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5. Southern Ocean and Global Dinoflagellate Cyst Events Compared: Index Events for the Late Cretaceous–Neogene[1]

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ABSTRACT

Late Cretaceous to Quaternary organic walled dinoflagellate cyst (dinocyst) events were recognized at two sites offshore Tasmania during Ocean Drilling Program (ODP) Leg 189. Detailed magnetostratigraphic results from this leg allow, for the first time in the Southern Ocean, a detailed calibration of such dinocyst events. This calibration permits a comparison of dinocyst events for selected species between the Northern and Southern Hemispheres.

The independent age control compilation, based on data from stratotype sections and cores recovered during ODP (and other) drilling worldwide, shows that dinocysts are extremely sensitive temporal and spatial indicators. Spatially restricted dinocyst species can be grouped into low-, mid-, and high-latitude forms for both hemispheres, with the majority occurring in the mid- and low latitudes. Such taxa include *Apectodinium homomorphum,* which characterizes warm waters in the late Paleocene and early Eocene. Other taxa, such as *Arachnodinium antarcticum*, are found only in mid- or high latitudes and are known only from the Southern Hemisphere. A third group, including *Spinidinium macmurdoense*, is characteristic of high latitudes. By collating the ranges, we derive a sequence of dinocyst events that should greatly facilitate the use of these organisms for age determinations and correlations.

[1]Williams, G.L., Brinkhuis, H., Pearce, M.A., Fensome, R.A., and Weegink, J.W., 2004. Southern Ocean and global dinoflagellate cyst events compared: index events for the Late Cretaceous–Neogene. *In* Exon, N.F., Kennett, J.P., and Malone, M.J. (Eds.), *Proc. ODP, Sci. Results,* 189, 1–98 [Online]. Available from World Wide Web: <http://www-odp.tamu.edu/publications/189_SR/VOLUME/CHAPTERS/107.PDF>. [Cited YYYY-MM-DD]
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INTRODUCTION

Dinoflagellates are predominantly single-celled organisms (protists) with two characteristic flagella and a special type of eukaryotic nucleus, termed a dinokaryon (Fensome et al., 1993). They form a major component of the marine plankton; there are about equal numbers of autotrophic and heterotrophic dinoflagellates, including some species that use both feeding strategies. Some dinoflagellates are symbionts or parasites. Although most dinoflagellates are marine, they can occur in brackish and freshwater environments, ice, snow, and wet sand. Dinoflagellates have a simple to complex life cycle, which typically includes a motile stage. Nonmotile cells may be resting, temporary, vegetative, or digestion cysts. Those resting cysts (hereafter termed dinocysts) that have been studied are hypnozygotes, most being distinguished by a resistant wall and a predetermined excystment opening, the archeopyle.

Almost all dinocysts are assignable to the subclass Peridiniphycidae, with a few representing the subclasses Gymnodiniphycidae and Dinophysiphycidae (Fensome et al., 1993). The Late Cretaceous–Tertiary taxa discussed in this paper are almost all representatives of the Peridiniphycidae, which contains siliceous, calcareous, and organic walled cysts: this paper deals with the organic walled forms. The only nonperidiniphycideans treated here are the dinogymnioids *Alisogymnium euclaense* and *Dinogymnium* spp., which appear to represent fossilizable shed pellicles of gymnodiniphycidean dinoflagellates (Fensome et al., 1993). For simplicity and convenience, they are treated here as dinocysts.

The use of fossil dinocysts in biostratigraphy and paleoecology has been discussed in detail in several papers including Williams and Bujak (1985), Powell (1992), and Stover et al. (1996). Pioneer studies, primarily by palynologists working for petroleum companies, were based largely on subsurface sections. The need for more precise correlations led these and other palynologists to undertake extensive studies of classical surface sections, including stratotypes, and to the publication of formal zonations (e.g., Clarke and Verdier, 1967).

Biostratigraphic and paleoecologic studies of subsurface sections are dependent upon utilization of microfossils. Such studies were not only the domain of the petroleum exploration companies in the twentieth century: the Ocean Drilling Program (ODP) and its precursor, the Deep Sea Drilling Project (DSDP), focused attention on the utilization of planktonic foraminifers and nannofossils for correlation and zonation of deep-sea sediments and provided a much-needed framework for assessing the stratigraphic ranges of dinocysts. And a major bonus of ODP has been the widespread use of paleomagnetic ages, the ultimate degree of sophistication for defining the first and last occurrences of fossils. In Upper Cretaceous sequences, however, the use of the paleomagnetic polarity timescale is limited because there are fewer reversals.

The success of planktonic foraminifer and nannofossil dating led many dinocyst workers to also develop zonations based on the concept of index species. Comprehensive zonations for the Cretaeous–Cenozoic of the Northern Hemisphere have been published by numerous authors, including Monteil (1985, 1992) for the Early Cretaceous, Prössl (1990) for the Hauterivian–Turonian, Kirsch (1991) for the Turonian–Maastrichtian, Schiøler and Wilson (1993) and Schiøler et al. (1997) for the Maastrichtian, Powell (1992) for the Tertiary, Bujak and Mudge

(1994) and Mudge and Bujak (1994) for the Eocene, Brinkhuis and Biffi (1993) for the Eocene–Oligocene transition, Wilpshaar et al. (1996) for the Oligocene, Zevenboom (1995) for the Oligocene–Miocene, and Head (1998) for the Pliocene. These works have been major sources for our compilations.

Several detailed zonations for Late Cretaceous–Paleogene dinocysts of the Southern Hemisphere or circum-Antarctic realm have been published in recent years. These include Helby et al. (1987) and McMinn (1988) for the Late Cretaceous and Wilson (1988) for the Paleocene–Eocene. Other notable contributions highlight assemblages from Argentina, southeastern Australia, New Zealand, the Ross Shelf, and Seymour Island, as well as from several DSDP/ODP sites in the region (see, for example, Haskell and Wilson, 1975; Goodman and Ford, 1983; Askin, 1988a, 1988b; Wilson, 1985, 1988; Wrenn and Hart, 1988; Marshall, 1988, 1990; Mohr, 1990; Mao and Mohr, 1995; Crouch and Hollis, 1996; Truswell, 1997; Hannah, 1997; Hannah et al., 1997; Hannah and Raine, 1997; Levy and Harwood, 2000; Guerstein et al., 2002). These studies have documented Southern Ocean Paleogene dinocyst distribution and taxonomy in great detail, but there are difficulties with the chronostratigraphic calibration (**Brinkhuis, Sengers, et al.,** this volume).

There are fewer studies of Oligocene–Neogene dinocysts from the Southern Hemisphere. McMinn (1992b) proposed a zonation for the Pliocene–Holocene of southern Australia. Other authors have described assemblages from various ODP sites (McMinn, 1992a, 1993; McMinn et al., 2001; **Brinkhuis, Sengers, et al.,** this volume) and the Antarctic shelf (Wrenn et al., 1998; Hannah et al., 1998). One of the difficulties in developing a Neogene dinocyst zonation for the higher latitudes of the Southern Hemisphere is the general paucity of specimens. It appears that the organic wall of the dinocyst is not resistant to the oxygen-rich waters in the Antarctic region, and/or winnowing at depth and low sedimentation rates mean that these microfossils are not preserved (McMinn, 1995; **Brinkhuis, Munsterman, et al.,** this volume). McMinn (1995) believes that the absence of specimens reflects the disappearance of cyst-producing dinoflagellates from the Antarctic–Southern Ocean region since the Oligocene. This exclusion has resulted from the geographic and thermal isolation of Antarctica.

Independent chronostratigraphic control is essential to constrain a proposed biostratigraphic calibration. This is the case at Leg 189 Sites 1168 and 1172, where the Late Cretaceous (Maastrichtian) to Quaternary succession has a clear magnetostratigraphy, calibrated by biotic events (**Stickley et al.,** this volume; Schellenberg et al., in press). Hence, for the first time, we are able to tie Southern Ocean dinocyst events to the geomagnetic polarity timescale and, for the middle Eocene, to a calibrated Milankovich cyclostratigraphy (Röhl et al., in press). For further discussion of these topics, see also **Brinkhuis, Munsterman, et al.** (this volume), **Brinkhuis, Sengers, et al.** (this volume) and **Sluijs et al.** (this volume).

By compiling the dinocyst data from Leg 189 with the nannofossil, foraminiferal, and paleomagnetic results, we established a sequence of calibrated dinocyst events that can be compared with dinocyst events keyed to magnetostratigraphy and other fossil groups from type and other precisely dated surface or subsurface sections in both hemispheres. Thus for the first time, we can fully document selected dinocyst events in the Late Cretaceous–Cenozoic with a surprising degree of precision. The brevity of this paper does not denote a constrained data-base. Rather, it represents the culmination of a decade-long study, commencing with the 1-week workshop on Paleogene dinocysts, 6–10 June 1994. Subsequent workshops, input into the revised version of Haq et al. (1987; see Williams et al., 1998b), and the results from Leg 189 have led to the culmination of the results presented here. Background data for those desiring further clarification are provided in the workshop manuals, which are available from the author upon request.

