

RESTUDY OF SOME SMALLER DINOFLAGELLATE CYSTS FROM THE UPPER CRETACEOUS OF BELGIUM¹

by

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(10 figures and 2 plates)

RESUME.- Dans ce travail, sept types de kystes de petits dinoflagellés des silex du Crétacé Supérieur de Belgique sont réexaminés. Le genre nouveau *Rhiptocorys* est érigé pour des formes ayant un hypotract beaucoup plus grand que l'épitract, montrant un développement inégal de hautes crêtes et ayant un archéopyle épitractal ; la diagnose de son espèce-type, *Rhiptocorys veligera* (Deflandre), est amendée. La combinaison nouvelle *Druggidium fourmarierii* (Lejeune-Carpentier) est proposée ; la variété décrite antérieurement comme *Phanerodinium cayeuxi* Deflandre var. *laeve* Lejeune-Carpentier est élevée au rang spécifique sous l'appellation *Druggidium laeve* (Lejeune-Carpentier) *comb. nov.* Des diagnoses amendées sont proposées pour ces deux derniers taxons ainsi que pour *Dinogymnium avellana* (Lejeune-Carpentier). Des spécimens attribués par Lejeune-Carpentier (1951) à l'espèce *Phanerodinium cayeuxi* Deflandre sont réexaminés et l'un d'eux est redécrit sous l'appellation de ? *Phanerodinium* sp. Des photographies illustrent pour la première fois tous ces formes et des dessins interprétatifs, beaucoup exécutés sur les originaux du premier auteur, complètent le texte.

ABSTRACT.- An account is presented of the restudy of seven forms of small dinoflagellate cysts from Upper Cretaceous flints of Belgium. The new genus *Rhiptocorys* is erected for forms having a hypotract much larger than the epittract, showing an unequal development of high crests and having an epittractal archaeopyle ; the diagnosis for its type species, *Rhiptocorys veligera* (Deflandre), is emended. The new combination *Druggidium fourmarierii* (Lejeune-Carpentier) is proposed and a former variety elevated to specific status, as *Druggidium laeve* (Lejeune-Carpentier). Emended diagnoses are proposed for both these taxa and for *Dinogymnium avellana* (Lejeune-Carpentier). Forms attributed by Lejeune-Carpentier (1951) to *Phanerodinium cayeuxi* Deflandre are reconsidered and one is redescribed as ? *Phanerodinium* sp. Photographs of all these forms are presented for the first time and interpretative drawings, many redrawn from the first author's original figures, supplement the text.

In a earlier paper (Lejeune-Carpentier & Sarjeant, 1981), the results of a restudy of the type material of some larger dinoflagellate cysts and an acritarch from the Chalk flints of Belgium and Germany were presented. A brief resumé was given at that time of the early history of researches on fossil dinoflagellate cysts in Upper Cretaceous flint flakes ; this need not be repeated here. The present paper completes the publication of the results of our joint restudy, undertaken during the second author's visit to Liège in November, 1979.

The taxa here reconsidered were described originally by the first author, in Notes 11 and 13 of her series **L'étude microscopique des silex**. All share the common character of being unusually small for dinoflagellate cysts, their maximum cross-measurement

never exceeding 31 microns. Nowadays, palynologists normally would study cysts of such meagre dimensions using microscopes with X100 oil-immersion objectives ; however, the fact that these specimens are enclosed at varying depth in flints made this technique impossible. Under such circumstances, the precision of the observations made originally with low-power objectives may be considered truly remarkable ; our new observations

1 *Quinzième note de la série "L'étude microscopique des silex."* Manuscrit reçu le 15 janvier 1983.

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have furnished only a relatively few additional details. Nevertheless, changing views on the relative importance of morphological features in these cysts mean that major taxonomic revisions are necessary. The morphological terminology adopted follows the usages advocated by one of us (Sarjeant, 1982a).

To facilitate comparison with the earlier Notes, the original drawings are here presented anew, but modified or supplemented where necessary. The photographs - taken at low power since the microfossils were too deep in the flints for use of high-power objectives - have been enlarged considerably and, inevitably, are not as sharp as we would wish; nevertheless, we trust they will furnish a useful supplement to the drawings.

Class Dinophyceae Pascher

Order Peridiniales Schütt

Suborder Gonyaulacystineae Norris, 1978

Family GONYAULACYSTACEAE Sarjeant & Downie, 1966, *emend.* Sarjeant, 1982b

Genus *Druggidium* Habib, 1973

Remarks

This genus was included into the Family Gonyaulacystaceae by Norris (1978, p. 8) but was not among the genera listed as attributable to the family, following its emendation by one of us (Sarjeant, 1982b). In its small size and reduced epittract, it is indeed not typical of the family; however, it accords with the emended diagnosis in all other features and thus is reinstated with little hesitation.

Druggidium fourmarierii (Lejeune-Carpentier, 1951)
comb. nov., emend.

Pl. I : 1-2, Fig. 1-2.

1951 *Phanerodinium fourmarieri* Lejeune-Carpentier, p. B311, fig. 7.

1964 *Phanerodinium fourmarieri* Lej.-Carp. Downie & Sarjeant, p. 140.

1964 *Phanerodinium fourmarieri* Lej.-Carp. Eisenack & Klement, p. 687.

1966 *Phanerodinium fourmarieri* Lej.-Carp. Deflandre & Deflandre-Rigaud, fiche 3004.

1967 *Phanerodinium fourmarieri* Lej.-Carp. Sarjeant, tab. IV (p. 330).

1973 *Phanerodinium fourmarieri* Lej.-Carp. Lentin & Williams, p. 112.

1974 *Phanerodinium fourmarieri* Lej.-Carp. Foucher, p. 33.

1975 *Phanerodinium fourmarieri* Lej.-Carp. Harker & Sarjeant, chart. 9.

1977 *Phanerodinium fourmarieri* Lej.-Carp. Lentin & Williams, p. 129.

1977 *Phanerodinium fourmarieri* Lej.-Carp. Foucher & Robaszynski, p. 9.

1978 *Phanerodinium fourmarieri* Lej.-Carp. Stover & Evitt, p. 236.

1981 *Phanerodinium fourmarieri* Lej.-Carp. Lentin & Williams, p. 223.

Emended diagnosis

Cyst ovoidal to rounded-subpolygonal, of small relative size. Epittract roughly hemispheroidal, somewhat smaller than the hypottract; hypottract almost quadrate. Crests high and strong, vaginate to scalloped or phractate, higher on the hypottract (especially about the antapex) than on the epittract. Paratabulation 1 pr, 4', 1a, 6'', ?6c, 6' ', ?1p, 1' ', ?3s. Paraplate 2'' is reduced in size, as a result of the presence of the asymmetrically situated anterior intercalary paraplate. Cingulum of moderate breadth; sulcus relatively broad. Surface of phragma granulate. Archaeopyle precingular (type 2P), formed by the loss of paraplates 2'' and 3''.

