DINOFLAGELLATE CYSTS FROM THE APTIAN TYPE SECTIONS AT GARGAS AND LA BÉDOULE, FRANCE

by ROGER J. DAVEY and JEAN-PIERRE VERDIER

ABSTRACT. Microplankton assemblages are described for the first time from the Aptian type localities at La Bédoule and Gargas, south-east France. A total of sixty-eight species and varieties of dinoflagellate cysts are recorded, a number of which are discussed in detail, and four new species are erected. These are Apica secerigera, Cyclophelgium tubulatum, Meinouroygysades pseus, and Prototrochophyllum eliham. Microplankton distribution charts for the sections studied and a summary chart of selected age-significant forms are included. The following species are shown to be characteristic of, and confined to, the Aptian—Apica polymorpha, C. tubulatum, M. pseus and Trichodinum sp. These species, together with longer-ranging forms, may be used to distinguish Aptian from Albian and Barremian strata. Finally, our stratigraphic results are compared with those described in studies of similarly-aged sediments.

SEDiments of Aptian age have been rather neglected by earlier microplankton workers; they have been studied briefly only in Germany (Eisenack 1958; Alberti 1961), France (Milloud 1969), and Australia (Cookson and Eisenack 1958, 1960, 1962). The present paper, the first detailed study of Aptian dinoflagellate cysts, is intended to remedy this deficiency by presenting a taxonomic and stratigraphic analysis of microplankton recovered from Aptian stratotype material. This paper is a natural continuation from our previous contributions on Albian microplankton (Davey and Verdier 1971, 1973).

The sediments in the type localities of La Bédoule and Gargas, south-east France (text-fig. 1) consist predominantly of marls and clays, which usually yield rich paleontologic assemblages dominated by dinoflagellate cysts, although spores, pollen grains, and woody material are generally common. The basal Bedoulian (Lower Aptian) consists only of post-Urgonian reeval limestones which proved to be almost barren of palynomorphs.

All slides containing holotypes are housed in the Laboratoire de Micropaléontologie de l'École Pratique des Hautes Études, 8, rue de Buffon, Paris 5ème, France.

STRATIGRAPHIC AND GEOGRAPHIC LOCATION OF SAMPLES

The Aptian stage (text-fig. 2) was introduced in 1840 by d'Orbigny, who subsequently, in 1842 and 1850, slightly refined his original definition. As envisaged by d'Orbigny, the Aptian was a stratigraphic unit that included only what is now considered to be the Upper Aptian (Gargasian substage). His choice of the Apt region (Vaucluse) as the type area for the Aptian stage was unfortunate in that it later led to considerable controversy over delimitation of the stage. The main reason for this controversy was that in neighbouring areas, as several geologists pointed out (Matheron 1842; Reynes 1861; Hebert 1864, 1871, 1872), calcareous sediments containing a fauna with Aptian affinities were present between the massive ‘Urgonian limestones’ and the ‘Aptian
marls'. In the Apt region these latter two formations are practically in contact with only minor calcareous passage beds separating them; however, at La Bédoule (Bouches du Rhône) the passage beds are well developed. The above authors clearly recognized that the passage beds and the overlying marly sequence displayed sufficient faunal similarity to represent the same stratigraphic entity yet could be easily distinguished lithologically. Thus the concept of subdividing the Aptian stage originated. In 1887 Kilian introduced the term Gargasian for the 'Aptian marls', and in the following year Toucas (1888) defined the Bedoulian for the underlying passage beds. The positioning of the Gargasian-Bedoulian boundary resulted in considerable controversy but, suffice it to say, these terms have survived as substages and refer respectively to the Late and Early Aptian.
<table>
<thead>
<tr>
<th>STAGE</th>
<th>SUB-STAGE</th>
<th>AMMONITE ZONES</th>
</tr>
</thead>
<tbody>
<tr>
<td>APTIAN</td>
<td>LATE</td>
<td><em>Diadochoceras nodosoestatum</em></td>
</tr>
<tr>
<td></td>
<td>GARGASIAN</td>
<td><em>Cheloniceras subnodosoestatum</em></td>
</tr>
<tr>
<td></td>
<td>BEDOULIAN</td>
<td><em>Aconeceris nisus</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Deshayesites deshayesi</em></td>
</tr>
</tbody>
</table>

**Text-fig. 2.** Stratigraphic subdivision of the Aptian.

*La Bédoule Section*

Sediments of latest Barremian to Early Gargasian age crop out in several active and abandoned quarries on both sides of the Aubagne-Cassis road near the village of La Bédoule. The Aptian succession (text-fig. 3) here is highly calcareous and consists of alternating beds of marls and argillaceous limestones. The latter become increasingly abundant towards the base of the Bedoulian and grade into the massive Urgonian Limestone of probable Barremian age. The Urgonian Limestone of the Vocontian Trough represents deposition in a relatively shallow water, quiet environment. The initiation of Aptian deposition corresponds to the beginning of a progressive deepening of the sedimentary basin, to an increasing influx of argillaceous material and to less well-oxygenated bottom conditions. A total of ten samples of Bedoulian and Early Gargasian age were collected from the marl and clay beds at this locality.

*Gargas Section*

In the Apt region, the Aptian crops out in a series of exposures between the towns of Apt and Gargas. The top of the Urgonian limestones (text-fig. 4), here of Bedoulian age, is exposed near the railway bridge about two kilometres north-west of Apt. As
the hillside is ascended towards Gargas, progressively younger sediments are encountered, and the hill is capped by Albian marls and sands. A total of seven samples were collected and range in age from Bedoulian to Clansaysian.

**SYSTEMATIC DESCRIPTIONS**

This section is divided into two parts. The first part lists, in alphabetical order, the dinoflagellate cyst species which require no special remarks and have been previously described, with full stratigraphic annotations, by Davey and Verdier (1971, 1973). The second part deals with the cyst species recovered during the present study which were either not described in the above publications or require certain amplifying remarks. The species are arranged in alphabetical order within the Gonyaulacacean and Peridiniacean groups.
## PART 1

*Apicocolophion granulatum* Eisenack 1958.

*Astrocytta cretacea* (Pocock 1962) Davey 1970. (Pl. 93, fig. 4.)

*Broomia* micropoda Eisenack and Cookson 1960.

*Colloispharidium asymmetricum* (Deflandre and Courteville 1939) Davey and Williams 1966.

*Cumingia collivi* Cookson and Eisenack 1960.

*C. minor* Cookson and Hughes 1964.

*Cascasifora reticulata* Davey 1969.


*Chloephoridium armatum* (Deflandre 1937) Davey 1969.


*C. polypus clarum* Davey 1969.


