded. The periphragm is thin, dense, transparent, light, fine-grained. Endocyst large, round-oval, ovoid; occupies almost the entire space of the cyst. Endophragm dense, thick, unevenly coarse-grained, more dark and rough than the periphragm. On the surface of the endophragm, there is an observed inclusion of a limited material in the form of round spots; coarse grains concentrated on the fields. The ambitus is distinct, narrow. Epitheca and hypotheca slightly expanded. Paracingulum protrudes slightly on the lateral sides of the cyst where there is a weakly flexible wide groove; sometimes indicated parasutural thin suture. Parasulcus is expressed in a wide fold on the ventral side of the cyst. Periarcheopyle intercalary or combined intercalary-precingular type. Perioperculum attached. The periphragm usually includes plates Ia (2a), in the form round-hexagonal, slightly elongated. Paratabulation is expressed in forms periarcheopyle, paracingulum, parasulcus." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 47)

Dimensions: “(μm). Holotype: length of the pericyst, 73; pericyst width 51; endocyst length 46; endocyst width 45. Other specimens (2 specimens): length of the pericyst, 79.0–70.2; pericyst width 56–47; endocyst length 47–45; the width of the endocyst is 46–45.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 47)

Comparison. “*Alterbidinium saltanovae* shows signs of similarity with the species *Alterbidinium circulum* (Heilmann-Clausen, 1985) Lentin et Williams, 1986, but differs in proportions. The endocyst is of smaller diameter with a comparatively wider pericyst.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 47)

Age: early-middle Paleocene (Danian–Selandian); holotype as translated from Andreeva-Grigorovich et al. (2011, p. 100, text-fig. 18g, pl. 11, figs. 25, 26) by subsequent designation of Williams & Fensome (2016, p. 139). Range: early-middle Paleocene (Danian–Selandian) (translated from Vasilyeva in Andreeva-Grigorovich et al., 2011, p. 45)

Text-figure 18g, Vasilyeva in Andreeva-Grigorovich et al. (2011).



Plates 11, figures 25–28, Vasilyeva in Andreeva-Grigorovich et al. (2011).

Alterbidinium simplex (Vasilyeva in Andreeva-Grigorovich et al., 2011) Williams & Fensome, 2016

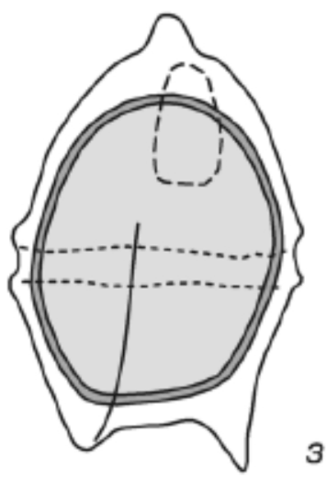
Diagnosis. “Peridinioid circumcavate cyst of intermediate size. Pericyst of oval, pentagonal shape. Left antapical horn developed longer or antapical horns almost equal. Apical horn quite small. Endocyst large oval-pentagonal shape. Pericoel narrow. Periphragm dark coloured, dense, granulated. Periarcheopyle wide, hexagonal, of intercalary type. Perioperculum attached. Paracingulum distinct, broad. Parasulcus marked by large folds of periphragm." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 48)

Description: "Pericyst oval-pentagonal shape. The epicyst length is equal to that of the hypocyst. Epicyst with round sides without bends. The apical horn protrudes weakly, its apex is blunt. Antapical horns can be almost equal in length or left antapical horn can be somewhat more developed. Endocyst large, elongated, oval-pentagonal. The periphragm is quite dense, indistinctly granular, transparent. The endophragm is very dense, thick, more dark than the periphragm. The ambitus is well expressed, narrow. Paracingulum clear with pronounced, wide sulcus with significantly raised edges and thin sutures on the periphragm. The periarcheopyle is wide, round-hexagonal, intercalary type. Attached is the periphragm. Parasulcus expressed in two large folds on the periphragm." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 48)

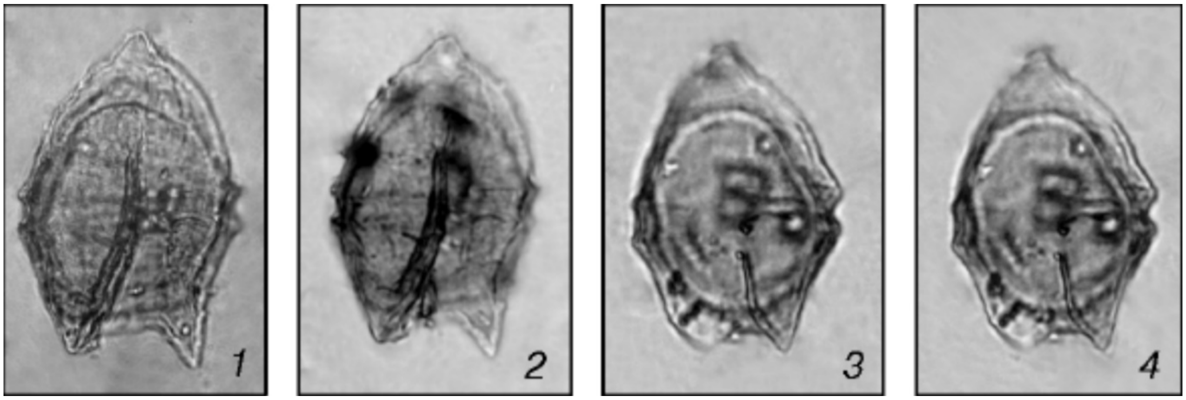
Dimensions: "(μm) Holotype: pericyst length, 59.4; pericyst width, 42.9; endocyst length, 46.2; endocyst width, 36.3; endophragm thickness, 3.5; paracingium width 5. Other specimens (3 specimens): pericyst length, 60.2–58.5; pericyst width, 43.0–42.6; endocyst length, 45.4–44.8; endocyst width, 38–36." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 48)

Comparison: "Differs from other species of *Alterbidinium* in its oval, prolate pericyst shape, dense oval-pentagonal endocyst and attached cingulum with a deep furrow." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 48)

Age: late Paleocene (Thanetian); holotype as translated from Andreeva-Grigorovich et al. (2011, p. 102, text-fig. 18h, pl. 12, figs. 1, 2) by subsequent designation of Williams & Fensome (2016, p. 139). Range: late Paleocene (Thanetian)–early Eocene (Ypresian) (translated from Vasilyeva in Andreeva-Grigorovich et al., 2011, p. 48)



Text-figure 18h, Vasilyeva in Andreeva-Grigorovich et al. (2011).



Plates 12, figures 1–4, Vasilyeva in Andreeva-Grigorovich et al. (2011).

Alterbidinium subtile (He Chengquan in Zheng Yahui & He Chengquan, 1984) Lentin & Williams, 1989

Description: "The body is nearly round-elliptical, longer than wide, flattened on the venter, more or less outward. The cyst is divided into two parts of unequal size by the transverse groove. The epitheca is generally larger than the hypotheca, conical-bell-shaped, with convex sides, with or without a short apex, cylindrical, 2–4.5 μ long, end with apical hole, 1.5–4 μ in diameter. Hypotheca inverted trapezoid, side flat, straight or slightly convex, the base is almost straight, with two small caudal horns far apart; the size is different, the larger one is 2–5.3 μ long, the end is blunt. Small cysts usually degenerate into a convex shape. Transversely shallow cingulum located at the widest part of the cyst, ring-shaped, 7–8 μ wide, bounded by smooth fine ridges. Vertical grooves are generally blurred. Except for the archaeopyle, there is no reflected tabuation. Thin cyst wall, two layers of sparse, fine granules on the surface of the outer wall. Or subsmooth, inner body weak, often wrinkled along the margin, almost completely filling the outer wall except at the base of the apex and antapex. Operculum is front style, nearly hexagonal, longer than wide. It is represented by the crack of the main archaeopyle. The operculum is in place, or with yellow-green nuclei." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 90, 91)

Dimensions: "Cyst length 48–63 μ, width 37.1–53 μ (15 specimens measured); holotype length 57 μ, width 48 μ, apex angle length up, tail angle length about 2.5 μ." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 91)

Age: Late Cretaceous (Campanian); age of the material ergo the holotype as translated from the abstract of Zheng Yahui & He Chengquan (1984, p. 55).

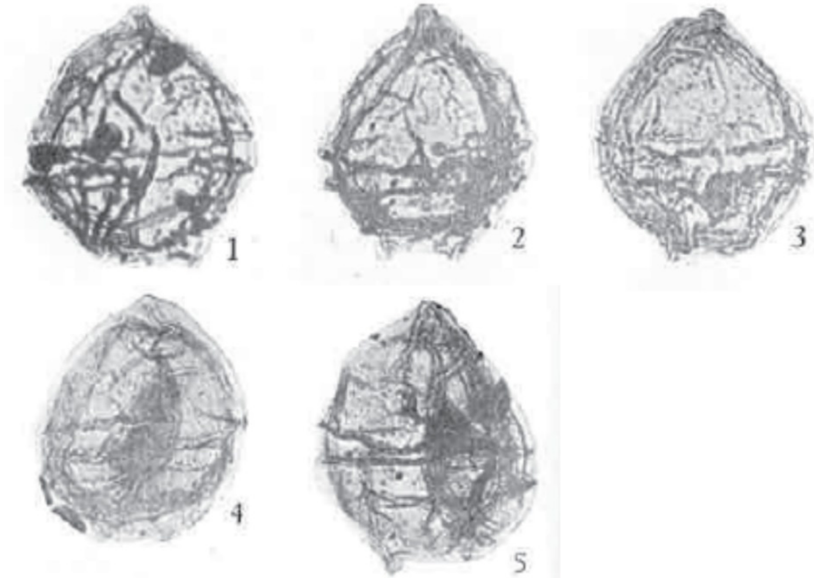


Plate 6, figures 1–6, He Chengquan in Zheng Yahui & He Chengquan (1984).

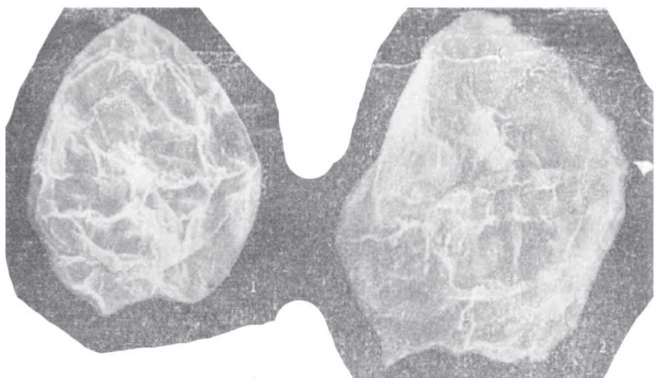


Plate 10, figures 1, 2, He Chengquan in Zheng Yahui & He Chengquan (1984).

?*Alterbidinium ulloriaq* Nøhr-Hansen, 1996

Description: "Cyst type: circumcavate to cornucavate. Shape: star-like: dorso-ventrally compressed elongate pericyst with 3 horns and an extended cingulum. The shape of the endocyst is ellipsoidal to spherical, and equatorially centred. The apical horn is broad based, elongate and often broken distally, as illustrated on the holotype. The two, more or less equal antapical horns are also relatively broad based, elongate, with a blunt to point tip. The angle between the base of the antapical horns is usually 90° or more. The lateral extension of cingulum are [sic] short (4–10 μm), with weak indented termination. Wall relationship: the cyst is composed of a smooth to scattered granulate pericyst and endocyst. Both pericyst and endocyst and rather thin-walled and almost hyaline. Tabulation: paratabulation is indicated by the archaeopyle and the pronounced cingulum. Granulate on the surface of the pericyst occasionally occur in rows indicating a peridinioid tabulation pattern and defining the cingulum. Archeopyle: periarcheopyle intercalary (2a) steno- to iso-deltaform, operculum free. The form of the endoarchaeopyle seems to be broader and not as elongate as the periarcheopyle, the exact form is difficult to distinguish (Plate 14, Fig. 7, 12), the endoarcheopyle is most likely of type I." — Nøhr-Hansen (1996, p. 28)

Dimensions: "Holotype: length of pericyst 104 μ (tips of apical and antapical horns broken), width of pericyst 76 μ, width of endocyst 58 μ, length of endocyst 51 μ; length of pericyst 108 (120) 132 μ (2 specimens), width of pericyst 68 (75) 84 μ (10 specimens), length of endocyst 47 (53) 59 μ (10 specimens), width of endocyst 57 (60) 68 μ (10 specimens), length of apical horn 10 (11) 12 μ (14 specimens)." — Nøhr-Hansen (1996, p. 28)

Discussion: "The combination of the characteristic star-like shape of the cyst and a 2a archeopyle may indicate that this new species represents a new genus. The species has questionably been placed in the genus *Alterbidinium* due to the presence of a 2a hexa periarcheopyle shape is one of the characteristics for the genus *Alterbidinium* (Khowaja-Ateequzzaman et al., 1991). The shape of the periarcheopyle in the new species *A.*? *ulloriaq* may suggest a placement in the genera *Cerodinium* or *Deflandrea*; the two genera have an iso-deltaform (*C.*) or lati-deltaform (*D.*) periarcheopyle (Lentin & Williams, 1987). However, the presence of the distinct lateral extension of the cingulum differentiates the new species from previously described species of the genera *Cerodinium* or *Deflandrea*. The distinctive outline of *A.*? *ulloriaq* is similar to the outline of *Muderongia* species, which differ by having an apical archeopyle. The outline of the new species also has some similarities with the genus *Rhombodinium*, however *Rhombodinium* differs by its quadraform archeopyle and by its very reduced or vestigial right antapical horn.

The species *Alterbidinium*? *ulloriaq* sp. nov. has almost the same distinctive outline of the pericyst and almost the same periarcheopyle form as described for *Deflandrea pentaradiatum* (now *Alterbidinium*? *pentaradiatum pentaradiatum*) by Cookson & Eisenack (1965). However, *A.*? *p. pentaradiatum* differs by the shape of the endocyst which is roughly oval in outline or tends to follow the outline of the pericyst, by the surface of the periphragm which is smooth or with fine longitudinal striae, especially in the vicinity of the cingulum, by having almost parallel antapical horns and by the size: length of pericyst 159–171 μ, width of pericyst 116–130 μ, length of endocyst 76–97 μ, width of the endocyst 82–96 μ. Lentin & Williams (1976, p. 49) questionably included the species in the genus *Alterbia* (*Alterbidinium*) and mentioned the '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'.

The questionable placement of the two species with pentaradiate shape in the genus *Alterbidinium*, may advocate the establishment of a new genus. However, the author has not examined the type specimen of *Alterbidinium*? *pentaradiatum pentaradiatum* and the available specimens (10) of *Alterbidinium*? *ulloriaq* are considered too few to erect a new genus." — Nøhr-Hansen (1996, p. 28, 29)

Age: earliest Paleocene (Danian); holotype of Nøhr-Hansen (1996, p. 28, fig. 11) as denoted from the position of Sample 408887.

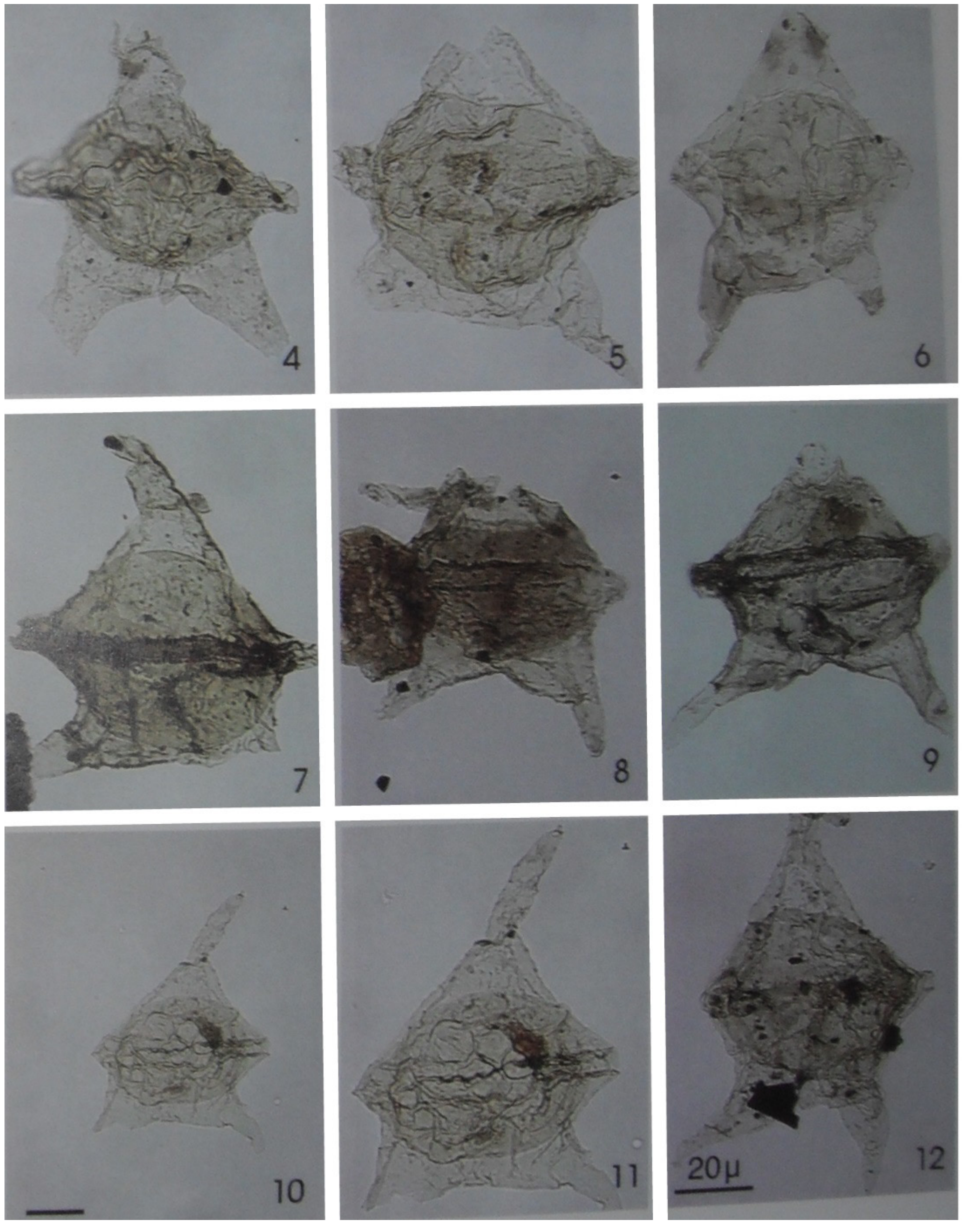


Plate 14, figures 4–12, Nøhr-Hansen (1996).

Alterbidinium varium Kirsch, 1991

Diagnosis: "Circumcavate, smooth cyst with an ovoid, rounded rhomboidal to spheroidal pericyst ambitus, two unequal, poorly developed antapical horns, and a subspheroidal to ellipsoidal endocyst. The variation in overall ambitus is striking. Archaeopyle intercalary (2a); type standard hexa (according to Lenin & Williams, 1976); Posterior operculum adnate." — Translated from Kirsch (1991, p. 98, 99)

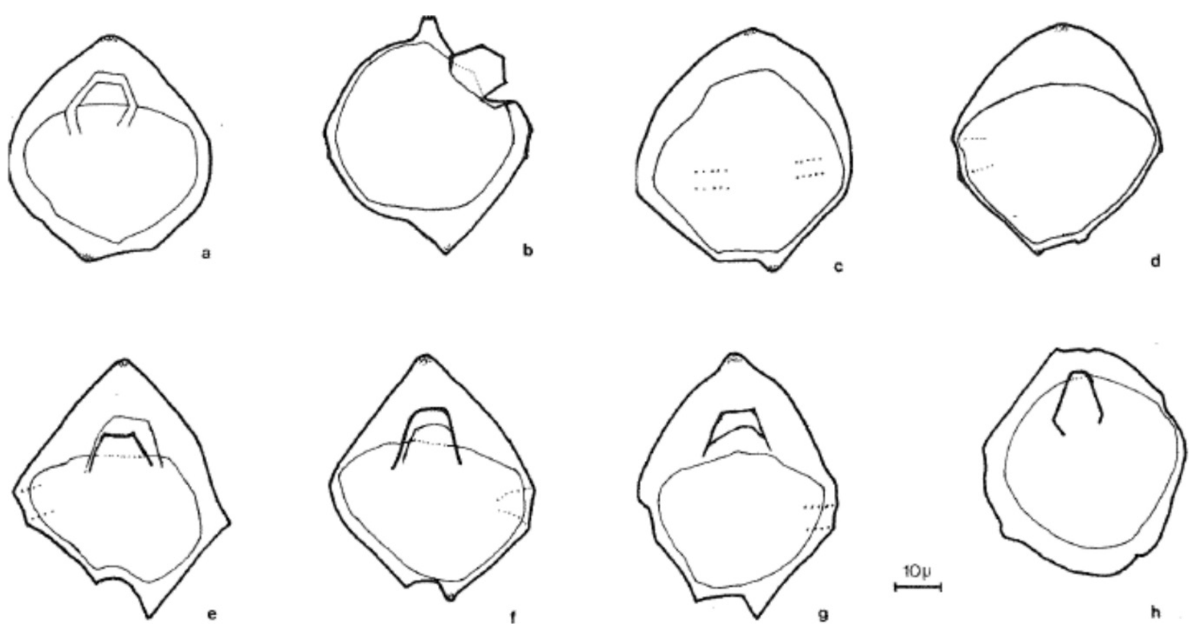
Description: "The slightly larger, ovoid epicyst is characterized by the rounded to slightly conical apex and its convex flanks. The apex may appear broadly blunted or show evidence of a developing process. A clearly distinguishable cingulum is absent. It may be indicated alone by somewhat distinct lateral areas or by faint granulation. The endocyst and pericyst are very thin and smooth. The smaller hypocyst is smooth and characterized by a tapered, longer right antapical horn and a sometimes almost completely reduced second antapical horn. The cysts are often heavily folded ventrally. An intercalary archaeopyle (2a) with standard hexa outline and a posterior adnate operculum can be demonstrated. A certain variability in the side lengths of the archaeopyle form can be observed." — Translated from Kirsch (1991, p. 99)

Dimensions: "holotype: size of endocyst 32 × 38 μ; size of pericyst 50 × 46 μ. Variation: size of the endocyst (L × W) 29–38 × 38–41 μ (rare: length of the endocyst max. 44 μ); size of pericyst 48–54 × 40–46 μ; Length of the antapical processes 2–6 μ." — Translated from Kirsch (1991, p. 99)

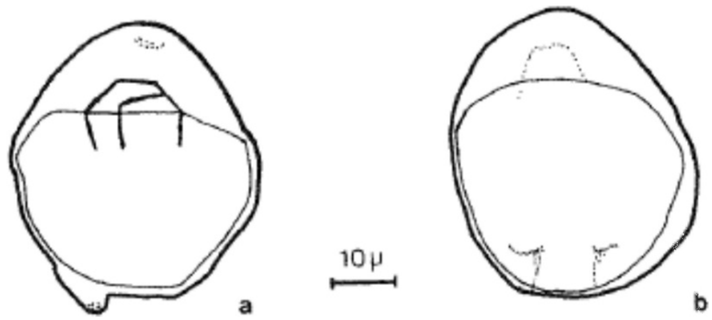
Remarks: "According to the description of the genus *Eurydinium* by Stover & Evitt (1978: 104), it is characterized by the absence of apical and antapical processes. Compared to *Isabelidinium*, the shape of the endocyst is decisive, since it is longer than wide in *Eurydinium*. This material clearly shows that the dimensions of the endocyst are highly variable and that endocyst developed predominantly wider than long. Due to the existing, albeit greatly reduced, antapical processes, this new species is not placed in *Eurydinium*. Forms with almost no antapical processes are still attributed to the variability of this species." — Translated from Kirsch (1991, p. 99)

Comparison: "*Alterbidinium varium* sp. nov. differs from the possibly related species *Alterbidinium minus* (Alberti 1959b) by its predominantly ovoid ambitus, its missing apical horn and cingulum, but which shows a very clearly pentagonal outline. *Ascodinium parvum* (Cookson & Eisenack 1958) has a combination archaeopyle. *Isabelidinium cretaceum* (Cookson 1956) is considerably larger, has no antapical processes and differs in archeopyle form. Compared to the similar species *Eurydinium saxoniense* Marshall & Batten 1988, *Alterbidinium varium* sp. nov. the cingulum is poorly developed, concentric rings around the apex are absent, and the second antapical horn is usually greatly reduced. In addition, *Alterbidinium varium* sp. nov. is a little smaller." — Translated from Kirsch (1991, p. 99)

Age: Late Cretaceous (early Maastrichtian); holotype as translated from Kirsch (1991, p. 98). Range: Late Cretaceous (early Maastrichtian) (Kirsch, 1991, p. 99).



Text-figures 46a–h, Kirsch (1991).



Text-figures 47a, b, Kirsch (1991).

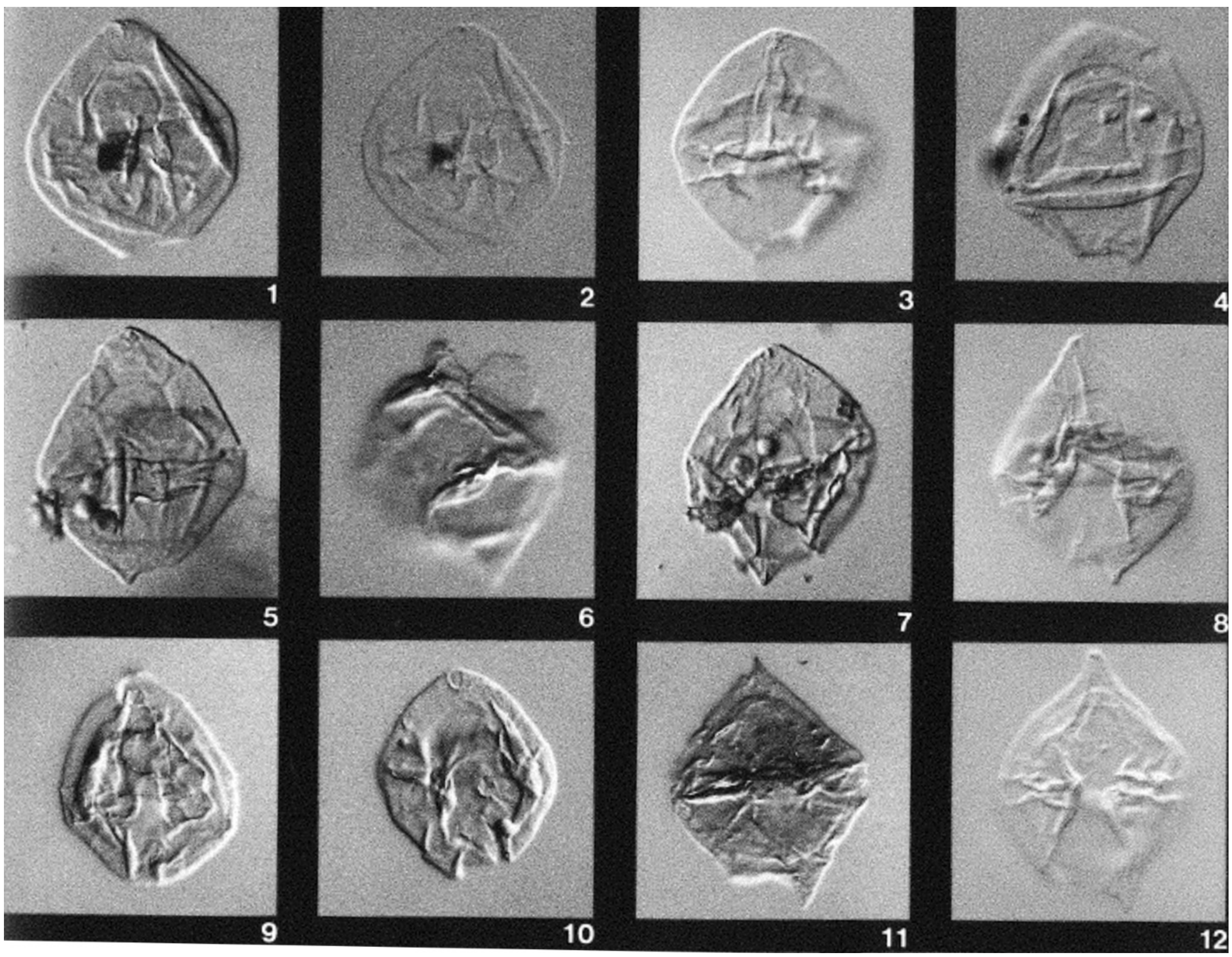


Plate 19, figures 1–10, Kirsch (1991).

Alterbidinium xinjiangense (He Chengquan, 1991) Lentin &Williams, 1993

<u>Description</u>: "The venter and back of the cyst are flat, and the outline of the outer wall is nearly fusiform or nearly pentagonal. The epitheca is slightly larger than the hypotheca shell, nearly isosceles. Angular, with a tapered corner extending from the top, blunt at the top; hypotheca nearly trapezoidal, straight or slightly concave sides, with no antapical horns, ranging in size, the larger ones are longer, conical, usually straight, the end is round, 15–20 μm long, the smaller ones degenerate into a convex shape or smooth steps. The loin is more or less swollen, but lacks side horns. The transverse groove is located at the widest part of the cyst, shallow and flat, with a ring-shape, 6 μm wide, its edges are marked by smooth thin ridges. Longitudinal furrows indistinct or absent. The outer wall is thin and the surface is smooth. Endocyst

relatively close in outline to the outer wall, usually strongly protruding into apical and antapical horn, slightly separated from each other on sides and outer wall or clinging to each other. Together, the inner body surface is smooth. Archeopyle front style, trapezoidal, but the outline is generally vague, and its length is greater than its width." — Translated from He Chengquan (1991, p. 74).

Dimensions: "Cyst length 60–87.5 μm, width 48–60 μm, inner body length 55–72 μm, width 48–60 μm (4 specimens measured). The [holotype?] specimen is 84 μm long, 50 μm wide, the inner body is 67.5 μm long, the 50 μm wide tail horn is 15 μm long, and the transverse groove is 6 μm wide." — Translated from He Chengquan (1991, p. 74).

Comparison: "This new species is characterized by the obvious apical and antapical horns of the inner body, and the obvious unequal size of the two antapical horns. Its shape is similar to *Alterbia curvicornis*, but with a smaller cyst, narrow apical and antapical horns, lack of lateral horns and inner and outer walls. The latter is close to the side of the cyst, and the latter has well-developed lateral horns, and the antapical horn is usually bent into a claw shape, so it is easy to distinguish." — Translated from He Chengquan (1991, p. 74).

Age: late Paleocene (Selandian–early Thanetian?); holotype of He Chengquan (1991, p. 226). Based on the range chart and translated from "lower part of Qimgen Formation" from He Chengquan (1991, p. 73, 226, fig. 4). Also, see Xi Dengpeng et al. (2020, fig. 18).

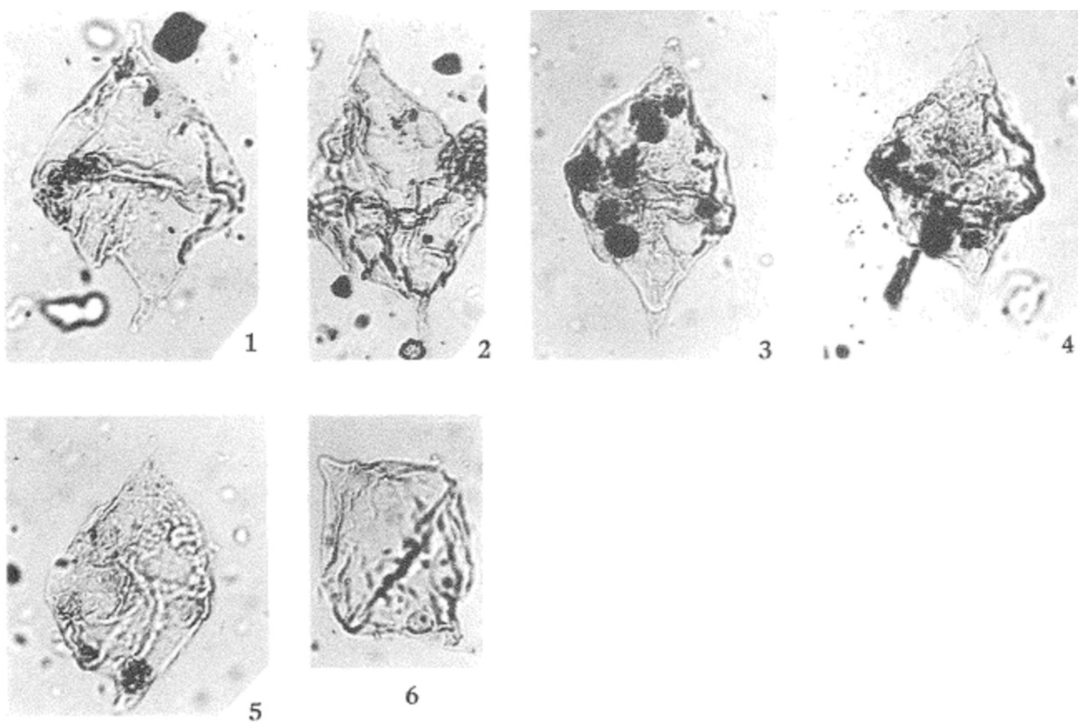


Plate 28, figure 1–6, He Chengquan (1991).

Genus ***CERODINIUM*** Vozzhennikova, 1963

1963 *Cerodinium* Vozzhennikova: 181.
1963 *Ceratiopsis* Vozzhennikova: 181 (illegitimate name).
1987 *Cerodinium* Vozzhennikova; emend. Lentin & Williams: 114.

Cerodinium albertii (Corradini, 1973) Lentin & Williams, 1987

Diagnosis: "Dinoflagellate cyst subpentagonal in outline with smooth, thick-walled inner body and striate-punctated periphragm. One apical and two antapical horns, well developed. Inner capsule subcircular in outline; pericoel antapical. Cingulum well defined; sulcus broad. Archeopyle intercalary." — Corradini, 1973 (p. 174)

Description: "The test is flattened dorsoventrally, showing the periphragm with a subpentagonal outline. Epitractal sides usually convex, hypotractal ones straight or concave. Apical and antapical horns tapering gradually from the bases to the apex, the former distally blunted, the latter normally acuminate. The length of the horns is approximately equal. The antapical horns are well separated, their axes being straight or slightly diverging. The inner capsule, smooth or slightly granular, is closely appressed to the periphragm of the epitract, except at the horn. On the contrary a well-developed pericoel is usually present on the lower part of the hypotract and the inner body is not in contact with the lateral walls of the test. The cingulum is well defined being delineated by two low, finely ondulose [sic] ridges, and is only slightly helicoidal. A wide, longitudinal furrow is normally observable, restricted to the hypotract. A sinuous impression, suggesting a poreflagellar mark, is sometimes present on the middle of the sulcus. The intercalary archeopyle is normally wide and polygonal in shape." — Corradini, 1973 (p. 174, 175)

Dimensions: "Holotype: diameter of the inner body 80 × 75 μ, width of the cyst 95 μ, total length 190 μ, dimensions of the archeopyle 40 × 23 μ. Range: diameter of the inner body 55 (64) 80 μ, width of the cyst 68 (80) 100 μ, total length 140 (160) 190 μ." — Corradini, 1973 (p. 174)

Remarks: "This new species is quite variable and also includes specimens with a particularly well developed apical horn or with an oval inner body having a well-developed pericoel also on the cingular area. Sometimes the inner body looks partially reabsorbed, showing only some pieces of the endophragm inside the cyst. The periphragm may present, instead of a fibrous puctate appearance, only one of these two characters." — Corradini, 1973 (p. 175)

Age: Late Cretaceous (middle Campanian); holotype of Corradini (1973, p. 174) given the age of the basal section of the Mt. Cassio Flysch provided by Catanzariti et al. (2007, fig. 5).

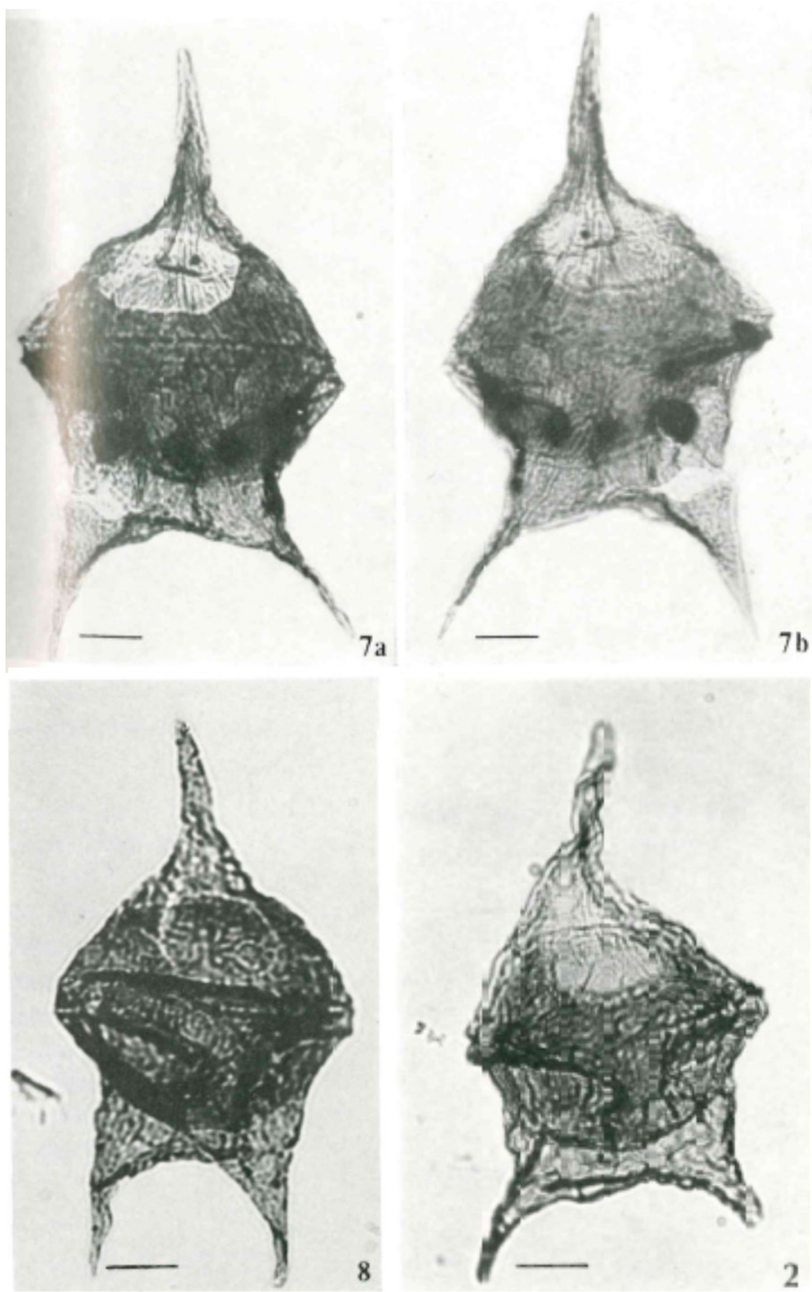


Plate 27, figures 7a, b, 8, Plate 28, figure 2, Corradini (1973). Scale bar = 20 μm.

Cerodinium angulatum Crouch et al., 2014

Description: "A cornucavate peridinioid cyst of intermediate size, with one apical horn and two antapical horns that are approximately of equal length. The base of the apical horn is quite narrow and the horn gently tapers to a rounded tip. The pericyst outline in dorsal—ventral view is typically elongate and the central part of the pericyst is somewhat angular. The periphragm is generally brown, thin, often folded and can range from a smooth to fine granulate-faintly striate appearance. The endocyst is oval to pentagonal in most specimens, with the length of the endocyst almost equal to or slightly greater than the width. Paratabulation is indicated by the paracingulum and sometimes by the archeopyle and the parasulcal region. The paracingulum is discernible by thickened parallel folds in the periphragm and it protrudes slightly in many specimens. The archeopyle is intercalary Type I (2a paraplate). The operculum is free, although it often remains in position on many specimens. On these, the archeopyle outline can be difficult to determine." — Crouch et al., 2014 (p. 65)

Dimensions: "(in μm) Overall length: holotype, 97; range: 72(90)101. Overall width: holotype: 42; range: 35(42)51. Endocyst length: holotype, 44; range: 36(42)51. Length of apical horn: holotype: 30, range: 14(25)30. Length of antapical horns: holotype: 26, range: 13(23)35. Number of specimens measured: 11." — Crouch et al., 2014 (p. 65)

Remarks: "*Cerodinium angulatum* sp. nov. differs from *Cerodinium depressum* (Morgenroth, 1966) Lentin and Williams, 1987 in having an endocyst that is slightly elongated (rather than the width being notably greater than the length), by not possessing a conical apical horn, by the central part of the pericyst being angular, and by lacking spines on the paracingulum. *Cerodinium angulatum* sp. nov. is smaller than *Cerodinium diebelii* (Alberti, 1959) Lentin and Williams, 1987 and the apical and antapical horns are not as long. *Cerodinium angulatum* sp. nov. differs from *Cerodinium striatum* (Drugg, 1967) Lentin and Williams, 1987 in being significantly smaller, having a more angular shape in the central part of the pericyst, and lacking longitudinal rows of grana on the pericyst wall. *Cerodinium angulatum* sp. nov. differs from *Cerodinium speciosum* (Alberti, 1959) Lentin and Williams, 1987 in being smaller and lacking longitudinal or tubercle ornamentation on the pericyst wall. *Cerodinium angulatum* sp. nov. is smaller than *Cerodinium nielsii* (Willumsen, 2011), the pericyst outline is more elongate and the apical and antapical horns are longer." — Crouch et al., 2014 (p. 65)

Age: late Paleocene (Thanetian)–early Eocene (Ypresian); no precise position given for holotype Sample U24/f1037 (Crouch et al., 2014, p. 65). Range: Paleocene (middle–late Danian) as *Vozzhennikovia angulata* (Crouch et al., 2014, fig. 14).

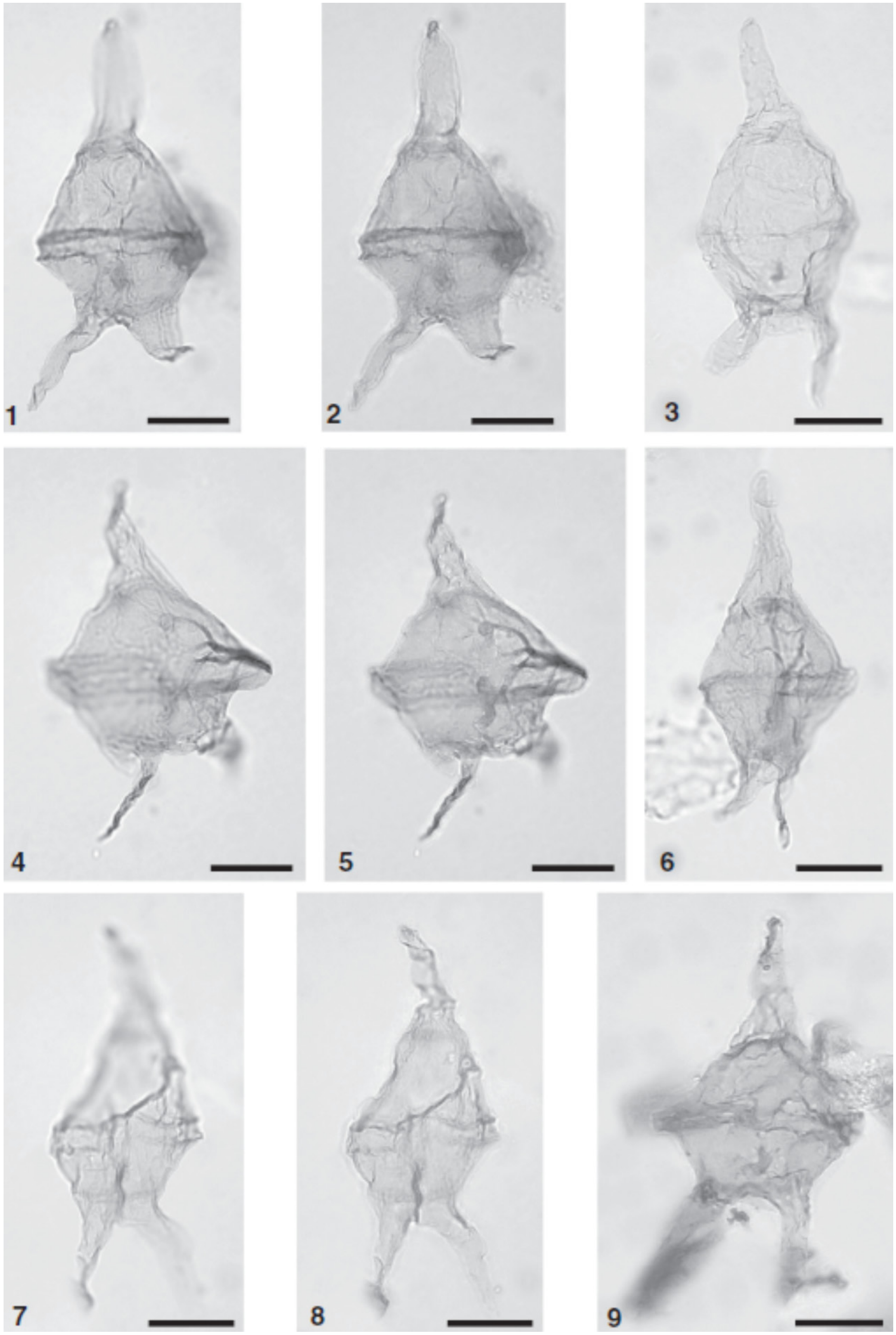


Plate 2, figures 1–9, Crouch et al. (2014). Scale bar = 20 μm.

Cerodinium balticum Vozzhennikova, 1967

Description: "Epitheca conical with a narrow, curved apical horn at the tip. Hypotheca smaller than epitheca, trapeziform with concave sides and straight or curved antapical horns which are widely separated. Transverse furrow shallow, annulate, equatorial and somewhat projecting on the lateral walls of the theca. Longitudinal furrow; situated on the hypotheca. Margins of furrows with short outgrowths. Internal body oval bright yellow, its surface granular. Theca yellow coloured, smooth or finely dotted. Pylome trapeziform." — Vozzhennikova (1967, p. 240, translation: Lees & Sarjeant, 1971)

Dimensions: "(in mircons) Holotype: length of theca, 148; breadth 89.1; width of transverse furrow 5.4, length of internal body 62, breadth 70.2." — Vozzhennikova (1967, p. 240, translation: Lees & Sarjeant, 1971)

Comparison: "This species differs from *C. sibericum* in having a straight-sided epitheca, a curved apical horn and the presence of lateral outgrowths." — Vozzhennikova (1967, p. 240, translation: Lees & Sarjeant, 1971)

Discussion: "There are very few specimens of this large species of *Cerodinium* in the original material investigated by Vozzhennikova. It is most similar in shape to *Cerodinium depressum* (Morgenroth) Lentin and Williams, 1987 from the Early Eocene of Germany, but is much larger." — Lentin & Vozzhennikova (1990, p. 35)

Age: Eocene; holotype of Vozzhennikova (1967, p. 240, translation: Lees & Sarjeant, 1971).

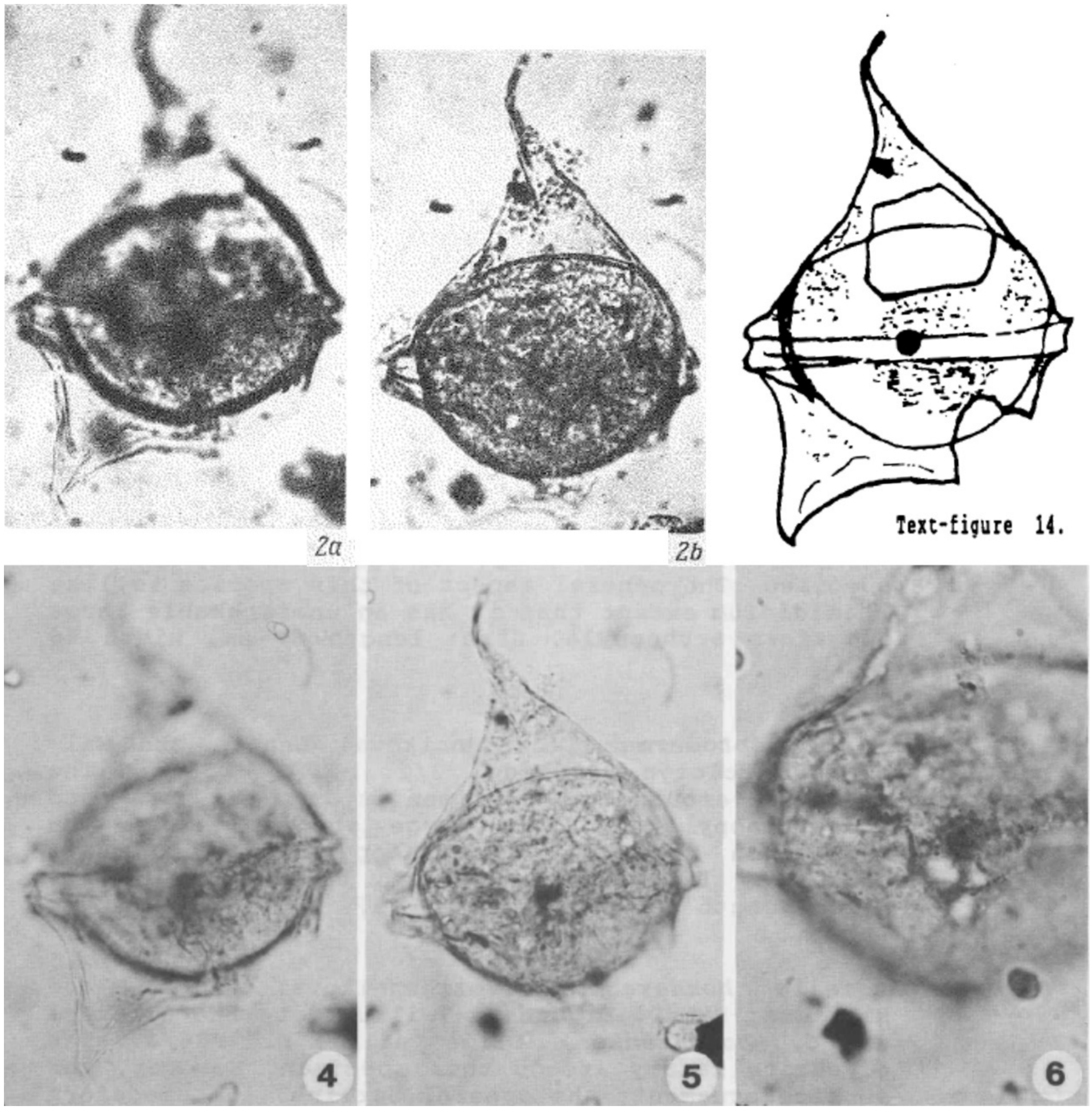


Plate 117, figures 2a, b, Vozzhennikova (1967);
Text-figure 14, Plate 3, figures 4–6 (holotype), Lentin & Vozzhennikova (1990).

Cerodinium boloniense (Riegel, 1974) Lentin & Williams, 1989. Emendation: Riegel & Sarjeant, 1982, p. 296, 297.

Diagnosis: “Large species of *Deflandrea*. Outline of body pentagonal with straight sides and well-developed apical and equal antapical horns. Capsule closely adhering to sides and base of outer wall, but not extending into horns. Girdle conspicuous by low ledges and folds in outer wall, sulcus bordered by longitudinal folds bearing flagellar pocket on its left side. Intercalary archeopyle large, six-sided with alternating long and short sides. Surface showing irregular longitudinal striations.” — Riegel (1974, p. 354)

Description: “The straight sides of the body and the resulting pentagonal outline are a consistent characteristic of this species except for a few unusually small specimens having slightly convex sides. The general lack of larger compression folds indicates that the cysts were flattened dorsa-ventrally prior to compression.

The apical horn is a slightly tapering to nearly parallel sided extension of the outer wall with a broadly flaring base measuring about 2/5 of the length of the body. In the majority of specimens its extreme tip is bent over or indented thus appearing slightly blunted. Only the largest specimens have a fully inflated and pointed tip. The antapical horns are more or less equal in size, somewhat shorter than the apical horn and steeply pyramidal, terminating in an acute point. The distance between them equals or slightly exceeds the width of the horns at base.

The conspicuous girdle is weakly helicoidal, but sinuous, crossing the body about midway. It consists of a narrow groove about 5 μ in width bordered on either side by a fine, frilled ledge and simple continuous folds. The sulcus is considerably broader, open at both ends and bordered laterally by minor folds. Slightly below the juncture of the girdle and the left bordering fold a dark semicircular area projecting into the sulcus is formed by a pocket-like invagination of the wall corresponding to flagellar markings observed by other authors (Eisenack 1966; Gocht 1967).

The capsule normally fills the body completely, but never extends into the horns. In a few exceptionally small forms the capsule is smaller than the body and more rounded. Along the sides of the body the capsule wall appears to be fused to the outer wall. Opposite the horns the capsule wall is frequently somewhat thickened or covered with tubercles.

The intercalary archeopyle, involving outer as well as capsule wall, is unusually large extending from the base of the apical horn almost to the girdle and leaving only a narrow strip in the position of plate 3'''. It is shaped like a triangle with truncated corners, its posterior side being about double the length of the anterior side. Smaller cysts show incomplete or no archeopyle.

The irregular longitudinal striations on the shell surface are formed by fine wrinkles in the outer wall. Near the girdle they tend to be wavy and arranged at more regular intervals. In some well-preserved specimens single rows of pores have been observed between them.

The thickness of the capsule wall rarely exceeds 1 μ the outer wall is considerably thinner. Both walls, particularly the capsule wall, have a distinctive brown colour." — Riegel (1974, p. 355, 356)

Dimensions: "Holotype total length: 144 μ, body length 84 μ, width 93 μ. Range of length including horns: 78–156 μ; mean: 113.8 μ.; standard deviation: 17.5. Range of capsule length: 35–87 μ; mean: 70.1 μ. Range of width: 50–99 μ; mean: 76.8 μ; standard deviation: 11.7. 52 specimens measured."
— Riegel (1974, p. 356)

Remarks: "The sample includes some specimens which deviate from the general population of *D. boloniensis* by their distinctly smaller size, by somewhat convex sides, a proportionately smaller capsule and thinner walls (see text-fig. 3d and Pl. I, fig. 6). They agree, however, with typical representatives of *D. boloniensis* in general aspect as well as such diagnostic details as the flagellar pocket, the indented tip of the apical horn and the brownish colour of the shell. They also conform with the length: width ratio of the normal *D. boloniensis* population (see text-fig. 4) and are therefore considered to represent different developmental stages. The variation represented in text-fig. 3 suggests that archeopyle formation is dependent on the size of the specimens." — Riegel (1974, p. 356)

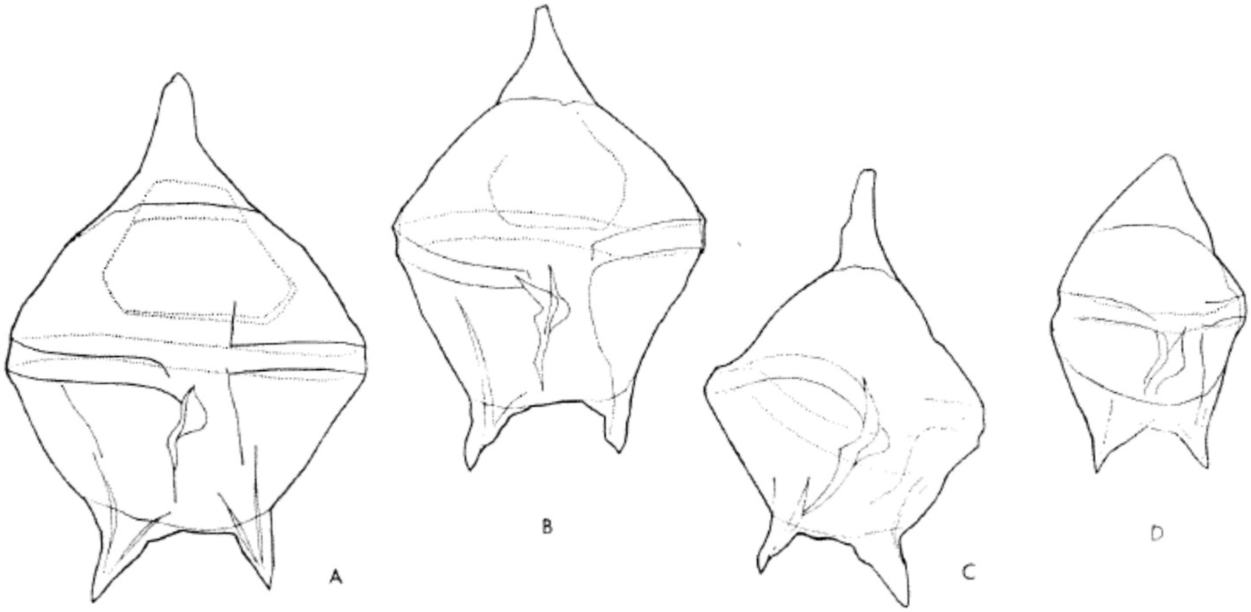
Comparison: "Great size and equal antapical horns as exhibited by *D. boloniensis* are unusual among Cretaceous species of *Deflandrea*." *D. boloniensis* resembles *D. magnifica* Stanley 1965 and *D. pannucea* Stanley 1965, both from the Paleocene Fort Union formation of South Dakota, U.S.A., by its pentagonal outline and longitudinal striations. *D. magnifica*, however, has shorter and broader horns and is occasionally covered with spines, whereas *D. pannucea* differs in archeopyle shape and in having proportionately longer antapical horns. Both species appear distinctly lighter in colour and flagellar markings have not been mentioned for either of them. *D. striata* Drugg 1967 differs in shape and nature of striations (rows of grana). *Cerodinium sibiricum* Vozzhenikova 1963 is somewhat similar with regard to shape, surficial striations and girdle border, but appears to lack an archeopyle and flagellar pocket." — Riegel (1974, p. 356)

Emended diagnosis: "Cyst cornucavate, the apical cavation extending beyond the horn base so that (save for the presence of antapical horns) the epicavate condition is approached. Ambitus of central body roughly hexagonal; epitract in the form of a truncated cone, hypotract more rounded. Apical and antapical horns well developed and of closely similar length: apical horn typically blunt tipped, antapical horns with pointed tips. Paracingulum defined by low crests and folds; parasulcus marked by longitudinal folds, with a flagellar pocket on its left median flank. The periphragm surface exhibits irregular longitudinal striations. Intercalary archaeopyle of standard hexa type, developed by loss of paraplate 2a; it is very large, extending almost to the paracingulum and penetrating both wall layers (type I/I); the epipericoel opens to the exterior through the anterior section of the archaeopyle. The operculum may be free or may retain some degree of antapical attachment." — Riegel & Sarjeant (1982, p. 297)

Discussion: "The 'modified description' of the genus *Senegalinium* set forth by Stover & Evitt (1978, p. 111–123) clearly constitutes an emendation, since it introduces several new features. Their reattribution of the species *boloniense* to that genus, as thus emended, presents some problems. First of all, a feature stressed is that the epipericoel does not open to the exterior; in *boloniense*, however, the very large intercalary archaeopyle extends anteriorly sufficiently far to mean that the epipericoel does open to the exterior. Secondly, the archaeopyle is very much larger than in the type species of that genus, *S. bicavatum* Jain & Millepied 1973. Thirdly, the sharply angular cyst is at its widest in equatorial position and this does not correspond with the specification 'without equatorial protrusions' specified for *Senegalinium* by Stover & Evitt (op. cit.).

In ambitus and style of archaeopyle, the species *boloniense* corresponds well with that of the contemporary genus *Lejeunecysta* Artzner & Dörhöfer, 1978 (formerly *Lejeunia*). However, the fact that it is not truly proximate but distinctly cavate (and indeed, as noted, rather more than cornucavate!) occasions its attribution instead to the genus *Phelodinium*, with whose diagnosis it appears to correspond in all essential features." — Riegel & Sarjeant (1982, p. 297)

Age: Late Cretaceous (Senonian?); holotype of Riegel (1974, p. 355).



Text-figure 3a–d, Riegel (1974).

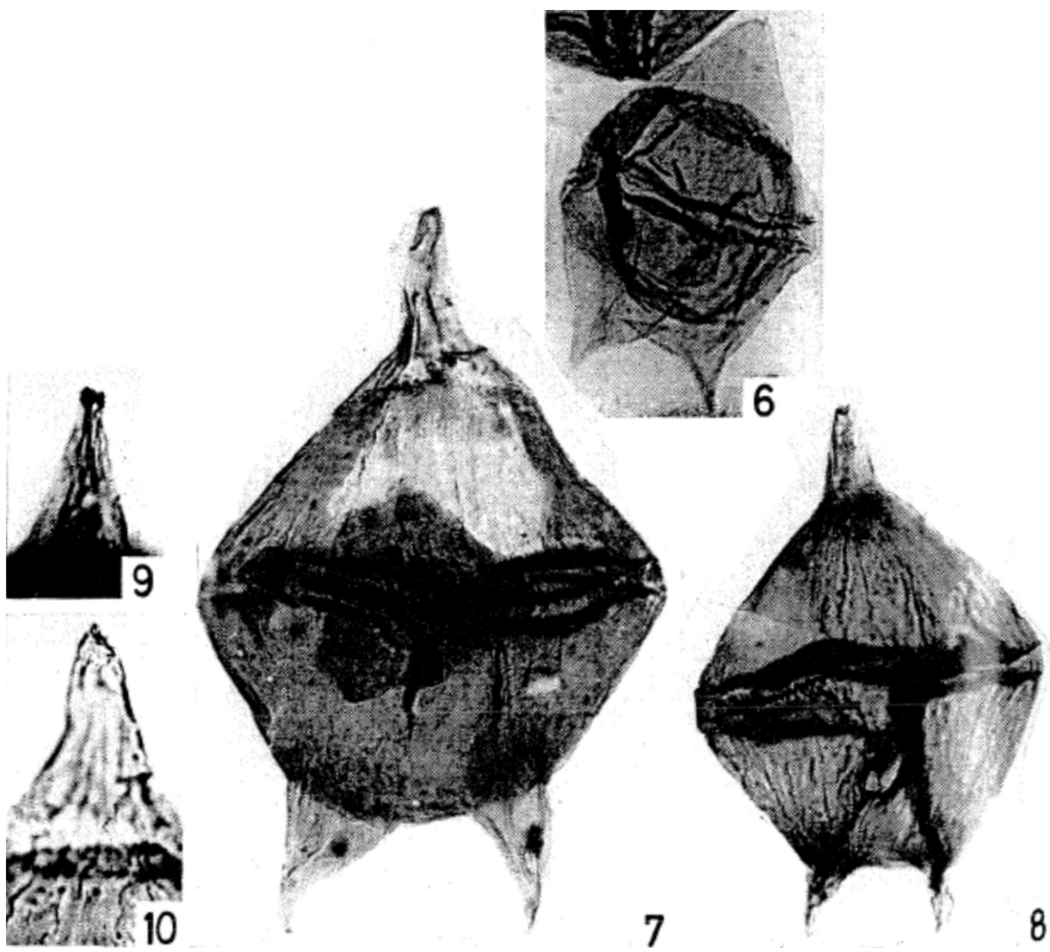


Plate 1, figures 6–10, Riegel (1974).

Cerodinium conspicuum Marheinecke, 1992

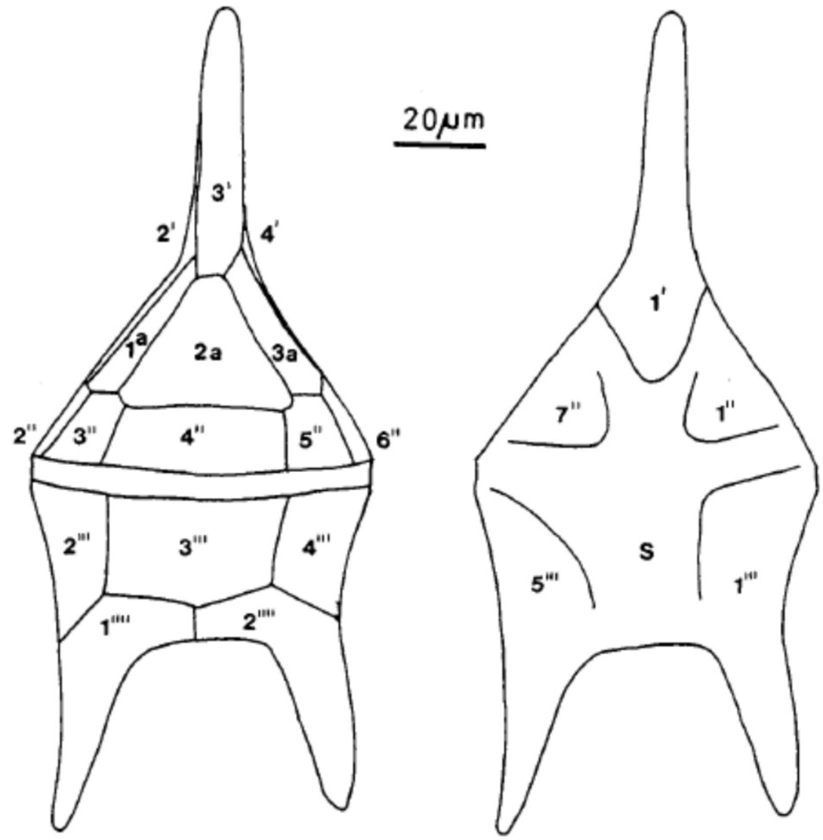
Description: “Cyst ambitus peridinoidal. Periblast: epitheca triangular with distinct rounded blunt apical horn equal or even greater in length than the epitheca. Hypotheca almost rectangular, only slightly concave sides. Two antapical horns, mostly equal in size. Only rarely is the right horn smaller. The edge between the two almost parallel antapical horns is typically straight. Cingulum clearly traced by two folds covered with granules. Sulcus formed only on the hypotheca. Ornamentation: intratabular and penitabular, consisting of c. 1 μm granules whose number towards the center of the area decreases. The penitabular granule border is not always clearly developed. Endoblast: ambitus ovaloidal, somewhat thicker than the periblast. No ornamentation. Cingulum, sulcus and tabulation are not shown. Tight-fitting just above the cingulum. Tabulation: 4', 7'', 3a, ?5c, 5''', 2'''', traced by fine lines. Plate 1a and 3a are very narrow, elongated pentagonal; 3'' and 5'' are small almost square; 2' and 4' are large and reach almost to the height of the lower edge of archeopyle. Periarcheopyle: Intercalary, 2a. Very large, quasi-triangular by reducing the finish to 3s, 3'' and 5''. Operculum free. Endoarcheopyle: intercalary, la +2a + 3a. Operculum free.” — Translated from Marheinecke (1992, p. 81)

Remarks: “The shape is very large and conspicuous. The periarcheopyle is sometimes difficult to determine in transmitted light, since the thick-walled endoblast is usually also slightly stained. Reflected growth zones could not be observed.” — Translated from Marheinecke (1992, p. 82)

Comparison: “Distinguished from all similar forms by the visible area and the distinctive shape. The development of the areas on the dorsal side of *Deflandrea spinulosa* and *D. phosphoritica* is particularly different concerning development of la, 2a, 3a, 3'' and 5''.” — Translated from Marheinecke (1992, p. 82)

Dimensions: “Holotype: periblast length 141; periblast width 68; endoblast length 65; endoblast width 57. Archeopyle index 6.8. Range: periblast length 129(133)141; periblast width 54(62)68; endoblast length 50(56)65; endoblast width 47(55)57. Archeopyle index ca. 6.8.” — Translated from Marheinecke (1992, p. 82)

Age: Late Cretaceous (late Maastrichtian); holotype of Marheinecke (1992, p. 81). Range: Late Cretaceous (late early–late Maastrichtian) (Marheinecke, 1992, p. 82, table 1).



Text-figure 15, Marheinecke (1992).

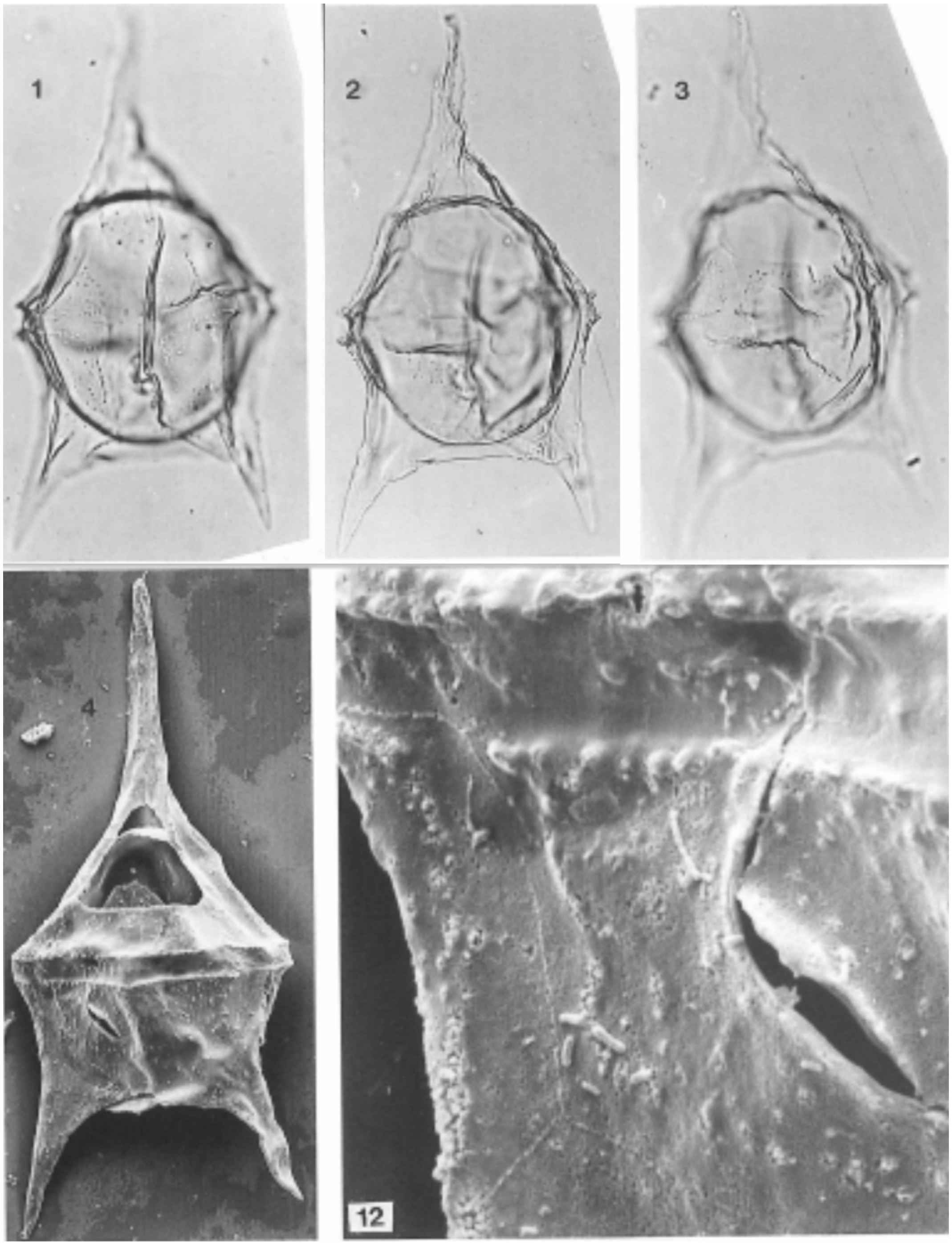


Plate 17, figures 1–4, 12, Marheinecke (1992).

Cerodinium cordiferum (May, 1980) Lentin & Williams, 1987

Description: "Cyst triangular in outline; slightly expanded at cingulum; bearing long, slender, equal gently-tapering, irregularly-striate, sharp-tipped, apical and antapical horns, measuring ca. ½–⅔ central body length; antapical horns diverging. Central body occupies most of cyst interior, extending a few microns into apical and antapical horn cavities, imparting a somewhat inverted heart-shaped appearance. Cyst dorso-ventrally flattened. Periphragm longitudinally striate, striae continuing to tips of horns; nontabulate. Endophragm smooth; closely appressed to periphragm, except within the horns where long pericoels are developed. Cingulum formed of parallel, discontinuous, equatorial folds in periphragm; bears numerous, closely-spaced vertical striae; levorotatory offset ca. ½ cingulum width. Sulcus outlined by low folds in periphragm, beginning between terminal ends of cingulum, broadening posteriorly to tips of antapical horns. Archeopyle intercalary (Type I/I); large, occupying ca. ⅔ or more of medial dorsal epitract; excystment opening in endophragm of similar shape and size." — May (1980, p. 74)

<u>Dimensions</u>: "Holotype L × W, 160 × 70 µm, apical horn from apex of endoblast 43 µm antapical horns from antapex of endoblast 32 µm. Observed range (15 specimens measured): length 158–186 µm width 63–70 µm; apical horns ca. ½ to ⅔ central body length; wall layers ca. 1 µm similar thickness." — May (1980, p. 75)

<u>Discussion</u>: "The most diagnostic feature is general shape of periblast and endoblast. The roughly triangular periblast with slightly convex-outward lateral margins and long, slender, pointed apical and antapical horns arc distinctive. The inverted, heart-shaped endoblast sets it apart from similar species, e.g., *D. diebeli* Alberti 1959, and *D. striata* Drugg 1967." — May (1980, p. 74)

<u>Affinity</u>: "Monmouth Group specimens are somewhat similar to *D. diebeli* Alberti 1959 (p. 99, pl. 9, figs. 18–21); however, are distinctive in being less striate, having generally shorter apical and antapical horns from antapex of endoblast 32 µm. Observed range *D. diebeli* is narrower in appearance in the hypotract area. *D. cordifera* differs from *D. striata* Drugg 1967 by having an inverted heart-shaped endoblast." — May (1980, p. 74)

<u>Age</u>: Late Cretaceous (late Maastrichtian); holotype and range of May (1980, p. 74, 75, text-fig. 2, range charts I. II).

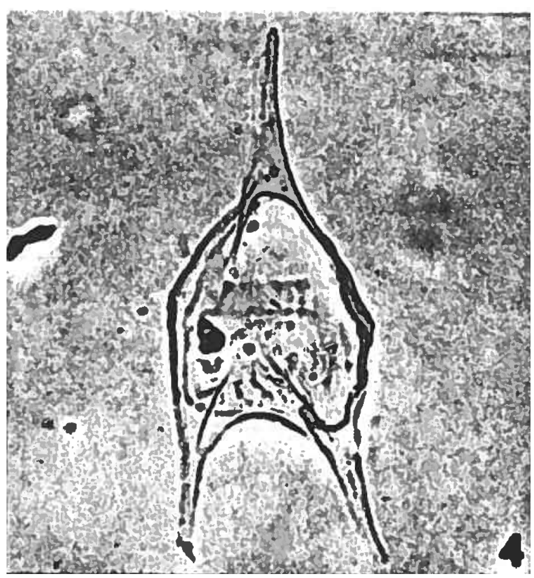


Plate 8, figure 4, May (1980).

Cerodinium crassistriatum (Jain et al., 1975) Lentin & Williams, 1987

Diagnosis: "Shell ovoidal, two layered; periphragm thin, granulate, grana arranged in longitudinal rows forming narrow ridges; forming a broad and tapering apical and two antapical horns. Endophragm moderately thick, ornamented with broad longitudinally thickened strips, each strip followed by a narrow thin, unornamented zone. Capsule rounded to oblong, nearly as big as pericoel, periphragm and endophragm remain in close contact, apically giving a bicavate appearance to cyst. Archaeopyle intercalary, below apical horn." — Jain et al. (1975, p. 8)

Dimensions: "Cyst length, holotype 90 μ, range 90–110; width, holotype 75 μ, range 75–90 μ; capsule size, holotype 55 × 75, range 55–70 × 75–90."— Jain et al. (1975, p. 9)

Comparison: "*Deflandrea striata* Drugg (1967) comes nearest to *D. classistriata* sp. nov. in having similar cyst shape, size and periphragm ornamentation. Present species is distinguished from *D. striata* in having broad strips of endophragm and having grana arranged parallel to longitudinal axis of the test." — Jain et al. (1975, p. 9)

Age: early Paleocene (Danian); holotype of Jain et al. (1975, p. 8).

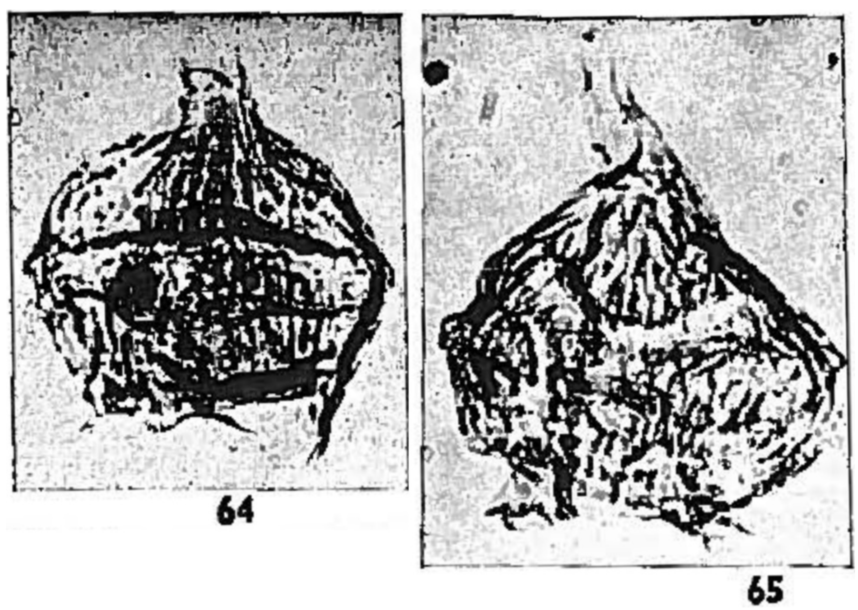


Plate 6, figures 64, 65, Jain et al. (1975).

Cerodinium dartmoorium (Cookson & Eisenack, 1965b) Lentin & Williams, 1987

Description: "Shells rather flat, nearly twice as long as broad and well tabulated, the surfaces of the plates ornamented with small dot-like thickenings. Epitheca longer than hypotheca, triangular in outline gradually narrowing to a well-developed, bluntly-pointed horn. Hypotheca with almost parallel sides, a concave base and two well-developed pointed horns. Girdle distinct, slightly helicoid with finely denticulate edges. Longitudinal furrow broad, nearly straightsided, its borders sometimes extending almost to the tips of the antapical horns. In the middle of the furrow the concavo-convex thickening in the vicinity of the flagella-pore, noted as occurring in three other Australian species of Dinophyceae (Cookson & Eisenack 1965), is always conspicuous.

The tabulation, although always present, is not completely identifiable. The apical horn appears to be formed by four long apical plates beneath which are intercalary plates of which the largest, 2a, forms the hexagonal, precingular archeopyle. The precingular plates number six or possibly seven with 4" a broad plate in the middle of the dorsal surface. The postcingular plates are five or possibly six with 3"' strongly developed. The antapical plates 1"" and 2"" are restricted to the lower halves of the antapical horns. Thus the approximation arrived at is 4', 4a, 6 (or 7)", 5 (or 6)"', 2"" (Fig. 1). The sutures are made by clean breaks, fine lines on the ventral surface of the epitheca, or by small dot-like thickenings as at the borders of the antapical horns." — Cookson & Eisenack (1965b, p. 133, 134)

Dimensions: "Holotype, c. 152 μ long, 80 μ broad; capsule c. 62 x 68 μ. Range, c. 119–152 μ long, c. 79–95 μ broad." — Cookson & Eisenack (1965b, p. 134)

Age: Paleocene; holotype of Cookson & Eisenack (1965b, p. 133).

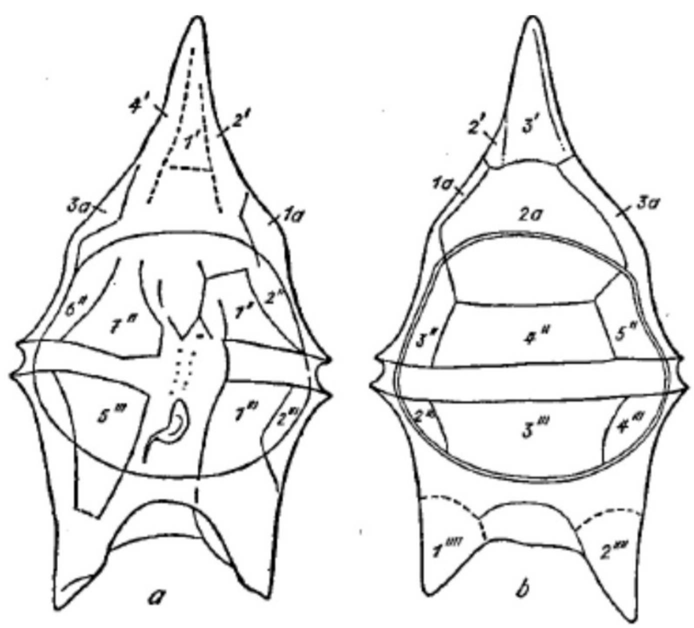
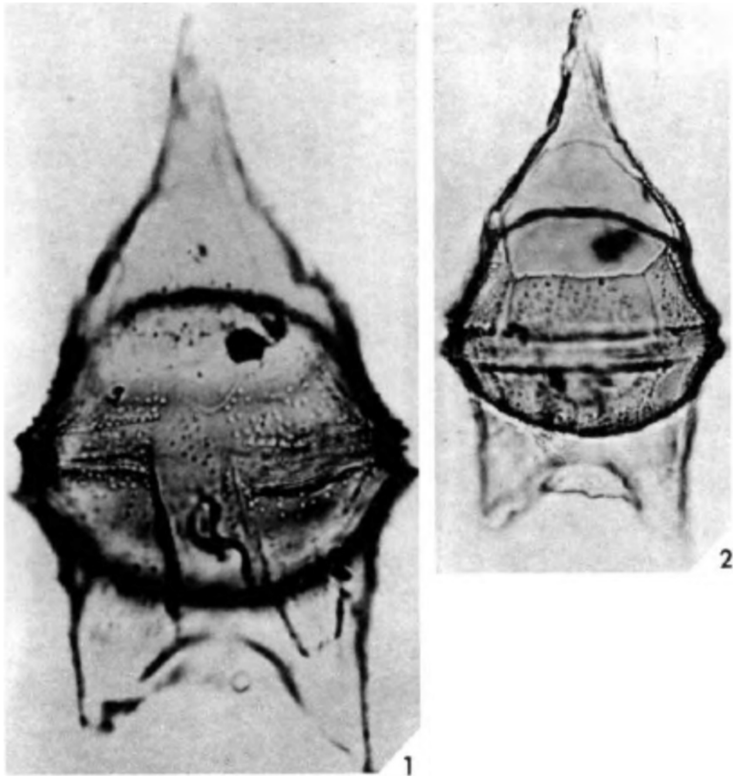


FIG. 1—*Deflandrea dartmooria* Cookson & Eisenack.
Text-figure 1, Cookson & Eisenack (1965b).



Plates 16, figures 1, 2, Cookson & Eisenack (1965b).

Cerodinium depressum (Morgenroth, 1966) Lentin & Williams, 1987

Diagnosis: “A species of the genus *Deflandrea* with a long, pointed apical horn and two distinct antapical horns. Inner capsule strongly flattened in a sagittal direction.” — Translated from Morgenroth (1966, p. 8)

Description: “The cyst has an elongated-pentagonal outline. The epitheca is long, conically extended into a pointed apical horn. The hypotheca ends in two somewhat divergent, pointed antapical horns. The outer armor has fine longitudinal stripes. The inner capsule, always in a sagittal direction downwards, is only on the side of the outer wall. The clearly developed, circular transverse furrow has tiny thorns along its edges. On the hypotheca, a wide longitudinal furrow is visible. Several specimens contain a rounded trapezoidal archeopyle below the apical pole.” — Translated from Morgenroth (1966, p. 8)

Dimensions: “Capsule length 26 (20/28) μ, capsule width 38 (31/50) μ, specimen length 80 (70/ 140) μ. Specimen width 38 (31/50) μ (identical to capsule width) (30 measurements).” — Translated from Morgenroth (1966, p. 8)

Age: early Eocene; holotype of Morgenroth (1966, p. 8).

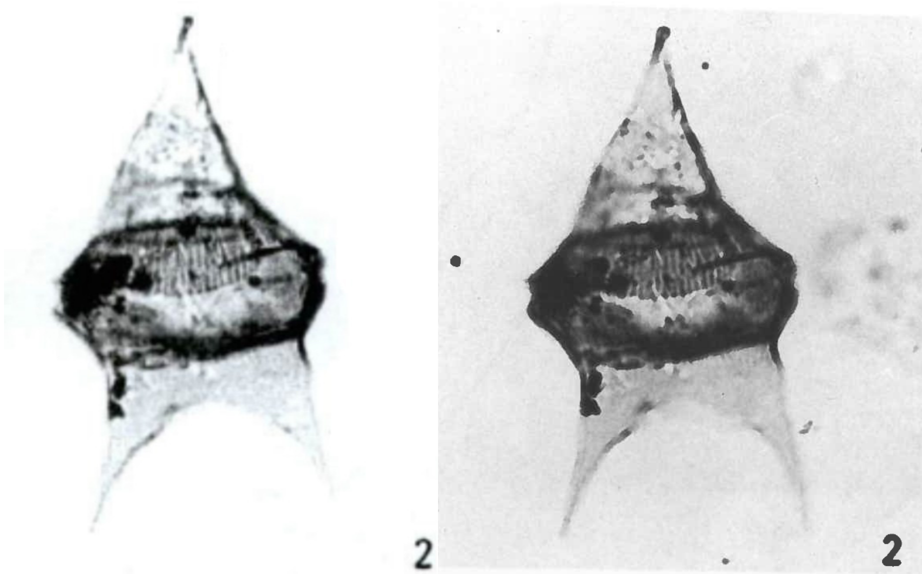


Plate 1, figure 2, Morgenroth (1966).

Cerodinium diebelii subsp. ***diebelii*** (Alberti, 1959) Lentin & Williams, 1987

Diagnosis: “Cyst flattened, elongated. Epitheca usually an acute triangle extended into a long, horn-like process tapering toward the free end. Transverse furrow usually absent, if present, slightly deepened. Two long antapical horn extensions. Horn-like projections which, like the apical horn, sometimes have fine longitudinal striations on their surface. Inner body oval, very close fitting to the outer edge of the cyst.” — Translated from Alberti (1959, p. 99)

Additions: “Characteristic of the species are the long horn processes, which on their free ends taper and end in a point or are slightly blunted. They are almost the same length. The membrane of the cyst is delicate, transparent and sometimes very finely punctured. A rounded trapezoidal archeopyle is present just below the apex.” — Translated from Alberti (1959, p. 100)

Differential diagnosis: “Differs from all other species of the genus by the outline of the cyst and the very long horns.” — Translated from Alberti (1959, p. 100)

Dimensions: “Holotype: length 180 μ (the top part of the apical horn is cut off broken), width 44 μ. In other specimens, the length varies between 110 μ and 210 μ, the width between 40 μ and 50 μ.” — Translated from Alberti (1959, p. 100)

Age: Late Cretaceous (late Senonian, Maastrichtian); holotype as translated from Alberti (1959, p. 100).

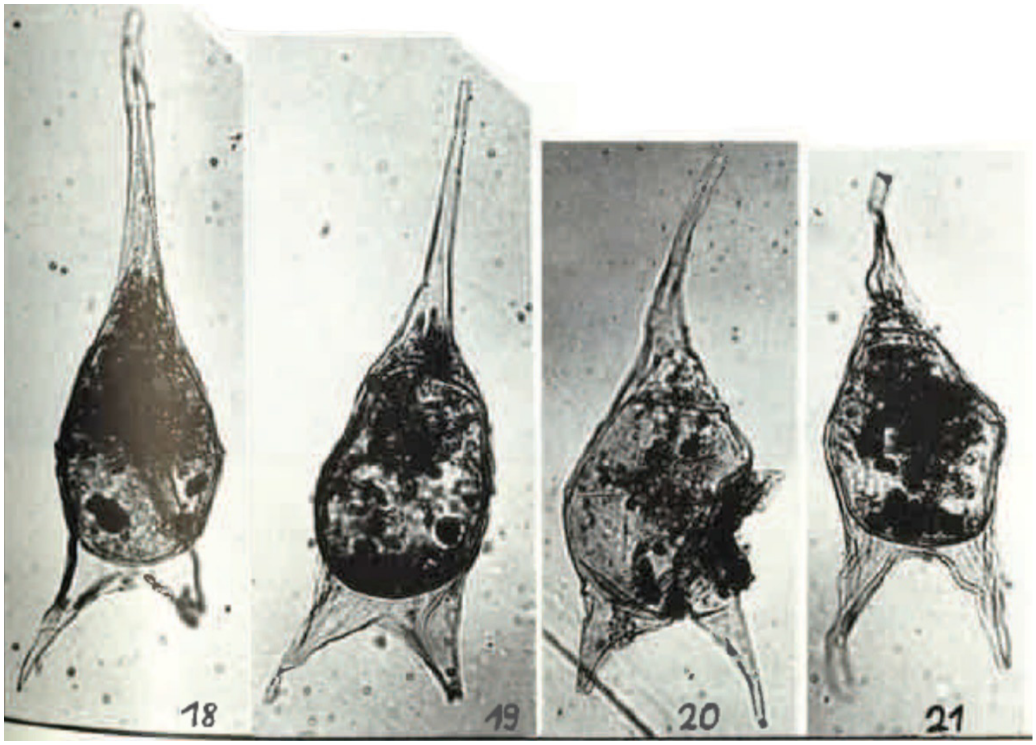


Plate 9, figures 18–21, Alberti (1959).

Cerodinium diebelii subsp. ***rigidum*** (May, 1980) Lentin & Williams, 1987

Description: "Periblast rigid in construction, peridinioid triangular in outline, being extended apical and antapical horns of similar length, which are generally broader based and more tapering than in *D. diebel*i. Equatorial margins are enlarged slightly outward, terminating in oblique angles at lateral margins of cingulum. Periphragm finely winkled longitudinally, except within sulcus. Endoblast ovoidal, loosely filling the central cavity, leaving small lateral pericoels and large anterior and posterior pericoels within the horns, beginning near the bases of the horns, measuring roughly the same length as the endoblast. Endophragm is smooth. No tabulation observed on either wall layer. Cingulum strongly developed on periphragm and faintly developed on endophragm, formed of parallel periphragm equatorial folds somewhat crenulated by intersecting longitudinal wrinkles of periphragm. Vertical, closely-spaced wrinkles occur within cingulum. Cingulum weakly levorotatory; occasionally nonspiral. Sulcus extends from terminal ends of cingulum, broadening posteriorly, bounded by subtle folds directed toward antapical horn tips. Archeopyle intercalary (Type I/I), attenuated hexagonal with alternating long and short sides, occupying c. ⅔ of medial dorsal epitract; operculum seldom found in place." — May (1980, p. 75, 76)

Dimensions: "Holotype L × W, 292 ×115 µm; endoblast length 103 µm, apical horn above endoblast 103 µm; antapical horns beneath endoblast ca. 103 µm each. Observed range (45 specimens measured); length 237–248 µm, width 71–118 µm apical and antapical horn length approximately equal to endoblast length." — May (1980, p. 76)

Discussion: "*D. diebeli* subsp. *rigida* differs from *D. diebeli* mainly in its robust, regularly striate structure. Periphragm is not 'draped' over endoblast, but rather forms a rigid, generally nonflexuous periblast, with a well-marked and striate cingulum." — May (1980, p. 76)

Age: Late Cretaceous (early Maastrichtian); holotype of May (1980, p. 75, text-figure 2). Range: Late Cretaceous (late Campanian?–late? Maastrichtian) (May 1980, p. 76, text-figure 2).

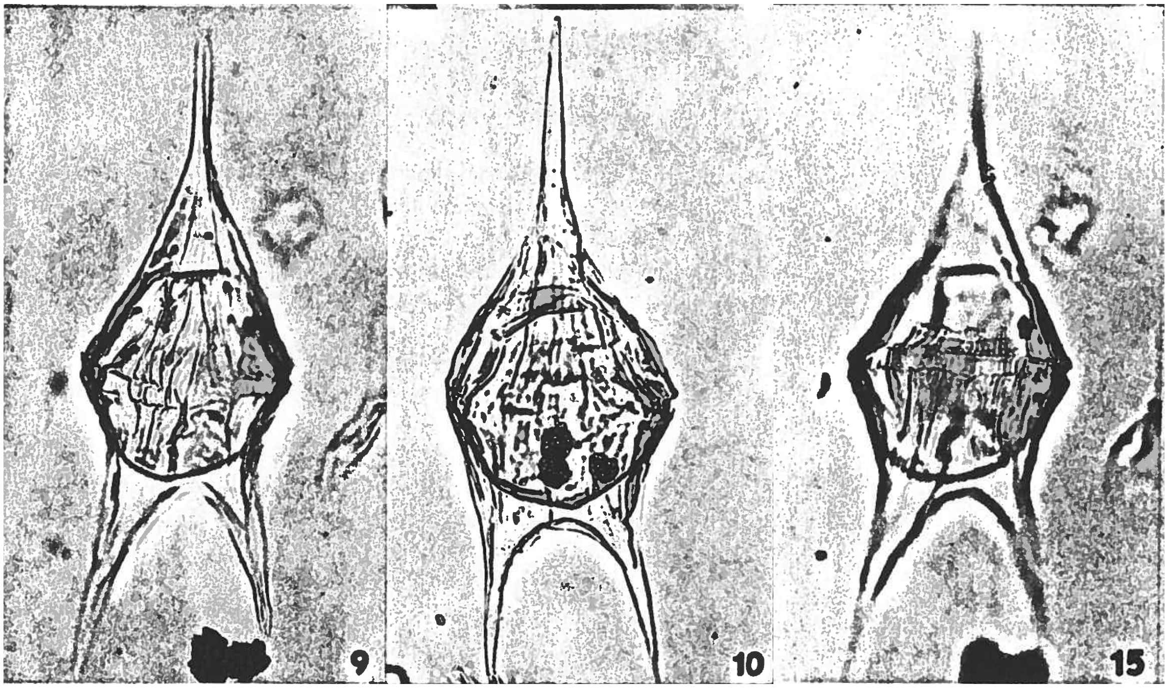


Plate 8, figures 9, 10, 15, May (1980).

Cerodinium fusiforme (He Chengquan, 1991) Lentin & Williams, 1993

Description: "The cyst profile is elongated pentagonal or spindle-shaped. The epitheca is large, elongated isosceles triangle, tapering towards the top, forming a vertex with a sharper tip. The hypotheca is inverted trapezoidal, the sides are slightly convex and concave, the antapex is nearly straight and roughly parallel to the girdle, with two antapical horns, usually unequal, tapered, blunt at the end (sometimes rod-shaped or with two coarse grains); large antapical horn is 22–25 μm long, the smaller one is 12–17 μm long, and the two are far apart (50–62.5 μm) and diverged. The cingulum is located on the widest side of the cyst and the loop shaped narrow, 4–5.5 μm wide, bordered by thin ridges. The longitudinal groove is limited to the hypotheca, and the outline is vague with thin outer wall. The surface is coarse and granular, relatively thin, and the size is different. The diameter of the larger grains is about 1 μm. There are often wrinkles on the wall. Inner body nearly round, wall relatively thin, its surface nearly smooth. It is completely separated from the outer wall at the top, horns and side convex, and close to each other on the sides (except side convex) or pasted together. The archeopyle is large, anterior, with a hexagonal pseudo-square outline, and its size is about 30 × 30 μm. Operculum detached." — Translated from He Chengquan (1991, p. 75)

Dimensions: "The cyst is about 110 μm long and 70–80 μm wide, and the inner body is 52–70 μm long and 67.5–70 μm wide (2 specimens measured). The holotype specimen is 110 μm long and 70 μm wide, and the inner body is 52 μm long and 67.5 μm wide." — Translated from He Chengquan (1991, p. 75)

Comparison: "Compared with this species, the cyst is an obviously elongated isosceles triangle, the antapical horns are relatively developed, and the surface of the outer wall is coarse-grained. It differs from *Deflandrea cygniformis* in that its apical horn is far braided and its caudal horns are very underdeveloped. It is also similar to *Ceratiopsis subquadra* in shape, but the latter has a larger hypotheca and wrinkled outer wall surface, which makes the two easy to distinguish." — Translated from He Chengquan (1991, p. 75)

Age: late Paleocene (Selandian–early Thanetian?); holotype of He Chengquan (1991, p. 228). Based on the range chart and translation of “lower member of Qimgen Formation” from He Chengquan (1991, p. 75, 228, fig. 4). Also, see Xi Dengpeng et al. (2020, fig. 18).

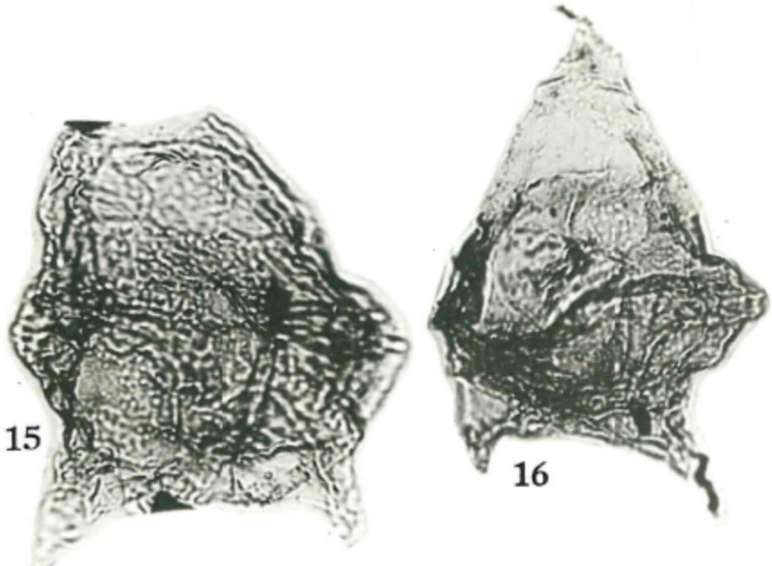


Plate 34, figures 15, 16, He Chengquan (1991).

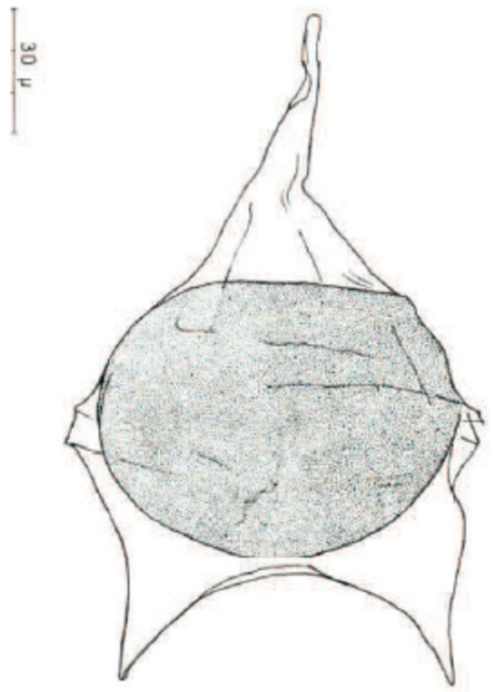
Cerodinium glabrum (Gocht, 1969) Fensome et al., 2009

Description: “In outline, forma *glabra* corresponds well to the illustrated specimens Alberti and thus also to those above described finds from the Meckelfeldrt lower Paleocene. The smooth, not very thick-walled inner body is wider than high and touches the lateral edge of the outer body. The apical horn is long and pointed; the two antapical horns, also pointed, diverge strongly. One specimen bears an archaeopyle. The membrane surface is smooth.” — Translated from Gocht (1969, p. 11)

Dimensions: “Outer casing 142–157 μ long, 95–100 μ wide. Inner body 55–64 μ long, 76–87 μ wide.” — Translated from Gocht (1969, p. 11)

Remarks: “In our view, it is useful to recognise smooth specimens of *Cerodinium* at specific rank, especially since surface ornamentation is a prime character in separating other species of the genus. Hence, we raise this taxon to specific rank. *Cerodinium pannuceum* is very similar to *Cerodiniumglabrum* but the nature of the archaeopyle in the holotype of the former species (Stanley 1965: pl. 22, figs 1–2) is unclear. If the two taxa are considered synonymous, *Cerodinium pannuceum* would be the correct name.” — Fensome et al. (2009, p. 19).

Age: late Paleocene (Thanetian); holotype as translated from Gocht (1969, p. 10).



Text-figure 3, Gocht (1969).

Plate 2, figure b, Fensome et al. (2009). Scale bar = 20 μm.

Cerodinium granulostriatum (Jain & Millepied, 1973) Lentin & Williams, 1987

Diagnosis: "Ambitus pentagonal, non-tabulate, periphragm fairly thin, extending to form one well marked apical horn and two antapical horns, granulostriate, striations longitudinal. Endophragm darker in colour, surface micrgranulate, densely varrucose along the pericoel areas. Transverse furrow well developed, circular; longitudinal furrow seen, broader near girdle but narrows towards antapex. Archeopyle intercalary, broad, below apical horn." — Jain & Millepied (1973, p. 24)

Description: "Epi- and hypotract equally divided by circular, transverse, 8 μ wide girdle. Epitract conical, with a pore at the apex of apical horn. Formation of verrucae on endophragm surface along pericoel areas seem to have been formed as a result of grana fusion." — Jain & Millepied (1973, p. 24, 25)

Dimensions: "Holotype, cyst length 104 μ, breadth 75.4 μ, capsule length 54.6 μ; breadth 75.4 μ; apical horn length 22 μ, breadth 17.5 μ; antapical horn length 20.5 μ; breadth 13 μ. Observed range: cyst length 100–155 μ, breadth 60–80 μ; capsule length 50–85 μ, breadth 60–80 μ; apical horn length 15–31 μ, breadth 15–35 μ; antapical horn length 10–25 μ, breadth 10–18 μ." — Jain & Millepied (1973, p. 24)

Comparison: "*Senegalinium granulostriatum* sp. nov. differs from the two previously described new species in having distinct transverse furrow, granulo-striate periphragm and granulate endophragm." — Jain & Millepied (1973, p. 25)

Age: Late Cretaceous (Maastrichtian); holotype of Jain & Millepied (1973, p. 24).

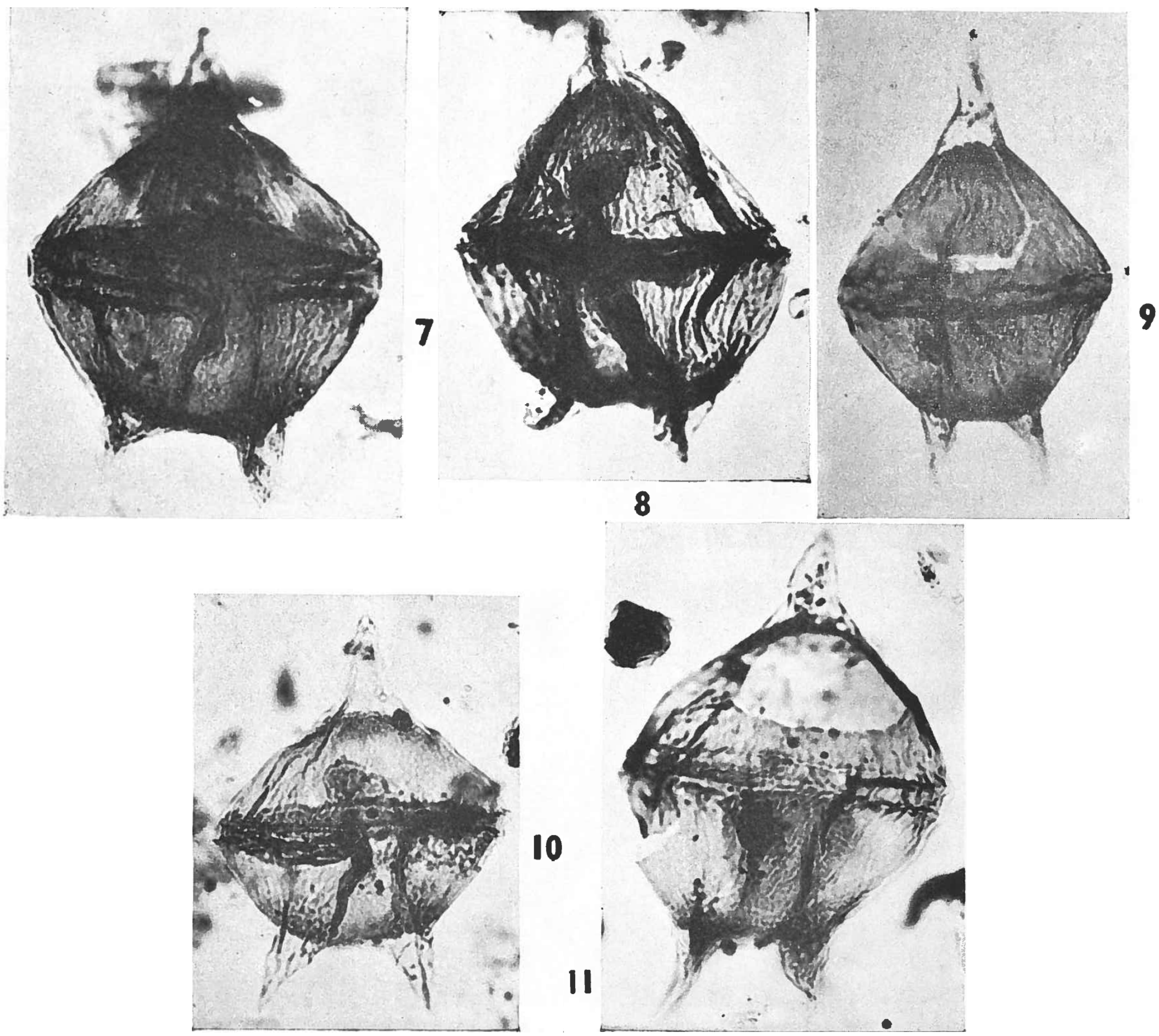


Plate 1, figures 7–11, Jain & Millepied (1973) (holotype: fig. 7).

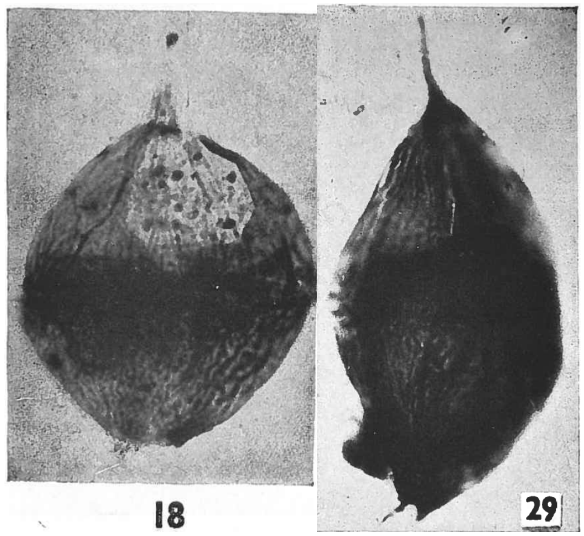


Plate 2, figures 18, Plate 3, figure 29, Jain & Millepied (1973).

Cerodinium kangiliense Hansen in Nøhr-Hansen & Heilmann-Clausen, 2001

Description: "Cyst type: bivacate [sic], peridinioid. Shape: dorso-ventrally compressed cyst, pericyst elongate with a moderately long tapering apical horn and two slightly shorter antapical horns. Endocyst pentagonal to sub-circular. Wall relationship: the cyst is two-layered, bicavate to cornucavate, composed of a smooth pericyst with short parasutural rows and/or intratabular clusters of granulae or echinae. The endocyst is darker and without any visible ornamentation. Tabulation: paratabulation is reflected partly by the archeopyle and by parasutural granulae or short echinae and by intratabular arrangement of granulae or echinae. Peridiniacean, with the formula 4', 3a, 7'', Xc, 5''', 2'''', 0–5s. Periarcheopyle: intercalary (2a) large elongate hexagonal periarcheopyle or *Cerodinium*-type." — Hansen in Nøhr-Hansen and Heilmann-Clausen (2001, p. 158, 160)

Dimensions: "Holotype overall length 104 μ width 62 μ, length of apical horn 24 μ, length of antapical horn 24 μ. Minimum, average and maximum dimensions of specimens from Nuussuaq: overall length 90 (111.6) 115 μ, width 54 (59.7) 66 μ, length of apical horn 16 (27.4) 38 μ, length of antapical horn 16 (20) 26 μ. Minimum, average and maximum dimensions of 9 specimens from Denmark overall length 82 (93.1) 100 μ width 48 (51.4) 54 μ, length of apical horn 21 (24) 33 μ, length of antapical horn 15 (16.6) 21 μ." — Hansen in Nøhr-Hansen and Heilmann-Clausen (2001, p. 158, 160)

Comparison: "*Cerodinium kangiliense* differs from the somewhat similar species *C. dartmoorium* Cookson & Eisenack 1965a and *C. medcalfii* Stover 1973 by being smaller and by its more prominent sculpture elements, *C. medcalfii* is recorded from the Thanetian of Denmark (Heilmann-Clausen 1985) and southern England (Powell et a1. 1996) and there is no stratigraphical overlap between *C. medcalfii* and *C. kangiliense*." — Hansen in Nøhr-Hansen and Heilmann-Clausen (2001, p. 158, 162)

Age: early Paleocene (Danian); holotype of Hansen in Nøhr-Hansen and Heilmann-Clausen (2001, p. 160, fig. 3). Range: early–middle Paleocene (middle Danian–earliest Selandian) (Hansen in Nøhr-Hansen and Heilmann-Clausen (2001, p. 164).

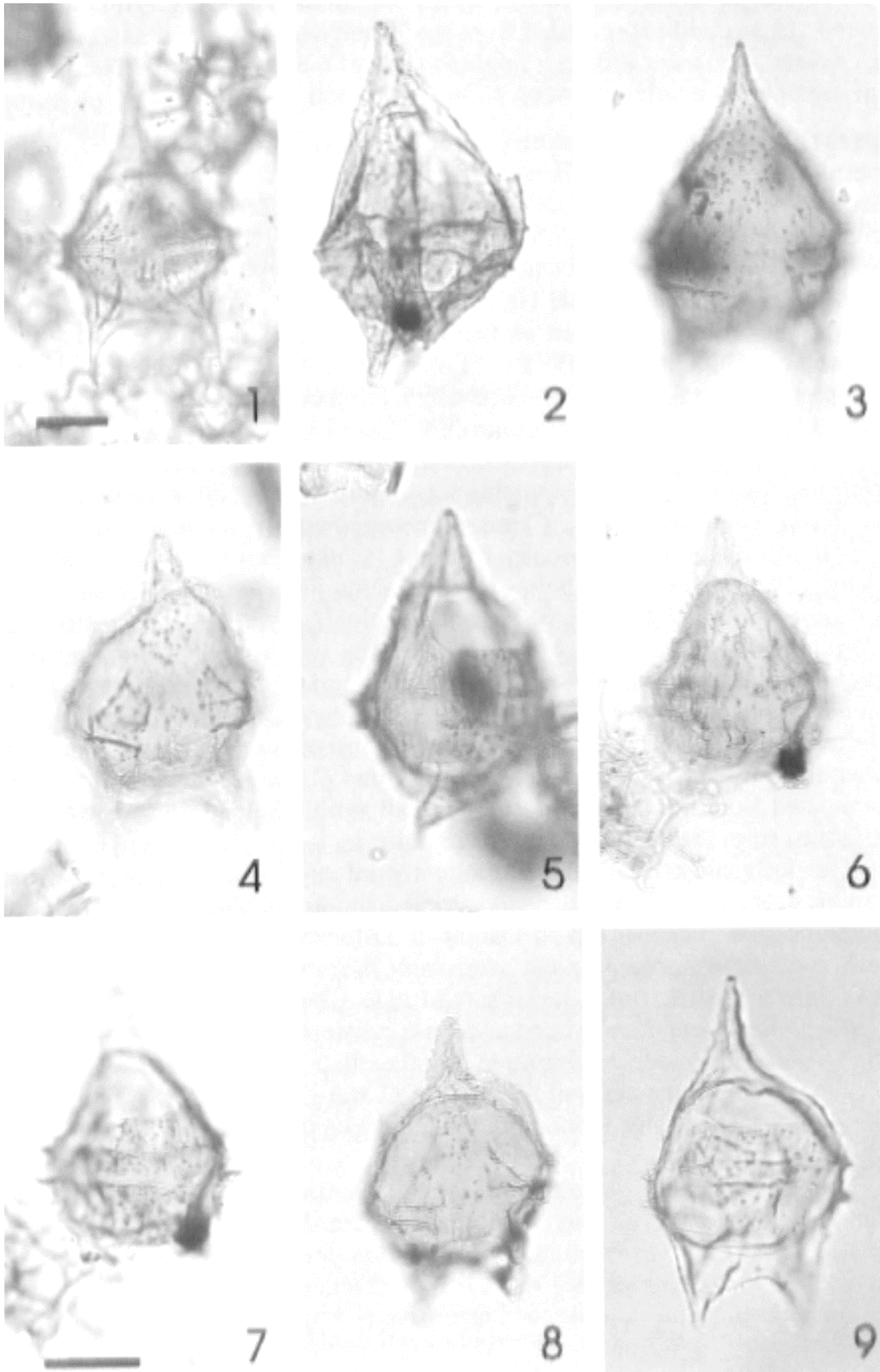


Figure 4, nos. 1–9, Hansen in Nøhr-Hansen and Heilmann-Clausen (2001). Scale bar = 20 μm.

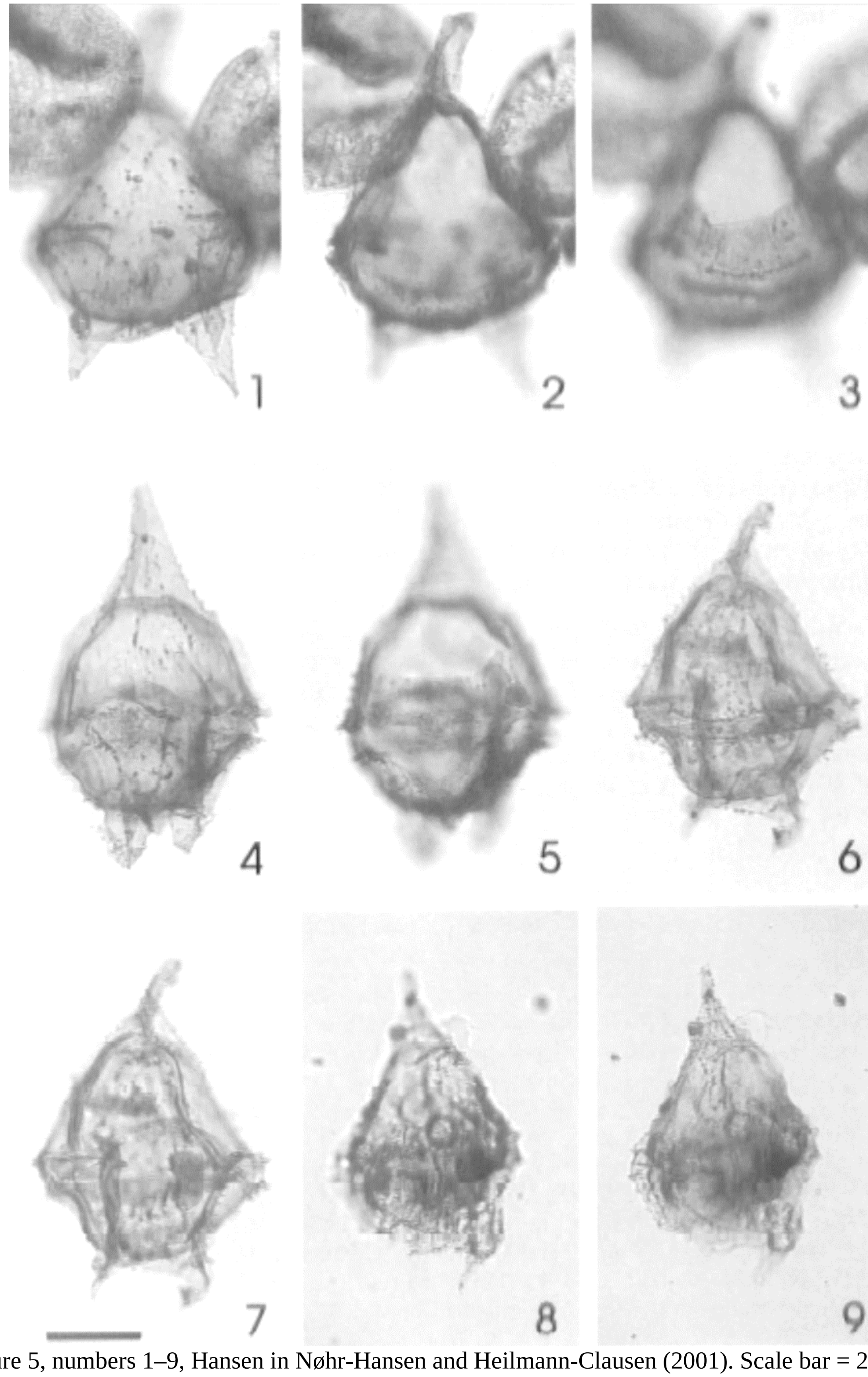


Figure 5, numbers 1–9, Hansen in Nøhr-Hansen and Heilmann-Clausen (2001). Scale bar = 20 μm.

Cerodinium leptodermum (Vozzhennikova, 1963) Lentin & Williams, 1987

Description: "Theca strongly elongated along the longitudinal axis, with long apical and antapical horns gradually tapering to the bluntly rounded distal end. Antapical horns lie parallel to each other or are slightly divergent. Transverse furrow broad, shallow, annulate, equatorial in position or slightly displaced towards the apical end. Its margins are wavy. Longitudinal furrow extending to the antapex straight or obliquely curved. Internal body large, ellipsoidal, its surface smooth or more rarely finely granular. Theca thin walled, smooth or with longitudinal wrinkles. Internal body and theca coloured bright yellow or pale brown. Pylome large, ovally trapeziform, sometimes difficult to discern or absent altogether." — Vozzhennikova (1963, p. 181, translation: Lees & Sarjeant, 1971)

Emended description: "Cyst elongated peridinioid with one long apical and two long antapical horns; endocyst elongated oval: apically cornucavate, antapical pericoel well developed. Periphragm thin with delicate longitudinal wrinkles or folds; endophragm smooth or minutely granulose, both wall layers tend to show a dark brown color. Paratabulation absent except as expressed by the archeopyle and paracingulum. Archeopyle large standard hexa (iso-deltaform) formed by the loss of the 2a paraplate in both wall layers. Paracingulum is shallow, indistinct to distinct, bordered by crenulations which are expressions of the folds in the periphragm. The perisulcus is shallow and expressed only as a depression on the hypocyst." — Lentin & Vozzhennikova (1990, p. 36)

Dimensions: "(in microns) Holotype: total length of theca 126.5, breadth 51, length of apical horn 34.5, length of antapical horns 20 and 23, width of transverse furrow 7, internal body length 64.4, breadth 50. In other examples: total length 126.5–177, breadth 50.6–60, length of apical horn 34.5–52.9, length of antapical horns 20–32, width of transverse furrow 6.5–7, length of internal body 78.5–92, breadth 53–55." — Vozzhennikova (1963, p. 181, 182, translation: Lees & Sarjeant, 1971)

Comparison: "This species differs from others in the ellipsoidal shape of its internal body, the wrinkled sculpturing to the theca and the length of the horns." — Vozzhennikova (1963, p. 182, translation: Lees & Sarjeant, 1971)

Discussion: "The diagnosis of this species has been expanded to emphasize the distinctive, well developed antapical pericoel which occurs below the endocyst and above the antapical horns. This species is often confused with *Cerodinium diebelii* (Alberti) Lentin and Williams, which is most unfortunate. In *C. diebelii* the endocyst is more circular so that the body of the cyst between the apical and antapical horns is much shorter. The tendency to combine these two species under the name *C. diebelii* has lead [sic] to the masking of what may be an important aspect of the distribution of the two species. For example, the form illustrated by McIntyre, 1975 (pl. 4, fig. 1–2) as *Deflandrea diebelii* from the McIntyre flora (Lentin and Williams, 1980) is *Cerodinium leptodermum*. Forms illustrated by numerous authors from the Williams floral province are *Cerodinium diebelii s.s*. It is possible that the species are mutually exclusive. The specimens illustrated by Boltenhagen, 1977, pl. 22, fig. 1–3 as *C. leptodermum* are *C. diebelii* from the Malloy floral province.

The holotype of *Cerodinium leptodermum* is located on a slide in which the glycerine has dried. New glycerine was added to render the specimen more photogenic; however, ridges of dry glycerine with different optical properties are under the specimen. These ridges defract the light in such a way that one might be tempted to interpret the presence of a 3I endoarcheopyle from the photograph. Such an interpretation would be incorrect. Both the periarcheopyle and the endoarcheopyle are formed by the loss of the large 2a paraplate." — Lentin & Vozzhennikova (1990, p. 37)

Age: Paleocene; holotype of Vozzhennikova (1963, p. 181, translation: Lees & Sarjeant, 1971).

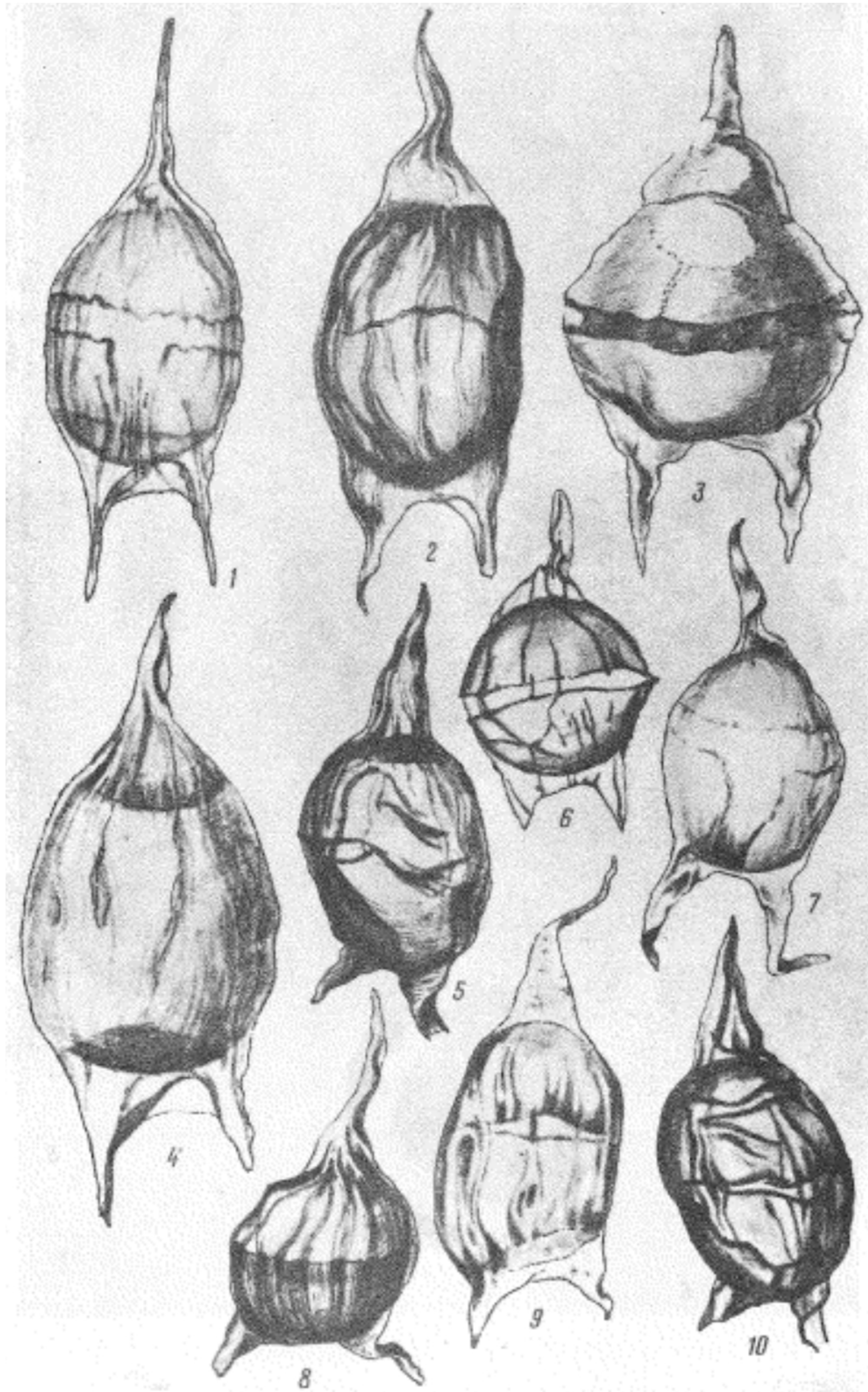


Plate 118, figures 1–10, Vozzhennikova (1963).

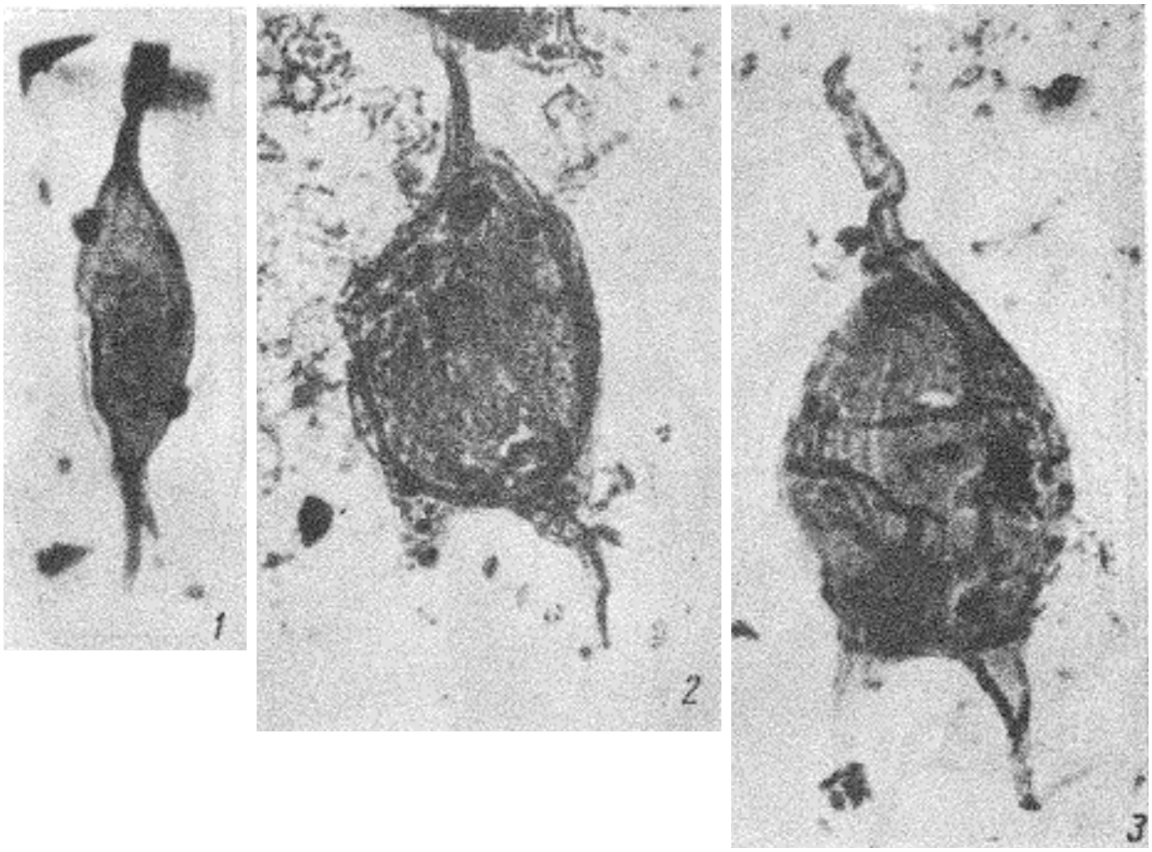
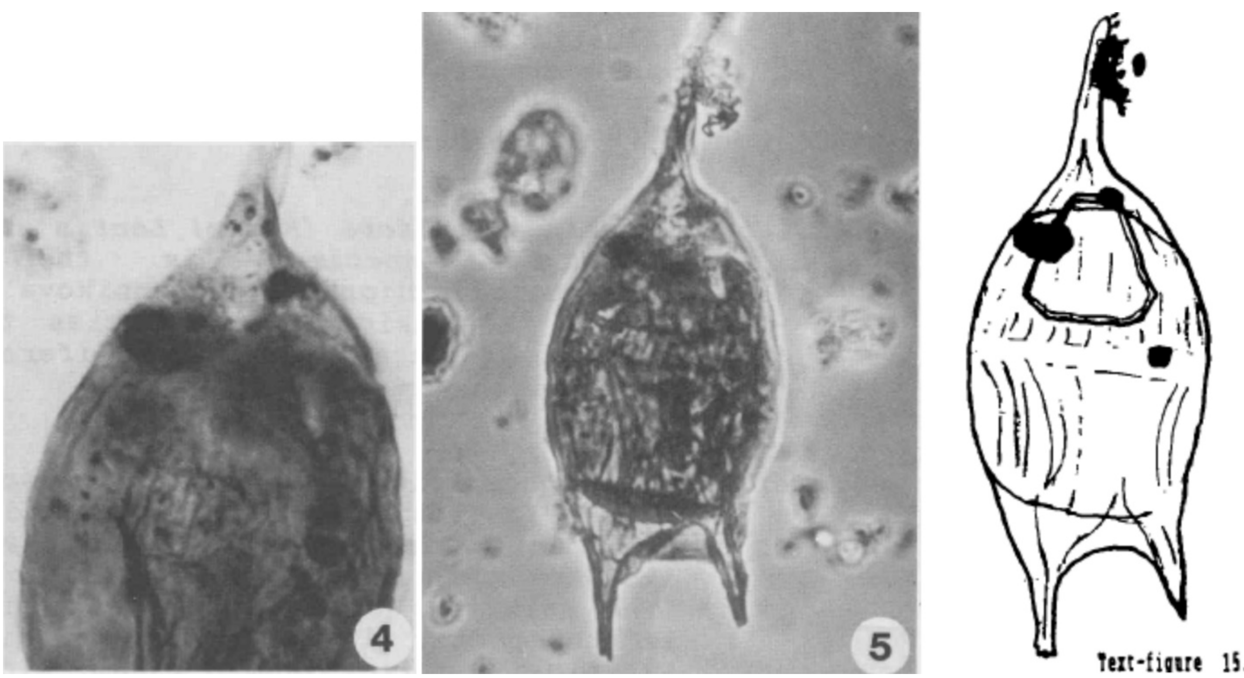


Plate 119, figures 1–3, Vozzhennikova (1963).



Text-figure 15.

Plate 4, figures 4, 5 (holotype), Text-figure 15, Lentin & Vozzhennikova (1990).

Cerodinium markovae (Vozzhennikova, 1967) Lentin & Williams, 1987

<u>Description</u>: “Epitheca larger than hypotheca, with outline conical or more rarely funnel-shaped. The apical horn is short, bluntly rounded or pointed, slightly tapering or not tapering. Hypotheca smaller than epitheca with short triangular apical horns. Transverse furrow shallow, annulate, displaced towards the hinder end of the theca. Longitudinal furrow extends to the antapex. Internal body large, ovoid, its surface finely granular and coloured bright yellow or pale brown. Theca closely adpressed to the internal body, thin walled, transparent, delicate. Surface of theca smooth or finely tuberculate. Pylome large, round trapeziform and situated near to the transverse furrow or more rarely nearer to the apex.” — Vozzhennikova (1967, p. 257, translation: Lees & Sarjeant, 1971)

<u>Dimensions</u>: “(in microns) Holotype: total length of theca 132, breadth 72. 9, width of transverse furrow 5.4, length of internal body 62.5, breadth 48.6. In other specimens: thecal length 121–132, breadth 54–73, width of transverse furrow 5.4, length of internal body 49–62.1, breadth 48–56.” — Vozzhennikova (1967, p. 257, 258, translation: Lees & Sarjeant, 1971)

<u>Comparison</u>: “This species differs from the other species of the genus in having a light coloured, transparent theca, a marked displacement of the transverse furrow towards the posterior end and short triangular antapical horns.” — Vozzhennikova (1967, p. 258, translation: Lees & Sarjeant, 1971)

<u>Emended description</u>: “Cyst shape peridinioid with one short, conical apical horn and two nearly equal, short antapical horns: endocyst elongate oval: apical pericoel well developed, antapical pericoel poorly developed, not extending to paracingular area. Periphragm extremely thin with delicate intratabular granules, very delicate ridges on the periphragm produce longitudinal striae: endophragm finely granulose. Paratabulation expressed by the archeopyle, and paracingulum only. Archeopyle large standard hexa (isodeltaform) formed by the loss of the 2a paraplate in both wall layers. Paracingulum is shallow, indistinct to distinct, occasionally bordered with crinulations [sic] caused by the striae, displaced towards the antapex. The perisulcus is shallow and expressed only as a depression on the hypocyst.” — Lentin & Vozzhennikova (1990, p. 38)

<u>Discussion</u>: “The holotype of this species is located in a dry section of the glycerine slide. Because the periphragm is extremely thin it is almost invisible in transmitted light, however, the endophragm can be clearly seen with the operculum inside. Using phase contrast illumination to photograph the periphragm resulted in severe light defraction around the endocyst. However, introduction of xylene under the coverslip resulted in a better photograph (Plate 3, Figure 8). The short antapical horns and extremely thin periphragm separate this form from other species of *Cerodinium*.” — Lentin & Vozzhennikova (1990, p. 39)

<u>Age</u>: Eocene; holotype of Vozzhennikova (1967, p. 257, translation: Lees & Sarjeant, 1971). Paleocene–Eocene (Vozzhennikova (1967, p. 258, translation: Lees & Sarjeant, 1971).

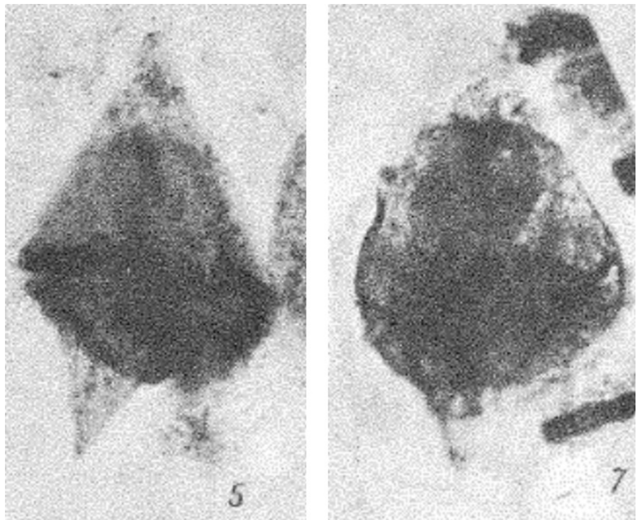


Plate 119, figures 5, 7, Vozzhennikova (1967).

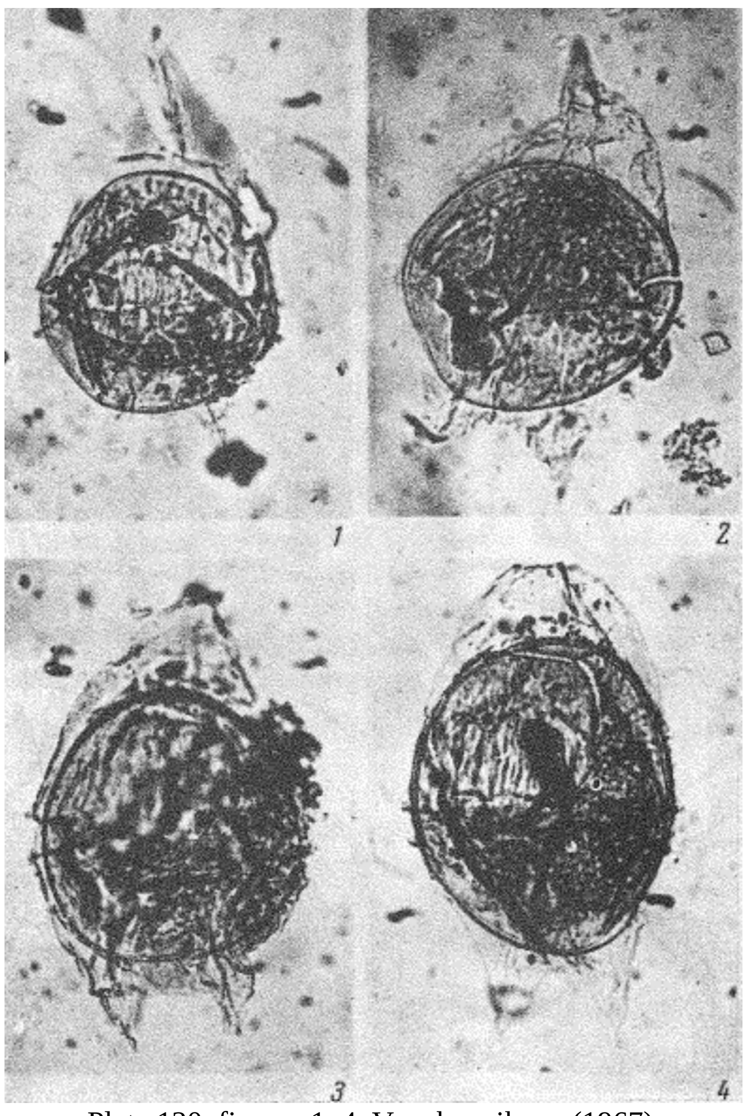
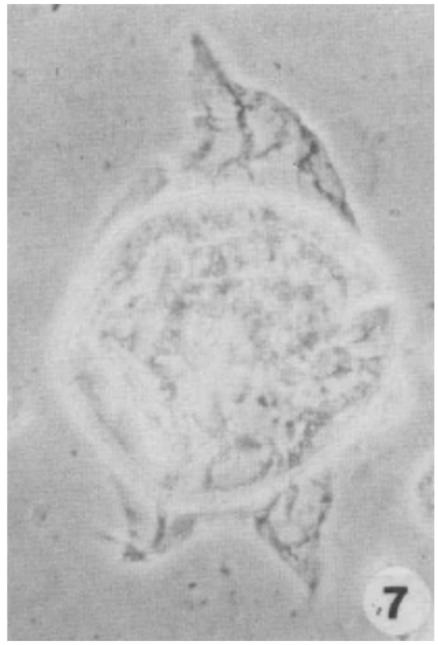
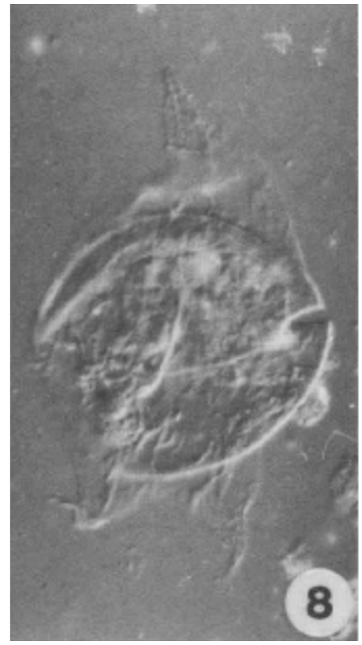


Plate 120, figures 1–4, Vozzhennikova (1967).

Text-figure 16.





Text-figure 16, Plate 4, figures 7, 8, Lentin & Vozzhennikova (1990).

Cerodinium medcalfii (Stover, 1973) Lentin & Williams, 1987

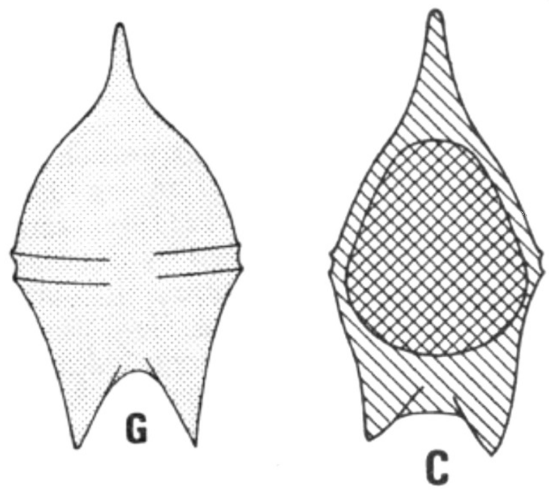
Description: “Cysts are tricornate with an elongate, tapered apical horn and prominent antapical horns of about equal size and with narrowly rounded or pointed tips. Antapical horns separated by a broad medial concavity. Lateral margins of periphragm are gently convex anterior to the cingulum, and straight to slightly concave posterior to the cingulum. Periphragm less than 1 μ thick and clear except for areas with small coni. The species has a typical peridinioid tabulation of 4', 3a?, 7'', 5''', 2'''' with the size, shape, and position of the plates represented by the conate areas. Cingulum defined by transverse parallel ridges about 1 μ high, 5–7 μ apart, and fringed with coni, denticles, or spinules. On some specimens the cingulum is subdivided by longitudinal ridges and its floor is smooth or bears scattered coni. Sulcal margins generally indefinite, and on most specimens, a hook-shaped scar occurs in the sulcus near its junction with the cingulum and generally a little right of centre. Endoblast is comparatively large, broadly elliptical to ovoid in dorso-ventral view, generally wider than long although on some specimens the reverse is true, and located about centrally with respect to the periphragm. Endoblast configuration approximates that of the periblast laterally but deviates apically and antapically. Endophragm is smooth and ca 0.5 μ thick. Archeopyle intercalary, large, irregularly hexagonal in outline, and with a narrower apical than antapical margin. Opening in endophragm corresponds with that in the periphragm. Operculum free.” — Stover (1973, p. 175)

Dimensions: “Length of periphragm is 106–140 μ, width of periphragm is 68–75 μ and the specimens have a length: width ratio between (1:0.53) and 1:0.73 (mean 1:0.64). Length of endophragm is 53–70 μ, width 58–76 μ. Apical horn is 22–34 μ long; antapical horns 20–36 μ long. Measurements based on 12 complete specimens.” — Stover (1973, p. 175)

Comments: “Plates 1', 2a, 1'', 5'' 7'', 1''', 3''' and 5''' are usually clearly recognizable. Other plates are displayed with varying degrees of clarity depending upon the density and size of the coni and the orientation of the specimens. Plates on the epitract are nearly always shown better than those of the hypotract. On the apical horn, and to a lesser extent on the antapical horns, the coni tend to be so closely spaced that the horns have a scaly appearance.” — Stover (1973, p. 175)

Comparison: "*Deflandrea medcalfii* differs from *D. flounderensis* by having a smooth and thinner endophragm, and by having the antapical horns distinctly separated. Generally, the apical horn is longer and narrower in *D. medcalfii* and the tabulation is expressed somewhat more clearly." — Stover (1973, p. 175, 176)

Age: Paleocene; holotype of Stover (1973, p. 176).



Text-figures 3G, 6C, Stover (1973).

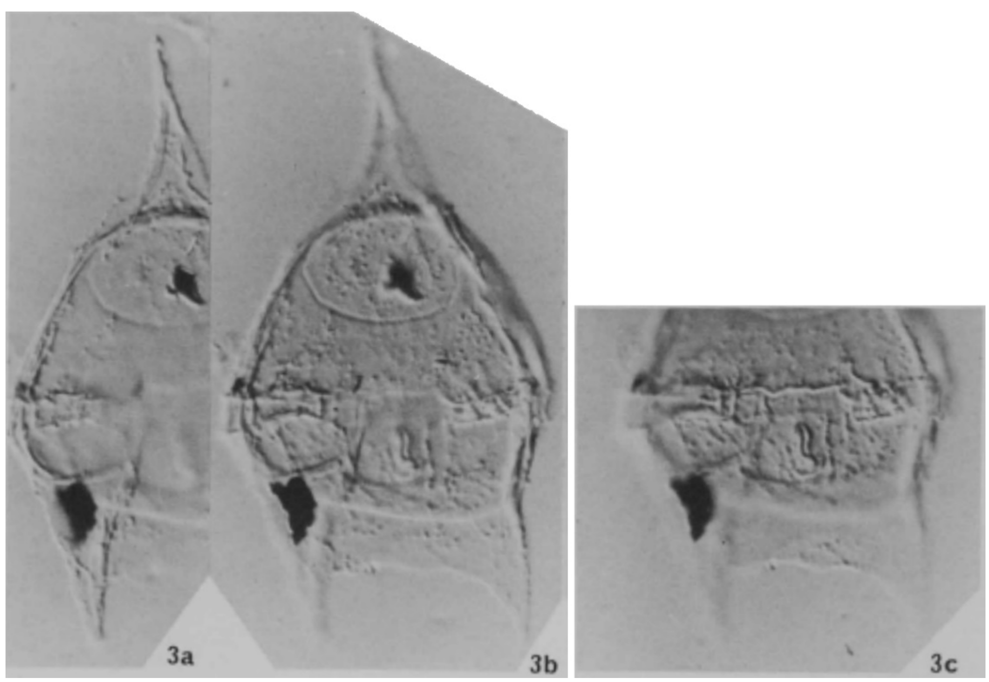


Plate 3, figures 3a–c, Stover (1973).

Cerodinium mediterraneum Slimani et al., 2008

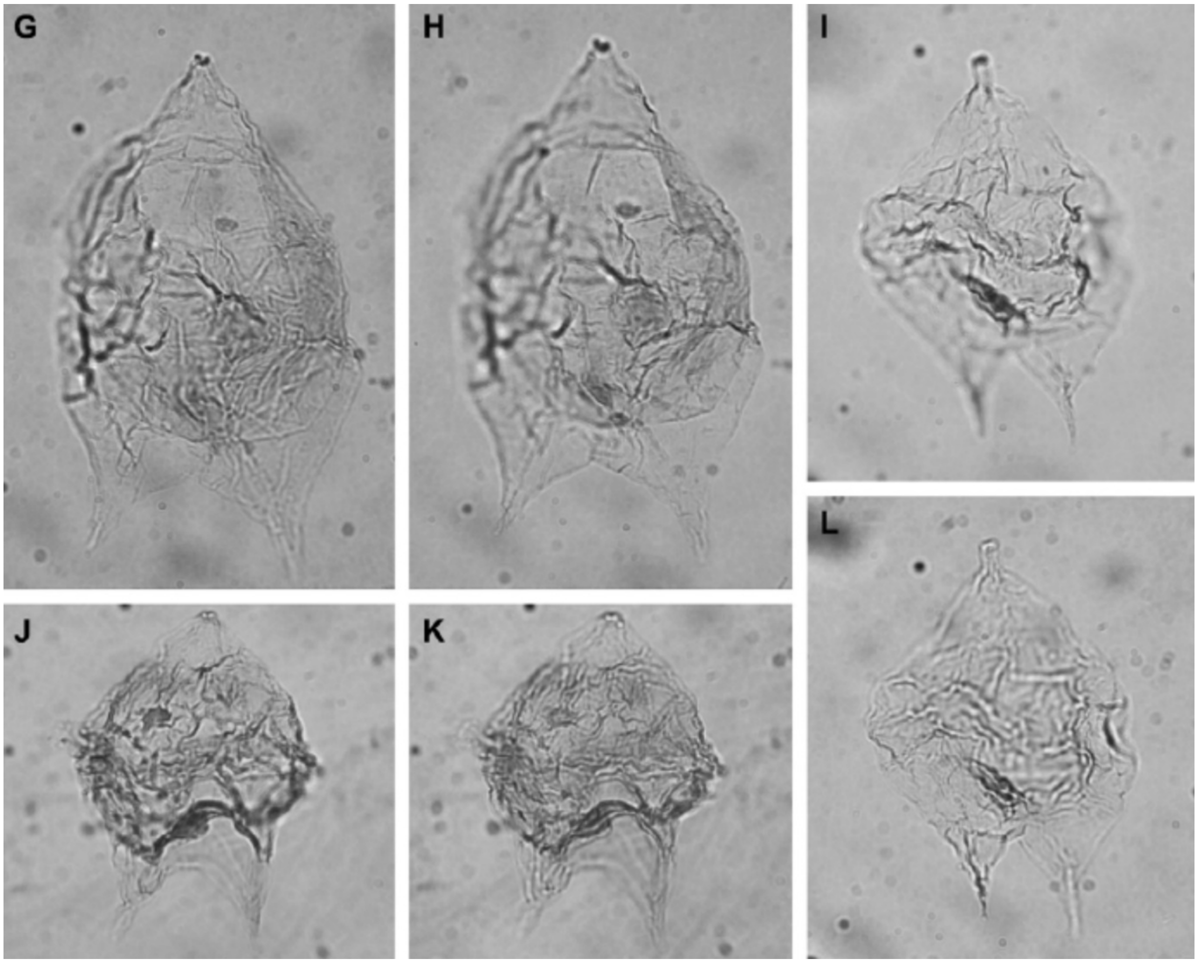
Diagnosis: "Small ovoid, convex-sided, thin-walled *Cerodinium* with narrow pericoels separating horns from endocyst. Cingulum indicated by transverse ledges or folds. Sulcus expressed by a longitudinal depression and folds. Intercalary archeopyle of standard hexa type, expressed by loss of intercalary plate 2a." — Slimani et al. (2008, p. 340)

Description: "Peridinioid, proximate, bicavate to circumcavate, dorsoventrally compressed cyst, which consists of a thin (<0.5 μm), smooth endophragm and a thinner, smooth, finely folded periphragm [sic]. Endocyst generally oval, only slightly smaller than pericyst. Apical horn conical with a blunt tip, broadening proximally to merge with epipericyst. Antapical horns elongate, more or less equal in size, broad-based and tapering distally to pointed tips. They are separated from endocyst by a hypo-pericoel. Slightly laevorotatory cingulum is indicated by transverse ledges or folds. Sulcus is indicated by a slight longitudinal depression of periphragm, often delimited between two longitudinal folds, which are sometimes extended to distal ends of antapical horns (Fig. 9H). When developed, intercalary archeopyle is of type 2a (Fig. 9G) and located on mid-dorsal line. Operculum is free." — Slimani et al. (2008, p. 340)

Dimensions: "(in μm) Holotype, paratype and range for 13 specimens measured: overall length 86, 65, 57(69)86; length excluding horns 55, 35, 35(41)55; overall width 50, 42, 40(45)50." — Slimani et al. (2008, p. 340)

Discussion: "*Cerodinium mediterraneum* sp. nov. closely resembles *Senegalinium* sp. of Kurita and McIntyre (1995, text-figs 3, 4, p. 133, pl. 2, figs 7, 8) and *Cerodinium* sp. A of Oboh-Ikuenobe et al. (1998, fig. 2, pl. 4, figs 2, 3). *Alterbidinium*? *bicellula* (Islam, 1983) Lentin and Williams, 1985 is similar in shape and also bicavate, but differs in being smaller and in having relatively short and unequal antapical horns. *Cerodinium depressum* (Morgenroth, 1966) Lentin and Williams, 1987 is smaller, has a longitudinally striated periphragm, and much more developed pericoels in comparison to the size of the cyst; *C. bolniense* (Riegel, 1974) Lentin and Williams, 1989 is larger, has a pentagonal outline, a striated periphragm, and an endocyst that completely fills the pericyst. However, the specimen included in *C. boloniense* and interpreted by Riegel (1974, pl. 1, fig. 6) as an unusually small form with convex sides resembles *C. mediterraneum*." — Slimani et al. (2008, p. 340)

Age: early Paleocene (early Danian); holotype of Slimani et al. (2008, p. 340). Range: Late Cretaceous (early Campanian)–early Paleocene (early Danian) (Slimani et al. 2008, p. 340).



Figures 9G–L, Slimani et al. (2008).

Cerodinium navarrianum (Srivastava, 1995) Williams et al., 1998

Description: “Cysts compressed peridinioid, pentagonal to roundly pentagonal with single long apical and two equal divergent tapering antapical horns, sides straight to slightly convex cornucavate, rarely slightly bicavate; endocyst pentagonal to roundly pentagonal filling the main body; periphragm smooth with a few wrinkles aligned longitudinally, sometimes anastomosing in certain areas; endophragm smooth; paratabulation indicated by an archeopyle and a low irregular paracingulum; archeopyle intercalary, 2a type, operculum free; paracingulum low transverse parallel ridges, ridges sometimes granular.” — Srivastava (1995, p. 274)

Dimensions: “Total length × breadth range: 104–169 × 49–99 μm in eight specimens.” — Srivastava (1995, p. 274)

Remarks: “*C. navarrianum* is distinct from *C. albertii* (Corradini), *C. striata* (Drugg), and *C. subquadra* (Corradini) in being cornucavate; from *C. cordifera* (May) and *C. leptoderma* Vozzhennikova in having pentagonal endocyst; from *C. crassistriata* (Jain et al.) and *C. granulostriata* (Jain & Millepied) in having smooth endocyst and from *C. pannuceum* (Stanley) in lacking well-developed paracingulum.” — Srivastava (1995, p. 274)

Age: Late Cretaceous (Maastrichtian); holotype of Srivastava (1995, p. 274).

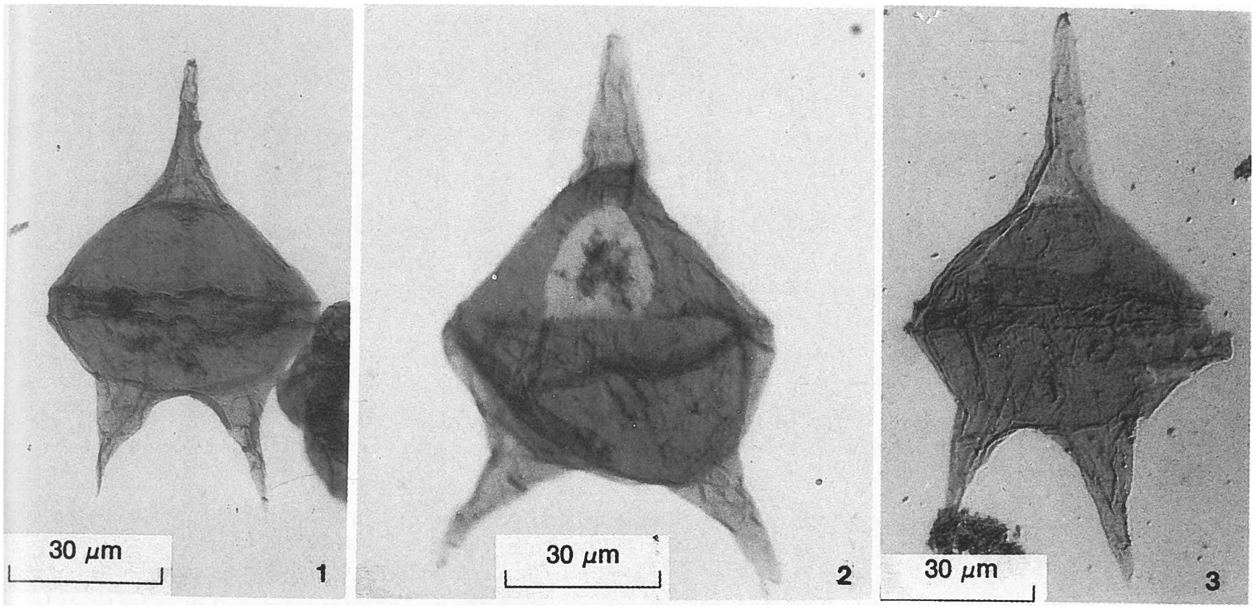


Plate 7, figures 1–3, Srivastava (1995).

Cerodinium nielsii Willumsen, 2011

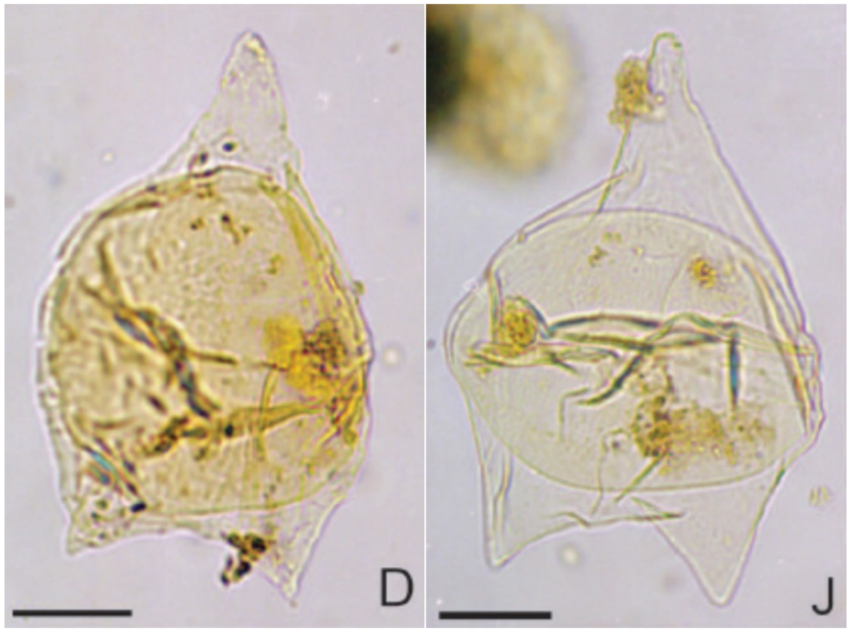
Diagnosis: "Pericyst ovoid, convex-sided *Cerodinium* with three relatively short, conical horns. Endocyst spherical to ellipsoidal and only slightly smaller than the pericyst. Cyst wall smooth. Cingulum and sulcus indicated by folds. Intercalary archeopyle of steno-deltaform type, expressed by the loss of intercalary plate 2a. Operculum is detached." — Willumsen, 2011 (p. 218)

Description: "Peridinioid, proximate, cornucavate to bicavate, dorsoventrally compressed cyst with thin hyaline endophragm and periphragm. Endocyst is spherical to ellipsoidal and smaller than the pericyst. Cyst wall layers are hyaline, 1–2 μm thick. The apical and two antapical horns are short, each with a rounded conical tip. Parasulcus is not indicated and the paratabulation is marked by longitudinal folds at the cingulum. The archeopyle is located on the mid-dorsal line and is intercalary, steno-deltaform, type I(2a)." — Willumsen, 2011 (p. 218)

Dimensions: "The total length is 129(102)86 μm [5 specimens measured] and total width 76(64) 59 μm [5 specimens measured]. Endocyst 68(64)57 μm [5 specimens measured]." — Willumsen, 2011 (p. 218)

Remarks: "*Cerodinium nielsii* sp. nov. differs from *C. albertii*, *C. subquadrum* Corradini, 1973, *C. balticum* Vozzhennikova, 1967, *C. sibiricum* Vozzhennikova, 1963 and *C. striatum* Drugg, 1967 in having a thin, smooth, hyaline periphragm and a hyaline endocyst. *Cerodinium warrenii* Schumacker-Lambry, 1978 has serrated edges in the apical and precingular areas; *Cerodinium navarrianum* Srivastava, 1995 has a circular endocyst, and *C. pannuceum* Stanley, 1965 and *C. conspicuum* Marheinecke, 1992 have a paracingulum. *Cerodinium nielsii* differs from *C. cordiferum* May, 1980 by having a circular endocyst, a smooth periphragm and no indication of the sulcus. *Cerodinium nielsii* differs from *C. mediterraneum* Slimani, 2007 by having three short conical horns with rounded tips and a smooth periphragm." — Willumsen, 2011 (p. 219)

Age: early Paleocene (Danian); holotype of Willumsen, 2011 (p. 219, fig. 6).



Figures 7D, J, Willumsen (2011). Scale bar = 20 μm.

Cerodinium obliquipes (Deflandre & Cookson, 1955) Lentin & Williams, 1987

Description: “Theca with a somewhat pentagonal outline. Transverse girdle hollowed, longitudinal furrow not observed. Epitheca conical, surmounted by a strong, truncate or rounded horn. Hypotheca like a frustum of a cone with short, straight flanks, a wide flat base and a stout, divergent process at each angle. Cyst rounded-pentagonal. Opening on epitheca apparently triangular with a rounded apex. Membrane of both cyst and theca finely punctulate.” — Deflandre & Cookson (1955, p. 252)

Dimensions: “Overall length 100–108 μ, breadth 69–79 μ, apical horn c. 28 μ, basal horns c. 20 μ.” — Deflandre & Cookson (1955, p. 252)

Comment: “This curious species has the general appearance of certain types of living *Peridinium* and species of *Palaeoperidinium* from Cretaceous flints (O. Wetzel 1933, Plate 11, Fig. 14; Deflandre 1936, Plate 4, Fig. 7).” — Deflandre & Cookson (1955, p. 252)

Age: early Eocene; holotype of Deflandre & Cookson (1955, p. 252). Range: Paleocene–early Eocene (Deflandre & Cookson, 1955, p. 252).

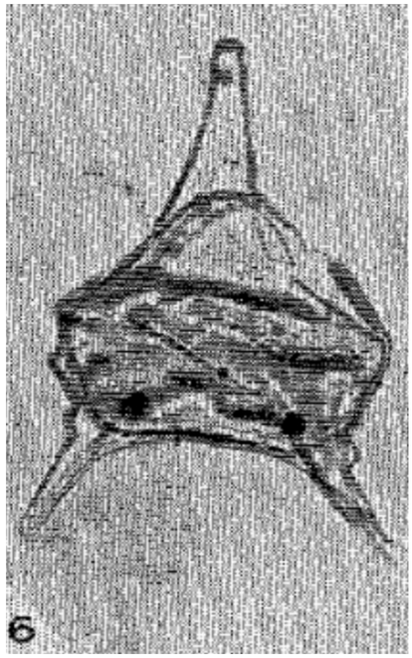


Plate 4, figure 6, Deflandre & Cookson (1955).

Cerodinium pannuceum (Stanley, 1965) Lentin & Williams, 1987

Description: “Outer cyst more or less pentagonal in dorso-ventral view; length 80–100 μ, width 55–78 μ; outer cyst membrane smooth, thin and characteristically longitudinally wrinkled. Apical horn 15 μ in length, hollow with what appears to be a distal pore present. Antapical horns typically divergent, length of horns about 25 μ with left horn always slightly longer than the right one. Interior cyst large, commonly subpentagonally shaped with the posterior end flattened; interior cyst more or less completely fills the outer cyst. Girdle distinct and well developed whereas furrow is usually indistinct. Archeopyle distinct to indistinct with the length of the posterior side approximately equaling that of the anterior side.” — Stanley (1965, p. 220)

Differential diagnosis: “*Deflandrea pannucea*, n. sp. somewhat resembles *D. obliquipes* Deflandre and Cookson with its diverging antapical horns and the subpentagonal inner cyst filling the outer one. It differs from this species of Deflandre and Cookson in that it is slightly smaller in size and, more importantly, has a smooth outer cyst membrane that is not longitudinally wrinkled.” — Stanley (1965, p. 220)

Dimensions: “Length 80–100 μ; width 55–78 μ; apical horn length 15 μ; length of antapical horns about 25 μ.” — Stanley (1965, p. 220)

Age: early Paleocene (Danian); holotype of Stanley (1965, p. 220). Warwick et al. (2004) places the Cannonball Member of the Fort Union Formation as 65–61 Ma.

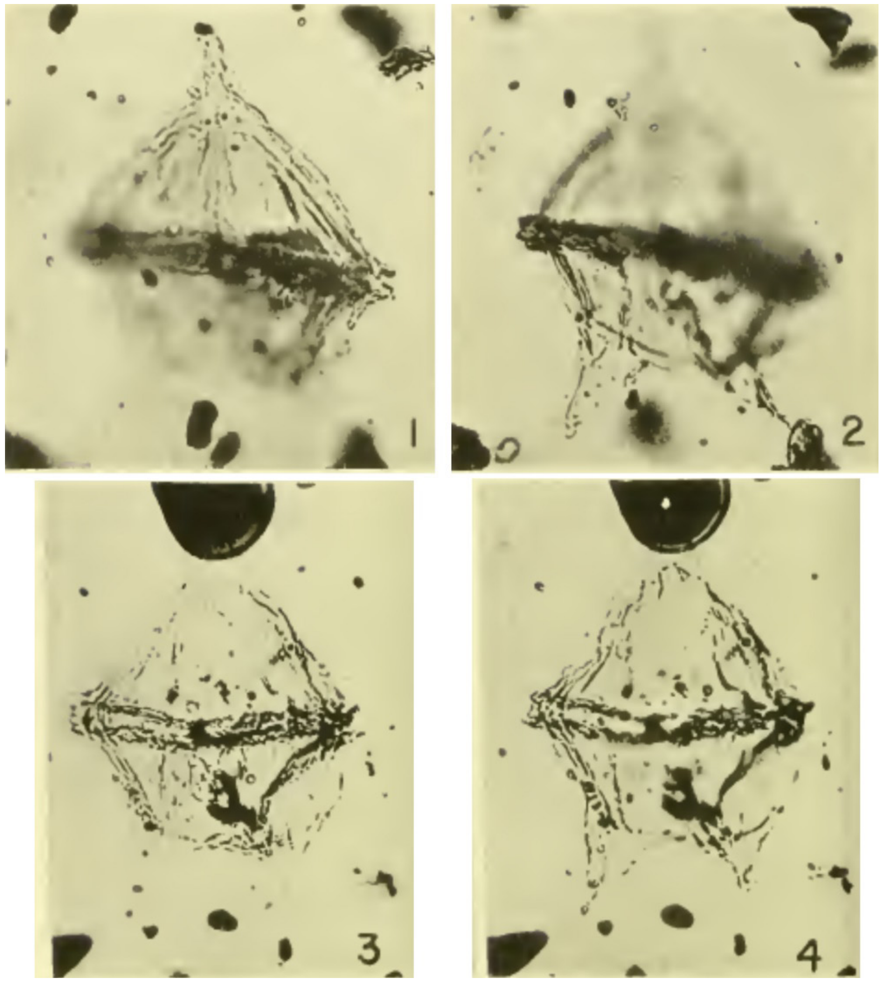


Plate 22, figures 1–4, 8–10, Stanley (1965).

Cerodinium pedibaculiferum (He Chengquan, 1991) Lentin & Williams, 1993

Description: "Outline pentagonal or dinoflagellate-shaped, with straight sides and somewhat convex waist. The epitheca is slightly smaller than the hypotheca; large, close to an isosceles right-angled triangle, with a horn extending from the top, about 171 μm long, with a sharp tip. The hypotheca is inverted trapezoidal, the base is gently arc-shaped, with two nearly equal caudal horns, about 17 μm in length, far pole rod-shaped, the rod-like part is 2 to 3 μm long, mutually. The distance is about 44 μm. The girdle is slightly concave, ring-shaped at the equator, about 7.5 μm wide, with thin ridges and associated transverse grooves along its edges for the sign. The longitudinal groove is limited to the hypotheca, nearly triangular, narrow in front and wide in back, and its edge is decorated with fine ridges. Thin outer wall has fine particles on the surface; granular, partly seems to have thorns. The inner body is nearly round, and the surface is granular. Except for the apical and antapical horns, it is closely attached to the outer wall. Together, they are quite close to each other or slightly separated at the antapex. The archeopyle is relatively wide front-to-front, and has a fuzzy hexagonal outline. Its length and width are nearly equal. The operculum is completely detached but kept in place." — Translated from He Chengquan (1991, p. 75, 76)

Dimensions: "The cyst is 122 μm long, 75 μm wide, and the inner body has a diameter of 72.5 μm." — Translated from He Chengquan (1991, p. 76)

Comparison: "This new species with the lack of periphragm external cavity and *Certatopsis taenialis* is different with the two antapical horns far apart, it shows that it is also different from the lack of thin stripes as in *C. boloniensis* and other characteristics." — Translated from He Chengquan (1991, p. 76)

Age: late Paleocene (Selandian–early Thanetian?); holotype of He Chengquan (1991, p. 228). Based on the range chart and translation of "lower part of Qimgen Formation" from He Chengquan (1991, p. 76, 228, fig. 4). Also, see Xi Dengpeng et al. (2020, fig. 18).

Plate 34, figure 14, He Chengquan (1991).

Cerodinium prutense (Grigorovich, 1971) Lentin & Williams, 1987

Diagnosis: The theca is strongly elongated, with an internal body protruding along the sides. Epitheca triangular, gradually transitioning into a long apical horn. Hypotheca with two antapical processes, wide at the base, one of which is often reduced. The inner body is spherical. Theca is smooth and transparent." — Translated from Grigorovich (1971, p. 92, 94)

Dimensions: "holotype, length 120 µm, width 69 µm." — Translated from Grigorovich (1971, p. 94)

Age: early Eocene (Ypresian); holotype of Grigorovich (1971, p. 94).

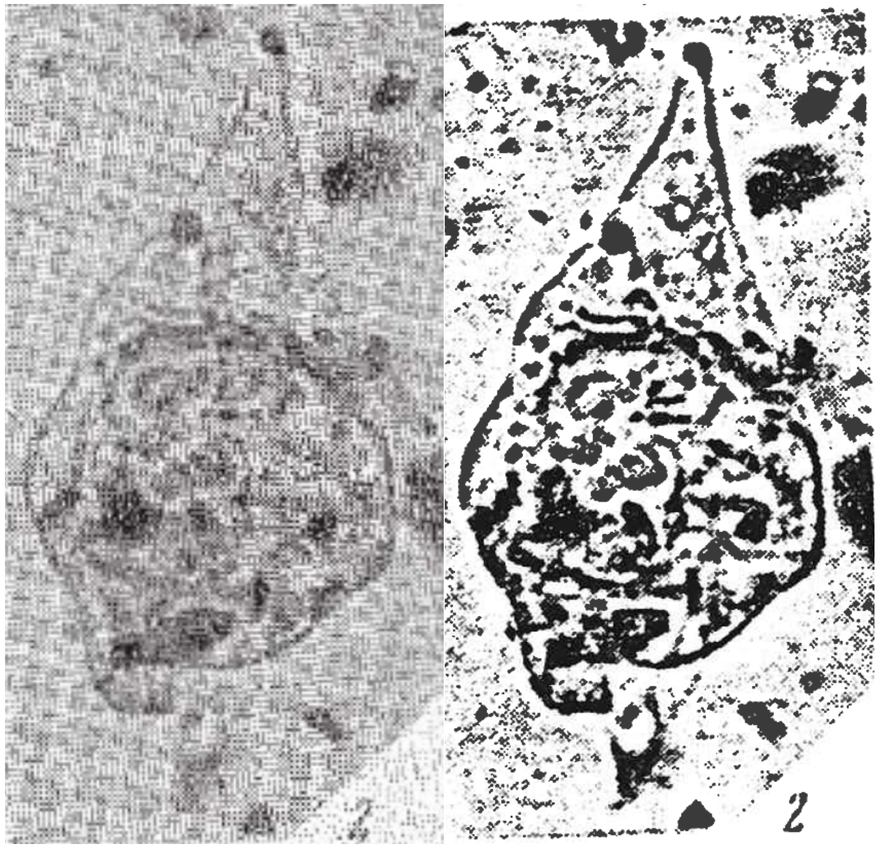


Plate 2, figure 2, Grigorovich (1971).

Cerodinium quiriquinaense (Takahashi, 1979) Lentin & Williams, 1989

Description: "Outer cyst large, more or less pentagonal in dorso-ventral view; length 75–100.2 μ overall; width 63–79.7 μ; outer cyst membrane smooth to irregularly granulate or punctate. Apical horn more than 10–17.5 μ in length; antapical horns more than 25–30 μ in length with left horn slightly longer than the right one; antapical horns tend to slightly diverge from each other. Inner cyst completely fills the outer one. Girdle wall developed by ridges, about 6–6.6 μ in width. Furrow about 10–20 μ wide and is bordered by more or less frilled border. Intercalary archeopyle large, usually outlines by a lateral oval in form." — Takahashi (1979, p. 33)

Dimensions: "Holotype . . . outer cyst 100.2 × 79.7 μ, inner cyst 58.8 × 76.3 μ; apical horn more than 17.5 μ in length; antapical horns more than 30 μ in length; girdle about 6.3 μ in width." — Takahashi (1979, p. 33)

Remarks: "The present specimens are differentiated from *Deflandrea dilwynensis* Cookson & Eisenack from the Paleocene Pebble Point Formation, SW Victoria, Australia, by its larger size, its longer antapical horns, and a laterally oval form of archeopyle." — Takahashi (1979, p. 33)

Age: Late Cretaceous (Maastrichtian); holotype of Takahashi (1979, p. 33) based on the age for the Quinquina Formation given by Salazar et al. (2010).

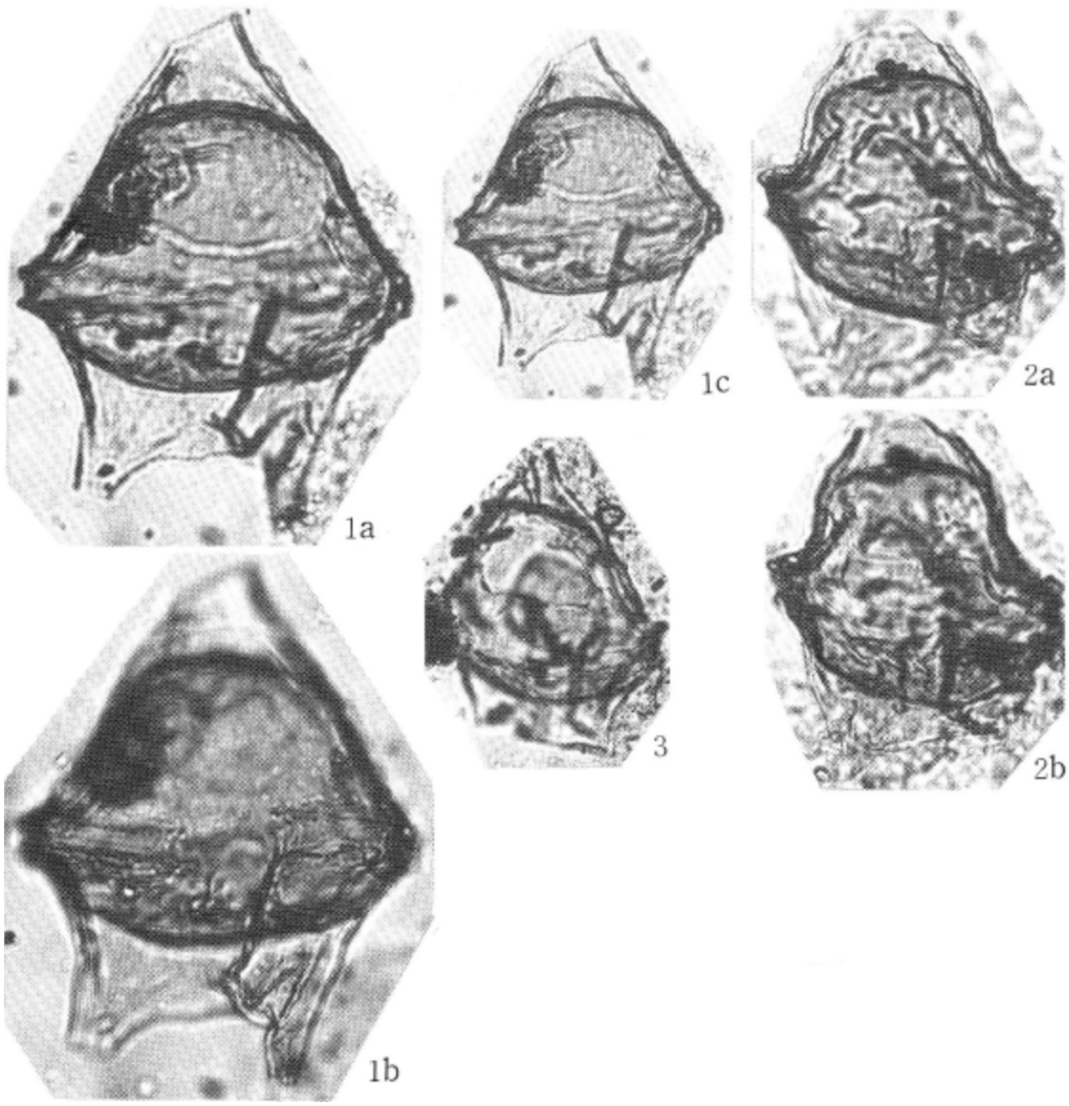


Plate 1, figures 1a–c, 2a, b, 3, Takahashi (1979).

***Cerodinium sibiricum** Vozzhennikova, 1963. Emendation: Lentin & Vozzhennikova, 1990

<u>Description</u>: “Theca oval with a long or short apical horn, gradually tapering towards the distal end and varying in size. Antapical horns short, slightly diverging. Transverse furrow divides theca into equal, or unequal parts. Longitudinal furrow extends to the end of the hypotheca. Edge of grooves smooth or provided with fine teeth or tubercles. Internal body lens-shaped or spherical, its surface smooth or granular. Walls of theca thin or s lightly thickened at the sides. Thecal surface smooth or covered with fine spines or tubercles. Pylome large, trapeziform, situated below the apical horn.” — Vozzhennikova (1963, p. 239, translation: Lees & Sarjeant, 1971)

<u>Dimensions</u>: “(in microns) Length of theca 95, breadth 80, length of apical horn 35, length of antapical horns 15, width of transverse furrow 8, length of internal body 69, width 7l. In other specimens, thecal length 70–142, breadth 70–94.5, length of apical horn 30–54, length of antapical horns 10–20, width of transverse furrow 7–9, length, of internal body 69–72.9, width 71.5–81, width of pylome 43, height 14.” —

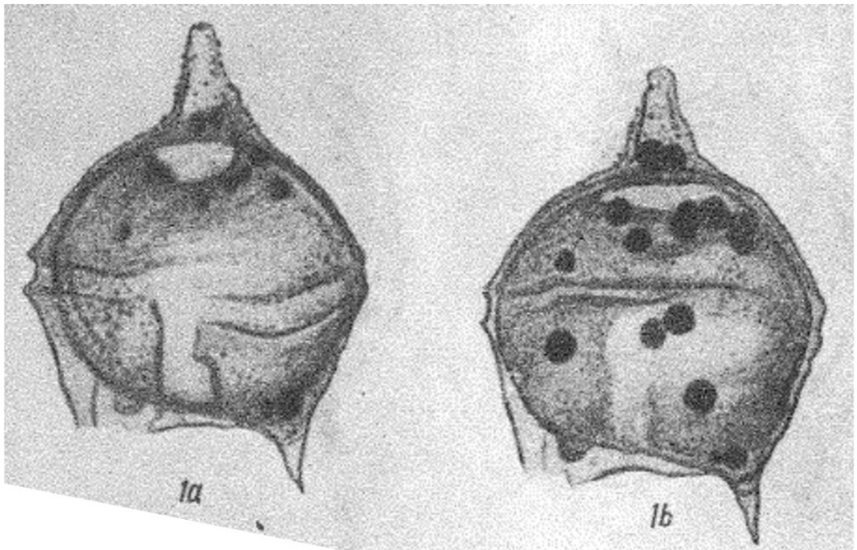
Vozzhennikova (1963, p. 239, translation: Lees & Sarjeant, 1971)

<u>Comparison</u>: “This species differs from *C. balticum* in its more compact theca and the richer sculpturing to its surface; also, in the conical shape of the horns.” — Vozzhennikova (1963, p. 239, translation: Lees & Sarjeant, 1971)

<u>Emended description</u>: “Cyst shape rounded peridinioid with one apical and two short, widely spaced antapical horns; endocyst broadly oval: cornucavate to circumcavate. Periphragm thin with occasional delicate longitudinal wrinkles or folds; endophragm smooth or minutely granulose, both wall layers tend to show a dark brown color. Paratabulation absent except as expressed by the archeopyle and paracingulum. Archeopyle large standard hexa (iso-deltaform) formed by the loss of the 2a paraplate in both wall layers. Paracingulum is shallow, indistinct to distinct, bordered by delicate spinules. The parasulcus is shallow and expressed only as a depression on the hypocyst. A crescent shaped opisthopyle may be present in the parasulcus.” — Lentin & Vozzhennikova (1990, p. 39–40)

<u>Discussion</u>: “Vozzhennikova (1967) described the periphragm as smooth or covered with fine spines or tubercles. However, using interference contrast it was possible to see that the surface of the holotype is covered with minute particles of organic material, not spines or tubercles. The fine ‘teeth’ or spinules which border the paracingulum are very distinctive (see Plate 4, Figure 2).” — Lentin & Vozzhennikova (1990, p. 40)

<u>Age</u>: Paleocene; holotype of Vozzhennikova (1963, p. 239, translation: Lees & Sarjeant, 1971). Range: Paleocene–Eocene (Vozzhennikova (1963, p. 239, translation: Lees & Sarjeant, 1971).



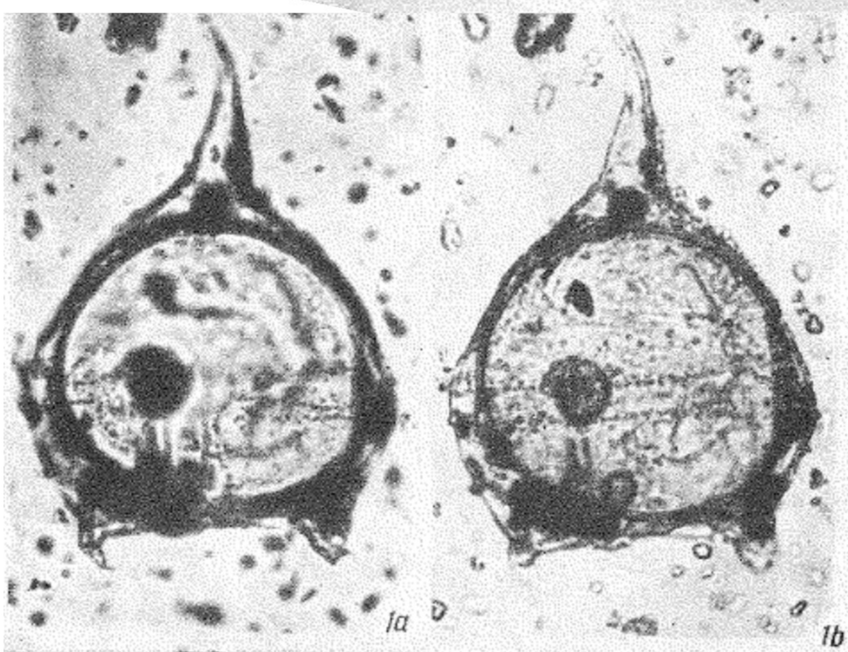
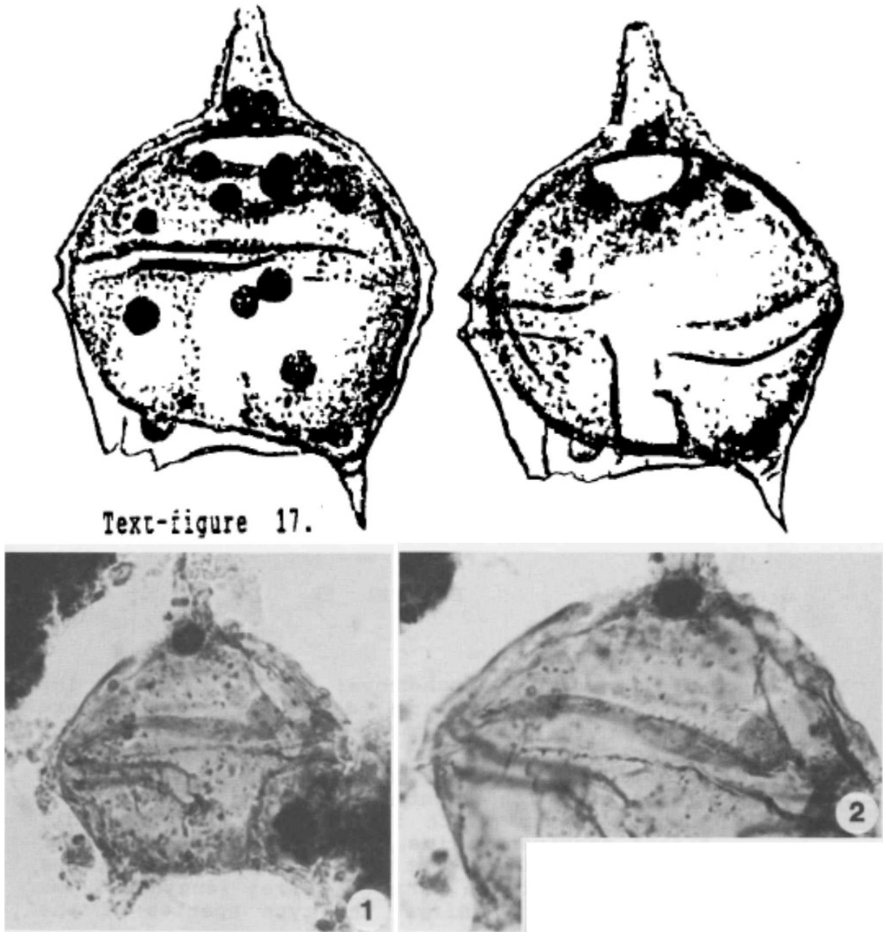


Plate 67, figure 1a, b, Plate 117, figures 1a, b, Vozzhennikova (1963).



Text-figure 17, Plate 4, figures 1, 2, Lentin & Vozzhennikova (1990).