THE DATA SET

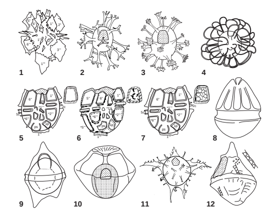
In this paper, we present the stratigraphic ranges of Late Cretaceous–Tertiary dinocysts, based primarily on an unpublished manuscript distributed at a short course at the University of Urbino, Italy, in June 2001 (see **"Appendix,"** p. 22). Stratigraphic ranges are given as first occurrence (FO) and last occurrence (LO) in mega-annum age (Ma) for each taxon (Tables **T1, T2, T3**). The age was determined from correlation with surface or reference sections with independent age control, primarily planktonic foraminifers, nannofossils, and paleomagnetism. Thus, our main control for the Northern Hemisphere is from stratotypes and other surface sections. For the Southern Hemisphere, especially in the Tertiary, we utilized the results from Leg 189, Sites 1168 through 1172. We selected the Gradstein and Ogg (1996) timescale, in which the Mesozoic is based on Gradstein et al. (1995) and the Cenozoic is based on Berggren et al. (1995). For each selected taxon, both line drawings (*Achilleodinium, Achomosphaera, Adnatosphaeridium, Alisocysta, Alisogymnium, Alterbidinium, Amiculosphaera, Apectodinium, Apteodinium, Arachnodinium, Areoligera, Areosphaeridium, Ataxiodinium* [Pl. **P1**]; *Barssidinium, Biconidinium, Cannosphaeropsis, Callaiosphaeridium, Carpodinium, Carpatella, Cassiculosphaeridia, Cerebrocysta, Cerodinium, Charlesdowniea, Chatangiella* [Pl. **P2**]; *Chichaouadinium, Chiropteridium, Conosphaeridium, Cordosphaeridium, Corrudinium, Cyclapophysis, Cousteaudinium, Cyclonephelium, Damassadinium, Deflandrea, Dinogymnium* [Pl. **P3**]; *Dinopterygium, Diphyes, Distatodinium, Dracodinium, Eatonicysta, Ectosphaeropsis, Edwardsiella, Ellipsodinium, Endoscrinium, Enneadocysta, Epelidosphaeridia* [Pl. **P4**]; *Filisphaera, Florentinia, Galeacysta, Gerdiocysta, Glaphyrocysta, Gramocysta, Habibacysta, Heterosphaeridium, Hemiplacophora, Heteraulacacysta, Homotryblium, Hystrichokolpoma* [Pl. **P5**]; *Hystrichosphaeridium, Hystrichosphaeropsis, Impagidinium, Invertocysta, Isabelidinium, Kleithriasphaeridium, Labyrinthodinium, Laciniadinium, Leptodinium, Lentinia, Litosphaeridium, Manumiella* [Pl. **P6**]; *Melitasphaeridium, Membranilarnacia, Membranophoridium, Mendicodinium, Nematosphaeropsis, Octodinium, Odontochitina, Oligosphaeridium, Operculodinium, Ovoidinium, Palaeocystodinium* [Pl. **P7**]; *Palaeohystrichophora, Palaeoperidinium, Palaeotetradinium, Palynodinium, Phthanoperidinium, Pyxidinopsis, Raetiaedinium, Raphidodinium, Renidinium, Reticulatosphaera, Rhombodinium, Saturnodinium, Schematophora, Selenopemphix* [Pl. **P8**]; *Senoniasphaera, Spinidinium, Spiniferites, Spongodinium, Stephodinium, Sumatradinium, Stoveracysta* [Pl. **P9**]; and *Sumatradinium, Surculosphaeridium, Thalassiphora, Triblastula, Trichodinium, Trigonopyxidia, Trinovantedinium, Trithyrodinium, Impagidinium, Wetzeliella, Wilsonidium, Xenascus, Xiphophoridium* [Pl. **P10**]) and photomicrographs (*Achilleodinium, Achomosphaera, Adnatosphaeridium, Alisocysta, Alisogymnium, Alterbidinium, Amiculosphaera, Apectodinium, Apteodinium, Arachnodinium* [Pl. **P11**]; *Areoligera, Areosphaeridium, Ataxiodinium, Barssidinium, Biconidinium, Callaiosphaeridium, Cannosphaeropsis* [Pl. **P12**]; *Carpatella, Carpodinium, Cassiculosphaeridia, Cerebrocysta, Cerodin-*

T1. Stratigraphic ranges of dinocysts, p. 43.

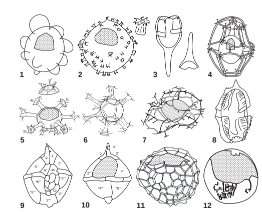
T2. Sequential list of references, p. 44.

T3. Alphabetic list of references, p. 45.

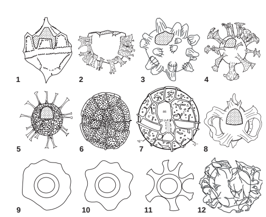
P1. *Achilleodinium–Ataxiodinium*, p. 47.



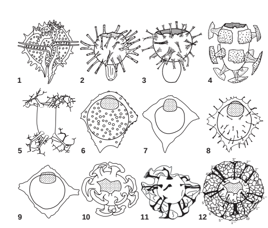
P2. *Barssidinium–Chatangiella*, p. 49.



P3. *Chichaouadinium–Dinogymnium*, p. 51.



P4. *Diphyes–Epelidosphaeridia*, p. 53.



ium, Charlesdowniea, Chatangiella, Chichaouadinium [Pl. **P13**]; *Chiropteridium, Conosphaeridium, Cordosphaeridium, Corrudinium, Cousteaudinium, Cyclapophysis, Cyclonephelium* [Pl. **P14**]; *Damassadinium, Deflandrea, Dinogymnium, Dinopterygium, Diphyes* [Pl. **P15**]; *Distatodinium, Dracodinium, Eatonicysta, Ectosphaeropsis* [Pl. **P16**]; *Edwardsiella, Ellipsodinium, Enneadocysta, Epelidosphaeridia, Filisphaera, Florentinia, Galeacysta, Gerdiocysta* [Pl. **P17**]; *Glaphyrocysta, Gramocysta, Habibacysta, Hemiplacophora, Heteraulacacysta, Heterosphaeridium, Homotryblium, Hystrichokolpoma* [Pl. **P18**]; *Hystrichosphaeridium, Hystrichosphaeropsis, Impagidinium, Invertocysta, Isabelidinium, Kleithriasphaeridium* [Pl. **P19**]; *Labyrinthodinium, Laciniadinium, Lentinia, Leptodinium, Litosphaeridium, Manumiella, Melitasphaeridium, Membranilarnacia* [Pl. **P20**]; *Membranophoridium, Mendicodinium, Nematosphaeropsis, Octodinium, Odontochitina, Oligosphaeridium, Operculodinium* [Pl. **P21**]; *Ovoidinium, Palaeocystodinium, Palaeohystrichophora, Palaeoperidinium, Palynodinium, Phthanoperidinium, Pyxidinopsis, Raetiaedinium, Raphidodinium, Renidinium* [Pl. **P22**]; *Reticulatosphaera, Rhombodinium, Saturnodinium, Schematophora, Selenopemphix* [Pl. **P23**]; *Senoniasphaera, Spinidinium, Spiniferites, Spongodinium* [Pl. **P24**]; *Stephodinium, Stoveracysta, Sumatradinium, Surculosphaeridium, Thalassiphora* [Pl. **P25**]; *Triblastula, Trichodinium, Trigonopyxidia, Trinovantedinium, Trithyrodinium, Unipontidinium, Wetzeliella* [Pl. **P26**]; and *Wilsonidium, Xenascus, Xiphophoridium* [Pl. **P27**]) are provided to aid identification. To facilitate verification of the stratigraphic data, we provide the references on which we base each FO and LO (Tables **T1, T2, T3**).

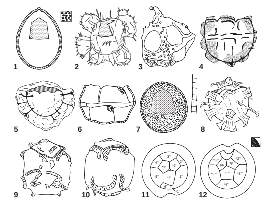
In Table **T1** the taxa are listed alphabetically to help access the data. For each taxon, we provide two citation numbers for each latitudinal record, the first for the source of the FO and the second for the source of the LO. The citation corresponding to an individual number is given in Tables **T2** and **T3;** Table **T2** is a numeric listing of the references and Table **T3** is an alphabetic listing of the references. Table **T4** gives the ages, in millions of years, for each geochronologic division in Table **T1.** The figures sequentially show the FOs and LOs of taxa for the Late Cretaceous and Tertiary stages: Cenomanian (Fig. **F1**); Turonian (Fig. **F2**); Coniacian (Fig. **F3**); Santonian (Fig. **F4**); Campanian (Fig. **F5**); Maastrichtian (Fig. **F6**); Danian (Fig. **F7**); Selandian and Thanetian (Fig. **F8**); Ypresian FOs (Fig. **F9**); Ypresian LOs (Fig. **F10**); Lutetian (Fig. **F11**); Bartonian and Priabonian (Fig. **F12**); Rupelian (Fig. **F13**); Chattian (Fig. **F14**); Aquitanian and Burdigalian (Fig. **F15**); Langhian, Serravallian, Tortonian, and Messinian (Fig. **F16**); and Zanclean, Piaenzian, Gelasian, Calabrian, and Ionian (Fig. **F17**). Taxonomy is in accordance with that cited in Williams et al. (1998a).

DISCUSSION

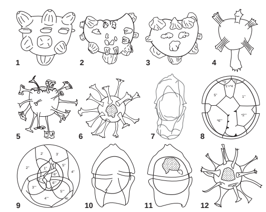
As is evident from Table **T1,** the stratigraphic range of a dinocyst species is rarely synchronous worldwide. This is especially true for the Tertiary, where paleoclimatic control on taxa has been demonstrated by several authors. Bujak and Williams (1979) noted that some species did not have uniform stratigraphic ranges throughout the North Atlantic. For example, *Polysphaeridium zoharyi* (as *Hemicystodinium zoharyi*) had a range of early Eocene to Holocene in offshore Florida, whereas on the Labrador Shelf, its LO was in the Oligocene. Williams and Bujak concluded that a worldwide range for a species was not to be expected.

Brinkhuis and Biffi (1993), in an analysis of the Massignano and Monte Cagnero Eocene/Oligocene boundary sections in central Italy,

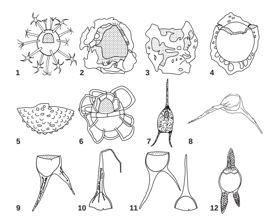
P5. *Filisphaera–Hystrichokolpoma*, p. 55.



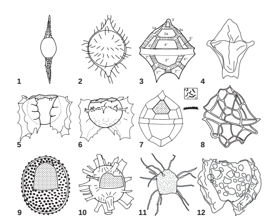
P6. *Hystrichosphaeridium–Manumiella*, p. 57.



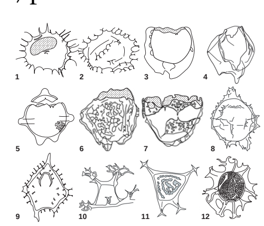
P7. *Melitasphaeridium–Palaeocystodinium*, p. 59.



P8. *Palaeohystrichophora–Selenopemphix*, p. 61.



P9. *Senoniasphaera–Xiphophoridium*, p. 63.



identified lower- and higher-latitude taxa. Bujak and Mudge (1994) distinguished temperature-sensitive species in North Sea Eocene assemblages. They found that warmer-water species include *Diphyes colligerum, Diphyes ficusoides, Dracodinium rhomboideum*, and *Dracodinium pachydermum*. *Eatonicysta ursulue* was inferred to indicate cooler water conditions. Bujak and Brinkhuis (1998) used the abundance of *Apectodinium* at the Paleocene/Eocene boundary as an indicator of warmer-water conditions. This hypothesis was further advanced in the studies of Crouch et al. (2001), who noted the correspondence of *Apectodinium* peaks with the Paleocene/Eocene Thermal Maximum. In the Neogene, the recognition of warmer- and colder-water species is becoming extremely sophisticated and is being tied to modern-day modeling of sea-surface temperatures and oceanic currents. Papers highlighting recent developments are de Vernal et al. (2000, 2001), Head (1994, 1996, 1997), Head et al. (2001), McMinn and Wells (1997), Mudie and Rochon (2001), and Rochon et al. (1999).

Several dinocyst papers also deal with the differentiation of Northern and Southern Hemisphere assemblages. Wilson (1967a, 1967b, 1967c, 1988) drew attention to the distinctive nature of some of the New Zealand assemblages and Deflandre and Cookson (1955) and Cookson and Eisenack (1958, 1960a, 1960b, 1962a, 1962b, 1965a, 1965b, 1965c) demonstrated the same for the Australian assemblages. Some of these differences reflect a paucity of studies of higher-latitude Northern Hemisphere assemblages, but some are undoubtedly real (see also **Brinkhuis, Sengers, et al.,** this volume).