Holotype

Specimen XIX-8, lodged in the collections of the Laboratoire de Paléontologie, Université de Liège, Belgium; figured by Lejeune-Carpentier, 1951, fig. 7 and herein, Pl. I : 1, text-fig. 1.

Paratype (here designated)

Specimen XIX-18, same lodgement; figured herein, Pl. I : 2, text-fig. 2.

Type Horizon and Locality

Flint from Gulpen Formation (now Craie de Zeven Wegen, Upper Cretaceous: Senonian), Hallem-baye, Belgium. (Details of other occurrences are given by Lejeune-Carpentier, 1951, p. B311).

Description

The holotype is presented with dorsal surface

uppermost, the two-paraplate archaeopyle being well displayed (Fig. 1). The unusual situation of the anterior intercalary paraplate and the consequently meagre dimensions of paraplate 2'' are well shown. In part because of the dark colour of this specimen, the details of the ventral surface could not be determined with sufficient precision for full illustration.

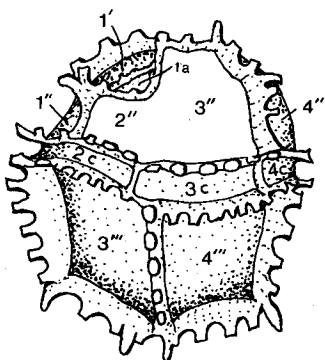


Figure 1

Druggidium fourmarierii (Lejeune-Carpentier, 1951) comb. nov., emend. The holotype, in slightly oblique dorsal view. X c. 2000.

Further morphological details of the structure of the epittract are furnished by the paratype, which is in exactly apical view (Fig. 2). The anterior intercalary paraplate and the distinctive form of the archaeopyle may again be seen, the number and situation of the apical paraplates determined and the presence of a tiny preapical paraplate at the exact apex noted. In this case, it is the antapical surface that is obscured from view, by the deep colour of the specimen and because of its depth in the enclosing flint.

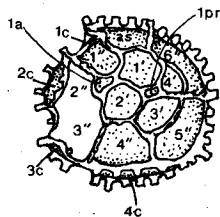


Figure 2

Druggidium fourmarierii (Lejeune-Carpentier, 1951) comb. nov., emend. The paratype, in apical view. X c. 1250.

Although the other specimens reported originally by the first author were also examined, none afforded a satisfactory picture of the ventral surface. The following features, however, may be noted :

- (1) The sulcus is quite broad and is certainly subdivided into one anterior, at least one median, and one posterior paraplate.
- (2) The cingulum forms a laevorotatory spiral, its two ends differing in antero-posterior position by at least half its breadth.
- (3) The antapical paraplate is unusually large.
- (4) Presence of a posterior intercalary paraplate is presumed but could not be confirmed.

Dimensions

Holotype : overall length 21.5 μm , overall breadth 19.5 μm . Paratype : overall diameter c. 18 μm . Range of dimensions : length 20 to 24 μm , breadth 18 to 22 μm .

Remarks

Although the epittract is less pronouncedly smaller than the hypottract than in other species of *Druggidium*, the general comparability of its paratabulation and the nature of its archaeopyle, we consider, fully justify our reassignment of this species to that genus. It is recognized, however, that the taxonomic position may have to be reassessed when the ventral paratabulation of *D. fourmarieri* becomes more fully known.

Druggidium cf. *fourmarierii* (Lejeune-Carpentier, 1951) emend. Lejeune-Carpentier & Sarjeant, herein
Pl. 1 : 6

1951 *Phanerodinium* cf. *fourmarieri* Lej.-Carp. Lejeune-Carpentier, p. B313, fig. 8.

1966 *Phanerodinium* cf. *fourmarieri* Lej.-Carp. Deflandre & Deflandre-Rigaud, fiche 3005.

Remarks

This specimen is presented in oblique lateral view. It has a more elongate-ovoidal ambitus than typical *D. fourmarierii*. Its crests are machicolate rather than vaginate, and much lower ; the form of its archaeopyle (situated at upper left in the photograph) could not be perceived. Almost certainly it represents a species of *Druggidium* hitherto undescribed ; but the morphology of this specimen is too uncertain for it to be made the type for a new taxon.

Druggidium laeve (Lejeune-Carpentier, 1951)

stat. et comb. nov., emend.

Pl. I : 4-5 ; Fig. 3

- 1951 *Phanerodinium cayeuxi* Deflandre var. *laeve* Lejeune-Carpentier, p. B310-B311, fig. 6.
- 1964 *Phanerodinium cayeuxi* Defl. var. *laeve* Lej.-Carp. Downie & Sarjeant, p. 140.
- 1966 *Phanerodinium cayeuxi* Defl. var. *laeve* Lej.-Carp. Deflandre & Deflandre-Rigaud, fiche 3003.
- 1973 *Phanerodinium cayeuxi* Defl. subsp. *laeve* (Lej.-Carp.) Lentin & Williams, p. 112.
- 1975 *Phanerodinium cayeuxi* Defl. var. *laeve* Lej.-Carp. Harker & Sarjeant, chart 9.
- 1977 *Phanerodinium cayeuxi* Defl. subsp. *laeve* (Lej.-Carp.) Lentin & Williams, p. 129.
- 1981 *Phanerodinium cayeuxi* Defl. subsp. *laeve* (Lej.-Carp.) Lentin & Williams, p. 223.

Emended diagnosis

Cyst broadly ellipsoidal to elongate-subpolygonal, of small relative size. Epitract markedly smaller than hypotract, roughly hemispheroidal in shape. Hypotract hemiovoidal to hemiellipsoidal, its posterior end having almost the form of a truncated cone. Crests low, entire, but forming rounded-triangular prominences at most points of intersection. Paratabulation ?0pr, ?4', 6'', 6-?7c, 6''', 1p, 1''', ?s. The posterior ventral paraplate is unusually large ; the antapical plate is tilted toward the dorsal surface. Cingulum very broad and only weakly helical ; sulcus of moderate breadth. Surface of phragma laevigate to minutely granulate. Archaeopyle not observed.

Holotype

Specimen CXII-17, lodged in the collections of the Laboratoire de Micropaléontologie, Université de Liège, Belgium ; figured by Lejeune-Carpentier, 1951, fig. 6 and herein, Pl. I : 4-5 ; Fig. 3.

Type Horizon and Locality

Flint from Craie de Spiennes (Upper Cretaceous ; Senonian), quarry of Mortiau, Cuesmes (Hainaut), Belgium.