*Cyclonephelium distinctum* Deflandre and Cookson 1955.
E. phragmites Davey, Downie, Sarjeant and Williams 1966.
Fromeca amphora Cookson and Eisenack 1958.
Hystrichosphaeridium pulchrum Deflandre 1935.
Hystrichosphaeridium asperulum Eisenack and Cookson 1960.
Kalyptra sp. (as in Davey and Verdier 1971).
Microdiatium crinitum Davey 1969.
Olistochitina opercularis (G. Wettel 1933) Deflandre 1946.
Ovoidinium spinulosum (Cookson and Hughes 1964) Davey 1970.
Polyosphaeridium laminospermum Davey and Williams 1966.
Procellariopsis spinocristatans Davey and Verdier 1971.
P. spinosum Davey and Verdier 1971.
S. ramosus ramosus (Ehrenberg 1838) Sarjeant 1970.
Tetanychosphaeridium variicellularum Davey and Williams 1966.

PART 2

Class Dinophyceae Pascher
Order Peridiniales Lindemann

Gonyaulacacean Group

Genus Achomospheara Evitt 1963

Achomospheara neptuni (Eisenack) Davey and Williams 1966

1958 Bathyosphaeridium neptuni Eisenack, p. 51, pl. 26, figs. 7, 8.

Achomospheara cf. neptuni (Eisenack) Davey and Williams 1966

Plate 92, fig. 2

Description. This ovoidal cyst has a smooth to minutely granular, thin wall which bears many smooth to slightly fibrous processes. Each process has a wide flat base and tapers rapidly to become thin and parallel-sided. Towards the distal extremity they divide into two, rarely three, filamentous branches which occasionally can be seen to further bifurcate at their distal extremities. Some alignment of the processes is present and appears to mark the cingular margins; a short, stouter apical process is sometimes discernible. These two features allow cyst orientation which suggests that the archaeocyde is precingular in position. It is formed by the loss of a single plate and is roughly triangular in shape. The processes are apparently both gonial and sutural in position.
Dimensions.

<table>
<thead>
<tr>
<th>Central body diameter</th>
<th>44±51</th>
<th>41-51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of processes</td>
<td>7-15</td>
<td>7-15</td>
</tr>
</tbody>
</table>

**Remarks.** *A. neptuni* differs from *A. cf. neptuni* by being thicker walled with a coarser granulation and by having fewer and wider processes which often join proximally with neighbouring processes. The processes of *A. neptuni* appear to be only gonial and usually trifurcate distally to give thick spines.

**Genus CHLAMYDOPHORELLA** Cookson and Eisenack 1958

*Chlamydomphorella nyei* Cookson and Eisenack 1958

1958 *Chlamydomphorella nyei* Cookson and Eisenack, p. 56, pl. 11, figs. 1–3.

**Remarks.** *C. nyei* is distinguished from *Gardadinum trabeculosum* (Gocht 1959) by being more or less rounded in outline (except for the apical prominence) and by not possessing a tabulation and process alignment.

**Reported occurrence.** Barremian, England (Davey 1974 in press, as *G. cf. trabeculosum*). Aptian to Lower Turonian, Australia (Cookson and Eisenack 1958, 1962); Albian to Cenomanian, England (Cookson and Hughes 1964); Canada (Manum and Cookson 1964; Davey 1979; Cox 1971; Brideaux 1971a, b, Singh 1971).

**Genus CORONIFERA** Cookson and Eisenack 1958

*Coronifera oceanica* Cookson and Eisenack 1958

1958 *Coronifera oceanica* Cookson and Eisenack, p. 45, pl. 12, figs. 5, 6.

**Remarks.** *C. oceanica* occurs in most of the Aptian samples but is never abundant and, being thin-walled, is usually distorted. The range of morphological variation exhibited by this species is very great, and specimens approaching *C. albertii* Millioud 1969 are present. The variation can be summarized as follows: the cyst wall may be smooth, granular, or pseudo-reticulate; the processes may be simple or fusiform, briefly or deeply, and distally may be acuminate, capitulate, or knobbed; the apical process, when distinctive, is trifurcate and may be situated on an apical boss; the antapical process is cylindrical but varies considerably in size and denticulation of the distal margin. A precingular archaeocele is always present.


**Genus CRIBROPERIDINIUM** Neale and Sarjeant emend. Davey 1969

*Cribroperidinium septimentum* Neale and Sarjeant 1962

Plate 91, fig. 5

1962 *Cribroperidinium septimentum* Neale and Sarjeant, p. 443, pl. 19, fig. 4.

**Remarks.** The present specimens from the Bédoulian closely resemble the type material. However, it is difficult to discern whether the cyst wall is densely microperforate or microgranulate.
**Genus Cyclonephelium Deflandre and Cookson emend. Cookson and Eisenack 1965**

*Cyclonephelium tabulatum* sp. nov.

Plate 92, figs. 1, 4; Plate 93, fig. 6

*Derivation of name.* Latin, *tabulatus*, plated or tabulate— with reference to the distinctive tabulation.

*Diagnosis.* The cyst is subcircular in outline and possesses a thin, smooth to lightly tuberculate wall. The processes are predominantly peritabular in position and clearly define the precingular and postcingular plates and the cingulum. The central part of the plates and the sulcal region are practically devoid of processes. The processes are short, stout, and capitata; they rarely branch distally or are joined proximally. The archaeopyle is apical and has a strongly zigzag margin and a sulcal notch; the operculum is typically detached.

*Holotype:* Slide FR 445/2, La Bédoule, south-east France; Upper Aptian (Gargasian).

*Dimensions.*

<table>
<thead>
<tr>
<th></th>
<th>Holotype</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyst height (without operculum)</td>
<td>57</td>
<td>52 (56) 60</td>
</tr>
<tr>
<td>Cyst width</td>
<td>72</td>
<td>59 (66) 72</td>
</tr>
<tr>
<td>Length of processes</td>
<td>4-8</td>
<td>2 (6) 9</td>
</tr>
</tbody>
</table>

*Description.* Since all the identified specimens possessed an apical archaeopyle and only rarely detached opercula were identified, it is difficult to precisely define the shape of the apical region. It is surmised, however, that it is of similar shape to that found in related species. That is, the cyst is rounded apically or has a reduced apical boss. The main part of the cyst is subcircular, or rarely slightly angular, in outline. The processes are neatly aligned just within the plate margins and hence clearly define the tabulation in the precingular and postcingular regions. In each case five or six plates appear to be present. The parallel lines of processes, either side of a plate boundary,
are 3 to 4 \( \mu \text{m} \) apart. Rare processes on the cingulum may indicate the position of plate boundaries; a distinct cingular tabulation, however, is not present. Two to three antapical and four apical plates appear to be present.