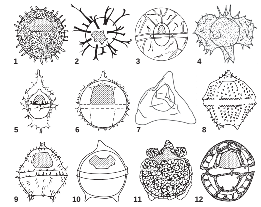
The above and other findings convinced us that we had to accommodate latitudinal and hemispherical control of dinocyst assemblages in the Tertiary plots. Accordingly, we give ranges for low, mid-, and high latitudes in both Northern and Southern Hemispheres. Use of the terms low, mid-, and high relates to the present day. But there is a relationship to some extent with the paleogeography, depending on a location's paleolatitude at any given time. Not surprisingly, our data are most comprehensive for the mid-latitudes of the Northern Hemisphere, a reflection of the much greater study of assemblages from these regions.

Uniform climatic conditions are more widespread in the Cretaceous, and thus we have not yet been able to separate many high- and low-latitude taxa. That such differences exist, however, has been documented by, for example, Lentin and Williams (1980), Williams et al. (1990), Mao and Mohr (1992), and **Brinkhuis, Sengers, et al.** (this volume).

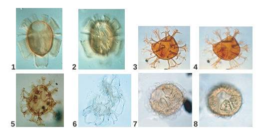
CONCLUDING REMARKS

We have not attempted to draw any conclusions regarding stratigraphic ranges of individual taxa since our findings are preliminary and too little is known about low-latitude taxa in general, high-latitude taxa in the Northern Hemisphere, and mid-latitude taxa in the Southern Hemisphere. And we know that many taxa are ubiquitous, with their stratigraphic ranges reflecting latitudinal control. It is imperative that we know which species are restricted to low, mid-, or high latitudes and which are more widespread but show latitudinal control on ranges. These insights should allow us to plot palinspastic reconstructions showing Late Cretaceous–Tertiary distribution patterns and help us define dinocyst paleoprovinces. We know that such paleoprovinces exist

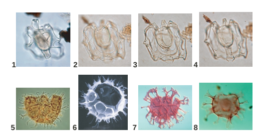
P10. *Sumatradinium–Xiphophoridium,* p. 65.



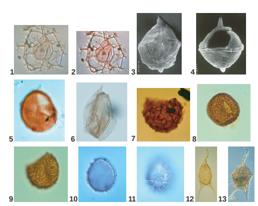
P11. *Achilleodinium–Arachnodinium,* p. 67.



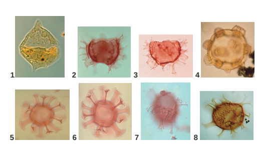
P12. *Areoligera–Chichaouadinium,* p. 69.



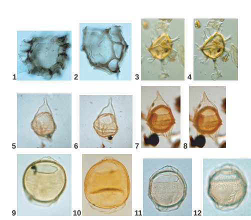
P13. *Carpatella–Chichaouadinium,* p. 71.



P14. *Chichaouadinium–Cyclonephelium,* p. 73.



P15. *Damassadinium–Diphyes,* p. 75.



(Lentin and Williams, 1980), but we need to generate more precise biostratigraphic data before drawing conclusions. Moreover, we need to identify those taxa, such as *Apectodinium*, that are strong indicators of warmer-water conditions. Utilization of such knowledge will make fossil dinocysts both key biostratigraphic and critical paleoecologic indicators in shelfal- and deeper-water regions.

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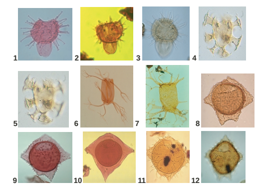
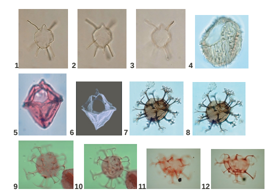
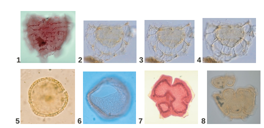
P16. *Distatodinium–Ectosphaeropsis,* p. 77.



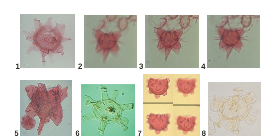
P17. *Edwardsiella–Gerdiocysta,* p. 79.



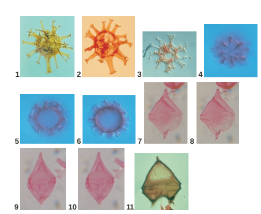
P18. *Glaphyrocysta–Hystrichokolpoma,* p. 81.



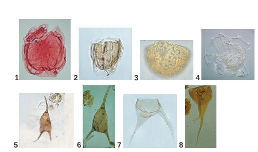
P19. *Hystrichosphaeridium–Kleithriasphaeridium,* p. 83.

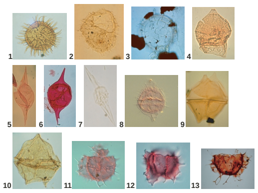


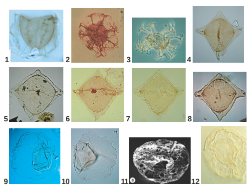
P20. *Labyrinthodinium–Membranilarnacia*, p. 85.

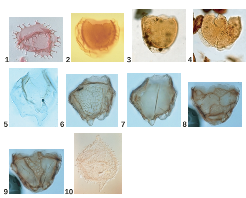


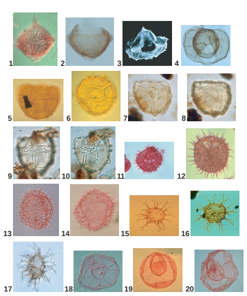
P21. *Membranophoridium–Operculodinium,* p. 87.

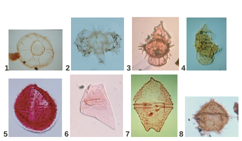


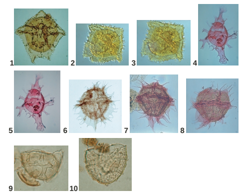


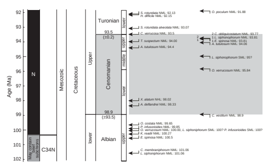


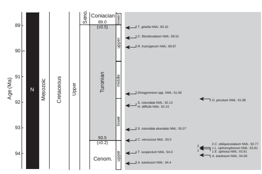


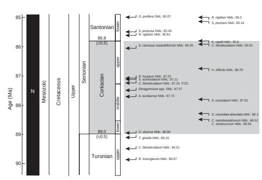


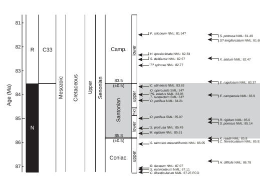


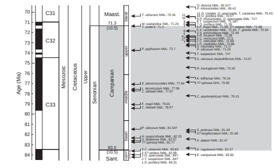


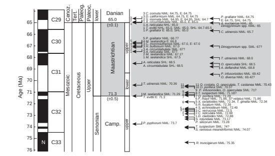


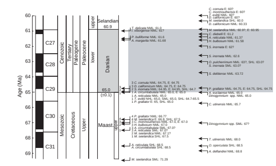


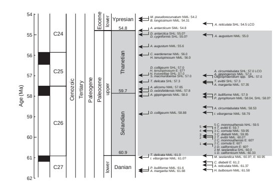


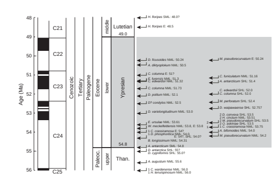


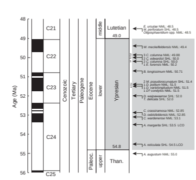


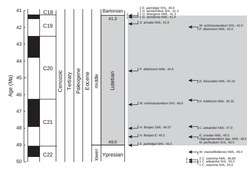


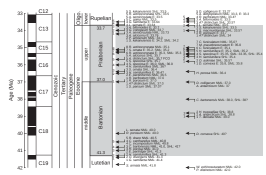


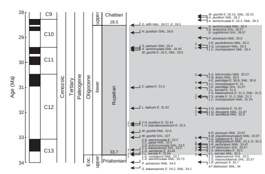


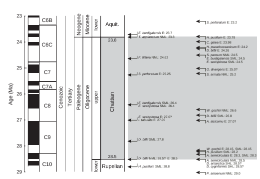


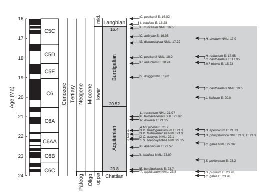


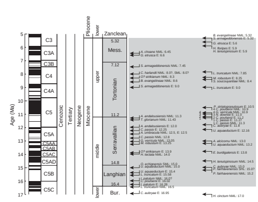


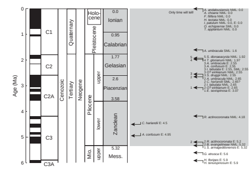












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APPENDIX

List of Taxa

The ages, in millions of years, for the taxa in this list are given in Table T1. (The names established in Zevenboom, 1995, were considered by the originating authors to be not validly published manuscript names, and hence are labeled as "invalid names" here.)

Achilleodinium biformoides (Eisenack 1954b) Eaton 1976

Achomosphaera alcicornu (Eisenack 1954b) Davey and Williams 1966a

Achomosphaera andalousiensis Jan du Chêne 1977

Adnatosphaeridium tutulosum (Cookson and Eisenack 1960a) Morgan 1980

Alisocysta circumtabulata (Drugg 1967) Stover and Evitt 1978

Alisocysta margarita (Harland 1979a) Harland 1979a

Alisocysta reticulata Damassa 1979b

Alisogymnium euclaense (Cookson and Eisenack 1970a) Lentin and Vozzhennikova 1990

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

Amiculosphaera umbraculum Harland 1979b

Apectodinium augustum (Harland 1979c) Lentin and Williams 1981

Apteodinium deflandrei (Clarke and Verdier 1967) Lucas-Clark 1987

Arachnodinium antarcticum Wilson and Clowes 1982

Areoligera gippingensis Jolley 1992

Areoligera semicirculata (Morgenroth 1966b) Stover and Evitt 1978

Areosphaeridium diktyoplokum (Klumpp 1953) Eaton 1971

Ataxiodinium choane Reid 1974

Ataxiodinium confusum Versteegh and Zevenboom in Versteegh 1995

Barssidinium evangelineae Lentin et al. 1994

Biconidinium longissimum Islam 1983c

Callaiosphaeridium asymmetricum (Deflandre and Courteville 1939) Davey and Williams 1966b