Cerodinium speciosum subsp. ***speciosum*** (Alberti, 1959) Lentin & Williams, 1987

Diagnosis: "Cyst flattened, its outline elongated pentagonal, with a short forward tapering apical horn and two sharply diverging antapical horns with pointed ends. Transverse furrow shallowly depressed, longitudinal furrow sometimes indicated on top of hypotheca. Serrated ridges on the surface of the cyst, forming tabulation. Inner body mostly tight-fitting, large, membrane of the cyst and inner body with small tubercles, which are arranged in different densities are and may be missing in some places." — Translated from Alberti (1959, p. 97)

Additions: "For the species, the mostly strong divergence of the far apart antapical horns is characteristic. Whether there is tabulation of the theca cannot be decided with certainty. Below the apex is a ± rounded-trapezoidal archeopyle. The cyst membrane is transparent of the inner body brownish." — Translated from Alberti (1959, p. 97)

Dimensions: "Holotype: length 120 μ, width 74 μ. It varies with other specimens with the length between 110 μ and 130 μ, the width between 60 μ and 80 μ. About 30 specimens." — Translated from Alberti (1959, p. 97)

Differential diagnosis: "Differs from *Defl. obliquipes* Defl. & Cooks. through the different outline of cyst, distinguished from the other species of the genus by the stout divergent antapical horns." — Translated from Alberti (1959, p. 97)

Age: late Paleocene (Thanetian); holotype of as translated from Alberti (1959, p. 97).

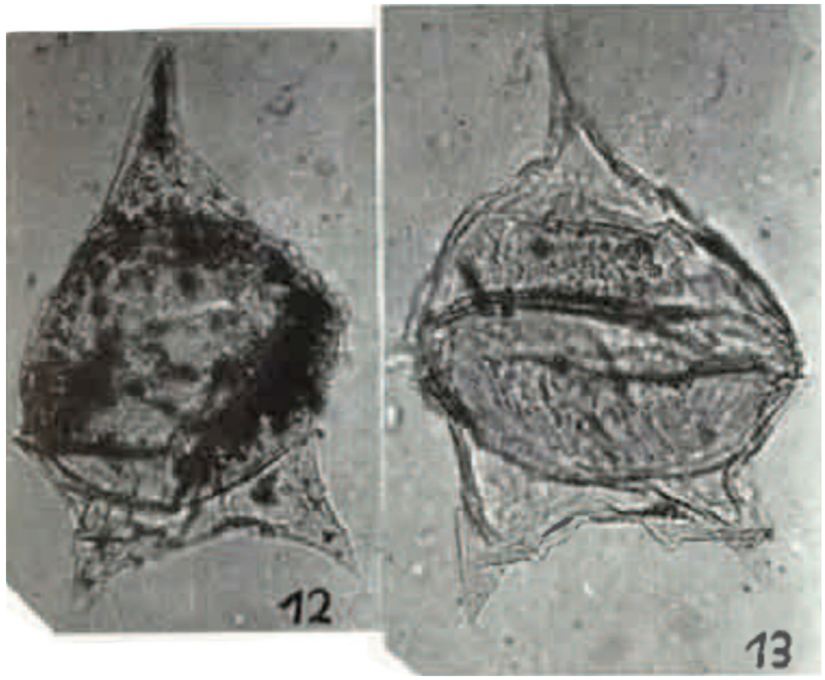


Plate 9, figures 12, 13, Alberti (1959).

Cerodinium speciosum subsp. ***elongatum*** (Mao Shaozhi & Norris, 1988) Lentin & Williams, 1989

Diagnosis: "Cyst proximate, circumbicavate. Ambitus elongate, length relatively longer than width, epitract distinctly bigger than hypotract. Apical horn long, protruding. Antapical horns two, typically equal, divergent, with broad bases and pointed distal ends. Periphragm ornamented with coarse granules, tubercules, and cones, giving rise to denticulate lineation of cyst. Endophragm smooth. Endoblast subspherical, its length greater than its width, filling in middle part of pericoel. Cingulum slightly levorotatory, shallow. Archeopyle intercalary, type (I) formed by loss of 2a, broad hexa style." — Mao Shaozhi & Norris (1988, p. 42)

Description: "Epitract shaped like an equilateral triangle plus an attenuated apical horn; apical horn long, sinuous, usually 30 to 40 μm long and 8 to 12 μm wide at the base. Hypotract trapezoid with two divergent claw-like antapical horns wider at bases (24 to 36 μm), 20 to 38 μm long, pointed distally. Endoblast subspherical, occupying middle part of pericoel, giving rise to 0-to-6-μm-wide narrow ambital pericoels and well-developed apipericoel and antapipericoels. Periphragm covered with coarse granules, irregularly shaped, sometimes faintly intratabular, and with tubercules and cones. Tubercules and cones sometimes fused proximally, forming low ridges. Cingulum marked laterally by ridges and dorsoventrally by aligned granules and tubercules." — Mao Shaozhi & Norris (1988, p. 42)

Dimensions: "Length 148 to 160 μm (holotype 160 μm), width 68 to 80 μm (holotype 80 μm); 20 specimens measured." — Mao Shaozhi & Norris (1988, p. 42)

Discussion: "This new subspecies is closely comparable to *Ceratiopsis speciosa* subsp. *glabra*. The overall shape of the new subspecies is more elongate than that of the latter, and the periphragm is ornamented with features of low relief rather than being typically smooth." — Mao Shaozhi & Norris (1988, p. 42)

Age: late Paleocene (Selandian–early Thanetian?); holotype of Mao Shaozhi & Norris (1988, p. 42). Based on the age of the Qimgen Formation provided by Xi Dengpeng et al. (2020, fig. 18).

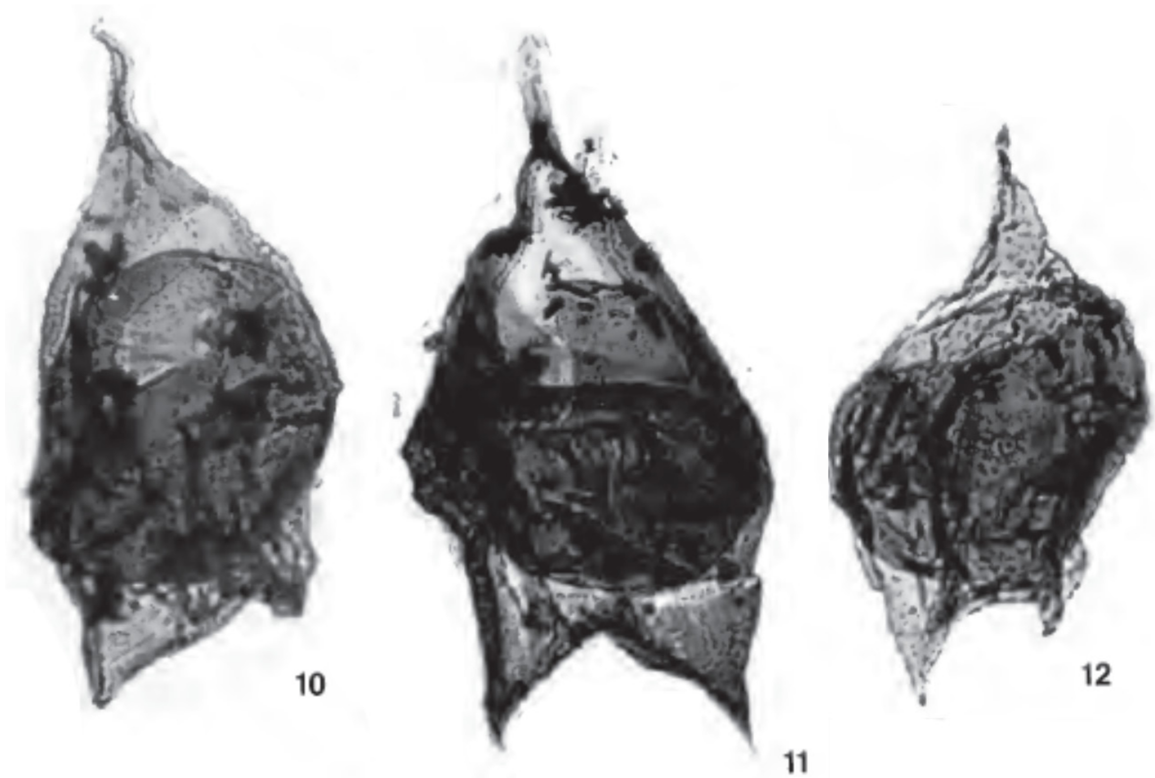


Plate 9, figures 10–12, Mao Shaozhi & Norris (1988).

Cerodinium striatum (Drugg, 1967) Lentin & Williams, 1987

Diagnosis: "Apical horn long, tapered, bluntly pointed. Antapical horns broad, tapered, pointed, connected to each other below the cyst by a web. Large internal cyst always present, circular to ellipsoidal in outline. Cyst wall single layered, unornamented, about 1 µ thick. Test wall thin, ornamented with rows of grana paralleling the long axis of the test. These grana sometimes coalesce to form low ridges. Parallel wrinkles often present, grana, ridges, and wrinkles together presenting a markedly striate appearance. Girdle circular, shallow, about 8 µ wide, delineated by two parallel rows of grana (beading) or by low, denticulate walls. The center line of the girdle sometimes marked by a single row of grana, but the girdle is more often ornamented only by close-set vertical wrinkles. Longitudinal furrow broad, usually indistinct. Opening in cyst always present, large, somewhat angular but in gross outline semicircular, about 35 µ wide and 22 µ high. It is dorsally located but sometimes extends onto the ventral side of the cyst as though the top were sliced off with a cut inclined dorsally. The archeopyle in the test wall is less distinct but coincides with the cyst opening. The opercula of both openings break free first on the lower border." — Drugg (1967, p. 18)

Dimensions: "79 to 97 µm broad, 138 to 168 µ long." — Drugg (1967, p. 18)

Comment: "This species differs from *Deflandrea delineata* Cookson and Eisenack 1965 in that it is slightly smaller, lacks tabulation, and is more uniformly striate. In addition, the girdle is bordered by beaded or denticulate edges, a feature lacking on *O. delineata*." — Drugg (1967, p. 18)

Age: early Paleocene (Danian); holotype of Drugg (1967, p. 18).

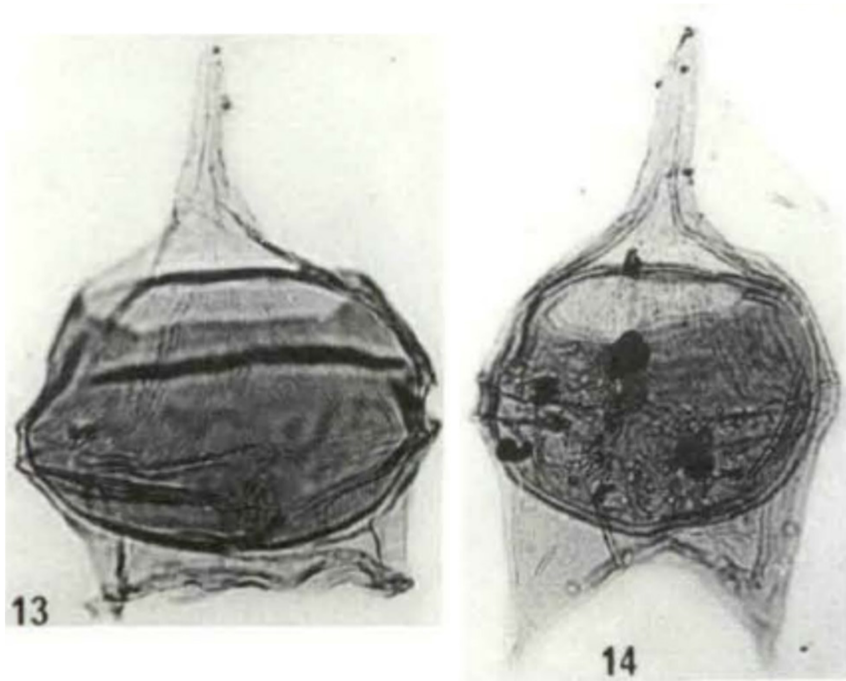


Plate 2, figures 13, 14, Drugg (1967).

Cerodinium subquadrum (Corradini, 1973) Lentin & Williams, 1987

Diagnosis: “Dinoflagellate cyst having a more or less triangular epitract and a wide rectangular hypotract. Large apical horn with broad base; antapical horns relatively little developed. Inner capsule subcircular to subquadrate in outline, normally in contact with the outer wall. Archeopyle intercalary.” — Corradini (1973, p. 176)

Description: “The test is flattened dorso-ventrally and is composed of a thick smooth endophragm and of an irregularly punctate or vermiculate, thin periphragm. The inner body possesses a slightly thick wall while the outer membrane is thinner. The sides of the triangular epitract are sometimes partially convex but normally rectilinear. Apical horn with broad base tapering to the blunt apex with the same inclination as the sides of the epitract. The hypotract is less wide than the cingulum and almost quadrangular in shape. The antapical horns, fairly well developed, are distally blunted and well separated, their axes being straight diverging. Cingulum and sulcus well developed, but the latter only on the hypotract. Large intercalary archeopyle.” — Corradini (1973, p. 176)

Dimensions: “Holotype: diameter of the inner capsule 60 × 65 μ, width of the cyst 74 μ, overall length 143 μ. Range: diameter of the inner capsule 55–60 × 60–65 μ, width of the cyst 72–75 μ overall length 115–143 μ.” — Corradini (1973, p. 176)

Age: Late Cretaceous (middle Campanian); holotype of Corradini (1973, p. 176) given the age of the basal section of the Mt. Cassio Flysch provided by Catanzariti et al. (2007, fig. 5).

Plate 28, figure 1, Corradini (1973). Scale bar = 20 μm.

Cerodinium taeniale (He Chengquan, 1991) Lentin & Williams, 1993

<u>Description</u>: "The cyst is flattened ventrally and dorsally, with an elongated pentagonal outline, divided into two nearly equal parts by transverse grooves. The epitheca is a nearly acute angle, triangular, with slightly convex and concave sides; conical apex is 25 μm long, and the base of the apex is constricted, and the top is sharper. The hypotheca is inverted trapezoidal; side slightly concave, antapex straight (and parallel to transverse groove) or slightly concave, with two antapical horns, nearly equal in size, 20–25 μm long. Terminal apexes, usually strongly divergent, are quite far from each other (54–80 μm), no lateral convexity is shown. The transverse groove is located on both sides of the convex, spatial, slightly concave, microspiral ring, 7–12 μ in width, its margins are decorated with granular ridges, separated by longitudinal grooves on the ventral surface. Longitudinal groove limited to the hypotheca. The surface of the outer wall is in the shape of particles and short spines, the size of the particles is different, and the diameter of the thicker ones is up to 1 μm. The longest spines can be up to 2.5 μm, and usually appear intermittently on the contour line, that is, the spines appear alternately with the near-smooth segments, and the spines segment width is about 8 μm. The relationship between the distribution of spines and the plate type has not been observed clearly, and in the holotype specimen looks like a band (reflecting the expansion structure of seams?), but linear in other specimens (possibly distributed along interplate seams). The outer walls of most specimens are dense with linear ridges that are well developed especially on the epitheca or lid. Inner body oval-horizontal ellipse, wider than long, surface thin or coarse granular. It is completely separated from the outer wall, and the surrounding external cavity is well developed. The front room of the archeopyle is quite wide, and its outline is round trapezoidal or subquadrate, generally equal in length and width or occasionally slightly wider than long. The opercula are completely detached and come off or are kept in place." — Translated from He Chengquan (1991, p. 76)

<u>Dimensions</u>: "Cyst length 125 (incomplete)–165 μm, width 87–105 μm, inner body length 65–80 μm,

width 82.5–95 μm (5 specimens measured). The holotype is 165 μm long and 95 μm wide, the inner body is 80 μm long and 86 μm wide, the apex horn is 25 μm long, and the horn of the antapex is 20 μm long, The width of the transverse groove is 10–12 μm." — Translated from He Chengquan (1991, p. 76)

<u>Discussion</u>: "Compared with *Defandrea*, this species is similar in shape and structure to *Ceratiopsis* (al. *Deflandrea*) *speciosa*, but the former has a surface of the inner and outer walls of the latter as granular, and the inner body and the outer wall are completely separated. The inner and outer walls of the latter are both nodular and they are in contact with each other on the side of the bright body, so the two are easy to distinguish. But there may be a kinship between the two. In addition, the new species is also different from *Deflandrea oebisfeldensis* and *D. andromiensis* in terms of the characteristics of the archeopyle and the short spines on the surface of the outer wall, which may be slit type." — He Chengquan (1991, p. 76)

<u>Age</u>: late Paleocene (Selandian–early Thanetian?); holotype of He Chengquan (1991, p. 227). Based on the range chart and translation of "lower part of Qimgen Formation" from He Chengquan (1991, p. 76, 227, fig. 4). Also, see Xi Dengpeng et al. (2020, fig. 18).

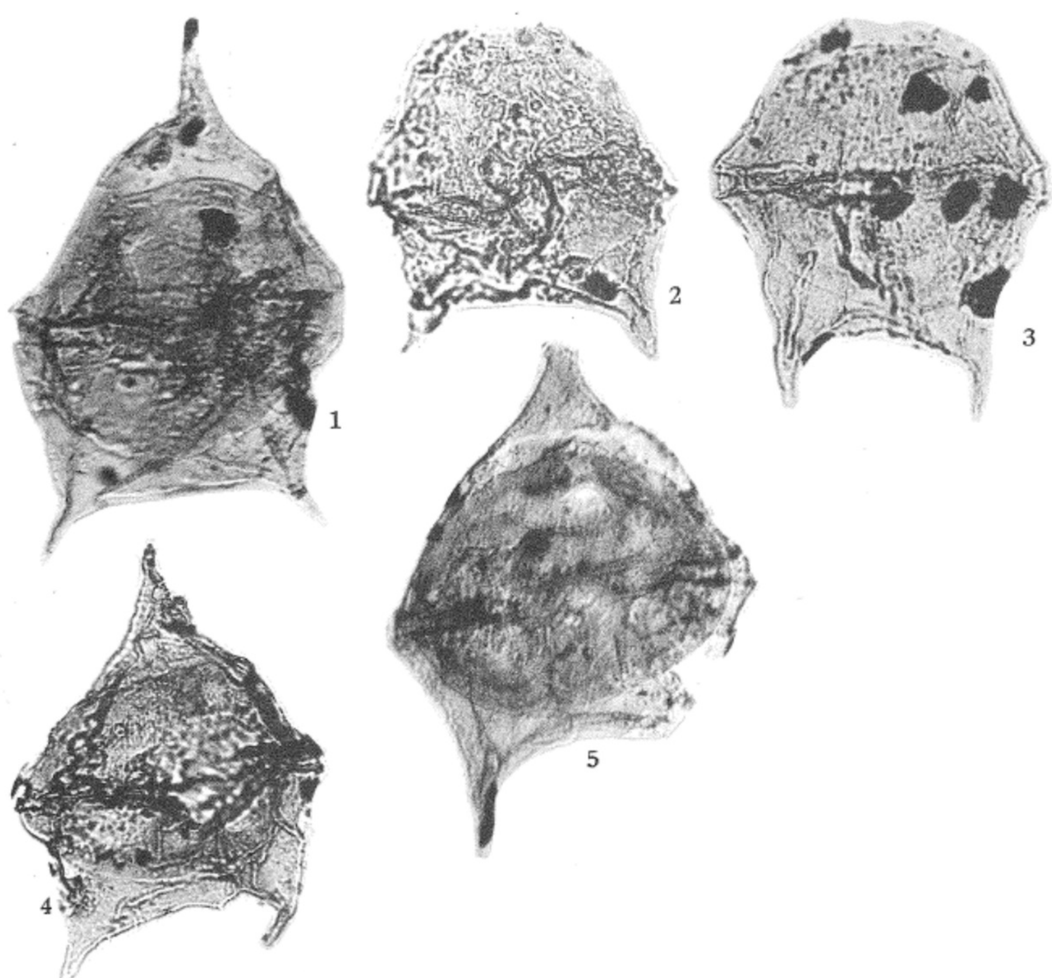


Plate 32, figures 1–5, He Chengquan (1991).

Cerodinium verrucosum (Heisecke, 1970) Lentin & Williams, 1989

<u>Diagnosis</u>: "Cyst cavate, subcircular to rhomboidal outline composed of two layers. Thick, opaque, infragranular endophragm with verrucous sculpture; delicate, hyaline periphragm forming an apical horn and two small antapical horns. In the equatorial zone a poorly defined cingulum is observed. Presents precingular archeopyle." — Translated from Heisecke (1970, p. 232)

<u>Description</u>: "Subspherical cavate cyst with a circular to subcircular outline and a tendency to be rhomboidal, composed of two layers. The endophragm, opaque, of a reddish brown color, presents a warty sculpture; the warts are distributed quite widely and irregularly, and the shapes of these warts are diverse, from irregular outline, in some cases elongated, uniting one wart with another. The periphragm is delicate, hyaline and forms a bulge or small apical horn and two antapical horns, one larger than the other, also small. Both layers are separated forming a pericoel 1–1.5 u wide, except in the apical and antapical zone, where they separate to form the horns. In the equatorial zone, irregular thickenings of the wall are observed, which would indicate the presence of a little cingulum, characteristic or definitive. It presents a precingular archeopyle with an irregular pentagonal outline." — Translated from Heisecke (1970, p. 232, 234)

<u>Dimensions</u>: "Holotype: total length 84 μ, long without horns 68 μ, width 67 μ, length of apical horn 8 μ, length of the greater antapical horn 9 μ, length of the minor antapical horn 4 μ. Total length 84–86 μ, long (without horns) 64–68 μ, width 67–68 μ, length of apical horn 8–10 μ, length of greater antapical horn 9–15 μ, length of antapical horn minor 4–7 μ. Number of specimens measured: 2." — Translated from Heisecke (1970, p. 232, 234)

<u>Discussion</u>: "This new species differs of those observed corresponding to the same genus, mainly in the verrucate structure of the endophragm and the great contrast between the thick, opaque endophragm and delicate, hyaline periphragm. *Deflandrea endopapillata* Archangelsky, 1959, is the only comparable species to the one described here for having the endophragm with papillae. However, *Scrinodinium verrucosum* differs from said shape by the position of the archeopyle; the horns of the new species are relatively smaller, the periphragm is smooth (it does not present more condensed granules in the horns and in the pericingular region as in *D. endopapillata*) and the size is minor." — Translated from Heisecke (1970, p. 234)

<u>Age</u>: early Paleocene? (Danian?); holotype of — Translated from Heisecke (1970, p. 225, 234).

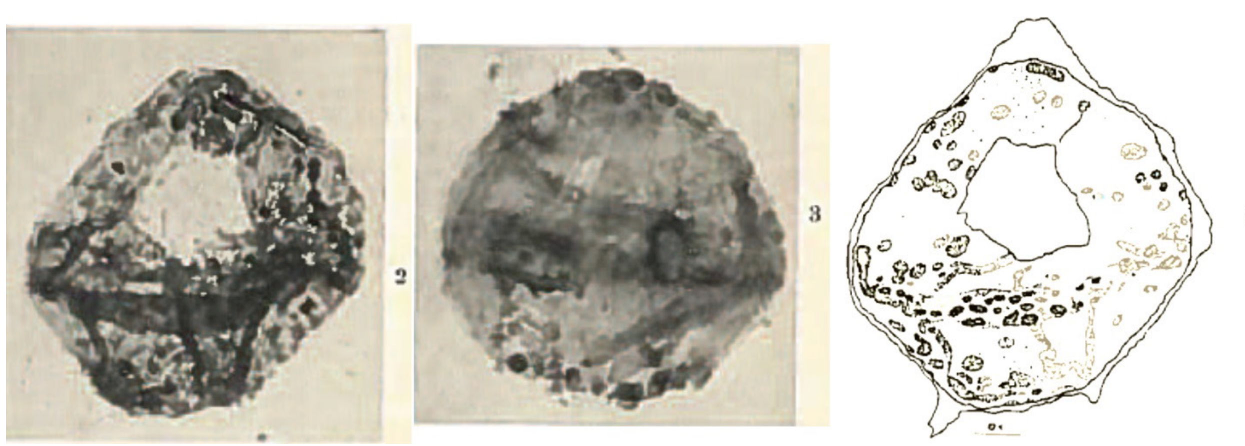


Plate 9, figures 2, 3; Plate 10, figure 3, Heisecke (1970).

Cerodinium wardenense (Williams & Downie, 1966) Lentin & Williams, 1987

Diagnosis: "Cavate cysts, sub-circular to ovoidal periphragm, one apical and two short antapical horns. Conical apical horn merging imperceptibly into lateral walls; two antapical horns more positively delimited and straight or slightly diverging. Length of antapical horns approximately equal. Thin-walled ovoidal capsule, closely appressed to periphragm except at horns. Surface of periphragm has short acuminate or blunt processes, not restricted to sutures of cingulum and sulcus. Archaeopyle common." — Williams & Downie (1966, p. 233)

Description: "The epitract is longer than the hypotract. In outline the former is conical with convex lateral sides, the latter is rounded with the antapical horns being sharply delimited. All three horns can be acuminate but are more commonly blunt. The antapical horns are well separated. The equatorial and longitudinal furrows are both wide with the latter broadening posteriorly. Five postcingulars have been discerned; the rest of the tabulation is too difficult to decipher." — Williams & Downie (1966, p. 233)

Dimensions: "Holotype: periphragm, length 57 μ, breadth 46 μ; capsule, length 36 μ, breadth 43 μ. Observed range: periphragm, length 46–64 μ, breadth 43–50 μ, capsule, length 33–41 μ, breadth 40–46 μ. Number of specimens measured 6." — Williams & Downie (1966, p. 233)

Remarks: "Species of *Deflandrea* having processes on the sutures of the cingulum, sulcus and plate boundaries are *D. denticulata*, *D. echinoidea* Cookson & Eisenack 1958 (Upper Cretaceous; Australia), and *D. spinulosa* Alberti 1959 (Oligocene; Germany). All these have distinctive outlines which readily distinguish them from *D. wardenensis*." — Williams & Downie (1966, p. 233)

Age: Eocene; holotype of Williams & Downie (1966, p. 233).

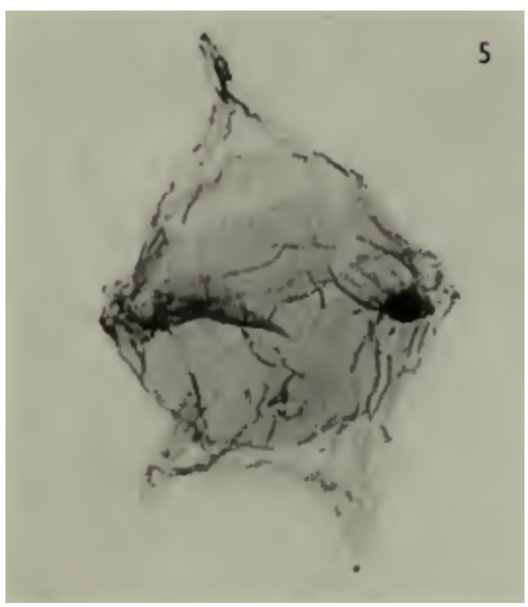


Plate 26, figure 5, Williams & Downie (1966).

Cerodinium warrenii (Schumacker-Lambry, 1978) Lentin & Williams, 1987

Diagnosis: "Cyst with rhomboidal to subpentagonal range; ovoid 'endocyst' adheres closely to the sides of the 'pericyst', and stretches in the antero-posterior direction; one triangular apical horn thinning strongly at the top; two antapical horns with length equal to that of the apical horn; dorsal archeopyle, intercalary (2a?) of 'hexagonal-standard' type; endophragm slightly thicker than the periphragm, smooth to granular; thin and transparent periphragm finely granulated and presenting some fine denticulations mainly at the range and on the apical horn, as well as in border of the pericingulum; depressed pericingulum, weakly marked by folds of the periphragm, its two ventral extremities exactly at the same level; faintly outlined perisulcus on the ventral side of the hypocyst only; pericoel limited to the three horns; everywhere else endocyst and pericyst are joined closely; indeterminable paratabulation except (?) at the level of the archeopyle." — Translated from Schumacker-Lambry (1978, p. 40, 41)

Dimensions: "Pericyst: length, 110 μ to 140 μ; width, 50 to 60 μ (in the widest part of the cyst; endocyst: length, 60 to 70 u; width, 50 to 60 μ; archeopyle index (sensu Lentin & Williams 1975): 0.55 to 0.65; archeopyle transverse ratio (sensu Lentin & Williams 1975) 1.25; length/width ratio of archeopyle I/I." — Translated from Schumacker-Lambry (1978, p. 41)

Comparison: "The species *D. warrenii* is close to *D. denticulata* Alberti 1959 (Paleocene–Eocene). It is similar in size and in the denticulation of the periphragm, by the subpentagonal range and the presence of two antapical horns of equal length. On the other hand, it differs from *D. denticulata* by a more ovoidal central body, narrower archeopyle, H3 and H5 sutures less developed and less marked denticulation, especially on the central body." — Translated from Schumacker-Lambry (1978, p. 40, 41)

Age: late Paleocene (Thanetian); holotype as translated from Schumacker-Lambry (1978, p. 41). Range: Late Cretaceous (Maastrichtian)–late Paleocene (Thanetian) (Schumacker-Lambry, 1978, p. 41).

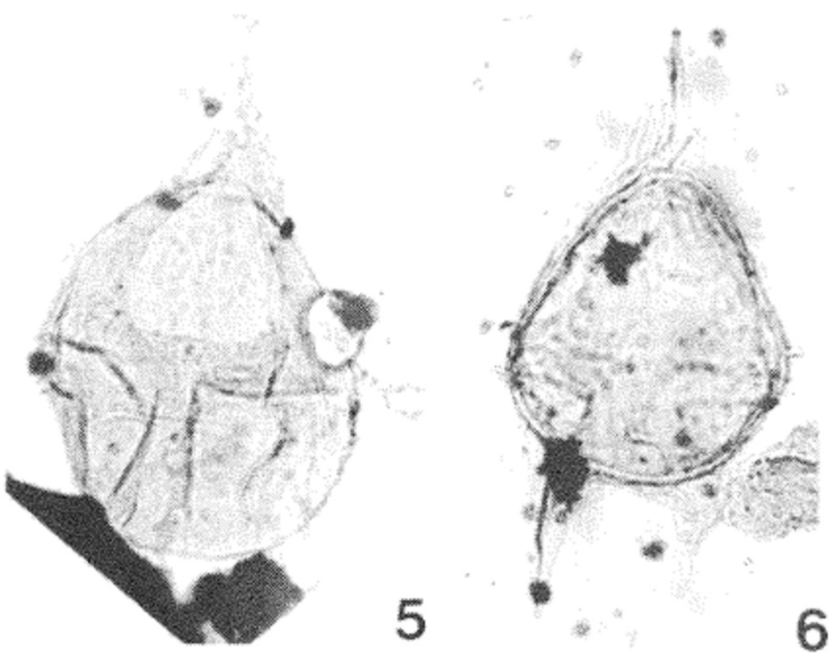


Plate 4, figures 5, 6, Schumacker-Lambry (1978).

Genus ***CHATANGIELLA*** Vozzhennikova, 1967

1967 *Chatangiella* Vozzhennikova: 128, 129.
1967 *Australiella* Vozzhennikova: 129, 130.
1967 *Cooksoniella* Vozzhennikova: 183, 184.
1976 *Chatangiella* Vozzhennikova; emend. Lentin & Williams: 51, 52.
1988 *Chatangiella* Vozzhennikova; emend. Marshall: 199, 200 (but see Lentin & Vozzhennikova, 1990: 40).
2016 *Chatangiella* Vozzhennikova; emend. Fensome et al.: 32.

?*Chatangiella biapertura* (McIntyre, 1975) Lentin & Williams, 1976

Description: "Cyst cavate, dorsoventrally flattened, more or less spherical in dorsoventral view except for apical and antapical horns, and is divided into equal epitract and hypotract by a simple cingulum. Apical horn 10–30 μm long and usually rounded at the end. Left antapical horn 15–30 μm long, narrow, and pointed; right antapical horn normally appears only as an angular bulge. Cingulum about 7 μm wide and bordered on both edges by slightly raised irregular ridges. A large wide sulcus is present on the ventral surface. The large intercalary (2a) archeopyle is rounded hexagonal and the operculum is often attached at the posterior margin. There is no sign of an archeopyle in the endoblast. A large circular opening (antapical archeopyle?) is usually present in the periblast between the antapical horns (Pl. 3, fig. 5, 6). Endoblast large, spherical, normally not folded, and usually closely appressed to periblast laterally, especially in hypotract. Apical and antapical pericoels are present. Endophragm about l μm thick and finely scabrate to finely granulate, especially on anterior and posterior ends. Periphragm less than l μm thick and smooth to finely scabrate. It is often wrinkled and has a somewhat striate appearance (Pl. 3, fig. 7)." — McIntyre (1975, p. 66)

Dimensions: "Holotype, 136 μm long, 78 μm wide; endoblast, 60 μm long; range, 94–145 μm long, 60–92 μm wide; endoblast 41–78 μm long." — McIntyre (1975, p. 66)

Remarks: "*D. biapertura* is abundant in Division H3 in Section CR16B and is recorded as *D*. sp. 5 in McIntyre (1974). A similar form was illustrated by Wilson (1971) as *Deflandrea* aff. *sverdrupiana*. *D. biapertura* is similar to *D. sverdrupiana* in shape and also possesses a relatively large endoblast, but it is larger and lacks the tabulation features of *D. sverdrupiana*. *D. magna* Davey (1970) has a tapering epitract and less well-developed apical and antapical horns. Apparently, it also has a smooth endoblast, and the cyst is smaller than that of *D. biapertura*. There appear to be no other species of *Deflandrea* known that have the antapical opening typical of *D. biapertura*. An antapical opening with an attached operculum has been noted in *Ovoidinium ostium* by Davey (1970)." — McIntyre (1975, p. 66)

Age: Late Cretaceous (early Maastrichtian); holotype of McIntyre (1975, p. 66, text-fig. 2). Range: Late Cretaceous (late Campanian–early late Maastrichtian) (McIntyre 1975, text-fig. 2).

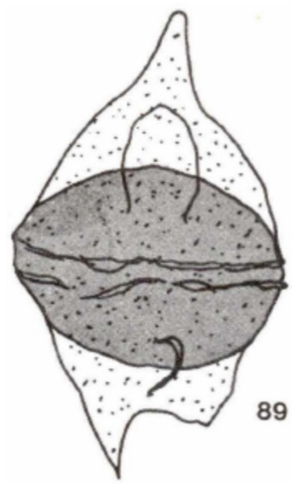


Plate 7, figure 89, Lentin & Williams (1976).

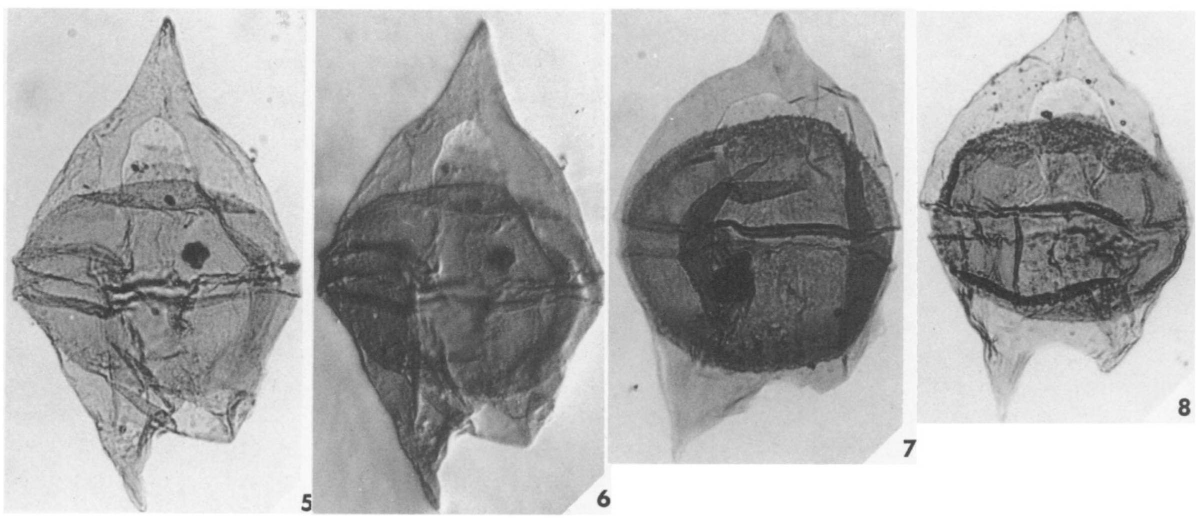


Plate 3, figures 5–8, McIntyre (1975).

Chatangiella bondarenkoi (Vozzhennikova, 1967) Lentin & Williams, 1976. Emendations: Lentin and Vozzhennikova, 1990, p. 42 and Lebedeva in Ilyina et al., 1994, p. 68, 69.

<u>Description</u>: "Theca elongated along the longitudinal axis, somewhat convex equatorially and tapering towards the poles. Epitheca on the level of the upper edge of the internal body, truncated or not truncated. Apical margin broadly rounded with a short, blunt ending apical horn. Hypotheca with straight or slightly concave sides and with a single broadly or narrowly conical antapical horn situated at one side of the antapical margin. The other side of the antapical margin is obliquely truncated or lies parallel with the equatorial plane. Transverse furrow equatorial slightly deflected to the left. Margin of furrow delineated by short, blunt terminated outgrowths. Longitudinal furrow represented by a depression running from the end of the transverse furrow to the antapex. Internal body large, oval and with its lateral walls closely applied to the sides of the theca. The walls of the internal body are thicker at the poles than elsewhere. The surface of the internal body and of the theca is granular. Pylome ovally polygonal and corresponding in position to plate 3cp." — Vozzhennikova (1967, p. 130, 131, translation: Lees & Sarjeant, 1971)

<u>Dimensions</u>: "In microns: holotype, length of theca 148.5, breadth 72.9, width of transverse furrow about 6, length of internal body 67.5, width 70.9. In other specimens, length of theca 127–230, breadth 64.8–

67.5; width of transverse furrow 6–8, length of internal body 67.5–70.2, width 64.8." — Vozzhennikova (1967, p. 130, 131, translation: Lees & Sarjeant, 1971)

Comparison: "This species differs from others of the genus in the absence of any narrowing of the theca at the level of the upper and lower edges of the internal body, and in having a truncated margin to the antapex and a more oval pylome." — Vozzhennikova (1967, p. 130, 131, translation: Lees & Sarjeant, 1971)

Emended description: "Cyst longitudinally elongate, rounded rectangular outline with a short apical horn; antapex nearly flat with two poorly developed antapical horns, occasionally the left antapical horn may be more developed; endocyst round to roundly rectangular in outline, dividing the cyst equally; bicavate. Periphragm granulose with occasional small spines; endocyst densely granulose with thickened apical and antapical margins within the epi- and hypopericoels, thickenings appear to be fibrous. Paratabulation peridinioid, indicated by periarcheopyle and paracingulum only. The periarcheopyle is iso-omegaform with the 4''–2a suture about one half the length of the 2a–3' suture, operculum remains attached; the endoarcheopyle is not developed on the holotype; an opisthopyle may be formed by an arcuate suture on the mid-ventral surface of the hypocyst. The paracingulum is outlined by parallel ridges of dense granulations with occasional spines, faintly pentapartite. Parasulcus indicated by a faint depression on the hypocyst." — Lentin & Vozzhennikova (1990, p. 42)

Emended description: "The cyst is bicavate, longitudinally elongating with some constrictions at the level of epi- and hypopericavities. Epicyst with broad shoulders, on which a wide-conical, large apical horn is impaled. The hypocyst is trapezoidal, with a well-developed large, pointed antapical horn. The left one is cut obliquely or slightly developed. The endocyst is coarse, tightly adhering to the sides of the pericyst. The endophragm is single-layered, densely granular, rarely with fibrous thickenings on the margins. Paratabulation is indicated only by periarcheopyle and paracingulum. Periarcheopyle iso-omegaform; operculum attached. The endoarcheopyle is not observed. The paracingulum is expressed by two rows of dense granularity or low ribs. The parasulcus is marked by a shallow fold on the hypocyst. Periphragm densely granular with individual frequent tubercles." — Translated from Lebedeva in Ilyina et al. (1994, p. 68, 69)

Remarks: "Unlike *Chatangialla chetiensis*, this species has a thin endophragm, and fibrous thickenings on the margins are rarely observed. The described species has a well-developed apical horn; the difference between the antapical horns is largely pronounced; the ornamentation of the surface of the periphragm is more pronounced. The compared species also differ in their stratigraphic position. *Ch. bondarenkoi* appears in the deposits of the upper Turonian and disappears in the lower Santonian with a maximum of development in the lower Coniacian. Single *Ch. chetiensis* appear in Coniacian and peak in the Santonian. Since these species are morphologically distinct and have a different stratigraphic range, it is proposed to conserve both species." — Translated from Lebedeva in Ilyina et al. (1994, p. 69)

Age: Late Cretaceous (Santonian); holotype of Vozzhennikova (1967, p. 130, table 4, translation: Lees & Sarjeant, 1971). Range: Late Cretaceous (Turonian–Santonian) as translated from Lebedeva in Ilyina et al. (1994, p. 69).

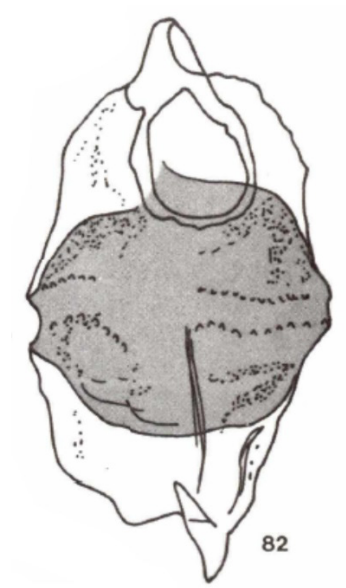


Plate 6, figure 82, Lentin & Williams (1976).

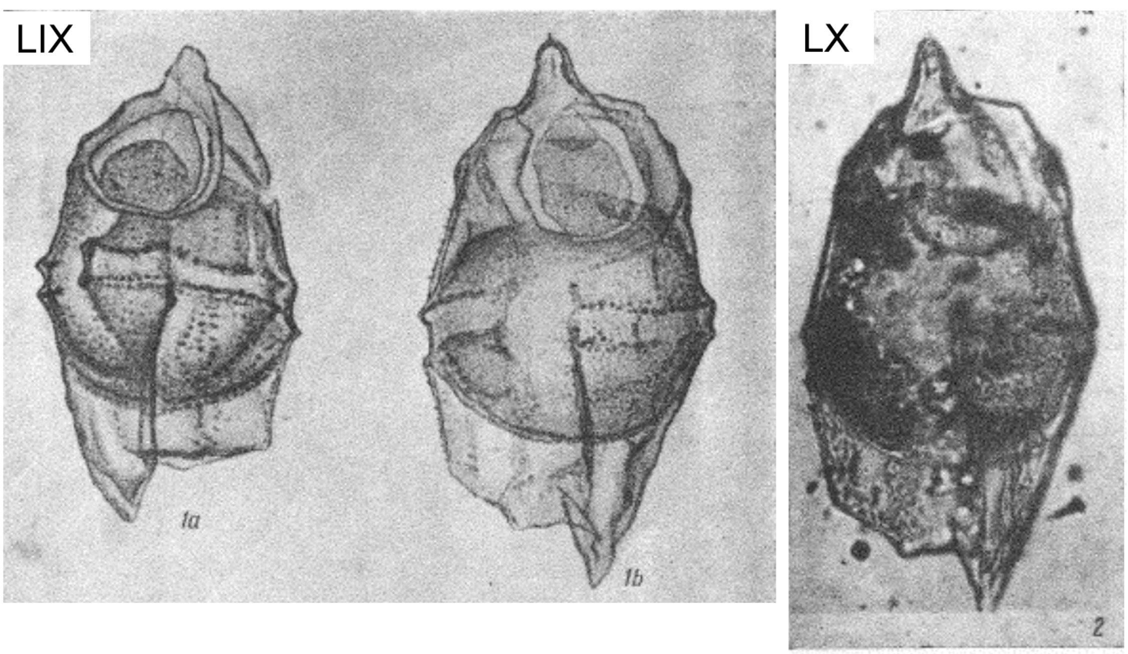


Plate 59, figures 1a–b, Plate 60, figure 2, Vozzhennikova (1967).

Chatangiella cassidea Lebedeva, 1988

<u>Description</u>: “The pericyst is elongated along the longitudinal base with a somewhat convex central part and constrictions on the borders of the endocyst. The epipericyst is slightly larger than the hypopericyst, helmet-shaped, with well-defined humeri, gradually changing into a conical, attenuated, relatively long (10–16 μm) apical horn with a depression at the distal end. The hypopericyst with straight or slightly convex lateral sides forms two unequal horns located on a relatively even antapical margin. The left horn is larger than the right one, conical with a wide base, 12–18 μm long. The right horn is small (6–8 μm), triangular-rounded. The endocyst is large, rounded-quadrangular, elongated along the longitudinal axis and not adjacent to the lateral sides of the pericyst. The mesophragm at the poles has a thickness of 4 μm, and

wedged out on the lateral sides. The endocyst has a granular or warty sculpture. The archeopyle is rounded or horseshoe-shaped. The operculum is attached along the lower border or may separate, leaving jagged edges of the archeopyle. The cingulum is shallow, clearly visible on the lateral sides, and is emphasized by a row of large (up to 1 µm) tubercles, which can fold together to form serrated ribs. The width of the cingulum is 6–9 µm. The sulcus is expressed by divergent folds extending from the cingulum to the antapical margin. Pericyst granular with sparsely located tubercles." — Translated from Lebedeva (1988, p. 76)

Dimensions: "(µm): holotype, pericyst 90 long, 48 wide; length of endocyst 48, epipericyst 42, hvpopericyst 45; archeopyle 20 high, 24 wide. Other specimens: pericyst 83–96 long, 48–58 wide; length of endocyst 46–48, epipericyst 45–48, hypopericyst 39–48; archeopyle 16–20 in height, 20–24 wide." — Translated from Lebedeva (1988, p. 76)

Variability: "Within this species, there manifests a change in the shape of the pericyst and sculpture. Relatively stable, defining features are the helmet form of the apex, the oval-quadrangular endocyst elongated along the longitudinal axis, the presence of a mesocoel, and the rounded horseshoe shape of the archeopyle." — Translated from Lebedeva (1988, p. 76)

Comparison: "*Chatangiella cassidea* is more like *Ch. tripartita* the shape of the epipericyst, apical horn and archeopyle, the presence of a mesophragm wedging out on the lateral sides. However, there are also significant differences. The tripartite division of the pericyst and the protrusion into the area of the cingulum, forming corners, are less pronounced in *Ch. cassidea*. It is also distinguished by the presence of two well-developed antapical horns with a depression between them and a large rounded-quadrangular endocyst. In *Ch. tripartita* the second antapical horn is practically absent, and the endocyst is round-ellipsoidal, somewhat compressed along the longitudinal axis. *Chatangiella cassidea* differs from *Ch. victoriensis* (Manum) Lentin et Williams in the shape of the pericyst and endocyst, the presence of the mesocoel, and the shape of the archeopyle." — Translated from Lebedeva (1988, p. 76, 77)

Age: Late Cretaceous (Santonian); holotype as translated from Lebedeva (1988, p. 77).

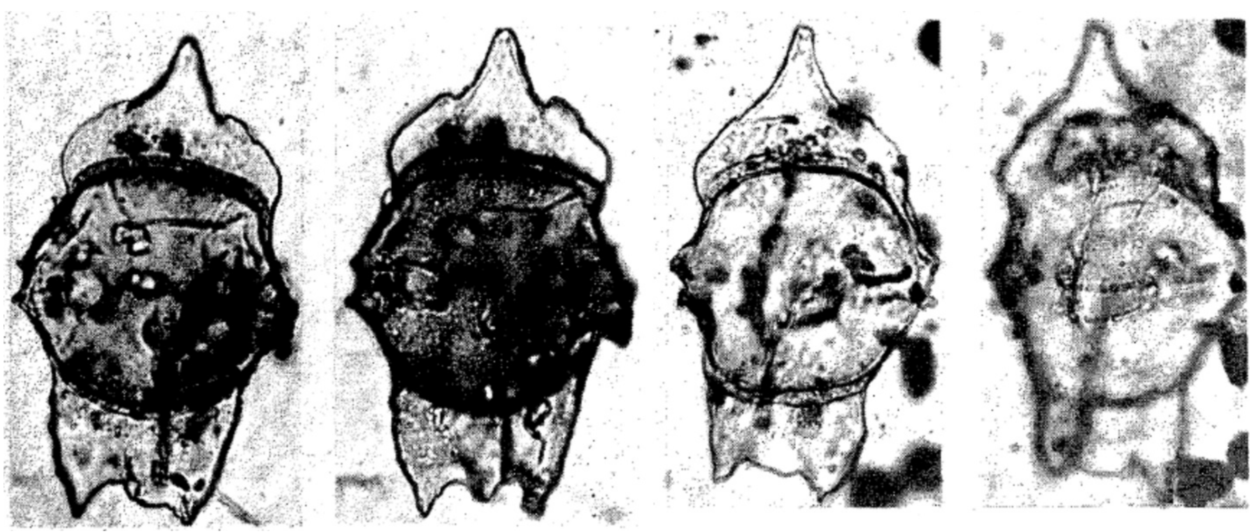


Plate 19, figures 1–4, Lebedeva (1988).

Chatangiella chetiensis (Vozzhennikova, 1967) Lentin & Williams, 1976

Description: "Theca elongated along the longitudinal axis and slightly constricted about the upper level of the internal body. It is divided into equal parts by a slightly spiral, equatorial girdle. Epitheca strongly expanded in the upper part which then tapers sharple [sic] to give a short apical horn at the distal end of which there is a small club-shaped process. Hypotheca gradually tapering towards the ant apex, with two antapical horns of different sizes. The internal body is large, oval and occupies the greater part of the theca, being closely adpressed [sic] to the thin, slightly convex lateral walls of the theca. The walls of the internal body are thickened dorsally and ventrally and are granular. The middle part of the theca is covered with short spinous processes, the density of which diminishes towards the poles. Transverse furrow and longitudinal furrow bounded by rows of spines. The longitudinal furrow is situated on the hypotheca and extends to the antapex. Dimensions in microns: holotype - thecal length 129.6, breadth 51.3, width of girdle 5.4, internal body - length 65.5, breadth 51." — Vozzhennikova (1967, p. 131, translation: Lees & Sarjeant, 1971)

Comparison: "This species differs from others of the genus in having a clavate process to the apical horn, a spinous surface to the theca and a less strongly convex equatorial part." — Vozzhennikova (1967, p. 131, translation: Lees & Sarjeant, 1971)

Age: Late Cretaceous (Santonian); holotype as translated from Vozzhennikova (1967, p. 131, table 4, translation: Lees & Sarjeant, 1971).

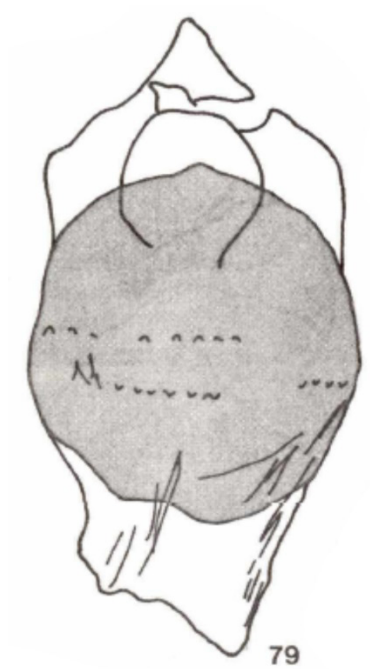


Plate 6, figure 79, Lentin & Williams (1976).

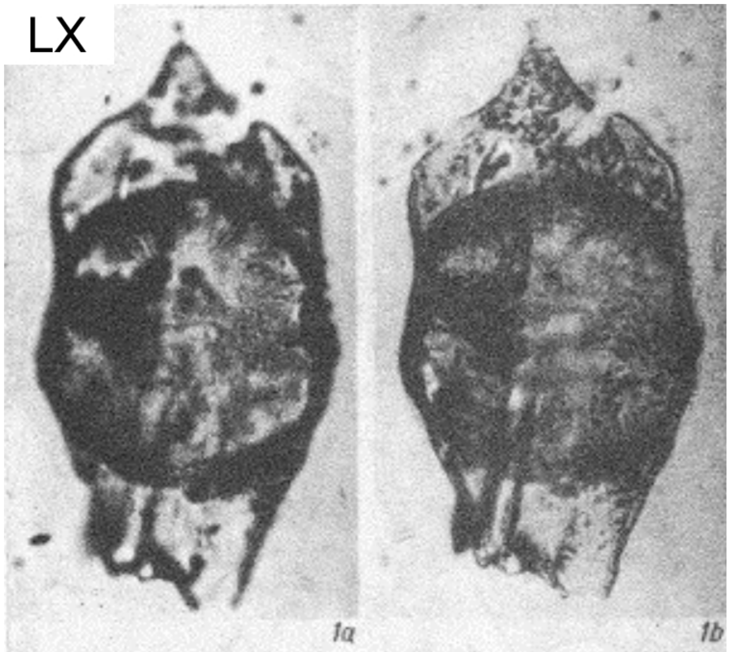


Plate 60, figures 1a–b, Vozzhennikova (1967).

Chatangiella coronata (McIntyre, 1975) Lentin & Williams, 1976

Description: "Cyst cavate, dorsoventrally flattened, somewhat hexagonal in dorsoventral view, protruding markedly laterally in the equatorial region, and divided into approximately equal epitract and hypotract by a slightly laevorotatory cingulum. On the epitract the periblast normally bulges pronouncedly above the top of the endoblast to form shoulders which are usually square and flat topped. A blunt-ended apical horn 15–25 μm long occurs on top of the shoulders and is often inclined slightly to the dorsal surface. Left antapical horn usually short and pointed; right antapical horn is a triangular bulge. The cingulum is about 7 μm wide and is bordered on its anterior and posterior margins by discontinuous ridges usually consisting of rows of pustules that are sometimes joined. Occasionally the ridge pieces consist of clavae. The 7 pieces on the epitractal side represent the precingular reflected plates and the 5 hypotractal side pieces, the postcingular reflected plates. The ridge pieces are usually of different lengths, depending on the reflected plate they represent, but they are not always seen clearly and sometimes appear as continuous ridges (Pl. 3, fig. 4). In some specimens the ridge piece of reflected plate 4'' is not seen (Pl. 3, fig. 4). A large, wide sulcus on the ventral surface usually has margins indicated by folds or, occasionally, a row of pustules. The large intercalary (2a) archeopyle is hexagonal and the angles are usually rounded. Normally anterior margin significantly longer (2 or 3 times) than posterior margin. Operculum usually remains attached at posterior margin. No other indications of tabulation are visible. The tabulation is probably of typical peridinioid type 4' 3a 7'' 5''' 2''''. Endoblast large, usually folded at its margins, and always separated laterally from periblast but probably attached dorsally. A large pericoel is present. Sometimes a ring of verrucae occurs on the endoblast but, these may indicate the margin of dorsal attachment of the endoblast to the periblast. Endophragm about ½ μm thick and smooth to faintly scabrate. Periphragm less than 1 μm thick and smooth to faintly scabrate. Pustules scattered over the periphragm but no definite pattern can be seen. Density of pustules variable, some specimens having very few (Pl. 3, fig. 3)." — McIntyre (1975, p. 64)

Dimensions: "Holotype, 168 μm long, 122 μm wide; endoblast, 73 μm long, 85 μm wide; range, 140–190 μm long, 90–125 μm wide; endoblast, 50–70 μm long, 60–90 μm wide." — McIntyre (1975, p. 64)

Remarks: “*D. coronata* is recorded in McIntyre (1974) as *D*. sp. 4. It is abundant in the upper part of Division H2 in Section CR16B, and many tens of specimens were examined. *Deflandrea verrucosa* Manum (1963) has an archeopyle similar to that of *D. coronata* and also possesses similar large square shoulders. The two species have somewhat similar shapes, but *D. coronata* protrudes more in the equatorial region and is considerably larger than *D. verrucosa*, which has an endoblast filling the periblast laterally. Both the endoblast and periblast of *D. verrucosa* are much more heavily sculptured than those of *D. coronata*.” — McIntyre (1975, p. 64, 65)

Age: Late Cretaceous (late Campanian); holotype of McIntyre (1975, p. 64, text-fig. 2). Range: Late Cretaceous (late Campanian); McIntyre (1975, text-fig. 2).

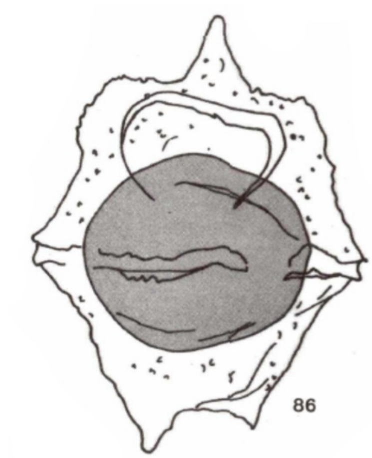


Plate 6, figure 86, Lentin & Williams (1976).

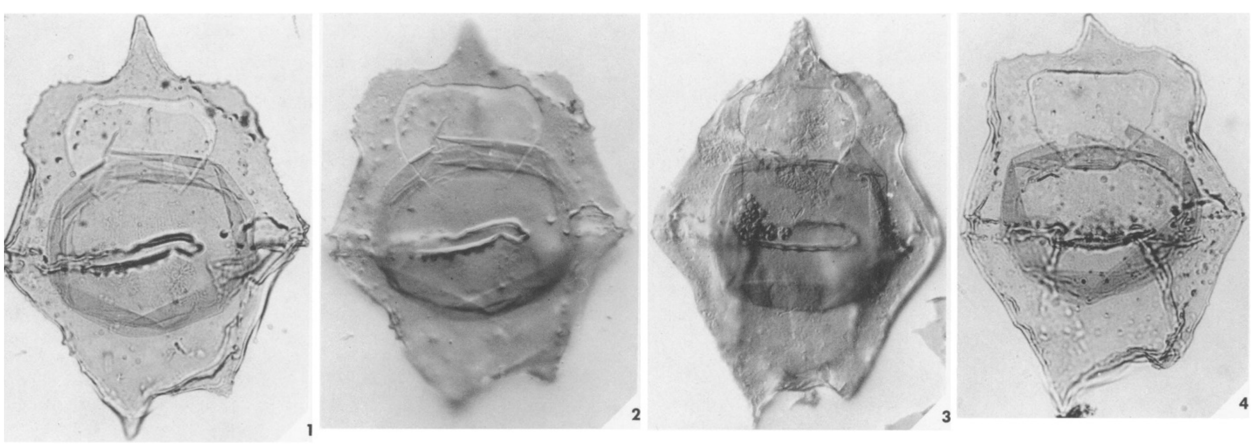


Plate 3, figures 1–4, McIntyre (1975).

?*Chatangiella dakotaensis* (Stanley, 1965) Stover & Evitt, 1978

Description: “Outer cyst distinctly anterior-posteriorly elongated with a bulge in the equatorial region and dorso-ventrally flattened; length about 120 μ, width approximately 84 μ; membrane smooth, approximately 1 μ thick in anterior portion of outer cyst and thins to a fraction of a micron posteriorly. Apical horn about 25 μ in length and terminated with a small, solid papilla. Antapical horns approximately equal in size with the left one slightly longer than the right horn; antapical horns connected to each other by a membrane. Interior cyst anterior-posteriorly flattened, granular. Furrow and girdle not observed. Intercalary archeopyle distinct with posterior side longer than anterior side.” — Stanley (1965, p. 217, 218)

Differential diagnosis: “*Deflandrea dakotaensis* resembles *D. bakeri* Deflandre and Cookson and *D. pellucida* Cookson and Eisenack. It differs from those species in that the cell membrane is smooth and there is no or only a faint suggestion of a girdle. It differs from *D. phosphoritica* Eisenack in that the posterior region is much longer. Also, *D. dakotaensis* lacks the girdle and the furrow of *D. phosphoritiea* (as recently discussed in the fine paper of Mannm, 1960).” — Stanley (1965, p. 218)

Age: Paleocene; holotype of Stanley (1965, p. 217). Warwick et al. (2004) places the Cannonball Member of the Fort Union Formation as 65–61 Ma.

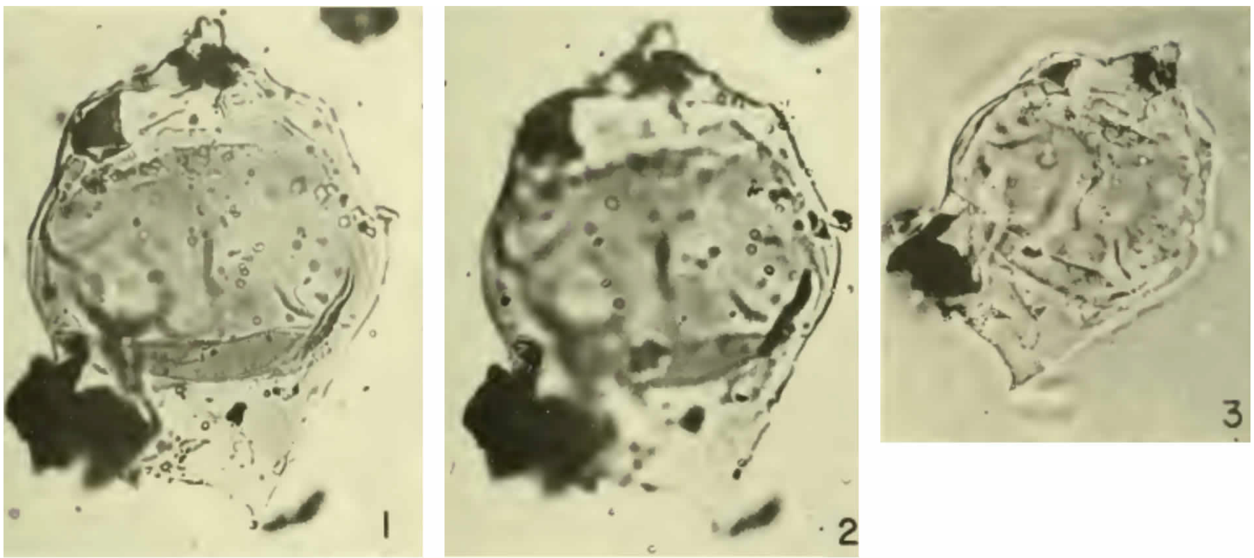


Plate 19, figures 1–3, Stanley (1965).

Chatangiella decorosa (McIntyre, 1975) Lentin & Williams, 1976

Description: “Cyst cavate, dorsoventrally flattened, protruding in equatorial region, and divided into equal epi- and hypotracts by a slightly laevorotatory cingulum. Rounded shoulders of varying degrees of development occur on the epitract, where the periblast bulges above the level of the endoblast. A blunt-ended, broad based apical horn 15–30 μm long is produced from the shoulders. Some specimens taper almost directly from the cingulum to the apex. A sharply pointed left antapical horn up to 40 μm long is always present and the right antapical horn appears as a rounded to angular bulge. Cingulum about 7 μm wide and bordered on anterior and posterior margins by discontinuous ridges consisting of rows of pustules, which may join to form narrow grooves (Pl. 2, fig. 2). Epitractal side of cingulum has 7 pieces of ridge and hypotractal side has 5 pieces. These apparently represent the pre- and post-cingular reflected plates, and the pieces differ in length, depending on the reflected plate represented. A group of pustules, sometimes in the form of an arc (Pl. 2, fig. 2), usually appears on the periblast adjacent to each cingulum ridge piece and probably represent intratabular ornament. Pustules are commonly present on other parts of the periblast (Pl. 2, fig. 3), but no definite pattern can be seen and some specimens have very few pustules (Pl. 2, fig. 2). Rows of small pustules or granules that indicate the apical reflected plates are sometimes present on the apical horn. A large, wide sulcus is present on the ventral surface. The large intercalary (2a) archeopyle is rounded hexagonal (Pl. 2, fig. 3) to broadly rounded hexagonal (Pl. 2, fig. 2). Occasionally anterior margin significantly longer than the posterior margin (Pl. 2, fig. 4). Operculum usually attached at posterior margin (Pl. 2, fig. 1, 3, 4). Endoblast also has indications of an archeopyle (Pl. 2, fig. 3). The tabulation pattern is probably of the typical fossil peridinioid type 4' 3a 7'' 5''' 2''''. Endoblast large with smooth endophragm about ½ µm thick. Periphragm less than 1 µm thick and ornamented with pustules described above. Otherwise, it is smooth (Pl. 2, fig. 2) to faintly scabrate (Pl. 2, fig. 3) and appears to have a faint LO pattern. The endoblast is somewhat folded at its anterior and posterior ends, well rounded and normally separated laterally from the periblast except in the postcingular plate area, where the endophragm and periphragm usually appear to be fused into one layer. Large apical and antapical pericoels are present." — McIntyre (1975, p. 64, 65)

Dimensions: "holotype, 156 µm long, 96 µm wide; endoblast, 73 µm long; range, 130–175 µm long, 80–110 µm wide; endoblast, 85–110 µm long." — McIntyre (1975, p. 64, 65)

Remarks: "*D. decorosa* is abundant in the lower part of Division H2 in Section CR16B, and many dozens of specimens were examined. It differs from *D. ditissima* in being larger, having more pustules, and having a large, more rounded endoblast that is almost completely separated laterally from the periblast. In the Horton River section, it occurs in abundance after *D. ditissima* has almost disappeared, but first appears along with *D. ditissima*. *D. decorosa* is much larger than *D. scheii* and has a more pronounced left antapical horn, thinner endophragm and lacks tabular ridges found on *D. scheii*. *Cooksoniella vnigri* Vozzhennikova (1967) is much smaller than *D. decorosa*, has a thicker-walled granulate endoblast that abuts the periblast laterally, and has spines on the periblast. *D. decorosa* is listed in McIntyre (1974) as *D.* sp. 3." — McIntyre (1975, p. 64)

Age: Late Cretaceous (late Campanian); holotype of McIntyre (1975, p. 64, text-fig. 2). Range: Late Cretaceous (early Campanian–early Maastrichtian) (McIntyre, 1975, text-fig. 2; Harker & Sarjeant in Harker et al., 1990, p. 118; text fig. 26).

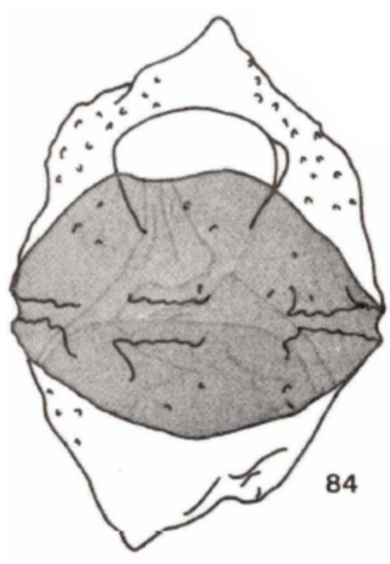


Plate 6, figure 86, Lentin & Williams (1976).

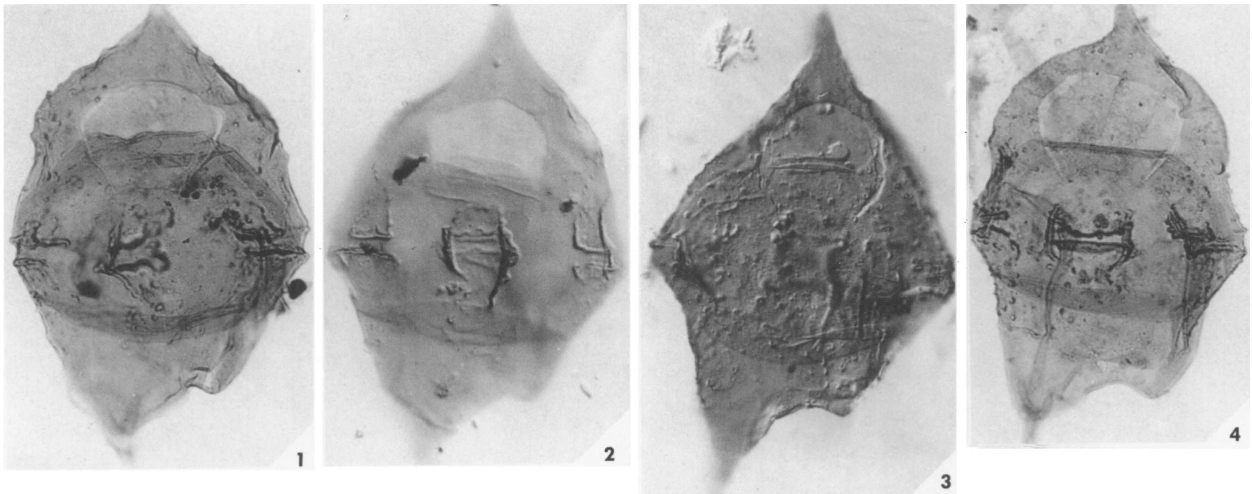


Plate 2, figures 1–4, McIntyre (1975).

Chatangiella ditissima (McIntyre, 1975) Lentin & Williams, 1976

<u>Description</u>: "Cyst cavate, dorsoventrally flattened, approximately pentagonal in dorsoventral view, protruding laterally in equatorial region and divided equally into epitract and hypotract by a slightly laevorotatory cingulum. On the epitract the periblast usually bulges above the level of the endoblast to form rounded shoulders, which vary in their degree of development. A blunt-ended, broad-based apical horn 15–25 μm long is produced from the shoulders. Left antapical horn sharply pointed and about 10–15 μm long; the short right antapical horn usually appears as an angular bulge. Cingulum about 7 μm wide and bordered on both sides by discontinuous ridges consisting of rows of pustules that may join to form narrow grooves (Pl. 1, fig. 4). Anterior margin of cingulum has 7 pieces of ridge and posterior margin has 5 pieces of ridge. These apparently represent 7 precingular and 5 postcingular reflected plates. Cingulum ridge pieces are of different lengths, according to the reflected plates they represent. Each ridge piece normally has an arc of intratabular pustules from one end to the other on its reflected plate (Pl. 1, fig. 2). A large wide sulcus is usually seen on the ventral surface (Pl. 1, fig. 4). Four rows of small pustules or granules, indicating the margins of the apical reflected plates, are present on the apical horn (Pl. 1, fig. 2), which is probably capped by 1 preapical reflected plate. The large intercalary (2a) archeopyle is rounded hexagonal to broadly rounded hexagonal in shape. Occasionally anterior margin considerably longer than posterior margin (Pl. 1, fig. 4). Operculum often attached at posterior margin (Pl. 1, fig. 2). Endoblast usually has an archeopyle indicated by 2 breaks (Pl. 1, fig. 1). This is probably also an intercalary archeopyle, although it appears apical. Indications of other intercalary reflected plates have not been seen in this species nor have apical to intercalary, and intercalary to precingular reflected plate boundaries been seen. The evidence available suggests that the tabulation is 4' 3a 7'' 5''' 2''''. Endoblast large, with smooth endophragm about ½ μm thick. Anterior and posterior ends of endoblast folded and flattened. The periphragm is less than 1 μm thick and is smooth, except for the pustules described above and occasional pits, which may be less well-developed pustules or perhaps corrosion features. The endophragm and periphragm are apparently fused in the region of the cingulum and pre- and postcingular reflected plates, and only one wall layer is visible laterally in this region. Large apical and antapical pericoels are present." — McIntyre (1975, p. 62, 63)

<u>Dimensions</u>: "Holotype, 147 μm long, 80 μm wide; endoblast, 53 μm long; range, 115–150 μm long, 60–90 μm wide; endoblast, 40–60 μm long." — McIntyre (1975, p. 62, 63)

<u>Remarks</u>: "This species is abundant in Section CR16A and many hundred specimens were seen. The breaks in the cingulum of some species of *Deflandrea* were noted by Manum (1963), who illustrated 7 anterior and 5 posterior ridge pieces in *D. scheii*, *D.* cf. *scheii* and *D. sverdrupiana*, but emphasized the

cingulum breaks rather than the ridges. In *D. sverdrupiana*, arcs of spines, similar to the arcs of pustules in *D. ditissima*, were noted by Manum (1963). *D. ditissima* is similar to *D. scheii* in general morphology, but it differs in being larger, having a thinner-walled, folded, smooth endoblast, larger antapical horns, and less definite tabulation. McIntyre (1975) records *D. ditissima* as *Deflandrea* sp. cf. *D. victoriensis*. The specimens recorded as *D. victoriensis* by Clarke and Verdier (1967) and *Australiella victoriensis* by Williams and Brideaux (1974) appear to be very close, morphologically, to *D. ditissima*, but they are much smaller. *D. victoriensis* Manum and Cookson (1964) apparently has a more densely sculptured periblast than *D. ditissima* and also has a thicker-walled, rounded, granular endoblast." — McIntyre (1975, p. 63)

<u>Age</u>: Late Cretaceous (early Campanian); holotype of McIntyre (1975, p. 64, text-fig. 2). Range: Late Cretaceous (late Santonian–early Maastrichtian) (McIntyre, 1975, text-fig. 2; Harker & Sarjeant in Harker et al. (1990, p. 118; text fig. 26).

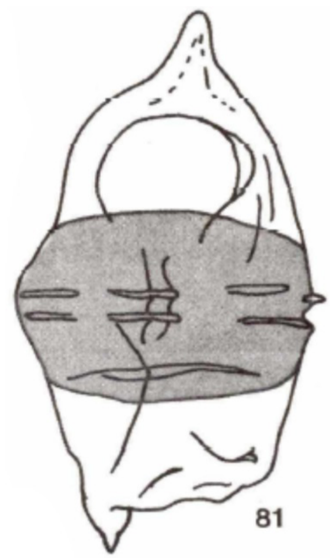


Plate 6, figure 86, Lentin & Williams (1976).

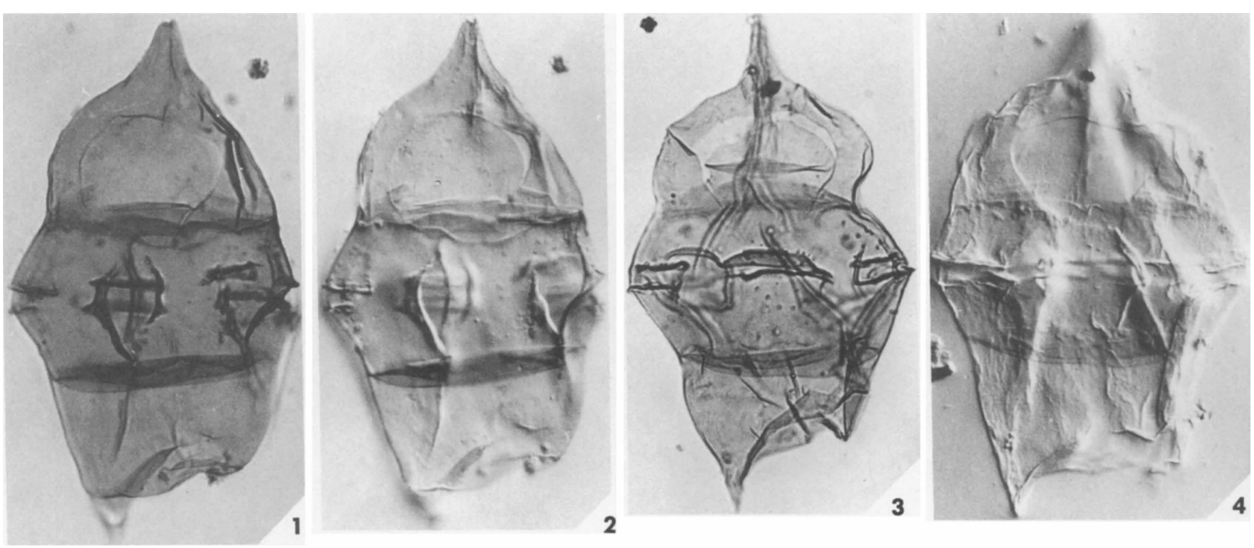


Plate 1, figures 1–4, (McIntyre (1975).

Chatangiella eminens Pearce, 2010

Diagnosis: "A species of *Chatangiella* possessing prominent spines on the paracingulum that are particularly well developed at the ambitus. Shorter spines are arranged in intratabular fields on the pre- and postcingular paraplates which may fuse on the margin of the pentapartite paracingulum and be randomly (but rarely) scattered elsewhere." — Pearce (2010, p. 67)

Description: "Medium-sized to large cornucavate peridinioid dinoflagellate cyst. The wall is two-layered composed of a smooth to finely granular (1 µm thick) endophragm and a smooth to finely granular (~0.5 µm thick) periphragm that forms solid penitabular spines. The spines are generally 2–4 µm in length, simple, evexate to capitate, longest when adjacent to paracingulum and are conspicuously long at the ambitus of the paracingulum. The spines are typically arranged in intratabular fields particularly on the pre- and postcingular paraplates and fuse on the paracingular margin where they demarcate a pentapartite paracingulum. Rare spines may also be randomly scattered over the pericyst. The pericyst is ventrodorsally compressed, longitudinally elongate, forming a short and blunt apical horn, two antapical horns (right antapical horn shorter), and a slight bulge around the paracingulum. Below the apical horn, the epicystal ambitus is convex with weakly to moderately well-developed rounded to sub-angular shoulders. From the paracingulum to the antapical horns, the ambitus of the hypocystal [sic] is concave to occasionally straight. The endocyst is sub-spherical to ovoidal, and follows the general shape of the pericyst. The left endo-antapical horn protrudes slightly into the antapical pericoel, the right endo-antapical horn is reduced. The paratabulation is incompletely indicated by the intratabular clustering of spines and the position of the archaeopyle: x', 3a, 7'', ?c, 5''', ?2''. The parasulcus is indicated by a deep longitudinal depression. The peri-archaeopyle is intercalary (Type I, operculum detached) and formed by the loss of an iso-thetaform to iso-deltaform 2a paraplate. The endo-archaeopyle type has not been determined." — Pearce (2010, p. 67)

Dimensions: "Holotype, central body (w/l) 43 × 42 µm, overall (w/l) 47 × 95 µm, spine length (max.) 3 µm; range, central body (w/l) 30(39.5)44 × 30(39.7)50 µm, overall (w/l) 33(43.2)52 × 52(78.9)95 µm, spine length (max.) 2(2.9)4 µm. 20 specimens measured." — Pearce (2010, p. 67)

Comparison: "This species most closely resembles *Chatangiella madura* Lentin & Williams, 1976 (see Cookson & Eisenack, 1970, pl. 11, fig. 10) but differs by possessing longer and more strongly developed paracingular spines at the ambitus." — Pearce (2010, p. 67)

Age: Late Cretaceous (late Santonian); holotype of Pearce (2010, p. 67, fig. 2). Range: Late Cretaceous (middle–late Santonian) Pearce (2010, p. 67, fig. 2).

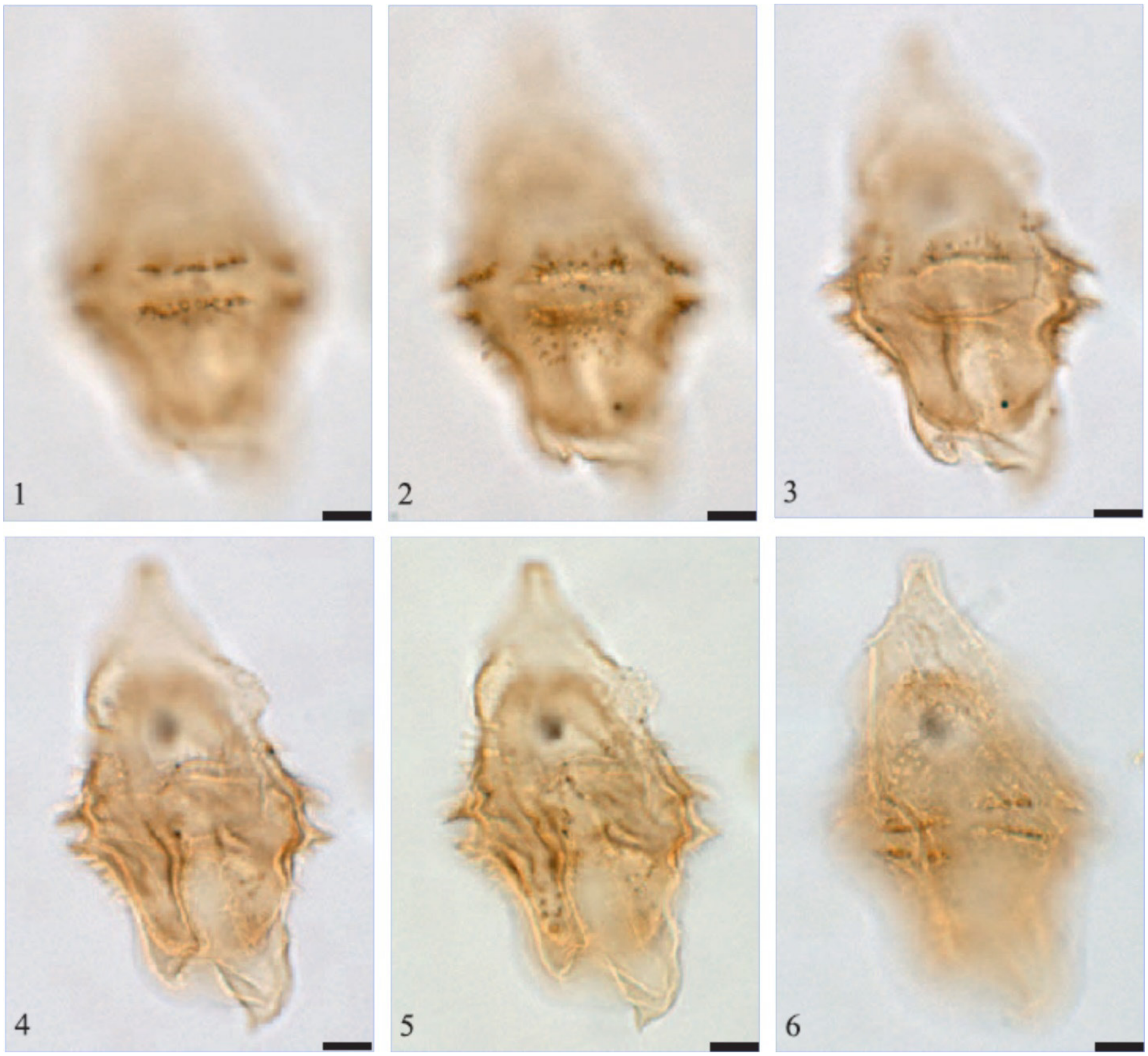


Plate 2, figures 1–6, Pearce (2010). Scale bar = 10 µm.

Chatangiella granulifera subsp. ***granulifera*** (Manum, 1963) Lentin & Williams, 1976

Diagnosis: "Theca in dorsoventral view elongate, divided into nearly equal parts by a slightly spiral, laevorotatory girdle. Equatorial region convex; epitheca widened in the upper part, apex slightly rounded with a blunt horn; hypotheca obliquely truncate to slightly concave, with a short, pointed horn on the left-hand side and a suggestion of one on the right-hand side. Intercalary archeopyle rounded hexagonal in shape. Theca-membrane up to 1 µ thick, with a delicate granulation. Girdle bordered by ridges with conspicuous discontinuities. Central portion of the theca occupied by a capsule of circular outline." — Manum (1963, p. 61)

Dimensions: "Holotype: length 112 µ, width 70 µ. Range: length 95–124 µ, width 60–84 µ; average of 19 specimens 112.5 × 79.5 µ." — Manum (1963, p. 61)

Description: "The widened upper portion of the epitheca forms rounded 'shoulders'. The apical horn is c. 11 µ long. The sides of the lower portion of the hypotheca may be parallel, slightly divergent or convergent. The antapical horn on the left-hand side is either distinct with a triangular outline, or it is only indicated by the acute angle of the obliquely truncate antapex. The shape of the archeopyle is clearly hexagonal and almost equilateral in same specimens, but usually it is rounded and sometimes almost circular. The granulation of the theca-membrane varies in distinctness. In surface view it is usually seen as a fairly dense pattern of dark dots less than 0.5 μ in diameter, and in optical section of the membrane as distinct, delicate projections which sometimes are slightly longer than broad. In some specimens the dotted surface pattern is less distinct and even faint, and in the optical section of the membrane projections are not apparent. Such specimens usually have a very thin membrane, while in the more distinctly granular ones its thickness may go up to 1 μ. The density of the granulation is constant all over the theca. The girdle is 'broken' in exactly the same positions as in *D. verrucosa*. Longitudinal folds in the ventral hypotheca indicate a longitudinal furrow. The capsule usually reaches the lateral walls of the theca. The wall of the capsule is usually about 2 μ thick and sometimes clearly two-layered with the inner layer solid and the outer one of granular composition; the granulation is denser and coarser than that on the theca. In a few specimens the wall of the capsule is not appreciably thicker than that of the theca and a distinct granulation is lacking. The mode of opening of the capsule is similar to that in *D. verrucosa*, including the lateral breaks." — Manum (1963, p. 61, 62)

<u>Comments</u>: "As indicated in the description, some of the specimens included in *D. granulifera* are quite smooth (although dotted on the surface) and the capsule is thin-walled, smooth, and does not extend to the lateral margins of the theca. It appears possible that these specimens represent a separate species, distinct from the typical specimens of *D. granulifera* in which the capsule entirely fills the middle portion of the theca and has a granular wall c. 2 μ thick. However, since the distinction would depend largely on the characters of the capsule, the diagnostic value of which is as yet uncertain, *D. granulifera* has been made broad enough to include the entire range in this respect. The specimens of *D. granulifera* with a smooth, thin-walled capsule not extending to the lateral margins of the theca show certain resemblances to *D. spectabilis* Alberti (1959 p. 99). The latter has a finely dotted theca-membrane, rounded hexagonal, intercalary archeopyle, and a girdle that is often bordered by interrupted ridges. The position of these interruptions are not mentioned in Alberti's description, but his figures suggest that they correspond to those in *D. granulifera* and the other species described herein. The theca in *D. spectabilis* is somewhat similar in shape to that of *D. granulifera*, but it narrows gradually from the equator towards both apices and lacks the typical epithecal shoulders. In *D. spectabilis* the range in length of the theca is 10–15 μ less than in *D. granulifera*.

D. granulifera is closely similar in shape and size to *D. verrucosa*. The most reliable distinguishing character is the ornamentation, hut sometimes the use of a high power oil immersion lens is necessary for the recognition. Heavily warty specimens of *D. verrucosa* are easily distinguished, but under a low power lens prominently granular specimens of *D. granulifera* may be confused with the less coarsly [sic] and heavily ornamented specimens of *D. verrucosa*. However, under high power *D. granulifera* is seen to have a fine, dotted pattern of granules evenly distributed over the theca and warts are never present, while in *D. verrucosa* warts are always present, at least equatorially, and the granules which may occur towards the apex and antapex are scattered and never form a pattern of evenly distributed dots over the whole surface of the theca. The two species also differ in the shape of the theca, but in this respect there is some overlapping of the characters. In *D. granulifera* the 'shoulders' are rounded, whereas in typical examples of *D. verrucosa* they are angular with a flat upper limit. The apical horn in *D. granulifera* is fairly narrow and blunt and usually with somewhat concave sides, while in *D. verrucosa* it is broader and usually more distinctly triangular in outline.

The size-ranges in the two species also overlap but measurements of a number of specimens distinguished by the ornamentation show that there is a distinct difference in the mean size of the two species (cp. diagram in text-fig. 4). Furthermore, *D. granulifera* is closely similar to *D. tripartita* in its extended description and illustration by Cookson & Eisenack (1961 p. 70, text-fig. 1). The shape of the theca comes dose to *D. granulifera* and the girdle is broken in the same manner. However, in *D. tripartita* sensu C. & E. (1961) the ornamentation is coarser and the projections more sparse, and the apical horn is longer in relation to the length of the theca and with a much broader base. Furthermore, *D. tripartita* sensu C. & E. (1961) is on the average smaller than *D. granulifera* although their size-ranges overlap. In 51 examples of *D. tripartita* from the Belfast Mudstone, Victoria, the range of the length was 76–116 μ, and of the width 49–73 μ, the arithmetical mean was 98.0 × 59.5 μ (Text-fig. 4).

D. granulifera also resembles *D. micracantha* Coohson & Eisenack (1 960 p. 3). The ornamentation in *D. micracantha* is similar to that of *D. granulifera* in its closeness in the equatorial region, however, it is not constant all over the theca and the very fine rods or spinules are 1.0–1.5 μ long. The shapes of the thecae are roughly similar, but in *D. micracantha* it is broader in the middle portion and has less pronounced shoulders. It is interesting to note that in *D. micracantha* linearly arranged spinules suggest a tabulation as mentioned in the original description; it corresponds to that observed in *D. scheii* and *D. sverdrupiana*. Furthermore, the girdle is laevo-rotatory, and it is broken, although not so distinctly as in *D. tripartita* (sensu C. & E. 1961) and *D. granulifera*.

The resemblances noted between *D. granulifera*, *D. micracantha*, *D. spectabilis*, *D. tripartita* sensu C. & E. (1961), and *D. verrucosa* indicate dose relationship between these species." — Manum (1963, p. 62–64)

<u>Age</u>: "Approx. middle Cretaceous" based on a sample from Graham Island (approx. 77° 20' N, 91 ° W) (Manum, 1963, p. 55). Range: Late Cretaceous (early–late Campanian) based on Harker & Sarjeant in Harker et al. (1990, p. 118; text fig. 26); Late Cretaceous (Coniacian–late Campanian) Nøhr-Hansen (1996, pocket 1, 13, 39).

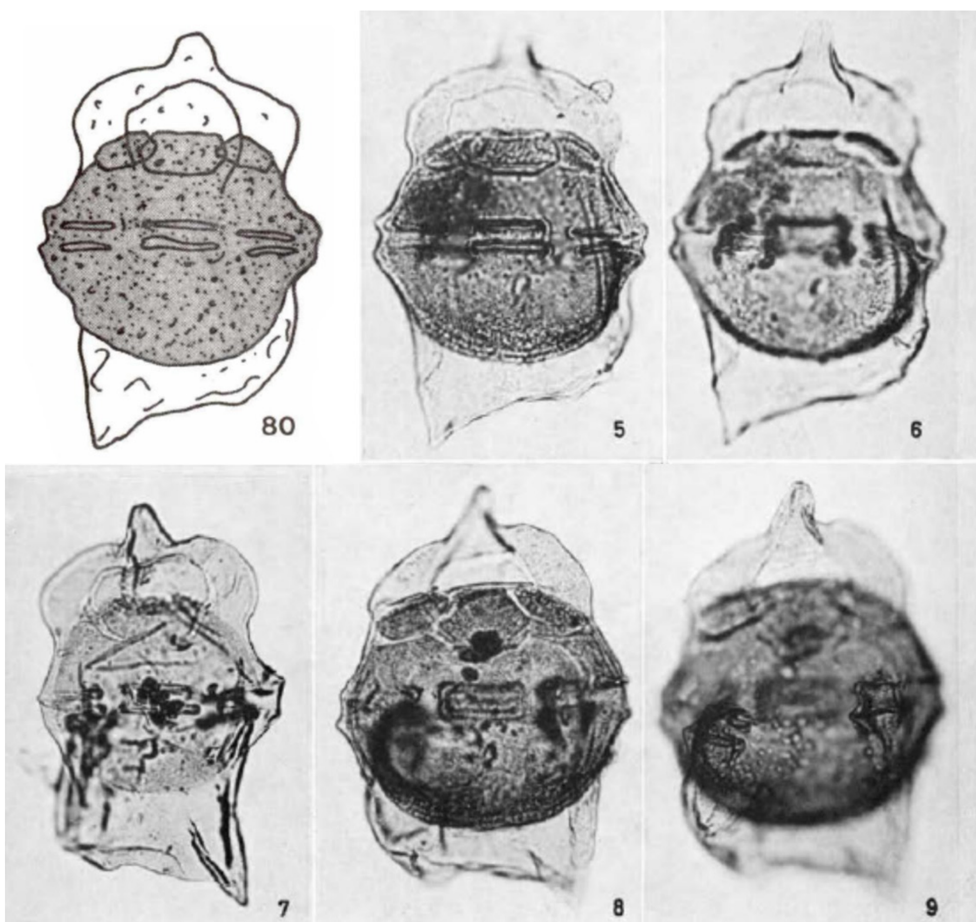


Plate 6, figure 80, Lentin & Williams (1976); Plate 3, figures 5–9, Manum (1963).

Chatangiella granulifera subsp. ***tenuis*** (Davey, 1970) Lentin & Williams, 1976

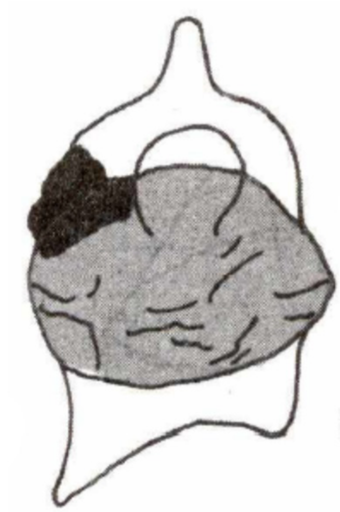
Diagnosis: “A variety of *D. granulifera* Manum possessing smooth to lightly granular outer membrane surrounding relatively small, thin-walled inner body.” — Davey (1970, p. 340)

Dimensions: “Holotype: shell diameter 85 by 60 μ, inner body diameter 39 by 60 μ. Range: overall length 85–114 μ, overall width 52–63 μ, diameter of inner body 39–60 μ. Number of specimens measured, 8.” — Davey (1970, p. 340)

Description: “*D. granulifera* var. *tenuis* has only been obtained from the Saskatchewan samples and appears to be quite variable. The shell is elongate, typically widest in the cingular region and narrowing slightly anteriorly before broadening to form rounded ‘shoulders’. The epitract terminates with a conical apical horn, blunted distally. The posterior end of the shell is flat to concave, bearing one pointed conical horn and sometimes a second rudimentary one. The slightly spiral cingulum is always well developed and bordered by fairly high ridges possessing knobbly margins. At regular intervals the bordering ridges of the cingulum are absent, thus it is discontinuous. The sulcus is wide and extends anteriorly from the antapical horns. A rounded, hexagonal intercalary archaeopyle is typically present. The outer membrane is thin and may be smooth or densely granular. The inner body is subspherical, has a slightly thicker wall and is usually more heavily granular than the outer membrane. Occasionally the inner body is in contact with the lateral walls of the shell but more often its small size does not permit this.” — Davey (1970, p. 340)

Remarks: “Manum (1962) gave a detailed analysis of *D. granulifera* from the Upper Cretaceous of Arctic Canada and noted that two forms appeared to be present. These forms differed in the density of the granulation and also in the thickness of the inner body wall. Since some intergradation between the two forms existed, Manum considered that both forms should be placed in the single species *D. granulifera*. The more typical form possesses a dense granulation with an inner body wall of approximately 2 μ in thickness. The other, rarer form, which is the only one represented in the Saskatchewan material, possesses a smooth to lightly granular outer membrane, and an inner body with a thin wall only slightly thicker than the outer membrane. Another differentiating feature is that the inner body is smaller in this form and is not in contact with the lateral walls of the shell. This form because of these distinguishing features is here created a variety of *D. granultfera*. *D. granulifera* var. *tenuis* nov. is rather similar to *D. spectabilis* Alberti (1959), especially in some specimens when the shoulders are not particularly pronounced. The inner body of *D. spectabilis*, from the Senonian of Germany, is extremely delicate and difficult to discern. Thus *D. granulifera* var. *tenuis*, which possesses a light granulation and a thin-walled inner body, appears to occupy an intermediate position between the typical form of *D. granulifera* and *D. spectabilis* and warrants its distinction as a variety. Moderately, well preserved specimens are extremely rare due to the thinness of the shell wall.” — Davey (1970, p. 340, 341)

Age: Early Cretaceous (Albian); holotype of Davey (1970, p. 340).



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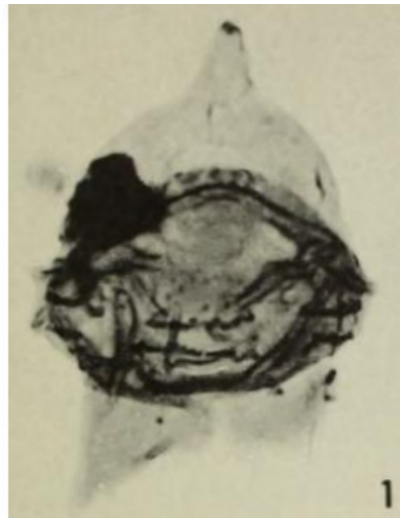


Plate 7, figure 99, Lentin & Williams (1976) (left); Plate 2, figure 1, Davey (1970) (right).

Chatangiella hexacalpis Harker & Sarjeant in Harker et al., 1990

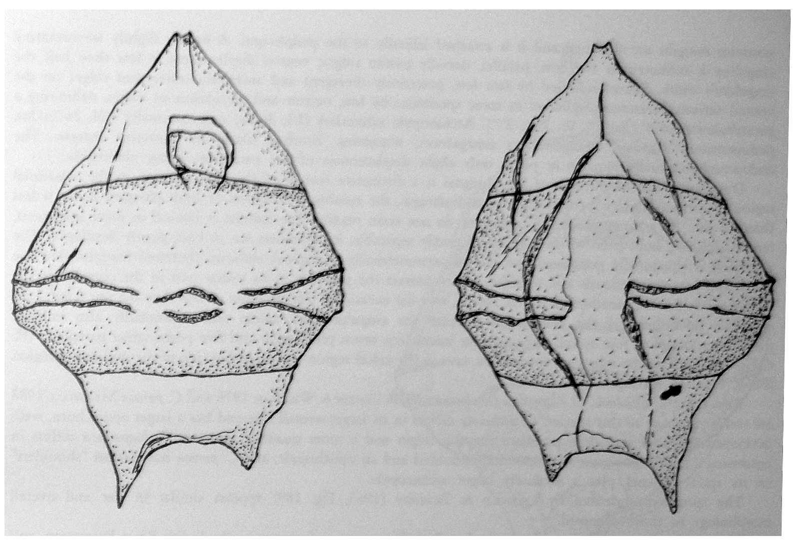
Diagnosis: “Bicavate cysts with a subpentagonal ambitus. Periblast smooth to finely granular, thin-walled, tapering into an apical horn, the apical region and pericoel having almost the shape of an isosceles triangle; sometimes with feebly developed ‘shoulders’. Tip of apical horn indented. Antapical pericoel broad-based, giving rise to two unequal antapical horns: a long, sharply tapering and pointed left and a shorter subconical right horn, with a pronounced concavity between. Greatest ambital width in the cingular region. Epitract and hypotract of about equal size. Endoblast smooth and thin-walled, with a broadly subhexagonal ambitus; its anterior and posterior margins are flattened and it is attached laterally to the periphragm. A broad, slightly laevorotatory cingulum is indicated by two low, parallel, dorsally partite ridges; ventral displacement is less than half the cingulum’s width. Sulcus indicated by two low, posteriorly divergent and anteriorly convergent ridges on the ventral surface. Parasutures indicated in some specimens by low, narrow and discontinuous ridges, delimiting a paratabulation of 4', 3a, 7'', 0c, 7''', 2''''. Archaeopyle intercalary (I/I, 2a/2a; or occasionally I/3I, 2a/1/a/3a); perioperculum standard hexagonal to omegaform, remaining attached along its posterior margin. The endoperculum usually remains in place, only slight displacement of the paraplates being observable.” — Harker & Sarjeant in Harker et al. (1990, p. 117, 118)

Description: “The thinness of the phragma is a distinctive feature of this species; even in the equatorial region of the contract between periphragm and endophragm, the combined thickness of both phragma layers is less than 0.5 μm. As a consequence the specimens do not stain readily. The epitract is conical in most specimens, terminating in a horn from which it is not distinctly separable; its shoulders are, at best, poorly developed. The endoblast is equatorially positioned and has an asymmetrically hexagonal ambitus; flattened margins abut the apical and antapical pericoels and rounded angles contact the periblast at its widest part in the cingular region (Text-fig. 22). Surface ornament is largely absent, save for occasional fine granules of less than 0.5 μm relief. Low ridge-like thickenings of the periphragm indicate the cingulum and sulcus and occasionally also indicate parasutures, outlining four apical, three anterior intercalary, seven precingular and five postcingular paraplates (Pl. 8, Fig, 16). The cingular ridges are continuous, save in the sulcal region and on either side of the mid-dorsal region (Pl. 8, Fig. 11; Text-fig. 22).” — Harker & Sarjeant in Harker et al. (1990, p. 118)

Dimensions: “Holotype: overall length 108 μm, breadth 72 μm, length of endoblast 57 μm, apical horn 8 μm, left antapical horn 20 μm, right antapical horn 7 μm, cingulum width 6 μm, transverse peripyle index 0.47, transverse peripyle ratio 0.71. Range of 207 measurable specimens: periblast length 64–116 μm, mean 89 µm; breadth 40–83 µm, mean 65 µm; length of endoblast 28–47 µm, mean 43 µm; apical horn 6–9 µm, mean 7 µm; length of left antapical horn 10–26 µm, mean 13 µm; length of right antapical horn 1–9 µm, mean 3 µm; cingulum width 4–8 µm, mean 6 µm; transverse peripyle index 0.44–0.51, mean 0.48; transverse peripyle ratio 0.71–1.10, mean 0.79. 526 specimens were counted." — Harker & Sarjeant in Harker et al. (1990, p. 118)

Remarks: "*C. ditissima*, *C. biapertura* (McIntyre 1975) Lentin & Williams 1976 and *C. porosa* Marshall 1988 are similar in shape to this species: *C. ditissima* differs in its larger overall size and has a larger apical horn, well-developed epitract shoulder, pustulate cingular ridges and a more quadrate antapex; *C. biapertura* differs in possessing a thicker phragma, a subspherical endoblast and an opisthopyle; and *C. porosa* has distinct 'shoulders' on its apical pericoel, plus a markedly larger archaeopyle. The specimen illustrated by Leopold & Tschudy (1965, fig. 189) appears similar in size and overall morphology to those observed." — Harker & Sarjeant in Harker et al. (1990, p. 118)

Age: Late Cretaceous (early Campanian); holotype of Harker & Sarjeant in Harker et al. (1990, p. 118; text fig. 26) as correlated with the zones M2 and M3 corresponding to the Pembina Member of the Pierre Formation (Harker & Sarjeant in Harker et al., 1990, text-fig. 33). Range: Late Cretaceous (early–middle Campanian) (Harker & Sarjeant in Harker et al., 1990, text-fig. 26).



Text figure 22, Harker & Sarjeant in Harker et al. (1990).

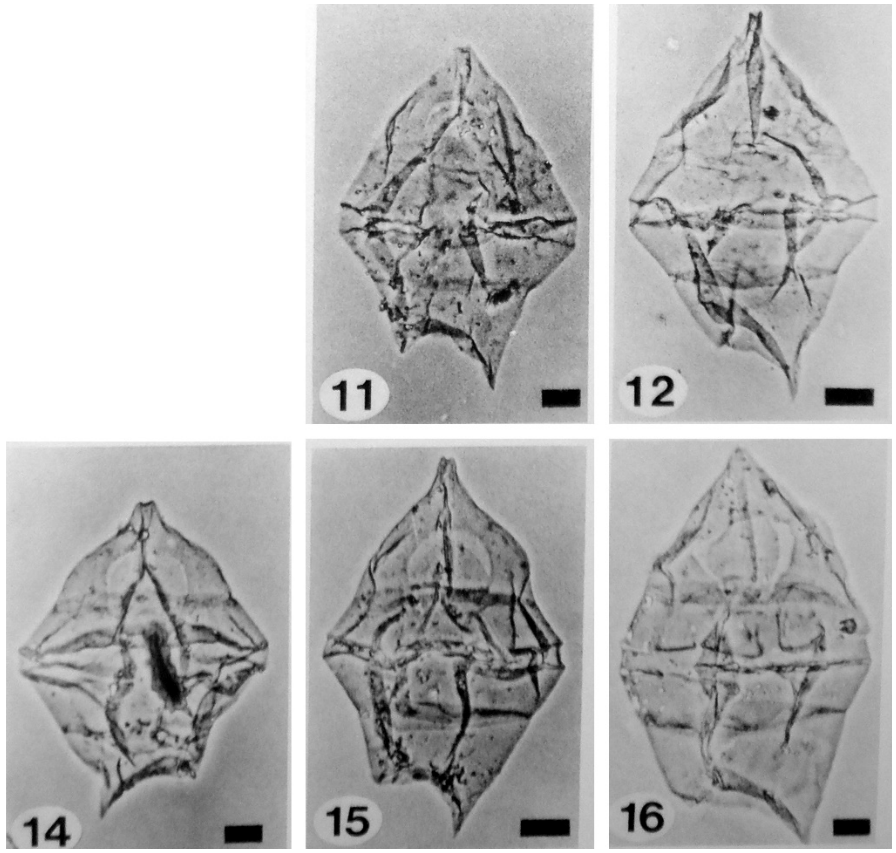


Plate 8, figures 11, 12, 14–16, Harker & Sarjeant in Harker et al. (1990). Scale bars = 10 μm.

Chatangiella kangukensis Núñez-Betelu, 1994

Diagnosis: "Elongate, subrectangular to polygonal with angular, narrow shoulders; bicavate cysts with strongly developed apical and antapical pericoels. Peridiniacean paratabulation. Intercalary archeopyle Type I/I, and opercula free. Paracingulum dorsally tripartite. This species differs from other *Chatangiella* species in being relatively more elongated, and in having very straight, angular shoulders." — Núñez-Betelu (1994, p. 289)

Description: "Cyst type: bicavate. Shape: compressed peridinioid. Pericyst elongated, subrectangular to polygonal; straight, angular shoulders on the epicyst and a broad based, straight sided. Pointed apical horn. Poor to fairly well differentiated antapical horns. Endocyst circular to ovoidal. Wall relationships: bicavate. apical and antapical pericoels strongly developed. Wall features: no parasutural features. Periphragm uniformly, faintly granulate. And with scattered verrucae, more abundant adjacent to the paracingulum. Endophragm smooth. Paratabulation: indicated by archeopyle and paracingulum. Archeopyle: intercalary, Type I/I. Opercula free. Paracingulum: well developed, indicated by strongly developed, transverse, parallel parasutural ridges with granulate margin. Dorsally tripanite. Parasulcus: expressed as a folded, shallow depression on the hypocyst." — Núñez-Betelu (1994, p. 289, 290)

Dimensions: "Holotype: pericyst, length 102 μm, width 56 μm. Endocyst, length 48 μm, width 56 μm. Apical horn, length 12 μm. Size range: pericyst, length 88 (106) 124 μm, width 50 (61) 68 μm. Endocyst, length 44 (52) 68 μm, width 48 (60) 68 μm. Apical horn, length 9 (12) 14 μm. (22 specimens)." — Núñez-Betelu (1994, p. 290)

Comparison: “This species differs from the other species of *Chatangiella* in its elongated subrectangular to polygonal shape with markedly straight angular shoulders. Both the apical and antapical pericoles of *C. kangukensis* sp. nov. are relatively more elongated than in the other species of this genus. The ornamentation of the periphragm of *C. kangukensis* sp. nov. is intermediate between the granulose ornament of *C. granulifera* (Manum 1963) Lentin and Williams 1976) and the verrucate ornament of *C. verrucosa* (Manum 1963) Lentin and Wiliams 1976). The elongated subrectangular to polygonal shape and the markedly angular shoulders are the basis for establishment of this new species.” — Núñez-Betelu (1994, p. 290, 291)

Remarks: “*Chatangiella kangukensis* sp. nov. occurs in samples with other species of *Chatangiella*, such as *C. granulifera*. However, the stratigraphic range of the former seems to be restricted to the lower part of the Upper Cretaceous whereas the latter is present through most of the Upper Cretaceous. Both species can be easily distinguished on the basis of their morphology.” — Núñez-Betelu (1994, p. 291)

Age: Late Cretaceous (Turonian, ?Coniacian); holotype of Núñez-Betelu (1994, p. 291).

Note: name not validly published in the thesis of Núñez-Betelu (1994).

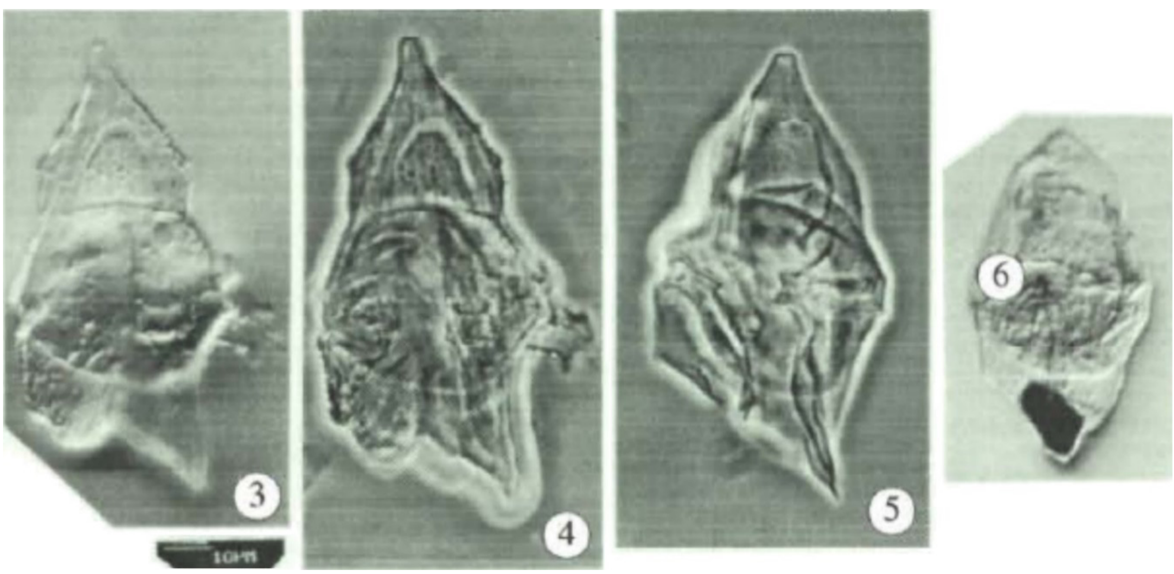


Plate 25 figures 3–6, Núñez-Betelu (1994).

Chatangiella madura Lentin & Williams, 1976

nom. subst. pro. *Chatangiella manumii* Cookson & Eisenack, 1970, comb. nov. pl. 11, fig. 10

Description: “Shell relatively large, considerably longer than broad, divided approximately equally by a clearly-defined discontinuous girdle. The epitheca, which is slightly longer than the hypotheca, consists of a prominent apical region with strongly convex shoulder-like sides, a short, broad, median apical horn with a straight apex and outwardly slanting sides, and a slightly broader lower portion with convex sides which extends to the girdle. The sides of the hypotheca narrow gradually inwards towards a squarish antapex with a slightly pointed prominence on the right-hand side. The girdle is relatively wide, strongly defined and broken at regular intervals. The archeopyle is rather large and slightly angular in outline. The wall of the shell is finely granular throughout. In addition, relatively large clearly-defined areas both above and below the individual subdivisions of the girdle, which resemble fields of *Peridinium* type (Manum 1963), are outlined by relatively prominent, closely arranged, bluntly-pointed solid thickenings which are circular in outline in surface view. The walls of the central body and shell are thin and in close contact." — Cookson & Eisenack (1970, p. 141, 142)

Dimensions: "Holotype: c. 102 μ long, c. 60 μ broad. Range: 20 specimens c. 95–138 μ long, c. 52–80 μ broad." — Cookson & Eisenack (1970, p. 142)

Comment: "Both the shape and the size of the shell of *D. manumi* are closely similar to those of *D. tripartita* Cookson & Eisenack 1960, *D. victoriensis* Manum & Cookson 1964 and *D. verrucosa* Manum 1963, and show the *Peridinium* type of tabulation discussed by Manum in 1963. The fields outlined on the surface of the shell of *D. manumi* are 3'', 4'' and 5'' and 2''', 3''' and 4'''. Between the individual fields there are clearly marked longitudinal intercalary strips." — Cookson & Eisenack (1970, p. 142)

Age: Late Cretaceous (Senonian); holotype of Cookson & Eisenack (1970, p. 141). Range: Late Cretaceous (late Campanian) based on Harker & Sarjeant in Harker et al. (1990, p. 118; text fig. 26).

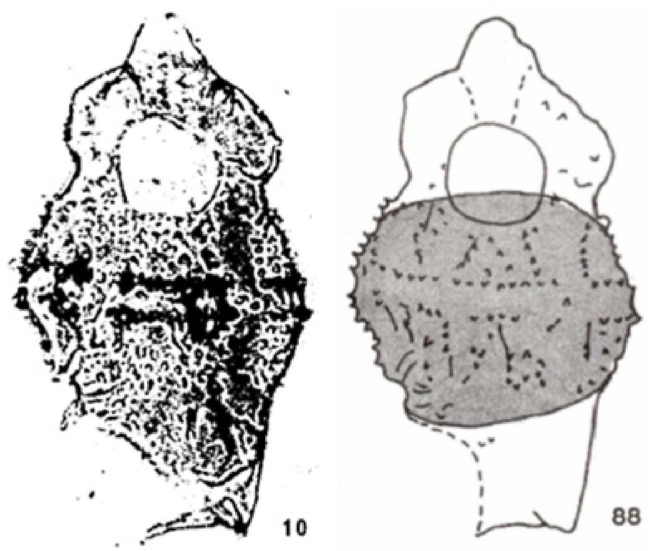


Plate 11, figure 10, Cookson & Eisenack (1970) (left);
Plate 7, figure 88, Lentin & Williams (1976) (right).

Chatangiella manumii (Vozzhennikova, 1967) Lentin & Williams, 1976

Description: "Theca oval-pentagonal, tabulated and divided into almost equal parts. Epitheca triangular, with convex lateral walls or somewhat tapering at the level of the top of the internal body, after which the walls diverge somewhat before coming together to give a conical apical horn which is bluntly truncated at the distal end. Hypotheca trapeziform with two antapical horns of different size. One is short and rounded at the end and may be barely discernible; the other is considerably larger acutely pointed and triangular in outline although sometimes it may be blunt ended and somewhat curved. Transverse furrow equatorial, annulate and between its ends there is a depression, corresponding in position to the longitudinal furrow and extending a little way onto the epitheca as well as reaching almost to the end of the hypotheca. Theca divided into fields, the boundaries of which are marked by pointed spines. Similar spines occur more sparsely on the surface of the plates and more densely along the margins of the furrows. In many specimens there are small areas between the fields which are devoid of sculpturing and probably correspond to tile sutures of tabulated Peridinia. The number of fields has not yet been determined accurately. The internal body is oval and occupies the central part of the theca; its lateral walls are adjacent to or at some distance from the thecal walls which in turn vary in thickness. Pylome oval-hexagonal." — Vozzhennikova (1967, p. 184, 185, translation: Lees & Sarjeant, 1971)

Dimensions: "In microns, holotype: length of theca 61.5, breadth 45.9, width of transverse furrow 6, length of internal body 35.1, breadth 37.8. In other specimens: length of theca 62.3–72.0, breadth 37.8–51.3, width of transverse furrow 5.4–6, length of internal body 29.1–40.0, breadth 45.9, length of pylome 15.6, breadth 16 .8." — Vozzhennikova (1967, p. 185, translation: Lees & Sarjeant, 1971)

Comparison: "This differs from other species in the genus in the more oval outline of the theca and the presence of spinous sculpturing. There is some similarity to *Deflandrea* cf. *scheii* Manum (Manum, 1963, plate 2, fig. 4,5, text fig. 2) from which it differs in its smaller size and more pointed spinules bordering the fields and furrows. The noted similarity between our specimens and *Deflandrea* cf. *scheii* together with the difference between the latter and the species *D. scheii* Manum,1963 may well serve as a reason for separating the former as a separate species, particularly when well preserved material permits the determination of its tabulation." — Vozzhennikova (1967, p. 185, translation: Lees & Sarjeant, 1971)

Age: Late Cretaceous (Turonian–Campanian); holotype of Vozzhennikova (1967, p. 184, translation: Lees & Sarjeant, 1971). Range: Late Cretaceous (Campanian) (Vozzhennikova, 1967, table 4, translation: Lees & Sarjeant, 1971).

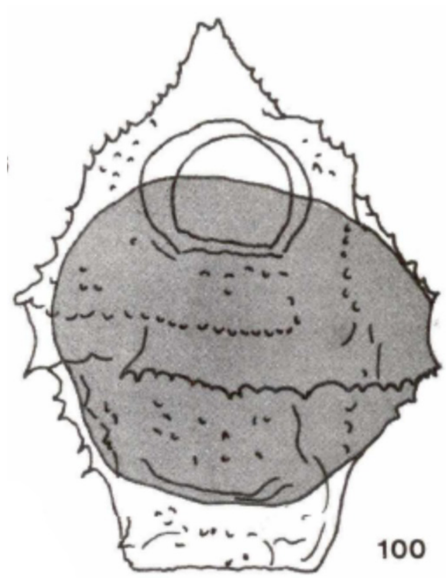


Plate 7, figure 100, Lentin & Williams (1976).

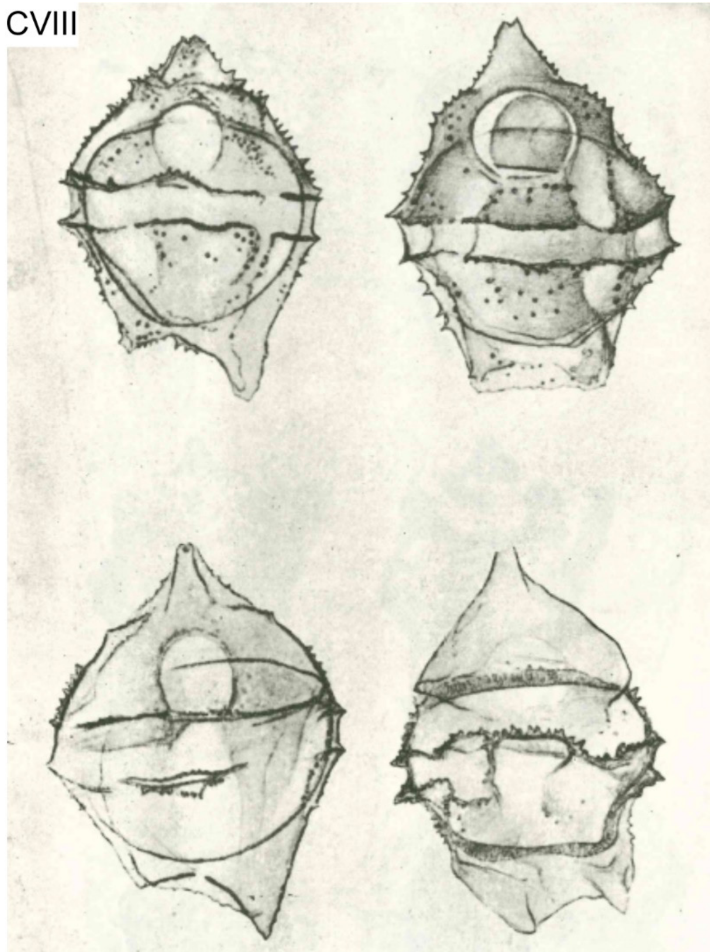


Plate 108, figures 1–4, Vozzhennikova (1967).

Chatangiella mcintyrei Nøhr-Hansen, 1996

<u>Description</u>: “Circumcavate. Peridinioid. Shape: dorso-ventrally compressed cyst, elongate, almost box-shaped. The width of the cyst is almost the same from the broad apical shoulders to the antapical ‘horns’, except from the areas at the apical and antapical ends of the endocyst, where the periphragm has, slightly concave sides. The epicyst and hypocyst are almost the same length. The apical horn is broad-based, short and blunt, with slightly concave sides. The left antapical horn is short and pointed, the right antapical horn is only represented by a bulge.

Wall relationship: the cyst is composed of a smooth to scattered granulate box shaped pericyst and a spherical to slightly apical-antapical compressed endocyst, equatorially centred. Both pericyst and endocyst are rather thin-walled and almost hyaline, which occasionally make it difficult to distinguish the outline of the endocyst.

Tabulation: paratabulation is indicated only by the archeopyle and the cingulum, which on both anterior and posterior margins is bordered by discontinuous ridges with tubercles. Five pairs of ridges have been observed; but more likely 7 pieces of anterior ridges and 5 pieces of postcingular ridges should be expected, as in most *Chatangiella* species. A large wide sulcus is present on the ventral surface.

Archaeopyle: intercalary (2a) rounded iso-omegaform archeopyle. Operculum often attached at posterior margin. One example of 3I endoarcheopyle with the three plates attached along their posterior margins has been observed (Plate 2, Fig. 7). The complete archeopyle formula for the species if of type I/I or seldom type I/3I.” — Nøhr-Hansen (1996, p. 31)

Dimensions: "Holotype: length of pericyst 101 µ, width of pericyst 70 µ, length of endocyst 52 µ, width of endocyst 56 µ, length of apical horn 11 µ. Size range: length of pericyst 87 (95) 108 µ, width of pericyst 53 (61) 70 µ, length of endocyst 36 (45) 52 µ, width of endocyst 40 (47) 56 µ, (15 specimens) length of apical horn 10 (11) 12 µ (14 specimens)." — Nøhr-Hansen (1996, p. 32)

Discussion: "The pericyst size and shape in the new species *Chatangiella mcintyrei* are quite similar to that of *C. granulifera* and *C. verrucosa*, from which it is easily distinguished by being circumcavate. The box-shaped outline of *C. mcintyrei* distinguishes it from the rhombic-shaped, circumcavate species *C. spectabilis*." — Nøhr-Hansen (1996, p. 32)

Age: Late Cretaceous (Coniacian); holotype of Nøhr-Hansen (1996, p. 32).

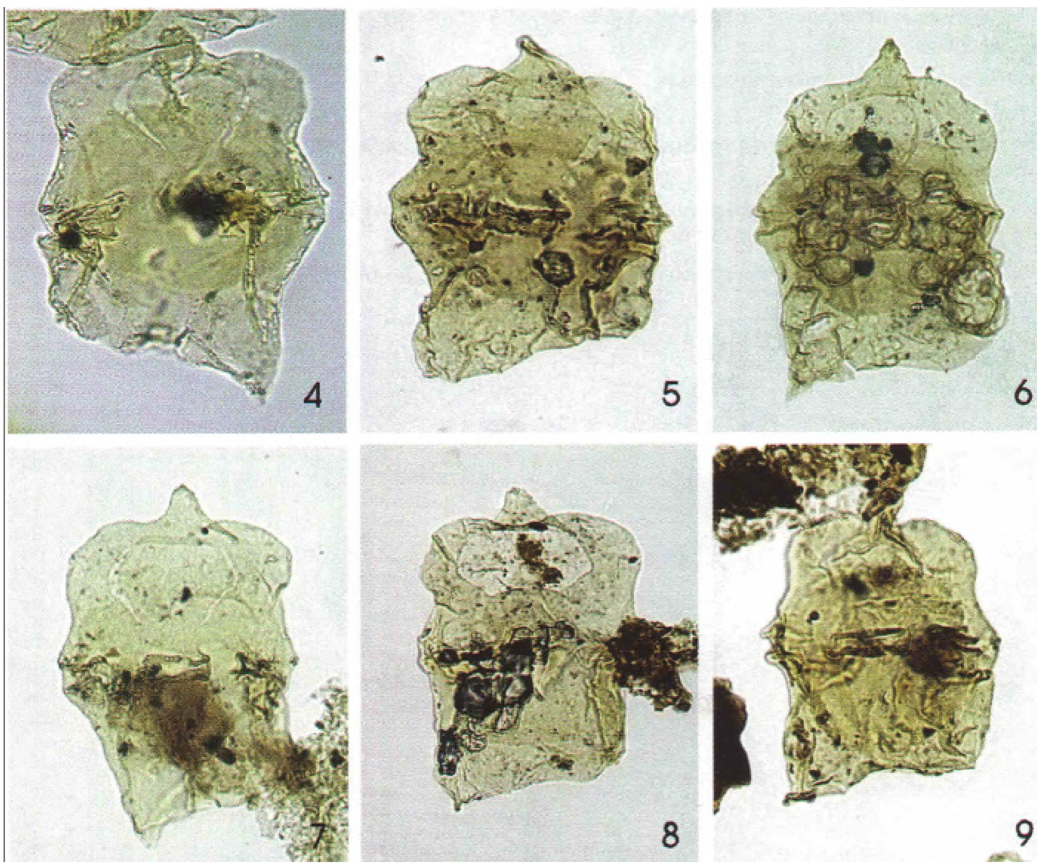


Plate 3, figures 4–9, Nøhr-Hansen (1996).

Chatangiella micracantha (Cookson & Eisenack, 1960) Lentin & Williams, 1976

Description: "Shell elongate, flat, equally divided by a rather broad and slightly helicoid girdle, epitheca and hypotheca narrowing toward the apex and antapex, respectively. The epitheca terminates in a broad, bluntly pointed, triangular horn, the hypotheca in two broad and bluntly pointed horns of unequal size. A longitudinal furrow, bordered by divergent ledges, is situated on the ventral surface of the hypotheca. A faint indication of tabulation is present. The capsule is circular in outline and fills the shell laterally. The shell membrane is closely spinulose in the capsular region, becoming more sparsely so toward both apex and antapex. The membrane of the capsule is finely granular." — Cookson & Eisenack (1960, p. 3)

Dimensions: “Holotype: 133 μ long; 81 μ broad; capsule 72 × 74 μ; girdle 10 μ wide; diameter of pylome 30 μ. Range: 114–133 × 72–87 μ.” — Cookson & Eisenack (1960, p. 3)

Age: Late Cretaceous (Campanian); holotype of Cookson & Eisenack (1960, p. 3).

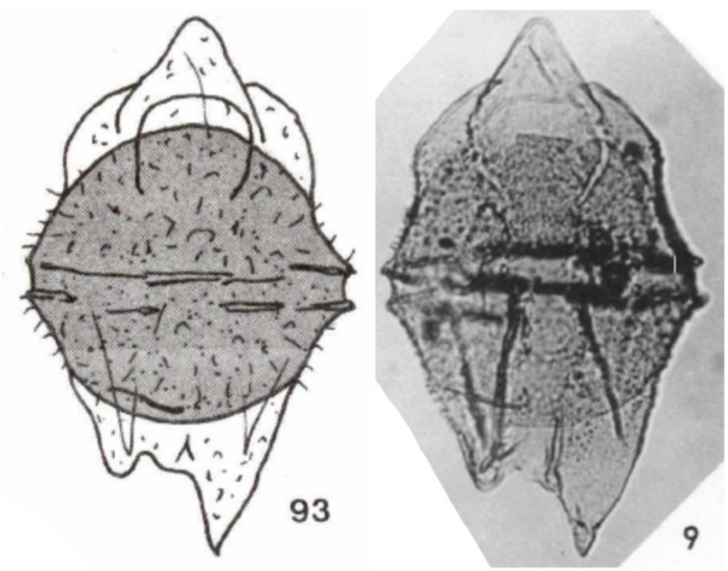


Plate 7, figure 93, Lentin & Williams (1976); Plate 1, figure 9, Cookson & Eisenack (1960).

?*Chatangiella multispinosa* (Cookson & Eisenack, 1970) Lentin & Williams, 1976

Description: “Shell small, slightly longer than broad. Epitheca somewhat larger than the hypotheca with slightly convex sides and a short, centrally placed apical horn which, when entire, is bluntly pointed. The sides of the hypotheca, which are straight or slightly convex, slant downwards towards a relatively narrow and straight base with two short but distinct antapical horns of unequal length, the left-hand one being the larger. In two specimens only one relatively large antapical horn is developed (Pl. 11, fig. 7). The girdle is prominent, circular and discontinuous on the dorsal surface, the breaks being to the right and left of a median portion and near the lateral walls. The wall of the shell is distinctly and closely ornamented with short, sharply pointed spines. A large internal capsule, oval in shape, almost fills the shell. The archeopyle is squarish to circular in outline.” — Cookson & Eisenack (1970, p. 141)

Dimensions: “Holotype: c. 96 μ long, 62 μ, broad. Range of 10 specimens: c. 67–102 μ long, 46–72 μ broad.” — Cookson & Eisenack (1970, p. 141)

Comment: “The slight broadening of the epitheca below the apical horn and the lateral interruptions of the girdle on the dorsal surface are characters which, to some extent, link *D. multispinosa* with *D. tripartita* Cookson & Eisenack 1960, *D. victoriensis* Cookson & Manum 1964, *D. verrucosa* Manum (1963) and *D. manumi* n. sp.” — Cookson & Eisenack (1970, p. 141)

Age: Cretaceous (Albian or Cenomanian); holotype of Cookson & Eisenack (1970, p. 141).

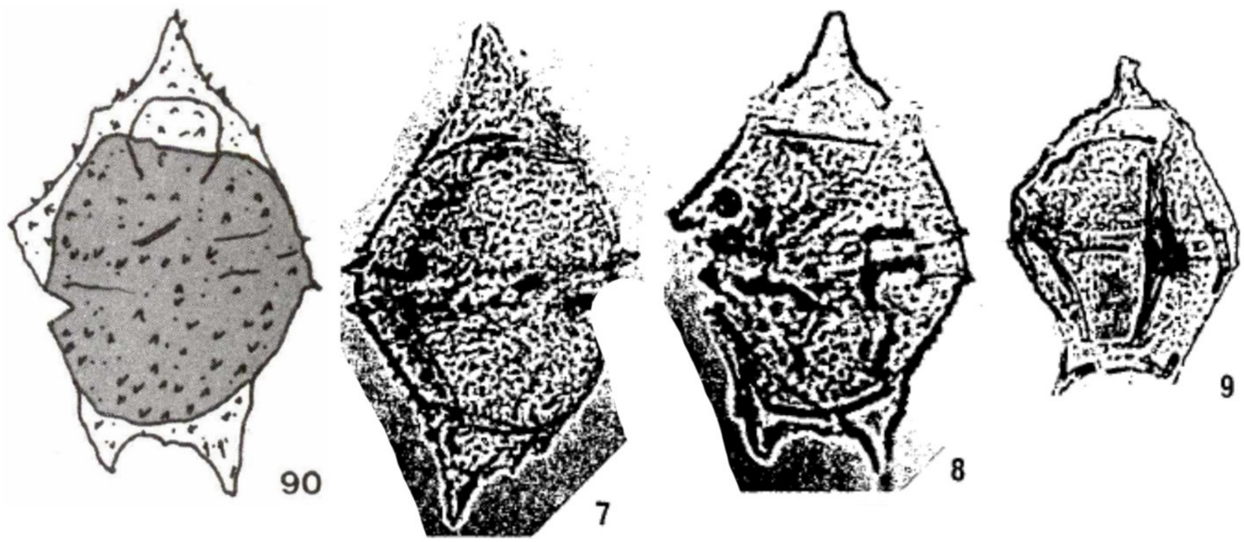


Plate 7, figure 90, Lentin & Williams (1976); Plate 11, figures 7–9 Cookson & Eisenack (1970).

Chatangiella niiga (Vozzhennikova, 1967) Lentin & Vozzhennikova, 1990

<u>Description</u>: "Epitheca on a level with the upper edge of the internal body slightly or strongly tapering and then broadening again. In the middle of the uncurved or slightly concave apical margin of the theca there is a conical, bluntly rounded, apical horn. The hypotheca lies on the level of the lower boundary of the internal body, also tapers and then widens again, thus forming a trapeziform or rectangular antapical end to the theca. The antapical end is acutely or bluntly rounded and somewhat extended to form an antapical horn. The internal body is oval, slightly compressed along the longitudinal axis and closely applied to the convexly curved lateral walls of the theca. The surface of the internal body is smooth and dotted. The transverse furrow is shallow, equatorial and slightly spiral. The longitudinal furrow reaches the posterior margin. The thecal surface is granular with sparsely arranged, short spines which lie in the middle of the theca and on the margin of the transverse furrow. The pylome is polygonal, with its broader rectangular part lying in the expanded apical portion of the theca and its narrower part extending into the tapering portion of the theca. The pylome reaches the upper edge of the internal body and may even extend towards the transverse furrow." — Vozzhennikova (1967, p. 129, translation: Lees & Sarjeant, 1971)

<u>Dimensions</u>: "In microns, holotype: length of theca 113.4, width 59.4, length of internal body 45.9, width of transverse furrow about 3. In other specimens: length 108–121.5, breadth 59.4–62.1, length of internal body 44.9–54.0 and width of transverse furrow 3–8." — Vozzhennikova (1967, p. 129, translation: Lees & Sarjeant, 1971)

<u>Emended description</u>: "Cyst shape elongate rectangular with a short apical horn between well-developed shoulders and a convex paracingular region; antapex nearly flat with two poorly developed antapical horns, occasionally the left antapical horn may be more developed; endocyst round to roundly rectangular in outline, dividing the cyst equally; bicavate. Periphragm smooth to finely granulose with randomly located rare small spines; endocyst finely granulose with thickened apical and antapical margins within the epi- and hypopericoel, thickenings appear to be fibrous or sponge-like. Paratabulation peridinioid, indicated by archeopyle and paracingulum only; the periarcheopyle is iso-omegaform with the 4''–2a parasuture about one third the length of the 2a–3' parasuture, operculum remains attached along the 4''–2a parasuture; the endoarcheopyle is 3I or undeveloped; an opisthopyle may be formed by an arcuate suture on the mid-ventral surface of the hypocyst. The paracingulum is outlined by parallel ridges of occasional spines, faintly pentapartite. Parasulcus indicated by a shallow depression on the hypocyst." — Lentin & Vozzhennikova (1990, p. 45, 46)

Age: Late Cretaceous (Santonian); holotype of Vozzhennikova (1967, table 4, translation: Lees & Sarjeant, 1971).

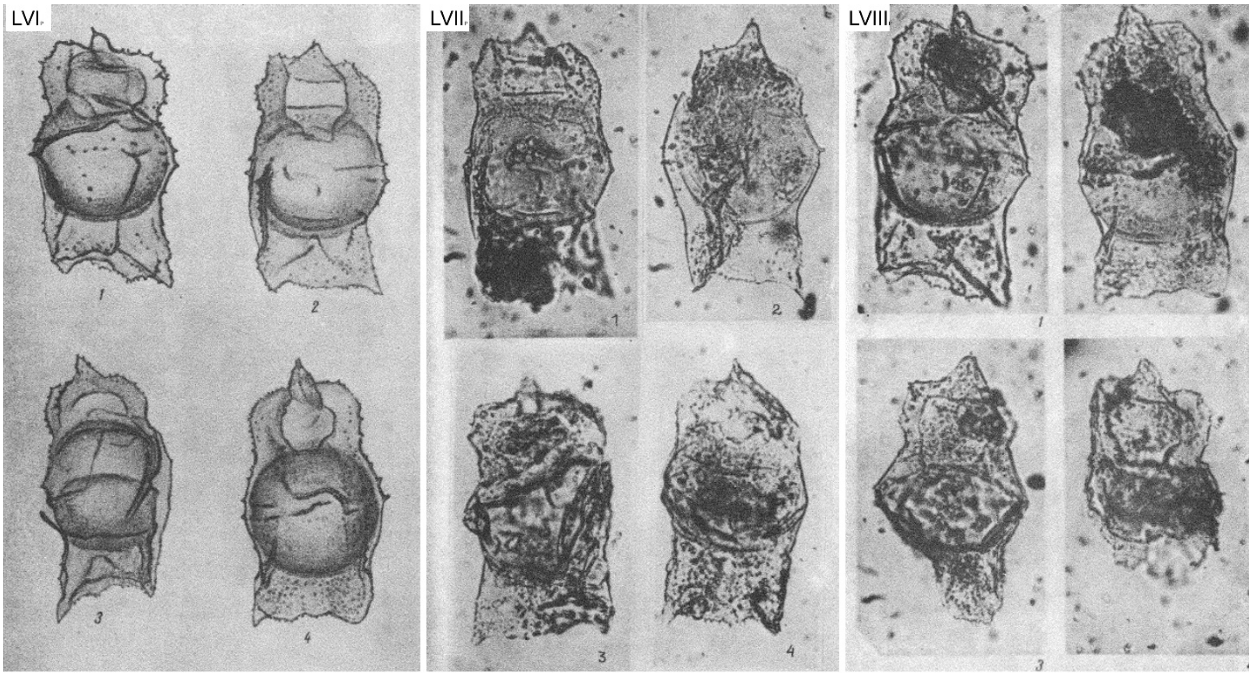


Plate 56, figures 1–4, Plate 57, figures 1–4, and Plate 58, figures 1–4, Vozzhennikova (1967).

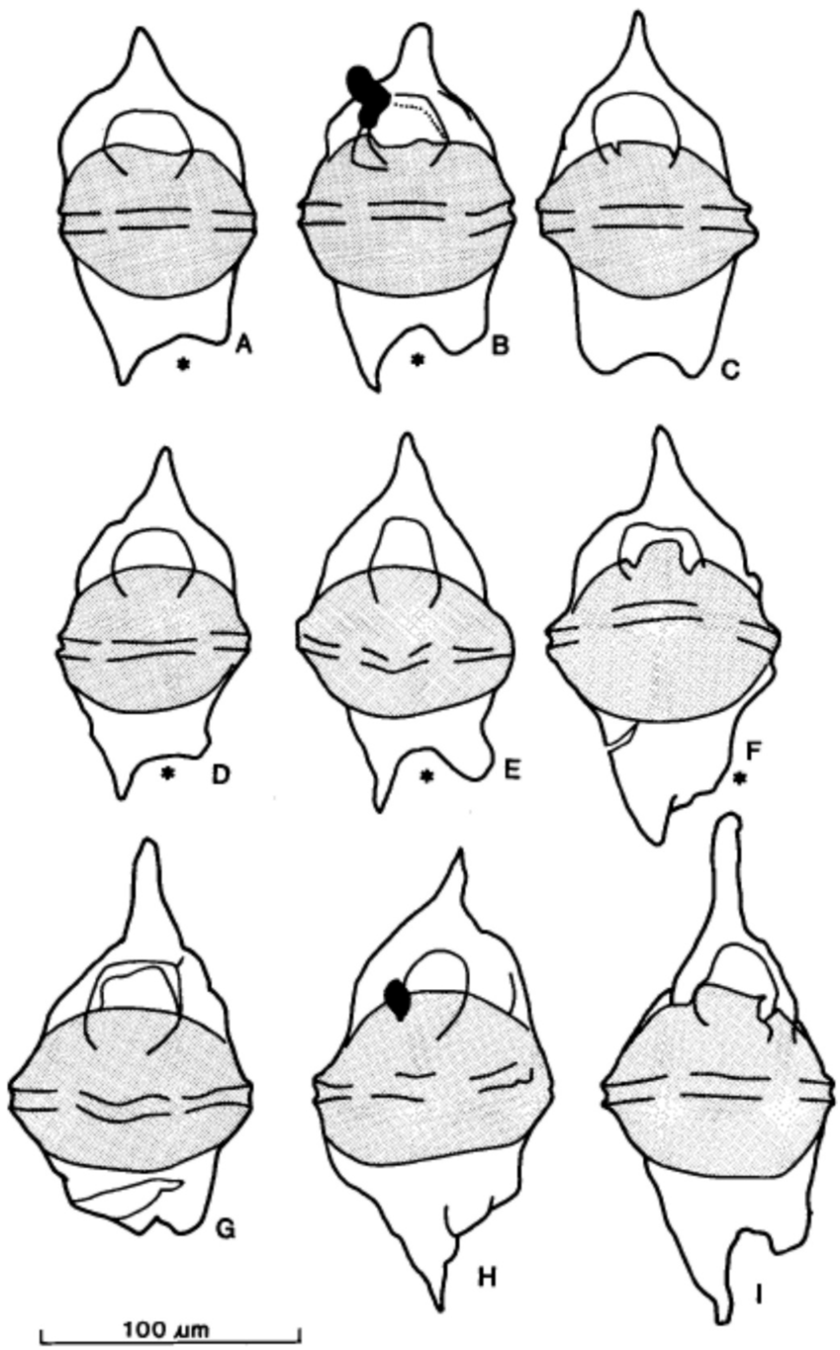
Chatangiella packhamii Marshall, 1990

Description: "Ventrodorsal outline elongate, subpentagonal. Lateral margins on epicyst tapering towards apex, or more commonly, modified by 2 rounded shoulders. Apex bearing a prominent apical horn with a rounded tip. Lateral margins on hypocyst tapering towards 2 antapical horns: left horn subtriangular, right horn indicated by a weak to distinct rounded bulge. Cysts bicavate, often with isolated pericoels below paracingular ridges. Ventrodorsal outline of endocyst subcircular to ovoidal, width greater than length. Endophragm surface usually with fine grana or rods up to 0.5 µm wide and 2.0 µm high. Sculptural elements isolated or fused to form discontinuous rugulae. Rods occasionally extremely fine, densely packed, and linked distally, producing a fibrous layer. Periphragm scabrate to finely granulate equatorially: grana less than 0.5 µm high and wide, becoming scabrate towards the poles. Paracingulum partite, marked by 2 parallel rows of ridges 6–8 µm apart with smooth, irregular, or denticulate crests. Periarcheopyle Type la, isodeltaform to isothetaform, operculum usually attached along its posterior margin. Endoarcheopyle often indicated by a transverse split between adjoining boundaries of paraplates 2–4' and 1–3a, and frequently, by additional incomplete sutures between adjoining margins of paraplates 1–3a (Fig. 12D)." — Marshall (1990, p. 20, 22)

Dimensions: "Pericyst length 115(158)194 µm, width 74(84)100 µm; endocyst length 49(65)80 µm, width 67(79)96 µm (19 specimens)." — Marshall (1990, p. 22)

Discussion: "There is considerable variation in the length of the apical and antapical horns and development of shoulders on either side of the apex (fig. 11). The most common forms encountered are similar to those in Fig. 11AE. The ornament on both wall layers is also variable, and examples with the coarser endophragm sculpture also have the coarser periphragm sculpture. *Chatangiella packhamii* is similar to *C. tripartita* (Cookson & Eisenack) Lentin & Williams 1976, but differs in being larger and having a more prominent sculpture on the periphragm. It is distinguished from the specimens of *C. victoriensis* (Cookson & Manum) Lentin & Williams 1976 recorded by Cookson & Manum (1964, p. 522, pl. 76, figs 3–8) from the Otway Basin, southern Australia, in having a finer, more evenly distributed sculpture on the equatorial part of the pericyst and in usually being larger. Examples of *C. victoriensis* studied by Marshall (1988) from the Gippsland Basin with the weaker periphragm sculpture are more difficult to separate from *C. packhamii* and the most obvious difference is the predominantly larger size of the latter." — Marshall (1990, p. 20, 22)

<u>Age</u>: Late Cretaceous (middle Campanian); holotype of Marshall (1990, p. 20, fig. 6).



Figures 11A–I, Marshall (1990).

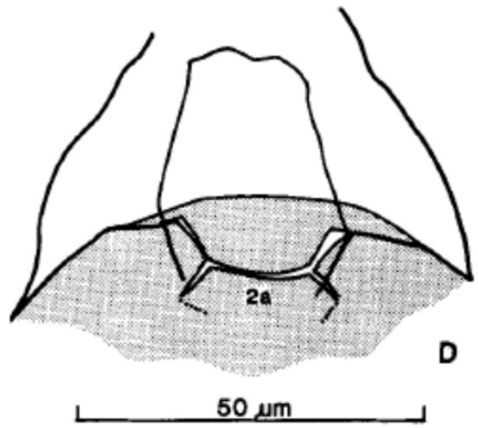
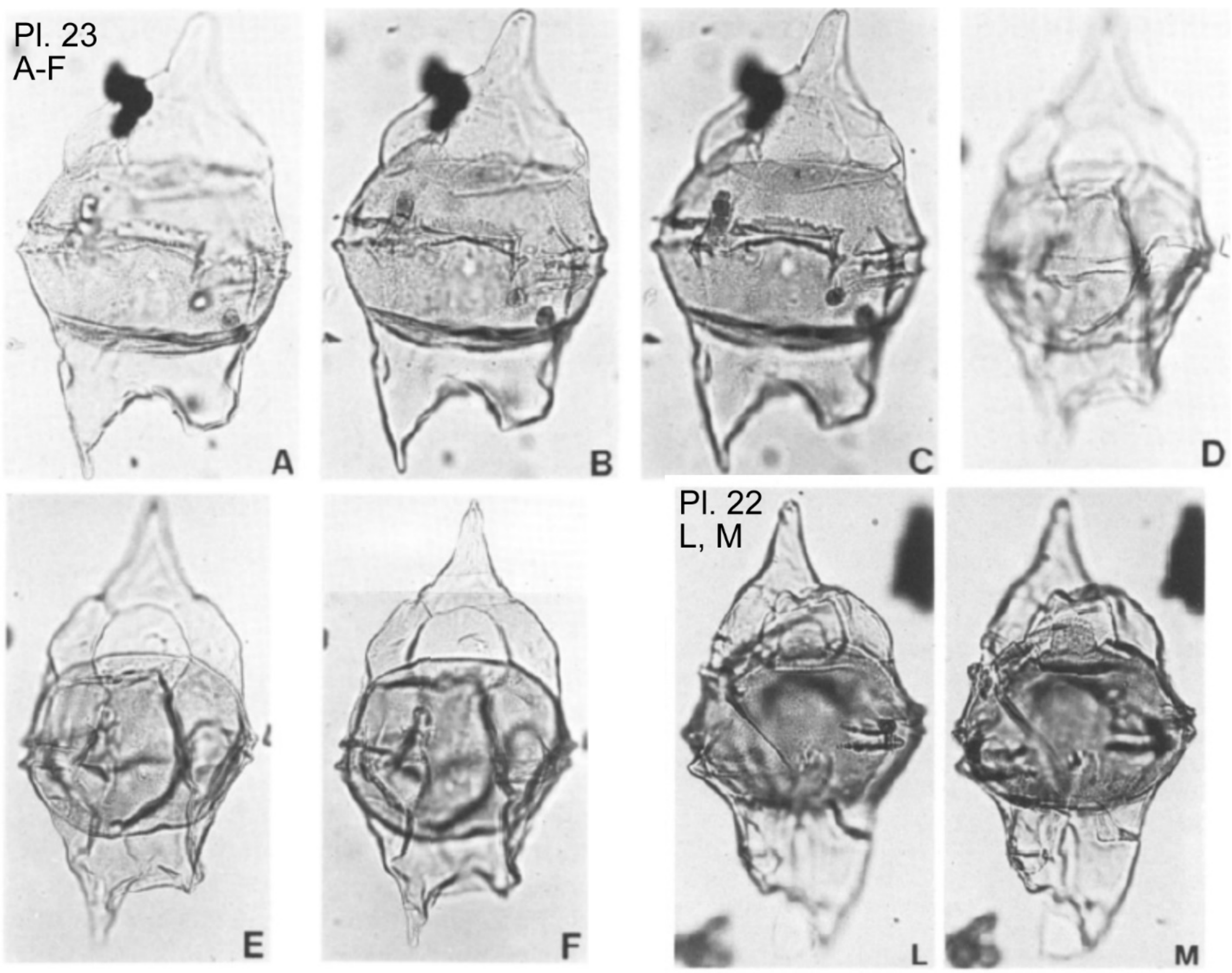


Figure 12D, Marshall (1990).



Figures 22L, M, 23A–F, Marshall (1990).

Chatangiella porata Aurisano, 1984

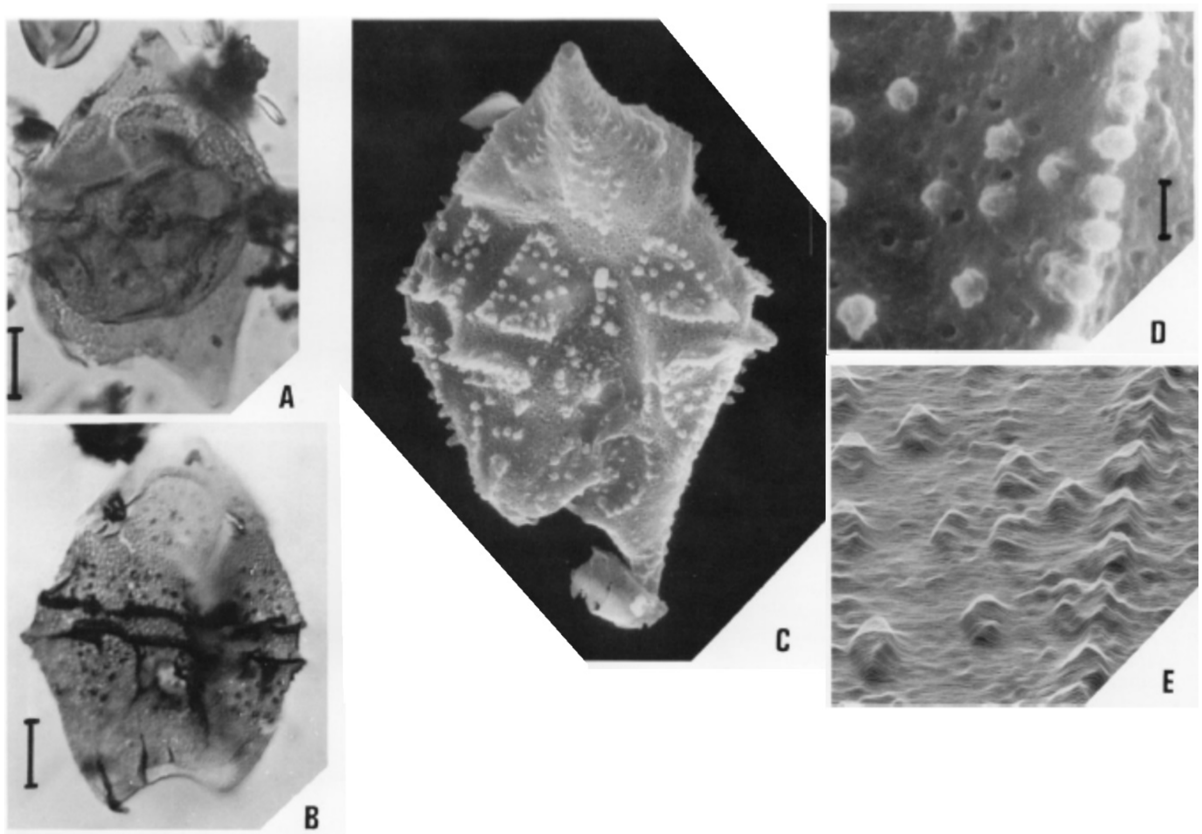
Diagnosis: "A species of *Chatangiella* whose pericyst surface appears to be uniformly porate in optical section but is actually foveolate." — Aurisano (1984, p. 1, 2)

Description. "A circumcavate dinoflagellate cyst which is pentagonal to ellipsoidal in outline. The pericyst terminates in one apical and two antapical horns, the left of which is fully developed and pointed, while the right is weakly developed, when present. The apical horn terminates in a sharp invagination. Epicystal expression of shoulders varies from weak to strong. The pericyst is dorsally convex, ventrally planar. The pericyst surface appears porate in optical section but is demonstrated to be foveolate through scanning electron microscopy. The individual foveolae are less than 1 µm in diameter and uniformly and densely distributed. In addition, pericyst is characterized, more or less, by intratabular fields of large granules and/or rods (granules larger than foveolae but smaller than 1 µm in diameter), separated by pandasutural bare zones-especially in the pre- and postcingular series of paraplates. The density of distribution of positive ornament is variable but foveolate condition is a more or less consistent feature of this species. Endocyst is spherical in outline; surface is finely granulate to smooth. Paracingulum is denoted by finely serrated parasutural ridges and is tripartite on the dorsal surface. Paratabulation is incompletely expressed but peridinoid on the basis of archeopyle type, the interrupted paracingulum, and pandasutural bare zones in the pre- and post-cingular series. Occasionally, weakly developed granules in apical region are arranged intratabularly and delimit the apical plate series. Archeopyle formula is I/I (2a/2a); the outline is an omega form hexa. The peri-operculum and endo-operculum are posteriorly attached." — Aurisano (1984, p. 1, 2)

Dimensions. "(on 10 specimens) Maximum length 55–80 µm; maximum width 35–50 µm." — Aurisano (1984, p. 2)

Remarks: "*Chatangiella porata* is distinguished from other species of *Chatangiella* by its distinctively foveolate periphragm. That its foveolate condition is a specific taxonomic character and not due to a preservational factor is determined by the uniform character of the individual foveolae, the dense distribution of the foveolae and the consistent appearance of the foveolae on several specimens. That is, specimens are equally foveolate from sample to sample and section to section." — Aurisano (1984, p. 2)

Age: Late Cretaceous (late Campanian); holotype of Aurisano (1984, p. 2).



Figures 3A–E, Aurisano (1984). Figures A–C, scale bar = 10 µm; figure D, E, scale bar = 1 µm.

Chatangiella porosa Marshall, 1988

Diagnosis: "Ventrodorsal outline elongate, generally subpentagonal. Lateral margins on epicyst tapering towards apex or modified by rounded shoulders on each side of archeopyle. Apex marked by a prominent subconical horn with a truncate tip. Lateral margins on hypocyst tapering towards 2 antapical horns: the left subconical, tip rounded; the right reduced, forming a subconical or rounded projection. Cysts usually bicavate: narrow pericoels often apparent near equator, especially beneath paracingular ridges. Ventrodorsal endocyst outline subcircular to ovoidal, width usually exceeds length. Periphragm 0.3–0.5 µm thick, surface smooth, distinctly perforate. Perforations ovoidal to subcircular, 0.5–4.0 µm in maximum dimension, usually appearing irregularly distributed, occasionally arranged in intratabular fields and separated by non-perforate parasutural bands. On specimens with clearest intratabular fields, only fragments of paraplates discernible, pattern most apparent around equator. Paracingulum partite, indicated on periphragm by 2 parallel sets of ridges, with smooth to irregular crests, separated by a shallow groove. Archeopyle Type 1a/?: periarcheopyle stenothetaform to isothetaform, operculum usually attached along posterior margin. Endoarcheopyle often indicated by splits, type uncertain." — Marshall (1988, p. 200)

Dimensions: "Pericyst length 89 (100) 119 µm, width 59 (66) 79 µm; endocyst length 39 (52) 64 µm, width 54 (63) 76 µm (17 specimens)." — Marshall (1988, p. 200)

Discussion: "The ventrodorsal outlines of the wall layers are variable (Fig. 6). Perforation of the periphragm, distinctive of the species, varies in density; only examples with the highest numbers of pores have clear indications that they are arranged in intratabular fields." — Marshall (1988, p. 200)

Age: Late Cretaceous (early Santonian); holotype of Marshall (1988, p. 200, fig. 2).

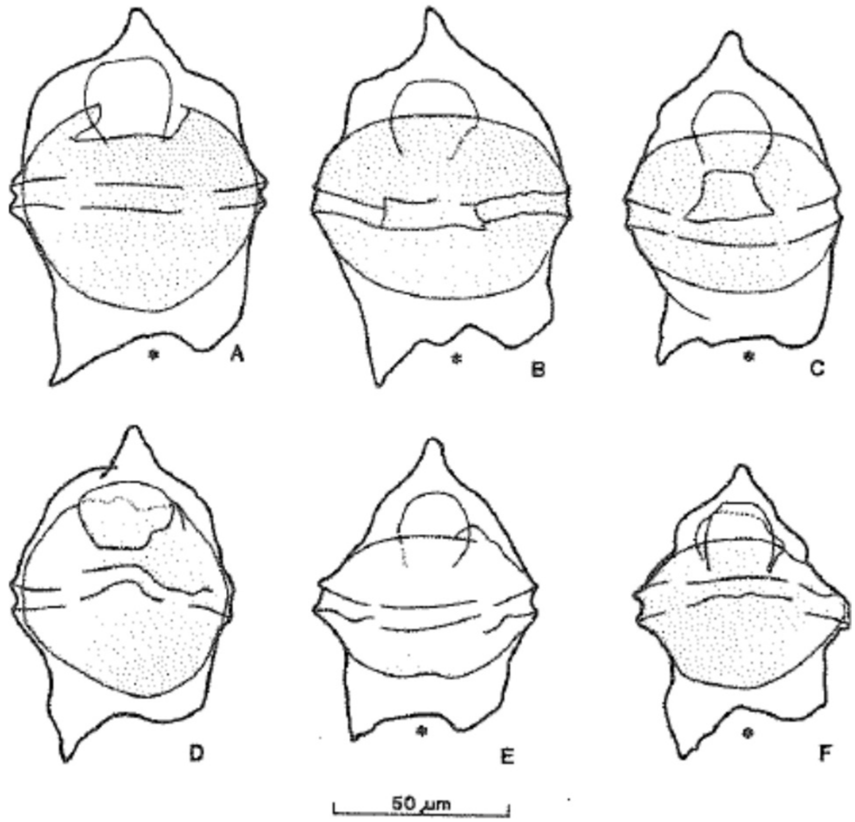


Figure 6, Marshall (1988).

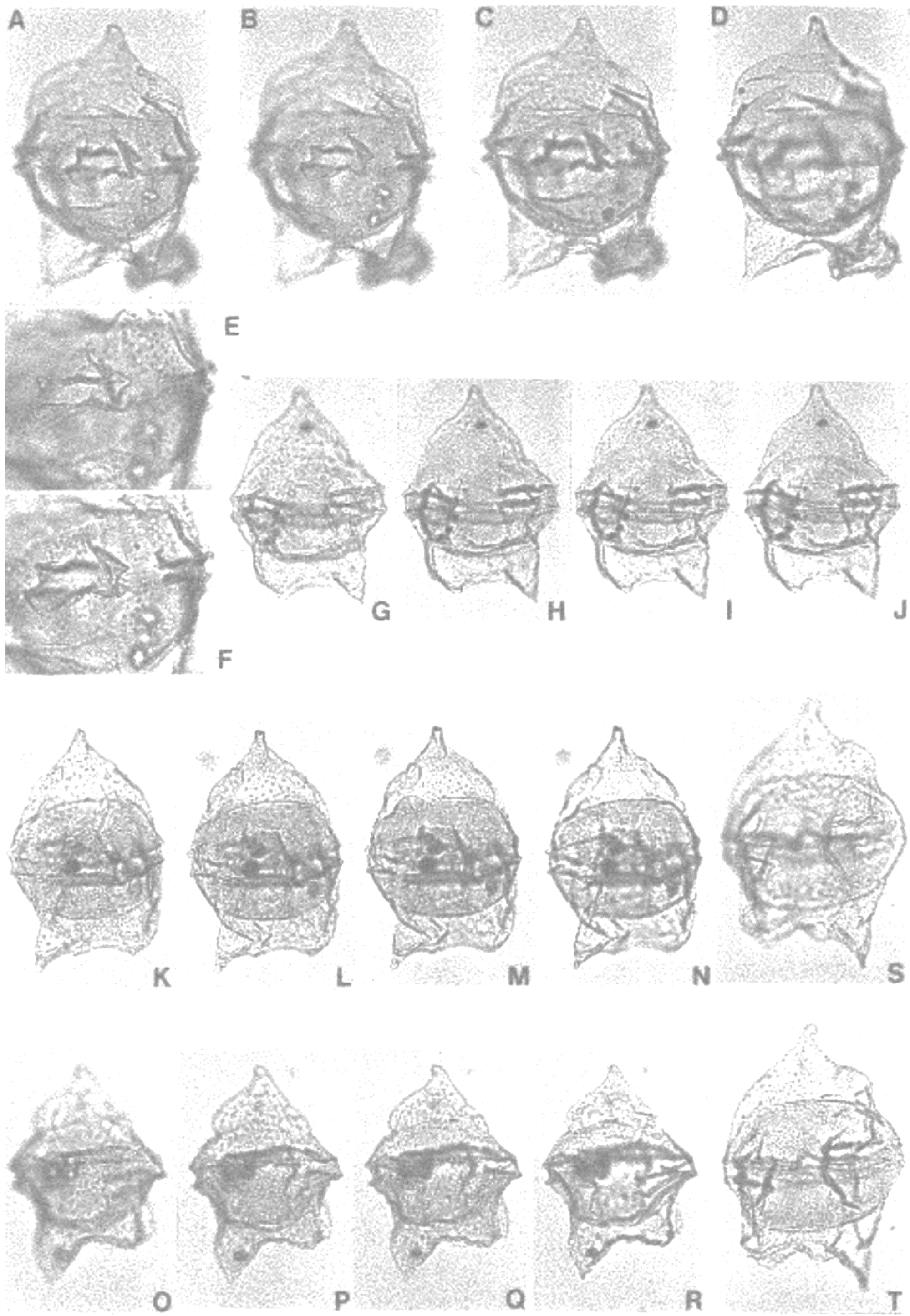


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Figure 16A–T, Marshall (1988).

?*Chatangiella robusta* (Benson, 1976) Stover & Evitt, 1978

Description: "Cavate cyst with pronounced apical horn, antapical horns, and large circular to elliptical endoblast. Left antapical horn twice as long as right. Tabulation reflected by intratabular coni: 4', 3a, 6–7'', ?c, 5''', lp, 2''''. Archeopyle type 3I on endoblast, type I on periblast. Cingulum levorotary, slightly greater than 1 cingulum width. Sulcus restricted to hypotract, up to 15 micra in width. Endoblast microreticulate to microgranulate. Endophragm 1 micron in thickness, increasing to 2 micra at apical and antapical ends. Periphragm slightly less than 1 micron in thickness." — Benson (1976, p. 198)

Dimensions: "Holotype: periblast length 153 micra; width 78 micra; endoblast length 69 micra; width 71 micra; apical pericoel 43 micra. Range: 20 specimens measured; periblast length 101–153 micra; width 53–82 micra; endoblast length 44–79 micra; width 46–75 micra; apical pericoel 29–47 micra." — Benson (1976, p. 198, 200)

Comparison: "The shape of *T. robustum* resembles the forms which Vozzhennikova (1967) placed in the genus *Australiella*; however, it lacks the strong development of epithecal 'shoulders' as exhibited by the other members of that genus. Vozzhennikova's transfer included *Deflandrea tripartita* (Cookson and Eisenack, 1960), *D. thomasii* (Cookson and Eisenack, 1961), etc. All of these species possess a similar periblast shape, particularly with regard to the strong development of epithecal 'shoulders'. There is, however, a fundamental difference present within the above mentioned species. The archeopyle of *D. granulifera* and *D. thomasii* is type 3I with regard to the endoblast and type I with regard to the periblast (Manum and Cookson, 1964, plate 1, figures 5, 6, 8). *D. cooksonii* (Manum and Cookson, 1964, plate 1, figures 2, 3) and *D. tripartita* (Cookson and Eisenack, 1960, plate 1, figure 10), on the other hand, possess a type I archeopyle in both the endoblast and periblast. The transfer of species that have a similar periblast shape but different mode of archeopyle formation into the same genus appears to be questionable and will be dealt with in a separate publication.

It would appear that the affinities of *T. robustum* lie with those species of *Australiella* that exhibit a type 3I/I archeopyle. It differs from those species; however, in the weak development of epithecal 'shoulders', and the presence of tabulation and larger antapical horns." — Benson (1976, p. 200, 202)

Age: Late Cretaceous (late Maastrichtian); holotype of Benson (1976, p. 178, 202). Range: Late Cretaceous (late Maastrichtian) in Zone A of Benson (1976, figs. 2, 3).

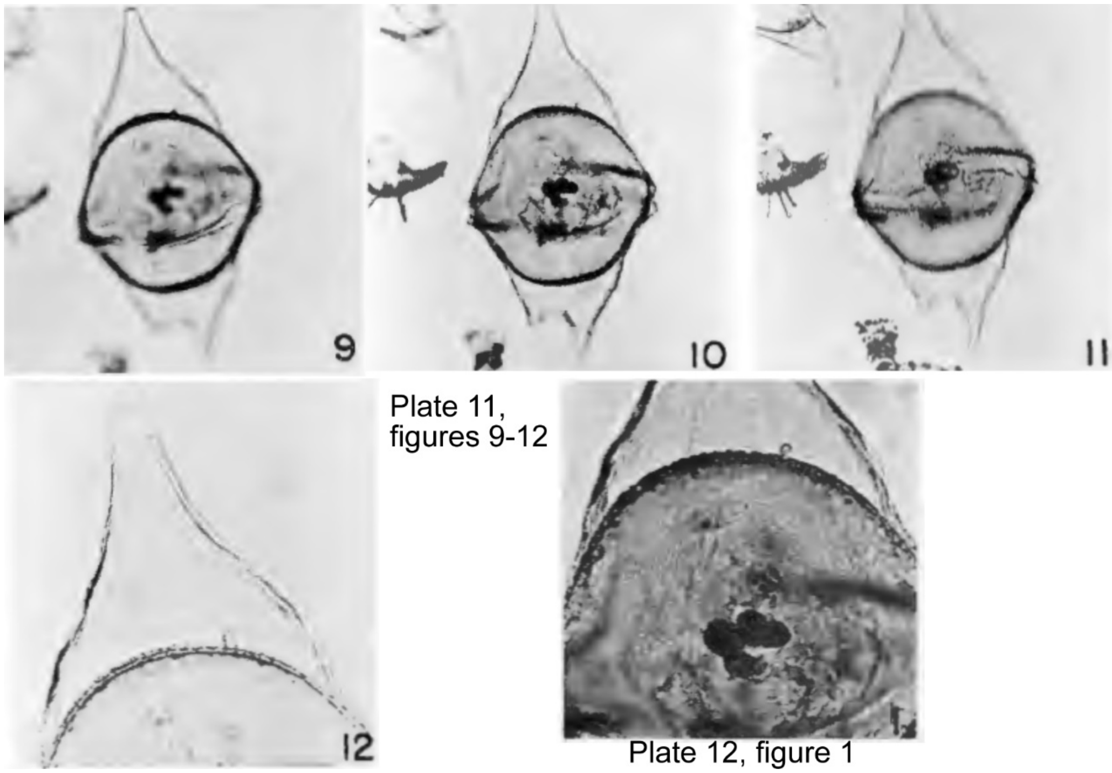

Plate 11, figures 9–12, Plate 12, figure 1, Benson (1976).

Chatangiella serratula (Cookson & Eisenack, 1958) Lentin & Williams, 1976

Description: "The theca is somewhat longer than broad and is widest in the region of the well defined transverse girdle, narrowing from thence towards a prominent apical region which is shaped like a pointed arch, and towards a more or less concave antapex on one side of which is a short pointed horn. A broad longitudinal furrow is present on the hypotheca, but it does not extend to the antapex. The outer membrane is thin, transparent and rather coarsely granular, but on both sides of the epitheca, between the girdle and the distal limits of the apical arch, it is finely serrated. The capsule is large in proportion to the size of the theca and extends to the lateral margins. In the type, the position of the future pylome is clearly indicated." — Cookson & Eisenack (1958, p. 28)

Dimensions. "Type—theca 73 × 48 μ; capsule 38 × 47 μ; pylome 14 μ across." — Cookson & Eisenack (1958, p. 28)

Age: Late Cretaceous (Campanian); holotype of Eisenack (1958, p. 75, table 2). Range: Late Cretaceous (Campanian–early Maastrichtian) (Eisenack, 1958, p. 28); early–middle Campanian based on Harker & Sarjeant in Harker et al. (1990, p. 118; text fig. 26).

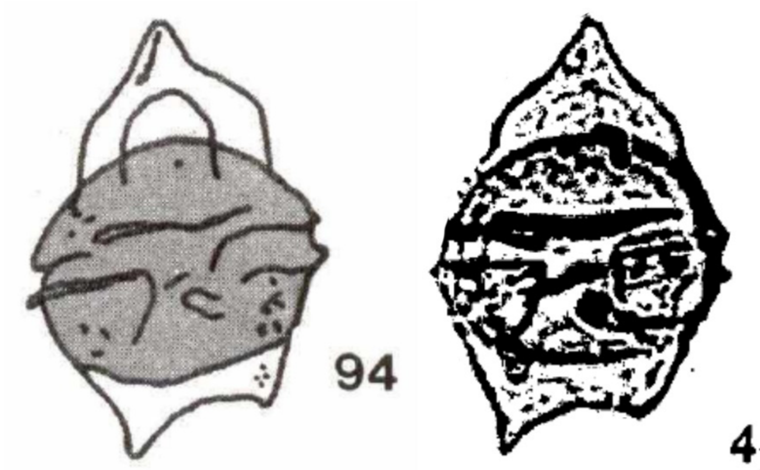

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Plate 7, figure 94, Lentin & Williams (1976); Plate 4, figure 4, Cookson & Eisenack (1958).

Chatangiella spectabilis (Alberti, 1959) Lentin & Williams, 1976

Diagnosis: “Carapace flattened, its outline elongated pentagonal to almost rhombic. The epitheca, which is somewhat larger than the hypotheca, has a detached, short apical horn that tapers forward and is blunted at the free end. Transverse furrow narrow, strongly deepened. Usually only a small pointed antapical horn present. With a delicate rounded inner body. Shell membrane finely punctured.” — Translated from Alberti (1959, p. 99)

Additions: “A longitudinal furrow (longitudinal gap) is on the hypotheca, in some specimens implied. What is striking is the delicate inner body, which hardly differs in color from where the membrane of the cyst lifts off and does not touch its outer edge. below the apex there is a hexagonal rounded hatch. The edges of the transverse furrow become frequently formed by two broken ridges.” — Translated from Alberti (1959, p. 99)

Differential Diagnosis: “By the elongated angular outline of the carapace, the high, inverted trapezium-forming archeopyle and the very delicate inner body is distinguished from the other species of the genus.” — Translated from Alberti (1959, p. 99)

Dimensions: “Holotype: length 104 µm, width 66 µm. For other specimens, the length varies between 86 µm and 110 µm, the width between 52 µm and 68 µm. 16 specimens.” — Translated from Alberti (1959, p. 99)

Age: Late Cretaceous (late Senonian); holotype as translated from Alberti (1959, p. 99). Late Cretaceous (late Santonian–early Maastrichtian) (Harker & Sarjeant in Harker et al., 1990, p. 118; text fig. 26).

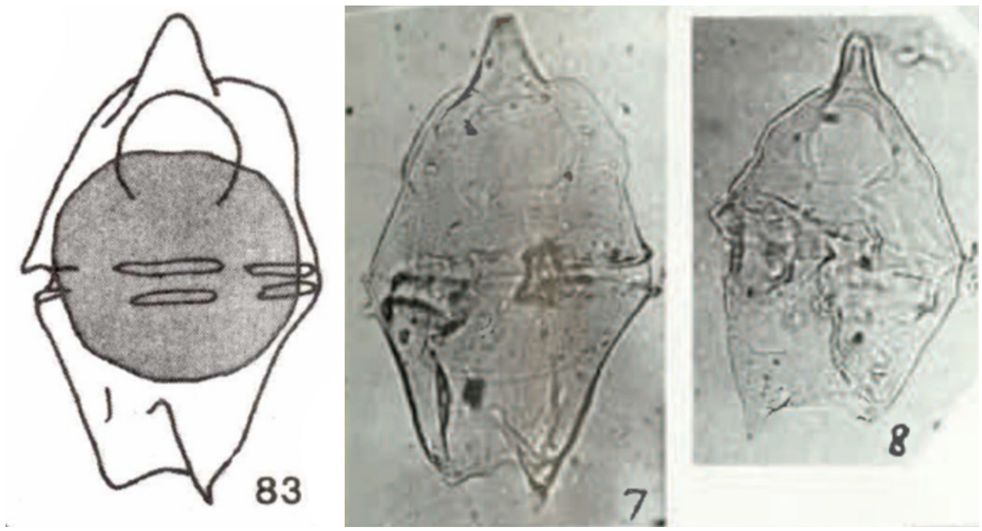


Plate 6, figure 83, Lentin & Williams (1976); Plate 9, figures 7, 8, Alberti (1959).

Chatangiella spinata Lebedeva, 2000

<u>Diagnosis</u>: “Cyst bicavate, longitudinally elongate, rounded rectangular outline with a short apical horn. Endocyst large, rounded rectangular. Periphragm smooth on scabrate with intratabular spines. Endophragm smooth or finely granulose with occasional fibrous apical and antapical margins. Peridinioid paratabulation indicated by periarcheopyle and paracingulum only. The periarcheopyle is lati-omegaform I(2a). Paracingulum marked by parallel ridges of thin spines. Parasulcus indicated by a depression on the hypocyst.” — Translated from Lebedeva (2000, p. 116)

<u>Description</u>: “The cyst is bicavate, longitudinally elongated, oval-rectangular with straight lateral sides and a slightly protruding central part. The epicyst is equal to or slightly smaller than the hypocyst, with broad straight arms. Apical horn short, broadly conical, usually with a club-shaped spike at the end. Hypocyst nearly rectangular, rarely trapezoidal, with two poorly developed antapical horns. The endocyst is large and tightly attached to the sides. Periphragm smooth or fine-grained, with irregularly arranged thin long spines and tubercles. In some forms, the spines are coarse, widening at the base. The endophragm is smooth, fine-grained, often with fibrous thickenings at the poles. Periarcheopyle lati-omegaform 1(2a). Endoarcheopyle is not observed. The paracingulum is shallow, expressed by a protrusion on the lateral sides and parallel rows of thin long spines (2–4 μm). The parasulcus is represented by a shallow fold on the hypocyst.” — Translated from Lebedeva (2000, p. 116)

<u>Dimensions</u>: “In microns. Holotype: length — 86, width — 73, endophragm length[?] — 54, paracingulum width — 9; other specimens: length — 86–76, width — 73–60, endophragm length[?] — 54–58, endophragm width[?] — 52–56, paracingulum width — 8–9.” — Translated from Lebedeva (2000, p. 116)

<u>Variability</u>: “The shape of the pericyst and the degree of development of the antapical horns vary slightly (they may be approximately equal in size or one of them is completely reduced).” — Translated from Lebedeva (2000, p. 116)

<u>Comparison</u>: “From *Chatangiella manumii* [Vozzhennikova, 1967, pl. 108, figs 1–4], it is distinguished by its larger size, broad, straight shoulders, and coarser sculpture. From *Chatangiella niiga*, it differs in a more rectangular shape of the pericyst, densely located and long spines, and a well-marked paracingulum.” — Translated from Lebedeva (2000, p. 116)

Age: Late Cretaceous (Campanian); holotype as translated from Lebedeva (2000, p. 116).

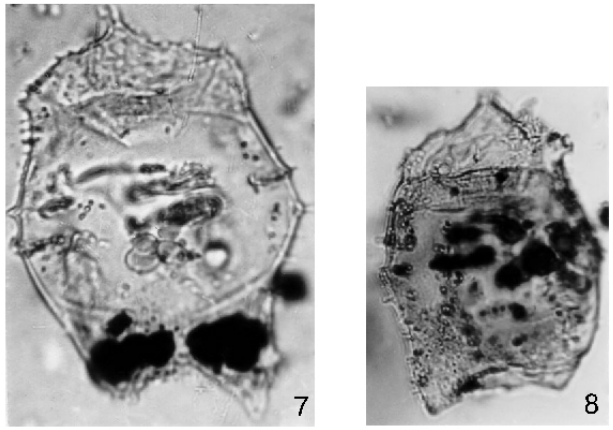


Plate 1, figures 7, 8, Lebedeva (2000).

Chatangiella tanamaensis Lebedeva, 1988

Description: "The pericyst is elongated in the longitudinal direction, with more or less pronounced constrictions at the level of the endocyst borders. In the region of the cingulum, it protrudes rather sharply, forming the characteristic angular outlines of the central part and endocyst. The epipericyst is somewhat larger than the hypopericyst, with well-defined, sometimes slightly sloping shoulders, ending in an elongated (10–19 μm), tubular apical horn with an indentation at the distal end. Hypoperycist with straight or slightly convex sides ends in two unequal antapical horns. The left horn is large (16–22 microns), acute-angled, the right horn is small triangular-rounded or rounded, sometimes cut off. The endocyst occupies the central part of the pericyst, repeats its outline, also protruding in the region of the cingulum, and has a characteristic polygonal-rounded outline. The surface of the endocyst is fine-grained. The archeopyle is comparatively small, round, silty or horseshoe-shaped, with an indented lower border. The operculum is usually absent, but sometimes remains attached along the lower border. The cingulum is slightly left-handed, expressed by protrusion on the lateral sides and discontinuous, sometimes merging into thin ribs, rows of tubercles (2 μm). In some forms, parts of the cingulum end in large (6 μm) spikes that are wide at the base. The sulcus is narrow, expressed by a shallow indentation on the hypopericyst. The surface of the pericyst is smooth, fine-grained, sometimes with sparsely located tubercles." — Translated from Lebedeva (1988, p. 74)

Dimensions: "Holotype: length of pericyst 128, width 57, length of endocyst 45, epipericyst 67, hypopericyst 54; cingulum width 10; other specimens had a pericyst length of 105–128, a width of 51–58; length of endocyst 41–48, epipercyst 54–67, hypopercyst 42–54; the width of the cingulum is 6–10." — Translated from Lebedeva (1988, p. 74)

Remarks: "The shape of the pericyst varies most significantly, especially in the apical part. Shoulders may be well developed and cut obliquely to form a bell shape. The apical horn may vary from elongated to conical. The shape of the hypopericyst varies less. Here the right horn is most changeable. It can be well defined, triangular-rounded or rounded, then there is an indentation between the antapical horns. If the right horn is broken off, then the left one gradually turns into a flat horizontal platform." — Translated from Lebedeva (1988, p. 74, 75)

Comparison: "Some representatives of *Chatangiella tanamaensis* are similar to *Ch. spectabilis* (Alberti) Lentin et Williams in outline of the epipericyst, convex central part, rounded archeopyle, but differ in the angular outline of the endocyst, large pointed horn, and more elongated tubular apical horn. *Ch. tanamaensis* differs from *Ch. ditissima* (McIntyre) Lentin and Williams in possessing a different form of epipericist, outlines of an endocyst, and a relatively large rounded archeopyle." — Translated from Lebedeva (1988, p. 75)

Age: Late Cretaceous (Santonian); holotype as translated from Lebedeva (1988, p. 76).

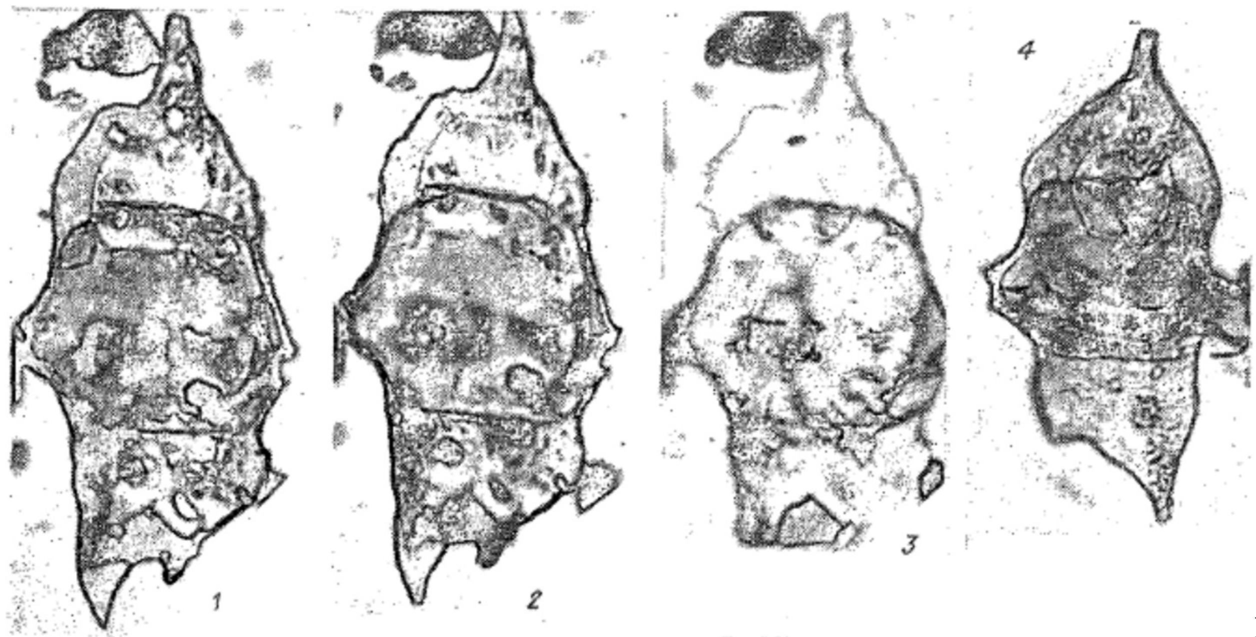


Plate 18, figures 1–4, Lebedeva (1988).

Chatangiella tripartita (Cookson & Eisenack, 1960) Lentin & Williams, 1976

Description: "Shell elongate, somewhat flat, divided approximately equally by a shallow, circular girdle, the borders of which form re-entrant angles on both sides. The middle portion of the shell, which is almost entirely filled with a large capsule, is widest at the girdle, narrowing from thence, rather abruptly, both proximally and distally. Above the upper limit of the capsule the shell again bulges prominently before terminating in a short, broad, bluntly pointed horn. The distal portion of the shell, i.e., the portion below the lower limit of the capsule, is straight-sided, truncate, and prolonged on one side into a short pointed horn. The shell-membrane is rather sparsely, finely to coarsely granular. The capsular membrane is more finely and closely granular. The pylome is circular to hoof-shaped."— Cookson & Eisenack (1960, p. 3)

Dimensions: "Holotype: 100 μ long; 59 μ broad; capsule 48 × 48 μ; pylome 22 × 22 μ. Other examples: 120 × 71 μ, capsule 60 μ; 109 × 62 μ, capsule 58 × 58 μ." — Cookson & Eisenack (1960, p. 3)

Age: Late Cretaceous (late Turonian–Santonian); holotype of Cookson & Eisenack (1960, p. 2). Late Cretaceous (late Santonian–early Maastrichtian) Harker & Sarjeant in Harker et al. (1990, p. 118; text fig. 26.

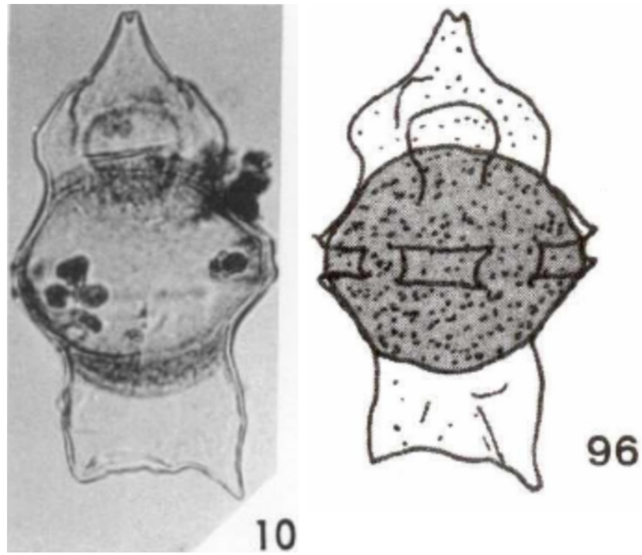


Plate 1, figure 10, Cookson & Eisenack (1960) (left)**;**
Plate 7, figure 96, Lentin & Williams (1976) (right).

?*Chatangiella tubifera* (Cookson & Eisenack, 1982) Lentin & Williams, 1985

Description: "A species of the genus *Deflandrea*, shape flattened, longer than wide, with roughly triangular epitract and trapezoidal hypotract. Lateral margins of the epitract often convex. The epitract runs out into a short, clearly separated tube (Fig. 14). The hypotract has a broad but pointed antapical horn; the other is often indicated as a broad, short lobe. The girdle (cingulum), which separates the epi- and hypotract at its widest point, is quite broad but only slightly deepened, formed by low folds of the periphragm. A longitudinal furrow (sulcus) is not formed. The Archaeopyle is rounded almost circular and quite large. The endophragm is oval, longer than wide; it mostly laterally touches the periphragm. Endo- and periphragm are thin and delicate and atabulate. The periphragm does not bear very dense granules. Only very rarely are these arranged in rows, as in the case of the paratypoid at the top right in the apical area as an indication of a disguised paneling." — Translated from Cookson & Eisenack (1982, p. 31, 32)

Age: Early Cretaceous (Barremian–early Aptian) as translated for Meadow Station Bore No. 9 from Cookson & Eisenack (1974, p. 48; 1982, p. 31).

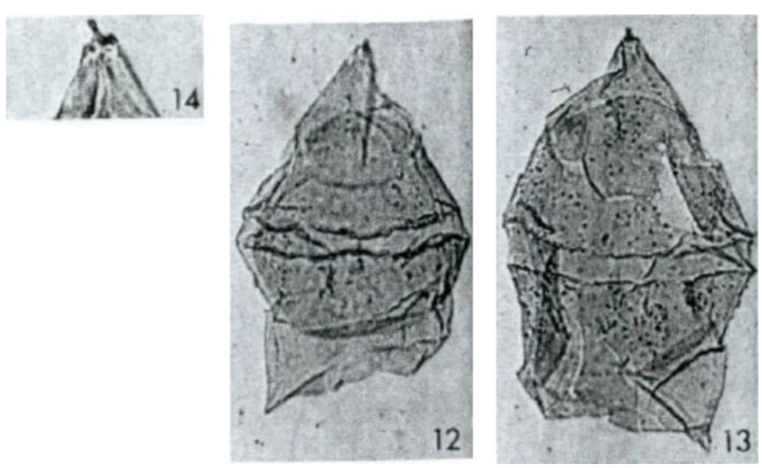


Plate 3, figures 12–14, Cookson & Eisenack (1982).