Remarks. The shape of the cyst and its processes are identical to that of \textit{C. distinctum} Deflandre and Cookson 1955. \textit{C. tabulatum} differs significantly from \textit{C. distinctum}, and other members of \textit{Cyclonephelium}, by the possession of periapical processes and an encircling cingulum; the processes of \textit{C. distinctum} are concentrated towards the circumferential region. The two species are clearly closely related, and although \textit{C. tabulatum} does not conform exactly with the generic diagnosis of \textit{Cyclonephelium} it is considered best placed in this genus at present.

Genus \textit{Dingodinium} Cookson and Eisenack 1958

\textit{Dingodinium albertii} Sarjeant 1966

Plate 91, fig. 6

1966b \hspace{1em} \textit{Dingodinium albertii} Sarjeant, p. 210, pl. 21, fig. 3; pl. 23, fig. 1.

Remarks. \textit{D. albertii} is distinguished from \textit{D. cervicum} Cookson and Eisenack 1958 by its considerably smaller size. At the moment the latter species appears to be restricted to Australia. The specimens described by Brideaux 1971b as \textit{D. cervicum} do, however, approach the type material in size but are here considered still to fall within the range of \textit{D. albertii}.


Genus \textit{Gardodinium} Alberti 1961

\textit{Gardodinium trabeculatum} (Gocht) Alberti 1961

1959 \hspace{1em} \textit{Sciniodinium trabeculatum} Gocht, p. 62, pl. 4, fig. 5; pl. 8, fig. 2.


Genus \textit{Gonyaulacysta} Deflandre emend. Sarjeant 1969

\textit{Gonyaulacysta} sp.

Plate 93, fig. 5

1958 \hspace{1em} Gen. et sp. indet. (ex. aff. \textit{Wormia}?) Eisenack, p. 398, pl. 25, fig. 2.

Description. Two well-preserved examples of this distinctive species were found and allow a relatively complete description to be given. The cysts are flattened and oriented such that the view is apical–antapical. Equatorially the cyst is subcircular (50–57 \( \mu \text{m} \) diameter) in outline and is surrounded by a distinctive flange 7–12 \( \mu \text{m} \) in height which is indented at the sulcus. This flange is formed by two expansions of the periphery along the cingulum; these run parallel to the two cingular margins with the expansion on the apical side being less than the antapical one. Distally the expansions may be irregular and may bear conical or small bifid spines (1–2 \( \mu \text{m} \) in height). The apical region is broadly conical (20 \( \mu \text{m} \) at the base) and terminates with
a short, blunt process. The cyst surface is microgranulate and bears low, smooth ridges which appear to give a *Gonyaulacysta*-type tabulation. The archaeopyle is formed by the loss of one or two dorsal precingular plates.

**Remarks.** The present Gargasian specimens appear to be identical to Eisenack's form and are assigned to the genus *Gonyaulacysta*. Similar forms also have been described and figured as *Dinopterygium* sp. A by Brideaux (1971b, p. 97, pl. 28, figs. 89, 92) from the Albian of Canada. However, because of the unfavourable orientation of our specimens, they are impossible to describe completely and compare thoroughly with previously described species. The microgranulate ornamentation, the type of apical horn and sutural ridges, and the distinctive cingular periphragm expansions adequately differentiate this species from all known forms. *Wamea* Cookson and Eisenack 1958, from the Middle and Upper Jurassic, appears somewhat similar but differs significantly by the possession of an epitractal archaeopyle.


**Genus Kleithriasphaeridium** Davey 1974

*Kleithriasphaeridium simplicispinum* (Davey and Williams) Davey 1974

1966b *Hystrichosphaeridium simplicispinum* Davey and Williams, p. 59, pl. 9, fig. 3.

**Remarks.** *K. simplicispinum* is extremely uncommon in the type Aptian and was only recorded a single time in each of four samples.


**Genus Meiourorogonyaulax** Sarjeant 1966

*Meiourorogonyaulax* cf. *bulloidea* (Cookson and Eisenack) Sarjeant 1969

Plate 92, fig. 5

1966b *Gonyaulax bulloidea* Cookson and Eisenack, p. 247, pl. 37, fig. 11.

**Dimensions.** (Single specimen.) Shell length 55 μm, shell width 60 μm, height of crests less than 2 μm.

**Remarks.** The single specimen of *M. cf. bulloidea* found during the present study differs from *M. bulloidea*, from the Portlandian of Australia, by the nature of its sutural crests. In *M. bulloidea* these are low, entire and granular; in *M. cf. bulloidea* they are smooth distally and composed of low, broad spines which widen and often join distally. Very similar specimens were described as *M. bulloidea* by Davey (1974 in press) from the Barremian of England.

*Meiourorogonyaulax stoveri* Millioud 1969

Plate 93, figs. 2, 8


**Dimensions.** Length of shell (complete specimens) 64 (72) 83 μm, length of shell (with archaeopyle) 71–73 μm, width of shell 61 (73) 81 μm, maximum height of crests 7–12 μm.

**Remarks.** The present Aptian specimens resemble the type material in all respects. *M. stoveri* is characterized by its more or less circular outline, its thick (up to 3 μm),
perforate wall, and by its membranous crests which are often perforate and most strongly developed in the antapical region.

Reported occurrence. Lower Hauterivian, Switzerland; Upper Hauterivian, Barremian and Lower Aptian, France (Millindorf 1969). Early and Middle Albian, France (Davey and Verdier 1971, questionable attribution).

Meiouragonaulax psuros sp. nov.

Plate 92, figs. 8, 9

Derivation of name. Greek, psuros, scabby or mangy—with reference to the irregularly tubercled surface of the cyst wall.

Diagnosis. The cyst is subcircular to slightly angular in outline. The cyst wall is relatively thick and is characterized by a variable surface ornamentation consisting of isolated tubercles to low irregular verrucular ridges. The sutural ridges are low and are difficult to discern except at the margins of the cyst; they are formed by the coalescence of aligned tubercles and/or broad, flat-topped processes. The cingulum, which is narrow, is displaced by approximately one cingular width along the sulcus. The latter broadens on the hypotrac and has a noticeable deep, centrally placed longitudinal groove. The apical archaeopyle is angular and the operculum sometimes remains attached.

Holotype. Slide FR 441/2, La Bédoule, south-east France; Lower Aptian (Bedoulian).

Paratype. Slide FR 444/2, La Bédoule, south-east France; Lower Aptian (Bedoulian).

Dimensions.