Description

The holotype is presented with left lateral surface uppermost ; it is a specimen whose archaeopyle apparently did not open. The lower (right lateral) surface

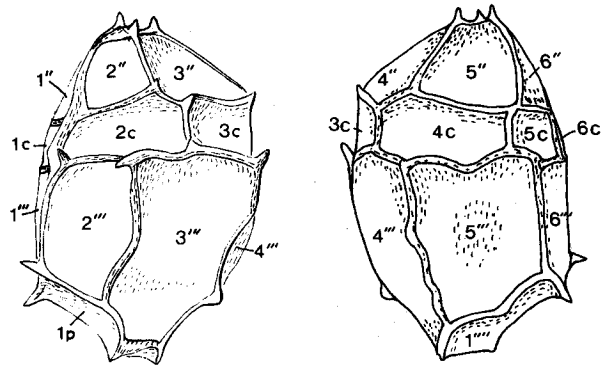


Figure 3

Druggidium laeve (Lejeune-Carpentier, 1951), stat. et comb. nov., emend. The holotype. Left : in left lateral view. Right : in right lateral view. X c. 1650.

was not elucidated in the earlier description (Lejeune-Carpentier, 1951), but modern microscopic equipment enables its character to be perceived also (Fig. 3). Most features of the paratabulation thus can be elucidated with confidence, save for the features of the exact apex and the ventral surface.

Noteworthy features are (1) the low, solid, entire crests, extending upwards at their points of junction to form triangular projections ; (2) the nature of the posterior paratabulation, as noted in the emended diagnosis ; (3) the very broad cingulum, swelling outward between, and narrowing at, the positions of sutures between the cingular paraplates ; and (4) the small relative size of the epitract.

Dimensions

Holotype (unique) : overall length 28 μm , overall breadth c. 16 μm .

Remarks

Though the nature of its archaeopyle remains to be determined, this species corresponds so completely in all its other features with the genus *Druggidium* that its reassignment is proposed with confidence. Among existing species, the most similar is *Druggidium apico-paucicum* (Habib, 1973) ; however, the crests of the latter species are even lower and lack prolongations in gonal position, while the disproportion between epitract and hypotract is even more marked and the antapex more rounded.

Only one specimen was available to us for examin-

ation. For fuller information on the nature of the apical and ventral paratabulation and the nature of the archaeopyle, we must await the discovery of an ampler material.

Family CTENIDODINIACEAE Sarjeant & Downie,
1966, *emend.* Norris, 1978

Genus *Rhiptocorys* nov.

Derivation of Name

Gr., *rhipto*, throw ; *korys*, helmet : with reference to the throwing-off of the small epittract.

Diagnosis

Proximate to proximochorate cysts, typically of small size. Cyst spheroidal to ovoidal or subpolygonal, with epittract markedly smaller than hypottract. Paratabulation : ?', ?5-6", 6c, 6"', 1p, 1"'. Epittractal paraplates marked feebly by lines or low ridges, or not at all ; hypottractal paraplates demarcated by high crests which may be suturocavate. Cingulum either represented by a single suturocavate structure on its anterior margin or bounded by variably developed crests on both sides. Sulcus of variable breadth, often discernible only on the hypottract. Ornamentation of phragma also variable. Archaeopyle epittractal, formed either by the loss of a single operculum or by progressive loss of opercular pieces.

Type species

Rhiptocorys veligera (Deflandre, 1937b *emend.* Lejeune-Carpentier, 1943) Lejeune-Carpentier & Sarjeant, *comb. nov., herein.* Upper Cretaceous (Senonian), France.

Remarks

This new genus differs from *Ctenidodinium* Deflandre, 1938, *emend.* Sarjeant, 1975 in its unequal development of epittract and hypottract and the lack of crests on the epittract. It differs from *Energlynia* Sarjeant, 1976, and *Wanaea* Cookson & Eisenack, 1958, *emend.* Fensome, 1981 in its hypottractal crests and lack of an antapical horn, and from *Actinotheca* Cookson & Eisenack, 1961, in having parasutural crests on the hypottract and in lacking gonol processes.

Rhiptocorys veligera
(Deflandre, 1937b *emend.* Lejeune-Carpentier, 1943),
comb. nov., emend.
Pl. II : 2-7 ; Fig. 4-8

1937b *Micrhystridium veligerum* Deflandre, p. 81,
Pl. 12 : 9.

1943 *Ceratocorys veligera* (Defl.) *emend.* Lejeune-Carpentier, p. B24-B25, fig. 1-6.

1952a *Ceratocorys veligera* (Defl.) Deflandre, p. 120,
Fig. 102.

1952b *Ceratocorys veligera* (Defl.) Deflandre, Fig.
304 A-E.

1964 *Ceratocorys veligera* (Defl.) Downie & Sarjeant, p. 102.

1967 *Eisenackia crassitabulata* Defl. & Cooks. Clarke & Verdier, p. 64, Pl. 8 : 4-6.

1967 *Microdinium veligerum* (Defl.) Sarjeant, tab. III
(p. 329), *nomen nudum.*

1969 *Microdinium veligerum* (Defl.) Davey, p. 136,
Pl. 3 : 6 ; Pl. 4 : 4.

1973 *Microdinium veligerum* (Defl.) Lentini & Williams, p. 96.

1975 *Microdinium veligerum* (Defl.) Harker & Sarjeant, chart 7 (p. 240).

1977 *Microdinium veligerum* (Defl.) Lentini & Williams, p. 108.

1978 "*Microdinium*" *veligerum* (Defl.) Stover & Evitt, p. 66.

1979 *Microdinium veligerum* (Defl.) Barss, Bujak & Williams, p. 78.

1981 *Microdinium veligerum* (Defl.) Lentini & Williams, p. 188.

non
1971 ?*Ceratocorys veligera* (Defl.) Wilson, Pl. 4 : 19.

non
1979 *Microdinium veligerum* (Defl.) *sensu* Wilson.
Barss, Bujak & Williams, p. 78.