Chatangiella turbo Harker & Sarjeant in Harker et al., 1990

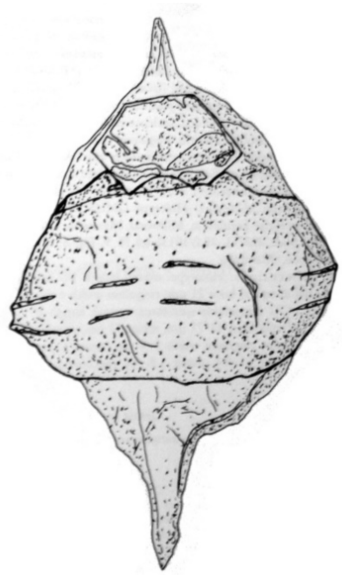
<u>Diagnosis</u>: "Bicavate cysts having a spindle-shaped ambitus. Periblast smooth to finely granular, thin-walled. Epitract and hypotract are of about equal size. Apical region of the epitract with broad shoulders and prolonged into a long, tapering apical horn having a blunt or slightly indented distal termination. Greatest width is in the cingular region. Hypotract prolonged into a long, tapering, sharply pointed, left antapical horn, but a right antapical horn is indicated only by a slight protuberance or absent. Endoblast ovoidal, finely granular, thin-walled, its breadth greater than its length; it is closely attached to the periblast around the equatorial region. Flattened anterior and posterior margins abut a large apical and a smaller antapical pericoel. A broad, slightly laevorotatory cingulum is represented by low, granulate ridges or close-set rows of granules, broken by gaps into elements that indicate the presence of seven precingular and five postcingular paraplates; ventral displacement is less than one cingulum width. A posteriorly divergent and anteriorly convergent sulcus is indicated by low, narrow thickening of the periphragm on the ventral surface of the hypotract of the periblast. Archaeopyle intercalary (I/3I, 2a/1a–3a), perioperculum omegaform to broadly hexagonal in shape. Opercular paraplates normally remain attached after opening." — Harker & Sarjeant in Harker et al. (1990, p. 119)

<u>Description</u>: "The long, tapering antapical horn is only slightly offset from the apical-antapical axis of the cyst, giving it a distinctive spindle shape. The right antapical horn may be indicated by a small protuberance of the periphragm (Pl. 9, Fig. 6) or may be altogether lacking. The epitract has broad shoulders and the apical horn has an indented distal termination (Pl. 9, Fig. 8). The periphragm is smooth to finely granulate and less than 0.5 μm thick; the endophragm is 0.5–1.0 μm thick, with a finely granulate ornament (relief less than 0.5 μm). The apical and antapical flattening of the endoblast is very marked. The rows of granules that mark the cingular margins are 1–3 μm wide, 0.5–1 μm high; their division into units, indicating the presence of seven precingular and five postcingular paraplates, is well seen on several specimens (Pl. 9, Fig. 7, 8; Text-fig. 24). The archaeopyle is formed by the displacement of a large omegaform to broadly hexagonal paraplate (2a) in the periblast and of three paraplates in the endoblast (1a–3a). All paraplates involved in archaeopyle formation remain attached, though the perioperculum is frequently folded (as in the holotype, Pl. 9, Fig. 7; Text-fig. 23)" — Harker & Sarjeant in Harker et al. (1990, p. 119, 120)

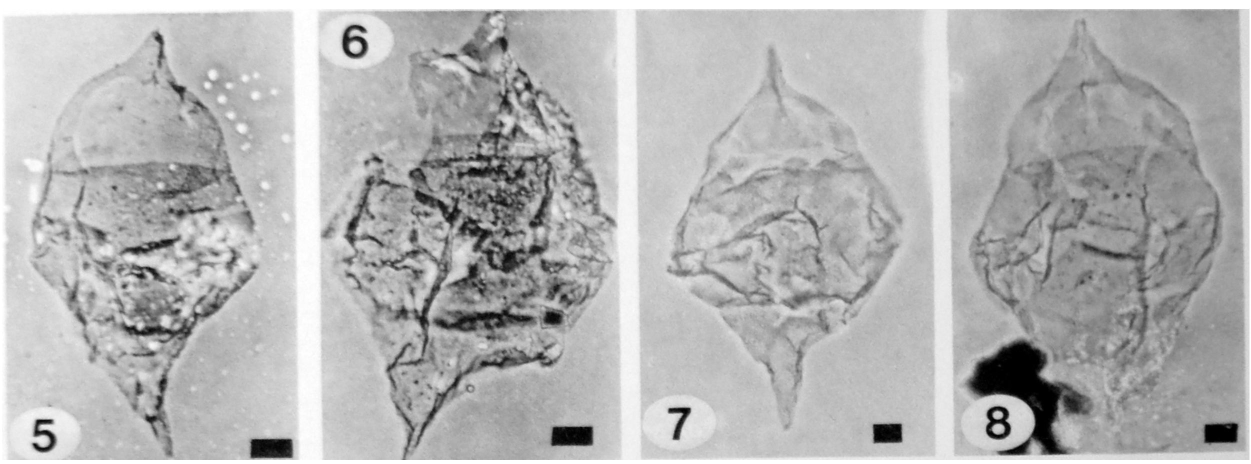
<u>Remarks</u>: "This species is similar to *C. granulifera*, but differs in its lighter granulation and extreme development of the left antapical horn, producing the spindle-shaped ambitus. *Trithyrodinium druggii* Stone 1973, differs in having a rounded, scabrate endoblast with tufted apical and antapical regions, a three-paraplate peripyle (1a–3a) and no observable cingulum or sulcus." — Harker & Sarjeant in Harker et al. (1990, p. 120)

<u>Dimensions</u>: "Holotype: overall length 107 μm; breadth 64 μm; length of endoblast 46 μm; apical horn 12 μm; left antapical horn 21 μm; cingulum width 6 μm; transverse peripyle index 0.70; transverse peripyle ratio 2.4. Range of 32 measurable specimens: overall length 89–138 μm, mean 107 μm; breadth 50–83 μm, mean 67 μm; length of endoblast 43–77 μm, mean 52 μm; apical horn 12–18 μm, mean 13 μm; left antapical horn 17–31 μm, mean 21 μm; cingulum width 5–9 μm, mean 6 μm; transverse peripyle index 0.67–0.81, mean 0.74; transverse peripyle ratio 1.1–2.4, mean 1.8. 44 specimens were counted." — Harker & Sarjeant in Harker et al. (1990, p. 120)

<u>Age</u>: Late Cretaceous (middle Campanian); holotype of Harker & Sarjeant in Harker et al. (1990, p. 120, text-fig. 33). Range: Late Cretaceous (early–middle Campanian) (Harker & Sarjeant in Harker et al., 1990, text-fig. 26).



Text-figure 23, Harker & Sarjeant in Harker et al. (1990).



Plates 9, figures 5–8, Harker & Sarjeant in Harker et al. (1990). Scale bars = 10 µm.

Chatangiella verrucosa (Manum, 1963) Lentin & Williams, 1976

Diagnosis. "Theca in dorsoventral view roughly rectangular with a convex equatorial region and divided into nearly equal parts by a slightly spiral, laevorotatory girdle. Epitheca widens towards the truncate apex; apical horn almost equilaterally triangular in outline. Hypotheca narrows slightly towards a truncate to concave distal end with a distinct, triangular horn on the left-hand side, and a minute one on the right-hand side. Intercalary archeopyle hexagonal to trapezium-shaped. Theca-membrane c. 1 µ thick with warts of very variable size and shape, up to 2 µ high and 6 µ wide; warts largest and most closely spaced equatorially. Girdle bordered by ridges with more or less conspicuous discontinuities. Central portion of theca occupied by a capsule of almost circular outline which touches the theca in the equatorial region, wall c. 2 µ thick and granular." — Manum (1963, p. 60)

Description: "The broadening of the theca above the upper limit of the capsule forms 'shoulders' which usually have angular outlines and straight upper limits, but sometimes they are rounded. The triangular apical horn is about 15 µ long and sometimes has a solid tip. The larger antapical horn is similar to it in size and outline, and it is usually pointed. The smaller one is indistinct. The archeopyle is roughly trapezium-shaped with the shorter parallel side proximal to the girdle and the longer one (by 3–4 times) distal to it. The lateral sides, however, are more or less rounded towards their distal ends, thus indicating the basically hexagonal shape of the corresponding plate, with alternating short and long sides. In same specimens this shape is quite distinct. The warty ornamentation of the theca is usually less dense and finer towards the apex and antapex where there may be scattered granules only, but examples have been observed which were heavily warty all over. The bordering of the girdle sometimes seems to be produced by merging of warts, and usually there are warts in the girdle itself. Same specimens are so heavily ornamented in the equatorial region that the girdle is obscured. In heavily warty specimens the ‘breaks’ in the girdly [sic] may be indistinct, but when seen they are in positions corresponding to those in *D. scheii* and *D. sverdrupiana*. A longitudinal furrow is suggested by more or less conspicuous longitudinal folds in the hypotheca. The capsule opens by the release of a roughly hexagonal apical portion of the wall; in addition, distinct breaks extend laterally in the wall on either side of the main opening.”— Manum (1963, p. 60, 61)

Dimensions: “Holotype: length 134 μ, width 83 μ. Range: length 112–135 μ, width 65–87 μ. Average of 24 specimens 124 × 73 μ.” — Manum (1963, p. 60)

Age: “Approx. middle Cretaceous” based on a sample from Graham Island (approx. 77° 20' N, 91 ° W) (Manum, 1963, p. 55).

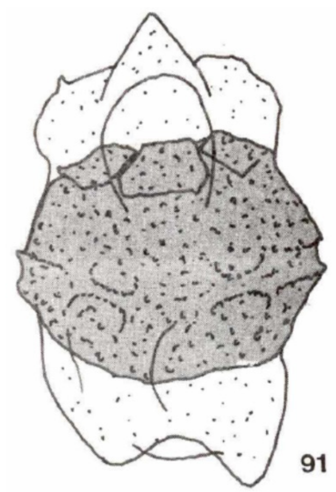


Plate 7, figure 91, Lentin & Williams (1976).

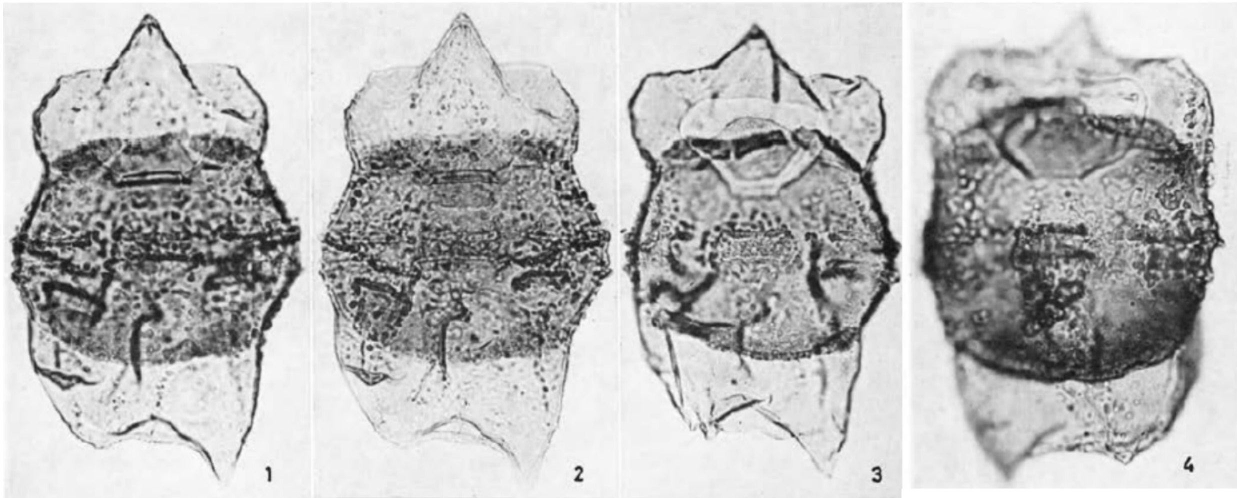


Plate 3, figures 1–4, Manum (1963).

Chatangiella victoriensis (Cookson & Manum, 1964) Lentin & Williams, 1976

<u>Description</u>: "The theca is elongate and divided approximately equally by a slightly laevorotatory girdle, the borders of which are interrupted dorsally at some distance on either side of the mid-line of the theca and ventrally near the lateral margins. The middle portion of the theca is conspicuously convex when viewed dorsoventrally and is filled with a large capsule. Above the upper limit of the capsule the theca bulges to varying degrees. The apex is rounded and the apical horn broadly triangular. The hypothecal portion below the lower limit of the capsule is of almost uniform width or slightly widened towards the antapex, which is more or less obliquely truncate with the longer left-hand side usually terminating in a short, pointed horn. The wall of the theca is c. 1.0–1.7 μ thick and ornamented with fairly evenly scattered rod-like projections c. 0-5–1.5 μ long; in surface view the rods appear as dots usually between 0.5 and 10 μ in diameter but a few smaller and larger ones are usually present. The girdle is bordered by conspicuous ridges or by linearly arranged wart-like thickenings of varying size and shape. The wall of the capsule varies in thickness, being thinnest, less than 1 μ, where it is in contact with the theca and thicker, over 1 μ in both anterior and posterior regions where it is also more conspicuously granular. The intercalary archeopyle is rounded to equilaterally hexagonal." — Cookson & Manum (1964, p. 522)

<u>Dimensions</u>: "Holotype: 112 μ long, 73 μ wide. Range: overall length 76–116 μ, width 49–73 μ, Average of 57 examples 98.0 × 59.5 μ."— Cookson & Manum (1964, p. 522)

<u>Comparison</u>: "The chief distinction between *D. victoriensis* and D. *tripartita* lies in the constant development in the former of an ornament composed of small, scattered rods. Even when, as occasionally happens, the wall shows little sign of projecting rods in optical section, small, more or less widely spaced dots can be seen in surface view. In D. *tripartita*, on the other hand, there is no conspicuous ornamentation. Other contrasting features are the distinctness of the girdle in *D. victoriensis* and the shape of the archeopyle which, basically, is almost equilaterally hexagonal in contrast to the more elongate heterolateral shape in *D. tripartita*.

D. micracantha, the holotype of which is refigured on Pl. LXXVI, fig. 9–11, differs from *D. victoriensis* in its larger size; the narrowing of the theca towards both apices; the denser arrangement and finer character of the rods (not spinules as given in the original description) comprising the ornament which are c. 1.0 μ rarely 1.5 μ. long and, in surface view, appear as small dots usually less than 0.5, occasionally up to l .0 μ; the greater coarseness and concentration of the ornament in the capsular region as compared with that in the more distal parts of the theca; the more obvious linear arrangement of the larger rods suggestive of a tabulation corresponding with that of some other species of *Deflandrea* (Manum 1963); and the inconspicuousness of the interruptions in the girdle.

D. victoriensis seems to be related to *D. granulifera* from Graham Is., Arctic Canada, which is one of a group of species (Manum 1964) having interrupted girdles comparable in all respects to those of *D. victoriensis*. However, *D. granulifera* has a finer and denser ornamentation, a smaller apical horn in proportion to the size of the theca with a narrower base and is distinctly larger, the average size being 112.5 × 79.5 μ, as against an average of 98.0 × 59.5 μ (Manum 1964, Fig. 4) for *D. victoriensis*." — Cookson & Manum (1964, p. 523)

<u>Age</u>: Late Cretaceous (Senonian); holotype of Cookson & Manum (1964, p. 522). Range: Late Cretaceous (early–late Campanian) (Harker & Sarjeant in Harker et al., 1990, text-fig. 26).

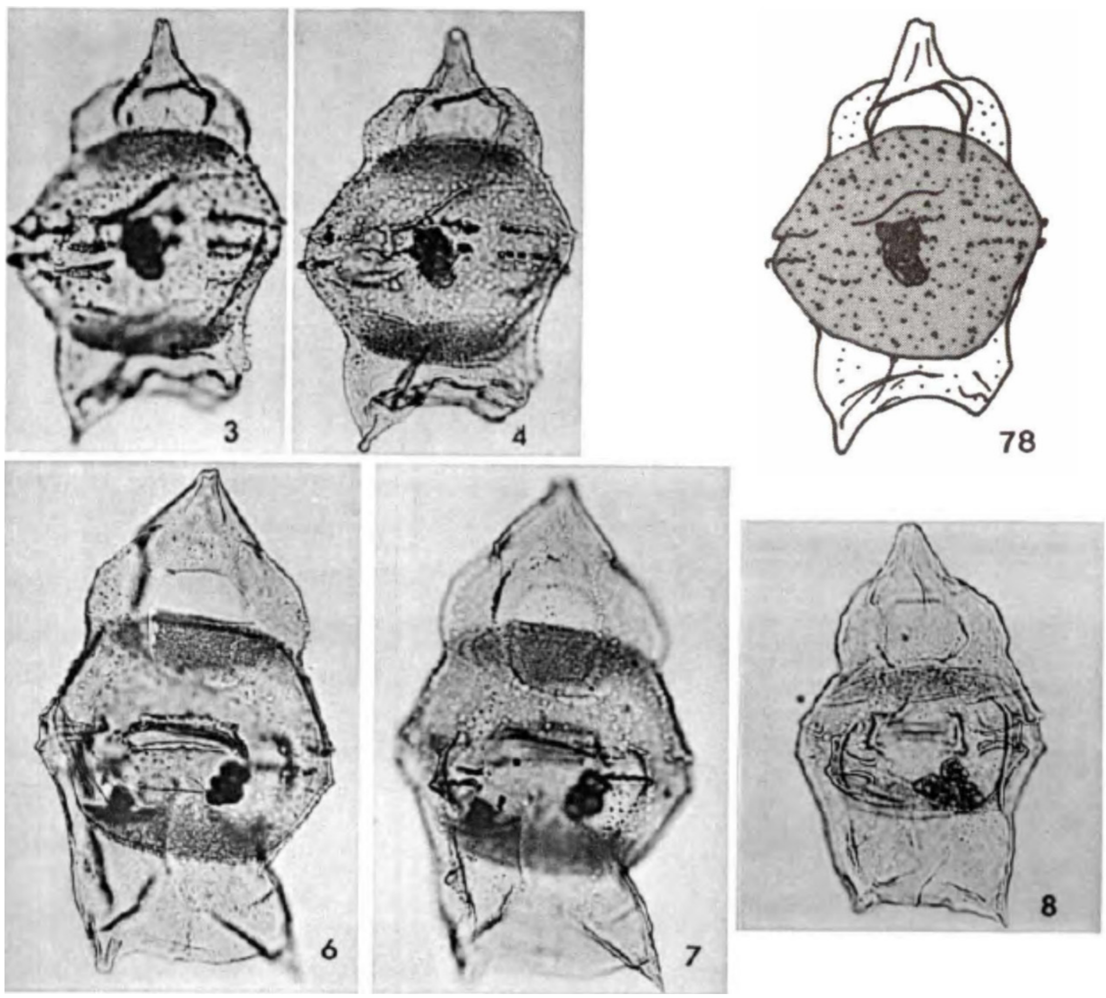


Plate 76, figures 3–8, Cookson & Manum (1964); Plate 6, figure 78, Lentin & Williams (1976).

Chatangiella vnigrii (Vozzhennikova, 1967) Lentin & Williams, 1976. Emendation: Lebedeva in Ilyina et al., 1994, p. 70.

<u>Description</u>: "Theca elongated along the longitudinal axis, with convex equatorial part and some tapering at the level of the upper and lower boundaries of the internal body. Theca divided into two equal parts. Epitheca broad and rounded anteriorly to form a straight 'shoulder' to the outline. Apical horn short, conical, somewhat bent and bluntly rounded at the distal end. Hypotheca with straight or slightly convex

walls posteriorly and with its posterior margin truncated or curved as a result of the formation of the two antapical horns of different size. One horn is short, broadly triangular and rounded at the end, the other is longer, triangular and acutely pointed. Transverse furrow equatorial, annulate. Between the ends of the furrow, on the ventral side, there is a depression which extends a little way onto the epitheca and finishes at the antapex of the hypotheca. The depression corresponds in position to the longitudinal furrow. The internal body is compressed so that its breadth exceeds its length and the two sides are closely applied to the lateral walls of the theca. Surface of internal body granulate, thickness of wall uniform or slightly greater towards the poles. Thecal surface punctate, divided into fields by coarse spines. Similar spines occur on the edge of the transverse furrow, where they are interrupted in places which apparently correspond to the position of the sutures. Pylome of rounded hexagonal form." — Vozzhennikova (1967, p. 185, translation: Lees & Sarjeant, 1971)

Dimensions: "In microns, holotype: length of theca 91.8, breadth 48.6, width of furrow about 6, length of internal body 42.4, breadth 48. In others specimens: length of theca 99.9–102.6, breadth 59.5–62, width of furrow 6, length of internal body 40.5–43.2, breadth 59.4–62.1." — Vozzhennikova (1967, p. 185, translation: Lees & Sarjeant, 1971)

Comparison: "This species differs from others in the genus in having a more elongate theca. It is somewhat similar to *Australiella tripartita* from which it differs in having a coarser theca and in the presence of tabulation and a spinous sculpturing." — Vozzhennikova (1967, p. 185, translation: Lees & Sarjeant, 1971)

Emended description: "The cyst is bicavate, longitudinally elongated, rectangular in outline. Epicyst with straight or slightly sloping shoulders. The apical horn is short, conical, sometimes with a depression at the distal end. The hypocyst is trapezoidal with two unequal antapical horns: the right one is longer, triangular, pointed, the left one is short, obtuse or undeveloped. The endocyst is rounded, occupies most of the pericoel, closely adjacent to the sides. Endophragm densely granular, sometimes thickened at the poles. Paratabulation is expressed by periarcheopyle, paracingulum and penitabularly located large tubercles (2–3 microns) or spines. Periarchaeopyle iso-omegaform. The operculum may be free or attached. Endoarchepyle is rarely seen. The paracingulum is distinctly divided into five parts and is indicated by two rows of non-confluent large tubercles. Parts of the paracingulum end in large spines. The parasulcus is shallow, formed by striated folds. The periphragm is smooth or fine-grained with sparse coarse tubercles and spines located penitabularly." — Translated from Lebedeva in Ilyina et al. (1994, p. 70)

Remarks. "The holotype of *Chatangiella vnigri* was attributed to *Ch. granulifera* (Manum) Lentin et Williams [Lentin, Vozzhennikova, 1990] on the grounds that penitabular ornamentation was not found on the periphragm of the holotype. However, images of other specimens (for example, Table IX, fig. 2; Table CVII, fig. 1; Table CIV, figs 1, 2; Table CX, figs 2, 3) confirms the accuracy of the so-called Vozzhennikova (1967) drawings and descriptions, as well as the legitimacy of identifying this species. In the Upper Cretaceous deposits of the Ust-Yenisei region, a large number of specimens were found that correspond to the description and images of *Ch. vnigri* and are not similar to *Ch. granulifera*. Therefore, it is proposed to preserve the form *Ch. vnigri*, selected by Vozzhennikova." — Translated from Lebedeva in Ilyina et al. (1994, p. 70)

Age: Late Cretaceous (Santonian); holotype of Vozzhennikova (1967, p. 185, table 4, translation: Lees & Sarjeant, 1971).

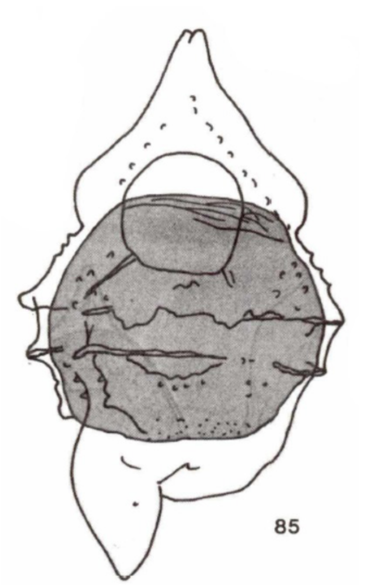


Plate 6, figure 85, Lentin & Williams (1976).

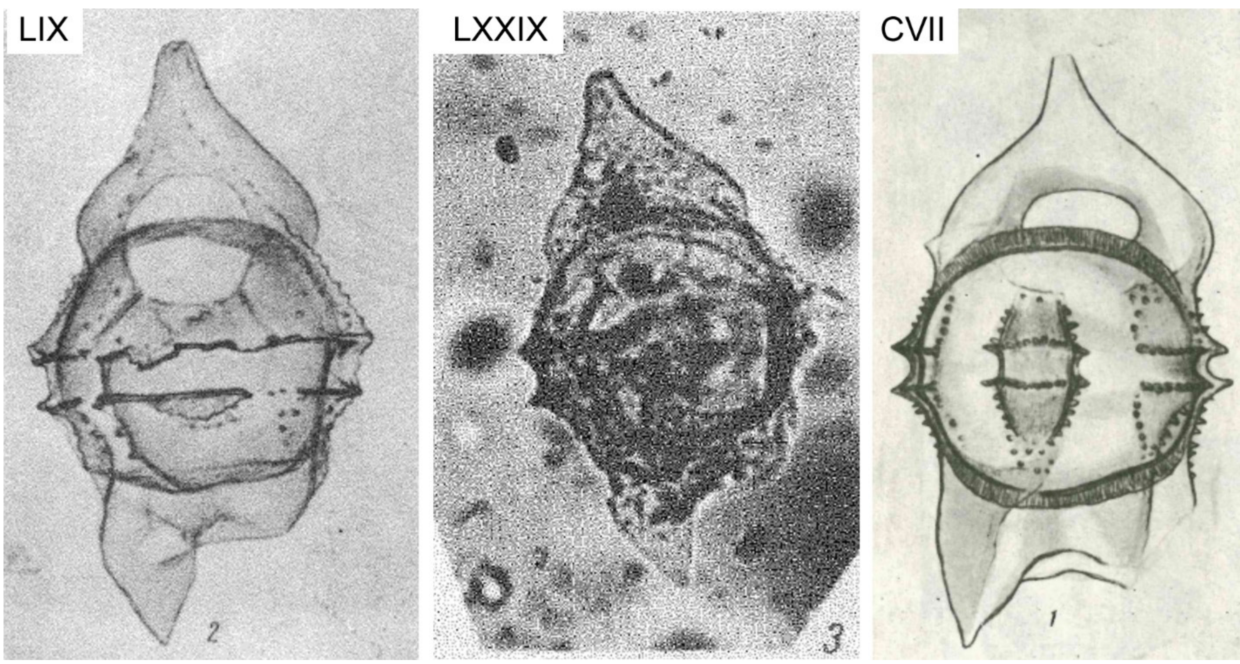


Plate 59, figures 2, Plate 79, figures 3, Plate 107, figures 1, Vozzhennikova (1967).

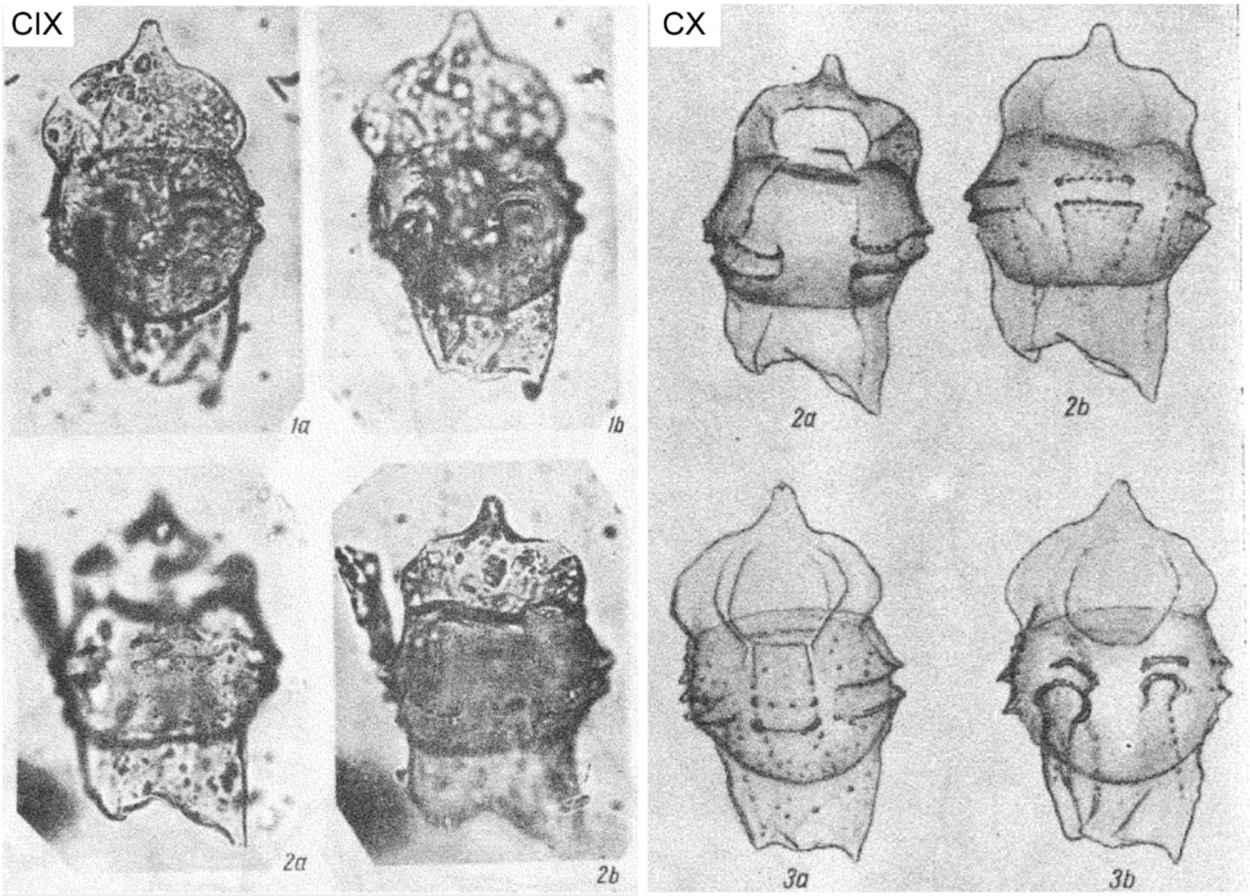


Plate 109, figures 1, 2, Plate 110, figures 2, 3, Vozzhennikova (1967).

Chatangiella williamsii Yun Hyesu, 1981

Diagnosis: "The pentagonal bicavate cyst has an interrupted paracingulum with border ribs, a wide parasulcus, an ablated AH, and a more developed left AAH. The operculum of the periarchaeopyle is omega-shaped. It corresponds to paraplate 2a, which remains attached to the H4 suture." — Translated from Yun Hyesu (1981, p. 67)

Description: "The dorsoventrally flattened cyst is pentagonal in outline and divided by a periparacingulum about 6 µm wide into a periepicyst and a perihypocyst, which are of equal size. The periepicyst is approximately triangular on the same side. The two bilaterally symmetrical side margins show a slight one halfway up the epicyst bulge ('shoulder'). The hypocyst, apart from the left antapical horn, is inverted trapezoidal and has straight lateral margins. The slightly helical periparacingulum is characterized by border ribs or knots arranged in a row on both paracingulum edges, which are regularly briefly interrupted dorsally. The periparasulcus is 14–18 µm wide and narrows towards both poles. The distally rounded apical forn is developed to varying degrees and cannot be clearly distinguished from the central body. The two antapical horns are always of different sizes, with the left one being larger and longer. The rim is concave between the two horns. The transverse oval endocyst lies equatorially with the pericyst at a distance of 1–2.5 µm, so that a large pericoel is formed in the hypocyst and epicyst. A horseshoe-shaped, ca. 15 µm-wide periarchaeopyle is intercalary. The operculum always remains attached, its posterior border connected to the cyst." — Translated from Yun Hyesu (1981, p. 67)

Dimensions: "Size of the endocyst = 27(29.5)30 × 48(49)51, size of the pericyst = 50(53)57 × 66(74.5)78, TAI = 0.45(0.49)0.52, TAR = 0.83(0.94)1.06. Width/length ratio (apical horn - right antapical horn) =

0.69-0.88. Holotype: size of the pericyst = 54 × 78, epicyst = 30 × 48, width/length = 0.7, TAI = 0.46, TAR = 0.83.” — Translated from Yun Hyesu (1981, p. 66)

Comparison: “This form differs from the following species: *Alterbia minor* (McIntyre 1975) has an elongated hexa-archaeopyle, a continuous paracingulum, a distinctly developed apical horn with a distal notch, and a rounded rhombic endocyst. *Subtilisphaera pirnaensis* (Alberti 1959) has no archaeopyle, a continuous paracingulum, a clearly developed apical horn and a round endocyst. The proportion of width/length (measured from the apical horn to the right antapical horn) is small in *Chatangiella magna* (Davey 1970). It also shows prominent antapical horns, a round endocyst, and lateral margins of the epicyst tapering very slowly posteriorly. The proportion of width/length of the species ?*C. biapertura* (McIntyre 1975) is small, the apical horn and left antapical horn are larger and pointed distally, the equatorial outline is rounded and the endocyst is oval to around. *Laciniadinium biconiculum* (McIntyre 1975) has a combined archaeopyle and low, continuous paracingulum ribs.” — Translated from Yun Hyesu (1981, p. 66)

Comment: “The development of the oval inner body cannot be attributed to the state of preservation, because in 40 examined specimens it lies very regularly with the longer diameter parallel to the paracingulum. In addition, its size in relation to the pericyst and its shape are very constant. Since the inner body is not equatorially connected to the periphragm, a possible southern hull would have resulted in a change in shape in any direction.” — Translated from Yun Hyesu (1981, p. 66)

Age: Late Cretaceous (Santonian); holotype as translated from Yun Hyesu (1981, p. 66).

Note: The figured images do not suggest a width<length for the endophragm, but rather the opposite. Therefore, the dimensions of 30 × 48 given by Yun Hyesu (1981, p. 66) should probably be reversed.

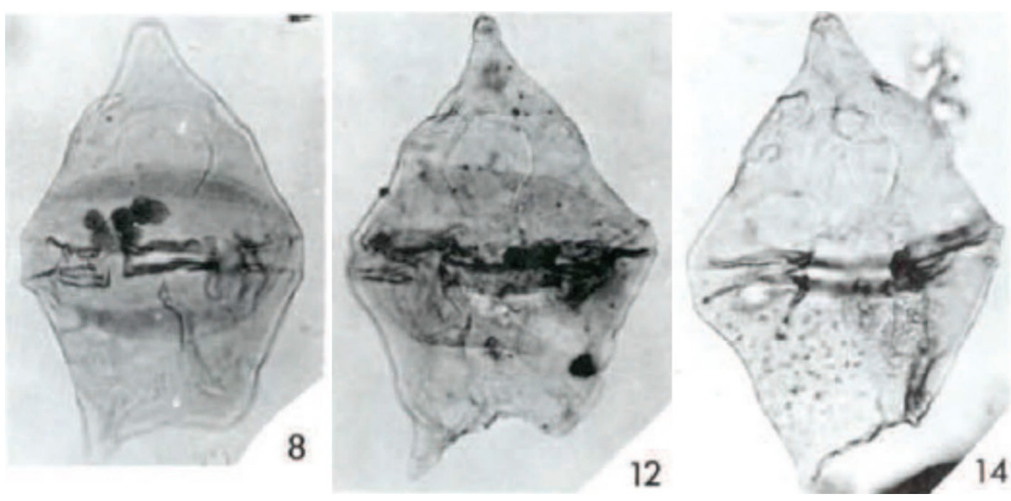


Plate 13, figures 8, 12, 14, Yun Hyesu (1981).

Genus ***DEFLANDREA*** Eisenack, 1938

1938 *Deflandrea* Eisenack: 187.
1966 *Deflandrea* Eisenack; emend. Williams & Downie: 231.
1973 *Deflandrea* Eisenack; emend. Stover: 169, 170 (as a revised description).
1976 *Deflandrea* Eisenack; emend; Lentin & Williams: 35, 36.

Deflandrea amabilis He Chengquan, 1991

Description: "The cyst body has a flat abdomen and back, pentagonal outline, longer than wide, and epitheca and hypotheca are nearly equal in size. The epitheca is bell-shaped, with convex sides concave, with a distinct apical horn, conical or cylindrical, 12–23 μm long, the base of the apical horn is strongly contracted, the apex is truncated or slightly pointed. The hypotheca is nearly trapezoidal, the side is concave or nearly straight, and the caudal side is strongly concave into a nearly right-angle or obtuse-arc with two antapical horns of nearly equal size, 10–27 μm long, broad at the base, blunt at the ends, quite far apart (35–45 μm). The waist is more or less outwardly convex, sulcus is usually visible. The transverse groove is located at the equator where both sides are convex, concave, circular, 6–7.5 μm wide, its edges are marked by ridges. The longitudinal grooves are usually clear, limited to the hypotheca, and some specimens have well-developed longitudinal grooves with parallel sides, wide (17.5 μm). Thin outer wall, smooth or granular-nearly smooth surface. The inner body is round or oval, with dense surface of fine grains. It almost completely fills the body cavity except for the corners and side projections. Archeopyle front style, outline horizontal oval, wider than long. The operculum comes off or is kept in place." — Translated from He Chengquan (1991, p. 77)

Dimensions: "Cyst length 80–107 μm, width 72.5–82.5 μm, inner body length 70 μm, width 67.5–75 μm (6 specimens measured); holotype length is 87 μm and width is 87 μm, the inner body is 75 μm wide, and the apical horn is 10 μm long. The antapical horns are 20 μm long and the cingulum is 7.5 μm wide." — Translated from He Chengquan (1991, p. 77)

Discussion: "The shape and size of this species is quite similar to *Deflandrea sibirica* (Vozzhennikova, 1963), but the caudal edge of the former is not straight, concave into a right or obtuse angle, and the two caudal horns always touch each other at the base; quite long, the antapex is straight (parallel to the transverse groove), and the bases of the two antapical horns are far apart from each other, never touching each other; it is the same as *D. sibirica* subsp. *obesa*. The difference of *sibirica* is that the body is pentagonal, the transverse groove is concave, and the bases of the two caudal horns are in contact." — Translated from He Chengquan (1991, p. 77)

Age: late Eocene (Priabonian); holotype corresponding to the "third section of the Bashibulake Formation" as translated from He Chengquan (1991, p. 226). Range: middle Eocene (Lutetian)–late Eocene (Priabonian) corresponding to the "Wulagen Formation" and "second and third sections of the Bashibulake Formation" as translated from He Chengquan (1991, p. 77) given the ages of the units presented by Xuejiao Wang et al. (2022) and Xi Dangpeng et al. (2020, p. 166) respectively.

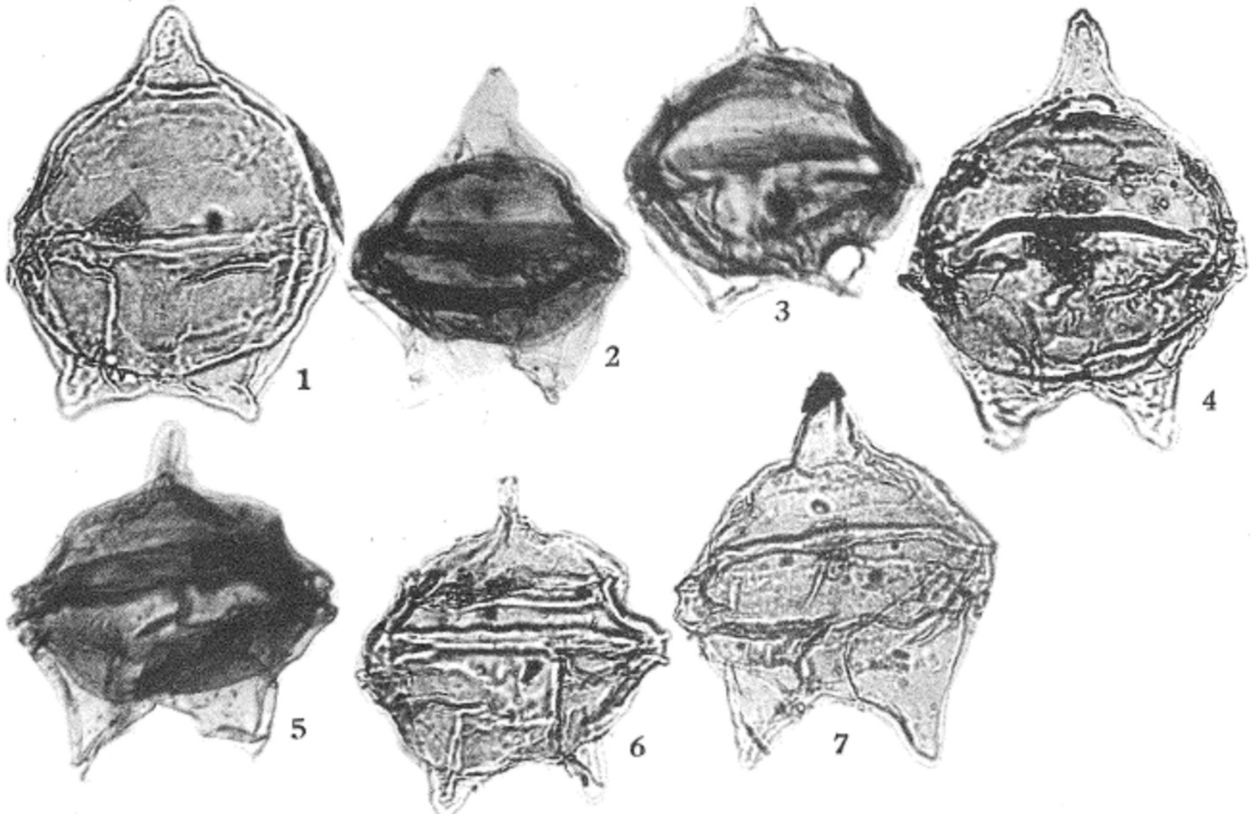


Plate 30, figures 1–7, He Chengquan (1991).

Deflandrea andromiensis Vozzhennikova, 1967

<u>Description</u>: "Theca pentagonal with a round internal body which occupies the whole of the convex middle portion of the theca. Epitheca larger than hypotheca with rounded lateral walls. These walls do not come into contact with the internal body but are separated from it by a considerable distance. Apical horn conical, blunt at the tip. Hypotheca trapeziform with straight or slightly concave lateral walls and a transverse furrow which is almost parallel with the antapical margin. The two short, conical antapical horns are adjusted at some distance from each other and are slightly divergent. The lateral walls of the theca bear small blunt outgrowths with a shallow depression for the transverse furrow. The latter is annulate, equatorial and from its ends runs the longitudinal furrow towards the antapical end. The surface of the theca is smooth or finely granular and is sometimes covered with a few small spines, particularly noticeable on the margins of the theca. The sculpturing to the internal body is often coarsely granular. Pylome trapeziform." — Vozzhennikova (1967, p. 222 translation: Lees & Sarjeant, 1971)

<u>Dimensions</u>: "(in microns): holotype, length 135, breadth 86.4, width of transverse furrow about 8; internal body, length 72.9, breadth 62.1. Other specimens, length of theca 145–148, breadth 86.4–91.8, width of transverse furrow 8–10; internal body, length 64.6–67.5, breadth 70.5–75.6." — Vozzhennikova (1967, p. 222, translation: Lees & Sarjeant, 1971)

<u>Comparison</u>: "This species differs from others of the genus in its great morphological diversity. It is however typically characterised by the presence of small, acutely terminated antapical horns and a conical apical horn which is truncated distally. It also has very convex lateral walls to the theca." — Vozzhennikova (1967, p. 222, translation: Lees & Sarjeant, 1971)

Age: Eocene; holotype of Vozzhennikova (1967, p. 221, 222, translation: Lees & Sarjeant, 1971).

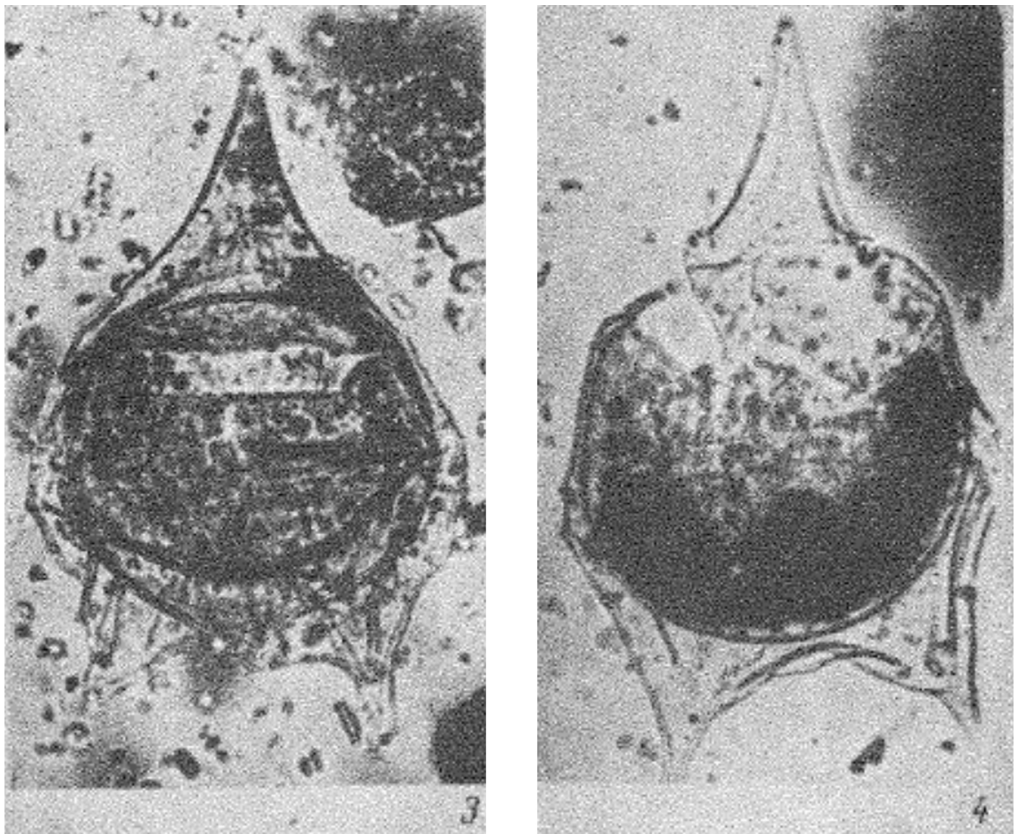


Plate 71, figures 3, 4, Vozzhennikova (1967).

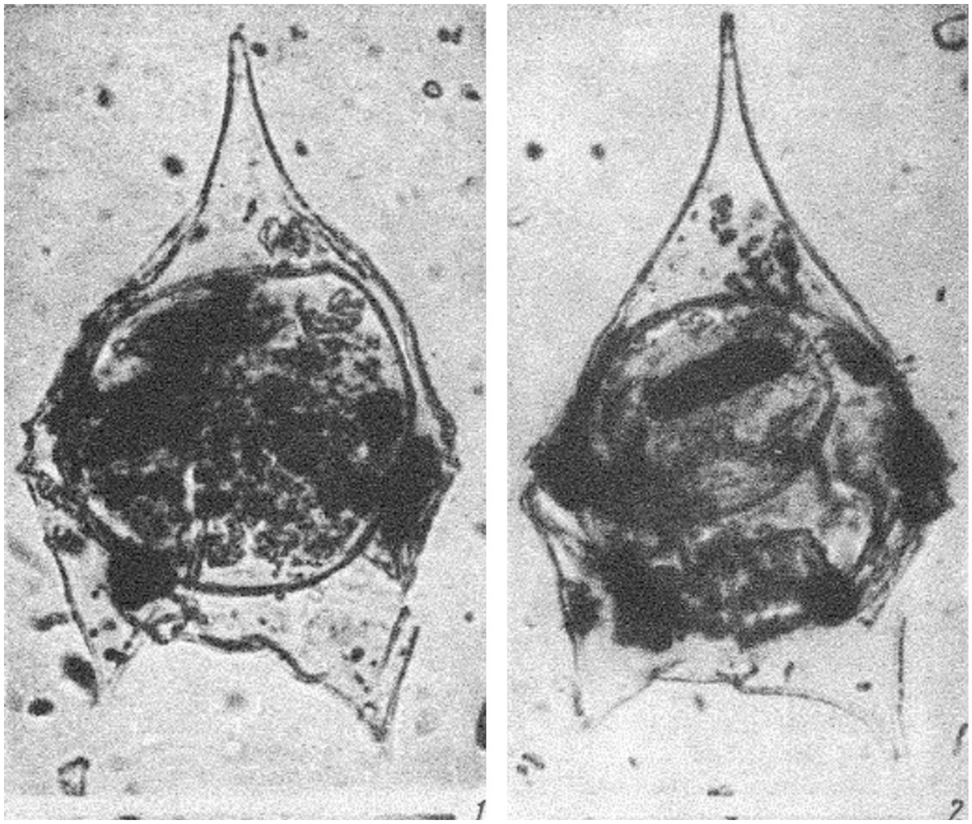


Plate 72, figures 1, 2, Vozzhennikova (1967).

Deflandrea antarctica Wilson, 1967a

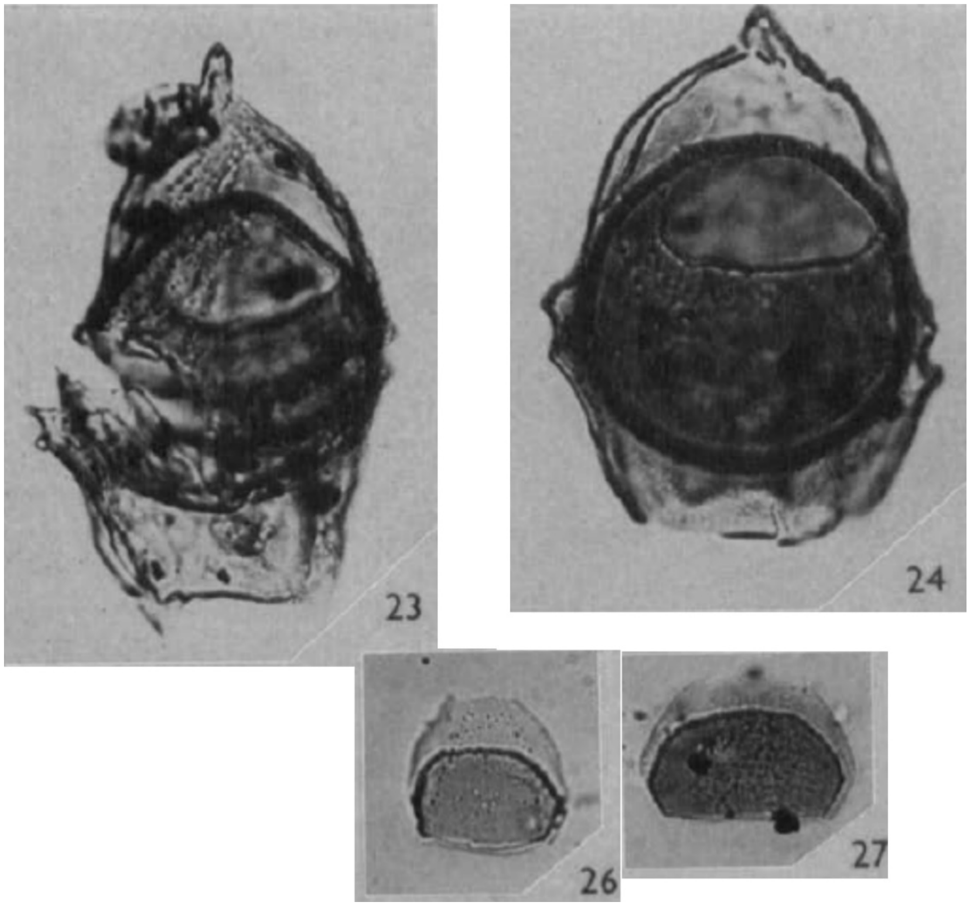
<u>Description</u>: "Test peridinioid in shape, bi-layered, divided into epitheca and hypotheca by a slightly laevorotatory transverse girdle. Apical horn broad at base, narrow at apex which is usually capped with a small papilla; antapical horns short, approximately equal in size. Outer cyst usually covered with numerous granules forming a dotted pattern. Inner cyst fairly thick-walled, smooth, and approximately circular in outline. Archeopyle broad, intercalary, subhexagonal. Operculum free, bi-layered; inner layer smaller, denser, and of more regular shape than the membranous outer layer; the large and small layers of the operculum represent segments of the outer and inner cysts respectively (Figs. 26. 27). Apparently atabulate, although granules sometimes concentrated into polygonal clusters possibly indicative of reflected tabulation." — Wilson (1967a, p. 58, 60)

<u>Dimensions</u>: "Holotype *1* = 138 μ, *b* = 72 μ, diameter of inner cyst 69 μ. Range *1* = 110(130)152 μ, *b* = 72(84)91 μ. (7 specimens)." — Wilson (1967a, p. 60)

<u>Discussion</u>: "*Deflandrea antarctica* broadly resembles *D. rohusta* Defl. & Cooks. but has a more coarsely textured outer cyst and much broader archeopyle. It differs from *D. phosphoritica* in having a much more broadly rounded epitheca. The species was recorded as *Deflandrea* aff. *bakeri* in the preliminary species list of McIntyre and Wilson (1966. table 2). *D. antarctica* occurs in both the Black Island and Minna Bluff material. In general the Minna Bluff specimens are more numerous and better preserved than those from Black Island, although complete specimens from both localities are rare. Detached archeopyle opercula of *D. antarctica* are common and distinctive (Figs. 26. 27) and provide a method for recognising the presence of the species even in the absence of the parent cyst." — Wilson (1967a, p. 60)

<u>Age</u>: Eocene? (erratic); holotype of Wilson (1967a, p. 58).

45).



Figures 23, 24, 26, 27, Wilson (1967a).

Deflandrea apiculiformis Andreeva-Grigorovich & Savitskaya, 1993

Description: "The pericyst is pentagonal-oval, elongated along the longitudinal axis. The epicyst is triangular, and gradually narrows in the form of a paracingulum and ends with an acute-angled apical horn. Hypocyst with straight sides and two triangular antapical horns of the same size. The cingulum is well-extended on the lateral sides, small protrusions are formed from them. The endocyst is rounded, occupying almost the entire pericyst. The pericoel is observed only near the apical and antapical horns. The surface of the endophragm is fine-grained, and the periphragm is smooth or fine-grained, often with wrinkles. The archaeopyle is intercalary." — Translated from Andreeva-Grigorovich & Savitskaya (1993, p. 45)

Dimensions: "(µm) Holotype: length 105, width 83; endocyst length 71, width 72. Other specimens: length 95–110, width 79–85." — Translated from Andreeva-Grigorovich & Savitskaya (1993, p. 45)

Comparison: "The described species differ from *D. phosphoritica* by the shape of the epicyst and antapical horns." — Translated from Andreeva-Grigorovich & Savitskaya (1993, p. 45)

Age: early Eocene (Ypresian); holotype as translated from Andreeva-Grigorovich & Savitskaya (1993, p. 45).

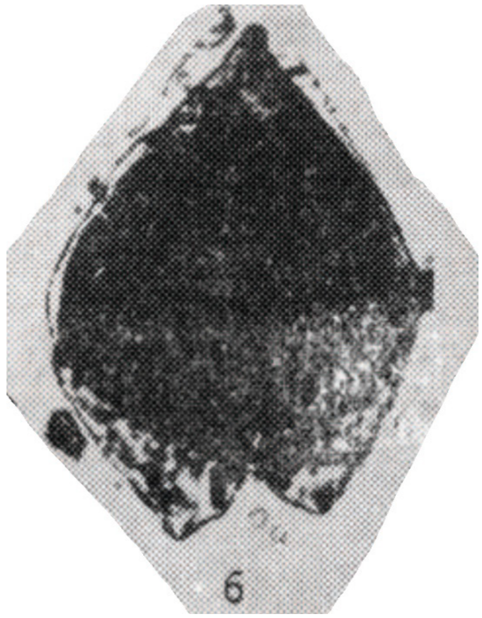


Plate 1, figure 6, Andreeva-Grigorovich & Savitskaya (1993).

Deflandrea arcuata subsp. ***acuata*** Vozzhennikova, 1967. Emendation: Lentin & Vozzhennikova, 1990, p. 50.

Description: “Theca elongate oval with uniformly thickened lateral walls and an ovoid internal body. Epitheca larger than hypotheca with an arciform outline and a small blunt apical process (horn). Hypotheca trapeziform with straight lateral walls. Antapical margin slightly concave with its margins forming two slight rounded outgrowths which represent the antapical horns. Transverse furrow shallow, equatorial and noticeable on the lateral walls of the theca but not on the dorsal and ventral walls. Longitudinal furrow barely discernible. Surface of theca smooth, coloured; internal body finely punctate. Pylome trapeziform or elliptical.” — Vozzhennikova (1967, p. 223, translation: Lees & Sarjeant, 1971)

Dimensions: “(in microns) Holotype: length of theca 118.8, breadth 86.4, width of transverse furrow 8.1, length of internal body 64.8, breadth 70.2. Other specimens: length 108–116, breadth 75–81, width of transverse furrow 8.1; internal body length 64.5–67.5, width 53.3–64.5.” — Vozzhennikova (1967, p. 223, translation: Lees & Sarjeant, 1971)

Comparison: “This species differs from others in the genus in having an arciform epitheca and an internal body which is ovoid. The horns are also very feebly developed. The species bears some similarity to *Deflandrea* cf. *heterophlycta* Defl. et Cooks. described by Alberti (1959, plate 8, fig. 7) from the lower Eocene of Germany. It differs however from the latter in having less strongly developed apical and antapical horns, in the sculpturing to the theca and the internal body and also in size. — Vozzhennikova (1967, p. 223, translation: Lees & Sarjeant, 1971)

Age: late Eocene (Priabonian)–early Oligocene (Rupelian); holotype of Vozzhennikova (1967, p. 223).

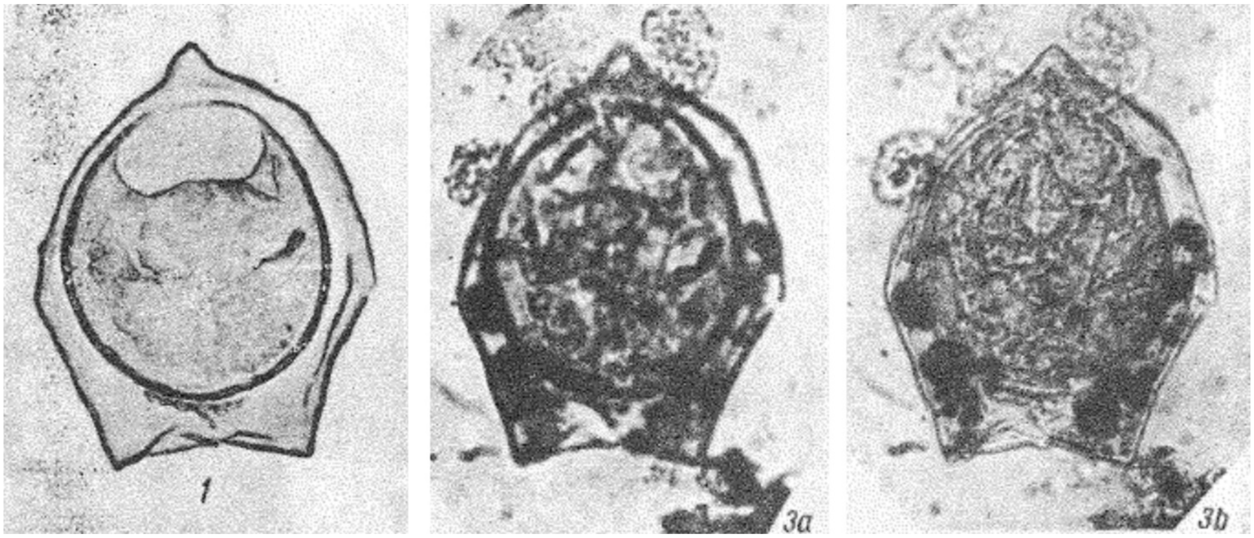


Plate 66, figure 1; Plate 68, figures 3a, b, Vozzhennikova (1967).

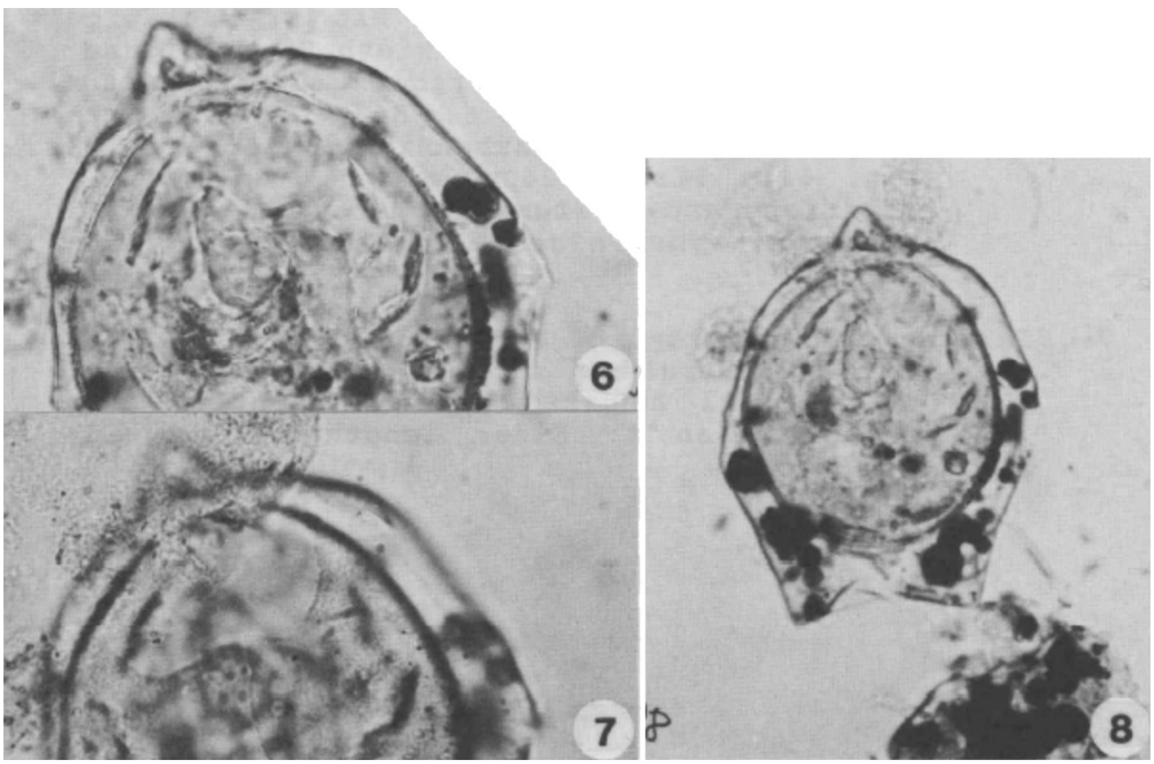


Plate 6, 6–8, Vozzhennikova (1967).

Deflandrea arcuata subsp. ***oporiensis*** (Grigorovich, 1971) Lentin & Williams, 1977b

Diagnosis: “The theca is pentagonal with convex sides. The epitheca is triangular with a small apical projection. Hypotheca with straight lateral sides with two small antapical protrusions connected between themselves by an integrated septum. The inner body is ellipsoidal, on the epitheca it adheres to the walls of the theca. The transverse sulcus is absent, although in its place there are small protrusions observed on the sides of the theca. The archeopyle is large, elliptical.” — Translated from Grigorovich (1971, p. 92)

Dimensions: “Holotype: the length of the theca is 95, the width 93.” — Translated from Grigorovich

(1971, p. 92)

Age: Eocene; holotype as translated from Grigorovich (1971, p. 92).

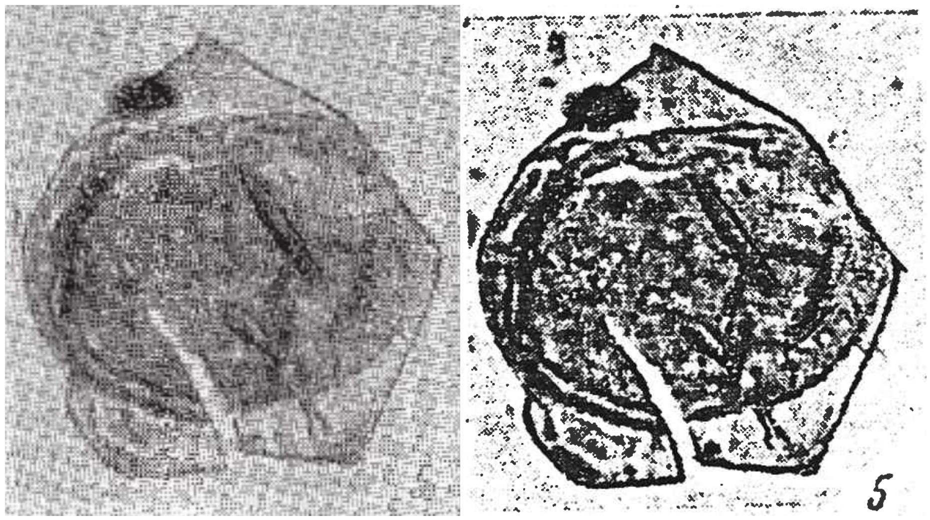


Plate 1, figure 5, Grigorovich (1971).

Deflandrea bella He Chengquan, 1991

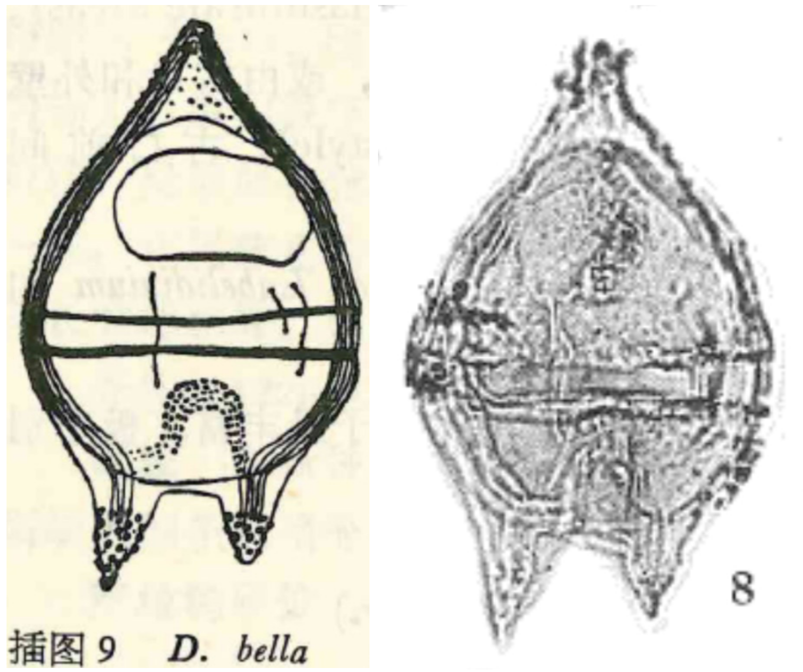
Description: “The cyst is flat on the abdomen and back, and the outline is elongated. It is a pentagonal dinoflagellate, and is divided into two parts of unequal size by a transverse groove. The epitheca is large, acutely triangular, with slightly concave sides, with a distinct vertex, conical, 15 µm long. The apex is sharper and the hypotheca is inverted, trapezoidal, with slightly concave sides, nearly straight antapex, with two nearly equal antapical horns, triangular conical, parallel to each other and extending backward, 18 µm long. The cingulum is round and free of side convexity. Significant laterally, shallow flat, annular, 10 µm wide, with 2–3 layered ridges on the edge for the sign. Longitudinal grooves are clear and limited to the hypotheca. The surface of the outer wall is nearly smooth, with a few particles locally, and in the far part of the horn (especially the antapicals) is a granular-perforated from the top corner along the edge of the cyst to the antapex corner and the edge of the longitudinal groove with a layered structure, consists of five distinct, continuous fine ridges. Inner body ovoid, surface finely granular. It is connected to the outer wall except at the corner. Almost touching or slightly separated. The archeopyle is front style, the outline is round and hexagonal, the length is smaller than the width. The operculum is completely separated and preserved in situ.” — Translated from He Chengquan (1991, p. 77)

Dimensions: “The cyst is 91 µm long and 52.5 µm wide, and the inner body is 91 µm long and 50 µm wide.” — Translated from He Chengquan (1991, p. 78)

Comparison: “Compared with this one, the apical horn is short, the two antapical horns are parallel and not divergent, and the lamellar knot is unlike *Deflandrea striata*, where the structure is limited to cyst edges and other features.” — Translated from He Chengquan (1991, p. 78)

Age: middle Eocene (Lutetian); holotype from the “Wulagen Formation” as translated from He Chengquan (1991, p. 227) corresponding to the age of the section given by Xuejiao Wang et al. (2022). Range: middle Eocene (Lutetian)–late Eocene (Priabonian) based on occurrence within the “Wulagen Formation” and

"Bashibulake Formation" as translated from He Chengquan (1991, p. 78) corresponding to the age of the units given by Xuejiao Wang et al. (2022) and Xi Dangpeng et al. (2020, p. 166) respectively.



Text-figure 9; Plate 30, figure 8, He Chengquan (1991).

Deflandrea borealis Fensome et al., 2016

Diagnosis: "A relatively small, squat and generally rounded species of *Deflandrea* with a scabrate to granulate wall and a latiform archaeopyle, the operculum of which commonly remains attached posteriorly." — Fensome et al. (2016, p. 41)

Dimensions: "Holotype: length (including horns) 57 μm, width 55 μm. Length (including horns) 46–59 μm, width 46–55 μm; three specimens measured." — Fensome et al. (2016, p. 40).

Age: late Paleocene (Thanetian); holotype of Fensome et al. (2016, p. 40). Range: late Paleocene (Thanetian)–latest Eocene (latest Priabonian) (Fensome et al., 2016, p. 41).

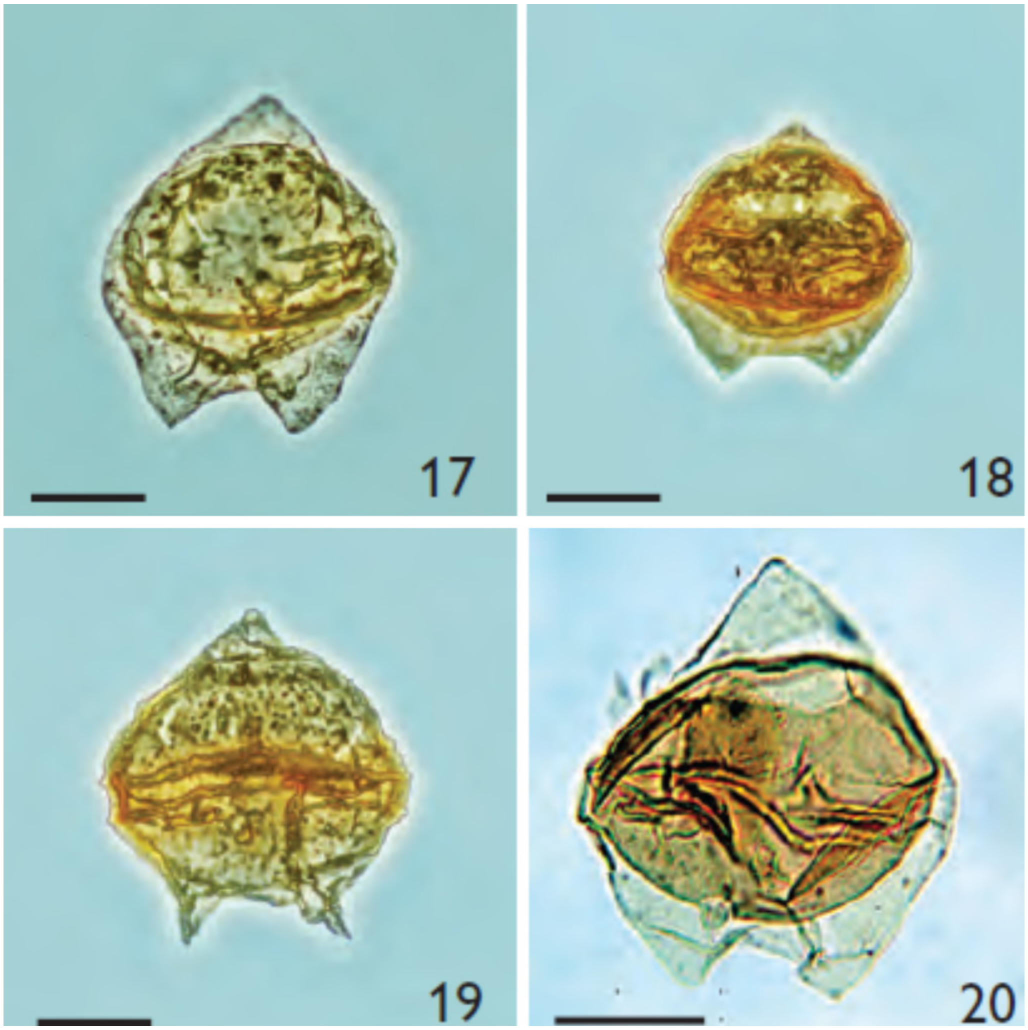


Plate 5, figures 17–20, Fensome et al. (2016). Scale bars = 20 µm

Deflandrea carpatica Grigorovich, 1969

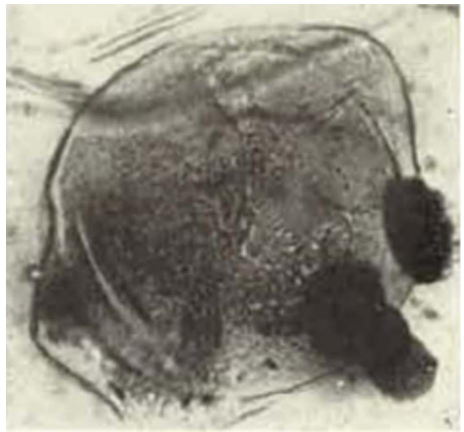
Description: "The theca is oval in outline, slightly elongated along longitudinal axis. The epitheca is somewhat smaller than the hypotheca, wide rounded shape, without pronounced apical process. Hypotheca with two very short antapical processes. The inner body is spherical, on the sides it merges with the theca. In the center of the body, a transverse furrow is very faintly traced. Surface of the theca smooth, inner body slightly granular. Archeopyle big, ellipsoidal. The color of theca is light yellow. The color of the inner body is yellow." — Translated from Grigorovich (1969, p. 68, 69)

Dimensions: "Total length of the theca 115.0, width 97.75; length of the inner body 92.0, width 97.75." — Translated from Grigorovich (1969, p. 69)

Comparison: "The studied species exhibits similarity with *Deflandrea cretacea* (Cookson, 1956), from which it differs in the more rounded outlines of the theca, the shape of the inner body, and also in the shape, size, and disintegration of the pylome, which has outlines. Archeopyle similar to that of *Deflandrea phosphoritica*." — Translated from Grigorovich (1969, p. 69)

Note: "In the center of the body of the studied specimen, there is a large transverse indentation resembling a transverse furrow. The possibility is not ruled out that this is a theca rupture." — Translated from Grigorovich (1969, p. 69)

Age: Paleocene; holotype as translated from Grigorovich (1969, p. 68).



2

Plate 1, figure 2, Grigorovich (1969).

Deflandrea communis He Chengquan, 1991

Description: "The cyst is flattened ventrally and dorsally, with a pentagonal outline. Epitheca larger, conical, lateral, slightly convex, with obvious apical horn, conical, 6 μm long, blunt or truncated at the apex. Small hypotheca, inverted trapezoidal, straight sides, concave bottom, with two small antapical horns close to each other, conical, 7.5–10 μm long, with a pointed end. The transverse furrow is biased toward the hypotheca, distinctly concave, ring-shaped, 5–8 μm wide, and marked by smooth ridges, which are taller and thicker. Longitudinal groove obvious, trapezoidal, limited to hypotheca. The surface of the outer wall (including corners) is nearly smooth. The contour of the inner body is nearly round, the wall is thin, and the surface is slightly weakly granular, with relatively regular layered structure on the edge of the epitheca and the edge of the longitudinal and transverse grooves except the corner, the inner body and the outer wall are completely attached to each other. The archeopyle of the holotype is blurred, but in the unphotographed specimen it is clearly on the anterior. The width is greater than the length. The operculum is kept in situ or falls off." — Translated from He Chengquan (1991, p. 78)

Dimensions: "The cyst is 54–62 μm long and 42–50 μm wide (measured in 3 specimens). The holotype specimen is 62 μm long, 50 μm wide, and the apical horn is 6 μm long. The antapical horn is 7.5 μm long. The width of the transverse groove is 8 μm." — Translated from He Chengquan (1991, p. 78)

Comparison: "This species differs from *Deflandrea kashiensis* in that the transverse furrows are clearly concave." — Translated from He Chengquan (1991, p. 78)

Age: late Eocene (Priabonian); holotype corresponding to the "second section of the Bashibulake Formation" as translated from He Chengquan (1991, p. 226). Range: late Eocene (Priabonian) corresponding to the "second and third sections of the Bashibulake Formation" as translated from He Chengquan (1991, p. 78) given the age of the section presented by Xi Dangpeng et al. (2020, p. 166).

Plate 29, figure 18, He Chengquan (1991).

Deflandrea convexa Wilson, 1988

Description: "Pericyst intermediate to large, ovoidal, elliptical to almost circular in dorso-ventral view with a subrounded apex and a broadly convex antapical margin lacking horns. Surface finely reticulate, 1–1.5 µm thick. Paracingulum may be defined by lineation of reticulum; on other specimens it is not seen. Parasulcus defined by narrow smooth area on ventral surface of some specimens. Endocyst circular, smooth, slightly thicker walled than pericyst (2–3 µm). Narrow pericoels (length up to 12 µm) are developed only at the apex and antapex. Intercalary archeopyle broad (width 37–42 µm), hexagonal; operculum free and comprises two adherent pieces from periphragm and endophragm." — Wilson (1988, p. 17)

Dimensions: "Holotype: overall length 93 µm, breadth 76 µm, length of endocyst 76 µm, breadth 76 µm. Range: overall length 78 (90) 103 µm, breadth 71 (76) 83 µm, diameter of endocyst 69 (77) 85 µm (n = 10)." — Wilson (1988, p. 17)

Discussion: The species has some resemblance to *D. truncata* Stover and *D. leptodermata* Cookson & Eisenack and is distinguished from them by its more rounded, convex antapex, and its reticulate periphragm. It is further distinguished from *D. truncata* by its shorter apical pericoel." — Wilson (1988, p. 17)

Age: middle Eocene (Lutetian); holotype of Wilson (1988, p. 17, fig. 4).

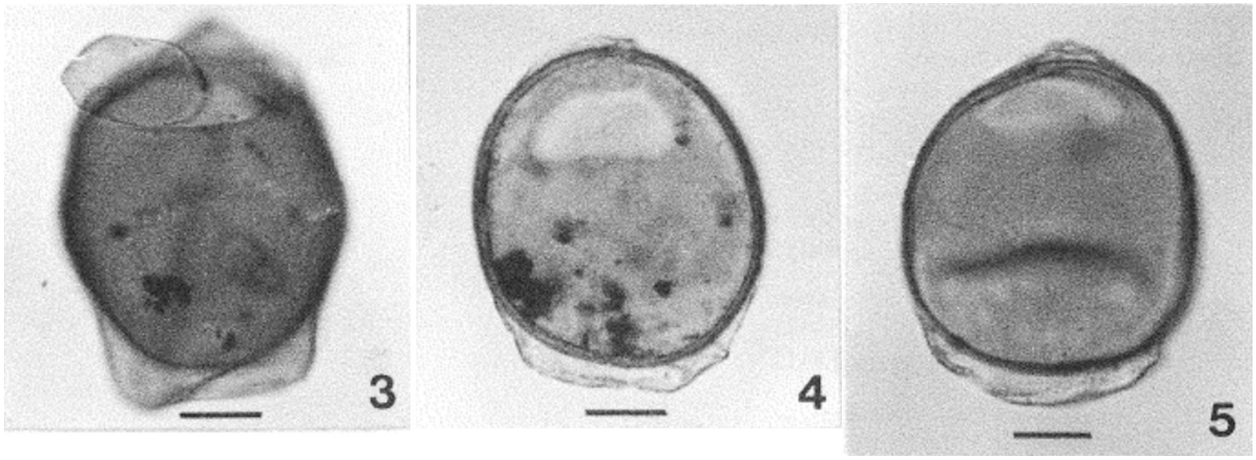


Plate 6, figures 3–5, Wilson (1988). Scale bars = 10 μm.

Deflandrea cornumammillata Jan du Chêne & Châteauneuf, 1975

Diagnosis: "Cavate cyst whose periphragm is elongated, bilaterally symmetrical and with convex lateral margins. The apical horn is short, low, rounded at the end. The periphragm forms a sac in the antapical zone. The two horns are reduced to small nipples at the lower corners of this bag. The periphragm is finely and regularly dotted over its entire surface. Tabulation is not visible. The equatorial furrow is not very marked. The archeopyle, in intercalary position, is trapezoidal with convex sides. The endophragm is subcircular ovoid, closely attached to the periphragm in the cingulate area." — Translated from Jan du Chêne & Châteauneuf (1975, p. 31, 32)

Description: "The antapical horns are short and vary between 4 and 6 μ in length. One specimen shows a pointed antapical horn reaching 25 μ (Pl. 2, fig. 10). By its general morphology, its periphragm-shaped phrase and the position of the antapical horn to the inferior angle of the periphragm, this specimen can however be attached to *Deflandrea cornumammillata*. Scanning electron microscopy observation allows for a more detailed description of this species: the periphragm is regularly punctuated over its entire surface. The endophragm is composed of two layers: the outer layer shows dense granulation over its entire surface (Pl. 2, fig. 11–13), the inner layer is regularly perforated. Equatorial furrow sometimes distinguished. The tab is not visible." — Translated from Jan du Chêne & Châteauneuf (1975, p. 32)

Dimensions: "Holotype height 90 μ, width 66 μ, apical horn 14 μ, height of the antapical sac 10 μ, length of the antapical horns 4 μ, capsule height 72 μ. Variations in dimensions (number of specimens measured: 36): height 80 (94) 110 μ, width 56 (70) 82 μ, apical horn 8 (15) 24 μ, height of antapical sac 6 (11) 20 μ, length of antapical horns 4–6 μ, specimen shows an antapical horn of 25 μ (Pl. 2, fig. 10)." — Translated from Jan du Chêne & Châteauneuf (1975, p. 31, 32)

Comparison: "Characteristic morphological elements of this species are the sac form of the periphragm in the antapical zone and the reduced form in nipples of the antapical horns. By its general ovoid outline, *Deflandrea cornumammillata* sp. nov. recalls *D. eocenica* Baltas 1969. This author also describes (1969, p. 34) *D. hialina* whose antapical horns are joined and very vaguely demarcated. Balts (1969, pl. l, fig. 3) shows *D. hialina* showing antapical horns in the form of nipples and resembling by this character *D. cornumammillata*. The dimensions of *D. hialina* whose height varies from 55 to 60 μ, are however significantly lower than those of *D. cornumammillata* whose height reaches 80 to 110 μ. *D. dakotaensis* Stanley 1965 differs from *D. cornumammillata* by its more pointed apical horn terminated with a small solid papilla (Stanley 1965, p. 217) and its antapical horns which do not show the characteristic nipples of our species. *D. pellucida* Deflandre and Cookson 1955 has a pointed apical horn, a punctuated periphragm, and a taller and narrower archeopyle than that of *D. cornumammillata*. *D. micropoda* Cookson and Eisenack 1974 has a smooth periphragm and endophragm, and an archeopyle in a very high position in the apical area. This species has two small antapical horns and resembles in this character *D. cornumamillata*." — Translated from Jan du Chêne & Châteauneuf (1975, p. 32)

Age: early Eocene (early Ypresian); holotype as translated from Jan du Chêne & Châteauneuf (1975, p. 32).

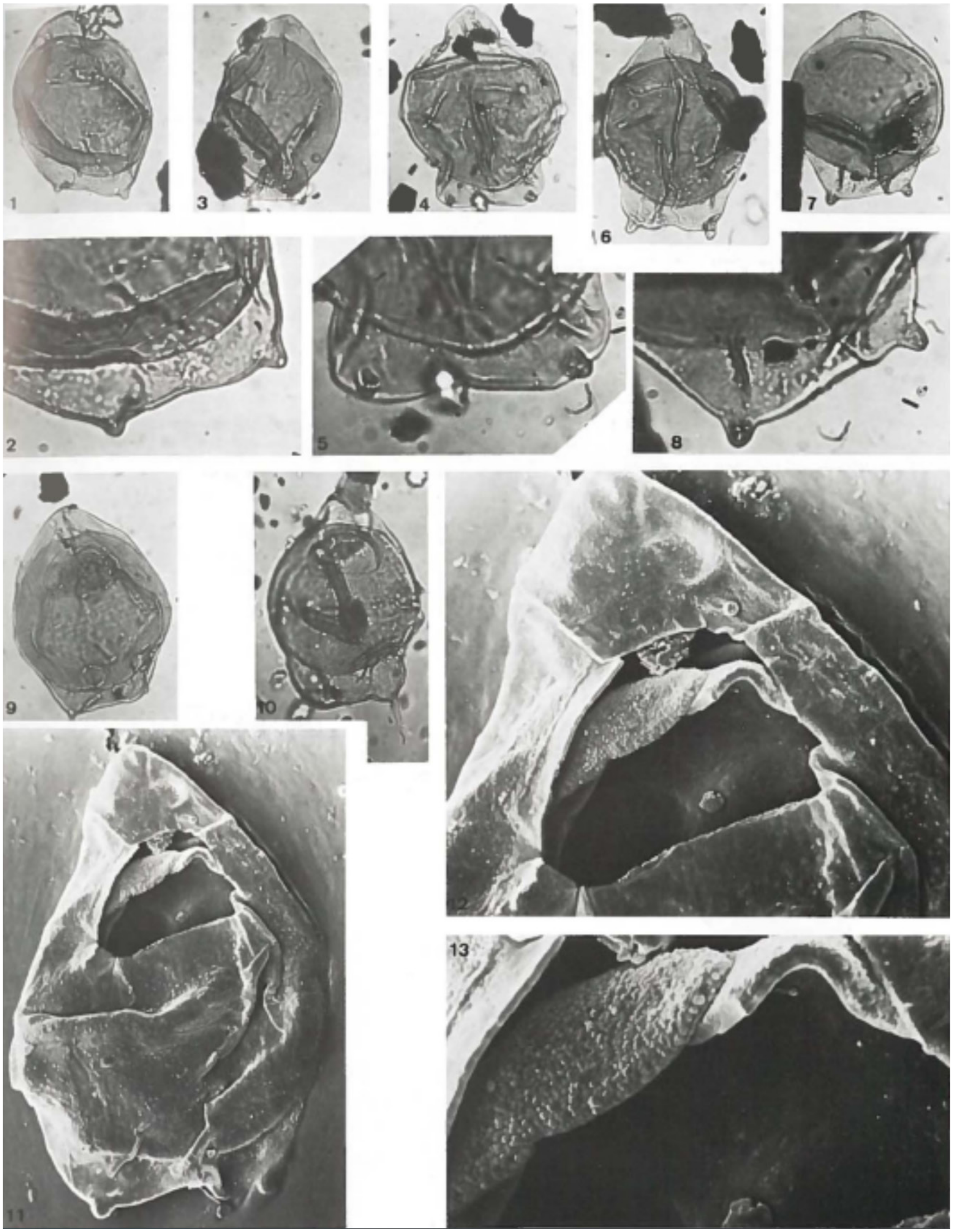


Plate 2, figures 1–13, Jan du Chêne & Châteauneuf (1975).

Deflandrea cygniformis Pöthe de Baldis, 1966

Diagnosis: “Fusiform, elongated theca with finely-grained surface. Epitheca three times as long as the hypotheca. Hypotheca with poorly defined antapical appendages, ending in an irregular edge. Large, subrounded cyst that occupies more than half of the specimen. The opening of the dorsal face is also large and oblong. The cingulum is narrow and poorly defined with a smooth edge.” — Translated from Pöthe de Baldis (1966, p. 221)

Description: “All the specimens seen have in general the same characteristics, although they extend some variations with respect to the length of the epitheca and the rest of the theca, but maintaining this variation within the specific characters. The theca with a pentagonal, spindle-shaped outline can present with a granulated or very smooth surface. The epitheca is much higher than the hypotheca. After separating from the cyst, the epitheca converges smoothly and evenly, forming a long neck. In its lower part, the epitheca separates a little from the cyst, while the hypotheca is completely separated from it. The cingulum is excavated and its edge is smooth or very finely granulated. The cyst is oval in shape, its largest diameter being the transverse one. In all the observed specimens there is not a good development of the antapical appendages, for which reason it is believed that the way they are found is their typical form. The antapical appendages are united to form an irregular border.” — Translated from Pöthe de Baldis (1966, p. 221)

Dimensions: “Holotype, total length: 195.8 μ. Total width: 99 μ. Hypotheca: 50 μ. Epithecal length: 145 μ. Longitudinal diameter of the cyst: 85.8 μ. Cross-sectional diameter of the cyst: 102.3 μ.” — Translated from Pöthe de Baldis (1966, p. 221)

Considerations: “This specimen does not show similarities with any of the specimens described above, being that the length of the epitheca is its most notable specific characteristic.” — Translated from Pöthe de Baldis (1966, p. 222)

Age: early Tertiary; holotype as translated from Pöthe de Baldis (1966, p. 222).

Plate 2, figure c, Pöthe de Baldis (1966).

Deflandrea danica Lange, 1969

Diagnosis: "The cyst is flattened, its outline (without processes) appears circular to slightly elliptical. The epi- and hypotheca are of equal size. The epitheca ends in a long apical horn clearly separated from the cyst. The hypotheca bears two more or less strongly diverging, tapering, narrow antapical horns. The transverse furrow runs in a circle and is only clearly visible on the side edges. Below the apex there is an elongated, rectangular pylome. The delicate inner capsule lies on the outer edge of the cyst very closely." — Translated from Lange (1969, p. 114)

Additions: "For the species, the circular to slightly oval outline of the body as well as the development of the processes is characteristic. The membrane of the carapace is finely granulated. In contrast to the specimen described by Drugg (1967) from the Danian of California and Stevns-Klint molds do not have a longitudinal groove." — Translated from Lange (1969, p. 114, 115)

Dimensions: "Holotype: 151 [periphragm length?] (80 [endophragm length?]): 80 [periphragm width?] (78 [endophragm width?]). Measurements (average of 7 specimens): 155 (81): 83 (80)." — Translated from Lange (1969, p. 115)

Age: early Paleocene (Danian); holotype as translated of Lange (1969, p. 114).

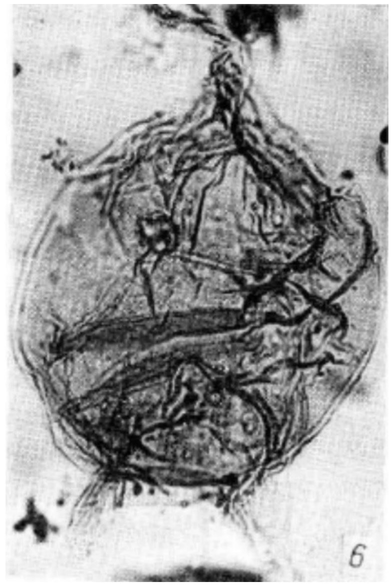


Plate 1, figure 6, Lange (1969).

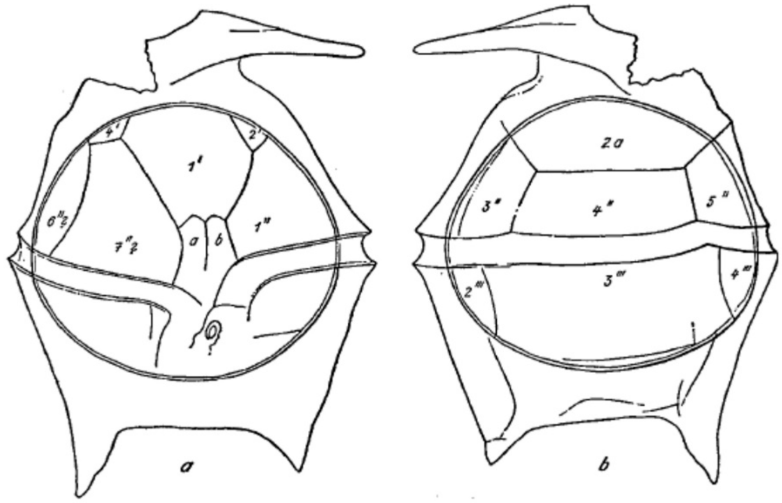
Deflandrea delineata Cookson & Eisenack, 1965b

Description: "Shell rather flat, roughly five-sided in outline, longer than broad. Epitheca somewhat longer than the hypotheca with a prominent, broadly-based, tapering apical horn. The short antapical horns, which are equal in size, are broadly-based, sharply-pointed, widely separated and strongly divergent. Girdle circular, indicated laterally by shallow concavities on both sides of the shell, rather narrow and delimited by low ledges which, on the ventral surface, curve downwards to pass over the boundaries of the longitudinal furrow in which the thickening associated with the flagella-pore is evident (Pl. 18, fig. 3). Wall of shell thick, slightly tabulated, its surface variously striated as the result of the longitudinal arrangement of the small dot-like to elongate surface thickenings (Pl. 18, fig. 3). The degree of clearness and extent of the tabulation varies considerably in individual specimens. It has been best seen in the holotype (Pl. 18, fig. 4, 5; Fig. 1). On the dorsal surface of this specimen 3 plates, numbered as in *Peridinium* 3'' 4'' 5'', are situated between the girdle and archeopyle; no clear tabulation is evident on the hypotheca but a small plate 2''' seems to be outlined on the lefthand side, and a corresponding one 4''' on the right-hand side of plate 3'''. On the ventral surface of the epitheca two small plates (Fig. 1a, b) and a large, broad and elongate one p', situated immediately above them, are clearly outlined. Capsule circular or ellipsoidal in outline with the long axis perpendicular to the long axis of the shell; its wall varies in thickness in individual specimens. The archeopyle is broader than long and seems to correspond with plate 2a." — Cookson & Eisenack (1965b, p. 140, 141)

Dimensions: "Holotype, overall length 171 μ; overall width 105 μ; capsule 86 × 95 μ. Range, overall length 159–190 μ; overall width 116–130 μ; capsule 69–84 × 85–92 μ." — Cookson & Eisenack (1965b, p. 141)

Comment: "Of the previously described species of the genus *Deflandrea*, the one to which *D. delineata* seems to be most closely related is *D. speciosa* Alberti (1959) from an Upper Paleocene deposit in N. Germany. However, the presence of a ± distinct form of tabulation, the stronger development of the girdle, the characteristic arrangement of the ornament of the shell wall, as well as the lack of the denticulate ledges mentioned by Alberti as present in the German species, seem sufficient justification for the separation herein proposed." — Cookson & Eisenack (1965b, p. 141)

Age: Paleocene; holotype of Cookson & Eisenack (1965, p. 140).



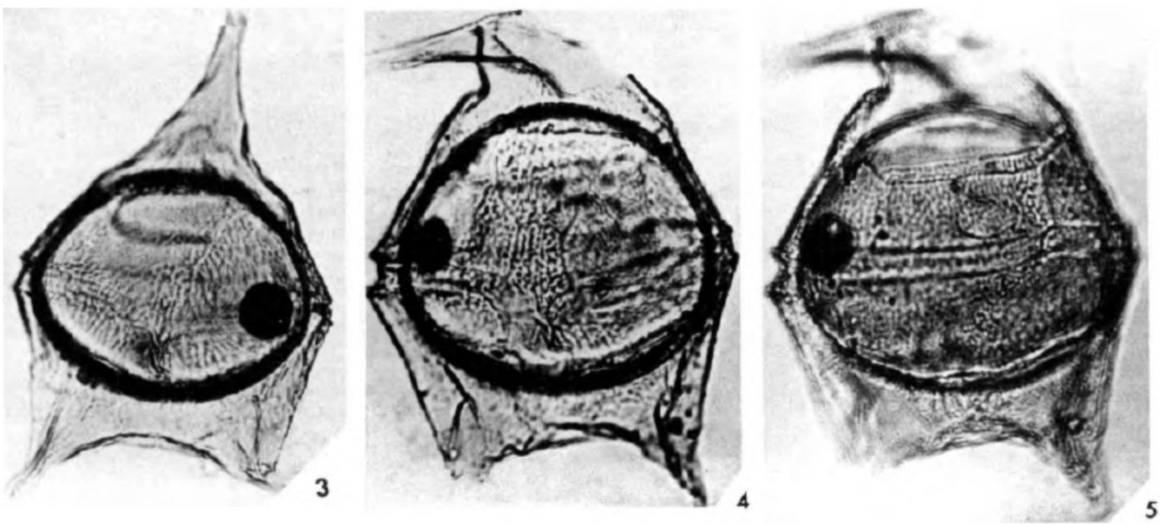


Plate 18, figures 3–5; Text-figure 1, Cookson & Eisenack (1965).

Deflandrea denticulata subsp. ***denticulata*** Alberti, 1959

Diagnosis: “Cyst flattened, its outline elongated pentagonal, epitheca acute to right-angled triangle extended into a long apical horn, which extends and tapers toward the free end. Hypotheca slightly smaller than the epitheca, inverted ± trapezoidal, with two long, often tapering, barely diverging antapical horns. Transverse furrow narrow, ± strongly deepened. Always with a tight-fitting outer body, large, delicate inner body. Outer edge of cyst finely serrated, apical horn and antapical horns with short bristle-like appendages.” —Translated from Alberti (1959, p. 102)

Additional notes: “Characteristic of the species (in almost all specimens) is the regular outline of the cyst and the serrations on its outer edge, which are only found in a few shapes is uneven. It is characterized by very short bristle-like extensions, between which the outer edge of the theca is inflected. The surface of the apical horn and the antapical horns (less those of the ventral and dorsal side) bears a dense stocking of somewhat longer bristles.

The transverse furrow is sharply incised in some specimens, a longitudinal furrow on the hypotheca probable. The only indicated side horns are on the notched tip. The antapical horns are ± equal in length and taper on the free end as well. The membrane of the cyst is often folded so that sutures are simulated, but tabulation could not be detected. An archeopyle that is similar to that of *Deflandrea phosphoritica* lies just below the apex. All examined specimens have an inner body whose membrane differs little in color from that of the cyst." —Translated from Alberti (1959, p. 102, 103)

Relationships: "Those mentioned by Pasteils 1948, p. 50 and on Plate 5, Figs. 17–20. Specimens probably belong to this species. Under no circumstances, however, can they go to *Peridinium* Ehrenberg, since they are the ones for this genus for which tabulation is characteristically missing. In addition, they have an inner body similar to those specimens I examined where it was never missing, so an integrating part of the species (or even the genus *Deflandrea*). From *Deflandrea spinulosa* n. sp. the given kind differs in the different outline of the cyst, the teeth along its outer edge, and the much more delicate inner body, which is never globular. In *D. denticulata* the transverse furrow is ± sharply deepened." —Translated from Alberti (1959, p. 102)

Dimensions: "Measurements of the holotype: length 119 μ, width 77 μ. For other specimens, the length varies between 126 μ and 156 μ; the width between 82 μ and 90 μ (30 specimens)." —Translated from Alberti (1959, p. 102)

Age: early Eocene (Ypresian); holotype of as translated from Alberti (1959, p. 102, 103).

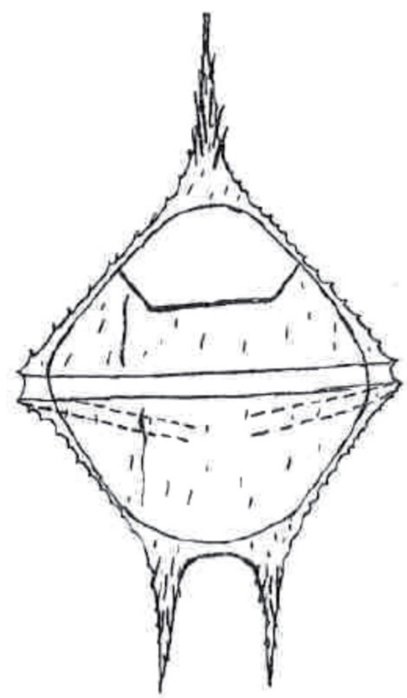


Abb. 1. *Deflandrea denticulata* n. sp

Text-figure 1, Alberti (1959).

Deflandrea denticulata subsp. ***minor*** (de Coninck, 1969) Lentin & Williams, 1973

Diagnosis: "The roughly globular body is enveloped in a theca which forms the apical horn and the antapical horns. A serrated crest marks the weakly helicoidal and interrupted cingulum. I did not observe an archaeopyle. Ornamentation of the theca consists of numerous small teeth on the horns and the body."

— Translated from de Coninck (1969, p. 16)

Dimensions: "Cyst body about 46 μ by 40 μ. Length of horns: apical about, 25 μ; antapical: 20 μ and 22 μ. Total width: approximately 48 μ by 85 μ." — Translated from de Coninck (1969, p. 16)

Remarks: "The forma *minor* differs from the type species of Alberti by its more reduced size and also by its relatively longer horns and its divergent antapical horns. Another specimen of 376 m, preparation 2; coordinate 34.6–104 (Pl. II, figs. 1 and 2) differs from the *minor* form only by its smaller apical horn and by its antapical horns being less acute and closer together. In addition, it presents an intercalary archaeopyle. It is nevertheless preferable to relate it to the same form." — Translated from de Coninck (1969, p. 16)

Age: early Eocene (middle Ypresian); holotype as translated from de Coninck (1969, p. 8, 16).

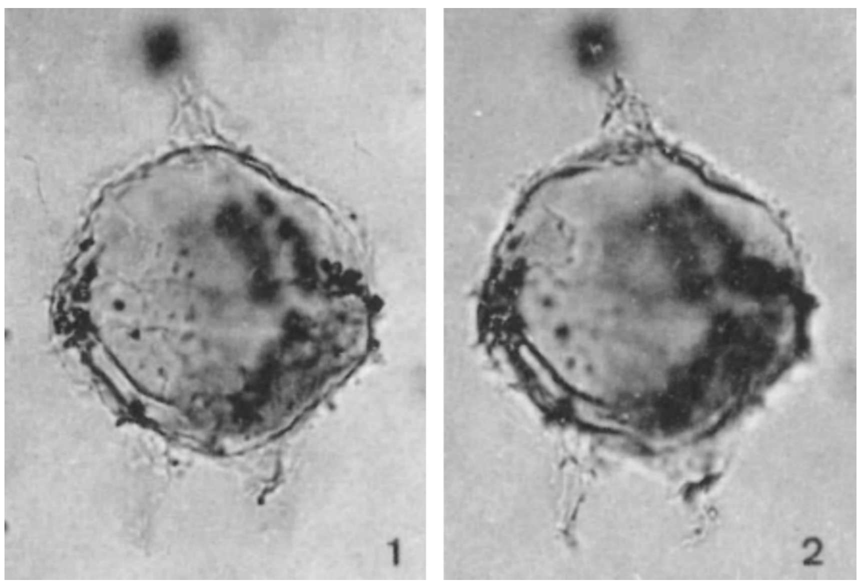


Plate 2, figures 1, 2, de Coninck (1969).

Deflandrea dissoluta Vozzhennikova, 1967

Description: "Theca pentagonal. Epitheca larger than hypotheca, funnel shaped, with walls of equal thickness over the middle part of the epitheca but thinner laterally. The apical horn is long or short, conical and straight or slightly inclined. Hypotheca broadly trapeziform with concave lateral walls and a concave antapical margin. Antapical horns small, acutely pointed and broadly divergeant [sic]. On the lateral walls of the theca where the epitheca and hypotheca come together there are blunt outgrowths with a slightly depressed transverse furrow. The lateral [sic] is shallow, annulate and it ends serve as the beginning for the longitudinal furrow which extends over the hypotheca to the antapex. Internal body oval, its lateral walls sometimes attaining the thin lateral walls of the middle portion of the epitheca. The internal body occupies the greater part of the theca and its surface is more coarsely sculptured than that of the theca itself. Surface of theca smooth or finely granular. Pylome large, trapeziform." — Vozzhennikova (1967, p. 224, translation: Lees & Sarjeant, 1971)

Dimensions: "(in microns) Holotype: length of theca 154, breadth 89.1, width of transverse furrow 5.4, length of internal body 58.7, breadth 70.2. In other specimens: length 145–175.5, breadth 140–158, width of transverse furrow 6–8, length of internal body 58–75.6, width 70–78.3.” — Vozzhennikova (1967, p. 224, translation: Lees & Sarjeant, 1971)

Comparison: “This species differs from others of the genus in the shape of its theca, the divergent antapical ends and the presence of a large pylome.” — Vozzhennikova (1967, p. 224, translation: Lees & Sarjeant, 1971)

Age: Eocene; holotype and range of Vozzhennikova (1967, p. 224, translation: Lees & Sarjeant, 1971).

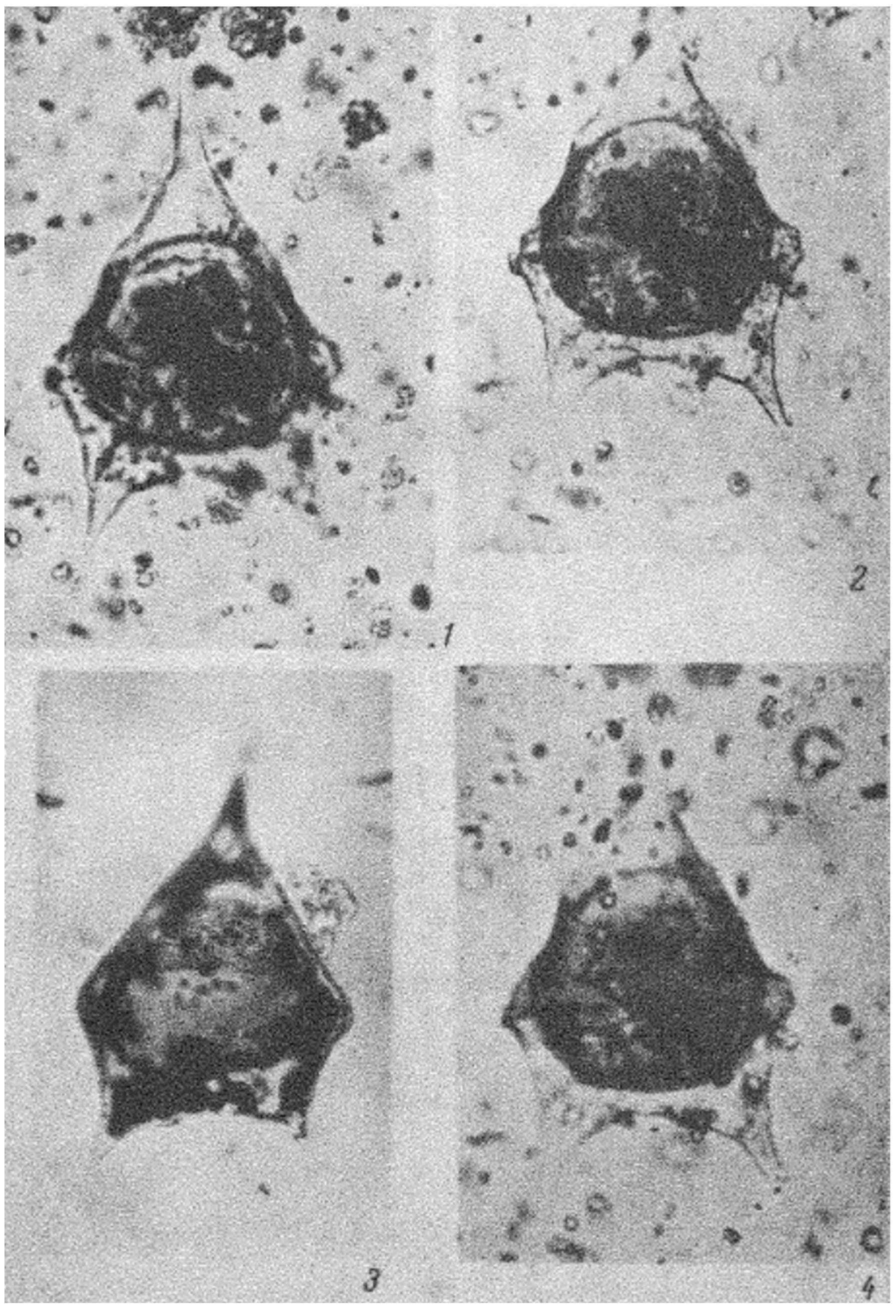


Plate 73, figures 1–4, Vozzhennikova (1967).

Deflandrea elegantica Andreeva-Grigorovich & Savitskaya, 1993

Description: "Pericyst pentagonal-oval, slightly elongated in length, with slightly convex sides. The hypocyst is triangular, ending in a small apical horn. The epicyst is trapezoidal, with small antapical growths of the same size, all three horns identical in shape. The paracingulum is clear, formation of fissures on the sides of the periphragm. The endocyst is rounded, the apical part is 'cut'. On the epicyst, it practically adjoins the pericyst, pericoel almost absent. Archaeopyle is large oval, intercalary type. The periphragm is rather rough, finely granular. The endophragm is fine-grained, almost absent. Archaeopyle is large oval, intercalary type. The periphragm is rather rough, finely granular. The endophragm is fine-grained." — Translated from Andreeva-Grigorovich & Savitskaya (1993, p. 45)

Dimensions: "(µm) Holotype: length 126, width 96; length of internal body 11, width 60; paracingulum width 6; length of apical horn 15, length of antapical horns 6; distance between antapical horns 42 (at bases), 60 (between peaks)." — Translated from Andreeva-Grigorovich & Savitskaya (1993, p. 45)

Comparison: "It is most similar to some specimens of *Deflandrea phosphoritica* [tab. 20, fig. 4, 6; 6, tab. 26, fig. 9; 5, tab. 1, fig. 1 2]. Distinguished by the shape of the hypocyst, antapical horns and granular pericyst on top of it." — Translated from Andreeva-Grigorovich & Savitskaya (1993, p. 45)

Age: late Eocene–Oligocene?; holotype and range as translated from Andreeva-Grigorovich & Savitskaya (1993, p. 45, 46).

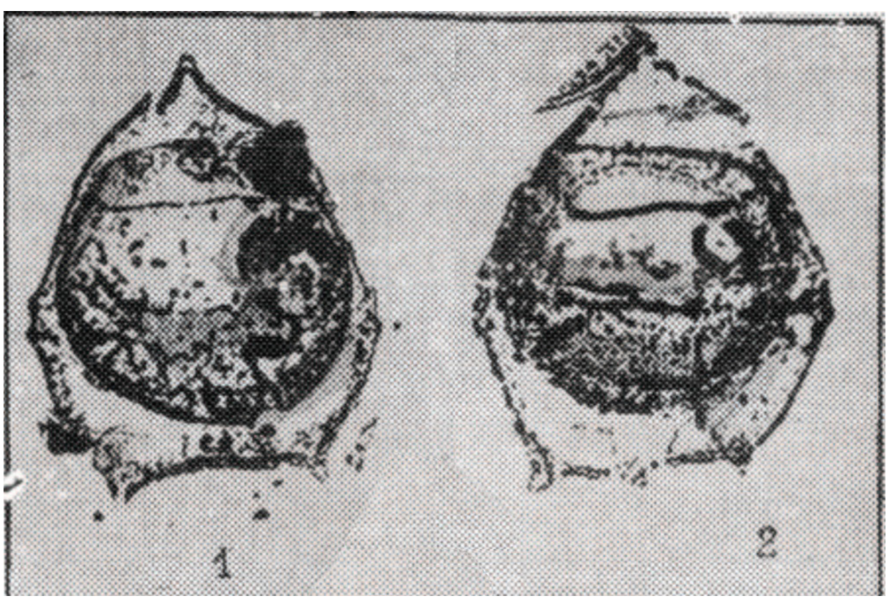


Plate 1, figures 1, 2, Andreeva-Grigorovich & Savitskaya (1993).

Deflandrea eocenica Balteş, 1969 ex Lentin & Williams, 1973

Description: "Cyst generally hexagonal in shape with rounded ends. Central spherical capsule well demarcated, without cingulum visible. Slightly demarcated apical horn. Horns antapical, rounded or even joined. Periphragm transparent, finely granulated. Trapezoidal, elongated intercalary archeopyle." — Translated from Balteş (1969, p. 34)

Dimensions: “Total length 88–92 microns.” — Translated from Balteş (1969, p. 34)

Discussion: “Some of our specimens can be compared with *Deflandrea cretacea* Cookson without fully presenting its characteristics.” — Translated from Balteş (1969, p. 34)

Age: early Eocene (Ypresian); holotype as translated from Balteş (1969, p. 34).

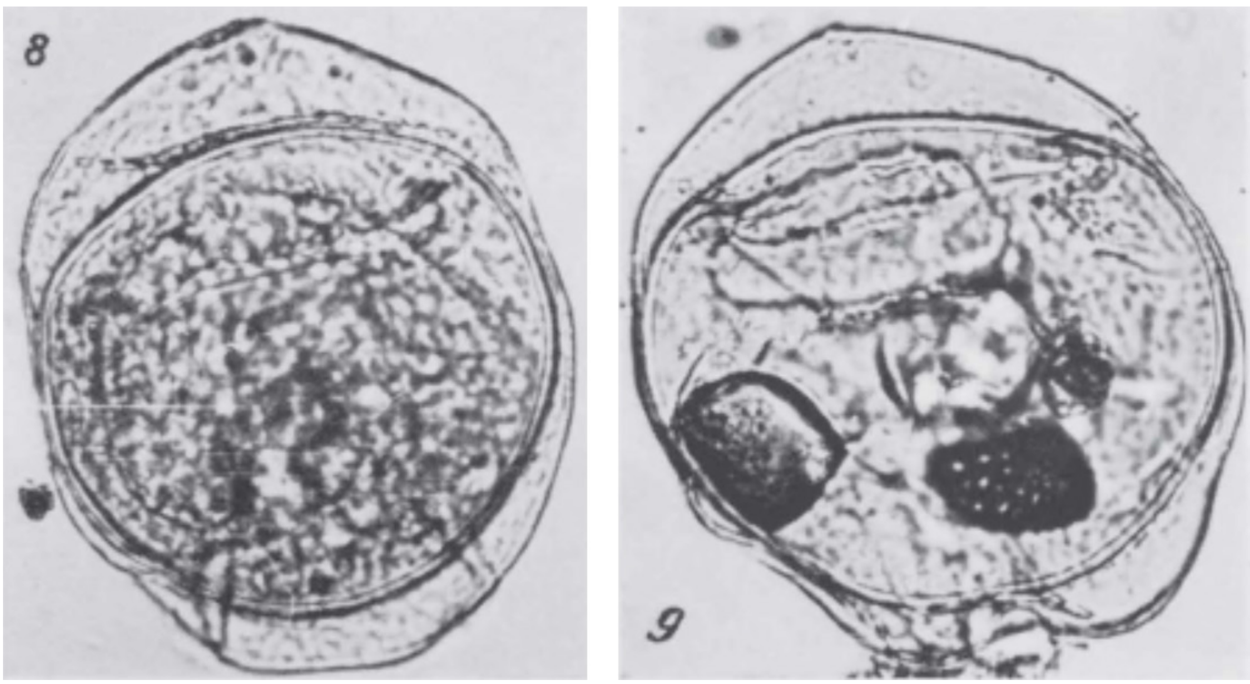


Plate 5, figures. 8, 9, Balteş (1969).

Deflandrea flounderensis Stover, 1973

Diagnosis: “Periphragm outline triangularly elongate in dorso-ventral view. Apical horn usually prominent and well defined; antapical horns less well defined and with the right horn commonly longer than the left, but not greatly so. On many specimens, the dorsal antapical part of the periphragm forms a skirt-like membrane between the horns (Plate 3, Figs 1, 2) with a nearly straight antapical margin; however, in the same area on the ventral surface the margin of the periphragm is concave between the antapical horn. Lateral margins convex to straight and interrupted at about midheight by the ridges of the cingulum. Periphragm is ca 1 μ thick, in part smooth and in part finely granulate or conate with the sculpturing corresponding to plate areas. Tabulation peridinioid (4', 3a?, 7'', 5''', 2''''). On most specimens the shapes and boundaries of the apical plates, except of 1', and the lateral plates are difficult to determine; whereas those for the medial plates are usually evident. Cingulum is marked by parallel transverse ridges, commonly with beaded crests, offset ventrally, undivided, and the floor of the cingulum is smooth, or rarely with scattered grana. Sulcus generally poorly defined, and a comma-shaped scar is discernible on some specimens in the sulcus near its junction with the cingulum.

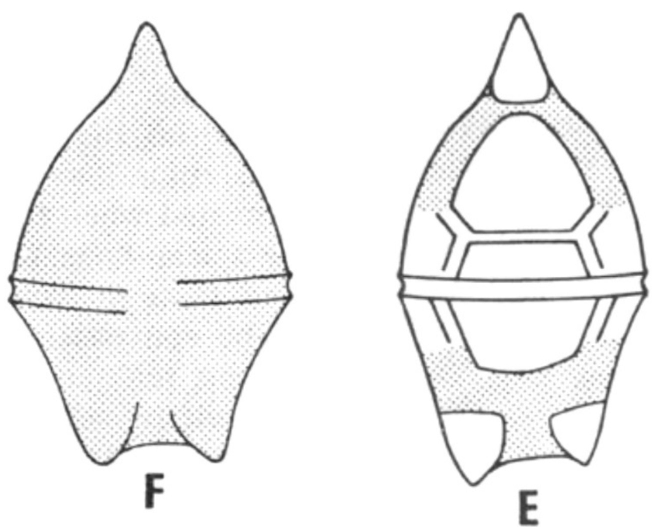
In dorso-ventral view, the outline of the endoblast is circular or nearly so. Endophragm is smooth, granulate, or coarsely vermiculate and 1–2.5 μ thick. Almost invariably the endophragm is thicker than the periphragm. Laterally, the periphragm and endophragm are close together and the distance between the two walls increases apically and antapically.

The large intercalary archeopyle is broadly trapezoidal, about as wide as high, and with a relatively narrow apical end. The corresponding opening in the endophragm is as wide as in the periphragm, but the height is only about half as much. Operculum free." — Stover (1973, p. 174, 175)

Comparison: "*Deflandrea flounderensis* differs from *D. dartmooria* Cookson & Eisenack, 1965b by having a larger length to width ratio, generally more subdued sculpturing on the periphragm, sculpturing on the endophragm (on most specimens), and by lacking linear markings at plate boundaries." — Stover (1973, p. 175)

Dimensions: "Complete specimens are 112–166 μ long and 76–98 μ wide at the cingulum. Approximately three-quarters of the specimens are less than 135 μ long. The length to width ratio is 1:0.55–1:0.70 (mean 1:0.65). Maximum diameter of the endoblast is 60–88 μ and in about threequarters of the specimens, its width is greater than its length. Width of endophragmal opening is 37–46 μ and its length is 17–24 μ (width consistently about twice the length). Measurements based on 25 specimens." — Stover (1973, p. 175)

Age: early Eocene (Ypresian); holotype of Stover (1973, p. 175).



Text-figures 3F, 4E, Stover (1973).

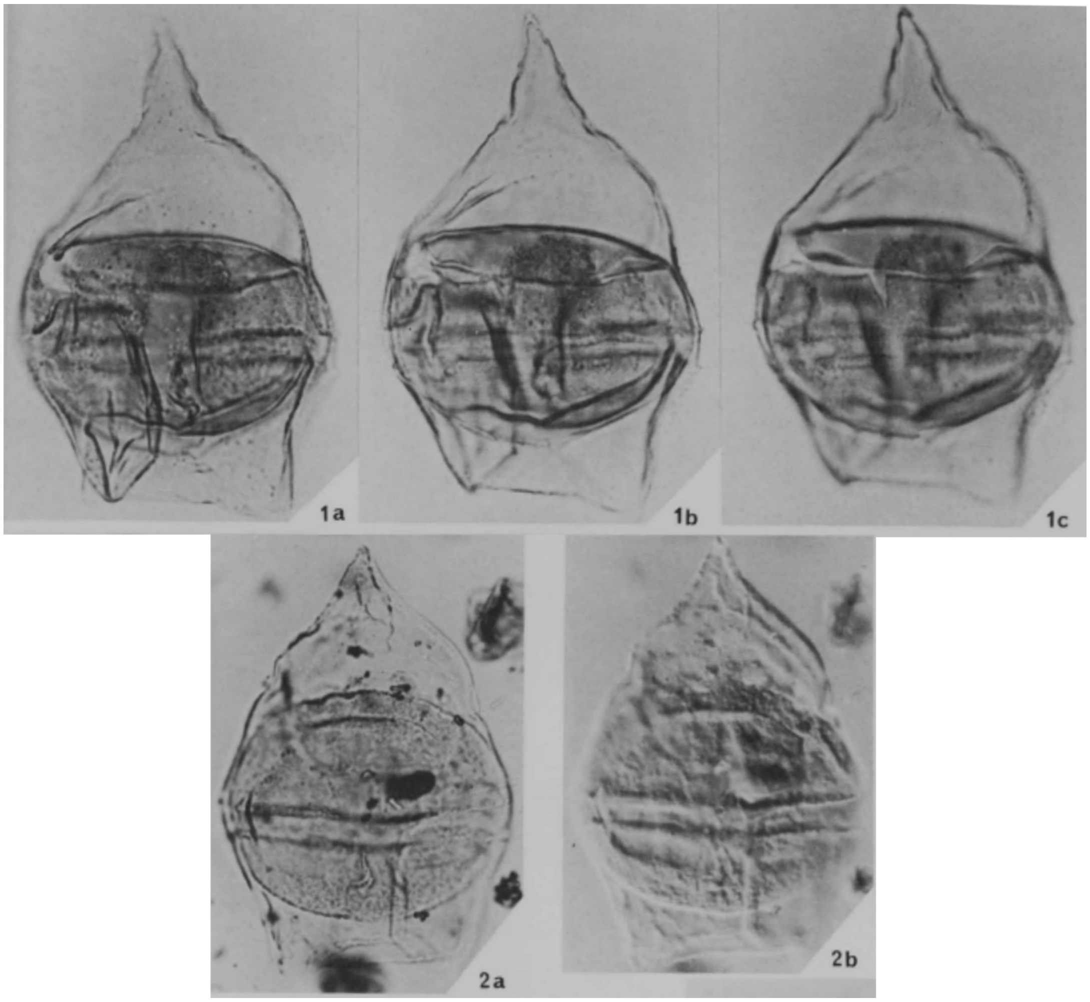


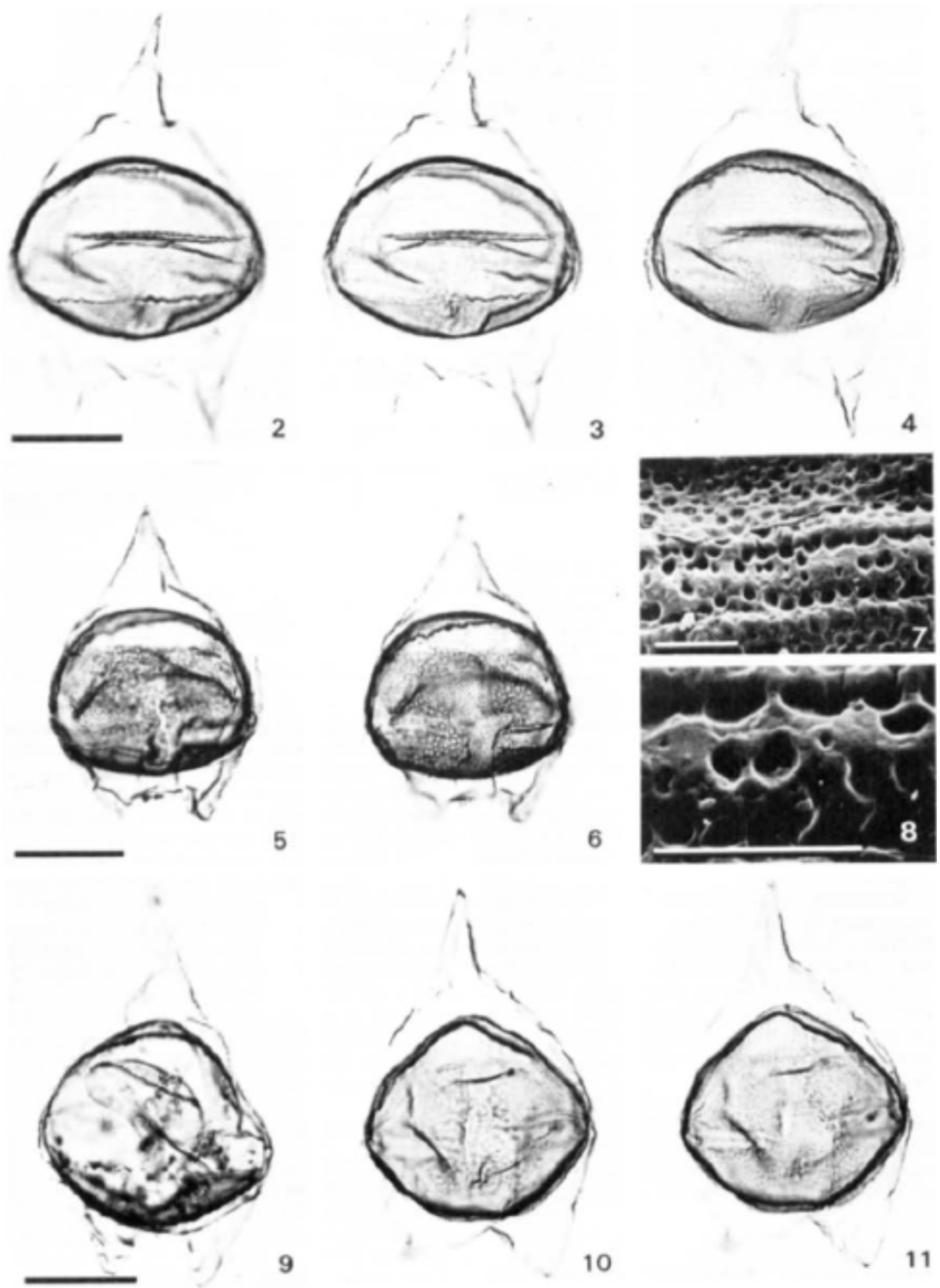
Plate 3, figures 1a–c, 2a, b, Stover (1973).

Deflandrea foveolata Wilson, 1984a

Description: “Cyst large, elongate, bicavate with fairly prominent apical horn and two equal antapical horns; all horns usually capped with a solid papilla. Periphragm thin, densely foveolate over most of surface; foveolae circular to polygonal, up to 6 µm in diam.; small perforations usually occur in addition to foveolae, particularly near paracingular margins (Fig. 7 and 8). Endocyst smooth, relatively thick-walled, breadth greater than length, and usually in close contact with pericyst of central area; prominent pericoels developed in apical and antapical regions. Archeopyle very broad, subhexagonal, Type I/I or occasionally Type 3I/3I; operculum free, endoperculum somewhat smaller than perioperculum. Paracingulum usually represented by low ridges or by lineations of either relatively deep foveolae or perforations. Paratabulation not well defined although low solid ridges sometimes delimit polygonal areas. Parasulcus normally represented by narrow depression on ventral surface.” — Wilson (1984a, p. 547)

Dimensions: “Holotype, overall length 189 µm, breadth 111 µm, length of endocyst 78 µm, breadth 89 µm. Range (20 specimens), overall length 157(165)189 µm, breadth 81(95)116 µm, maximum diameter of endocyst 73(87)108 µm.” — Wilson (1984a, p. 547)

Age: early Paleocene (Danian); holotype of Wilson (1984a, p. 547).



Figures 2–11, Wilson (1984a). Figures 2–6, 9–11, scale bar = 50 μm; figures 7, 8, scale bar = 10 μm.

Deflandrea fuegiensis Menéndez, 1965

Diagnosis: “Theca broadly fusiform, smooth or fine with irregularly granulated surface, with two antapical appendages or horns. Epitheca higher than the hypotheca; conical apex with slight neck, with approximately polygonal opening on the dorsal face. Hypotheca with two irregularly tapered antapical horns. Cingulum excavated. With grainy margin, interrupted on the ventral side by the longitudinal sulcus. Longitudinal groove slightly marked in the epitheca, it widens in the cingulum, opening at its distal end, toward the antapical horns. Rounded cyst with oblong height in the dorsal chamber. Apical zone, with irregularly granulated, thin membrane.” — Translated from Menéndez (1965, p. 8)

Description: “The holotype (Plate 1, fig. 1) possesses an overall theca shape that is fusiform, broadened, but somewhat angular. The surface of it is largely smooth, but in certain parts, generally near the equator, it has a fine and irregular granulation.

The epitheca, higher than the hypotheca, is conical with convex lateral margins or somewhat angular, but with a slight inflection in the apical part in the manner of a neck; on its dorsal face it presents an opening of approximately flared pentagonal shape. Due to the position it occupies, it would correspond to an intercalary archeopyle. Plate delimitation is not distinguished, although certain folds or breaks of the theca seem to hint at traces of apical and precingular plates; but this is very unclear and unconfirmed in other specimens.

The hypotheca, obviously lower than the epitheca, is more or less truncated and conical in shape, whose lower angles are prolonged into two irregularly conical appendages or horns of subparallel position.

The cingulum, excavated in the equatorial zone, divides the theca into two unequal parts and is well visible both on the dorsal and on the ventral side; has a constant width of 6.5 μ at the edges. Marginal parts of it are regularly granulated or jagged; on the ventral side the continuity of the cingulum is interrupted by the longitudinal sulcus.

The sulcus marked in the epitheca by a slight oblong notch 10 μ high, widens at the cingulum and part top of the hypotheca, opening sharply at its distal end toward the antapical horns.

Inside the theca presents a body (or cyst, for some authors) that occupies the entire width and approximately two-fourths of the height of the theca. Cyst transversely elongated measuring 67.5 μ on its transverse axis and 54 μ on the longitudinal dorsal side of the apical part, and has an oblong opening that is somewhat below the pentagonal opening of the theca. The cyst membrane is about 1 μ thick, thickening towards the cingular zone, it is irregularly granular and more noticeable than that of the theca. From the apex to the appendages, antapical, this specimen measures 112.5 long and 67.5 μ maximum width in the equatorial zone.

The sample 1301 (2), coord. 35.4-84.9 (Plate 1, Fig. 2), differs somewhat in its general appearance of the holotype specimen, mainly by the apex more sharpened and the reduction of its appendages antapical, although one of them seem to be broken. The size of the cyst is 78 by 72 μ, and the total height is 130 μ. In sample 1301 (2), coord. 34.2-89.4 (Plate 1, fig. 3), has one of the reduced antapical appendages. The total height is 130 μ; 67.5 μ the width maximum, and 67.5 by 66 μ the size of the cyst.” — Translated from Menéndez (1965, p. 8, 9)

Dimensions: “Total length (with appendages), 112.5 μ; maximum width, 67.5 μ. Width of the cingulum, 6.5 μ; across axis of cyst, 67.5 μ; across longitudinal axis, 54 μ.” — Menéndez (1965, p. 8)

Comparison: “*Deflandrea fuegiensis* is very similar to *D. phosphoritica* Eisenack, especially with those specimens described by Manum (1960) for the lower Tertiary of Spitsbergen, but with which the Tierra del Fuego species can be differentiated for the further development of its epitheca, the lesser thickness of the cyst membrane, the largest size of the epitheca in relation to the hypotheca, and the cingulum being more marked in some of the specimens. Furthermore, in almost all specimens from *D. phosphoritica* the theca separates laterally of the cyst in the hypotheca, and the less developed epitheca fringes partly to the cyst. Another species of *Deflandrea* also similar to *D. fuegiensis* is *D. robusta* Deflandre et Cookson (1955), from the lower Eocene of Princetown, Australia although differentiated from *D. fuegiensis* by its unexcavated cingulum separating the theca in two more or less equal parts, and by its smooth surface." — Translated from Menéndez (1965, p. 8, 9)

Age: Late Cretaceous? Holotype as translated from of Menéndez (1965, p. 7, 8), but no precise age given for the interval between 1121–1812 m within a 2000 m core said to span the Late Cretaceous early–Tertiary (Menéndez, 1965, p. 7).

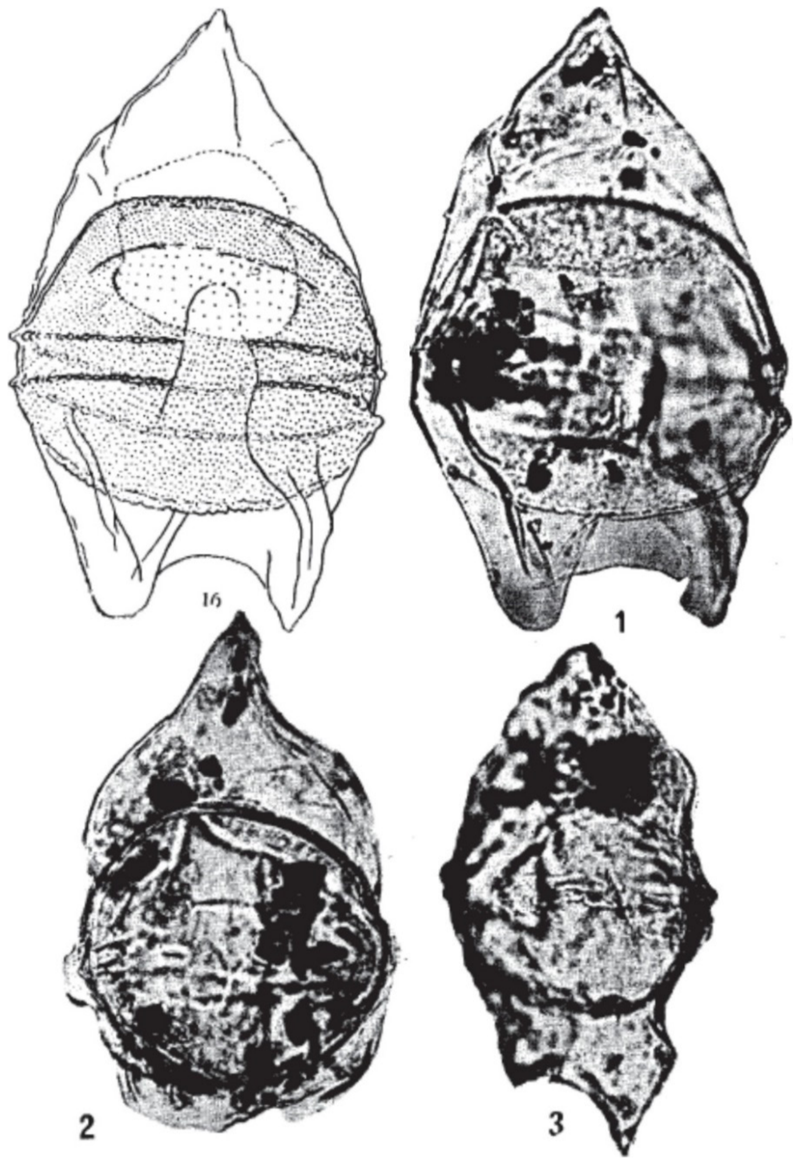


Plate 1, figures 1–3; Plate 3, figure 16, Menéndez (1965).

Deflandrea galeata (Lejeune-Carpentier, 1942) Lentin & Williams, 1973. Emendation: Lejeune-Carpentier & Sarjeant, 1981, p. 18, 19.

Description: "Large species, still similar to certain species of the Oceanica Jörgensen group, recognizable by its helmet-shaped epitheca and posterior horns with large leafy expansions. Theca a little wider than high, dorsi-ventral depression (fig. 17). Epitheca in the form of a lowered dome, surmounted a large horn, very wide at the base and regularly attenuated to the top. Wide, trapezoidal, nearly sided hypotheca. Subequal antapical horns, with wide expansions and ending in a sharp point; they diverge strongly, opening between them at an angel of about 60° (fig. 15 and 16). Cingulum, equatorial, narrow, slightly hollowed out, barely levorotatory; the protruding lips are cut into a number of festoons, which had to be quite flexible on the living cell. Ventral area (fig. 19) deeply hollowed; almost not developed in the epitheca, but on the other hand occupying the whole height of the hypotheca and broad about one-third of it. Flagellar pore located on the right side. Tabulation: plate offering (1) a common suture with 2"; relations of the same lozenge plate on the right side which could not be defined: type therefore meta or para. Intercalary 2a probably hexagonal. Theca of a brownish colour, with a very apparent sculpture under a form of black dots, representing as many large thorns, very short and thick at the base; these thorns (according to the copy fig. 17) located at the nodes of a fine polygonal network. Some folds fairly regularly distributed on the specimen fig. 18 could be only the result of wall subsidence; we do not find them identical on the type (fig. 15) whose contours are much more regular." — Translated from Lejeune-Carpentier (1942, p. B186, B187)

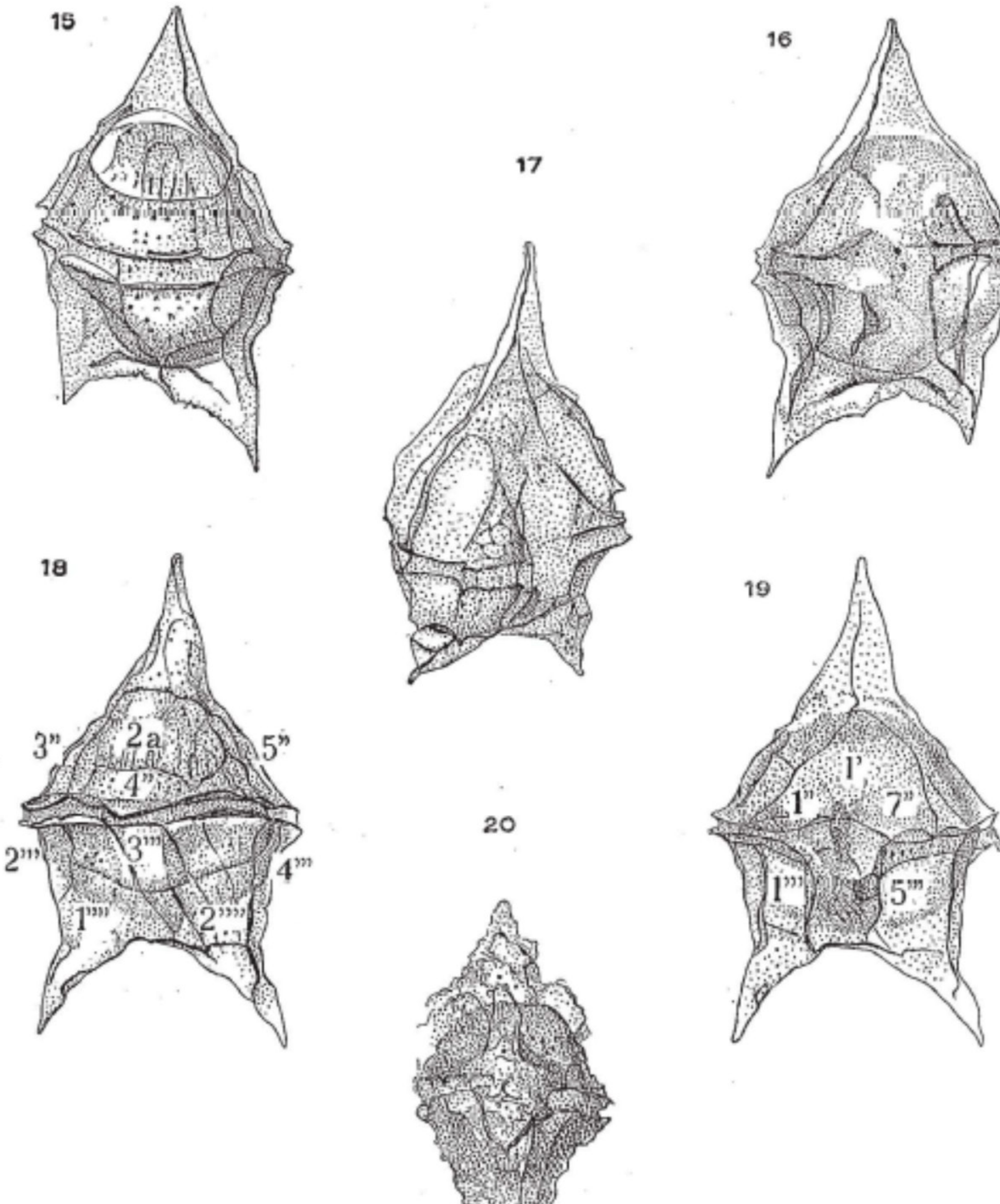
Dimensions: "Length (including horns) = 95 to 116 μ; width in ventral view = 51 to 72 μ; profile width = 36 to 89 μ." — Translated from Lejeune-Carpentier (1942, p. B187)

Affinities: "O.Wetze1 (1933, p. 164) tried to identify the species referred to here at *P. claudicans* Paülsen, who reduced, for some authors (Schiller, 1935, p. 249), to a smaller form of the *oceanicum* Vanhöffen. It cannot be denied that, in terms of size and general shape, some analogies unite our new species with *P. claudicans*. Nevertheless, the belt of the latter is strongly oblique, while that of *P. galeatum* is roughly perpendicular to the long axis. There apical horn (such as it is preserved in the holotype) is more strong and above all more massive; the spacing of the antapicals is distinctly larger than in *claudicans*.

It is with good reason that O. Wetzel postponed the reconciliation entered by W. Wetzel (1922) between our *P. galeatum* and the *P. pedunculatm* Schütt. The latter was interpreted by the authors of many different ways. Holding us, with J. Schiller (1935, p. 112), to data from Jörgensen (1905), we find that *P. pedunculatum* Schütt (section of Pellucida) does not offer any resemblance to *galeatum*: hypotheca attenuated distally as in the epitheca, slender apical horn, antapical spines close together, dextrorotatory belt, etc." — Translated from Lejeune-Carpentier (1942, p. B188)

Emendation: "Circumcavate cysts of relatively large size. Apical horn large, symmetrically tapering from a very broad base to a slightly blunt tip: the horn base is about three-quarters as wide as the horn length, which in turn is between one-third and one-half the length of the endoblast. The two antapical horns are only slightly smaller and almost equally broad-based, with lateral margins straight to slightly convex and inner margins concave. Epitract of periblast in the form of a truncated cone from which the apical horn arises: hypotract trapezoidal, its profile altered by the two horns. Endoblast spheroidal to broadly ovoidal. Cingulum well marked on the periblast by strong ridges but only slightly hollowed; sulcal region quite deeply indented. Paraplate boundaries elsewhere indicated only by folds or low ridges on the periphragm; paratabulation ?4', ?3a, 7'', ?c, 5''', 0p, 2''''. Surface of periphragm very irregularly papillate to echinate, the papillae and short spines corresponding in position to nodes on a fine polygonal network (not otherwise expressed). Archaeopyle single-plate intercalary (type I/I), of broad-hexa type and formed by the loss of paraplate 2a." — Lejeune-Carpentier & Sarjeant (1981, p. 18, 19)

Age: Late Cretaceous (late Senonian); holotype as translated from Lejeune-Carpentier (1942, p. B191).



Figures 15–20, Lejeune-Carpentier (1942).

Deflandrea granulata Menéndez, 1965

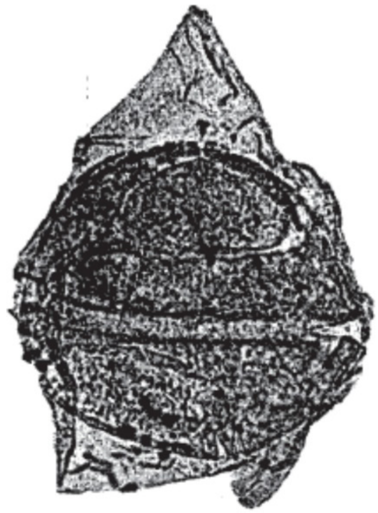
Diagnosis: "Theca broadly fusiform, surface finely granulated or partly prickly. Conical epitheca taller than the hypotheca. Hemispherical hip with two relatively short antapical appendages. Excavated cingulum, very clear, with grainy and spiny awns. Longitudinal groove rectangular in the hypotheca, widening to the antapical appendages. Rounded cyst occupying much of the theca, with a more or less pentagonal opening to round it off, with operculum; 2.5 μ membrane thick coarsely granulated, with papillae isolated in the apical and antapical zone." — Translated from Menéndez (1965, p. 9, 10)

Description: "The shape of the holotype, largely imposed by the rounded cyst, is generally fusiform with a finely granular surface or prickly, especially in the equatorial area where the spines have further development. The epitheca is conspicuously higher than the hypotheca and conical in shape; no opening visible. The hypotheca is hemispherical due to the almost complete occupation of the cyst, it projects two relatively short appendages. The cingulum appears excavated with well-marked boundaries; has a width from 8 to 9 μ, and its marginal edges are grainy or spiny; on the ventral side. The continuity of the cingulum is interrupted by the presence of the longitudinal furrow. The longitudinal sulcus, whose contour is obscured by the strong sculpture of the cyst, can only be seen in the hypotheca and is rectangular in shape with their distal ends flared toward the antapical appendages. The rounded cyst occupies a large part of the theca; measures 90 μ on its transverse axis and 82 μ on the longitudinal axis. On the dorsal side of the apical part, it has an approximately widened pentagonal opening with rounded angles, covered by an operculum. The cyst membrane is 2.5 μ, thick, and has a coarsely granulated surface; towards the apical and antapical zone, the granulation becomes thicker, the membrane thickens and presents isolated papillae. From the apex to the antapical appendages, this specimen measures 130 μ in length and 92 μ in maximum width. At level 1121, the specimens abound of this species, in which the size variation of the cysts themselves ranges from 130 to 157 μ in total height of the theca, and the inner bodies 78 to 101 μ on their transversal axis by 70 to 100 μ on the longitudinal axis." — Translated from Menéndez (1965, p. 9, 10)

Dimensions: "130 μ in length, 92 μ in maximum width; girdle width 8–9 μ; transverse axis of cyst, 90 μ; longitudinal axis, 54 μ." — Translated from Menéndez (1965, p. 9)

Comparison: "There is quite the similarity between this species and *D. fuegiensis*, but the consistency of the cyst and ornamentation of the theca are different. Also, *D. granulata* is similar to *D. phosphoritica* Eisenack, from which it differs by the same characters used to distinguish *D. fuegiensis* from *D. phosphoritica*, with the exception of the ornamentation of the cyst, closest in details to that of *D. phosphoritica*. *D. spinulosa* Albertí (1959), from the Oligocene of Germany, with a character common to *D. granulosa* due to the presence of small spines on the thecal surface, differs principally between other details, for having thorns that border the furrow." — Translated from Menéndez (1965, p. 10)

Age: Late Cretaceous? Holotype as translated from of Menéndez (1965, p. 9), but no precise age given for the interval between 1121–1202 m within a 2000 m core said to span the Late Cretaceous early–Tertiary (Menéndez, 1965, p. 7).



4

Plate 1, figure 4, Menéndez (1965).

Deflandrea guangraoensis Xu Jinli, 1987

Description: “The body has a flat venter. Outer outline is pentagonal, with straight margins and protruding belly. The epitheca is equal to or slightly larger than the hypotheca, triangular shaped, with convex corners. Conical apical horn 8.5–17.6 µm long. Hypotheca trapezoidal. The two antapical horns are far away from each other, and the left antapical horn is slightly large, triangular, pointed at the end, 8–14.7 µm long, the right antapical horn is slightly smaller or a little degenerated, and blunt at the end. Obvious transverse groove. Cingulum 7.5–10.5 µm wide, with wider marginal ridges, protruding on the sides of the cyst. Longitudinal groove is shallow and indistinct. The outer layer should be about 1 µm thick, the surface is evenly-distributed granular, and the contour line is obvious. At the top, the base of the antapical horn and the edge of the transverse groove, the wall is obviously overlaid. It is dark brown. The inner body is wide, because the pentagonal ambitus is close to the same shape. The inner and outer bodies are separated only at the top and base of the horns. Archeopyle often does not detach, intercalary-type, wide, hexagonal, length-to-width ratio is about 0.6.” — Translated from Xu Jinli (1987, p. 150)

Dimensions: “The length is ~73.3–79.2 µm, the width is 64.6–76.3 µm, the inner body is 48.4–57.2 µm long, and the width is 58.6–67.5 µm. The holotype is 76.2 µm in length and 73.3 µm in width, and the inner body is 51.3 µm in length and 61.5 µm in width.” — Translated from Xu Jinli (1987, p. 150, 51)

Discussion: “Compared with this species, the body outline is pentagonal, the legs are protruding, the apex and horns are distinct, and the apex, the base of the antapical horns, and the edge of the transverse groove is obvious almost equal to that of *Subtilisphaera dongyingensis* (Jiabo ,1978) Song & He, 1982. Its two antapical horns are far away from each other, and its abdomen is protruding, which seems to be similar to that of *Deflandrea sibirica* (Vozz., 1963) Lenttin [sic] &Williams, 1976 is similar, but the width of the body of the latter is obviously larger than that of the length, and the cyst is insignificant.” — Translated from Xu Jinli (1987, p. 151)

Age: middle Eocene (early Lutetian) corresponding to the “fourth member of the Shahejie Formation” as translated from Xu Jinli (1987, p. 151). This interval corresponds to between 43 and 45 Ma according to Zi-Ran Jiang et al. (2019, fig. 2).

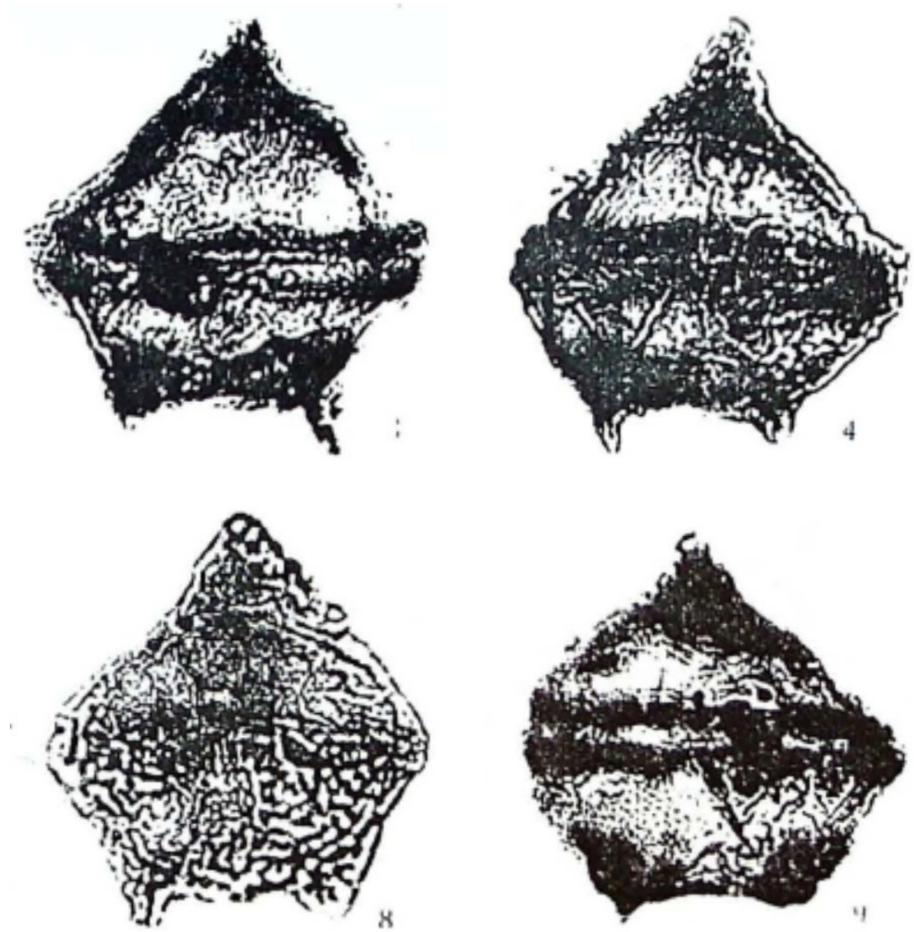


Plate 2, figures 3, 4, 8, 9, Xu Jinli (1987).

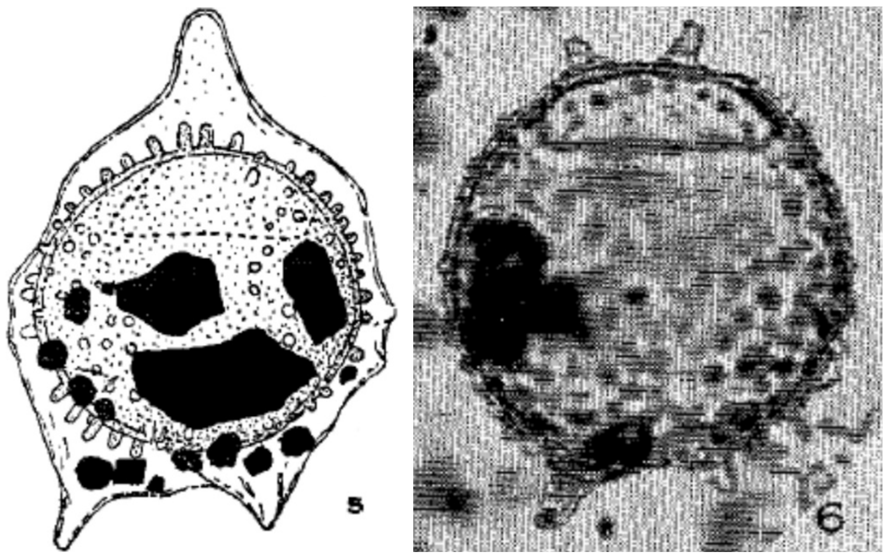
Deflandrea heterophlycta Deflandre & Cookson, 1955

Description: "Epitheca broadly conical with slightly convex flanks and a somewhat rounded, unthickened apex; hypotheca a little smaller than the epitheca and provided with 2 short, blunt, slightly divergent horns. Transverse girdle clear but shallow. Cyst spheroidal, ornamented with irregularly dispersed tubercles more numerous and coarser towards the poles. Cyst membrane finely punctate. Opening laterally extended situated towards the apical pole. Membrane of theca very finely and sparsely punctate."— Deflandre & Cookson (1955, p. 249, 250)

Dimensions: "Total length 115 μ, breadth 80 μ; cyst 70 by 72 μ." — Deflandre & Cookson (1955, p. 250)

Discussion: "The general form of this species recalls *D. phoscphoritica* Eis. but it is clearly distinct in the tuberculate ornamentation of the cyst. This description is based on the single specimen constituting the holotype. However, thanks to the clear information it has supplied, it has been possible to recognize isolated cysts of *D. heterophlycta* in the same material and to study their variations. Some of the cysts are identical with the one still contained in the normal dinoflagellate theca. The one shown in Plate 5, Figure 6, shows a considerable enlargement of some of the polar tubercles, which may attain dimensions of as much as 13 [3?] by 5 μ, but like the smaller tubercles they are always solid and have a granular surface. The wall of the cyst is also very finely and irregularly punctate. All the cysts possess an aperture beneath the apical pole. This is the first time that it has been possible to precisely place in a genus of the Dinoflagellata a microfossil which, as an isolated unit, would perhaps have been classified in the Hystrichosphaeridae. The cyst of *D. heterophlycta* by its morphology could have found a place in the genus *Leiosphaera* Eisenack—a precarious position, however, because in the development of the polar tubercles it would also have approached the genus *Hystrichosphaeridium*. This example shows that we may still hope to improve our knowledge of those microfossils to which an exact systematic position cannot be given and which at present are provisionally relegated to Incertae Sedis." — Deflandre & Cookson (1955, p. 250)

<u>Age</u>: early middle–late Eocene (Ypresian to Lutetian?); holotype of Deflandre & Cookson (1955, p. 249, 300).



Text-figure 5; Plate 5, figure 6, Deflandre & Cookson (1955).

Deflandrea hialina Balteş, 1969 ex Lentin & Williams, 1973

<u>Description</u>: "Cyst of cavate type, length 55–60 microns. Periphragm forming a subspherical or ovoid outer cover. Apical horn practically nonexistent though vaguely outlined in some specimens. Antapical horns forming between their axes a very large angle, in some specimens these even being joined. Periphragm smooth and hyaline. Trapezoidal archeopyle elongated from the base." — Translated from Balteş (1969, p. 34)

<u>Age</u>: Oligocene–early Miocene; holotype as translated from Balteş (1969, p. 34).

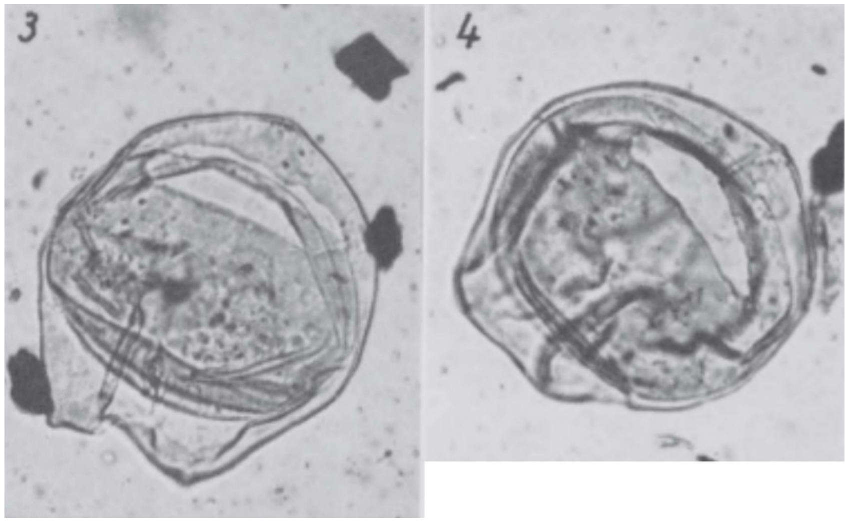


Plate 1, figures 3, 4, Balteş (1969).

Deflandrea intrasphaerula Mao Shaozhi & Norris, 1988

Diagnosis: "Cyst proximate, circumbicavate, two lateral sides strongly convex. On one apical and two antapical sides, horns pointed and moderately developed. Ambital pericoel almost absent or very narrow because of relatively large and spherical endoblast filling most of pericoel. Archeopyle intercalary, type (I), broad hexa 2a; transverse AI 0.74 to 0.80 (holotype 0.75); operculum usually free." — Mao Shaozhi & Norris (1988, p. 43)

Description: "Cyst appearing plump, owing to large spherical endoblast occupying most of pericoel. Ambital pericoel very narrow (less than 4 µm wide) or completely absent. Apical horn bluntly pointed with broad base; two divergent antapical horns typically equal or slightly unequal, triangular in shape. Asymmetric appearance of two antapical horns resulting from specimens not being mounted in dorsoventral direction. Periphragm thin, smooth or finely granulate. Endophragm finely granulate to granulate. Cingulum, where present, indicated by faint low ridges. Sulcus broad, almost reaching the antapex." — Mao Shaozhi & Norris (1988, p. 43)

Dimensions: "Length 85 to 120 µm (holotype 117 µm), width 35 to 78 µm (holotype 76 µm); 25 specimens measured." — Mao Shaozhi & Norris (1988, p. 43)

Discussion: "This species is characterized by a relatively large spherical endoblast that fills most of the pericoel. As a result, the cysts look plump, the ambital pericoels are very narrow (less than 4 µm wide) or even absent, and the antapical pericoel is also reduced. In these features, therefore, *Deflandrea intrasphaerula* sp. nov. differs from *D. phosphoritica* and *D. oebisfeldensis*." — Mao Shaozhi & Norris (1988, p. 43)

Age: late Eocene (Priabonian); holotype of Mao Shaozhi & Norris (1988, p. 43) given as early Oligocene, but the occurrence within the "Bashibulake Formation" corresponds to the more recent age of the unit given by Xi Dangpeng et al. (2020, p. 166).

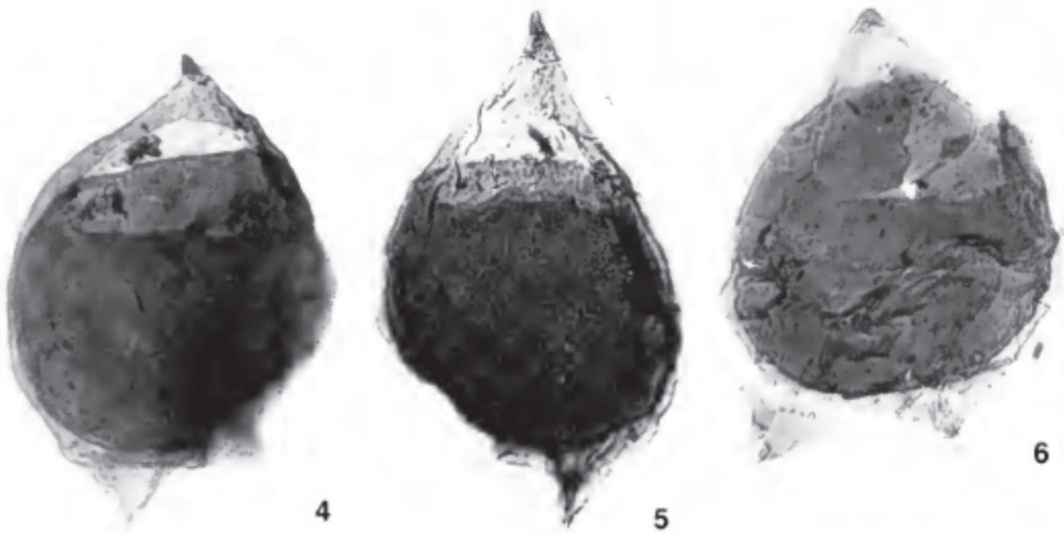


Plate 10, figures 4–6, Mao Shaozhi & Norris (1988).

Deflandrea kashiensis He Chengquan, 1991

Description: “The cyst is small, the abdomen and back are flat, and the outline is round or pentagonal. The epitheca is larger than the hypotheca, nearly right-angled triangle shaped, sides nearly straight, with a short apex, domed conical or triangular, 5-12.5 µm long. The hypotheca is inverted trapezoidal, sides straight or slightly concave, with two caudal horns far apart, subequal, triangular, broad at base, pointed at end, 10–12.5 µm in length. The loins are prominently convex. The transverse groove is located at the widest part of the cyst, shallow, ring-shaped, narrow, 5–5.7 µm wide, and its edge is smooth with fine ridges as the hallmark. Longitudinal groove obvious, long trapezoidal, wide, limited to hypotheca. Thin outer wall, fine granular or flat surface. Smooth, usually fine grained on top and/or antapical horns. The outline of the inner body is the same as that of the main body, oval-round rhombus, wall thin, with regular secondary lamellar structure at contour margins (occasionally along transverse grooves), smooth or microgranular surface; nearly smooth which is nearly in contact with the outer walls except at the corners. Archeopyle outline is rectangular (length 10 µm, 20 µm wide), similar to the archeopyle shape of *Deflandrea leptodermata*. The operculum comes off or adheres to the edge of the archeopyle.” — Translated from He Chengquan (1991, p. 80)

Dimensions: “Cyst length 55–72.5 µm, width 45–63 µm, inner body length 40–47.5µm, width 42.5–61 µm (measured 3 specimens). The holotype is 55 µm in length and 45 µm in width; the inner body is 40 µm in length and 42.5 µm in width; the apical horn is 7.5 µm in length, antapical horn is 10 µm in length, and the width of the transverse groove is 7.5 µm.” — Translated from He Chengquan (1991, p. 80)

Notes: “This species has a small cyst with thin walls, and the edge of the inner body often has a regular layered structure. The inner and outer walls (except the corners), outer almost touching and cross-rectangular archeopyle, etc., which are different from the known species in this genus. Its cysts more or less present features such as the rounded pentagonal ambitus and the lack of conspicuous ornamentation of the distal pole of the antapical horn angle which distinguish it from *Deflandrea bella*.” — Translated from He Chengquan (1991, p. 80)

Age: middle Eocene (Lutetian); holotype from the “Wulagen Formation” as translated from He Chengquan (1991, p. 227) corresponding to the age of the section given by Xuejiao Wang et al. (2022). Range: middle

Eocene (Lutetian)–late Eocene (Priabonian) based on occurrence within the “Wulagen Formation” and “second and third sections of the Bashibulake Formation” as translated from He Chengquan (1991, p. 80) corresponding to the age of the units given by Xuejiao Wang et al. (2022) and Xi Dangpeng et al. (2020, p. 166) respectively.

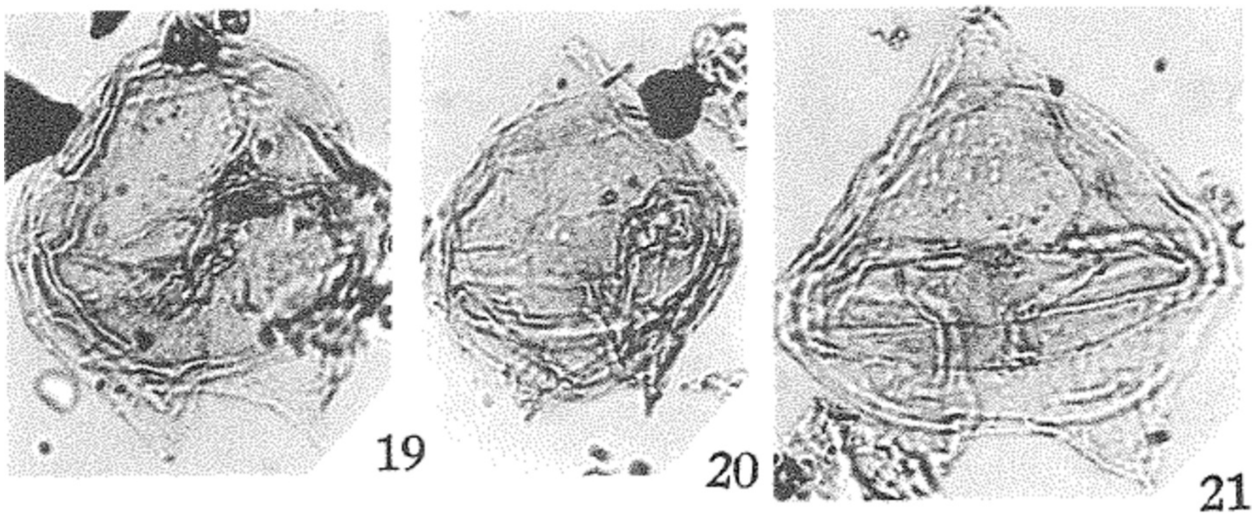


Plate 29, figures 19–21, He Chengquan (1991).

Deflandrea leptodermata Cookson & Eisenack, 1965a

Description: “Shell untabulated, longer than broad with strongly convex sides, a short, blunt apical horn and two short, broad, slightly pointed antapical horns. Girdle usually not indicated. Wall of shell thin, distinctly granular. Capsule large, circular in outline, almost filling the shell, wall very thin and densely granular. Archeopyle usually indistinctly outlined, broader than long, possibly 6-sided. In the specimen shown in Pl. 11, fig. 7 the basal suture of the archeopyle is evident as a fine line crossing the upper part of the shell at a right angle.” — Cookson & Eisenack (1965a, p. 121, 122),

Dimensions: “Holotype—118 μ, long, 92 μ. broad. Range—87–123 μ long, 78–102 μ broad.” — Cookson & Eisenack (1965a, p. 122)

Discussion: “*D. leptodermata* appears to be restricted to the lower portion of the Browns Creek section. It is infrequent in the greensand.” — Cookson & Eisenack (1965a, p. 122)

Age: late Eocene (Priabonian); holotype of Cookson & Eisenack (1965a, p. 121).

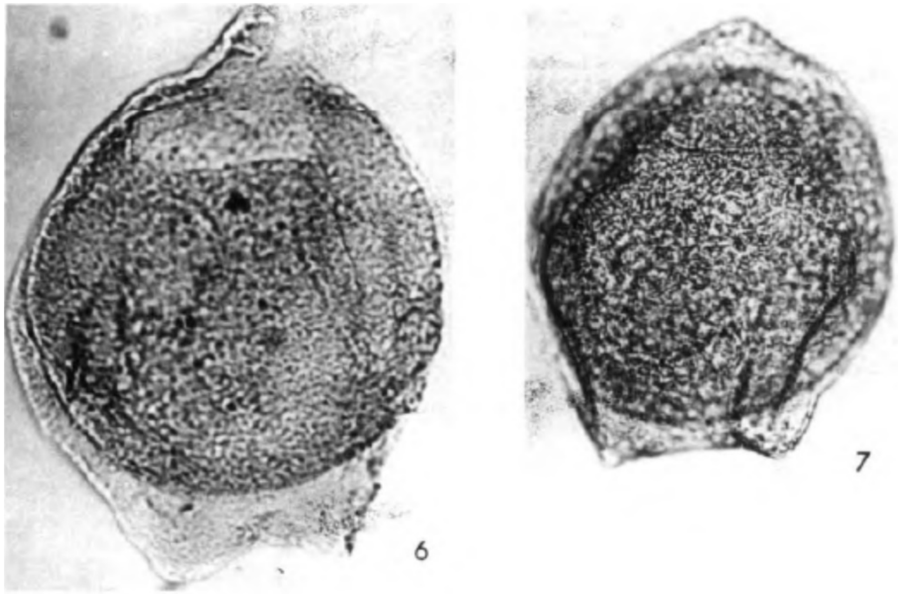


Plate 11, figures 6, 7, Cookson & Eisenack (1965a).

Deflandrea lucyedwardsiae Lucas-Clark, 2006

Diagnosis: "Highly variable small to medium pale peridinioid with medium to long apical horn and two approximately equally developed short to medium antapical horns. Slender, ovoidal, peridinioid shape with varying amounts of granular ornamentation, sometimes incompletely penitabular. Periarcheopyle large and rounded, circular to ovoidal to hexa-euryform, differing from endoarcheopyle and sharing dorsal margin with endoarcheopyle." — Lucas-Clark (2006, p. 193)

Description: "Small to medium, proximate peridiniacean, circumcavate cysts, slightly dorsoventrally compressed, with medium to long apical horn and two short to medium length antapical horns. Antapical horns approximately equal in length. Endocyst circular in outline; endophragm smooth, thicker than periphragm, not appressed to periphragm except along posterior margin of archeopyle, or may be appressed to periphragm in cingular region. Periphragm thin, outline peridinioid or rounded peridinioid, lateral margins convex, antapical margin concave. Surface minutely ornamented with scattered granules that sometimes align to form faint, longitudinal striations and are sometimes partly penitabular or may seem organized into intratabular groups. Granules may be fine or relatively coarse, numerous or sparse. Tabulation indicated by archeopyle, cingulum, and partially where some ornament is penitabular or intratabular indicating the positions of precingular and postcingular plates. Archeopyle type I/I (2a), periarcheopyle nearly circular to ovoidal to rounded hexagonal, rarely angular hexagonal. Endoarcheopyle also circular to rounded hexagonal and sharing its posterior margin with periarcheopyle. Cingulum usually, but not always, indicated by rows of granules or denticles that give it a beaded appearance; sometimes indicated by ridges or folds in the periphragm. Sulcus indicated by break in cingulum and slight depression of the ventral hypocyst. Accumulation bodies sometimes present." — Lucas-Clark (2006, p. 193)

Dimensions: "Length, 50–85 µm; width, 35–50 µm (10 specimens measured)." — Lucas-Clark (2006, p. 193)

Remarks: "The generic assignment is consistent with the limitations indicated by Lentin and Williams (1976) in that the species exhibits antapical horns of approximately equal length and a broad pseudoquadra to broad hexa intercalary archeopyle. The archeopyle is similar to that of *Deflandrea phosphoritica* in that the endoarcheopyle and periarcheopyle share a posterior edge (W. R. Evitt, oral communication, 2004).

This species is abundant in the Paleocene of the Savannah River Site and in other parts of South Carolina and Georgia. It exhibits a wide range of intraspecific, gradational variation; the shape may be more rounded than the holotype, horns can be shorter, and the archeopyle rarely more angular. Surface ornamentation is variable so that the cyst may seem granular or almost smooth. The similarity of this species to others that have different geologic ranges suggests the possibility of a lineage starting with *Deflandrea severnensis* in the latest Cretaceous, to *Spinidinium pulchrum* in the earliest Paleocene, to *Deflandrea lucyedwardsiae* sp. nov. in the Paleocene, to *Cerodinium depressum* in the early Eocene. If this is the case, the generic taxonomy is apparently artificial, and may need to be revised for the small peridinioids in general." — Lucas-Clark (2006, p. 193, 194)

Comparison: "*Deflandrea lucyedwardsiae* sp. nov. resembles *Spinidinium pulchrum* but has a distinctly different archeopyle; *Spinidinium pulchrum* has an angular archeopyle which either includes the dorsal precingular plate or has accessory sutures that extend along the edges of this precingular plate. *Spindinium pulchrum* also has more definitely intratabular to penitabular, spinose ornamentation, and has a reduced right antapical horn. *Deflandrea lucyedwardsiae* sp. nov. also resembles *Deflandrea severnensis*, which has much more reduced horns, a less rounded overall shape, and an angular archeopyle, probably not sharing a posterior margin with the endoarcheopyle. *Cerodinium depressum* has an endocyst that is wider than long, and has pronounced striae across the cingular area. *Senegalinium microgranulatum* has a granular endocyst and smooth periphragm with no traces of tabulation on the periphragm." — Lucas-Clark (2006, p. 194)

Age: Paleocene (Danian?); holotype from Savanah River Site core LFW-10SB at 37.26 m (Lucas-Clark, 2006, p. 192). Range: Paleocene (Danian–Thanetian) (Lucas-Clark, 2006, p. 194, text-figure 2).

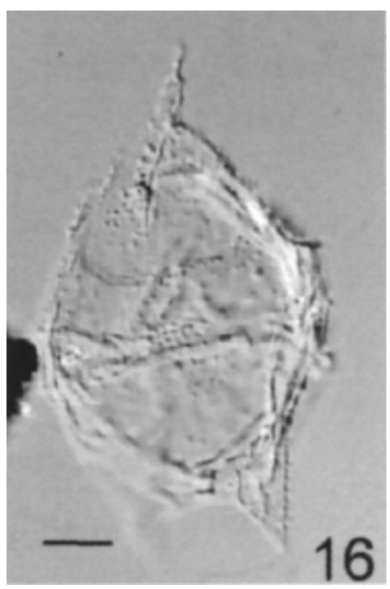
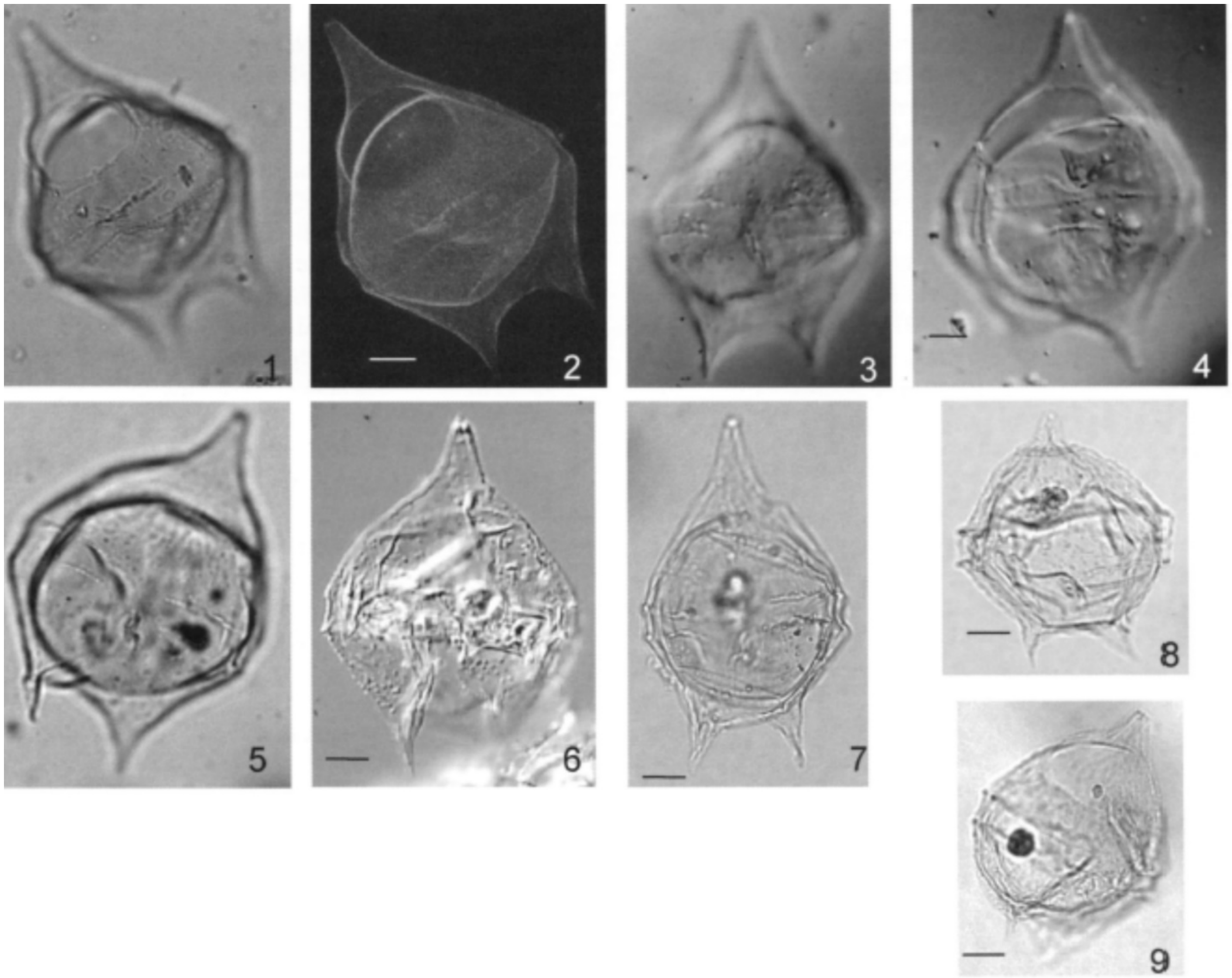


Plate 1, figure 16, Lucas-Clark (2006). Scale bar = 10 μm.



Plates 2, figures 1–9, Lucas-Clark (2006). Scale bar = 10 μm.

Deflandrea majae (Schiøler, 1993) Fensome et al. 2016

Diagnosis: “A cavate peridinioid cyst with a smooth endo- and periphragm without indications of paracingulum. The ambitus shows overall axial symmetry. The periarcheopyle is lati-deltaform.” — Schiøler (1993, p. 108)

Description: “Cavate peridinioid cyst. Cyst outline is almost bilateral symmetric in ambital view. The periphragm is smooth and has a broad-based rounded to acute apical horn and two acute to broad rounded antapical horns. The epicyst lacks shoulders, and has a concave margin. The area between the antapical horns has a moderately concave curvature. The endophragm is smooth and subcircular to oval in ambital view. The peri- and endophragm are often in contact laterally. The archaeopyle type is I(2) and is lati-deltaform with Transversal Archaeopyle Index (TAl) c. 0.70. The paracingulum is not indicated. The parasulcus is often indicated by a longitudal [sic] fold in the periphragm. Apart from the archaeopyle and the parasulcus no other paratabulation is present.” — Schiøler (1993, p. 108)

Dimensions: “(in μm) Holotype: length of pericyst 96, width of pericyst 61, length of endophragm 55, width of endophragm 55. Range: length of pericyst, 87 (95) 104; width of pericyst 55 (61) 73; length of endophragm 55 (58) 61; width of endophragm 52 (58) 64. Specimens measured: 12.” — Schiøler (1993, p. 108)

Remarks: "*Isabelidinium majae* sp. nov. differs from all other species of *Isabelidinium* by being almost axially symmetrical and having a lati-deltaform periarchaeopyle with a TAI considerably higher than 0.5. These characters are typical of the genus *Deflandrea* Eisenack 1938 emend. Lentin and Williams 1978, but as the new species lacks any signs of a paracingulum, referral to the latter genus is precluded. *lsabelidinium cooksoniae* (Alberti 1959) Lentin and Williams 1977 differs from the new species in having shoulders or at least a convex epicystal outline, a reduced right antapical horn, and a thetaform to omegaform archaeopyle. *Isabelidinium glabrum* (Cookson and Eisenack 1969) Lentin & Williams 1977 differs in having an almost biconical ambitus, and a TAI around 0.46 as well as a reduced right antapical horn. *Isabelidinium bakeri* (Deflandre and Cookson 1955) Lentin and Williams 1977 lacks a pronounced left antapical horn, but differs from *I. majae* sp. nov. in being widely fusiform, and having a narrow archaeopyle with a TAI around 0.44. *Isabelidinium pelucidum* (Deflandre and Cookson 1955) Lentin and Williams 1977 has an elongate ovale [sic] ambitus and a distinct hexagonal archaeopyle. *Isabelidinium belfastense* (Cookson & Eisenack 1961) Lentin & Williams 1977 and *lsabelidinium greenense* Marshall 1990 differs from the new species in archaeopyle-shape and in having antapical horns of different size. *I. belfastense* furthermore differs in having distinct apical and antapical granulation on the pericyst, and *I. greenense* has abundant fine perforations surrounding the horns. *Manumiella*? *cretacea* (Cookson 1956) Bujak & Davies 1983 is smaller than *I. majae* sp. nov. and has an almost circular ambitus and a TAI around 0.38. Camera lucida tracings of the ambital outline of the new species are shown in text-fig. 4." — Schiøler (1993, p. 110)

Remarks: "Schiøler (1993) noted that this species has a latideltaform archaeopyle with a transverse archaeopyle index (TAI) considerably higher than 0.5. Schiøler (1993, p. 110) stated that although these characters are '… typical of the genus *Deflandrea* … as the new species lacks any signs of a paracingulum, referral to the latter genus is precluded'. In our view, archaeopyle shape is critical in diagnosing *Deflandrea* and similar genera and that the presence or absence of a cingulum is not significant. Therefore, this species is transferred herein to *Deflandrea*. However, M. Pearce (personal communication 2015) has pointed out that the archaeopyles of specimens otherwise attributable to this species show a wide variation in archaeopyle shape. For example, he has observed specimens of *Deflandrea majae* with stenodeltaform archaeopyles; we would recommend that such forms be included in another genus. As noted under *Alterbidinium*, a detailed re-evaluation of archaeopyle shapes in *Deflandrea* and similar genera in relation to the taxonomy of the group is clearly needed but beyond the scope of the present work." Fensome et al. (2016, p. 41)

Age: Late Cretaceous (latest Maastrichtian); holotype of Schiøler (1993, p. 108).

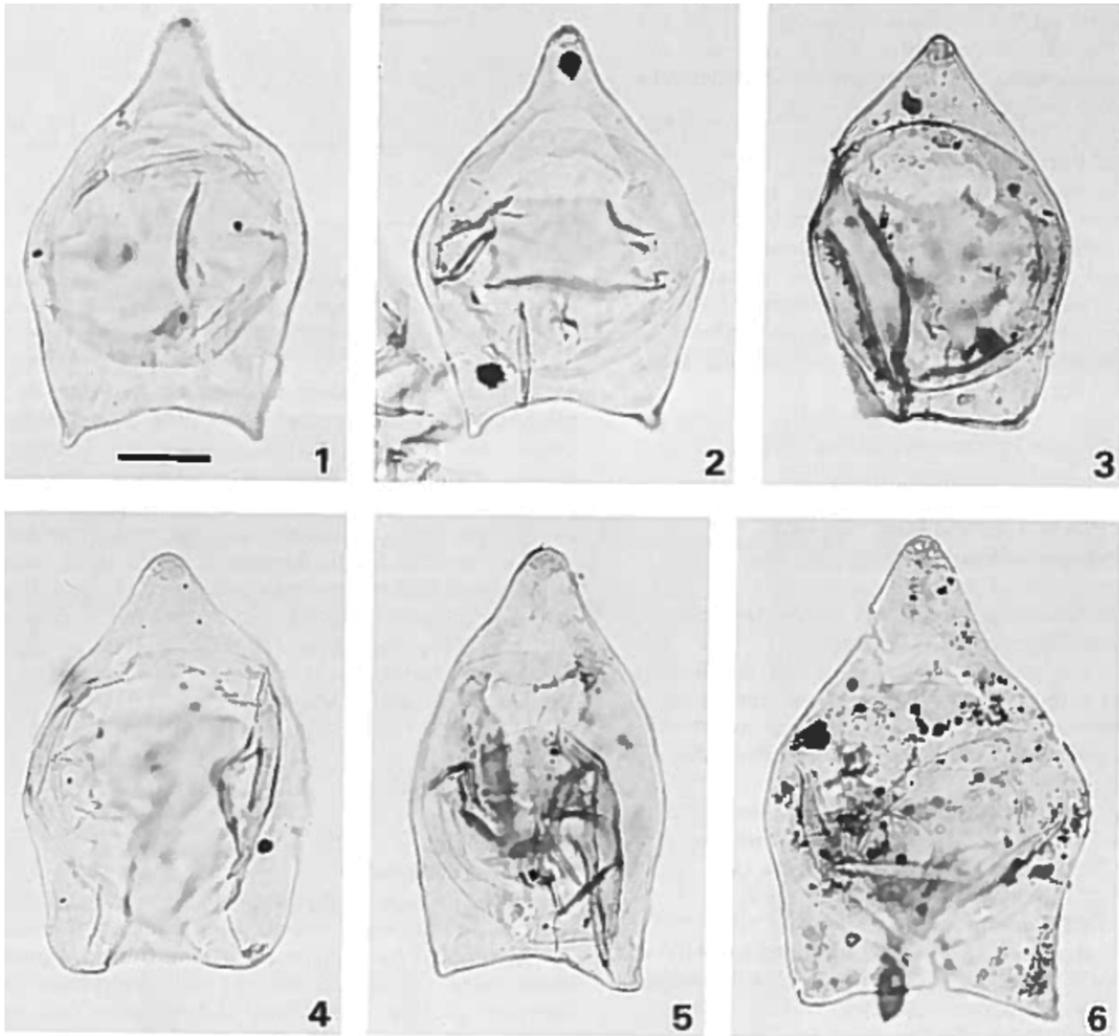


Plate 1, figures 1–6; Text-figures 4a–h, Schiøler (1993). Scale bar = 20 μm.

Plate 6, figure 2, Fensome et al. (2016). Scale bar = 20 μm.