<table>
<thead>
<tr>
<th></th>
<th>Holotype</th>
<th>Paratype</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(μm)</td>
<td>(μm)</td>
<td>(μm)</td>
</tr>
<tr>
<td>Cyst length (complete specimens)</td>
<td>69</td>
<td>51-69</td>
<td></td>
</tr>
<tr>
<td>Cyst length (specimens with archaeopyle)</td>
<td>61</td>
<td>51 (55-60)</td>
<td></td>
</tr>
<tr>
<td>Cyst width</td>
<td>66</td>
<td>64</td>
<td>52 (60-68)</td>
</tr>
</tbody>
</table>

Description. On one specimen a low (5 μm), conical, membranous apical horn is present. The remaining complete specimens only possess slight apical prominences which are indistinguishable from the other angularities of the cyst outline. The thick (up to 3 μm) cyst wall is densely warty and rugulate. The sutural ridges, which are often discontinuous, are of similar height (up to 5 μm) to this ornamentation and thus are difficult to locate. Only on the cyst margin is it possible to see that the ridges

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EXPLANATION OF PLATE 92

Figs. 1, 4. Cyclonephelium tabulatum sp. nov. Holotype. 1. dorsal view, ×600 ph. 4. ventral view, ×600 ph.
Fig. 2. Achaeonephelium cf. neptuni (Eisemann 1958). Precingular archaeopyle is visible just beneath the apex.
Slide La Bédoule FR 442/2, ×500 ph.

Figs. 3, 6. Meiouragonaulax sp. Ventral views. Note the deeply incised sulcal notch, the insignificant crests on the ventral surface except for the cingulum and the high lateral crests. 3, slide La Bédoule FR 447/1, ×650. 6, slide La Bédoule FR 442/1, ×650.

Fig. 5. Meiouragonaulax cf. bullioides (Cookson and Eisenack 1960). Slide Gargas FR 454/1A, ×650.

Fig. 7. Trichonemurina sp. Archaeopyle view; note long, fine spines. Slide La Bédoule FR 443/1, ×1090.

Figs. 8, 9. Meiouragonaulax psuros sp. nov. 8, paratype, ventral view with apical archaeopyle developed, ×550. 9, holotype, complete specimen with operculum partially detached, ×550.
DAVEY and VERDIER, Aptian dinoflagellate cysts
are sometimes composed of long broad processes which anastomose distally. The
cingulum is narrow (3–5 μm in width), does not appear to be tabulate, and sometimes
forms ledges on the cyst circumference.

Remarks. *M. psoros* sp. nov. is easily distinguished from all other species of *Meiou-
rogonyaulax* by its distinctive rugulate ornamentation and low sutural crests.

*Meiourogonyaulax* sp.
Plate 92, figs. 3, 6

Description. The cyst is subcircular in outline and has a wall of moderate thickness
(approximately 1 μm) which is smooth to lightly pitted. The tabulation is distinctive
and is marked by high crests around the lateral margins of the cyst and by low crests
on the ventral and dorsal surfaces. The crests are smooth, rarely perforate, with
a smooth distal margin and may develop pericoels on the lateral sides of the hypo-
tract. The tabulation appears to be ‘4’, ‘6’, ‘8’, ‘5–6’”, ‘lp’, ‘1’”. The cingular plate
crests are almost absent on the dorsal and ventral surfaces. Plate ‘1’” is narrow and
poorly defined and is practically part of the suture. The sulcus is wedge-shaped,
widening antapically, with a deeply indented central groove; sulcal plates are absent.
The apical archaeopyle is slightly angular with a deeply indented sulcal notch.

Figured specimens. Plate 92, fig. 3. Central body length 58 μm, width 55 μm, maximum height of crests
10 μm. Plate 92, fig. 6. Central body length 53 μm, width 51 μm, maximum height of crests 9 μm.

Remarks. The present specimens, only two were observed, strongly resemble *M.
valensii* Sarjeant 1966a. *M. valensii* differs from *M. sp.* by the possession of a more
evenly punctate wall and striate crests which are sometimes finely denticulate distally.
*M. stoveri* differs in being larger, thicker walled, and having less uniformly developed
lateral crests.

Genus *Oligosphaeridium* Davey and Williams 1966

*Oligosphaeridium nannum* Davey 1974

1974 *Oligosphaeridium nannum* Davey, pl. 4, figs. 9, 10 (in press).

Remarks. This species, which has only been reported from the Lower Barremian
(Davey 1974 in press), was represented by a single specimen in one sample (FR 454)
and may be reworked. Very rare (3) examples have been observed in the Albion of the
Paris Basin and are also probably reworked.


Genus *Prolixosphaeridium* Davey, Downie, Sarjeant and Williams 1966

Remarks. In the discussion below it is considered that *P. deirense* Davey et al. 1966
is a junior synonym of *P. parvispinum* (Deflandre 1937c) Davey et al. 1969. Hence,
the latter species now becomes the type species of this genus.

Type species. *Prolixosphaeridium parvispinum* (Deflandre 1937c) Davey, Downie, Sarjeant and Williams
1969, Lower Cretaceous (Aptian), France.
Prolixosphaeridium parvispinum (Deflandre) Davey et al. 1969

1937: Hystrichosphaeridium xanthopyxides var. parvispinum Deflandre, p. 29, pl. 16, fig. 5.
1958 Hystrichosphaeridium parvispinum Deflandre; Cookson and Eisenack, p. 45.
1960 Bullosphaeridium parvispinum (Deflandre) Klement, p. 29.
1966 Prolixosphaeridium deirense Davey et al., p. 171, pl. 3, fig. 2; text-fig. 45.
1969 Prolixosphaeridium parvispinum (Deflandre) Davey et al., p. 17.

Description. The present specimens of P. parvispinum are identical with P. deirense as described by Davey et al. 1966. It should be noted, however, that firstly, the two antapical processes of this latter form are not always distinctive; and secondly, that the basal portion of the larger processes may be perforate.

Remarks. P. parvispinum is undoubtedly identical to P. deirense. This relationship has been overlooked previously mainly because Deflandre’s Aptian species was recorded in a publication dealing primarily with Late Cretaceous flints.


Genus Protoellipsodinium Davey and Verdier 1971

Protoellipsodinium clavulum sp. nov.

Plate 93, fig. 7

Derivation of name. Latin, clavus, nail—with reference to the shape of the processes.

Diagnosis. The cyst is elongate to ovoidal with a smooth wall. The cingulum usually lacks processes, and the hypotrack is larger than epitrack. The processes are fairly numerous and less than half the cyst width in length. They are typically hollow, with a restricted lumen, and distally are capitate or rarely bear two or three small spines. The archaeopyle is precingular, formed by the loss of a single plate.

Holotype. Slide FR 454/2, Gargas, south-east France; Upper Aptian (Gargasian).

Dimensions.