Emended diagnosis

Cyst spheroidal, with hypottract almost twice as large as epittract. Proximochorate, with high suturocavate crests (c. one-quarter of the cyst diameter) bounding the paraplates of the hypottract. The cingulum is marked by a single suturocavate structure on its anterior margin and by low ridges, or not at all, on its posterior margin. Epittractal paraplates feebly marked by low ridges or not demarcated at all. Sulcus extending from posterior end of epittract to the antapex, fairly narrow but widening somewhat in its posterior portion. Paratabulation : ?', ?5", 6c, 6"', 1p, 1"'. Posterior intercalary paraplate (1p) relatively large. Phragma scabrate to granulate overall ; some paraplates show

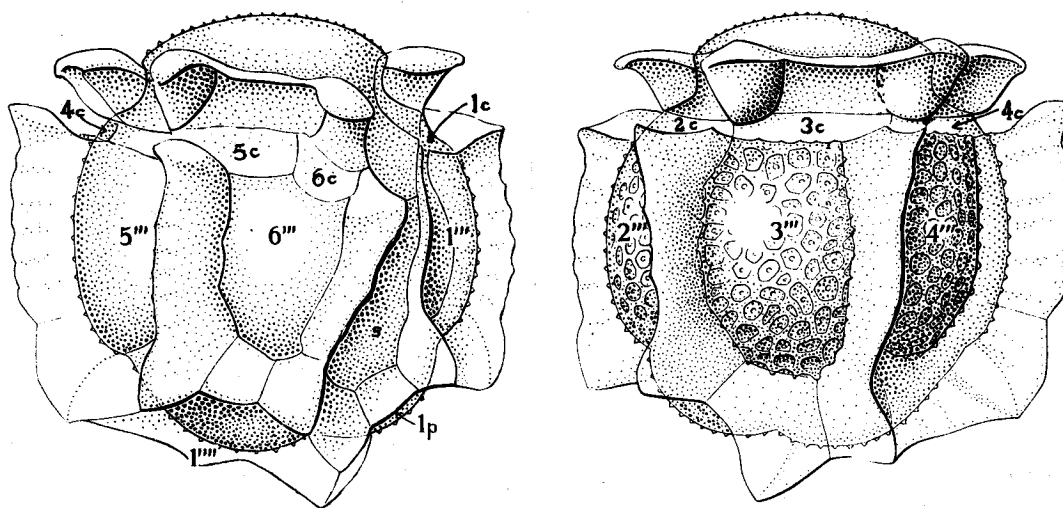


Figure 4

Rhiptocorys veligera (Deflandre, 1937b, emend. Lejeune-Carpentier, 1943) comb. nov., emend. Specimen CXII-170. Left : in oblique right lateral view. Right : in oblique left lateral view. X c. 2000.

a variable development of areolae, each areola typically having a pustule at its centre. Archaeopyle epitracial ; operculum either thrown off as a unit or formed by the partial or complete loss of a series of opercular pieces.

Holotype

Specimen A535, flint S, Deflandre Collection, lodged in the Ecole Pratique des Hautes Etudes, Paris, France ; illustrated by Deflandre, 1937, Pl. 12 : 9.

Figured Specimens

Specimens CXII-170 (figured by Lejeune-Carpentier, 1943, figs. 1-2 and *herein*, text-fig. 4), CXII-173 (figured by Lejeune-Carpentier, 1943, fig. 3 and *herein*, text-fig. 6), CXIII-133 (figured by Lejeune-Carpentier, 1943, fig. 4 and *herein*, text-fig. 5), CXII-419 (figured by Lejeune-Carpentier, 1943, fig. 5, and *herein*, Pl. 2 : 2-4, text-fig. 7) and CXII-291 (figured by Lejeune-Carpentier, 1943, fig. 6, and *herein*, text-fig. 8).

Type Horizon and Locality

Flint, collected in Paris, France (probably from a path in the Jardin des Plantes) : Upper Cretaceous (?Senonian).

Horizons and Localities of Figured Specimens

Flints, Craie de Spiennes (Upper Cretaceous : Senonian), Mortiau quarry, Cuesmes (Hainaut), Belgium.

Description

The epitract is low-arched, having the form of a longitudinal hemiellipsoid ; the hypotract, in contrast, is much larger and has the form of two-thirds of a spheroid. The cingulum between is always visible but is variably marked. In some specimens (for example specimen CXII-170 ; fig. 4) there is a high suturocavate crest on its anterior margin, surrounding the epitract, and only a low ridge on the posterior margin, while in others (e.g. CXII-419 ; fig. 7) the posterior margin is scarcely perceptible at all. In contrast, yet other specimens (e.g. CXIII-133 ; fig. 5) have a crest on the posterior margin that is quite well marked, albeit lower and less inflated than the anterior cingular crest. Though the divisions between them are not always well marked, six cingular paraplates may be distinguished, of which the sixth is less longitudinally elongate than the others.

The paraplates of the epitract are so very poorly marked in the specimens examined that our remarks concerning them must be in the highest degree tentative. On some specimens (e.g. CXII-173 ; fig. 6) the entire epitract has been lost in archaeopyle formation ; in others (e.g. CXII-170 ; fig. 4) it is present but shows no indication of any separation into paraplates. However, in a few favourable specimens (e.g. CXII-419 ; Pl. II : 3 ; Fig. 7), the paraplates of the epitract, though they have begun to separate into opercular pieces, are still attached. The apical paraplate or paraplates - the latter seems more likely, though we could not be confi-

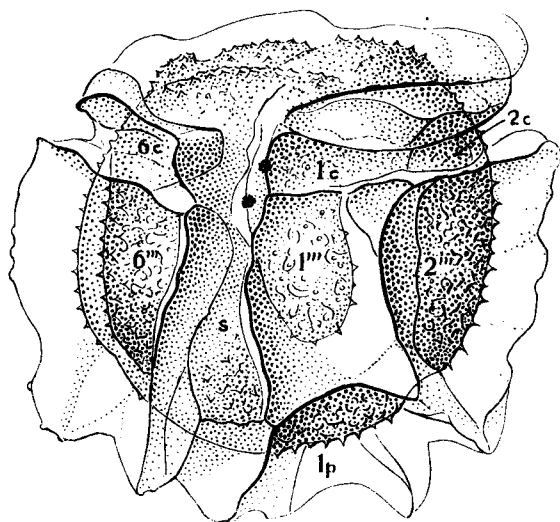


Figure 5

Rhiptocorys veligera (Deflandre, 1937b, emend. Lajeune-Carpentier, 1943) comb. nov., emend. Specimen CXIII-133, in slightly oblique ventral view. X c. 2200.

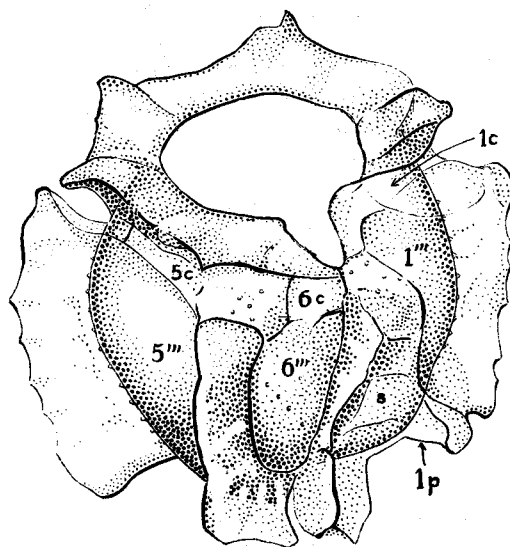


Figure 6

Rhiptocorys veligera (Deflandre, 1937b, emend. Lajeune-Carpentier, 1943) comb. nov., emend. Specimen CXII-173 in oblique anterior ventral view, showing the epittractal archaeopyle. X c. 2200.

dent - appear to be thrown off as a single opercular piece, the precingular paraplates as separate opercular pieces. Four precingular paraplates were distinguished with confidence (Fig. 7) but their total number probably is five or possibly six.