Cannosphaeropsis passio de Verteuil and Norris 1996a

Cannosphaeropsis utinensis O. Wetzel 1933b

Carpatella cornuta Grigorovich 1969a

Carpodinium obliquicostatum Cookson and Hughes 1964

Cassiculosphaeridia reticulata Davey 1969a

Cerebrocysta bartonensis Bujak in Bujak et al. 1980

Cerebrocysta poulsenii de Verteuil and Norris 1996a

Cerodinium diebelii (Alberti 1959b) Lentin and Williams 1987

Cerodinium wardenense (Williams and Downie 1966c) Lentin and Williams 1987

Charlesdowniea columna (Michoux 1988) Lentin and Vozzhennikova 1990

Charlesdowniea crassiramosa (Williams and Downie 1966b) Lentin and Vozzhennikova 1989

Charlesdowniea edwardsii (Wilson 1967c) Lentin and Vozzhennikova 1989

Chatangiella verrucosa (Manum 1963) Lentin and Williams 1976

Chichaouadinium vestitum (Brideaux 1971) Bujak and Davies 1983

Chiropteridium galea (Maier 1959) Sarjeant 1983

Conosphaeridium striatoconum (Deflandre and Cookson 1955) Cookson and Eisenack 1969

Cordosphaeridium cantharellus (Brosius 1963) Gocht 1969

Cordosphaeridium funiculatum Morgenroth 1966a

Corrudinium harlandii Matsuoka 1983b

Corrudinium incompositum (Drugg 1970b) Stover and Evitt 1978

Cousteaudinium aubryae de Verteuil and Norris 1996a

Cyclapophysis monmouthensis Benson 1976

Cyclonephelium filoreticulatum (Slimani 1994) Prince et al. 1999

Cyclonephelium membraniphorum Cookson and Eisenack 1962b

Damassadinium californicum (Drugg 1967) Fensome et al. 1993b

Deflandrea antarctica Wilson 1967a

Deflandrea convexa Wilson 1988

Deflandrea cygniformis Pöthe de Baldis 1966

Deflandrea oebisfeldensis Alberti 1959b

Deflandrea phosphoritica Eisenack 1938b

Dinogymnium spp.

Dinopterygium cladoides Deflandre 1935

Diphyes colligerum (Deflandre and Cookson 1955) Cookson 1965a

Diphyes ficusoides Islam 1983b

Distatodinium apenninicum Brinkhuis et al. 1992

Distatodinium biffii Brinkhuis et al. 1992

Dracodinium condylos (Williams and Downie 1966b) Costa and Downie 1979

Dracodinium politum Bujak et al. 1980

Dracodinium varielongitudum (Williams and Downie 1966b) Costa and Downie 1979

Dracodinium waipawaense (Wilson 1967c) Costa and Downie 1979

Eatonicysta furensis (Heilmann-Clausen in Heilmann-Clausen and Costa 1989) Stover and Williams 1995

Eatonicysta pterococcoides (O. Wetzel 1933b) Sarjeant 1985b

Eatonicysta ursulae (Morgenroth 1966a) Stover and Evitt 1978

Ectosphaeropsis burdigalensis Londeix and Jan du Chêne 1988

Edwardsiella sexispinosa Versteegh and Zevenboom in Versteegh 1995

Ellipsodinium rugulosum Clarke and Verdier 1967

Endoscrinium campanula (Gocht 1959) Vozzhennikova 1967

Enneadocysta partridgei Stover and Williams 1995

Enneadocysta pectiniformis (Gerlach 1961) Stover and Williams 1995

Epelidosphaeridia spinosa Cookson and Hughes 1964 ex Davey 1969a

Filisphaera filifera Bujak 1984

Florentinia mayi Kirsch 1991

Galeacysta etrusca Corradini and Biffi 1988

Gerdiocysta conopeum Liengjarern et al. 1980

Glaphyrocysta semitecta (Bujak in Bujak et al. 1980) Lentin and Williams 1981

Gramocysta verricula (Piasecki 1980) Lund and Lund-Christensen in Daniels et al. 1990

Habibacysta tectata Head et al. 1989b

Hemiplacophora semilunifera Cookson and Eisenack 1965a

Heteraulacacysta porosa Bujak in Bujak et al. 1980

Heterosphaeridium difficile (Manum and Cookson 1964) Ioannides 1986

Homotryblium floripes (Deflandre and Cookson 1955) Stover 1975

Homotryblium tenuispinosum Davey and Williams 1966b

Hystrichokolpoma bulbosum (Ehrenberg 1838) Morgenroth 1968

Hystrichokolpoma cinctum Klumpp 1953

"*Hystrichokolpoma pseudooceanicum*" Zevenboom and Santarelli in Zevenboom 1995: an invalid name

Hystrichokolpoma pusillum Biffi and Manum 1988

"*Hystrichokolpoma reductum*" Zevenboom and Santarelli in Zevenboom 1995: an invalid name

Hystrichosphaeridium truswelliae Wrenn and Hart 1988

Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937b

Hystrichosphaeropsis quasicribrata (O. Wetzel 1961) Gocht 1976

Impagidinium patulum (Wall 1967) Stover and Evitt 1978

Invertocysta tabulata Edwards 1984

Isabelidinium? *viborgense* Heilmann-Clausen 1985

Kleithriasphaeridium loffrense Davey and Verdier 1976

Kleithriasphaeridium readii (Davey and Williams 1966b) Davey and Verdier 1976

Labyrinthodinium truncatum Piasecki 1980

Laciniadinium biconiculum McIntyre 1975

Lentinia serrata Bujak in Bujak et al. 1980

Leptodinium italicum Biffi and Manum 1988

Litosphaeridium siphonophorum (Cookson and Eisenack 1958) Davey and Williams 1966b

Manumiella seelandica (Lange 1969) Bujak and Davies 1983

Melitasphaeridium pseudorecurvatum (Morgenroth 1966a) Bujak et al. 1980

Membranilarnacia? *picena* Biffi and Manum 1988

Membranophoridium perforatum Wilson 1988

"*Mendicodinium robustum*" Zevenboom and Santarelli in Zevenboom 1995: an invalid name

Nematosphaeropsis downiei Brown 1986

Octodinium askiniae Wrenn and Hart 1988

Odontochitina costata Alberti 1961

"*Odontochitina diversa*" Pearce 2000 unpublished thesis name

Odontochitina operculata (O. Wetzel 1933a) Deflandre and Cookson 1955

Odontochitina porifera Cookson 1956

Oligosphaeridium poculum Jain 1977b

Oligosphaeridium pulcherrimum (Deflandre and Cookson 1955) Davey and Williams 1966b

Oligosphaeridium spp.

Operculodinium divergens (Eisenack 1954b) Stover and Evitt 1978

Operculodinium echigoense Matsuoka 1983b

Operculodinium? *eirikianum* Head et al. 1989b

Ovoidinium verrucosum (Cookson and Hughes 1964) Davey 1970

Palaeocystodinium bulliforme Ioannides 1986

"*Palaeocystodinium striatogranulosum*" Zevenboom and Santarelli in Zevenboom 1995: an invalid name

Palaeohystrichophora infusorioides Deflandre 1935

Palaeoperidinium pyrophorum (Ehrenberg 1838 ex O. Wetzel 1933a) Sarjeant 1967b

Palaeotetradinium silicorum Deflandre 1936b

Palynodinium grallator Gocht 1970a

Phthanoperidinium amoenum Drugg and Loeblich Jr. 1967

Phthanoperidinium distinctum Bujak 1994
Pyxidinopsis fairhavenensis de Verteuil and Norris 1996a
Raetiaedinium truncigerum (Deflandre 1937b) Kirsch 1991
Raphidodinium fucatum Deflandre 1936b
Renidinium rigidum Prince et al. 1999
Reticulatosphaera actinocoronata (Benedek 1972) Bujak and Matsuoka 1986
Rhombodinium draco Gocht 1955
Rhombodinium perforatum (Jan du Chêne and Châteauneuf 1975) Lentin and Williams 1977b
Rhombodinium porosum Bujak 1979
Saturnodinium pansum (Stover 1977) Brinkhuis et al. 1992
Saturnodinium perforatum Brinkhuis et al. 1992
Schematophora speciosa Deflandre and Cookson 1955
Selenopemphix armageddonensis de Verteuil and Norris 1992
Selenopemphix armata Bujak in Bujak et al. 1980
Selenopemphix dionaeacysta Head et al. 1989b
Senoniasphaera inornata (Drugg 1970b) Stover and Evitt 1978
Senoniasphaera protrusa Clarke and Verdier 1967
Senoniasphaera rotundata Clarke and Verdier 1967
Senoniasphaera rotundata subsp. *alveolata* Pearce et al., 2003
Spinidinium echinoideum (Cookson and Eisenack 1960a) Lentin and Williams 1976
Spinidinium macmurdoense (Wilson 1967a) Lentin and Williams 1976
Spiniferites porosus (Manum and Cookson 1964) Harland 1973
Spiniferites ramosus subsp. *maeandriformis* (Corradini 1973) Lentin and Williams 1975
Spiniferites? *velatus* (Clarke and Verdier 1967) Stover and Evitt 1978
Spongodinium delitiense (Ehrenberg 1838) Deflandre 1936b
Stephodinium coronatum Deflandre 1936a
Stoveracysta kakanuiensis Clowes 1985
Stoveracysta ornata (Cookson and Eisenack 1965a) Clowes 1985
Sumatradinium druggii Lentin et al. 1994
Sumatradinium soucouyantiae de Verteuil and Norris 1992
Surculosphaeridium? *longifurcatum* (Firtion 1952) Davey et al. 1966
Thalassiphora delicata Williams and Downie 1966c
Thalassiphora? *spinosa* (Clarke and Verdier 1967) Foucher 1975
Triblastula utinensis O. Wetzel 1933b
Trichodinium castanea Deflandre 1935 ex Clarke and Verdier 1967
Trigonopyxidia ginella (Cookson and Eisenack 1960a) Downie and Sarjeant 1965
Trinovantedinium applanatum (Bradford 1977) Bujak and Davies 1983
Trinovantedinium glorianum (Head et al. 1989b) de Verteuil and Norris 1992
Trithyrodinium evittii Drugg 1967
Trithyrodinium suspectum (Manum and Cookson 1964) Davey 1969b
Unipontidinium aquaeductum (Piasecki 1980) Wrenn 1988
Wetzeliella gochtii Costa and Downie 1976
Wetzeliella meckelfeldensis Gocht 1969
Wilsonidium echinosuturatum (Wilson 1967c) Lentin and Williams 1976
Xenascus ceratioides (Deflandre 1937b) Lentin and Williams 1973
Xiphophoridium alatum (Cookson and Eisenack 1962b) Sarjeant 1966b

Figure F1. First and last occurrences of selected dinocyst taxa in the Cenomanian. NHL = Northern Hemisphere high latitudes, NML = Northern Hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