<table>
<thead>
<tr>
<th></th>
<th>Holotype</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body length (μm)</td>
<td>40</td>
<td>40 (42) 45</td>
</tr>
<tr>
<td>Central body width (μm)</td>
<td>23</td>
<td>23 (28) 32</td>
</tr>
<tr>
<td>Length of processes (μm)</td>
<td>11</td>
<td>4 (10) 13</td>
</tr>
</tbody>
</table>

Description. The cyst is thin-walled and often distorted, hence making orientation and archaeopyle identification difficult. The shape and structure of the processes are, however, very characteristic. Each process has a relatively broad base (2–5 μm wide), narrows rapidly above this, and for the more distal part of its length tapers only slightly and is more or less parallel sided (width approx. 1 μm). The processes expand at their distal extremities and are basically capitate; this expansion is usually slight (approx. 1 μm in width) but occasionally is wider and gives rise to two or three recurved spines (up to 2.5 μm long). The processes are rigid to slightly flexuous.

Remarks. The distal extremities of the processes distinguish P. clavulum sp. nov. from the two other species in this genus. The form of the processes is very similar to that
found in Cleistosphaeridium haguemioni (Valensi) var. pertusum Davey 1969 from the Upper Cenomanian of southern England and northern France. That species, however, is spherical to subspherical in shape and has an apical archaeopyle.

**Genus Spiniferites** Mantell emend. Sarjeant 1970

*Spiniferites* sp.

Plate 91, figs. 7, 9

**Description.** The specimens assigned to *Spiniferites* sp. are ovoidal in outline, smooth-walled, and have a distinct tabulation marked by membranous, sutural crests. The latter are highest at the plate corners where two or three crests meet and are especially noticeable in the apical region but do not appear to be best developed exactly at the apex. Between these gonial points the crests are lower (1–3 μm) and distally may vary from being slightly irregular to bearing strong, regularly or irregularly distributed, sutural spines up to 3 μm in height. In certain specimens, and in varying positions, the periphragm is detached from the endophragm, producing a bladder-like expansion reminiscent of Lejeune-Carpentier’s (1937c and 1938a) specimens of *Spiniferites ramosus* (Ehrenberg 1838).

**Dimensions.** Length of central body 41.52 μm; width 31.45 μm; height of crestal spines up to 3 μm; height of gonial elevations up to 7 μm.

**Remarks.** *Spiniferites* sp. is not an easy species to classify; with only slight morphological variation, and such variations occur in the present specimens, this species can be assigned to any of three genera. The disappearance of sutural spines leads to a *Leptodinium* Klement or *Spiniferites cingulatus* (O. Wetzel 1933) assignation. The development of an apical expansion of the periphragm, or apical horn, leads to affinities with the *Gonyaulacysta cretacea* helicoidea complex. The typical specimen of *Spiniferites* sp., however, does appear to represent a spiny form of *S. cingulatus*.

---

**EXPLANATION OF PLATE 93**

Fig. 1. *Pareocysta cf. aceras* (Manum and Cookson 1964) comb. nov. Specimen illustrating surface reticulation and attached opercular plates. Slide Gargas FR 455/2, ×1000 ph.


Fig. 3. *Deflandrea serrata* Davey 1974 (in press). Dorsal view illustrating tabulation and intratubular granulation. Slide La Bédoile FR 443/1, ×600 ph.

Fig. 4. *Astrocyclus cretaceous* (Pocock 1962). Specimen illustrating quasi-tabular ridges on the dorsal hypotropical surface. Slide Gargas FR 454/1A, ×800 ph.

Fig. 5. *Gonyaulacysta* sp. Apical view illustrating large precingular archaeopyle and two cingular flanges. Slide Gargas FR 455/1A, ×650 ph.

Fig. 6. *Cyclonephyllum tabulatum* sp. nov. Apical operculum illustrating peritubular processes outlining four apical plates. Slide La Bédoile FR 443/2, ×1000 ph.

Fig. 7. *Protoellipsoidium clavatum* sp. nov. Holotype illustrating bivalve cingular region, ×900 ph.

Fig. 9. *Pareocysta* sp. Partially detached opercular plates are present just beneath the cyst apex. Slide Gargas FR 457/1B, ×800 ph.
DAVEY and VERDIER, Aptian dinoflagellate cysts
Genus systematophora Klement 1960
Systematophora schindewolfii (Alberti) Sarjeant 1966

1958 *Hystrichosphaeridium anthophorum* Cookson and Eisenack; Eisenack, p. 402, pl. 26, figs. 1–2.
1961 *Hystrichosphaeridium schindewolfii* Alberti, p. 38, pl. 10, figs. 1–3, 6, 7.
1961c *Hystrichosphaeridium* sp. 4 Evitt, p. 398, pl. 4, figs. 4–5.
1966a Systematophora schindewolfii (Alberti) Sarjeant, p. 209, pl. 22, fig. 5.
1969 *Perissiella schindewolfii* Davey and Williams, p. 6.
1974 *Perissiella schindewolfii* Eisenack, Davey and Williams; Davey, pl. 6, fig. 5 (in press).

Remarks. Alberti’s type specimen of *S. schindewolfii* comes from the Pirna borehole of Germany and was originally dated as Turonian; he also recorded specimens from the Upper Barremian of Salzgitter, Germany. Sarjeant (1966a) recognized this species in the Barremian of England and validly transferred it to *Systematophora*. Earlier, however, Evitt (1961c) had redescribed Eisenack’s 1958 specimens of *Hystrichosphaeridium anthophorum*, and it is now obvious that the latter specimens belong to *S. schindewolfii*. Davey and Williams (1969), however, overlooked this relationship and erected a new species, *Perissiella schindewolfii*, using Eisenack’s specimens; this species is now considered to be a junior synonym of *S. schindewolfii*. An important stratigraphic point is that the dating of the Pirna borehole material has long been contested since seven of the reported fifteen species are of Aptian or older age; the oldest forms reported cannot be younger than Barremian. It thus appears probable that the type material of *S. schindewolfii* from the Pirna borehole is of Barremo–Aptian age rather than Turonian.

Reported occurrence. Middle to Upper Barremian, England (Sarjeant 1966a; Davey 1974 in press), Upper Barremian to Upper Aptian, Germany (Eisenack 1958; Alberti 1961).

Genus trichodinium Eisenack and Cookson emend. Clarke and Verdier 1967
Trichodinium sp.

Plate 97, fig. 7

Description. The rare specimens placed in *Trichodinium* sp. differ from *T. castanea* (Deflandre 1935a) in possessing finer and longer spines. An apical structure is not present. The cingulum and, more rarely, other sutural boundaries are marked by low thickenings of the shell wall.

Dimensions. Shell length 47–61 μm, width 44–59 μm, maximum length of spines 6–8 μm.

Peridiniacean Group
Genus apta Eisenack 1958 emend.