The paratabulation of the hypotract is, in contrast, readily determinable because of the high, suturocavate crests that bound them. Six postcingular paraplates are developed; paraplate 1''' is smallest and separated from the antapex by a large, subquadrate posterior intercalary paraplate (fig. 7 and 8); paraplate 6''' is somewhat narrower than the remaining postcingulars, which are of closely similar size. The antapical paraplate is moderately large and of rounded-hexagonal outline (Fig. 8).

The suturocavate crests have entire to undulate or scalloped distal edges.

The surficial ornament is highly variable, not only between specimens but even on individual cysts (see in particular Figs 5 and 7). There is an overall cover of granules, sometimes fine to medium, sometimes coarse and becoming enlarged, on parts or the whole of some paraplates, into scabrae, even (rarely) into tubercles or echinae (Fig. 5). Many specimens exhibit, on some but never (in the material seen) on

all paraplates, a pattern of areolae, usually of rather regular shape and typically centred on a papilla (Pl. 2: 4-5 and Figs 4, 6). Other specimens, however, lack this ornament entirely (e.g. CXII-291; Fig. 8). The cysts vary in colour from amber to mid-brown.

Dimensions

Holotype: overall diameter 25 μm , diameter of central body 18 μm . Figured specimens: overall diameter 27 to 31 μm , diameter of central body 21-26 μm .

Remarks

The holotype was examined briefly by the second author during a visit to Paris in 1980, through the courtesy of Mme. Marthe Deflandre-Rigaud, and seen to be a specimen in oblique lateral view, corresponding in all essential particulars with those from Belgium.

When Davey described specimens of this species from the Cenomanian of England (1969), he perceived most major features of its morphology. However, in the forms he observed, the epittractal archaeopyle appears not to have been fully developed: one of the specimens he illustrated lacks the apical paraplate(s) but retains the precingulars, though they appear to be separated by sutures and to have flapped open (*ibid.*,

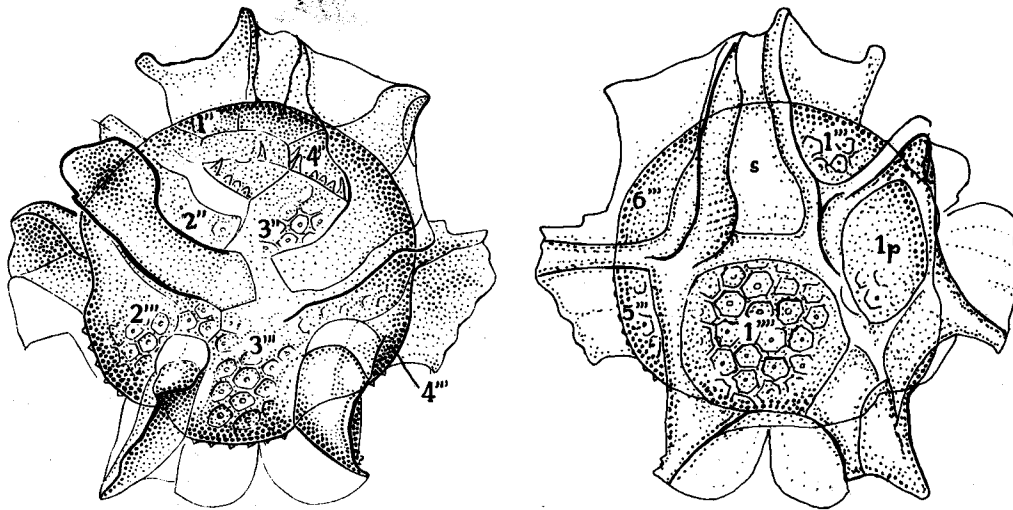


Figure 7

Rhiptocorys veligera (Deflandre, 1937b, emend. Lejeune-Carpentier, 1943) comb. nov., emend. Specimen CXII-419. Left : in anterior ventral view, showing partial separation of the opercular pieces. Right : in posterior dorsal view. X c. 2200.

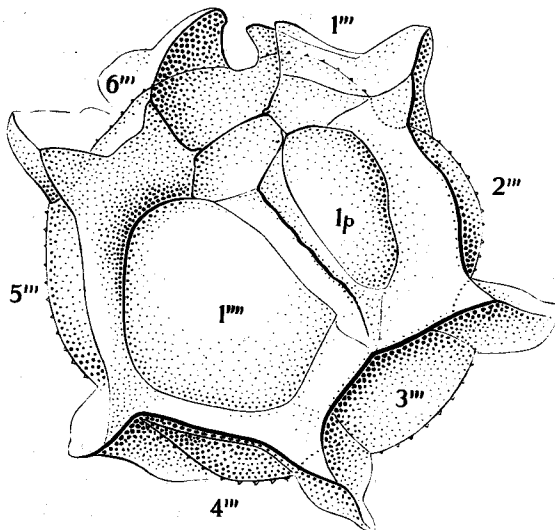


Figure 8

Rhiptocorys veligera (Deflandre, 1937b, emend. Lejeune-Carpentier, 1943) comb. nov., emend. Specimen CXII-291, in antapical view. X c. 2200.

Pl. 4 : 4). Under these circumstances, his attribution of the species to *Microdinium* becomes perfectly comprehensible. The second specimen he illustrated shows the antapical paratabulation especially well (*ibid.*, Pl. 3 : 4). The only other acceptable record of this species - though no illustration is furnished - is from an offshore borehole on the Grand Banks off Newfoundland, eastern Canada (Barss *et al.*, 1979), in sediments to which a Maastrichtian date was assigned. The known

range of *Rhiptocorys veligera* is thus Upper Cretaceous (Cenomanian-Maastrichtian).

The specimen illustrated by Wilson (1971), from the Maastrichtian of Denmark, certainly is not attributable to this species, having too markedly ovoidal an ambitus and too large an epitract ; and the forms from a borehole on the Grand Banks, offshore eastern Canada, compared by Barss *et al.* (1979) to Wilson's form must be presumed likewise to be of different taxonomic affinity.