Deflandrea musculopsis Mao Shaozhi & Norris, 1988

Diagnosis: “Cyst proximate, circumcavate to cornucavate, small in size (less than 70 µm). Ambitus rounded, pentagonal, with apical horn and two small antapical horns. Endoblast spherical to subspherical, relatively large, occupying major portion of pericoel. Wall thin and smooth. Archeopyle intercalary, type (I), broad hexa 2a; transverse AI 0.6 to 0.7 (holotype 0.63). Operculum free.” — Mao Shaozhi & Norris (1988, p. 43, 44)

Description: “Cyst small, length usually less than 60 µm. Apical horn blunt or rounded, usually with broad base, 6 to 11 µm long, 6 to 18 µm wide at base. Two antapical horns small (2 to 5 µm long, 3 to 6 µm wide at their bases), equal or slightly unequal, with left one bigger. Periphragm smooth or finely granulate; endophragm smooth, thin, with many longitudinal folds. Ambital pericoel very narrow (0 to 2.5 µm wide) because of relatively large spherical to subspherical endoblast filling large portion of pericoel. Cingulum 4 to 6 µm wide, delimited by folds or low ridges, planar or slightly levorotatory. Indications of tabulation other than archeopyle and cingulum absent. Omphalos often found near junction of cingulum and sulcus, spherical to subspherical in shape, readily stained, darker colour than adjacent wall.” — Mao Shaozhi & Norris (1988, p. 44)

Dimensions: “Length 45 to 67.5 µm (holotype 57 µm), width 31 to 54 µm (holotype 41 µm); 45 specimens measured (see Text-Fig. 14).” — Mao Shaozhi & Norris (1988, p. 44)

Discussion: “On the basis of its small size (usually less than 60 µm) and its thin and almost smooth wall, this species can be distinguished from all other species of *Deflandrea*, with the exception of *D. psilata*, which has a circumcavate cyst with oval endoblast and broad ambital pericoel, and a standard hexa (I) archeopyle. *D. musculopsis* is closely comparable to *Senegalinium microgranulatum* and *Subtilisphaera venthosa*. It differs from *Senegalinium microgranulatum* in the combination of the following features: (1) the wall is smooth rather than granulate; (2) the ambital pericoel is always weakly developed instead of absent; (3) the archeopyle is broad hexa style rather than standard hexa style. *Subtilisphaera ventriosa* has no indication of an archeopyle. *D. musculopsis* is also similar to *Phelodinium pumilum*; however, the latter species has a very thin and transparent periphragm and an intercalary archeopyle 2a typically with the antapical margin close to the cingulum.” — Mao Shaozhi & Norris (1988, p. 44)

Age: middle Eocene (Lutetian); holotype of Mao Shaozhi & Norris (1988, p. 43) corresponding to the “Wulagen Formation” given the age of the unit presented by Xuejiao Wang et al. (2022). Range: late Paleocene (Thanetian)–middle Eocene (Lutetian) corresponding to the ages of the “Qimgen Formation” and “Wulagen Formation” provided by Xi Dangpeng et al. (2020, fig. 12) and Xuejiao Wang et al. (2022) respectively.

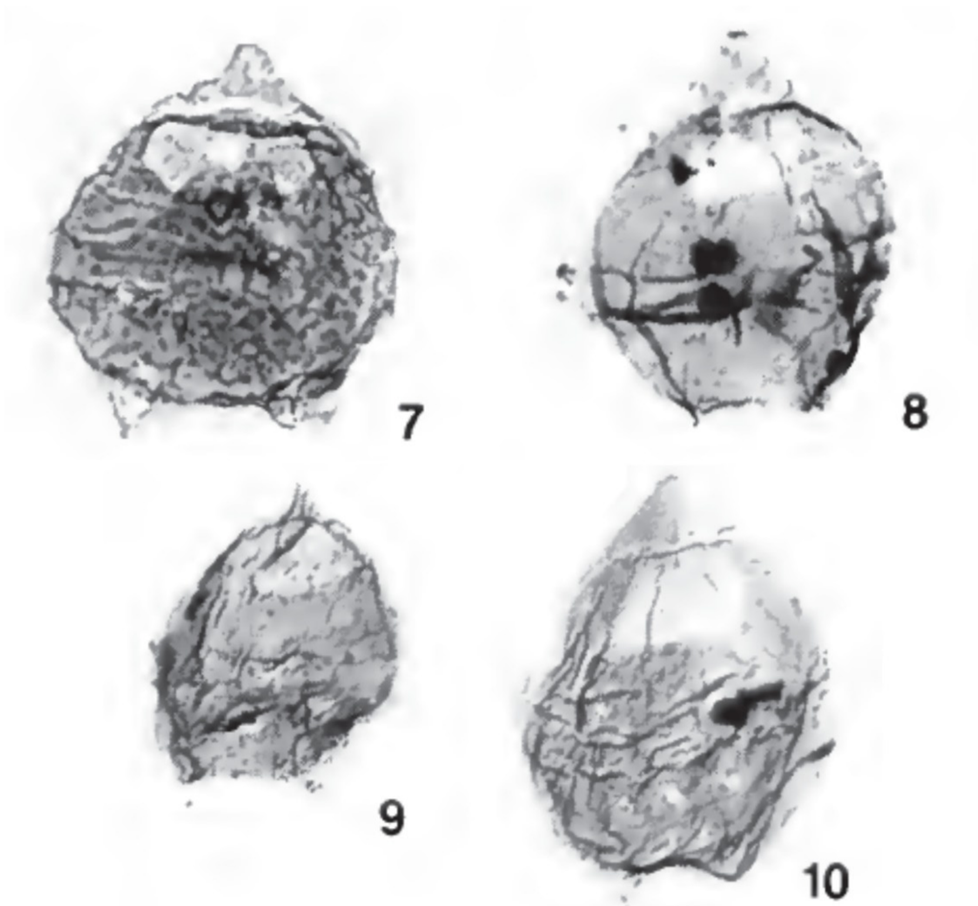


Plate 10, figures 7–10, Mao Shaozhi & Norris (1988).

Deflandrea oebisfeldensis subsp. ***angustata*** (Vozzhennikova, 1967) Lentin & Williams, 1973

Description: “Theca oval pentagonal with slightly projecting lateral angles, sometimes barely discernible. Epitheca triangular with convex, almost uniformly thickened lateral walls which taper sharply to a conical apical horn, or begin by tapering gradually and then narrow rapidly to give finger-like apical process. Hypotheca trapeziform with slightly concave lateral walls, an uneven posterior margin and two short acutel [sic] pointed antapical horns which stick out in opposite directions. Transverse furrow shallow, annulate. The narrow longitudinal furrow runs across the ventral side of the hypotheca from the ends of the transverse furrow to the antapex. Internal body oval, its surface coarsely granular. Surface of theca granular with widely separated short spines. Pylome trapeziform.” — Vozzhennikova (1967, p. 228, translation: Lees & Sarjeant, 1971)

Dimensions: “(in microns) Holotype, length of theca 162, breadth 108, width of transverse furrow 8, length of internal body 72.9, breadth 73.9. Other specimens: length of theca 153.9, breadth 94.5, width of transverse furrow about 10, length of internal body 72.9, width 81.0.” — Vozzhennikova (1967, p. 228, translation: Lees & Sarjeant, 1971)

Comparison: “This form differs from others of the species in having a sharply tapering apical part of the theca, a narrow apical horn and short, divergent acutely pointed antapical horns.” — Vozzhennikova (1967, p. 228, translation: Lees & Sarjeant, 1971)

Age: Eocene; holotype and range of Vozzhennikova (1967, p. 227, 228, translation: Lees & Sarjeant, 1971).

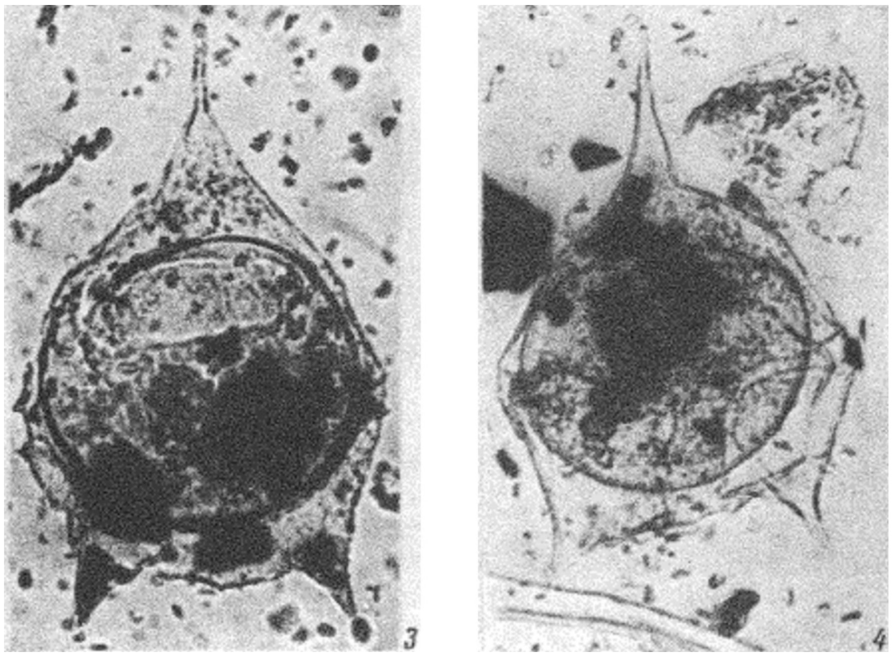


Plate 72, figures 3–4, Vozzhennikova (1967).

Deflandrea oebisfeldensis subsp. ***longicornis*** He Chengquan, 1991

Description: “The venter and dorsum of the cyst are flat, the outline is elongated and pentagonal, and the inner body is subcircular. Epitheca inverted funnel-shaped, at the base of the apex. The two sides are more or less ‘shouldered’, the apical horn is longer (about 37.5 μm), and it is conical. The hypotheca is trapezoidal, with slightly concave sides and nearly straight, flat bottom with two long caudal horns, nearly equal in size, conical, 50 μm long (measured from endosome side), roughly parallel to each other, and quite far apart (65 μm). The waist is relatively round, without obvious side convex. The girdle is at the equator, ring-shaped, 7.5 μm wide, and its edge is decorated with thin ridges. The longitudinal groove is limited to the hypotheca, and the outline is vague. The surface of the outer wall is fine-grained and wrinkled. The inner body is ovate, and the surface has no obvious ornamentation. It is clearly separated from the outer wall. Archeopyle style, oval outline, wider than long. The operculum adheres to the edge of the archeopyle.” — Translated from He Chengquan (1991, p. 81, 82)

Dimensions: “Cyst length 150–152 μm, width 80–85 μm, inner body length 67 μm, width 70–80 μm (2 specimens measured); positive. The holotype is 152 μm long and 80 μm wide, and the inner body is 55 μm long and 70 μm wide.” — Translated from He Chengquan (1991, p. 82)

Comparison: “Comparing this subspecies with *Deflandrea oebisfeldensis* in terms of its long antapical horns and no spine-like ornamentation on the outer wall surface sees subsp. *angustata* as different.” — Translated from He Chengquan (1991, p. 82)

Age: late Paleocene (Thanetian); holotype corresponding to the “lower part of the Qimgen Formation” as translated from He Chengquan (1991, p. 227). Range: late Paleocene (Thanetian)–late Eocene (Priabonian) corresponding to the “Qimgen Formation” and “lower Bashibulake Formation” as translated from He

Chengquan (1991, p. 82) given the ages of the units presented by Xi Dangpeng et al. (2020, p. 166) and Xuejiao Wang et al. (2022) respectively.

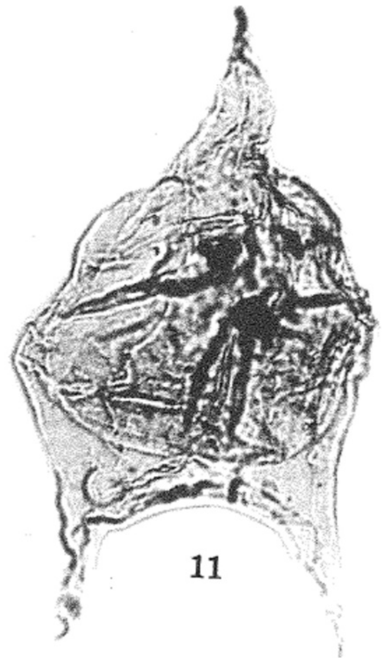


Plate 31, figure 11, He Chengquan (1991).

Deflandrea oebisfeldensis subsp. ***oebisfeldensis*** Alberti, 1959

Diagnosis: "Cyst flattened, its outline elongated pentagonal. The epitheca, slightly larger than the hypotheca forms an acute to right triangle. Cyst margins are sometimes slightly in or out. Epitheca into a short apical horn moved out. Hypotheca an approximately isosceles inverted trapezium whose antapical boundary is slightly incurved. With two very small antapical horns. Lateral horns only indicated, ± notched at the tip. Narrow transverse band on the dorsal and flanks of the ventral side, broad longitudinal furrow on the hypotheca. Cyst smooth, rarely covered with a few very small thorns. Inner body with tough membrane." — Translated from Alberti (1959, p. 95)

Differential Diagnosis: "Differs from *Defl. bakeri* Defl. & Cooks. in relation to the length much broader forms, the larger dimensions, the formation of the hypotheca and the possession of a longitudinal furrow." — Translated from Alberti (1959, p. 96)

Additions: "The antapical horns can be deducted from the hypotheca and in some forms, the lateral margins of the epitheca are somewhat incurved, in others they are bent out. The latter are usually wider, in extreme cases the width of the cyst is the same as its length. Below the apex lies an archeopyle similar to that of *Defl. phosphoritica*. The inner body has a slightly granulated membrane, which at no point touches the outer edge of cyst." — Translated from Alberti (1959, p. 96)

Dimensions: "Holotype: length 150 μ, width 88 μ. Length of a second specimen 126 μ width 98 μ. Length of a third specimen 125 μ, width 94 μ. For other specimens, the length varies between 115 μ and 150 μ, the width between 86 μ and 104 μ. Over 20 specimens." — Translated from Alberti (1959, p. 96)

Age: early Eocene (Ypresian); holotype as translated from Alberti (1959, p. 95). Range: Paleocene–early

Eocene (Alberti, 1959, p. 95, 96).

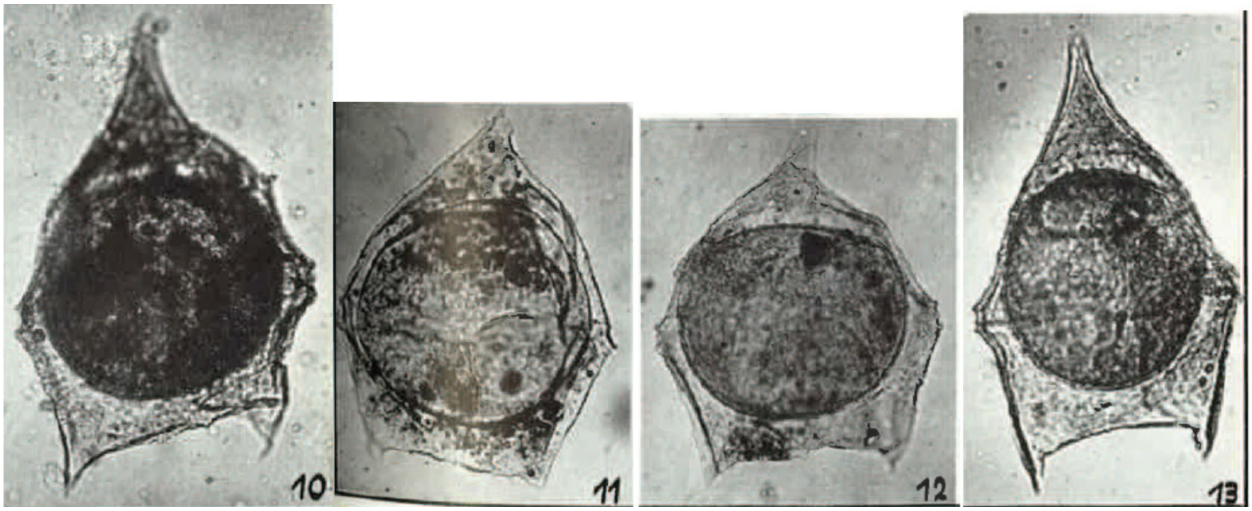


Plate 8, figures 10–13, Alberti (1959).

?*Deflandrea pachycera* Deflandre & Cookson, 1955

Description: "Cell encysted, polygonal with a shallow transverse girdle, epitheca and hypotheca about equal. Epitheca widely conical, terminated by a slightly truncate apex; hypotheca provided with 2 strong, somewhat divergent, conical horns with straight or slightly concave sides and blunt apices. Cyst ellipsoidal, tending in the type (Plate 4, Fig. 7) to protrude towards the apex. Membrane of theca entirely covered with small spines or warts." — Deflandre & Cookson (1955, p. 252)

Dimensions: "Length 89 μ, breadth (56) 64 μ. The lateral position in which the holotype is lying reduces its breadth (56 μ)." — Deflandre & Cookson (1955, p. 252)

Age: early Eocene (Ypresian); holotype of Deflandre & Cookson (1955, p. 252).

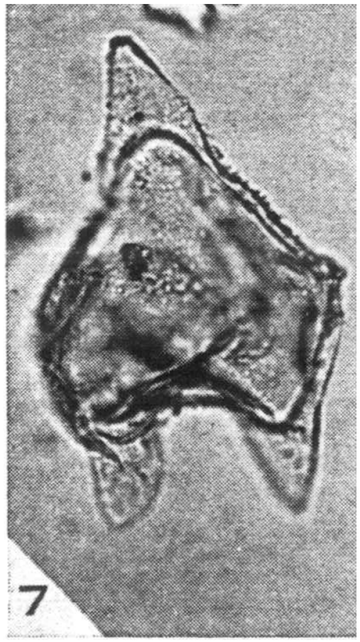


Plate 4, figure 7, Deflandre & Cookson (1955).

?*Deflandrea papillata* Oleinik, 1975

Description: “Theca is oval with relatively weakly developed horny protrusions. The epitheca is larger than the hypotheca, with slightly convex lateral sides, with a rather large apical horn cut at the distal end. Apical horn ends in a small nipple. Hypotheca trapezoidal, lateral sides straight or slightly concave, antapical margin straight. Antapical horns small, close to each other. Lateral horns are not developed. Transverse furrow quadrilateral, shallow, well visible on the ventral side of the theca and its sides. A longitudinal furrow was not observed. The inner body is ovoid, relatively thick-walled, densely adjacent to the lateral sides of the theca. The surface of the theca is smooth, internal body is granular. Archeopyle elliptical.” — Translated from Oleinik (1975, p. 227)

Dimensions: “Holotype: theca length 109, width 65.7, length: inner body 75, width 60, length of apical horn 20.5, papilla length 2.85, length of antapical horns 7.6 and 12.4, width of the transverse furrow 7.05. Other specimen dimensions: theca length 120, width 75, inner body length 65.1–84.3, its width 70–75, length of apical horn 22.3–33.4, papilla length 3–4.6., length of antapical horns 12.1–18.9, width of the transverse furrow 5.1–7.6.” — Translated from Oleinik (1975, p. 227)

Comparison: “It differs from other species of the genus in the shape of the apical horn with papilla and poorly developed antapical horns. The species *D. endopapilata* Archang. is most similar to our species from the Eocene of Argentina. The difference is that the described species has an ovoid body, not a round one, the dimensions of our species are smaller, and according to the surface of the inner body which is more densely granular.” — Translated from Oleinik (1975, p. 227)

Age: late Eocene (Priabonian); holotype as translated from Oleinik (1975, p. 226, 227).

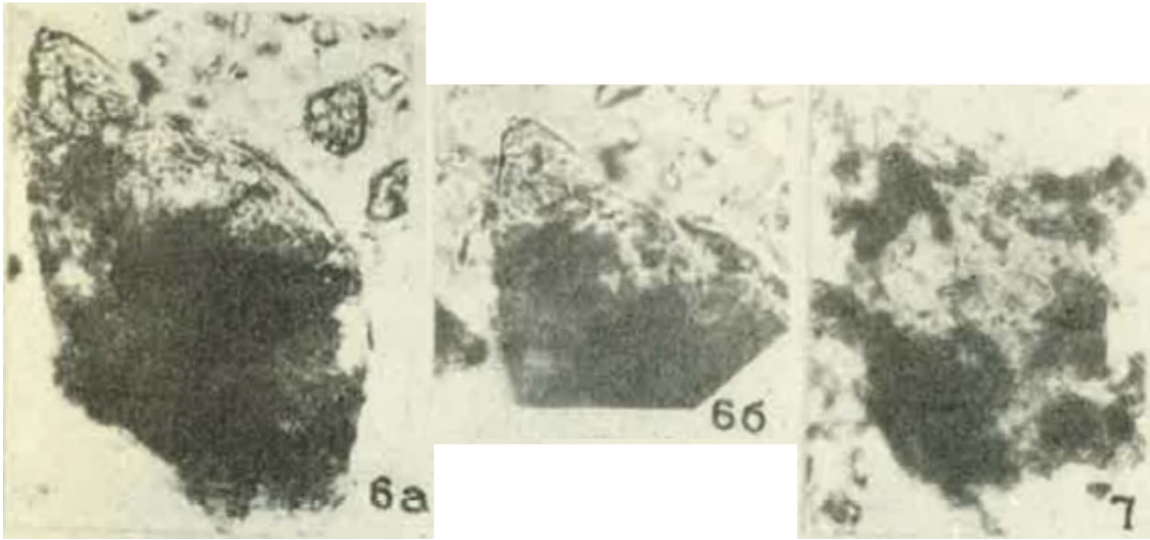


Plate 1, figures 6a, b, 7, Oleinik (1975).

Deflandrea phosphoritica subsp. ***australis*** Cookson & Eisenack, 1961b

Description: "Specimens which differ in certain constant characters from typical examples of *D. phosphoritica* are not uncommon in the Rottnest deposit between 1,480 and 1,541 feet. However, these features do not seem of sufficient importance for specific separation. A new subspecies is therefore proposed for them on the basis of the following differences from the type: (a) the theca is proportionally longer and narrower: (b) the outer membrane is more closely and coarsely granular especially in the apical and antapical regions; (c) the horns are more sharply pointed: (d) the apical horn is surmounted by a well-defined solid cylindrical process: (e) the longitudinal furrow is more clearly marked and can be traced downwards from the lower borders of the girdle. The left hand ridge sometimes being straighter than the right hand one." — Cookson & Eisenack (1961b, p. 39, 40)

Dimensions: "Type length 146 μ, breadth 94 μ, internal body 71 × 80 μ. Range: 105–146 μ, breadth 83–102 μ." — Cookson & Eisenack (1961b, p. 40)

Age: early Tertiary based on the age estimate of the assemblage (Cookson & Eisenack, 1961b, p. 39).

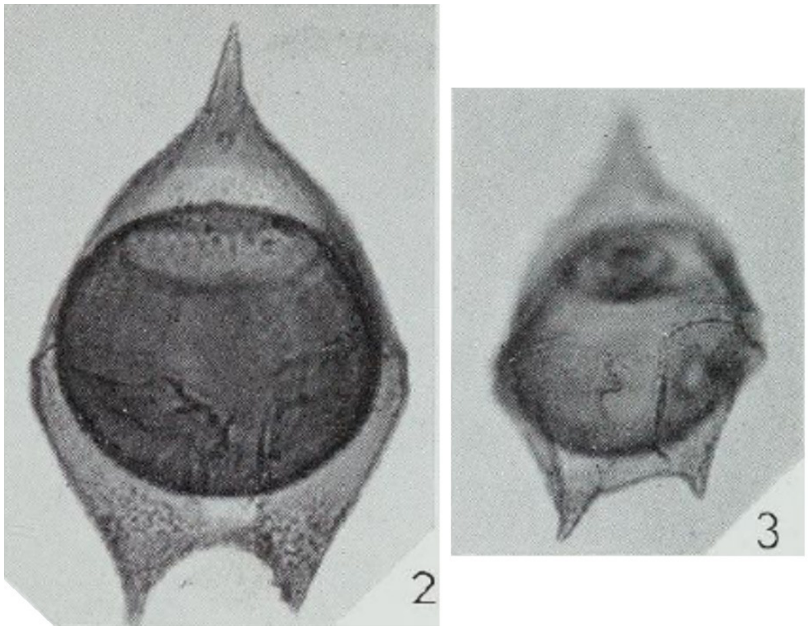


Plate 1, figures 2, 3, Cookson & Eisenack (1961b).

Deflandrea phosphoritica subsp. ***phosphoritica*** Eisenack, 1938

<u>Description</u>: “The first of these three types were discovered by O. Wetzel in 1935 in the Eocene siliceous clays of Holstein, but was not named at the time. Upon my communication to their discoverer of their occurrence in the Blue Earth of Samland, she marked my request for a name with O. Wetzel *Paleoperidinium articulatum* and named the bristle dress and their powerful, almost ‘limb-like’ body projections as characteristic features.” — Translated from Eisenack (1938, p. 187)

<u>Dimensions</u>: “Type specimen: 116 × 90 µ. The length varies between 95 and 128 µ, the width between 75 and 100 µ, on average (32 specimens) 108 × 84 µ; an oversized specimen also measured 152 ×105 µ.” — Translated from Eisenack (1954, p. 53)

<u>Diagnosis</u>: “Body somewhat flattened in outline an elongated bilaterally symmetrical pentagon, whose unpaired side is strongly retracted. An apical horn and two antapicals of almost the same size stand out, while the lateral horns represent only obtuse, loping angles, which at their apex are indented. Cyst crystal clear, isotropic, without tabulation, on the front with a fairly wide, slightly deepened transverse (girdle) band, which is the equivalent of the transverse furrow, located slightly below the equator. Oval fissure as an opening on the back, between the antapical horns. Inside a spherical one, capsule in which the apical calotte is mostly absent.” — Translated from Eisenack (1954, p. 53)

<u>Discussion and description</u>: “The assignment of this species to *Peridinium* by Pastiels is untenable. Three important differences speak against it: the smooth and crystal-clear cyst shows no tabulation. A pronounced transverse furrow with enclosing ridges running down the body on either side surrounds—a characteristic almost always present in *Peridinium*—is not present, nor is there a longitudinal furrow. The spherical central body, as will be explained in more detail below, is not a temporary existing cyst, but it is never absent here and is therefore a characteristic of the genus. The opening proves this, as does its presence in all (and not a few) individuals examined. However, the unmistakable peridineene-like shape assigns our species to the dinoflagellates. The external extensive similarity with *Peridinium galeatum* Lejeune-Carpentier underlines this affiliation. Compare also *Peridinium divergens* Ehrenb. (recent) with a very similar shape and a similar flagellar cleft, which is often illustrated (e.g. in Doflein-Reichenow

1927/28, p. 138, fig. 173).

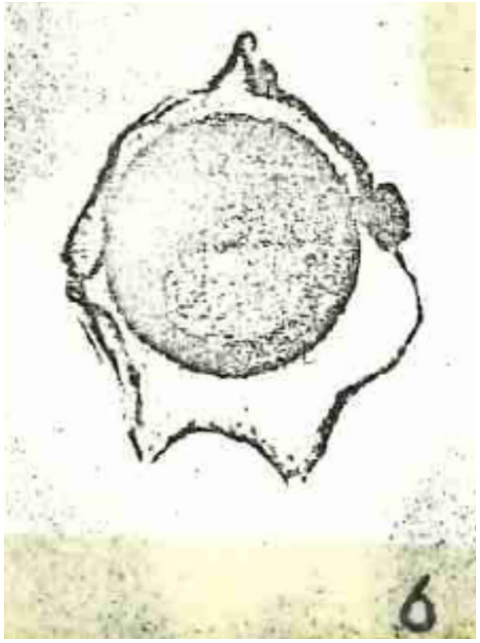
The cyst does not have a pronounced transverse furrow (cf. on the other hand Pastiels, p. 50), but as an equivalent furnishing, firstly the notching on both sides of the side horns, which are only indicated, and secondly, the broad, horizontal, slightly recessed transverse fascia located on the front. The equivalent of a longitudinal furrow is, however, in a fairly parallel limited opening on the back of the cyst between the antapical horns, which occurs in all well-preserved specimens. That opening, apparently a scourge gap, but does not reach into the central part of the cyst, which is dominated by the inner sphere above.

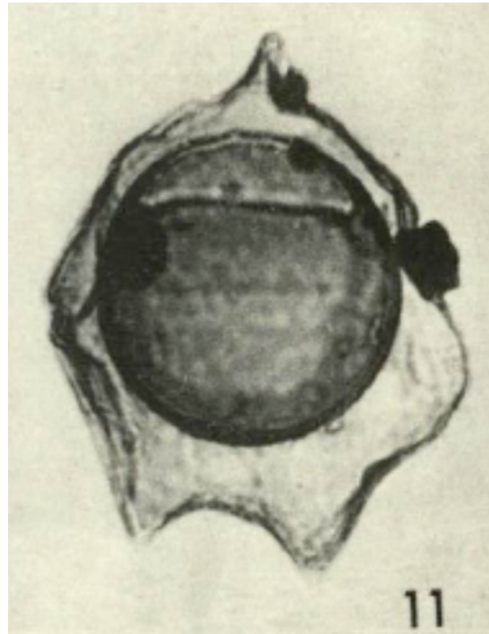
In contrast to the smooth and transparent carapace, the inner sphere is always darker reddish brown (obviously also thicker) and slightly granulated. Nevertheless, it remains transparent enough to contain other content bodies to be recognized (cf. p. 84). A lack of this capsule was never observed. On some specimens it is complete. In the vast majority of cases, however, the apical calotte is absent. There are also some cases in which the sphere is still complete but has a circular crack, which separates the top cap from the base. This crack or the edge of the permanent part of the sphere, although not completely smooth, it always lies in one plane, perpendicular to the longitudinal axis, and always at the same height. With specimens lying at an angle, you can see well into the opening. In a few cases, the whole is not missing the cap but only the front half, and the ball is complete on the back; seen from the side then the sphere has a cross-section as shown in Fig. 1. Apparently, this pylom was a hatch for the contents of the ball, which means that by lifting the cap opens. The fact that the inner sphere opens up inside the cyst is proof that it is an integrating one that was part of the overall skeleton and does not represent a temporary condition.

One wonders how the protoplast slipping out of the sphere could also leave the carapace. That too can be answered. The cysts with missing apical calotte (and only these) have open the front (the belt side) an opening, the lower edge of which runs exactly at the level of the edge of the ball, while the side margins draw upwards on the flanks, but still on the front; the upper margin traverses the front horizontally slightly below the apical tip. The type specimen also has this opening, which, due to the transparency of the cyst, is hardly visible in the photographic reproduction to recognize it. It also escapes visual inspection at first and only reveals itself with careful observation. Cysts also occur whose apical part is completely absent (cf. Plate 12 fig. 8). The regularity of this phenomenon speaks clearly against accidental damage.

A few numbers may underline what has been said: 65 specimens have been prepared. Of 56 specimens, 11 had the complete inner sphere, 4 of which were intact, while 7 specimens had the spherical cap through separated from the lower part by a crack and in one case it was already somewhat lifted off. In 45 specimens, the inner sphere was opened, so the contents hatched out, in the case of 36 specimens by lifting off the whole calotte, while in 9 examples only half the calotte was missing; so, the bullet was just after one side opened. Remarkably, the copies illustrated by Reissinger and by Klumpp are missing likewise the apical calottes of the inner spheres. Thus, the open cysts predominate, mainly empty, abandoned cysts have been embedded." — Translated from Eisenack (1954, p. 53, 54)

<ins>Age</ins>: Eocene; holotype as translated from Eisenack (1938, p. 187).





Text-figure 6, Eisenack (1938); Plate 9, figure 11 (not Plate 9, figure 8 as indicated in Eisenack, 1954, noted by Fensome et al., 2019).

Deflandrea phosphoritica subsp. ***vozzhennikovae*** Grigorovich, 1972

Description: “The theca is slightly extended along the longitudinal axis with a convex, large apical horn. Epitheca with obtuse-angled (shoulders) with antapical ending, forming two small, rounded horns. The transverse groove is annular, dividing the cyst into two equal halves. On the lateral sides, it forms serrations. The internal body is spherical, somewhat compressed along the vertical axis. Surface is grainy. Color of theca is light yellow.” — Translated from Grigorovich (1972, p. 66)

Dimensions: “(µm) Theca length 100–102, width 80–86.” — Translated from Grigorovich (1972, p. 66)

Comparison: “Our specimens are differentiated from other subspecies of *D. phosphoritica* by the presence of obtuse-angled ‘shoulders’.” — Translated from Grigorovich (1972, p. 66)

Age: early Miocene; holotype as translated from Grigorovich (1972, p. 66).

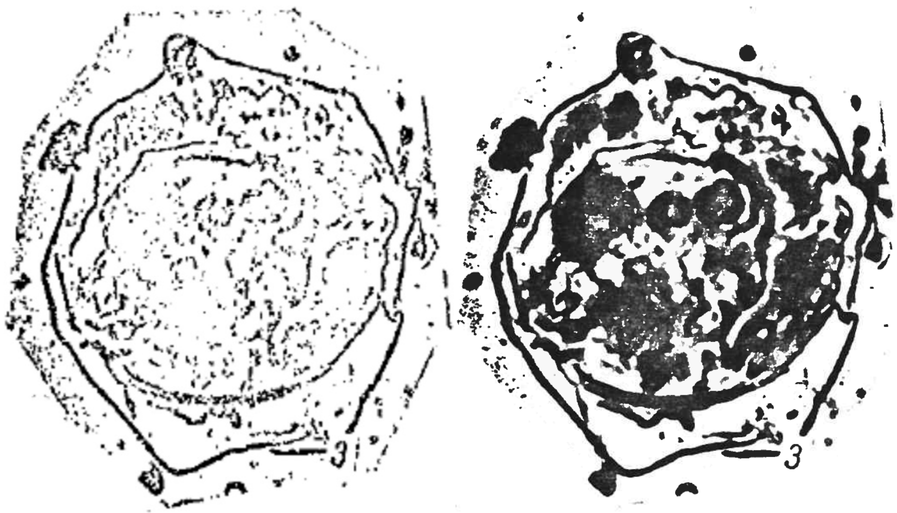


Plate 1, figure 3, Grigorovich (1972).

?*Deflandrea plea* (Tasch in Tasch et al., 1964) Lentin & Williams, 1973

Diagnosis: "Full, spherical theca, bearing a brief, apical horn, and very broad antapical horns. Epithecal plate system partially defined, but apical plates unclear and hypothecal plates not distinguishable. Broad, dark, central band which loops around anteriorly is a contracted cyst. Epitheca gently tapered apically, and about twice as large as hypotheca." — Tasch in Tasch et al. (1964, p. 196)

Dimensions: "Length, excluding apical horn, 68 μ; width, 62 μ; width of girdle, 5 μ; length of apical horn, 6 μ." — Tasch in Tasch et al. (1964, p. 196)

Discussion: "Living species assigned to the genus *Peridinium* embrace a wide range of morphologies. Fossil species assigned to this genus are generally less variable in morphology. The new species described herein is unlike any previously assigned to this genus in the nature of the antapical horns and the more spherical configuration. It is strikingly different from *P. kansanum* Tasch, n. sp. (plate 1, figure 1)." — Tasch in Tasch et al. (1964, p. 196)

Age: Early Cretaceous (Albian); holotype of Tasch in Tasch et al. (1964, 191, 196).

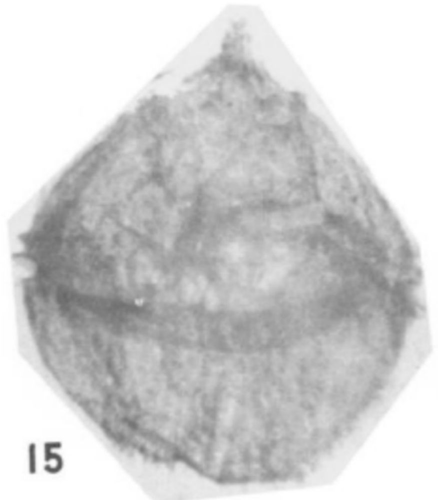


Plate 1, figure 15, Tasch in Tasch et al. (1964).

Deflandrea robusta Deflandre & Cookson, 1955

Description: “Theca with widely convex sides, a regular conical apex, and 2 strong, conical, non-divergent antapical horns. Transverse girdle marked by the thickness of its edge, not depressed, separating the theca into 2 nearly equal parts. Membrane smooth with only a few very fine granulations. Cyst ellipsoidal, flattened, smooth.” — Deflandre & Cookson (1955, p. 250)

Dimensions: “Holotype length 123 μ, breadth 74 μ.” — Deflandre & Cookson (1955, p. 250)

Discussion: “This species, unfortunately represented by only a single specimen, is well characterized. It possesses an epitheca analogous to that of *D. bakeri* . . . and a hypotheca with 2 horns similar to those of *D. phosphoritica* but proportionally narrower. The membrane is quite distinct from that of *D. bakeri*.” — Deflandre & Cookson (1955, p. 250)

Age: early Eocene (Ypresian); holotype of Deflandre & Cookson (1955, p. 250).

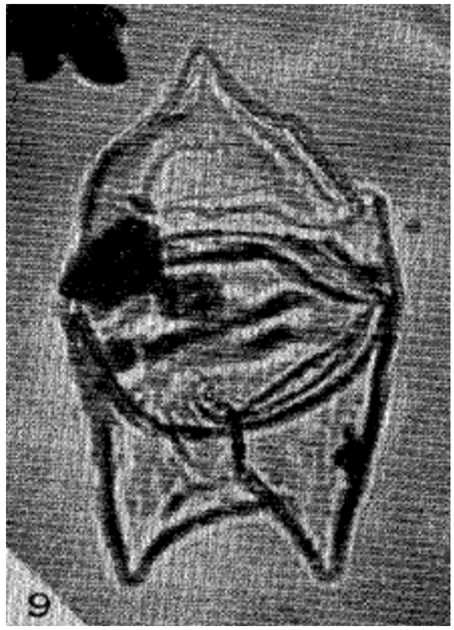


Plate 4, figure 9, Deflandre & Cookson (1955).

Deflandre scabrata Wilson, 1988

Description: "Pericyst fairly large, slightly elongate in dorso-ventral view with pointed apical horn and two relatively blunt antapical horns. Periphragm thin; surface adorned with scattered grana or spines which may be clustered or linear; margin often finely serrated. Endophragm thick (up to 6 µm); characteristically scabrate to somewhat spongy especially near poles and around margin, central part relatively smooth and devoid of ornament. Intercalary archeopyle broad (width up to 50 µm); operculum free and comprises two adherent opercula from periphragm and endophragm. Paracingulum well defined by parallel rows of grana (width c. 8 µm) and by notch in lateral margin. Parasulcus prominent, narrow, largely confined to hypocyst. Paratabulation indicated by archeopyle and occasionally by clusters or rows of grana." — Wilson (1988, p. 18)

Dimensions: "Holotype: overall length 135 µm, breadth 84 µm, length of endocyst 84 µm, breadth 76 µm, apical horn 22 µm, antapical horns 16 µm, 19 µm. Range: overall length 105 (119) 135 µm, breadth 73 (80) 86 µm (n = 10)." — Wilson (1988, p. 18)

Remarks: "The species has some resemblance to *Deflandrea phosphoritica* Eisenack but differs mainly in having a characteristically scabrate thickened endocyst, and also in having a periphragm adorned with clusters of grana or spinules, and a finely serrate margin. It differs from *D. antarctica* Wilson and *D. flounderensis* Stover in having a thicker, more heavily scabrate endophragm, and in having significantly more prominent antapical horns." — Wilson (1988, p. 18)

Age: early Eocene (Ypresian); holotype of Wilson (1988, p. 18).

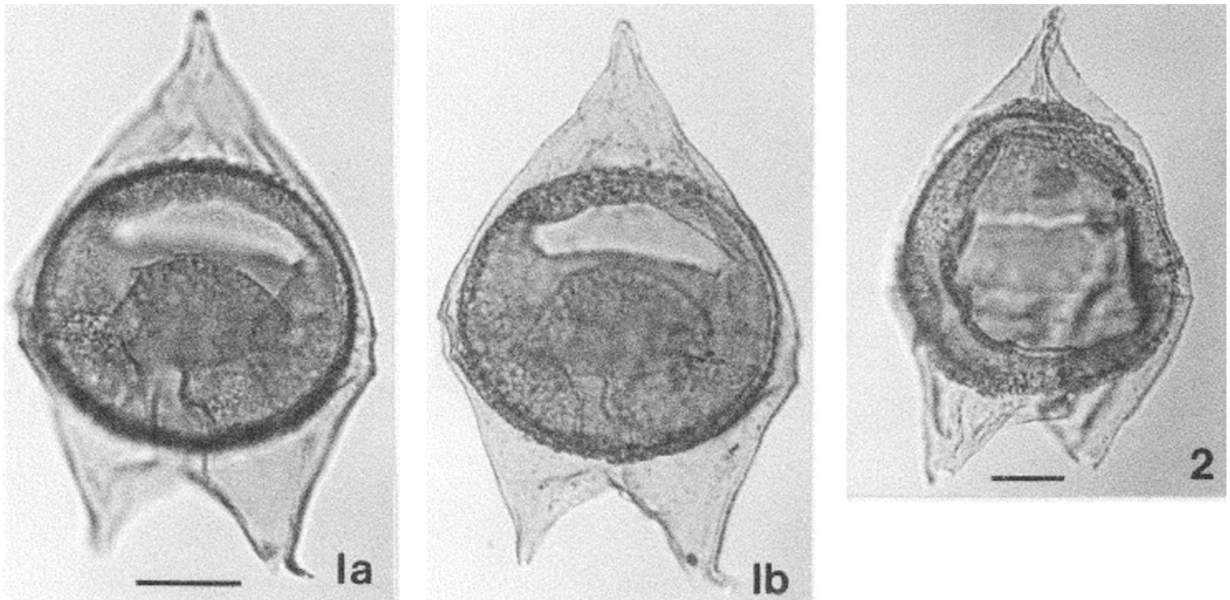


Plate 6, figures 1a, b, 2, Wilson (1988). Scale bars = 20 µm.

Deflandrea scitula He Chengquan, 1991

Dimensions: "The cyst is flat on the dorsum and venter, elongated in the transverse direction, approximately equal in length and width. Two parts nearly equal in size. The epitheca is bell-shaped, with a conical vertex, about 14 µm long, and the apex is blunt. The hypotheca has two nearly equal caudal horns, conical or triangular, 15 µm long, with slightly pointed ends, about 60 µm apart from each other, obviously. It seems that the horns are not on the same plane, so there is a partial overlap between the two at the base, and their bases are adjacent. The loin is strongly convex and rounded, but lacks side convexity. The equatorial position of the girdle is obvious, circular, flat on the cyst contour line. Rather than concave, about 7.5 µm wide, its edges are marked by thin ridges. Longitudinal furrow clear, trapezoidal, wide, limited to the hypotheca. The outside wall is filmy, transparent, and the surface is smooth. The inner body is transversely elliptical, wider than long, its wall is thicker than the outer wall, and the surface is densely packed with fine particles and granular; it is completely separated from the outer wall, and the periphragm outer cavity is slit-like. Archeopyle style very clear, the outline is horizontal and oval. It is about 20 µm long and 44 µm wide. The opercula have been clearly detached and kept in place." — Translated from He Chengquan (1991, p. 83, 84)

Dimensions: "The cyst is 95 µm long and 92.5 µm wide, and the inner body is 67.5 µm long and 85 µm wide." — Translated from He Chengquan (1991, p. 84)

Comparison: "Compared with *Deflandrea sibirica* (Vozzhennikova) in terms of cyst shape and size, the new species is similar, but the apical horn of the former is short, the two caudal horns may not be in the same plane, the transverse groove is flat but not concave, and the body is typically elongated laterally. Broadly elliptical and lacking lateral convexity, the latter being distinctly pentagonal, with two caudal horns far apart at the base. Probably, the archeopyle is equal in length and width rather than horizontal width. Since the nature of the archeopyle was not exactly the same, the latter was relocated to *Ceratiopsis*." — Translated from He Chengquan (1991, p. 84)

Age: late Eocene (Priabonian); holotype corresponding to the "second section of the Bashibulake

Formation” as translated from He Chengquan (1991, p. 227). Range: late Eocene (Priabonian) corresponding to the “second and third sections of the Bashibulake Formation” as translated from He Chengquan (1991, p. 84) given the age of the unit presented by Xi Dangpeng et al. (2020, p. 166) respectively.

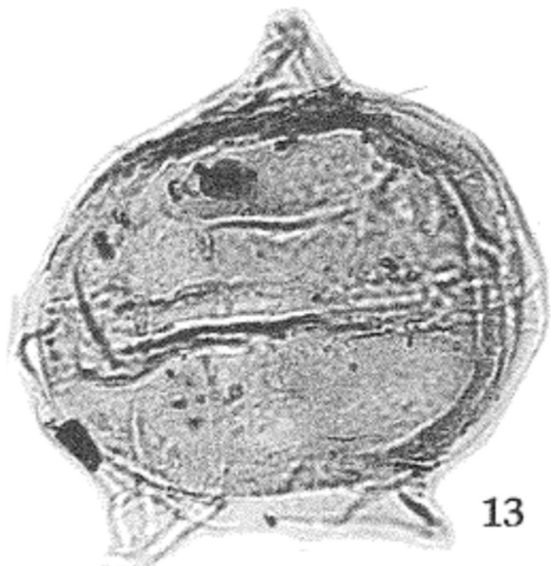

13

Plate 30, figure 13, He Chengquan (1991).

Deflandrea scolensis Grigorovich, 1971

Diagnosis: “The theca is elongated along the longitudinal axis, pentagonal. The epitheca gradually narrowing from the level of the transverse furrow, ends with an apical horn, on the distal side of which has a small hole. Hypotheca is trapezoidal with strong concave lateral sides and identical antapical processes. The transverse groove is clearly visible. The longitudinal furrow is observed only on the hypotheca. The inner body is spherical. Theca surface granulated.” — Translated from Grigorovich (1971, p. 92)

Dimensions: “Holotype: length 102, width 9[0?].” — Translated from Grigorovich (1971, p. 92)

Age: early Eocene (Ypresian); holotype as translated from Grigorovich (1971, p. 92).

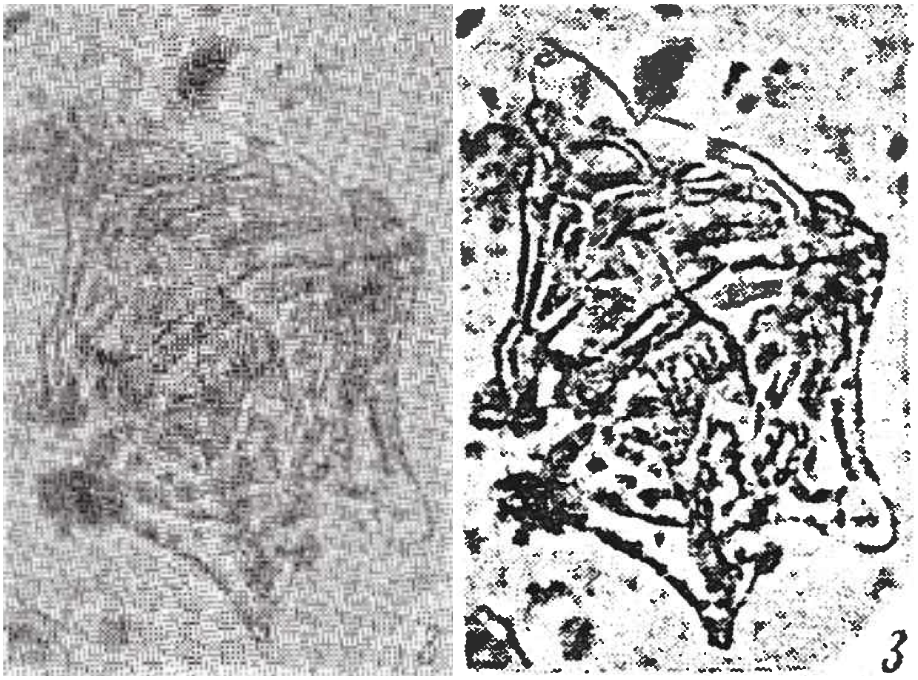


Plate 1, figure 3, Grigorovich (1971).

Deflandrea severnensis Benson, 1976

Description: "Cavate cyst with reduced apical and antapical horns. Periphragm and endophragm thin, each less than 0.9 micron in thickness. Periblast ornamented with varying numbers of short spines, frequently but not always intratabulary arranged reflecting a tabulation of 4', 3a, 7'', ?c, ?5'''' [?5'''], 2''''. Tabulation generally incomplete on individual specimens. Archeopyle intercalary (Type I/I). Cingulum equatorial; slightly levorotary. Sulcus strongly developed. Endoblast closely appressed to periblast." — Benson (1976, p. 195)

Dimensions: "Holotype: Periblast length 71 micra, width 65 micra; endoblast length 52 micra; width 61 micra; apical pericoel 9 micra. Range: 15 specimens measured; periblast length 61–78 micra; width 56–65 micra; endoblast length 40–58 micra; width 51–61 micra; apical pericoel 6–13 micra." — Benson (1976, p. 195)

Comments: "*Deflandrea severnensis* is variable in the density of ornamentation, which frequently masks the tabulation. Tabulation was determined by examining many specimens. Because of the delicate walls, specimens are commonly distorted." — Benson (1976, p. 195)

Comparison: "*Deflandrea severnensis* resembles *D. ventriosa* (Alberti, 1959), differing from the latter in possessing tabulation as reflected by the spinose ornamentation. It also resembles *D. microgranulata* Stanley (1965); however, *D. severnensis* does not possess the fine granulations on the endoblast surface and tabulation is not evident on *D. microgranulata*. These three species are perhaps closely related and may reflect an evolutionary lineage or variation." — Benson (1976, p. 195)

Age: Late Cretaceous (Maastrichtian); holotype and range of Benson (1976, p. 178, 195, figs. 2, 3).

Plate 10, figures 1–3, Benson (1976).

Deflandrea shandongensis Xu Jinli, 1987

<u>Description</u>: “The outline of the cyst is mostly shield-shaped, and it is close to the base. Epitheca and hypotheca nearly equal in size. Epitheca semicircular, with a small solid conical apex, 3.5–5 μm long, blunt apex with apical hole, hypotheca nearly semicircular, inverted trapezoidal. Two antapical horns isolated from each other; small subequal, triangular, pointed or tonulate, 3.5–5 μm long. Recognizable by a ring-shaped, very shallow, 5.5–7.5 μm wide cingulum, with marginal, slightly convex ridges. The outer wall is relatively straight, often with irregular wrinkles, the surface is rough and fine, with grain-like, quasi-reticular patterns. Inner body width large, almost filling the entire body. The inside wall should be thick, the color should be dull, and the surface should be thin. Except at the horns and in the vicinity of the transverse groove, the inner and outer walls are appressed. Paleostia are usually poorly developed, and discontinuous archeopyle fissures can be seen in a few specimens, showing wide hexagonal spaces. Sometimes parasutural cracks are developed.” — Translated from Xu Jinli (1987, p. 151)

<u>Dimensions</u>: “Endophragm length 58.7–67.9 μm, width 57.2–6 1.6 μm, endosome length 54.5–56.5 μm, width 52.8–58.5 μm. The holotype is 67.9 μm long and 61.6 μm wide; the inner body is 56.5 μm wide and 58 μm wide.” — Translated from Xu Jinli (1987, p. 151)

<u>Discussion</u>: “Comparing this species with *Subtilisphaera dongyingenss* (Jiabo, 1978) Song & He, the difference is that the antapical horns are nearly equal in size, with a wide hexagonal archeopyle.” — Translated from Xu Jinli (1987, p. 151)

<u>Age</u>: middle Eocene (early Lutetian) corresponding to the “middle and upper part of the fourth member of the Shahejie Formation” as translated from Xu Jinli (1987, p. 151). This interval corresponds to between 43 and 45 Ma according to Zi-Ran Jiang et al. (2019, fig. 2).

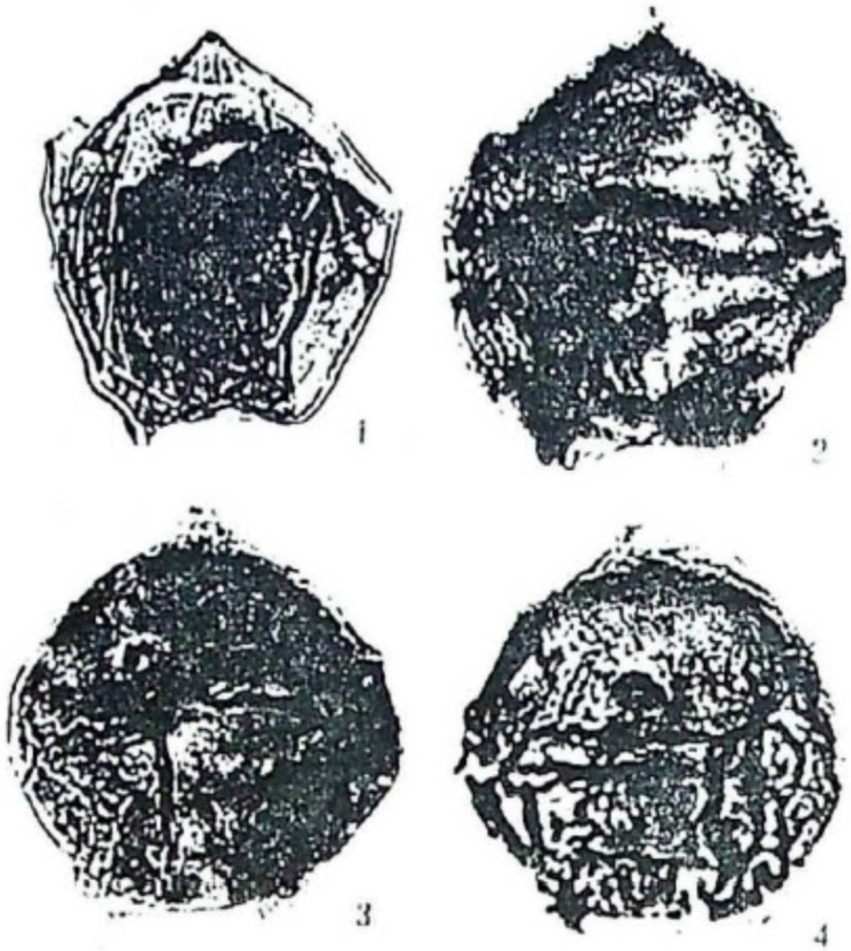


Plate 1, figures 2–4, Xu Jinli (1987).

?*Deflandrea stagonoides* (Benedek, 1972) Lentin & Williams, 1976. Emendation: Benedek & Sarjeant, 1981, p. 324.

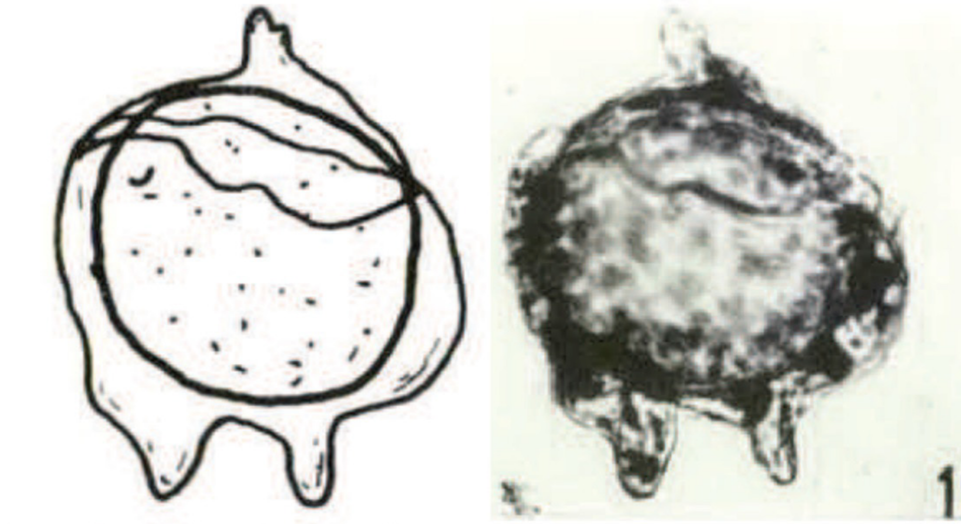
<u>Diagnosis</u>: “A species of the genus *Ascodinium* with dorsoventrally flattened thick-walled inner and smooth outer wall. The apex ends in a broad, long, rounded horn. The antapical processes are pronounced with rounded ends.” — Translated from Benedek (1972, p. 10)

<u>Description</u>: “The thick-walled inner body is spherical to ellipsoidal and stands with the outer body in contact only dorsally and ventrally, without adhesions being recognizable. The finger-like apical and antapical processes are approximately the same size. When the capsule is opened, the apical part is blown off. The rearing line can be identified as a jagged suture. The membrane of the inner capsule is thick, probably granulated and yellow-brown in color. In contrast, the outer membrane is relatively thin-walled, light yellow in color and crystal clear. An opaque mineral (pyrite?) has frequently separated out between the two walls.” — Translated from Benedek (1972, p. 11)

<u>Dimensions</u>: “Capsule 65 μ (62–70 μ). Specimen 78 μ (76–80 μ), apical processes 13–15 μ, antapical processes 12–20 μ (3 measurements). Number of examined specimens: 3.” — Translated from Benedek (1972, p. 11)

Comparison: “The new species closely resembles *Chiropteridium aspinatum* Gerlach from which they differ by the complete encapsulation of the inner capsule.” — Translated from Benedek (1972, p. 11)

Age: late Oligocene (Chattian); holotype of Benedek (1972, p. 10).



Text-figure 5; Plate 2, figure 12, Benedek (1972).

Deflandrea subtilis He Chengquan, 1991

Description: “Cyst ventrally and dorsally flattened, elongated pentagonal in outline. The epitheca is slightly larger than the hypotheca, an acute triangle, elongated at the top, protruding into a shorter, conical, blunt apex, 10–14 μm long. Hypotheca inverted trapezoidal, with two nearly equal antapical horns, conical, 7.5–15 μm long, with pointed or slightly blunt ends. The transverse groove is slightly inclined to the hypotheca and obvious. The groove is shallow and flat, and ring shaped, 6–7.5 μm wide, marked by fine ridges at its edges. Longitudinal furrow visible, limited to hypotheca. The cyst wall is weak and consists of two layers. The surface of the outer wall is fine-grained or nearly smooth. Inner body round or oval, with smooth surface except for corners and (or hypotheca), in contact with the outer wall. Front style archeopyle, with relatively clear outline, horizontal width is oval, and the width is greater than the length. The operculum is completely detached and in situ.” — Translated from He Chengquan (1991, p. 84)

Dimensions: “Cyst length 57.5–70 μm, width 42–45 μm, inner body length 40–45 μm, width 37.5–42 μm (3 specimens measured); the holotype specimen is 70 μm long and 45 μm wide, the inner body is 43 μm long and 42 μm wide, the apical horn is 14 μm long, the antapical horn is 15 μm long, and the transverse groove is 6.5 μm wide.” — Translated from He Chengquan (1991, p. 84)

Discussion: “This species is similar to *Deflandrea phosphoritica* in morphology, but the former is small, inner and outer walls are extremely thin, and touch each other laterally.” — Translated from He Chengquan (1991, p. 84)

Age: late Eocene (Priabonian); holotype corresponding to the “second section of the Bashibulake Formation” as translated from He Chengquan (1991, p. 226). Range: late Eocene (Priabonian) corresponding to the “second and third sections of the Bashibulake Formation” as translated from He Chengquan (1991, p. 84) given the age of the unit presented by Xi Dangpeng et al. (2020, p. 166) respectively.

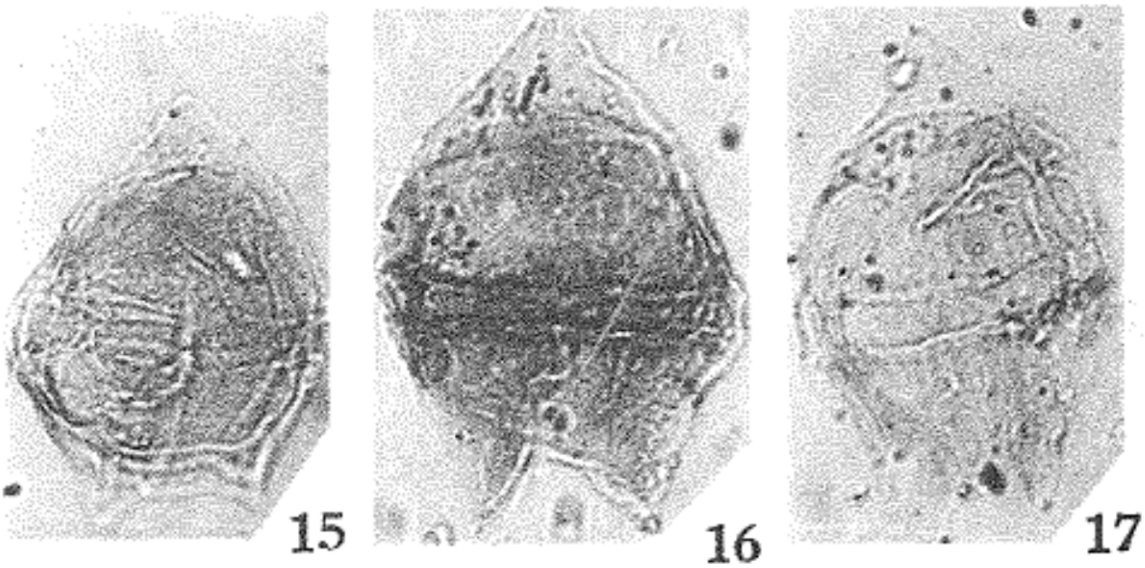


Plate 29, figures 15–17, He Chengquan (1991).

Deflandrea superposita He Chengquan, 1991

Description: "The venter and dorsum of the cyst are flat, the outline is nearly pentagonal, the length is longer than the width, and the outline of the body is nearly round. The epitheca is slightly smaller than the hypotheca. Large, triangular, with nearly straight or slightly concave sides, with a vertex, typically triangular, 12.5–27 μm long, without base. Constricted apex pointed or blunt. The hypotheca is nearly inverted trapezoidal, the sides are relatively straight, and the antapex is concave into an angle, with two horns of nearly equal size. Horns triangular, 17.5–19 μm long, ends far apart (32–42.5 μm), but wide at base, always partially overlapping each other, indicating that the two caudal horns are not in the same plane. The waist is round and free of side convexity. The horizontal groove is slightly deviated. Hypotheca very shallow, barely concave on the sides, ring-shaped, 7–7.5 μm wide, marked by low ridges on its margin. Longitudinal furrow visible or blurred. The surface of the outer wall is fine-grained or nearly smooth, and the grains are arranged in longitudinal lines on the top corner of the holotype specimen, and some corroded specimens have secondary broken mesh wrinkles on the edge of the cyst. The inner body is round-elliptical, and the outer densely granular or rough, usually on the side of the epitheca where it contacts the outer wall, and on the side of the hypotheca separated by a narrow outer cavity. Front style archeopyle with clear outline, nearly hexagonal, wider than long. The operculum is completely detached and stored in place." — Translated from He Chengquan (1991, p. 84, 85)

Dimensions: "Cyst length 97.5–115 μm, width 67.5–90 μm, inner body length 62.5–85 μm, width 62.5–77.5 μm (3 specimens measured); the holotype specimen is 105 μm long and 85 μm wide, the inner body is 72.5 μm long and 77.5 μm wide, the apical horn is 17 μm long, and the antapical horn is 17.5 μm long μm, the transverse groove width is 7.5 μm." — Translated from He Chengquan (1991, p. 85)

Comparison: "Comparing this species is similar to *Deflandrea amabilis,* but the epitheca of the former is conical, and the sides are straight and slightly concave, triangular at the apex, the base does not shrink, the two caudal angles are not in the same plane, the base is quite wide and partially overlaps each other. The transverse groove is shallow and the surface of the outer wall is fine-grained. This species has a cyst that is longer than wide, and the body is nearly round instead of wide and oval. It is different from *D. scitula* in features such as close antapical horns." — Translated from He Chengquan (1991, p. 85)

Age: late Eocene (Priabonian); holotype corresponding to the "third section of the Bashibulake Formation" as translated from He Chengquan (1991, p. 228). Range: middle Eocene (Lutetian)–late Eocene (Priabonian) corresponding to the "Wulagen Formation" and "second and third sections of the Bashibulake Formation" as translated from He Chengquan (1991, p. 85) given the ages of the units presented by Xuejiao Wang et al. (2022) and Xi Dangpeng et al. (2020, p. 166) respectively.

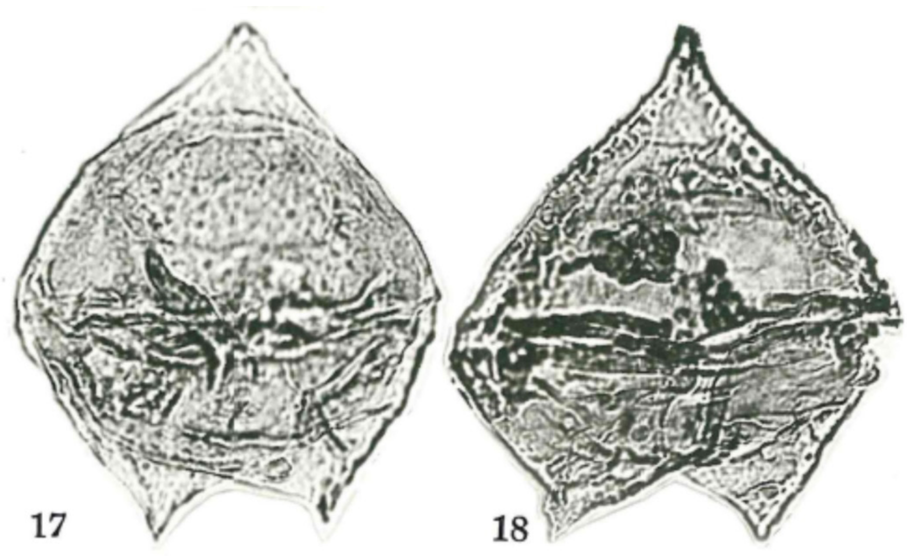


Plate 34, figures 17, 18, He Chengquan (1991).

Deflandrea translucida Châteauneuf, 1980

Diagnosis: "Peridinioid cyst with a more or less rounded oval lateral outline. Apical horn often triangular in shape, truncated and flattened at the top, asymmetrical and reduced antapical horns. Bicavate cyst. Well-marked endocoele at the level of the horns but non-existent in the cingular zone. Endophragm often faint and translucent. Peripheral often wrinkled and smooth or very slightly grainy. Little marked parasutural characters. The paratabulation is marked here only by the archeopyle and the paracingular zone. Intercalary archeopyle type I/I, operculum free. Paracingulum fairly clear and very visible in optical section on the contours of the cyst. Parasulcus inconspicuous." — Translated from Châteauneuf (1980, p. 138)

Dimensions: "Holotype: width: 55 μ, height: 60 μ (counting the horns); endocoel: 55/45 μ, archeopyle: 20/10 μ. Size variations (10 specimens) of the cyst: 40–55 μ/50–60 μ." — Translated from Châteauneuf (1980, p. 138)

Note: "This species does not resemble any of the Tertiary forms known from the literature. It is characterized by its very rounded shape and by the fineness of the walls of the endo- and the periphragm." — Translated from Châteauneuf (1980, p. 138)

Age: middle–late Eocene (Lutetian–Priabonian); holotype of Châteauneuf (1980, p. 138).

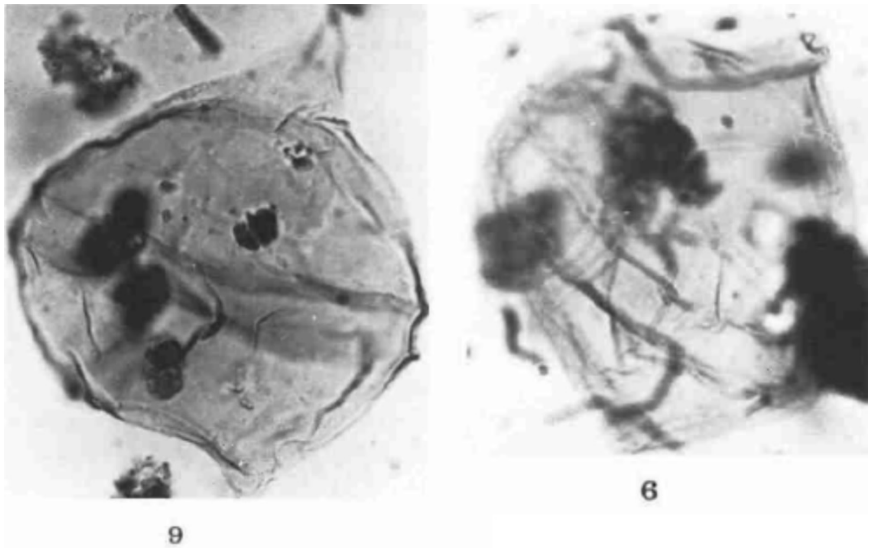


Plate 22, figure 9; Plate 23, figure 6, Châteauneuf (1980).

Deflandrea tribulosa Islam, 1983b

Diagnosis: "Cyst dorsoventrally compressed peridinioid with short to moderate apical and two antapical horns, horns low and conical with broad bases, antapical horns sometimes considerably reduced but themselves more or less equal; apical pore sometimes present; circumcavate to bicavate; both phragma chagrinate; periphragm bears sparsely distributed small spines, linear rows of spines border paracingulum, spines sometimes rounded looking like grana; archeopyle intercalary type I/I and of broad hexa-style." — Islam (1983b, p. 85)

Dimensions: "Holotype: pericyst 62 × 47 µm, endocyst 47 × 42 µm. Range: pericyst length 55(60)68 µm, breadth 42(48)54 µm, endocyst length 42(44)48 µm, breadth 36(46)53 µm. Specimens measured 9." — Islam (1983b, p. 85)

Discussion: "This species differs from *D. denticulata* Alberti 1959 and *D. spinulosa* Alberti 1959 in smaller size and much reduced horns, and from the former also in possessing fewer spines." — Islam (1983b, p. 85)

Age: middle Eocene (Lutetian); holotype and range of Islam (1983b, p. 85, text-fig. 9).

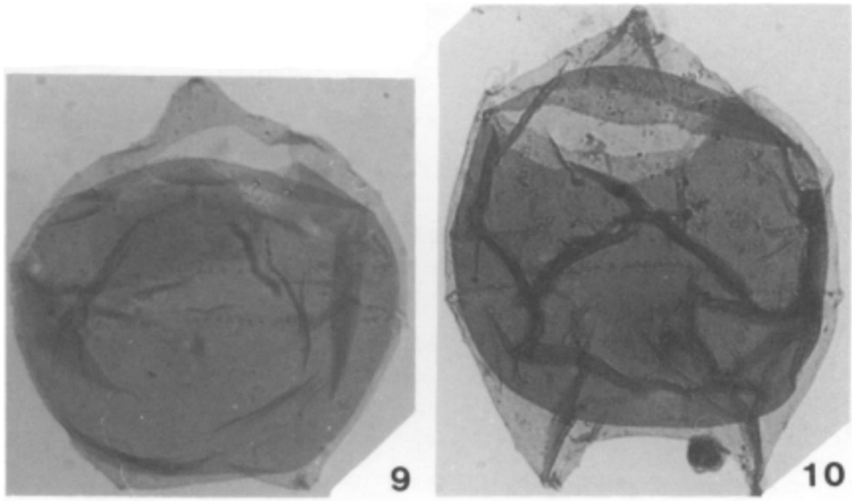


Plate 1, figures 9, 10, Islam (1983b).

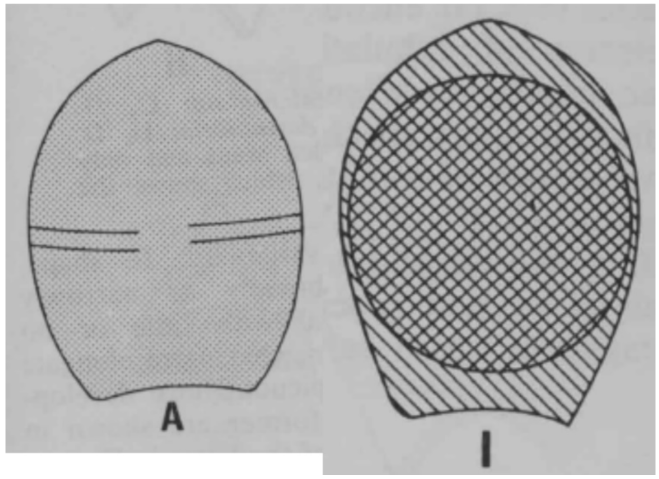
Deflandrea truncata Stover, 1973

Description: “Periphragm is elliptical to ovoid in dorso-ventral view and has an obtusely rounded apical margin and a truncated, straight to slightly concave antapical margin. Surface 1–1.5 μ thick; smooth, finely pitted, or granulate (sculpturing evenly distributed). Cingulum is poorly defined by a shallow transverse band about 6 μ wide located just below midheight. Ventrally, the cingulum is not offset and is interrupted by an ill-defined sulcus. Cingulum and sulcus discernible on about half the specimens. Periphragm may be thickened slightly at the apex and a thickening or a nipple-like projection may occur at each antapical corner. Outline of the endoblast is circular or nearly so in dorso-ventral view; endophragm is smooth and as thick as or slightly thicker than the periphragm. Endoblast occupies a considerable part of the pericoel. Intercalary archeopyle trapezoidal and the opening in the endophragm is nearly as large as that in the periphragm but usually appears shorter due to foreshortening. Operculum is free and isolated. Opercula usually consist of adherent pieces from both wall layers.” — Stover (1973, p. 176, 177)

Dimensions: “Archeopyle is 34–40 μ wide and 16–22 μ long (width consistently about twice the length). Entire specimens are 86–104 μ long and 68–86 μ wide (mean length:width ratio is 1:0.8). The nearly circular endoblast is 65–78 μ long and 66–79 μ wide. Usually the length-width dimensions on any specimen will be within 5 μ of each other. Measurements taken on 10 specimens.” — Stover (1973, p. 177)

Comparison: “*Deflandrea truncata* differs from *D. leptodermata* by having less well-developed horns, a straight or slightly concave antapical margin and a more elongate outline in dorso-ventral view.” — Stover (1973, p. 177)

Age: early Eocene (Ypresian); holotype of Stover (1973, p. 177).



Text-figures, 3A, 6I, Stover (1973).

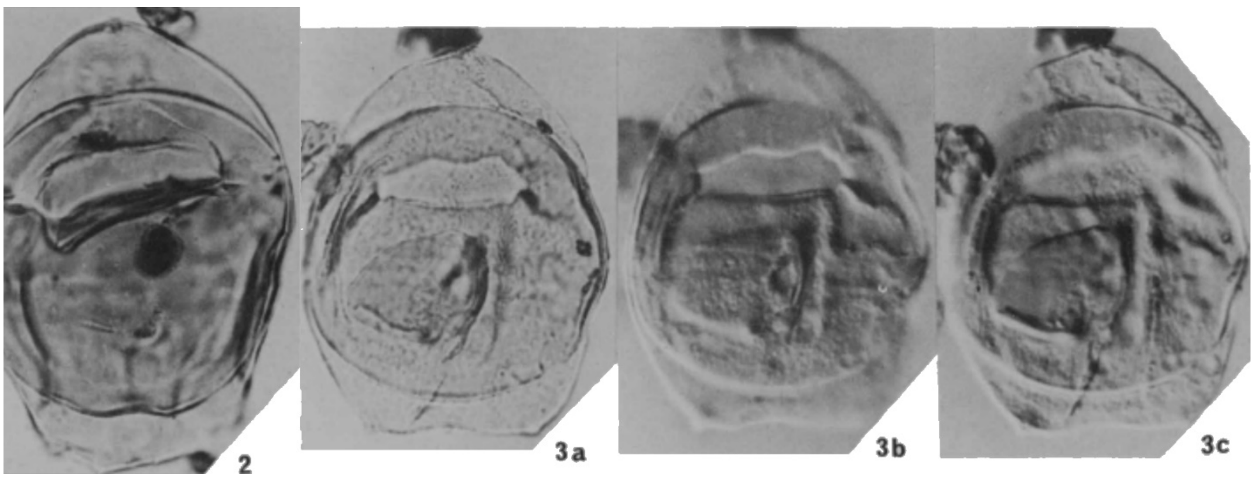


Plate 5, figures 2, 3a–c, Stover (1973).

Deflandrea tuberculata Hultberg, 1985

Description: "The cyst is apically cornucavate and antapically hypocavate. The surface of the endophragm is smooth. The surface of the periphragm is striate and strongly tuberculate. The shape of the endophragm is spherical. The periphragm is peridinioid, with one sharply pointed apical horn, and two almost asymmetrical antapical horns. The margins of the periphragm are serrate. Paratabulation is indicated by parasutural lineations and intratabular groups of tubercles. The tubercles may form parasutural crests. The paratabulation is peridiniacean, paratabulation formula: 4', 3a, 7'', xc, 5''', 2''''. The archeopyle is intercalary, type I, formed by the detachment of paraplate 2a. Operculum free. The archeopyle is broad and has a triangular appearance, although being hexagonal. Paracingulum is clearly discernible by folds in the periphragm, parasutural arrangement of tubercles, and lineations on the margins of the paracingulum. One line of tubercles is present in the center of paracingulum. Parasulcus is indicated by a depression in the midventral part of the periphragm. A bulge is present in the lower right part of the parasulcus." — Hultberg (1985, p. 120, 121)

Dimensions: "118–130 µm (length), 72–79) µm (breadth)." — Hultberg (1985, p. 121)

Remarks: "*Deflandrea tuberculata* can be distinguished from other species by the surface morphology of the periphragm, consisting of a combination of parasutural and intratabular tubercles, and striation in the periphragm." — Hultberg (1985, p. 121)

Age: Late Cretaceous (late late Maastrichtian); holotype of Hultberg (1985, p. 121).

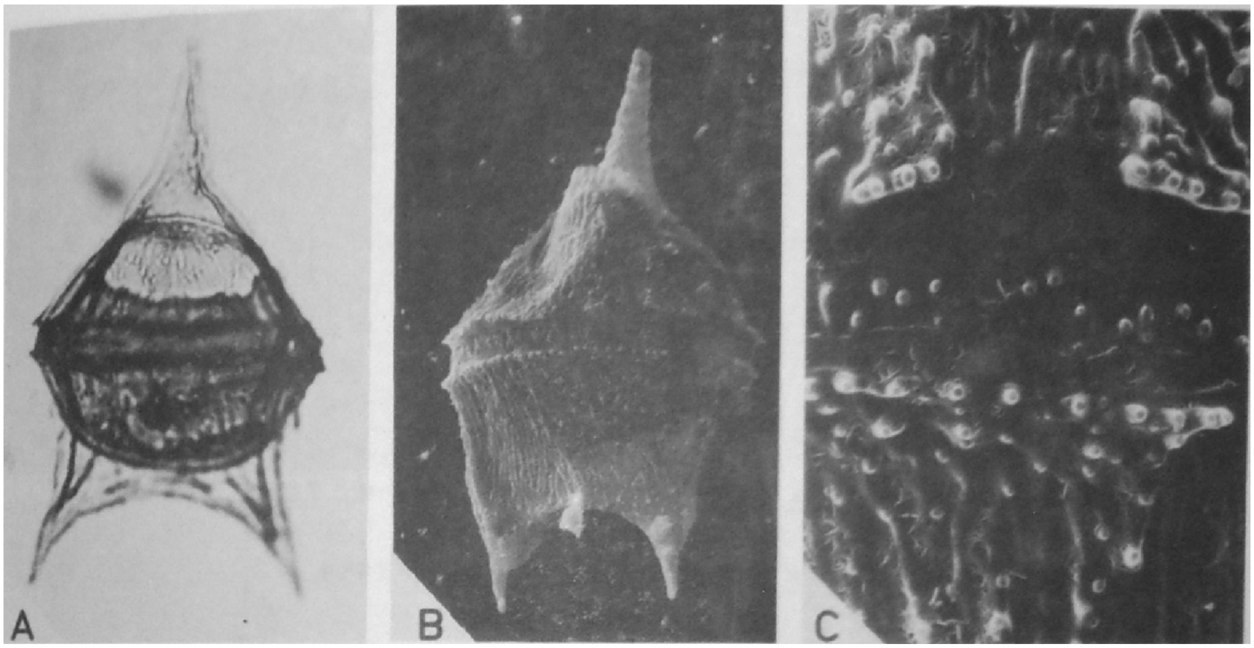


Plate 3, figures A–C, Hultberg (1985).

Deflandrea variabilis Vieira et al., 2018

Diagnosis: "Peridinoid [sic], circumcavate to bicavate cyst, sub-circular, ovoidal to elliptical in dorsoventral view. Intercalary archaeopyle is occasionally wide, resulting from the detachment of paraplate 2a; paratabulation discernible and usually recognisable. The cyst is composed of periphragm and endophragm very closely adpressed together; maximum wall separation is in the apical and antapical areas. The periphragm is relatively thin, always smooth to finely granulate and often bearing verrucae up to 2.5 µm in high and width, with a very distinct, short, symmetrically placed apical horn, and with or without two similarly short, well separated antapical horns (of which one is usually reduced). Antapical horns are low and conical with broad bases. Endophragm is spherical to oval in shape, thicker than periphragm and variable in thickness. The epicyst and hypocyst are more or less equal in length; both show rounded to convex lateral sides in outline. Narrow pericoels are well developed and become wider at the apex and antapex. The antapical side and occasionally the antapical horns are well separated, visible with some low parasutural crests seeming to delimit individual cingular paraplates, but not clear enough to determine the number." — Vieira et al. (2018, p. 187)

Dimensions: "Holotype pericyst length 62.5 µm, breadth 56 µm, endocyst length 47 µm, breadth 53 µm, apical horn 11 µm in length. Pericyst length 38 (62) 78 µm, breadth 27 (52) 63 µm, endocyst length 27 (47) 68 µm, breadth 27 (47) 59 µm, apical horn 5 (9) 15 µm in length. Number of specimens measured = 25." — Vieira et al. (2018, p. 187)

Remarks: "This species exhibits considerable intraspecific variation, namely in the ambital outline of the pericyst, the wall structure of both endo- and periphragm, and the shape of the apical and antapical horns. Within the populations examined there is a complete intergradation between forms having greatly reduced antapical horns or simply a rounded antapical margin. The periphragm varies from smooth to occasionally showing densely scabrate to verrucate sculpture. However, when compared with other *Deflandrea* types, this form is clearly differentiated. Nøhr-Hansen et al. (2002) cited several forms as Dinocyst sp. 1 in their fig. 7h–k, Dinocyst sp. 2 in fig. 8a–c, Dinocyst sp. 3e–j and Dinocyst sp. 4k–o, but they did not describe them formally, although these forms have differences when compared with *Deflandrea variabilis* sp. nov." — Vieira et al. (2018, p. 187)

Age: early Paleocene (middle Danian); holotype of Vieira et al. (2018, p. 187, fig. 3). Range: early Paleocene (middle–late Danian) (Vieira et al., 2018, fig. 3).

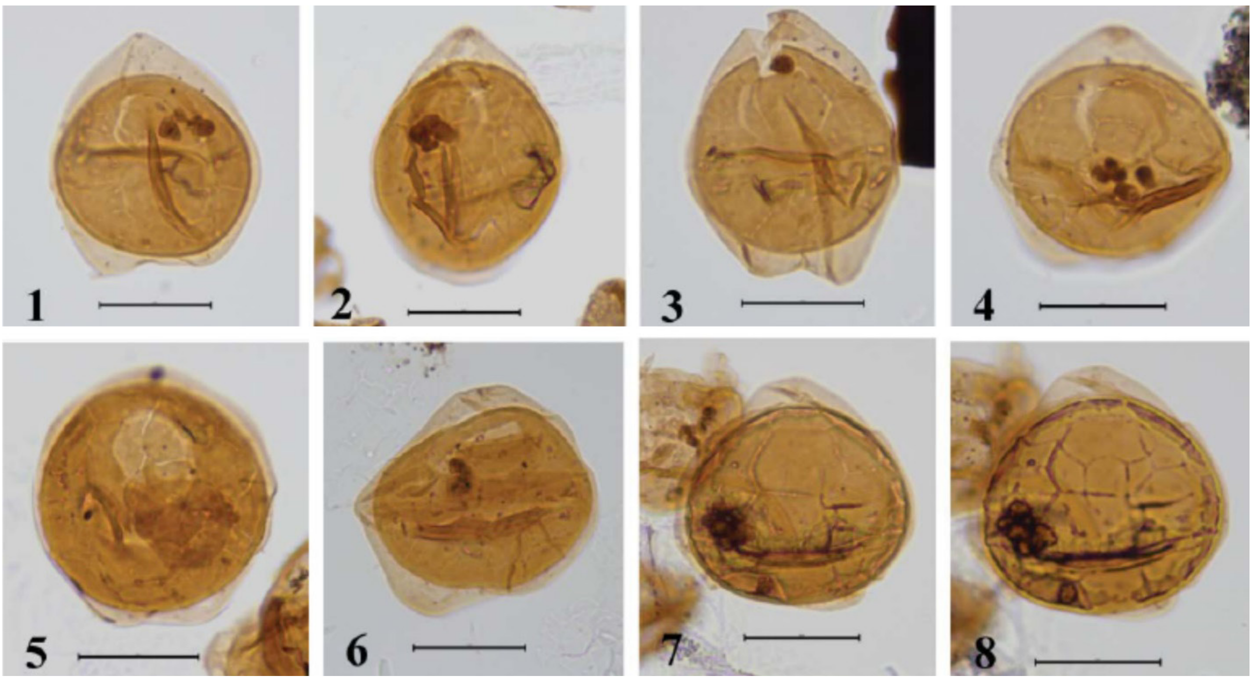


Plate 3, figures 1–8, Vieira et al. (2018). Scale bars = 30 µm.

Deflandrea webbii Wrenn & Hart, 1988

Diagnosis: "A species of *Deflandrea* bearing well-developed parasutural striae that delineate paraplate boundaries. Intraparaplate areas are reticulate and bear verracae that may mark the location of trichocyst pores on the theca. A complex flagellar scar lies on the ventral surface at the intersection of the parasulcus and the paracingulum." — Wrenn & Hart (1988, p. 352)

Description: "Shape: the pericyst is peridinioid in outline, whereas the shape of the endocyst varies from subcircular to subpentagonal in outline. The hypocyst bears two short antapical horns. The antapex may be truncated or slightly concave. The length of the apical horn varies. Phragma: the thin periphragm (<0.5 µm) is divided into paraplates by pandasutural striae that may be as much as 17 µm wide. The paraplates are irregularly reticulate and bear scattered verrucae that may correspond to trichocyst pores on the original thecae. The endophragm is granular and nontabulate. Paratabulation: pandasutural striae are well developed, and delineate a paratabulation of 4', ?3a, 7'', 6–7C, 5''', 2'''', ?5S. Paracingulum: the paracingulum is laevorotatory and offset approximately the width of the paracingulum. The paracingulum is variably incised, bordered by low denticulate ridges and divided into six or seven paraplates by pandasutural striae. The paraplates within the paracingulum are reticulate and bear verrucae. Parasulcus: the parasulcal depression widens posteriorly and is bordered by low pandasutural striae. As many as five parasulcal paraplates are delineated by pandasutural striae. A complex flagellar scar is present in the parasulcal area just posterior of the paracingulum. The right parasulcal paraplate projects over the flagellar scar and is convex toward the sulcus; i.e., toward the specimen's left. Archeopyle: the broad hexa 2a archeopyle appears to be Type I/I; some specimens, however, suggest a Type I/3I archeopyle. Free, broad hexa 2a (I/I) opercula bearing pandasutural striae along parasutures H2–H6 have been observed. The endoperculum remains attached to the perioperculum. No free la or 3a paraplates have been observed, nor have opercula composed of paraplates la, 2a, and 3a. This strongly suggests that the archeopyle is Type I/I and not a Type I/3I." — Wrenn & Hart (1988, p. 352)

Dimensions: "Observed range (six specimens): pericyst length, 81 to 110 µm (mean, 94 µm); pericyst width, 68 to 77 µm (mean, 72 µm); endocyst length, 51 to 80 µm (mean, 63 µm); endocyst width, 50 to 76 µm (mean, 66 µm); endoarcheopyle height, 12 to 22 µm (mean, 15 µm); endoarcheopyle width, 34 to 48 µm (mean, 42 µm). Periarcheopyle (1 measurable specimen): length, 28 µm; width, 46 µm." — Wrenn & Hart (1988, p. 352)

Discussion and comparison: "The distinctive characterstics of *Deflandrea webbii* sp. nov. are the presence of pandasutural striae, reticulate intraparaplate areas bearing verrucae, and a very complex flagellar scar. One of us has observed very faint and scattered pandasutural striae on *D. phosphoritica* (J. H. Wrenn, unpublished data) but never so distinctly or completely developed as that on *D. webbii* sp. nov. The flagellar scar is morphologically complex, and the flap that projects over it appears to protect one or more pores. If the pores were the functional site of flagellar insertion, *Deflandrea webbii* sp. nov. is not a cyst but a schizont. This interpretation is supported by the fact that the pandasutural striae are not mere surface features. The striae actually run under the surface paraplate reticulation (Fig. 41.1, 3), just as they would if they had been formed by wall growth. The overall shape and the flat truncated antapex observed on some specimens is similar to that of *D. antarctica*. However, *D. webbii* sp. nov. differs in having distinctive surface sculpture, a consistently thinner endophragm and by never developing paratabular grana or spines like those on *D. antarctica*." — Wrenn & Hart (1988, p. 352)

Age: middle to late Eocene; holotype of Wrenn & Hart (1988, p. 352). Range: late early Eocene (Lutetian?)–early Oligocene (Rupelian) (Wrenn & Hart, 1988, p. 352, 353).

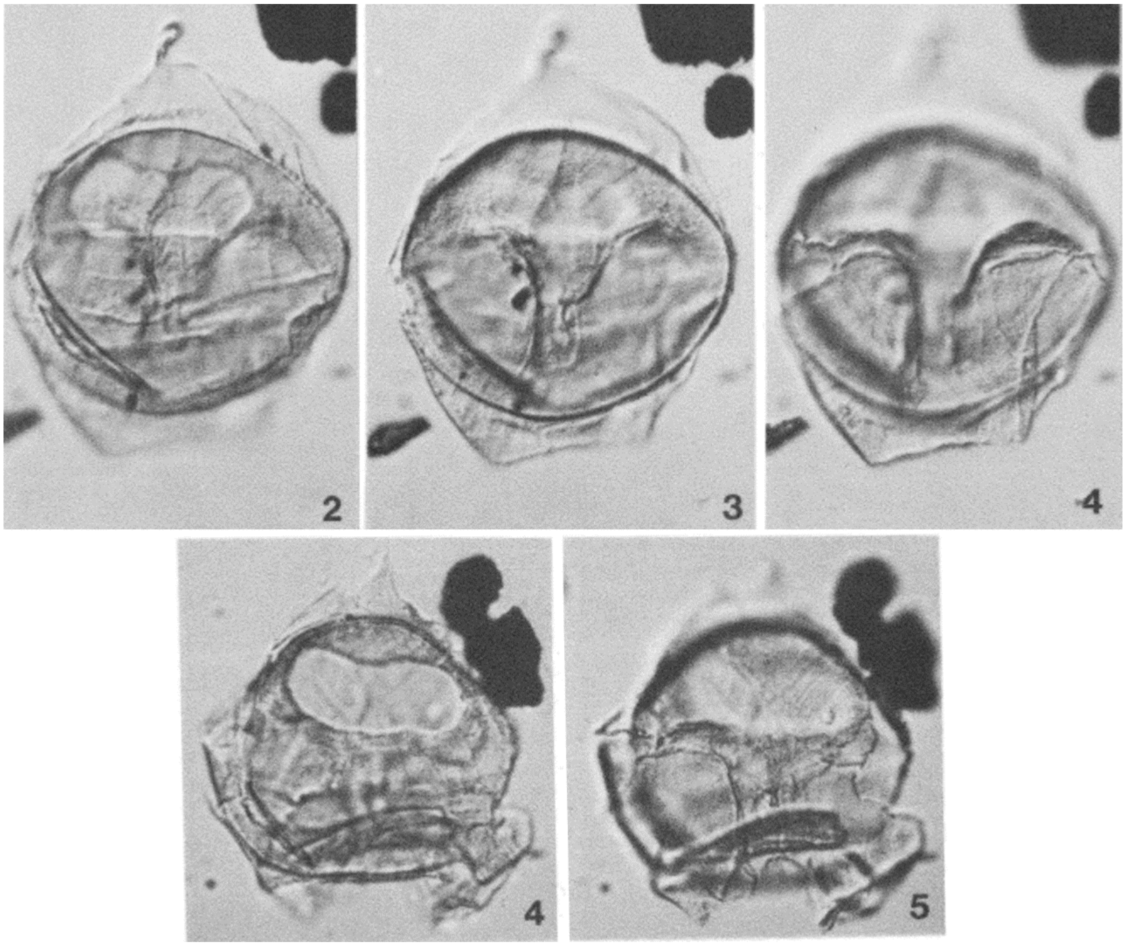


Figure 22, nos. 2–4; Figure 23, nos. 4, 5, Wrenn & Hart (1988).

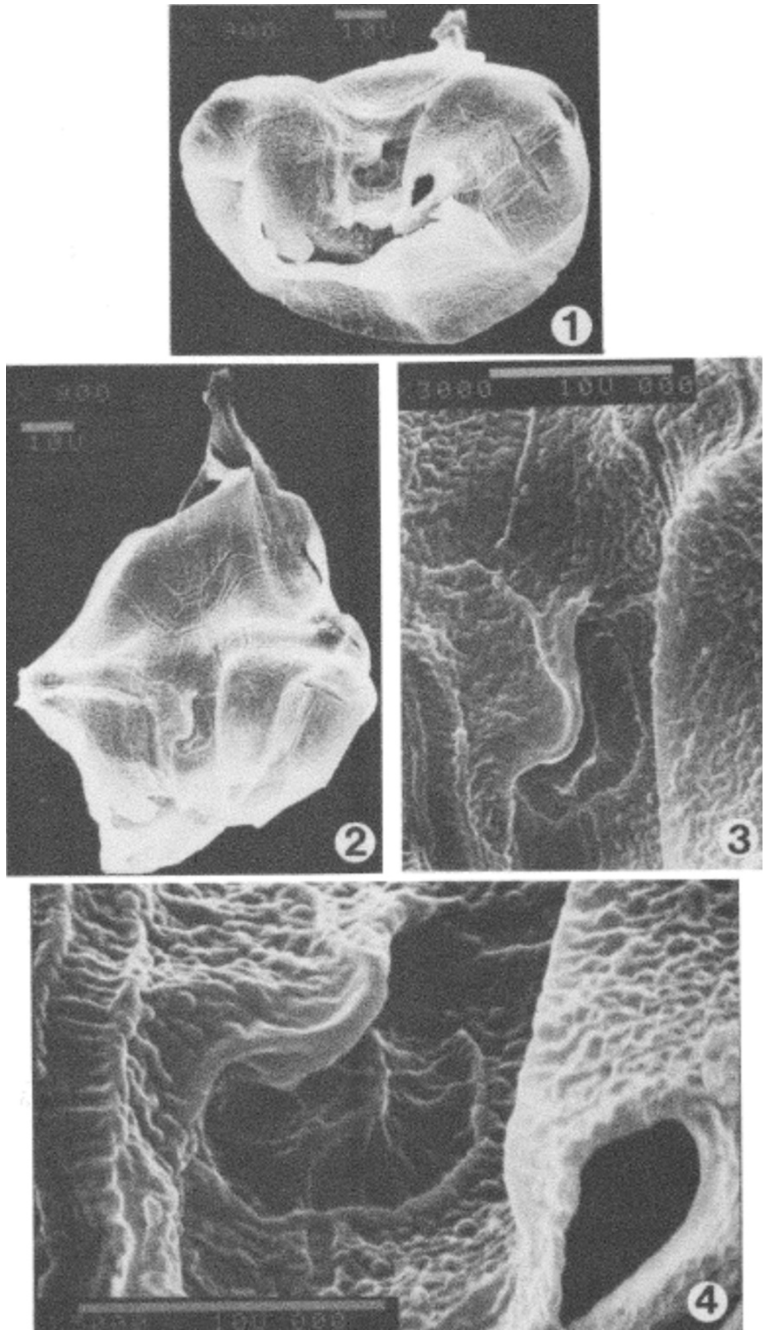


Figure 40, nos. 1–4, Wrenn & Hart (1988). Scale bars = 10 μm.

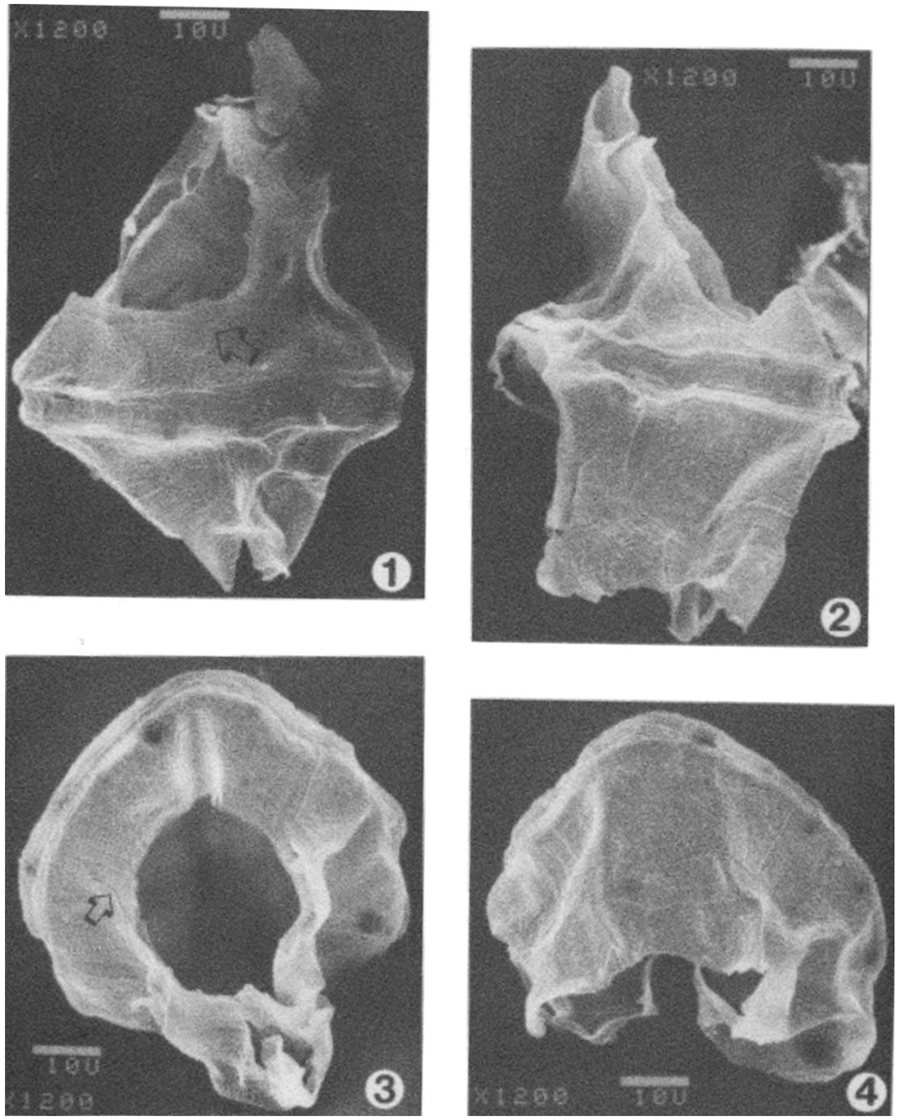


Figure 41, nos. 1–4, Wrenn & Hart (1988). Scale bars = 10 μm.

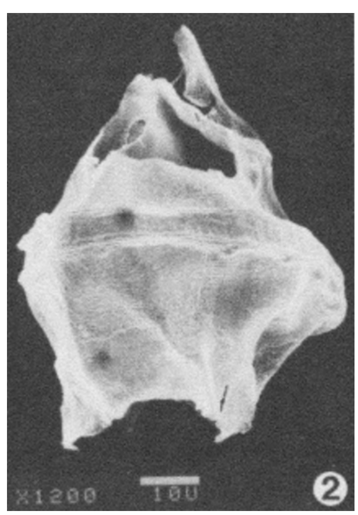


Figure 42, no. 2, Wrenn & Hart (1988). Scale bar = 10 μm.

Genus ***DICONODINIUM*** Eisenack & Cookson, 1960

1960 *Diconodinium* Eisenack & Cookson: 3.
1977 *Diconodinium* Eisenack & Cookson; emend. Morgan: 125.

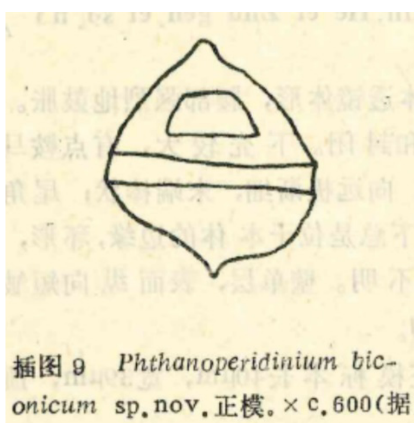
Diconodinium biconicum (Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al., 1989) Mao Shaozhi et al., 1995

Description: "The cyst profile is biconical. The epitheca and hypotheca are nearly equal in size, the conical horns are obvious, their length 2–4 μm, and the apex is relatively blunt. Endoterminal blunt, with or without a central weak caudal horn (1–1.5 μm long). The reflective girdle is visible, located at the widest part of the whole body, ring-shaped, 2–5 μm wide. Its margins are finely ridged, with distinct or indistinct ridges. The wall is one layer, relatively thin, and the surface is obvious. Fine or coarse particles with a size generally about 1 μm, some particles can be connected into short wrinkles. The reflected plate type is only indicated by the archeopyle and the cingulum, and there is no obvious seam ridge. Archeopyle (when evident), anterior type I." — Translated from Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al. (1989, p. 62)

Dimensions: "Cyst length, 43.5–48 μm, width 34.5–41.5 μm; holotype length is 45 μm, the width is 41.5 μm." — Translated from Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al. (1989, p. 62)

Discussion: "The morphology of the species *Phthanoperidinium obscurum* Harland et Sharp is similar, but the former lacks the plate style and the surface lacks short stick-shaped ornamentation." — Translated from Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al. (1989, p. 62)

Age: middle Eocene (late Lutetian) corresponding to the "third member of the Shahejie Formation" as translated from He Chengquan, Zhu Shenzhao & Jin Guangxing in He Chengquan et al., 1989, p. 62). This interval corresponds to between 41 and 43 Ma according to Zi-Ran Jiang et al. (2019, fig. 2; also see: Yang Jun-sheng & Fan Tai-liang, 2007).



Text-figure 9, Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al. (1989).

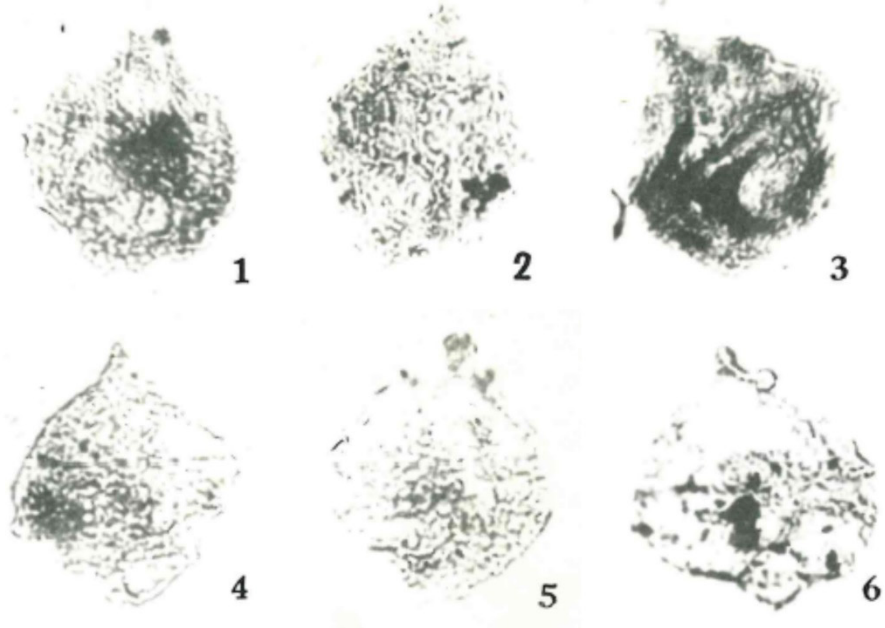


Plate 7, figures 1–6, Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al. (1989).

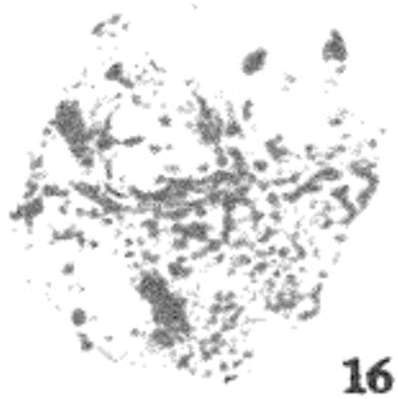
Diconodinium brevispinum He Chengquan & Zhu Shenzhao in He Chengquan et al., 1989

Description: "The outline of the cyst is rhomboid or biconical, with flat or slightly convex sides, up and down. Cyst subequal, triangular. The top of the orthodox specimen is damaged, hypotheca with a central antapical horn, slightly visible, transitions from body, blunt at end. Cingulum bright, obviously located at the widest part of the cyst, ring-shaped, about 6 µm wide, and its edge is bounded by thin ridges. No reflective longitudinal groove. Thin walled, single layer. The surface has relatively dense, short rod-like protrusions, the longest of which is about 1.5 µm, most of which are shorter than 1 µm, and the surface of the wall is granular to short wrinkled, reflecting the decrease in ornamentation in the girdle area. The archeopyle is clear, the front type is type I, and the outline is rough (10 µm in height, 7 µm in width at the bottom and top, respectively). The operculum is completely detached but remains in place." — Translated from He Chengquan, Zhu Shenzhao & Jin Guangxing in He Chengquan et al., 1989, p. 45, 46)

Dimensions: "The large and small cysts are 42–50 µm long, 30.6–50 µm wide; the holotype is 50 µm long (with the top lost) and 50 µm wide." — Translated from He Chengquan, Zhu Shenzhao & Jin Guangxing in He Chengquan et al., 1989, p. 46)

Discussion: "The new species is distinguished from others in this genus by the absence of a distinctly elongated apical and caudal angle." — Translated from He Chengquan, Zhu Shenzhao & Jin Guangxing in He Chengquan et al., 1989, p. 46)

Age: middle Eocene (late Lutetian) corresponding to the "middle and upper part of the third member of the Shahejie Formation" as translated from He Chengquan, Zhu Shenzhao & Jin Guangxing in He Chengquan et al., 1989, p. 46). This interval corresponds to between 41 and 42 Ma according to Zi-Ran Jiang et al. (2019, fig. 2; also see: Yang Jun-sheng & Fan Tai-liang, 2007).



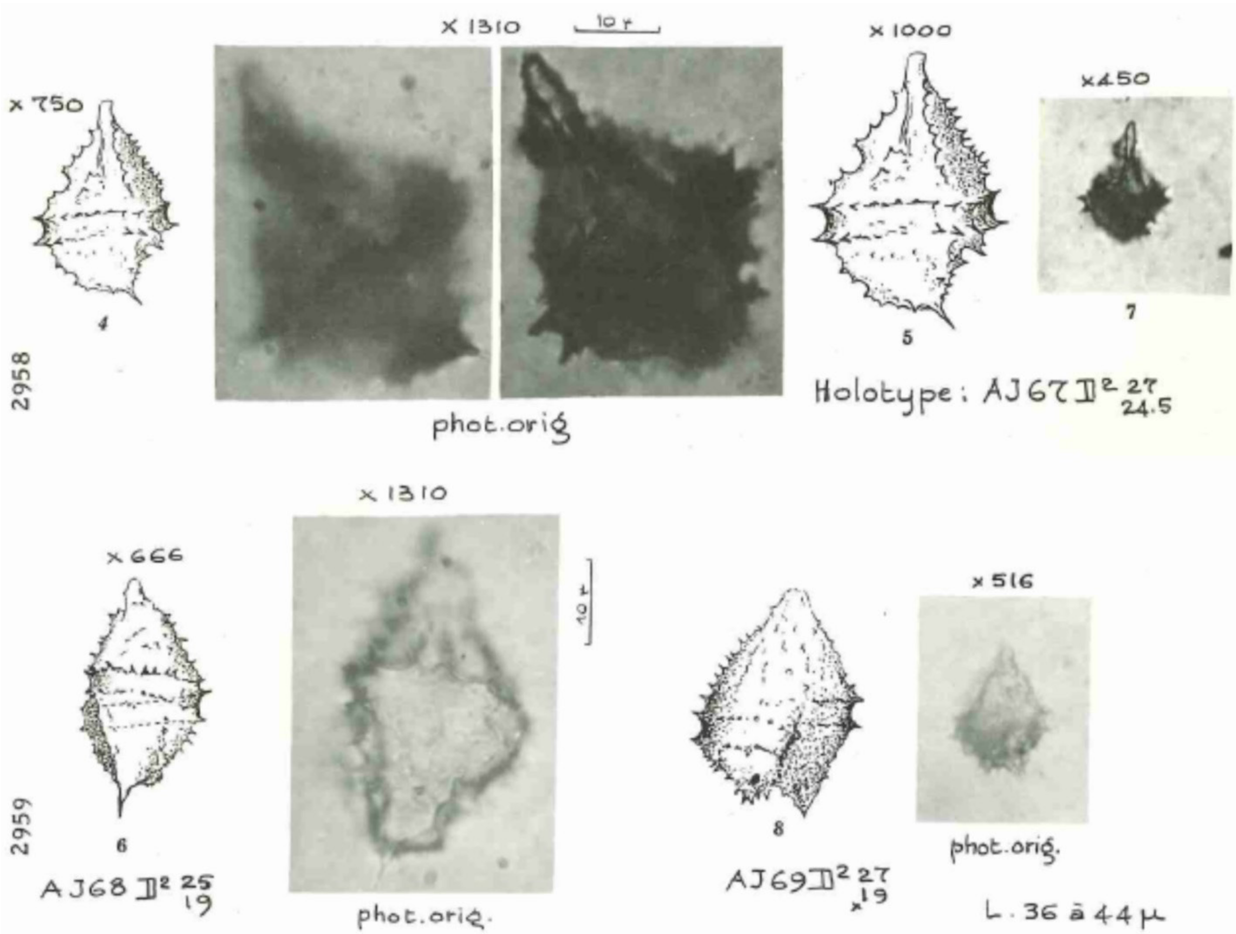
Text-figure 2; Plate 5, figure 16,
He Chengquan, Zhu Shenzhao & Jin Guangxing in He Chengquan et al. (1989).

?*Diconodinium caulleryi* Deflandre, 1935 ex Lentin & Williams, 1973

Description: “*Palaeoperidinium caulleryi* . . . has a fairly developed apical horn and a very distinct antapical spine; the membrane is bristling with thorns, as well as the transverse furrow, which gives it a very particular appearance. These last spines could moreover have supported two aliform blades framing the furrow.” — Translated from Deflandre (1935, p. 229)

Comment: “Until the wall layering is conclusively demonstrated, its taxonomic position is unclear. The ornamentation resembles that of *Spinidinium*.” — Morgan (1977, p. 129)

Age: Late Cretaceous (Senonian) as translated and inferred from Deflandre (1935, p. 215). Range: Late Cretaceous (Turonian–Campanian) (see Morgan, 1977, p. 129).



Plates 2958, 2959, Deflandre & Deflandre-Rigaud (1966)
after Deflandre (1935 Pl. 6, fig. 4) and Deflandre (1936, pl. 5, figs. 5–8).

Diconodinium cristatum Cookson & Eisenack, 1974. Emendation: Morgan, 1977, p. 126.

<u>Diagnosis</u>: “A *Diconodinium* whose antapex has a spine about halfway along the antapical horn with a sharp ridge (crista) running obliquely to the left (ventrally above), which after a short distance, merges into the left edge of the ventral area.” — Translated from Cookson & Eisenack (1974, p. 77)

<u>Dimensions</u>: “Over 12 specimens (8 measured). Type: 90 × 42 μ. The length of the above examples is between 76 and 104 μ, the width is approximately between 40 and 60 μ.” — Translated from Cookson & Eisenack (1974, p. 77)

<u>Remarks</u>: “The species is closely related to *D. glabrum*, with which they are easily confused if the bar [?] is not visible when tilted. As with *D. glabrum*, the cyst is very delicate and sometimes wrinkled; it sometimes bears clear dots, which can be arranged in longitudinal rows. The antapical spine is shifted slightly to the right and the rounded interior space is limited at the antapex.” — Translated from Cookson & Eisenack (1974, p. 77)

<u>Emended Description:</u> “Ambitus rhomboidal to fusiform, prolonged into a truncate apical horn and a sharp antapical horn located close to the midline. Apparent autophragm mostly thin, but distinctly thickened at the apex (forming a partly or wholly solid apical horn) and at the antapex (forming a distinctive solid ‘keel’

2–3 μm deep along its entire length and extending from the solid sharp antapical horn to the bulge of the undeveloped second antapical horn, as in Pl. 1, fig. 3). Ornamentation absent, or consisting of granules or spinules, usually uniform in size on individual specimens. Slightly longer aligned spines may incompletely reflect paratabulation on the cyst. Slightly raised parasutural ridges and aligned ornamentation outline the paracingulum and parasulcus (see Pl. 1, fig. 3), but individual paraplates not yet distinguished. Archeopyle Ia or IPa." — Morgan (1977, p. 126)

Dimensions: "76–104 μm long and 40–60 μm broad." — Morgan (1977, p. 126)

Comment: "Cookson and Eisenack (1974) included a specimen previously assigned to *D. glabrum* by Eisenack and Cookson (1960, Pl. 1, fig. 10) in *D. cristatum* on the basis of the antapical 'keel' like thickening, and described the ornamentation as psilate or granulate. I have retained the antapical thickening as the diagnostic feature, but have included a wider range of ornamentation." — Morgan (1977, p. 126)

Comparison: "The antapical thickening of the autophragm distinguishes *D. cristatum* from other *Diconodinium* species. For a more detailed discussion, see treatment of *D. arcticum*." — Morgan (1977, p. 126)

Age: Cretaceous (Albian); holotype of Morgan (1977, p. 47, 126). Range: Cretaceous (Albian–Cenomanian) (Morgan, 1977, p. 127).

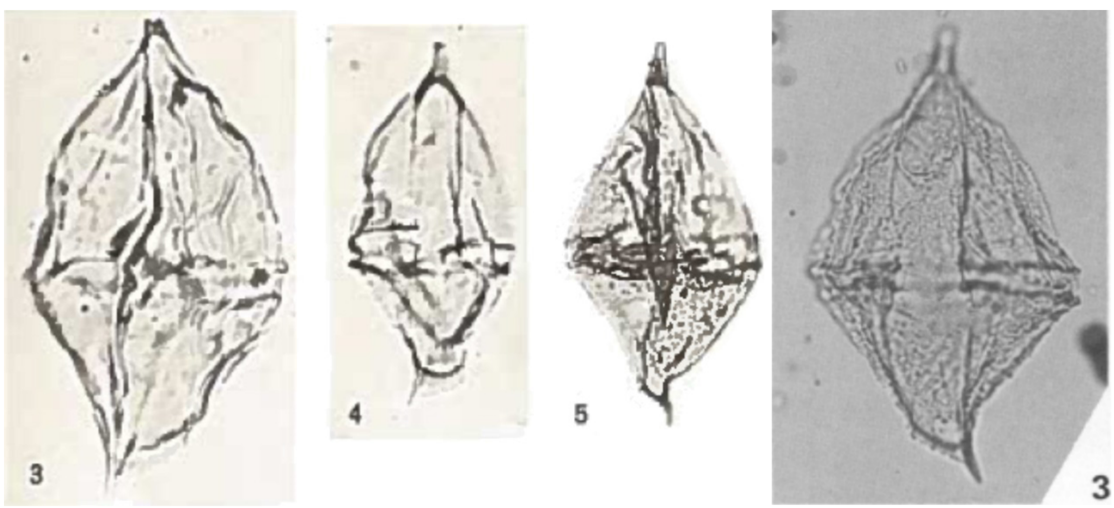


Plate 24, figures 3–5, Cookson & Eisenack (1974, p. 77); Plate 1, figure 3, Morgan (1977).

Diconodinium davidii Morgan, 1975

Description: "Cyst consists of a broadly subtriangular epitract bearing a long steeply conical, distally truncate apical horn, and a broadly rounded hypotract bearing a single strong, sharply pointed antapical horn slightly offset from the longitudinal axis. The cingulum is about 5 μ wide, and offset slightly at the sulcus. The autophragm bears a moderately dense cover of small solid spinulae or clavae about 1.0–1.5 μ high and about 1.0 μ thick. These are absent from the cingulum and rare on the sulcus area, but otherwise cover the entire autophragm. The spinulae or clavae may be randomly distributed but are more often, at least partly, aligned in rows to reveal traces of tabulation, and are always aligned in two rows along the margins of the cingulum. If aligned, the peritabular spinulae or clavae are larger and stouter than the intratabular ones. On some specimens, most of the clavae are peritabular with few or none intratabular. The archeopyle is type Ia or IPa. The former type results when only the lateral and apical sutures of the reflected 2a plate open, and the plate remains attached antapically to the 4" reflected plate. Commonly, the lateral sutures of plate 4" at least partly open, so that the operculum consists of a single piece (comprising plates 2a and 4") that remains attached at, or close to, the cingulum." — Morgan (1975, p. 157)

Dimensions: "72 (83) 96 μ long and 41 (50) 57 μ broad (10 specimens measured). Holotype: 80 μ long and 47 μ broad." — Morgan (1975, p. 157, 158)

Comparison: "This species is similar to *Diconodinium arcticum* Manum and Cookson which has shorter horns, less dense and finer ornament (minute granules up to 0.5 μ in diameter rather than spinulae or clavae 1.0–1.5 μ high and about l μ in diameter) and is smaller (50–73 μ long, 32–53 μ broad rather than 72–96 μ long and 41–57 μ broad). *D. pusillum* Singh (1971) differs from the new species by having shorter horns, finer, sharply pointed spines 0.5 μ long and by being smaller (40 (47) 54 μ long and 28 (36-5) 43 μ broad). *D. firmum* Harland (1973) can be distinguished by its small size (36.0 (42.7) 50.0 μ long and 18.0 (29.3) 30 μ broad), solid (not hollow) apical horn, fine granulation (no size given), thin wall and broad cingulum. A precingular archeopyle may be present in *D. firmum*. *Diconodinium pelliferum* (Cookson and Eisenack, 1958) (85 μ long and 59 μ broad) and *Diconodinium dispersum* (Cookson and Eisenack, 1958) (64–90 μ long and 38–62 μ broad) are similar in size to *D. davidii* (72–96 μ long and 41–57 μ broad). Surface ornament in *D. pelliferum* consists of long (1.0–2.5 μ) sharply pointed spines, and in *D. dispersum* of long (2.0–3.0 μ) strongly capitate spines, while the new species has blunt non-capitate spinulae or clavae (1.0–1.5 μ long).

The species most similar to *D. davidii* is *Diconodinium multispinum* (Deflandre and Cookson, 1955). The holotype of the latter species is very different from the described and figured specimen assigned to *Palaeohystrichophora multispina* by Cookson and Eisenack (1958) and subsequently transferred to *Diconodinium* by Eisenack and Cookson (1960). I have examined the latter specimen but not the holotype of *D. multispinum*. In general, the name seems to be applied to forms with the following features: broadly fusiform cyst having a narrow cingulum that divides the cyst approximately equally; a short apical and a single antapical horn; autophragm bears a dense covering of small granulae or short spinulae (about 0.5 μ long and broad), that are rarely aligned. From this concept the new species differs by having longer horns and coarser, less dense ornament. Strictly, the name *D. multispinum* should be applied to the morphologically and time-stratigraphically distinct holotype. A new name would then be necessary for the forms assigned by Cookson and Eisenack (1958) to *Palaeohystrichophora multispina*. Taxonomic changes await study of the holotype.

The new species differs from most other described species of *Diconodinium* by the possession of an archeopyle, and from all species, other than those mentioned herein, by type of surface ornament, and by overall shape." — Morgan (1975, p. 157–159)

Age: Early Cretaceous (Albian); holotype of Morgan (1975, p. 159).

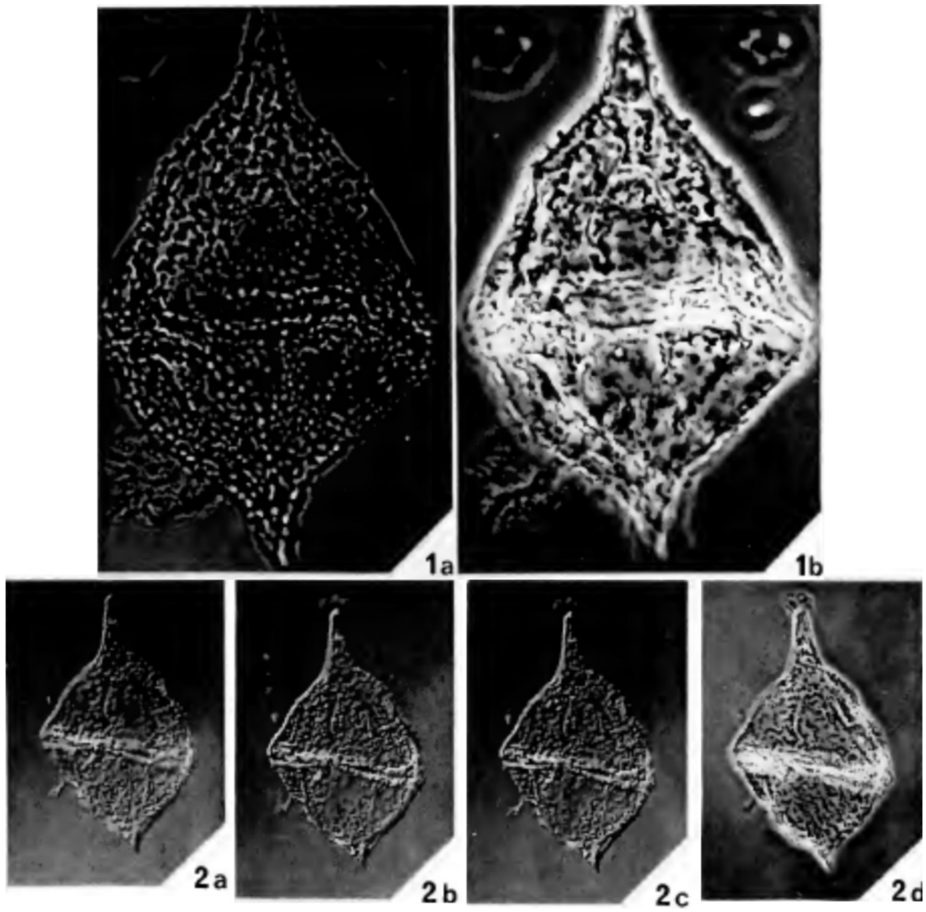


Plate 1, figures 1a, b, 2a–d, Morgan (1975).

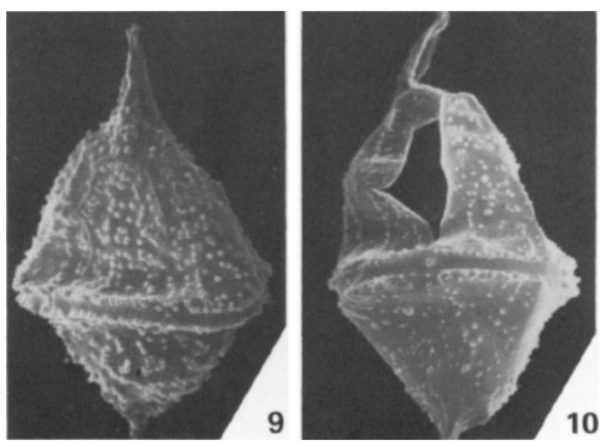


Plate 1, figures 9, 10, Morgan (1977).

Diconodinium distinctum Jain & Millepied, 1975

<u>Diagnosis</u>: “Shell fusiform without capsule; girdle circular, distinct, dividing unequally into larger epitract than hypotract. Clear lines run from apex to antapex forming distinct longitudinal aperture on one side, broader near girdle. Shell membrane thickly ornamented with bifid, short spines, arranged in longitudinal lines giving an indication of tabulation. Apex and antapex pointed.” — Jain & Millepied (1975, p. 154)

Dimensions: "Holotype: shell length, 78 μ; shell width, 33 μ; spine length, 1.5 μ. Range: shell length, 70–90 μ; shell width, 30–60 μ; spine length 1.5–3 μ."— Jain & Millepied (1975, p. 154)

Comparison: "*Diconodinium distinctum* sp. nov. compares closest with *D. dispersum* (Cookson & Eisenack) Eisenack & Cookson (1960), *D. multispinum* (Deflandre & Cookson) Eisenack & Cookson (1960), *D. pelliferum* (Cookson & Eisenack) Eisenack & Cookson (1960) in having spinose shell surface. But differs in its distinct longitudinal aperture running from pole to pole and slight indication of tabulation. The aperture is comparable to archaeopyle[s] of dinoflagellates though unique in its situation. It is formed from plate detachment. The indication of tabulation, cingulum and longitudinal archaeopyle suggests its inclusion in dinoflagellate [sic] and confirm the view of Cookson and Eisenack (1960, p. 490)." — Jain & Millepied (1975, p. 154, 155)

Age: Late Cretaceous (Campanian–Maastrichtian); holotype of Jain & Millepied (1975, p. 154, text-fig. 3).

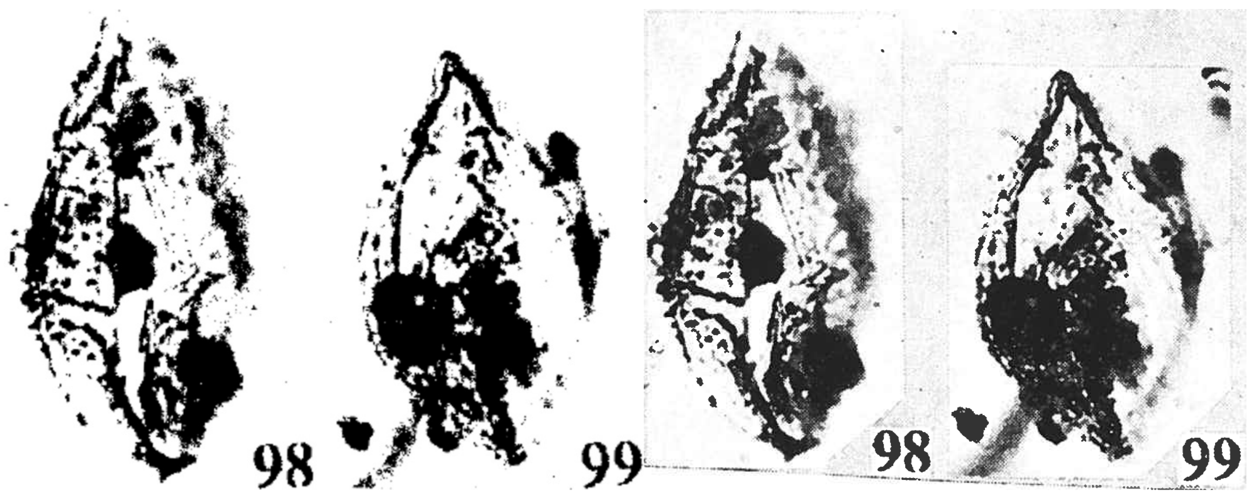


Plate 6, figures 98, 99, Jain & Millepied (1975).

Diconodinium ellipticum He Chengquan & Huang Guanjun, 1997

Description: "The pericyst hugs close to the endocyst, and the outline of the body is oval, which is divided into two parts of nearly equal size by a reflecting belt. The epitheca is a bit arched and more slightly conical than the hypotheca, with a small apex that is faintly displayed. The hypotheca is semicircular, and has no caudal convex. The original wall is thin, the surface is decorated with short rod-like protrusions that are thin and solid, with blunt ends, medium density, non-plate-like distribution, and the wall surface between protrusions is nearly smooth. The is cingulum is reflected at equatorial position, and is circular, shallowly concave, about 7 μm wide, bordered by fine ridges, with reduced or absent protrusions in the girdle region. The two ends of the cingulum are discontinuous on the ventral surface, but no longitudinal groove is seen. The reflected plate style is expressed by the cingulum and the archeopyle. Archeopyle anterior style, Type I (2a only), circular quadrilateral in outline; operculum detached." — Translated from He Chengquan & Huang Guanjun (1997, p. 34)

Dimensions: "Large and small cysts are 65–70 μm long and 50–52.5 μm wide; the body is 63–67 μm long and 49–50 μm wide; the protrusion is long 0.5–3 μm; holotype length 70 μm, width 52.5 μm; body length 67 μm, width 50 μm, protrusion length 1–3.5 μm." — Translated from He Chengquan & Huang Guanjun (1997, p. 34)

Comparison: “See *D. brevispinum* He, Zhu et Jin. (1989) and other species in this genus”. — Translated from He Chengquan & Huang Guanjun (1997, p. 34)

Age: Late Jurassic (Oxfordian); holotype from the “middle part of the Suibin Formation” as translated from He Chengquan & Huang Guanjun (1997, p. 34) corresponding to the age placement of Xueqin Zhao et al. (2022, fig. 2).

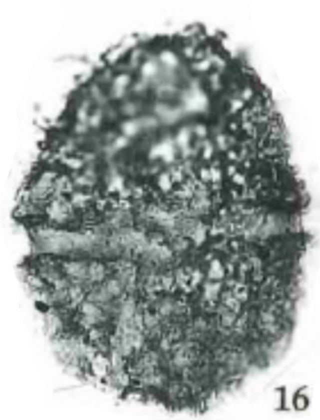


Plate 1, figure 16, He Chengquan & Huang Guanjun (1997).

?*Diconodinium fehmarnense* (Morgenroth, 1966) Lentin & Williams, 1973

Diagnosis: “A species of the genus *Gymnodinium* with a delicate, smooth capsule membrane, and pear shaped outline. Epitheca rounded. Hypotheca pulled out in a small corner. Transverse furrow strongly pronounced.” — Translated from Morgenroth (1966, p. 4)

Description: “The pear-shaped body consists of a delicate membrane whose surface is smooth. The epitheca is rounded at the apex, and bigger than the hypotheca. This is similar to *Gymnodinium dabendorfense* Alberti, distinguished by a clear tip. Next to this there is the suggestion of a second pointed bulge. The transverse groove is 5–6 μ wide and very pronounced. It appears to be circular.” — Translated from Morgenroth (1966, p. 4)

Comparison: “The new species shows a similar structure of the hypotheca as *Gymnodinium dabendorfense* Alberti and *Gymnodinium nelsonense* Cookson, differs—apart from the measurements—from the former in having a rounded epitheca, and from the latter in having a smaller, pointier hypotheca in proportion to the epitheca.” — Translated from Morgenroth (1966, p. 4, 5)

Dimensions: “Holotype: length 70 μ, width 61 μ. Paratype: length 65 μ, width 50 μ. Number of specimens: 2.” — Translated from Morgenroth (1966, p. 5)

Age: early Eocene?; holotype as translated from Morgenroth (1966, p. 4).

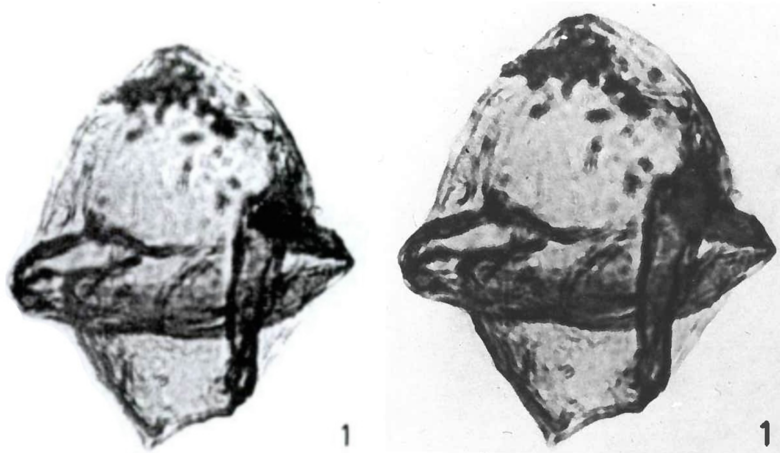


Plate 1, figure 1, Morgenroth (1966).

?*Diconodinium glabrum* Eisenack & Cookson, 1960

Description: “Shell fusiform, epitheca usually longer than hypotheca, girdle prominent, ‘longitudinal furrow’ strongly or weakly outlined; apical process prominent, usually slightly bifid, antapical process well developed and sharply pointed. Shell-membrane smooth in optical section, surface either completely smooth or sparsely dotted with tiny granules.” — Eisenack & Cookson (1960, p. 3, 4)

Dimensions: “Type—120 μ long, 70 μ broad. Range—62–142 μ long, 41–72 μ broad.” — Eisenack & Cookson (1960, p. 4).

Comments: “Forms which in surface structure appear to be intermediate between typical examples of *D. glabrum* and *D. multispinum* occur in the Lower Gearle Siltstone and Moora Bore deposit (Pl. I, fig. 10).” — Eisenack & Cookson (1960, p. 4).

Comment: “Parasutural septa outlining the paracingulum, parasulcus and incompletely outlining hypocyst paraplates distinguish this species from all other species of *Diconodinium* except ?*D. rhombiforme*, which is one third to one half as large. In view of the size variation of other species of *Diconodinium*, the two are probably synonomous, but until a more complete size gradation is recorded, the two species are maintained. The only specimen so far assigned to ?*D. glabrum*, the holotype, (Pl. 2, fig. 4) has in ambital view, a fusiform periphragm, an ellipsoidal endophragm, and small apical and single antapical pericoels beneath the horns, instead of the apparent autophragm typical of *Diconodinium*. Until additional specimens are seen, showing that the second wall is a ‘freak’ occurrence as it is in *D. multispinum*, this species cannot be confidently assigned to the genus.” — Morgan (1977, p. 129)

Age: Cretaceous (late Albian?–Cenomanian); holotype of Eisenack & Cookson (1960, p. 3).

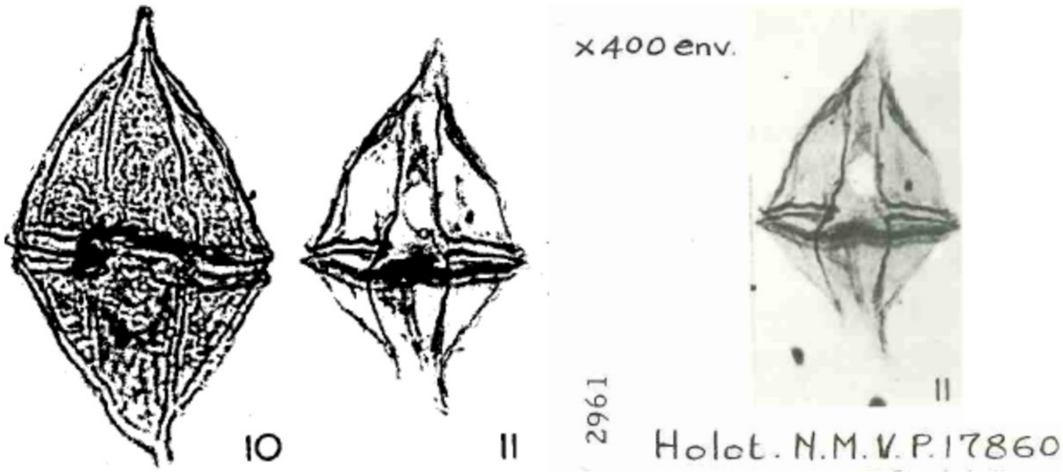


Plate 1, figures 10, 11, Eisenack & Cookson (1960); Plate 2961, Deflandre & Deflandre-Rigaud (1966).

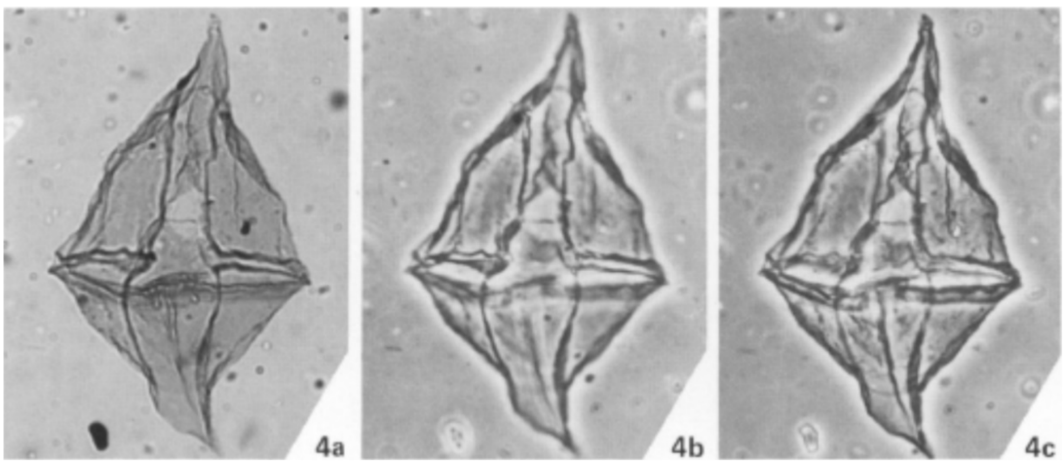


Plate 2, figures 4a–c (holotype), Morgan (1977).

Diconodinium gracile Oleinik, 1975

<u>Description</u>: “Theca is elongated-diamond-shaped, the sides are slightly convex. The epitheca is equal to the hypotheca. The surface of the theca is granular, divided by ribs into large triangular fields. The ribs separating the fields are rather wide and smooth. The epitheca ends with a large protrusion, the hypotheca with a pointed, curved spine. The transverse furrow is equatorial, wide, slightly curled to the right.” — Translated from Oleinik (1975, p. 225)

<u>Dimensions</u>: “Holotype: theca length 55.5, width 30; width of transverse furrow 5.85. Ranges from other specimens: theca length 52.1–63.7, width 30–42.7; width of transverse furrow 4.6–5.7.” — Translated from Oleinik (1975, p. 225)

<u>Comparison</u>: “It differs from other species of the genus by more elongate theca, bulging sides of theca, and wider transverse furrow. The described species is most similar to the *D. rhombiformis* Vozzen.” — Translated from Oleinik (1975, p. 225)

<u>Note</u>: “Our species is the second type from the Eocene deposits, the other species are known from the Cretaceous deposits of the USSR and Australia.” — Translated from Oleinik (1975, p. 225)

Age: late Eocene (Pirabonian); holotype as translated from Oleinik (1975, p. 225). Range: late Eocene (Pirabonian)–late Oligocene (Chattian) (Oleinik, 1975, p. 225).

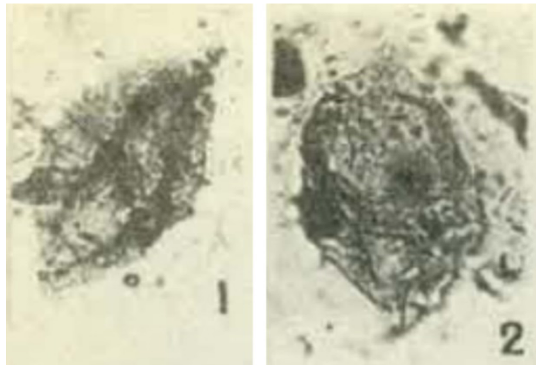


Plate 1, figures 1, 2, Oleinik (1975).

Diconodinium longicorne Olaru, 1978

Diagnosis: "Rhomboid subspherical capsule with equatorial cingulum. A tabulation is a characteristically observed on epitheca and hypotheca. It presents a thin, long apical horn and an asymmetric antapical horn, thinner and shorter than the first." — Translated from Olaru (1978, p. 89)

Description: "The capsule is divided into two unequal parts by the equatorial cingular cord. Into the upper part, the tabulated epitheca that extends when the apical horn is larger. The hypotheca at the bottom, with less visible tabulation, and asymmetric antapical horn, is smaller. Membrane covering is finely grained, thin, without fringes." — Translated from Olaru (1978, p. 89)

Dimensions: "Capsule 65 × 60 μ, apical horn 32.30 μ, antapical horn 27.50 μ. Total length 122.50 μ." — Translated from Olaru (1978, p. 89)

Comparative relationships: "This species approaches *Diconodinium glabrum* Eis. & Cook. 1960 (1964, Eis. catalogue vol. I, 1, 245), having a similar form. The described form, however, has a well-contoured capsule, from which the two horns, apical and antapical, detach. In the form described, the cingulum is continuous, and the tabulation can be observed on the surface of the capsule. The apical and antapical horns, in the form described, are much longer than those of *Diconodinium glabrum*." — Translated from Olaru (1978, p. 89)

Age: Late Cretaceous (Santonian–Maastrichtian); holotype as translated from Olaru (1978, p. 89).

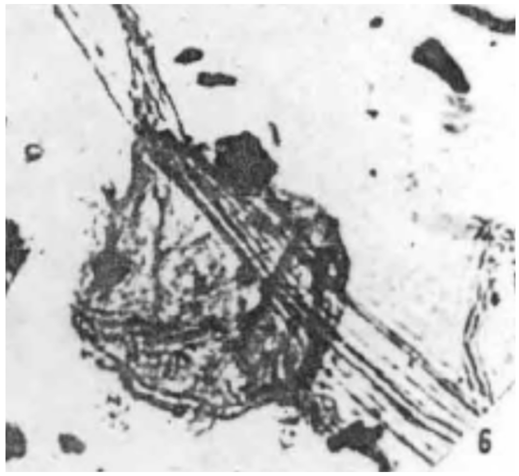


Plate 12, figure 6, Olaru (1978).

Diconodinium lurense Guerstein et al., 2005

Diagnosis: "A species of *Diconodinium* characterized by relatively long apical and antapical horns and with an autophragm densely covered by short nontabular spines." — Guerstein et al. (2005, p. 335)

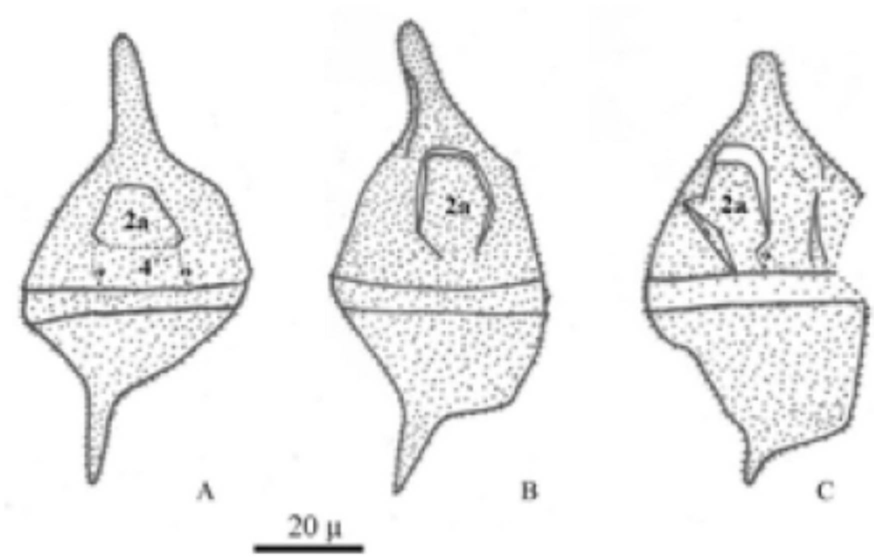
Description: "Cyst fusiform in shape, consisting of a subtriangular epitract slightly larger than the rounded hypotract. The epitract extends into a 20 to 30 µm long apical horn with a rounded distal tip. The hypotract bears a single, pointed, 15 to 25 µm long antapical horn clearly offset to the left from the midline of the cyst. The cingulum is about 4 µm wide, and slightly offset at the sulcus. The autophragm is densely covered by thin, solid spines up to 1.5 µm high. The spines are all of the same type and size. They are distributed randomly except along the margin of the cingulum, where they are always aligned in rows (figures 3.A–C). The archeopyle is rarely discernible but, when visible, is intercalary normally type Ia but occasionally IPa. The former type includes the stenodeltaform plate 2a only with clear apical and lateral sutures (figures 3.B, 4.H). When having a type Ipa archeopyle the lateral sutures of plate 4'' are partly open but never reach the cingulum (figures 3.A, 4.F, G). In both archeopyle types the operculum remains in situ and is always adnate posteriorly (figures 4.H, I, 5.H, I)." — Guerstein et al. (2005, p. 335)

Dimensions: "Overall length: 55 (80) 110 µm; width: 30 (41) 50 µm (53 specimens measured)." — Guerstein et al. (2005, p. 335)

Comparison: "*Diconodinium lurense* differs from most other described species of *Diconodinium* in having a fusiform shape and relatively long apical and antapical horns. Other species also bearing relatively long horns are *Diconodinium martianum* Srivastava and *Diconodinium longicorne* Olaru. The former resembles *Diconodinium lurense* closely in shape and size, but differs in having the antapical horn located close to the midline and in having a smooth autophragm. *Diconodinium longicorne* Olaru is characterized by having a subspherical to rhomboidal body, an epitract that is bigger than the hypotract, and an apical horn that is longer than the shorter antapical horn. In addition, its surface is finely granulate and shows tabulation on both epitract and hypotract. *Diconodinium davidii* Morgan is similar in size to *Diconodinium lurense* sp. nov. and also has a slightly offset antapical horn, but differs in having coarser, aligned spines that may reveal traces of tabulation. *Diconodinium pusillum* Singh also has an asymmetrically aligned antapical horn and an epitract that is longer than the hypotract. It differs from the new species by having a shorter, bifid apical horn and finer spines 0.5 µm long, and in being smaller. *Diconodinium lurense* also resembles *Diconodinium multispinum* (Deflandre and Cookson) Eisenack and Cookson emend. Morgan, however, the latter shows signs of paratabulation, especially on the epitract. Furthermore, *Diconodinium multispinum* has ornamentation which is slightly larger and adjacent ornamentation elements may be fused to form discontinuous parasutural ridges. *Diconodinium vitricornu* Roncaglia et al. differs from *Diconodinium lurense* in having a smooth autophragm, mostly thin but thickened at the apex to form a solid tip of the horn. *Alterbidinium acutulum* (Wilson) Lentin and Williams possesses a similar outline and comparable horns to *Diconodinium lurense*, and also has an epitract larger than the hypotract. However, *Alterbidinium acutulum* (Wilson) Lentin and Williams is characteristically circumcavate and both endophragm and periphragm are smooth." — Guerstein et al. (2005, p. 335)

<u>Remarks</u>. "A few specimens of *Diconodinium lurense* appear to show cavation, especially below the apical horn (figures 4.F, H). A detailed examination of our specimens revealed that this is an optical effect, produced by folding of the thin autophragm at the anterior margin of the archeopyle, and does not indicate a second wall layer. According to Fensome et al. (1993, p. 131), *Diconodinium* is morphologically intermediate between the two subfamilies Palaeoperidinioideae and Deflandroideae [sic], since the type species can have either a single plate intercalary archeopyle type 1Ia or a single plate intercalary plus single plate precingular archeopyle type 1I1Pa. Although the archeopyle sutures are not always clearly discernible, most of our specimens have an archeopyle type Ia and just a few of them seem to present an Ipa type. This variation reinforces the comments of Fensome et al. (1993)." — Guerstein et al. (2005, p. 335)

<u>Age</u>: Late Cretaceous (Late Maastrichtian); holotype of Guerstein et al. (2005, p. 335, fig. 2). Range: Late Cretaceous (Late Maastrichtian–Danian); Guerstein et al. (2005, p. 335).



Figures 3.A–C, Guerstein et al. (2005).

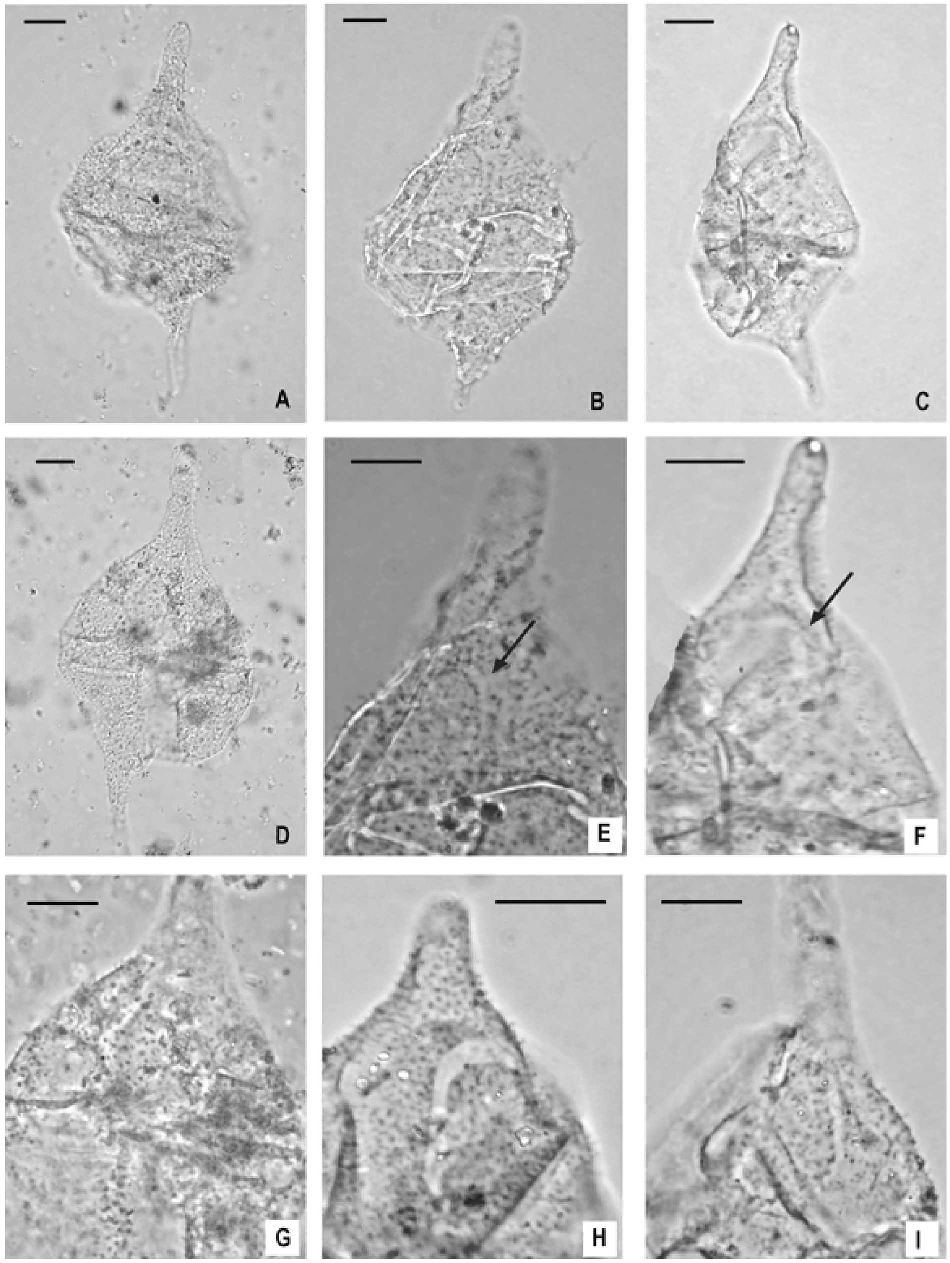


Figure 4.A–I, Guerstein et al. (2005). Scale bars = 10 μm.

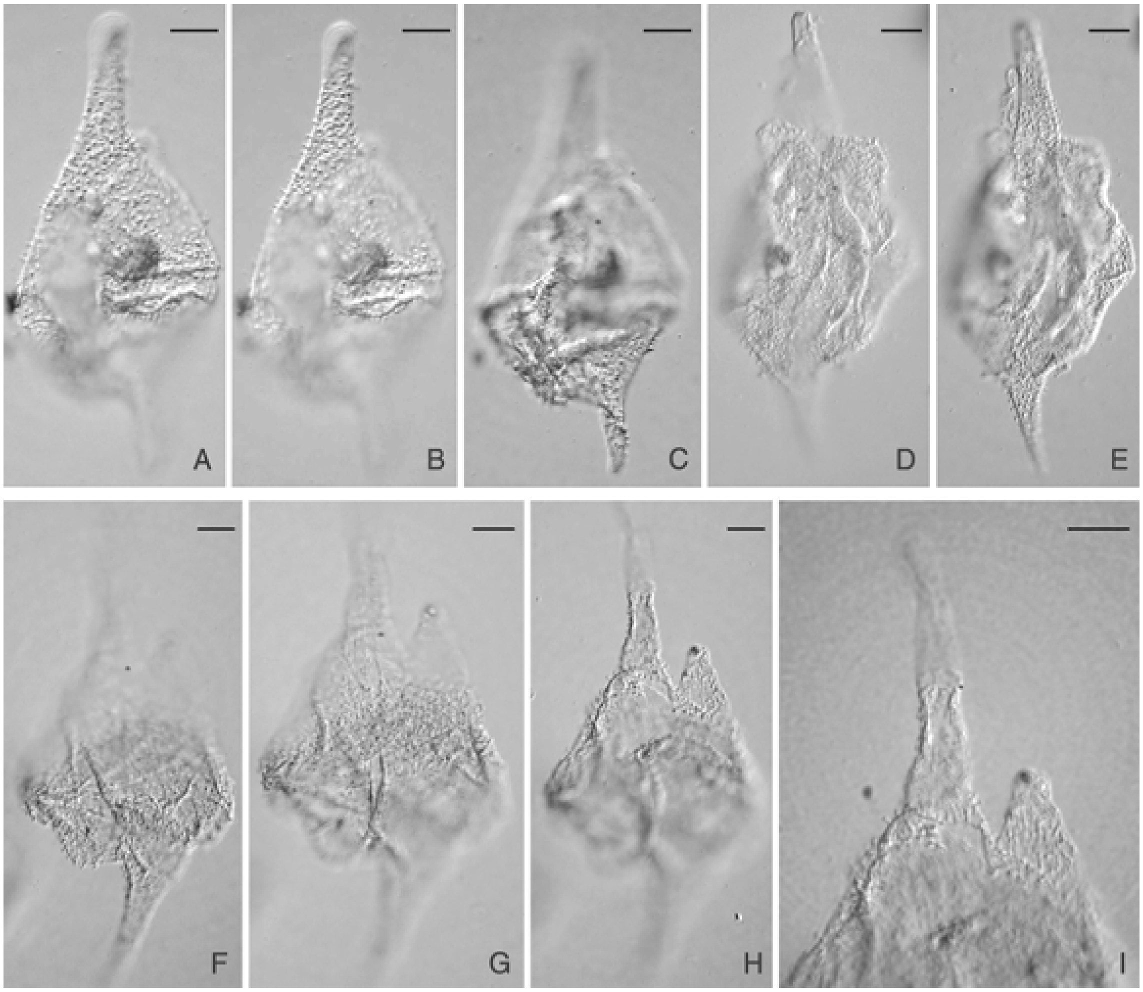


Figure 5.A–I, Guerstein et al. (2005). Scale bars = 10 μm.

Diconodinium martianum Srivastava, 1995

Description: "Body shape fusiform to rhombioidal with single apical and antapical horns of almost equal size and shape; autophragm thin, surface smooth, non-tabular except that paracingulum indicated: paracingulum slightly raised, smooth ridges about 6–8 μm apart, paracingulum groove smooth, parasulcus also smooth: archeopyle generally not indicated, intercalary when present." — Srivastava (1995, p. 286)

Dimensions: "Holotype total length × breadth range 94 × 52 μm. Total length × breadth range 84–110 × 26–44 μm in nine specimens of this study." — Srivastava (1995, p. 286)

Remarks: "*Diconodinium martianum* is distinct from *D. pusillum*, *D. glabrum*, and *D. rhombiforme* in having longer apical and antapical horns." — Srivastava (1995, p. 286)

Age: Late Cretaceous (late Maastrichtian); holotype of Srivastava (1995, p. 286).

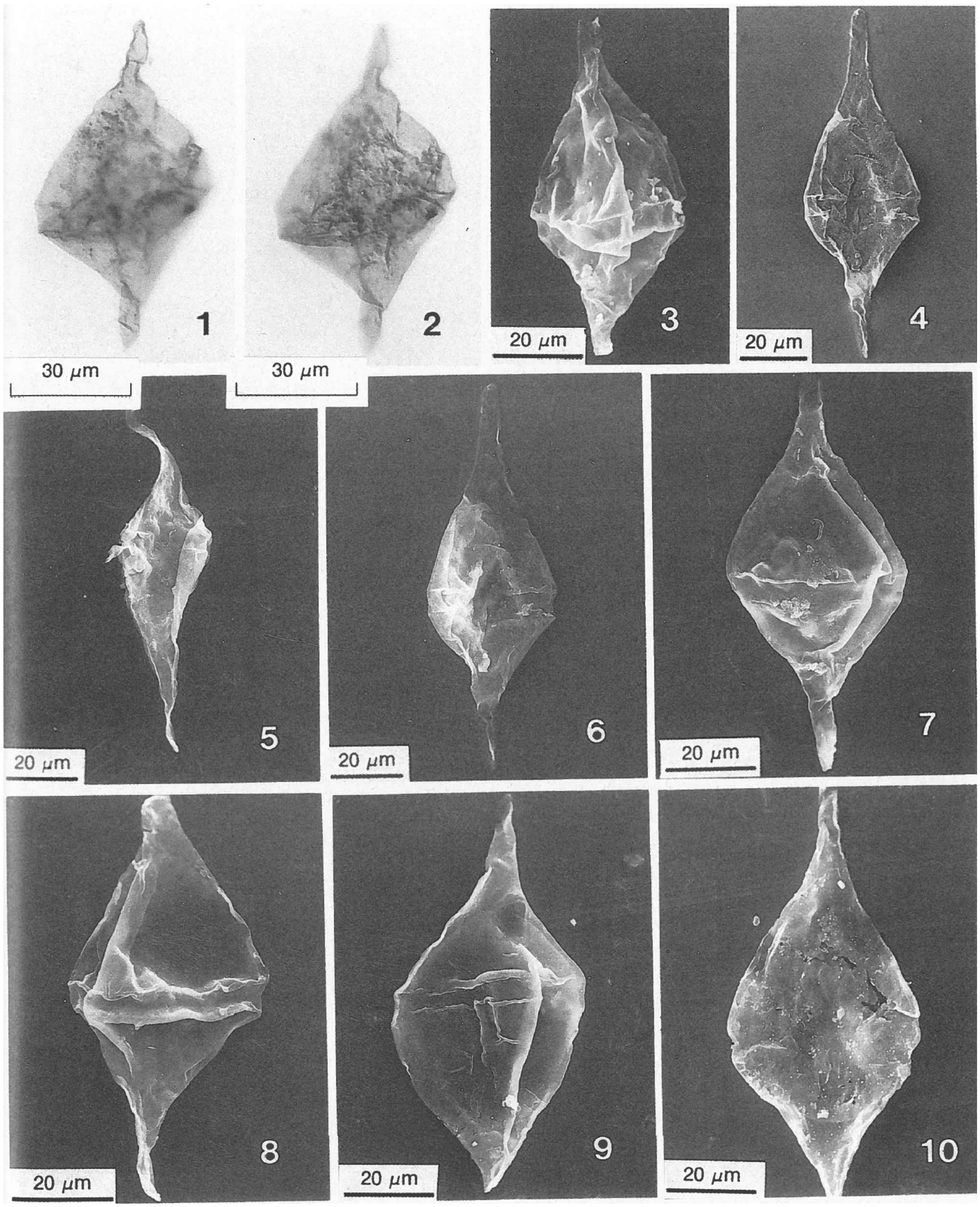


Plate 14, figures 1–10, Srivastava (1995).

Diconodinium micropunctatum Backhouse, 1988

Description: "Cyst small, proximate, subovoid to biconical; epicyst and hypocyst approximately equal in size. Apical horn short (3 µm) solid and truncate; antapical horn usually a short acicular process offset slightly to the left. Autophragm 0.5 µm thick, entirely covered by continuous longitudinal grooves and ridges. Distance between ridges approximately 1 µm. Grooves lined by rows of closely spaced shallow foveolae, that impart a finely punctate appearance to the autophragm. Paratabulation expressed only by archeopyle and paracingulum. Paracingulum, 4 to 6 µm wide, indicated by transverse ridges 0.5 µm high, offset approximately 3 µm. Parasulus [sic] not indicated. Archeopyle intercalary, type Ia (2a only), standard hexa, seldom clearly observed; operculum free." — Backhouse (1988, p. 84)

Dimensions: "Length of holotype 44 µm, width 37 µm. Range of length (17 specimens) 34(42)51 µm, width 25(33)38 µm." — Backhouse (1988, p. 84)

Remarks: "*Diconodinium micropunctatum* is distinguished from other species of *Diconodinium* by its small size and finely grooved foveolate surface. *Laciniadiniuim*? *tenuistriatum* (Eisenack and Cookson) Morgan 1977 is larger than *D. micropunctatum* and lacks foveolae." — Backhouse (1988, p. 84)

Age: Early Cretaceous (late Barremian–early Aptian); holotype of Backhouse (1988, p. 84, fig. 12).

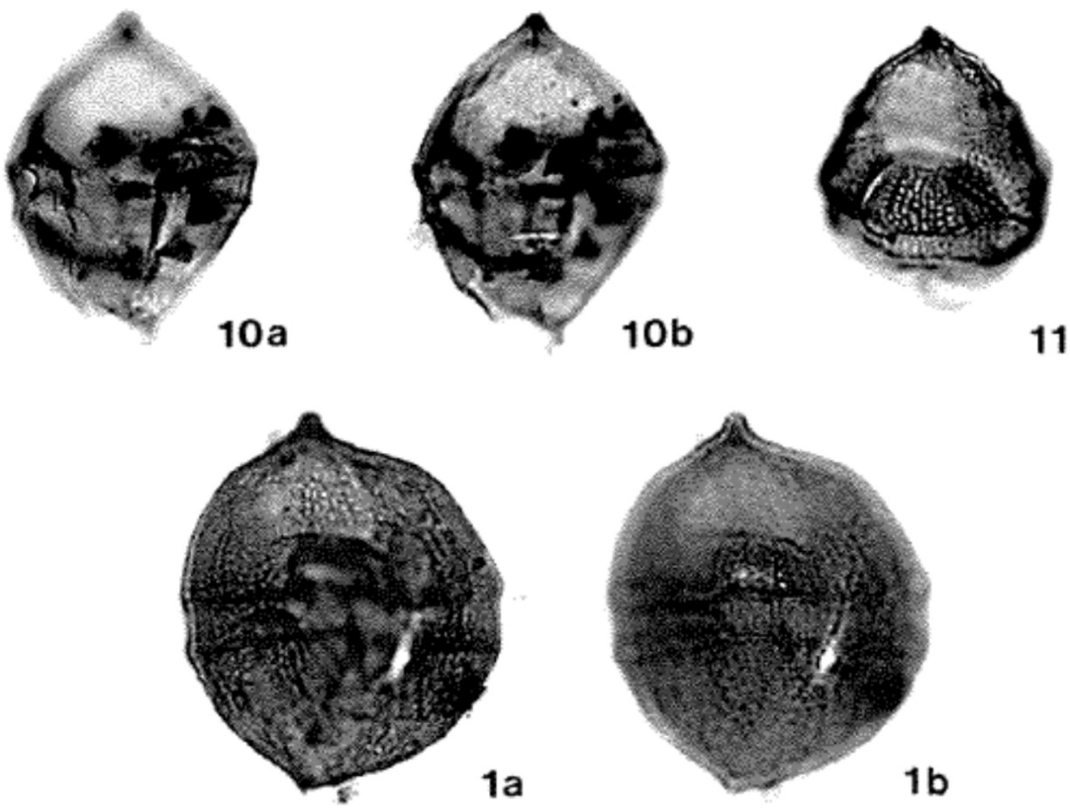


Plate 25, figures 10a, b, 11; Plate 26, figures 1a, b, Backhouse (1988).

Diconodinium minutum (Deflandre & Cookson, 1955) Deflandre & Deflandre-Rigaud, 1966

Description: "Theca biconical with slightly convex sides; transverse girdle relatively wide and shallow; epitheca and hypotheca approximately equal, epitheca prolonged into a short, cylindrical, truncate process, hypotheca terminating in a short, sharp point. Membrane without trace of plates rather sparsely clothed with short, irregularly disposed spines." — Deflandre & Cookson (1955, p. 257, 258)

Dimensions: "Length 40 μ, breadth 26 μ. The single specimen on which this species is based (holotype) is at present the smallest of the Australian Cretaceous dinoflagellates." — Deflandre & Cookson (1955, p. 258)

Age: Late Cretaceous (Senonian); holotype of Deflandre & Cookson (1955, p. 257).

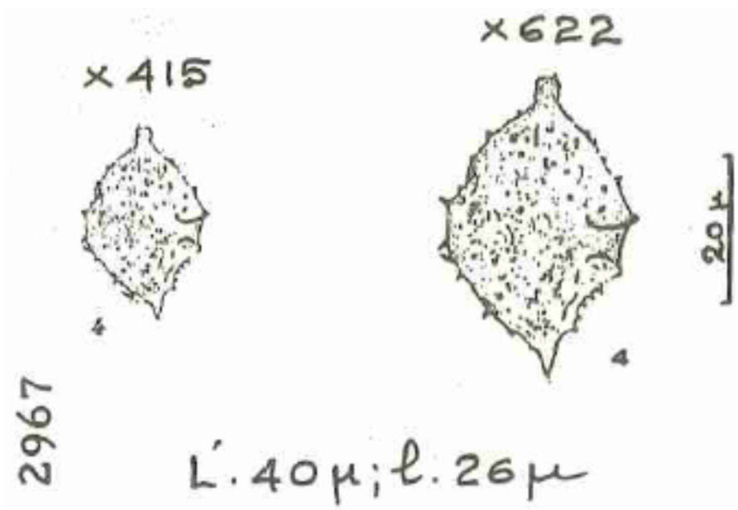


Plate 2967, Deflandre & Deflandre-Rigaud (1966) after Deflandre & Cookson (1955, text-fig. 4).

Diconodinium multispinum (Deflandre & Cookson, 1955) Eisenack & Cookson, 1960. Emendation: Morgan, 1977, p. 127, 128.

Description: "Theca biconical with an approximately median, straight, probably helicoidal girdle. The portion taken as the epitheca is terminated by a short truncate process, the hypotheca being prolonged into a short, stout point. The membrane, which shows no trace of plates, is entirely covered with short spines. The single specimen is clearly flattened and slightly broken laterally. However, it is a well-characterized and easily recognizable form." — Deflandre & Cookson (1955, p. 257)

Dimensions: "Length 56 μ, breadth 38 μ." — Deflandre & Cookson (1955, p. 257)

Age: Late Cretaceous (Senonian); holotype of Deflandre & Cookson (1955, p. 257). Range: Cretaceous (Barremian–Maastrichtian) (Morgan, 1977, p. 128).

Emended description: "Ambitus rhomboidal to fusiform, prolonged into a truncate apical horn of variable length, and into a single, sharp antapical horn located close to the midline. Epicyst and hypocyst of approximately equal size, or hypocyst slightly larger. Apparent autophragm mostly thin, but may thicken to form wholly or partly solid apical and antapical horns. Surface densely covered with ornamentation, which is homogeneous on individual specimens but in populations varies from fine granules to 1.0 μm long weakly capitate spines. Paratabulation may be weakly discernible over the cyst, especially the epicyst, by slightly larger parasutural ornamentation, or fusing of adjacent ornamentation elements to form discontinuous parasutural ridges (Pl. 1, figs. 6, 8). Paracingulum defined by two slightly raised ridges bearing aligned ornamentation, individual paraplates not discernible. Parasulcus may be incompletely outlined by larger parasutural ornamentation, individual paraplates not discernible. Archeopyle Ia or IPa." — Morgan (1977, p. 127, 128)

Dimensions: "40–100 μm long and 28–71 μm broad." — Morgan (1977, p. 128)

Comments: "*D. pusillum* is considered a junior synonym of *D. multispinum*; the differing autophragm outlines of *D. pusillum* and *D. multispinum* are considered intraspecific variance. On the basis of the emended description, the specimen of *Diconodinium* cf. *glabrum* in Cookson and Eisenack 1974, is included here in *D. multispinum*, as its ornamentation is within intraspecific variation." — Morgan (1977, p. 128)

Comparison: "Ornamentation ranging from fine granules to 1.0 μm long weakly capitate spines is characteristic of *D. multispinum*. For discussion of other species, see treatment of *D. arcticum*." — Morgan (1977, p. 128)

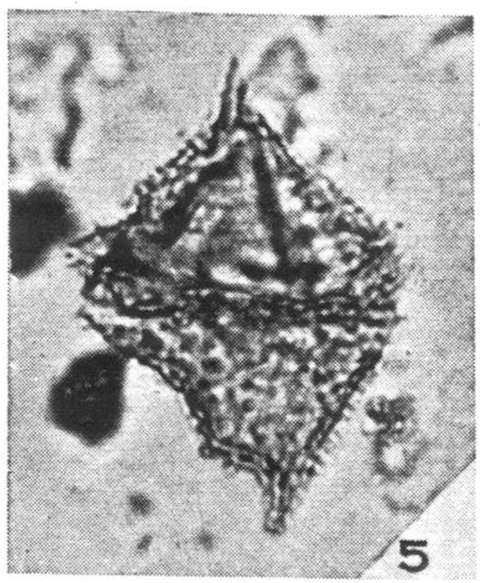


Plate 1, figure 5, Deflandre & Cookson (1955).

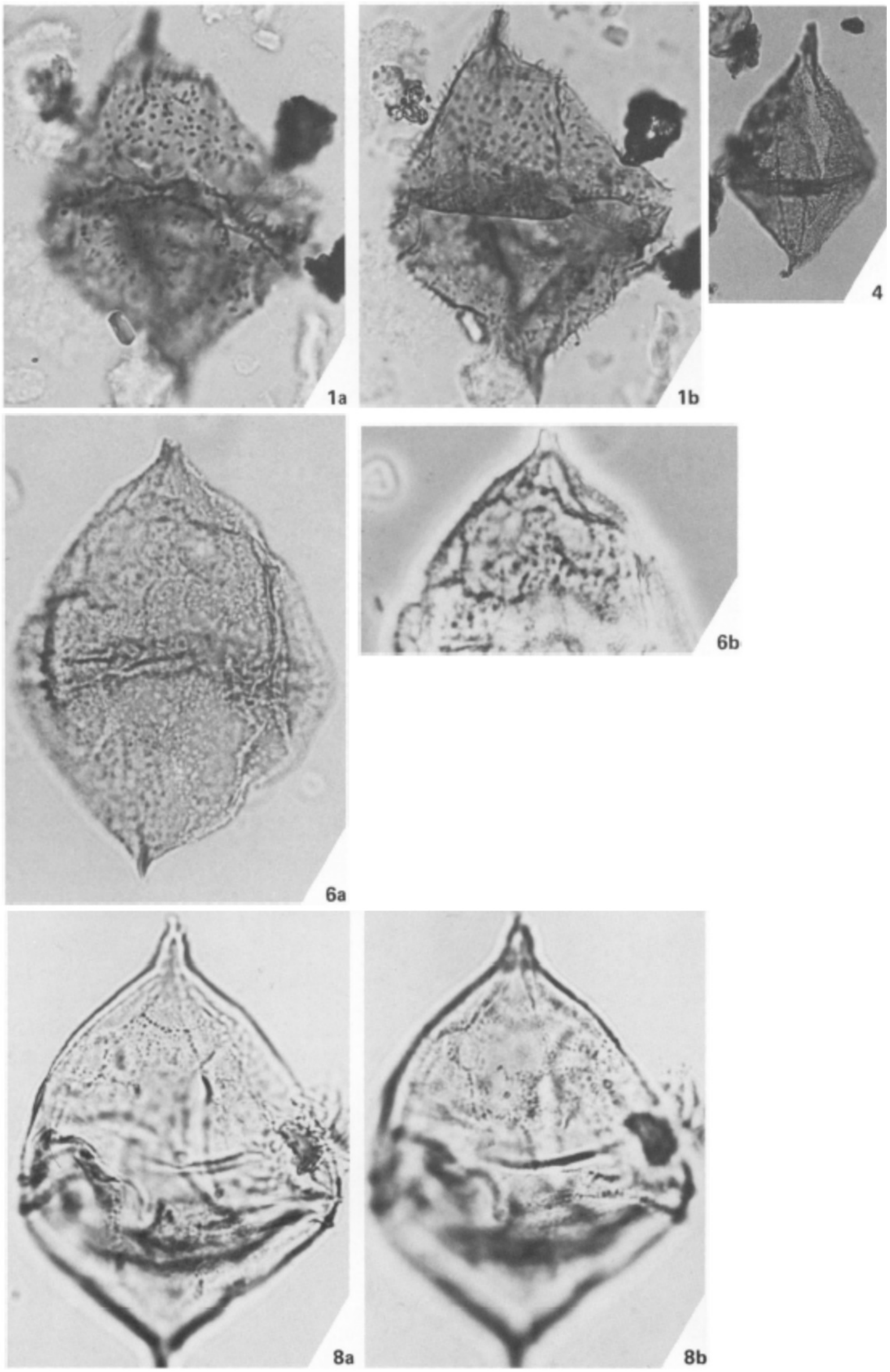


Plate 1, figures 1a, b, 4, 6a, b, 8a, b, Morgan (1977).

Diconodinium paucigranulatum Burger, 1980

Description: "Cyst biconical, epicyst longer than hypocyst, with a prominent and thin, tubular or tapering horn 8–18 µm long; hypocyst with a similar but shorter (2–10 µm) horn. A small intercalary archaeopyle with a triangular to hemispherical outline is formed in a few specimens. A paracingulum is vaguely indicated in several specimens; no other traces of paratabulation are visible. Cyst wall thin, sparsely and to all appearances randomly granulate." — Burger (1980, p. 86)

Dimensions: "Length (14 specimens) 67–85 µm, width (11 specimens) 40–56 µm." — Burger (1980, p. 86)

Comments: "The species is a typical representative of *Diconodinium*. It differs from *D. arcticum* Manum & Cookson, 1964, in lacking a broad paracingulum and having longer horns. *D. glabrum* Eisenack & Cookson, 1960, displays a more or less prominent parasulcus and paracingulum. *D. inflatum* Eisenack & Cookson, 1960, has shorter horns and a clearly delimited parasulcus. *D. davidii* Morgan, 1975, is of similar size but has a much denser and more accentuated granulate-verrucate ornament, which clearly shows alignment along parasutural boundaries." — Burger (1980, p. 86)

Age: Early Cretaceous (late Aptian); holotype of Burger (1980, p. 86).

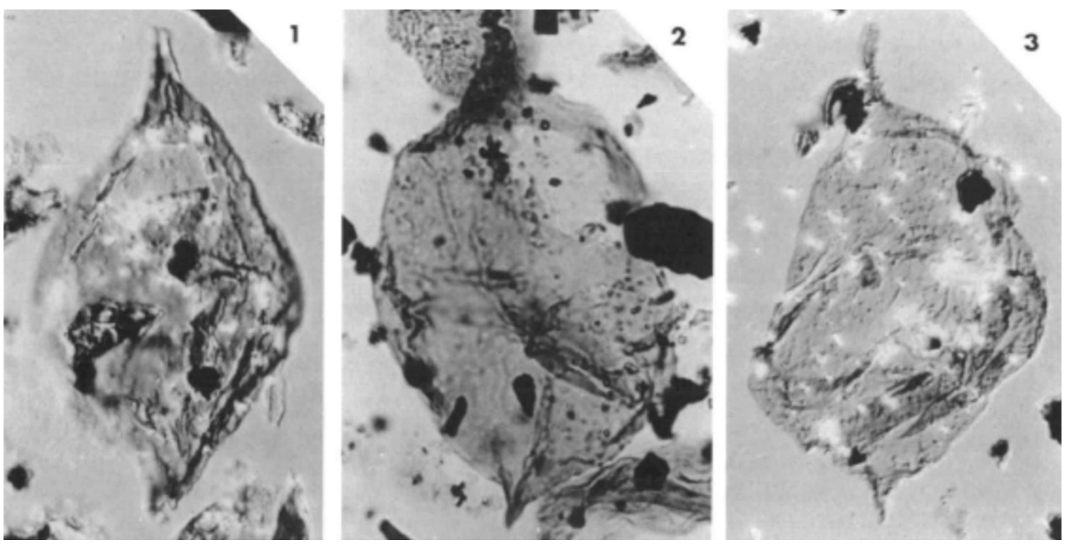


Plate 44, figures 1–3, Burger (1980).

Diconodinium pelliferum (Cookson & Eisenack, 1958) Eisenack & Cookson, 1960. Emendation: Morgan, 1977, p. 128.

Description. "The theca is broadly fusiform and divided unequally by the transverse girdle; the 'epitheca' is terminated by a shortly bifid process, the 'hypotheca' by a short pointed process. The surface is densely covered with spines c. 1–2.5 µ long." — Cookson & Eisenack (1958, p. 39)

Dimensions. "Type—85 µ x 59 µ; the 'Tertiary' specimen 122 µ x 56 µ." — Cookson & Eisenack (1958, p. 39)

Comments. "From the present investigation it would appear that the genus *Palaeohystrichophora* is restricted to the Cretaceous Period. It seems likely, therefore, that the example from the Princetown member of the Dilwyn Clay is a remanié fossil." — Cookson & Eisenack (1958, p. 39)

Emended description: "Ambitus rhomboidal to fusiform, prolonged into a truncate apical horn and a single sharply pointed antapical horn close to the midline. Epicyst larger than hypocyst. Apparent autophragm mostly thin, but may thicken to form a partly solid apical horn and a wholly or partly solid antapical horn. Surface covered with dense, weakly capitate spines 1.0–2.5pm long, nontabular. Spines of uniform length over most of cyst, slightly shorter near apical horn. Only indication of paratabulation at the paracingulum, delineated by two slightly raised ridges bearing aligned spines, individual paraplates not visible. Archeopyle not observed, presumed Ia or IPa as for other species of the genus." — Morgan (1977, p. 128)

Dimensions: "85–122 µm long and 56–59 µm broad." — Morgan (1977, p. 128)

Comparisons: "Dense surface ornamentation of 1.0–2.5 µm long, weakly capitate spines is characteristic of *D. pelliferum*. For discussion of other species, see the treatment of *D. arcticum*." — Morgan (1977, p. 128)

Comment: "The Eocene occurrence recorded by Cookson and Eisenack (1958, p. 38) is considered reworked from underlying Upper Cretaceous strata. Geological Range: Aptian and Albian, Australia (Cookson and Eisenack 1958, unpublished data)." — Morgan (1977, p. 128)

Age: Early Cretaceous (Albian); holotype of Cookson & Eisenack (1958, p. 38, 77). Range: Early Cretaceous (Albian)–early Eocene (Ypresian) Cookson & Eisenack (1958, p. 38).

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Plate 10, figure 11, Cookson & Eisenack (1958).

Diconodinium psilatum Morgan, 1977

Description: "Ambitus rhomboidal to fusiform, prolonged into a truncate apical horn and a single sharp antapical horn set close to the midline. Epicyst and hypocyst of approximately equal size, or epicyst slightly larger. Apparent autophragm mostly thin, but may thicken to form a partly or wholly solid antapical horn. Surface psilate. Paracingulum may be delineated by two slightly raised ridges which may bear aligned granules or may not be discernible. Individual plates or parasulcus not discernible. Archeopyle rare, probably Ia or IPa." — Morgan (1977, p. 128)

Dimensions: "70–89 μm long and 36–54 μm broad. Average 77 μm long and 47 μm broad (10 specimens)." — Morgan (1977, p. 128)

Comparisons: "The lack of surface ornamentation, except at the paracingulum, is characteristic of *D. psilatum*. For discussion of other species, see treatment of *D. arcticum*." — Morgan (1977, p. 128)

Comments: "Restudy of the holotype of ?*Diconodinium glabrum* revealed that many specimens dissimilar to the holotype had been assigned to that species. *D. psilatum* is erected to contain these incorrectly assigned specimens." — Morgan (1977, p. 128)

Age: Not given for holotype position in Santos Oodnadatta No. 1 at 327 ft (Morgan, 1977, p. 132). Range: Cretaceous (Albian–Maastrichtian) (Morgan, 1977, p. 128).

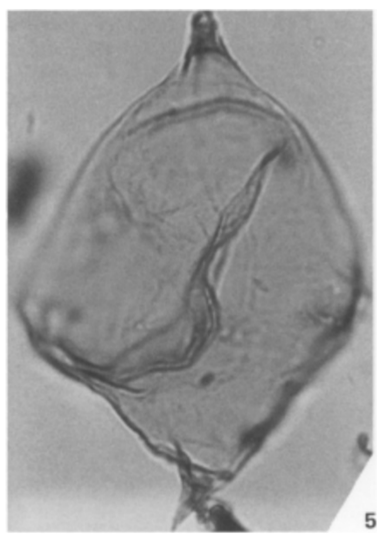


Plate 1, figure 5, Morgan (1977).

Diconodinium pusillum Singh, 1971

Description: "Test broadly fusiform with one side more convex than the other; body with one short, blunt, and bifid apical horn, and a single, spine-like, 2- to 4-micron long antapical horn; antapical horn situated closer to one side, and not median in position; cingulum faint, 2 to 3 microns wide, and dividing the body unequally into a larger, slightly conical epitract and a smaller, rounded hypotract; sulcus very faint and wide, barely discernible on the ventral surface of some specimens; body wall ornamented by 0.5-micron long spinules; test thin walled and hyaline." — Singh (1971, p. 383)

Dimensions: "Total length of the test (16 specimens) 40(47)54 microns; holotype 50 microns. Total breadth of the test (16 specimens) 28(36.5)43 microns; holotype 36 microns." — Singh (1971, p. 383)

Remarks: "*Diconodinium multispinum* (Deflandre and Cookson) Eisenack and Cookson, 1960, resembles *Diconodinium pusillum* n. sp. but differs in being larger (overall length: 56 to 100 microns) and in having equally convex sides. The antapical horn in *D. multispinum* is in median position and the cingulum divides the body equally. *Diconodinium arcticum* Manum and Cookson, 1964, can be distinguished from *D. pusillum* n. sp. in being larger (overall length: 50 to 73 microns) and in having a granular ornamentation. The apical horn in *D. arcticum* is truncate or toothed, and the body wall is double layered." — Singh (1971, p. 384)

Age: Early Cretaceous (middle–late Albian); holotype of Singh (1971, p. 384).

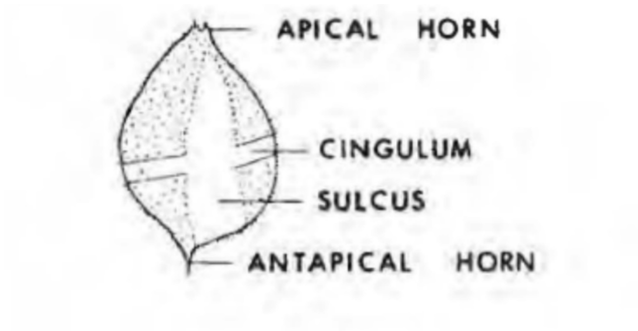


FIGURE 70. Diconodinium pusillum *n. sp. Ventral view.*
Text-figure 70, Singh (1971).

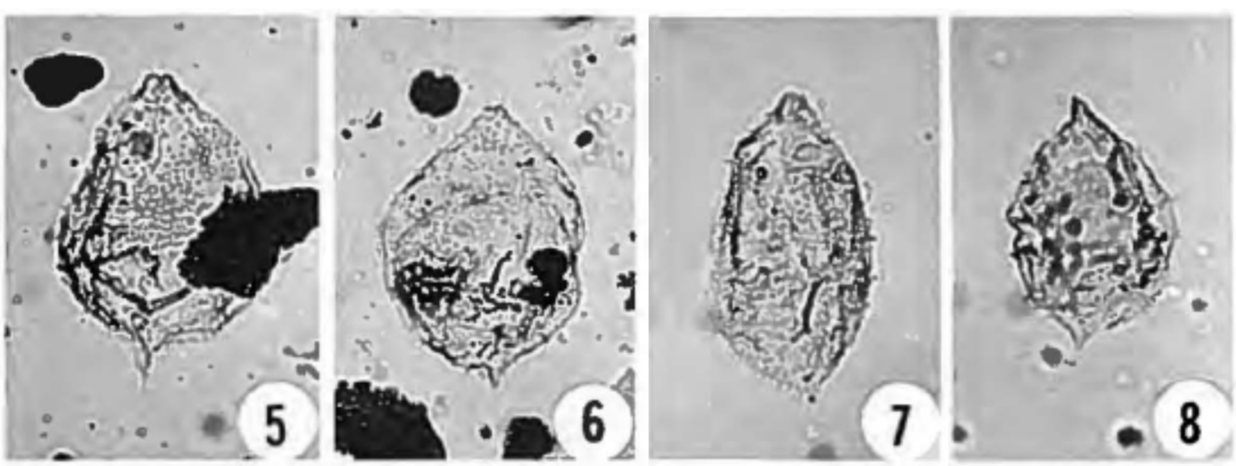


Plate 68, figures 5–8, Singh (1971).

Diconodinium sinense He Chengquan, 1991

Description: "The cyst is flat and has a double-conical shape and a rhombic shape. The sides are symmetrical and the waist is somewhat convex. Epitheca and hypotheca shape is similar, but the epitheca is larger, with an apical and antapical horn, and the ends are relatively blunt. Sometimes the antapical horn is narrower than the apical horn, the length is 5 μm, and the apical horn is 7.5–10 μm. The cingulum is biased to the hypotheca, which is more pronounced or blurred, about 5 μm wide, and has a thin ridge or equatorial transverse trough as a sign. Longitudinal grooves lacking. No endosomes. The cyst wall is single layer, thin and smooth. Anterior archeopyle, with outline of trapezoid or hexagon formed by plate 2a being lost or moved. The operculum is peeled off or set in place." — He Chengquan (1991, p. 174)

Dimensions: "The length of the cyst is 75 μm and the width is 45–55 μm (measured by 6 grains). The positive model specimen is 62.5 μm long and 46.5 μm wide." — He Chengquan (1991, p. 174)

Discussion: "This species is distinguished from *Diconodinium paucigranulatum* by wall surface smoothing; the characteristics of the archeopyle and the smooth surface are also different from other species in the genus. As far as is known, the vast majority of taxa attributed to the genus have a surface with short thorns and indiscernible archeopyle." — He Chengquan (1991, p. 174)

Age: late Paleocene; holotype of corresponding to "lower member of Qimgen Formation" as translated from He Chengquan (1991, p. 174, 215) based on the geological age of the unit provided by Xi Dangpeng et al. (2020, fig. 12). Range: Late Cretaceous (Cenomanian)–late Paleocene (Thanetian) corresponding to a range from the "lower and middle member of Kukebai Formation" to "lower member of Qimgen Formation" as translated from He Chengquan (1991, p. 174) based on the geological ages for these units provided by Xi Dangpeng et al. (2020, fig. 12).