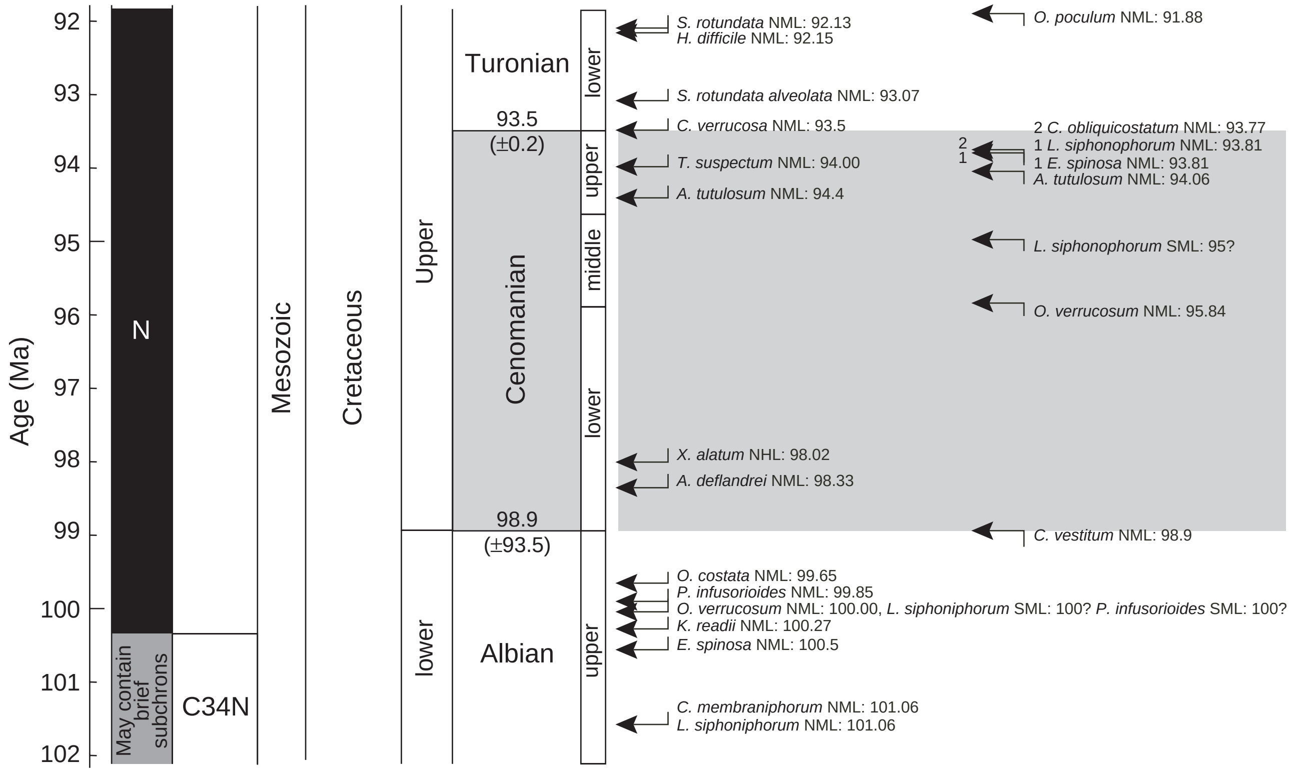


Figure F2. First occurrences of selected dinocyst taxa in the Turonian. NML = Northern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

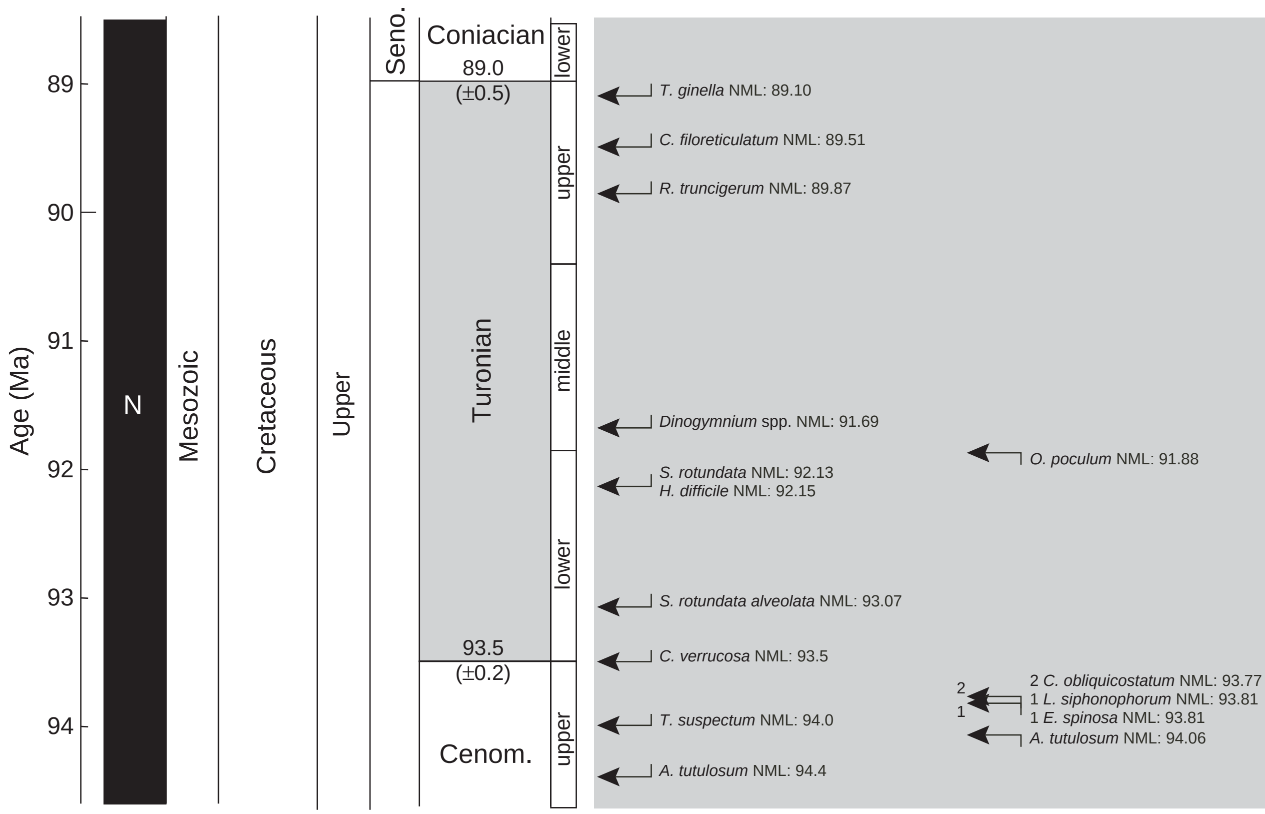


Figure F3. First and last occurrences of selected dinocyst taxa in the Coniacian. NML = Northern Hemisphere mid-latitudes, SML = Southern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

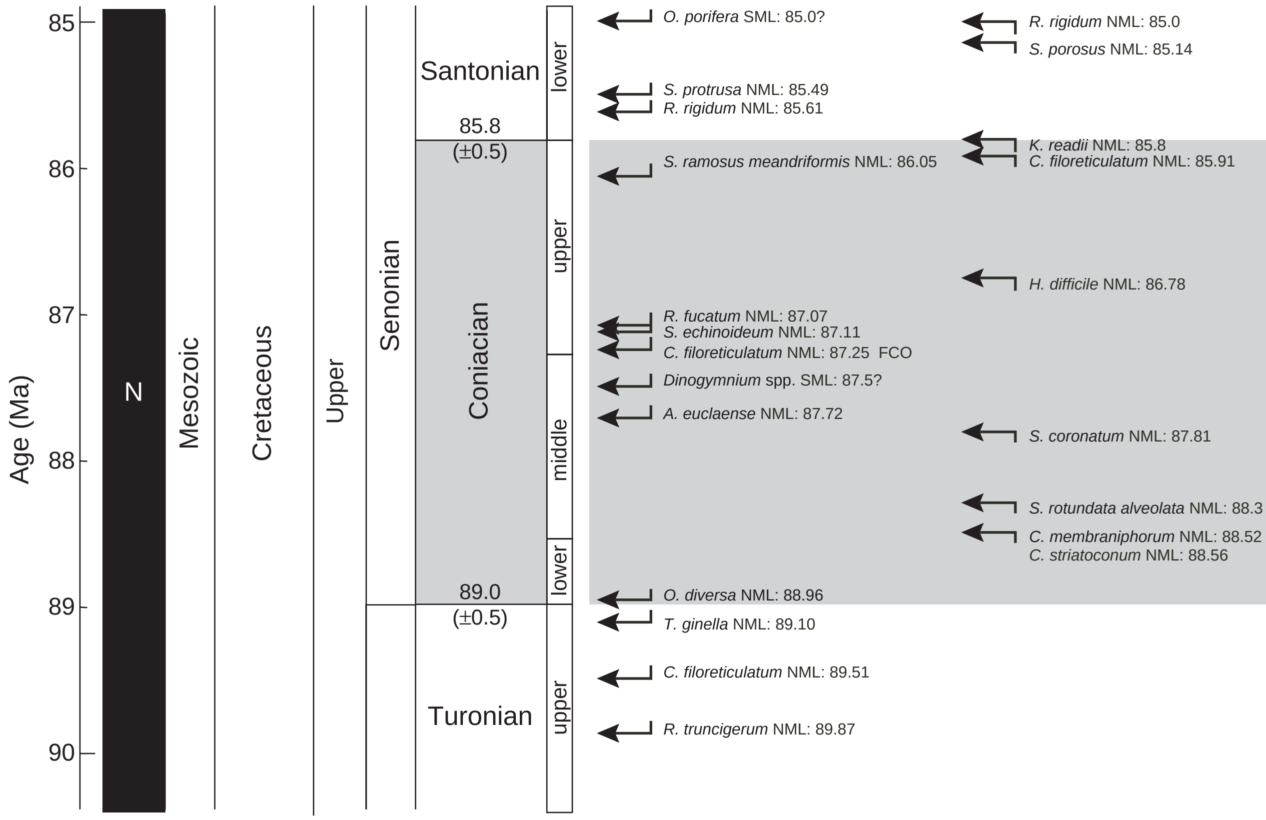


Figure F4. First and last occurrences of selected dinocyst taxa in the Santonian. NML = Northern Hemisphere mid-latitudes, SML = Southern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