Family Uncertain

Genus *Phanerodinium* Deflandre, 1937a

Phanerodinium cayeuxii

(Deflandre, 1935b) Deflandre, 1937a

Pl. II : 1

- 1934 *Palaeoperidinium cayeuxi* Deflandre, p. 967, Fig. 5, *nomen nudum*.
- 1935a *Palaeoperidinium cayeuxi* Deflandre, p. 118, Fig. 5, *nomen nudum*.
- 1935b *Palaeoperidinium cayeuxi* Deflandre, p. 229, Pl. 6 : 2-3.
- 1936a *Palaeoperidinium cayeuxi* Deflandre, p. 57-58, Fig. 98.
- 1936b *Palaeoperidinium cayeuxi* Deflandre, p. 171-172, Pl. 6 : 8-15 ; Pl. 7 : 8.

- 1937a *Phanerodinium cayeuxi* (Defl.) Deflandre, p. 110-111, Fig. 1-4.
- 1951 *Phanerodinium cayeuxi* (Defl.) *pars.* Lejeune-Carpentier, p. B310, fig. 4.
- 1952a *Phanerodinium cayeuxi* (Defl.) Deflandre, Fig. 84.
- 1964 *Phanerodinium cayeuxi* (Defl.) Eisenack & Klement, p. 685-686.
- 1964 *Phanerodinium cayeuxi* (Defl.) Downie & Sarjeant, p. 140.
- 1966 *Phanerodinium cayeuxi* (Defl.) Deflandre & Deflandre-Rigaud, fiches 3002-3003.
- 1967 *Phanerodinium cayeuxi* (Defl.) Sarjeant, tab. IV (p. 330).
- 1971 *Phanerodinium cayeuxi* (Defl.) Foucher, p. 108, Pl. 10 : 13-18.
- 1973 *Phanerodinium cayeuxi* (Defl.) Lentin & Williams, p. 112.
- 1974 *Phanerodinium cayeuxi* (Defl.) Foucher, p. 142.
- 1975 *Phanerodinium cayeuxi* (Defl.) Harker & Sarjeant, chart 9 (p. 242).
- 1977 *Phanerodinium cayeuxi* (Defl.) Foucher & Robaszynski, p. 9.
- 1977 *Phanerodinium cayeuxi* (Defl.) Lentin & Williams, p. 129. p. 129.
- 1978 *Phanerodinium cayeuxi* (Defl.) Stover & Evitt, p. 236.
- 1981 *Phanerodinium cayeuxi* (Defl.) Lentin & Williams, p. 223.

Remarks

Through the courtesy of Mme. Deflandre-Rigaud, the second author was permitted to examine the type material during his visit to the Ecole Pratique des Hautes Etudes, Paris, in 1982. Unfortunately the holotype could not be located ; however, two paratypes (AJ76 and AF43) were examined. The asymmetry of the two parts of the cyst is striking, the epitract being very much smaller than the hypotract (in Deflandre's illustrations, the orientation consistently is inverted). In both specimens, an apical archaeopyle appeared to be developed. Since a fuller study of this genus, along with the other genera of the *Microdinium* group, currently is being prepared for publication by David K. Goodman, William R. Evitt and Lewis E. Stover, no taxonomic revisions are attempted here.

Of the specimens attributed to this species by

the first author in 1951, several show the same angularity of the hypotract that is so conspicuous a feature of the type material. One of these (specimen CXII-159), originally figured by Lejeune-Carpentier (1951, fig. 6) is here reillustrated (Pl. II : 1). It differs in being shorter and squarer in shape than the type specimens, but may well fall within the range of variation of *Ph. cayeuxii*. Because of its orientation - it is in exactly lateral view - and its depth of burial in the flint, a full interpretation of its morphology was not feasible and no new interpretation is presented here. The second specimen illustrated in 1951 (Lejeune-Carpentier, *ibid.*, fig. 5) is no longer considered attributable to this species and is redescribed below.

?*Phanerodinium* sp.

Pl. I : 7-9 ; Fig. 9

1951 *Phanerodinium cayeuxi* Defl. (*pars.*) Lejeune-Carpentier, p. B310, Fig. 5.

Description

This single specimen has a broadly ovoidal cyst, with the apex lost in archaeopyle formation. A very broad, only slightly laevorotatory cingulum divides a small, low-arched epitract from a much larger, hemiovoidal hypotract. The paraplates are differentiated in variable fashion : (a) on the epitract, by low crests with entire or undulate to scalloped distal edges ; (b) in the cingulum, by low crests with, or without, a bridge-like structure immediately above them ; and (c) on the hypotract, by low crests, scalloped to machicolate distally, which break up in places into lines of longitudinally-elongate verrucae. In addition, a sparse scatter of isolated verrucae is present on the principal paraplates of the hypotract. Elsewhere the surface of the phragma is laevigate to minutely granular.

Unfortunately the specimen is in oblique lateral view, with the ventral surface seen at an angle, and its shape is that of a deflated football, with the left lateral surface curving inward. Moreover, the specimen is at moderate depth in the flint. The drawing originally published (Lejeune-Carpentier, 1951, Fig. 5) showed the lower (right lateral) surface by transparency ; and indeed, that surface is more readily interpreted than the upper surface. The reconstruction here presented (Fig. 9) thus must be regarded as a possible interpretation, rather than a direct rendition, of the paratabulation. The notes which follow are in order of decreasing confidence :

- i. Six postcingular paraplates are present, the

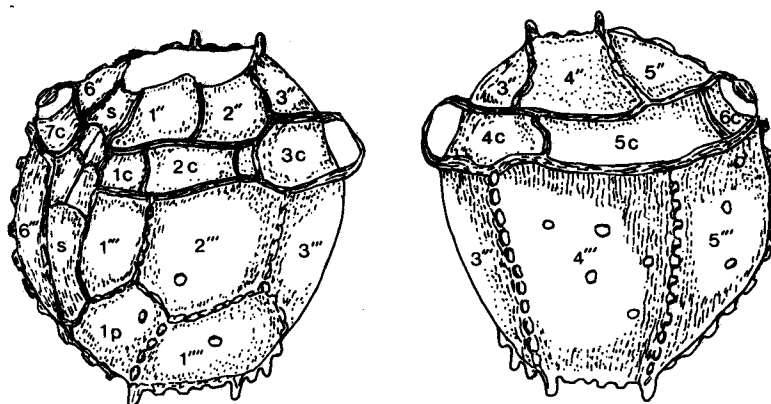


Figure 9

?*Phanerodinium* sp. Specimen Xa-9. Left : in oblique left lateral view. Right : in oblique right lateral view. (See text discussion concerning the reconstruction of the paratabulation). X c. 2200.

first and second reduced in size to accommodate a large posterior intercalary paraplate. The latter is only slightly smaller, and somewhat more elongate, than the antapical paraplate.

ii. The cingulum is divided into at least five paraplates, of which paraplates 2c to 5c in Fig. 9 are relatively clearly defined, paraplates 1c, 6c and 7c much less clear. Nevertheless, it is our belief that at least six cingular paraplates are present.

iii. The ventral and left lateral surfaces of the epitract presented such extreme difficulties in interpretation that our interpretation of their paratabulation and even of the outline of the archaeopyle, is speculative only.

iv. Though the sulcus can be seen clearly and is evidently subdivided into paraplates, the pattern of those paraplates could not be established. Our drawing suggests a possible interpretation but certainly must be wrong in detail.