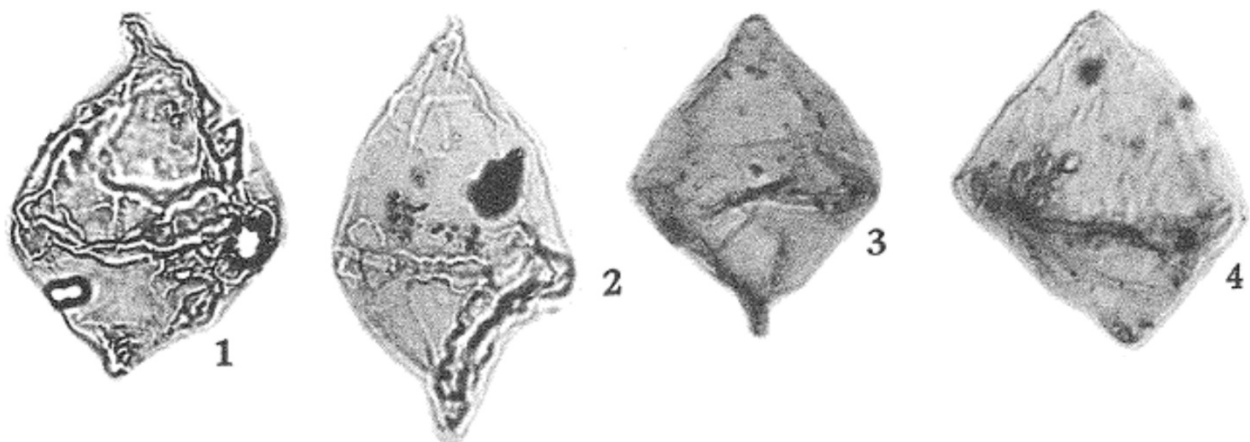


Plate 2, figures 1–4, He Chengquan (1991).

Diconodinium ventriosum (Alberti, 1961) Lentin & Williams, 1973

Diagnosis: "Body lemon shaped, dorsoventrally flattened. Epi- and hypotheca almost the same size. Sometimes a small, often somewhat pointed tip at both poles. Transverse furrow narrow, slightly deepened, like the indistinct longitudinal furrow. Surface of the body rough." — Translated from Alberti (1961, p. 5, 6)

Additions: "The outline of the body is often somewhat asymmetrical. The delicate membrane causes a fine wrinkling of the entire surface." — Translated from Alberti (1961, p. 6)

Dimensions: "Holotype: length, 95 μ; width, 80 μ. Specimens vary in length from 85 to 95 μ, and in width from 68 to 80 μ." — Translated from Alberti (1961, p. 6)

Age: Late Cretaceous (Turonian); holotype as translated from Alberti (1961, p. 5). Range: Cretaceous (Hauterivian–Turonian) (Alberti (1961, p. 6).

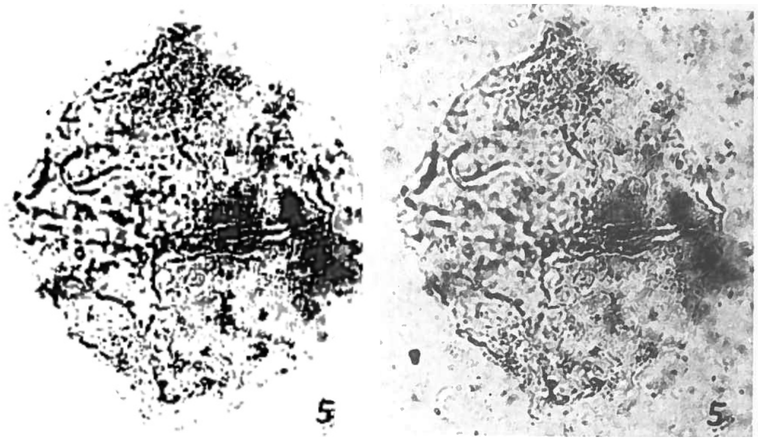


Plate 3, figure 5, Alberti (1961).

Diconodinium vitricorne Roncaglia et al., 1999

<u>Diagnosis</u>: "Large, acavate, oval to almost biconical cyst, with one sharp apical horn ending in a solid, hyaline tip, and one sharp, left antapical horn located close to the long axis. The autophragm is smooth, mostly thin, but thickened at the apex, and occasionally at the antapex, to form the solid tip of the horn. Two continuous parallel, equatorial ridges indicate the paracingulum. The parasulcus is marked by a deep midventral depression. The archeopyle, type I(2a), is rarely discernible and the operculum is usually attached. The paratabulation is indicated by paracingulum, parasulcus and archeopyle only." — Roncaglia et al. (1999, p. 305)

<u>Description</u>: "Cyst large, acavate, elongate, oval to nearly biconical, with one apical and one left antapical horn located close to the long axis. The apical horn is subconical, with an acuminate, solid, hyaline tip; occasionally, fine, hair-like elements are present on the solid part of the horn. The antapical horn is subconical, sharp and usually hollow; however, an antapical horn with a solid tip was observed in a few specimens. A small bulge on the phragm, on the right side of the antapical horn, indicates the location of a second, undeveloped antapical horn. The autophragm is smooth and thin (0.5 µm), but becomes distinctively thickened at the apex and, occasionally, at the antapex, to form a horn with a solid tip. The paracingulum is indicated by continuous, parallel, equatorial ridges on the autophragm. The parasulcus is marked by a deep depression in the midventral area. The archeopyle is intercalary, type I(2a), rarely discernible. The paratabulation is indicated by paracingulum, parasulcus and, rarely, by the archeopyle." — Roncaglia et al. (1999, p. 305)

<u>Dimensions</u>: "Dimensions (in µm, 11 specimens measured). Holotype overall length, 148, range: 113 (142) 186. Holotype overall width, 72, range: 48 (72) 90." — Roncaglia et al. (1999, p. 305)

<u>Discussion</u>: "*Diconodinium vitricornu* differs from *D. cristatum* in having an acuminate apical horn and a parasulcus marked by a deep, midventral depression, and in being much bigger. It differs from all other species of *Diconodinium* by having a smooth autophragm that is distinctly thickened at the apex, and occasionally at the antapex, to form a horn with a solid tip. Since *D. vitricornu* occurs within a narrow stratigraphic interval in the Haumuri Blu and Conway River sections, it may be of stratigraphic importance." — Roncaglia et al. (1999, p. 305)

<u>Age</u>: Late Cretaceous (late Campanian); holotype of Roncaglia et al. (1999, p. 305).

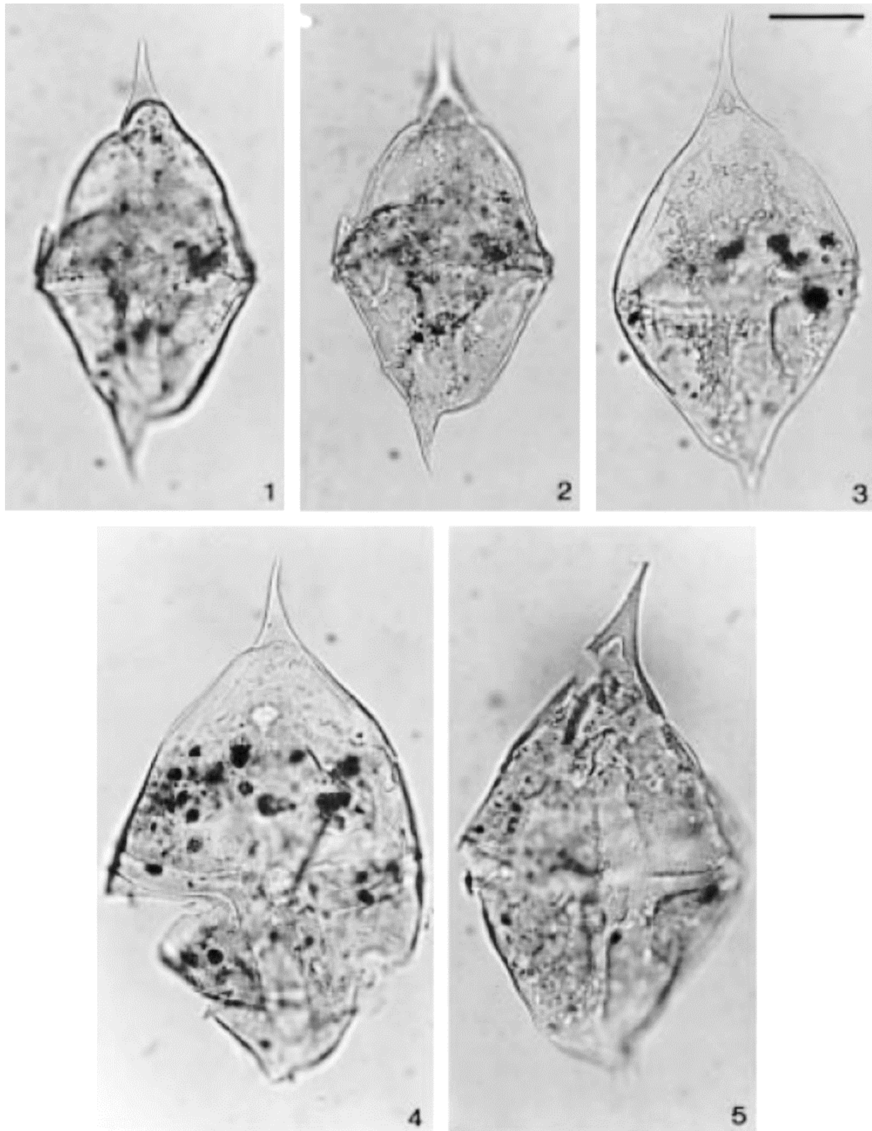


Figure 16, nos. 1–5, Roncaglia et al. (1999). Scale bar = 30 μm.

Diconodinium wilsonii Aurisano, 1984

Diagnosis: "Apical horn has very thick borders and appears solid or almost solid; solid antapical spinelike horn lies close to longitudinal axis. Autocyst surface finely granulate with linear, longitudinal folds in cyst wall." — Aurisano (1984, p. 3)

Description: "A proximate dinoflagellate cyst with a fusiform, biconical outline and two horns—one apical, the other antapical. The apical horn has very thick borders and appears solid or almost solid. The antapical horn is close to the longitidinal [sic] axis and is a solid, spinelike projection. The cyst body appears to be unilayered, although in the apical region a case could be made for separation of wall layers just below the apical horn. The surface of the autocyst is covered with fine, nontabularly arranged granules that are less than 1 μm in diameter. Paracingulum and parasulcus are indicated by faint or weakly developed ridges. Paracingulum is continuous and only slightly laevorotatory. Parasulcus is comparatively wide. Paratabulation is incompletely expressed by the intercalary archeopyle. Archeopyle formula appears to be I (2a only); its outline is a standard hexa, which has been observed in one specimen only." —

Aurisano (1984, p. 3)

Dimensions: “(on numerous specimens) Maximum length 33–46 μm; maximum width 24–30 μm.” — Aurisano (1984, p. 5)

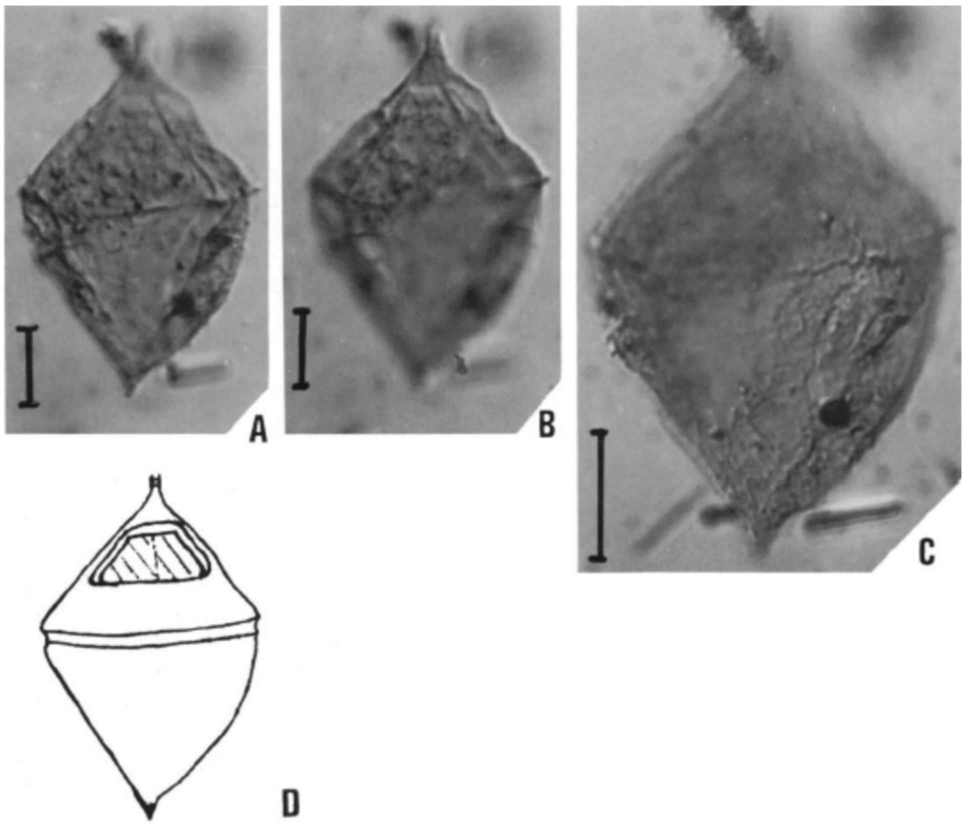
Remarks: “Aurisano and Habib (1976) originally identified specimens of *Diconodinium wilsonii* from the Toms River core as *D. firmum* Harland (1973). Subsequently, *D. firmum* was transferred to *Laciniadinium* by Morgan (1977) on the basis of its combination archeopyle, type tI3Pa. The operculum has a flaplike appearance, a feature which has not been observed in the specimens from New Jersey and Delaware. The type specimen has a standard hexa, type I (2a only) archeopyle. On this basis, the specimens from this study are placed in *Diconodinium* and given the specific name *wilsonii* as they are similar to specimens of *D. parvum* described by Wilson in an unpublished thesis (1974).

Diconodinium wilsonii differs from *D. arcticum*, Manum and Cookson, 1964. The shape of *D. arcticum* is generally inflated with convex margins. In addition, the apical protrusion of *D. arcticum* is wider and stouter in appearance, its walls thinner, and its granules less densely distributed than those of *D. wilsonii*.

D. wilsonii differs from *D. glabrum* Eisenack and Cookson, 1960 in that the epicyst and hypocyst are approximately equal in length, while the epicyst is generally longer in *D. glabrum*. Also, *D. glabrum* has distinct apical and antapical pericoels and its antapical horn is not spinelike.

Specimens identified as *Diconodinium rhombiformis* Vozzhennikova, 1967 by May (1980) appear to be similar to those of *D. wilsonii*. The type of *D. rhombiformis* figured by Vozzhennikova (1967, p. 74, Pl. 7, fig. 3) appears to be more elongate than *D. wilsonii*. Also, the apical and antapical horns are characterized by a microreticulate ornamentation, which is not present in *D. wilsonii*.” — Aurisano (1984, p. 5)

Age: Late Cretaceous (early Maastrichtian); holotype of Aurisano (1984, p. 3). Range: Late Cretaceous (late Campanian–latest Maastrichtian) (Aurisano, 1984, p. 5).



Figures 4A–D, Aurisano (1984). Scale bar = 10 μm.

Genus ***IBAIDINIUM*** Núñez-Betelu, 1994

Ibaidinium canadensis Núñez-Betelu, 1994

Diagnosis: "Elongate, subrounded pentagonal with a short apical horn and two short, poorly developed antapical horns, incipient rounded shoulders; bicavate cyst with fairly well developed apical and antapical pericoels. Peridiniacean paratabulation indicated by poorly developed parasutural ridges; bipesioid episomal paratabulation; second intercalary plate is hexa (Kofoid tabulation system). Intercalary periarcheopyle and endoarcheopyle Type I/I, endoarcheopyle rarely Type I/3I, opercula free. Paracingulum, well developed, indicated by parasutural ridges bearing granulate rims; dorsally tripartite. Parasulcus expressed by parasutural ridges and a folded shallow depression." — Núñez-Betelu (1994, p. 294)

Description: "Cyst type: bicavate. Shape: pericysl elongate, subovoidal to polygonal; slightly developed shoulders on the epicyst and a broad based, wide, short, blunt apical horn. Poorly developed antapical horns. Endocyst ovoidal to subcircular. Wall relationships: bicavate, apical and antapical pericoels well developed. Wall features: faint parasutural ridges. Periphragm smooth to faintly granulose, endophragm smooth and hialine. Paratabulation: indicated by parasutural ridges, archeopyle and paracingulum. Peridiniacean, hexa style paratabulation (4', 3a, 7'', Xc?, 5''', 2'''', and possibly 0–5s, as in *Deflandrea*). Archeopyle: periarcheopyle intercalary, Type I/I; in some specimens endoarcheopyle Type I/3I. Opercula free. Paracingulum: well developed, indicated by coarsely developed, transverse, parallel parasutural ridges formed by fused granula. Dorsally tripartite. Parasulcus: expressed as a folded, shallow depression on the hypocyst extending antapically; some faint parasutural ridges are present." — Núñez-Betelu (1994, p. 295)

Dimensions: "Holotype: Pericyst, length 76 µm, width 60 µm. Endocyst, length 52 µm. Apical horn, length 8 µm. Paracingulum, width 5 µm. Size range: Perlcyst, length 68 (75) 80 µm, width 46 (52) 56 µm. Endocyst, length 50 (58) 64 µm. Apical horn, length 6 (7) 9 µm. Paracingulum, width 4 (5.2) 6 µm. (22 specimens)." — Núñez-Betelu (1994, p. 296)

Discussion: "The main features of *Ibaidinium canadensis* sp. nov. are the subrounded to polygonal outline, the faintly developed parasutural ridges, the smooth intraplate areas of the periphragm and the smooth endophragm, and the well-developed paracingulum formed by joined granula and dorsally tripratite. In comparison with *I. mertxei* sp. nov., *I. canadensis* sp. nov. has a more rounded to polygonal outline, much less developed to faint parasutural ridges and a smooth to faintly granulose periphragm." — Núñez-Betelu (1994, p. 296)

Remarks: "Similar to *I. mertxei* sp. nov., *I. canadensis* sp. nov. is also abundant in only one sample and occurs very rarely in others. Intermediate forms between the two species are present." — Núñez-Betelu (1994, p. 296)

Age: Late Cretaceous (late Coniacian); holotype of Núñez-Betelu (1994, p. 296).

Note: name not validly published in the thesis of Núñez-Betelu (1994).

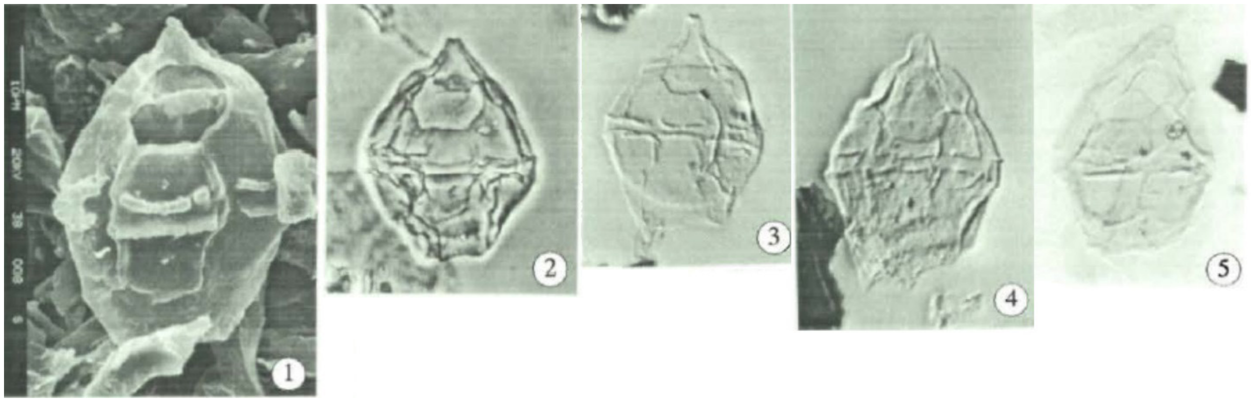


Plate 28, figures 1–5, Núñez-Betelu (1994).

Ibaidinium inuitei Núñez-Betelu, 1994

<u>Diagnosis</u>: “Elongate, subovoidal to pentagonal with a short apical horn and two short, poorly-developed horns, incipient rounded shoulders; bicavate cysts with fairly well developed apical and antapical pericoels. Peridiniacean paratabulation indicated by penitabular granula, archeopyle. and paracingulum; bipesioid episomal paratabulation; second intercalary plate is hexa (Kofoid tabulation system). Intercalary archeopyles Type I/I, opercula free. Paracingulum, very strongly developed, indicated by parasutural ridges with denticulate rims; dorsally tripartite. Parasulcus expressed by penitabular granula and a folded shallow depression.” — Núñez-Betelu (1994, p. 296, 297)

<u>Description</u>: “Cyst type: bicavate. Shape: pericyst elongate, subovoidal to polygonal; slightly developed shoulders on the epicyst and a broad based, wide, short, blunt apical horn. Poorly developed antapical horns. Endocyst ovoidal to subcircular. Wall relationships: bicavate, apical and antapical pericoels fairly well developed. Wall features: well-developed parasutural ridges. Periphragm smooth to faintly granulose and with scattered granula in the areas close to the paracingulum. Endophragm hialine [sic]. Paratabulation: indicated by penitabular granula in the pre- and postcingular areas, archeopyle and paracingulum. Archeopyle: intercalary, Type I/I. Opercula free. Paracingulum: strongly developed, indicated by high, transverse, parallel parasutural ridges with denticulate rims. Dorsally tripartite. Parasulcus: expressed as a folded, shallow depression on the hypocyst extending antapically; some penitabular granula present.” — Núñez-Betelu (1994, p. 297)

<u>Dimensions</u>: “Pericyst, length 70 μm, width 56 μm. Endocyst, length 48 μm. Apical horn, length 8 μm. Paracingulum, width 12 μm; denticulate rims 2–3 μm high. Size range: Pericyst, length 64 (72) 78 μm, width 50 (56) 60 μm. Endocyst, length 44 (49) 54 μm. Apical horn, length 7 (8.4) 9 μm. Paracingulum, width 8 (11) 14 μm; denticulate rims 1.4–4 μm high (19 specimens).” — Núñez-Betelu (1994, p. 297)

<u>Discussion</u>: “The main features of *Ibaidinium inuitei* sp. nov. are the strongly granulate penitabular areas in the proximity of the paracingulum and the wide, strongly developed paracingulum with denticulate rim, and dorsally tripratite. The paracingular denticulate rim, granulated penitabular areas, and the scattered granula are not present in *I. mertxei* sp. nov. or *I. canadensis* sp. nov. which have parasutural ridges and less strongly developed paracingula.” — Núñez-Betelu (1994, p. 297)

<u>Remarks</u>: “Similar to *I. mertxei* sp. nov. and *I. canadensis* sp. nov. the dinocyst *I. inuitei* sp. nov. is also abundant in only one sample and occurs very rarely in others. Intennediate forms between *I. canadensis* sp. nov. and *I. inuitei* sp. nov. are present.” — Núñez-Betelu (1994, p. 297)

<u>Age</u>: Late Cretaceous (late Coniacian); holotype of Núñez-Betelu (1994, p. 298).

Note: name not validly published in the thesis of Núñez-Betelu (1994).

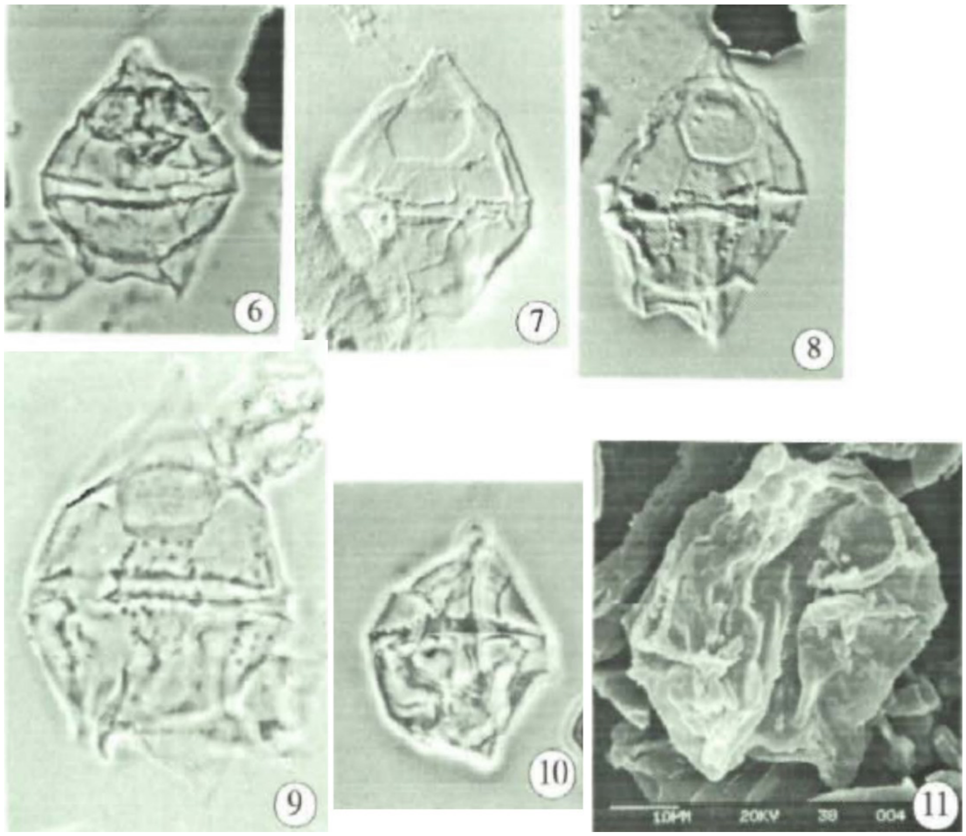


Plate 28, figures 6–11, Núñez-Betelu (1994).

Ibaidinium mertxei Núñez-Betelu, 1994

Diagnosis: "Elongate, subrounded pentagonal with a short apical horn and two short, poorly-developed horns, incipient rounded shoulders; bicavate cysts with fairly well-developed apical and antapical pericoels. Peridinacean [sic] paratabulation well expressed by strongly developed parasutural ridges; bipesioid episomal para tabulation; second intercalary plate is hexa (Kofoid tabulation system). Intercalary archeopyles Type I/I, and opercula free. Paracingulum, well developed, indicated by parasutural ridges hearing granulose ridges; dorsally tripartite. Parasulcus expressed by parasutural ridges and a folded shallow depression." — Núñez-Betelu (1994, p. 292)

Description: "Cyst type: bicavate. Shape: pericyst elongated, subrectangular to polygonal; slightly developed shoulders on the epicyst and a broad based, wide, short, blunt apical horn. Poorly developed antapical horns. Endocyst ovoidal. Wall relationships: bicavate. apical and antapical pericoels well developed. Wall features: well-developed parasutural ridges. Periphragm and endophragm smooth and hialine. Paratabulation: bipesioid episomal paratabulation; second intercalary plate is hexa (Kofoid tabulation system). Paratabulation indicated by parasutural ridges, archeopyle and paracingulum. Peridiniacean, hexa style paratabulation (4', 3a, 7'', Xc?, 5''', 2'''', and possibly 0–5s, as in *Deflandrea*). Archeopyle: Intercalary, Type I/I. Opercula free. Paracingulum: well developed, indicated by strongly developed, transverse, parallel parasutural ridges with granulose margin. Dorsally tripartite. Parasulcus: expressed as a folded, shallow depression on the hypocyst extending antapically; some individual paraplates may be discernible." — Núñez-Betelu (1994, p. 292, 293)

Dimensions: "Holotype: pericyst, length 76 µm, width 52 µm. Endocyst, length 54 µm. Apical horn, length 6 µm. Paracingulum, width 6 µm. Size range: pericyst, length 70 (78) 83 µm, width 46 (52) 56 µm. Endocyst, length 50 (55) 58 µm. Apical horn, length 4 (6) 7 µm. Paracingulum, width 5 (6) 7 µm. (18 specimens)." — Núñez-Betelu (1994, p. 293)

Discussion: "The main features of *Ibaidinium merrxei* sp. nov. are the strongly developed parasutural ridges which permit detailed reconstruction of the paratabuiation, the smooth intraplate areas of the periphragm and the smooth endophragm, and the coarsely granulate ridges of the dorsally tripratite paracingulum." — Núñez-Betelu (1994, p. 293)

Remarks: "The species *Ibaidinium mertxe;* n. sp. is abundant in only one sample but occurs very rarely in others. The morphological features of this species represent a combination of those of the genera *Chatangiella*, *Deflandrea*, and *Isabelidinium*. In summary, *Ibaidinium mertxei* has a paralabulation formula very similar to that of *Deflandrea,* a dorsally tripartite paracingulum typical of *Charangiella*, and a cyst outline intermediate among those of *Chatangiella*, *Deflandrea*, and *Isabelidinium*. The archeopyle in *Ibaidinium* n. gen., and in *Chatangiella*, *Deflandrea,* and *Isabelidinium* is hexa, Type I/I." — Núñez-Betelu (1994, p. 294)

Age: Late Cretaceous (late Coniacian); holotype of Núñez-Betelu (1994, p. 294).

Note: name not validly published in the thesis of Núñez-Betelu (1994).

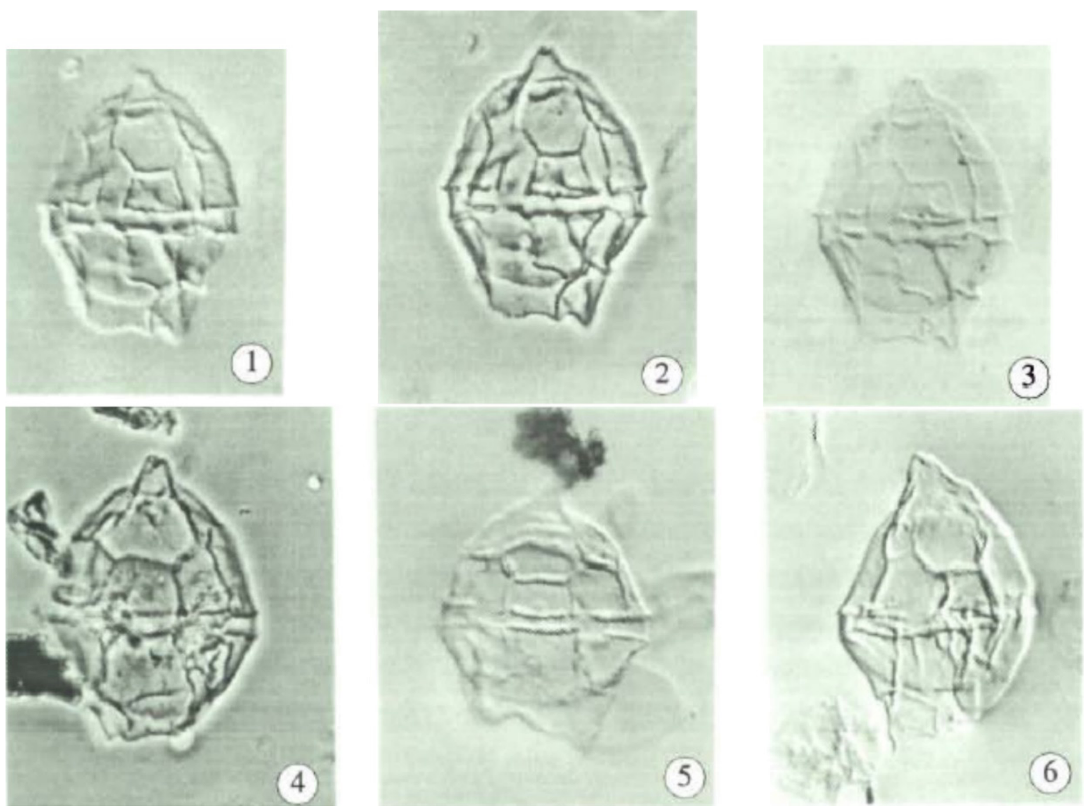


Plate 29, figures 1–6, Núñez-Betelu (1994).

Genus ***ISABELIDINIUM*** Lentin & Williams, 1977a

1976 *Isabelia* Lentin & Williams: 56 (name illegitimate).
1977a *Isabelidinium* Lentin & Williams: 167.
1988 *Isabelidinium* Lentin & Williams; emend. Marshall: 203, 205.
2009 *Isabelidinium* Lentin & Williams; emend. Fensome et al.: 39.

Isabelidinium acuminatum (Cookson & Eisenack, 1958) Stover & Evitt, 1978

Description: "Theca broadly oval with convex sides or almost spherical, apex acuminate, antapex obliquely truncate, prolonged on one side into a small pointed horn. A transverse girdle is perceptible at the lateral margins of the theca. The capsule, which is always separated from the membrane of the theca by a relatively wide space is approximately spherical, and slightly pointed on the side directed towards the apex of the theca. Both the internal and external membranes are smooth. A rounded or polygonal pylome is present above the apex of the capsule." — Cookson & Eisenack (1958, p. 27)

Dimensions: "Type—theca 85 × 62 μ; capsule 48 × 48 μ. Range theca 66–99 × 52–62 μ; capsule 38–47 × 38–47 μ." — Cookson & Eisenack (1958, p. 27)

Age: Late Cretaceous (Cenomanian–early Turonian); holotype of Cookson & Eisenack (1958, p. 27).

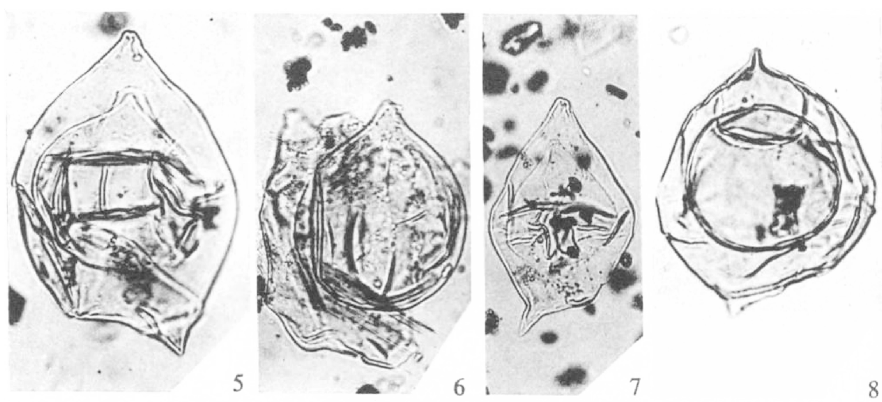


Plate 4, figures 5–8, Cookson & Eisenack (1958).

?*Isabelidinium amphiatum* (McIntyre, 1975) Lentin & Williams, 1977a

Description: "Cyst cavate, approximately pentagonal in dorsoventral view, dorsoventrally flattened and convex in equatorial region. The epitract and hypotract are of equal size and the periblast is often folded in the equatorial region. On the epitract the periblast tapers to a short apical horn which often has a short papilla. Periblast usually has slight lateral bulges opposite top of archeopyle. The left antapical horn is a short, rounded bulge and is only slightly larger than the right antapical horn, which is usually indicated as a rounded right angle in the periblast. Cingulum not normally present, but some specimens have faint indications of a cingulum (Pl. 2, fig. 7). A wide sulcus is very indistinctly indicated on some specimens by longitudinal folds (Pl. 2, fig. 8). The very large intercalary (2a) archeopyle occupies much of the dorsal surface of the epitract and extends almost to the cingulum on the equatorial region. Archeopyle hexagonal; operculum usually attached at posterior margin. No other indications of tabulation are visible. The endoblast is usually short and extends to or nearly to the periblast lateral margin in the equatorial region. Endoblast often folded and often rather indistinct. Endophragm smooth and less than ½ μm thick. Periphragm 1 μm or less thick and smooth to finely scabrate and sometimes partly striate. Large apical and antapical pericoels are present." — McIntyre (1975, p. 65)

Dimensions: "Holotype, 113 µm long, 60 µm wide; endoblast, 28 µm long; range, 99–133 µm long, 53–67 µm wide; endoblast 28–42 µm long." — McIntyre (1975, p. 65, 66)

Remarks: "*D. amphiata*, recorded in McIntyre (1974) as *D.* sp. 8, is abundant in the upper part of Division H2, Section CR16B. No previously described species of *Deflandrea* appear to have such a large hexagonal archeopyle that extends nearly to the cingulum as in *D. amphiata*. The cyst of *D. bakeri* Deflandre and Cookson (1955) is of similar shape to that of *D. amphiata*, but has a punctate periphragm. *D. cretacea* Cookson (1956) is smaller and more spherical and lacks an apical horn. *D. korojonensis* Cookson and Eisenack (1958) is smaller than *D. amphiata*, has shoulders developed, and lacks an apical horn; *D. rectangularis* Cookson and Eisenack (1962) has pronounced shoulders and no apical horn." — McIntyre (1975, p. 66)

Age: Late Cretaceous (Campanian); holotype of McIntyre (1975, p. 65, text-fig. 2). Range: Late Cretaceous (middle Campanian–late early Maastrichtian) (McIntyre 1975, text-fig. 2).

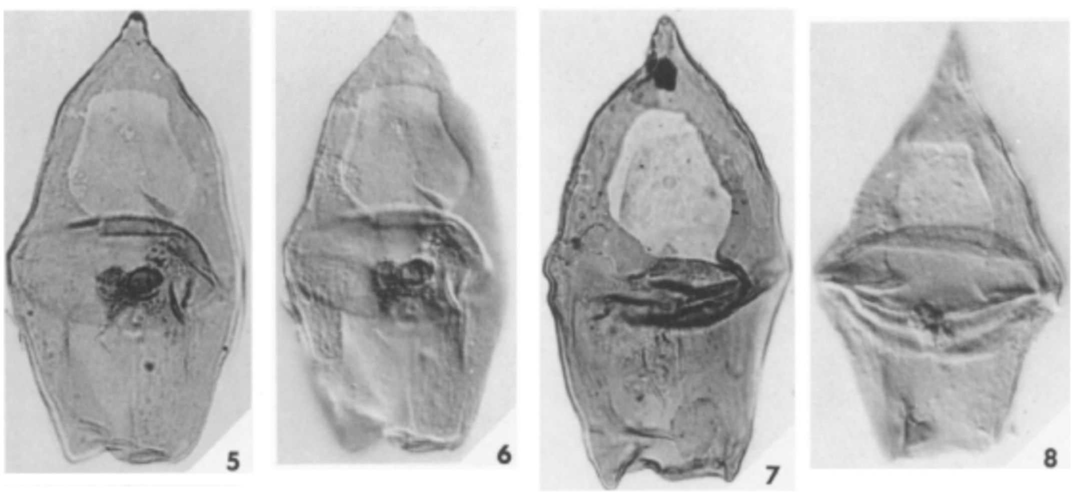


Plate 2, figures 5–8, McIntyre (1975).

Isabelidinium armatum (Cookson & Eisenack, 1970) Lindgren, 1984

Description: "Shell relatively large, considerably longer than broad, divided approximately equally by a clearly-defined discontinuous girdle. The epitheca, which is slightly longer than the hypotheca, consists of a prominent apical region with strongly convex shoulder-like sides, a short, broad, median apical horn with a straight apex and outwardly slanting sides, and a slightly broader lower portion gradually inwards towards a squarish antapex with a slightly pointed prominence on the right-hand side. The girdle is relatively wide, strongly defined and broken at regular intervals. The archeopyle is rather large and slightly angular in outline. The wall of the shell is finely granular throughout. In addition, relatively large clearly-defined areas both above and below the individual subdivisions of the girdle, which resemble fields of *Peridinium* type (Manum 1963), are outlined by relatively prominent, closely arranged, bluntly-pointed solid thickenings which are circular in outline in surface view. The walls of the central body and shell are thin and in close contact." — Cookson & Eisenack (1970, p. 142, 143)

Dimensions: "Holotype: c. 102 µ long, c. 60 µ broad. Range: 20 specimens c. 95–138 µ long, c. 52–80 µ broad." — Cookson & Eisenack (1970, p. 143)

Age: Late Cretaceous (Senonian); holotype of Cookson & Eisenack (1970, p. 142).

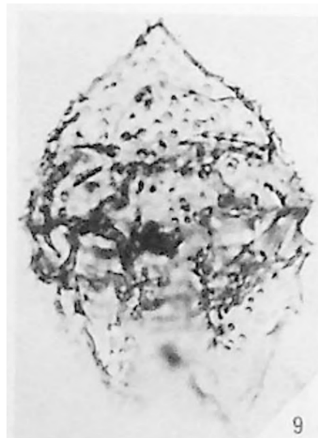


Plate 13, figure 9, Cookson & Eisenack (1970).

Isabelidinium bakeri (Deflandre & Cookson, 1955) Lentin & Williams, 1977a. Emendation: Stover, 1973, p. 169, 170.

Description: “Cell generally but not always encysted. Theca widely fusiform, somewhat obliquely truncated posteriorly; transverse girdle faint, neither hollowed nor shallow, sometimes quite indistinct, dividing the theca into 2 unequal parts. Longitudinal furrow not observed. Epitheca larger than the hypotheca, widely conical or bell-shaped, surmounted by a short, more or less bluntly pointed, slightly thickened prominence. Hypotheca like a frustum of a cone, sometimes with 2 very short unequal horns and occasionally a 3rd submedian conical expansion, sometimes with the lower angles simple or 1 of the 2 rounded. In lateral view (Plate 2, Fig. 4) the encysted cells have an asymmetrical outline with, at the level of the cyst, 1 face plane and the other convex. This convexity does not seem to exist in the rare non-encysted examples that have been examined. The cyst also causes a slight frontal enlargement. The cyst is ellipsoidal, more or less regular when viewed from the front, more asymmetrical in lateral view. The encysted cells have a rather regular polygonal aperture on the convex side of the epitheca. Membrane of the theca more or less strongly and irregularly punctate, except in the region of the transverse girdle, where it is generally smooth.” — Deflandre & Cookson (1955, p. 251)

Dimensions: “Holotype (Plate 3, Fig. 2): theca, length 108 μ, breadth 61 μ; cyst, length 51 μ, breadth 56 μ. Range: theca, length 87–108 μ, breadth 54–69 μ; cyst, length 41–50 μ, breadth 50–56 μ.” — Deflandre & Cookson (1955, p. 251)

Emended description: “In dorso-ventral view, the lateral margins of the periphragm are more or less evenly and gently convex along most of their length with no apparent demarcation between the epitract and hypotract. A slight inflection occurs along the lateral margins anterior to the archeopyle in some specimens. Above the inflection, the margins of the periphragm converge to form a short, usually blunt apical horn. Antapical margin is straight or nearly so on most specimens and truncates the lateral margins rather abruptly. On one specimen (Plate 1, Fig. 1), the antapical margin has a medial peak between shallow concavities. A small, hollow projection about 2 μ long may occur at one antapical corner, or a broadly rounded right antapical horn may be developed.

Endophragm is circular to subcircular in dorso-ventral view, folded in nearly all specimens, and lies approximately midway between the apical and antapical ends of the periblast. Lateral margins of the endophragm are close to or in contact with the inner surface of the periphragm. Endophragm is smooth, about 1 μ thick; periphragm varies in thickness from slightly less than 1 to nearly 2 μ. Periphragm surface is weakly verrucate (Plate 1, Fig. 2); verrucae low, irregularly polygonal and separated by narrow grooves. Specimens show no definitive indications of cingulum or sulci. Archeopyle is intercalary, hexagonal, greater in height than in width and the operculum is attached, hinged along its antapical margin. Cracks and tears in the endophragm suggest an opening most likely occurs in this body, at least on some specimens." — Stover (1973, p. 169, 170)

Age: Paleocene–early Eocene; holotype of Deflandre & Cookson (1955, p. 251). Middle Paleocene (Selandian) of same type section, Pebble Point Formation (Stover, 1973, p. 170).

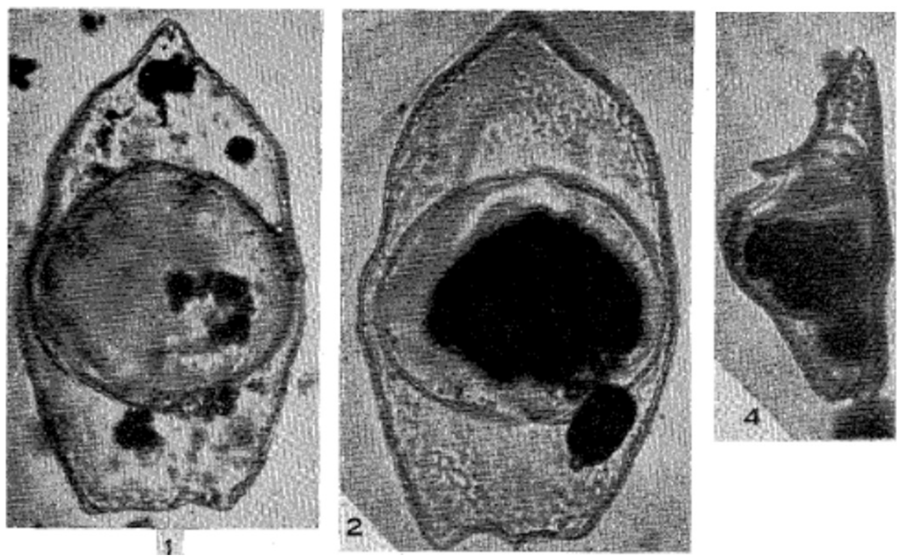


Plate 4, figures 1, 2, 4, Deflandre & Cookson (1955).

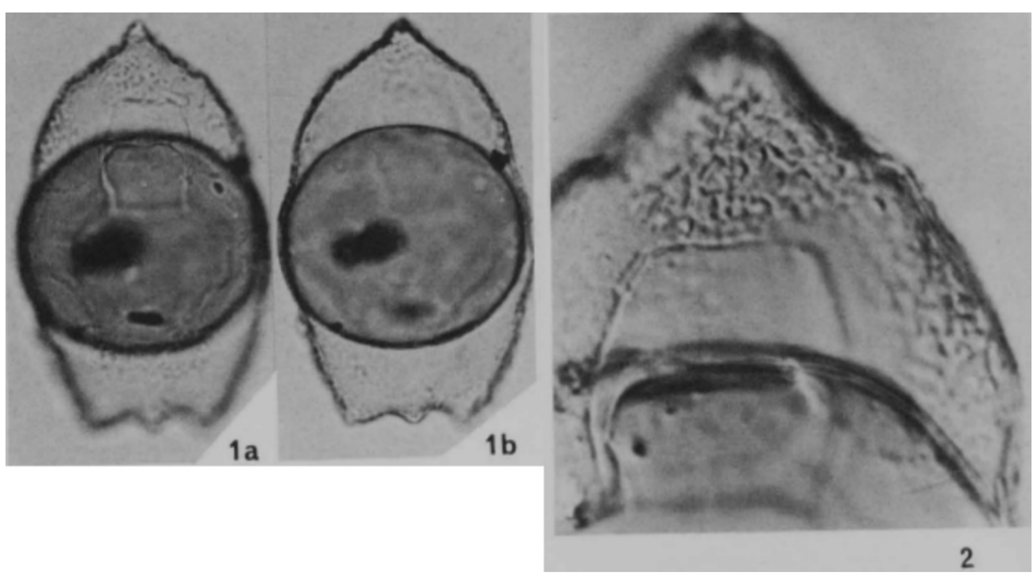


Plate 1, figures 1a–b, 2, Stover (1973).

Isabelidinium brunae Roncaglia et al., 1999

<u>Diagnosis</u>: "Bicavate, elongate peridinioid cyst, with one short to prominent, rounded apical horn and two unequal, divergent antapical horns. The endocyst is oval, typically broader than long, smooth and centrally located. The periphragm is thin, smooth to microgranulate. At the poles, epi- and hypo-pericoel are well developed, elongate and typically narrower than the width of the endocyst. The archeopyle is intercalary, type I(2a); operculum free. The paratabulation is indicated by the archeopyle only." — Roncaglia et al. (1999, p. 307)

<u>Description</u>: "Bicavate, elongate peridinioid cyst with one apical and two antapical horns. The apical horn is a short to prominent (length 1–5 μm) nipple-like structure, distally rounded. The length of the left antapical horn is variable (length 2–6 μm); when present, the right antapical horn is shorter than the left (length 1–3 μm). Both antapical horns are broadly rounded to truncate, occasionally conical with rounded tips; the tips diverge from each other. A median antapical bulge may occur between the antapical horns (Figure 14.7). The endocyst is oval, typically broader than long, and the endophragm is thin and smooth. The periphragm is thin and smooth to microgranulate; it is closely appressed to the endophragm in the equatorial and subequatorial area. At the poles, the periphragm forms large, elongate epi- and hypo-pericoels, which are of similar size and typically narrower than the width of the endocyst. The paracingulum and parasulcus are not indicated. The archeopyle is intercalary, type I(2a), iso-thetaform to iso-deltaform, and the operculum is generally free. The paratabulation pattern is indicated by the archeopyle only." — Roncaglia et al. (1999, p. 307)

<u>Dimensions</u>: "(in μm, 12 specimens measured) Overall length: holotype 100, range 63 (81) 100; Overall width: holotype 74, range 33 (56) 74; Length of endocyst: holotype 43, range 28 (38) 50; Width of endocyst: holotype 74, range 33 (56) 74." — Roncaglia et al. (1999, p. 307)

<u>Discussion</u>: "In *I. brunae*, the shape of the epi-pericoel varies with the size of the apical protrusion: specimens with a short apical protrusion have a subtrapezoidal epi-pericoel; specimens with a longer, prominent apical horn have a subtriangular epipericoel. The taxon resembles *I. korojonense* in size and general appearance, but lacks the generally quadrangular outline of the pericyst and the distinctive serrate shoulders characteristic of that species. *Isabelidinium brunae* differs from *I. papillum* in having antapical horns, epi- and hypo-pericoels that are narrower than the endocyst, and in having an isothetaform to iso-deltaform archeopyle. It is distinct from *I. foucheri* in being much shorter, in having a nipple-like, rounded apical horn, and an isothetaform to iso-deltaform archeopyle. It differs from *I. amphiatum*, *I. bakeri*, *I. belfastense*, and *I. glabrum* in being bicavate, and in having well-developed epi- and hypo-pericoels that are, throughout their extent, narrower than the width of the endocyst. *Amphidiadema denticulata* and *A. nucula* resemble *I. brunae* in size, archeopyle shape, and in having epi- and hypopericoels that are narrower than the endocyst, but differ in lacking antapical horns, and in having an endocyst that is longer than broad. Furthermore, *A. denticulat*a differs from *I. brunae* in having conspicuous granulae and denticles on the periphragm. *Chatangiella tripartita* is similar to *I. brunae* in general appearance, but differs in having a truncate, conical apical horn, an indication of a paracingulum, and an omegaform archeopyle." — Roncaglia et al. (1999, p. 307)

<u>Age</u>: Late Cretaceous (middle Campanian); holotype of Roncaglia et al. (1999, p. 305, fig. 5); Late Cretaceous (middle–upper Campanian) (Roncaglia et al., 1999, p. 307).

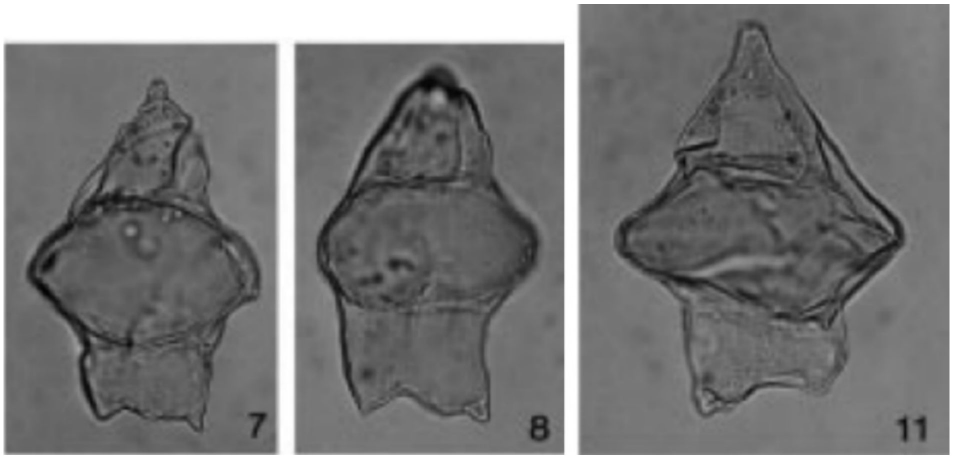


Figure 14, nos. 7, 8, 11, Roncaglia et al. (1999).

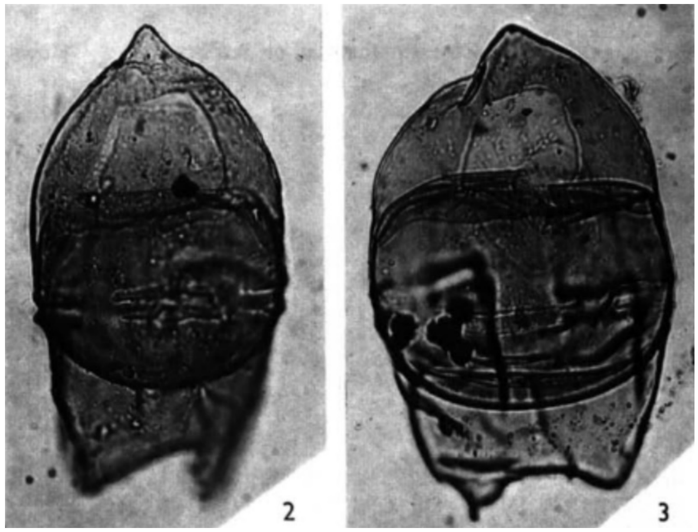
Isabelidinium campbellensis (Wilson, 1967b) Lebedeva, 2000

Description: “Test large, dorso-ventrally flattened; broadly rounded epitheca tapers to a fairly blunt apical horn (*l* = 41–55 μ) sometimes terminated by a papilla. Anterior of inner cyst flat; breadth greater than length. Antapical horns unequal, right horn being slightly longer than left and usually terminated by a papilla. Surface of outer cyst smooth. Prominent spiral transverse girdle tripartite on dorsal surface. Atabulate. Archeopyle fairly large, trapezoidal, intercalary, located on dorsal epitheca. Opening of inner cyst semi-apical or apical.” — Wilson (1967b, p. 225)

Dimensions: “Holotype: *1* = 153 μ, *b* = 83 μ, inner cyst 63 × 80 μ. Range (6 specimens): *1* = 146(162)179 μ, *b* = 72(85)99 μ.” — Wilson (1967b, p. 225)

Remarks and affinities: “Over 100 specimens were observed and the species is the most abundant fossil dinoflagellate in the sample. *Deflandrea campbellensis* has a somewhat similar shape to *Defiandrea bakeri* Defl. & Cooks. (1955), but differs in overall size and in the prominence and structure of the transverse girdle. Other species with tripartite transverse girdles have been described by Cookson and Eisenack (1961, p. 70) and Manum (1963).” — Wilson (1967b, p. 225)

Age: ?Teurian (Paleocene); holotype of Wilson (1967b, p. 225) later designated as ?Maastrichtian by Wilson (1972, p. 184).



Figures 2, 3, Wilson (1967b).

Isabelidinium cingulatum Wilson, 1988

Description: “Cyst of intermediate size, bicavate, outline longitudinally elongate. Well developed subtriangular apical pericoel and sub rectangular antapical pericoel. Apex somewhat conical without horn; antapex broad and flat, without horns or with short pointed left antapical horn. Periphragm thin, finely reticulate and sometimes longitudinally striate; endocyst sub circular, thin-walled, finely reticulate or smooth. Archeopyle intercalary, Type Ia, relatively narrow (archeopyle index 0.5); operculum usually attached antapically. Paracingulum characteristically well developed (breadth 5–7 µm) defined by low parallel ridges on periphragm. Parasulcus indicated by termination of paracingulum on ventral surface and sometimes by narrow depression on ventral hypocyst. Partial paratabulation defined by archeopyle, paracingulum, and by somewhat vague low parasutural ridges.” — Wilson (1988, p. 25)

Dimensions: “Holotype: overall length 71 µm, breadth 54 µm, length of endocyst 42 µm, breadth 44 µm. Range: overall length 59 (68) 85 µm, breadth 49 (56) 66 µm (n = 10).” — Wilson (1988, p. 25)

Remarks: “The relatively prominent paracingulum is a major characteristic feature of this species. Other distinguishing features include the microreticulate periphragm and the generally broad, flat antapex. The species is also smaller than most previously described species of *Isabelidinium*.” — Wilson (1988, p. 25)

Age: early Paleocene (Danian); holotype of Wilson (1988, p. 25, fig. 4). Range: early Paleocene (Danian) (Wilson, 1988, p. 25, fig. 4).

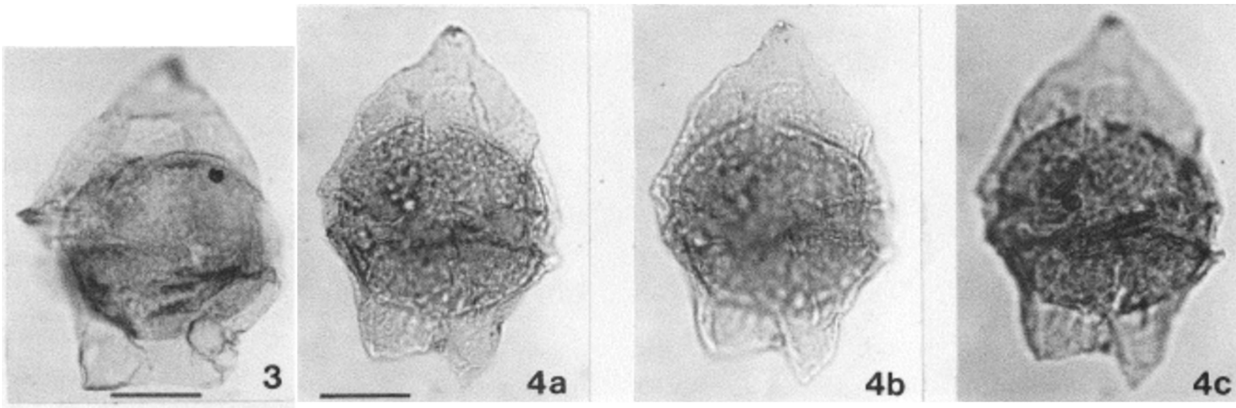


Plate 14, figures 3, 4a–c, Wilson (1988). Scale bars = 20 μm.

Isabelidinium cooksoniae (Alberti, 1959) Lentin & Williams, 1977a

Diagnosis: "Carapace flattened, its outline is elongated, pentagonal-rounded to oval, often deviating from it. The shoulder-shaped epithelium, which is about the length of the hypotheca, is extended into a small detached apical horn. Transverse furrow mostly absent, if present, very shallowly depressed. Usually purely antapical horn, which is often oblique to the longitudinal axis of the carapace. Inner body elliptical, its length lying transversely to that of the cyst, this causes a bulge of the inner body close-fitting membrane. Cyst membrane granulate, inner body rough." — Translated from Alberti (1959, p. 97, 98)

Comment: "One of the two antapical horns can be fully or partially reduced. At the level of the completely receded lateral horns, the carapace is sometimes slightly notched, a transverse furrow is rarely present. The hatch is trapezoidal, rounded. The apical horn has an opening at its free end." — Translated from Alberti (1959, p. 98)

Differential diagnosis: "The outline of the epi - and hypotheca and the antapical horn, which is oblique to the longitudinal axis, distinguish it from the Australian species *Defl. pellucida* (Cookson & Eisenack. Compared to all other species of the genus, *Delf. Cooksoni* n. sp. is well marked." — Translated from Alberti (1959, p. 98)

Dimensions: "Holotype: Length 72 μ. Width 48 μ. In other specimens, the length varies between 68 μ and 96 μ, the width between 40 μ and 54 μ." — Translated from Alberti (1959, p. 98)

Age: Late Cretaceous (late Senonian); holotype as translated from Alberti (1959, p. 98).

Plate 9, figures 1–6, Alberti (1959).

Isabelidinium cretaceum (Cookson, 1956) Lentin & Williams, 1977a

Description: "Cell always encysted. Theca broadly and bluntly fusiform to almost circular in outline, truncate or slightly concave posteriorly, either concave, rounded, or broadly tapered anteriorly; epitheca sometimes with a minute blunt median projection (Plate 1, Fig. 4); neither transverse girdle nor longitudinal furrow observed; in the region of the cyst one face is plane, the other convex. The cyst, which is generally crumpled, is large in proportion to the size of the cell, and when fully expanded occupies the greater part of the theca (Plate 1, Fig. 3). A clearly marked, roughly polygonal aperture is present on the convex side of the epitheca. The membrane of the theca is more or less coarsely granular, that of the cyst is smooth." — Cookson (1956, p. 184)

Dimensions: "Holotype (Plate 1, Fig. 1): theca 55 μ long and 52 μ broad. Range: length of theca 45–65 μ, breadth of theca 43–56 μ." — Cookson (1956, p. 184)

Discussion: "*D. cretacea* is of essentially the same type as *Deflandrea bakeri* Deflandre & Cookson, 1955 (Paleocene Pebble Point Formation, Vic.), and *D. bakeri* f. *pellucida* Defl. & Cookson (Nelson Bore, Vic., at 3874 ft), but differs from both in its length, which is only about half that of these forms, and in the absence of a well-marked anterior prominence. It is questionable whether these differences are sufficient to justify specific distinction. Wood (1954, p. 175) has noted that frequently amongst living dinoflagellates 'a given size group is dominant in anyone catch, but when the same species, e.g. *Gonioderma*, varies in size in a catch two distinct size-groups occur, representing, no doubt, different generations of the same species'. Wood suggests that size as a differential character should be used with caution. However, in view of the considerable depth that separates the sediments containing *D. cretacea* and *D. bakeri* f. *pellucida*, and the impossibility of satisfactorily resolving such a question with fossil material, it has seemed desirable to specifically differentiate the older, simpler, and consistently smaller Cretaceous form from *D. bakeri* and its form *pellucida*.

The few examples isolated from the Nelson Bore at 5304 ft diverge somewhat from *D. cretacea* in its typical form; the membrane of the epitheca tends to be more coarsely granular and the cysts are thicker-walled. In the specimen shown in Plate 1, Figure 7, the membrane of the hypotheca is smooth. Usually the cysts of *D. cretacea* contain small groups of variously placed spherical bodies similar to those reported by Eisenack (1954) as occurring in *Deflandrea phosphoritica* Eis. Eisenack made the suggestion that such bodies might be nuclei." — Cookson (1956, p. 184, 185)

Age: Late Cretaceous; holotype of Cookson (1956, p. 184). Range: e.g. Late Cretaceous (late Campanian) (Sumner, 1992, fig. 4).

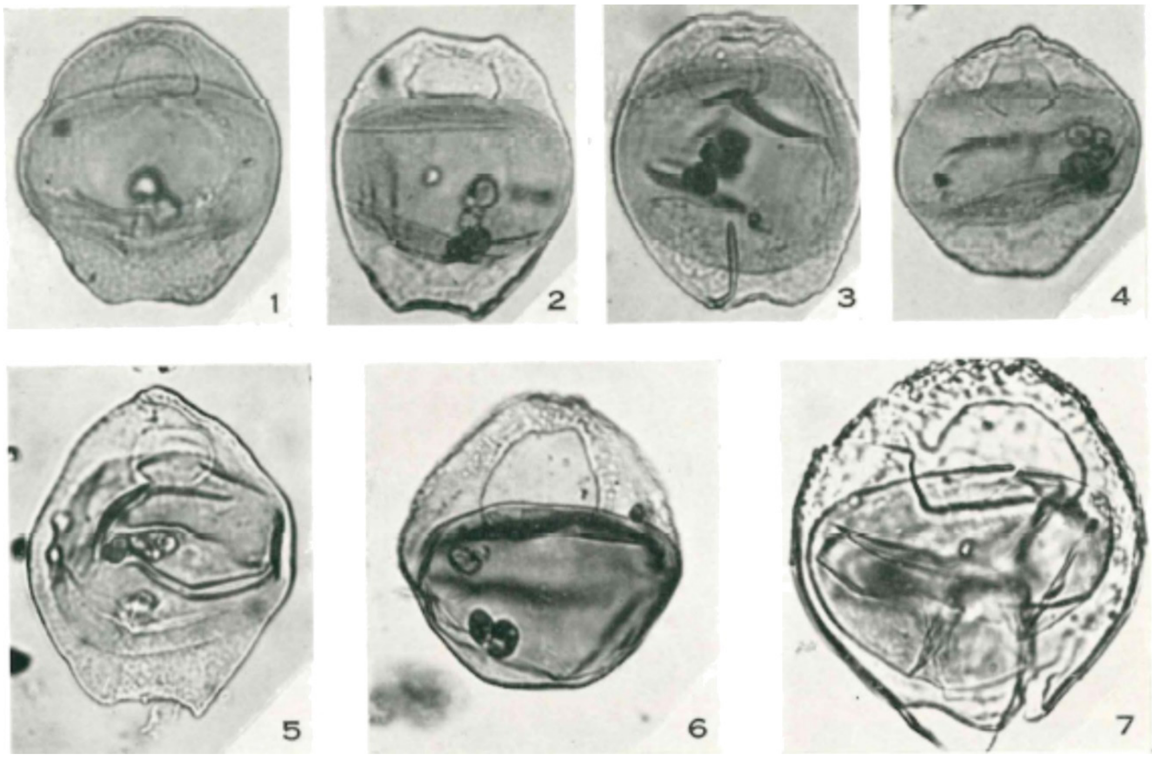


Plate 1, figures 1–7, Cookson (1956).

Isabelidinium foucheri Schiøler, 1992

Diagnosis: "A relatively large species of *Isabelidinium* that has slender epi- and hypopericysts which are sharply delimited from the rounded, almost bulging central area of the pericyst. The epipericyst is elongate, subtriangular in ambitus, without pronounced shoulders. Periarchaeopyle rounded steno-deltaform with TAI 0.5 or higher. Endocyst in contact with pericyst laterally and dorsoventrally. The periphragm is psilate to scabrate, but may possess discrete granules on the apical and antapical areas." — Schiøler (1992, p. 12, 16)

Description: "Cavate peridinoid cyst. The central part of the periphragm, which is occupied by the endocyst, is ± 1.5 × wider than the cavate portions of the cyst. The margins of the free part of the periphragm, close to their contact with the endocyst, are subparallel. The apical part of the epipericyst tapers gently to a blunt-pointed horn, giving the epipericyst the overall shape of an elongate triangle. The epipericyst has no (or only weakly developed) shoulders. The lateral margins of the hypopericyst are parallel from their contact with the endocyst, until the left side tapers into an acute antapical horn. The endocyst is subcircular and often slightly broader than long, and is capped posteriorly by a mucoid layer or mesophragm which extends 3–5 μm into the hypopericoel, giving the impression of a thickened posterior part of the endophragm. Some of the specimens observed have lost their endocyst, due to damage of the periphragm (Plate I, 8). Paracingulum not present, but indicated by a periphragmal fold on a few specimens. Parasulcal depression sometimes present on the hypopericyst. The periarchaeopyle is of type I(2a) and gently rounded steno-deltaform with TAI often above 0.5. The TAI-value is relatively high for the genus, and results from the slenderness of the upper part of the pericyst. Perioperculum free. Endoarchaeopyle type not determined. Apart from the periarchaeopyle, no other indications of paratabulation were observed." — Schiøler (1992, p. 16, 20)

Dimensions: "(in μm) Length of pericyst: holotype 120, range 110–131; width of pericyst: holotype 49, range 38–53; length of endocyst: holotype 39, range 30–51; width of endocyst: holotype 46, range 34–50." — Schiøler (1992, p. 20)

Remarks: "The strong morphological contrast between the slender peri- and hypopericyst and the bulging central part of the cyst readily separates this form from all other species of *Isabelidinium*. In comparison, *Isabelidinium belfastense* (Cookson and Eisenack 1961) Lentin and Williams 1977 lacks contact between the endo- and pericyst in the central area of the cyst and has distinct apical and antapical granulation on the pericyst. The new species bears some ambital similarity to the specimen of *I. belfastense* figured by Kjellström (1973, p. 19, fig. l l) which, from the photograph, has a rather high TAI (0.48) and also appears to have an endocystal capping (or mesophragm). In contrast to *I. foucherii* sp. nov., however, the specimen figured by Kjellström has coarse pericystal granulation. If the presence or absence of coarse granulation on the periphragm is insignificant for the distinction between *I. beljastense* and *I. foucherii* sp, nov., the specimen figured by Kjellström should be included in the synonymy of the latter species. *Isabelidinium amphiatum* (McIntyre 1975) Lentin and Williams 1977 differs from *I. foucherii* sp. nov. in having a large hexagonal archaeopyle that extends nearly to the paracingulum, as well as in lacking a pronounced left antapical horn, and *I. microarmum* (Mclntyre 1975) Lentin and Williams 1977 differs in always having a distinguisable [sic] endo- and periphragm, as well as having echinae on the apical and antapical part of the periphragm. *Isabelidinium glabrum* (Cookson and Eisenack 1969) Lentin and Williams 1977 has an almost biconical ambitus, and no contact between the endo- and periphragm, as well as a somewhat lower TAI (0.46, estimated from the photograph of the holotype) than *I. foucherii* sp. nov. *Isabelidinium bakeri* (Deflandre and Cookson 1955) Lentin and Williams 1977 is widely fusiform in ambitus with a bell-shaped epipericyst and has no pronounced left antapical horn, and *I. pellucidum* (Deflandre and Cookson 1955) Lentin and Williams 1977 has an elongate oval ambitus and a distinct hexagonal archaeopyle. *Isabelidinium greenense* Marshall 1990 has abundant fine perforations surrounding the horns, and often has indications of a paracingulum. Extreme variants of the latter species (Marshall 1990, fig. 22, A, B) have some ambital resemblance to *I. foucherii* sp. nov., but are much larger. *Isabelidinium korojonense* (Cookson and Eisenack 1958) Lentin and Williams 1977 and *Manumiella*? *cretacea* (Cookson 1956) Bujak and Davies 1983 are considerably smaller than *I. foucherii* sp. nov. Furthermore, *I. korojonense* has a quadrangular ambitus and an iso-omcgaform archaeopyle whereas *M.*? *cretacea* has an almost circular ambitus and a relatively low TAI." — Schiøler (1992, p. 20)

Age: Late Cretaceous (early–mid Coniacian); holotype of Schiøler (1992, p. 2, 12).

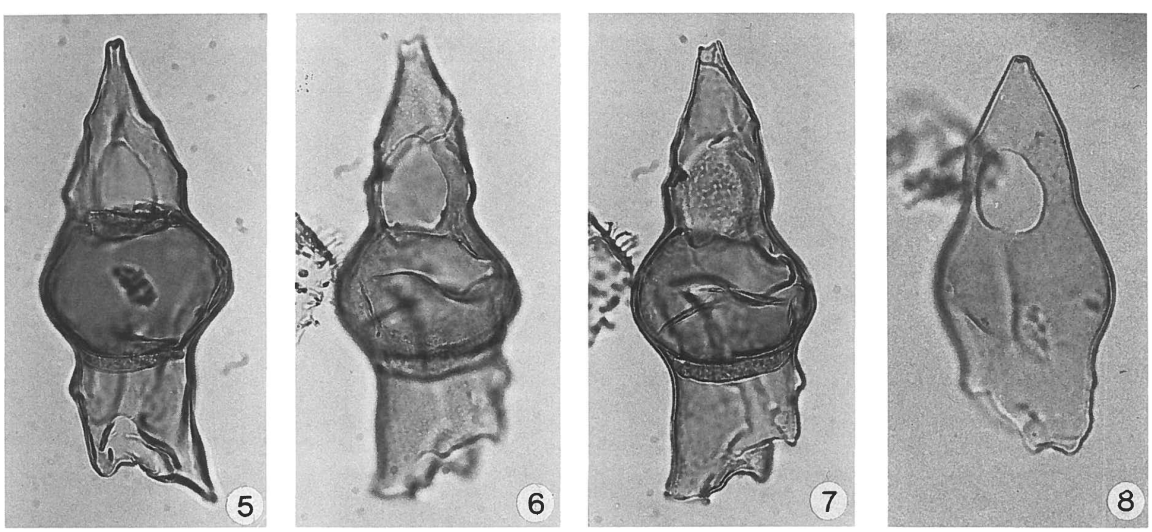


Plate 1, figures 5–8, Schiøler (1992).

Isabelidinium gallium (Davey & Verdier, 1973) Stover & Evitt, 1978

Diagnosis: "This species of *Deflandrea* has an elongate pentagonal outline, the epitract being longer than the hypotract, with a subspherical to ovoidal inner body. The sides of the epitract are moderately convex and there is a slight apical bulge. The lateral sides of the hypotract are more or less straight and taper distally to the small antapical side which may be truncated with a small antapical horn on the left side. The cingulum is delimited by well defined ridges which bear strong spines. It is only slightly helicoidal and abuts against a wide sulcal region. The latter widens antapically to embrace the entire antapical «side»; on the hypotract the sulcus is bordered by ridges. A few strong, thorn-like spines are present on the outer wall and are most concentrated along the plate boundaries of the pre- and postcingular series. A relatively thick-walled inner body is always present and touches the outer wall only in the cingular region. The intercalary archaeopyle (2a) is of an elongate hexagonal outline; the operculum often remains attached at its precingular margin." — Davey & Verdier (1973, p. 197)

Dimensions: "Overall length, holotype 52 μ, range 48 (53) 55 μ; overall width, holotype 42, range 34 (38) 42 μ." — Davey & Verdier (1973, p. 197)

Description: "The spines on the outer wall are few in number and appear to be only tabular. They occasionally occur at the apical and antapical extremities of the cyst but are mostly confined to the plate boundaries perpendicular to the cingulum. Sometimes thickening of the outer wall occurs along these boundaries. Seven precingular and five postcingular plates appear to be defined; cingular plates are not present. The inner body tends often to be transversely folded and a poorly developed excystment breakage always appears to be present in its apical region." — Davey & Verdier (1973, p. 197)

Remarks: "*D. gallia* sp. nov. is most similar to *D. minor* Cookson & Eisenack 1960 but differs in being more fusiform, having a stronger cingulum and, to a lesser extent, in other morphological features. *D. echinoidea* Cookson & Eisenack 1960 differs considerably from *D. gallia* in overall shape and spine cover. However, the specimen illustrated by Cookson & Eisenack (1960, pl. 1, fig. 6), as *D. echinoidea*, differs from the holotype of this species and appears to be a larger and more spiny form of *D. gallia*. *Spinidinium vestitum* Brideaux 1971b is larger, more spinous and apparently lacks an inner body. *Deflandrea* cf. *echinoidea*, as described by Davey 1970, is placed in synonymy with *S. vestitum* by Brideaux and on page 101 it is stated that Davey reported this species from Cenomanian of Saskatchewan. *D.* cf. *echinoidea*, however, was only recorded from England and the similar form *D. echinoidea* (Davey, 1970, p. 339, pl. 1, fig. 5) was reported only from Saskatchewan. It is only this latter form that may be synonymized with S. *vestitum*, although a well-developed inner body is present. Finally, *Deflandrea armata* Cookson & Eisenack 1970 is another similar species, differing from *D. gallia* in being larger and having more numerous, broader spines." — Davey & Verdier (1973, p. 197)

Age: Early Cretaceous (late Albian); holotype of Davey & Verdier (1973, p. 197).

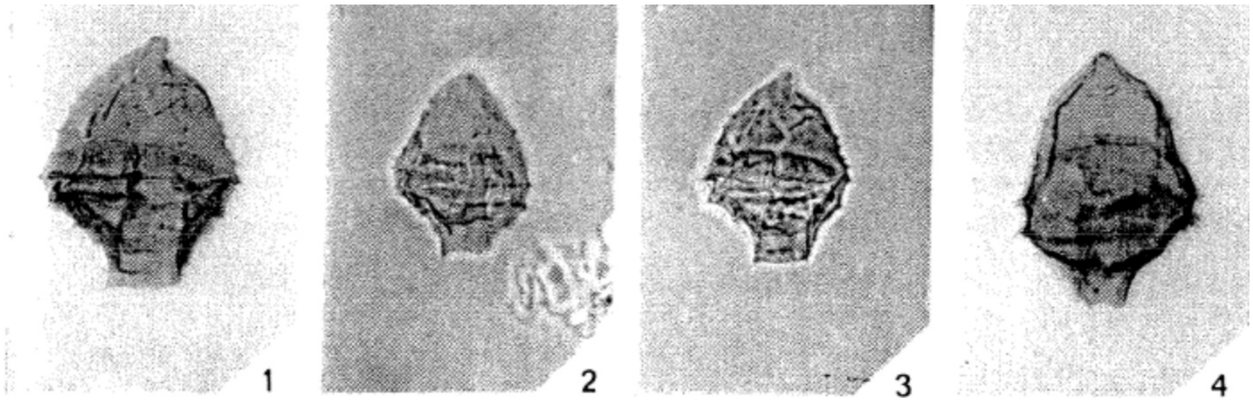


Plate 3, figures 1–4, Davey & Verdier (1973).

Isabelidinium glabrum (Cookson & Eisenack, 1969) Lentin & Williams, 1977a

Description: "Shell considerably longer than broad with convex sides that slant towards both apex and antapex. The apex ends in a short and bluntly pointed horn; the antapex is truncate or slightly concave with a sharply pointed horn on one side. There is no indication of tabulation, girdle or longitudinal furrow. Both the outer wall and that of the capsule are thin and smooth. The capsule is spherical in outline and does not extend to the lateral walls. The archeopyle is relatively large, trapezoidal with rounded corners." — Cookson & Eisenack (1969, p. 3)

Dimensions: "Holotype: length 95 μ, width 52 μ. Range: length about 95–142, width about 52–82 μ." — Cookson & Eisenack (1969, p. 3)

Comment: "The shape of *D. glaga* [sic] is close to that of *D. belfastensis* Cookson and Eisenack 1961 from an Upper Cretaceous deposit in the Belfast North Bore in S.W. Victoria between 4645 and 4652 feet. However, the wall of *D. belfastensis* is prominently granular, whereas that of *D. glaba* is smooth." — Cookson & Eisenack (1969, p. 3)

Age: Cretaceous (Albian–Cenomanian); holotype of Cookson & Eisenack (1969, p. 3).

Figure 1A, Cookson & Eisenack (1969).

?*Isabelidinium globosum* (Davey, 1970) Lentin & Williams, 1977a

Diagnosis: "Shell subspherical to subpolygonal, with small number of concentric folds at apex, and very reduced single antapical horn placed asymmetrically. Apical horn, cingulum and sulcus absent. Inner body entirely in contact with outer membrane. Wall smooth to slightly granular. Intercalary archaeopyle, angular, six-sided." — Davey (1970, p. 344)

Dimensions: "Holotype: shell length 69 μ, shell width 66 μ. Range: shell length 62 (67.5) 78 μ, shell width 48 (58.8) 66 μ. Number of specimens measured, 6." — Davey (1970, p. 344)

Description: "This species is extremely simple in form, possessing only a very rudimentary antapical horn to mar its smooth outline. The operculum is typically in place and the archaeopyle outline is only discerned with some difficulty." — Davey (1970, p. 344)

Remarks: "In overall appearance *D. globosa* sp. nov. strongly resembles *D. glomerata*. They differ in that *D. globosa* possesses a very rudimentary antapical horn and that the inner body is entirely in contact with the outer membrane. The lack of an apical horn (apical wrinkles being present), any tabulation and the spherical form indicate that these two species are closely related. Because of this and the presence of an intercalary archaeopyle, *D. globosa* is placed in the genus *Defiandrea*." — Davey (1970, p. 344)

Age: Late Cretaceous (Cenomanian); holotype of Davey (1970, p. 343).

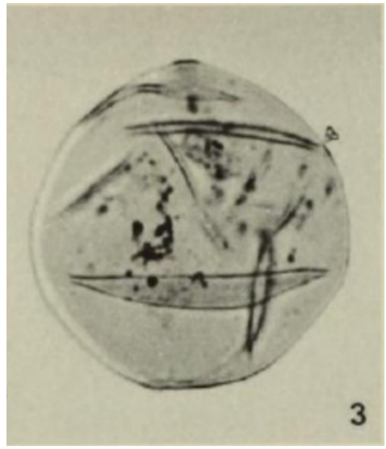


Plate 2, figure 3, Davey (1970).

Isabelidinium greenense Marshall, 1990

Description. “Ventrodorsal outline subcircular or longitudinally elongate and ranging from ovoidal to subpentagonal. Specimens with subpentagonal outlines modified by an apical horn and 1–2 antapical horns defining rounded subconical projections or rounded bulges. Lateral margins on either side of apex occasionally marked by rounded to slightly angular shoulders. Cysts usually bicavate, occasionally with narrow pericoels along parts of the lateral margins, rarely circumcavate. Ventrodorsal outline of endocyst subcircular to ovoidal and longitudinally elongate. Endophragm 0.4–0.5 μm thick, surfaces adjacent to pericoels finely granulate or with fine, close spaced rods that can connect distally. Periphragm 0.5–1.0 μm thick near contacts with endocyst, thickening in the polar areas with an irregular inner surface. Outer surface smooth and usually unsculptured, occasionally with scattered, isolated grana adjacent to pericoels. Grana with rounded outlines, height up to 0.5 μm, width up to 1.0 μm, usually concentrated in, or restricted to, areas adjacent to the lateral margins midway between the equator and polar areas. Areas surrounding horns marked by concentric wrinkles and fine, close spaced, circular perforations up to 1.0 μm in diameter. Perforations occasionally also extend over much of the periphragm adjacent to pericoels. Specimens with circular to ovoidal ventrodorsal outlines have concentric wrinkles and perforations, often surrounding a knob or bulge, marking the positions of 1 apical and 2 antapical horns. Periphragm on rare variants marked by irregular clusters of rounded, solid projections of variable shape and distribution (e.g. Fig. 21Q, R). On specimens with highest concentration of projections, the outermost surface of these elements has a smooth, regular shape similar to that of the periphragm. These forms can also have solid tips on the horns. Paracingulum absent, indicated by faint rounded ridges, or defined by clear rounded ridges on outer periphragm surface and/or by a rounded groove on inner periphragm surface. Internal groove separated from underlying endophragm, producing pericoels along narrow bands. Paracingular markings 7–8 μm apart, usually discontinuous and having a partite arrangement, rarely forming two almost continuous bands around dorsal surface and edges of ventral surface. Periarcheopyle Type I, outline variable, general shape ranging from stenodeltaform to eurydeltaform. Endoarcheopyle usually indicated by a transverse split between adjoining boundaries of paraplates 2–4' and 1–3a, and frequently, by additional incomplete sutures between adjoining margins of paraplates 1–3a (Fig. 12A–C). Faint markings often outline positions of remaining boundaries of paraplates l–3a and anterior margins of paraplates 3–5''.” — Marshall (1990 p. 24, 26)

Dimensions: “Pericyst length 81(105)206 μm, width 66(74)85 μm; endocyst length 56(67)78 μm, width 67(71)80 μm (20 specimens).” — Marshall (1990 p. 24, 26)

Discussion: "Abundant exceptionally well-preserved specimens were recovered from the Cook Cruise sample C1/83 9DB. Through study of many hundreds of examples it became apparent that a number of distinct morphotypes could be recognised. However, there appeared to be a continuous gradation in morphology between these forms in what seems to be a single, highly variable population. Since these intergradational variants cannot be separated from one another stratigraphically graphically in the material studied, they are all treated within the one species.

Within this assemblage there is an extreme range of variation in the length of the horns (Fig. 14), and other highly variable features are the development of the paracingulum, periphragm sculpture, the thickness of the periphragm, and the outline of the periarcheopyle. The wide range in periarcheopyle outline shown in Fig. 14, especially the asymmetry of some examples, may be due to compression of the curved dorsal surface of the pericyst. Despite this possibility, there is sufficient evidence to indicate a range in outlines from isodeltaform to eurydeltaform. The outlines of paraplates surrounding the actual rupture of the endoarcheopyle are often partially defined by faint lines on the surface of the endophragm.

The most common variants are similar to those in Fig. 14G–N, S–W, and Y–CC, and are characterised by a smooth periphragm, weakly to moderately developed horns, faint indications of a partite paracingulum, and being bicavate. Less common variants include specimens with (a) a sculptured periphragm (Fig. 21A–C), (b) ventrodorsal pericyst outlines ranging from subcircular to ovoidal, and lacking clear indications of horns; these forms are bicavate to circumcavate (Fig. 14A–F), (c) unusually long horns (Fig. 14EE–GG), and (d) irregular clusters of rounded, solid projections on the periphragm (Fig. 21Q, R).

lsabelidinium greenense differs from *I. pellucidum* (Cookson & Eisenack) Lentin & Williams 1977 in lacking, or having considerably weaker sculpture on the periphragm. It also differs in having an abundance of fine perforations surrounding the horns, a thickened periphragm with an irregular internal surface in the polar regions, and in the morphology of the paracingulum. However, it is difficult to assess the importance of these latter characters at a specific level." — Marshall (1990 p. 24, 26)

Age: Late Cretaceous (middle–late Campanian); Marshall (1990 p. 28, fig. 2).

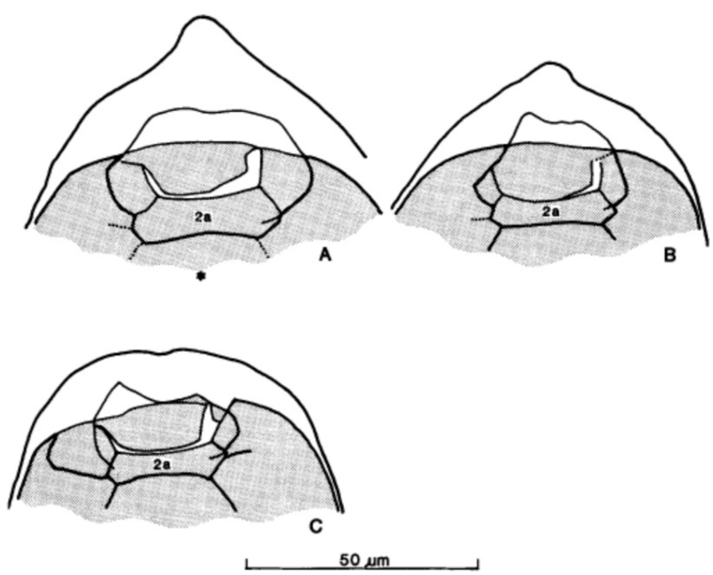


Figure 12A–C, Marshall (1990).

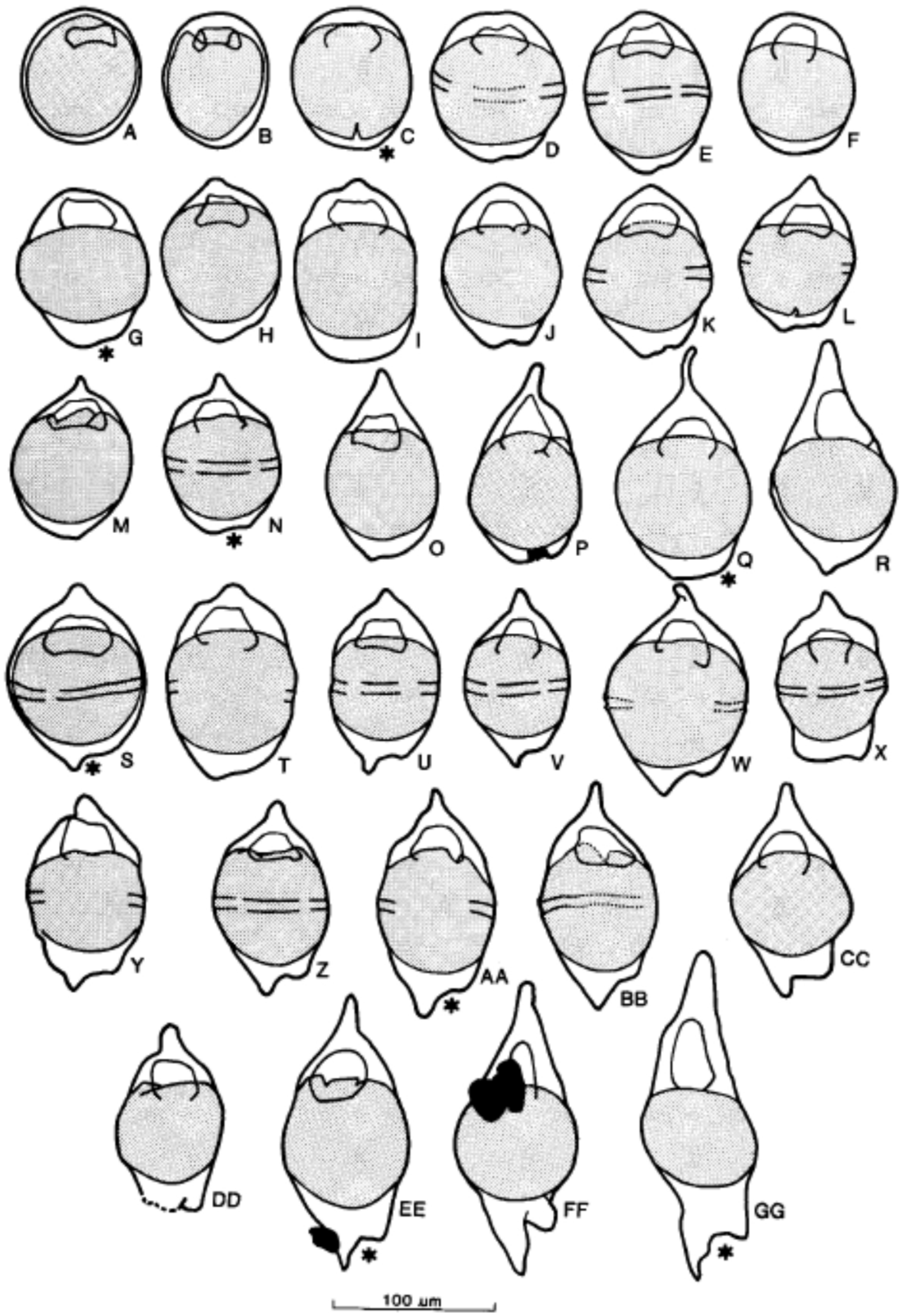


Figure 14A–Z, AA–GG, Marshall (1990).

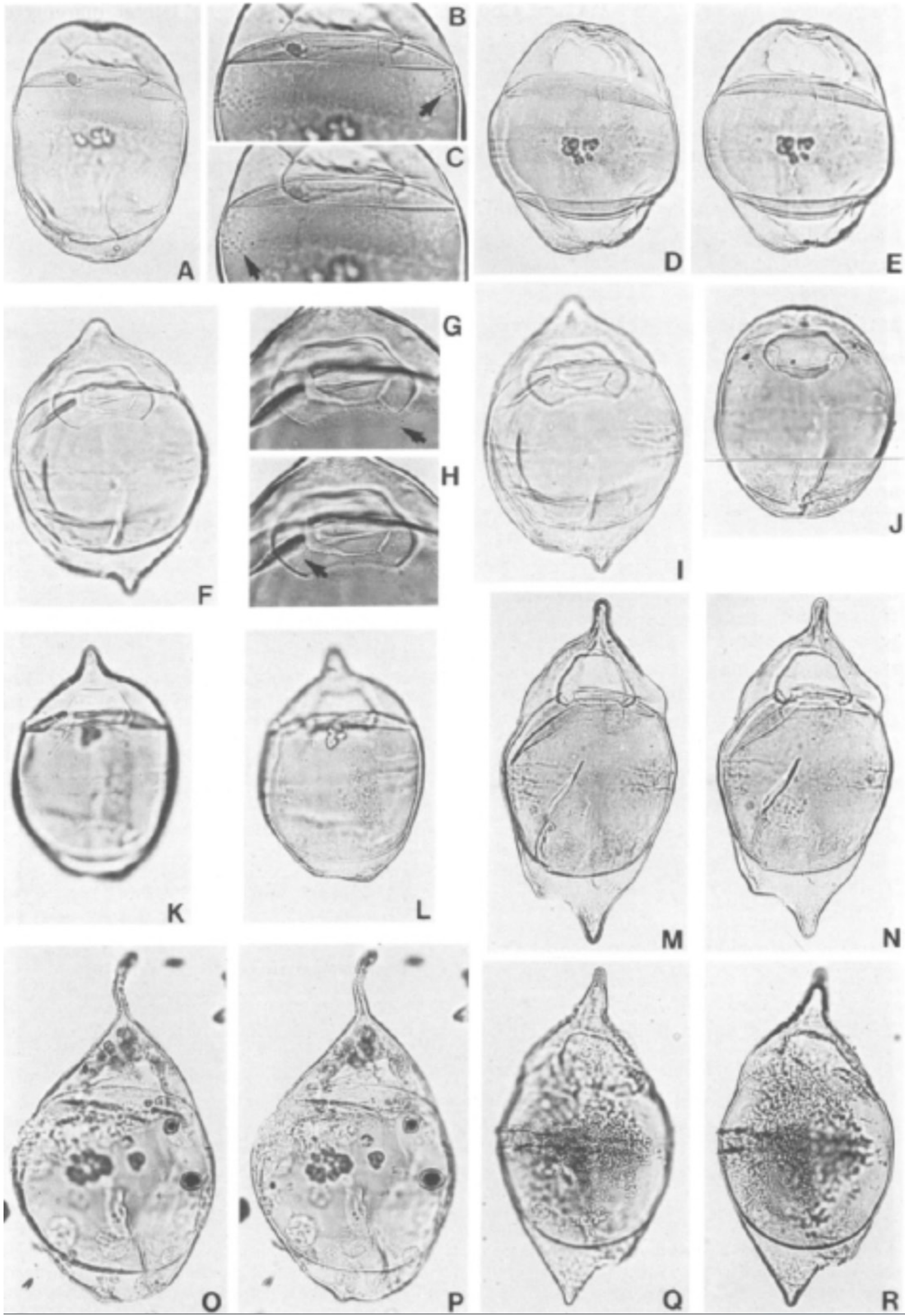


Figure 21A–R, Marshall (1990).

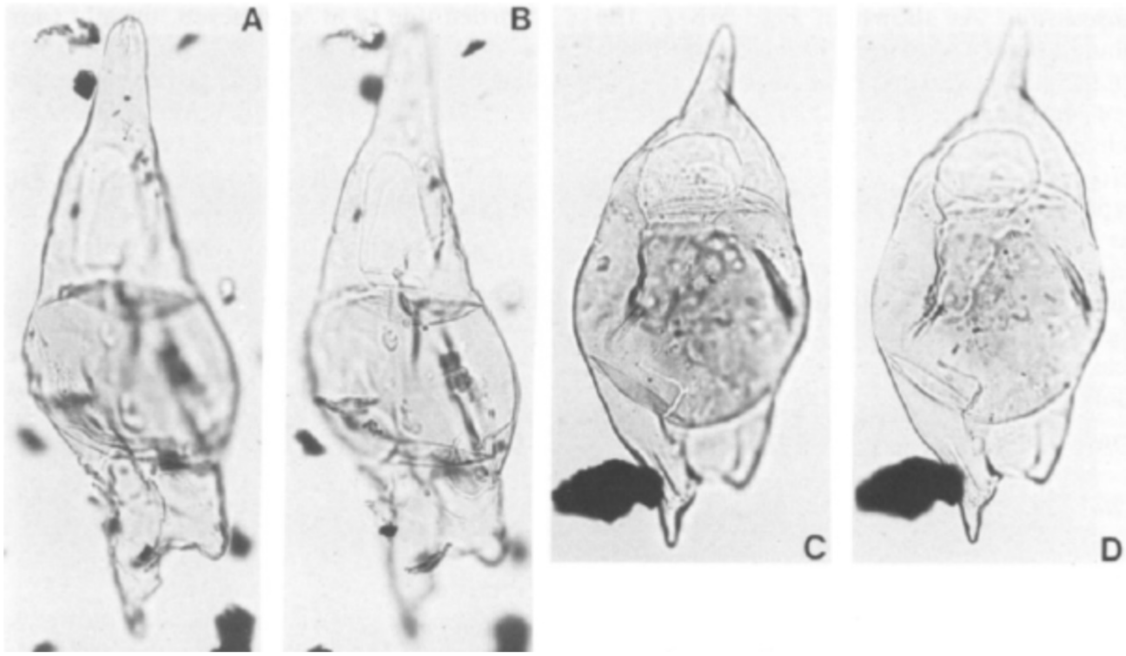


Figure 22A–D, Marshall (1990).

Isabelidinium korojonense (Cookson & Eisenack, 1958) Lentin & Williams, 1977a

Description: "Theca rather variable in outline, typically somewhat quadrangular, with convex sides which become concave beneath the broadly rounded or bracket-shaped apex and narrow gradually towards a more or less truncate antapex, sometimes one side is prolonged as an abbreviated horn; a transverse furrow is not indicated. The capsule fills the theca laterally and is usually broader than long; a slightly polygonal pylome is present near its anterior end. The membrane of the theca is smooth, that of the capsule faintly granular." — Cookson & Eisenack (1958, p. 28)

Dimensions: "Type—theca 71 × 52 μ; capsule 38 × 50 μ. Range—theca 61–80 × 38–53 μ; capsule 32–42 × 36–50 μ." — Cookson & Eisenack (1958, p. 28)

Age: Late Cretaceous (Campanian–early Maastrichtian); holotype of Cookson & Eisenack (1958, p. 27). Range: Late Cretaceous (middle Campanian–early Maastrichtian) given the ranges of Campanian–early Maastrichtian of Cookson & Eisenack (1958, p. 27) and middle–late Campanian of Marshall (1990 p. fig. 2).

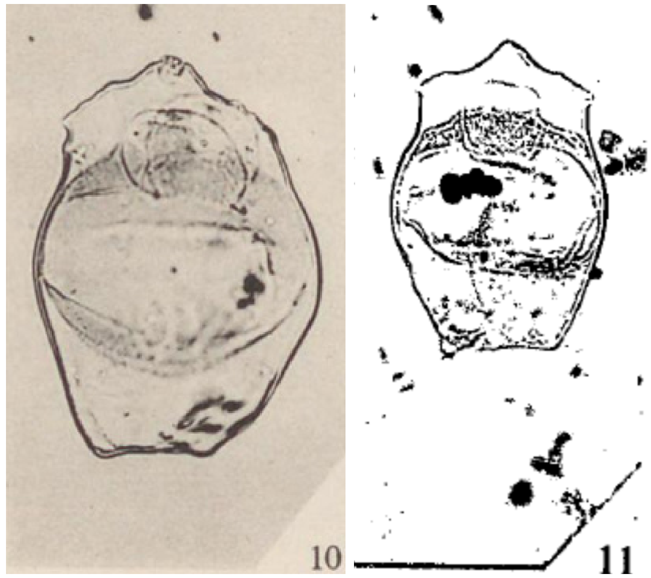


Plate 4, figures 10–11, Cookson & Eisenack (1958).

Isabelidinium magnum (Davey, 1970) Stover & Evitt, 1978

Diagnosis: "Shell elongate—ovoidal, truncated posteriorly with single, pointed antapical horn. Epitract subconical, apical horn not differentiated. Outer membrane smooth or slightly granular, enclosing subspherical inner body. Inner body and outer membrane sometimes in contact laterally but more often separated by narrow space. Cingulum, on outer membrane, well defined, weakly spiral, marked by low ledges having knobbly margin. Sulcus broad. Archaeopyle subpolygonal, operculum typically in place." — Davey (1970, p. 342, 343)

Dimensions: "Holotype: overall length 102 μ, overall width 67 μ, length of inner body 55 μ, width of inner body 57 μ. Range: overall length 69 (95.9) 118 μ, overall width 49 (64.7) 85 μ, length of inner body 36 (51.0) 61 μ, width of inner body 43 (51.6) 57 μ. Number of specimens measured, 12. — Davey (1970, p. 343)

Description: "Due to the fineness of the outer membrane, it is always folded to some extent. The cingulum (7 to 10 μ in width) is slightly concave and is sometimes crossed by low ridges marking the cingular plate boundaries. The lower boundary of the cingulum is occasionally interrupted. The archaeopyle is elongate-ovoidal anteriorly and polygonal posteriorly; the operculum typically remains in position. The inner body possesses a slightly thicker wall, is subspherical rarely with a posterior concavity, and usually has an apical region composed of disarranged plates. Sometimes the three anterior intercalary plates are obvious. Rarely the latter plates, together with the apical plates, are absent." — Davey (1970, p. 343)

Remarks: "*D. magna* sp. nov. most closely resembles *D. accmninata* Cookson & Eisenack (1958) from the Cenomanian to lower Turonian of Australia. *D. accuminata* differs in that the inner body is relatively small, it possesses an apical horn, and the cingulum is poorly defined. The forms illustrated by Manum & Cookson (I964) from Arctic Canada are more similar, but again the cingulum is very reduced. *D. pirnaensis* Alberti (I959) resembles *D. magna* but has a more pronounced apical horn and does not usually possess an obvious archaeopyle." — Davey (1970, p. 343)

Age: Late Cretaceous (Cenomanian); holotype of Davey (1970, p. 343).

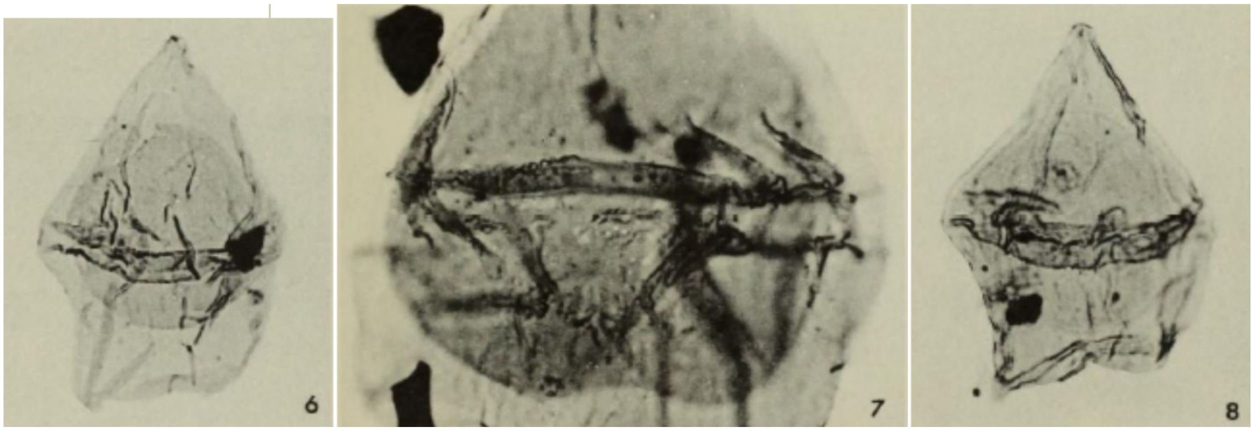


Plate 2, figures 6–8, Davey (1970).

Isabelidinium marshallii Roncaglia, 2000

Diagnosis: "Large, bicavate, dorso-ventrally compressed, elongate, peridinioid cyst, with one apical and one left antapical horn. The pericyst is thin-walled, smooth to granulated. The endocyst is located centrally, oval to sub circular in shape, thin-walled and smooth. The parasulcus is indicated by divergent, longitudinal folds on the periphragm and a shallow groove on the midventral surface. Occasionally, the paracingulum is indicated by parallel, low ridges or transverse folds in the periphragm. The archeopyle is intercalary, type I(2a), iso- to steno-deltaform; the operculum is always attached posteriorly." — Roncaglia (2000, p. 138)

Description: "Cyst large, bicavate, elongate, dorso-ventrally compressed, with one apical and one left antapical horn. The epicyst and hypocyst are approximately equal in size. The pericyst is thin-walled (0.5–1 μm), smooth to granulated. When occurring, the granulae are evenly distributed near the poles, but sparse to absent on the mid-ventral and mid-dorsal surface of the, pericyst (Fig. 4A, B). The apical horn is hollow, 5 to 30 μm long, and distally rounded; occasionally, the apical horn bears a solid, sharp spine on the top (Figs 3E, 4N). The left antapical horn is hollow, long (10–25 μm) and sharp. The right antapical horn is absent or poorly developed. The endocyst is oval to subcircular and centrally located. The endophragm is thin and smooth, closely appressed to the mid-ventral and mid-dorsal part of the pericyst. In most specimens, the endophragm is transparent and the endocyst barely visible. The parasulcus is indicated by two, divergent, longitudinal folds on the periphragm, separated by a shallow groove on the mid-ventral surface of the hypocyst (Figs 3M, 4F). When expressed, the paracingulum is indicated by either 2 parallel, partite, low ridges or transverse folds on the periphragm (Figs 31, 4C–F). An iso- to steno-deltaform intercalary archeopyle, type I(2a), is always present; archeopyle index (mean value in brackets): 0.3 (0.4) 0.52. The operculum is always attached posteriorly. The paratabulation is indicated by the parasulcus, archeopyle and occasionally the paracingulum." — Roncaglia (2000, p. 138)

Dimensions: "(in μm; mean value in brackets) Pericyst (15 specimens measured): overall length 137 (166) 195, holotype 184; overall width 70 (88) 110, holotype 91. Endocyst (10 specimens measured) length 43 (73) 90, holotype 70; width 57 (75) 95, holotype 91." — Roncaglia (2000, p. 139)

Comparison: "*Isabelidinium marshallii* differs from *I. greenense* by having a thin, smooth endophragm, by having a single, sharp, left antapical horn and indication of parasulcus. *Isabelidinium marshallii* closely resembles *I. glabrum* in general outline. However, it differs from the latter by being bicavate, larger in size, having an iso- to steno-deltaform archeopyle and having indication of a parasulcus. In addition, *I. glabrum* always has a readily discernible endophragm. *Isabelidinium marshallii* differs from *I. bakeri*, *I. belfastense, I. korojonense,* and *I. pellucidum* by being larger, having an iso- to steno-deltaform periarcheopyle, and having a single, sharp, left antapical horn." — Roncaglia (2000, p. 139)

Discussion: "*Isabelidinium marshallii* resembles species of the genus *Alterbidinium* in outline and archeopyle shape. Lentin & Williams (1985) proposed and Khowaja-Ateequzzaman et al. (1991) emended the genus *Alterbidinium* to accommodate [sic] proximate, dorso-ventrally compressed, circumcavate cysts, with one apical and two unequal antapical horns, indication of paracingulum, and intercalary, steno-/isodeltaform peri-archeopyle (Fig. 6). However, being bicavate, the new taxon cannot be included within the genus *Alterbidinium*. Few circumcavate specimens with the pericyst outline similar to *I. marshallii* and a distinctive endocyst were observed within the assemblages (Fig. SD). These specimens are considered transitional between *I. marshallii* and *Alterbidinium longicornutum*.

Isabelidinium marshallii resembles *Amphidiadema rectangularis* in size and archeopyle shape. However, the new species differs by having one apical horn, the operculum attached, and indication of paratabulation other than the archeopyle (the parasulcus and, occasionally, paracingulum are expressed in *I. marshallii*). *Isabelidinium marshallii* differs further from species of *Amphidiadema* by lacking epi- and hypo-coels that are narrower than the width of the endocyst.

Isabelidinium marshallii resembles specimens of *Manumiella seymourensis* Askin (1999) with apical and left antapical horn (see Askin 1999, fig. 3.3). However, *I. marshallii* differs from the latter by being bicavate, more elongate, and by having an iso- to steno-deltaform periarcheopyle. Furthermore, the average size of *I. marshallii* is significantly larger than *M. seymourensis* (Fig. 51), and the length ranges of the two species do not overlap. Figure 7 shows the stratigraphic range of 13 selected peridinioid dinoflagellates from the Coniacian-Maastrichtian interval in southern Marlborough (after Schiøler & Wilson 1998; Roncaglia et al. 1999). In southern Marlborough, the stratigraphic range of *M. seymourensis* (as *Manumiella* sp. 3 of Askin 1988 in Roncaglia et al. 1999) overlaps the range of *I. marshallii* and *Satyrodinium* species (Fig. 7). Lentin & Williams (1975) defined *Isabelidinium* for bicavate to circumcavate, elongate, peridinioid cysts, with one apical and two antapical horns, indications of paracingulum, and intercalary, omegaform peri-archeopyle (Fig. 6). Marshall (1988) emended *Isabelidinium* for elongate peridinioid cysts with a deltaform to thetaform peri-archeopyle. Based on Marshall (1988), the genus *Isabelidinium* may include taxa with an iso- to steno-deltafonn peri-archeopyle (Fig. 6). Therefore, the new taxon is included in *Isabelidinium*.

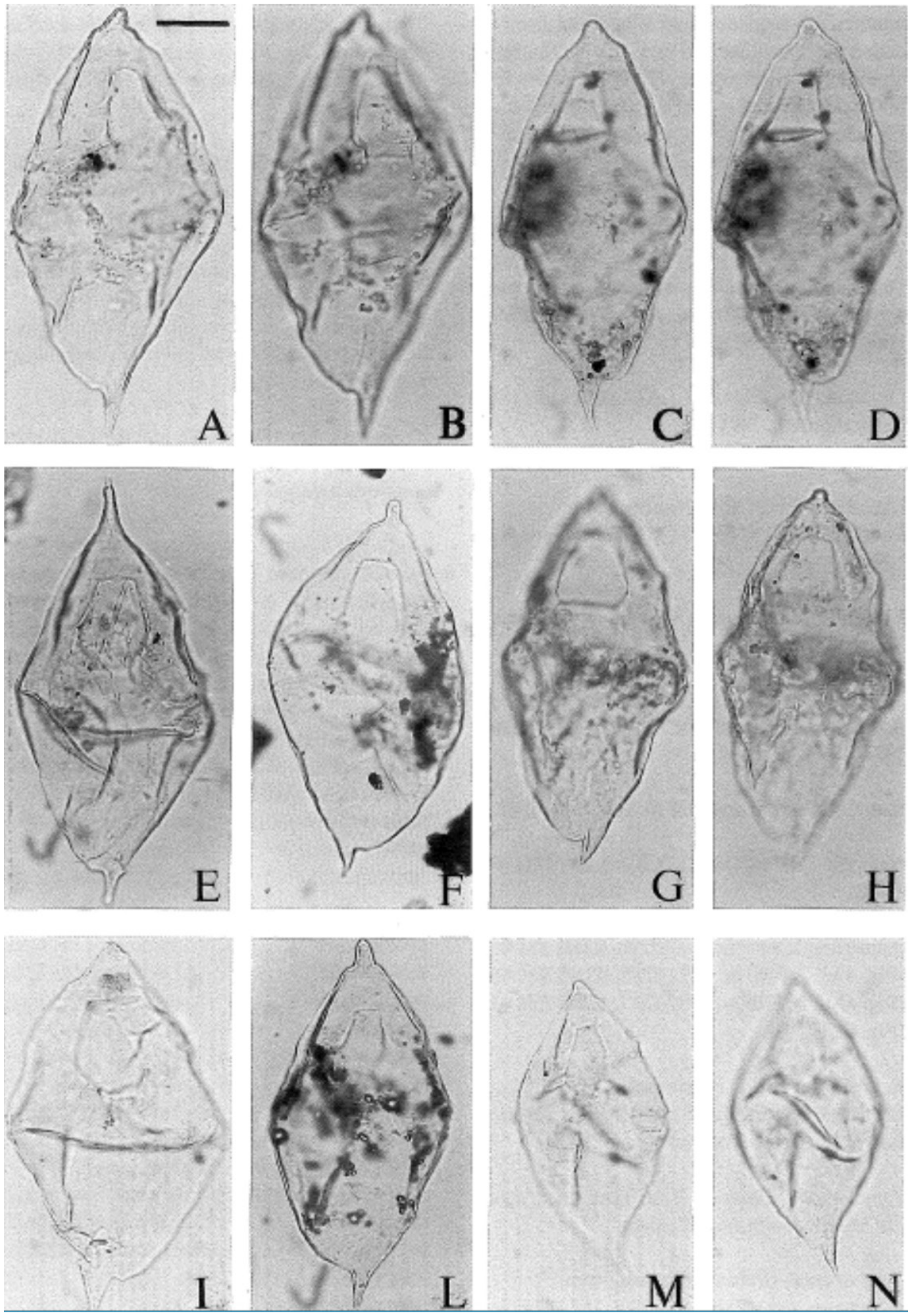
Isabelidinium marshallii closely resembles *S. haumuriense* in size, archeopyle shape, and hypocyst outline (Fig. 5A, B, L). Abundant, well-preserved specimens of *I. marshallii* and *S. haumuriense* were recovered at Haumuri Bluff and in the Conway River section. In particular, the assemblages document the continuous morphologic gradation between *I. marshallii* and *S. haumuriense*. Lentin & Manum (1986, p. 112) proposed the genus *Satyrodinium* for bicavate, compressed elongate, peridinioid cysts, with two to three apical and one or more antapical horns, with amid-apical pore-like structure between the apical horns, and without indication of paratabulation apart from the archeopyle (Fig. 6). Thus, the original diagnosis of the genus *Satyrodinium* (Lentin & Manum 1986, p. 112) implies the presence of at least 2 apical horns. The new taxon differs from S. *haumuriense* byhaving only one apical horn, and indication of parasulcus; thus, it cannot be included in *Satyrodinium* (Fig. 6).

The overall similarity between the species *S. haumuriense* and *I. marshallii* suggests a close relationship between *Satyrodinium* and *Isabelidinium*. Despite the attribution of *S. haumuriense* and *I. marshallii* within two different genera, one of the two species may have evolved from the other. In New Zealand, *S. haumuriense* and *I. marshallii* first occur above *Isabelidinium* species (i.e. *I. beifastense*, *I. cretaceum*, and *I. glabrum*) and below *S. bengalense*, the only other species of the genus (Fig. 7).

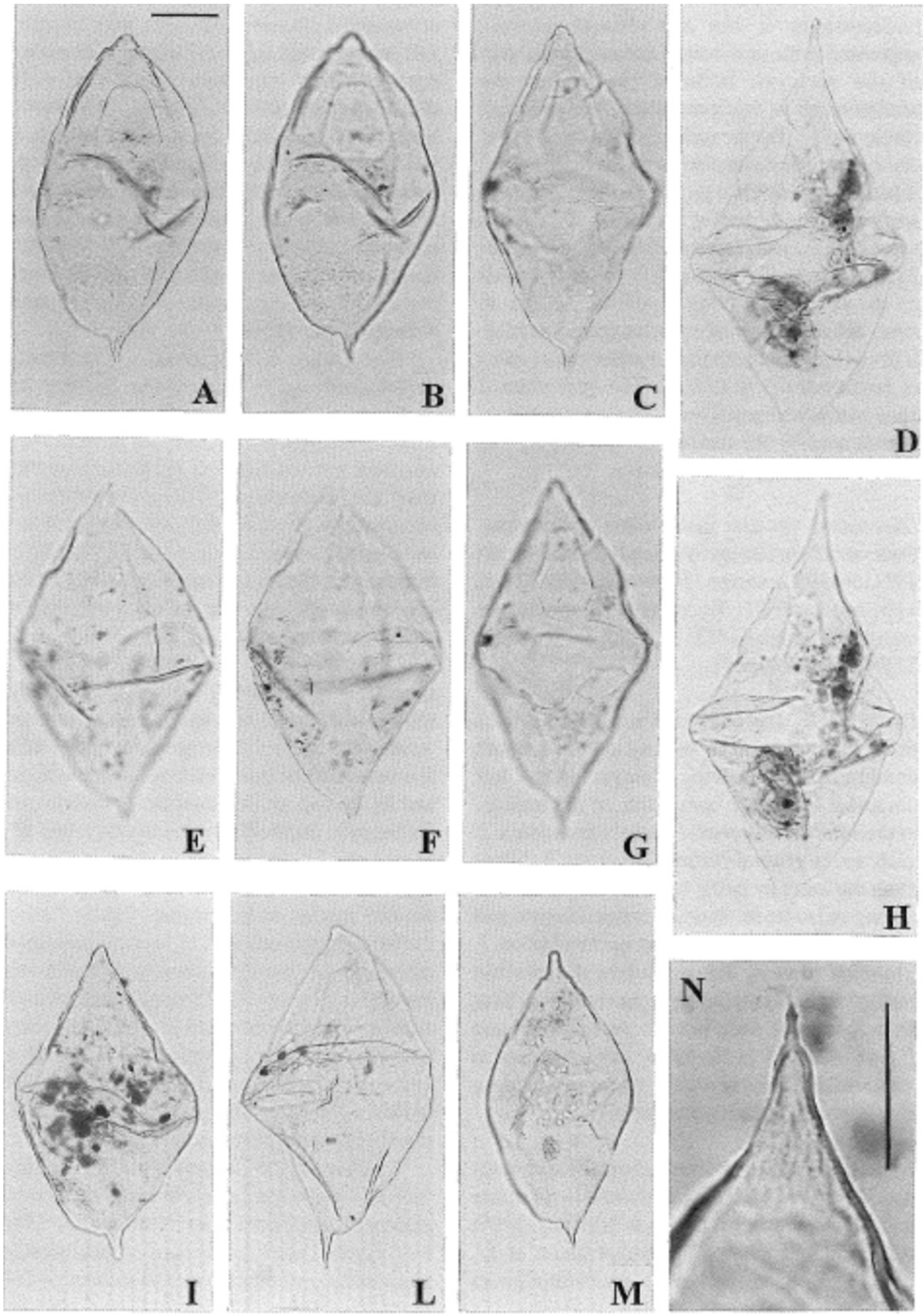
According to Wilson (1984b, p. 554), *S. haumuriense* is characterised by a broadly truncated apex with a central notch and, occasionally, short rounded projection (Fig. 5A, B, L). The type species of *Satyrodinium*, *S. bengalensi*, bears two well-developed lateral apical horns which tend to recurve towards the apex, and a central apical notch which might develop into a low mid-apical horn (Lentin & Manum 1986, p.114; Fig. 5C). Specimens showing a transition between *S. haumuriense* and *S. bengalense*, as well as transitional specimens between *I. marshallii* and *S. bengalense* were encountered in southern Marlborough, and do occur in the Late Cretaceous of New Zealand (Wilson, pers. comm. 1999). These specimens have either the epicyst of *I. marshallii* (single central apical horn) or the epicyst of *S. haumuriense* (truncate apex with central notch), combined to the hypocyst of *S. bengalense*. Four transitional morphotypes are illustrated in Fig. 5E–H. Based on the continuous morphologic gradation observed between the end-forms *I. marshallii*, *S. haumuriense* and *S. bengalense*, and the stratigraphic range of *Isabelidinium* and *Satyrodinium* species in southern Marlborough (Fig. 7), it may be inferred that *I. marshallii* represents one of the linking morphotypes between the genus *Isabelidinium*, and *S. haumuriense* and *S. bengalense*. Thus, the genus *Satyrodinium* may have evolved from *Isabelidinium*. *Isabelidinium marshallii*, *S. haumuriense*, *S. bengalense* and their intergradational variants last occur within the upper Campanian *I. korojonense* Zone in southern Marlborough (Fig. 7).

In conclusion, a highly variable morphological complex spanning populations of *Alterbidinium*, *Isabelidinium* and *Satyrodinium* occurs in the Campanian of New Zealand. It is uncertain whether the morphotypes observed within the complex indicate palaeoenvironmental and/or palaeogeographical variations. However, even though the generic attribution of species from the complex may change, the stratigraphic value of discrete populations such as *I. marshallii*, *S. haumuriense* and *S. bengalense* should remain firm." — Roncaglia (2000, p. 139, 142, 143, 145)

<u>Age</u>: Late Cretaceous (Campanian); holotype of Roncaglia (2000, p. 138). Range: Late Cretaceous (early–middle Campanian) (Roncaglia, 2000, p. 138, fig. 7). Note: see Roncaglia (2000, fig. 7) for ranges of other taxa in Upper Cretaceous of New Zealand.



Figures 3A–N, Roncaglia (2000). Scale bar = 30 μm.



Figures 4A–N, Roncaglia (2000). Figure A, scale bar = 30 μm; figure N, scale bar = 20 μm.

Isabelidinium microarmum (McIntyre, 1975) Lentin & Williams, 1977a

Description: "Cyst cavate, convex in equatorial region, with approximately equal-sized epitract and hypotract. Periphragm usually folded in equatorial region, but a definite cingulum is not present. Indications of a large, wide sulcus on the ventral surface are seen occasionally. On the epitract the periblast bulges laterally above the endoblast to form small angular or sometimes rounded shoulders, on which a short, broad apical horn is situated. Apical horn usually round or blunt at the end, but occasionally has a short papilla (Pl. 1, fig. 5). Left antapical horn short, 8–12 μm long and either pointed (Pl. 1, fig. 7) or rounded (Pl. 1, fig. 5). Right antapical horn less than 5 μm long, appearing as an angular bulge or a short sharp projection. A few small echinae, about 1–1.5 μm in diameter and height, are commonly present on the shoulders (Pl. 1, fig. 5), apical horn, and antapical horns especially the left and occasionally between antapical horns (Pl. 1, fig. 7). The large intercalary (2a) archeopyle is rounded hexagonal with a straight posterior margin. Operculum often still attached at posterior margin. No other indications of tabulation visible. Endoblast large and extends close to periblast laterally. Endophragm smooth to faintly scabrate and less than 1 μm thick. Endoblast sometimes has several folds (Pl. 1, fig. 6). Periphragm smooth, except for echinae described above and is about 1 μm thick. Endophragm and periphragm always distinguishable. Apical and antapical pericoels, or occasionally a single pericoel, are present. Rarely, a large opening occurs in periblast between antapical horns." — McIntyre (1975, p. 65)

Dimensions: "Holotype, 101 μm long, 62 μm wide; endoblast, 48 μm long; range, 99–122 μm long, 41–64 μm wide; endoblast, 39–54 μm long." — McIntyre (1975, p. 65)

Remarks: "*D. microarma* is recorded as *D.* sp. cf. *D. belfastensis* by McIntyre (1974). The Australian Upper Cretaceous species *D. belfastensis* Cookson and Eisenack (1961) has a coarsely granular periblast in the apical and antapical regions. *D. cooksoni* Alberti (1959) differs from *D. microarma* in being smaller, having rounded shoulders, a longer left antapical horn, and a granular periphragm, and lacking the echinae noted on *D. microarma*." — McIntyre (1975, p. 65)

Age: Late Cretaceous (Campanian); holotype of McIntyre (1975, p. 65, text-fig. 2). Range: Late Cretaceous (early Campanian– late early Maastrichtian) (McIntyre 1975, text-fig. 2).

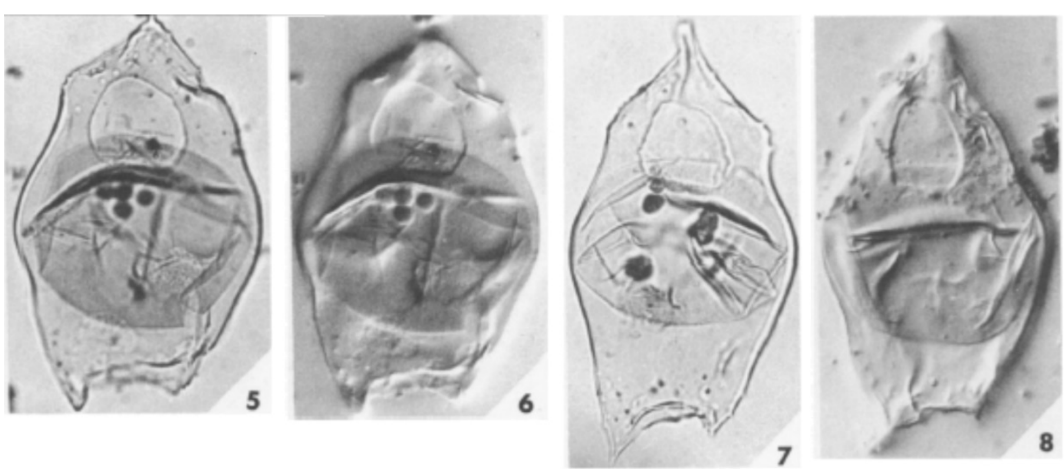


Plate 1, figures 5–8, McIntyre (1975).

Isabelidinium papillum Sumner, 1992

Diagnosis: "A bicavate, peridinacean [sic] dinoflagellate cyst, generally oval in outline with a distinct equatorial bulge and spherical to oval endocyst. The periphragm possesses a short apical protrusion. The cyst shows no paracingulum or other evidence of tabulation except a steno-deltaform intercalary periarchaeopyle, corresponding to the 2a paraplate. The periphragm is smooth to finely granulate." — Sumner (1992, p. 306)

Description: "A dinoflagellate cyst species with a bicavate wall relationship and a generally oval to elongate oval outline, bulging at the equator where the endophragm and periphragm are closely appressed. The endocyst is spherical to oval in outline. The cyst has a blunt conical epicyst with a prominent, hollow apical protrusion up to 14 µm in length. The antapex is often truncated, or less commonly shows slight development of two antapical horns, the left commonly showing stronger development. The only indication of paratabulation is the periarchaeopyle which is a single plate intercalary (type I), corresponding to the 2a paraplate, with a steno-deltaform shape. No endoarchaeopyle has been observed. The operculum is usually free. The surface of the cyst is smooth to finely granulate, many specimens possessing nontabular granular ornament towards the apex and antapex." — Sumner (1992, p. 306)

Comparative remarks: "*Isabelidinium papillum* sp. nov. is similar in size and general outline to *I. pellucidum* and *I. korojonense,* but it possesses a relatively smaller endocyst than *I. pellucidum* and has a more rounded apex. It differs from *I. korojonenses* [sic] by lacking the distinctive serrated shoulders and having amore elongate archaeopyle shape. It differs from all other members of the genus by the posession [sic] of a distinctive apical protrusion." — Sumner (1992, p. 306, 308)

Dimensions: "(µm) Overall length: min, 54; mean, 69; max, 89. Overall breadth: min, 36; mean, 48.1; max, 56; Endocyst length: min, 21; mean, 33.3; max, 50. Length of apical protrusion: min, 2; mean, 3.7; max, 14." — Sumner (1992, p. 308)

Age: Late Cretaceous (late Campanian); holotype of Sumner (1992, p. 306, fig. 5). Range: Late Cretaceous (middle–late Campanian) (Sumner, 1992, fig. 5).

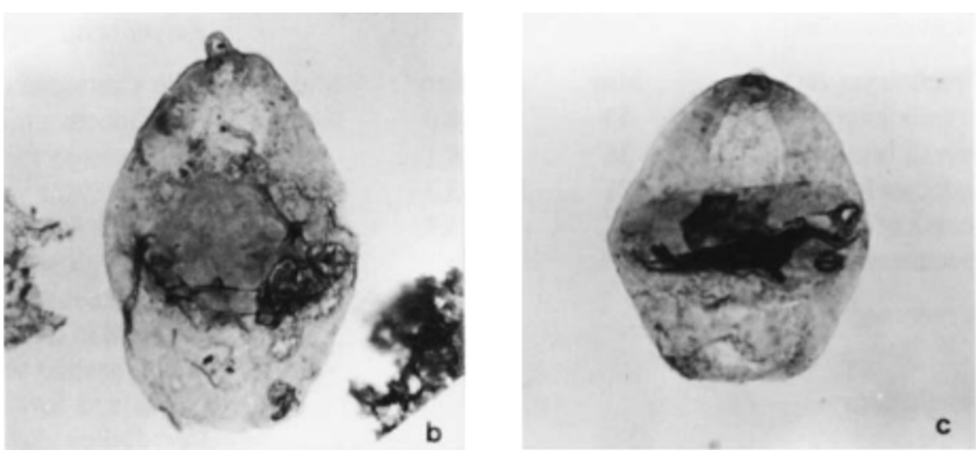


Figure 3b, 3c, Sumner (1992).

Isabelidinium pellucidum (Deflandre & Cookson, 1955) Lentin & Williams, 1977a

Description: "Membrane of the theca thinner and more finely punctate than that of the type. Outline not especially enlarged in the region of the cyst. Posterior end simply and obliquely truncate, slightly depressed in the middle." — Deflandre & Cookson (1955, p. 251)

Dimensions: "Type (Plate 2 [sic 4], Fig. 3): theca, length 118 μ, breadth 77 μ; cyst, length 67 μ, breadth 74 μ. Other specimens: length up to 113 μ, breadth up to 92 μ."

Age: Paleocene–early Eocene; holotype of Deflandre & Cookson (1955, p. 251). Middle Paleocene (Selandian) of same type section, Pebble Point Formation (Stover, 1973, p. 170); Range: Late Cretaceous–middle Paleocene (late Campanian–Selandian) after Selandian of Stover (1973) and late Campanian–early Maastrichtian of Sumner (1992, fig. 4).

Notes: Originally erected as a subspecies of *I. bakeri* (Deflandre & Cookson, 1955, p. 251).

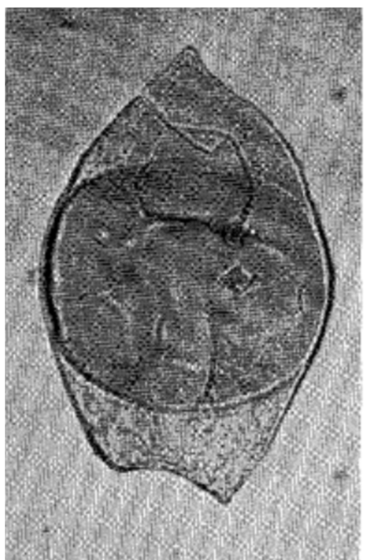

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Plate 4, figure 3, Deflandre & Cookson (1955); Plate 4, figure 9, Cookson & Eisenack (1958).

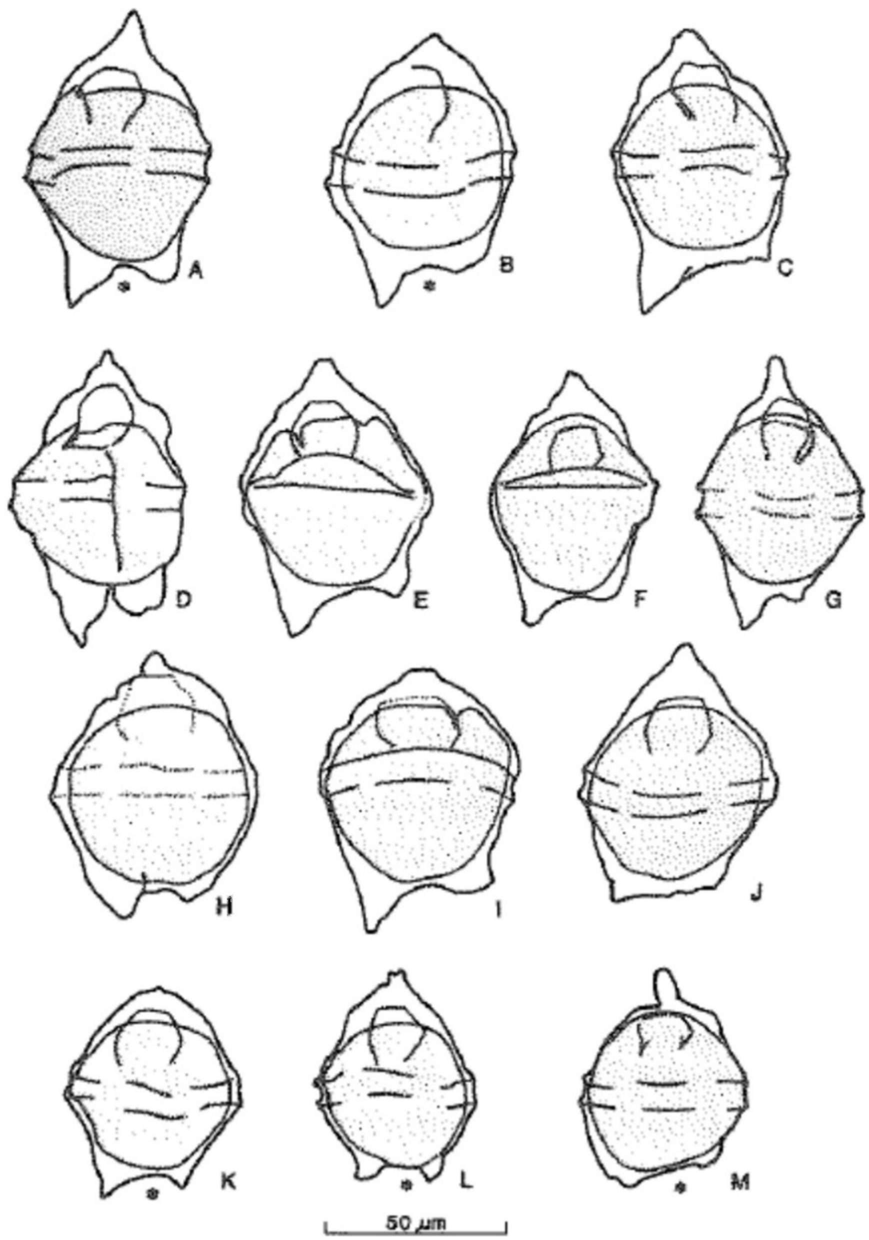
Isabelidinium ponticum Marshall, 1988

Diagnosis: "Ventrodorsal outline subpentagonal, weakly to markedly elongate. Lateral margins on epicyst tapering towards apex or modified by weak, rounded shoulders adjacent to archeopyle. Apex bearing a rounded knob or subconical horn with a truncate tip. Lateral margins on hypocyst tapering towards 2 antapical horns: the left subconical, tip rounded; the right reduced, forming a rounded to subconical projection. Cysts bicavate or circumcavate with a narrow pericoel along lateral margins. Bicavate specimens frequently with isolated pericoels near equator, especially beneath paracingular ridges. Ventrodorsal endocyst outline subcircular to ovoidal, length exceeding width. Periphragm c. 0.4–0.5 μm thick, surface smooth; bearing numerous close-spaced perforations. Pores subcircular, 0.5–1.5 μm in diameter, usually distributed irregularly, occasionally arranged in intratabular fields and separated by non-perforate pandasutural bands. Only fragments of paraplates evident. Paracingulum partite, defined by 2 parallel sets of ridges separated by a shallow groove on periphragm. Archeopyle Type Ia/?: periarcheopyle stenothetaform to isothetaform, operculum usually attached posteriorly. Endoarcheopyle often indicated by splits, type uncertain." — Marshall (1988, p. 205)

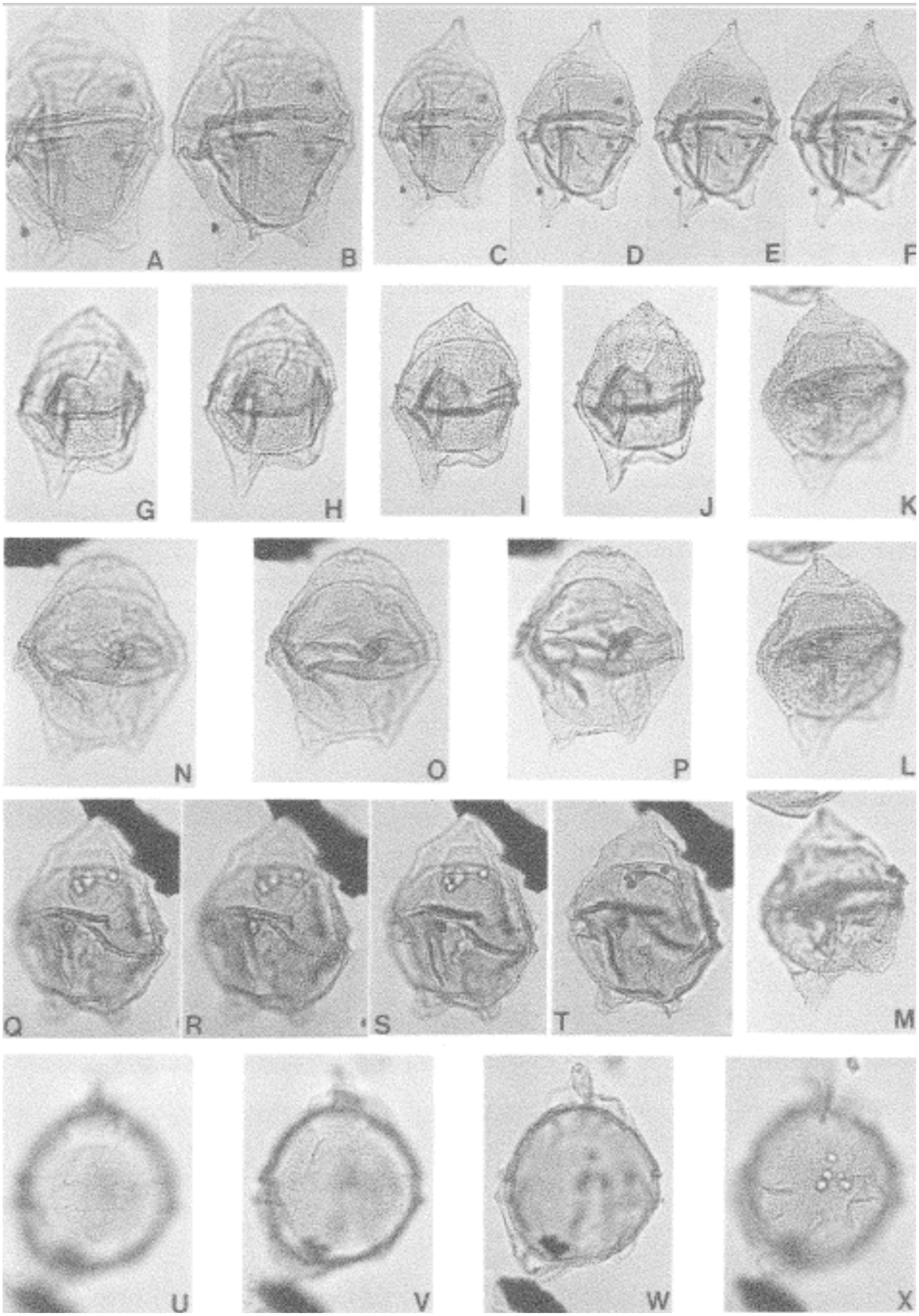
Dimensions: "Pericyst length 59 (78) 90 µm, width 46 (52) 63 µm; endocyst length 41 (48) 53 µm, width 40 (48) 59 µm (29 specimens)." — Marshall (1988, p. 205)

Discussion: "Variation exists in the ventrodorsal outline of the pericyst and in size and shape of the anterior and posterior pericoels (Fig. 8). More elongate and prominently horned specimens appear similar to *C. porosa*, but differ in being smaller, with finer, more closely spaced perforations and weaker indications of a paracingulum. Rare specimens with largest perforations seem almost transitional with *C. porosa*. Morphological gradation exists between the smaller examples of *I. ponticum* and *I. variable* subsp. A; manifested by decrease in size of the perforations on the periphragm." — Marshall (1988, p. 205)

Age: Late Cretaceous (early Santonian); holotype of Marshall (1988, p. 205, fig. 2).



Figures 8A–M, Marshall (1988).



Figures15A–X, Marshall (1988).

Isabelidinium psilatum (Yu Jingxian & Zhang Wangping, 1980) Lentin & Williams, 1985

Dimensions: "The length of the bursa is 48.3–50.6 microns, holotype 48.3 microns, width 33–34.5 microns, holotype 3.3 [sic 33.3?] microns." — Translated from Yu Jingxian & Zhang Wangping (1980, p. 108)

Description: "Centrosome length 34.5–39.1 microns, holotype length 39.1 microns, width 28–29.9 microns, holotype 29.9 microns. The dorsal ventricle of the sac is flat, the outline is nearly pentagonal, and the wall is thin. The apex angle is small, conical, the end is opened to communicate with the outside, and the bottom has two angles; one is less obvious, the one on the left is slightly visible, solid. The centrosome is oval, almost filling the whole cyst, and the width of the transverse groove is about 5.7 microns, slightly helical. The surface is smooth. Intercalary archaeopyle is polygonal." — Translated from Yu Jingxian & Zhang Wangping (1980, p. 109)

Comparison: "Smooth surface shape, with *D. korojonensis* Cookson & Eisencack somewhat similar; but the horizontal groove is clear, the centrosome almost fills the whole cyst, and the individual is smaller and different." — Translated from Yu Jingxian & Zhang Wangping (1980, p. 109)

Age: Late Cretaceous (early Turonian). Based on the age of the "upper part of Kukebai-Wuyitake Formation" translated from Yu Jingxian & Zhang Wangping (1980, p. 109) as given by Mingzhen Zhang et al. (2022, fig. 2).

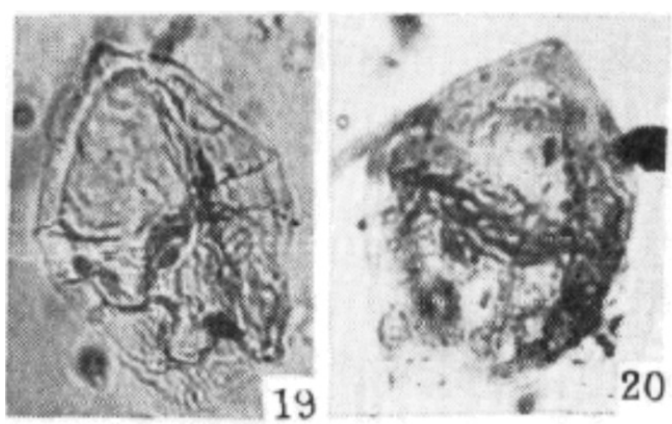


Plate 2, figures 19, 20, Yu Jingxian & Zhang Wangping (1980).

?*Isabelidinium rhombovale* (Cookson & Eisenack, 1970) Lentin & Williams, 1977a

Description: "Shell small, somewhat flat, rounded-rhomboidal to nearly oval in outline, with a short, blunt to truncate apical horn and a small, pointed to rounded antapical horn situated towards one side of the hypotheca. Girdle median, slightly indicated or missing. In the holotype the ventral furrow is in evidence and the wavy thickening which we associate with the flagellum pore and have herein recorded for several other types (p. ??) is clearly indicated. The capsule is approximately circular in outline and does not fill the shell laterally; its wall is only slightly thicker than that of the shell. The shell opens by means of a small, approximately five-sided archeopyle, as is evident in the holotype, but to one side of the epitheca due to faulty preservation." — Cookson & Eisenack (1970, p. 143)

Dimensions: "Based on 20 examples. Holotype: length c. 54 µ, breadth 44 µ. Range: length c. 46–56 µ, breadth 36–44 µ." — Cookson & Eisenack (1970, p. 143)

Comment: "The differences between this species and other small and smooth species of *Deflandrea* are the blunt, truncate and slightly inverted apical horn and the pointed antapical horn." — Cookson & Eisenack (1970, p. 143)

Age: Cretaceous (Albian–Senonian); holotype of Cookson & Eisenack (1970, p. 143).

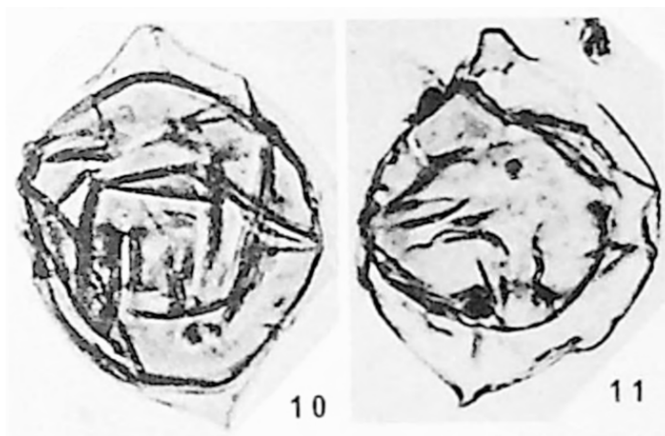


Plate 12, figures 10, 11, Cookson & Eisenack (1970).

Isabelidinium spasicum (Grigorovich, 1969) Lentin & Williams, 1981

Description: "Theca is oval, somewhat elongated along the longitudinal axes. The epitheca in the upper part is slightly expanded and forms obtuse-angled 'shoulders'. Ends with a small horn. Trapezoidal hypotheca forms without antapical horns. The inner body is oval in outline, tightly adjacent to the lateral walls of the theca, smooth. Mushroom-shaped saw [?]. The theca is thin and transparent, almost colorless. The described instance is characterized by the presence in the center of the internal body. It has a body of a trihedral hole or slot, a rupture is possible." — Translated from Grigorovich (1969, p. 68)

Dimensions: "(µm) Length 82.5, width 55.0; inner length body 27.5, width 55.0". — Translated from Grigorovich (1969, p. 68)

Comparison: "General shape of the studied species resembles *Deflandrea bakeri* (Deflandre et Cookson, 1955), from which differs in the shape of the internal body, hypotheca, and also the saw shape [?]. This species differs from *Australiella cooksoni* (Alberti, 1959) this species differs in the shape of a hypotheca, pilome, and the general outlines of a theca." — Translated from Grigorovich (1969, p. 68)

Age: Late Cretaceous; holotype as translated from Grigorovich (1969, p. 67).

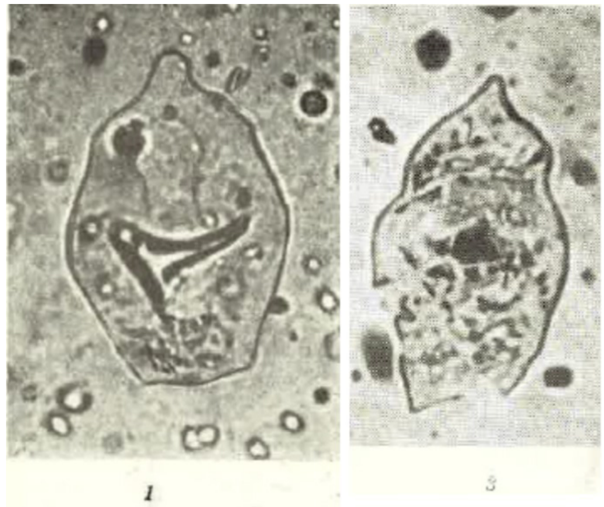


Plate 1, figures 1, 3, Cookson & Eisenack (1970; Fensome et al. 2019 only cite Pl. 1, figure 10).

Isabelidinium svartenhukense Nøhr-Hansen, 1996

Description: “Cyst type: hypocavate-circumcavate, peridinioid. Shape: dorso-ventrally compressed cyst, with an almost ovoidal to elongate quasi-pentagonal outline. The apical horn on the ovoidal specimens is reduced to a small bulge and the left antapical horn is very shorty whereas the right antapical horn is only a bulge. Specimens with a more elongate outline have a small blunt apical horn and a short antapical horn. The right antapical horn is very short or more commonly appears as a bulge. Both forms have a spherical body. Wall relationships: the cyst is composed of a smooth to scabrate, hyaline pericyst and a hyaline endocyst. The endophragm approaches the periphragm at the equator or just above and the two wall layers are parallel, with a very narrow epipericoel (1–3 μ), up to the apical part of the cyst where the epipericoel can extend up to 10 μ forming an apical horn or bulge. The hypopericoel on the ovoidal forms is smaller than on the more elongate forms. Tabulation: paratabulation is only indicated by the archeopyle and the cingulum, when present. Cingulum is most common on the elongate forms, where its anterior and posterior margins are bordered by ridges with small granulae. On the ovoidal specimens a very weak tabulation pattern and cingulum outline is occasionally indicated by rows of granulae. Archeopyle: intercalary (2a) thetaform archeopyle. Operculum often attached at posterior margin. It has not been possible to observe the endoarcheopyle.” — Nøhr-Hansen (1996, p. 34, 35)

Dimensions: “Holotype: length of pericyst 65 μ, width of pericyst 58 μ, length of endocyst 45 μ. Paratype: length of pericyst 93 μ, width of pericyst 65 μ, length of endocyst 54 μ. Size range: Ovoidal forms (10 specimens) length of pericyst 60 (71) 83 μ, width of pericyst 45 (55) 63 μ, length of epicyst 45 (52) 61 μ. Elongate forms (14 specimens) length of pericyst 74 (82) 93 μ, width of pericyst 43 (56) 65 μ., length of epicyst 43 (52) 60 μ.” — Nøhr-Hansen (1996, p. 35)

Discussion: “The shape of the pericyst, endocyst and very narrow epipericoel distinguish the new species of *Isabelidinium svartenhukense* from most other *Isabelidinium* species. *I. svartenhukense* is very similar in shape to *I. variabile* Marshall (1988), especially the informally described subspecies A and D (Marshall, 1988, p. 207, 211). However, *I. variabile* differs by having a periphragm with closely spaced perforation and a scabrate, granulate or verrucate endophragm. The species *Eurydinium glomeratum* (Davey, 1970) Stover & Evitt 1978, is distinguished from *I. svartenhukense* by having a much smaller hypopericoel and by having an endocyst that is in contact with the periphragm except in the apical and antapical regions.” — Nøhr-Hansen (1996, p. 35)

Age: Late Cretaceous (late Coniacian); holotype of Nøhr-Hansen (1996, p. 35, 44, enclosure 8). Range: Late Cretaceous (late Coniacian–early Santonian) (Nøhr-Hansen, 1996, p. 35, fig. 8).

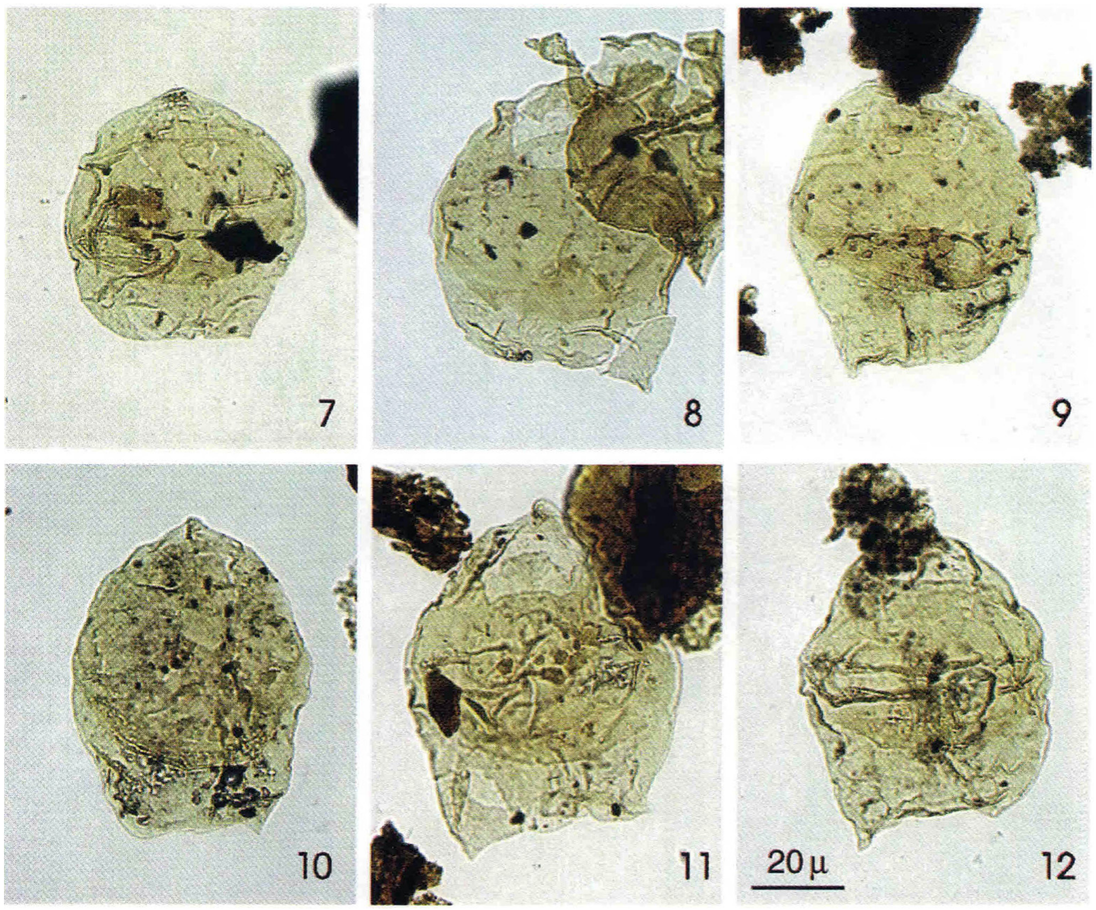


Plate 3, figures 7–12, Nøhr-Hansen (1996).

Isabelidinium thomasii (Cookson & Eisenack, 1961a) Lentin & Williams, 1977a

Description: "Shell longer than broad, roughly oval with a median girdle with low borders which, sometimes, is only indicated at the lateral margins; the epitheca has a short, solid pointed horn which terminates in a minute hyaline prominance [sic]. The antapex is variable in outline, it may be indented, obliquely truncate with a single short, pointed, lateral horn or broadly rounded. The shell membrane is 2-layered; the inner layer is thin and hyaline, the outer is formed of densely arranged minute granules or rods; it is from this layer that the apical horn is formed. In poorly preserved specimens the outer layer tends to be destroyed. The internal body is oval in outline and thin-walled; it appears to be absent from some specimens. The pylome is trapezoid in shape." — Cookson & Eisenack (1961a, p. 71, 72)

Dimensions: "Type—length 108 µ, breadth 82 µ. Range—length 85–114 µ, breadth 50–90 µ." — Cookson & Eisenack (1961a, p. 72)

Comments: "The specimens of this species, though not rare, have been invariably badly preserved in contrast to those of *D. cretacea* with which it is associated. This may be due to the thinner walls of both the shell and internal body of *D. thomasi*. *D. thomasi* can be distinguished from other species of *Deflandrea* by the finely and densely patterned surface and the construction of the solid apical horn." — Cookson &

Eisenack (1961a, p. 72)

Age: Late Cretaceous (Senonian); holotype of Cookson & Eisenack (1961a, p. 69, 71).

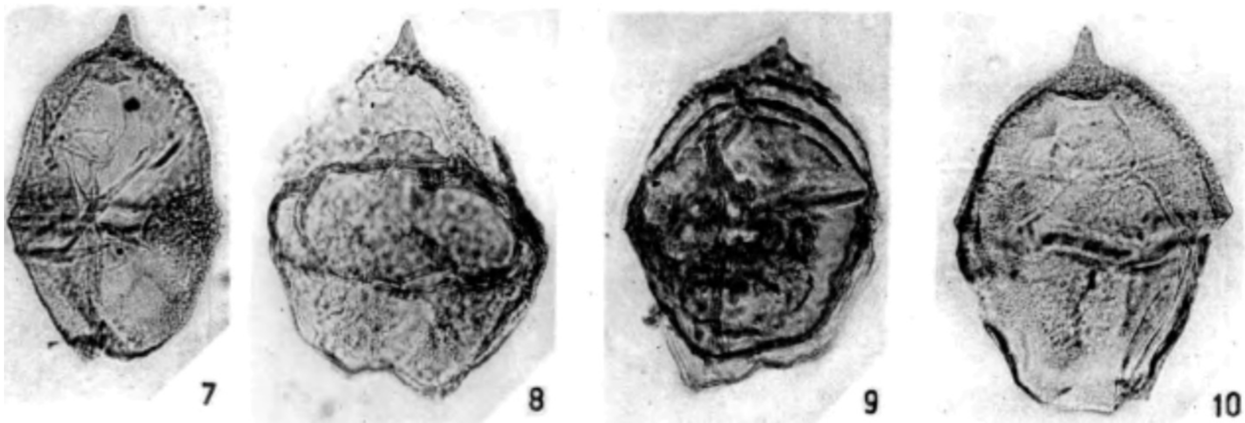


Plate 11, figures 7–10, Cookson & Eisenack (1961a).

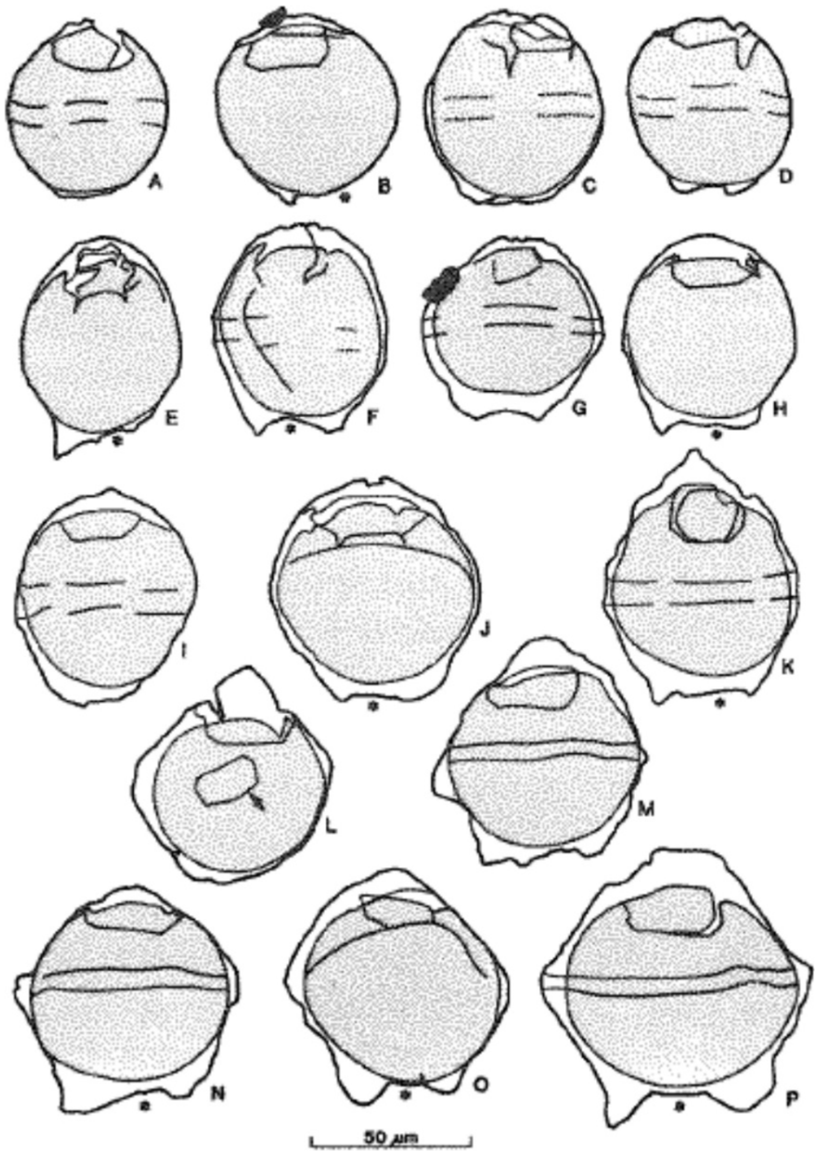
Isabelidinium variabile Marshall, 1988

Diagnosis: "Cysts weakly compressed ventrodorsally, length usually slights greater than width, ventrodorsal outline subcircular to subpentagonal. Each lateral margin usually evenly convex, occasionally modified by a weak equatorial bulge. Apex bearing a rounded knob or subconical horn with truncate tip. Antapical margin nearly straight to convex, usually with 1–2 faint horns indicated by rounded bulges or subconical projections. Cysts cornucavate, bicavate, or circumcavate with a narrow pericoel along lateral margins. Ventrodorsal endocyst outline subcircular to ovoidal with length exceeding width. Periphragm c. 0.2–0.5 μm thick, surface smooth, often bearing numerous fine perforations c. 0.1–1.0 μm in diameter. Parasutural ornament on periphragm absent or indicated by rows of low ridges and/or pores. Paraplates defined: 1–4', 1–3a, 1–7'', 1–4''', 1'''', 2'''' (Fig. 10). Endophragm c. 0.75–1.5 μm thick, surface scabrate, granulate, verrucate, or rugulate; sculpture nontabulate. Paracingulum faint to distinct, indicated on periphragm by 2 parallel ridges or rows of pores 5–8 μm apart. Ridges usually with a partite arrangement, appearing almost continuous on dorsal and edges of ventral surfaces. Archeopyle Type Ia/I. Periarcheopyle isodeltaform to isothetaform; operculum apparently attached posteriorly, not on many specimens. Endo-operculum often in place with sutures apparent along all boundaries; additional sutures also frequently evident on endophragm along paraplate boundaries surrounding operculum." — Marshall (1988, p. 205, 207)

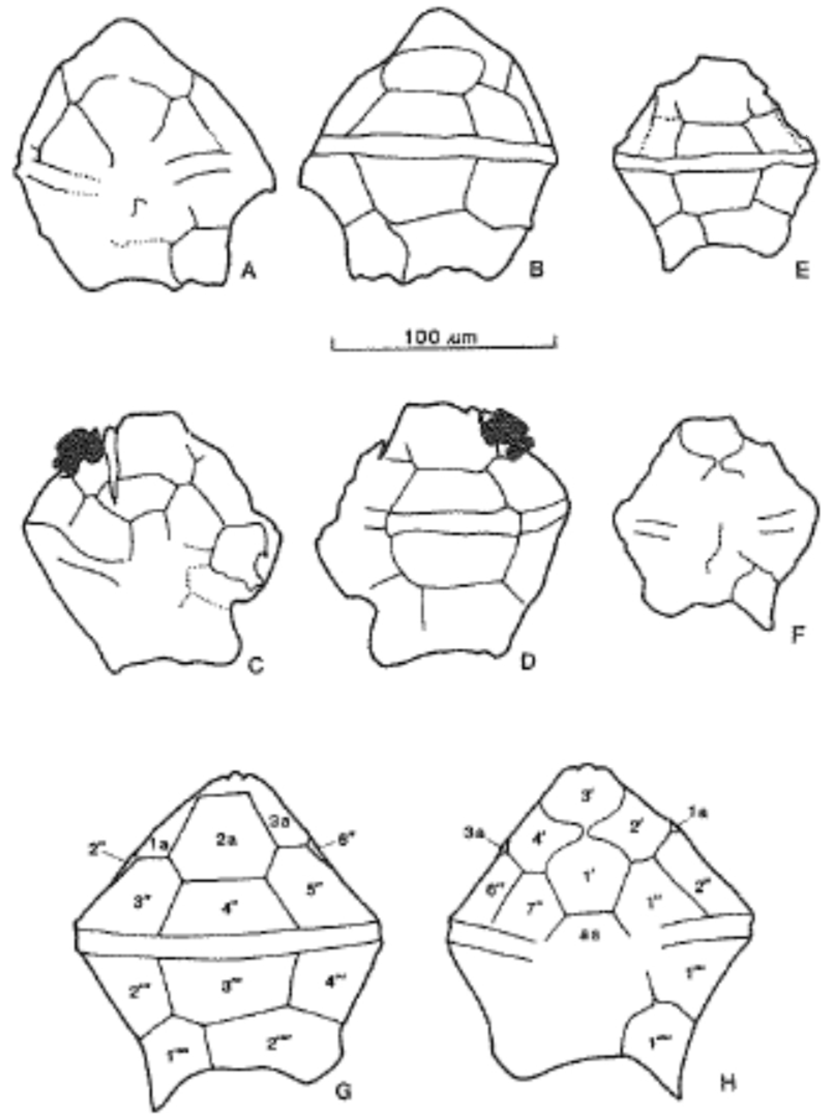
Dimensions: "Pericyst length 53 (65) 90 μm, width 44 (61) 84 μm; endocyst length 48 (55) 64 width 43 (60) 74 μm (45 specimens)." — Marshall (1988, p. 207)

Discussion: "This group of cysts is difficult to circumscribe because of extreme variation. Common attributes are: 1, fairly consistent thicknesses and dimensions of the wall layers; 2, cysts weakly compressed ventrodorsally; 3, endocyst occupying much of the pericyst; 4, periphragm usually finely perforate; and 5, partite paracingulum usually indicated. Four intergrading morphotypes (subspp. A–D) are based on differing wall layers." — Marshall (1988, p. 207)

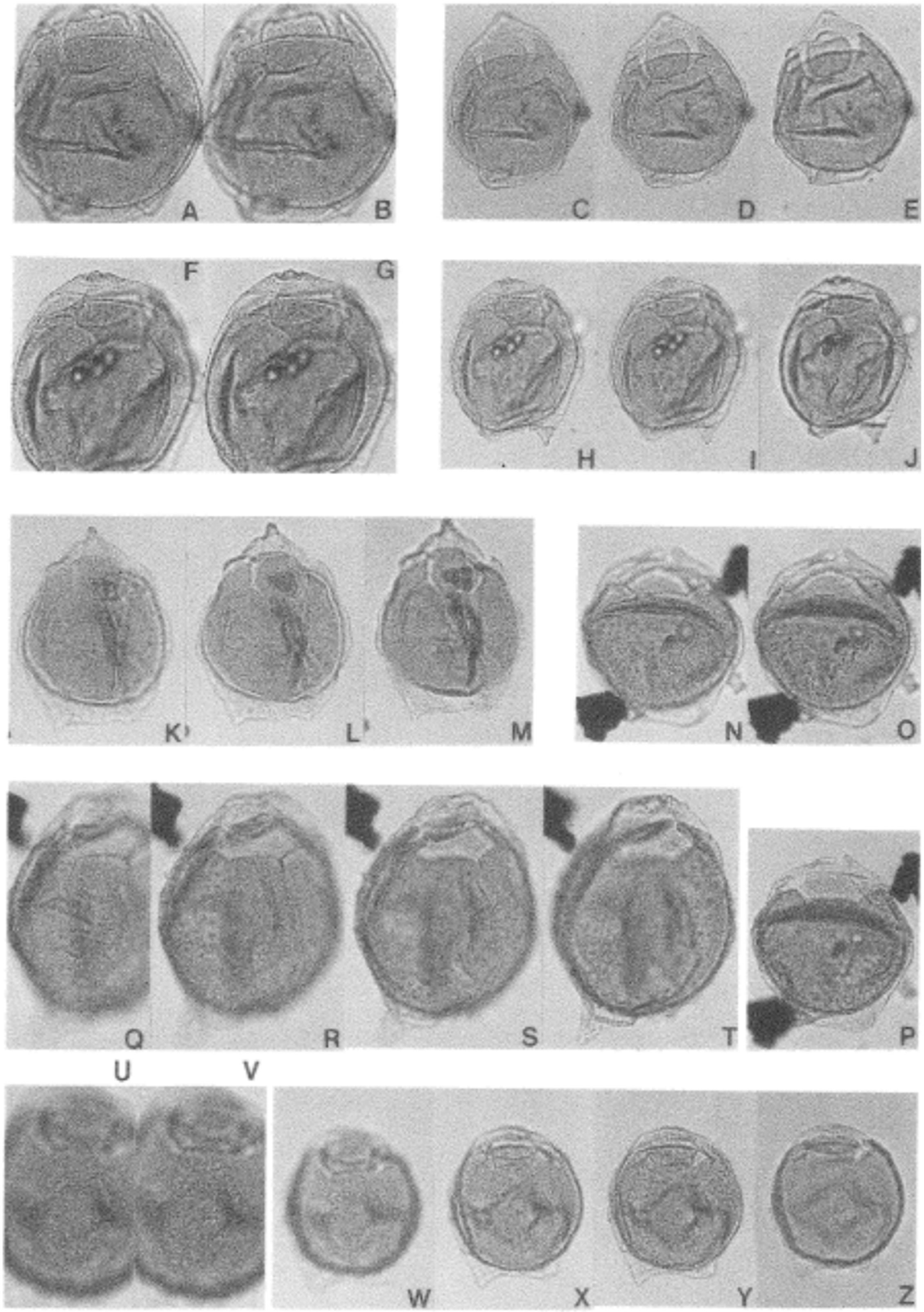
Age: Late Cretaceous (early Santonian); holotype of Marshall (1988, p. 207, fig. 2).



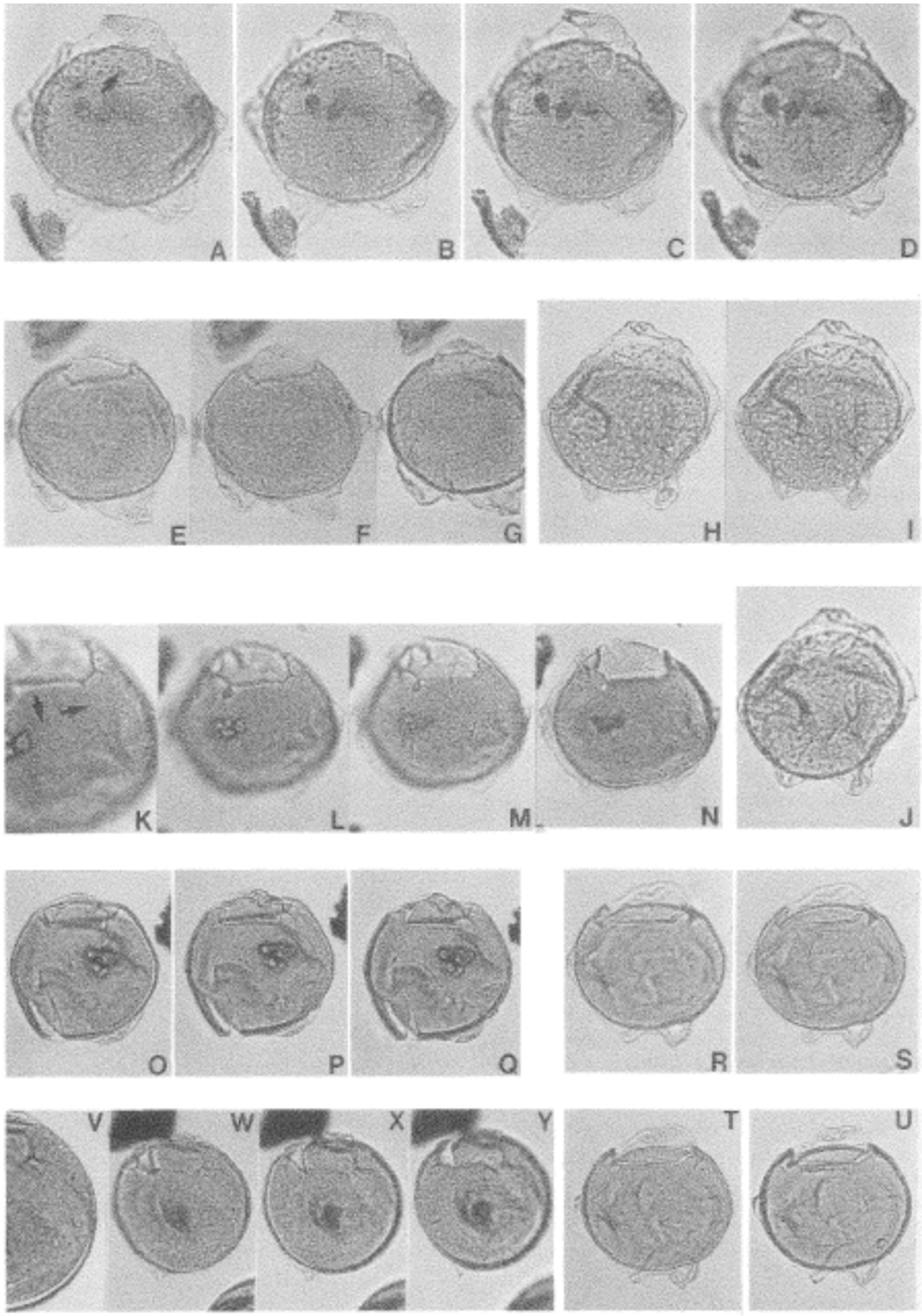
Figures 9A–P, Marshall (1988).



Figures 10A–H, Marshall (1988.)



Figures 13A–Z, Marshall (1988).



Figures 14A–Y, Marshall (1988).

?*Isabelidinium viborgense* Heilmann-Clausen, 1985

Diagnosis: "A smooth-walled, circumcavate, peridiniacean cyst. The pericyst-ambitus is almost pentagonal, the apical and both antapical horns being strongly reduced. Epi- and hypo-pericyst are of almost equal size. The broad and deeply depressed paracingulum gives rise to deep notches of the lateral margins of the cyst. The deep parasulcus extends to the antapical corners. The periarchaeopyle is intercalary, or is an intercalary precingular combination type. Two additional openings are present in the periphragm: one near the apex on the ventral surface, and another opening is present in the posterior part of the parasulcus. The endocyst is subcircular in ambitus and thinner-walled than the pericyst." — Heilmann-Clausen (1985, p. 22)

Description: "A circumcavate peridiniacean cyst. Pericyst: the pericyst is smooth-walled and sub-pentagonal in ambitus. The lateral margin between apex and paracingulum is convex, while the posterior margin between the strongly reduced antapical horns is concave. The apex is truncate or concave. A broad and deeply depressed, scarcely offset paracingulum is present in an equatorial position, and the epicyst and hypocyst are therefore almost equal in size. The parasulcus is broad and deep; it is mainly confined to the hypocyst, and extends to the two antapical corners. The peri-archeopyle is either intercalary with an operculum attached at the posterior margin, type Ia(2a) (fig. 9B, C), or is a combination-archaeopyle, type IPa(2a, 4") (fig. 9A, D). In addition to the archaeopyle two other openings are present in the periphragm (fig. 9). One opening is situated near the apex, on the ventral surface. The other is located in the posterior part of the parasulcus; it is offset to the right and often appears to be composed of two coalescent, round holes. Endocyst: the endocyst is thin-walled and smooth with a subcircular ambitus. It is clearly separated from the periphragm in the ambital plane. An endo-archaeopyle is only rarely visible (fig. 9D). It appears to be a hexa I(2a) archaeopyle. A few specimens without a detactable [sic] central body have been seen." — Heilmann-Clausen (1985, p. 23)

Dimensions: "Pericyst, length, max., (mean), min.: 70, (59), 47 µm, width: 57, (48), 37 µm. Endocyst, length: 41, (34), 27 µm, width: 41, (34), 26 µm. (10 specimens measured). Holotype: pericyst length 58 µm, width 41 µm; endocyst length 34 µm, width 33 µm." — Heilmann-Clausen (1985, p. 23)

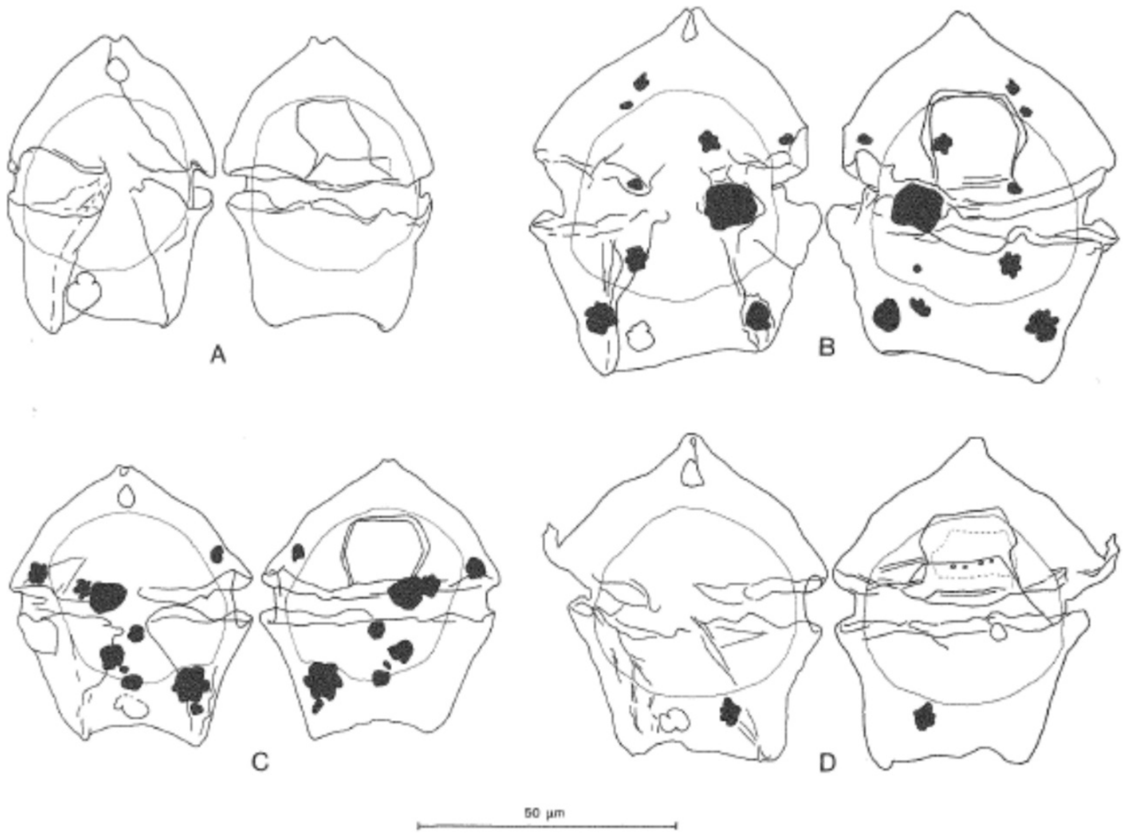
Remarks: In typical specimens of *Isabelidinium* the paracingulum is not distinct. The present species has a strongly developed paracingulum and is therefore only provisionally referred to *Isabelidinium*.

I.? *viborgense* resembles, to some extent, *Senegalinium*? *dilwynense* (Cookson & Eisenack) Stover & Evitt 1978. The latter species differs, however, in several respects: 1) the epicyst is much longer than the hypocyst, 2) a left ant apical horn is well developed, 3) the endocyst is much larger, 4) the periphragm has a distinct pattern of longitudinal folds and 5) no additional openings seem to be present in the periphragm.

The possible functions of the additional openings in the periphragm are not known. The small apical concavity probably corresponds to the position of the apical pore-platelet of the theca. The opening, which is placed ventrally and posterior to this concavity, may reflect the position of the ventral apical platelet of the theca. forms.

Holes with a well-defined antapical or posterior-ventral position are present in widespread cavate genera, such as the peridiniacean genera *Ovoidinium* and *Angustidinium* and the gonyaulacacean genera *Sirmiodinium*, *Tubotuborella* and *Hystrichosphaeropsis*. Sarjeant (1974) proposed that a posterior-ventrally placed hole be termed an opisthopyle, and that the function was to release internal pressures during encystment." — Heilmann-Clausen (1985, p. 23)

Age: middle Paleocene (Selandian); holotype of Heilmann-Clausen (1985, p. 23).



Text-figure 9A–D, Heilmann-Clausen (1985).

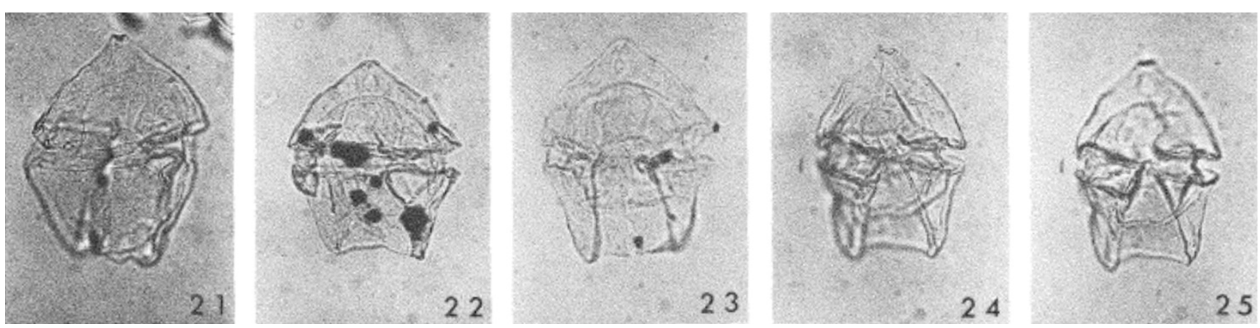


Plate 1, figures 21–25, Heilmann-Clausen (1985).

Isabelidinium weidichii Kirsch, 1991

<u>Diagnosis</u>: “Dorsoventrally compressed, bicavate to circumcavate, intermediate cyst forming an ellipsoidal shape to spheroidal, smooth central body. The likewise smooth pericyst is rounded by an apical area characterized and showing except for the archaeopyle with no signs of tabulation. In rare cases a hypocystal (?) opening can be observed.” — Translated from Kirsch (1991, p. 107)

<u>Description</u>: “The most bicavate cyst, its length greater than its width, has a subpentagonal outline. In bicavate specimens, a lateral, narrow pericoel is present. Except for one weakly developed apical bulge no apical horn is developed. At the hypocyst are two weak, pointed, conical converging antapical processes variable in their length. The left antapical horn is slightly longer. The flanks of the hypocyst are nearly straight, while those of the epicyst are slightly convex. One ‘shoulder’ in the area of the epicyst is not present. The periarchaeopyle is intercalary (2a) and isotheta- to iso-omegaform(?), the perioperculum is posteriorly adnate. One specimen could have an additional, regularly polygonal opening observed in the

area of the hypocyst." — Translated from Kirsch (1991, p. 107)

Remarks: "An additional opening at the hypocyst is used by McIntyre (1975) for *Chatangiella*? *biapertura* (McIntyre 1975) as a distinguishing criterion from other species. According to Ioannides (1986: 14), this is also the opening in *Chatangiella granulifera* (Manum 1963)." — Translated from Kirsch (1991, p. 107)

Comparison: "*Isabelidinium weidiehii* sp. nov. is differentiated from *Isabelidinium cretaceum* (Cookson 1956) by the elongate form of the cyst and from *Isabelidinium belfastense* (Cookson & Eisenack 1961) by the almost completely reduced apical horn. *Isabelidinium*? *rhombovale* (Cookson & Eisenack 1970) lacks the apical horn and the single antapical horn, and *Isabelidinium korojonense* (Cookson & Eisenack 1958) differs in the formation of the epicyst." — Translated from Kirsch (1991, p. 107)

Dimensions: "Holotype: endocyst size (L × W) 34 × 50 µm; size of pericyst 76 × 52 µm. Variation: endocyst size (L × W) 34–36 × 44–50 µm; Size of pericyst 72–80 × 47–60 µm (measured copies 5)." — Translated from Kirsch (1991, p. 107)

Age: Late Cretaceous (early Maastrichtian); holotype as translated from Kirsch (1991, p. 107). Range: Late Cretaceous (early Maastrichtian) as translated from Kirsch (1991, p. 108).

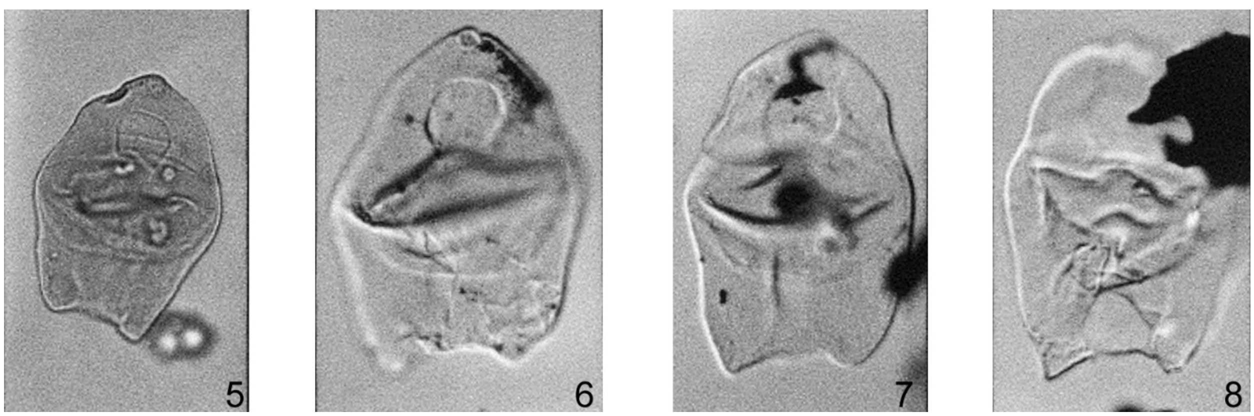


Plate 21, figures 5–8, Kirsch (1991).

Genus ***LACINIADINIUM*** McIntyre, 1975

1975 *Laciniadinium* McIntyre: 70.
1981 *Bellatudinium* Yu Jingxian et al.: 261.
1981 *Apiculadinium* Yu Jingxian et al.: 261, 262.
1984a *Sinocysta* He Chengquan: 769, 773.

?*Laciniadinium aquiloniforme* Schiøler et al., 1997

Diagnosis: "Small rhombic two-layered dorsoventrally compressed cornucavate cyst with a prominent apical horn bearing a short acuminate solid process. The peri- and endophragm are closely appressed except below the apical horn and in the extreme antapical and lateral parts of the cyst. The periphragm is smooth and flat on the dorsal and ventral sides. The endophragm is ellipsoidal to rhomboidal in ambital view with length approximately equal to the width, thin and smooth. The paracingulum is always expressed by parallel septate ridges connecting the dorsal and ventral surfaces on the lateral margins. The archeopyle type is uncertain." — Schiøler et al. (1997, p. 85)

Description: "The periphragm is smooth and has the shape of a rhombic box, formed by two flat surfaces connected by lateral sides. The dorsal and ventral side of the periphragm are bounded marginally by low ridges, and meet at the poles of the cyst. An acuminate process arises from the apex of the cyst (length of apical process: 3–5 μm). The apical process is solid, but often contains 2–5 small vacuoli. Laterally, two pairs of low parallel ridges connect the dorsal and the ventral surface of the periphragm in the equatorial part of the cyst thereby indicating the paracingulum (distance between ridges: 4–5 μm, Plate II, 10, 13, 16). The ridges bear low septa (height of septa: 2 μm, Plate II, 9). At the junctions with the dorsal and ventral sides of the cyst each ridge form a spine-like and apparently solid projection. The antapical part of the periphragm is acute and sometimes pulled out to a small horn, but lacks a terminal process. The endophragm is ellipsoidal to rhomboidal in ambital view with length approximately equal to the width, smooth and closely appressed to the periphragm except below the apical horn and in the extreme antapical and lateral parts of the cyst where small pericoels are developed. A large delta-shaped opening sometimes occurs in the epicyst (Plate II, 10) but the archeopyle type is uncertain. The paracingulum is indicated by two parallel low ridges on the lateral sides of the cyst, and on some specimens by two very faint equatorial lines on the dorsal side (Plate II, 10). The parasulcus is not indicated. The paratabulation is indeterminate, indicated by paracingular ridges and possibly marginal ridges." — Schiøler et al. (1997, p. 85)

Dimensions: "In μm, 6 specimens measured, dimensions given as holotype, minimum (mean) maximum]: length of pericyst, 45, 36 (45) 50; width of pericyst, 33, 33 (37) 44, length of endocyst, 26, 26 (32) 38; width of endocyst, 25, 25 (30) 36." — Schiøler et al. (1997, p. 85)

Discussion: "As the archeopyle type has not been determined, it is with some hesitation that the new taxon is placed in *Laciniadinium*. The new species resembles *Laciniadinium rhombiforme* (Vozzennikova, 1967) Lentin & Vozzennikova, 1990, but differs in being considerably broader and in lacking paratabulation other than indications of paracingulum and in having septa in marginal position on the paracingular ridges. *Laciniadinium*? *aquiloniforme* differs from all other species of *Laciniadinium* in having a regular rhombic shape with wide and flat dorsal and ventral surfaces, and in having lateral spines." — Schiøler et al. (1997, p. 85)

Age: Late Cretaceous (early late Maastrichtian); holotype of Schiøler et al. (1997, p. 85). Range: Late Cretaceous (early late Maastrichtian) (Schiøler et al., 1997, p. 83, fig. 5).