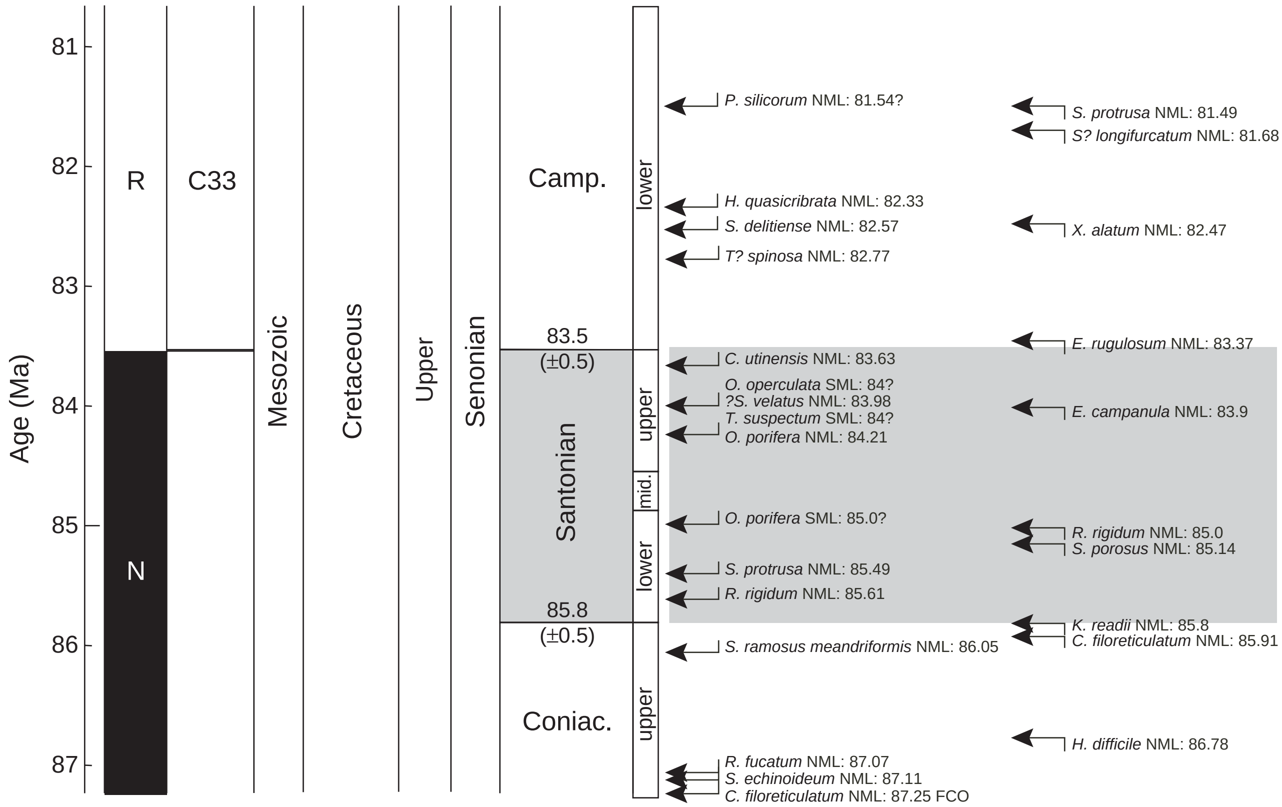


Figure F5. First last occurrences of selected dinocyst taxa in the Campanian. E = equatorial, NML = Northern Hemisphere mid-latitudes, SML = Southern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

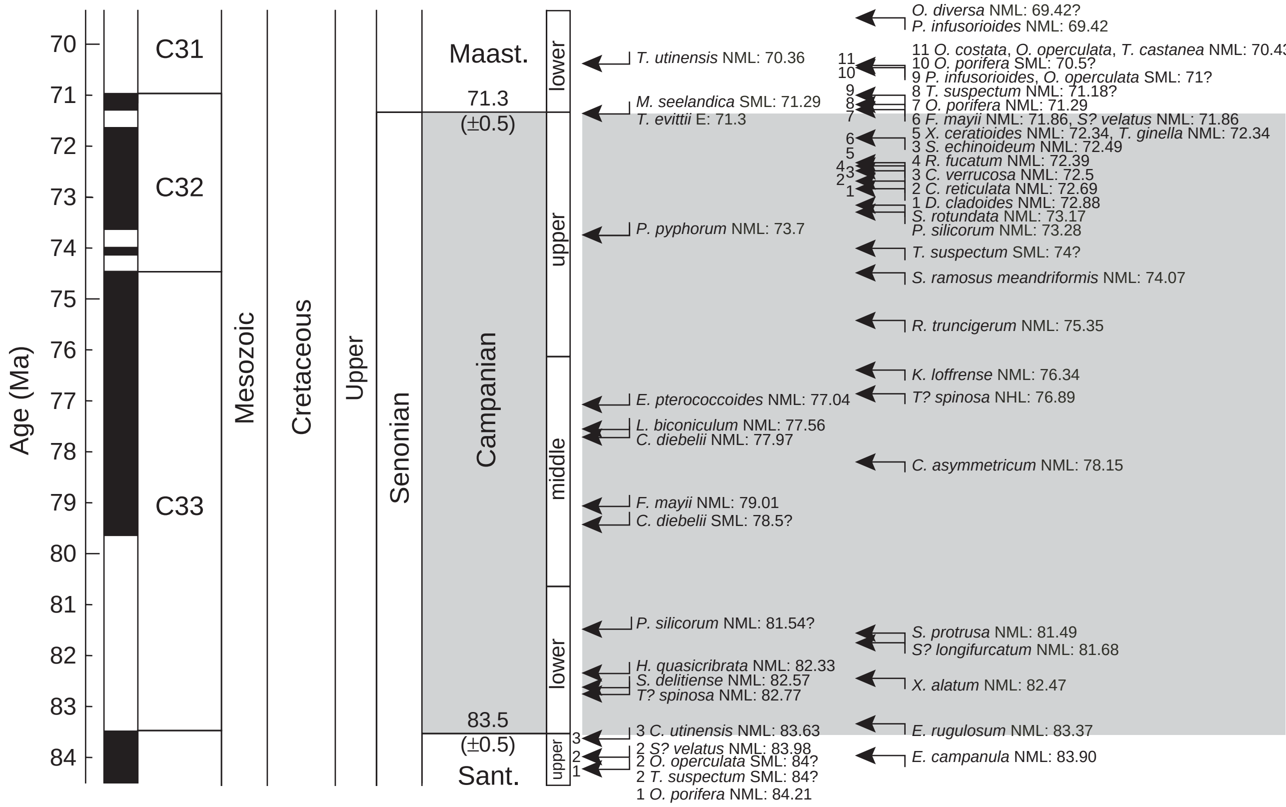


Figure F6. First and last occurrences of selected dinocyst taxa in the Maastrichtian. E = equatorial, NHL = Northern Hemisphere high latitudes, NML = Northern hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes, SML = Southern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

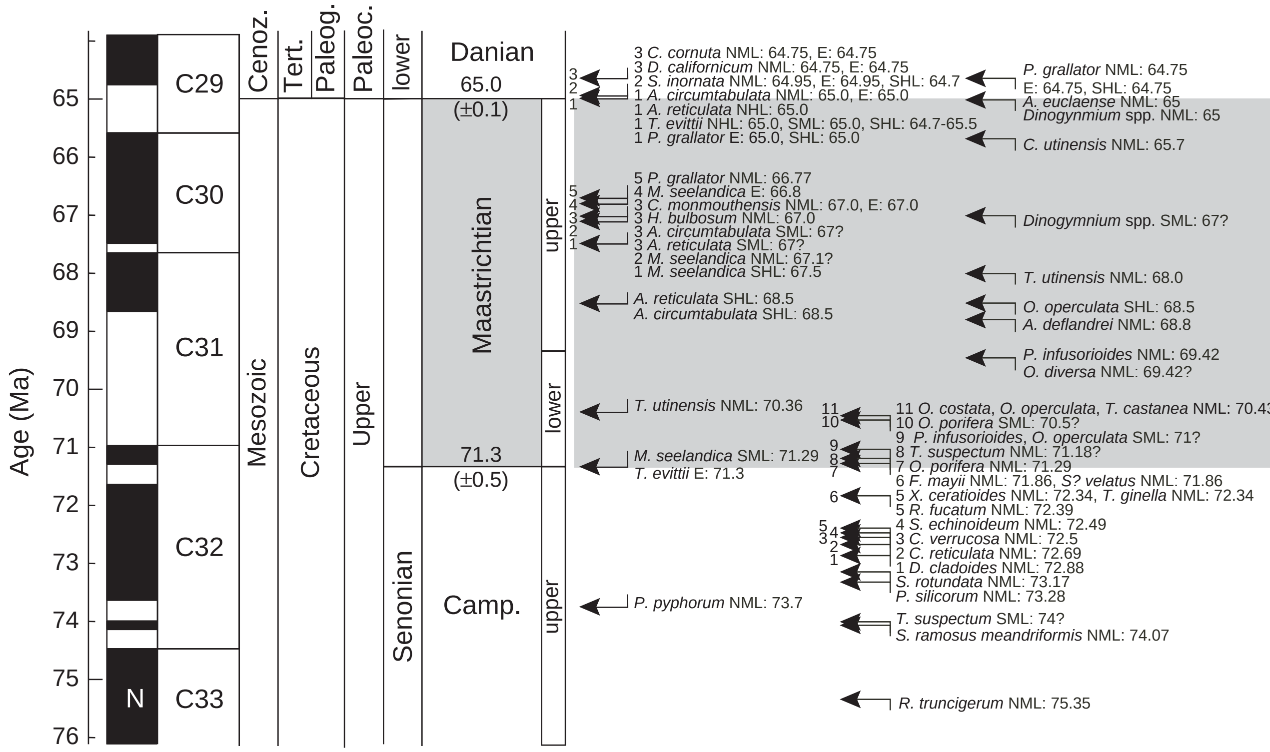


Figure F7. First and last occurrences of selected dinocyst taxa in the Danian. E = equatorial, NML = Northern Hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes, SML = Southern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