Figured Specimen

Specimen Xa-9, lodged in the collections of the Laboratoire de Paléontologie, Université de Liège, Belgium ; figured by Lejeune-Carpentier, 1951, Fig. 5, and *herein*, Pl. I : 7-9 ; Fig. 9.

Horizon and Locality

Flint from Craie de Spiennes (Upper Cretaceous : Senonian), Mortiau quarry, Cuesmes, Belgium.

Dimensions

Overall length c. 23 μ m, overall breadth 22 μ m.

Remarks

This specimen presented extreme problems of interpretation. If the paratabulation outlined in fig. 9 is approximately correct, then it belongs with the group of small genera that includes *Microdinium*, *Histiocysta* and *Cladopyxidium*, appearing indeed most closely comparable with the last genus. As noted above, the exact paratabulation of *Phanerodinium* remains to be ascertained ; but this form lacks the angularity of the hypotract that typifies *Ph. cayeuxi*, the type (and, at present, only) species. Its retention in the genus *Phanerodinium* thus must be viewed only as an interim procedure, pending the discovery of further specimens capable of a more confident interpretation.

Order Gymnodiniales Lemmerman

Family DINOGYMNIACEAE Sarjeant & Downie, 1974

Genus *Dinogymnium* Evitt, Clarke & Verdier, 1967

Dinogymnium avellana (Lejeune-Carpentier, 1951),
Evitt, Clarke & Verdier 1967, *emend. nov.*

Pl. I : 3 ; Fig. 10

1951 *Gymnodinium*(?) *avellana* Lejeune-Carpentier, p. B309, Fig. 3.

1964 *Gymnodinium*(?) *avellana* Lej.-Carp. Eisenack & Klement, p. 419.

1964 ?*Gymnodinium avellana* Lej.-Carp. Deflandre & Deflandre-Rigaud, fiche 2913.

1967 *Gymnodinium avellana* Lej.-Carp. Sarjeant, tab. IV (p. 330).

- 1967 *Dinogymnium avellana* [sic] (Lej.-Carp.) Evitt, Clarke & Verdier, pp. 16-17.
- 1973 *Dinogymnium avellanum* [sic] (Lej.-Carp.) Lentin & Williams, p. 48.
- 1975 *Dinogymnium* (*Gymnodinium*) *avellana* (Lej.-Carp.) Harker & Sarjeant, chart 9 (p. 242).
- 1977 *Dinogymnium avellana* (Lej.-Carp.) Lentin & Williams, p. 50.
- 1978 *Dinogymnium avellanum* [sic] (Lej.-Carp.) Stover & Evitt, p. 38.
- 1981 *Dinogymnium avellanum* [sic] (Lej.-Carp.) Lentin & Williams, p. 84.

Emended Diagnosis

Cyst ovoidal, with epitract and hypotract of equal size, having convex flanks. Phragma penetrated by close-set wall canals. Cingulum prominent and nearly equatorial, narrow, moderately deeply impressed and bordered by two ridges, that on its anterior side being more prominent than that on its posterior side. The cingulum forms only a weak laevorotatory spiral, its two ends differing in antero-posterior position by less than the cingulum's breadth. Sulcus feebly marked on the epitract, more clearly marked on the hypotract and most deeply impressed in its central portion, where there is a deep hollow bordered by slight ridges within the sulcus on both its anterior and posterior sides; flagellar marks may be present within this hollow. Numerous longitudinal folds (some 40 in number) extend outward from the cingulum, becoming less prominent or fading out entirely close to the poles. These folds are not uniform, some being more strongly developed than others. Apex and antapex rounded.

Holotype

Specimen XVI-45, lodged in the collections of the Laboratoire de Paléontologie, Université de Liège, Belgium; figured by Lejeune-Carpentier, 1951, Fig. 3, and *herein*, Pl. 1 : 3, Fig. 10.

Horizon and Locality

Flint from Gulpen Formation (Upper Cretaceous : Maastrichtian) Loën (Limburg), Belgium.

Description

As noted by Evitt *et al.* (1967, p. 17), the holotype is obliquely oriented and, in their terminology, "inflated". Wall-canals certainly are present; but we could not determine whether, in addition, any

surface granulation was developed. The holot

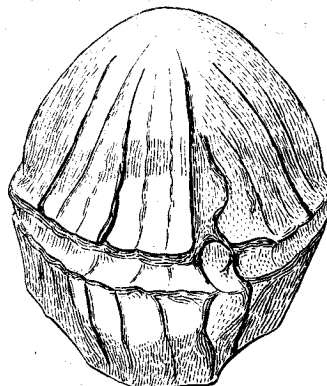


Figure 10

Dinogymnium avellana (Lejeune-Carpentier, 1951), Evitt *et al.*, 1967, emend. The holotype, in anterior ventral view. X c. 2200.

surface granulation was developed. The holotype affords faint suggestion that an apical archaeopyle has begun to develop, but of this we could not be confident.

Dimensions

Holotype (unique) : length (in oblique position) 23 μm , breadth 18 μm .

Remarks

Evitt *et al.* (1967, p. 17) suggested that this species, represented as it then was by only a single specimen, might fall within the range of variation of *Dinogymnium heterocostatum* (Deflandre, 1936b) Evitt *et al.*, 1967. However, we cannot accept this conclusion. The smoothly convex ambitus of both epitract and hypotract in *D. avellana*; their similarity in shape, with both poles smoothly convex; the more numerous and less well marked longitudinal ridges; and the lack of the very short secondary ridges all afford differentiating characters.

D. avellana is, in many features, more closely comparable with *D. acuminatum* Evitt *et al.*, 1967, resembling that species in the nature and density of its ribbing; however, it differs in ambitus, in having a narrower cingulum bordered by less prominent ridges, and in having rounded poles. Nevertheless, it should be stressed that the range of variation of *D. avellana* remains to be determined.

The forms described from Gabon by Boltenhagen (1977) resemble *G. avellana* in most particulars -

and demonstrate the existence elsewhere of rotund forms! However, their cingulum is markedly broader and their longitudinal ribs are even less prominent.