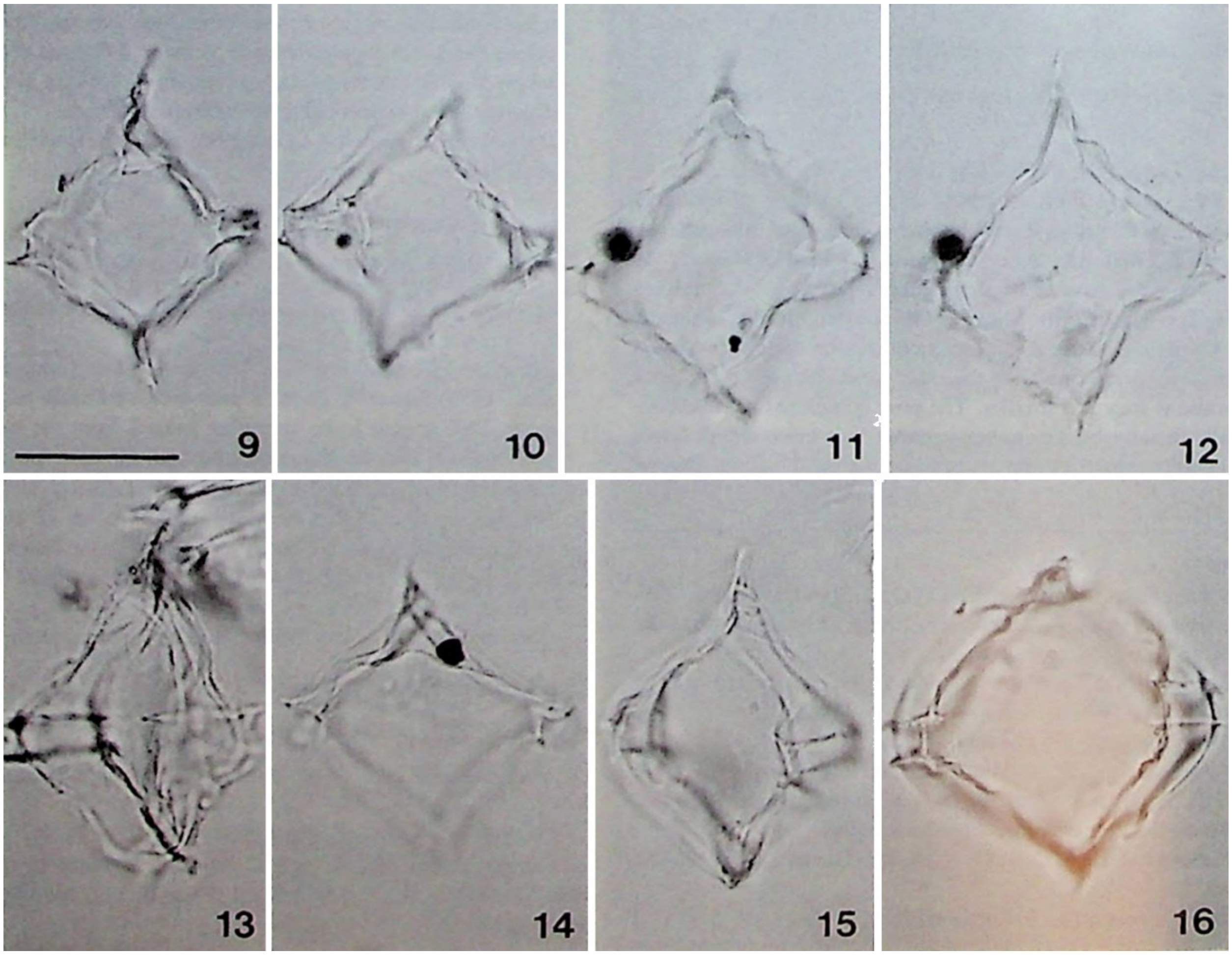


Plate 2, figures 9–16, Schiøler et al. (1997). Scale bar = 20 μm.

Laciniadinium arcticum Manum & Cookson, 1964

Description: "Shell broadly fusiform with one side slightly longer and more convex than the other, almost equally divided by a relatively broad girdle. Apical horn short, truncate and sometimes toothed, antapical spine 3–6 μm long, situated obliquely in relation to the longitudinal axis of the theca. Theca-membrane less than 1 μm thick, two-layered, as most dearly shown at the apices, ornamented with minute granules up to 0.5 μm in diameter. A longitudinal furrow has not been clearly evident." — Manum & Cookson (1964, p. 18, 19)

Dimensions: "Holotype: 71 × 45 μ. Range: 50–73 μ long; 32–53 μ broad." — Manum & Cookson (1964, p. 19)

Comment: "The genus *Diconodinium* is readily recognizable by the more or less fusiform shape of the thin-walled theca, the small median apical process, the short antapical spine, and the absence of a capsule (unless the inner wall is regarded as delimiting a capsule which fills the theca except near both apical and antapical processes). Six species have already been distinguished (Eisenack & Cookson 1960), mainly on the basis of the ornamentation which consists of variously spaced granules or small processes. Of these species *D. arcticum* comes closest to *D. glabrum* E. & C., the differences between them being the much lower size-range in *D. arcticum* (50–73 μ × 32–53 μ as against 62–142 μ × 41–72 μ), its smaller apical and antapical processes, the equal size of the epitheca and hypotheca, and the constant presence of the ornamentation." — Manum & Cookson (1964, p. 19)

Age: Late Cretaceous (?Cenomanian); holotype of Manum & Cookson (1964, p. 10, 31).

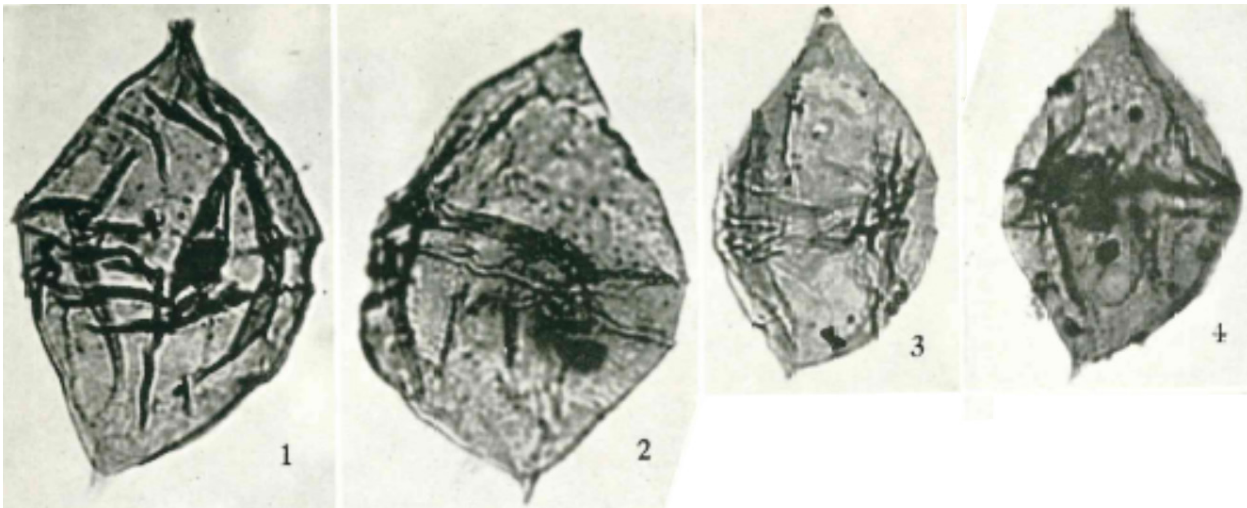


Plate 6, figures 1–4, Manum & Cookson (1964).

Laciniadinium biconiculum McIntyre, 1975

Description: "Cyst proximate, biconical in dorso-ventral view; epitract and hypotract of approximately equal size. Apical projection is short with a blunt top and 2 short papillae. The 1 antapical horn (left?) is about 8 μm long and sharp pointed. Cingulum 4–6 μm wide, with its edges marked by low ridges. Sulcus rarely clearly seen. The archeopyle is of the 3I3P type formed by the 3 intercalary and the precingular reflected plates 3'', 4'', 5''. Operculum remains attached at cingulum as a flap, which is usually folded. The intercalary reflected plates are small because of the conical nature of the epitract. No other visible indications of tabulation. One wall layer (autophragm), about ½ μm thick, is present. Ornamentation consists of small granules less than 1 μm in size and ridges of the same width and height as the granules, but of varying lengths. Granules and ridges often arranged in rows and give cyst a somewhat striate appearance." — McIntyre (1975, p. 71)

Dimensions: "Holotype, 78 μm long, 53 μm wide; range, 55–85 μm long, 34–53 μm wide." — McIntyre (1975, p. 71)

Remarks: "*L. biconiculum* is abundant in the upper part of Division H2 and is recorded in McIntyre (1974) as *Diconodinium* sp. 2. *L. biconiculum* differs from *L. orbiculatum* in having a smaller size and conical shape. *L. biconiculum* has the same shape as some species of *Diconodinium*, but an archeopyle has been reported in only one species of *Diconodinium*. *D. firmum* was considered by Harland (1973) to have a precingular archeopyle, but his illustrations suggest that the archeopyle for this species could be of the 3I3P type. Specimens of *D. firmum* seen in the Horton River section did not possess an obvious archeopyle. *D. rhombiformis* Vozzhennikova (1967) is similar to *L. biconiculum* in shape, but it is smaller and has well-defined areas that are divided by smooth or finely serrated ridges. No obvious pattern of areas on epitract and hypotract can be seen in *L. biconiculum*." — McIntyre (1975, p. 71)

Age: Late Cretaceous (late Campanian); holotype of McIntyre (1975, p. 71, text-fig. 2). Range: Late Cretaceous (late Campanian) (McIntyre, 1975, text-fig. 2).

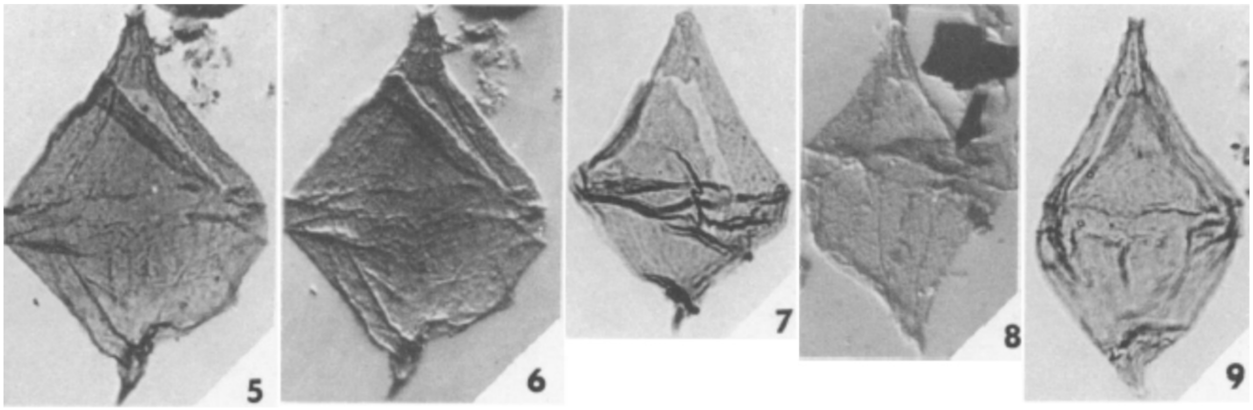


Plate 4, figures 5–9, McIntyre (1975).

Laciniadinium conpicuum (Yu Jingxian et al., 1981) He Chengquan et al., 2009

Description: "The outline is crooked pear-shaped pentagonal. It appears to be one thin, transparent layer. The margin has thin line ridges that are suitable for the side. The epitheca is obviously larger than the hypotheca, and it is an oblique triangle or an isomorphic triangle. The apical horn is not obvious, and the top of the epitheca shrinks gradually, the apex is conical, and the hypotheca is irregular quadrilateral or trapezoidal, 16–20 μm in height, two slightly-developed antapical horns, varying in size. Tabulation and archeopyle not seen. Angular furrow, 3–4 μm wide, staggered to abdomen, with obvious fine ridges on furrow edge, longitudinal furrow. Up the epitheca, there are often 2–3 circular 'nuclei' arranged in rows along the edge of the longitudinal groove." — Translated from Yu Jingxian et al. (1981, p. 263)

Dimensions: "Length 52.9–57.5 μm, 23–29 μm, holotype 52.9 × 39 μm." — Translated from Yu Jingxian et al. (1981, p. 263)

Discussion: "This species is large, pear-shaped-elongated pentagonal in profile, with a long longitudinal furrow, and often has 2–3 'nuclei' arranged in rows along the furrow to distinguish it from others in the genus." — Translated from Yu Jingxian et al. (1981, p. 263)

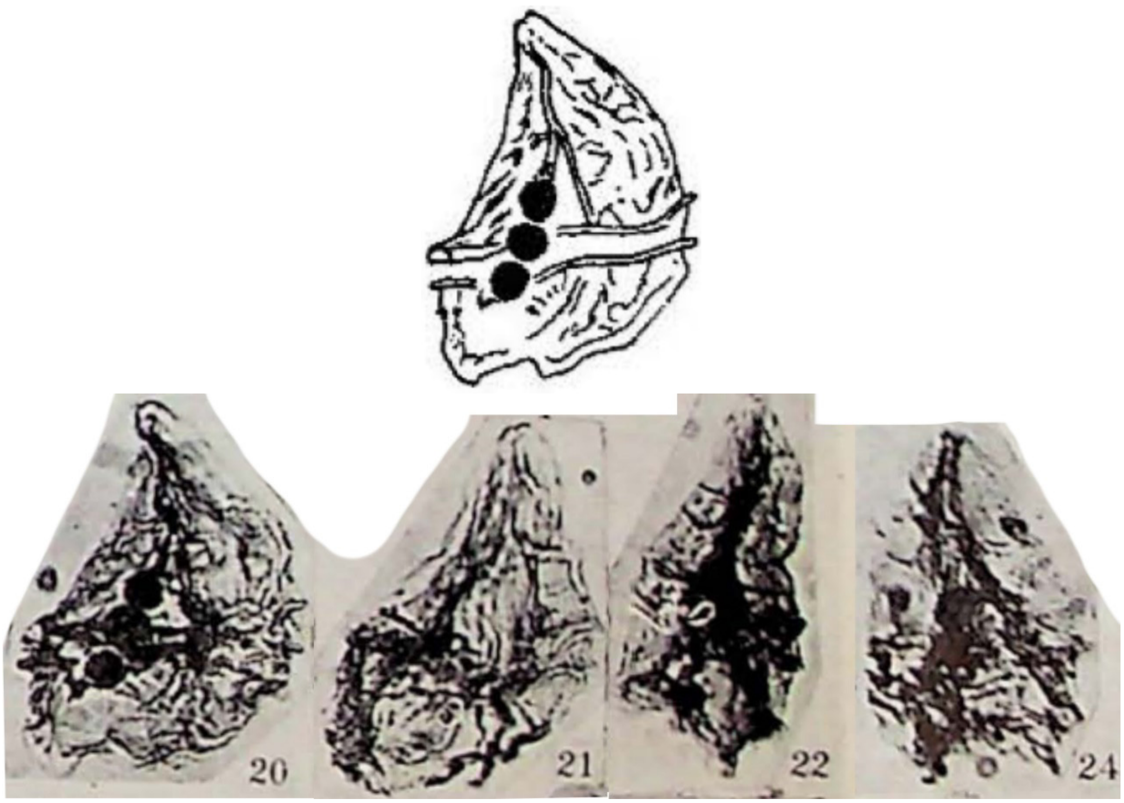
Description: "The outline of the cyst is crooked pear-shaped, elongated pentagon. Epitheca significantly larger than hypotheca, crooked triangular or elongated isosceles triangular, straight on one side or bow-shaped on the other side; the horn is not obvious, formed by the gradual contraction of the top of the epitheca, and the apex; the hypotheca is irregular quadrilateral or trapezoidal, and the two antapical horns are well developed, ranging in size. Thin layer, transparent, with a pendant along the edge of the cyst. Thin ridges straight to the side across a rough surface, reflect a transverse ring, 3–4 μm wide, with obvious thin ridges towards the side; reflecting longitudinally toward the apex of to the epitheca. The reflective plate type is indicated by the reflective horizontal opening. Archeopyle joint type, (tI3P) type a; the rear edge is connected with the reflective transverse groove. It often has 'nuclei'." — Translated from He Chengquan et al. (2009, p. 387)

Dimensions: "The cyst is 52.9–57.5 μm long and 23–29 μm wide; the holotype is 52.9 μm long and 29 μm wide." — Translated from He Chengquan et al. (2009, p. 387)

Discussion: "From its holotype picture, this species shows more credible (tI3P) type a combined archeopyle. Therefore, this book makes a new combination. In the identification, because the lower wall of the capsule is thin and the skirt has many wrinkles, the archeopyle is generally not easy to identify. It is elongate, pentagonal in outline, with two well-developed horns, reflecting the characteristics of wide and long longitudinal groove are different from those of *Laciniadinium ovatum*.” — Translated from He Chengquan et al. (2009, p. 387)

Age: Late Cretaceous; Yu Jingxian et al. (1981, p. 263); “second member of the Dalangshan Formation” as translated from He Chengquan et al. (2009, p. 387).

Note: The “nuclei” described by Yu Jingxian et al. (1981, p. 263; also see: He Chengquan et al. (2009, p. 387) are likely pyrites preserved within the cyst.



Text-figure 2, Plate 1, figures 20–22, 24, Yu Jingxian et al. (1981).

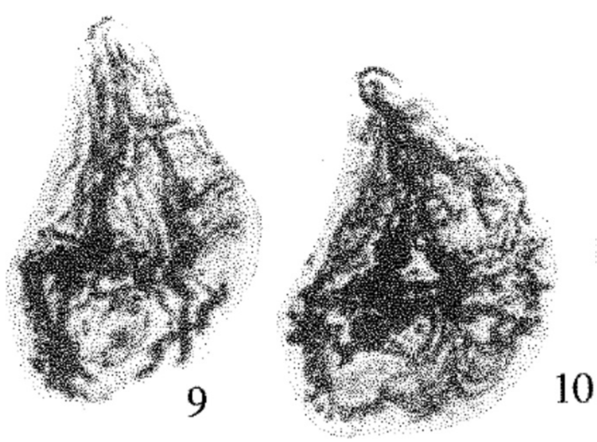


Plate 3, figures 9, 10, He Chengquan et al. (2009), *redux* Plate 1, figures 20, 21, Yu Jingxian et al. (1981).

Laciniadinium elongatum He Chengquan 1991

Description: "The cyst is elongated, asymmetrical, biconical, widest at the girdle. Epitheca larger, conical sided, nearly flat, straight, with a short, blunt apex, about 5 μm long, the base of which is not connected to the inside of the cyst. The dome of the hypotheca is conical or semicircular in height, lacking an antapical horn. Girdle partial to hypotheca, annular, 7.5–10 μm wide, margin marked by two low ridges. Longitudinal groove vague or lacking. The cyst wall is thin, the surface is granular or granular-short wrinkled, usually with several longitudinal grooves, sometimes there are spines along the caudal margin. Archeopyle present, but inconspicuous, located between girdle and parietal region, large, trapezoidal, united. Operculum detached or in situ. A yellow-green nucleus is attached to the abdominal wall." — Translated from He Chengquan (1991, p. 62, 63)

Dimensions: "The cyst is 82 μm long and 57.5 μm wide (measured in 2 grains); the holotype is 82 μm long and 57.5 μm wide." — Translated from He Chengquan (1991, p. 63)

Comments: "The archeopyle of this species is a bit like the front loin, but it is larger and the outline is not clear. According to the elongated cyst, it is speculated that this archeopyle may be combined, so the new species was not classified as *Apteodinium* with anterior waist archeopyle." — Translated from He Chengquan (1991, p. 63)

Age: late Paleocene (Thanetian); holotype of corresponding to "lower member of Qimgen Formation" as translated from He Chengquan (1991, p. 63, 215) based on the geological age of the unit provided by Xi Dangpeng et al. (2020, fig. 12).

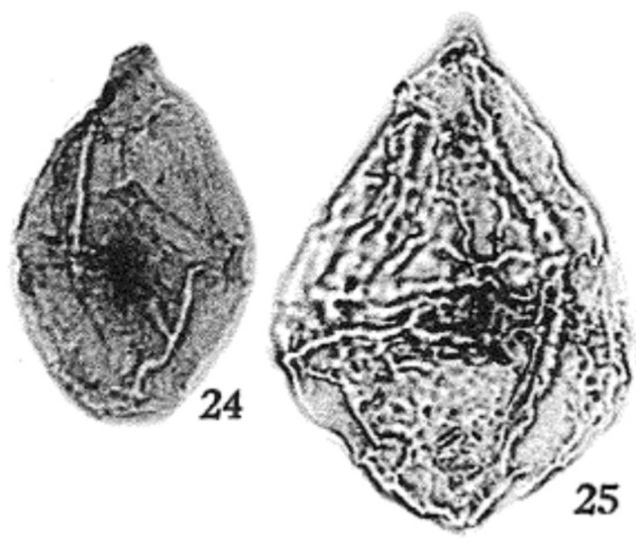


Plate 4, figures 24, 25, He Chengquan (1991).

Laciniadinium firmum (Harland, 1973) Morgan, 1977

Diagnosis: "Proximate cyst, commonly fusiform in shape, consisting of autophragm or two wall layers very closely adpressed. Test finely granulate. Epitract extends into an apical horn having a solid distal tip which may be oblate, acuminate, or bifurcate. The antapical horn always acuminate, and hollow throughout. The cingulum conspicuous and takes the form of a slight laevorotatory helicoid. Tabulation not usually seen. Archeopyle precingular of the P type (Evitt 1967), and rounded polygonal in shape. (Pl. 84. figs. 5, 6.).” — Harland, 1973 (p. 669)

Description: “The granules on the walls are of variable size, usually fairly fine, but always conspicuous. The solid apical tip appears to have a definite structure (Pl. 84, fig. 15). It was often seen to be banded but its exact nature must await further study. The cingulum is displaced by less than one-quarter of its width. Very little variation was seen in this cyst species except as documented in dimensions and in the nature of the apical tip.” — Harland, 1973 (p. 669, 670)

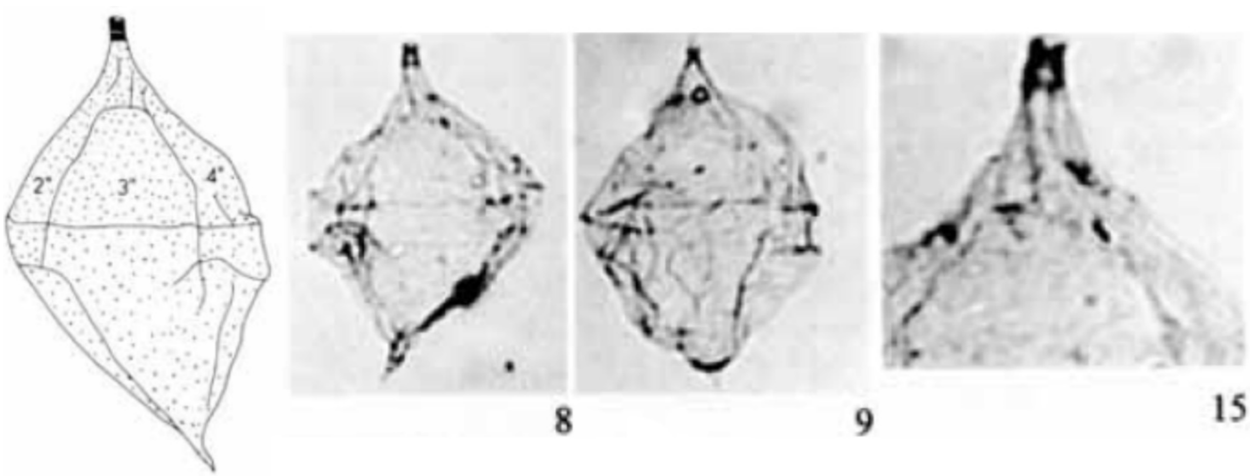
Dimensions: “Holotype: length 42.0 μ; breadth 29.0 μ. Range: length 36.0 (42.7) 50.0 μ; breadth 18.0 (29.3) 32.0 μ. Fifty specimens measured, out of a studied population of sixty-four.” — Harland, 1973 (p. 670)

Remarks: “This species is characterized by its shape and the solid structure at the distal extremity of the apical horn. It appears close to *Diconodinium rhombiformis* Vozzhennikova 1967 but is different in its lack of a distinct tabulation and the lack of small gonal processes in the cingular region. Although the archeopyle was rarely observed the conspicuous nature of 3'' also suggests that the archeopyle is formed by the loss of this plate. The species has gonyaulacacean affinities with apteodinioid lineage.” — Harland, 1973 (p. 670)

Comment: “Examination of specimens of *Laciniadinium firmum* have confirmed a 3I3Pa archeopyle as suggested by McIntyre (1975, p. 71), so this species is transferred from *Diconodinium*.” — Morgan (1977, p. 136)

Comparisons: “*L. firmum* is characterized by its rhomboidal ambitus and psilate periphragm. For comparisons to other species, see treatment of ?*L. inflatum*.” — Morgan (1977, p. 136)

Age: Late Cretaceous (late Campanian); holotype and range given by Harland (1973, p. 670, text-figure 13).



Text-figure 6; Plate 84, figures 8, 9, 15, Harland (1973).

Laciniadinium fusum (Yu Jingxian et al., 1981) He Chengquan et al., 2009

Description: "Outline fusiform-pentagonal. Outer wall one layer, thin, with irregular line ridges along the sides, or narrow ridges with flat bottom. Surface granular or disordered with thin ridges. Epitheca and hypotheca are triangular and large, with obvious apical and antapical horns, tubular or needle-shaped, 2.3–7 µm high, and the ends are closed. The lower ones are irregular, trapezoidal, with two equal or different-based horns. If unequal size, the long one is 4–6 µm, the short one is 2.3–4 µm. The polar groove is annular, 3–4.6, µm wide, the edge of the groove is limited by an i-shaped thin side, protruding outside the outline of the longitudinal groove. Often shared at the junction of the abdominal longitudinal groove and the transverse groove; 'nuclei' surrounded by radial ridges." — Translated from Yu Jingxian et al. (1981, p. 261).

Dimensions: "Length 39–43.7 µm, width 29.6–34.5 µm, holotype 48.3 × 29.6 µm." — Translated from Yu Jingxian et al. (1981, p. 213).

Discussion: "The cyst body is small, fusiform-pentagonal in outline. The epitheca is larger than the hyotheca, and the apex is obviously tubular or needle-shaped. It is a radial line, like a flower, so it is different." — Translated from Yu Jingxian et al. (1981, p. 261).

Description: "The outline of the cyst is fusiform-pentagonal. The epitheca is larger than the hypotheca, triangular, with obvious tubular or needle-shaped antapical horns, 2.3–7 µm in high; the ends are closed. The hypotheca is irregularly trapezoidal, and the two antapical horns are equal or unequal in size, the longer one is 4–6 µm the shorter one is 2.3–4 µm. One-walled, thin, surface grainy or with disorganized fine ridges, irregular fine-line ridges along the cyst margin, or low, flat ridges. Reflected transverse groove ring ~3–4.6 µm wide with wavy, thin ridges on the edge, protruding outside the contour line reflecting the triangular shape of the longitudinal groove from the top of the epitheca. It often has 'nuclei'." — Translated from He Chengquan et al. (2009, p. 388)

Discussion: "This species has the characteristics of a small body, fusiform-pentagonal outline, epitheca larger than hypotheca, and an apical horn that is obviously tubular or needle-shaped, etc. Signs different from *Laciniadinium ovatum*." — Translated from He Chengquan et al. (2009, p. 388)

Age: Late Cretaceous; holotype as translated from Yu Jingxian et al. (1981, p. 261).

Note: The "nuclei" described by Yu Jingxian et al. (1981, p. 261; also see: He Chengquan et al. (2009, p. 388) are likely pyrites preserved within the cyst.

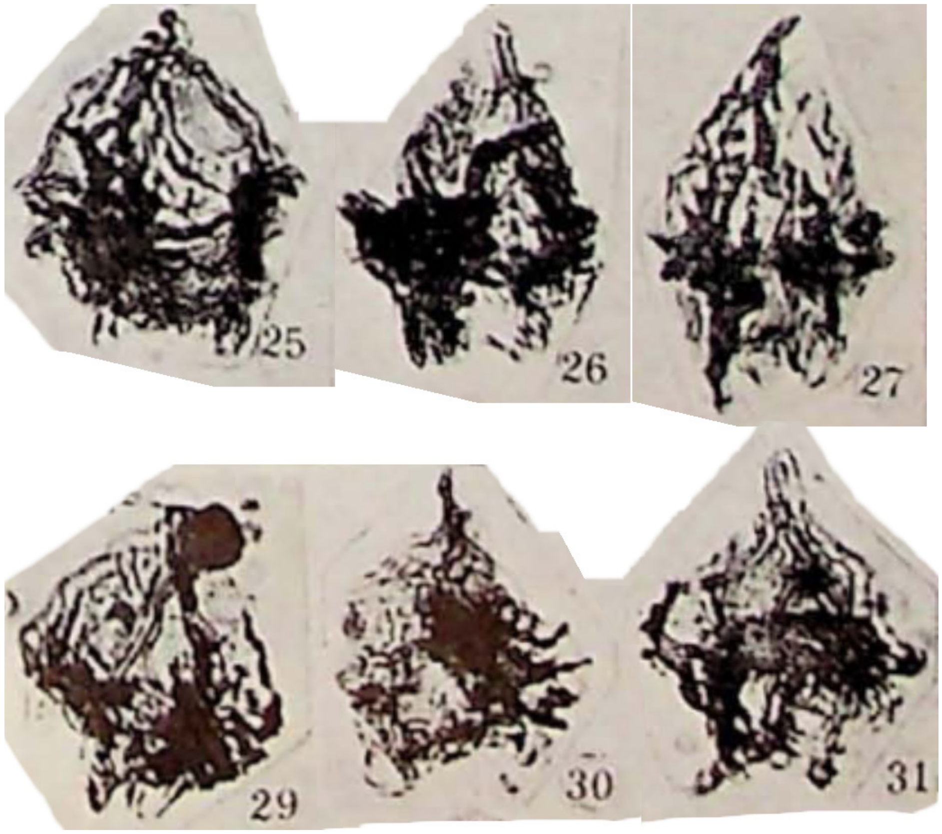


Plate 1, figures 25–27, 29–31, Yu Jingxian et al. (1981).

Laciniadinium granulare He Chengquan in Zheng Yahui & He Chengquan, 1984

<u>Description</u>: "The outline is oval, nearly pear shaped, longer than wide, rounded at both poles, without apical and antapical horns. The cyst is divided by the girdle. Two parts of unequal size, the epitheca is usually slightly larger, the dome is conical or highly semicircular, tapering slightly towards the top than the hypotheca, which is half round. The girdle is clear, located at the widest point of the bright body, bordered by low ridges, straight or curved, circular or slightly spiral, 6.2–10 μ wide, slightly concave on sides of cyst. Longitudinal grooves are generally unclear. No tabulation. Cyst wall is thin, sparse particles are evident on the surface. Partial grains may be connected or nearly smooth, often with sickle-shaped skirt wrinkles. No endosome. Archeopyle is generally not seen, except in scanning electron microscopic photographs, where it appears to have combined archeopyle fractures. Often with yellow-green nuclei." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 92)

<u>Dimensions</u>: "The cyst is 47–60 μ long and 35–45 μ wide (measured from 10 specimens). The holotype is 47.1 μ long and 36.4 μ wide, and the first paratype is 52.2 μ long and 45 μ wide." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 92)

<u>Discussion</u>: "Compared with the new species, the cyst is high arched instead of conical, and the apex is smooth without convex top, which is different from *Laciniadinium rhomboidale*, distinguished from *L. simplex* by an elongated ovate cyst." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 92)

<u>Age</u>: Late Cretaceous (Campanian); holotype as translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 108).

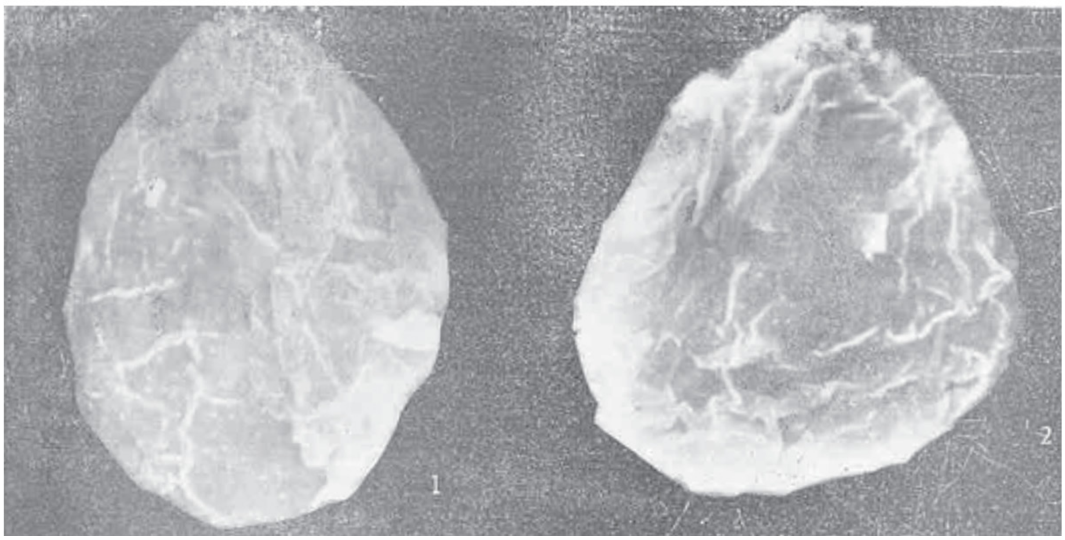


Plate 8, figures 1–3, Plate 11, figures 1, 2, He Chengquan in Zheng Yahui & He Chengquan (1984).

Laciniadinium granulatum (He Chengquan, 1991) Lentin & Williams, 1993

Description: "The cyst is medium-large, the abdomen and back are flat, the outline is nearly oval-pentagonal, and the length is longer than the width or the length and width are similar. The epitheca is conical, with straight or slightly convex sides. The apical horn is not obvious, and the apex has an apical pore, and sometimes a small papillary apex develops. The hypotheca is inverted trapezoidal, with round square or hypotenuse, lacking an antapical horn, 12–20 μm in length. Clear, transverse groove, shallow, flat, equatorial, ring-shaped, 6–8 μm wide, bordered by fine ridges, smooth or granular, only when longitudinal grooves exist in the hypotheca. The cyst wall is thin, the surface is granular, and the grains of most specimens are clear and obvious, and the grains become finer in some specimens. No reflective plates and endosomes. The archeopyle is not obvious, joint type, tI3P) type a. The operculum is kept in place." — Translated from He Chengquan (1991, p. 64)

Dimensions: "The cyst is 48.5–59 μm long and 40–50 μm wide (6 samples were measured); the holotype specimen is 52.5 μm long and 45 μm wide, groove width 6 μm." — Translated from He Chengquan (1991, p. 64)

Age: Late Cretaceous (early Turonian); holotype from lower Wuyitake Formation as translated from He Chengquan (1991, p. 64, 215). Based on the range chart from He Chengquan (1991, p. 16, 215, fig. 4) and the corresponding age of the lower Wuyitake Formation given as early Turonian by Mingzhen Zhang et al.

(2022, fig. 2), which interestingly did not reference He Chengquan (1991) or report the presence of any deflandreoid species in its survey of dinocyst taxa.

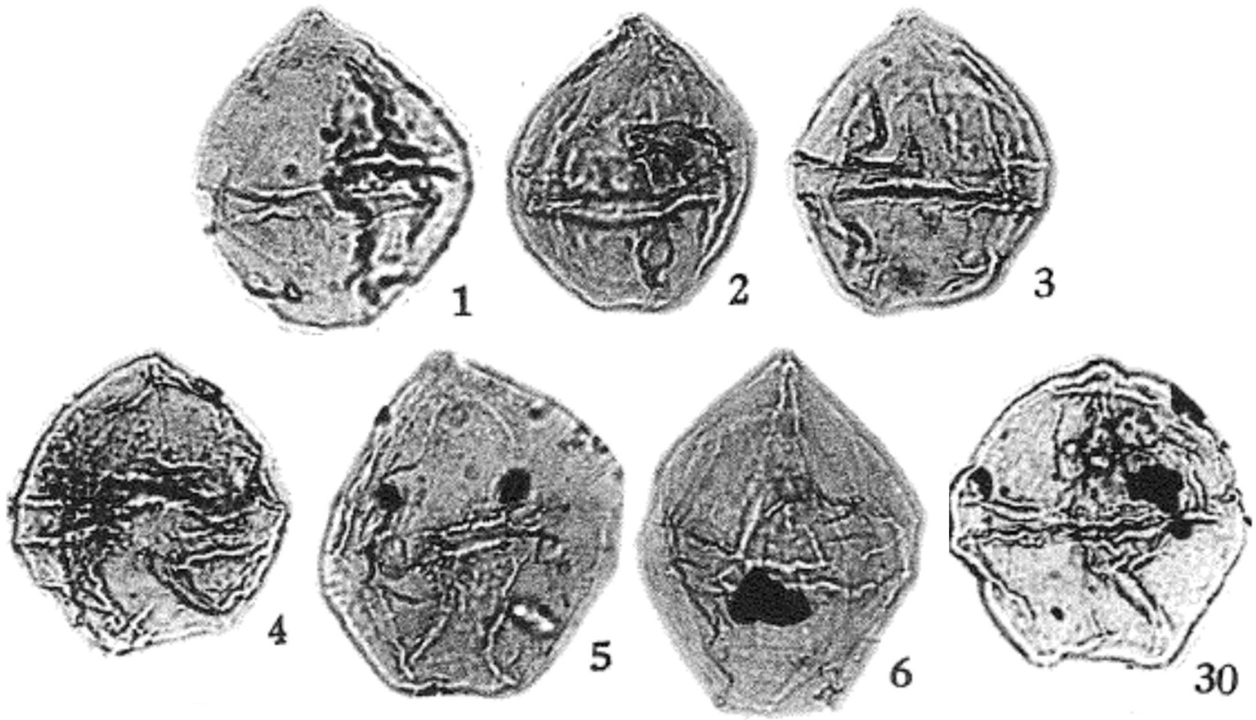


Plate 1, figures 1–6, 30, He Chengquan (1991).

Laciniadinium hokkaidoanum (Kurita & Matsuoka, 1995) Williams et al., 2017

Diagnosis: "Proximate cyst, peridinioid, rounded pentagonal or ovoidal, with a broad and short apical horn and with or without two small antapical horns, bosses or lobes. Autophragm thin, easily deformed and folded, transparent, generally smooth or laevigate without surface ornamentation rarely finely granulate. Paracingulum indicated by two equatorial, parallel ridges deriving from low folds of the phragma. Parasulcus indicated by shallow indentation, widens toward antapex. Archeopyle not discernible. Paratabulation not indicated other than as paracingulum and parasulcus." — Kurita & Matsuoka (1995, p. 146)

Description: "The species varies extremely in cyst outline from ellipsoidal, ovoidal to roundly pentagonal. The height of the epicyst is more or less equal to that of the hypocyst. The apical horn is usually present and very wide and short, but sometimes lacking. The antapical horns are also variable; some specimens bear two small bosses with a very short projection which are sometimes unequally developed, and these features are lacking in other specimens. The autophragm is smooth, slightly laevigate or rarely finely granulate, and easily folded. Occasionally small grana are sparsely present around apical and antapical horns. There are sometimes faint traces of parasutures, but not sufficient for determining the paratabulation. The paracingulum is almost equatorial, wide and clear, and indicated by indentation of the autophragm or by two parallel folds which margins are smooth and never dentate. The displacement of the paracingulum is not clear. The parasulcus widens toward the antapex and is indicated by a shallow indentation. The archeopyle is not discernible; however, a questionable archeopyle was observed in a single specimen (Plate I, 6, 7). It appears to be isodeltaform type I with the posteriorly adnate operculum and with accessory sutures along paraplate boundaries 3''/4'' and 4''/5''." — Kurita & Matsuoka (1995, p. 146)

Dimensions: "(in µm): Holotype; cyst length 40, width 36: range; length 35–44 (average 39), width 31–41 (average 37), nine specimens measured." — Kurita & Matsuoka (1995, p. 146)

Remarks: "*Bellatudinium hokkaidoanum* Kurita and Matsuoka, sp. nov. differs from *B. conspicuum* Yu et al., 1981 in having an epicyst which is equal in size as the hypocyst, not definitely tapered toward the apex, and in being smaller. The new species differs from *B. fusum* Yu et al. 1981 in lacking a prominent apical horn." — Kurita & Matsuoka (1995, p. 146, 147)

Age: late Eocene (Priabonian); holotype of Kurita & Matsuoka (1995, p. 146). Range: middle to late Eocene (Kurita & Matsuoka, 1995, p. 147).

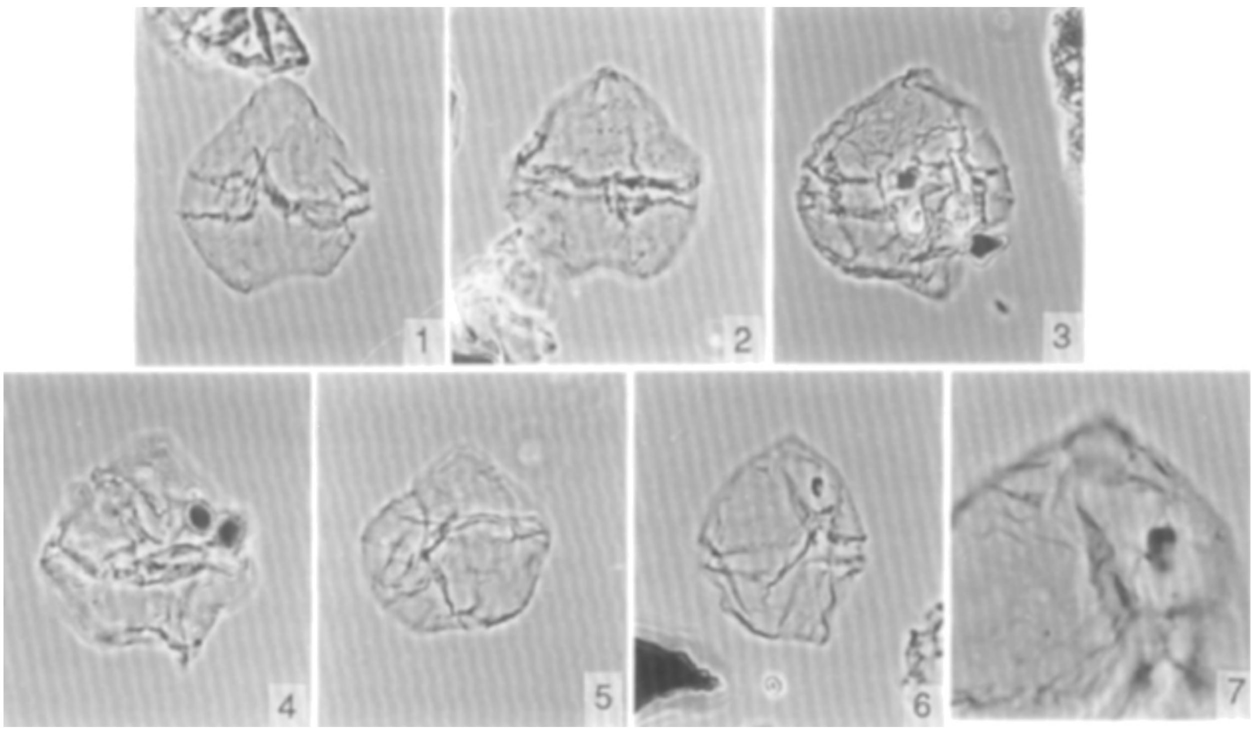


Plate 1, figures 1–7, Kurita & Matsuoka (1995).

?*Laciniadinium inflatum* (Eisenack & Cookson, 1960) Morgan, 1977

<u>Description</u>: "Shape broadly oval in outline, epitheca longer than hypotheca and terminated by a rather short, hollow, bifid process, hypotheca with a short spine. Shell-membrane two-layered, outer layer ornamented with rather widely-spaced spinules which tend to be arranged in longitudinal rows and to project slightly beyond the surface in optical section; region of 'longitudinal furrow' smooth, lines bounding it clearly defined." — Eisenack & Cookson (1960, p. 4)

<u>Dimensions</u>: "Type: 88 μ long, 67 μ broad. Range: 80–95 μ long, 52–67 μ broad." — Eisenack & Cookson (1960, p. 4)

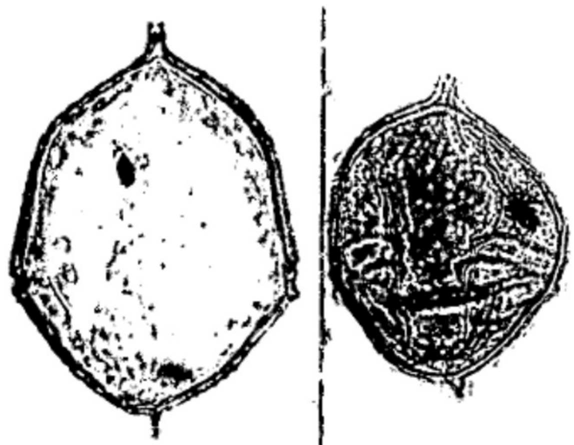
<u>Discussion</u>: "*D. inflatum* agrees in general morphological features with the other described species of *Diconodinium* but differs from them in having a two-layered wall." — Eisenack & Cookson (1960, p. 4)

<u>Emended description</u>: "Pericyst ambitus subcircular, with short truncate apical horn, and short sharp single antapical horn located close to midline. Endocyst ambitus subcircular. Small pericoels developed in the vicinity of the horns, slight ambital pericoel (2–3 μm wide) developed. Epicyst slightly larger than hypocyst. Periphragm thin, bearing sparse, 1 μm, nontabular granules. Pericingulum delineated by two slightly raised parasutural ridges, planar. Perisulcus outlined by slightly raised parasutural ridge, extends almost to antapex, individual paraplates not distinguishable. Endophragm psilate. Periarcheopyle apparently 3I3Pa (pl. 2, fig. 5b, c). Endoarcheopyle not observed." — Morgan (1977, p. 136)

<u>Comments</u>: "Only the holotype of ?*L. inflatum* shows incipient development of a 3I3Pa archeopyle (Pl. 2, fig. 5b, c). ?*L. inflatum* differs from the diagnosis of *Laciniadinium* by having an ambital pericoel, so it cannot be confidently assigned to the genus." — Morgan (1977, p. 136)

<u>Comparisons</u>: "If the wall separation in ?*L. inflatum* has been chemically induced, ?*L. inflatum* may be a senior synonym of *L. orbiculatum*; both have a subcircular ambitus and sparse, nontabular, 1.0 μm granulation; the former differs by being double walled, and by having longer horns. ?*Laciniadinium tenuistriatum* (Eisenack and Cookson 1960) comb. nov. has a subcircular ambitus and dense aligned granules. *Laciniadinium biconiculum* McIntyre 1975 differs by having a rhomboidal ambitus and bearing fine periphragm granules and ridges." — Morgan (1977, p. 136)

<u>Age</u>: Early Cretaceous (late Albian? –Cenomanian); holotype of Eisenack & Cookson (1960, p. 4).



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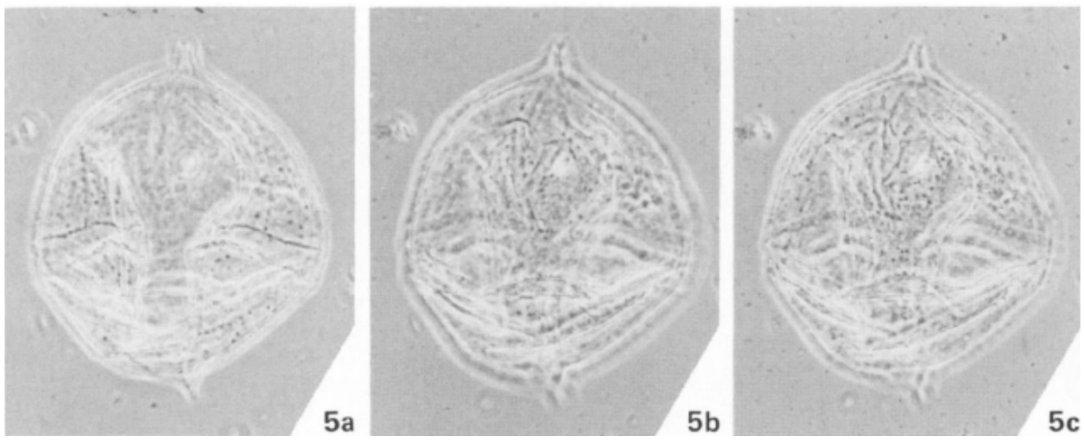


Plate 1, figures 12, 13, Eisenack & Cookson (1960); Plate 2, figure 5a–c (holotype), Morgan (1977).

Laciniadinium macrocephalum (Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al., 1989) Lentin & Williams, 1993

Description: “The outline of the cyst is pentagonal, the epitheca and hypotheca are nearly equal in size or slightly larger than the epitheca. The epitheca is slightly elongated, isochoric, triangular; the top is broad. The hypotheca is inverted trapezoidal, the caudal edge is flat or concave, and the two caudal horns are different. One antapical horn degenerates, and the length of the horn is 2–4.2 μm. Reflecting the polar groove ring, relatively shallow, its edge is bounded by thin ridges, 7–7.5 μm wide. Reflected longitudinal groove is blurred. Single-layered, relatively beige, with fine-grained or smooth surface. Reflected plates are only those of the cingulum and archeopyle. Archeopyle joint type, tI3Pa. Operculum in place.” — Translated from Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al. (1989, p. 69)

Dimensions: “Cyst 48.3–51.8 μm long and 44.9 μm wide; the holotype is 51.8 μm long and 44.9 μm wide.” — Translated from Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al. (1989, p. 69)

Discussion: “The main features of this species are the elongation of the cyst and the hypertrophy of the top of the epitheca, so as to distinguish it from other species in this session.” — Translated from Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al. (1989, p. 69)

Age: late Eocene (Ypresian); holotype corresponding to the “upper part of the third member of Shahejie Formation” as translated from Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al. (1989, p. 69) in light of the age of this interval given by Kashif et al. (2020, fig. 2).

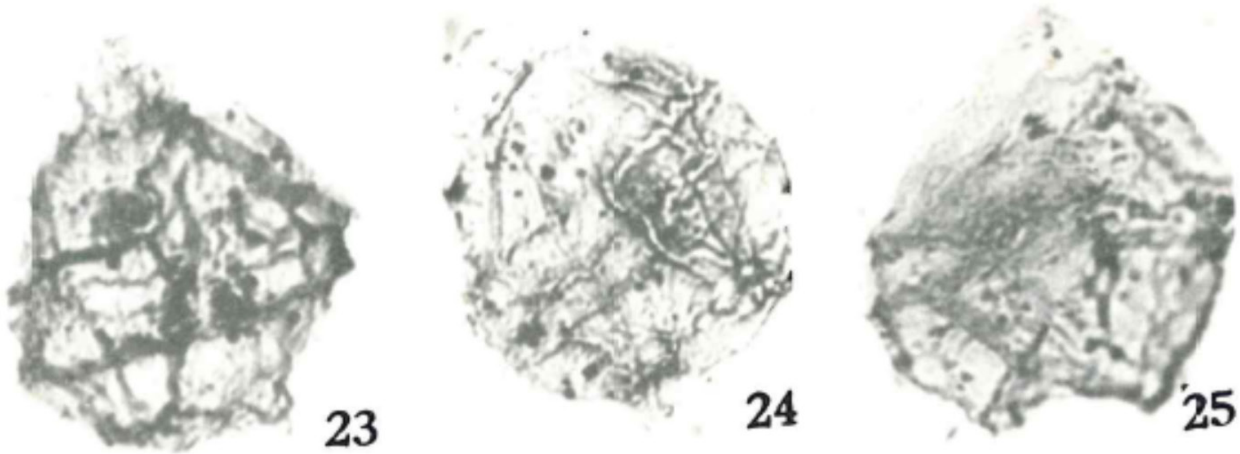


Plate 6, figures 23–25, Jin Guangxing, He Chengquan & Zhu Shenzhao in He Chengquan et al. (1989).

Laciniadinium minutum (He Chengquan, 1984) Chen et al., 1988

Description: "The cyst is small, the abdomen and back are flat, the outline is round and pentagonal, the length and width are nearly equal, and the waist is obviously bulging. The epitheca is triangular, slightly larger than the hypotheca, the top is slightly convex, with an apical pore; the hypotheca is inverted trapezoidal, lacking two antapical horns. The girdle is shallow, located at the widest part of the shell, slightly offset from the lower shell, ring-shaped, about 5 μ wide, and its edge is decorated with fine ridges. The longitudinal groove is much wider than the girdle and is located on the ventral surface of the hypotheca. Cyst wall thin, single layered, surface with short longitudinal stripes. The archeopyle is located on the back under the top, combined type, tI3Pa type, and does not include the top plate in its composition." — Translated from He Chengquan (1984, p. 769)

Dimensions: "Cyst length 37.5–45 μ, width 38.5–40 μ (measured on 3 specimens); the holotype is 42.5 μ long and 40 μ wide, cingulum 5 μm wide, the width of the longitudinal groove is about 12 μ." — Translated from He Chengquan (1984, p. 769)

Note: "This species is characterized by small cyst kernels and a lack of antapical horns." — Translated from He Chengquan (1984, p. 769)

Age: late Paleocene (Thanetian); holotype corresponding to "lower member of Qimgen Formation" as translated from He Chengquan (1984, p. 770) based on the geological age of the unit provided by Xi Dangpeng et al. (2020, fig. 12).

插图 1 *Sinocysta minuta*

Text-figure 1, He Chengquan (1984).

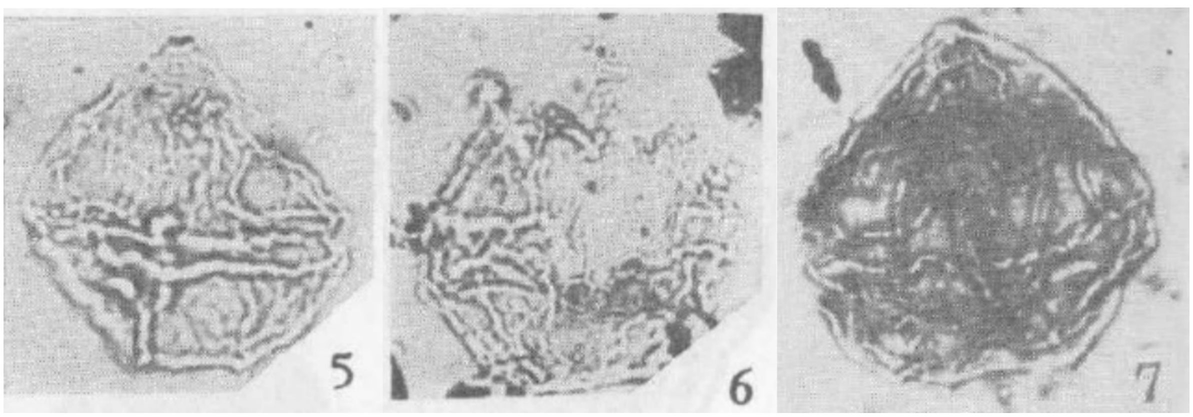


Plate 1, figures 5–7, He Chengquan (1984).

Laciniadinium orbiculatum McIntyre, 1975

Description: "Cyst proximate, oval to spherical in dorsoventral view and dorsoventrally flattened. Apical projection 2–4 µm long, having a depressed apex with 2 papillae. No antapical horns visible. Cyst often folded or broken. Epitract often slightly larger than hypotract. Cingulum 3–5 µm wide, appearing as low granular to spiny ridges or rows of granules or spines. Sulcus wide but rarely seen. The archeopyle is large and formed of the 3 intercalary and the precingular reflected plates 3'', 4'' and 5'' and is of the type 313P. Operculum simple, remains attached at cingulum margin (Pl. 4, fig. 10, 11), and often seen as a folded flap (Pl. 4, fig. 11). The operculum is often in place and the archeopyle position is indicated by the outline of the 6 reflected plates and there is no separation along the sutures (Pl. 4, fig. 12, 13). No other visible indications of tabulation. Cyst ornamented by granules and small spines up to 1 µm long. No ornament pattern evident. Only one wall layer, less than 1 µm thick, is visible except at the apex where a separation into 2 very thin layers can be seen. A few small folds can sometimes be seen near the apex." — McIntyre (1975, p. 71)

Dimensions: "Holotype, 87 µm long, 78 µm wide; range, 70–110 µm long, 70–97 µm wide." — McIntyre (1975, p. 71)

Discussion: "*L. orbiculatum* is recorded in McIntyre (1974) as Deflandreoid Form 2, and it occurs in Division H1 in section CR16A, often in abundance. Specimens in the lower part of Division H1 usually are smaller and less granular than later forms. *L. orbiculatum* differs from *L. biconiculum* in being larger and having a rounded outline in dorsoventral view." — McIntyre (1975, p. 71)

Age: Late Cretaceous (Campanian); holotype of McIntyre (1975, p. 70).

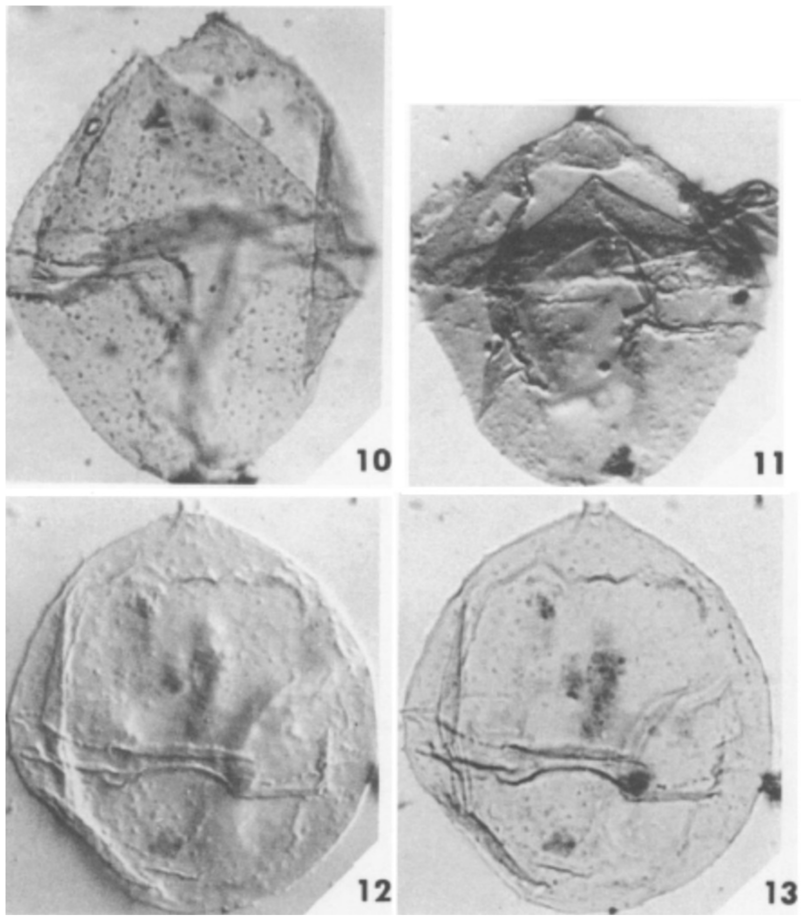


Plate 4, figures 10–13, McIntyre (1975).

Laciniadinium orientale He Chengquan, 1991

Description: "The cyst is medium in size, rhomboid-oval in outline. The epitheca is larger, bell-shaped, with a vertex, variable in size, usually papillary or truncated-conical. The hypotheca is semicircular, lacking a caudal horn. The transverse groove is shallow concave, near the equator or slightly lower, ring-shaped, 5–7 µm wide, its margin decorated with thin ridges that are straight or slightly curved, usually clearer on the venter. There is a presence or absence of a longitudinal groove. Cyst wall is thin, single layered, surface granular and with some short wrinkles. The archeopyle is relatively large, and the joint fitted, contoured horseshoe or bow. Operculum attached and in situ." — Translated from He Chengquan (1991, p. 63)

Dimensions: "Cyst is 45–62 µm long and 42–59 µm wide, and the holotype specimen is 62 µm long and 59 µm wide, with a transverse groove about 6 µ wide." — Translated from He Chengquan (1991, p. 63)

Comparison: "This one is morphologically similar to *Laciniadinium orbiculatum*, but the latter is larger and has a granular surface with grains and thorns." — Translated from He Chengquan (1991, p. 63)

Age: middle Eocene (Lutetian); holotype from the "Wulagen Formation" as translated from He Chengquan (1991, p. 63) corresponding to the age of the section given by Xuejiao Wang et al. (2022).

Plate 4, figures 14–16, He Chengquan (1991).

Laciniadinium petaloidum Vasilyeva in Andreeva-Grigorovich et al., 2011

Diagnosis: Peridinioid proximate cysts are of intermediate size without apical horn. Antapical horns present, slightly prominent, rounded, equal or left horn more developed than right one. Lateral horns absent. Cingulum is not expressed or visible as low ridges. Periphragm thin, smooth or slightly granulated. Periarcheopyle of combined type, intercalary-precingular, type tI3Pa (fig. 17). Operculum usually attached at cingulum side." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 35)

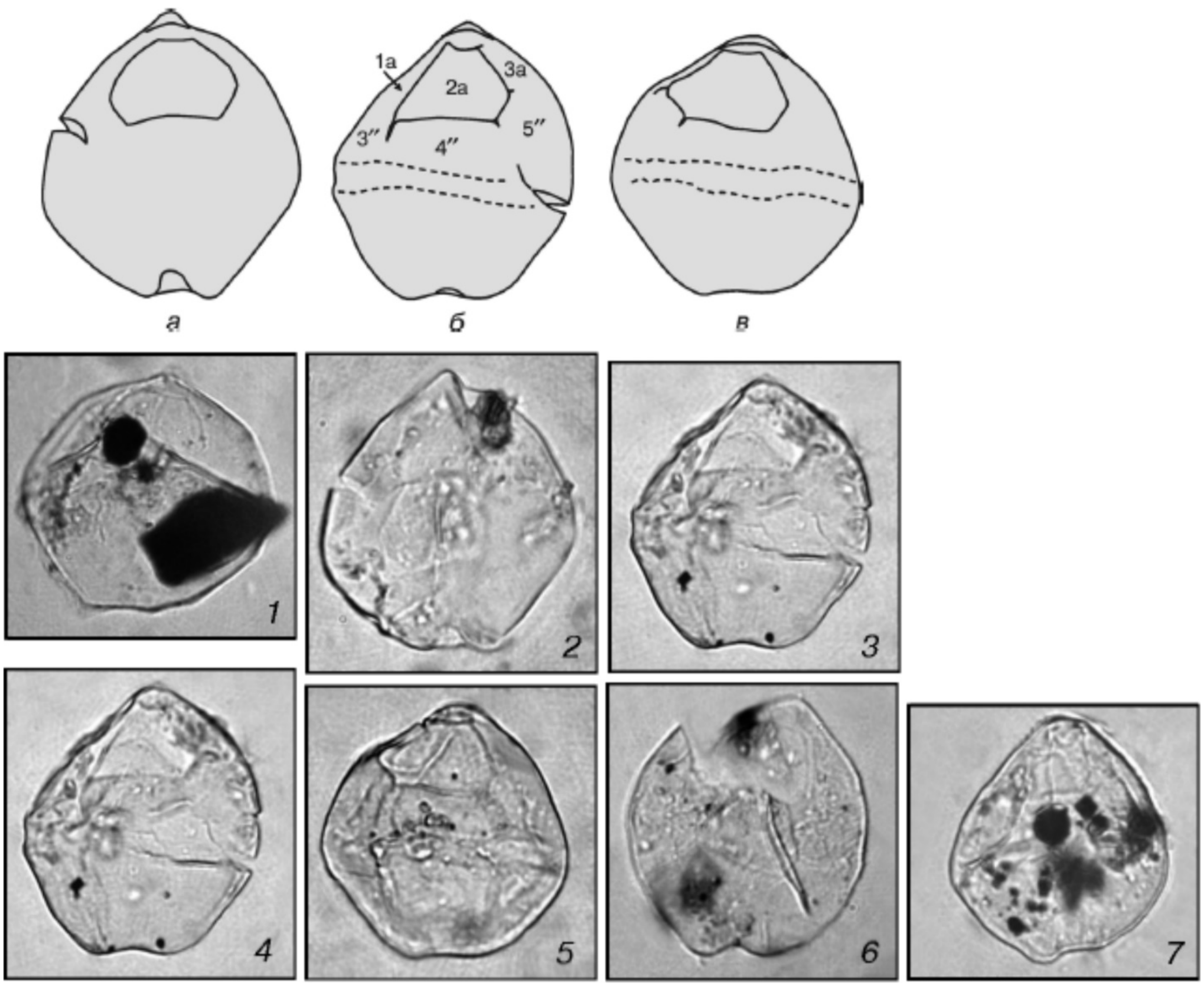
Description: "The pericyst is round-oval or oval-pentagonal. Apical horn absent; the apical part of the cyst is rounded. Antapical horns are slightly indicated by smooth symmetrical arcs or the left horn sticking out a little more. The periphragm is thin, smooth or fine-grained, sometimes slightly wrinkled. The endocyst repeats the shape of the pericyst. The endophragm is thin, tightly attached to the periphragm so that it is viewed as a separate layer only in the apical part of the cyst where there is a small epicenter. Signs of paratabulation are presented only by the periarcheopyle and paracingulum. The paracingulum expression is an uneven, slightly sagging furrow, sometimes not distinguishable at all. Periarchheopyle large, hexagonal, type t3IPa [sic tI3Pa] (Fig. 17). The operculum is attached on the singular side or on the free side. Parasulcus is indistinguishable or viewed by a wide arcuate fold on the ventral side of the cyst. Usually noted droplet inclusions of the limited material ('peep hole') in the triangular-sulcate zone." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 35)

Dimensions: "(μm) Holotype: Length and width of the pericyst, 39.6; height archeopyle 9.9; the width of the archeopyle is 16.5. Another specimen (Fig. 17, 1): length and width of the pericyst 41.3; the height of the archeopyle is 9.4; archeopyle width 14.2." — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 36)

Comparison: "Differs from *Laciniadinium williamsii* Ioannides, 1986 by its wider proportions, and absence of apical and antapical horns. Close in shape to *L. granulatum* He Chengquan, 1991, however the latter has a distinctly expressed granular periphragm and cingulum, denoted by a double fold. In addition, the stratigraphic distribution of *L. granulatum* is different: Turonian–upper Senonian. Morphologically similar to *L. minutum* He Chengquan, 1984, but the latter has distinct cingulum, wrinkled periphragm, and widespread in Upper Cretaceous deposits. It differs from the species *L. subtile* He Chengquan, 1991 by the smoother and rounder shape of the pericyst.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 36)

Remarks: “Cyst has the characteristics broad oval, petal-shaped form. Variable shape of hypocyst: antapical projections may be slightly asymmetric or the same, but does not have sharp forms. Between the antapical protrusions, there is often an arcuate fold. Morphological signs that indicate a paracingulum are varying, sometimes not showing up at all.” — Translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 36)

Age: early Paleocence (late Danian); holotype as translated from Vasilyeva in Andreeva-Grigorovich et al. (2011, p. 36).



Text-figures 17a–c; Plate 9, figures 1–7, Vasilyeva in Andreeva-Grigorovich et al. (2011).

Laciniadinium rhombiforme (Vozzhennikova, 1967) Lentin & Vozzhennikova, 1990

Description: “Theca rhomboid, somewhat asymmetrical about the longitudinal axis, the asymmetry being particularly noticeable in the hypotheca. Lateral walls straight or concave, rarely convex. Transverse furrow equatorial, broad but not deep and slightly twisted to the right. Its ends lie somewhat distant from each other and enclose a broad, slightly depressed ventral field. The epitheca is as large or slightly larger than the hypotheca. The thecal surface is smooth or finely granular and separated into large triangular areas by the ribbing. The number of these areas on the epitheca does not exceed 5–6, whereas on the hypotheca they are larger, unequal in size and form such that on one side there are 3 large triangular areas and on the other 2 small antapical and two or three irregular post equatorial areas. This causes the hypotheca to have an asymmetrical appearance (of plate VII, fig. 1, 3, 4). The ribs, which delimit the areas, are smooth or finely toothed and they terminate in small spines at the edge of the transverse furrow. The epitheca ends in a small sculptured process at the distal extremity [of] the hypotheca in a pointed and curved spine." — Vozzhennikova (1967, p. 50, translation: Lees & Sarjeant, 1971)

Dimensions: "(in μm) Type: length 40.5, breadth 27.4, width of transverse furrow about 4. In other specimens the width of the transverse furrow is 4–4.8, the breadth 24–30 and the length 40.5–56.7." — Vozzhennikova (1967, p. 50, translation: Lees & Sarjeant, 1971)

Comparison: "This differs from all other species in having clearly defined areas on the theca and a broader transverse furrow." — Vozzhennikova (1967, p. 50, translation: Lees & Sarjeant, 1971)

Note: "The presence of the thecal areas which is now regarded as diagnostic of this species may ultimately be found in other species." — Vozzhennikova (1967, p. 50, translation: Lees & Sarjeant, 1971)

Emendation: "Cyst shape biconical with epicyst somewhat longer than hypocyst which is slightly asymmetrical, the apical horn terminates with a solid plug which bifurcates into two sharp points, the single antapical horn (?left) terminates with a small solid spine; autophragm thin, minutely granulose. Paratabulation may be expressed by discontinuous fine ridges, the archeopyle suture and paracingulum; peridinioid. Archeopyle combination type, intercalary-precingular (3I3P), operculum attached at the paracingulum. Paracingulum is shallow, distinct, bordered by granules and occasional very small spines. The parasulcus is indicated poorly by a shallow depression at the ends of the paracingulum on the ventral surface." — Lentin & Vozzhennikova (1990, p. 58)

Age: Late Cretaceous (Turonian); holotype of Vozzhennikova (1967, p. 50, translation: Lees & Sarjeant, 1971).

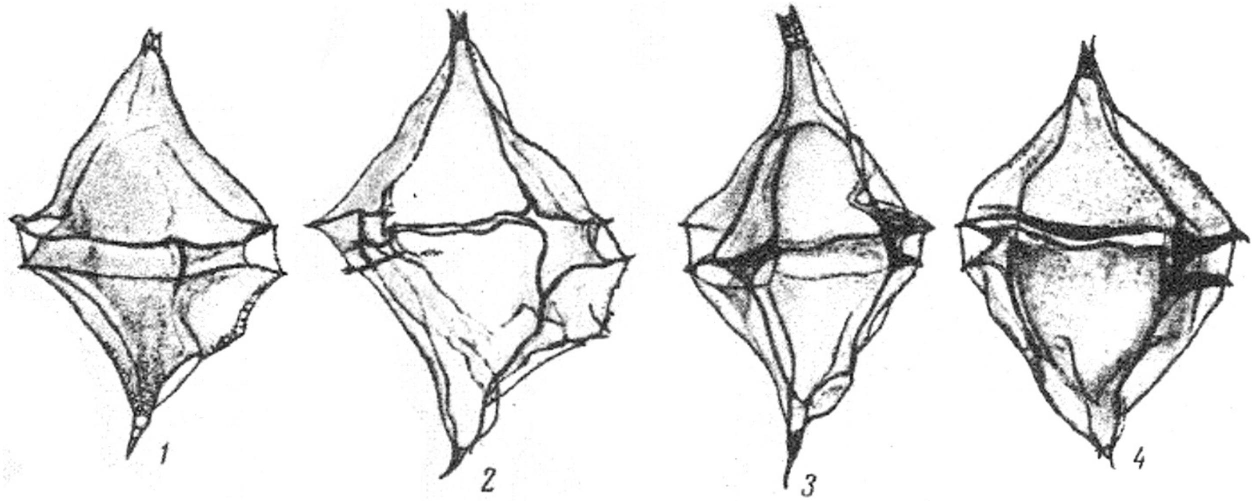


Plate 7, figures 1–4, Vozzhennikova (1967).

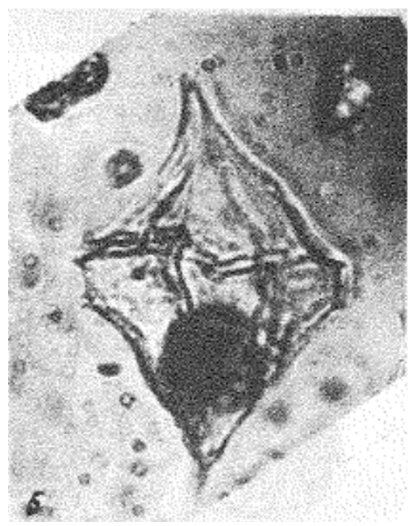


Plate 15, figure 5, Vozzhennikova (1967).

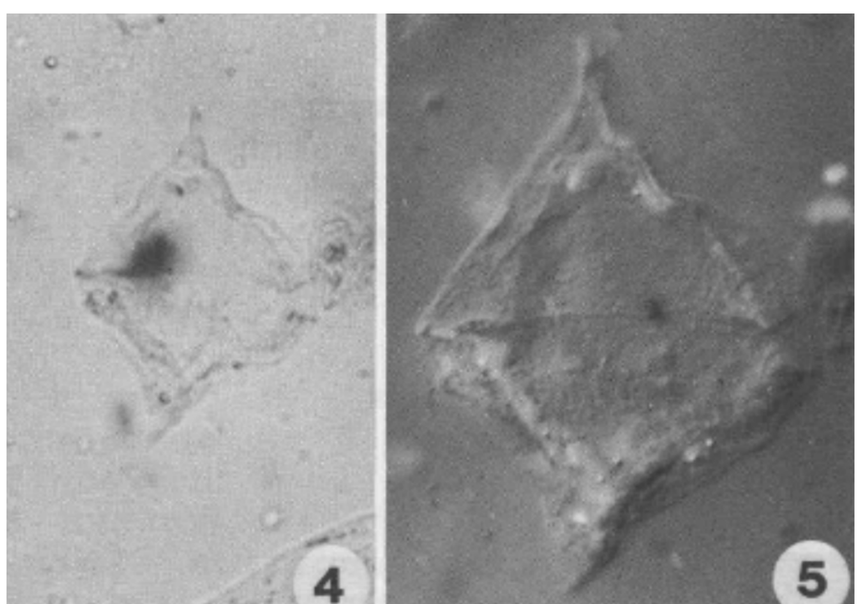


Plate 10, figures 4, 5, Lentin & Vozzhennikova (1990).

Laciniadinium rhomboidale He Chengquan in Zheng Yahui & He Chengquan, 1984

Description: "Subovate, near rhombic outline, compressed ventrally and dorsally, longer than wide. Epitheca slightly larger than hypotheca, somewhat conical, long, constricted into short vertices at the top. Epitheca apex truncated or with apical pore, with apertural diameter of 2.5–3.5 μ, bright semicircular hypotheca, no antapical horns. The girdle is obvious, slightly concave on the side, near the equator, circular or slightly spiral, 7.5–10 μ wide, with fine ridges on the edge, straight or slightly curved. Longitudinal channels usually well defined, limited to hypotheca, bounded by fine ridges. Without tabulation and inner body. The wall is delaminated and unclean, the surface has sparse fine granules and is nearly smooth, wrinkled. The archeopyle is generally not obvious, and some specimens seem to have joint archeopyles. Nucleate." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 92, 93)

Dimensions: "Cyst 43–66 μ long and 43–60 μ wide (15 specimens measured); the holotype is 59 μ long and 53 μ wide, and the side piece is long and 50 μ wide." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 93)

Discussion: "Cysts of the newer species are more or less conical, the sides are straight, the antapex is not wide and round, the surface is often nearly smooth and the longitudinal grooves are clear. It is distinguished by these characteristics from *Laciniadinium* cf. *orbiculatum*." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 93)

Age: Late Cretaceous (Campanian); holotype as translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 108).

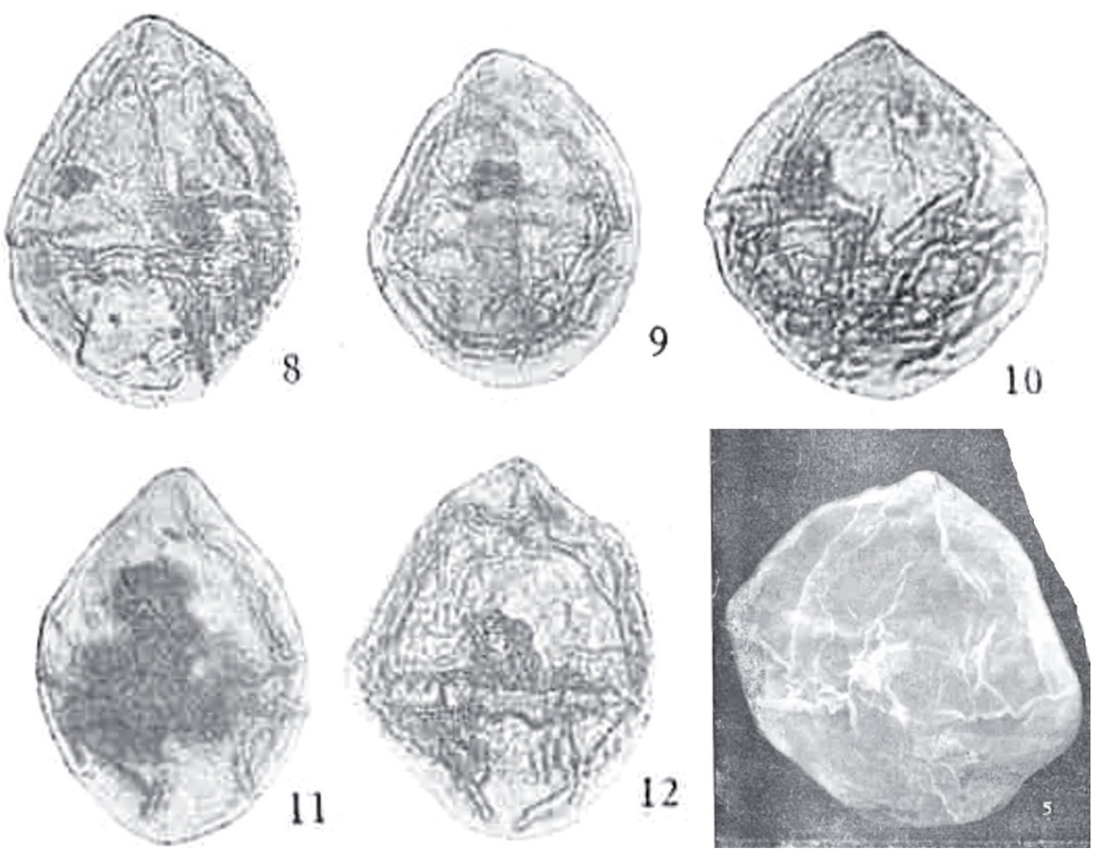


Plate 8, figures 8–12, Plate 11, figure 5, He Chengquan in Zheng Yahui & He Chengquan (1984).

Laciniadinium simplex He Chengquan in Zheng Yahui & He Chengquan, 1984

Description: "Oval to elliptical outline, more or less flattened dorsum and venter, longer than wide or equal in length and width, apex and antapex rounded, and no apical horn (convex). The epitheca and hypotheca are semicircular, but the epitheca is often a little thinner than the hypotheca, equal in size or slightly larger. The girdle is still clear. Margin decorated with thin ridges, near equator (mostly toward the hypotheca), ring-shaped, 6.5–7.5 µ wide, almost no reflection on outline. Vertical groove obscure and fuzzy. Without tabulation and inner body. The archeopyle is unknown." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 93)

Dimensions: "The cyst is 45–60 µ long and 37.5–56 µ wide (measured from 13 specimens); the holotype is 57 µ long and 56 µ wide." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 93)

Discussion: "The newer species is different from *Laciniadinium*? *ovatum* He et Li (He Chengquan et al., 1981, p. 66, pl. 31, fig. 13)." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 93)

Age: Late Cretaceous (Campanian); holotype as translated form He Chengquan in Zheng Yahui & He Chengquan (1984, p. 108).

Plate 8, figures 13–15, He Chengquan in Zheng Yahui and He Chengquan (1984).

Laciniadinium subtile (He Chengquan, 1991) Lentin & Williams, 1993

Description: "Outline is pentagonal, two antapical horns are strongly degenerated, but one of them is still shown with short spines, blunt tapered end, 1–3 µm long, and the other is broadly rounded. The surface of the cyst wall is finely granular, or with short longitudinal stripes. Cingulum width 5.5–7 µm. The archeopyle is not obvious, it may be a joint type, belonging to (tI3P) type a. Other characteristics are as described for *Sinocysta minuta* are stated." — Translated from He Chengquan (1991, p. 65)

Dimensions: "Cyst length 45–47 µm, width 38–47 µm (measured 7 specimens); holotype specimen length 47 µm, width 47.5 µm, cingulum width is about 5.5 µm, and the antapical horn is about 1.5 µm." — Translated from He Chengquan (1991, p. 65)

Discussion: "This species is compared to *Sinocysta minuta* in having an asymmetrical, slight antapical horn." — Translated from He Chengquan (1991, p. 65)

Age: Late Cretaceous (early Turonian); holotype corresponding to the "bottom of Wuyitak Formation" as translated from He Chengquan (1991, p. 215). Range: Late Cretaceous (early Turonian)–late Eocene (Priabonian), corresponding to the "upper part of the Kukebai Formation … to the Bashibulak Formation" as translated from He Chengquan (1991, p. 65), given the ages of the sections presented by Mingzhen Zhang et al. (2022, fig. 2) and Xi Dangpeng et al. (2020, p. 166) respectively.

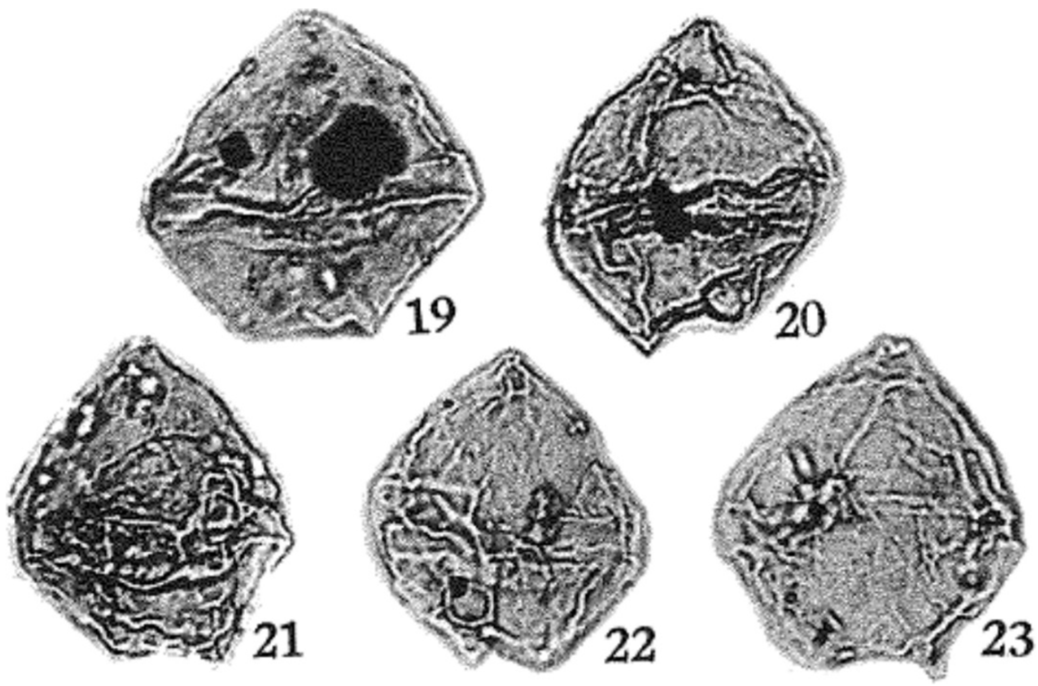


Plate 1, figures 19–23, He Chengquan (1991).

Laciniadinium tenuistriatum (Eisenack & Cookson, 1960) Morgan, 1977

Description: "Shell ovoidal to nearly spherical, girdle usually faintly marked, epitheca longer than hypotheca, apical process very short, concave, antapical spine only slightly represented. Shell-membrane thin, ornamented with close rows of regularly and closely arranged small granules which converge towards both apex and antapex. Striation on the ventral surface outwardly directed towards the ends of the girdle leaving a wide unpatterned area which corresponds in position to a longitudinal furrow." — Eisenack & Cookson (1960, p. 4).

Dimensions: "Type: 62 μ long, 58 μ broad. Range: 48–67 μ long, 46–60 μ broad." — Eisenack & Cookson (1960, p. 4).

Description: "Apparent autocyst, ambitus subcircular drawn into a 2–3 μm high and 6–8 μm broad apical bulge and a single, slightly eccentrically located, 2–3 μm high antapical bulge. Epicyst and hypocyst of approximately equal size. Autophragm mostly thin, except in apical bulge, where slight thickening to 1.0 μm may occur. Surface bears dense, 1.0 μm granules strongly aligned into semicontinuous nontabular rows starting at the apical horn, crossing the paracingulum and terminating at the single antapical horn. Planar paracingulum delineated by two slightly raised parasutural ridges; parasulcus not defined, individual paraplates not discernible. Archeopyle unknown." — Morgan (1977, p. 136, 137)

Comments: "As no archeopyle has been observed, this species is questionably assigned to *Laciniadinium*. The low apical and antapical bulges, and subcircular ambitus are similar to *L. orbiculatum*, from which ?*L. tenuistriatum* differs by having much more dense, and aligned, granular ornamentation. ?*L. tenuistriatum* is transferred from *Diconodinium*, which has rhomboidal to fusiform ambitus with a truncate apical horn and a single, sharp antapical horn located close to the midline." — Morgan (1977, p. 137)

Comparisons: "The subcircular ambitus and dense aligned granules are characteristic of ?*L. tenuistriatum*. For comparisons to other species, see treatment of ?*L. inflatum*." — Morgan (1977, p. 137)

Age: Early Cretaceous (late Albian?–Cenomanian); holotype of Eisenack & Cookson (1960, p. 4).

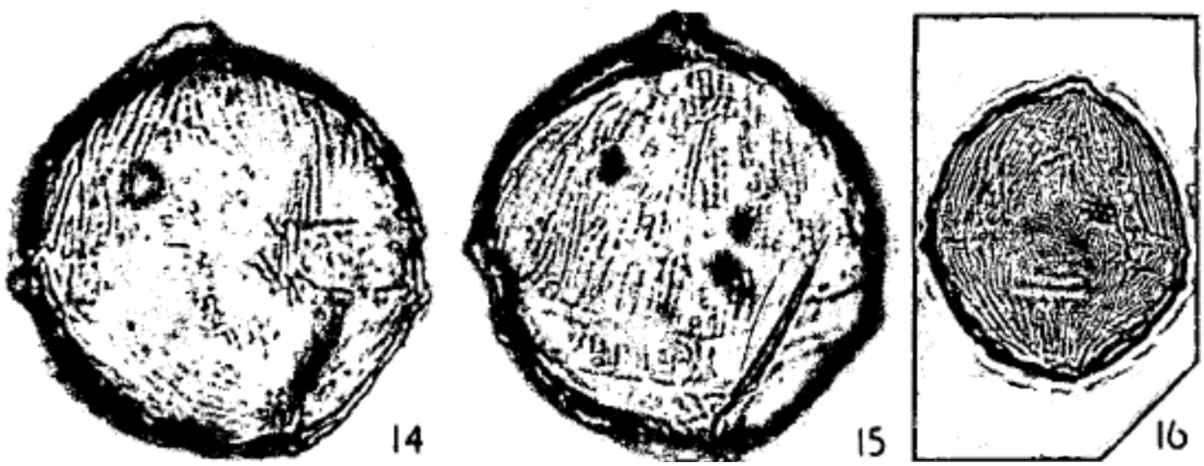


Plate 1, figures 14–16, Eisenack & Cookson (1960).

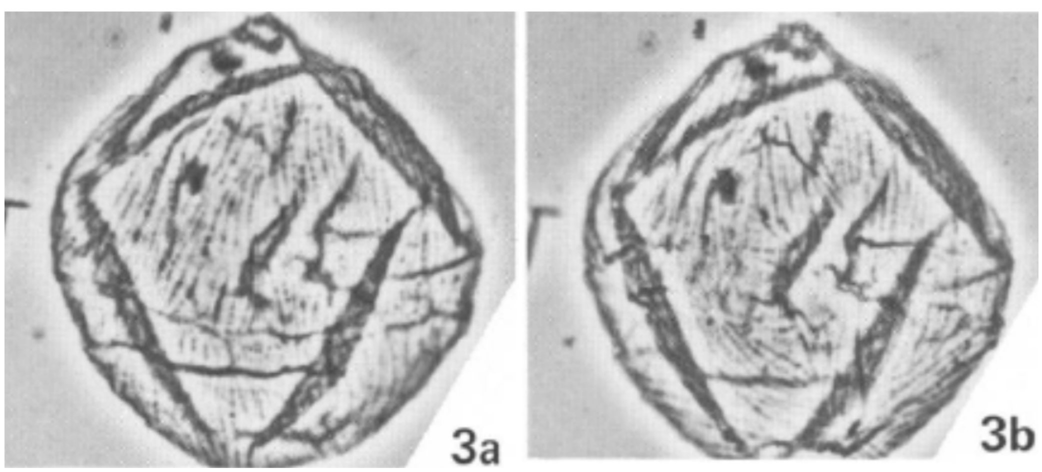


Plate 2, figures 3a, b, (holotype) Morgan (1977).

Laciniadinium tianshanense (He Chengquan, 1991) Lentin & Williams, 1993

Description: "The cyst is flattened ventrally and dorsally, with an outline longer than wide. Epitheca slightly larger than hypotheca, conical, lateral straight: undeveloped apical horn, low conical shape, about 5 μm long. The hypotheca is inverted trapezoidal, the antapex is slightly concave, and the two antapical horns are convex, and sometimes one of them may be obtusely tapered. The transverse groove is clear, shallow, and flat, ring-shaped, 6–7 μm wide, inclined to the hypotheca; its edges are decorated with fine ridges. The longitudinal groove is slightly sunken, limited to the hypotheca. The cyst wall is extremely thin, light-colored, smooth to nearly smooth, with weak longitudinal striations. The archeopyle is large, combined, (tI3P) type a, marked by the regular arched main crack of the archeopyle. The composition of the archeopyle does not include the top reflection plate. The operculum is kept in place. Several small yellow-green nuclei on the ventral surface." — Translated from He Chengquan (1991, p. 65)

Dimensions: "The cyst is 48–52.5 µm long and 32.5–40 µm wide (measured from 2 specimens). The holotype has a length of 48 µm and a width of 32.5 µm; the cingulum width is 7 µm, and the length of the apical horn is 5 µm." — Translated from He Chengquan (1991, p. 65)

Age: late Eocene (Priabonian); holotype corresponding to the "second section of the Bashibulake Formation" as translated from He Chengquan (1991, p. 215). Range: late Eocene (Priabonian) corresponding to the "second and third sections of the Bashibulake Formation" as translated from He Chengquan (1991, p. 65) given the age of the section presented by Xi Dangpeng et al. (2020, p. 166).

Plate 2, figures 8, 9, He Chengquan (1991).

Laciniadinium xinjiangense (He Chengquan, 1991) Lentin & Williams, 1993

Description: "The cyst is flat on the abdomen and back, the outline is pentagonal, the length is greater than the width or both are nearly equal, and the waist is more or less outwardly bulging. Epitheca conical or bell-shaped, with slightly convex-concave margins, slight or absent apical horn, blunt apex, generally closed, occasionally with apical pores. The hypotheca is inverted trapezoidal, and the two caudal horns degenerate to varying degrees, one of which is more obvious, conical, with blunt ends, up to 6 µm in length. The girdle is equatorial, ring-shaped, 5.5–7.5 µm wide, and bordered by thin ridges. Longitudinal groove lacking. The cyst wall is thin, the surface is granular, the grains are thin or prominent, or have knife-like wrinkle. Archeopyle may be combined, usually unknown." — Translated from He Chengquan (1991, p. 65)

Dimensions: "Cyst is 50–57 µm long and 40–54 µm wide (measured from 7 specimens). The holotype has a length of 54 µm and a width of 40 µm, with an antapical horn 3 µm long; cingulum width 5.5 µm." — Translated from He Chengquan (1991, p. 65)

Discussion: "This species is distinguished from *Sinocysta minuta*, *S. subtilis* (sp. nov.) by its larger cyst and usually without an apical pore." — Translated from He Chengquan (1991, p. 65)

Age: Late Cretaceous (early Turonian); holotype as translated from He Chengquan (1991, p. 215). Based on the range chart and translation of “bottom of the Wuyitake Formation” from He Chengquan (1991, p. 16, 65, fig. 4). Range: Late Cretaceous (early Turonian)–late Paleocene corresponding to “the bottom of the Wuyitak Formation . . . to the lower member of Qimgen Formation” as translated from He Chengquan (1991, p. 65, 215) based on the geological ages of these units provided by Mingzhen Zhang et al. (2022, fig. 2) and Xi Dangpeng et al. (2020, fig. 12) respectively.

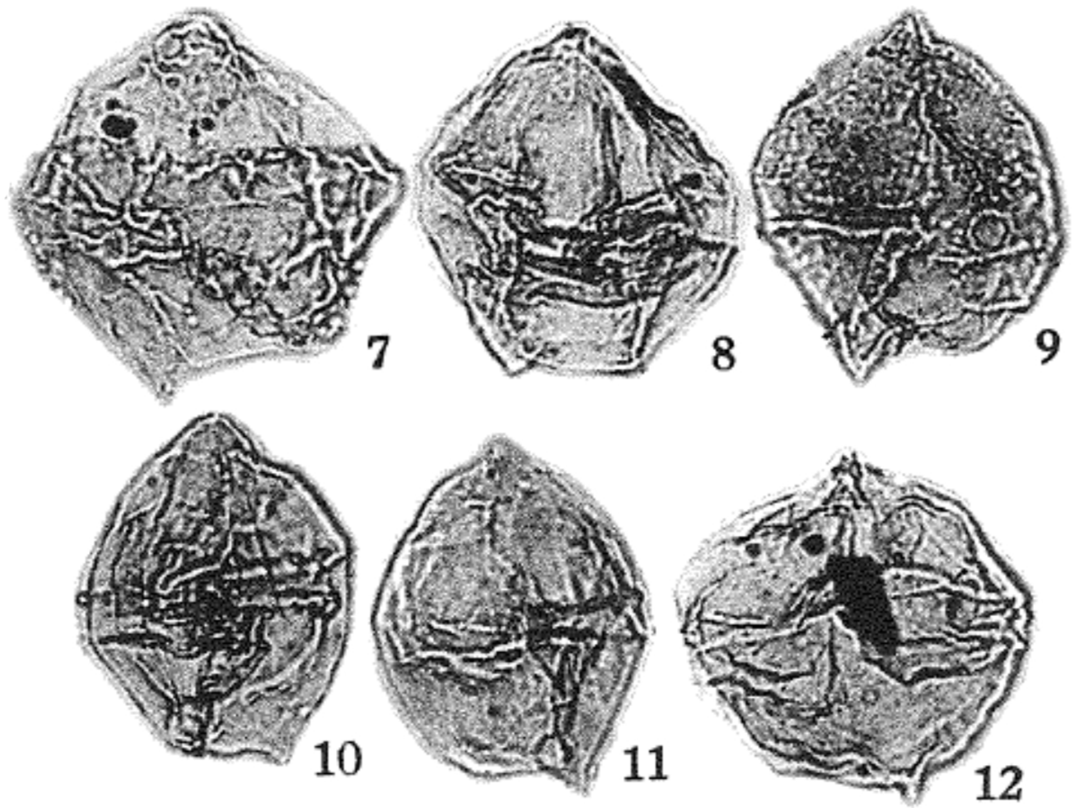


Plate 1, figures 7–12, He Chengquan (1991).

Genus ***MANUMIELLA*** Bujak & Davies, 1983

1983 *Manumiella* Bujak & Davies: 160.
2009 *Manumiella* Bujak & Davies; emend. Fensome et al.: 43.
2009 *Manumiella* Bujak & Davies; emend. Thorn et al.: 439.

Manumiella bertodano Thorn et al., 2009

Description: "Deflandreoid dinoflagellate cyst with an elongate, subpentagonal outline in dorsoventral view. Periphragm relatively thin, smooth, microscabrate to finely granular in surface texture. Circumcavate cyst organisation. Epicyst and hypocyst approximately equal in size. Smooth, relatively thin mesophragm present in some specimens, occupying varying amounts of the pericoel and closely following the internal surface of the periphragm (commonly adjacent to it) for most of its outline. The mesophragm does not normally reach into the extremities of the horns. Equatorial folding in the periphragm often suggests vague paracingulum development. However, there are no unequivocal traces of paratabulation other than the archeopyle, which is intercalary, monoplacoid, periarcheopyle (Type I/−/−). The archeopyle is bilaterally symmetrical, iso- to lati-deltaform hexa 2a, subrounded; free operculum. Prominent, sharply distally-tapering apical horn with a pointed or rounded tip. Two asymmetrical antapical horns are present; the left antapical horn is more prominent, and is typically distally pointed. The left antapical horn is shorter than the apical horn, but is significantly longer than the right antapical horn, which is typically reduced and forms a bulge. Endocyst smooth, relatively thick and prominent, ovoid in outline, infrequently folded." — Thorn et al. (2009, p. 439)

Discussion and comparisons: "*Manumiella bertodano* sp. nov. is distinguished by the following: a prominent endocyst; an elongate, subpentagonal outline; a consistently prominent distally-pointed apical horn; a large, distally-pointed left antapical horn; and a reduced typically rounded (bulge-like) right antapical horn. Specimens of *Manumiella bertodano* sp. nov. occur within the uppermost López de Bertodano Formation on Seymour Island from 969 to 834 m, except for rare probably reworked specimens up to 995 m, in the section (Fig. 3). These rare forms are interpreted as probably being reworked due to their scarcity, and their sporadic presence stratigraphically above the consistent occurrences of this species.

Askin (1988a, fig. 9.4) first illustrated *M. bertodano* sp. nov. as "*Manumiella*" n. sp. 2, but it was not formally described. *Manumiella bertodano* sp. nov. was also illustrated by Pirrie et al. (1991), Riding et al. (1992) and Roncaglia et al. (1999) from the late Maastrictian [sic] of Vega Island, Antarctica and New Zealand. The specimen of *Manumiella* sp. 2 of Askin 1988 in Mohr and Mao (1997, pl. 1, fig. 7) from the Maastrichtian of the Maud Rise off the coast of East Antarctica is bicavate, and hence cannot be referable to *Manumiella*. Furthermore, it has a short endocyst, a narrow antapical area, lacks a particularly prominent apical horn and is relatively small, hence is not conspecific with *M. bertodano* sp. nov.

Transitional forms possessing most, but not all, of the characteristic features were observed by Askin (1988a, figs. 9.3, 9.5) and herein; examples of these are *Manumiella* sp. (Plate I, figs. 4, 7, 8). Marenssi et al. (2004, fig. 6F) figured a specimen that appears to be transitional between *M. bertodano* sp. nov. and *M. seelandica*. This is within the '*Manumiella* complex' from the Calafate Formation of southern Patagonia, Argentina. This specimen would here be designated *Manumiella* sp. because it does not directly satisfy the criteria for either of these two species." — Thorn et al. (2009, p. 439, 441)

Dimensions: "Pericyst length 97(136)172 µm, standard deviation (sd) 19.4; pericyst width 68(91)112 µm, sd 11.3; pericyst length to width ratio 1:0.65 to 1:0.70. Endocyst length 37(68)88 µm, sd 10.8 µm; endocyst width 32(76)95 µm, sd 13.4. The range of apical horn length is not stated due to the difficulty of consistent measurement between specimens with no sharp break in slope at the 'base' of the horn. Thirty specimens were measured." — Thorn et al. (2009, p. 441)

Age: Late Cretaceous (latest Maastrichtian); holotype of Thorn et al. (2009, p. 441). Range: Late Cretaceous (latest Maastrichtian) (Thorn et al. (2009, p. 441, figs 2, 3).

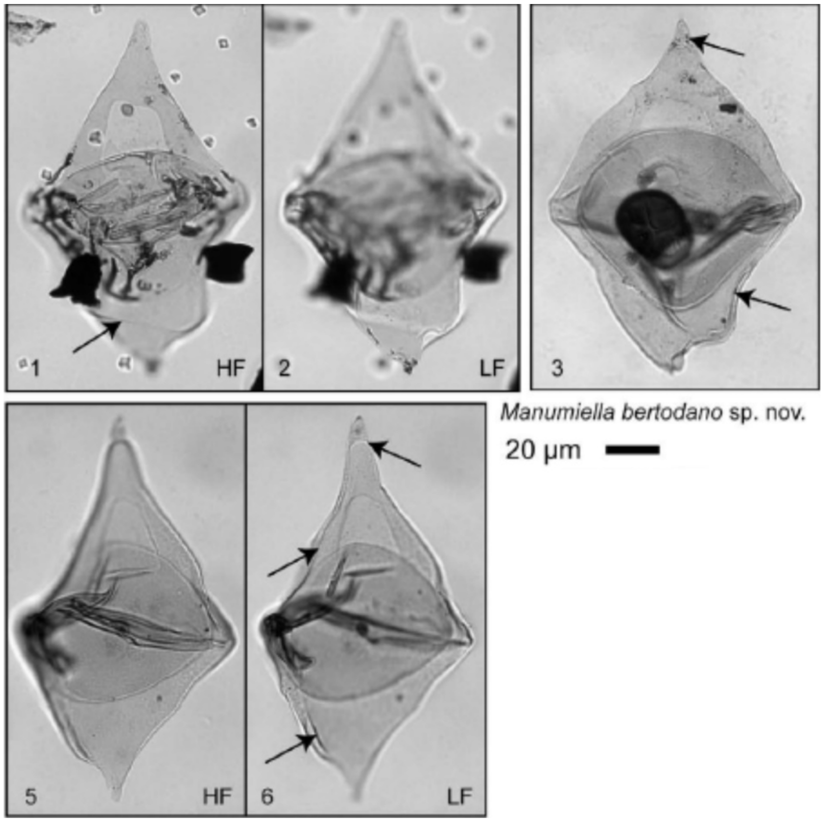


Plate 1, figures 1–3, 5, 6, Thorn et al. (2009).

Manumiella conorata (Stover, 1973) Bujak & Davies, 1983

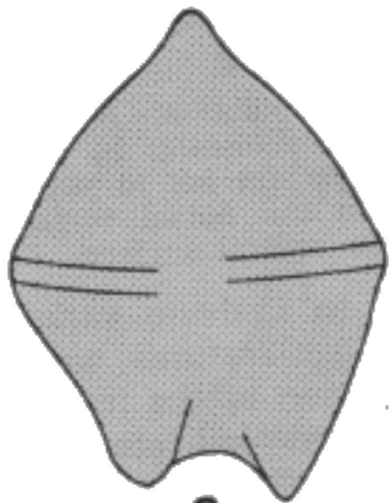
Description: "Outline in dorso-ventral view is somewhat lozenge-shaped with slightly convex and rounded lateral margins. Apical horn is short, usually blunt, weakly to moderately well developed, not prominent; antapical horns are rounded, fairly well differentiated, and unequal. On some specimens the larger antapical horn is more pointed than the smaller horn. Periphragm is ca 1 p. thick, faintly and uniformly scabrate to finely granulate. Traces of tabulation on the periphragm are lacking except for the intercalary archeopyle and a poorly defined cingulum indicated by faint, parallel, discontinuous transverse linear markings, ca 5 μ apart, and located at the widest part of the cysts.

Endoblast is circular to elliptical in dorsoventral view, smooth to faintly scabrate, from less than 1 to 2 μ-thick, and commonly folded. The endoblast occupies a major part of the pericoel and the margins of the endophragm do not touch the inner surface of the periphragm laterally. Comparatively small rectangular trapezoidal opercula, with generally rounded corners and apparently hinged antapically, occur on all specimens. Only a few specimens indicate an opening in the endophragm." — Stover, 1973 (p. 171, 172)

Dimensions: "Specimens of *Deflandrea conorata* vary in length (140–162 μ) and width (98–124 μ). Length: width ratio lies between 1:0.8 and 1:0.7. Endoblast is 92–112 μ long and 85–114 μ wide. The length is greater than the width on some specimens whereas on others the reverse is true; but reliable dimensions of the endoblast are difficult to obtain because of folding. Measurements are of 10 similarly oriented specimens." — Stover, 1973 (p. 172)

Comparison: "Specimens of *Deflandrea conorata* are similar to those of *D. pellucida* and differ from the latter by having a larger endoblast, relative to the periblast, and a rectangular to trapezoidal archeopyle whose height is at least equal to its width and generally greater. The sculpturing on the periphragm is also more evenly distributed on *D. conorata* in contrast to its interrupted distribution on *D. pellucida*." — Stover, 1974 (p. 172)

Age: early–middle Paleocene (Danian–Selandian); holotype of Stover, 1973 (p. 172).



Text-figure 3C, Stover (1973).

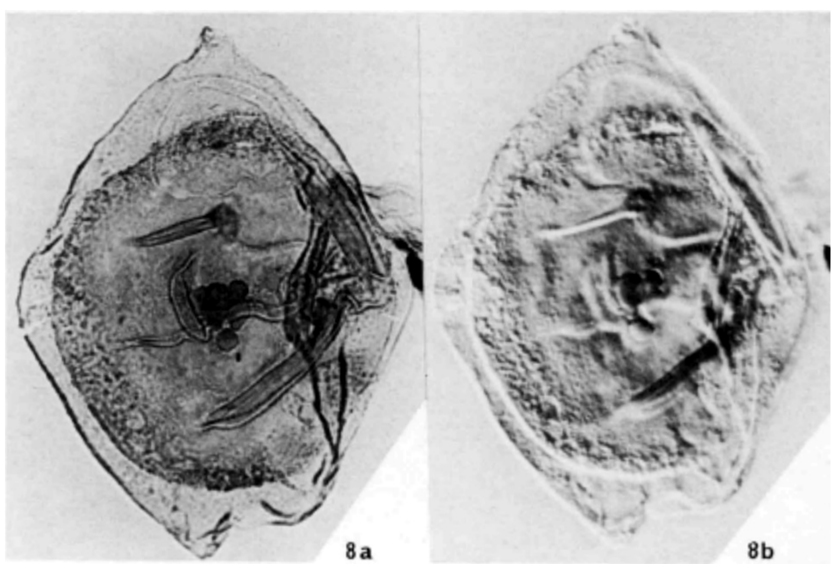


Plate 1, figures 8a, b; Stover (1973).

Manumiella delicata (Balteş, 1969 ex Lentin & Williams, 1973) Bujak & Davies, 1983

Description: "Cyst generally ovoid in shape, length 65–70 microns. Cingulum very thin, but visible. Slightly demarcated central capsule in some specimens. Very small apical horn in the form of a knob. Antapical horns joined, very vaguely demarcated. Smooth, extremely thin and transparent periphragm. Intercalary, trapezoidal archeopyle. Some specimens approximately similar to the form of *Deflandrea backeri* Deflandre and Cookson. Moderate frequency." — Translated from Balteş (1969, p. 34)

Age: early Eocene; holotype as translated from Balteş (1969, p. 34).

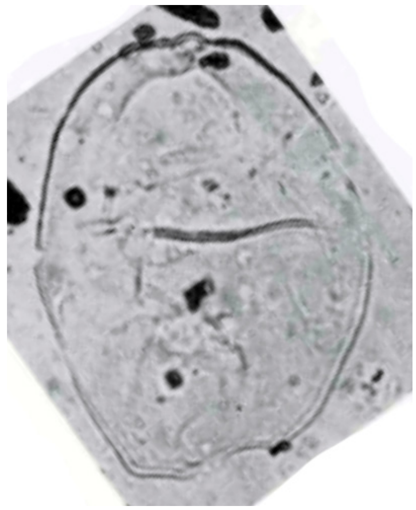


Plate 1, figure 7, Balteş (1969).

Manumiella druggii (Stover, 1973) Bujak & Davies, 1983

Description: "Outline of the periphragm in dorso-ventral view is broadly elliptical, rarely elongate and with a shallow antapical concavity which separates poorly developed antapical horns. Apical margin may be evenly rounded or a short, broadly-based, blunt apical horn may be present. Periphragm is about 1 μ thick, and is smooth, scabrate or irregularly granulate with the sculptural features varying in diameter from ca 0.5 μ to 2.0 μ. Usually, the coarser sculpturing is concentrated on the areas beyond the limits of the endoblast. Surface of periphragm lacks traces of tabulation except for small intercalary archeopyle.

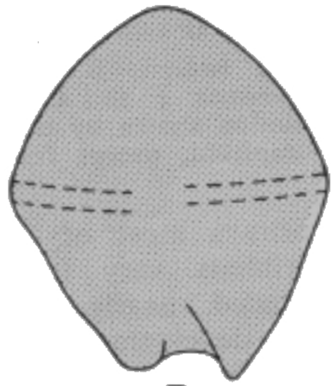
Endoblast outline circular or nearly so in dorso-ventral view, commonly modified by folding; endoblast occupies a major part of the pericoel, and is not in contact laterally with the inner surface of the periphragm. Endophragm is ca 1 μ thick, smooth or faintly scabrate. No opening observed in the endophragm in a position corresponding to the archeopyle in the periphragm. Operculum is relatively small, usually with a narrow apical margin, oblique and slightly convex sides, rounded antapical corners and is hinged antapically." — Stover (1973, p. 171)

Dimensions: "Specimens vary in width (92–103 μ) and length (104–122 μ); length:width ratio lies between 1:0.83 and 1:0.93. In nearly all specimens in which folding of the endoblast is not severe, its width exceeds its height." — Stover (1973, p. 171)

Comparison: "Specimens of *Deflandrea druggii* resemble those of *D. cretacea* Cookson, 1956 in outline, by having the endoblast filling a comparatively large part of the pericoel and by lacking prominent apical and antapical horns. The new species differs by being about twice the size of *D. cretacea* and by having the endoblast consistently separated laterally, as well as apically and antapically, from the periphragm.

Of the specimens illustrated and assigned to *D. cretacea* from California, U.S.A. (Drugg, 1967) the example shown on his Plate 2, Figure 17 is probably conspecific with *D. druggii*. Specimens of *D. cretacea* from the Nelson bore in southwestern Victoria (Cookson 1956, Plate 1, Figs 1–5; not Figs 6 and 7) have the endoblast touching the periphragm laterally, except for her Figure 5 in which the two bodies of the cyst are clearly separated laterally. In this respect and also by having the right antapical horn somewhat better developed, the specimen (Cookson's Fig. 5) resembles more closely those of *D. druggii* than do her other specimens of *D. cretacea*.” — Stover (1973, p. 171)

Age: early–middle Paleocene (Danian–Selandian); holotype of Stover (1973, p. 172).



B

Text-figure 3B, Stover (1973).

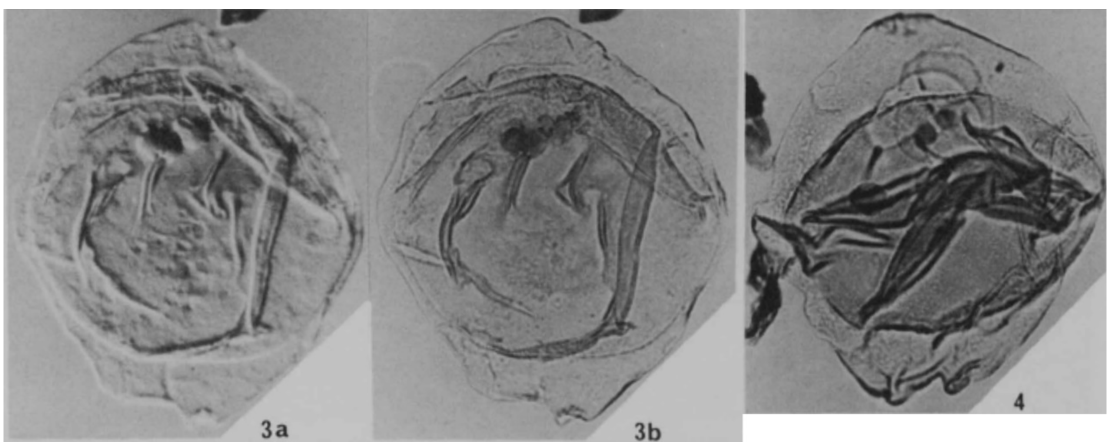


Plate 1, figures 3a–b, 4, Stover (1973).

?*Manumiella hemmoorensis* Marheinecke, 1992

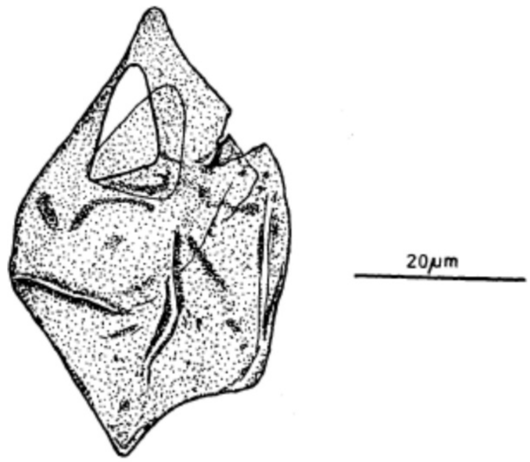
Description: “Cyst ambitus ovaloidal with horns, circumcavate, dorsoventrally compressed. Periblast terminating apically in a broad, blunt horn. Two antapical horns are developed. The left is short, broad, and blunt, the right rudimentary. Wall thin, undulate. Cingulum indicated by two slight folds. Sulcus indicated by concave longitudinal folds on the ventral side. Endoblast ovaloidal, thin-walled, slightly granulated. Periarcheopyle: intercalary, 2a, steno-deltaform, rounded. Operculum adnate at the margin 2a /4''. Endoarcheopyle: intercalary, 2a, steno-deltaform. Operculum adnate at the margin 2a /4''.” — Translated from Marheinecke (1992, p. 90)

Additional remark and comparison: “The unusual surface ornamentation of the periblast and the steno-deltaform archeopyle make the assignment to *Manumiella* uncertain. However, since the indication of the cingulum is not pronounced enough for an assignment to *Alterbidinium*, for example, the chosen solution is acceptable.” — Translated from Marheinecke (1992, p. 90)

Dimensions: “Holotype statistics: Periblast length: 61, width: 38; endoblast length: 33, width: 30.

Statistics: Periblast length: 52(56)61, width 32(38)47; endoblast length: 27(30) 33, width: 25(28)30." — Translated from Marheinecke (1992, p. 90)

Age: Late Cretaceous (late-early Maastrichtian); holotype as translated from Marheinecke (1992, p. 90, table 2). Late Cretaceous (late-early Maastrichtian) (Marheinecke, 1992, table 2).



Text-figure 1, Marheinecke (1992).

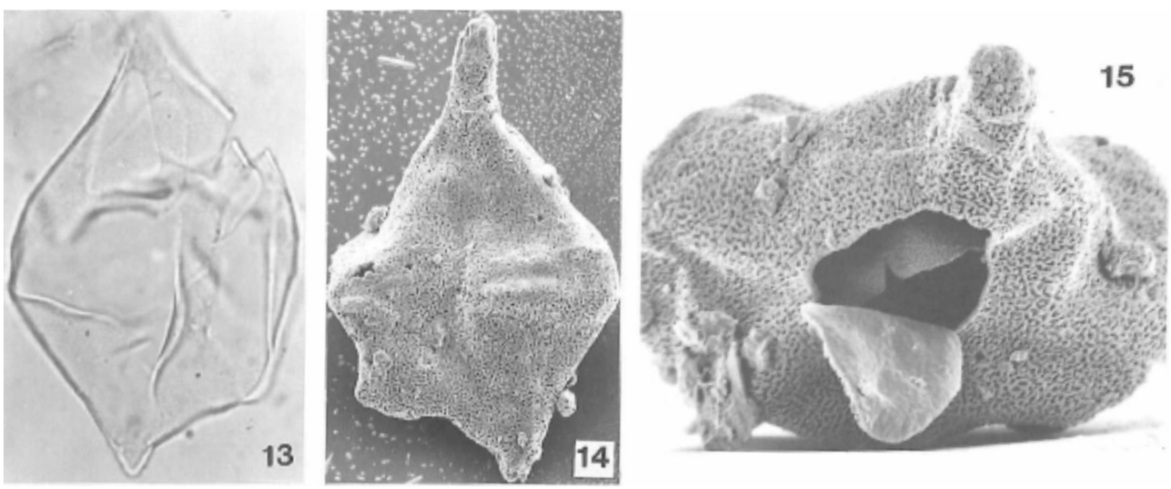


Plate 18, figures 13–15, Marheinecke (1992).

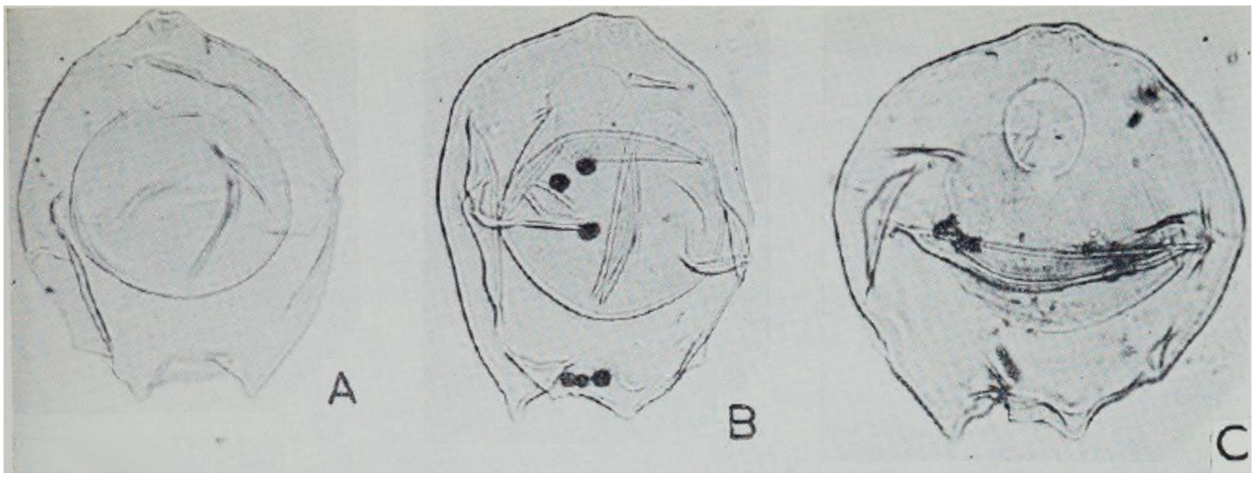
Manumiella lata (Cookson & Eisenack, 1968) Bujak & Davies, 1983

Description: "Shell rather flat, without tabulation, broadly oval to nearly circular in outline, without a clearly defined girdle, occasionally a slight marginal indentation suggestive of a girdle has been present (Fig. 1A). Apex of shell with a small median and slightly concave prominence; antapex narrower and more deeply concave than the apex with two short antapical horns. Capsule widely separated from the wall of shell, nearly spherical to broadly oval in outline, its longer axis being at right angles to the longitudinal axis of the shell. Archeopyle small, intercalary in position, circular to oval in outline. Wall of both shell and capsule smooth and thin, that of the capsule being the thinner of the two." — Cookson & Eisenack (1968, p. 110)

Dimensions: "Holotype: overall length 98 μ, overall width 84 μ, capsule c. 50 × 57 μ. Range: overall length c. 78–105 μ, overall width c. 76–97 μ; capsule length c. 48–50 μ, width c. 48–75 μ.” — Cookson & Eisenack (1968, p. 110)

Remarks: “Of the described species of *Deflandrea*. *D. lata* appears to come closest to *D. cretacea* Cookson 1956 originally described from three Upper Cretaceous deposits in the Nelson Bore, Victoria. It agrees with *D. cretacea* in the apparent absence of a girdle, but differs from this species in its rounded shape, the complete separation of the capsule from the shell, and the greater prominence of the antapical projections.” — Cookson & Eisenack (1968, p. 110)

Age: Late Cretaceous (?Santonian–early Campanian); holotype of Cookson & Eisenack (1968, p.110).



Figures 1A–C, Cookson & Eisenack (1968).

Manumiella minuta Marheinecke, 1992

Description: “Cyst ambitus ovaloidal with horns, circumcavate, dorsoventrally compressed. Periblast terminating apically in a broad, blunt horn. Two antapical horns are developed. The left is short, broad, and blunt, the right rudimentary. Wall thin, slightly granulated. Cingulum not indicated. Sulcus not visible. Endoblast ovaloidal, thin-walled, slightly granulated. Periarcheopyle: intercalary, 2a, iso-delta form with distinct corners. Endoarcheopyle: intercalary, 2a, iso-delta form with distinct corners. Operculum separated.” — Translated from Marheinecke (1992, p. 91)

Remarks: “The size range of the present species is not different from the variations known from other species of this genus. However, the specimens examined first were very small and led to the naming.” — Translated from Marheinecke (1992, p. 91)

Comparison: “The present species differs from *Alterbidinium minor* in the iso-deltaform archeopyle and the shape of the endoblast. It differs from ?*Manumiella hemmoorensis* in the archeopyle and the ornamentation of the periblast.” — Translated from Marheinecke (1992, p. 91)

Dimensions: “Holotype: periblast length (with horns): 72, width: 43; endoblast length: 42, width: 36. Periblast length: 56(62)72, width: 35(37)42; endoblast width: 25(28)36; 6 specimens.” — Translated from Marheinecke (1992, p. 91)

Age: Late Cretaceous (late-early Maastrichtian); holotype as translated from Marheinecke (1992, p. 91, table 2). Range: Late Cretaceous (late-early–early late Maastrichtian) as translated from Marheinecke

(1992, table 2).

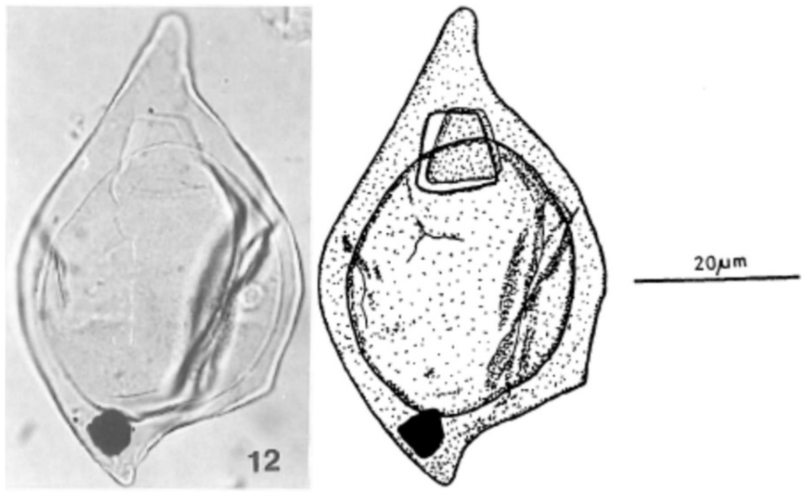


Plate 18, figure 12; Text-figure 19, Marheinecke (1992).

Manumiella raijae (Kjellström, 1973) Bujak & Davies, 1983

<u>Diagnosis</u>: "*Deflandrea* sp. with pentagonal, granular theca. Truncate apical horn and antapical horns. Psilate, pentagonal inner central capsule, the margins of which extend to the central part of the theca. Well-defined cingulum with margins bulging outwards. Archaeopyle intercalary." — Kjellström (1973, p. 20, 22)

<u>Dimensions</u>: "Length of theca: 70 μ; breadth of theca: 65 μ." — Kjellström (1973, p. 22)

<u>Age</u>: Late Cretaceous (middle Maastrichtian); holotype of Kjellström (1973, p. 22). Range: Late Cretaceous (middle–late Maastrichtian) (Kjellström (1973, p. 22).

Figure 16, Kjellström (1973).

Manumiella rotunda Wilson, 1988

<u>Description</u>: "Cyst of intermediate size, weakly circumcavate, occasionally bicavate, subcircular to slightly ovoidal. Apical pericoel poorly developed, antapical pericoel slightly longer. Apical horn not developed or represented by short protuberance (length up to 2 µm); antapical horns not developed. Periphragm thin, pale, smooth or finely reticulate. Endophragm fairly thick, dark coloured, finely reticulate. Archeopyle relatively broad, elongate, hexagonal; opening in pericyst and endocyst in close contact; operculum attached posteriorly. Paracingulum sometimes delineated by single transverse ridge or fold. Parasulcus not indicated. Paratabulation indicated only by archeopyle outline." — Wilson (1988, p. 26)

<u>Dimensions</u>: "Holotype: overall length 81 µm, breadth 76 µm, length of endocyst 76 µm, breadth 70 µm. Range: overall length 65(72)83 µm, breadth 62(68)79 µm (n = 10)." — Wilson (1988, p. 26)

<u>Remarks</u>: "The globular pericyst outline, narrow circumcavation, lack of well defined apical and antapical pericoels, and lack of horns help distinguish M. rotunda from other species of *Manumiella*. The species differs from superficially similar species of *Deflandrea* (e.g. *D. truncata*) in its archeopyle structure and from species of *Nelsoniella*, *Xenikoon* and *Isabelidinium* in generally being circumcavate rather than epicavate or bicavate." — Wilson (1988, p. 26)

<u>Age</u>: Paleocene; holotype of Wilson (1988, p. 26).

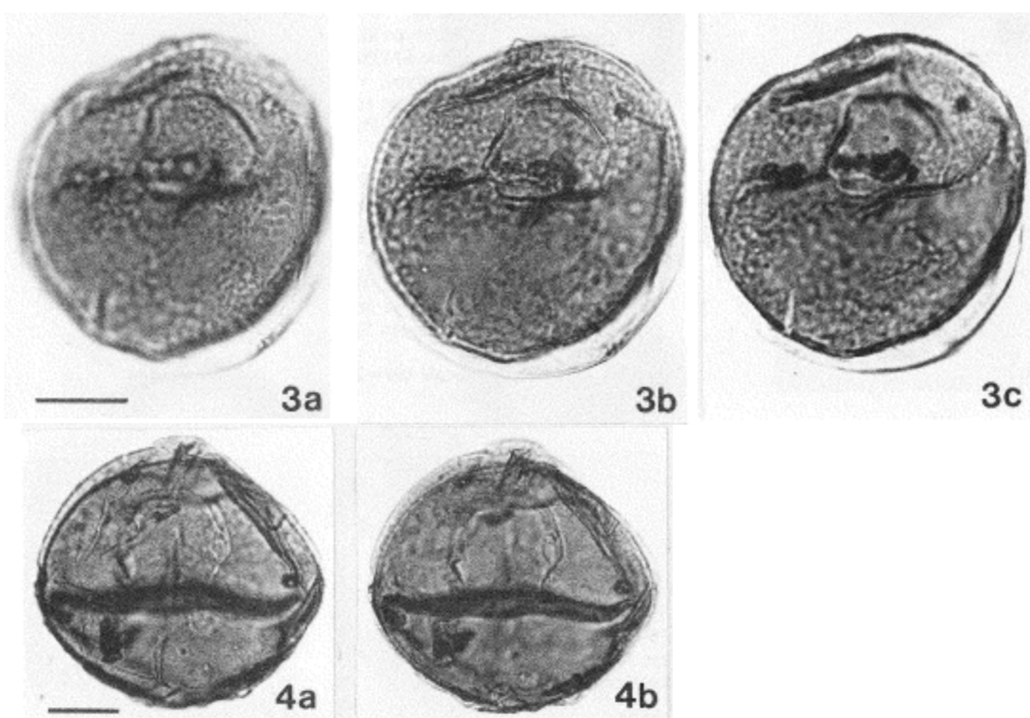


Plate 16, figures 3a–c, 4a, b, Wilson (1988)

Manumiella seelandica (Lange, 1969) Bujak & Davies, 1983. Emendation: Firth, 1987, p. 213, 214. Taxonomic junior synonym: *Deflandrea* (as *Manumiella*) *druggii*, according to Firth (1987, p. 213) — however Thorn et al. (2009, p. 443) retained *Deflandrea* (as *Manumiella*) *druggii*.

Diagnosis: "The cyst is flattened; its outline is oval to diamond-shaped. The epitheca runs into a more or less long apex that is blunted or slightly pointed at the free end of the apical horn. The larger hypotheca has only a small reduced antapical horn. A square to rectangular rounded pylome lies beneath the apex. The membrane is finely granulated." — Translated from Lange (1969, p. 113)

Additions: "A very shallow, deepened transverse furrow is only marginally closed in elliptical forms. It separates the significantly larger hypotheca from the almost rectangular epitheca. *Broomea seelandica* differs from the other species of the genus in outline of the body and the formation of the appendages." — Translated from Lange (1969, p. 114)

Dimensions: "Holotype: 106: 7l. Dimensions (average of 6 specimens): 104: 74." — Translated from Lange (1969, p. 114)

Emended description: "Medium to large bi-layered, circumcavate (rarely bicavate) cyst. Pericyst roundly rhomboidal to elongate ovoidal. Epicyst and hypocyst roughly equal in size. Ambitus of epipericyst varies from broad and rounded (sometimes with blunt to concave apical end) to triangular with pointed apex. An apical protrusion may exist which varies from a knob 1–2 µm high to a long, narrow acuminate horn greater than 30 µm in length. Base of horn may be narrow and distinct, or may be broad and merge into cyst proper. Hypocyst shape like that of epicyst, except that antapical horn is shorter than apical horn, and that antapex may sometimes have two short, broadly rounded antapical horns with a medial concavity. Periphragm more or less coarsely granular, with apical and antapical poles often having larger and more densely distributed grana than the rest of cyst. Endocyst large, spherical-ovoidal to heart-shaped, often folded or flattened. Endophragm thin, laevigate. Paratabulation indicated only by deltaform intercalary archeopyle (type Ia/Ia), and occasionally by a faint paracingulum and/or parasulcus." — Firth (1987, p. 213, 214)

Age: Paleocene (Danian); holotype as translated from Lange (1969, p. 113).

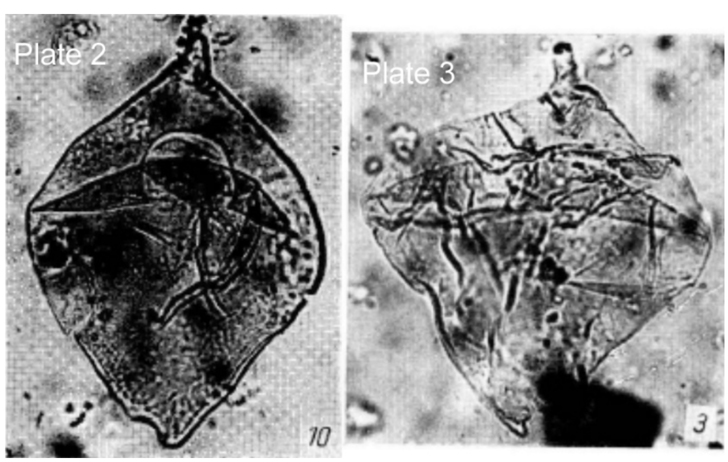


Plate 2, figure 10; Plate 3, figure 3, Lange (1969)

Manumiella seymourensis Askin, 1999

Diagnosis: “Deflandreoid cyst with ovoid outline, clearly circumcavate, epicyst and hypocyst approximately equal in size, endocyst very thin and barely visible. Apex of pericyst rounded to truncate, often with dimple, rarely with short apical horn; antapex rounded to truncate, often with slight thickening, rarely with short left antapical horn, right antapical protrusion typically absent. Intercalary periarcheopyle, hexa 2a eurydeltaform, rarely isodeltaform, operculum typically attached.” — Askin (1999, p. 373)

Description: “Cysts typically ovoid to rounded rhomboidal, circumcavate. Epicyst and hypocyst approximately equal in size. Apex usually rounded to broadly rounded or truncate, occasionally concave, or with short apical horn usually with rounded tip. Small dimple often apparent at apex, with a central pore rarely visible, or occasionally a central nipplelike structure (tending to small apical horn). Antapex rounded to truncate, often with pericyst slightly thickened or dimpled at the horn(s) position, or with small, variably developed antapical horns. Left antapical horn when present as small bulge to nipple, or with short horn, usually with rounded tip; right antapical horn absent, or indicated by slight bulge in outline or small rounded protrusion.

Periphragm <0.5 to 1 µm thick, to 2 µm at apex and antapex; typically smooth, or with scattered fine grana, especially near apex and antapex. Pericyst probably had a dorsal bulge, as indicated by dorsal folds in many specimens. Endocyst is barely visible, subcircular, usually centrally located; endophragm very thin, smooth, may have small folds.

Periarcheopyle intercalary, hexa 2a eurydeltaform, rarely isodeltaform (AR 0.33 to 1.0, mean 0.64), operculum usually remaining attached along 2a–4" boundary; no obvious opening on endocyst. Ventral antapical opening (claustrum), often as tear in pericyst wall, in some older specimens. Paracingulum rarely indicated by very faint parallel lineations, folds or splits. Paratabulation usually not evident, except for very rare linear arrangements of grana, or splits, along the 3"–4", 4"–5", la–3" and 3a–5" paraplate boundaries, and around the parasulcus.” — Askin (1999, p. 374)

Dimensions: “Pericyst length 71 (89.6) 122 µm, std.dev. 9.9; width 52 (67.6) 89 µm, std.dev. 6.7 (250 specimens). Holotype: Pericyst length 86 µm, pericyst width 71 µm; endocyst length 46 µm, endocyst width 59 µm (Fig. 2.1).” — Askin (1999, p. 374)

Discussion: “Morphology and size parameters are remarkably consistent throughout the stratigraphic range of this taxon, except for the lowermost and uppermost parts of its range. Some older specimens of *M. seymourensis* are slightly more elongate, the mean periphragm length of specimens in sections A6 and A7 (Lopez Units 3 and 4) being 101 µm, compared with a mean of 90 µm for the overall measured Lopez population (or mean of 87 µm for the younger population in Lopez Units 5 to 9). This may seem a subtle difference, however some older specimens are noticeably longer and relatively narrower (e.g., endmembers, Fig. 3.8, 3.9), and there are gradational specimens to this more elongate form. They differ from *Isabelidinium cretaceum* in their very thin endophragm and distinctly circumcavate form, although their periphragm shape and size can be similar.

Throughout most of its range the *M. seymourensis* population maintains its ovoid to rounded rhomboidal form with little or no horn development, as illustrated by the holotype. Rarely a left antapical horn is developed and even more rarely an apical horn. This phenomenon occurs in less than 2 percent of the population (and typically 1 percent or less) throughout most of its stratigraphic range. Towards the top of its range (in top of Lopez Unit 8 to Unit 9) the frequency of horn development increases, the highest proportion observed in sample Bl-29 where 7 percent of the population possesses horns (2.5 percent with left antapical horn or nipple, 0.5 percent with apical horn, and 4 percent with both an apical and antapical horn; 200 specimens counted).” — Askin (1999, p. 374)

Comparison: “Observation of thousands of specimens of *Isabelidinium*, *Manumiella* and related forms on Seymour and adjacent islands leaves no doubt that *Manumiella seymourensis* represents a discrete population of peridiniacean dinocysts in the Upper Cretaceous of the James Ross Basin. *Manumiella seymourensis* is readily distinguishable from other *Isabelidinium-Manumiella* species occurring in the southern regions (such as *I. cretaceum*, *I. greenense*, *I. korojenense*, *I. pellucidum*, *M. conorata*, *M. seelandica*, *M. druggii*) by its very thin, barely visible endophragm (on first glance not readily apparent), notably circumcavate form and, to a lesser extent, by its shape and size. Other species have an easily discernible, relatively larger endophragm that is thicker and/or darker in color than the periphragm.

Manumiella seymourensis differs from *Isabelidinium cretaceum* in its more delicate, thinner walls (especially the endophragm), well-developed circumcavate pericoel, and smaller size, although there is some overlap in the size ranges of the two species. *Isabelidinium cretaceum* is fairly variable, in pericyst shape, thickness and sculpture, in relative size and shape of endophragm and pericoel development (though typically bicavate, some are almost circumcavate), and archeopyle shape. The form '*cretaceum*', transferred from *Isabelidinium* by Bujak and Davies (1983) to '*Manumiella cretacea*' is included here as a species of *Isabelidinium*. *Manumiella* was proposed as a separate genus from *Isabelidinium* by Bujak and Davies to incorporate peridiniacean dinocysts with 'well-developed circumcavate pericoels and a lati-deltaform or occasionally iso-deltaform hexa 2a plate that forms the operculum of the I(2a) archeopyle and approaches a quadra style'. Bujak and Davies (1983) retained forms with a bicavate pericoel and omegaform I(2a) archeopyle in *Isabelidinium*.

Seymour Island populations of *Manumiella seymourensis* and younger *Manumiella seelandica* (includes *M. druggii*) are quite similar in most respects, except that *M. seelandica* always has a readily discernible endophragm. Interestingly, their stratigraphic ranges do not overlap nor are they subjacent, but are separated by about 22 m of section on Seymour Island (Askin, 1988a). Other species that intergrade morphologically with typical *M. druggii-M. seelandica* forms do overlap stratigraphically with the *M. seymourensi*s population. They were listed as '*Manumiella* n. sp. 1' (some of which should be assigned to *M. conorata*), and '*Manumiella* n. sp. 2' in Askin (1988a). *Manumiella* spp. l and 2, however, both have a more rhomboidal shape, a better developed paracingulum, a thicker, distinct endophragm, well-developed antapical horns, and, in sp. 2, a more elongate shape with well-developed apical horn.

The specimens illustrated from Seymour Island as '*Manumiella* cf. *druggii*' in Pirrie et al. (1997), with the ensuing incorrect age assignment of late Maastrichtian for the lower Lopez de Bertodano Formation, are actually examples of *M. seymourensis*.

The Southern Indian Ocean species *Eurydinium ellipticum* Mao and Mohr is a similar form to *M. seymourensis*. *Eurydinium ellipticum*, reported from the early Maastrichtian (Subzone C2 and Zone D, Cores 27R to 37R) of ODP Site 748C, southern Kerguelen Plateau, resembles the more ovoid forms of *M. seymourensis* that lack apical and antapical horns. The described population of *E. ellipticum*, however, has a thin periphragm, an iso-thetaform archeopyle, and is barely circumcavate, the ambital pericoel, where developed, being much narrower than in *M. seymourensis* (Mao and Mohr, 1992). Very rare specimens of *M. seymourensis* (e.g., Fig. 2.8), however, have a relatively large endocyst, closer to that seen in *E. ellipticum*.

Alterbidinium varium, described from the lower Maastrichtian of Oberbayern, Germany, has a superficial similarity to *M. seymourensis*, but is much smaller, with better developed antapical horns and paracingulum, and relatively larger endophragm with poorly developed hypocoel (Kirsch, 1991). Specimens of *Manumiella seymourensis* with rounded to truncate apex and a left antapical horn (e.g., Fig. 3.1, 3.2) resemble *Satyrodinium haumuriense* 1986, originally described as *Isabelidinium haumuriense* by Wilson (1984) from the Campanian-Maastrichtian (Haumurian Stage) of New Zealand. *Satyrodinium haumuriense* is quite similar to many *M. seymourensis* specimens in that it has a truncated apex (typically with a central notch or short rounded projection) and a thin-walled, somewhat indistinct endophragm. However, *S. haumuriense* differs in having a more elongate narrower form characterized by the relatively prominent left antapical horn, a more stenoform archeopyle and is not typically circumcavate." — Askin (1999, p. 374–377)

<u>Age</u>: Late Cretaceous (late Maastrichtian); holotype of Askin (1999, p. 374, fig. 1). Range: Late Cretaceous (Maastrichtian); holotype of Askin (1999, p. 374, fig. 1).

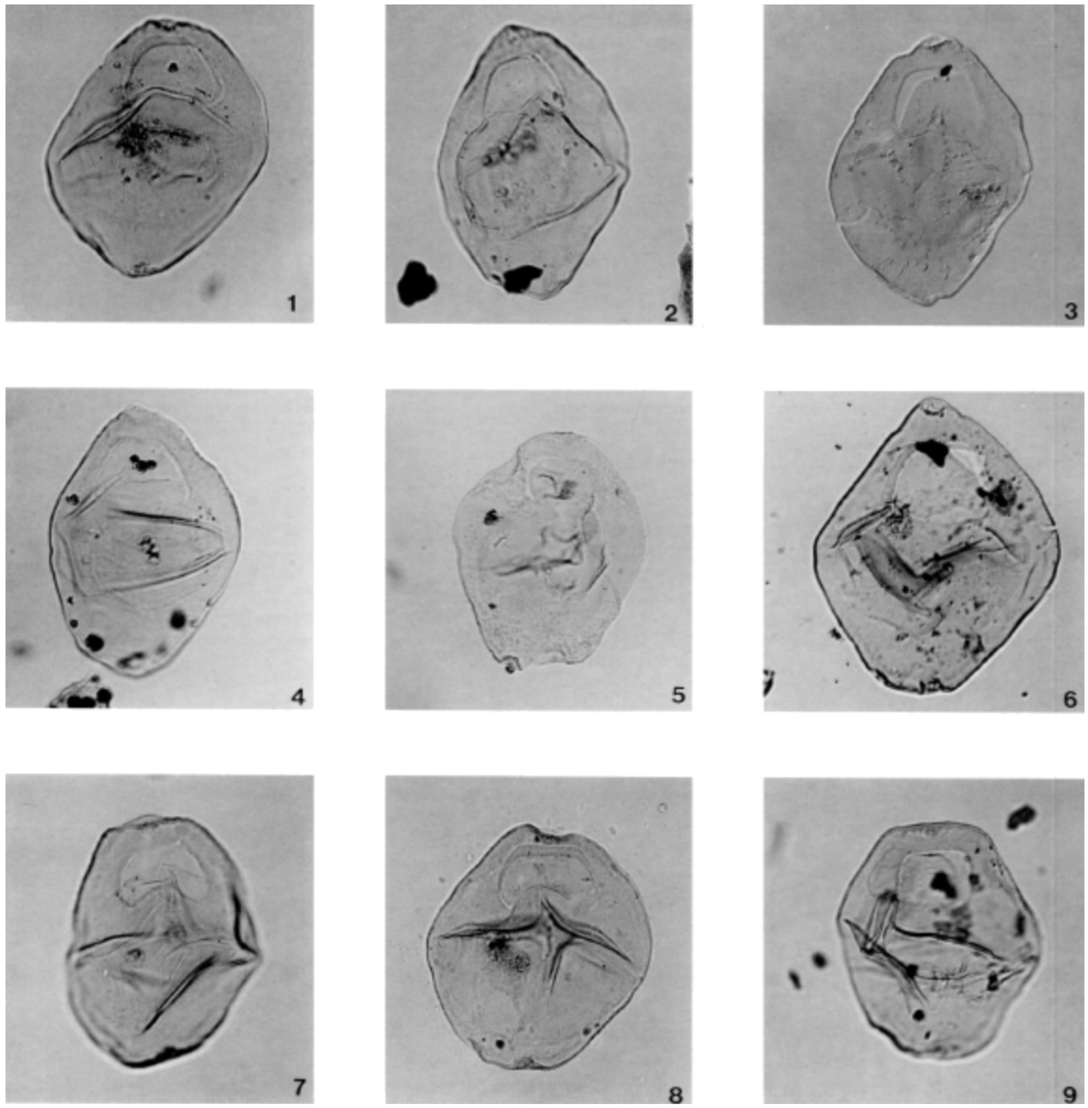


Figure 2, nos. 1–9, Askin (1999).

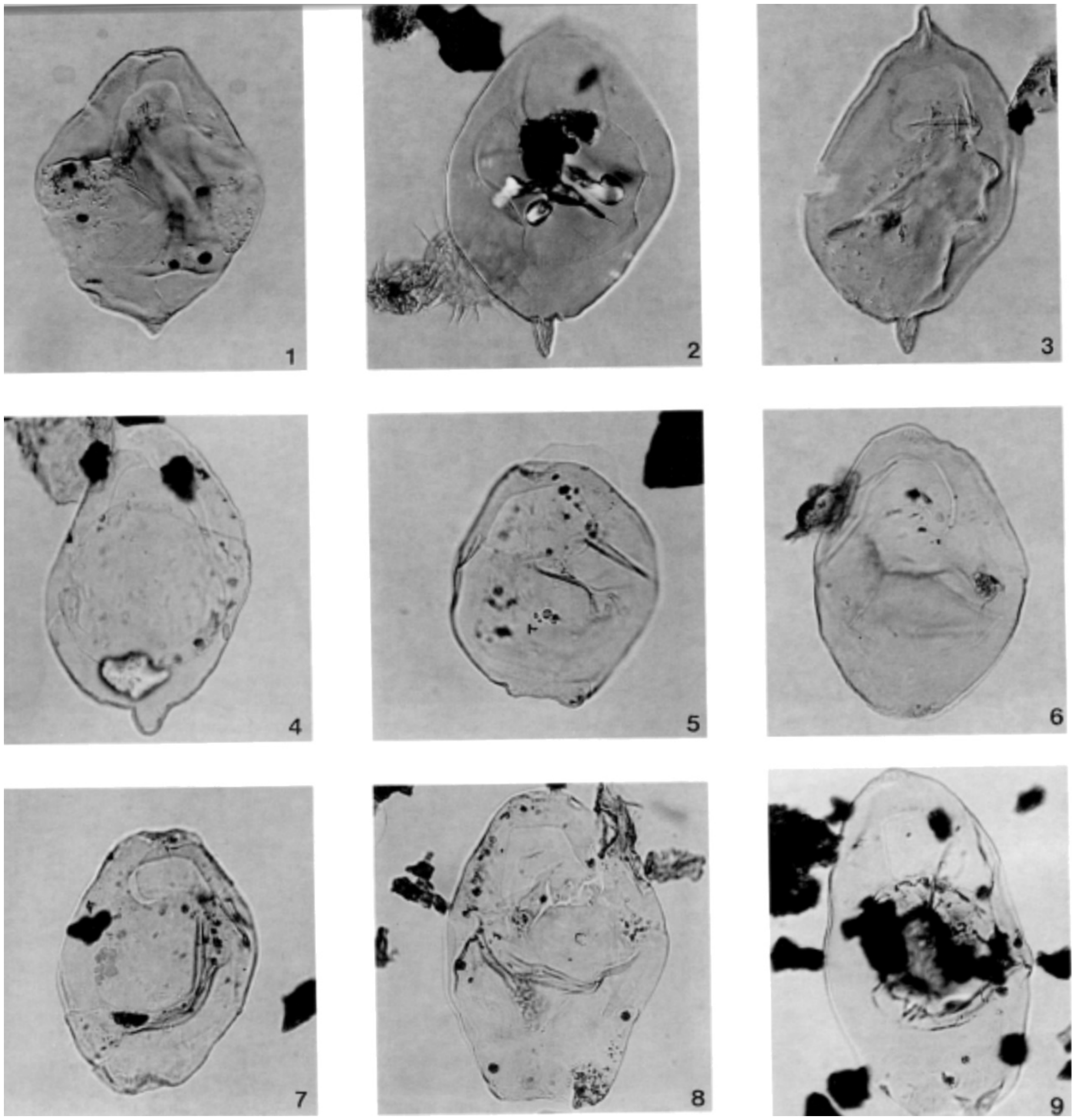


Figure 3, nos. 1–9, Askin (1999).

Genus ***SENEGALINIUM*** Jain & Millepied, 1973

1973 *Senegalinium* Jain & Millepied: 22, 23.

Senegalinium aenigmaticum (Boltenhagen, 1977) Lentin & Williams, 1981

Diagnosis: "Very slender base, provided with three pronounced conical horns; periphragm covered with hairs implanted on microwarts and partially adhering to the globular capsule. Well traced circular cingulum, sharing the theca into two equal parts; sulcus sometimes visible. Intercalary archeopyle of subtriangular outline, with truncated angles." — Translated from Boltenhagen (1977, p. 86)

Description: "The theca of this species is formed by an extremely thin and very fragile membrane which encloses a subspherical or ovoid capsule with somewhat thicker walls and sometimes slightly pitted. The conical epitheca has a prominent and pointed apical horn. The rounded hypotheca is provided with two smaller, antapical, also conical horns; they are well separated and are of substantially identical dimensions. These horns, by crumpling of the membrane, are often deformed and sometimes barely perceptible. The cingulum, well individualized on a large number of specimens, is identifiable on some, only by notches on the side.

The circular cingulum divides the capsule into two substantially equal parts. The rather wide sulcus reaches the base of the antapical horns, but it is only rarely clearly visible. The more or less triangular intercalary archeopyle, with truncated angles, is only exceptionally observable. On the other hand, tears in the region of the apex are frequent and it would seem that they are due to the fragility of the membrane around the archeopyle.

The membrane of the theca sometimes adheres to the capsule, except in the region of the horns. It is generally more or less floating on most specimens. This membrane is dotted with very fine hairs (3 to 4 μ in length), with tiny warts at the base. These hairs are hardly noticeable on the theca above the capsule and sometimes only the basal warts can be seen at 800× magnification and in phase contrast. In places and on some specimens, the hairs or warts are more or less aligned following preferred directions, which would indicate the outline of the limits of tabulation.

On a few rare specimens, the hairs of the ornamentation disappear completely, as well as almost all of their basal microwarts. These variations are due to the state of preservation of this extremely fragile. Irregular tearing of the theca is frequently observed which sometimes leads to denudation complete with capsule." — Translated from Boltenhagen (1977, p. 87)

Dimensions: "Holotype: theca with horns, L × W = 97 × 66 μ, capsule: L × W = 63 x 57 μ; Paratypes: theca L × W = 80 × 65 μ; 90 × 64 μ; 90 × 62 μ; capsule: L × W = 62 × 54 μ; 64 × 61 μ; 54 × 53 μ. According to 22 other specimens and their state of preservation: theca length: 88–66 μ, average length: 78 μ; theca width: 66–50 μ, average width: 57 μ; capsule length: 63–48 μ, average length: 54 μ; capsule width: 62–46 μ, average width: 54 μ; apical horn: apparent length: 20–10 μ, average: 15 μ; antapicals: apparent length: 18–4 μ, average: 14 μ." — Translated from Boltenhagen (1977, p. 87)

Comparison: "The ornamentation of the species considered to bear a very great resemblance to that of *Palaeohystrichophora infusorioides* Defl. 1937, described longer. Thus, poorly preserved specimens of these two genera and of these two distinct species can easily be confused and, in the absence of the typical horns of *Deflandrea*, are practically indistinguishable with certainty. A fortiori, the specimens of poor conservation, which are the most frequent, can be assimilated to one or the other of the two species considered, indistinctly.

By its general appearance, the species described is very reminiscent of *Ascodinium verrucosum* Cook. and Hug. 1964 (p. 41, Pl. 5, Fig. 5). The difference consists in the position and the shape of the archeopyle and in the ornamentation. Among the various species of the genus *Deflandrea, D. macrocysta* Cook. and Eis. 1960 (p. 3, Pl. 1, Fig. 7–8) is quite close to our form, but it differs from it by its ornamentation formed by a tight granulation and the position of the cingulum which divides the theca into two unequal parts.

Furthermore, *D. dilwynensis* Cook. and Eis. 1965a (Pl. 18, Fig. 6–9) resembles the form considered by his silhouette but is distinguished by the absence of ornamentation, the longitudinal folding and the pronounced cingulum." — Translated from Boltenhagen (1977, p. 87, 88)

Age: Late Cretaceous (Turonian); holotype as translated from Boltenhagen (1977, p. 86). Range: Late Cretaceous (latest Albian–latest Turonian) (Boltenhagen, 1977, p. 88, table 12).

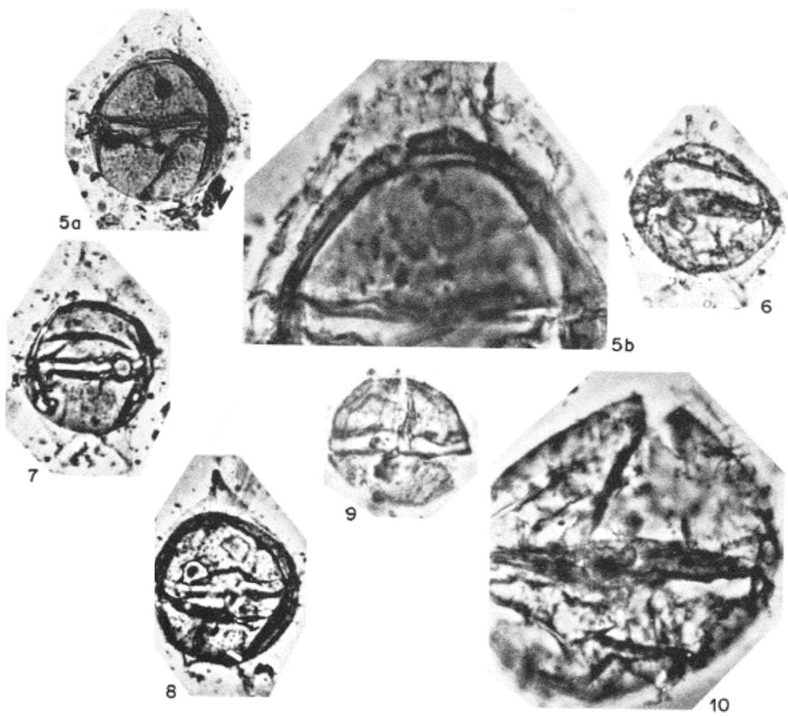


Plate 14, figures 5a–b, 6–10, Boltenhagen (1977).

?*Senegalinium ambiguum* He Chengquan in Zheng Yahui & He Chengquan, 1984

Description: "The outline is nearly *Peridinium*-shaped, the dorsum and venter are somewhat flattened, longer than wide, and the body is oval. Epitheca bell-shaped, with a short vertex, conical-triangular, about 5 μ long, blunt at the end, more or less 'shouldered' on both sides of the base of the vertices. Hypotheca inverted shape with two short antapical horns, same size and shape, blunt tip, 2.5–5 μ long, variable tail distance. The transverse groove is shallow, and the margin is marked by ridges, ridges or higher, short spines on the sides of the cyst near the equator, ring-shaped, 7.5–10 μ wide at the longitudinal groove limit. Under the light, fuzzy. No tabulation. The outer wall is thin, the surface is sparsely granular or nearly smooth, with creases, and the inner body is fuzzy and nearly elliptical. The capsule, except for its corners, is in contact with the outer wall. The surface is rough, and the edges are often wrinkled. Sulcus usually indistinct, occasionally in the anterior space there are cracks, which may be related to the archeopyle." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 100)

Dimensions: "The cyst is 60–68 μ long and 47.5–62 μ wide (7 specimens). The holotype is 68 μ long and 60 μ wide." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 100)

Comparison: "This one is quite similar to *Senegalinium microgranulatum* (Stanley, 1965, p. 219, pl .19, fig. 4-6), but the surface of the latter is smooth and the archeopyle is obvious. This species is dubiously placed in the genus *Senegalinium*." — Translated from He Chengquan in Zheng Yahui & He Chengquan (1984, p. 100)

Age: Late Cretaceous (Campanian); holotype as translated from the abstract of He Chengquan in Zheng Yahui & He Chengquan (1984, p. 55).

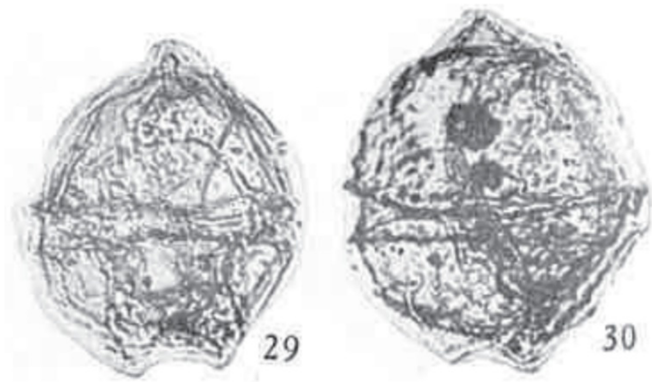


Plate 6, figures 29, 30, He Chengquan in Zheng Yahui & He Chengquan (1984).

Senegalinium bicavatum Jain & Millepied, 1973

Diagnosis: "Shell ovoid, non tabulate, bicavate, periphragm thin, zone of contact around equator large extending into one apical and two antapical horns leaving behind two or three pericoel area, surface serrate or smooth. Endophragm thick, dark, granulose with localized verrucose thickening along margins in pericoel areas. Archeopyle intercalary, penta- to hexagonal, below the apical horn. Transverse furrow indistinct, indication of longitudinal furrow present." — Jain & Millepied (1973, p. 23)

Description: "Epitract and hypotract nearly equal, epitract conical in outline, apical horn broader than long with apical pore; hypotract rounded antapically with two antapical horns of unequal size, acuminate. Intercalary archeopyle lies up to or below the capsule margin." — Jain & Millepied (1973, p. 23)

Dimensions: "Holotype: shell length 100 μ, breadth 65 μ; capsule length 63.7 μ, breadth 65 μ; apical horn length 6.5 μ, breadth (width of pericoel) 13 μ; antapical horn length 16.9 μ, breadth 12–20 μ. Range: shell length 90–100 μ, breadth 55–70 μ; capsule length 60–70 μ, breadth 55–70 μ; apical horn length 6–22 μ, breadth 13–30 μ; antapical horn length 6–16 μ, breadth 10–20 μ." — Jain & Millepied (1973, p. 23)

Age: Late Cretaceous (Campanian–Maastrichtian); holotype of Jain & Millepied (1973, p. 23).

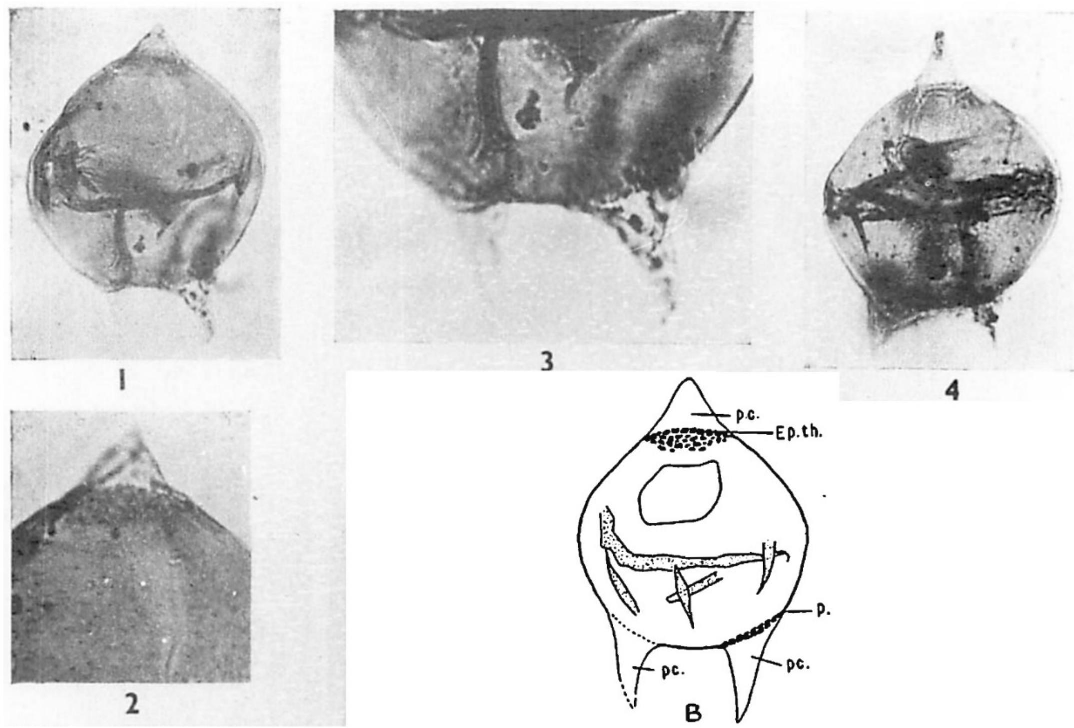


Plate 1, figures 1–4; text-figure 1B, Jain & Millepied (1973).

Senegalinium cuvillieri (Boltenhagen, 1977) Lentin & Williams, 1980

Diagnosis: "Theca of pentagonal outline, punctate to micrograulate, short horns, apical horn with rounded apex, pointed antapical horns, weakly-traced circular cingulum, usually edged with folds, wide sulcus. Capsule smooth almost adhering to the theca, except at the level of the horns." — Translation of Boltenhagen (1977, p. 99)

Description: "In dorsi-ventral projection, this species has an approximately pentagonal outline. The dimensions of the pentagon are sometimes strongly domed and the side belonging to the antapex is shorter than the others. In semi-lateral projection, the contour is ovoid. The fine membrane of the theca observed at 320× magnification, appears punctate or microgranulate. At 800× magnification and especially in phase contrast are perceptible in section median optic, microspinules of a few fractions of a micron in height, tightly packed which cover the whole surface of the theca. In projection on the theca, these microspinules produce the effect of tiny parallel dashes in places. The circular cingulum is weakly traced, usually more or less masked and deformed by folds of its edges. The sulcus crosses a large part of the hypotheca. Its edges are most often affected by folds. The apparently smooth capsule is almost adherent. A thin border is separated from the membrane of the theca, and its detachment is clearly visible only at the level of the horns. These last are short, conical or cylindrical-conical, more or less sunk into the theca. The apical horn is well rounded to the top, the other two are pointed. On the holotype, one sees on the epitheca sutures indications of a subtriangular intercalary archeopyle." — Translation of Boltenhagen (1977, p. 100)

Dimensions: "Holotype: theca with horns, L' = 88 μ, without horns = L'' × W = 77 × 84 μ; capsule: L''' × W = 72 × 80 μ; horns: apical, h' = 12 μ, antapicals: h''–h''' = 14, 10 μ; cingulum: W = 7 μ; Paratypes: theca with horns, L' = 108, 92, 83 μ, without horns = L'' × W = 80 × 90 μ, 73 × 74 μ, 71 × 80 μ; capsule: L × W = 77 × 84 μ, 69 × 72 μ, 69 × 76 μ; horns: apical, h' = 20, 23, 16 μ, antapicals: h''–h''' = 12, 17 μ; 13, 14 μ; 12, 20 μ; cingulum, W = 4, 5, 6 μ; three other specimens: theca with horns, L × W = 92 × 70 μ; 88 × 73 μ;

93 × 87 μ; capsule: L × W = 65 × 66 μ; 69 × 70 μ; 66 × 82 μ; horns: h = 12, 13, 15, 16, 17 μ; cingulum, W = 5, 6, 7 μ." — Translation of Boltenhagen (1977, p. 100)

Comparison: "This species is distinguished from other species of *Deflandrea* Eis. 1938 by its stubby theca that is completely occupied by the capsule, as well as by its cylindrical-conical apical horn, which is rounded while its antapical horns are pointed. By this last character, the species described resembles *D. conica* Voz. 1960 and differs by his microsculpture." — Translation of Boltenhagen (1977, p. 100)

Age: Late Cretaceous (Campanian); holotype as translated from Boltenhagen (1977, p. 99); Range: Late Cretaceous (late Santonian-late Campanian) (Boltenhagen (1977, p. 100, table 12).

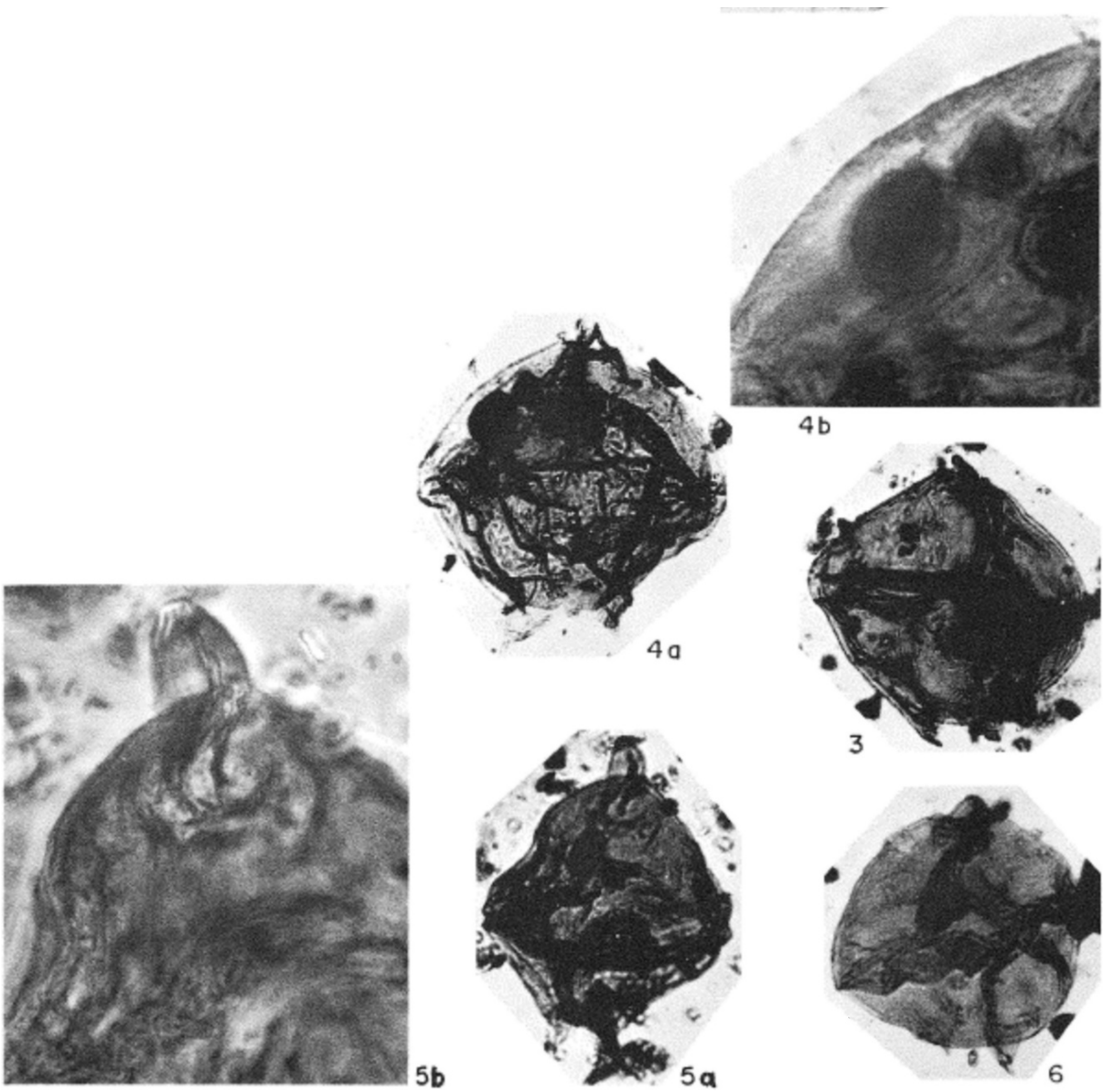


Plate 17, figures 3, 4a, b, 5a, b, 6, Boltenhagen (1977).

?*Senegalinium dilwynense* (Cookson & Eisenack, 1965c) Stover & Evitt, 1978

Description: "Shell small, not much longer than broad. Epitheca longer and broader than hypotheca with straight or more usually convex sides which continue into the short, blunt, apical horn, the tip of which is usually concave. Hypotheca with slanting sides and two short, widely separated horns; the one on the left-hand side is clearly defined, short, rather broad and pointed, the right-hand one usually considerably reduced. The wall of the shell thin, faintly dotted, untabulated, and usually with fine longitudinal folds. Girdle prominent, rather broad and slightly helicoid, bordered by two folds indicated laterally by deep concavities. Longitudinal furrow relatively broad, outlined by folds which extend from the epitheca to the bases of the antapical horns. Capsule relatively large, its outline following that of the shell which it almost fills. Archeopyle large, not always strongly outlined, trapezoidal, with either a straight or slightly convex distal edge which almost reaches the upper limit of the capsule." — Cookson & Eisenack (1965c, p. 141)

Dimensions: "Holotype: overall length 74 μ; overall width 62 μ; capsule 5[0?] × 47 μ. Range: overall length 56–76 μ; overall width 48–60 μ; capsule 42–57 × 42–52 μ." — Cookson & Eisenack (1965c, p. 141)

Age: Paleocene; holotype of Cookson & Eisenack (1965c, p. 141). Middle Paleocene (Selandian) given for the Pebble Point Formation by Stover (1973, p. 170)

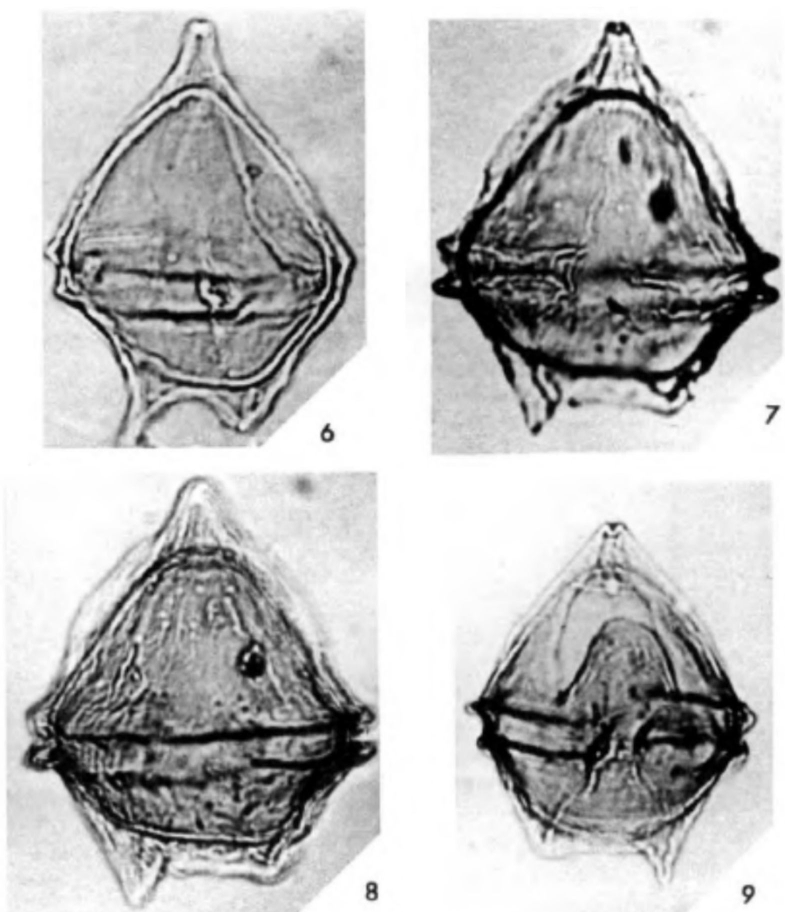


Plate 18, figures 6–9, Cookson & Eisenack (1965c).

Senegalinium ectorugosum (Archangelsky, 1969) Stover & Evitt, 1978

Diagnosis: "Subcircular to suboblong cyst, composed of two layers of even thickness. Periphragm smooth, marked and irregularly rough, with one apical horn and two antapical ones, one (right) much more developed than the another (left) that may even be missing. Cingulum present, helical. Endophragm smooth, subcircular in outline. Furrow marked by two most conspicuous folds of the periphragm, well-developed in the epi- and hypotract. Apical horn formed by abrupt narrowing of the periphragm and its subsequent projection. Archeopyle intercalary." — Translated from Archangelsky (1969, p. 192)

Dimensions: "Holotype (of 716 specimens): overall length: 78 μ, overall width: 57 μ, length of the endophragm: 50 μ; endophragm width: 50 μ; length of apical horn: 10 μ; length of the antapical horn: 5 μ. Other specimen measurements: total length: 61–87 (14 examples); total width: 40–60 μ (14 examples); endophragm length: 40–57 μ (14 examples); endophragm width: 41–53 μ (13 examples); length of apical horn: 8–16 μ (14 examples); length of right antapical horn: 3–11 μ (12 examples)." — Translated from Archangelsky (1969, p. 192)

Comparison: "This species belongs to the bilaterally asymmetrical *Deflandreae* group, a group that appears to dominate in the Río Turbio Formation. Its distribution is limited to the lower part of the formation, especially under the upper and lower carbonaceous layers. I only know it to have been located in surface profiles, since that the perforations of the wells do not arrive at depth. Its absence in higher levels seems to indicate extinction in the first stage of sedimentation of the Río Turbio Formation.

This species differs from all known in the genre by the nature of the irregularly folded or rough periphragm. The closest species is *Deflandrea microgramulata* Stanley (1965: 219) from the Paleocene of the USA; this is something minor and presents a microgranulated endophragm. Although the periphragm is rough, it is never as strong as in *D. ectorugosa*. Another comparable species is *Deflandrea asymmetrica*, which is larger and, although it presents folds, these are located in the marginal (lateral) sectors of the periphragm. Furthermore, the endophragm of this new species is typically circular in outline, having no projections towards horns as in *D. asymmetrica*." — Translated from Archangelsky (1969, p. 192)

Age: Eocene; holotype as translated from Archangelsky (1969, p. 192).

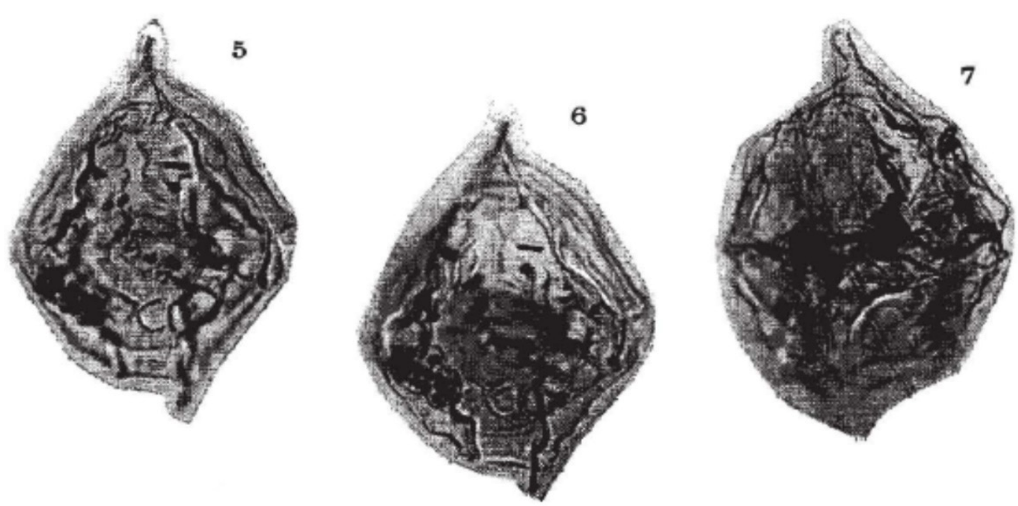


Plate 1, figures 5–7, Archangelsky (1969).

Senegalinium iterlaaense Nøhr-Hansen & Heilmann-Clausen, 2001

Description: "Cyst type: bicavate, peridinioid. Shape: dorso-ventrally compressed cyst, pericyst sub-pentagonal. The apical and the two antapical horns are strongly reduced. The antapical horns are almost equal in size and divided by a concave posterior margin. The epicyst and the hypocyst are divided by an outbulging, rather broad and deep cingulum, giving rise to deep notches on the lateral margins of the pericyst. The sulcus is deep and extends to the tips of the antapical horns. The epicyst is slightly longer than the hypocyst. The endocyst is ovoid to spherical. Wall relationship: the cyst is two-layered, bicavate and composed of a slightly striate/longitudinally folded, almost hyaline pericyst. The striation is often most pronounced in the cingular area, where the striation may give rise to weak denticles on the cingular parasutures. The endocyst is slightly darker than the pericyst. Tabulation: paratabulation is reflected by the archeopyle and the cingulum. The anterior and posterior parasutures of the latter [demarcated by?] continuous ridges. A wide and deep sulcus is present on the ventral surface. A precingular paraplate, presumably paraplate 4'', is recognised below or incorporated into the archeopyle. Two postcingular paraplates are recognised; one on each side of the sulcus, presumably paraplates 1''' and 5'''. Periarcheopyle: intercalary (2a) hexagonal, or an intercalary-precingular combination archeopyle (2a, 4'', with 4'' adnate at the posterior margin)." — Nøhr-Hansen & Heilmann-Clausen (2001, p. 164, 166)

Dimensions: "Holotype: overall length of pericyst 61 μ, width of pericyst 50 μ, length of endocyst 36 μ, width of endocyst 43 μ. Minimum, average and maximum dimensions of 9 specimens from Nuussuaq: overall length of pericyst 51 (59.8) 65 μ width of pericyst 36 (47.1) 52 μ, length of endocyst 27 (31.8) 36 μ, width of endocyst 34 (42) 47 μ. Minimum, average and maximum dimensions of 5 specimens from Hvalløse, Denmark: overall length of pericyst 48 (52.2) 56 μ width of pericyst 39 (41.0) 46 μ, length of endocyst 27 (29.4) 33 μ, width of endocyst 29 (31.6) 34 μ." — Nøhr-Hansen & Heilmann-Clausen (2001, p. 166)

Comparison: "*Senegalinium iterlaaense* n. sp. resembles, to some extent, *Senegalinium dilwynense* (Cookson & Eisenack 1965b) Stover & Evitt 1978. The latter species differs, however, by having a slightly longer epicyst and a well-developed left antapical horn. The most notable difference is that the cyst is cornucavate due to the sub-pentagonal endocyst which almost fills the pericyst. *Senegalinium iterlaaense* n. sp. also to some extent resembles *lsabelidinium*? *viborgense* which differs by having a smooth-walled almost pentagonal pericyst without any striation, and two small openings, one near the apex and one in the posterior part of the sulcus." — Nøhr-Hansen & Heilmann-Clausen (2001, p. 166)

Age: early Paleocene (late Danian); holotype of Nøhr-Hansen & Heilmann-Clausen (2001, p. 166, fig. 3). Range: early–middle Paleocene (middle Danian–early Selandian) (Nøhr-Hansen & Heilmann-Clausen (2001, p. 168).

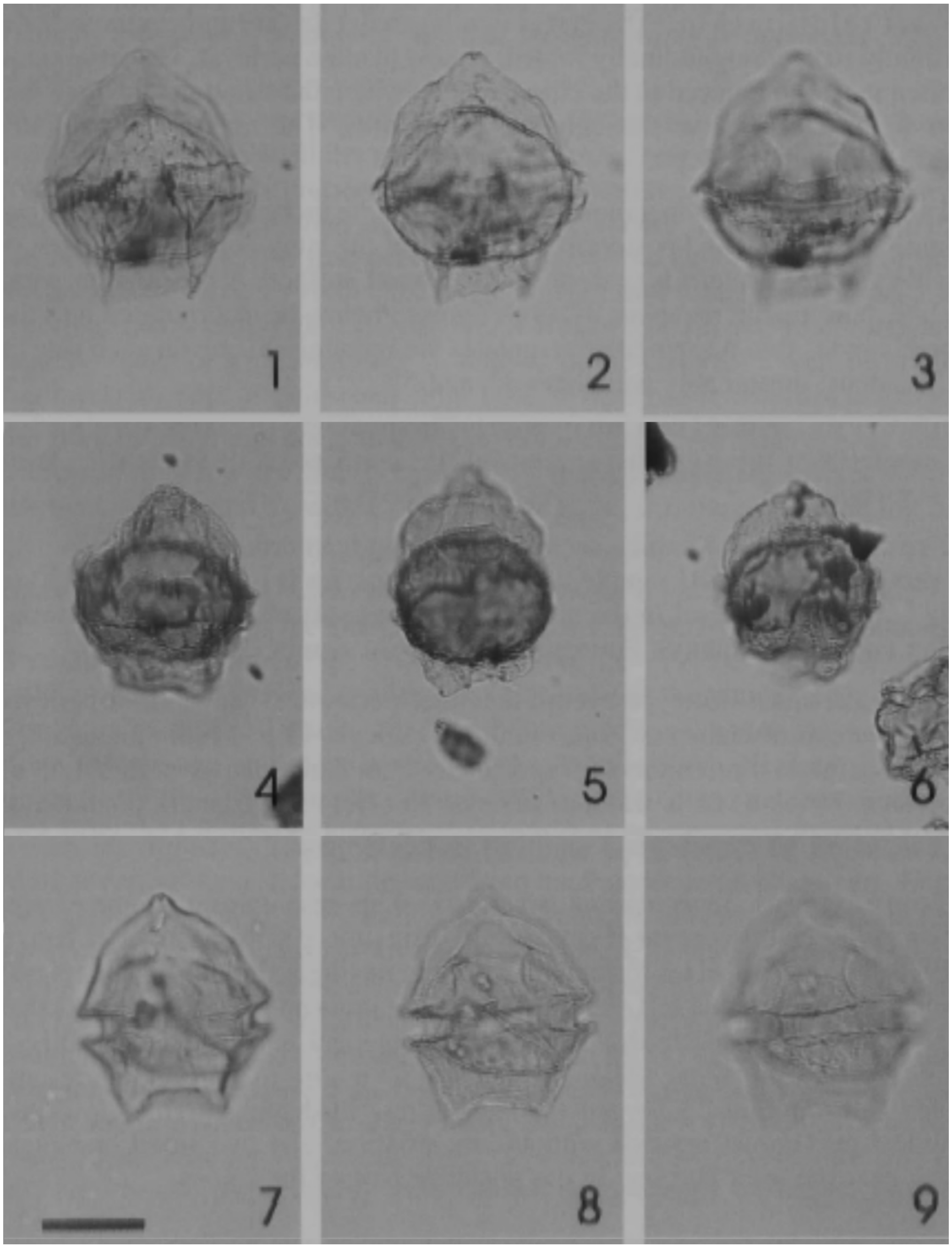


Figure 6, nos. 1–6, Nøhr-Hansen & Heilmann-Clausen (2001).

Senegalinium laevigatum (Malloy, 1972) Bujak & Davies, 1983

<u>Description</u>: "Outer cyst globose to sub-pentagonal in outline with a thin periphragm and a thick-walled inner cyst. The latter nearly fills the outer cyst and can be almost indistinguishable from it, except at the apices. Both apical and antapical horns are normally extremely low cones, and in globose specimens may be minute to nearly absent. Thickenings in the inner cyst wall are usually present at the bases of the horns. The surface of the periphragm is smooth, as is that of the endophragm, and both commonly display folding. The archeopyle is hexagonal, intercalary, and relatively large. No clear indications of either a girdle or tabulation are present, although transverse median folds are nearly always present in both the periphragm and endophragm." — Malloy (1972, p. 64)

Dimensions: "Holotype: length, normal to equatorial plane, overall, 64 μ; equatorial width, 72 μ; apical horn height 4, μ; antapical horns height 1.0, 1.5 μ. Length, normal to equatorial plane, overall 82 μ o 62 μ; equatorial width 74 μ to 52 μ." — Malloy (1972, p. 64)

Remarks: "*Deflandrea laevigta* sp. nov. appears to be a distinctively different species from those presently described for the genus. Its pronounced and heavy-walled inner cyst, often globose and filling almost the entire outer cyst, the extreme reduction of the apical and antapical horns, and the absence of a girdle structure set it apart. It shows only a moderate range of size variation in its major dimensions (20 and 22 μ respectively) which may be an indication of taxonomic stability. Other species of *Deflandrea* observed in the GLA-1X section are much more strongly cavate and clearly show reflected girdle, and often ventral furrow structures. *D. laevigatas* sp. nov. is Morphotype A of the lineage." — Malloy (1972, p. 64)

Age: Late Cretaceous (Senonian, pre-Maastrichtian); holotype of Malloy (1972, p. 64).

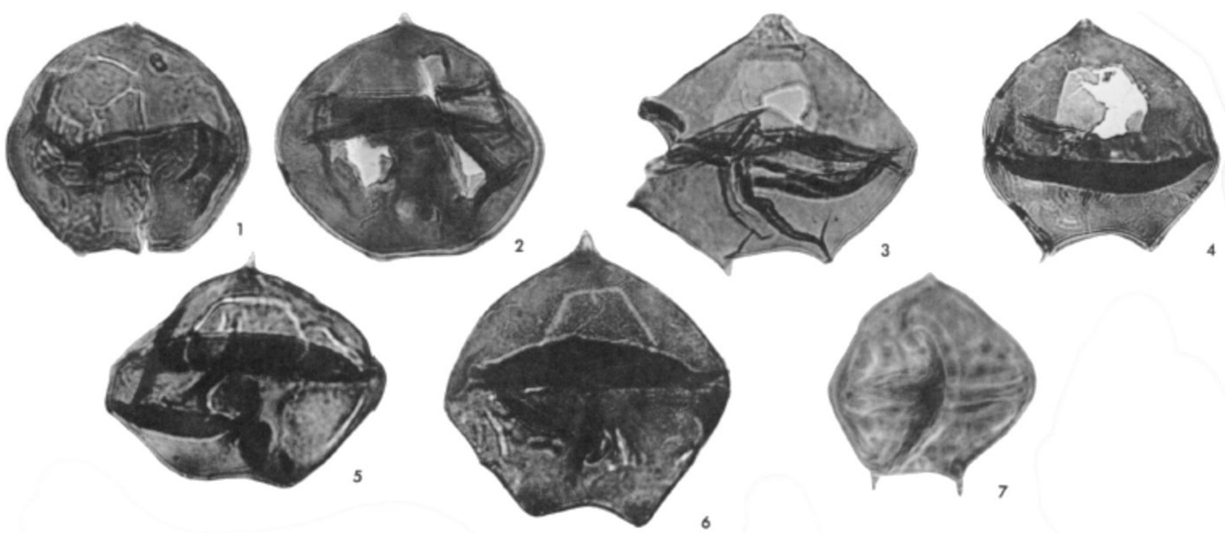


Plate 1, figures 1–7, Malloy (1972).