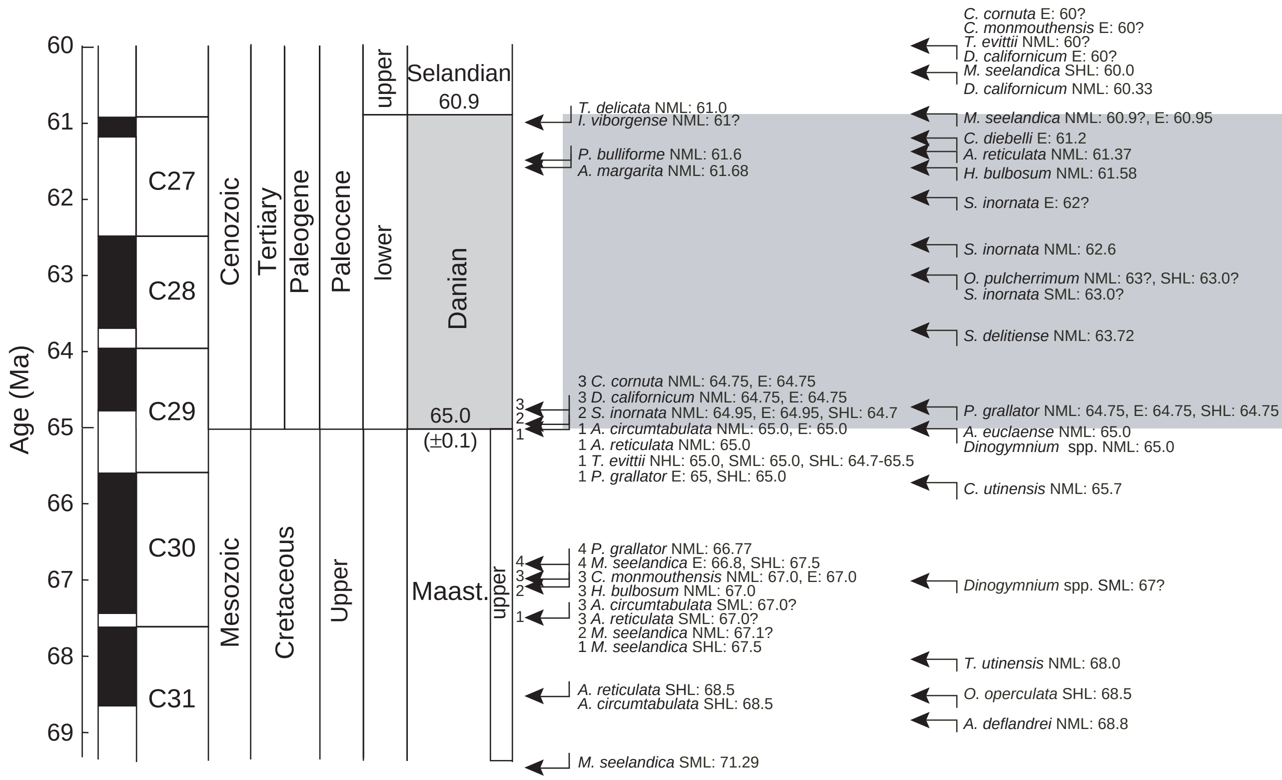


Figure F8. First and last occurrences of selected dinocyst taxa in the Selandian–Thanetian. E = equatorial, NHL = Northern Hemisphere high latitudes, NML = Northern Hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes, SML = Southern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

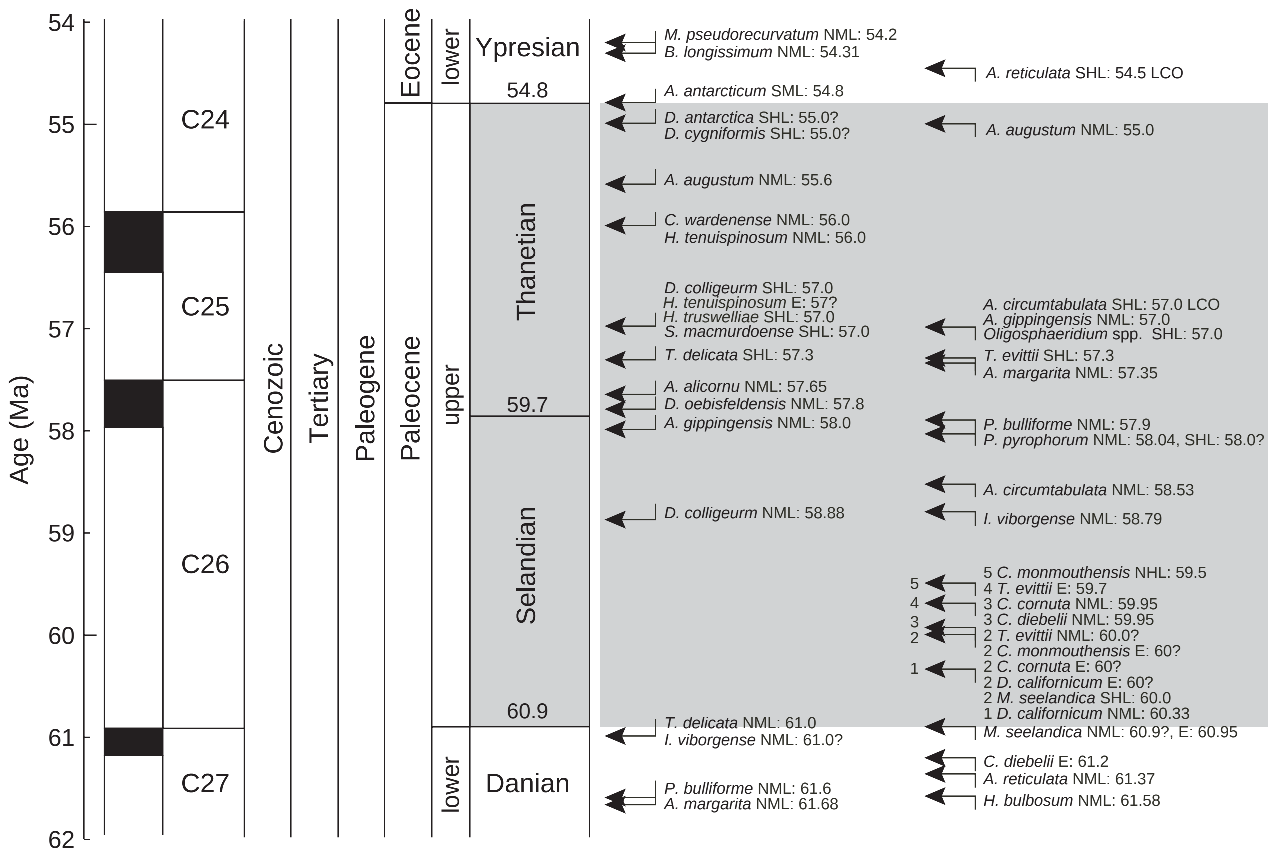


Figure F9. First occurrences of selected dinocyst taxa in the Ypresian. E = equatorial, NML = Northern Hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes, SML = Southern Hemisphere mid-latitudes.

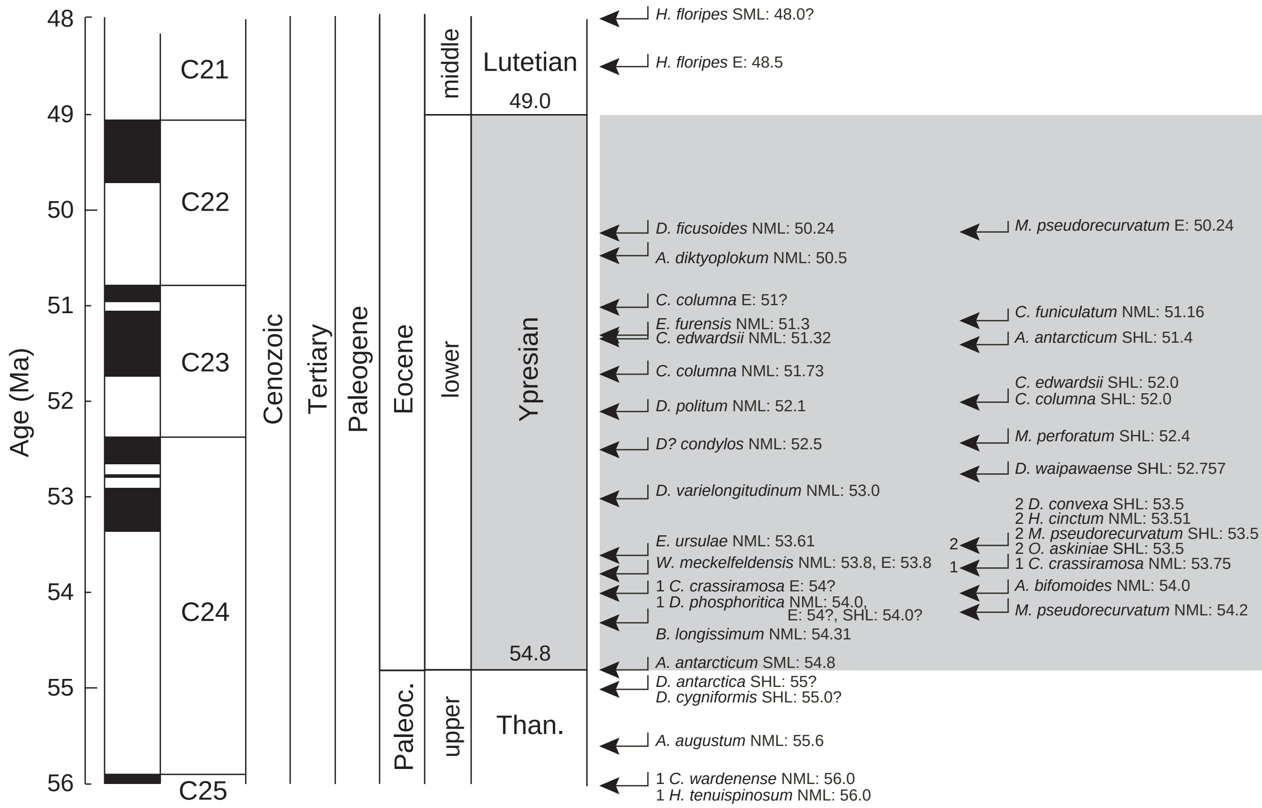


Figure F10. Last occurrences of selected dinocyst taxa in the Ypresian of the Northern Hemisphere. NML = Northern Hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes. LCO = last common occurrence.

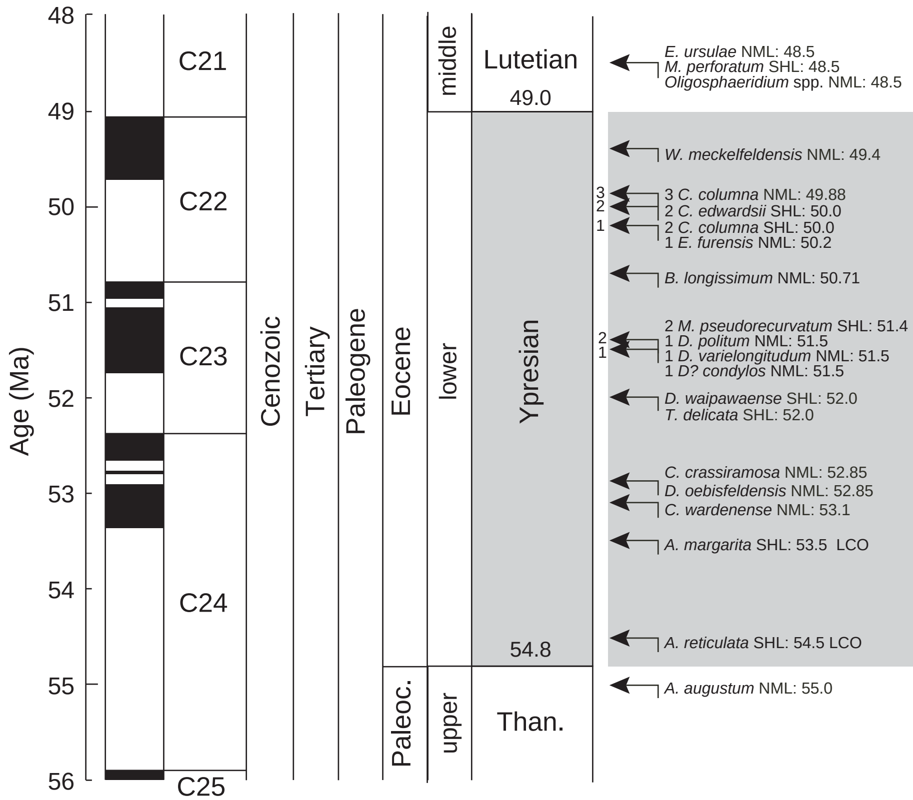


Figure F11. First and last occurrences of selected dinocyst taxa in the Lutetian. E = equatorial, NML = Northern Hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