Emended diagnosis. Dorso-ventrally flattened cysts with typically a rounded triangular outline and possessing an ornamentation of membranous crests and/or processes which is better developed in the circumferential region. The apices of the triangle are situated at the apex, antapex, and a little antapically to the right circular margin of the cyst; they are typically marked by distinctively high ornamentation, and the cyst wall may or may not have prominent rounded protuberances in these positions. A detached inner body, elongate horns, and a flat or indented (two horns) antapical...
region are never present. The crests and processes are intratabular and rarely show alignment parallel to plate boundaries. The archaeopyle is apical with a strongly zigzag margin and short breakages extending along the precingular plate boundaries. The sulcal notch is always offset from the mid-line of the cyst's ventral surface. Finally, the operculum often remains attached.

*Type species.* *Aptea polymorpha* Eisenack 1958, p. 394, pl. 22, figs. 5-12. Upper Aptian, Germany.

**Remarks.** The morphological structure of the genus *Aptea* is here described in detail so as to distinguish it from morphologically similar genera. Particular stress is placed on the typical and characteristic asymmetry of the cyst which, it is considered, distinguishes it from previously described and possibly related genera such as *Cyclonephelium* Deflandre and Cookson 1955, *Cumingia* Cookson and Eisenack 1960b, and *Tentia* Eisenack 1958. These three genera have either a rounded or indented antapex and if protuberances or bulges are present in theingular region then they are more or less symmetrically placed (text-fig. 5).

*Aptea* probably evolved directly from *Pseudoceratium* Gocht 1957 by the disappearance of the elongate horns, while still retaining the characteristic symmetry of this genus (text-fig. 5, viii); for this reason *Aptea* is here considered to belong to the Pseudoceratiod branch of the Peridiniacean Group. This morphological change is apparently rapid and the first specimens assignable to *Aptea* appear in the topmost Barremian (Davey 1974 in press). However, this genus did not become a common constituent of the dinoflagellate cyst flora until Aptian time, only to disappear by the end of the Albian. *Doidyx* Sarjeant 1966b (see text-fig. 5, ix) is related to *Aptea* and is generically difficult to distinguish. However, *D. anaphrissa* Sarjeant 1966b, which has a Lower to Middle Barremian range (Davey 1974 in press), is the only member of this genus and is relatively easy to distinguish from similar species. For this reason it appears unnecessary to synonymize at present *Doidyx* with *Aptea.*

*Aptea polymorpha* Eisenack 1958

Plate 91, fig. 1; text-fig. 5 (v, vi)

1958 *Aptea polymorpha* Eisenack, p. 394, pl. 22, figs. 5-12.
1960 *A. cf. polymorpha* Eisenack; Eisenack and Cookson, p. 9, pl. 3, fig. 2 only.
1971 *A. polymorpha* Eisenack; Singh, p. 370, pl. 63, figs. 5-7; pl. 64, fig. 1.

**Remarks.** The present Tethyan specimens differ only in detail from the Boreal type material. The most noticeable differences are that our specimens are thinner-walled, have weaker and less continuous crests, and do not stain with safranin. These characteristics, we consider, are primarily preservational features and are not specifically significant. The Tethyan specimens, however, are generally more angular than the type material and sometimes possess relatively strong apical and antapical protuberances. *Aptea eisenacki* (Davey 1969) comb. nov. is more similar to the present examples of *A. polymorpha* than to the type material and may be distinguished only by the extremely low height of the crests.

Aptea securigera sp. nov.

Plate 91, figs. 2, 3; text-fig. 5 (vn)

*Derivation of name.* Latin, securiger, axe-bearing—with reference to the axe-shaped terminations of the processes.

*Diagnosis.* The cyst central body is dorso-ventrally flattened and rounded triangular in shape. The left side is strongly, but evenly, convex; the right epitractal and hypotractal sides are slightly convex to straight and meet at approximately right angles in the singular region. The right hypotractal side often has a medial convexity. The apex and, to a lesser extent, the antapex are developed as protuberances of the central
body and are rounded distally. The cyst surface bears numerous short, flattened, solid processes which are concentrated in the circumferential region. A more or less circular area in the centre of the ventral and dorsal surfaces is devoid of, or possesses only rare, processes. The processes are of variable shape but are typically discrete, expanding both distally and proximally, and are flat-topped distally; their length is more than twice their medial width. The processes are longer and more variable at the cyst apices. Very rarely the cingular and other tabulation is marked by narrow bands devoid of processes. The archaeople is apical and possesses a strongly zigzag margin. The operculum is usually detached.

*Holotype.* Slide FR 446/1, La Bédoule, south-east France; Lower Aptian (Bedoulian).

*Paratype.* Slide FR 446/2, La Bédoule, south-east France, Lower Aptian (Bedoulian).

**Dimensions.**

<table>
<thead>
<tr>
<th></th>
<th>Holotype (µm)</th>
<th>Paratype (µm)</th>
<th>Range (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body length</td>
<td>73</td>
<td>73</td>
<td>73-90</td>
</tr>
<tr>
<td>Central body width</td>
<td>69</td>
<td>87</td>
<td>69 (75) 87</td>
</tr>
<tr>
<td>Central body length (operculum detached)</td>
<td>73</td>
<td>62 (67) 73</td>
<td></td>
</tr>
<tr>
<td>Height of processes</td>
<td>2-6</td>
<td>2-5</td>
<td>2 (3) 10</td>
</tr>
</tbody>
</table>

**Description.** The processes characteristically widen both distally and proximally. Very rarely, narrow processes may bifurcate or trifurcate, or neighbouring processes may be linked medially by a crest. Rarely the bases of two or three neighbouring processes may be linked by a low ridge or thickening of the cyst wall. These thickenings tend to parallel the cyst sides, as do the crests in *A. polymorpha*. Besides the longer processes at the cyst apices, slightly longer ones may also be present on the left side in the cingular region and on the convexity or bulge, if present, of the right hypotractal side. These longer processes were seen to be linked distally in one specimen.

**Remarks.** *A. securigera* sp. nov. is differentiated from *A. polymorpha* by the absence of well-developed crests and from *A. eisenacki* (Davey 1969) comb. nov. by the presence of numerous stout processes. *A. attadalica* (Cookson and Eisenack 1962b) comb. nov., from the Apto-?Albian of Australia, is most similar but possesses a wide distinctive cingular and usually a ventral furrow.

**Other species**

The following two species now fall within the emended diagnosis of *Apteia* and are transferred to this genus.