Senegalinium macrocystum (Cookson & Eisenack, 1960) Stover & Evitt, 1978

Description: "Shell almost entirely filled with a large spheroidal to ovoidal capsule; shell membrane thin and delicate, usually only evident at or near the apex, where it forms a triangular horn, and at the antapex, where it extends beyond the capsule as a flat expansion (often destroyed) in which occasionally there are indications of two antapical projections. A broad, shallow girdle divides the shell unequally, the epitheca being appreciably larger than the hypotheca. The wall of the capsule is rather thick and coarsely and densely granular. A pylome has not been observed." — Cookson & Eisenack (1960, p. 3)

Dimensions: "Holotype: 94 μ long; 67 μ, broad. Range: 80–109 μ × 55–70 μ." — Cookson & Eisenack (1960, p. 3)

Age: Late Cretaceous (Campanian); holotype of Cookson & Eisenack (1960, p. 3).

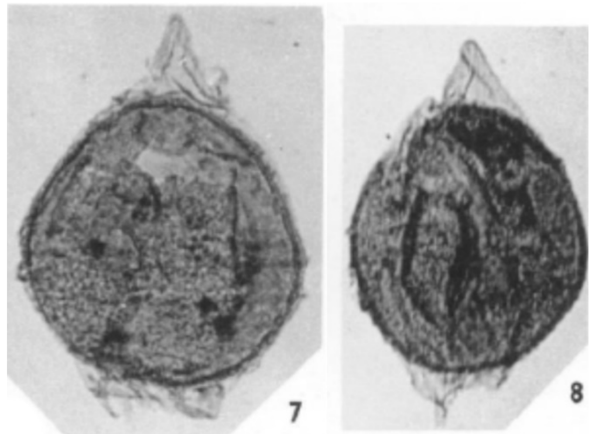


Plate 1, figures 7, 8, Cookson & Eisenack (1960).

Senegalinium maxicavernum Beilstein, 1994

<u>Diagnosis</u>: “A species of the genus *Senegalinium* Stover & Evitt 1978 by rounded hexagonal outline, bilayer cyst, hexagonal intercalary archaeopyle and dense granular pericyst sculpture.” — Translated from Beilstein (1994, p. 191)

<u>Description</u>: “In dorso-ventral view, the proximal, bicavate cyst has a rounded hexagonal outline. It has an intercalary, relatively narrow and also hexagonal archaeopyle. A planar cingulum divides the cyst into one of equal size hypo- and pericyst. The endocyst, which is transversely oval in outline and smooth, lies equatorially to the pericyst very closely, so that in both the epi- and the hypocyst a large pericoel is formed. A narrow one runs ventrally on the hypocyst sulcus almost to the antapex. The hypocyst bears two uniform antapical horns. These are symmetrical to the longitudinal axis of the cyst, gradually narrowing, and then taper distally. The epicyst has a triangular shape with slightly concave pages. A distally rounded apical horn arises from it. Evenly distributed over the pericyst are granules, sometimes to very small echinate sculptural elements thinned out, characterize the dense granular sculpture when viewed from the light microscope.” — Translated from Beilstein (1994, p. 191)

<u>Dimensions</u>: “Holotype: the specimen shown as Fig. 3 on plate 29, dimensions: periphragm length × width: 91 × 61, endophragm length x width: 51 × 67, apical horn: 10, antapical horn: 11, cingulum: 5 (GIK no. 1191). The specimen shown as Fig. 4 on plate 29 (preparation 1000/6, GIK no. 1192), dimensions: periphragm length × width: 85 (70–93) × 67 (50–68), endophragm length × width: 48 (43–60) × 66 (54–67), apical horn: 10 (7–12), antapical horn: 10 (8–13), cingulum: 6 (4–6).” — Translated from Beilstein (1994, p. 192)

<u>Remarks</u>: “Possibly they are *Senegalinium maxicavernum* n. sp. cysts identified by Lawal (1982) as *Senegalinium* sp. with 6 specimens described. However, these are not used here as synonyms for the new species, because Lawal (1982) did not provide a species diagnosis or pertinent made comparisons.” — Translated from Beilstein (1994, p. 192)

<u>Age</u>: Late Cretaceous (Maastrichtian); holotype as translated from Beilstein (1994, p. 300). Range: Late Cretaceous (Campanian–Maastrichtian) (Beilstein, 1994, p. 300).

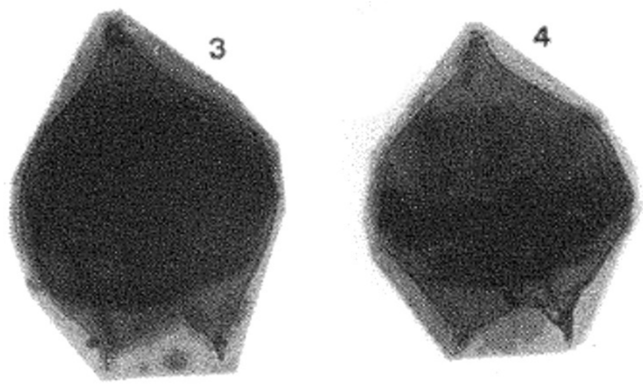


Plate 29, figures 3, 4, Beilstein (1994).

Senegalinium microgranulatum (Stanley, 1965) Stover & Evitt, 1978

Description: “Outer cyst subcircular in dorso-ventral view; length 54–57 μ, width 45–48 μ; outer cyst wall smooth and thin. Apical horn conically shaped, length about 7 μ; apical horn appears to bear a pore at its distal end. Antapical horns unequal in length with left one being short (about 5 μ in length), whereas the right one is only slightly developed. Inner cyst completely fills outer cyst, pentagonally shaped with the posterior end flattened; small granulations with a diameter of about 0.3 μ ornament [occur on] the membrane of the inner cyst. Girdle characterized by a wide band that is well developed on the dorsal side and blends into the furrow on the ventral side. Archeopyle often distinct with the anterior and posterior sides being about equal in length.” — Stanley (1965, p. 219)

Differential diagnosis: “*Deflandrea microgranulata,* n. sp. closely resembles *D. ventrisoa* Alberti, 1959. The only difference that could be determined from Alberti's description and illustration is that *D. microgranulata* has a slightly smaller size and the apical horn bears a distal pore. It may well be that *D. microgranulata* will have to be to put into synonomy [sic] at a later date. At present it is thought best to keep them separate.” — Stanley (1965, p. 219)

Age: early Paleocene (Danian); holotype of Stanley (1965, p. 217). Warwick et al. (2004) places the Cannonball Member of the Fort Union Formation as 65–61 Ma.

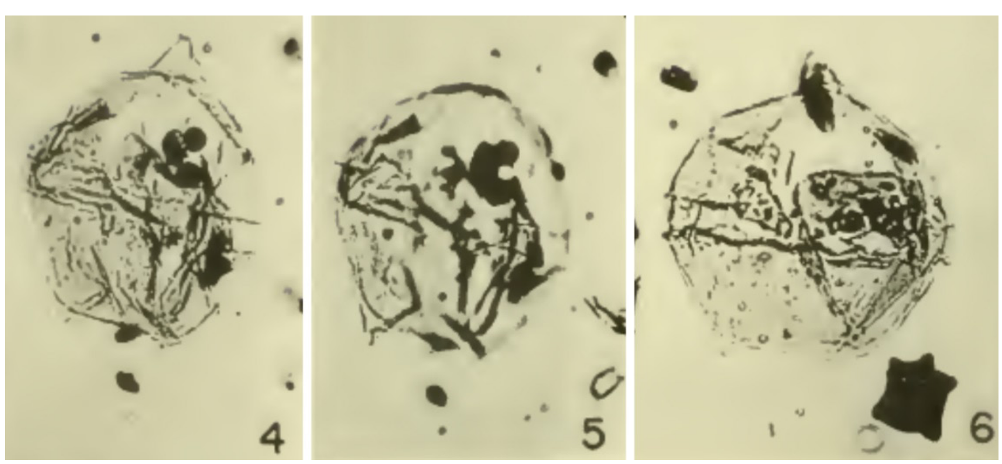


Plate 19, figures 4–6, Stanley (1965).

Senegalinium microspinosum (Boltenhagen, 1977) Lentin & Williams, 1980

Diagnosis: "Subspherical shape with short, conical horns of similar size; microwarts on theca; smooth capsule filling the theca and partially adhering to its walls. Pentagonal archeopyle with two straight lateral sides and three other arches. Cingulum broad, circular; open sulcus of subtriangular contour." — Translation of Boltenhagen (1977, p. 98)

Description: "This fragile species has a thin membrane that is rarely well preserved and is usually torn or deformed by folds. In dorso-ventral projection, the theca is subcircular in outline. The rounded epitheca extends by a more or less pronounced conical horn, often blunt or blunt at the top. The hypotheca is flattened between the two antapical horns. The latter, of a similar size, are also conical and generally blunted at their ends; their broad bases are perceptible between folds of the theca. The theca is entirely covered by conical microspinules or microwarts approximately 0.5 μ in height. That microsculpture is clearly visible only at magnification of 800× and especially in phase contrast. At magnification of 320× one sees only a microgranulation or on certain specimens simply a punctuation. The smooth capsule, voluminous of subcircular outline, is almost adherent to the theca. Folded or crumpled, it comes off entirely. The relatively wide cingulum is often masked by marginal folds but in this case stands out in median optical cross-section thanks to lateral notches. The sulcus observed on some specimens opening wide towards the cingulum; it ends in an acuminate furrow on two-thirds of the hypotheca. The archeopyle of theca, substantially pentagonal in outline, is 22–25 μ × 18–24 μ in opening along the diagonals, its outline roughly coincides with that of the capsule. On the latter, one observes a tear following the direction of the anterior suture of the operculum of the archeopyle. This tear causes a fold through the capsule, a phenomenon fairly frequently observed on the capsule of different species of the genus *Deflandrea*." — Translation of Boltenhagen (1977, p. 98, 99)

Dimensions: "Holotype: theca with horns, L' = 83 μ, without horns = L'' × W = 67 × 76 μ; capsule: L × W = 64 × 72 μ; horns: apical, h' = 12 μ, antapicals: h''–h''' = 12, 13 μ; cingulum: W = 6 μ. Paratypes: theca without horns, L'' × W = 66 × 68 μ; horns: apical (blunted), h = 7 μ; cingulum: W = 6 μ. According to 4 other specimens and their state of preservation: theca with horns, L' = 82–78 μ, without horns, L'' × W = 52–62 μ x 69–72 μ; horns: apical, h' = 10–14 μ, antapicals h'' = 12–15 μ; cingulum: W = 5–7 μ." — Translation of Boltenhagen (1977, p. 99)

Comparison: "The species described bears a certain resemblance to *Deflandrea* sp. Man. 1960 (p. 20, Pl. 1, Fig. 9) by the outline of the theca. It is distinguished essentially by the echinulated microsculpture of its theca, instead of fluted." — Translation of Boltenhagen (1977, p. 99)

Age: Late Cretaceous (Campanian); holotype as translated from Boltenhagen (1977, p. 98). Range: Late Cretaceous (late Santonian-late Maastrichtian) (Boltenhagen (1977, table 12).

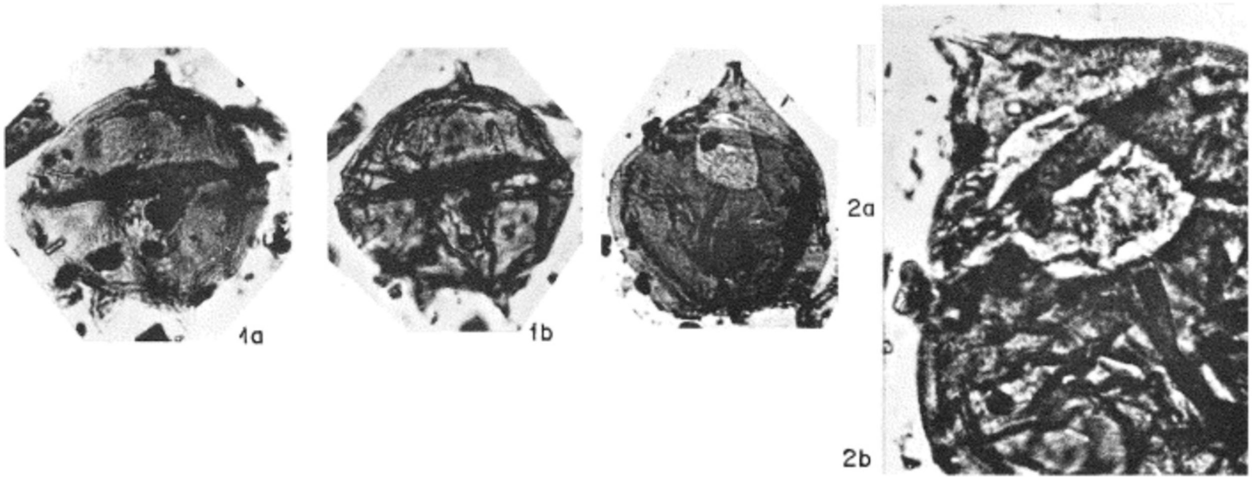


Plate 17, figures 1a–c, 2a, b, Boltenhagen (1977).

Senegalinium obscurum (Drugg, 1967) Stover & Evitt, 1978

Diagnosis: "Test ovoid in outline, bearing one short apical horn and two short unequally developed antapical horns. Test membrane closely adherent to the cyst which completely fills the test cavity except for the horns. Cyst wall thin and smooth, questionably punctate at times. Test wall smooth, occasionally bearing scattered grana. Girdle circular to slightly spiral, marked by low flanges which are sometimes denticulate. Longitudinal furrow delineated by folds on the hypotheca, barely extending onto the epitheca on some specimens. A six-sided archeopyle usually visible on the dorsal epitheca as is faint tabulation. The presence of this tabulation can be detected most easily by using phase contrast microscopy. The dorsal tabulation consists of 3 precingular plates, 3 intercalary plates (the center one functions as an operculum), and 1 apical plate. Sometimes 3 postcingular plates are also suggested as being present. The size ranges from 40 to 54 μ, wide and from 45 to 60 μ long. Abundant." — Drugg (1967, p. 17)

Comment: "By possessing rudimentary tabulation, this species resembles those described by Manum (1963) such as *Deflandrea scheii*, but differs considerably in gross detail. It differs from *D. minor* Alberti 1959 in possessing tabulation, reduced horns, and a cyst more closely appressed to the test. Other similar species are *D. venlriosa* Alberti 1959 and *D. microgranlliata* Stanley 1965. The non-granular cyst of *D. obscura* serves to separate it from these two species." — Drugg (1967, p. 17)

Age: Late Cretaceous (Maastrichtian)–early Paleocene (Danian); holotype of Drugg (1967, p. 17).

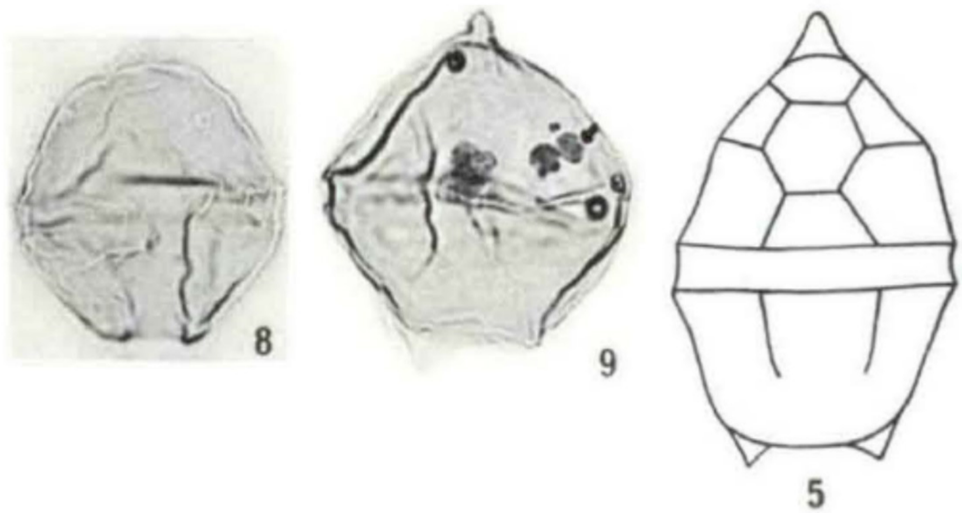


Plate 2, figures 8, 9; Plate 9, figure 5, Drugg (1967).

Senegalinium orei (Jan du Chêne & Adediran, 1985) Stover & Williams, 1987

<u>Description</u>: "Cyst proximate, cornucavate with a typically peridinoid [sic] shape, prolonged into one short, pointed apical horn and two longer symmetrically-located, antapical horns of more or less equal length. The endophragm is pentagonal and closely appressed to the periphragm except at the bases of the apical and antapical horns. The pericoels are extremely reduced; the endocyst may protrude slightly into the antapical horns. The periphragm is irregularly granulate. The characteristic penitabular ornamentation is difficult to observe. The paracingulum is well defined and is interrupted by the parasulcal furrow. The periarcheopyle is of hexa-type and corresponds to the 2a paraplate. The operculum is free but may remain adherent to the cyst on some specimens." — Jan du Chêne & Adediran (1985, p. 29)

<u>Dimensions</u>: "Holotype, overall length 96 μ, overall width 64 μ. Range, overall length 82–100 μ, overall width 50–64 μ. Number of specimens measured: 4." — Jan du Chêne & Adediran (1985, p. 29)

<u>Comparison</u>: "Bujak (1980) attributed two species to his genus: *Lentinia serrata* which shows a coarse denticulate ornamentation absent in our specimens, and *Lentinia wetzelii* which has a pericyst with similar breadth in the precingular, cingular and postcingular area. The pericoels are much larger in *L. wetzelii* than in *L. serrata* and *L. orei* n. sp." — Jan du Chêne & Adediran (1985, p. 29)

<u>Age</u>: late Paleocene (Thanetian); holotype of Jan du Chêne & Adediran (1985, p. 8, 29).

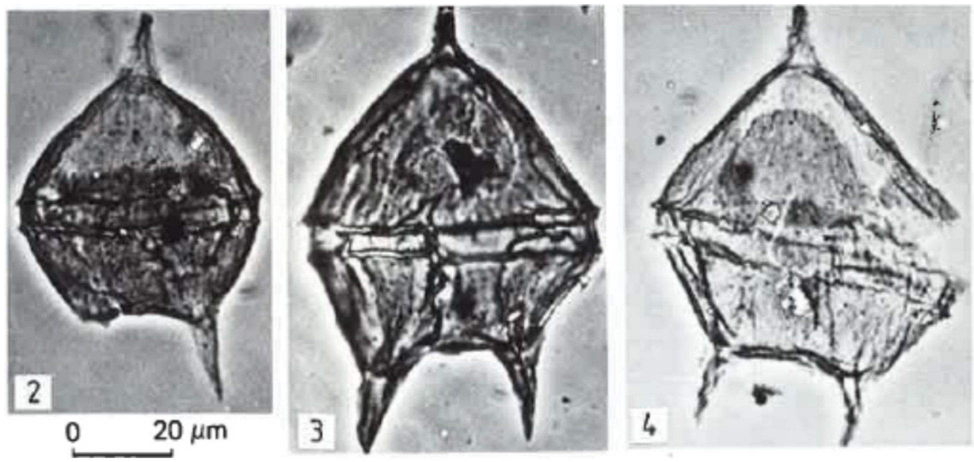


Plate 1, figures 2–4, Jan du Chêne & Adediran (1985).

Senegalinium pallidum Lucas-Clark, 2006

Diagnosis: “Medium to large pale peridinioid cyst. Circumcavate [sic, cornucavate], rounded ovoidal to rectangular in shape with short apical and antapical horns. Thin walled and pale. Distinguished by its size, shape, and pale, thin walls.” — Lucas-Clark (2006, p. 200)

Description: “Medium to large proximate peridinioid, cornucavate cysts, dorsoventrally compressed with short apical and antapical horns. The apical horn consists of a short knob-like protrusion; antapical horns are slight protrusions sometimes formed into short spines. The antapical horns are approximately equally developed. Endophragm smooth, thin, appressed to periphragm except beneath horns. Periphragm also thin, unornamented but with irregular folds and wrinkles not related to tabulation. Endocyst widely ovoidal; pericyst roundly, widely ovoidal to slightly peridinioid in shape; lateral margins convex smoothly from apical to antapical regions, antapical margin straight to slightly concave. Tabulation indicated by archeopyle and by faint wrinkling at cingulum that is expressed as a slight bulge in the lateral margins of the periphragm. Archeopyle type I/I (2a), rounded, probably hexagonal, but of somewhat uncertain shape, probably isodeltaform with rounded corners, difficult to observe. Sulcus not indicated.” — Lucas-Clark (2006, p. 200)

Dimensions: “Length, 110–120 μm; width, 90–100 μm (2 specimens measured).” — Lucas-Clark (2006, p. 200)

Remarks: “This species is rare. It is distinguished by the thin walls, irregularly folded and wrinkled surface, and its wide, rounded shape and small inconspicuous horns.” — Lucas-Clark (2006, p. 200)

Comparison: “This species resembles *Chatangiella*? *dakotaensis*, but it has a 2a archeopyle, thinner walls, and lacks apical and antapical pericoels. It resembles *Senegalinium simplex* sp. nov., but has a thinner walled endocyst, is not circumcavate, and is generally larger.” — Lucas-Clark (2006, p. 200)

Age: late Paleocene (Thanetian); holotype stratal position at 109.5 m in core P21 of Savannah River Site not provided (Lucas-Clark, 2006, p. 200). Range: Paleocene (late Danian–late Thanetian) (Lucas-Clark, 2006, text-fig. 2).

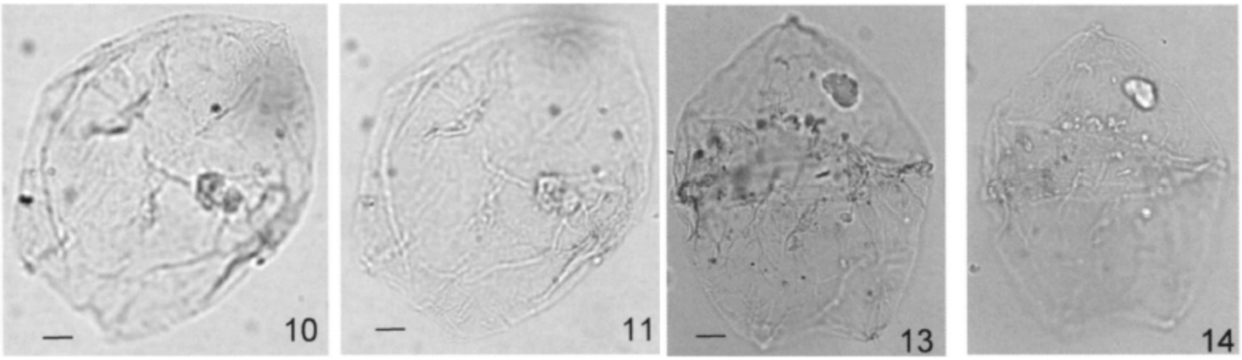


Plate 3, figures 10, 11, 13, 14, (Lucas-Clark, 2006).

Senegalinium sergipense (Herngreen, 1975) Lentin & Williams, 1980

Description: "Outer cyst irregular subglobose to pentagonal in outline. Periphragm in close contact with the endophragm but always clearly separated from it. Apical horn occasionally bulbous, at the base tapering into a conus. Two antapical horns which are equal in size. Thickenings in the endophragm are usually present at the bases of the horns. Endophragm smooth, periphragm scabrate to verrucate in some specimens more or less baculate or echinate. Presence of either a girdle or tabulation not clear; transverse folds are common. In some specimens an indistinct pentagonal archaeopyle occurs." — Herngreen (1975, p. 61)

Dimensions: "Holotype: overall length 108 µ, equatorial width 80 µ. Endophragm 84 x 74 µ, apical horn: height 13 µ, width 12 µ. Four other specimens 72 × 66 µ, 89 × 68 µ, 92 × 64 µ and 100 × 88 µ. Apical horn about 9–12 × 8–13 µ" — Herngreen (1975, p. 61)

Remarks: "*Deflandrea sergipensis* nov. sp. is distinctly different from the species included to date in the genus. The inner cyst filling almost the entire periphragm, the absence of a girdle and a tabulation and the presence of a scabrate-verrucate ornamentation set it apart.

The types *Senegalinium* sp. A and B of Jain & Millepied (1973) show some resemblance with *D. sergipensis* nov. sp. However, *Senegalinium* sp. A has e.g. slight longitudinal striations and the B-form possesses antapical horns which are unequal in size. *Deflandrea* sp. C in Drugg (1967), recorded from the Danian of California, it almost similar to *D. sergipensis* nov. sp. but differs from it by a more distinct girdle and a longitudinal furrow." — Herngreen (1975, p. 61, 62)

Age: Late Cretaceous (late Senonian); holotype of Herngreen (1975, p. 61).

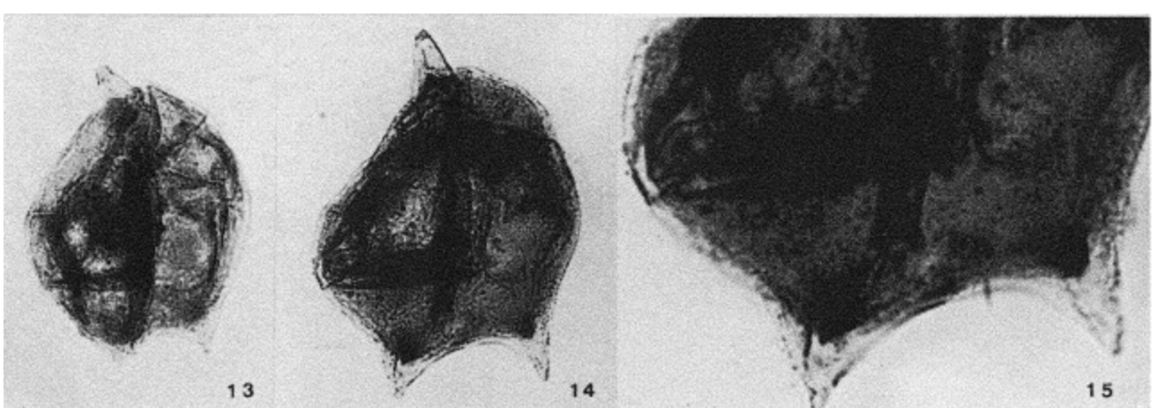


Plate 3, figures 13–15, Herngreen (1975).

?*Senegalinium simplex* Lucas-Clark, 2006

Diagnosis: "Small to medium pale peridinioid with thin, pale periphragm and more robust endophragm. Periphragm often lost. Smooth or with fine, irregularly shaped granules on periphragm. Short apical and antapical horns. Endoarcheopyle hexagonal 2a, eurydeltaform; periarcheopyle difficult to observe. Distinguished by extremely small horns, smooth surface and contrast between thin periphragm and thicker endophragm, clear endoarchopyle. Often found as isolated endocysts" — Lucas-Clark (2006, p. 201)

Description: "Small to medium proximate peridinioid, circumcavate cysts, dorsoventrally compressed, with short apical and antapical horns. Antapical horns usually approximately equally developed, or right horn reduced. Endophragm smooth, thicker than periphragm; endocyst ovoidal to peridinioid in shape, often found without enclosing periphragm endo- and periphragm may at first appear to be closely appressed except under horns, but careful examination indicates that they are not appressed. Periphragm thin, usually only discernible at the horns; pericyst ovoidal to roundly peridinioid in shape; lateral margins convex; antapical margin slightly concave. Periphragm rarely ornamented with a few granules or denticles randomly scattered; periphragm usually has some folds not related to tabulation except at the cingulum. Tabulation indicated by archeopyle and sometimes by partial cingulum. Other indications of tabulation absent. Archeopyle type I/I (2a), hexagonal, eurydeltaform; endoarcheopyle clearly expressed; nature of the periarcheopyle uncertain; endoperculum free, sometimes found within cyst. Cingulum sometimes incompletely indicated by weak folds in periphragm; sometimes indicated by a slight local indentation of the endocyst. Sulcus sometimes indicated by a slight depression of periphragm on ventral hypocyst." — Lucas-Clark (2006, p. 201)

Dimensions: "Length, 40–100 μm; width, 35–90 μm (10 specimens measured)." — Lucas-Clark (2006, p. 201)

Remarks: "This species is difficult to assign to a genus. Although it is questionably assigned to *Senegalinium* herein, it is circumcavate, and appears to lose the periphragm much of the time, hence its apical pericoel is in communication with the exterior, unlike most species of *Senegalinium* according to Stover and Evitt (1978, p. 122). It could be assigned to *Alterbidinium*, but in most cases, the antapical horns are approximately equally developed. *Phelodinium* is large, has straight to convex sides and is cornucavate. *Isabelidinium* has an endocyst that is wider than it is long and has a more prominent apical pericoel. *Andalusiella* has a long antapical horn in the periphragm and a substantial apical horn. *Senegalinium*? *simplex* is generally found as isolated endocysts (Plate 4, figs. 3–4). Although it is not certain that the endocyst is the same species, this seems likely because it occurs in the same samples as the cavate cysts, is the same size and shape as the endocysts of the cavate cysts, and has an identical archeopyle." — Lucas-Clark (2006, p. 201)

Comparison: "This species is similar to *Senegalinium obscurum*, but lacks the faint indications of tabulation described and illustrated by Drugg (1967). It also has a less clear cingulum, and lacks denticulation of the cingulum, and grana on the surface of either the endophragm or periphragm are rare or absent. ?*Andalusiella rhombohedra* is clearly a different species. It has a relatively long antapical horn and substantial apical horn. The overall shape is rhombohedral due to a pronounced difference in the development of the antapical horns, both in the endocyst and the pericyst. Also, Benson (1976) described and illustrated a 'microreticulate surficial sculpture' that is not present in ?*Senegalinium simplex* sp. nov., and this author did not mention isolated endocysts. However, Benson (1976) considered *Deflandrea rhombohedra* to be conspecific with *Deflandrea rhombohedra* of McLean (1971); the latter form is *Senegalinium*? *simplex* sp. nov. The pericyst does not extend out into long antapical horns nor a pronounced apical horn, and McLean (1971) stated that the pericyst is often torn, leaving an isolated endocyst. It differs from *Senegalinium*? [sic] *simplex* sp. nov. only in having a more pronounced difference in the antapical horns. This is believed to be within the normal range of variation for a species, and questions the use of this character for differentiation between genera. Edwards et al. (1984) and Edwards (2001) illustrated specimens like those of McLean (1971), with a pronounced difference between antapical horns, but otherwise closely resembling *Senegalinium* [sic] *simplex* sp. nov. Edwards (2001) expressed doubt about her assignment of the specimen to the species of Benson (1976) species by using the term '?*Andalusiella rhomohedra* of Edwards and others (1984)' . The latter specimen was found in the Ellenton Formation of Georgia, which again suggests it is *Senegalinium*? *simplex* sp. nov." — Lucas-Clark (2006, p. 201)

<u>Age</u>: late Paleocene (Thanetian); holotype stratal position at 92.7 m in core P18TB of Savannah River Site not provided (Lucas-Clark, 2006, p. 200). Range: Paleocene (late Danian?–late Thanetian) (Lucas-Clark, 2006, text-fig. 2).

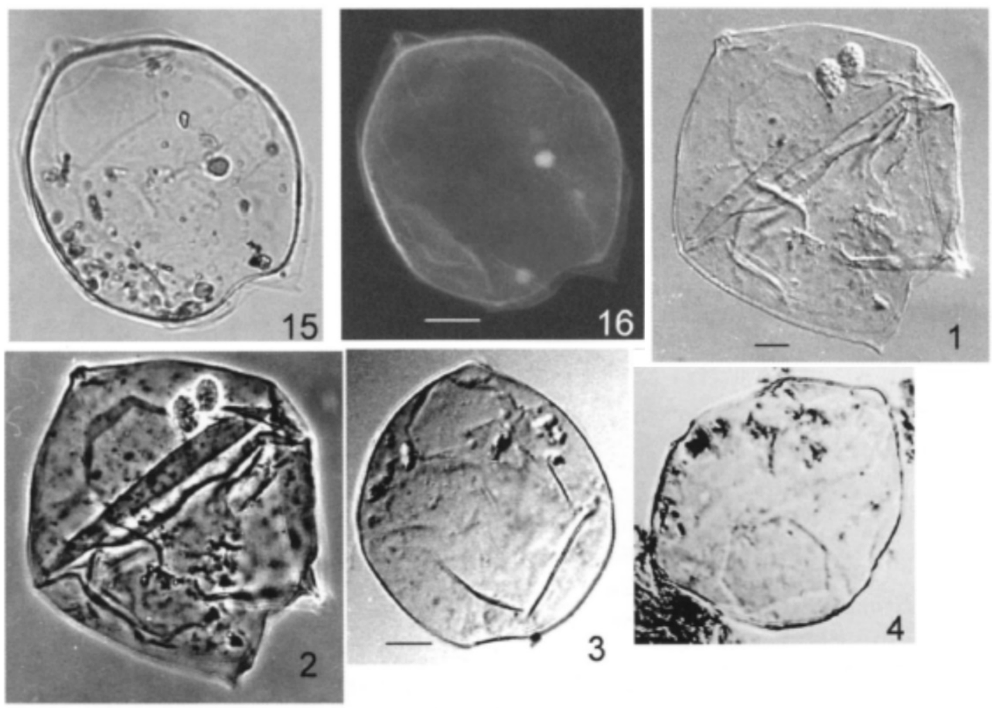


Plate 3, figures 15, 16; Plate 4, figures 1–4, Lucas-Clark (2006).

Genus ***SPINIDINIUM*** Cookson & Eisenack, 1962

1962 *Spinidinium* Cookson & Eisenack: 489.
2003 *Magallanesium* Quattrocchio & Sarjeant: 138, 140.
1976 *Spinidinium* Cookson & Eisenack; emend. Lentin & Williams: 62, 63.
2003 *Spinidinium* Cookson & Eisenack; emend. Quattrocchio & Sarjeant: 134, 135.
2009 *Spinidinium* Cookson & Eisenack; emend. Sluijs et al.: 46.

Spinidinium argentinium Lentin & Williams, 1985

Diagnosis: "Proximocorate ellipsoidal cysts with a short, wide, forked apical horn. In the antapical pole it presents a small toothed crest. The autophragm presents solid spines that do not reflect tabulation except in the paracingulum and the parasulcus. The archeopyle is intercalary of type Ia, sometimes faintly outlined. The operculum is always attached." — Translated from Pöthe de Baldis & Ramos (1983, p. 438)

Discussion: "According to Morgan (1975), *Dioxya* is characterized by a wide horn apical and an eccentric antapical horn or two unequal antapical horns. In our case, the antapical horn is replaced by a denticulate antapical ridge. We have not considered this fact sufficiently characteristic enough to separate it from the genus, since the rest of its features respond to it perfectly. The most similar species is *D. armata*, which differs entirely in the characteristic of the antapical horn." — Translated from Pöthe de Baldis & Ramos (1983, p. 438)

Dimensions: "Overall width: 48 μ (50) (20 copies); overall Length: 61 μ (65)." — Translated from Pöthe de Baldis & Ramos (1983, p. 438)

Age: Early Cretaceous (early Aptian); holotype of Pöthe de Baldis & Ramos (1983, p. 427).

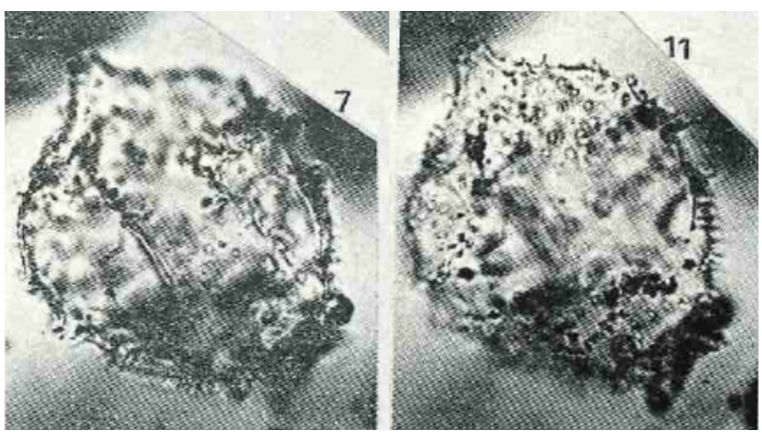


Plate 2, figures 7, 11, Pöthe de Baldis & Ramos (1983).

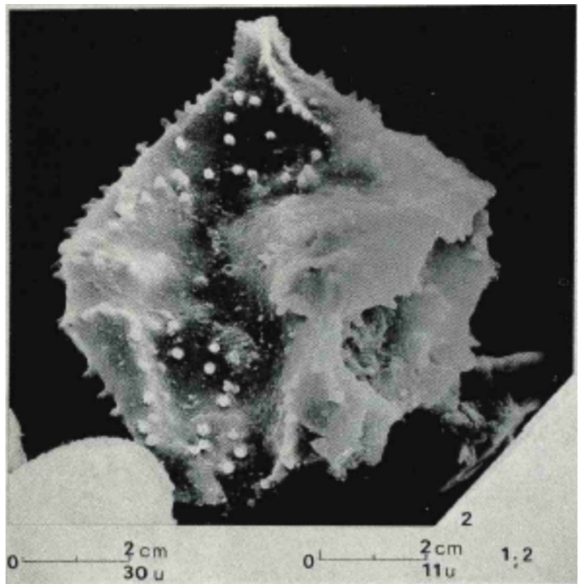


Plate 4, figure 2, Pöthe de Baldis & Ramos (1983).

Spinidinium balmei (Cookson & Eisenack, 1960) Cookson & Eisenack, 1962; Ioannides, 1986.
Emendation: Morgan, 1977, p. 130

Description: "Shell approximately oval, divided by a shallow but relatively broad girdle. The epitheca tapers to a short truncate or concave apex; the hypotheca is broadly rounded, with one or two small lateral points of unequal size. A rather broad longitudinal furrow is usually evident. The capsule is circular in outline and does not fill the shell laterally. The shell membrane is sparsely covered with small spines, which tend to be linearly arranged on the general surface as well as on the borders of the girdle and longitudinal furrow. The wall of the capsule is thin and smooth. The pylome is small and semicircular to trapezoid." — Cookson & Eisenack (1960, p. 2)

Dimensions: "Holotype: 52 μ long; 40 μ broad; capsule 33 μ. Range: 45–65 μ long; 37–43 μ broad." — Cookson & Eisenack (1960, p. 2)

Comments: "It seems probable that the single rather imperfect specimen from the Molecap greensand referred to as *Palaeohystrichophora minuta* by Deflandre and Cookson (1955, text-fig. 4) is identical with *Deflandrea minor* sp. nov. However, as neither author knows the whereabouts of the type of *Palaeohystrichophora minuta*, there is no way of establishing such an identity." — Cookson & Eisenack (1960, p. 2)

Emended description: "Broadly rhomboidal to subpentagonal ambitus, with a truncate apical horn and one, or two unequal, sharp antapical horn(s) on the periphragm and an ellipsoidal endophragm. The apical and antapical pericoels may be united by an ambital pericoel. The periphragm uniformly thin, and drawn into small, 2 μm high, sharply pointed spines. The endophragm is thin and psilate. Traces of paratabulation sometimes discernible by sutural alignment of spines on pericyst; pericingulum defined by two slightly raised ridges bearing aligned granules, slightly helicoidal, individual paraplates not seen; perisulcus psilate; periarcheopyle standard hexa Ia (2a only); endophragm psilate, endoarcheopyle not clearly discernible, probably Ia." — Morgan (1977, p. 130)

Comment: "The specimen referred to as *Palaeohystrichophora minuta* by Deflandre and Cookson (1955, p. 257–8, text. fig. 4) is considered to belong to *A. balmei* for the following reasons: The size of *P. minuta*

(40 × 26 μm) is considerably smaller than the smallest Australian specimen of *Diconodinium* (*D. multispinum*, 56 × 38 μm) yet recorded. Sparse, 1.5 μm sharply pointed spines of *P. minuta* are unknown in *Diconodinium* to date, but they are characteristic of *A. balmei*. The apparent autophragm of *P. minuta* may be a 'freak' *Alterbia balmei* specimen lacking an endophragm. Such a specimen was figured by Cookson and Eisenack (1960, Pl. 1, fig. 3). The paracingulum of *P. minuta* is not clearly delineated by dense aligned spines as in spinose *Diconodinium* species, but is poorly defined by sparse spines as in *A. balmei*. The paracingulum of *P. minuta* is broad relative to the total cyst length, a feature seen in *A. balmei*, but not seen in Australian specimens of *Diconodinium*." — Morgan (1977, p. 130, 131)

<u>Description</u>: "Shape compressed peridinoid, subpentagonal with a truncate apical horn and a left antapical horn; right antapical horn reduced. Antapical outline, between horns, straight to concave. Endocyst subcircular to elongate ovoidal. Cyst circumcavate but pericoel reduced medially. Parasutural features consist of cones and acuminate to oblate spines arranged in penitabular rows; periphragm otherwise smooth and thin, 1 μm or less. Endophragm thin, punctate to granular, grana more prominent on periphery when viewed dorsoventrally. Paratabulation peridiniacean, indicated by penitabular rows of ornament, formula ?4, 3a, 7", 5 or 6c, 5"', 2"". Archeopyle intercalary, type I or Ia (2a only). Paracingulum indicated by transverse folds and ornament arranged into two parallel interrupted rows suggesting the presence of at least 5 plates, dividing the cyst into a slightly larger epicyst than the hypocyst. Parasulcus indicated by longitudinal disposition of ornament, which delimits sulcal depression and may extend on epicyst." — Ioannides (1986, p. 35)

<u>Dimensions</u>: "Overall cyst length 62–74 μm, width 43–48 μm; endocyst length 40–50 μm, width 33–40 μm; apical horn up to 9 × 7 μm in height and width, antapical horn 10 × 10 μm; cingulum 8–10 μm wide, ornament 8–10 μm wide, ornament up to 3 × 2 μm in height and width (3 specimens measured)." — Ioannides (1986, p. 35)

<u>Age</u>: Late Cretaceous (late Turonian–middle Senonian); holotype of Cookson & Eisenack (1960, p. 2). Range: Late Cretaceous (Turonian–Maastrichtian) (Morgan, 1977, p. 131).

<u>Note</u>: The species *Deflandrea minor* of Cookson & Eisenack (1960) was changed to *Deflandrea balmei* by Cookson & Eisenack (1962, p. 486), and the species was subsequently reassigned to *Spinidinium* by Ioannides (1986, p. 35) "on the basis of ornament distribution".

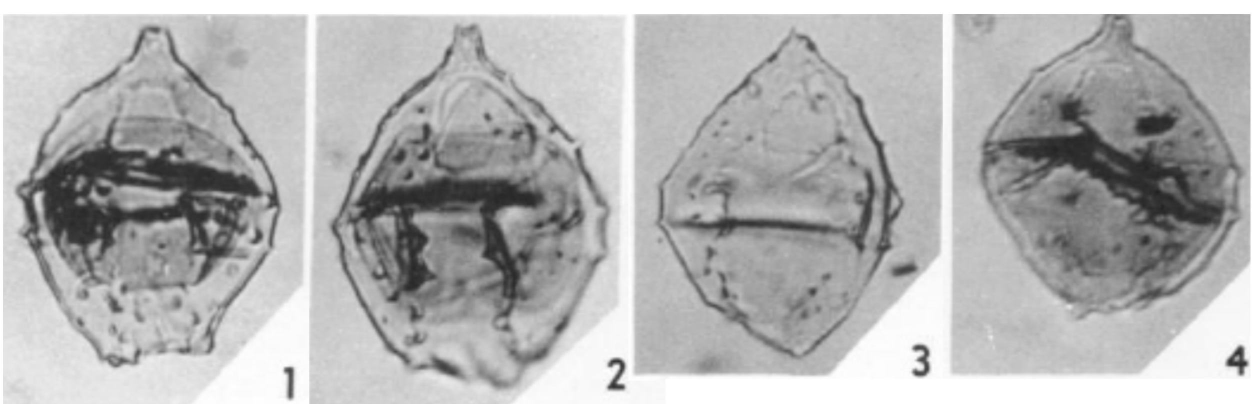
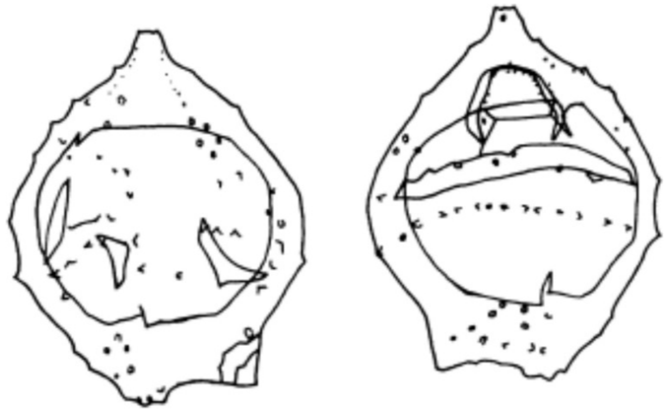


Plate 1, figure 1–4, Cookson & Eisenack (1960).



Text-figure 2, Morgan (1977).

Spinidinium bellum Lucas-Clark, 2006

Diagnosis: “Small to medium peridinioid cysts, circumcavate, with small to medium apical horn and small, unequally developed antapical horns. Covered in a unique spinose to reticulate ornamentation involving small knobs with widened and sometimes interconnected tips. Distinguished by its ornamentation.” — Lucas-Clark (2006, p. 202)

Description: “Small to medium, proximate peridiniacean, cornucavate to circumcavate cysts with a short apical horn and one or two short antapical horns. Antapical horns are unequal in length; right antapical horn reduced or absent. Endophragm smooth to finely granular, about equal in thickness to periphragm, may be appressed to the periphragm in the cingular region. Endocyst circular to ovoidal. Pericyst outline rounded peridinioid lateral margins convex; antapical margin concave. Periphragm surface ornamented with coarse, irregularly shaped granules and small processes with knobs and cauliflorate tips. Some knobs appear to be connected as if beginning to form an ectophragm. Ornament intratabular with bare or less ornamented spaces along most sutures. Tabulation indicated by archeopyle, cingulum, and intratabular ornamentation. Tabulation formula 4', 3a, 7'', ?c, 5''', ?s, 2''''. Archeopyle type I (2a), hexagonal, eurydeltaform; operculum free. Accessory archeopyle sutures lie on either side of plate 4'. Exact relationship of endoarcheopyle and periarcheopyle not clear. Cingulum indicated by ornamented ridges and by local indentation in the periphragm; offset at the sulcal region. Sulcus indicated by break in cingulum and depression in the ventral hypocyst. Accumulation bodies sometimes present.” — Lucas-Clark (2006, p. 202, 204)

Dimensions: “Length, 75–85 μm; width, 55–65 μm (5 specimens measured).” — Lucas-Clark (2006, p. 204)

Remarks: “Tabulation is not as clearly expressed in this species in some other forms, but some sutural smooth areas are discernible in all specimens. Tabulation is often not clear in this genus, e.g. in *Spinidinium densispinatum*. The unusual ornamentation of the periphragm makes generic assignment difficult, as no such ornamentation is included in the description of the genus, however, the intratabular arrangement and general aspect are similar to other species of *Spinidinium*.” — Lucas-Clark (2006, p. 204)

Comparison. “The unusual ornamentation of this species distinguishes it from others.” — Lucas-Clark (2006, p. 204)

Age: early Paleocene (Danian); holotype of Lucas-Clark (2006, p. 204, text-figure 2). Range: Paleogene (Lucas-Clark, 2006, p. 204).

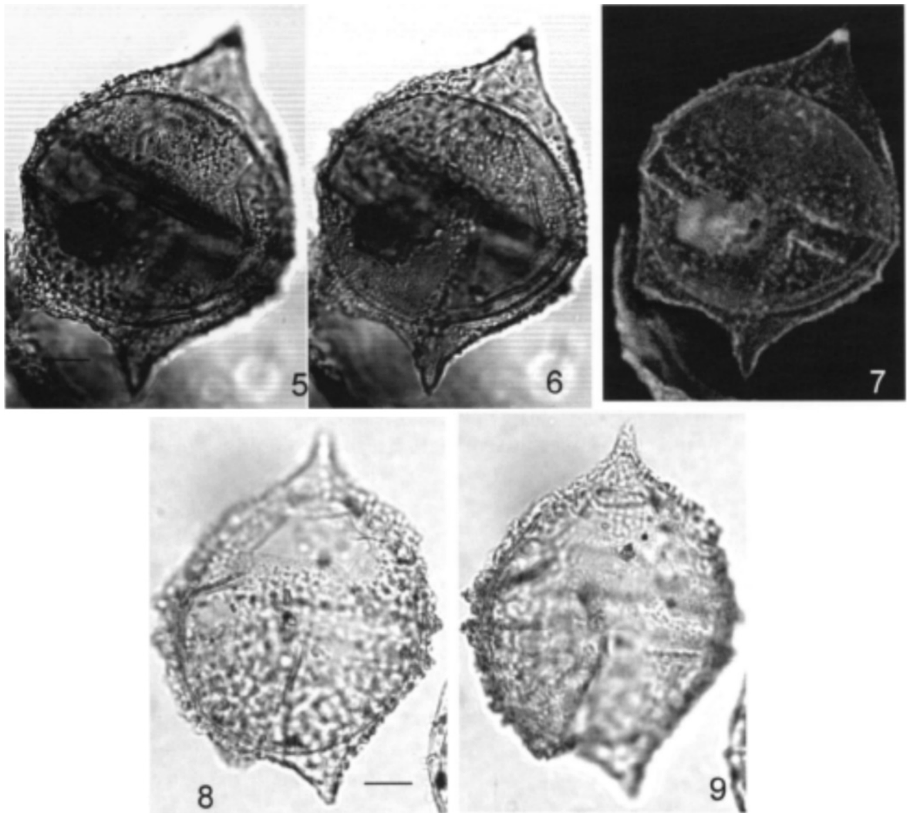


Plate 4, figures 5–9, Lucas-Clark (2006). Scale bar = 10 µm.

?*Spinidinium clavus* Harland, 1973

Diagnosis: “Cavate cyst fusiform in shape, made up of two wall layers closely adpressed except at the apex and antapex where pericoels may be evident. Test usually smooth with the presence of occasional discrete granules. Epitract slightly more conical than the hypotract. Prominent apical horn, tapering with a bifid tip: antapical horns acuminate. Sutural ridges, up to 5 µ tall, carry short oblate and acuminate processes. Certain plate areas of the tabulation may be delimited due to sutural development. A tabulation ?4', la, ?7'', ?4c. 5–6''', ?2'''' indicated. Cingulum planar, sulcus conspicuous extending on to both the epitract and hypotract. Archeopyle indeterminate, but it is almost certain that loss of the conspicuous intercalary plate forms the archeopyle.” — Harland (1973, p. 674, 675)

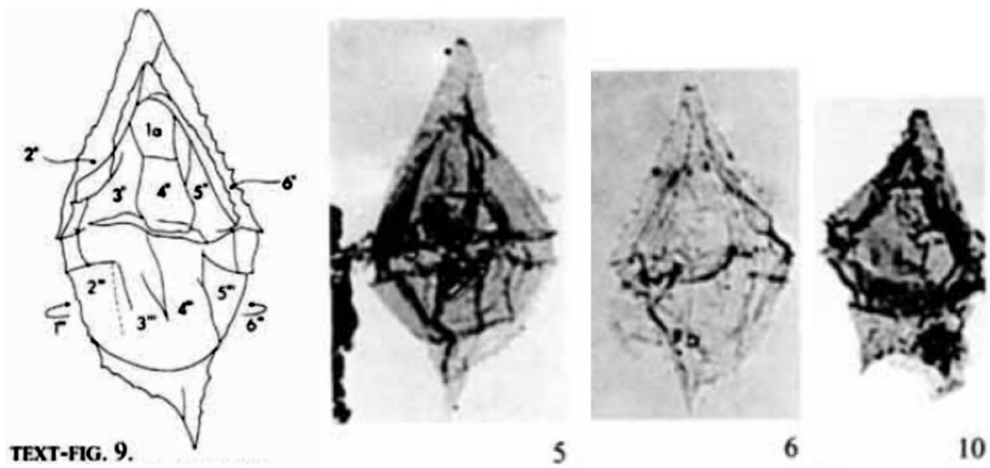
Description: “Cavate cyst often appears proximate because of poor pericoel development. The apex appears to be made up of four apical plates which are separated by large sutural ridges, characteristic of this species. These ridges add to the prominence of the apex. The crests of the ridges carry small oblate and acuminate processes. The precingular plate series appears to consist of five to seven plates, of which plate 4'' is conspicuous and polygonal in shape; directly above this plate there is a single rectangular anterior intercalary plate. The cingulum is often the focus for folding and crumpling of the cyst. The post-cingular plate series appears to comprise five or six plates but only certain indeterminate plate boundaries were seen. The hypotract is more rounded than the epitract. The sutural crests are better developed on the epitract than on the hypotract. The range of variation of this species is seen in Plate 84. The most variable feature is the size of the endoblast in relation to periblast.” — Harland (1973, p. 675)

Dimensions: “Holotype: Length 51.0 µ; breadth 29.0 µ. Range: Length 40.0 (45.3) 60.0 µ; breadth 20.0

(26.0) 35.0 µ. Seventeen specimens observed.” — Harland (1973, p. 675)

Remarks: “This species is characterized by the nature of the large sutural ridges. It is similar to *Palaeoperidinium caulleryi* Deflandre 1934 which Deflandre (1966) considers to be a member of the genus *Diconodinium*. It was not, however, formally combined (re Article 33 of I.C.B.N.). It has peridiniacean affinities with the deflandreoid lineage.” — Harland (1973, p. 675)

Age: Late Cretaceous (Campanian); holotype of Harland (1973, p. 675).



Text-figure 9; Plate 84, figures 5–6, 10, Harland (1973).

Spinidinium colemanii Wrenn & Hart, 1988

Diagnosis: “A species of *Spinidinium* characterized by its capitate, penitabular spines, small size, unequal hypo- and epicysts, and its posteriorly adnate 2a intercalary archeopyle.” — Wrenn & Hart (1988, p. 367)

Description: “Shape: cornucavate, subpentagonal to subelliptical dinocysts bearing one hundred or more penitabular spines. The paracingulum separates the epicyst from the hypocyst; the former is usually two to three times the length of the hypocyst. The paracingular area may bulge laterally, giving the dinocyst a subpentagonal shape. Phragma: both the endophragm and the periphragm are smooth. The wall layers are appressed except in the basal regions of the horns. The periphragm gives rise to capitate spines, whereas the endophragm lacks projections. The short apical horn is capped by two or more capitate spines. The right antapical horn is rarely evident, whereas the left horn is a long, spike-shaped projection bearing one or more accessory spines. Paratabulation: a paratabulation of x', 3a, 7'', xc, 5''', ?2'''' is delineated by penitabular capitate spines. The distribution and number of paraplates is obscured by the abundance of the closely spaced spines and by the presence of accessory rows of spines. The paracingulum and the parasulcus are not divided by rows of spines. Paracingulum: low folds capped with short capitate spines delimit the shallow excavation of the paracingulum. Paraplate divisions within the paracingulum were not observed. Parasulcus: A broad, bare area bordered by rows of spines indicates the location of the parasulcus. Spines are usually absent within the parasulcal area, although isolated spines occur on some specimens. Archeopyle: the archeopyle is formed by the partial detachment of the 2a paraplate, and occasionally by the partial detachment of the 4'' paraplate. The operculum is adnate along the H4 parasuture. A row of penitabular capitate spines occurs on each side of all archeopyle parasutures, except the H4 parasuture. The rows of spines along the H2-H3 and the H5-H6 parasutures of the 2a intercalary paraplate continue below the base of that paraplate and along the margins of the 4'' paraplate to the anterior margin of the paracinguium.” — Wrenn & Hart (1988, p. 366, 367)

Dimensions: “Observed range (10 specimens): pericyst length, 42 to 57 µm (mean, 50 µm); pericyst width, 36 to 45 µm (mean, 41 µm); endocyst length, 32 to 40 µm (mean, 37 µm); endocyst width, 30 to 41 µm (mean, 34 µm); process length, 3 to 8 µm; left antapical horn, to 10 µm; apical horn, to 8 µm.” — Wrenn & Hart (1988, p. 367)

Discussion and comparison: “The capitate spines and their distribution on the pericyst are reminiscent of *Spinidinium macmurdoense*. However, the overall shape, much smaller size, more numerous spines, more complete paratabulation, and unequal division of the dinocyst by the paracingulum differentiate *S. colemanii* sp. nov. from *S. macmurdoense*. The dense spinosity of the pericyst of *S. colemanii* sp. nov. is similar to a specimen of *Vozzhennikovia apertura* illustrated by Haskell and Wilson (1975; Plate 1, Fig. 6). However, the spines on the latter are more numerous, smaller, and generally non tabular, rather than penitabular.” — Wrenn & Hart (1988, p. 367)

Age: early late Paleocene (early Thanetian); holotype of Wrenn & Hart (1988, p. 367). Range: early late Paleocene (early Thanetian)–?Eocene (Wrenn & Hart, 1988, p. 367).

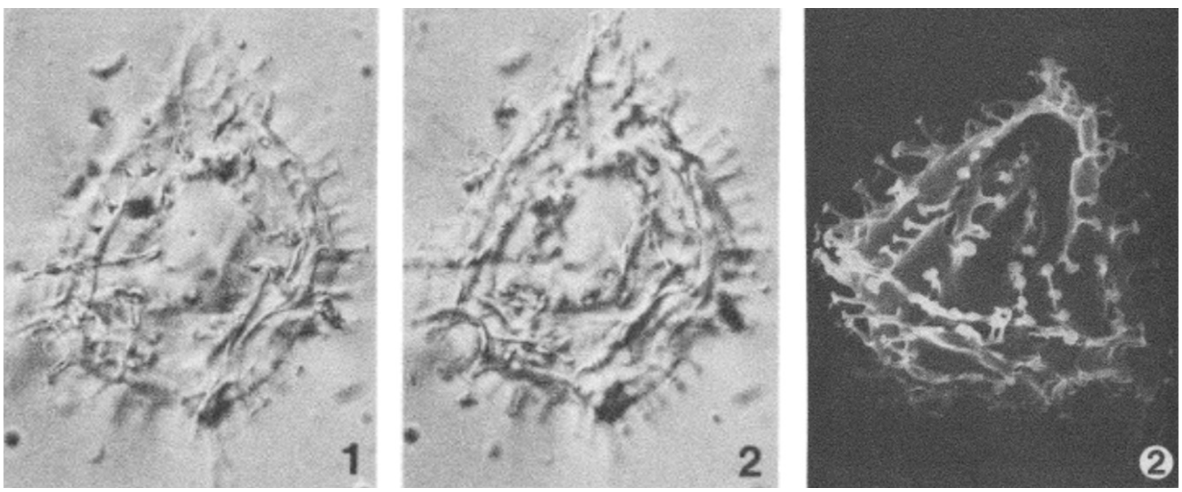


Figure 36, nos. 1, 2; Figure 39, no. 2, Wrenn & Hart (1988).

Spinidinium delicatum Slimani & Louwye, 2013

Diagnosis: “A small, cornucavate species of *Spinidinium* with a subpentagonal, longer than broad outline and very fine sutural crests. The distal edges of the crests are very finely serrate to finely denticulate. The tabulation is indicated by the sutural crests and the archaeopyle. The intratabular areas are devoid of ornamentation.” — Slimani & Louwye (2013, p. 19)

Description: “The small, proximate, peridinioid, cornucavate dinocyst is dorsoventrally compressed and has a pentagonal to subpentagonal endocyst and pericyst. The width of the cyst is about ¾ of the total cyst length. The pericyst bears a stiff, conical apical horn with an oblate or indented tip, and two pointed antapical horns of unequal length. The right antapical horn is reduced to absent. The left antapical horn is always present and longer, broad-based and tapering distally to a pointed tip. The thin endophragm has a maximum thickness of 0.5 µm. The periphragm is smooth, thinner than the endophragm, hyaline and closely adpressed to the endocyst, excepted for the horns where they are narrowly separated. The periphragm bears thin and continuous sutural crests (up to 2 µm height) which indicate a tabulation (4', 3a, 7'', xc, 5''', 2''''). The distal edges of the sutural crests—which are only faintly visible under high magnification— are very finely serrate to finely denticulate. The relatively wide (max. 5 µm width) cingulum is slightly laevorotatory and unsegmented. The sulcus is also unsegmented and extends on the epicyst and hypocyst. A flagellar scar can be observed. The sulcus is narrow between the cingular extremities and broadens progressively towards the apex and antapex, and contacts respectively apical plate (4') and antapical plates 1'''' and 2''''. No crests have been observed between the unsegmented cingulum and the sulcus. The rarely visible archaeopyle is intercalary and isodeltaform type I (2a). The operculum is free." — Slimani & Louwye (2013, p. 19)

<u>Discussion</u>: "Quattrocchio and Sarjeant (2003) erected the genus *Volkheimeridium* in order to separate species with sutural crests from species of *Spinidinium* Cookson and Eisenack, 1962, which are devoid of sutural crests. Sluijs et al. (2009, p. 37) however considered *Volkheimeridium* to be a taxonomic junior synonym of *Spinidinium* because of the relatively minor differences between both genera, especially when it is not possible to assess whether the crests are sutural or proximosutural. *Spinidinium delicatum* sp. nov. is thus included here in *Spinidinium* since it bears very fine sutural crests with finely serrate to finely denticulate distal margins. *Spinidinium delicatum* sp. nov. is conspecific with a species recognized as *Palaeoperidinium subconicoides* (Lejeune-Carpentier, 1942) Lentin and Williams, 1973 by Slimani (1995), and with *Spinidinium* sp. A. of Slimani et al. (2011). It differs from all the other *Spinidinium* species by its smaller size, the absence of intratabular ornamentation and its thin and continuous sutural crests with finely serrate to finely denticulate distal edges, only observed under high magnification. *Spinidinium clavus* Harland, 1973 and *Spinidinium uncinatum* May, 1980 also do not show intratabular ornamentation but they possess a larger pericoel, much larger and discontinuous sutural crests, and irregular large spines and processes. *Palaeoperidinium*? *subconioides* (Lejeune-Carpentier, 1941) Lentin and Williams, 1973 resembles the new species, but differs in having a segmented cingulum, crests separating the cingulum and sulcus, unornamented sutural crests and intratabular striations." — Slimani & Louwye (2013, p. 19)

<u>Dimensions</u>: "Length 30(38)45 µm, width 27(31)35 µm (12 specimens measured)." — Slimani & Louwye (2013, p. 19)

<u>Age</u>: Late Cretaceous (latest Maastrichtian); holotype of Slimani & Louwye (2013, p. 18, fig. 2). Range: Late Cretaceous–early Paleocene (late Maastrichtian–early Danian) (Slimani et al., 2011, table 1 as *Spinidinium* sp. A).

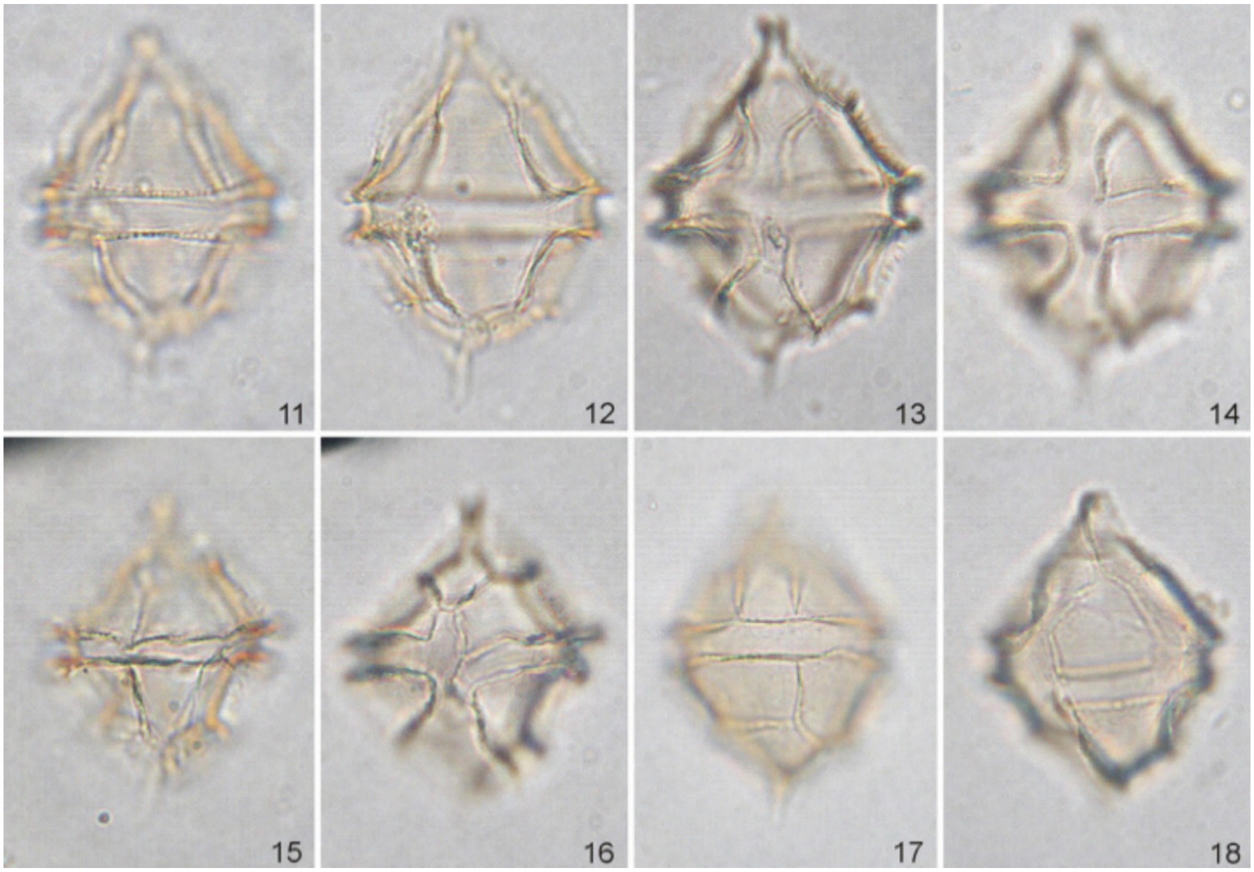


Plate 4, figures 11–18, Slimani & Louwye (2013).

Spinidinium densispinatum Stanley, 1965

Description: "Outer cyst subpentagonal in dorso-ventral view; length 50–65 μ, width 40–50 μ, epitheca larger than hypotheca. Outer cyst membrane thin and usually badly folded; ornamented with short rodlike, clublike, spinelike or grapple-like appendages that are about 2–3 μ long. Apical horn short, conelike with a broad base and a distal pore (?); horn length 4–5 μ. Antapical horns two in number with the right one weakly developed whereas the left horn is well developed, but short; length of the latter horn is about 4–5 μ. Inner cyst thin-walled, more or less circular in outline and almost fills outer cyst. Often two nuclei-like bodies that are 7–8 μ in diameter are present inside the inner cyst. Girdle distinct; girdle border fringed by a row of spinelike appendages. Furrow wide, usually indistinct. Archeopyle, when present, usually polygonal in outline." — Stanley (1965, p. 226, 227)

Differential diagnosis: "*Spinidinium densispinatum* n. sp. is readily distinguished from *S. microceratum* n. sp. by its more or less subcircular outline in dorso-ventral view and by its more densely spinate membrane. *Spinidinium densispinatum* differs from S. *styloniferum* Cookson and Eisenack by its shorter apical horn and by its subcircular outline dorso-ventral view." — Stanley (1965, p. 227)

Age: early Paleocene (Danian); holotype of Stanley (1965, p. 226). Warwick et al. (2004) places the Cannonball Member of the Fort Union Formation as 65–61 Ma.

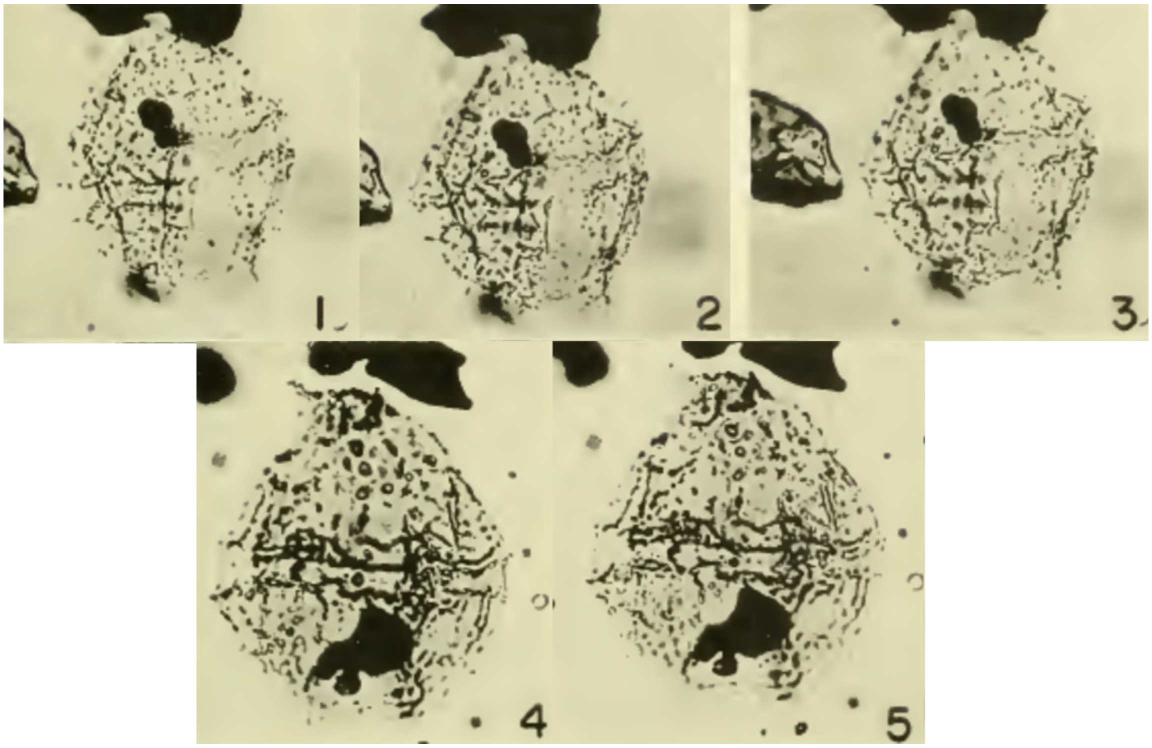


Plate 21, figures 1–5, Stanley (1965).

Spinidinium denticulatum Pöthe de Baldis & Ramos, 1983

Diagnosis: “The new form corresponds to the characteristics of the genus and is morphologically very similar to *Spinidinium styloniferum*, except in the presence of a denticulate antapical ridge, and developed instead of an antapical horn.” — Translated from Pöthe de Baldis & Ramos (1983, p. 441)

Dimensions: “Holotype length: 55 μ (53–57 μ), width: 44 μ (42–46 μ); eighteen specimens.” — Translated from Pöthe de Baldis & Ramos (1983, p. 441)

Age: Early Cretaceous (early Aptian); holotype of Pöthe de Baldis & Ramos (1983, p. 427).

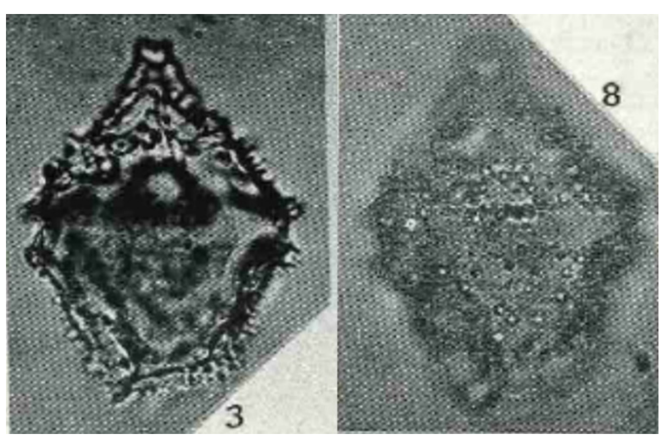


Plate 2, figures 3, 8, Pöthe de Baldis & Ramos (1983).

Spinidinium echinoideum subsp. ***echinoideum*** (Cookson & Eisenack, 1960) Lentin & Williams, 1976.
Emendation: Sverdlove & Habib, 1974, p. 58, 59.

Description: “Shell rather flat, somewhat pentagonal with convex sides, divided unequally by a circular girdle with high borders into a smaller hypotheca, with a clearly defined pointed horn on one side and occasional indications of a smaller one on the other side, and a larger epitheca which narrows toward a variously shaped apex, usually carrying a tuft of spines. The broad longitudinal furrow is restricted to the hypotheca. The shell membrane is thin and fairly densely covered with thin, stiff spines (up to 5 μ long). The capsule is spherical, rather thin walled, and fills the shell laterally. A narrow pylome is sometimes developed.” — Cookson & Eisenack (1960, p. 2)

Dimensions: “Holotype: 80 μ long; 57 μ broad; capsule ca. 43 μ. Range: 67–86 μ long; 50–57 μ broad.” — Cookson & Eisenack (1960, p. 2)

Emended diagnosis: “Cavate cysts with peridinioid outline. One apical horn; two antapical horns, short, more or less reduced or absent. Epitract with convex sides, tuft of spines at apex. Circular-based spines, tapering to points distally, formed solely by periphragm, arranged suturally or peritabularly, delineate cyst tabulation: 4', 3a, 7'', ?6c, 5''', 1–2''''. Variable concentration of intratabular spines present. Average spine length, 1.0 micron; range, 0.5–3.0 microns. Periphragm between spines smooth to slightly granular. Capsule oval to subcircular, smooth, bears no spines: in variable amount of contact with periphragm in equatorial region. Archeopyle intercalary; type I/I, plate 2a/2a. Periphragm may display accessory archeopyle sutures in precingular series causing irregular excystment apertures. Cingulum circular to slightly laevorotatory; divides cyst into smaller hypotract and larger epitract. Sulcus well developed on hypotract; extends onto epitract to base of plate 1'. Cingulum and sulcus contain few intratabular spines; delimiting spines frequently proximally joined, forming thickened cyst wall.” — Sverdlove & Habib (1974, p. 58, 59)

Dimensions: “Fifty-three specimens were measured. The maximum length varied from 40 to 73 microns and the maximum width from 29 to 61 microns. The apical pericoel length varied from 8 to 20 microns.” — Sverdlove & Habib (1974, p. 59)

Remarks: “This species is considered to be phylogenetically related to *Deflandrea vestita* (Brideaux) comb. nov. Davey (1970) reported specimens lacking antapical horns and referred them to *Deflandrea* cf. *D. echinoidea*. The authors include such specimens within *D. echinoidea* because the length of the antapical horns is a variable characteristic of the species. *Deflandrea limpida* Singh (1971) is considered a junior synonym of *D. echinoidea* because of the intraspecific variation of completeness of cyst tabulation and density of spine cover.” — Sverdlove & Habib (1974, p. 59)

Age: Late Cretaceous (Santonian–Campanian); holotype of Cookson & Eisenack (1960, p. 2). Range: Late Cretaceous (late Turonian–Campanian) (Cookson & Eisenack, 1960, p. 2).

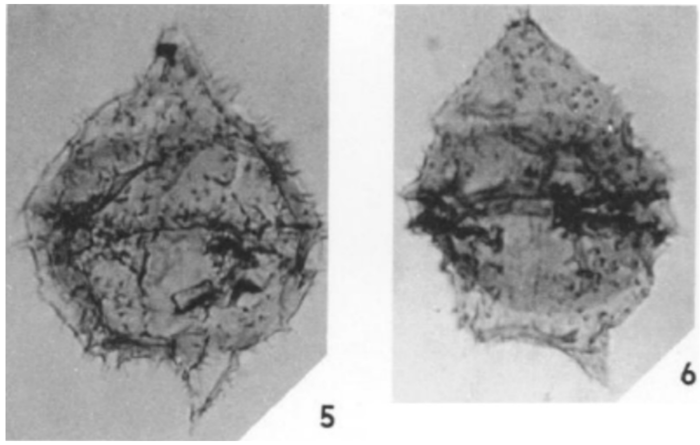


Plate 1, figure 5, 6, Cookson & Eisenack (1960).

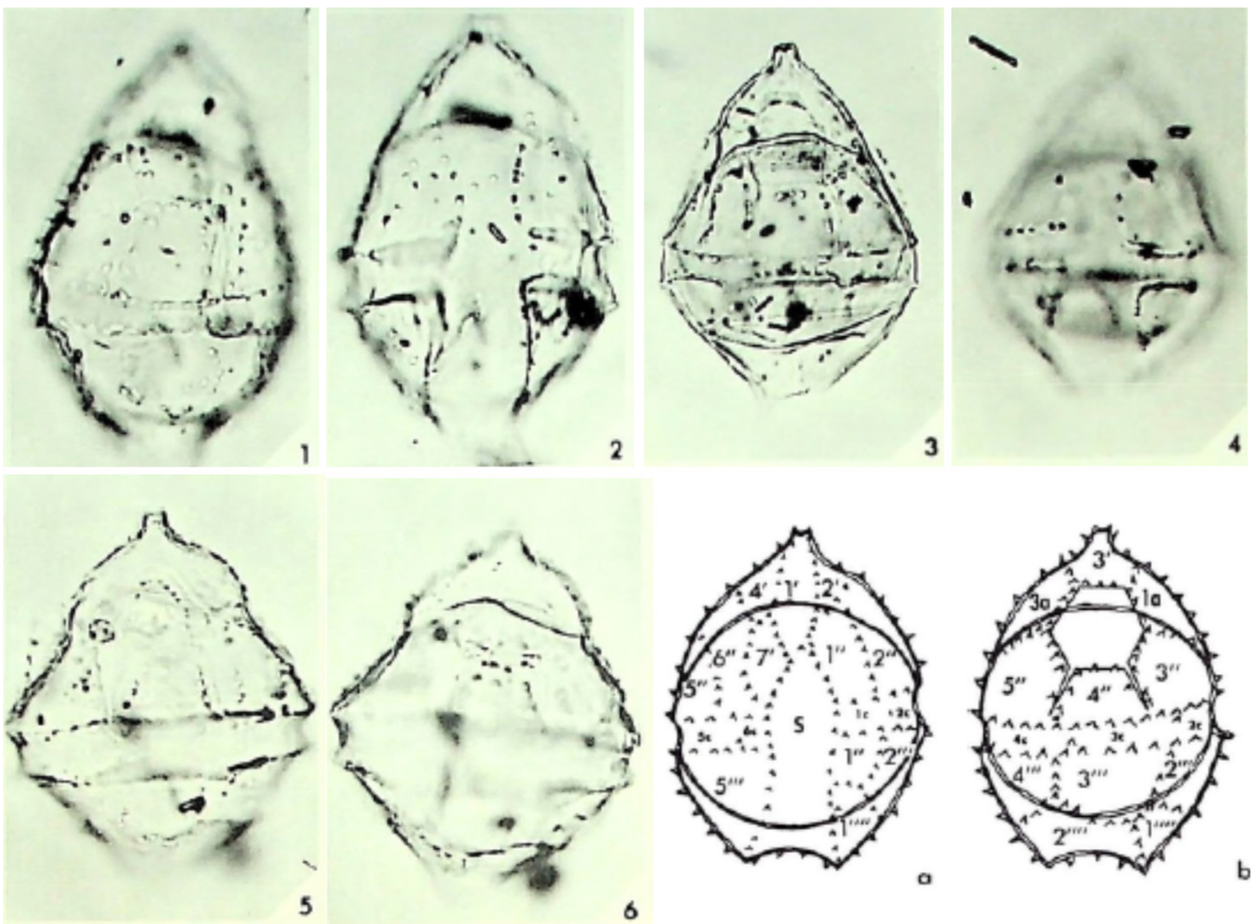


Plate 1, figures 1–6; Text-figure 2a, b, Sverdlove & Habib (1974).

Spinidinium echinoideum subsp. ***rhombicum*** (Cookson & Eisenack, 1974) Lentin & Williams, 1976

Diagnosis: “Shape seen as a whole, rhombic. Periphragm fairly flat, epitract forms the shape of an isosceles triangle with slightly convex to slightly concave flanks. The apical horn is not or only rarely somewhat separated with a truncated apex perpendicular to the long axis. Hypotract also triangular with a pointed antapical horn, and trapezoidal only when a second antapical horn is present, which then recedes very much in relation to the other. Usually only one antapical horn is developed, which is pointed, sometimes spike-like and can be strongly median shifted. The cingulum is rather wide, but usually very indistinct. The periphragm is short and pointed, but with broad-based spines, which are sparsely distributed and which are particularly strongly developed on the low folds of the cingulum, so that they emphasize this at the edges. There are also some (2–4) diverging spines at the apex, which emphasize its support. The endophragm is fairly circular in outline and clearly separated from the periphragm. An archaeopyle is usually present and trapezoidal to rounded triangular.” — Translated from Cookson & Eisenack (1974, p. 49, 50)

Remarks: “*D. rhombiea* is not a rare species. It is apparently related to *D. echinoidea* Cooks. & Eis. 1960, which is much more oval.” — Translated from Cookson & Eisenack (1974, p. 49, 50)

Age: Cretaceous (Albian–Cenomanian); holotype as translated from Cookson & Eisenack (1974, p. 47)

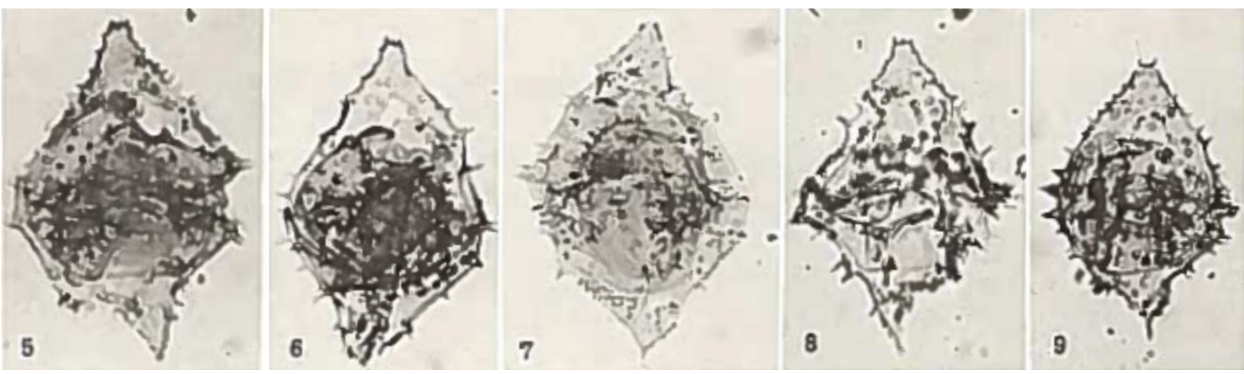


Plate 20, figures 5–9, Cookson & Eisenack (1974).

Spinidinium eggeri Kirsch, 1991

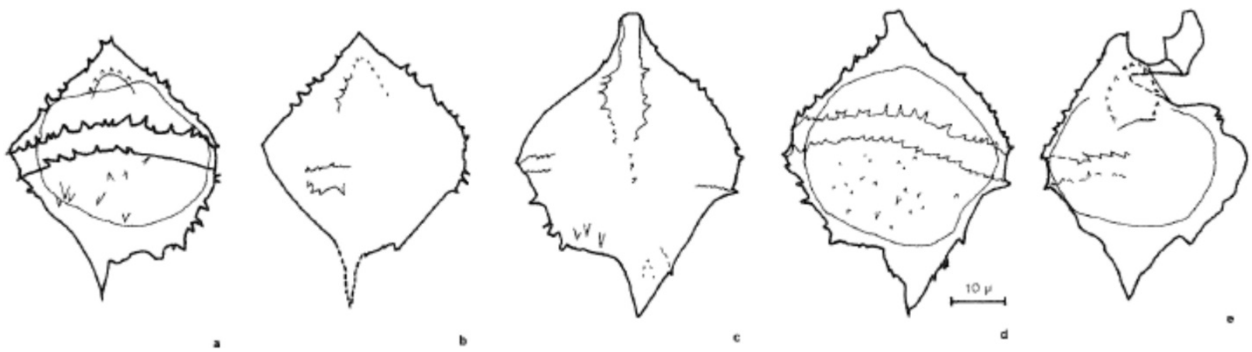
Diagnosis: “Circumcavate, smooth cyst with rhombic ambitus and a subsphaeroidal, smooth central body. The spines that are particularly developed on the cingulum are characteristically acuminate, basally widened, and commonly proximally connected by short spines. A mostly reduced right antapical horn follows a relatively long, acuminate left antapical horn opposite. Archaeopyle intercalary, attenuated-hexa-2a.” — Translated from Kirsch (1991, p. 113)

Description: “Cyst overall outline clearly diamond-shaped with a subsphaeroidal central body that does not fit the sides. The tapering epicyst is conspicuously trigonally built with straight flanks and an apical horn either receding almost entirely or conically shaped, distally blunt ended. The epicyst is approximately the same length as the hypocyst, whose flanks are straight to slightly convex. The acuminate or distally rounded spines extend to solid, narrowing spines; free, irregularly distributed and arranged in sutural rows, tracing plate boundaries. The most obvious of the plates are 2a and 1' (Kofoid) indicated by individual spines in a row. The sulcus is indicated by a process-free area. Spines connected proximally by ridges form the cingulum, a lateral one separated and free of processes appears. Archaeopyle intercalary, attenuated-hexa-2a, with posterior adnate operculum. Tabulation: ?4', 3a, 7'', xc, 5''', 2''''.” — Translated from Kirsch (1991, p. 113)

Dimensions: "Holotype: endocyst size 32 × 32 µ; size of pericyst 56 × 42 µ; length of apical horn 7 µ; length of antapical horn 10 µ; spine length max. 1.5 µ. Variation: overall size 47–56 × 38–42 µ; size of central body 28–32 × 30–32 µ; Length of apical horn 5–7 µ; Length of antapical horn 7–10 µ." — Translated from Kirsch (1991, p. 113)

Comparison: "*Spinidinium eggerii* sp. nov. is different from *Spinidinium rhombicum* (Cookson & Eisenack 1974) due to the diamond-shaped habit and the finer processes. Opposite the morphologically similar species *Spinidinium mariae* Aurisano 1984 lack the characteristic bifid and bifurcate spines (Aurisano 1984: 7)." — Translated from Kirsch (1991, p. 113)

Age: Late Cretaceous (late Santonian); holotype of Kirsch (1991, p. 113). Range: Late Cretaceous (early–late Santonian) (Kirsch, 1991, figs. 63, 71, 72).



Text-figures 56a–e, Kirsch (1991).

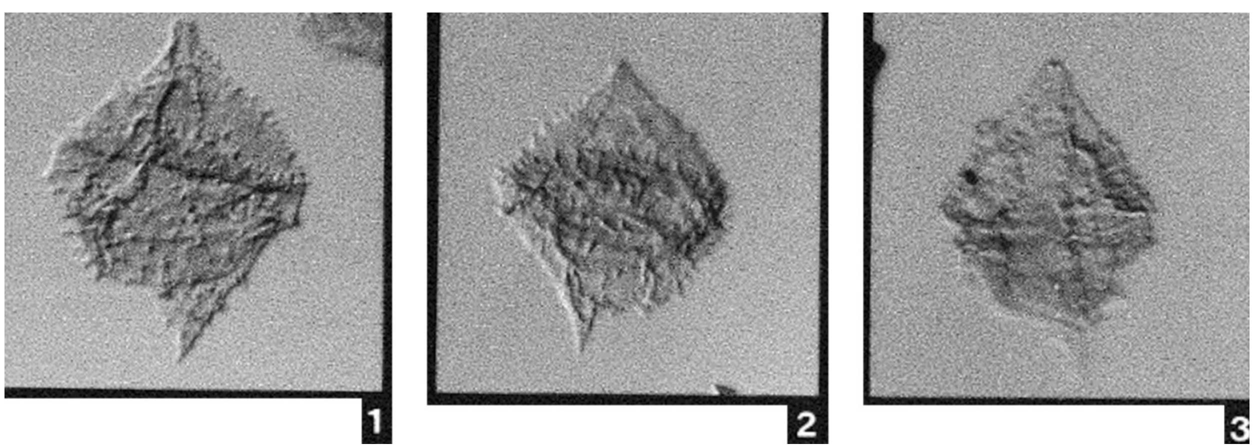


Plate 23, figures 1–3, Kirsch (1991).

Spinidinium essoi Cookson & Eisenack, 1967

Description: "Shell small, somewhat flattened and oval in outline, with straight to convex sides, a relatively broad, circular, equatorial girdle with high ledges bearing short thin spines, a short blunt apical horn and a single sharply-pointed horn on the left-hand side of the antapex. Both surfaces of the shell are partially tabulated, the areas being delimited by short spines. On the ventral surface of the epitheca a small, roughly rectangular area outlined by small dot-like thickenings is usually clearly evident, and a relatively wide furrow-like region, delimited by small spines, is typically present in the hypotheca. An intercalary, trapezoidal archeopyle is developed on the dorsal surface of the epitheca. In one specimen (Pl. 19, fig. 8) a relatively thin-walled cyst-like body, circular in outline, occupies approximately three-quarters of the cavity of the shell. The wall of the shell, which is rather sparsely ornamented with pointed or knobbed spines, appears to consist of two closely opposed layers which separate from one another only at or near the bases of the horns, the position of the diaphragnum [sic] varying in individual specimens. The apical horn tends to be straight-sided and its apex incurved; the antapical horn, which tapers to a sharp point, bears a few downwardly directed spines." — Cookson & Eisenack (1967, p. 135)

<u>Dimensions</u>: "Holotype overall length 60 μ, width 46 μ, girdle 5 μ wide. Range overall length c. 50–62 μ, width 40–52 μ, spines up to c. 3 μ." — Cookson & Eisenack (1967, p. 135)

<u>Comments</u>: "*S. essoi* differs from the Australian Cretaceous species *S. styloniferum* Cookson & Eisenack 1962 in the shape of the shell, the less numerous and finer spines, the presence of a simple form of tabulation and the shape of the archeopyle. It differs from the two American Paleocene species *S. densispinatum* and *S. microceratum* described by Stanley (1965) in the absence of a second antapical horn and, as far as can be judged from the illustrations of both species, the more regular and wider distribution of the spines." — Cookson & Eisenack (1967, p. 135)

<u>Age</u>: Paleocene; holotype of Cookson & Eisenack (1967, p. 135).

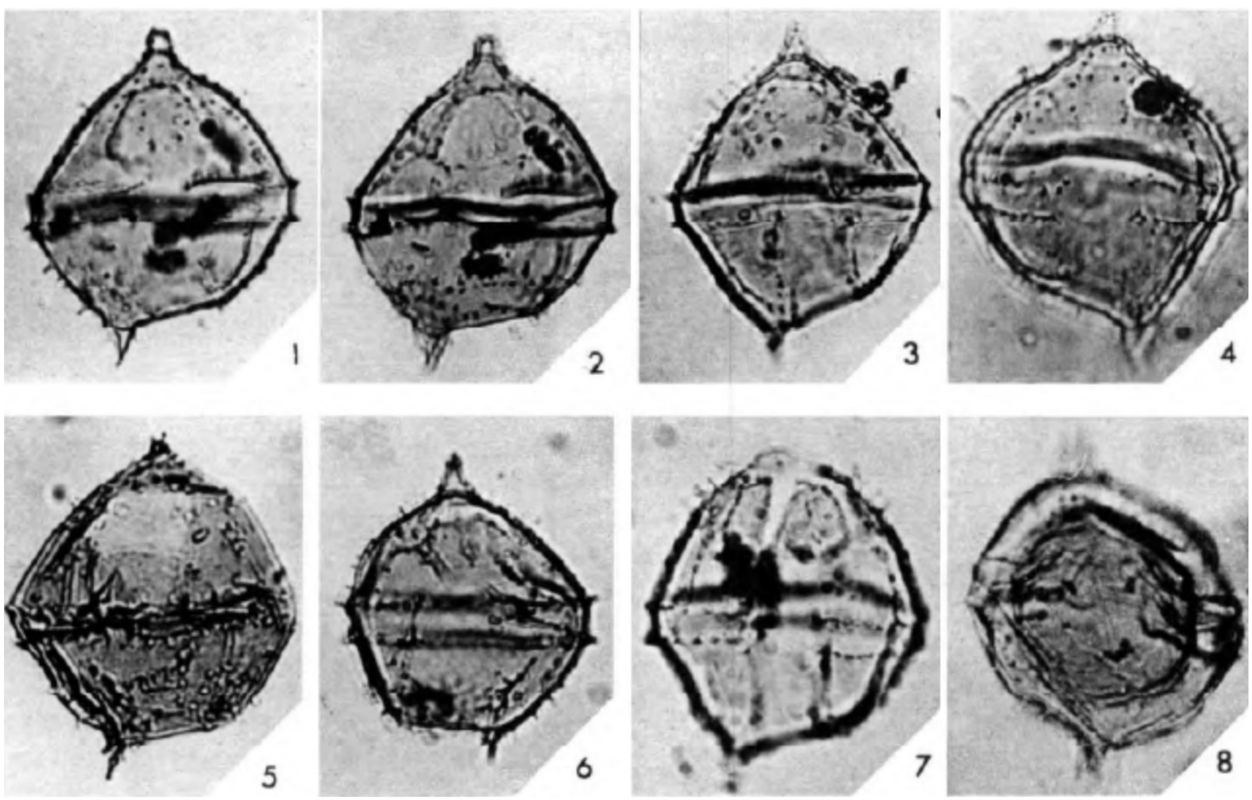


Plate 19, figures 1–8, Cookson & Eisenack (1967).

?*Spinidinium irmoechinatum* (Heisecke, 1970) Stover & Evitt, 1978

<u>Diagnosis</u>: "Cavate cyst with irregular bipyramidal outline. The wall is covered by spines, which forms an apical and an antapical horn. The spines are arranged preferentially in a row, often joined by delicate septa, delimiting a circular cingulum and a well-characterized sulcal area. No archeopyle observed." — Translated from Heisecke (1970, p. 230)

Description: “Cavate cyst with irregular bipyramidal outline. The wall is composed of two layers, the outer one forms a pyramidiform apical horn that culminates in two spines and an antapical horn densely covered by thorns. The surface is covered by spines that are preferably arranged in alignments and often joined by delicate partitions, thus delimiting the plates. In some cases, said delimitations are indicated by a partition of up to 9 μ tall that culminates in small thorns. The circular cingulum is very characteristic as it is depressed, free of spines and delimited almost continuously by spiny ridges or septa. The sulcal area is also delimited by ridges or spiny partitions, and is restricted to the hypotract and to the cingulum; in the epitract it, narrows forming a simple boundary between plates. Reflected tabulation is 5', 6'', 6c(–7c). 6''', 1s(2s), 1p(?), 1''''. Plate 7c is smaller than the other cingular plates since it coincides with the width of the sulcal area, which is why it is considered interchangeable as a cingular or sulcal plate. The plate considered doubtfully 1p has an unusual position, since it is located between 2''' and 3'''. The limit between the 3'' and 4'' plates is not clearly defined, but only hinted. No archeopyle observed.” — Translated from Heisecke (1970, p. 230)

Dimensions: “Holotype: total length 68 μ, length (without horns) 38 μ, width 43.5 μ, length of spines 1–3.5 μ, height of septa 2–9 μ, thickness of cingulum 3.5 μ, length of apical horn 12.5 μ, length of antapical horn 17 μ.” — Translated from Heisecke (1970, p. 230)

Observations: “The specimens are smaller size than previously described (total length 44–48 μ, width 23–30 μ) and they lack antapical horns, presenting only a prominence that culminates in a thorn. However, they look very similar to the one previously described, since they have a well-marked cingulum and a large number of spines joined by partitions, delimiting areas, but this feature is unclear so that the tabulation could not be determined. These specimens, due to the absence of antapical horns, present the antapical prominence that culminates in a thorn and due to their dimensions, also resemble *Spinidinium rallum* sp. nov. from which they differ in having a well delimited and possibly greater number of spines. From these similarities it can be deduced that the presence of the two genera, *Spinidinium* and *Deflandrea* is, in this case, arbitrary since in three forms with few differences between them, it is passed gradually from one genre to another.” — Translated from Heisecke (1970, p. 230)

Comparisons: “The new species resembles *Palaeoperidinium murciforme* Conrad, 1941 in its general appearance, the presence of a depressed cingulum and therefore ridges that culminate in spines. However, it differs from that species by the kind of thorns that are much stronger in *P. murciforme*, due to the presence of two antiapical horns, one very reduced, and the tabulation that cannot be determined. It differs from the specimen of *Deflandrea* cf. *macmurdoensis* described in this work because it has two more or less well developed antapical horns, a precingular archeopyle, and the absence of tabulation, as well as a different general look and shape. Therefore, despite being a single specimen and until more data is obtained, it is considered provisionally as a new species because the available specimen has very clear and defined characteristics.” — Translated from Heisecke (1970, p. 230)

Age: early Paleocene (Danian); holotype of Heisecke (1970, p. 230).

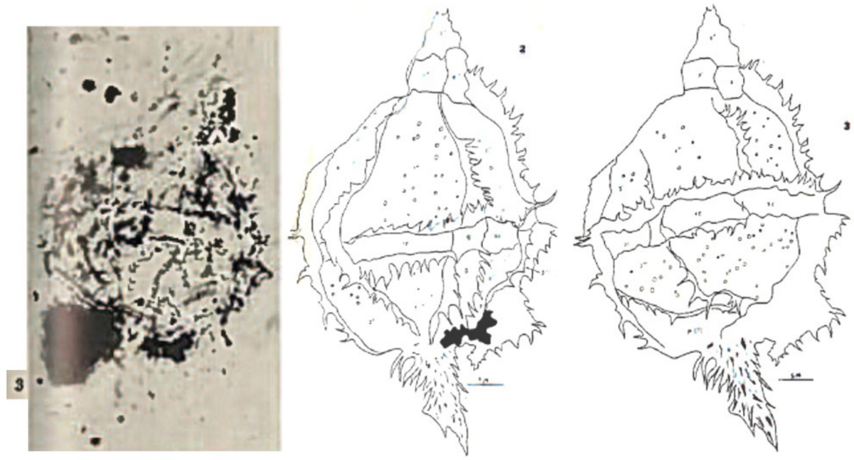


Plate 1, figure 3; Plate 2, figures 2, 3, Heisecke (1970).

Spinidinium lanterna Cookson & Eisenack, 1970

Description: “Shell somewhat biconical, clearly divided by a relatively conspicuous girdle into a longer epitheca with straight to slightly convex slanting sides and a short apical horn and a shorter, somewhat broader hypotheca with slanting, slightly convex sides and a narrow, pointed antapical horn to one side of the midline. The girdle is relatively broad, interrupted laterally on the dorsal surface, its ends on the ventral surface being rather widely separated. The tabulation, which is most evident in the epitheca, is difficult to determine. The plates appear to be long, narrow and triangular in outline and to extend from the girdle to near the apex. There seem to be six precingular plates in the epitheca; the number in the hypotheca has not been determined. However, in several specimens, a small semicircular area, outlined by a single row of small, evenly-spaced thickenings, which extends between the two lateral breaks in the girdle, has been evident on the dorsal surface of the hypotheca (Pl. 12, fig. 2). The outlines of both the shell and plates are ornamented with distinctly pointed spines which vary somewhat, both in size and density, in individual specimens. The archeopyle is small, intercalary and high in the epitheca. The internal body is large, thin and smooth-walled and, except at the extreme apex, almost fills the shell.” — Cookson & Eisenack (1970, p. 144)

Dimensions: “Based on 20 examples: Holotype: length c. 70 μ, breadth 50 μ. Range: c. 55–78 μ long, 37–57 μ broad.” — Cookson & Eisenack (1970, p. 144)

Comment: “Although the outer wall of *Spinidinium lanterna* is clearly tabulated and the species not uncommon, it has not been possible to determine the exact tabulation. The main features by which *S. lanterna* can be distinguished from *S. stylonifera* Cookson & Eisenack 1962 from Western and South Australian Aptian and Albian deposits are: the greater difference between the lengths of the epitheca and hypotheca, straighter sides, clearer tabulation, longer and more clearly outlined triangular plates and the finer type of ornamentation.” — Cookson & Eisenack (1970, p. 144, 145)

Age: Late Cretaceous (Senonian); holotype of Cookson & Eisenack (1970, p. 144).


1 2 3

Plate 12, figures 1–3, Cookson & Eisenack (1970).

Spinidinium luciae Wrenn & Hart, 1988

Diagnosis: "A species of *Spinidinium* that is characterized by penitabular and parasutural denticulate crests or rows of isolated denticles. The attenuated intercalary 2a archeopyle may have a free or posteriorly adherent operculum. Accessory parasutures may be developed along the lateral margins of the 4'' paraplate (i.e., the 3''/4'' and the 4''/5'' parasutures)." — Wrenn & Hart (1988, p. 368)

Description: "Shape: the pericyst outline is subpentagonal to subhexagonal, depending on the distal width of the apical horn. The subtriangular epicyst is terminated by a short, truncated apical horn that often is concave distally. Penitabular or parasutural denticulate crests or rows of individual denticles give the dinocyst margin a serrate appearance. Two lateral transapical crests, each bearing a row of denticles, run from the paracingulum over the apex of the apical horn and down to the paracingulum on the other side. The denticles may be distally rounded or pointed. The subrectangular hypocyst is approximately half the length of the epicyst. It is flattened antapically, but short, unequal antapical horns may be present. The left antapical horn is always more fully developed than is the right antapical horn, which may not be developed at all. The horns vary in shape from subrounded to sharp, spike-like protuberances. The pericyst is broadest in the paracingular region. The endocyst outline is subrounded to subpentagonal and often mimics the outline of the pericyst.

Phragma: cysts are circumcavate to cornuncavate. The periphragm is approximately 0.5 μm thick and may be shagreenate or uniformly granulate. The granules vary in size, but they are always smaller than the 1-to-3 μm-high denticles capping the penitabular or parasutural crests. The endophragm is shagreenate to scabbrate and approximately 1 μm thick.

Paratabulation: paratabulation is expressed on the pericyst by denticulate to serrate crests or isolated denticles. Penitabular rows of denticles delimit all paraplates, except perhaps along the margins of the parasulcus. Parasutural denticles cap the ridges bordering the paracingulum. The penitabular denticles are poorly developed in the parasulcal area. Ventral paratabulation similar to ortho epithecal tabulation. The paratabulation formula is 4', 3a, 7'', 5–7C, 5''', ?2''''. The only indication of paratabulation on the endocyst is the 2a intercalary archeopyle.

Paracingulum: the laevorotatory paracingulum is bordered by two discontinuous parallel denticulate to serrate parasutural crests. The ends of the paracingulum are offset less than one full width of the paracingulum. The discontinuous paracingular crests and/or denticles divide the paracingulum into five to seven paraplates.

Parasulcus: the parasulcus is delimited by denticulate to serrate crests that are less well developed and less continuous than those bordering the paracingulum. The parasulcus is broadest posteriorly and tapers anteriorly, where it runs up onto the epicyst. A single, large denticle in the right, middle area of the parasulcus may reflect the location of the flagellar pore of the theca. The parasulcus is not expressed on the endocyst.

Archeopyle: archeopyle type I/I. The operculum of the attenuated 2a archeopyle may be free or adherent along the H4 parasuture. The lateral parasutures of the 4" paraplate (i.e., 3"/4" and 4"/5") may be partially open, but the 4" is adnate along the anterior margin of the paracingulum. The 4" may or may not be involved in archeopyle formation; when 4" is involved, it is probably fortuitous." — Wrenn & Hart (1988, p. 368)

Dimensions: "Observed range (10 specimens): pericyst length, 51 to 87 µm (mean, 64 µm); pericyst width, 46 to 76 µm (mean, 61 µm); endocyst length, 45 to 66 µm (mean, 52 µm); endocyst width, 42 to 56 µm (mean, 46 µm); archeopyle dimensions (6 specimens): length, 16 to 32 µm (mean, 20 µm); width, 16 to 21 µm (mean, 19 µm); periphragm, approximately 0.5 µm thick; endophragm, 0.75 to 1.0 µm thick." — Wrenn & Hart (1988, p. 368)

Discussion: "The endocyst varies considerably in shape and size. Consequently, the relationship between the periarcheopyle and the epipericoel also varies. The epipericoel is in communication with the exterior through the intercalary periarcheopyle only on specimens bearing a circular endocyst. Communication is reduced or totally blocked by an elongate endocyst that mimics the outline of the pericyst. The denticulate to serrate transapical crests form distinctive crescent-shaped depressions at the apex of the apical horn." — Wrenn & Hart (1988, p. 368)

Comparison: "The denticulate parallel transapical crests and the variable archeopyle distinguish *Spinidinium luciae* sp. nov. from all other dinocysts. In particular, *S. luciae* sp. nov. differs from *S. stylonijerum* by having fewer, stouter and distally rounded denticules rather than spines; from *S. macmurdoensis* and *S. sverdrupianum* in overall cyst shape and in the type and distribution of ornamentation; and from *Chichaouadinium vestitum* and *C. boydii* by the type and distribution of ornamentation, in overall shape and archeopyle development." — Wrenn & Hart (1988, p. 368)

Age: late early Eocene; holotype of Wrenn & Hart (1988, p. 368).

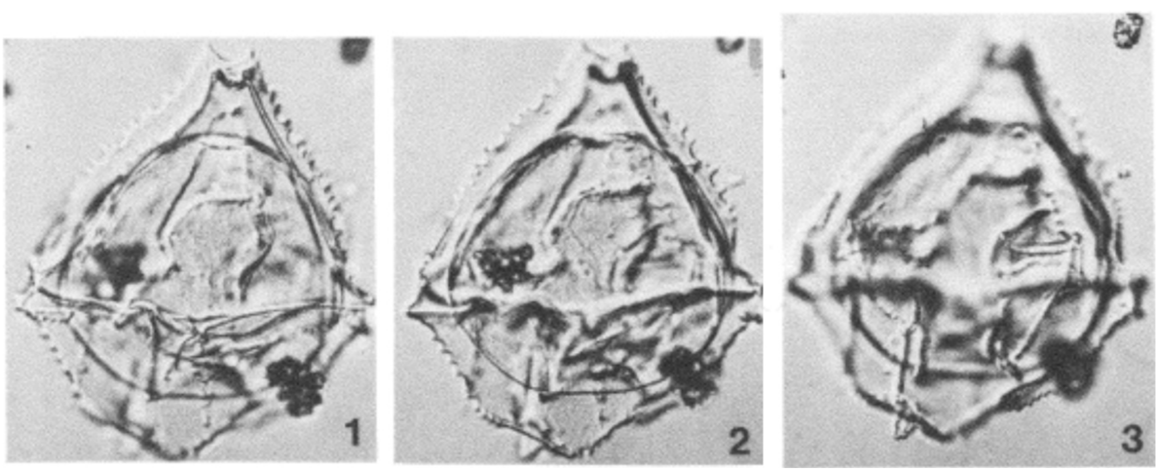


Figure 35, nos. 1–3, Wrenn & Hart (1988).

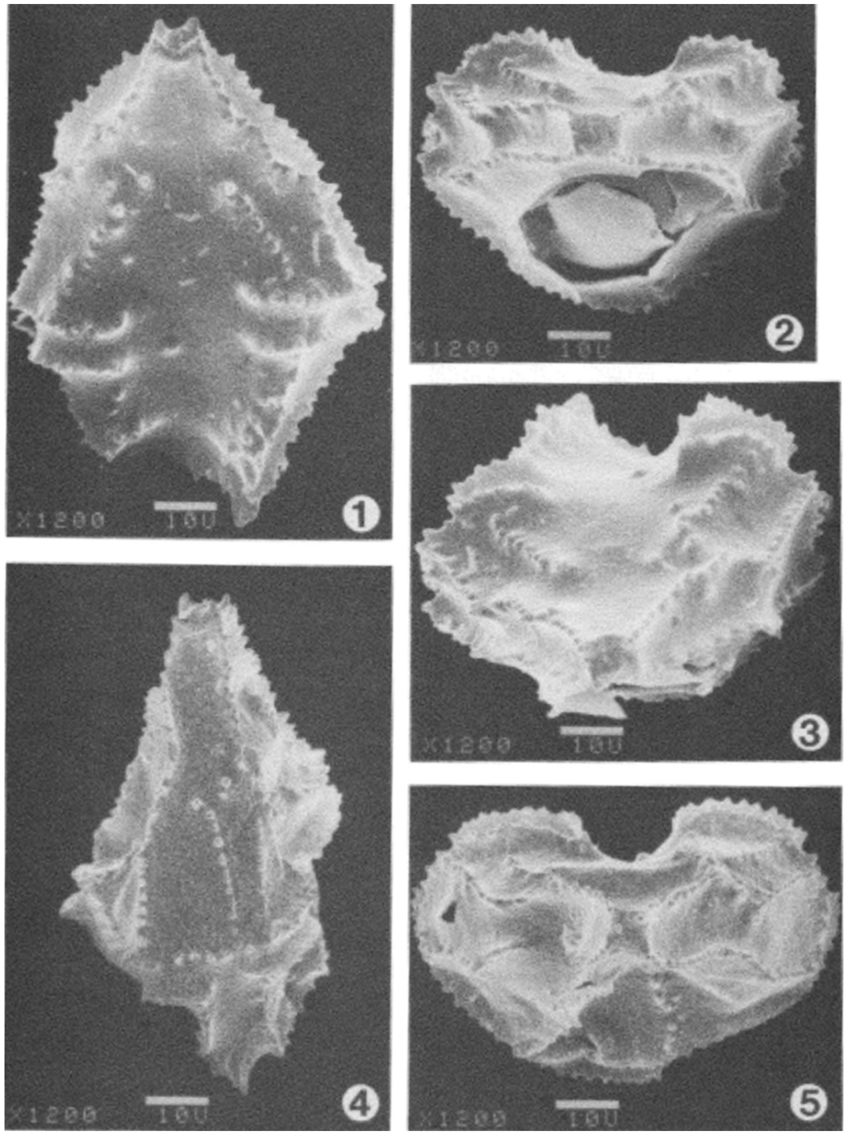


Figure 38, nos. 1–5, Wrenn & Hart (1988). Scale bars = 10 μm.

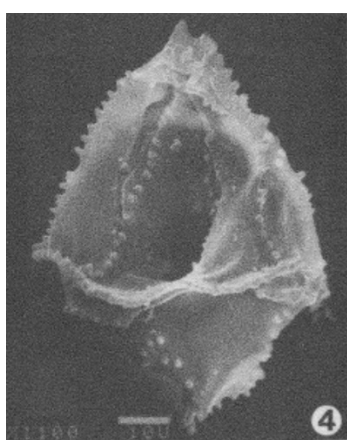


Figure 39, no. 4, Wrenn & Hart (1988). Scale bar = 10 μm.

Spinidinium macmurdoense (Wilson, 1967a) Lentin & Williams, 1976

Description: "Test bi-layered. dorso-ventrally flattened, angular, bilaterally asymmetric. Outer cyst divided into fields by small spines (*l* = 5–9 μ); smooth hyaline inner cyst closely follows outline of outer cyst. Horns formed by polar extensions of outer cyst; apical horn relatively long (*l* = 14–20 μ) narrow, blunt-ended and bordered by very small spines; right antapical horn pointed (*l* = 13–17 μ) and usually bordered with small spines; left antapical horn either non-existent or very small. Prominent slightly laevorotatory transverse girdle delimited by a double row of spines or sometimes on dorsal surface, by a spiny ridge. Archeopyle intercalary, hoof-shaped or subhexagonal, located on dorsal epitheca; operculum always fixed to shell by its posterior margin; remainder of archeopyle perimeter bordered by a double row of spines, one on operculum, the other on outer cyst, with line of rupture between the two rows (Figs. 2a, 22). Tabulation uncertain, but that of dorsal epitheca apparently consistent with *Gonyaulax* (Fig. 2a)." — Wilson (1967a, p. 60, 62)

Dimensions: "Holotype: *l* = 99 μ, *b* = 72 μ, inner cyst (72 × 63) μ. Range: *1* = 61(87)99 μ, *b* = 58(67)80 μ (10 specimens)." — Wilson (1967a, p. 62)

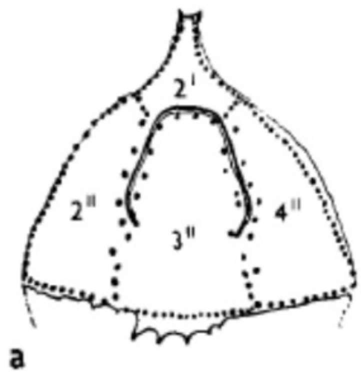
Discussion: "*Deflandrea macmurdoensis* represents an unusual and very distinctive species of *Deflandrea* and is quite unlike any previously described species. The only other *Deflandrea* species possessing spines are *D. echinoidea* Cooks. & Eis. *D. denticulata* Alberti and *D. spinulosa* Alberti. These differ from *D. macmurdoensis* in overall shape, in the structure of the archeopyle, in the nature of the spines, and are apparently all atabulate. The species was recorded as cf. *Wetzeliella* sp. in the preliminary species list of McIntyre and Wilson (1966. table 2).

Although *D. macmurdoensis* has a somewhat pentagonal outline, it is not considered that the lateral projections are sufficiently well developed to justify classification under the genus *Wetzeliella*. The writer restricts *Wetzeliella* to peridinioid forms having side horns approximately equal in size to the polar horns. The long. narrow. blunt-ended apical horn and relatively small antapical horns are characteristic of some fossil cysts of *Gonyaulax*.

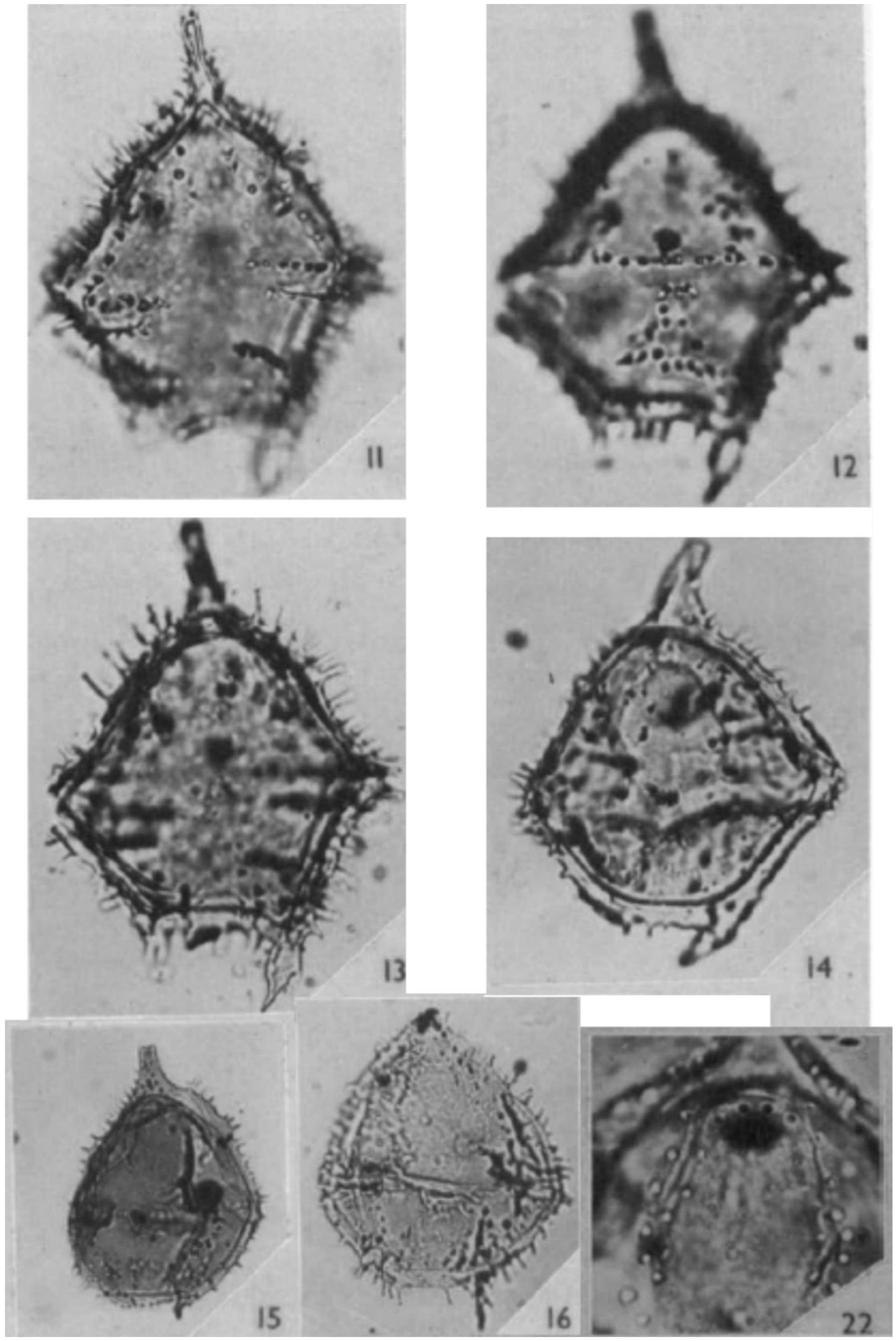
Archeopyle opercula are not found free, since after formation of the archeopyle the operculum always remains attached posteriorly to the test. The operculum is undoubtedly flexible and would have bent either outwards or inwards to enable excystment to occur. As there is no trace of a reflected plate border along its posterior margin-for example a row of spines-it is doubtful that the archeopyle can be correlated with an intercalary plate. It is considered more likely to correspond to the anterior portion of a mid-dorsal precingular plate (Fig. 2a); it is not equivalent to a complete precingular plate since it does not extend to the girdle. In other species of *Deflandrea* it has been conclusively demonstrated by Manum that the intercalary archeopyle corresponds in position to the 2a intercalary plate of *Peridinium*, thus helping to establish a natural relationship between *Peridinium* and some species of *Deflandrea* (Manum. 1963).

Deflandrea macmurdoensis is common in the Black Island samples, especially L 4729, and apart from two species of *Spinidinium* is the most common form. It is comparatively rare in the Minna Bluff sample and specimens from there are generally slightly smaller than those from the Type locality." — Wilson (1967a, p. 62)

Age: early Tertiary (erratic); Wilson (1967a, p. 60).



Figures 2a, Wilson (1967a).



Figures 11–16, 22, Wilson (1967a).

?*Spinidinium ornatum* (May, 1980) Lentin & Williams, 1981

<u>Description</u>: "Periblast peridinioid, slightly rhomboidal, tapering apically from cingulum in nearly linear fashion, forming a relatively short, flatly-truncated, apical horn, bearing a terminal pore; tapering antapically from cingulum to short, slightly conical, pointed, antapical horns. Outline between antapical horns concave. Left antapical horn larger than right. Periphragm generally smooth, and is formed into triangle to trapezoid-shaped, high, sutural fold arrangements; each fold bearing short to long (up to 3 μm), closely spaced, solid, simple to bifurcate spines. The triangular to trapezoidal fields which also may bear intratabular coni, are well separated from each other and outline plate equivalents. The lateral separation of the pre- and postcingular fields creates marked interruptions in the cingulum. Apical tabulation reflected by

a slender diamond-shaped pattern of intratabular coni on the ventral apex, and paired, longitudinal rows of spines extending down the lateral sides of the apex outlining the remaining apical plate fields. Precingular and postcingular series reflected by triangle to trapezoid-shaped, sutural fold arrangements bearing spines; triangular fields on the ventral surface, trapezoidal fields on the lateral and dorsal surfaces. Antapical series marked by rows of spines encompassing the antapical horns, suggesting that the lower portions of each horn represent one plate equivalent. Reflected tabulation 4', ?3", 7", 6-7c, 5"', 2"". Endoblast large, angularly ovoidal, closely appressed to periblast, filling nearly all of the central cavity, forming pericoels only within the short horns and under the elevated ridges of the cingulum and plate equivalents. Endophragm smooth, slightly indented along cingulum. Cingulum levorotatory, terminal ends offset ca. one cingulum width; interrupted due to separation of adjacent pre- and postcingular plate equivalents, formed of high sutural folds bearing long spines (up to 3 μm), pericoels occurring beneath the sutural folds. Sulcus extends antapically from between terminal ends of cingulum as two rows of spines which intersect the posterior periblast margin a short distance inward from the antapical horns. At each intersection a small, spike-like projection is directed posteriorly. Archeopyle intercalary (Type Ia/Ia); accessory sutures extend downward along the lateral margins of the 4".

Although most specimens are characteristically like those described in the above paragraph, the high degree of variability in the height of the sutural folds and spines can change greatly the general appearance of the cyst surface. Although cyst outline and plate shapes do not change, the overall relief of the margins of the plates, cingulum, and sulcus may be reduced, the sutural folds being altogether missing, except along the cingulum and sulcus. The spike-like projections at the base of the sulcus may also be lacking." — May (1980, p. 77, 78)

Discussion: "Diagnostic features are the rhomboidal outline, tabulation reflected by variable sutural folds and penitabular spines and occasional to frequent intratabular coni, well-separated plate fields, interrupted cingulum, and accessory sutures extending down lateral margins of 4"." — May (1980, p. 77, 78)

Affinities: "*D. ornata* is similar to *D. sverdrupiana* Manum 1963 and *D. scheii* Manum 1963. Both *D. sverdrupiana* and *D. scheii*, however, lack the long, bifurcating spines, spines on the antapical horns diverging antapical horns. *D. sverdrupiana* lacks the accessory sutures along the lateral sides of the 4"." — May (1980, p. 77, 78)

Dimensions: "Holotype L × W, 64 × 45 μm; apical horn above endoblast 16 μm; left antapical horn beneath endoblast 13 μm; spine length up to 3 μm; wall layers, endoblast ca. 1 μm, periblast ca. 1 μm. Observed range (23 specimens measured): length 53–72 μm, width 39–47 μm." — May (1980, p. 77, 78)

Age: Late Cretaceous (late Campanian); holotype of May (1980, p. 77, text-fig. 2). Late Cretaceous (late Campanian) (May, 1980, p. 77).

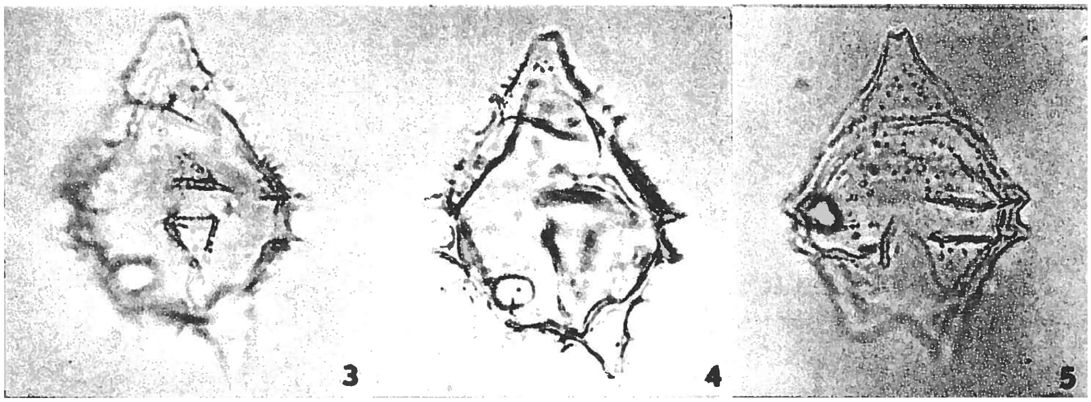


Plate 9, figures 3–5, May (1980).

Spinidinium ovale (Vozzhennikova, 1967) Lentin & Williams, 1977b

Description: "Theca oval, strongly compressed in a dorsoventral direction, with a small apical and sharply pointed antapical horn. The latter may be absent. Thecal surface divided into fields by rows of spinules which may be blunt or sharply ended. Field formula: on the epitheca 4a + 6np: on the hypotheca 6zd or (?5) zd + (?2cp') + la'. Apical plates of various shapes and sizes; the first rhomboidal, the second and fourth are small plates lying one to each side of the first, the third, which is trapeziform, lying above the first. The third anterior equatorial plate is recognizable because of its small size and rectangular form; it lies between the transverse furrow and the third apical plate. To the side of it lie the 2nd and 4th large anterior equatorial plates. The 1st and 6th plates are small and border onto the longitudinal furrow, above which lie the 2nd and 4th apical plates, and to the right and left of which lie the 2nd and 5th anterior equatorial plates. Among the posterior equatorial plates the first and 6th are considerably smaller than the others. Between them and the antapical plates lies a small intercalary plate (2cp') which is difficult to distinguish. The antapical plate is polygonal. The transverse furrow is faintly spiral but not subdivided into plates. The longitudinal furrow is straight and extends from the rhombic plate to the antapex. The theca is coloured and has a smooth surface." — Vozzhennikova (1967, p. 151, translation: Lees & Sarjeant, 1971)

Dimensions: "(in microns) Holotype: length 52.8, breadth 45.6, width of transverse furrow 6." — Vozzhennikova (1967, p. 152, translation: Lees & Sarjeant, 1971)

Comparison: "This species bears some resemblance externally to *Canninginopsis denticulata* from which it differs in its smaller size, different share of fields and the absence of any division of the transverse and longitudinal furrow into fields." — Vozzhennikova (1967, p. 152, translation: Lees & Sarjeant, 1971)

Age: Eocene; holotype of Vozzhennikova (1967, p. 153, translation: Lees & Sarjeant, 1971). Range: Paleocene–Eocene (Vozzhennikova, 1967, p. 153, translation: Lees & Sarjeant, 1971)

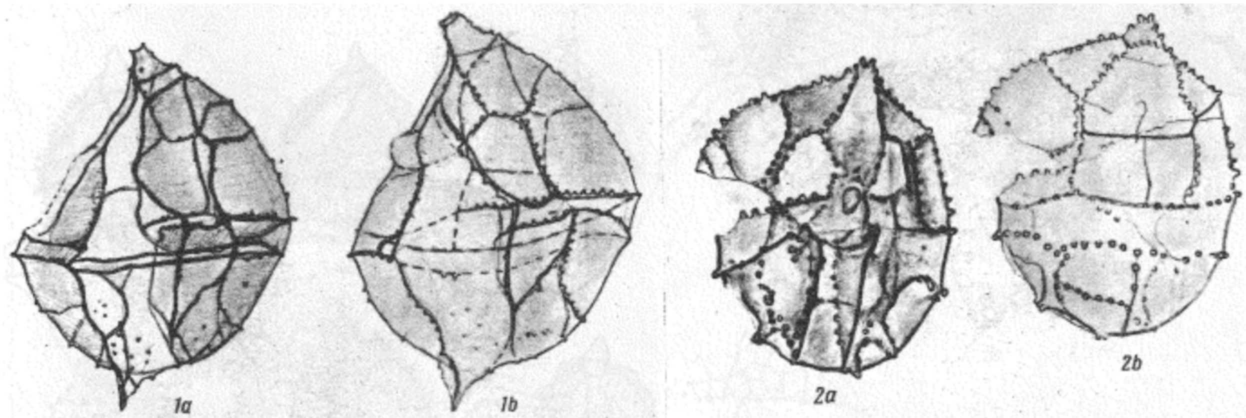


Plate 40, figures 1a, b, 2a, b, (Vozzhennikova, 1967, translation: Lees & Sarjeant, 1971).

Spinidinium pentagonum Kurita, 2004

Diagnosis: "A species of the genus *Spinidinium* with pentagonal to rounded pentagonal body and with triangular epicyst. Periphragm with numerous short spines which are usually acuminate, rarely capitate, and in penitabular spine arrangement. Apical pericoel generally large. Large, intercalary 2a archeopyle, Type Ia, which is hexagonal and isodeltaform. Operculum always in place, adnate posteriorly." — Kurita (2004, p. 38)

Description: "Proximate cyst, dorso-ventrally compressed peridinioid, cornucavate, pentagonal to rounded pentagonal, with triangular epicyst. Small or reduced apical horn present. Two antapical horns present or absent. When present, right antapical horn strongly reduced. On horns, relatively long, sometimes slightly membranous, spines present. Periphragm thin, generally smooth or laevigate, with numerous short spines which are usually acuminate, rarely capitate. Density of the spines on pericyst rather consistent. Penitabular spine arrangement present typically around archeopyle and on operculum. In other areas of pericyst, penitabular arrangement sometimes absent or developed only partially. Paracingulum, being indicated by two ridges with row of spines, relatively wide and generally well delineated in cyst ambitus. Displacement of paracingulum not clear, probably not prominent. Parasulcus indicated by lack of paracingular rows of spines or ridges, and by shallow depression of the cyst in the ventral area, widening toward antapex. Endocyst rounded hexagonal with thin, smooth endophragm without ornament, appressed to periphragm except beneath horns. Paratabulation indicated incompletely by paracingulum, parasulcus, archeopyle and partial penitabular arrangement of spines on pericyst. Intercalary archeopyle always discernible, derived from loss of paraplate 2a, hexagonal, isodeltaform, Type Ia, relatively large. Transverse archeopyle index = 0.49–0.77, average 0.59 (15 specimens measured). Accessory archeopyle sutures along paraplate boundaries 3''/ 4'' and 4''/ 5'' sometimes present. Operculum always in place, adnate posteriorly." — Kurita (2004, p. 38, 40)

Dimensions: "Cyst overall length 42–63 μm (average 51 μm), width 33–57 μm (average 41 μm), 137 specimens measured. Spine length up to 2 μm. Apical horn length 4.3 μm; larger antapical horn length up to 5 μm." — Kurita (2004, p. 40)

Remarks: "This new species is characterized by its rounded pentagonal body shape, large, triangular apical pericoel and large, isodeltaform hexagonal, 2a archeopyle. The cornucavate wall relationships are distinctive in most of the observed specimens. Although the spines are not always entirely penitabular, the consistent presence of penitabular spines, at least in parts of the body, and the cornucavate wall relationships confirm the generic assignment of this species to *Spinidinium*. Variation of the cyst shape is not profound as indicated in Plate 1, figures 1–16. Height of epicyst more or less equal to that of hypocyst.

Spinidinium pentagonum sp. nov. is distinguished from other species of the genus by its angular, pentagonal ambital shape. It differs from *Spinidinium*? *tripylum* sp. nov. in overall cyst shape, apical pericoel shape and archeopyle configuration. It also differs from *Spinidinium essoi* Cookson and Eisenack 1967 in having a larger apical pericoel. *Spinidinium pentagonum* sp. nov. frequently occurs with *Trinovantedinium boreale*, which also has a peridinioid outline, type I archeopyle and a general covering of relatively short spines. However, *Spinidinium pentagonum* sp. nov. is cornucavate and has a large, easily discernible archeopyle." — Kurita (2004, p. 38, 40, 42)

<u>Age</u>: late Eocene; holotype of Kurita (2004, p. 38, text-fig. 12h). Range: late middle–late Eocene (Kurita, 2004, p. 38).

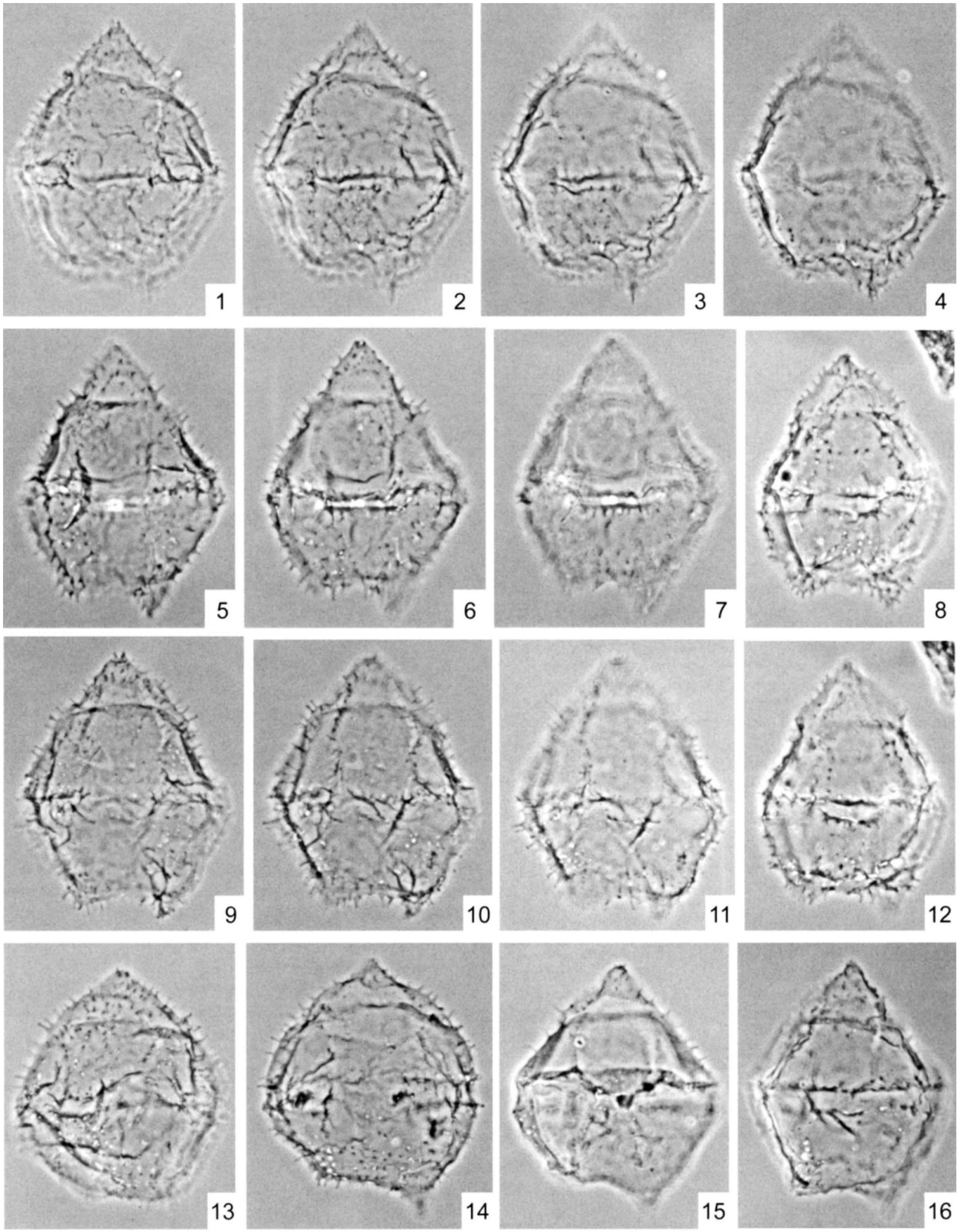


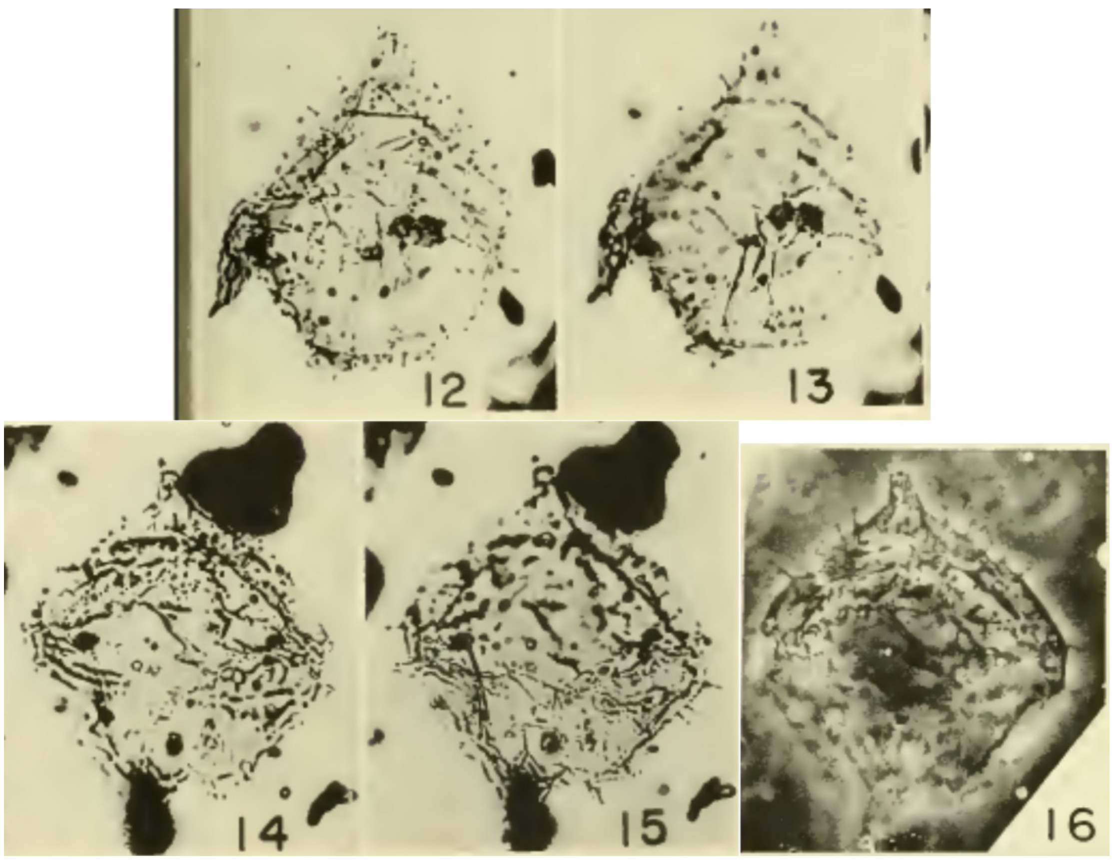
Plate 1, figures 1–16, Kurita (2004). Scale bar = 50 µm.

?*Spinidinium pilatum* (Stanley, 1965) Costa & Downie, 1979

Description: "Outer cyst more or less pyriform to rhomboidal in dorso-ventral view; length 42–49 μ, width about 30 μ. Hypotheca smaller than epitheca. Outer cyst membrane thin, moderately folded; membrane ornamented with rodlike elements that usually have a small ball-like expansion on the distal end (pila); length of spines 1.5 to 3 μ. Apical horn about 5 μ long. Left antapical horn approximately 9 μ long whereas the right antapical horn is usually not developed. Girdle on the order of 5 μ wide and more or less distinct; furrow and archeopyle indistinct." — Stanley (1965, p. 222)

Differential diagnosis: "*Wetzeliella pilata*, n. sp. differs from *W. rugosa*, n. sp. by having long sculpture elements that are expanded at their distal end." — Stanley (1965, p. 222)

Age: early Paleocene (Danian); holotype of Stanley (1965, p. 222). Warwick et al. (2004) places the Cannonball Member of the Fort Union Formation as 65–61 Ma.



Plates 21, figures 12–16, Stanley (1965).

?*Spinidinium pulchrum* (Benson, 1976) Lentin & Williams, 1977b

Description: "Cavate cyst, peridinoid outline with intratabularly arranged coni on periblast. Periphragm and endophragm each about 0.5 micron in thickness. Reflected tabulation 4', 3a, 7'', ?c, 5''', 2''''. Apical horn with two short spines on antero-lateral margin, the spines directed anteriorly. Archeopyle intercalary (Type I/I) with posteriorly and occasionally laterally directed accessory sutures. Cingulum levorotary, offset up to 4 micra. Sulcus strongly developed, may extend up to 5 micra on epitract. Left antapical horn longer than right. Endoblast closely appressed to periblast, may protrude slightly into antapical horns." —

Benson (1976, p. 194)

Dimensions: “Holotype: periblast length 69 micra; width 50 micra; endoblast length 46 micra; width 46 micra; apical pericoel 13 micra. Range: 20 specimens measured; periblast length 56–74 micra; width 43–57 micra; endoblast length 40–54 micra; width 38–51 micra; apical pericoel 7–13 micra.” — Benson (1976, p. 194)

Comments: “*D. pulchra* resembles *D. echinoidea* (Sverdlove and Habib, 1974); however, it differs in that the tabulation of *D. pulchra* is reflected by the intratabular rather than peritabular arrangement of the coni. Also, it is Paleocene rather than Cretaceous in age.” — Benson (1976, p. 194)

Age: early Paleocene (Danian); holotype of Benson (1976, p. 194). Range: early Paleocene (Danian) Benson (1976, figs. 2) given the age of the Brightseat Formation provided by Weems (2014).

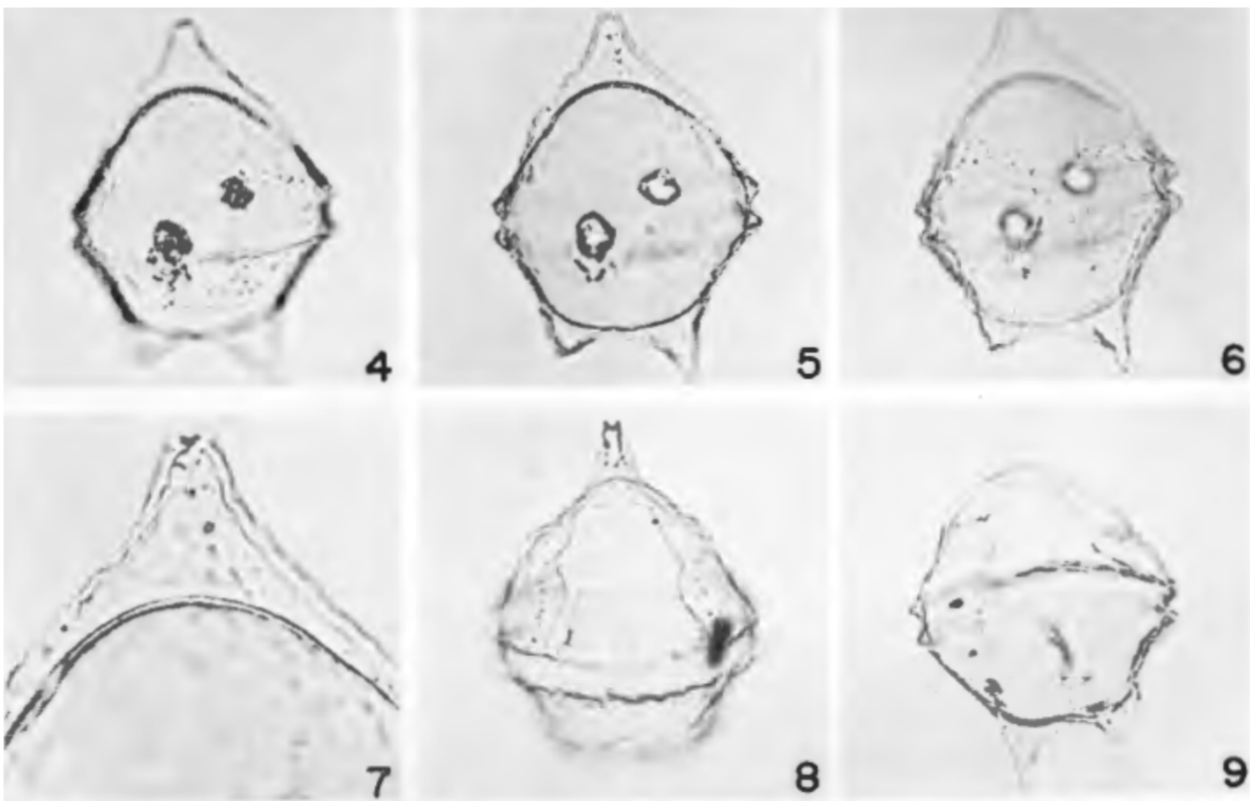


Plate 9, figures 4–9, Benson (1976).

?*Spinidinium rallum* Heisecke, 1970

Diagnosis: “Cyst cavate, ovoidal. The surface is covered by sharp spines, more long than usual for the genus, and distributed in a spaced and irregular way on the body, generally aligned and eventually joined together by partitions. The periphragm forms an apical horn and an antapical bulge; presents a slightly insinuated cingulum. No archeopyle has been observed.” — Translated from Heisecke (1970, p. 226)

Dimensions: “Cyst cavate, variegated in shape, usually ovoid. The contour is oval to irregular pentagonal, exceptionally triangular or conical. The surface is covered by few long, sharp spines that are preferentially distributed along lines forming boundaries between plates; in some cases are joined by partitions. The wall is composed of two layers, the periphragm which forms the spines, comprises a pyramidiform apical horn that usually culminates into an apical pore and an antapical bulge culminating in a spine. The endophragm forms a capsule that occupies the entire width and just over half the length of the cyst. The reflected tabulation is unclear, for which it is difficult to establish, however, the holotype clearly distinguishes 5 plates in the apical zone; in the body there is evidence of separate precingulate and postcingulate area by a series of plates of smaller height that would correspond to the cingulum. However, it has not been possible to determine the number of plates corresponding to each series. No type of archeopyle has been observed." — Translated from Heisecke (1970, p. 228)

Dimensions: "Holotype: total length 46 μ, long (without horns) 24 μ, width 32 μ, length of horn apical 16 μ, length of antapical protuberance 5.5 μ. Range across fourteen specimens: Total length 34.5–48 μ, long (without horns) 20–31 μ, width 24–34.5 μ, length of apical horn 11.5–22 μ, length of antapical protuberance 1–19 μ." — Translated from Heisecke (1970, p. 228)

Discussion and comparisons: "The new species has been included in the genus *Spinidinium* for presenting instead of antapical horns, a prominence or projection and for having the surface covered by spines, however the species previously described corresponding to this genus had surfaces more densely covered by spines and these are shorter, so the new species cannot be compared with any of those. Several of the specimens of *Deflandrea* described in this work have very similar spines to those of the new species. However, due to other characteristics (see the observations made for *Deflandrea irmoechinata*) it is concluded that these forms do not belong to the same species. The new species differs from *Deflandrea* cf. *macmurdoensis* and *Deflandrea* sp. 1 in which both have a well-marked cingulum, antapical horns, do not present division into areas or fields and *D.* cf. *macmurdoensis* presents an intercalated archeopyle, in addition to a different external aspect (shape, dimensions)." — Translated from Heisecke (1970, p. 228)

Age: early Paleocene; holotype of Heisecke (1970, p. 230).

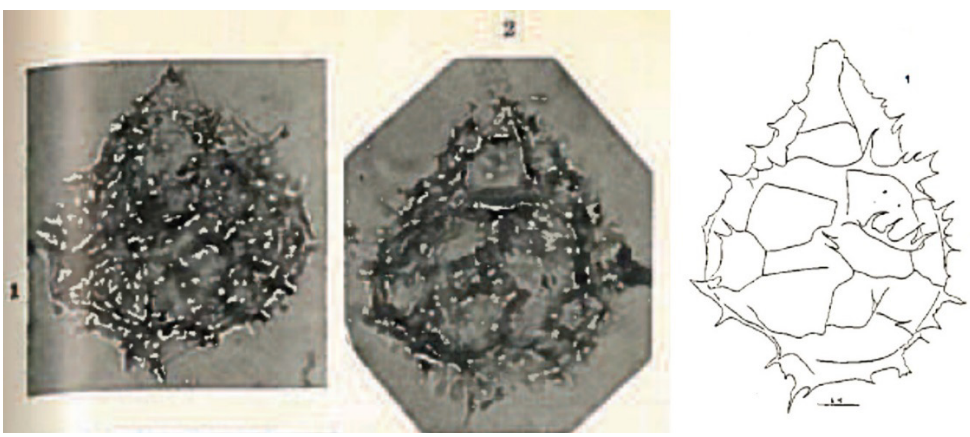


Plate 1, figures 1, 2; Plate 2, figure 1, Heisecke (1970). Scale bar = 5 μm.

Spinidinium rugosum (Stanley, 1965) Costa & Downie, 1979

Description: "Outer cyst rhomboidal to subrhomboidal in outline with the length being either slightly longer or slightly shorter than the width. Length varies between 50–60 μ whereas the width also varies between 50–60 μ. Outer cyst membrane thin and almost always irregularly folded or crumpled: membrane bears spinelike sculpture elements that have a length of about 1.5 to 2 μ. Apical horn about 3–5 μ in length; antapical horns two in number; the left one being well developed with a length of about 5 μ, whereas the right one is poorly developed. Girdle indistinct but does appear to be bordered on both edges by a row of spinelike processes. Interior cyst thin-walled and more or less completely fills the outer cyst." — Stanley (1965, p. 222, 223).

Differential diagnosis: "*Wetzeliella rugosa*, n. sp. is differentiated from *W. pilata*, n. sp. by its spinelike sculpture elements that lack any expansion at their distal ends." — Stanley (1965, p. 223).

Age: early Paleocene (Danian); holotype of Stanley (1965, p. 222). Warwick et al. (2004) places the Cannonball Member of the Fort Union Formation as 65–61 Ma.

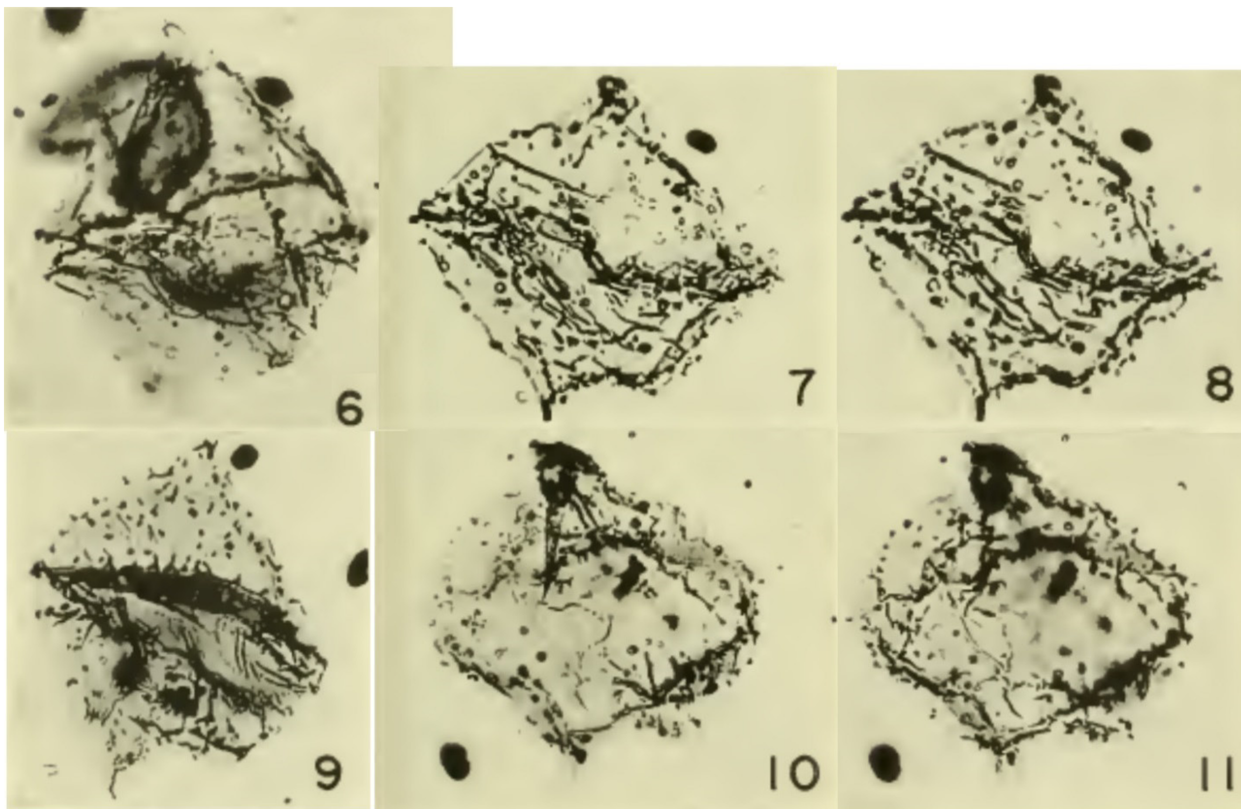


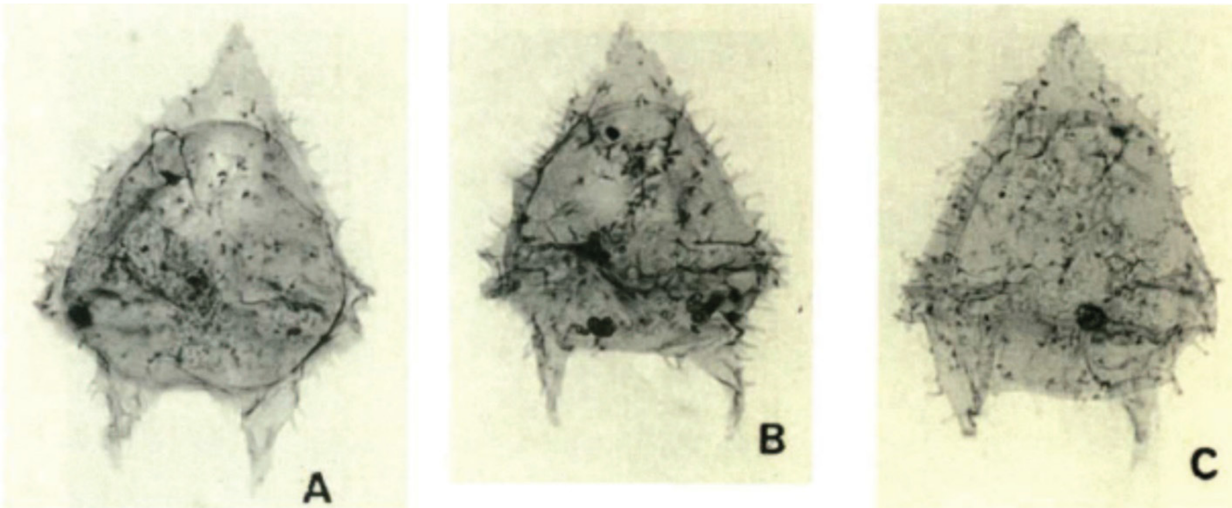
Plate 21, figures 6–11, Stanley (1965).

?*Spinidinium sagittula* (Drugg, 1970) Lentin & Williams, 1976

Description: "Tract arrow-shaped, epitract larger than hypotract. The cingulum is located low on the tract and is delineated by low ledges ornamented with short processes. Wall thin, two-layered, the endophragm forming a capsule with the periphragm usually closely appressed except in the area of the horns. The two antapical horns are about equal in size. Dorsal intercalary archeopyle of trapezoidal shape present in both endophragm and periphragm. The tract is ornamented with short processes (2 to 8 μ) which possess blunt to faintly capitate distal terminations. The overall length of this species ranges from 81 to 103 μ and the width from 64 to 74 μ." — Drugg (1970, p. 809)

Remarks: "The specific name is from the Latin *sagittula*, little arrow. This species differs from *Deflandrea longispinosa* Wilson, 1968, in that the processes are shorter and the ambitus is more arrow-shaped. It resembles *D. wetzeli* Morgenroth, 1966, in the placement of the cingulum but differs in possessing much more pronounced ornamentation." — Drugg (1970, p. 809, 810)

Age: early Eocene; holotype of Drugg (1970, p. 810).



Figures 1A–C, Drugg (1970).

Spinidinium schellenbergii Sluijs et al., 2009

Diagnosis: “A species of *Spinidinium* with small cysts that are circumcavate, proximate, with a rhomboidal to pentagonal, longer than broad outline. Parasutures bear hollow, distally rounded coni.” — Sluijs et al. (2009, p. 46)

Description: “Cysts with a thin, psilate endocyst that is rhomboidal in outline, with rounded corners. The pericyst is thin, with a rhomboidal to pentagonal outline, short apical horn and short left antapical horn. Plates may have a depressed intratabular area surrounded by raised parasutural margins. Parasutures bear short hollow distally rounded coni. The coni may show a partially penitabular arrangement on the hyposome. The cingulum is indented, and is anteriorly and posteriorly delineated by a sutural ridge that bears coni. The sulcus is wide, extending onto the epicyst, but considerably longer on the hypocyst reaching almost to the antapex. It is laterally delineated by sutural coni, sometimes connected by low crests. The archaeopyle is intercalary, stenodeltaform Type I (plate 2a), operculum free.” — Sluijs et al. (2009, p. 46)

Dimensions: “Holotype: 41 × 31 μm. Range: length 36(40)45 μm, breadth 26(31)34 μm. Specimens measured 10.” — Sluijs et al. (2009, p. 46)

Remarks: “*Spinidinium schellenbergii* differs from other species of *Spinidinium* by its small size and in having coni.” — Sluijs et al. (2009, p. 46)

Age: middle–late Eocene; holotype of Sluijs et al. (2009, p. 46).

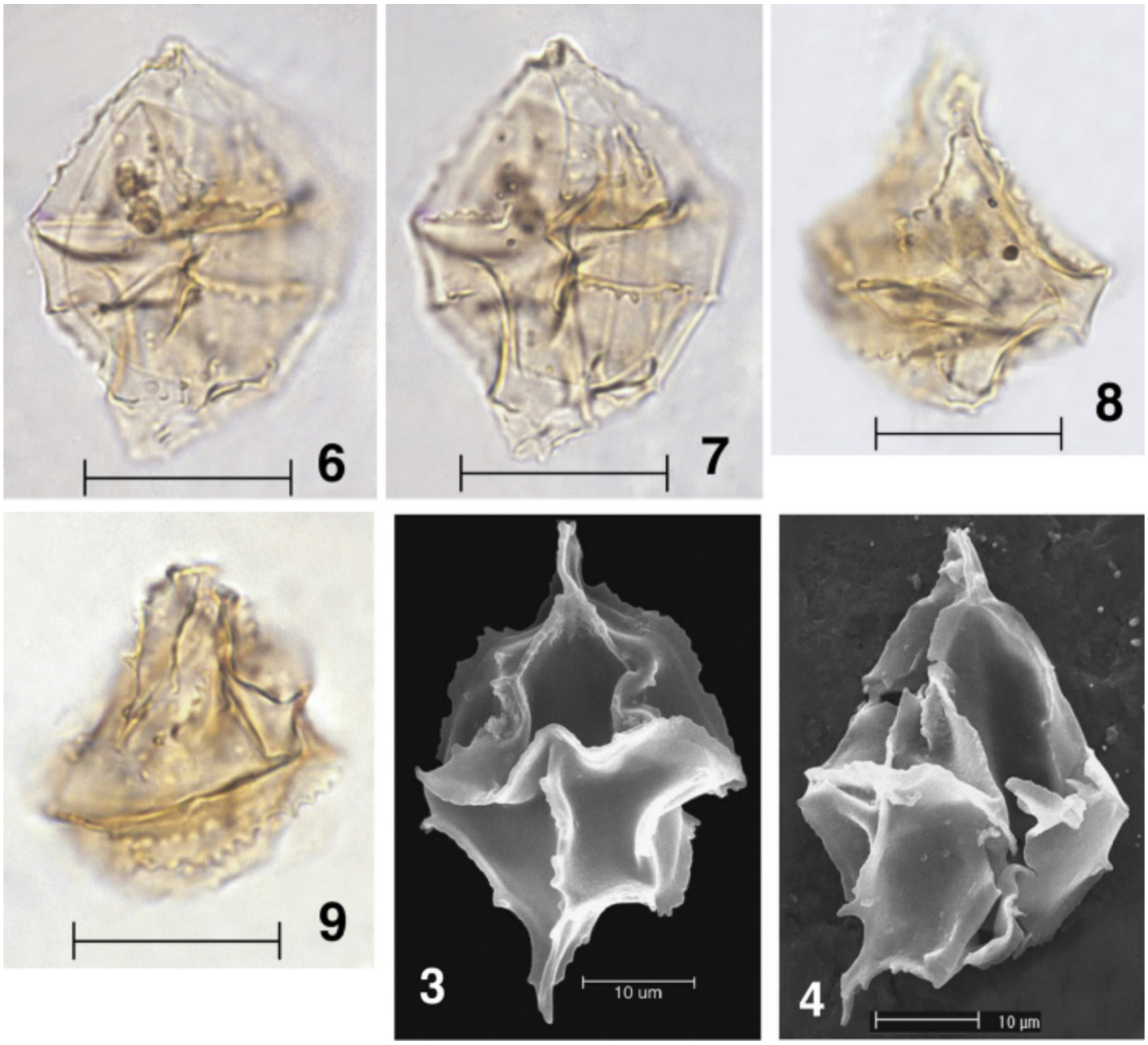


Plate 4, figures 6–9, scale bars = 20 μm; Plate 6, figures 3, 4, Sluijs et al. (2009).

Spinidinium stellatum Soncini, 1992

Diagnosis: "Rounded polygonal, compressed dorsoventrally, proximochorate two-layered cyst, circumcavate (to bicavate). Short apical horn truncated, left antapical horn variable in length, pointed, right antapical reduced or absent. Broad and laterally prominent paracingulum. Numerous projections on cyst surface, variable in length and shape complexity. Tapering proximally, with pericoele often protruding into their base; solid stem short to long, narrow to broad; distal part simple, bifurcate, trifurcate or more; at any scale, every distal extremity expanding and aculeate. Paratabulation evident (except in paracingular and parasulcal areas), peridinioid ortho- (ventral side) hexa type (dorsal side). Projections in parasutural position on ventral side, in penitabular position on dorsal side, partially missing on 2a intercalary paraplate (border-side with 4'') and on 3''' (borderside with paracingulum), absent in the paracingulum and the sulcal areas. Strong antapical dissymmetry, 2'''' large and almost centered, 1'''' reduced to the left antapical horn. Peri- and endo-archeopyle type Ia, eurydeltaform. Pedoperculum commonly adnate, endoperculum adnate, rarely discernible." — Soncini (1992, p. 335)

Description: "*Spinidinium stellatum* cysts are two-layered, the endophragm is thin and smooth, spheroidal, variably appressed to the periphragm (circumcavate to bicavate). The periphragm is generally smooth or shagrinate, but sometimes fovelate (Plate III, 5, 6). Straight, long and simple projections are particularly well developed on the extremities of apical and antapical horn (Plate III, 4). Paracingulum borders are also prominent, underlined by more complex projections: simple, bifid or trifid, they can be linked together proximally in a discontinuous ridge. Although they are homogeneous on a single specimen, projections show a great diversity in shape and length (Fig.7); it is then hard to call them 'spines' or 'processes'. With short or long, narrow or broad solid stem, straight or branched, bifid, trifid, they are all distally expanded and aculeate, but the rows of minute acuminate spines are hardly discernible (Plate III, 13, 14). Anyway, the first stricking [sic] feature all projections have in common is their roughly star-shaped tip (hence the species name: *stellatum*).

Projections are scarce on paraplates surface, but numerous in parasutural position on ventral side (Plate III, 3), and in penitabular position on dorsal side (Plate III, 1, 10, 11) (rare specimens with just few 'diminutive processes' underlying paratabulation). Lack of projection on posterior margin of intercalary paraplate 2a (contact 2a/u''), and on the anterior margin of postcingular paraplate 3''' (contact 3'''/paracing.) are also diagnostic features (Fig.8). Paratabulation peridinioid, with ventral ortho-type. Dorsally, la and 3a intercalaries seem to be smaller than the six-sided 2a (hexa-type). The archeopyle (type Ia) is eurydeltaform (Plate III, 1), the operculum (2a) is generally adnate (Plate III, 10). The endoperculum is also adnate and eurydeltaform, sometimes discernible inside the cyst (Plate III, 4)." — Soncini (1992, p. 335, 336)

<u>Dimensions</u>: "Holotype length: 95.5 μm, width: 77 μm; range: length: 67–116.5 μm, width: 60.5–112 μm, processes length: 2–9.5 μm (homogeneous on each specimen); 120 specimens measured." — Soncini (1992, p. 335)

<u>Comparison</u>: "Although it belongs clearly to the genus *Spinidinium*, *S. stellatum* differs greatly from other *Spinidinium* species: with the penitabular and parasutural distribution of the projections (commonly covering the surface of the cyst except on pandasutural areas on other paratabulated *Spinidinium* species); with the complexity of these projections: short to long spines (like most *Spinidinium*) or diminutive processes typically expanded and aculeate (very distinctive character).

Some features in *S. stellatum* suggest morphological affinities with the Wetzeliellaceae: processes distribution could compare with some *Wilsonidium* Lentin and Williams 1976, but not the ambitus (no equatorial extension for instance); distal rows of minute spines on narrow processes tip could compare with ornamentation on some *Apectodinium* (Costa and Downie) Lentin and Williams 1977, but paratabulation is generally not clear on *Apectodinium* cysts. However, in no case *Spinidinium stellatum* shows the characteristic quadra-type dorsal organization of the Wetzeliellaceae (2a quadra, large and broad 4''), nor the para ventral organization (/'contacts 2'' and 6'')." — Soncini (1992, p. 336)

<u>Age</u>: late Paleocene (early Thanetian); holotype of Soncini (1992, p. 333, fig 3). Range: late Paleocene (early Thanetian)–early Eocene (early Ypresian) (Soncini, 1992, p. 335, figs. 2, 3).

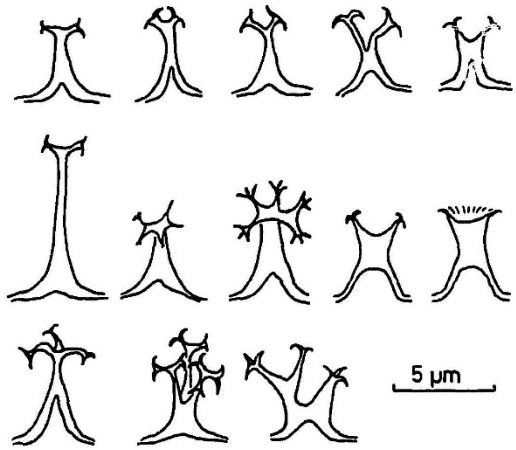


Fig.7. Sketch drawing of varying projections features (spines, diminutive processes) observed in optical section on ***Spinidinium stellatum*** sp. nov.

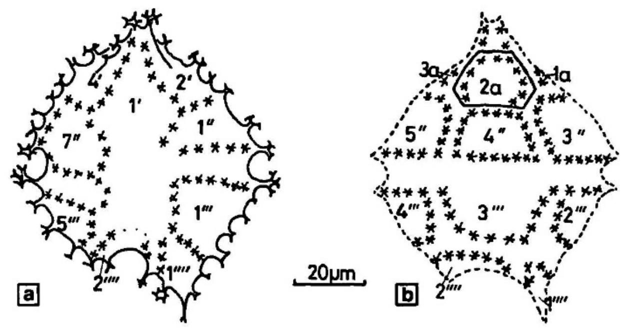


Fig.8. Paratabulation pattern (Kofoid notation) of ***Spinidinium stellatum*** sp. nov. reconstructed from parasutural and penitabular ornamentation. (a) external view of ventral side. (b) internal view of dorsal side.

Text-figures 7, 8a, b, Soncini (1992).

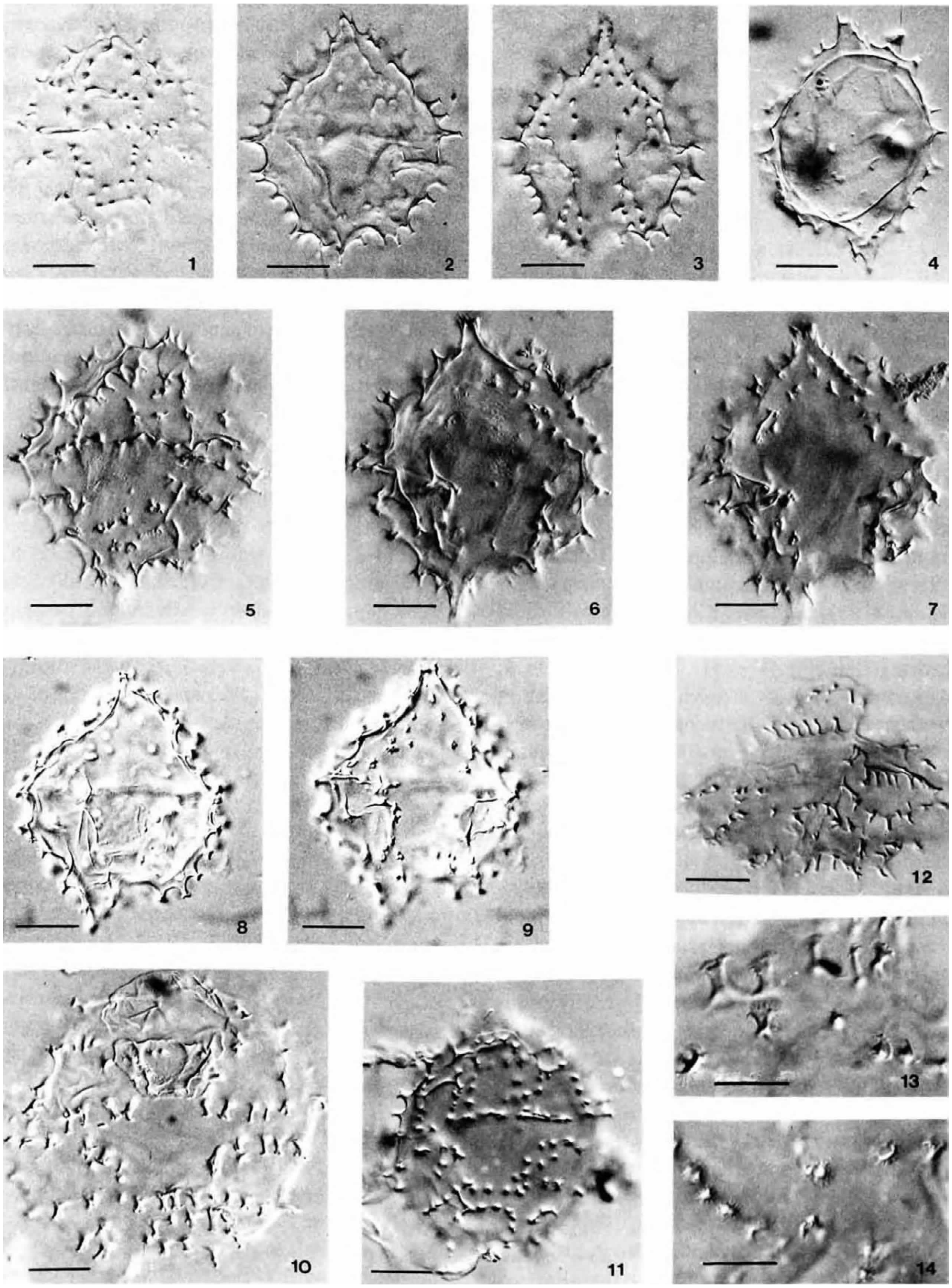


Plate 3, figures 1–14, Soncini (1992). Scale bar = 20 μm.

Spinidinium styloniferum Cookson & Eisenack, 1962

Description: "Shell small; ventral surface deeply concave; epitheca slightly longer than hypotheca; apical horn short, hollow; the end wall straight to concave, usually with a median, downwardly directed, tongue-like thickening and a few upwardly directed basal spines; antapex oblique or rounded, with a short projection on one side. Girdle well-defined, with decided marginal indentations; longitudinal furrow proportionately wide, especially in the hypotheca, narrowing in the epitheca to end shortly behind the apex.

Shell membrane two-layered, the inner layer smooth and thin, the outer layer somewhat thicker and ornamented with numerous short, finger-like processes or bluntly pointed spines, some of which outline the girdle, the longitudinal furrow, and the position of the eventual pylome. The outer layer frequently thickens appreciably toward one side of the antapex to contribute, together with one or two more prominent spines, to the formation of the antapical projection. Pylome narrowly hoof-shaped." — Cookson & Eisenack (1962, p. 489)

Dimensions: "Holotype: 53 µ long, 42 µ broad. Range: 42–60 µ long, 36–42 µ broad." — Cookson & Eisenack (1962, p. 489)

Age: Early Cretaceous (Aptian Albian); holotype of Cookson & Eisenack (1962, p. 489).

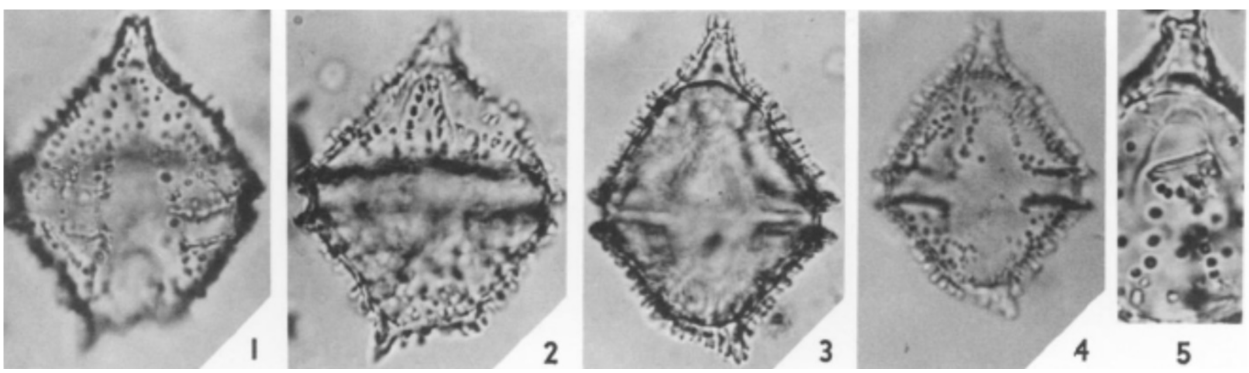


Plate 1, figures 1–5, Cookson & Eisenack (1962).

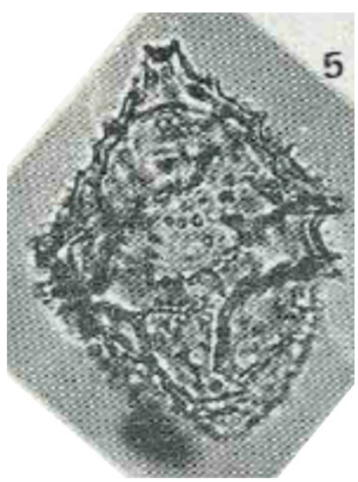


Plate 2, figure 5, Pöthe de Baldis & Ramos (1983).

Spinidinium sverdrupianum (Manum, 1963) Lentin & Williams, 1976. Emendation: Lebedeva in Ilyina et al., 1994, p. 64.

Diagnosis: "Theca in dorsoventral view roughly rhomboid with the obtuse angles in the equatorial region, and divided into nearly equal parts by a slightly spiral, laevorotatory girdle. Epitheca narrows towards a short, blunt or truncate apical horn. Hypotheca conspicuously asymmetric with a prominent, sharply pointed horn on the left-hand side, and a small bulge suggestive of a horn on the right-hand side. Theca ornamented by spine-like to conical processes up to 3 μ high arranged so as to indicate fields or plates according to the form ula 4', 3a, 7'', 5''', ?''''. The girdle is bordered by discontinuous lines of similar processes. Archeopyle (2a) elongate and roughly trapezium-shaped. A capsule of approximately circular outline fills the greater part of the theca." — Manum (1963, p. 59)

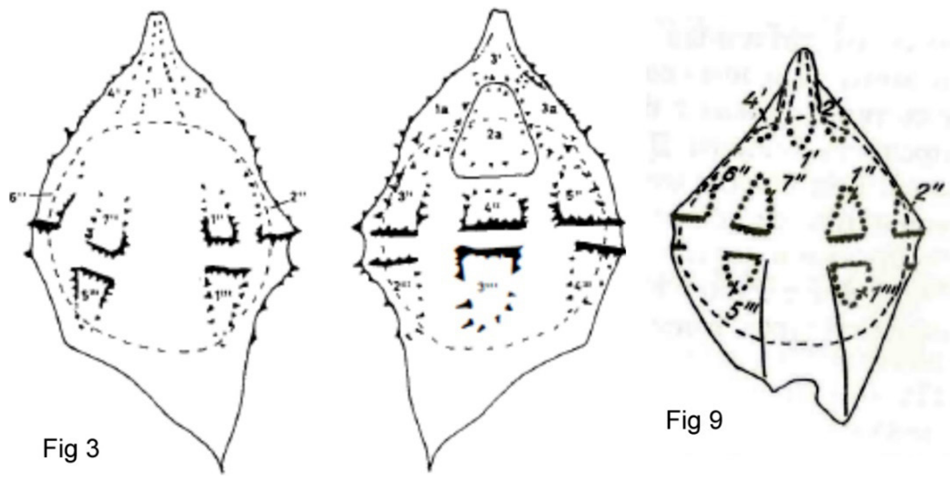
Dimensions: "Holotype: overall length 94 μ, width 53 μ. Range: length 51–98 μ, width 35–61 μ. Average of 32 specimens: 77 × 46 μ." — Manum (1963, p. 59)

Description: "The theca-membrane, less than 1 μ thick, is usually more or less folded so that the tabulation indicated by the linearly arranged spines could not be fully obtained from a single specimen. The prominence of the spines varies, usually they are most prominent along the girdle and for some distance on either side of it, thus the precingular and postcingular plates are the ones most easily distinguishable. Although the general shape of the archeopyle is reminiscent of a trapezium, its basic shape is hexagonal with alternating short and long sides. The conspicuous 'breaks' in the girdle occur dorsally at some distance on either side of the mid-line, and ventrally more or less dose to the lateral margins of the theca. The longitudinal furrow is not clearly outlined. The capsule usually does not quite reach the lateral walls of the theca. The wall of the capsule is less than 1 μ thick, its surface is usually granular." — Manum (1963, p. 59, 60)

Comments: "*D. sverdrupiana* is quite distinct from *D. scheii* in shape and ornamentation, but the two species have certain characters in common which indicate dose relationship. The tabulation indicated by the ornamentation in *D. sverdrupiana* corresponds to that of *D. scheii*. Furthermore, both species have a laevorotatory girdle with 'breaks' in identical positions, and the more strongly developed horn is on the left-hand side of the antapex. Of the previously described species of *Deflandrea* only three need to be compared with *D. sverdrupiana*. *D. pirnaensis* Alberti (1959) from German Turonian deposits is comparable with it in size and shape, but differs in having a granular theca-membrane, no breaks in the girdle, and no distinct archeopyle. *D. balmei* Cookson & Eisnack (1962) from the Upper Cretaceous of Western Australia agrees with *D. sverdrupiana* in having linearly arranged spines but is much smaller, more rounded in outline, and has no antapical horns. *D. echinoidea* Cookson & Eisenack (1960), also from the Upper Cretaceous of Western Australia, is similar to *D. sverdrupiana* in having one prominently developed antapical horn and an ornamentation of spines. However, the theca of *D. echinoidea* has a more circular outline, the girdle is unbroken, and the spines are longer (up to 5 μ), more numerous and more closely arranged. The specific name is given in memory of Otto Sverdrup, the leader of the 2nd 'Fram'-expedition." — Manum (1963, p. 60)

Emended description: "Cyst of peridinoid appearance, polygonal. Epicyst equal to a hypocyst with a well-defined, wide base, conical apical pore. Hypocyst trapezoidal with straight or concave lateral sides, with two antapical horns of different length. Left horn pointed, triangular, well developed; right smaller, obtusely triangular or cut off. The endocyst is large almost filling entire pericoel except for apical and antapical parts. Endophragm thin, smooth. Paratabulation is expressed by penitabular located blunt spines. Paraplates small, divided with parasuture stripes. Paratabulation formula 4b, b 3a, 7'', xs, 5''', 2''''. Archeopyle intercalary deltaform 2a, operculum usually attached. Paracingulum wide (6–8 microns), intermittent, expressed by parallel ribs with jagged edges formed by fused spikes. Parasulcus wide, deep, stretching from paracingulum to antapex. Periphragm thin, smooth, sculpture represented by penitabular spines 2–4 microns high (Fig. 9).” — Translated from Lebedeva in Ilyina et al. (1994, p. 64)

Age: “approx. middle Cretaceous” based on a sample from Graham Island (approx. 77° 20' N, 91° W) (Manum, 1963, p. 55).



Text-figure 3, Manum (1963); Text-figure 9, Lebedeva in Ilyina et al. (1994).

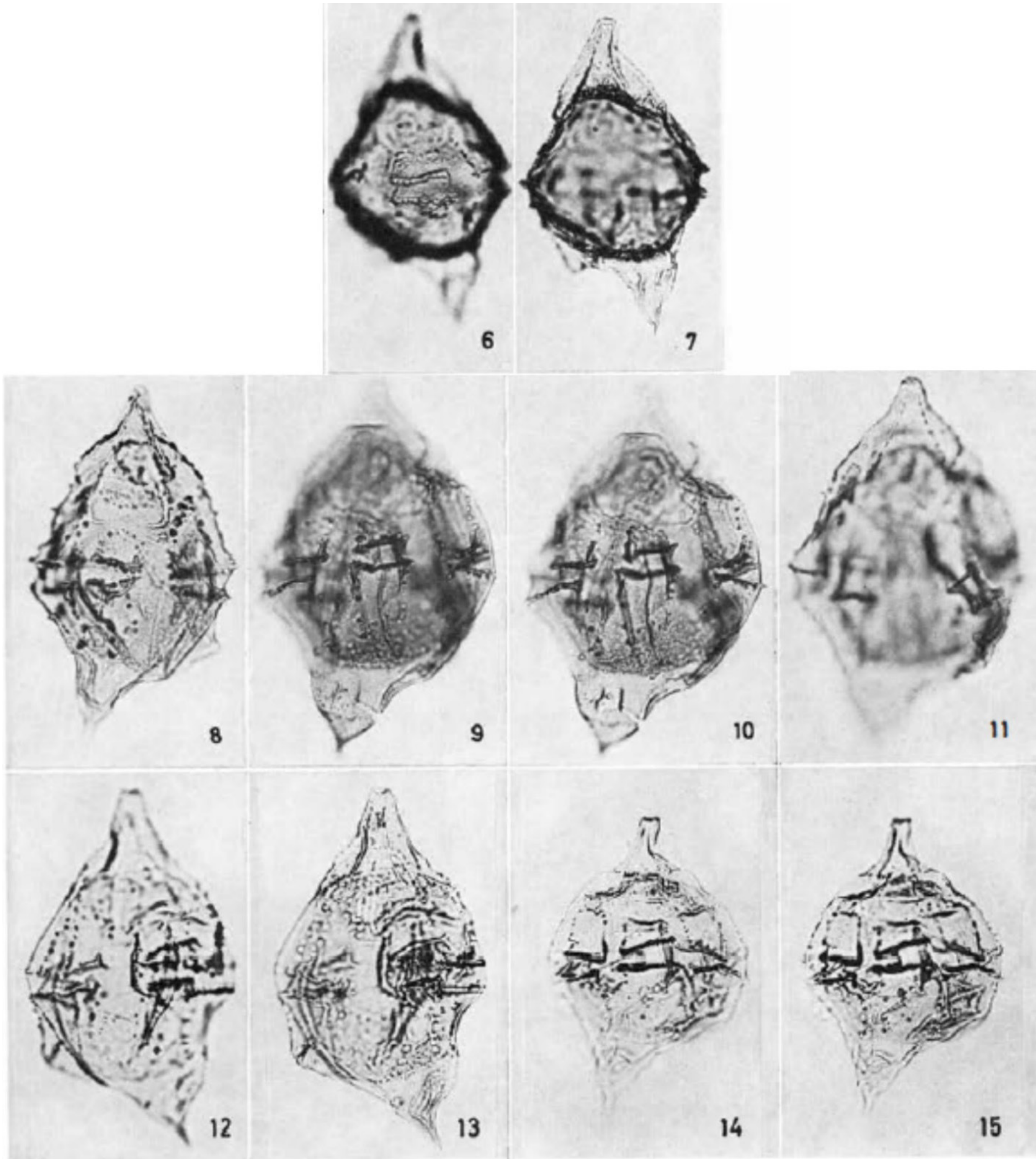


Plate 2, figures 6–15, Manum (1963).

?*Spinidinium tabulare* He Chengquan, 1991

Description: “Capsule-embracing cavity type, outline is nearly biconical-pentagonal, body is nearly round, with a short triangular vertex. Apical horn is about 5.5 μm long, with a blunt rounded apex and an off-centre antapical horn (blunt conical, about 5 μm long), and sometimes the other antapical horn is also slightly developed. The epitheca is slightly larger than the hypotheca, bell-shaped, and the hypotheca is nearly trapezoidal. The equatorial position of the girdle is obvious, ring-shaped, 5–6 μm wide, and its side margins are marked by smooth fine ridges. Longitudinal groove not seen. The cyst wall is thin, and the outer wall surface has several longitudinal toothed ridges. The length of the spines varies, and some are granular, some are longer, the longest is about 1 μm, these tooth-like ridges are located on the edge of the reflected pole plate. However, the reflected plate type cannot be determined, and the surface of the reflected plates are smooth or occasionally micro-granular, and sometimes there are short rods on the top corners; protrusions, about 2 μm long. The inner body is nearly round, the wall is slightly thicker than the outer wall, and the surface is smooth. Except for the corners, it is attached to the outer wall. Archeopyle anterior style, trapezoidal, but often blurred and invisible. The operculum comes off or remains in place." — Translated from He Chengquan (1991, p. 88)

Dimensions: "The holotype is 47.5 μm long and 42.5 μm wide, the inner body is 35 μm long and 37 μm wide, and the girdle is 6 μm wide; Range: the cyst is 47.5–52.5 μm long and 42.5 μm wide, and the inner body is 35–38 μm long and 37–42 μm wide (3 specimens measured)." — Translated from He Chengquan (1991, p. 88)

Comparison: "Characteristics of this new species are the surface of the outer wall being obviously floor-shaped, reflecting the characteristics of plate edges decorated with tooth-like ridges and short and blunt antapical horns. These indications are different from the known species in this genus. Although *Spinidinium clavum* also has a plate-shaped outer wall, the cyst is elongated and spindle-shaped; it is different from this new species." — Translated from He Chengquan (1991, p. 88)

Age: late Paleocene (Thanetian); holotype of corresponding to "lower member of Qimgen Formation" as translated from He Chengquan (1991, p. 88) based on the geological age of the unit provided by Xi Dangpeng et al. (2020, fig. 12).