A note on orthography: "avellana" (Gr., hazelnut) is a noun in apposition and thus should retain an unmodified ending. The variant spelling "avellanium", used by Stover & Evitt (1978) and Lentini & Williams (1973, 1981), thus is incorrect.

ACKNOWLEDGEMENTS

The visits of the second author to Europe were made possible by funds available under National Research Council of Canada Operating Grant A8393. Both authors are deeply indebted to Dr. Michel Vanguetaine (Université de Liège) for many courtesies, in particular for his assistance in microphotography and in furnishing the French translation of the abstract, and to Dr. Maurice Strel for permitting use of the facilities of the Laboratoire de Paléontologie, Université de Liège. The second author is indebted also to Mme. Marthe Deflandre-Rigaud, for her courteous assistance during and after his visit to the Ecole Pratique des Hautes Etudes, Paris, and to Dr. Philippe Taugourdeau for making microscope facilities available during that visit and for other assistance. The photographs were printed at the University of Saskatchewan (Audiovisual Services) and the manuscript typed by Mrs Linda Krukewich, Research Assistant to the second author.

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PLATE I

- 1-2 *Druggidium fourmarierii* (Lejeune-Carpentier, 1951) *comb. nov., emend.* 1. The holotype, in slightly oblique dorsal view. X c. 1900. 2. The paratype, in apical view. X c. 1900.
- 3 *Dinogymnium avellana* (Lejeune-Carpentier, 1951) Evitt *et al.*, 1967, *emend.* The holotype, in anterior ventral view. X c. 1600.
- 4-5 *Druggidium laeve* (Lejeune-Carpentier, 1951), *stat. et comb. nov., emend.* The holotype. 4. In left lateral view. 5. In right lateral view, by transparency. X c. 1900.
- 6 *Druggidium* cf. *fourmarieri* (Lejeune-Carpentier, 1951). Specimen CVII-15, in left lateral view. X c. 1600.
- 7-9 *?Phanerodinium* sp. Specimen Xa-9. 7. In oblique left lateral view. 8-9. In oblique right lateral view, by transparency, at two different focal levels. X c. 1900.

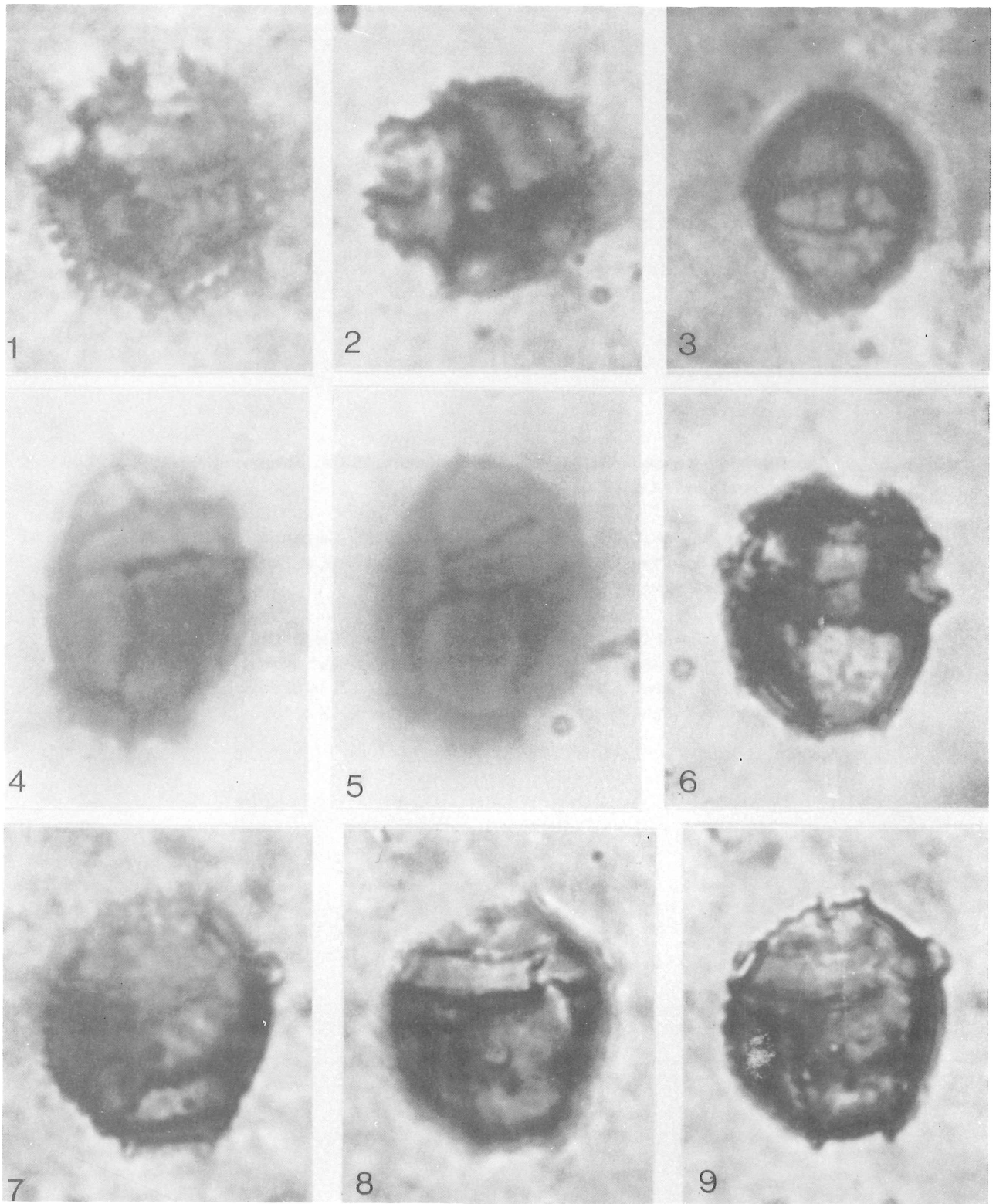


PLATE II

- 1 *Phanerodinium cayeuxii* (Deflandre, 1935) Deflandre, 1937a. Specimen CXII-159, in left lateral view. X c. 2000.
- 2-4 *Rhiptocorys veligera* (Deflandre, 1937b, *emend.* Lejeune-Carpentier, 1943) *comb. nov., emend.* Specimen CXII-419. 2-3. In left lateral view, at two levels of focus. 4. In right lateral view, by transparency. X c. 1600.
- 5-7 *Rhiptocorys veligera* (Deflandre, 1937b, *emend.* Lejeune-Carpentier, 1943) *comb. nov., emend.* Specimen CXIII-133. 5. In slightly oblique ventral view. 6. In median focus ; showing the character of the crests. 7. In oblique dorsal view, by transparency ; showing the areolate surficial ornament. X c. 1600.