*Apteia eisenacki* (Davey) Davey and Verdier comb. nov. = *Cyclonephelium eisenacki* Davey 1969, pp. 170, 171; pl. 8, figs. 3, 4; pl. 9, fig. 4; text-fig. 17A, B. Albian, Canada.
Genus Deflandrea Eisenack emend. Williams and Downie 1966

Deflandrea perlicida Alberti 1959

1959 Deflandrea perlicida Alberti, p. 102, pl. 9, figs. 16, 17.


Deflandrea terrula Davey 1974

Plate 93, fig. 3

1974 Deflandrea terrula Davey, pl. 8, figs. 4, 5 (in press).


Genus Muderorgia Cookson and Eisenack 1958

Muderorgia cf. staurota Sarjeant 1966

Plate 91, figs. 4, 8

Remarks. Three specimens attributable to M. cf. staurota were found, one in sample FR 445 and two in sample FR 448. In each case, preservation was poor and only the antapical region was present. It is characterized by a central body of subcircular outline, a single, proximally broad antapical horn, and two (or perhaps one) very reduced lateral horns. These forms are considerably smaller than the type material of M. staurota and closely resemble specimens described by Davey (1974 in press) from the late Middle and Upper Barremian of England.

Dimensions. Plate 91, fig. 8. Overall length 72 μm, length of antapical horn 27 μm, length of lateral horns 10 and 13 μm. Plate 91, fig. 4. Overall length 78 μm, length of antapical horn 33 μm, length of lateral horn 15 μm.

Stratigraphic comments. The presence of M. cf. staurota in the Lower Aptian extends the range of the genus Muderorgia upwards. It is now late Upper Kimmeridgian (see Gitmez and Sarjeant 1972) to Lower Aptian.

Genus Pareodinia Deflandre emend. Gocht 1970

Remarks. The present authors agree with Gocht (1970) that specimens attributable to Pareodinia may simply be poorly preserved specimens of Kalyptea Cookson and Eisenack 1960b which have lost their calyptra, the surrounding, veil-like covering. Hence, Kalyptea is considered to be a junior synonym of Pareodinia. The latter genus is characterized as being a single-walled, ovoidal cyst possessing a two-plate intercalary archaeopyle near the apex. A calyptra and apical horn are often present.

Imbatodinium Vozhennikova 1967 is distinguished from Pareodinia only with difficulty. It is characterized by an elongate body with a sulcus and cingulum, the latter being towards the antapex. The ornamentation may be coarse, and there may be an apical tentacle. At present the genus appears to be restricted to the latest Jurassic and earliest Cretaceous.

Caligodinium anniculatum Drugg 1970, from the Danian of the U.S.A., is very similar to the specimens herein assigned to P. cf. aceras. Caligodinium Drugg (1970) is closely related to Pareodinia but may be distinguished by the type of archaeopyle present;
in the former the operculum consists of three parts—two dorsal intercalary plates and a larger plate composed of the three or four apical plates. If the latter large plate becomes detached only in damaged specimens, as appears likely, then Caligodinium would be a junior synonym of Pareodinia.

Pareodinia cf. aceras (Manum and Cookson 1964) comb. nov.
Plate 93, fig. 1
1964 Kalyptra aceras Manum and Cookson, p. 27, pl. 6, figs. 9-11.

Remarks. The rare Aptian specimens encountered are identical to the Canadian type material except that they are considerably smaller. A small apical horn may be present, and the archeopyle is formed by the displacement of two intercalary plates just beneath the apex.

Dimensions. Plate 93, fig. 1. Shell length, 48 μm, width 37 μm. Range: shell length 48–54 μm, width 37–40 μm, wall thickness approximately 1 μm, reticulation approximately 0.5 μm.


Pareodinia sp.
Plate 93, fig. 9

Description. The cyst is elongate-ovoidal, coarsely granular to finely reticulate, and possesses a two-plate intercalary archeopyle just beneath the apex. A reduced calyptra is present. Polar structures and a cingulum are absent.

Dimensions. Plate 93, fig. 9. Shell length 62 μm, width 42 μm. Second specimen; length 58 μm, width 33 μm.

Remarks. Only two specimens of this distinctive species were recovered. Its lack of an apical horn distinguishes it from all associated species except P. aceras, from which it may be distinguished by its more elongate shape and less strongly reticulate wall.

Genus Walloidinium Loeblich and Loeblich 1968
Walladinium luna (Cookson and Eisenack 1960) comb. nov.
1960 Diplodinum luna Cookson and Eisenack, p. 10, pl. 3, fig. 21.

Remarks. During the present study the procedure used by Davey (1974 in press) was followed. That is, due to continuous variation within this genus, all specimens can be assigned for practical purposes, to a single species. W. luna comb. nov. has priority. It is not our intention, at present, to synonymize these three species because their distinction in younger strata may be of importance.

Reported occurrence. W. luna, W. kratzschii, and W. anglica have a combined stratigraphic range of Lower Hauterivian to Cenomanian (see Davey 1974 in press).

Other species
Walladinium anglica (Cookson and Hughes) Davey and Verdier, comb. nov. = Diplodinum anglica Cookson and Hughes 1964, p. 56, pl. 11, figs. 1–5. Albian to Cenomanian, England.
The distribution of all the dinoflagellate cysts recovered from the two sections investigated is shown on text-figs. 6–7. The ranges of sixty-two species and varieties which are particularly meaningful stratigraphically are shown on the summarizing range chart (text-fig. 8). Occurrences of these taxa in older and younger strata, as reported earlier by the authors and as taken from selected European literature, are also tabulated on this chart. The stratigraphic distribution of certain species and comparisons with previously described Aptian assemblages are discussed below.

The Barremian–Aptian boundary

Barremian sediments in the Provence region were not sampled during this study because of their palynologically unfavourable lithology (Urgonian Limestone). The lowest part of the Bedoulian (Couches de passage) consisted of relatively clean limestones and proved to be practically barren. The older fossiliferous Bedoulian samples yielded two species, *Cribroperidinium segmentum* and *Muderonga* cf. *staurota*, which had been reported previously only from the Barremian (Davey 1974 in press). These were extremely rare, and the latter form appears to be characteristically confined to the uppermost Barremian and lowermost Aptian. Of particular significance is the absence from the Lower Aptian of *Muderonga staurota* s.s. and *Pseudoceratium pelliferum*; these species apparently became extinct during the Late Barremian.

**Bedoulian**

The following species first appear in the Bedoulian and are restricted to the Aptian—*Apteia polymorpha*, *Cyclonephelium tabulatum*, *Melourogonaulax psoros*, and *Trychodinium* sp. *Deflandrea terrali* and *Melourogonaulax* sp. became extinct in the Provence region during the Early Aptian, whereas other species, such as *Gonyaulacysta caudadita* and *Protoellipodiidinium spinosissimum*, first occurred at that time and range into post-Aptian strata.