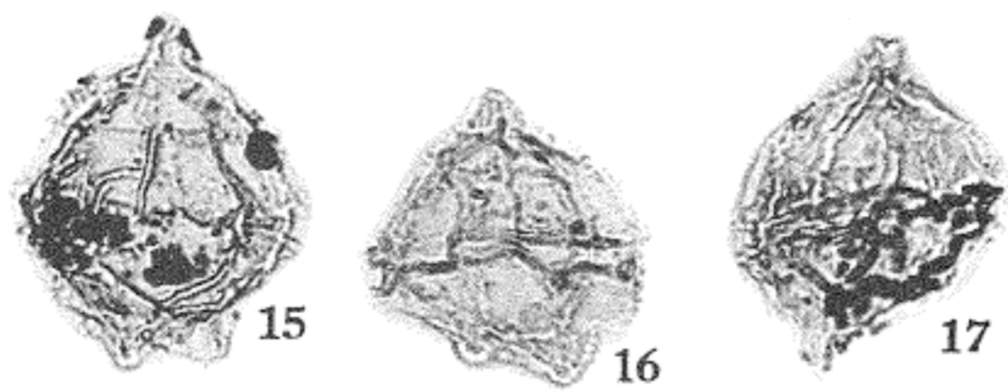


Plate 2, figures 15–17, He Chengquan (1991).

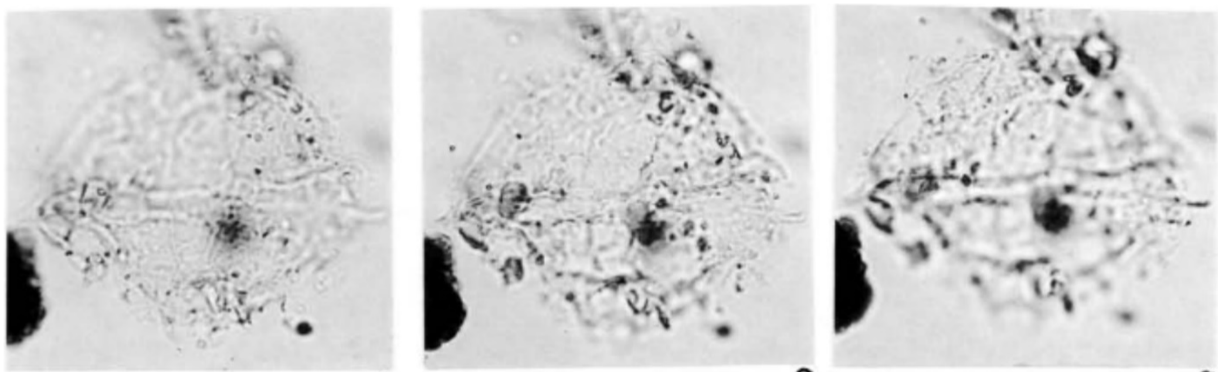
?*Spinidinium taiwanianum* Shaw Chenglong, 1999

Description: "Outer cyst sub-quadragonal in dorsa-ventral view, 39 μm long, 46 μm wide. Outer cyst membrane thin; ornamented with short rodlike, club-like, spine-like or grapple-like appendages. Apical horn weakly developed and antapical horn indistinct. Innercyst indistinct. Archeopyle intercalary type, operculum free or attached." — Shaw Chenglong (1999, p. 158)

Dimensions: "Holotype: Overall 39 μm long, 46 μm wide." — Shaw Chenglong (1999, p. 158)

Remarks: "The species differs from the type species *Spinidinium styloniferum* in having weakly developed indistinct apical and antapical horns and in having smaller size." — Shaw Chenglong (1999, p. 159)

Age: Eocene; holotype of Shaw Chenglong (1999, p. 159).



Figures 1–3, Shaw Chenglong (1999).

?*Spinidinium tripylum* Kurita, 2004

Diagnosis: "A species provisionally assigned to the genus *Spinidinium* with pericyst peridinioid to ovoidal and with one apical and two antapical horns. Cyst cornucavate, occasionally bicavate or epicavate. Archeopyle compound, (IP)@+ (IP)@+(IP)@ (text-fig. 10b)." — Kurita (2004, p. 42)

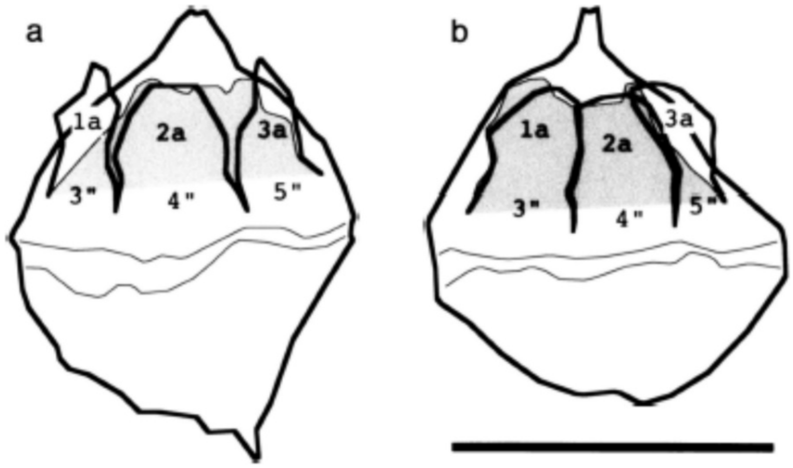
Description: "Pericyst peridinioid to ovoidal with one apical and two antapical horns; cornucavate, occasionally bicavate or epicavate. On pericyst, short spines which are usually simple solid ornaments, or rarely triangular, flap-like, somewhat membranous projection. Spines arranged generally in penitabular rows. Density of spines variable. Apical pericoel always relatively large, resulting from inflation of pericyst in epicyst (shoulders). Paracingulum indicated by two parallel rows of spines or by two parallel ridges with spines on them, about 2.5 μm apart. Parasulcus indicated by lack of paracingular rows or ridges and shallow depression of the cyst in the ventral area. Endocyst ovoidal to circular. Both pericyst and endocyst pale, transparent and smooth. Paratabulation indicated by the penitabular arrangement of the spines, paracingular rows or ridges, parasulcus and archeopyle. Archeopyle compound, (IP)@+(IP)@+(IP)@ (text-fig. 10a)." — Kurita (2004, p. 42)

Dimensions: "Overall cyst length 57–65 μm; width 45–57 μm. Spine length up to 1.2 μm. Apical horn length 7 μm; larger antapical horn length up to 5 μm." — Kurita (2004, p. 42)

Remarks: "*Spinidinium*? *tripylum* sp. nov. is characterized by its peridinioid to ovoidal shape, short spines which are arranged in penitabular rows and the compound archeopyle. The penitabular arrangement of the spines is often typically observed in the apical and intercalary paraplates. A relatively large apical pericoel is also characteristics of the species. The archeopyle is indicated by slits frequently observed between the precingular paraplates right beneath the intercalary paraplates (text-fig. S10b).

The archeopyle of *Spinidinium*? *tripylum* sp. nov. does not allow direct assignment to the genus *Spinidinium*, which has a simple 2a intercalary archeopyle; rather it could be included in *Williamsidinium*. Other genera whose archeopyle involves three anterior intercalary paraplates include *Ginginodinium*, *Pierceites*, *Ripea*, *Trithyrodinium* and *Trivalvadinium*. *Spinidinium*? *tripylum* sp. nov. is not comparable to those genera in view of wall relationship and cyst overall shape etc. Presently the species is provisionally assigned to *Spinidinium*, because of the well discernible penitabular spines which are characteristic to *Spinidinium* and have never been reported on *Williamsidinium* species." — Kurita (2004, p. 42)

Age: late Oligocene (Chattian); holotype occurrence and range of species (Kurita, 2004, p. 42).



Text-figure 10b, Kurita (2004). Scale bar = 50 µm.

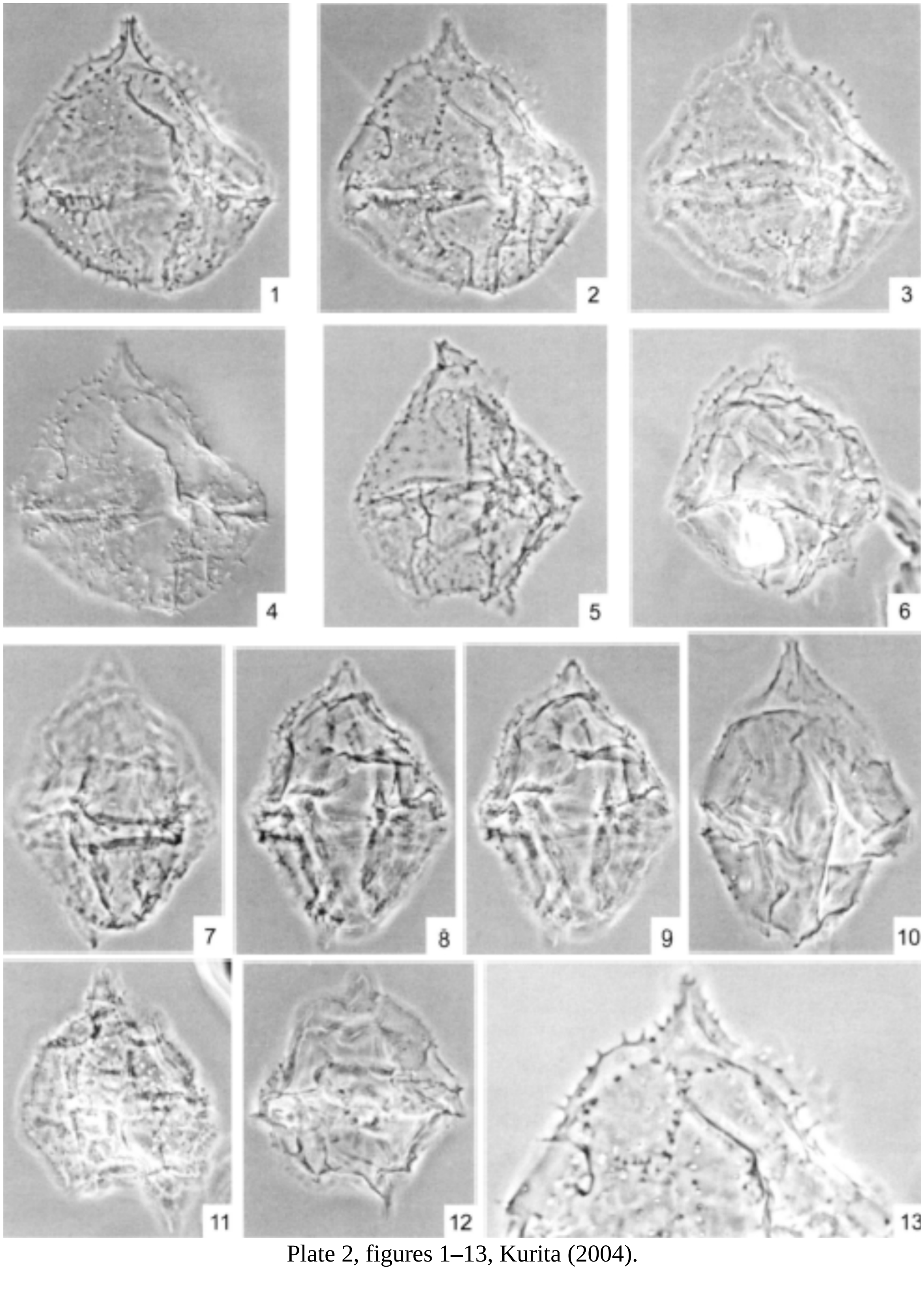


Plate 2, figures 1–13, Kurita (2004).

Spinidinium uncinatum May, 1980

Description: "Periblast pentagonal in dorsoventral outline; dorso-ventrally flattened; tapering apically from cingulum in near-linear fashion to base of short apical horn; tapering antapically from cingulum in near-linear fashion to truncated antapex bearing 2 reduced antapical horns. Short apical horn projects abruptly from apex, tapering and bluntly terminating, bearing 2 terminal lateral spines. Left antapical horn variable in size, may be slightly shorter or longer than apical horn, is conical, and tapers to a point. Right antapical horn generally appears as oblique deflection at right side of antapex. Periphragm smooth, formed into well-developed sutural folds bearing numerous, short, tapering, distally barbed spines, the sutural folds outlining plate equivalents. Plate equivalents well separated by intercalary areas on ventral and dorsal surfaces (except on dorsal epitract), causing the cingulum to be regularly interrupted. Plate equivalents on dorsal epitract positioned immediately adjacent to each other, lacking intercalary areas. Plate areas triangular on ventral surface, trapezoidal on lateral and dorsal surfaces. Reflected tabulation 4', ?3a, 7'', ?c, 5''', 2''''. Endoblast ovoidal, filling central cavity of periblast; anterior pericoel occurring in and a short distance beneath the apical horn; broad posterior pericoel occurring at base of apical region. Endophragm smooth. Cingulum interrupted, except on antero-dorsal side; levorotatory with ca. ½ cingulum width offset. Sulcus deep, bordered by sutural folds bearing spines, extends ca. 1 cingulum width above cingulum and broadens posteriorly to antapex, terminating between the antapical horns. Archeopyle intercalary (Type Ia/Ia) and is horshoe-shaped [sic]." — May (1980, p. 85, 86)

Discussion: "Diagnostic characteristics of *S. uncinatum* are the pentagonal outline, extended left antapical horn, separated plate fields, the barbed or hooked sutural spines and peridinioid tabulation. Scanning electron microscopy also shows that the periphragm is smooth between sutures, that the spines are capitate, barbed or hooked, and that small apical and antapica1 plates exist on the horn areas." — May (1980, p. 86)

Affinity: "*S. uncinatum* is similar in morphology to *S. clavum* Harland 1973, *S. styloniferum* Cookson & Eisenack 1962, and *S. lanternum* Cookson & Eisenack 1970. *S. clavum,* however, has oblate and acuminate processes along sutural positions, plate fields apparently not separated, and cingulum not interrupted or offset. *S. styloniferum* differs by having intratabular spines, which are bluntly pointed, and a more expanded outline in dorsa-ventral view. *S. lanternum* is most similar to *S. uncinatum* in overall morphology; however, differs by possessing distinctly pointed spines, and an apparently larger endoblast." — May (1980, p. 86)

Dimensions: "Holotype L × W, 56 × 31 μm; posterior pericoel length 10 μm, anterior 11 μm; spine length 1.5 μm maximum. Observed range (16 specimens measured): length 50–75 μm, width 29–47 μm: spine length less than 1.5 μm: wall layers, periphragm ca. 0.5 μm, endophragm ca. 0.5 μm." — May (1980, p. 86)

Age: Late Cretaceous (late Campanian?); holotype of May (1980, p. 85, text-fig. 2). Late Cretaceous (late Campanian?–early Maastrichtian) (May, 1980, p. 86, range charts I, II).

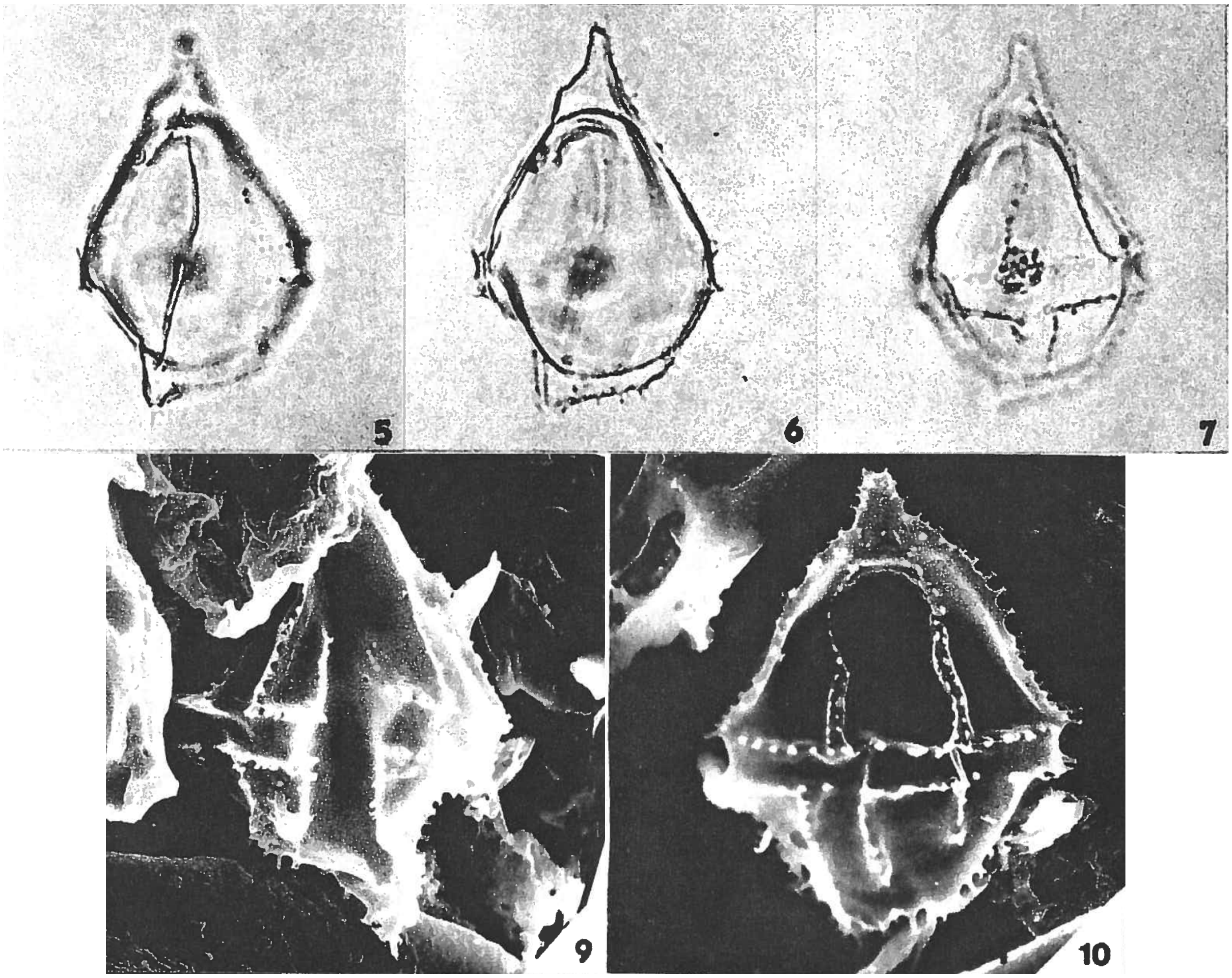


Plate 10, figures 5–7; Plate 13, figures 9, 10, May (1980).

Genus ***TRITHYRODINIUM*** Drugg, 1967

1967 *Trithyrodinium* Drugg: 20.
1969 *Trithyrodinium* Drugg; emend. Davey: 10.
1976 *Trithyrodinium* Drugg; emend. Lentin & Williams: 98–100.
1992 *Trithyrodinium* Drugg; emend. Marheinecke: 94, 95.

?*Trithyrodinium conservatum* Fensome et al., 2016

<u>Description</u>: “A species of *Trithyrodinium* with a commonly rounded but sometimes ovoidal pericyst that is always present. The endocyst generally mimics the shape of the pericyst. As a rule, the cyst is circumcavate, but the endocyst may occasionally be in partial contact with the pericyst. The periphragm and endophragm are both thin, at the most slightly over 1 µm thick. The periphragm varies from laevigate (the usual condition), to faintly granulate or verrucate. The I to 3I archaeopyle is formed from the loss of one to three intercalary plates individually, any of which can remain attached posteriorly.” — Fensome et al. (2016, p. 74)

<u>Dimensions</u>: “Pericyst length 48–60 µm, width 49–65 µm, endo cyst length 44–51 µm, width 43–56 µm; seven specimens measured.” — Fensome et al. (2016, p. 74)

<u>Remarks</u>: “*Trithyrodinium*? *conservatum* is unusual in that the pericyst is always preserved. When the pericyst has a subdued granulate or verrucate ornamentation, this tends to be restricted to the mid-dorsal and mid-ventral regions. Folds are consistently present on the pericyst but appear to be random. The exact nature of the archaeopyle is unclear. In some specimens its polygonal shape appears to indicate that multiple plates are missing, but in others it appears to reflect loss of a single intercalary plate. Because of the uncertainty regarding the archaeopyle, the species is only assigned questionably to *Trithyrodinium*.” — Fensome et al. (2016, p. 74)

<u>Age</u>: middle Eocene (Lutetian); holotype of Fensome et al. (2016, p. 74).

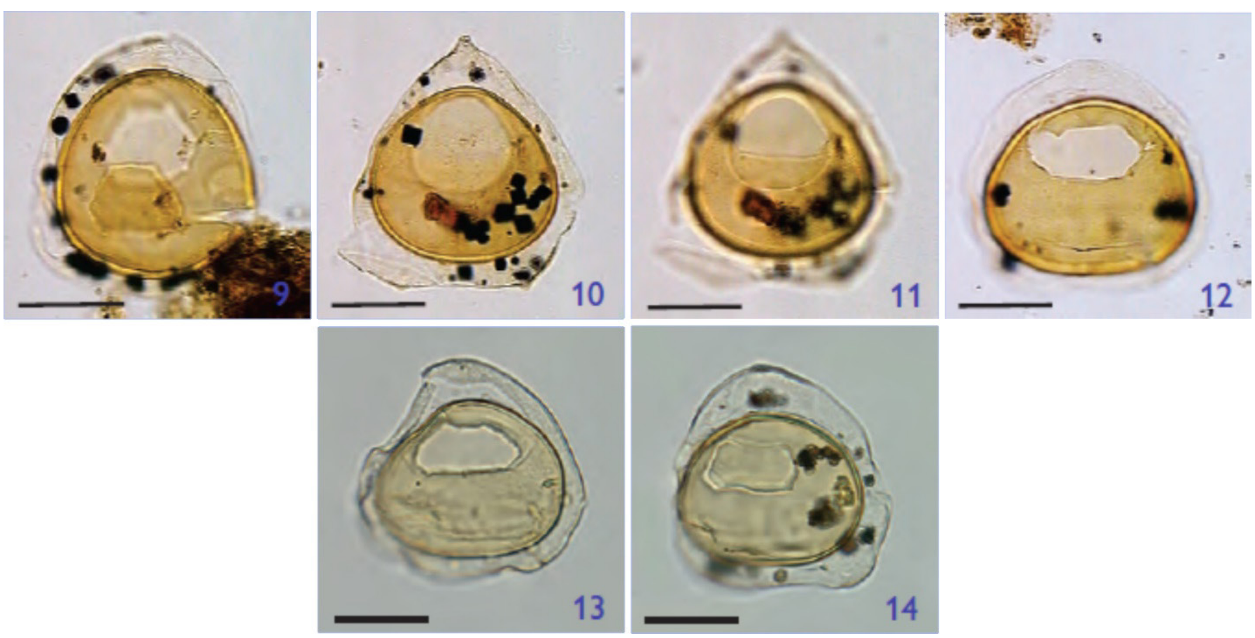


Plate 15, figures 9–14, Fensome et al. (2016). Scale bar = 20 µm.

Trithyrodinium druggii Stone, 1973

Diagnosis: "The distinctive endoblast is scabrate-granulate and exhibits apical and antapical tufts of granules. The archeopyle as observed on the endophragm is formed by the removal of three intercalary plates (la, 2a, 3a inferred) which may become disassociated." — Stone (1973, p. 54)

Description: "The periphragm is thin (less than 1 μ) and smooth. An apical horn about 28 μ in length is present. Two shorter antapical horns are present. A cingulum and sulcus are not known to be present. The periblast contains a rounded endoblast. The endophragm is scabrate with tufts of larger granules (ca. l μ) on the apical and antapical ends. As observed on the endoblast, an intercalary archeopyle is formed by the removal of three plates which may become disassociated. Additional tabulation ha not been observed." — Stone (1973, p. 54)

Dimensions: "The range of the length of the periphragm is 95 (108) 130 μ for three specimens. The width of the periphragm is about 62 μ. The size range of the length of the endophragm is 58 (69) 81 μ for 17 specimens." — Stone (1973, p. 54)

Discussion: "Three specimens with a periphragm and endophragm were observed. The exact nature of the antapical horns is not known. The free endoblasts are abundant. *T. evittii* Drugg is a comparable species, but it differs in having a finely punctate endophragm and in exhibiting a cingulum on the periblast. Specimen of *T. evittii* have been observed to have separated opercular plates (Drugg 1971, personal communication). The species is named for Warren S. Drugg." — Stone (1973, p. 55)

Age: Late Cretaceous (late Campanian); holotype of Stone (1973, p. 54). Range: Late Cretaceous (late Campanian) (Stone, 1973, p. 54).

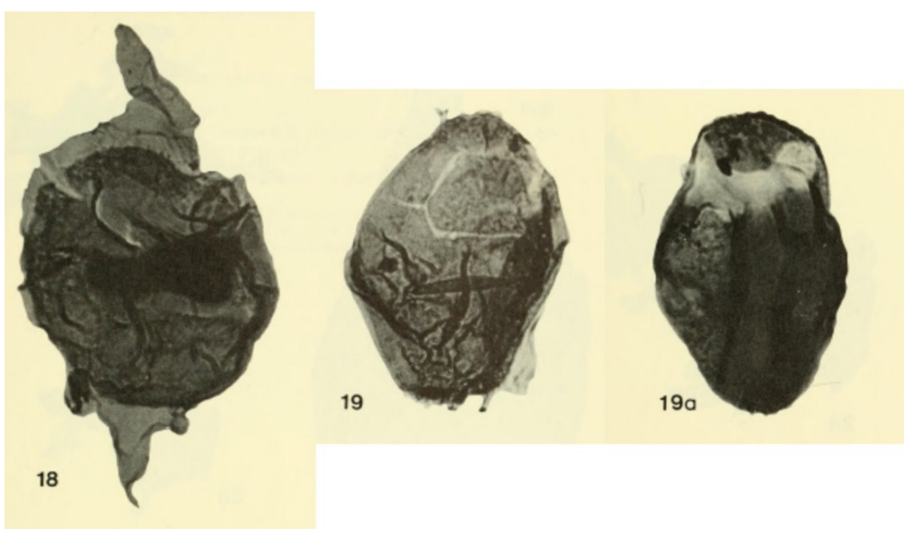


Plate 5, figures 18, 19, 19a, Stone (1973).

Trithyrodinium dubium Singh, 1983

Description: "Proximate, bicavate cysts with a subpentagonal and longitudinally elongated outline; apical horn short, blunt; left antapical horn short, conical, and pointed; right antapical horn not developed; pericyst membranous, smooth to finely granular; endocyst dark, subcircular with width greater than length, and in contact with the pericyst in the paracingular region; epipericoel and hypopericoellarge; paracingulum slightly helicoidal, 5 to 7 microns wide, and delineated by parallel, transverse, equatorial folds with knobbly margin and equatorial indentations on the lateral margins; parasulcus vaguely outlined as a shallow depression narrowing anteriorly on the ventral hypocyst; posterior parasulcal region sometimes with a slit-like opening (opisthopyle) in the periphragm; periarcheopyle intercalary, type 3I; paraplates la, 2a, and 3a released separately; endoarcheopyle intercalary, varying from type 3I (la, 2a, 3a) in some specimens to slightly disarranged paraplates with partially developed archeopyle parasutures in others; some specimens without endoarcheopyle; operculum free; all or some of the opercular paraplates usually remaining in place." — Singh (1983, p. 137)

Dimensions: "Length of the pericyst 70(74)81 microns. Holotype 72 microns. Breadth of the pericyst 48(53)57 microns. Holotype 51 microns. Length of the endocyst 34(41)47 microns. Holotype 39 microns. Breadth of the endocyst 45(52)57 microns. Holotype 51 microns. Specimens measured 8." — Singh (1983, p. 137)

Remarks: "An intercalary type 3I periarcheopyle, involving paraplates la, 2a, and 3a, is consistently present in *Trithyrodinium dubium* n. sp. However, the endoarcheopyle varies from a fully developed 31 (la, 2a, 3a) type to one with partially developed archeopyle parasutures. In some specimens the endoarcheopyle is not developed at all. All or some of the opercular paraplates usually remain in place or are only slightly displaced.

Although *T. dubium* n. sp. resembles *Isabelidinium magnum* (Davey) Stover and Evitt, 1978, and *Isabelidinium acuminatum* (Cookson and Eisenack) Stover and Evitt, 1978, in general appearance, it has been assigned to the genus *Trithyrodinium* Drugg, 1967, emend. Lentin and Williams, 1976, in the present study, due to the consistent presence of an intercalary 3I (la, 2a, 3a) periarcheopyle." — Singh (1983, p. 137)

Age: Late Cretaceous (middle Cenomanian); holotype of Singh (1983, p. 137).

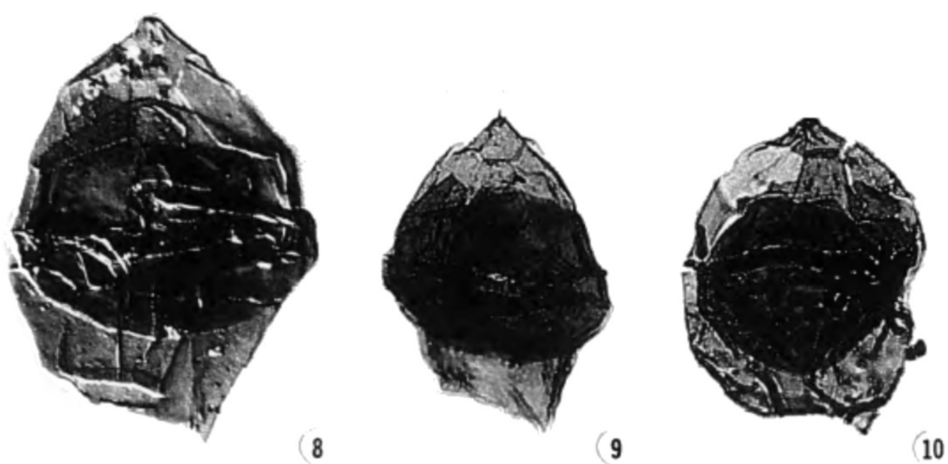


Plate 47, figures 8–10, Singh (1983).

Trithyrodinium evittii Drugg, 1967

Diagnosis: "Similar in morphology to members of the genus *Deflandrea* except that the archeopyle operculum is composed of three intercalary plates functioning as a unit (see Pl. 9 fig. 2). Test rounded with one short apical and two short antapical horns. The test wall is thin and smooth. The test cavity is filled by a large rounded cyst of fairly rigid construction. The cyst wall is a bout 1 μ thick and often finely punctate.

The cysts are commonly found separated from the tests in which case they are easily identifiable by the peculiar nature of the opening. A circular girdle is present on the test and is delineated by low flanges. A longitudinal furrow is suggested by folds originating near the antapical horns." — Drugg (1967, p. 20)

Dimensions: "The length of the test ranges from 75 to 95 μ, and the width ranges from 60 to 80 μ. Abundant." — Drugg (1967, p. 20)

Comment: "The forms *Deflandrea thomasi* Cookson and Eisenack 1961, *D. granulifera* Manum 1963, *D. verrucosa* Manum 1963, and *Hexagonifera suspecta* Manum and Cookson 1964 resemble *Trithyrodinium evittii* in that the opercula are tripartite. They differ in that the three plates of the operculum do not function as a unit. The generic name *Trithyrodinium* has been used informally by Dr. Evitt of Stanford University who has long been aware of such *Deflandrea*-like forms with tripartite opercula." — Drugg (1967, p. 20)

Age: Paleocene (Danian); holotype of Drugg (1967, p. 20).

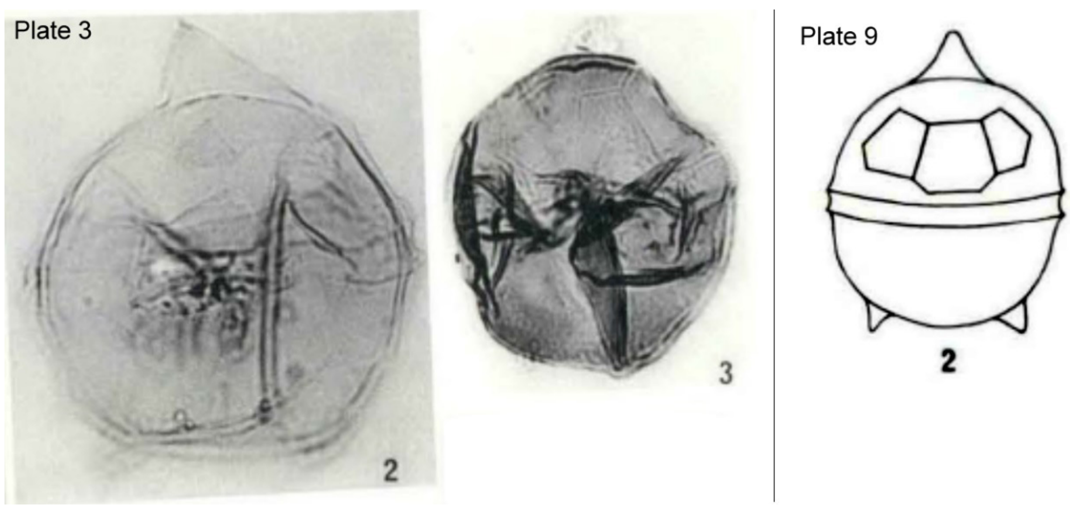


Plate 3, figures 2, 3; Plate 9, figure 2, Drugg (1967).

Trithyrodinium nigerianum Beilstein, 1994

Diagnosis: "A species of the genus *Trithyrodinium* Lentin & Williams 1976 with rounded hexagonal cyst outline, two-layered wall of smooth endocyst and fine-punctate pericyst as well as a large one composed of three paraplates. Intercalary archaeopyle." — Translated from Beilstein (1994, p. 194)

Description: "The bicavate cyst is rounded hexagonal in dorsal view. It changes from a slightly helical cingulum to a cingulum of the same size epi- and hypocyst divided. The displacement of the cingulum corresponds approximately to its width. Posterior and anterior boundaries of the cingulum and the course of the sulcus are denoted by clear, parallel folds. The endocyst also has a rounded hexagonal outline. In contrast to the pericyst, which is chagrenate to finely-punctuated, the endocyst is smooth. The pericyst, equatorially closely attached to the endocyst, forms a short and blunt-ended apical horn, and at the antapex, two uniform, tapering and slightly diverging antapical horns. The large intercalary archaeopyle arises by the loss of three opercular plates 1a, 2a and 3a. The 2a opercular plate is often developed so large that that the precingular 4" can only be recognized as a narrow stripe under the light microscope." — Translated from Beilstein (1994, p. 194)

Dimensions: "Holotype, the example shown on plate 29 as fig. 5: periphragm: 90 × 66, endophragm: 66 ×

65, apical horn: 10, antapical horns: 10, cingulum: 5 (4–6). Paratype, the specimen shown on plate 29 as fig. 6: periphragm: 80 (82–92) × 57 (66–68), endophragm: 60 (53–66) × 56 (54–67), apical horn: 8 (8–13), antapical horns: 9 (9–14), cingulum: 5 (4–6).” — Translated from Beilstein (1994, p. 194)

Remarks: “*Trithyrodinium nigerianum* n. sp. differs from the other *Trithyrodinium* species by the easily recognizable paratabulation (cingulum, sulcus, archaeopyle) and by the always clearly developed antapical processes.” — Translated from Beilstein (1994, p. 194)

Age: Late Cretaceous (Campanian); holotype as translated from Beilstein (1994, p. 300, 301).

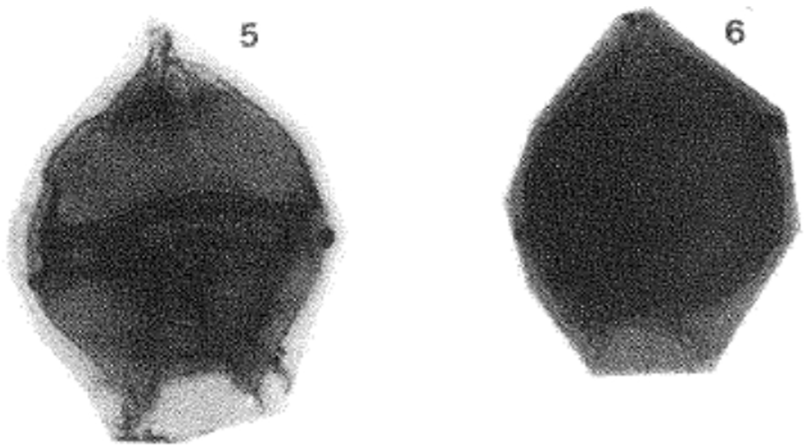


Plate 29, figures 5, 6, Beilstein (1994).

Trithyrodinium partridgei Willumsen & Vajda 2010

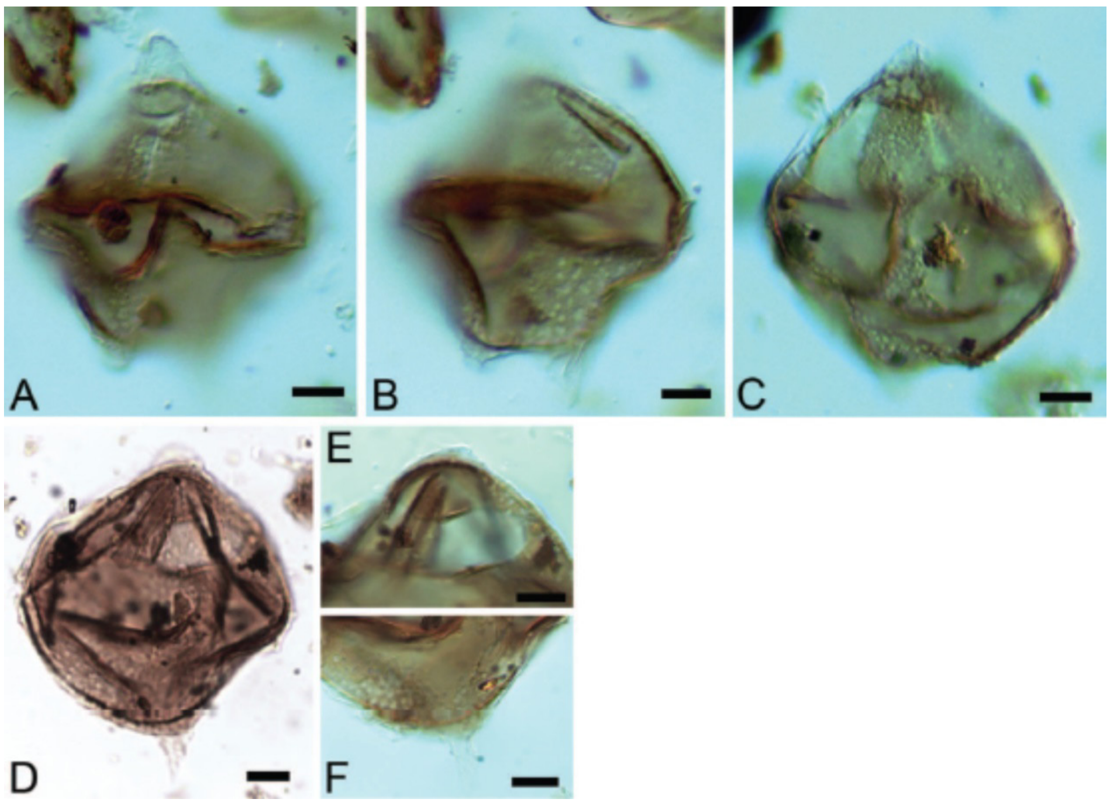
Diagnosis. “Circumcavate, ovoid peridinioid cyst with short apical horn and two antapical horns of unequal length. Wall consisting of three layers that are most distinguishable in apical and antapical areas where the walls are less appressed. Periphragm and mesophragm thin and appressed to each other except in apical and antapical areas; mesophragm foveolate. Paratabulation indicated by intercalary archeopyle of type 3I/3I. Paracingulum represented by a bulge in the cingular area on ventral surface of cyst. From a mid-dorsal view, the right antapical horn is larger and more pointed than the left antapical horn. Operculum consisting of three intercalary plates that are generally attached.” — Willumsen & Vajda (2010, p. 531)

Description: “Circumcavate, ovoid, dorsoventrally compressed peridinioid cyst, with one short conical and distally rounded apical horn (Fig. 5E). The two antapical horns are of unequal lengths but in a middorsal view the left antapical horn is smaller and less pointed than the right antapical horn (Fig. 5F). The total cyst length is 70(79)90 μm and total width is 60(65)70 μm (eight specimens measured). The cyst wall comprises three layers: peri-, meso- and endophragm. The periphragm is thin, smooth and closely appressed to the mesophragm. The mesophragm is relatively thin, transparent and foveolate. Foveolae are ca 0.5–1.0 μm in diameter and most recognizable in the apical and antapical areas where the wall layers are less compressed. The pericoel is fully developed only in the apical and antapical areas. The endocyst is ovoid, longer than broad, relatively thick and brown. The paratabulation is indicated by an intercalary (type 3I/3I) archeopyle. A bulge in the cingular area indicates the paracingulum of the cyst. This protrusion is best developed on the ventral surface of the cyst. The operculum consists of three intercalary plates and is commonly in place or partly attached (Fig. 5A–E).” — Willumsen & Vajda (2010, p. 531)

Remarks: “The foveolate mesophragm differentiates *Trithyrodinium partridgei* from all other

Trithyrodinium species. The brown colour of the endocyst, also evident in other *Trithyrodinium* species, is easily destroyed if the kerogen is extensively oxidized (see also Nøhr-Hansen & Dam 1999). Variations in the standard paraplate configuration such as a reduced 2a paraplate were not observed (May & Benson 1979)." — Willumsen & Vajda (2010, p. 531)

<u>Age</u>: early Paleocene (late Danian); holotype of Willumsen & Vajda (2010, p. 529, fig. 4). Range: early Paleocene (middle–late Danian) (Willumsen & Vajda, 2010, p. 529, fig. 4).



Figures 5A–F, Willumsen & Vajda (2010). Scale bars = 10 μm.

Trithyrodinium quinqueangulare Marheinecke, 1992

Description: "Periblast pentagonal without clear flattening. Apex rounded or terminating in an apical horn. Antapex straight. Two very small symmetrical antapical horns may be present. Length to width ≥ 1. Wall extremely thin, colourless, mostly puckered, smooth or granulated. The granulation can be traced through by the endoblast. Endoblast: pentagonal, closely attached to the periblast throughout except for the horns at the apex and antapex, which are formed exclusively by the periblast. Wall thick, light to very dark brown. Tabulation: only indicated by cingulum and archeopyle. Cingulum: well developed, sinistral, offset up to a cingulum width. The cingulum is represented by two parallel folds. Sulcus: indicated by the corresponding concavity of the hypocyst. Archeopyle: intercalary, 1a + 2a + 3a; operculum detached $1a_s + 2a_s + 3a_s$. Archeopyle index: > 0.7." — Translated from Marheinecke (1992, p. 95)

Additional remark: "Of the intercalary plates, plate la is the least defined. The archeopyle can be slightly thickened and is usually more or less rounded. The intercalary plates are so large that the precingular plates of this area become narrow strips. Plate 4" can often no longer be made out in light microscopy, so that it appears as if 2a is touching the cingulum. Only under electron microscopy is 4" recognizable as a narrow strip." — Translated from Marheinecke (1992, p. 95)

Dimensions: "Holotype: Length: 64, width: 67. Range across 10 specimens: length 50(67)90, width: 53(66)85, thickness [dorsoventral width?]: 45(53)64." — Translated from Marheinecke (1992, p. 95)

Age: Late Cretaceous (late-early Maastrichtian); holotype as translated from Marheinecke (1992, p. 95). Late Cretaceous (late-early Maastrichtian–late-late Maastrichtian) Marheinecke (1992, table 2).

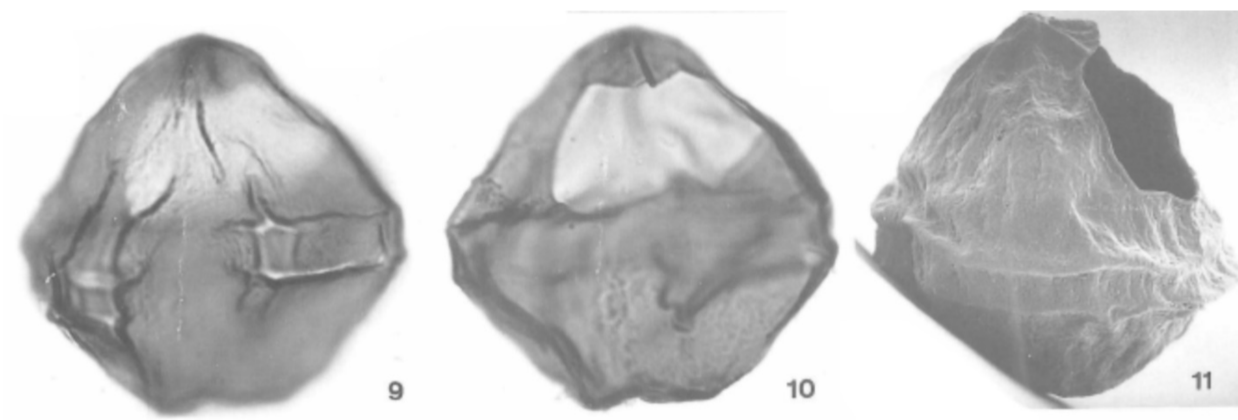


Plate 19, figures 9–11, Marheinecke (1992).

Trithyrodinium rhomboideum Singh, 1983

Description: "Proximate, cornucavate cysts with a rhomboidal body; epipericyst forming a broad, short, and distally rounded apical projection; hypopericyst prolonged into a 5- to 7-micron long, pointed, left antapical horn; right antapical horn rounded, vestigial, and frequently not developed; pericyst smooth, membranous, and transparent; endocyst rhomboidal, dark, and densely ornamented by minute granules or coni; endophragm about 1 micron thick; coni about 0.3 micron wide at the base; endophragm and periphragm closely appressed in the precingular, cingular, and postcingular regions and separated near the bases of the apical and antapical horns forming small pericoels; paratabulation, paracingulum and parasulcus not indicated; archeopyle intercalary, type 3I/3I; operculum free; para plates la, 2a, and 3a of the endophragm and periphragm released separately; all or some opercular paraplates often remaining in place." — Singh (1983, p. 136)

Dimensions: "Length of the pericyst 45(68)83 microns. Holotype 67 microns. Breadth of the pericyst 36(45)60 microns. Holotype 48 microns. length of the endocyst 38(60)76 microns. Holotype 54 microns. Breadth of the endocyst 36(45)56 microns. Holotype 48 microns. Specimens measured 38." — Singh (1983, p. 136)

Remarks: "*Trithyrodinium rhomboideum* n. sp. can be easily distinguished from *Trithyrodinium druggii* Stone, 1973, which has longer apical and antapical horns and tufts of large granules in the apical and antapical areas of the endocyst. The specimen illustrated as *Deflandrea suspecta* (= *Trithyrodinium suspectum* (Manum and Cookson) Davey, 1969) by Davey (1970, pl. 2, fig. 5) from the early Turonian of Saskatchewan has an endocyst with surface ornamentation similar to that of *T. rhomboideum* n. sp. However, it differs in having an ovoidal endocyst surrounded by a very fragile periphragm and in lacking antapical horns. Davey (pers. comm.) agrees that his specimens are distinct from *T. suspectum*, which has a much thicker and more complexly structured endophragm, but feels that they are also distinct from *T. rhomboideum* n. sp. The specimens illustrated as *Trithyrodinium* sp. A by Norvick (in Norvick and Burger, 1976, pl. 13, figs. 15, 16) from the early Cenomanian of northern Australia are comparable to *T. rhomboideum* n. sp. in shape but differ in possessing a paracingulum and very thin, finely granular endophragm and periphragm." — Singh (1983, p. 136, 137)

Age: Late Cretaceous (middle Cenomanian); holotype of Singh (1983, p. 136).

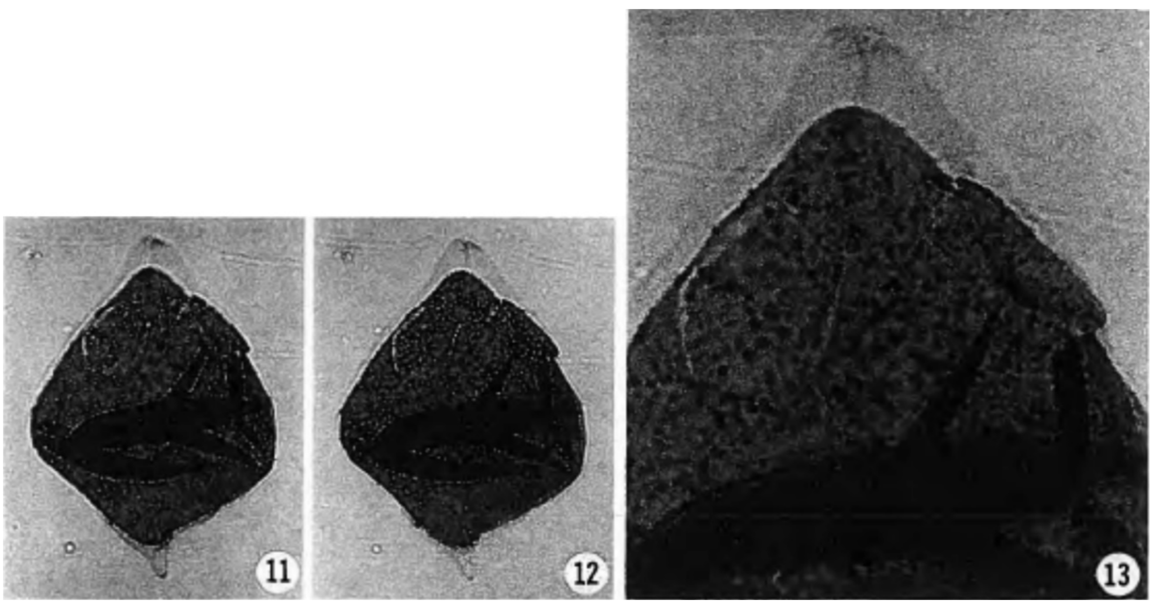


Plate 46, figures 11–13, Singh (1983).

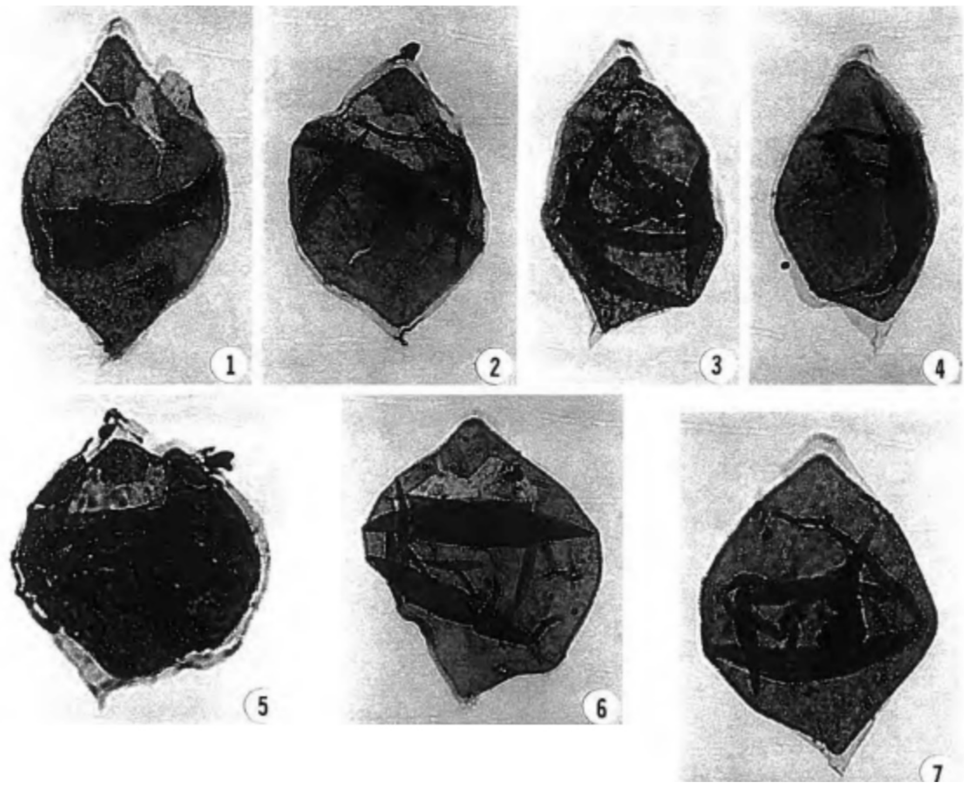


Plate 47, figures 1–7, Singh (1983).

Trithyrodinium sabulum Mao Shaozhi & Norris, 1988

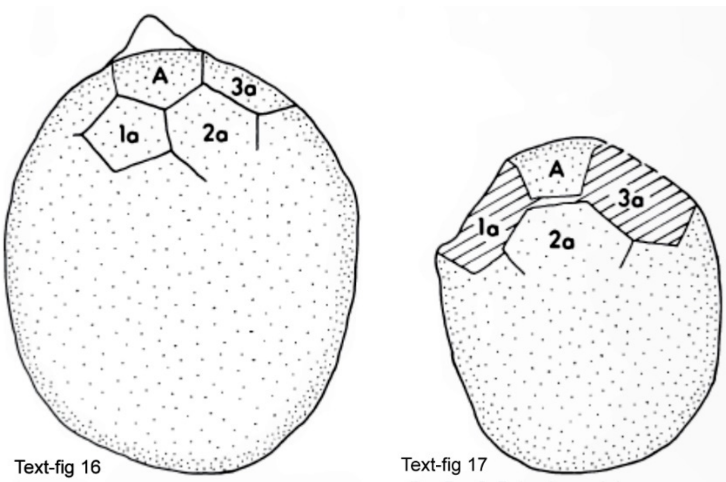
Diagnosis: “Cyst proximate, cornucavate, subspherical to elliptical with an apical horn, and with or without two poorly developed, unequal antapical horns appearing as angular bulges, the left one usually being longer. Wall layers thin (less than 1 μm), folded. Periphragm transparent and delicate, smooth or with scattered granules; endophragm granulate, thicker than periphragm. Archeopyle intercalary, more clearly indicated in endoblast than in periblast, type 3I/3I. Operculum compound, typically dislodged or la and 3a detached and 2a attached posteriorly.” — Mao Shaozhi & Norris (1988, p. 45)

Description: “Cyst transversely to longitudinally broad, elliptical in ambital view. Apical horn present, small, bluntly pointed or nipplelike, 4 to 7 μm long, formed usually by periphragm. Antapex rounded or stretched out to two angular bulges. Periphragm very thin, easily folded, transparent, lightly coloured or not easily stained. Periphragm sometimes lost, leaving endoblast free. Endophragm thin, thicker than periphragm, typically densely granulate; diameter of granules varying, commonly less than 1 μm. Intercalary 3I archeopyle compound and linteloid. When the archeopyle not fully developed and the periphragm not removed, plates 1 to 3a recognizable by slightly open sutures; in that case (18 of 38 specimens observed) the posterior suture of 2a absent (Text-Fig. 16). When periphragm completely lost (18 of 38 specimens), plates 1a and 3a detached, plate 2a remaining attached along its posterior margin (Text-Fig. 17); rarely (2 of 38 specimens observed), three opercular pieces totally free. Therefore, plate 2a may have stronger connection with endoblast than plates la and 3a, because it is removed after the other two. Plate 2a standard hexa, plates 1a and 3a pentagonal in shape. Indications of tabulation, other than archeopyle, absent.” — Mao Shaozhi & Norris (1988, p. 45, 46)

Dimensions: “Length 45 to 65 μm (holotype 54 μm), width 35 to 53 μm (holotype 44 μm); 38 specimens measured.” — Mao Shaozhi & Norris (1988, p. 46)

Discussion: "This species differs from *Trithyrodinium evittii* in that (1) its three opercular plates do not function as a unit, (2) the cingulum is typically not indicated, and (3) the endophragm is granulate rather than psilate. It differs from *T. suspectum* (Manum and Cookson, 1964) in having thinner wall layers; the wall layers of *T. suspectum* are composed of rod-shaped elements of unequal length, such structures being completely absent in *T. sabulum*." — Mao Shaozhi & Norris (1988, p. 46)

Age: Late Cretaceous (early Turonian); holotype of Mao Shaozhi & Norris (1988, p. 45). Based on the corresponding age of the Kukebai Formation given as early Turonian by Mingzhen Zhang et al. (2022, fig. 2). Range: Late Cretaceous (early Turonian–Campanian) based on a range from the upper Kukebai Formation to the top of Yigezia Formation (Mao Shaozhi & Norris (1988, table 2) as the former unit has been shown to be early Turonian (Mingzhen Zhang et al., 2022, fig. 2) with the top of the latter corresponding approximately to the Campanian (Tibert et al. 2003, p. 211).



Text-figures, 16, 17, Mao Shaozhi & Norris (1988).

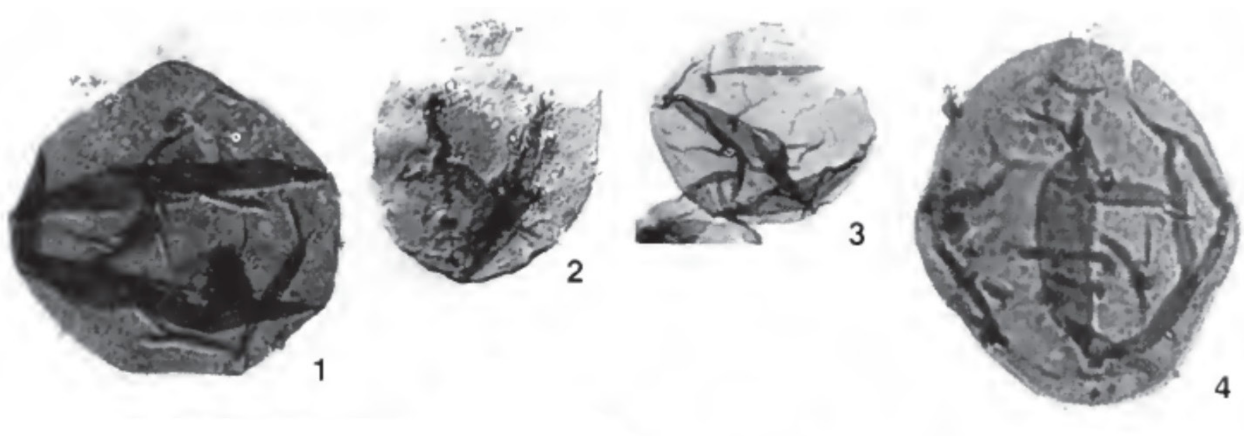


Plate 12, figures 1–4, Mao Shaozhi & Norris (1988).

Trithyrodinium striatum Benson, 1976

Description: "Cavate cyst with very thin, delicate periblast, which is frequently missing. Apical horn short, antapical horns unequally developed. Tabulation absent. Archeopyle intercalary, type 3I/3I. Periphragm thin, less than 0.5 micron thick with no distinct sculpture, endophragm about 1 micron thick, longitudinally striate with clear indication of cingulum." — Benson (1976, p. 197)

Dimensions: "Holotype: periblast length 82 micra; width 73 micra; endoblast length 65 micra; width 62 micra; apical pericoel 8 micra. Range: no additional intact specimens for periblast measurements; endoblast length 61–66 micra; width 59–63 micra (ten specimens)." — Benson (1976, p. 197)

Comments: "*Trithyrodinium striatum* is most frequently seen as an isolated endoblast due to the delicate nature of the periphragm. One of the specimens illustrated (plate 11, fig. 7) demonstrates the unusual nature of the intercalary plate relationship in this species. Plates la and 3a are fused in the midline anterior to the anterior edge of plate 2a. J. Lentin (in litt.) feels that the pentagonal nature of the 2a plate and the relationship of the la and 3a plates warrants the erection of a new genus; however, Evitt (in litt.) states that he has observed this morphology as one end member of a range of variation. Since the specimens are derived from a single locality the total variation cannot be determined and the author feels that the erection of a new genus would be premature. A fuller discussion of the variation in *T. striatum* is the subject of a forthcoming paper." — Benson (1976, p. 197)

Comparison with similar species: "*Trithynodinium striatum* is similar to *T. fragile* (Davey 1969b) and *T. evittii* (Drugg, 1967) in general morphologic aspects and size. All three species possess a thin periphragm; however, the fine punctae reported by Drugg (1967) are absent on *T. striatum*, and the endoblast is single layered rather than bilayered as reported by Davey (1969b) for *T. fragile*." — Benson (1976, p. 197, 198)

Age: Late Cretaceous (late Maastrichtian); holotype of Benson (1976, p. 178, 197). Range: Late Cretaceous (late Maastrichtian) in Zone A of Benson (1976, figs. 2, 3).

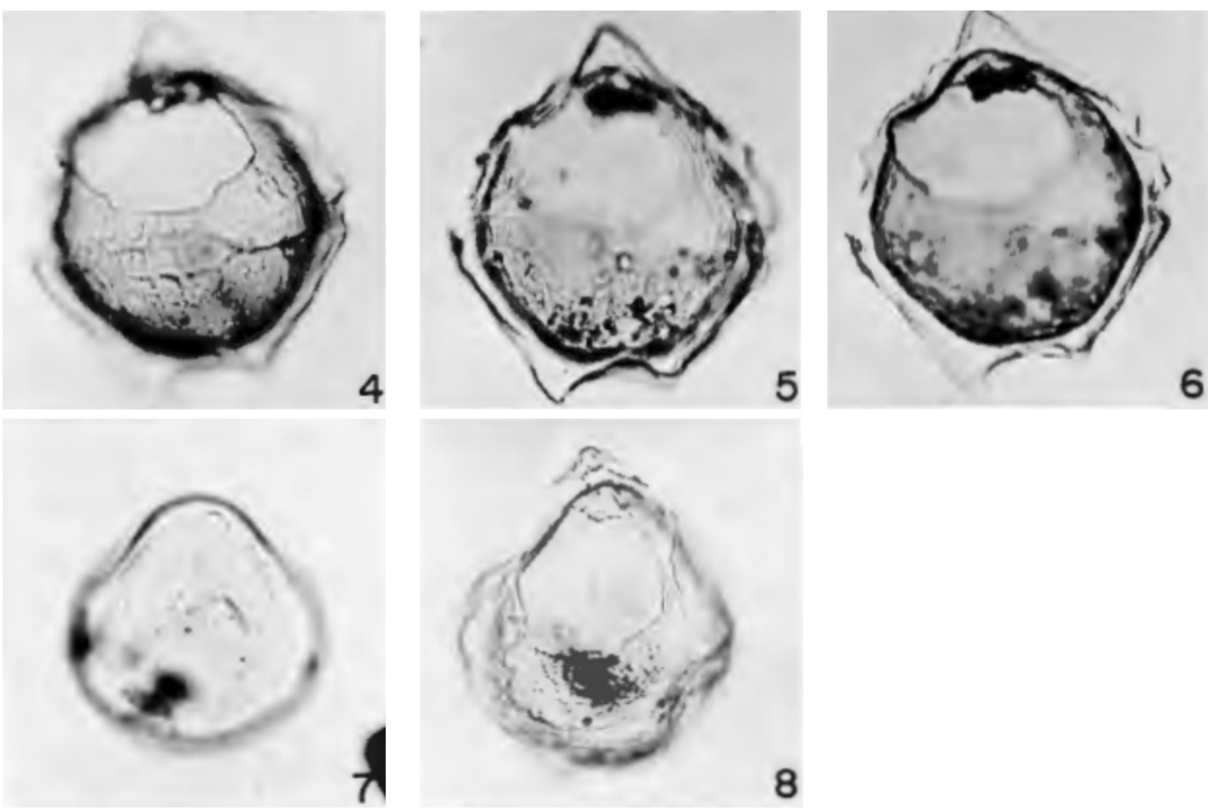


Plate 11, figures 4–8, Benson (1976).

Trithyrodinium suspectum subsp. ***suspectum*** (Manum & Cookson, 1964) Davey, 1969

<u>Description</u>: "Shell circular in outline, wall 2.5–4.0 µm thick, two-layered, dotted in surface view, unevenly wavy in optical section due to the thicker outer layer being composed of rod-shaped elements of unequal length. In addition, small, widely spaced warts sometimes occur on the surface. The shell opens somewhat obliquely at one end by the removal of three portions of the wall the median one of which is hexagonal with alternating short and long sides and the ones on either side of it roughly pentagonal. Usually, the shell is partially and sometimes entirely enveloped in a delicate, closely opposed, hyaline membrane. When entire, the membrane has a blunt apical horn and two smaller antapical horns. Slight lateral indentations in the membrane suggest the presence of an equatorial girdle." — Manum & Cookson (1964, p. 9, 10)

<u>Dimensions</u>: "Holotype: shell diameter 73 µ, overall length including the horns 118 µ. Range: shell diameter 65–78 µ overall length of three horned specimens 91 µ, 92 µ, and 97 µ respectively." — Manum & Cookson (1964, p. 10)

<u>Comment</u>: "The three species of *Hexagonifera* previously known (Cookson & Eisenack 1961, 1962a) have been mainly distinguished by the ornamentation of the shell. In *H. glabra* the wall is smooth, in *H. vermiculata* the pattern is vermiculate to reticulate, and in *H. chlamydata* verrucose. The ornament of *H. suspecta* differs from that of all three species in resulting from closely arranged rods which in surface view appear as small dots. These dots are much finer than the irregular spots of *H. chlamydata*. The closeness of the outer membrane to the wall of the shell parallels that in *H. glabra* and *H. vermiculata* in both of which portions of the membrane may adhere to the shell. The possession of horns in species of *Hexagonifera* has not been previously observed.

The general appearance of the horned specimens is strikingly like that of some species of *Deflandrea*, e.g. *D. phosphoritica* Eis. Furthermore, the mode of opening is exactly similar to that occurring in the capsules of *D. granulifera* and *D. verrucosa* Manum (1963) of which illustrations are included here for comparison (pl. I, figs. 7, 8). A similar mode of opening is seen in *D. thomasi* (cp. pl. I, fig. 6).

The specimens of *H. suspecta* with an entire outer membrane throw light on the morphology of the genus *Hexagonifera* (cp. Cookson & Eisenaek 1962a p. 495). They indicate that the outer thin membrane which sometimes is present in its entirety, but usually is partly or completely detached, corresponds to the theca of forms like *Deflandrea*. In fact, the resemblance which such specimens of *Hexagonifera suspecta* bear to *Deflandrea* indicates that a definite relationship exists between the two genera. It is for this reason that we have placed *Hexagonifera* together with *Deflandrea* under Peridiniaceae." — Manum & Cookson (1964, p. 10)

<u>Age</u>: Late Cretaceous (?Cenomanian); holotype of Manum & Cookson (1964, p. 10, 31).

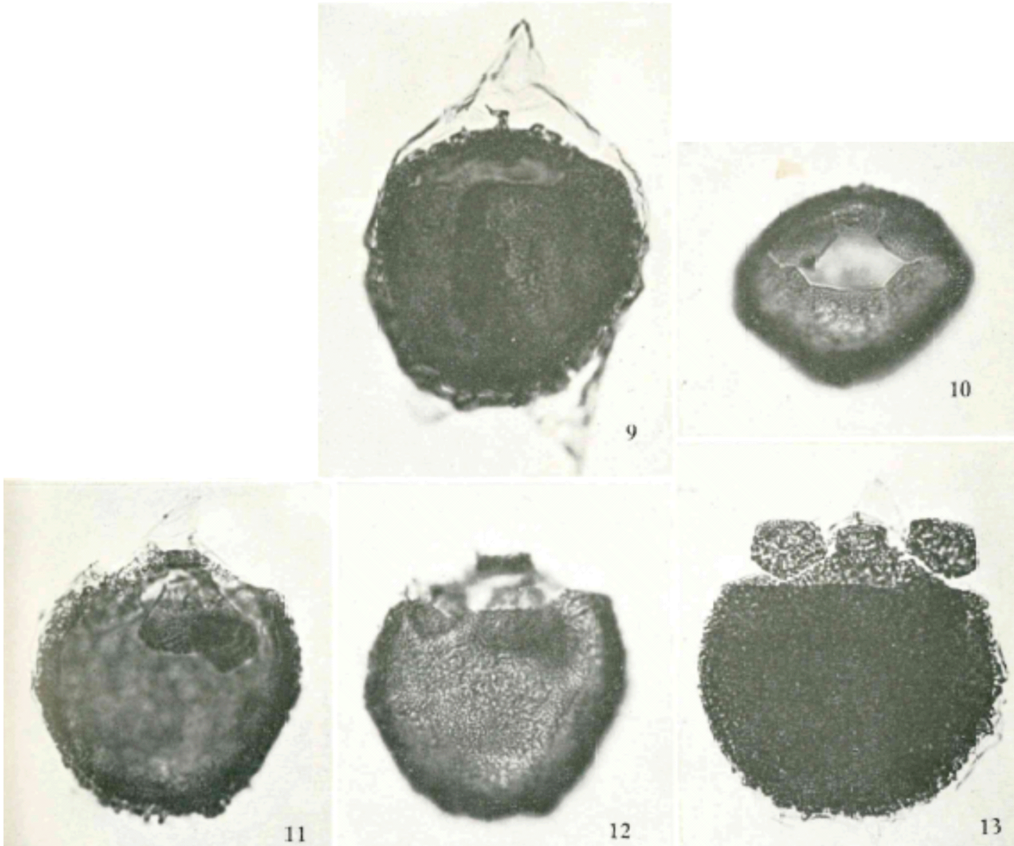


Plate 1, figures 9–13, Manum & Cookson (1964).

Trithyrodinium suspectum subsp. ***ukrainense*** Dodsworth, 2004

Diagnosis. "The taxon is a relatively small, thin walled and sparsely ornamented subspecies of *Trithyrodinium suspectum*. The endocyst is c. 0.5–0.75 μm thick and is ornamented with small (< 0.5–1 μm) grana/pilae that are isolated and evenly scattered or, to an extent, locally clustered. Areas devoid of any obvious ornament, c. 1–5 μm across are characteristic." — Dodsworth (2004, p. 130)

Description: "The endophragm is subspherical to ellipsoidal in shape. The periphragm is subspherical to ellipsoidal with a short apical horn and two poorly developed antapical horns of nearly equal size, although the right antapical horn is usually slightly longer than the left one. The cyst is circumcavate. The periphragm may be partly or missing in some specimens. The endophragm is ornamented with grana. Grana are generally less than 1 μm in size but may develop into pilae up to 2 μm in length. The grana/pilae are isolated and evenly scattered, as seen on the paratype (Plate 1, fig. 8) or, to an extent, locally clustered in atabular patches, up to 15 μm in diameter, as seen on the holotype (Plate 1, fig. 7). Areas devoid of any obvious ornament, c. 1–5 μm across, occur between grana/pilae. The periphragm is smooth but may possess sparse grana. Paratabulation is usually indicated by the archaeopyle(s) only. The archeopyle is intercalary, type 3I/3I. The periarchaeopyle is rarely discernible. In the endocyst, excystment features are occasionally absent or restricted to sutures around three intercalary plates (e.g. Plate 1, fig. 8). One to three plates are lost in archaeopyle formation with sutures surrounding any of the three plates that remain attached. The cingulum is generally not indicated but on some specimens the position is indicated by folds in the endophragm and periphragm and by shallow local concavities at the lateral margins. The sulcus is not indicated." — Dodsworth (2004, p. 130, 131)

Dimensions: "The size is intermediate: Pericyst, average length = 54 μm, range 40–72 μm, average width =

46 µm, range 36–62 µm, measured specimens (n) = 52. Endocyst, average length = 45 µm, range 32–68 µm, average width = 42 µm, range 32–60 µm, n = 100." — Dodsworth (2004, p. 131)

Comparisons: "*Trithyrodinium suspectum ukrainense* has features in common with *Trithyrodinium suspectum sensu stricto* and *Trithyrodinium evitii* [sic]. *T. suspectum sensu stricto* differs in being larger, possessing a thicker endocyst and denser ornament. The type material described by Manum and Cookson (1964) documented specimen length 91–118 µm, width 65–78 µm and wall thickness 2.5–4 µm (n = 4). Davey (1969) assigned smaller, thinner walled specimens to *T. suspectum*, length 61–68 µm, width 56–59 µm and wall thickness 1.5–2 µm (n = 5). Ioannides (1986) gave measurements for endocyst length 55–75 µm, width 55–72 µm and wall thickness 1.5–3.5 µm. In *T. suspectum sensu stricto*, the endophragm ornament of grana/rod-like structures is reported by all these authors to be more densely packed, lacking the c. 1–5 µm spaces developed between ornament elements seen in *T. suspectum ukrainense*.

Trithyrodinium evitii [sic] and *T. suspectum ukrainense* are comparable in terms of size and endophragm wall thickness. *T. evitii* [sic] differs in lacking prominent periphragm apical and antapical horns, possessing a smooth to minutely ornamented endophragm that is sometimes covered with a brown organic layer and lacking the distinct grana/pilae of *T. suspectum ukrainense*." — Dodsworth (2004, p. 131)

Discussion: "In carbonate samples taken from below and above the black shales at Aksudere, slightly thicker walls (c. 0.75–1 µm thick, excluding ornament) were recorded from some specimens. These are assigned to *T.* cf. *suspectum ukrainense* (Table 1). Many specimens observed from black shales in this study are from preparations that have been oxidised with Schulze's solution (Text-Fig. 2). This may have resulted in slight bleaching or even thinning endophragm walls. In a previous work (Schrank, 1988) extended oxidation has been shown to affect the cavation in certain peridinioids. Specimens from unoxidised carbonate preparations in the present study (e.g. Plate 1, fig. 6) are of similar size and exhibit similar cavation and ornament to those from the extended oxidation preparations. Nøhr-Hansen & Dam (1999) demonstrated that oxidation with concentrated nitric acid and subsequent treatment with potassium hydroxide in the removal of a brown non-sporopollenin organic layer that surrounds the endocyst of *T. evittii* [sic]. Layers of this type were not observed on *T. suspectum ukrainense* endocysts from unoxidised kerogen or extended oxidation preparations.

The specimens present in the Aksudere material are considered to be close in morphology to specimens that are often included in the taxon *Trithyrodinium suspectum.* They are sufficiently alike and sufficiently different from the type material of *T. suspectum*, in terms of size, wall thickness and possessing areas devoid of ornament, to warrant the erection of the new subspecies *T. suspectum ukrainense*." — Dodsworth (2004, p. 131, 133, 134)

Age: Late Cretaceous (late Cenomanian); holotype of Dodsworth (2004, p. 130, table 1). Range: Late Cretaceous (late Cenomanian–early Turonian) (Dodsworth, 2004, p. 130, table 1).

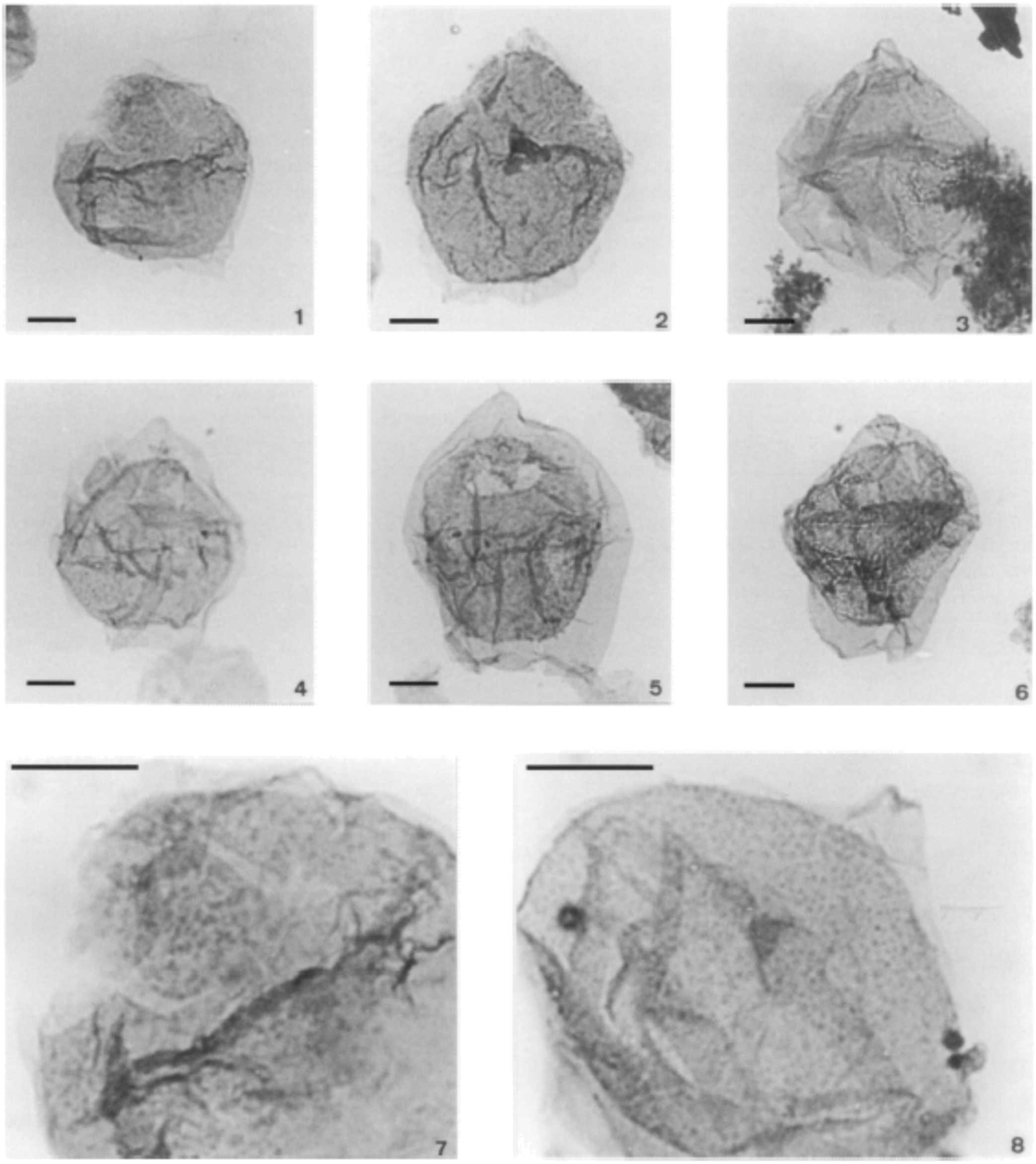


Plate 1, figures 1–8, Dodsworth (2004). Scale bars = 10 μm.

Trithyrodinium trendallii (Cookson & Eisenack, 1970) Pavlishina, 1995

Description: "Shell distinctly longer than broad, rather thin-walled, untabulated and very finely and inconspicuously dotted, with a bluntly pointed median apical projection and a downwardly slanting antapex with a short ± sharply pointed projection on the right-hand side. A well-developed subequatorial girdle delimits a longer epitheca from a shorter hypotheca, its ends on the ventral surface being widely separated. The internal capsule, which is distinctly oval in shape and relatively large, extends to the outer wall of the hypotheca but not quite to that of the epitheca. Its wall appears to be somewhat thicker than that of the shell. On the ventral surface of the hypotheca, between the ends of the girdle, the longitudinal wavy thickening, probably associated with the flagellum pore, is usually prominent. An archeopyle has not been observed." — Cookson & Eisenack (1970, p. 145)

Dimensions: "Holotype: overall length c. 70 μ, overall width 35 μ, internal capsule c. 38 × 30 μ. Range: length c. 67–93 μ, breadth c. 33–50 μ." — Cookson & Eisenack (1970, p. 145)

Comment: "In none of the many specimens examined (30 actually mounted) has an archeopyle been observed. In a few examples the apex of the shell has been partially or entirely removed but in none has the internal capsule been opened, nor the breach sufficiently clean-cut to suggest that it was due to a natural method of opening. For this reason, the present assignment of this readily recognizable form to the genus *Ascodinium* is regarded as provisional. In this respect, attention needs to be drawn to three of the Western Australian dinoflagellate species, referred to the genus *Deflandrea*, namely *D. rotundata* Eisenack & Cookson 1960, *D. foliacea* Eisenack & Cookson 1960, *D. balcattensis* Cookson & Eisenack 1969, in which archeopyles were not evident in the many examples studied.

As to the well-developed wavy thickening present in the mid-ventral surface of the hypotheca of ?*A. trendalli*, which appears to be similar to those associated with the flagellae of recent dinoflagellates, we have not been able to prove that a definite connection between them and the central body does exist. However, there seems little doubt that the clearly defined structure, so well represented in this species, is connected with the flagellum pore." — Cookson & Eisenack (1970, p. 145, 146)

Emended description: "Cysts bicavate to circumcavate. Pericyst outline is elongated. The epipericoel is prolongated into a long apical horn. The hypopericoel is with two antapical horns, one of them always is reduced. The endocyst is subspherical. Percingulum is prominent in all specimens, epicyst is longer than hypocyst. The periphragm is smooth, while the endophragm is more thick and finely granulated. The archeopyle is intercalary, type 3I/3I. The endoperculum often is separated into individual paraplates. Endopercular piece configuration is standard (sensu May & Benson, 1979). The 2a para plate is hexagonal, thus forming a standard anterior intercalary series. All three paraplates make contact with the apical series. Isolated endocysts are also common." — Pavlishina (1995, p. 138, 139)

Remarks: *Trithyrodinium trendalli* differs from *T. druggii* Stone, 1973 by its well recognizable cingulum and sulcus." — Pavlishina (1995, p. 139)

Age: middle Cretaceous (Albian–Cenomanian); holotype of Cookson & Eisenack (1970, p. 145).

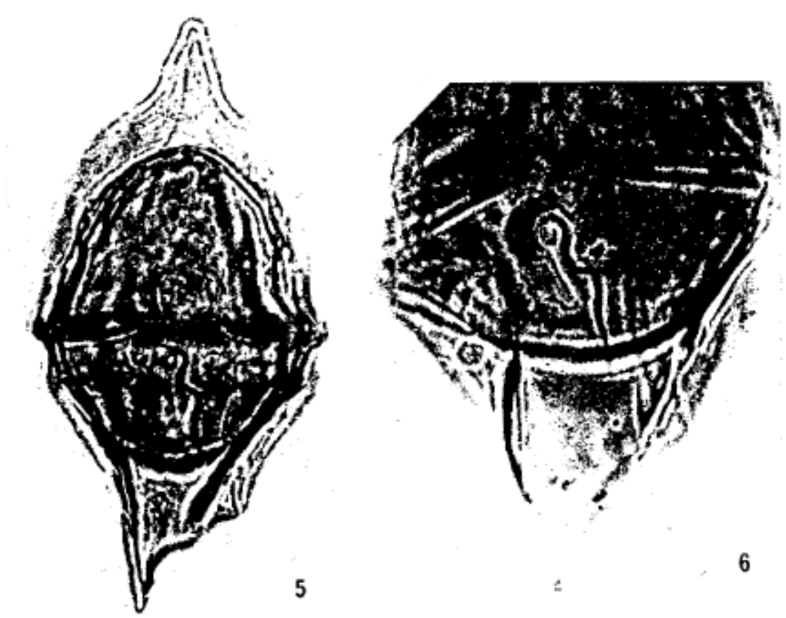


Plate 12, figures 5, 6, Cookson & Eisenack (1970).

Trithyrodinium unicorniculum Davey, 1975

Diagnosis: “Ovoidal cyst possessing a thick-walled, densely granular inner body and thin, closely-fitting periphragm. The latter is detached from the inner body only in the apical region, where it forms a short conical apical horn, and in the antapical region, where a similarly-shaped antapical horn is present. This is, however, asymmetrically placed with respect to the cyst axis represents the left horn. When the cingulum is discernable it is defined by two extremely faint ridges; the sulcus is represented by a sunken longitudinal groove. An archeopyle has never been observed. Rarely, the anterior intercalary plates on the inner body are seen to be displaced and extremely rarely are dislodged to give a large opening corresponding to plates 1a, 2a and 3a.” — Davey (1975, p. 158, 159)

Dimensions: “Holotype: overall length, 91 μ; overall width, 53 μ. Range: overall length, 82(87)93 μ; overall width 49(53)59 μ.” — Davey (1975, p. 159)

Description: “The archaeopyle probably occupies the anterior intercalary plate 2a position but is extremely difficult to observe due to the thinness of the periphragm. The anterior intercalary plates of the inner body are joined on their cingular margin, and after excystment had taken place normally returned to their original position. Hence the inner body usually appears to be entire.” — Davey (1975, p. 159)

Remarks: “Deflandroid [sic] species possessing a single asymmetrically placed antapical horn have only rarely been described. The most similar is *Deflandrea pernaensis* Alberti 1959 which, however, has a relatively small inner body.” — Davey (1975, p. 159)

Age: Late Cretaceous; holotype of Davey (1975, p. 159).

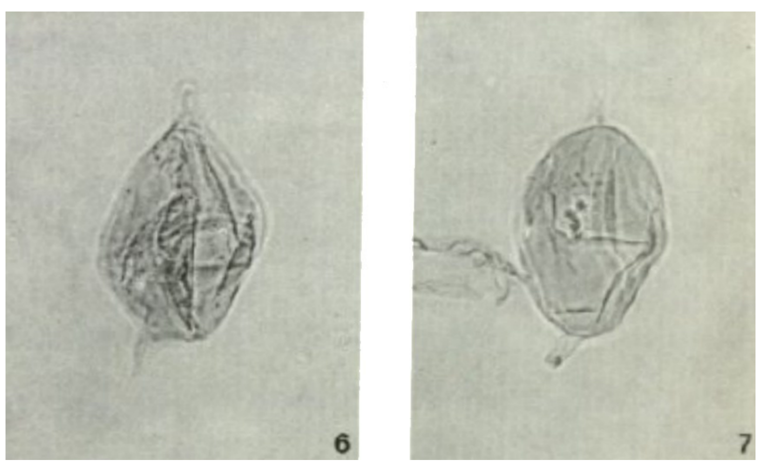


Plate 3, figures 6, 7, Davey (1975).

?*Trithyrodinium velatum* (Conrad, 1941 ex Sarjeant, 1967) Riding & Fensome, 2002

Description: “The shell is as wide as it is long, angular, bounded by large, concave, rough plates furnished with small irregular warts, which give the silhouette a crenulated outline. The apical and antapical regions are somewhat flattened; the first bears a cylindrical process, broad and short, truncated straight at its free extremity. This projection gives *P. velatum* a pronounced *Gonyaulax* physiognomy. The transverse furrow could only be observed on its dorsal side, the specimen unfortunately not lending itself to observation, by transparency, of the other side. It is clearly defined and very deep. It is to be presumed that its gap, if it really exists, can only be weak. The tabulation could not be deciphered. We had to content ourselves with noting the rather vague delimitation of a few large, median, pentagonal plates, located on either side of the transverse furrow. The lodge is surrounded by a refractile envelope, which goes far beyond it at the two extremities, along the longitudinal axis, by a barely colored portion, somewhat wrinkled; bizarre structure found in various microfossils." — Translated from Conrad (1941, p. 8, 9)

Dimensions: "Cyst diameter: 40–44 μ. Height of the apical horn: 6.5 μ. Antero-posterior span (including the extent of the biconical envelope): approximately 100 μ." — Translated from Conrad (1941, p. 8, 9)

Age: Late Cretaceous (Maastrichtian) based on Riding & Fensome (2002, p. 24).

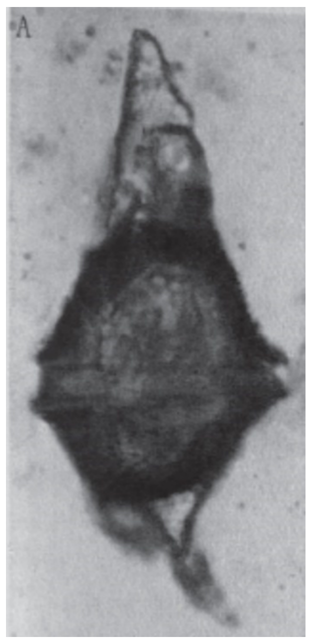


Plate 1, figure A, Conrad (1941).

Trithyrodinium vermiculatum (Cookson & Eisenack, 1961a) Lentin & Williams, 1976

Description: "Shell oval to almost circular in outline, surface ornamented with close and rather heavy vermiculate thickenings or a small-meshed thin-walled reticuloid pattern. The lid is seldom seen in position but the 6-sided shape of the opening indicates its shape. Remains of an outer transparent membrane are sometimes present." — Cookson & Eisenack (1961a, p. 74)

Dimensions: "Type — length 67 μm, breadth 58 μm. Range — length 56–76 μm, breadth 47–70 μm". — Cookson & Eisenack (1961a, p. 74)

Age: Late Cretaceous (Senonian); holotype of Cookson & Eisenack (1961a, p. 74).

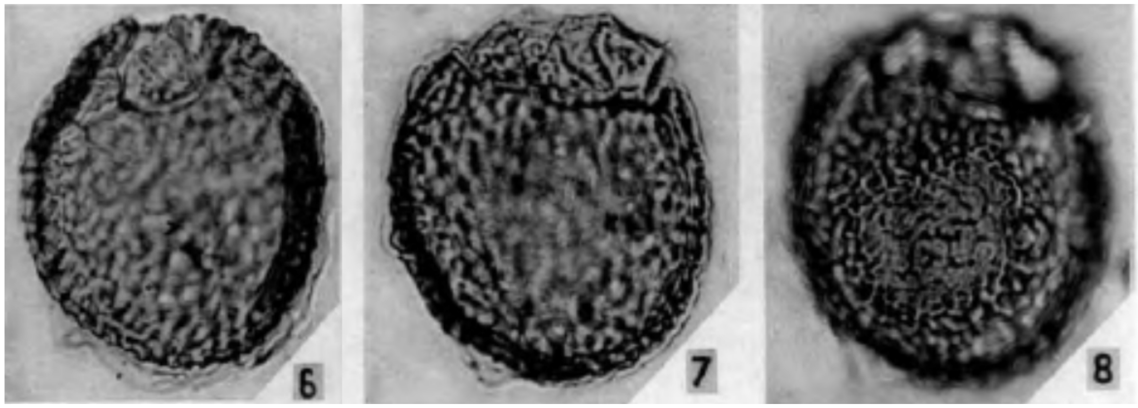


Plate 12, figures 6–8, Cookson & Eisenack (1961a).

Trithyrodinium verrucosum Núñez-Betelu, 1994

Diagnosis: "Spherical to ovoidal, cornucavate peridinioid cysts, periphragm usually absent or torn; ornamentation of higher relief than in other species of this genus and consisting of a densely granulate wall and strongly developed verrucae regular to irregularly distributed over the endophragm. Intercalary Type 3I archeopyle." — Núñez-Betelu (1994, p. 304)

Description: "Cyst type: cavate. Shape: spherical to ovoidal with a short, poorly developed apical horn. Often compressed. Wall relationships: cornucavate to partly circumcavate. Periphragm usually missing or partly tom. Wall features: periphragm smooth, very thin and membranous, endophragm thick, densely granulate to microrugulate. The endophragm presents a reticulate to foveolate character in some specimens. Variable, weak to strong, coarse verrucate ornamentation irregularly distributed over the endophragm outer surface, and restricted to random areas of the ventral face on some specimens. Paratabulation: expressed by endoarcheopyle only. Archeopyle: endoarcheopyle intercalary, Type 3I. Periarcheopyle not observed. No accessory archeopyle sutures present between precingular paraplates. Endooperculum free." — Núñez-Betelu (1994, p. 305)

Dimensions: "Holotype: length of endocyst 58 μm. Width of endocyst, 53 μm. Verrucae, 3.5 to 5 μm in diameter and 1.5 to 2 μm high. Size range: length of endocyst, 49 (56) 69 μm. Width of endocyst, 44 (61) 67 μm (21 specimens measured). Verrucae, 1.5 (4.2) 6 μm in diameter and 1 (1.8) 3 μm high (63 verrucae measured)." — Núñez-Betelu (1994, p. 305, 306)

Discussion: "This species differs from the other species of *Trithyrodinium* in having a very coarsely ornamented, microrugulate endophragm that bears well-developed verrucae. Species such as *T. suspectum* (Manum & Cookson 1964) Davey 1969 have a dense and irregular ornamentation evenly distributed over both the ventral and dorsal areas but much less developed than in *T. verrucosum* sp. nov. which has a microrugulate endophragm. The verrucate ornamentation of this species is restricted to the ventral area in some specimens, otherwise is evenly distributed over the entire surface at regularly spaced intervals. The thick, strongly microrugulate endophragm and the weak to coarsely developed verrucate ornamentation constitute the basis for the establishment of this new species." — Núñez-Betelu (1994, p. 306)

Remarks: "Both *Trithyrodinium verrucosum* sp. nov. and *T. suspectum* occur together in many samples of this study. However, the stratigraphic range of the former species is more restricted than that of the latter, and therefore, *T. verrucosum* sp. nov. may have stratigraphic significance. Also, intraspecific morphologic variations occur in these two species with forms that appear intermediate between them. Specimens of *Trithyrodinium* sp. of Ioannides (1986, pl. 20 figs. 9, 13, 19. and 20) correspond to these intermediate forms. Yet, many individuals present features characteristic of only one of these species, and two separate populations can be observed what is indicative of the presence of two separate species.” — Núñez-Betelu (1994, p. 306)

Age: Late Cretaceous (late Turonian or early Coniacian–Santonian); holotype of Núñez-Betelu (1994, p. 305, 206).

Note: not to be confused with “*verrucosum*” of Manum (1963, p. 60, 61, pl. 3, figs. 1–4) Davey, 1969b, p. 12 which is NOW *Chatangiella*. Also, the is name not validly published in the thesis of Núñez-Betelu (1994), thus superseded by *Trithyrodinium verrucosum* comb. of Estebenet & Guler (2023).

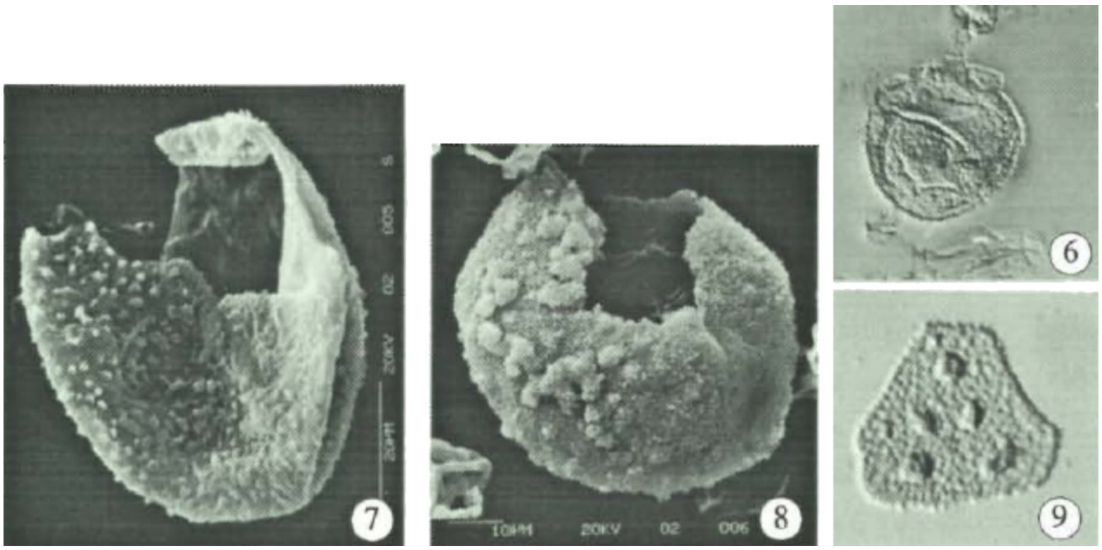


Plate 32, figures 6–9, Núñez-Betelu (1994).

Trithyrodinium verrucosum (Heisecke, 1970) Estebenet & Guler, 2023

Diagnosis: “Cavate dinoflagellate cyst with subcircular to rhomboidal outline composed of two layers. Endophragm thick, opaque, infragranulated, with verrucous sculpture; periphragm delicate, hyaline, forming one apical horn and two small antapical horns. In the equatorial zone, a poorly defined paracingulum is observed. Precingular archeopyle.” — Translated from Heisecke (1970, p. 232)

Description: “Cavate subcircular dinoflagellate cyst with a circular to subcircular outline with a rhomboidal tendency composed of two layers. The opaque, reddish-brown endophragm presents a verrucate ornamentation; the verrucae are fairly spaced and irregularly distributed. Verrucae shape is diverse, irregular in outline, in some cases elongated, joined each other. The periphragm is delicate, hyaline with a small bulge or apical horn and two small antapical horns, one larger than the other. Both layers are separated, forming a pericoel of 1–1.5 μm wide, except in the apical and antapical zones, where they separate to form the horns. In the equatorial zone, irregular thickenings in the wall may indicate the presence of a few characteristic or low-defined paracingulum. It presents a precingular archeopyle with an irregular pentagonal outline.” — Translated from Heisecke, 1970, p. 232, 234).

Emended diagnosis: “Peridiniacean (deflandreoid) dinoflagellate cyst. The cyst wall is composed of two layers: the periphragm thin and hyaline, and the endophragm moderately thick, bearing irregularly spaced non-tabular, spherical verrucae of moderate relief.” — Estebenet & Guler (2023, p. 512)

Emended description: “Proximate peridiniacean cysts, bicavate to circumcavate, spherical to subspherical in shape. The wall has two layers closely appressed except at the horns. A thin, hyaline periphragm forms a short apical horn (~10 μm) and two scarcely developed unequal antapical horns (Fig. 3.13, 3.15–3.16). A pigmented moderately thick (up to 2 μm) endophragm presents irregularly spaced non-tabular spherical (as ‘pearls’) of similar size verrucae of moderate relief, 1.3 (1.8) 2.6 μm in diameter, occasionally joined at their bases (e.g., Fig. 3.1). In some specimens an alignment of the verrucae is observed at the paracingulum (Figs. 3.2–3.3, 3.7). Archeopyle is intercalary type 3I with formula I(1–3a); most of the operculum is often attached (Figs. 2.1–2.11, 3.1–3.13).” — Estebenet & Guler (2023, p. 512, 513)

Dimensions: “Holotype: total length = 84 μ, hornless = 68 μ, width = 67 μ, apical horn length = 8 μ, major antapical horn length = 9 μ, minor antapical horn length = 4 μ.” — Translated from Heisecke (1970, p. 232) “Central body length 60 (67) 73 μm, width 61 (68) 72 μm; spherical verrucae of 1.3 (1.7) 2.6 μm of diameter. Number of specimens measured = 11.” — Estebenet & Guler (2023, p. 513)

Remarks and comparison: “Heisecke (1970) described this species as *Scriniodinium verrucosum*, as having precingular archeopyle. However, the new well-preserved specimens recovered from the PV borehole and the re-studied of the original material of the Roca Formation allowed us to identify an unequivocal intercalary archeopyle type 3I that led us to transfer the species to the genus *Trithyrodinium*. The emendation of the species also modified the original definition of the ornamentation. Whereas Heisecke (1970) includes broader reference to the variability of the verrucae, specimens herein analyzed exhibit only spherical verrucae. Because slides with the holotype material could not be located, a lectotype is designated (Fig. 2.9–2.10). *Senegalinium* sp. from the Jaguel Formation, Neuquen Basin (38° 08’ S; 68° 26’ W) illustrated by Papu et al. (1999, fig. 1.3) might be a specimen of *Trithyrodinium verrucosum*; the specimen shows an intercalary archeopyle of type 3I, and the endophragm ornamented with verrucae. This specimen should be designated at least as *Trithyrodinium* also that it does not satisfy the criteria for being considered *Senegalinium* genus.

Trithyrodinium verrucosum is similar to *Trithyrodinium verrucatum* Vieira & Mahdi, 2021 in having an endophragm with verrucae, but in *Trithyrodinium verrucosum* the endophragm is less thick and verrucae are smaller and more irregularly spaced distributed (less quantity) than in *Trithyrodinium verrucatum* (Vieira & Mahdi, 2021). Both species differ from all other species of *Trithyrodinium* by the presence of a verrucate ornamented endophragm. *Trithyrodinium ioannidesii* Vieira & Mahdi, 2021 bears numerous non-tabular grana and coni of variable size; *Trithyrodinium suspectum* (Manum & Cookson, 1964) Davey, 1969 contain rod-shaped elements of unequal length; *Trithyrodinium zakkii* Pearce *et al.*, 2019 possessed short, minutely non-tabular bifurcating spines; *Trithyrodinium evittii* is finely punctate ornamented; *Trithyrodinium striatum* Benson, 1976 is longitudinally striate, and *Trithyrodinium partridgei* Willumsen & Vajda, 2010 presents a foveolate mesophragm.” — Estebenet & Guler (2023, p. 513, 515)

Age: early Paleocene (early–late Danian); Estebenet & Guler (2023, p. 515, 516; fig. 4).

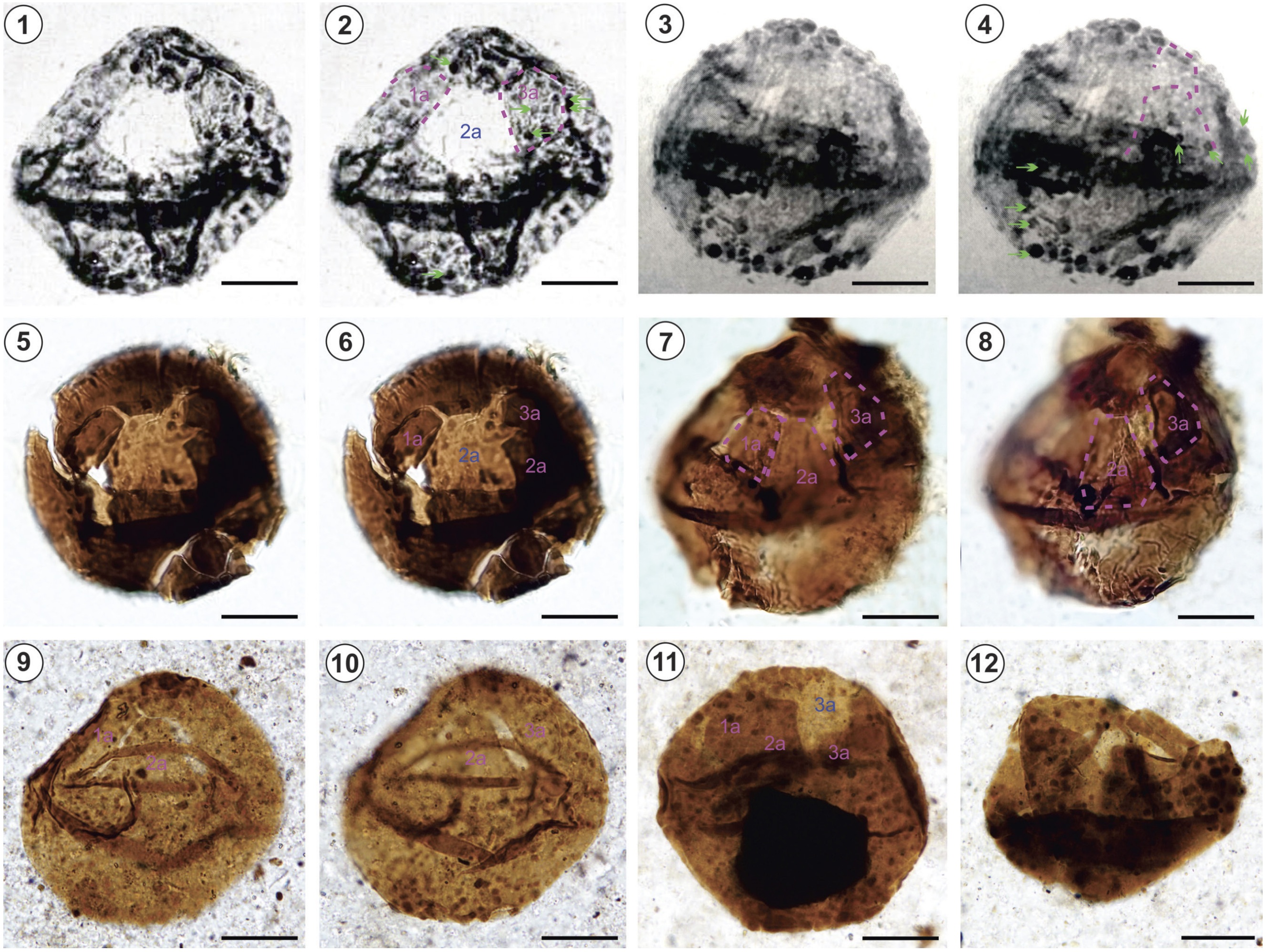


Figure 2, nos. 1–12, Estebenet & Guler (2023). Figures 1, 3, *redux* Heisecke (1970) plate 9, figs. 2, 3 respectively; nos. 2, 4 modified from Heisecke (1970) plate 9, figs. 2, 3 respectively. Scale bars = 20 µm.

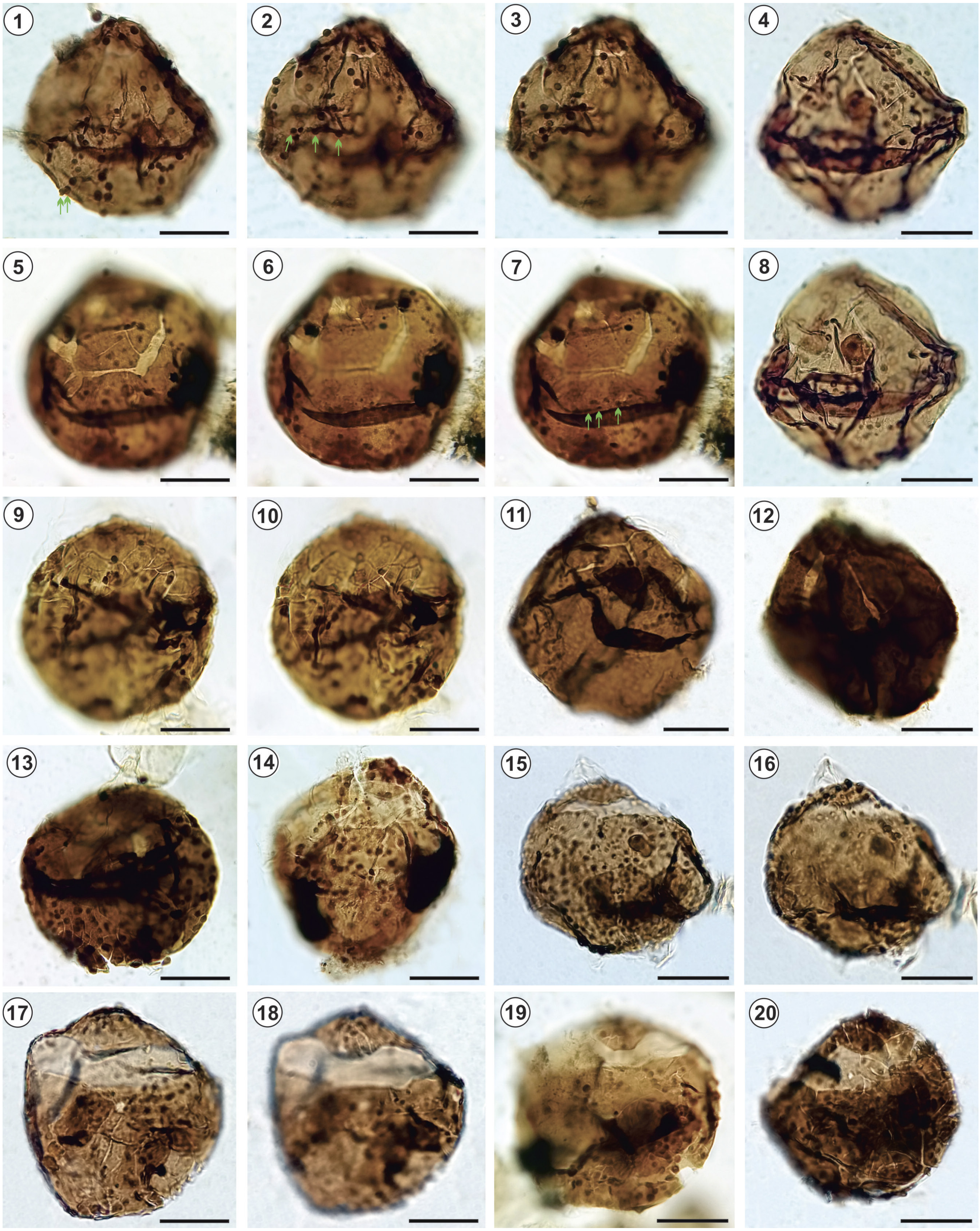


Figure 3, nos. 1–20, Estebenet & Guler (2023). Scale bars = 20 μm.

Trithyrodinium vozzhennikovae (Boltenhagen, 1977) Masure et al., 1996

<u>Diagnosis</u>: "Theca very fine, smooth, fusiform, provided at the poles with more or less conical horns and containing a globular capsule covered with verrucae." — Translated from Boltenhagen (1977, p. 108)

<u>Description</u>: "This species is characterized by a smooth and very fine fusiform theca formed by a prolonged globular body by two conical polar horns, large but short, rounded or pointed at the top. The subspherical capsule is thicker and entirely covered by conical granules more or less 0.5 μm in height. The theca adheres entirely to the capsule except around the horns. As a result, upon initial view, this microsculpture appears as a structure of the theca. The capsule archeopyle would be hexagonal with two upper sides three times longer than the other two lower ones; the lower base is approximately one-third larger longer than the upper. The sutures of the operculum indicate these relations. Under these conditions, in profile, this archeopyle would appear as a broken line made up of four segments. On the apex of one of the specimens, traces of the tabulation are seen starting from the angles of the archeopyle. On the theca, the outline of the latter is indeterminable due to the fragility of the membrane which tears and forms folds. The presence of traces of the cingulum is possible." — Translated from Boltenhagen (1977, p. 108)

<u>Dimensions</u>: "Holotype: length with horns = 75 μ; length without horns = 51 × 45 μ; capsule = 50 × 44 μ; horns = 14–18 μ (?). Two paratypes: length without horns = 48 × 50 μ and 56 × 55 μ; capsule = 48 × 50 μ and 56 × 55 μ; horns = 11 μ and 18 μ." — Translated from Boltenhagen (1977, p. 108)

<u>Comparison</u>: "We provisionally place this species in the genus *Svalbardella* Man. 1960 (p. 21). It should be noted however that the theca is not clearly fusiform having a globular body and that moreover the cingulum was not observed clearly. It is thus possible that it is in fact a new genre." — Translated from Boltenhagen (1977, p. 108)

<u>Emended diagnosis</u>: "Proximate, cornucavate dinoflagellate cyst, subspherical to ellipsoidal central body, with one short apical horn and two poorly developed antapical horns of inequal size; granulous endophragm, smooth periphragm; paratabulation indicated by endoarcheopyle, intercalary archeopyle, type 3I/3I, operculum polyplacoid, free, occasionaly [sic] adherent." — Masure et al. (1996, p. 182)

<u>Age</u>: Late Cretaceous (Campanian); holotype as translated from Boltenhagen (1977, p. 108).

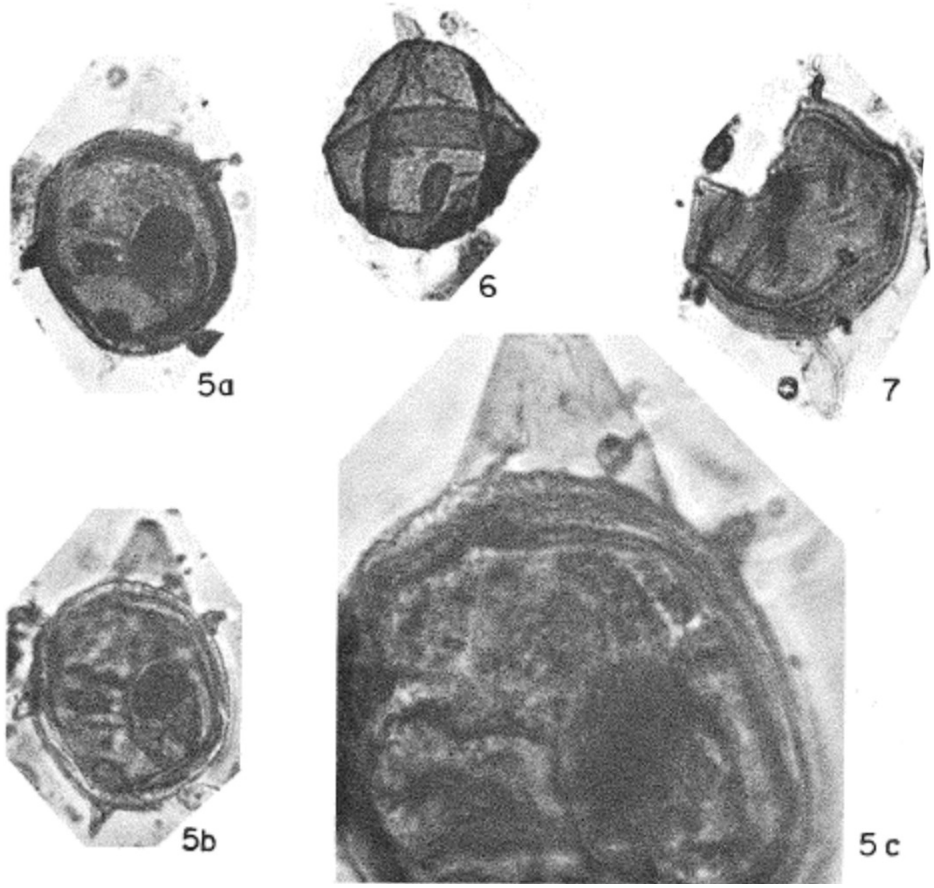


Plate 19, figures 5a–c, 6, 7, Boltenhagen (1977).

Genus ***VOZZHENNIKOVIA*** Lentin & Williams, 1976

1976 *Vozzhennikovia* Lentin & Williams: 65, 66.
2009 *Vozzhennikovia* Lentin & Williams; emend. Sluijs et al.: 48, 49.

Vozzhennikovia angulata Wilson, 1988

Description: "Cyst of intermediate size, generally circumcavate, occasionally cornucavate, relatively elongate, with angular pericyst outline. Periphragm thin, ornamented with closely-spaced thin, solid, capitate spines (length 2–4 µm); occasional areas devoid of spines, sometimes present. Endophragm thin and smooth; endocyst outline subangular, generally following pericyst outline except for horns. Short blunt apical horn usually present (length 4–6 µm). Left antapical horn well developed and pointed (length up to 15 µm); right antapical horn very short or occasionally absent (length up to 3 µm). Archeopyle fairly prominent, hexagonal, Type Ia; operculum remains attached posteriorly, peri operculum and endoperculum not separated. Paracingulum usually well defined by low parallel ridges (breadth 3–4 µm). Parasulcus poorly defined by narrow depression on ventral hypocyst." — Wilson (1988, p. 32)

Dimensions: "Holotype: overall length 73 µm, breadth 68 µm, apical horn 4 µm, left antapical horn 14 µm, right antapical horn 3 µm. Range: overall length 54(71)93 µm, breadth 46(61)73 µm (n = 10)." — Wilson (1988, p. 32)

Remarks: "*Vozzhennikovia angulata* is distinguished from the type species by its sharply angular pericyst outline, its slender capitate spines, and by usually possessing a short right ant apical horn. The spines are not considered to be arranged in intratabular clusters, although smooth areas (pandasutural areas?) sometimes occur and may indicate a partial paratabulation." — Wilson (1988, p. 32)

Age: lower Paleocene (Danian?); holotype of Wilson (1988, p. 32, fig. 4).

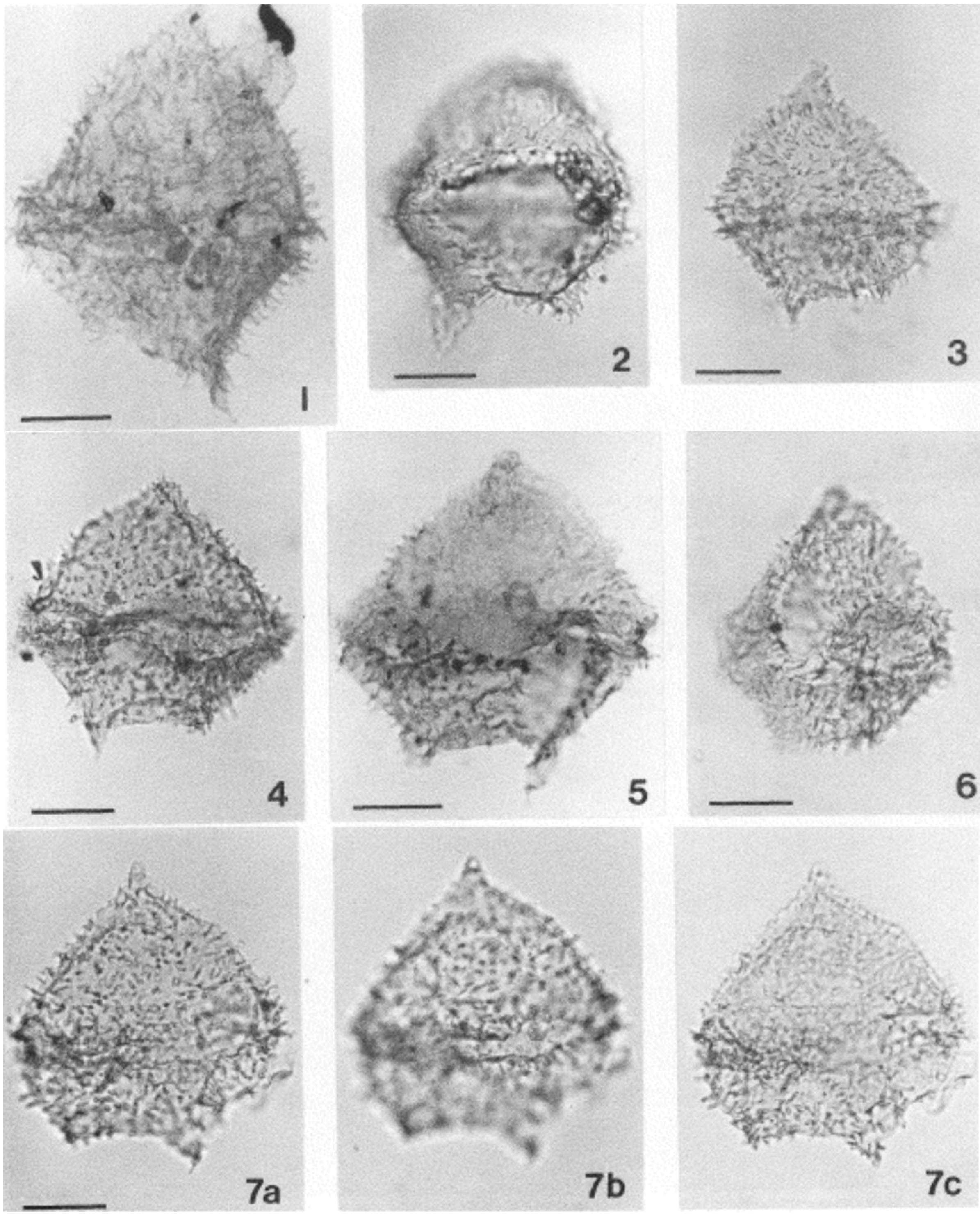


Plate 24, figures 1–6, 7a–c, Wilson (1988). Scale bars = 20 μm.

Vozzhennikovia apertura (Wilson, 1967a) Lentin & Williams, 1976

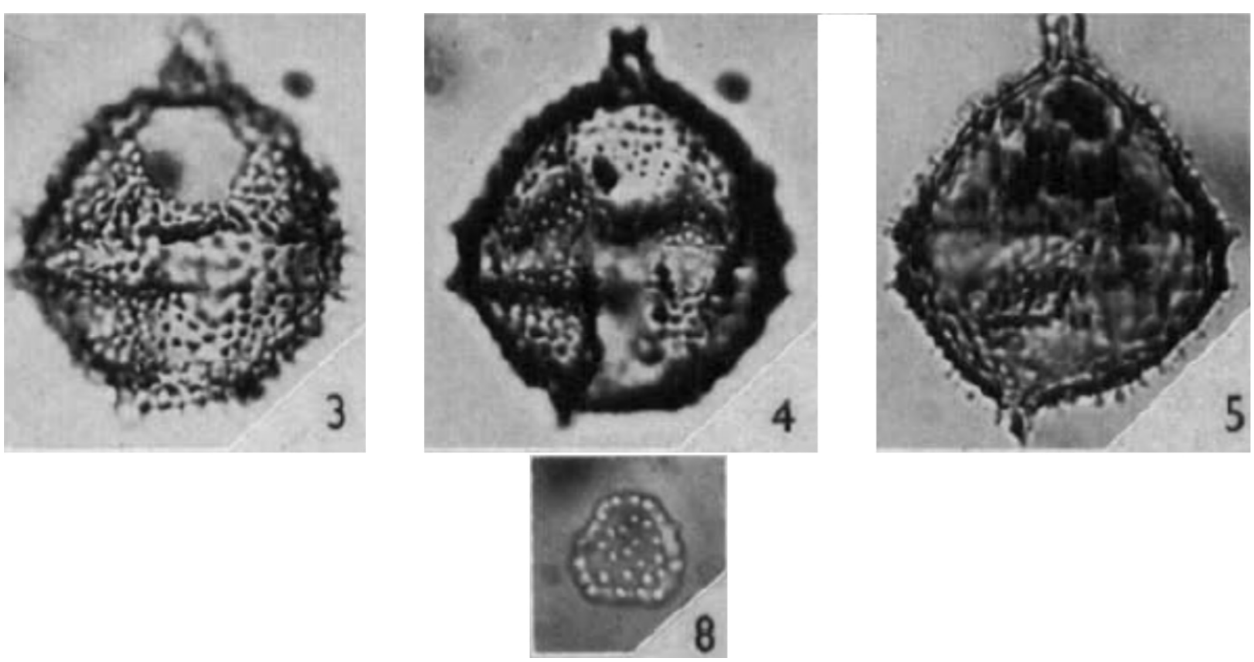
Description: "Test broadly rounded to sub-angular, differentiated into two closely joined layers forming inner and outer cysts. Surface of outer cyst thickly covered with pointed or flat-tipped spines, evenly distributed over the dorsal and ventral surfaces except on transverse girdle and longitudinal furrow. Transverse girdle wide, deeply grooved, either nonspiral or very slightly laevorotatory, delimited by two parallel rows of closely spaced spines. Longitudinal furrow a very prominent deep groove devoid of spines. Apical horn relatively long (l = 8–10 μ) rectangular and usually terminated by either one or two small spines; right antapical horn short (l = 2–3 μ) pointed; left antapical horn absent but position defined by slight angularity in shell outline. Archeopyle very prominent, intercalary, hexagonal, located on dorsal epitheca. Operculum free, distinctive, often occurs totally separated from parent shell (Fig. 8). Atabulate." — Wilson (1967a, p. 64, 65)

Dimensions: "Holotype: *1* = 52 μ, *b* = 44 μ. Range: *1* = 47(53)58 μ, *b* = 41(45)47 μ (7 specimens)." — Wilson (1967a, p. 65)

Discussion: "*S. aperturum* is a distinctive species characterised by the relatively large size of the archeopyle, transverse girdle and longitudinal furrow. The spines are relatively longer and more densely packed than those of both the type species and the species described by Stanley (1962). Certain features are shared with another Antarctic species. *S. rotundum* n. sp., described below. The species was recorded as *S. styloniferum* in the preliminary species list of McIntyre and Wilson (1966. table 2).

Spinidinium aperturum is extremely abundant in the McMurdo erratics, many hundreds of specimens having been observed. The specimens from Minna Bluff tend to be more globular than those from Black Island. They also have slightly longer spines (usually club-shaped) and a less conspicuous transverse girdle." — Wilson (1967a, p. 65)

Age: Paleocene–Oligocene? (erratic); holotype of Wilson (1967a, p. 64). Range: Paleocene–Oligocene; Sluijs et al. (2009, p. 50).



Figures 3–5, 8, Wilson (1967a).

Vozzhennikovia cearaichia Stover & Hardenbol, 1994

Description: "Proximate peridiniacean, cornucavate cysts with short apical and left antapical horns. Right antapical horn absent or poorly developed. Endocyst smooth, more or less circular in outline, appressed to periphragm almost everywhere and usually discernible only at the base of the apical and left antapical horns. Periphragm also thin, outline roundly peridinioid, lateral margins moderately convex, antapical margins straight or nearly so. Surface minutely wrinkled with sparse, seemingly randomly disposed, scattered denticulations. Accumulation bodies commonly present within the cysts. Paratabulation indicated by middorsal intercalary archeopyle, when discernible, and a weakly developed paracingulum expressed by faint fold and/or very low ridges. Monoplacoid operculum generally in place, otherwise partly displaced and adherent posteriorly, or rarely released entirely. Other indications of paratabulation absent." — Stover & Hardenbol (1994, p. 39)

Dimensions: "Intermediate; 50 to 56 μm, width 53 to 58 μm." — Stover & Hardenbol (1994, p. 39)

Comparison: "*Vozzhennikovia cearaichia* differs from *V. spinula* by having finer omamentation, a less well-defined paracingulum and a more round outline." — Stover & Hardenbol (1994, p. 39)

Age: early Oligocene (Rupelian); holotype of Stover & Hardenbol (1994, p. 39, fig. 7).

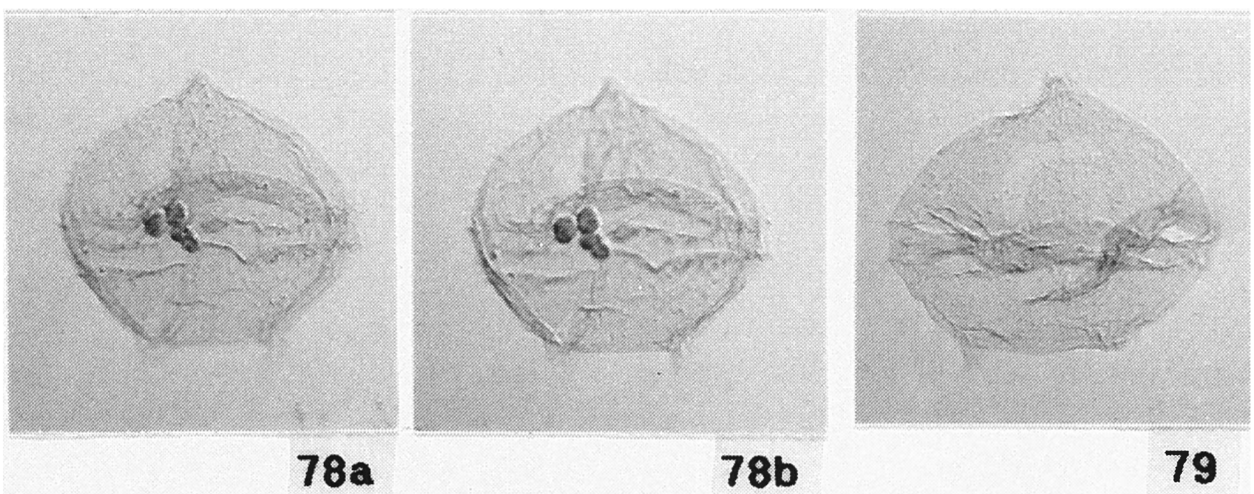


Plate 12, figures 78a, b, 79, Stover & Hardenbol (1994).

Vozzhennikovia mariae (Aurisano, 1984) Sluijs et al., 2009

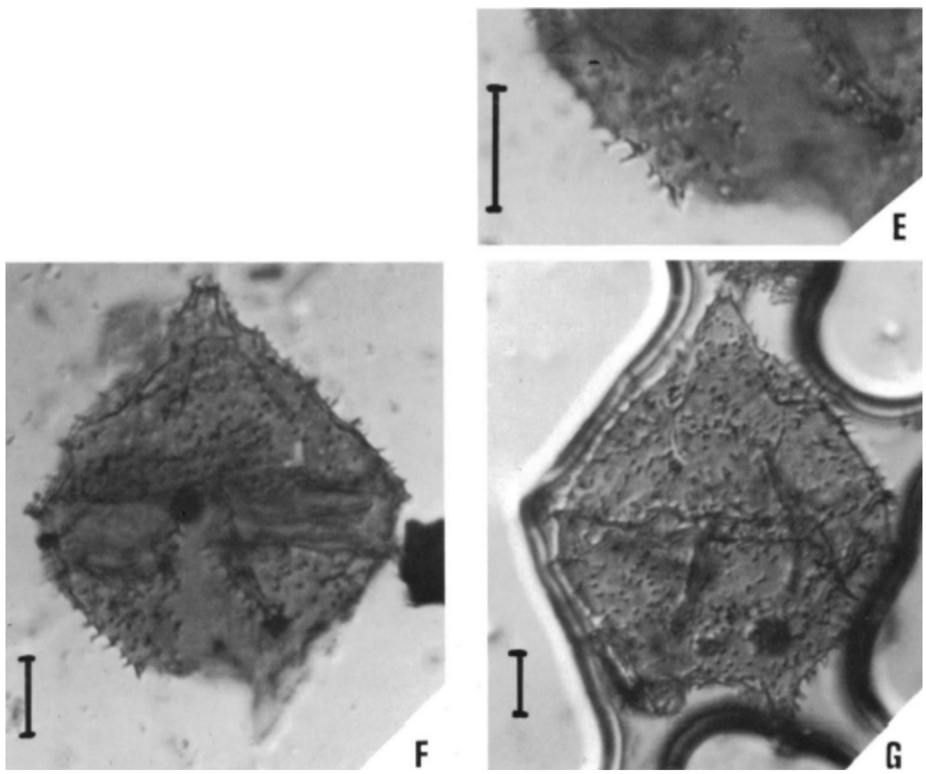
Diagnosis: "Cyst body ornamented with acuminate and bifid to bifurcating spines that show intraspecific variation in length. Perioperculum is an attenuated hexa and posteriorly attached." — Aurisano (1984, p. 7)

Description: "A cornucavate dinocyst that is approximately pentagonal in outline. It has one apical horn and two antapical horns. A right antapical horn is not usually present, but when present, is poorly developed. The apical horn often terminates with two spines which may be bifid. The pericyst surface is ornamented with spines. On a single specimen the spines vary from acuminate to bifid to bifurcating terminations. The endocyst is spherical to subspherical and appears laevigate. Paratabulation is not usually suggested by process alignment but this varies, and when present is faint and indistinct. Paracingulum is continuous and indicated by fine folds or ridges emphasized by spines. Parasulcus is indicated by a shallow depression and its margins outlined by spines. Archeopyle formula is I (2a) and its outline is that of an attenuated hexa (as indicated by the operculum shape) and posteriorly attached." — Aurisano (1984, p. 7)

Dimensions: "(on 10 specimens) Maximum length 55–68 µm; maximum width 45–50 µm." — Aurisano (1984, p. 7)

Remarks: "The most distinctive features of this species are the bifid terminations of some spines and the attached perioperculum. *Spinidinium essoi* Cookson and Eisenack differs in that its spines have acuminate terminations, as do those on *S. styloniferum* Cookson and Eisenack. *S. macmurdoense* (Wilson) Lentin and Williams is larger, has relatively long, acuminate spines with relatively long apical and antapical horns and is circumcavate." — Aurisano (1984, p. 7)

Age: Late Cretaceous (middle Santonian); holotype of Aurisano (1984, p. 7, fig. 2).



Figures 4E–G, Aurisano (1984). Scale bars = 10 µm.

?*Vozzhennikovia microornata* Slimani, 1994

Diagnosis: "Small *Vozzhennikovia* cyst, characterized by its surface evenly and densely covered with thin and short projections that are usually capitate." — Translated from Slimani (1994, p. 121)

Description: "Cyst proximal, cornucavate to rarely circumcavate and lenticular in shape. It has a subtriangular apical horn and a single smaller, more pointed antapical horn which apparently has an axial position. The periphragm is densely and evenly adorned with thin, short projections that are slightly capitate at the distal ends which gives it a micrograular appearance in superior view. The density and distribution of these projections are generally constant while their height is slightly variable intraspecifically. The endophragm is very fine, smooth, and often pleated. The type Ia intercalary archeopyle is stenodeltaform. The operculum is often adnate on the posterior edge of the archeopyle.

Except for the archeopyle, the cyst is not provided with other indices of paratabulation." — Translated from Slimani (1994, p. 121)

Dimensions: "Holotype: pericyst, length: 42 µm, width: 34 µm; endocyst, length 30 µm, width: 30 µm. Variations: pericyst, length: 34–50 µm, width: 28–34 µm; endocyst, length: 28–36 µm, width: 25–36 µm. Apical horn length: 6–8 µm. Length of antapical horn: 2–4 µm. Projection height: 0.5–1 µm. Number of specimens measured: 18." — Translated from Slimani (1994, p. 121)

Comparison: "*Vozzhennikovia microornata* sp. nov. is probably equivalent to *Vozzhennikovia* sp. A from Marshall (1990a) (see synonymy above). It is distinguished from *V. spinulosa* Wilson (1984c) by its lenticular shape, its larger size small, and by its shorter ornaments and denser distribution." — Translated from Slimani (1994, p. 121)

Age: Late Cretaceous (late Campanian); holotype of Slimani (1994, p. 120). Late Cretaceous (early Campanian–early Maastrichtian (Slimani, 1994, p. 121).

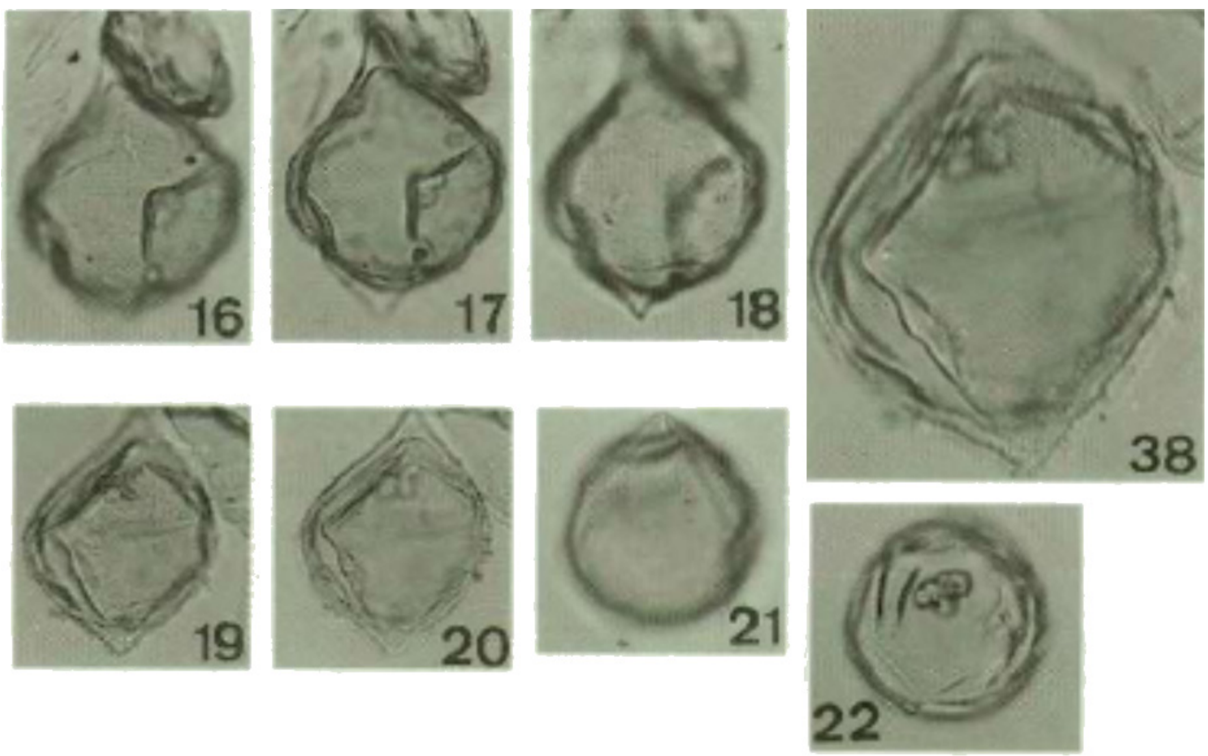


Plate 14, figures 16–22, 38, Slimani (1994).

Vozzhennikovia minus (He Chengquan & Wang Kede, 1990) Sluijs et al., 2009

Description: "Cyst small, compressed dorsoventrally, body rounded pentagonal in outline, with or without a small apical horn, lacking antapical horn. Wall most probably consisting of two layers closely adpressed, thin, covered with numerous, short, solid, baculate processes, extremities of processes varying from simple to capitate or slightly expanded to bifid in shape. Distribution of processes probably penitabular and intratabular. Wall surface between processes smooth. Paracingulum, if present, defined by a double row of processes or by low ridges bearing the processes, about 4.4 µm wide. Archeopyle, if present, intercalary, belonging to Type 1, broader than long. Operculum completely separated but adhered to the cyst." — Translated from He Chengquan & Wang Kede (1990, p. 423, 424)

Dimensions: "Body 35–37 μm long, 31–35.6 μm wide, processes 2.2–4.5 μm long. Holotype: body 37 μm long, 31 μm wide, processes up to 4.5 μm long." — Translated from He Chengquan & Wang Kede (1990, p. 424)

Comparison: "*Spinidinium minor* sp. nov. differs from *Spinidinium styloniferum, S. densispinatum* and *S.* ?*pilatum* in the small, rounded-pentagonal body, and in the absence of antapical horn and parasulcus." — Translated from He Chengquan & Wang Kede (1990, p. 424)

Age: early to middle Eocene; holotype of He Chengquan & Wang Kede (1990, p. 424).

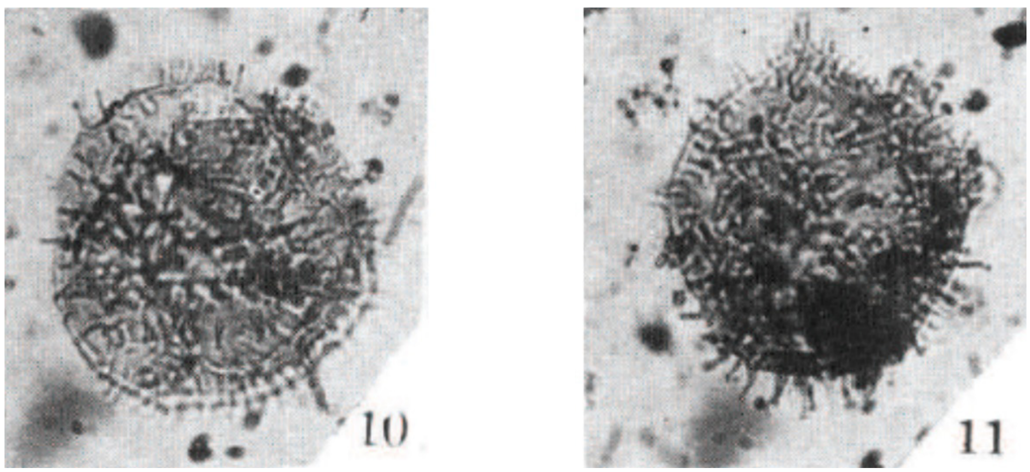


Plate 4, figures 10, 11, He Chengquan & Wang Kede (1990).

Vozzhennikovia minuta (Mao Shaozhi, 1988) Lentin & Vozzhennikova, 1990

Description: "Cysts proximate, subovoidal with a truncate apical projection, which is 5–7 μm high, dividing distally into two spines. Spines 3–4 μm high, with broad base and blunt end. Antapical side rounded, without horns. Cingulum delineated by two rows of baculate spines, 5–7 μm in width, slightly levorotatory. Epitract slightly larger than hypotract. Sulcus limited to the hypotract, delineated by a row of spines, Exine two-layered, with periphragm and endophragm separated only at the base of the projection, its surface covered with non-tabular spines which are 1–2.5 μm long and with rounded ends. Spines located around the cingulum higher and denser than those located elsewhere. Archeopyle intercalary (I), operculum free." — Mao Shaozhi (1988, p. 251)

Dimensions: "Length 58–64 μm, width 45–50 μm (measured from 12 specimens)." — Mao Shaozhi (1988, p. 251)

Discussion: "The new species differs from the two described species *U. nasutum* and *U. marginatum* in its distinctly smaller size (only ½ the size of the latter two species) and shorter apical projection. Besides, its spine ornamentation is slightly different from that of the latter two species." — Mao Shaozhi (1988, p. 251)

Age: Eocene (erratic); holotype of Mao Shaozhi (1988, p. 251).

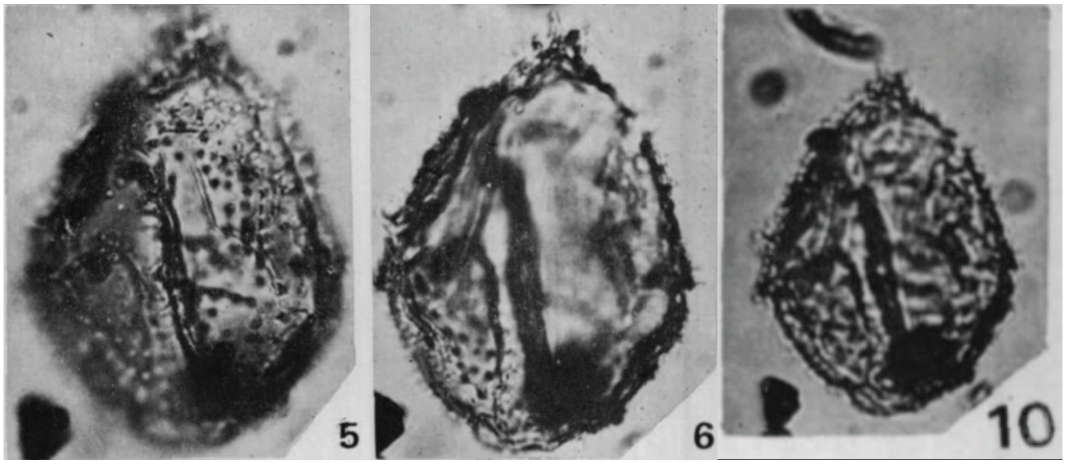


Plate 1, figures 5, 6, 10, Mao Shaozhi (1988).

Vozzhennikovia netrona Levy & Harwood, 2000. Emendation: Sluijs et al., 2009, p. 49.

Description: "Shape: pericyst sub-polygonal with long apical and left antapical horns. The lateral margins of the epipericyst and hypopericyst are typically straight to slightly convex. Phragma: a smooth endophragm is closely appressed to the periphragm except in the apical and antapical regions. The surface of the periphragm is covered with short (2 μ) capitate(?) spines which have a non-tabular distribution. Paratabulation: peridinioid, indicated by the intercalary archeopyle. Paracingulum: indicated by parasutural ridges that encircle the cyst in the adcingular region. The distal margins of the parasutural ridges possess capitate spines. Non-tabular spines occur within the paracingulum. The paracingulum is laevorotatory offset by 2 μ. Parasulcus: indicated by a break in the paracingulum. Posterior of the paracingulum, a depression in the surface of the cyst delineates the parasulcus. This depression has reduced surface ornamentation. Archeopyle: type I, hexa deltaform, formed by the complete removal of the 2a paraplate." — Levy & Harwood (2000, p. 210, 212)

Dimensions: "Observed range (six specimens): pericyst length 61 to 85 μ (mean 72 μ), pericyst width 44 to 31 μ (mean 40 μ), apical horn length 14 to 20 μ (mean 17 μ), antapical horn length 12 to 20 μ (mean 16 μ)." — Levy & Harwood (2000, p. 212)

Comments/comparison: "Possession of long apical and left antapical horns and a polygonal pericystal outline characterize this taxon. Otherwise, the species is similar to *Vozzhennikovia apertura*. This species was illustrated by Crouch and Hollis (1996), however, no description was given. Mohr (1990) recovered this taxon from ODP Hole 696 but assigned it to *Vozzhennikovia apertura*." — Levy & Harwood (2000, p. 212)

Emended description: "Cornucavate, proximate, ovoidal, dorso-ventrally compressed peridiniacean cysts with long apical and left antapical horns, which are approximately 1/3rd of the length of the central body. Pericyst bearing numerous uniformly distributed to proximosutural capitate spines, which may form intratabular clusters or are penitabular. The cingulum is indented and delineated by a row of spines. Sulcus indented, extending onto the epicyst but longer and wider on the hypocyst. The archeopyle is type I or 3I, with the operculum usually being detached." — Sluijs et al. (2009, p. 49)

Discussion: "*Vozzhennikovia netrona* differs from other species of the genus by having long apical and left antapical horns, which are approximately 1/3rd of the length of the central body." — Sluijs et al. (2009, p. 50)

Age: middle–late Eocene (erratic); holotype of Levy & Harwood (2000, p. 210).

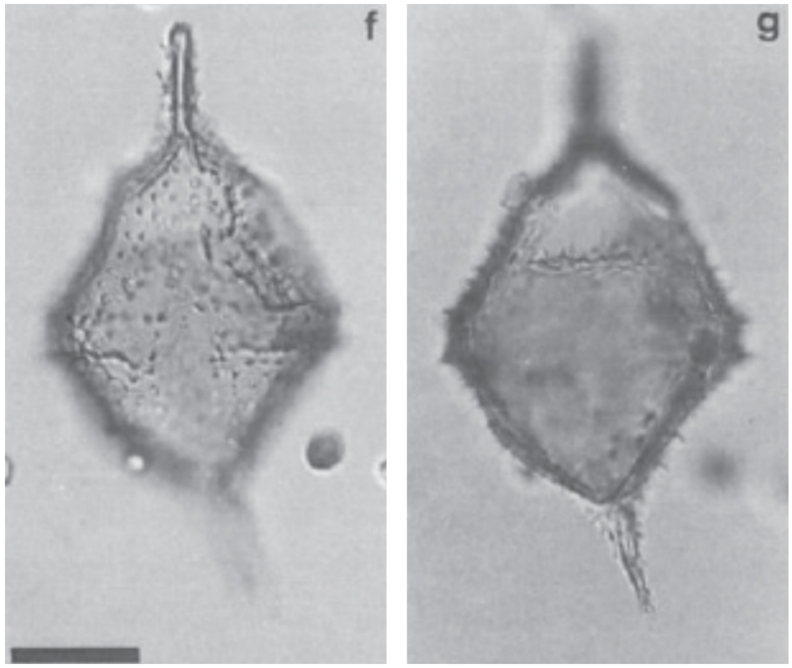


Plate 11, figures f, g, Levy & Harwood (2000). Sale bar = 20 μm.

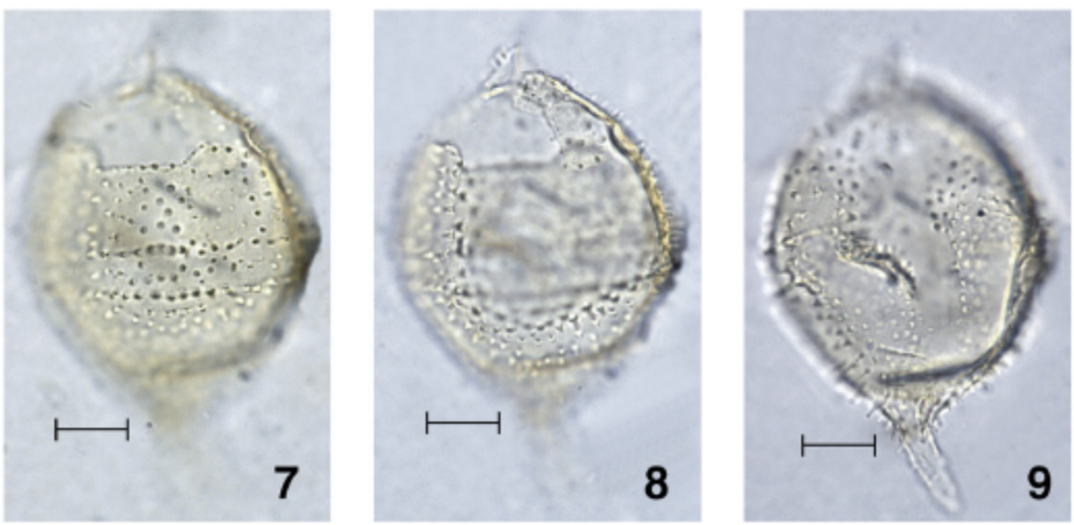


Plate 2, figures 7–9, Sluijs et al. (2009). Sale bars = 20 μm.

Vozzhennikovia roehliae Sluijs et al., 2009

Diagnosis: "A species of *Vozzhennikovia* with a verrucate pericyst and consistently a 3I archeopyle." — Sluijs et al. (2009, p. 49)

Description: "Cornucavate, proximate, ovoidal, dorso-ventrally compressed peridiniacean cysts, with an apical horn and a rounded antapex with a weakly developed left antapical horn. Endocyst thin and psilate. Pericyst ornamented with numerous hollow verrucae that are arranged in intratabular clusters or penitabular. The cingulum may be indented, and is delineated by a row of penitabular verrucae on the preand postcingular plates. The indented sulcus extends onto the epicyst but is considerably longer and wider on the hypocyst, reaching almost to the antapex. On both cingulum and sulcus, the verrucae are smaller. The archeopyle is type 3I, with plates 1a to 3a usually being free; plates 1a and 3a may remain attached to plates 2' and 4' respectively, whereas plate 2a may remain attached posteriorly to 4''." — Sluijs et al. (2009, p. 49)

Dimensions: "Holotype: 58 × 45 µm. Range: length 45(53)60 µm, breadth 36(41)45 µm. Specimens measured 10." — Sluijs et al. (2009, p. 49)

Discussion: "*Vozzhennikovia roehliae* differs from other species of the genus by having verrucae, which may be arranged penitabularly and/or in intratabular clusters and a consistent 3I archeopyle. Goodman and Ford (1983, p. 865) reported that specimens of *Vozzhennikovia apertura* may lose one, two or all three intercalary plates during archeopyle formation and that the distribution of the coni varies. We interpret the specimens illustrated by Goodman and Ford (1983, pl. 4, figs. 1–6) to be assignable to *Vozzhennikovia roehliae*." — Sluijs et al. (2009, p. 49)

Age: middle to late Eocene; holotype of Sluijs et al. (2009, p. 49).

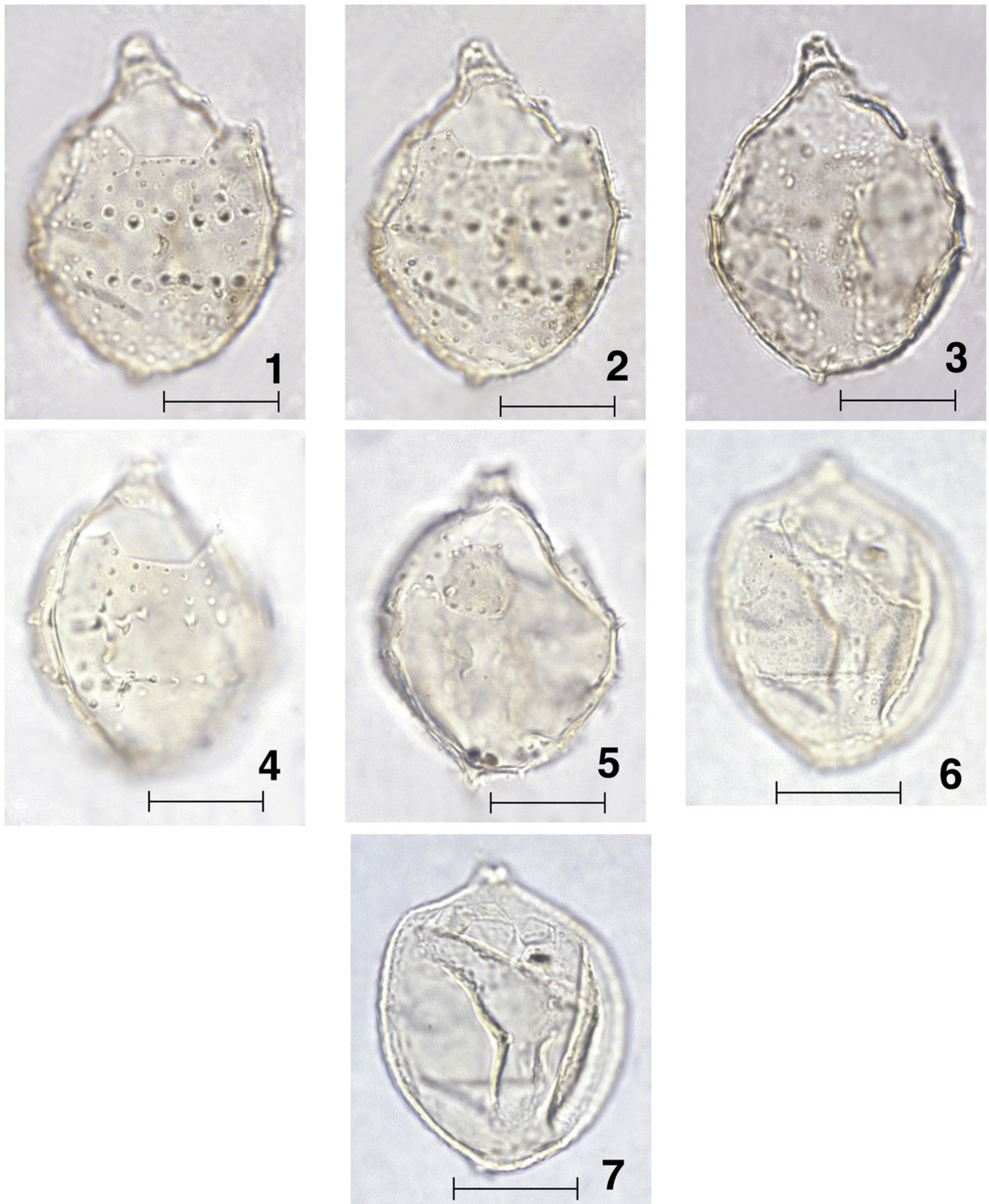


Plate 3, figures 1–7, Sluijs et al. (2009). Sale bars = 20 μm.

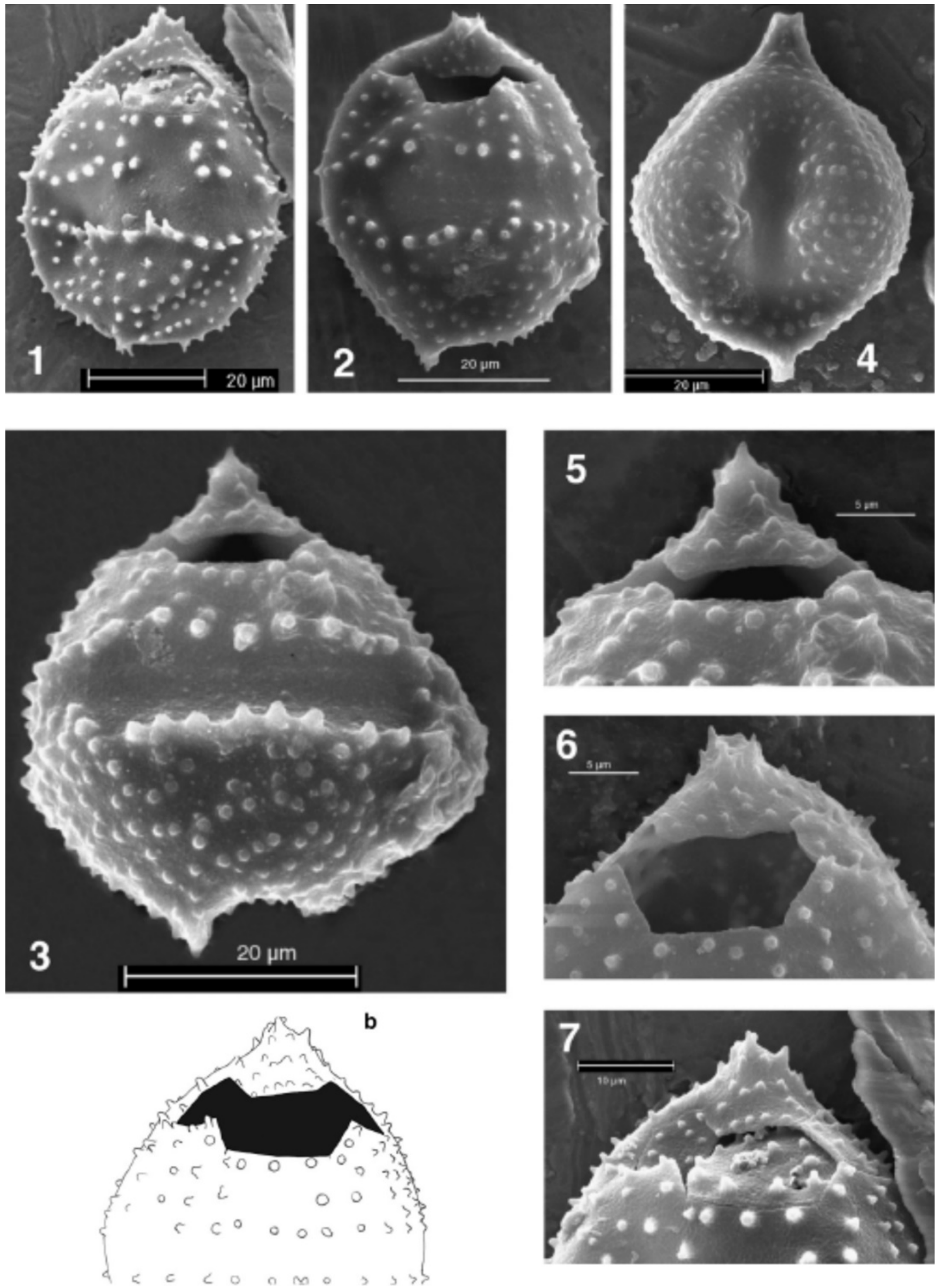


Plate 5, figures 1–7; Text-figure 2b (given as *Vozzhennikovia schellenbergii* sp. nov. in caption), Sluijs et al. (2009).

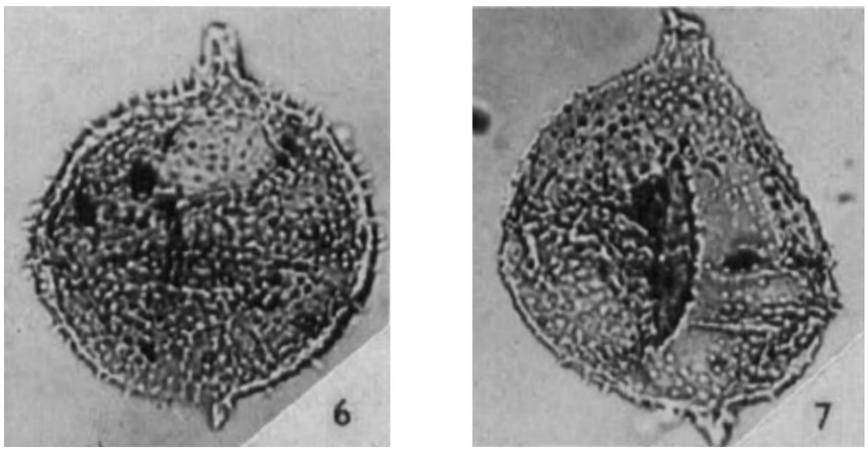
Vozzhennikovia rotunda (Wilson, 1967a) Lentin & Williams, 1976

<u>Description</u>: "Shell circular or near-circular, single-layered; surface covered with numerous small spines. Apical horn relatively large (*l* = 8–11 µ) rectangular; right antapical horn small, pointed (*l* = 4–5 µ); left antapical horn absent. Transverse girdle faintly defined by a double row of spine-bearing ridges which are usually discontinuous. Wide longitudinal furrow. Intercalary archeopyle wide, hexagonal, located on dorsal epitheca; operculum free. Atabulate." — Wilson (1967a, p. 65)

<u>Dimensions</u>: "Holotype *1* = 65 µ, *b* = 58 µ. Range *1* = 55(66)72 µ, *b* = 47(52)58 µ (4 specimens)." — Wilson (1967a, p. 65)

Discussion: "*Spinidinium rotundum* is distinguished from *S. aperturum* by its circular outline, discontinuous transverse girdle, thinner-walled single-layered shell, smaller and finer spines, and by its generally larger size. A few intermediate specimens were observed in some of the Black Island slides. The species was recorded as *S.* cf. *styloniferum* in the preliminary species list of McIntyre and Wilson (1966. table 2)." — Wilson (1967a, p. 66)

Age: Paleocene–Oligocene? (erratic); holotype of Wilson (1967a, p. 65).



Figures 6, 7, Wilson (1967a).

Vozzhennikovia spinalis He Chengquan, 1991

Description: "The ventral and back of the cyst are flat, the outline is oval-pentagonal, and the length is longer than the width. Divided into two parts of nearly equal size by the horizontal groove; divided epitheca triangular, straight sides, with a short vertex, cylindrical, flat top; hypotheca inverted trapezoidal, base is hypotenuse, on one side it has a blunt conical small antapical horn, about 4 μm long, on the other it is completely degenerated. The horizontal groove is shallow and flat, ring-shaped, about 6 μm wide. At the equator, its edge is bounded by thin ridges. The longitudinal groove is limited to the hypotheca. The ornamentation in the longitudinal and transverse grooves is reduced. Reflected plate formula unclear. The cyst wall is thin, with unclear layers, and the surface has obvious particles and sparse denticulate (thorn)-like protrusions, and the length of the spines is about 1 μm. Endocyst not identified. The archeopyle is visible, small, anterior, indicated by the archeopyle main crack. The flap is completely detached and situated in place." — Translated from He Chengquan (1991, p. 72)

Dimensions: "The cyst is 56 μm long and 48 μm wide." — Translated from He Chengquan (1991, p. 72)

Discussion: "In *Vozzhennikovia villosa*, to which Burger (1980b) has classified Australian specimens similar to this new species, the middle is defective because the latter lacks a belt. This new species in the Surat Basin of Australia is as early as the Late Cenozoic strata."

Age: Late Cretaceous (early Turonian). Based on the age of the "bottom of the Wuyitake Formation" as translated from He Chengquan (1991, p. 72) as given by Mingzhen Zhang et al. (2022, fig. 2).

Plate 2, figure 23, He Chengquan (1991).

Vozzhennikovia spinula Stover & Hardenbol, 1994

<u>Description</u>: “Proximate peridiniacean, cornucavate cysts with short apical and two antapical horns, right antapical horn usually reduced. Endophragm thin, smooth. More or less circular in outline, appressed to the periphragm almost everywhere and typically discernable only at the bases of horns. Periphragm also thin, outline peridinioid, lateral margins gently convex, antapical margin straight or nearly so. Periphragmal surface ornamented with numerous, but not densely arranged, spinules and/or coni. Their distribution appears to be nontabular, but some of the ornamentation may be intratabular or possibly penitabular. Accumulation bodies usually present within the cysts. Paratabulation indicated by the middorsal archeopyle, when discernible, and the nearly planar paracingulum. Latter expressed by two, transverse, parallel low ridges with finely denticulate crests. Operculum commonly in place, occasionally released entirely or adherent posteriorly. Other indications of paratabulation absent.” — Stover & Hardenbol (1994, p. 39, 40)

<u>Dimensions</u>: “Intermediate; length 55 to 61 µm, width 52 to 58 µm.” — Stover & Hardenbol (1994, p. 40)

<u>Comparison</u>: “*Vozzhennikovia spinula* differs from *V. cearaichia* (this paper) by being more coarsely ornamented and by having a better developed paracingulum and a less rounded outline. Other species of *Vozzhennikovia*, *V. apertura* (Wilson 1967) Lentin and Williams 1976, *V. rotunda* (Wilson 1967) Lentin and Williams 1976 and *V. spinulosa* Wilson 1984, are more densely ornamented than *V. spinula*.” — Stover & Hardenbol (1994, p. 40)

<u>Age</u>: early Oligocene (Rupelian); holotype of Stover & Hardenbol (1994, p. 40, fig. 7).

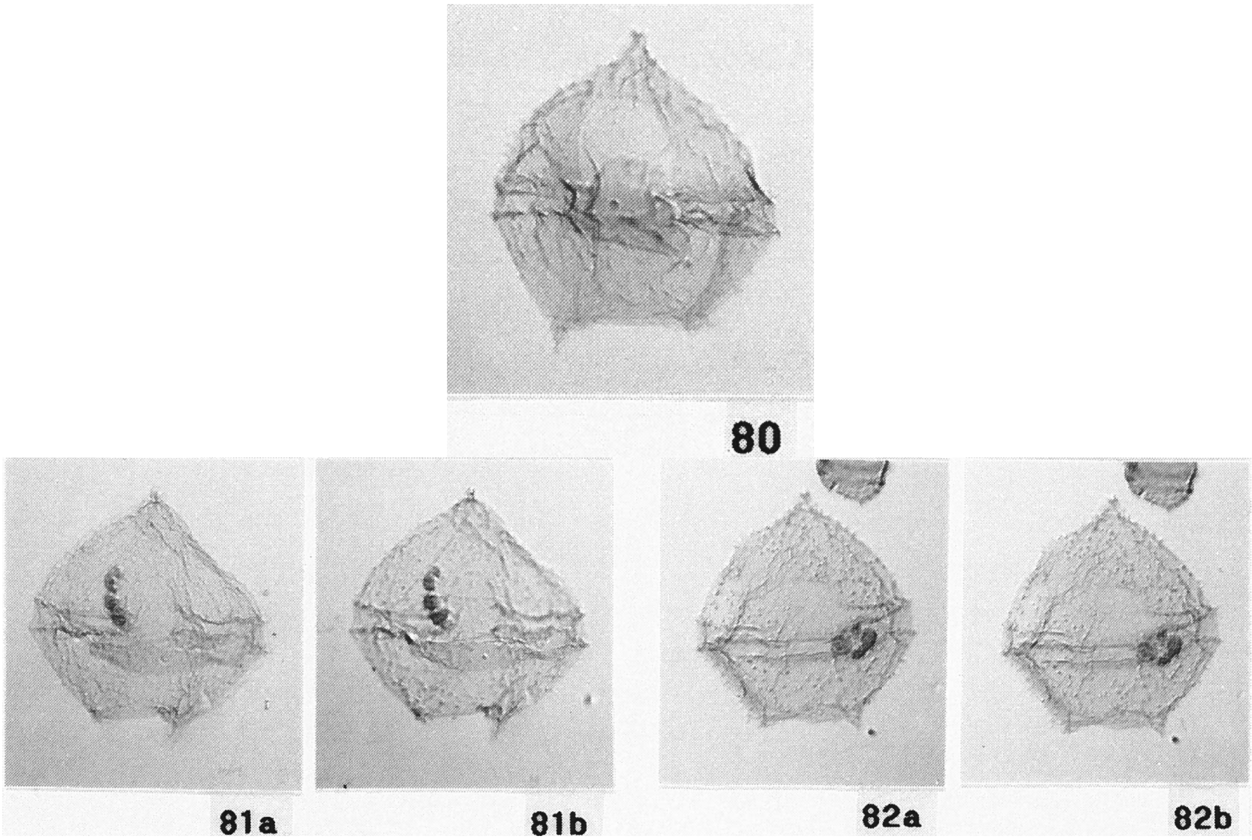


Plate 12, figs. 80, 81a, b, 82a, b, Stover & Hardenbol (1994).

Vozzhennikovia spinulosa Wilson, 1984b

<u>Description</u>: "Cysts generally circumcavate, occasionally cornucavate, pear-shaped, with thin periphragm and endophragm. Periphragm surface uniformly ornamented with many closely spaced small spines of up to 2 µm. Fairly short rounded or blunt apical horn c. 15 µm and small pointed antapical horn c. 8 µm, invariably present; antapical horn located near polar axis, no evidence of a second antapical horn. Archeopyle (Type I) relatively narrow; operculum generally free, occasionally attached at base. No indication of paracingulum, parasulcus or paratabulation." — Wilson (1984b, p. 549)

<u>Dimensions</u>: "Holotype: overall length 92 µm, breadth 73 µm, length of endocyst 65 µm, breadth 62 µm. Range (20 specimens): overall length 57(76)92 µm, breadth 51(64)81 µm." — Wilson (1984b, p. 549, 552)

<u>Discussion</u>: "*Vozzhennikovia spinulosa* has smaller, more closely spaced spines than other species of *Vozzhennikovia*. Its rounded pear-shaped outline and type of cavation are other distinctive features. The species is a useful index fossil for the Haumurian Stage, although it is apparently absent from the uppermost Haumurian." — Wilson (1984b, p. 552)

<u>Age</u>: Late Cretaceous; holotype of Wilson (1984b, p. 549).

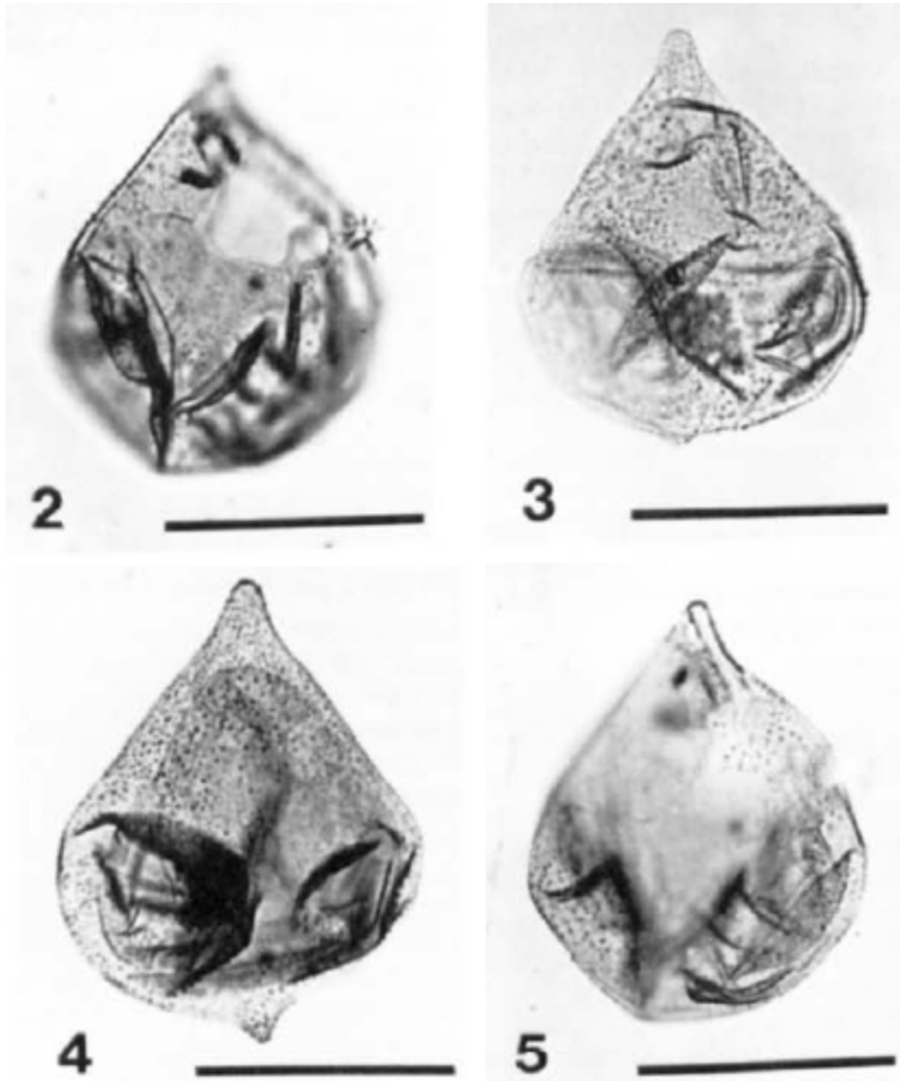


Figure 2–5, Wilson (1984b). Scale bars = 50 µm.

Vozzhennikovia stickleyae Sluijs et al., 2009

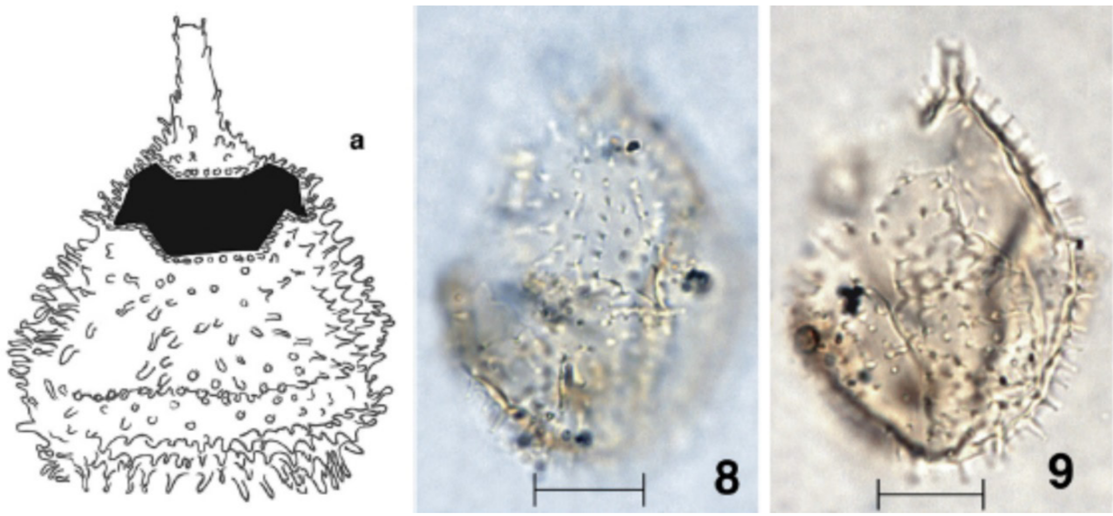
Diagnosis: "A proximochorate species of *Vozzhennikovia* with spines up to 10 µm long." — Sluijs et al. (2009, p. 49)

Description: "Cornucavate, proximochorate, ovoidal to pentagonal, dorso-ventrally compressed peridiniacean cysts with an apical horn and a rounded antapex, usually with a weakly developed left antapical horn. Endocyst thin, psilate. Pericyst bearing numerous uniformly distributed to proximosutural capitate spines, which are up to 10 µm long. Spines are often more than 10% of the cyst body on length and sometimes form intratabular clusters or are penitabular. The cingulum is indented and delineated by a row of spines. Sulcus indented, extending onto the epicyst but longer and wider on the hypocyst. The archeopyle is type I or 3I, with the operculum usually being detached." — Sluijs et al. (2009, p. 49)

Discussion: "*Vozzhennikovia stickleyae* differs from *Vozzhennikovia apertura* in having more robust spines and being proximosutural, thereby having spines that are more than 10% of the cyst body in length." — Sluijs et al. (2009, p. 49)

Dimensions: "Holotype: 40 × 28 µm. Range: length 40(45)55 µm, breadth 26(32)39 µm. Specimens measured 10." — Sluijs et al. (2009, p. 49)

Age: middle–late Eocene; holotype of Sluijs et al. (2009, p. 49).



Figures 2a; Plate 3, figures 8, 9, Sluijs et al. (2009). Sale bar = 20 µm.

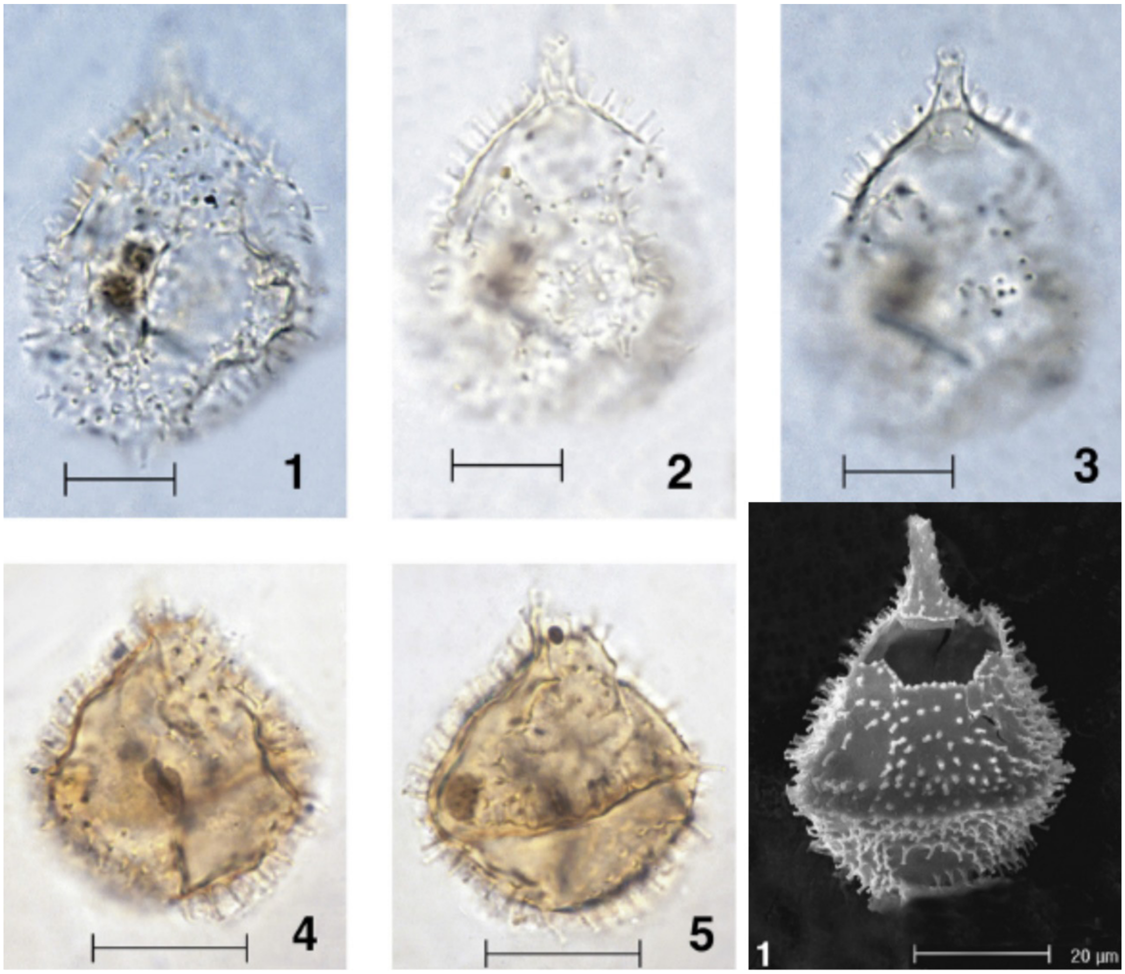


Plate 4, figures 1–5; Plate 6, fig. 1, Sluijs et al. (2009). Sale bar = 20 µm.

Vozzhennikovia tawanuiensis Crouch et al., 2014

Description: "A proximate cyst of intermediate size, with a broad rounded apex and two very low antapical protrusions that taper into short horns. The left antapical horn can be slightly more developed than the right, although both antapical horns are short (up to 9 µm specimens recorded). The apex lacks protrusion and horn. The cyst is cornucavate and the cavation is generally most obvious in the hypocyst near the base of the antapical horns. The epicyst and hypocyst are approximately the same size. The periphragm and endophragm are both thin and rounded to pentagonal in outline in dorso-ventral view. The periphragm is ornamented with short (up to 5 µm in specimens recorded), rod-like capitate processes that are closed distally. The processes are not densely arranged and ornamentation is non-tabular. The processes tend to be more common in the anterior and posterior regions, and also on the margins. The endophragm is difficult to delineate in most specimens. The archeopyle is an intercalary, type I (2a paraplate), that can be obscure. The operculum is free but remains in position in some specimens." — Crouch et al. (2014, p. 65)

Dimensions: "(in µm) Holotype: overall length 58, overall width 61, endocyst length 51, endocyst width 56; Range: overall length 52 (58) 71, overall width 50 (58) 70, endocyst length 47 (52) 65, endocyst width 46 (52) 64. Number of specimens measured: 12." — Crouch et al. (2014, p. 65, 71)

Remarks: "*Vozzhennikovia tawanuiensis* sp. nov. is placed in the genus *Vozzhennikovia* Lentin and Williams, 1976, following discussion by Sluijs et al. (2009). They "retain *Vozzhennikovia* for peridiniacean dinocysts with an isodeltaform to isothetaform 2a, an archeopyle that can result from the loss of the 2a only

or all three intercalary plates and a more or less uniform covering of spines of coni on the cyst that may or may not reflect tabulation". *Vozzhennikovia tawanuiensis* sp. nov. differs from *Vozzhennikovia angulata* Wilson, 1988 in lacking a periphragm that is sharply angular in outline, in not having densely arranged processes, and in lacking an easily discernible paracingulum. It differs from *Vozzhennikovia rotunda* (Wilson, 1967) Lentin and Williams, 1976 in lacking development of an apical and left antapical horn, in having a less globular shape, and in lacking spinules in the paracingulum area. *Vozzhennikovia tawanuiensis* sp. nov. is distinguished from *Spinidinium densispinatum* Stanley, 1965 by lacking a distinct paracingulum, by having no evidence of sutural spines and by lacking a well-developed left antapical horn and apical horn. Some specimens of *Vozzhennikovia tawanuiensis* sp. nov. resemble rounded forms of *Apectodinium homomorphum* (Deflandre and Cookson, 1955) Lentin and Williams, 1977; however, the short rod-like capitate processes are distinctive for *V. tawanuiensis* sp. nov. and, furthermore, *A. homomorphum* has a more uniform distribution of processes and evidence of intratabular ornamentation."
— Crouch et al. (2014, p. 73)

Age: late Paleocene (Thanetian); holotype of Crouch et al. (2014, p. 71).

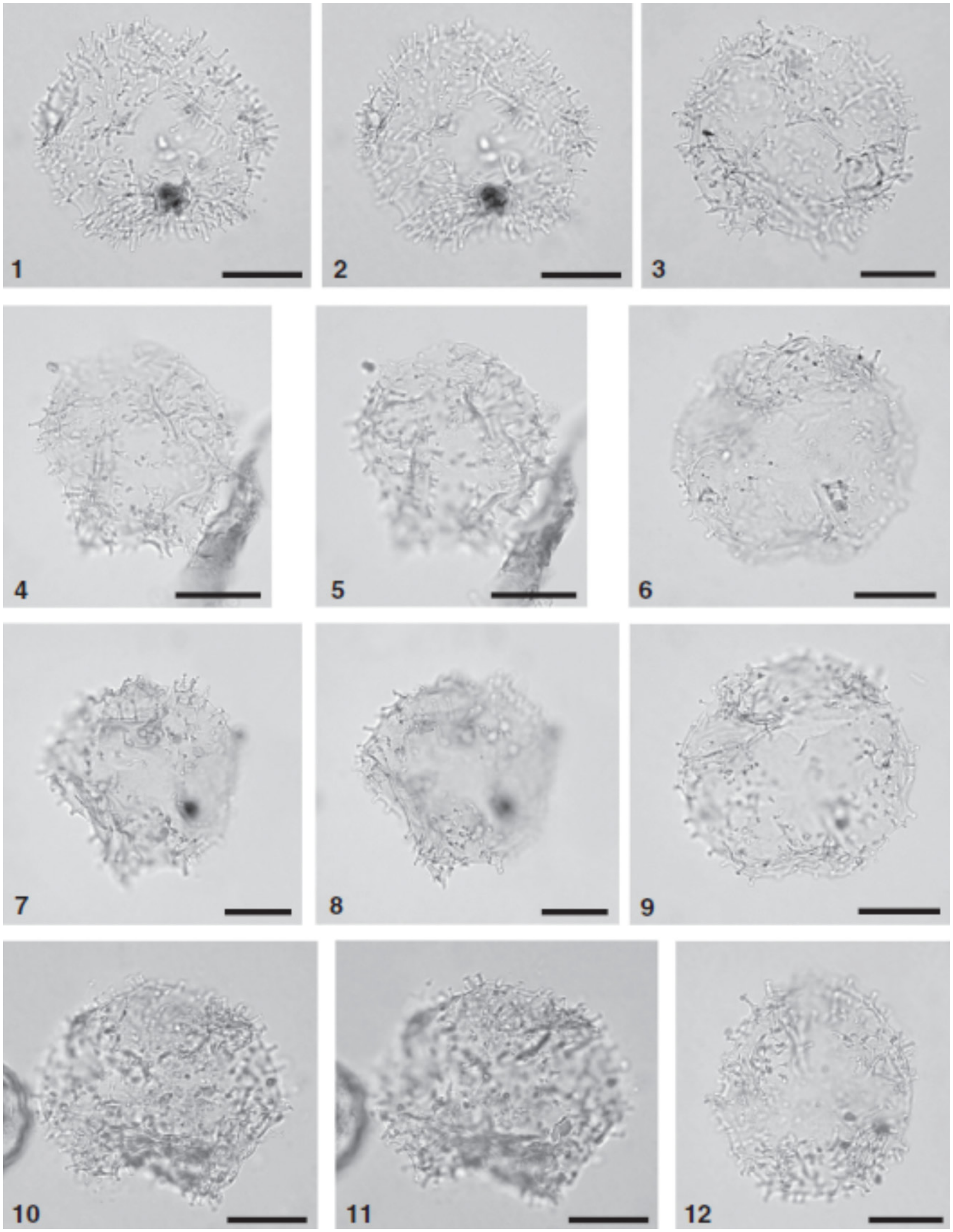


Plate 3, figures 1–12, Crouch et al. (2014). Sale bar = 20 μm.

Appendix A

Appendix A (provided as an Excel workbook) contains diagnostic tables, one for each genus treated herein, enabling the comparison of the following morphological features in each species:

- dimensions (µm),
- ambital shape,
- cavation,
- wall surface texture,
- horn development,
- archaeopyle type and geometry,
- cingulum,
- ventral sulcus,
- tabulation features and formulae,
- additional distinguishing characteristics.

Reported ages for the holotypes (when available) and source(s) of descriptions are also tabulated.

Tabulated entries may be paraphrased from the original source or based on what is evident from figured images.

Abbreviations used in the tables are as follows:

- L = periphragm length
- W = periphragm width
- Le = epitheca length
- Lh = hypotheca length
- Li = endophragm length
- Wi = endophragm width
- C = cingulum width
- Ap = apical horn length
- L_1 = left lateral horn
- L_2 = right lateral horn
- An_1 = left antapical horn length
- An_2 = right antapical horn length
- Ah = archaeopyle height
- Aw = archeopyle width
- Et = endophragm thickness
- Pt = periphragm thickness
- Op = periphragm projected ornamentation length
- Oe = endophragm projected ornamentation length
- * = holotype value

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