**Gargasian**

A few species first appear in the Upper Aptian and range into younger strata. Among these, the most restricted stratigraphically are *Astrocytrea cretacea*, *Prolixospheridium parvipinum*, *Ovoidinium scabrum*, and *Cleistospheridium polypus clavulum*. *Parodinia* sp. and *Gonyaulacysta* sp. have limited ranges and seem, at present, to be restricted to the Gargasian. A number of species which first appear in pre-Aptian strata become extinct in the Gargasian and may be used, as may be the Aptian-restricted species, for differentiating Lower Aptian and Upper Aptian. These include *Aechinosphaera neptuni*, *Dinogodinium albertii*, *Gardoddinium trabeculosum*, *Melourogonaulax stoveri* s.s., and *Systematophora schindewolfii*.

**Comparison with previously described Aptian assemblages**

*Europe.* Eisenack 1958. Of the twenty-seven distinct species described by Eisenack from the Upper Aptian of Germany, eighteen have been found in the French stratotype sections. The restricted distributions of *Apteia polymorpha*, *Florentinia laciniata* (as *Hystrixospheridium ferox*), and *Gonyaulacysta* sp. (as *Gen. and sp. indet.*) in
<table>
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<tr>
<th>AGE</th>
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<td>A. <em>securigera</em></td>
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<td>K. <em>calyptrae sp. in D/V, 1971</em></td>
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<td>M. <em>psoros</em></td>
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<td>M. <em>iagregonyaulax sp.</em></td>
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<td></td>
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<td>T. <em>castanea</em></td>
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<tr>
<td></td>
<td>Trichodinium sp.</td>
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<td></td>
<td>W. <em>luna</em></td>
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</table>

**TEXT-FIG. 6.** Microplankton distribution in the samples analysed from the La Bédoule section.
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<th>GARGASIAN</th>
<th>AGE</th>
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A. nepituni
A. cf. nepituni
A. granulatum
A. polymorpha
A. crassica
B. micropedia
C. exigua
C. asynmeicricum
C. calvelli
C. minor
C. rastiquea
C. parva
C. pyri
C. armati
C. hugonotae hugonoti
C. polycystis clavisum
C. polycystis polycystis
C. eodica
C. edwardsii
C. distincticum
C. tubulatum
D. punctata
D. terminus
D. alberti
D. arace
E. phragmites
E. fascinata
E. mannii
E. amphora
G. trachonosum
G. quadricoma sp.
G. carnea
G. helicoida
G. tenuecera
H. pusilum
H. arundinum
H. recurvatum
H. tubiferum
K. pyrethrus, sp. in 0/4, 1971
K. simpliciplum
M. of bullae
M. pomica
M. stoveri
M. criminum
M. oerquistata
M. crippa
M. namun
M. sebrosum
P. edulis of aceras
P. edulis sp.
P. limnaspisnoicum
P. parvus
P. clavisum
P. spinosum
P. spinosummum
P. spinosum sp.
S. cingulatus cingulatus
S. ramosus multigere
S. ramosus ramosus
S. ramosus ramosus
S. ramosus ramosus
S. schindewolfii
T. varicellatum
T. castanea
Trichodon sp.
W. luna

Text Fig. 7. Microplankton distribution in the samples analysed from the Gargas section.
TEXT-FIG. 8. Range chart of selected Aptian microplankton observed in this study and as reported in certain European Cretaceous publications.
our samples support the Late Aptian age for the German material and also confirm
the stratigraphic value of these species.
Alberti 1961. Alberti describes three assemblages from the German Aptian; two
are assigned to the Lower Aptian and one to the Upper Aptian. All three assemblages
contain *Pseudoceratium pelliferum*, which has been reported otherwise only from pre-
Aptian Early Cretaceous strata, and one assemblage contains *Muderongia simplex*,
which occurs only in the pre-Barremian Early Cretaceous. Hence, it appears probable
that these assemblages are of Burrenian or older Early Cretaceous age.

Milioud 1969. The Angles section (south-eastern France) studied by Milioud
included three samples of Early Aptian age. The assemblages he reported agree well
with the microplankton distribution at La Bédoule, with the exceptions that *Gonyaulac-
cysta aptiana* and *Phoberocysta neoconica* were not present in our samples. Their
absence could be explained by the fact that the two oldest Aptian samples at La
Bédoule (limestone facies) were practically barren and/or that these two species
disappeared during earliest Aptian time.

from various formations and localities have been described by these authors. Although
the assemblages do vary somewhat in species composition basically two associations
are represented. The first one, from the Roma Formation (Santos Oodnadatta No. 2
borehole), and Osborne Formation (Rakich borehole), contains *Cunningia colliveri*,
*Gonyaulacysta cassidula*, *Spinidinium styloniferum*, *Carpodinium granulatum*, *Tri-
choderinum castanea*, and *Gonyaulacysta tenaceras*. Although in Europe, none of
these species are restricted to the Aptian, the age of this association, according to the
present study, could well be Aptian. The second association, reported from the
Muderong Shale, Windalia Radiolarite, Birdrong Formation (Grierson Member),
Roma series and several borehole samples from unspecified formations, contains
*Dingodinium cerviculum*, *Muderongia mcwhaei*, and *M. tetracantha*. Unless these
species of *Muderongia* have a younger range in Australia than in Europe, their
presence would indicate a pre-Aptian age.

*Canada*. Singh 1971. Although reportedly no Aptian material was studied by Singh,
some of the species he recovered strongly suggest an Aptian age for the lower part of
the section. The upper part of the section does appear to be of the late Albian age,
as assigned. However, the presence of *Gardodiicium trabeculosum* (as *G. eisenacki*),
*Dingodinium albertii* (as *D. cerviculum*), *Chlamydophorella nyei*, and certain of the
illustrated specimens of *Aptea polymorpha* is certainly indicative of an Aptian age
according to our recent studies. The association of some of these species with *De-
flandrea limpida* (D. gallia Davey and Verdier 1973 is a junior synonym) and *Ovoodinium
verrucosum* (as *Ascodinium verrucosum*), which indicate a Late Albian age, strongly
suggests that there is reworked Aptian in the upper part of Singh’s section.

Brideaux 1971b. The assemblages described by Brideaux from the Middle to Upper
Albian of Canada strongly resemble those of Singh (1971) and also include *Chlamy-
dophorella nyei* and *Dingodinium albertii* (as *D. cerviculum*), together with *Gonyaulac-
cysta* sp. (as *Dinoptyrgium* sp. A). These species are strongly suggestive of an Aptian
age, and their presence in Albian strata signifies erosion and redeposition of Aptian
sediments during Albian time.
REFERENCES

All references to fossil microplankton not listed below are to be found in the "Bibliography and index of fossil dinoflagellates and acritarchs" by Downe and Sarjeant 1964.


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