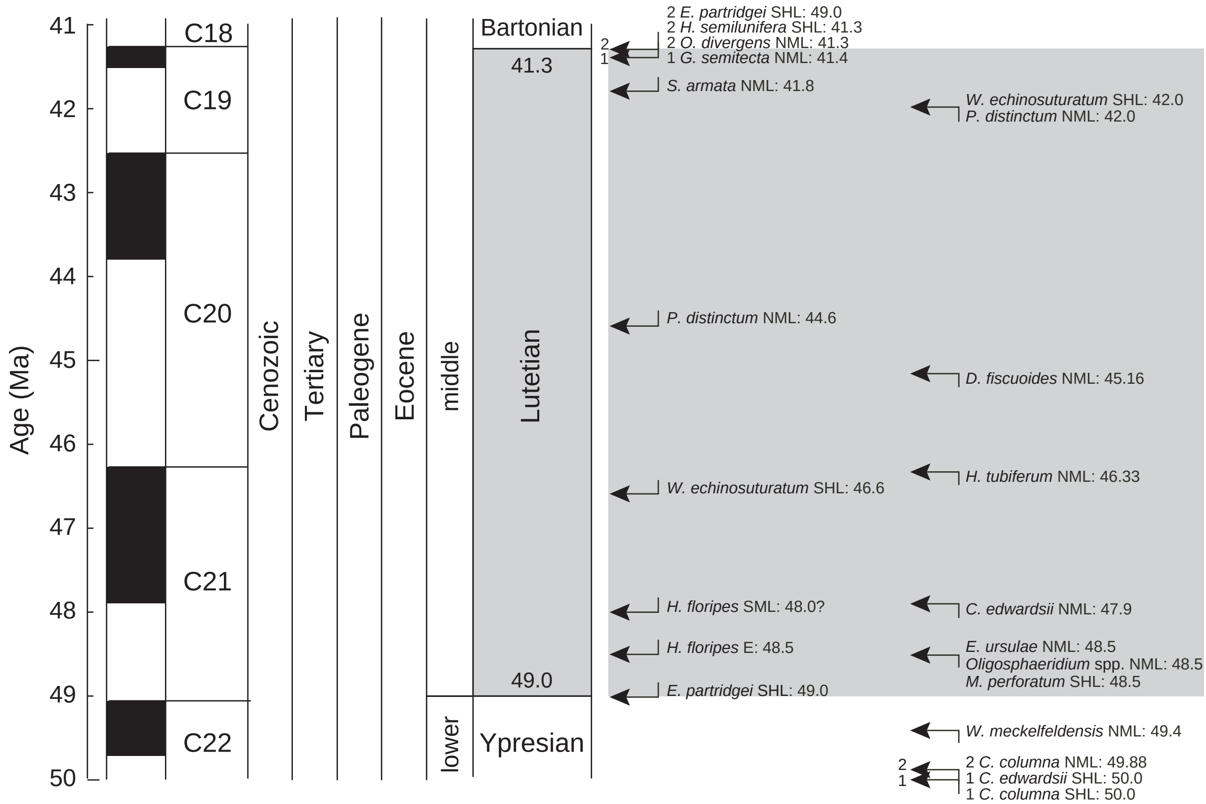


Figure F12. First and last occurrences of selected dinocyst taxa in the Bartonian–Priabonian. E = equatorial, NML = Northern Hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes, SML = Southern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

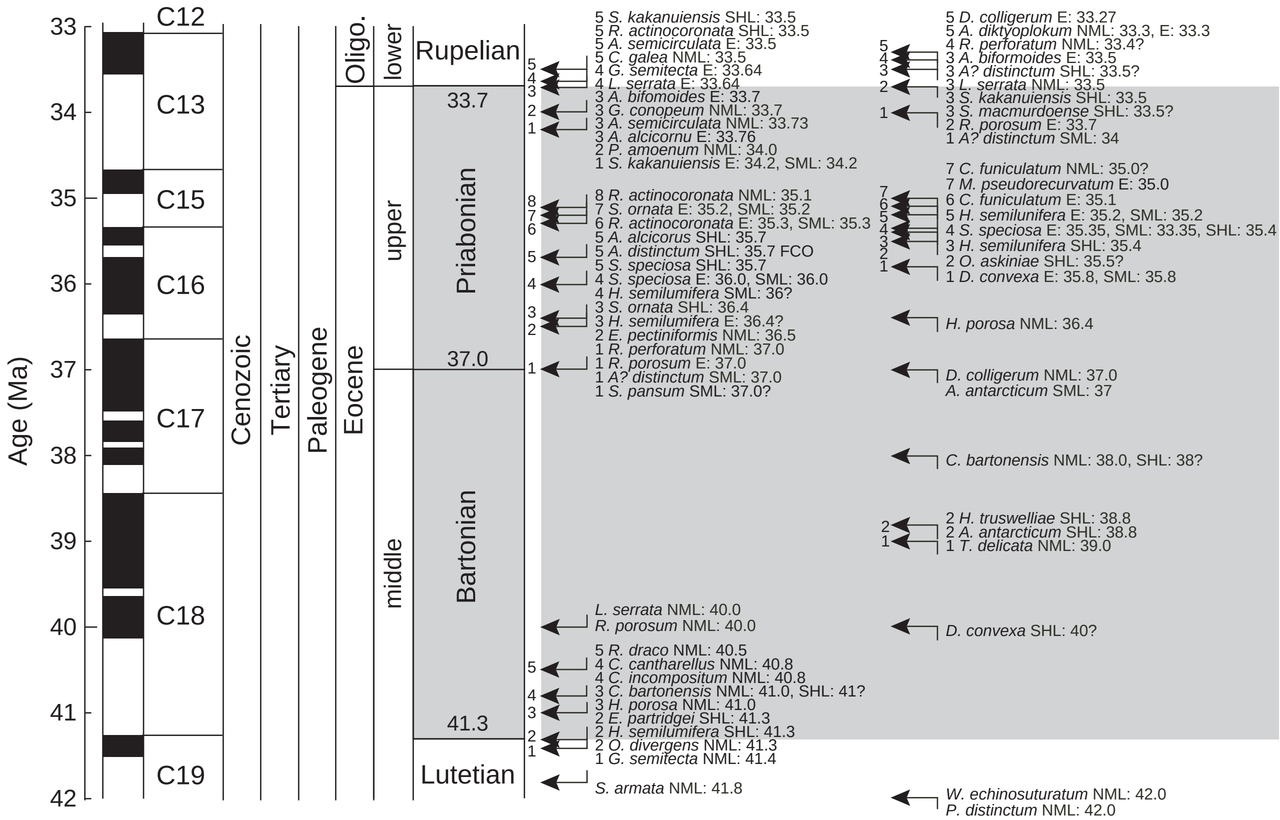


Figure F13. First and last occurrences of selected dinocyst taxa in the Rupelian. E = equatorial, NML = Northern Hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes, SML = Southern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

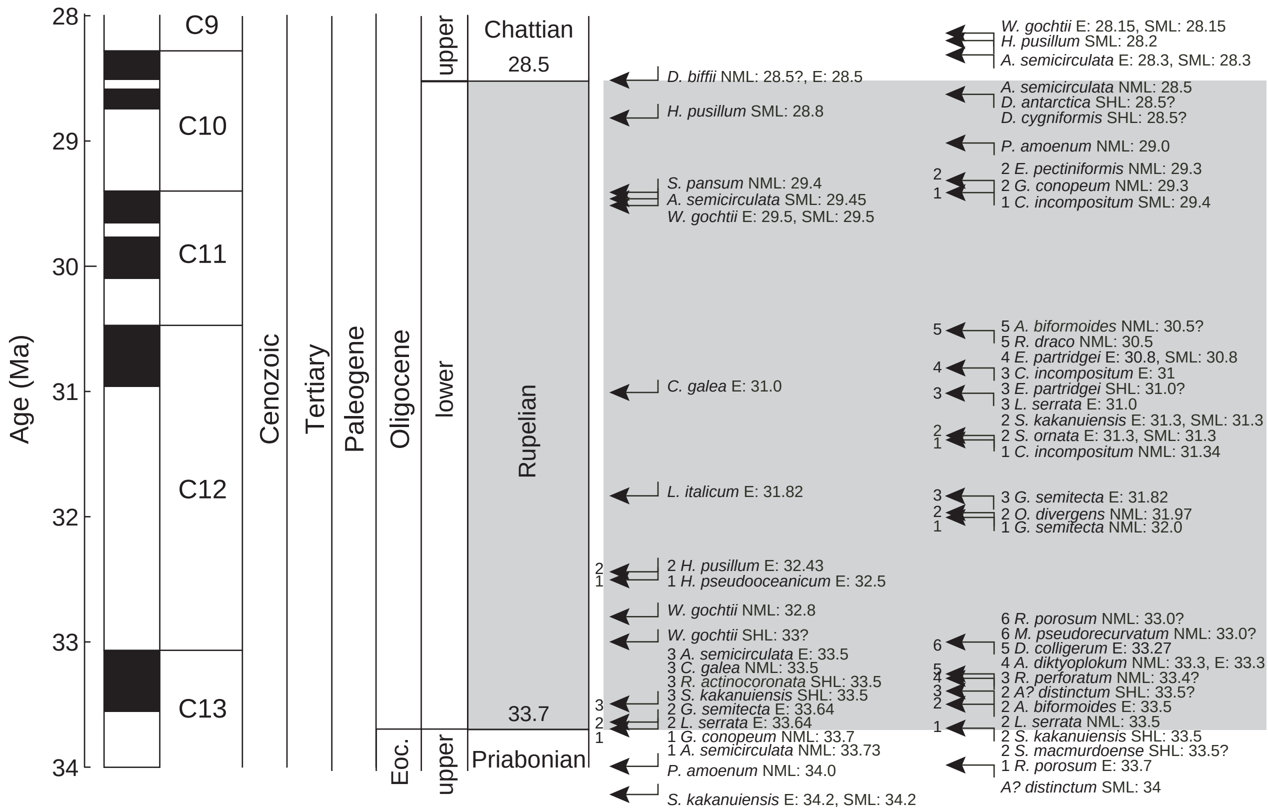


Figure F14. First and last occurrences of selected dinocyst taxa in the Chattian. E = equatorial, NML = Northern Hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes, SML = Southern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

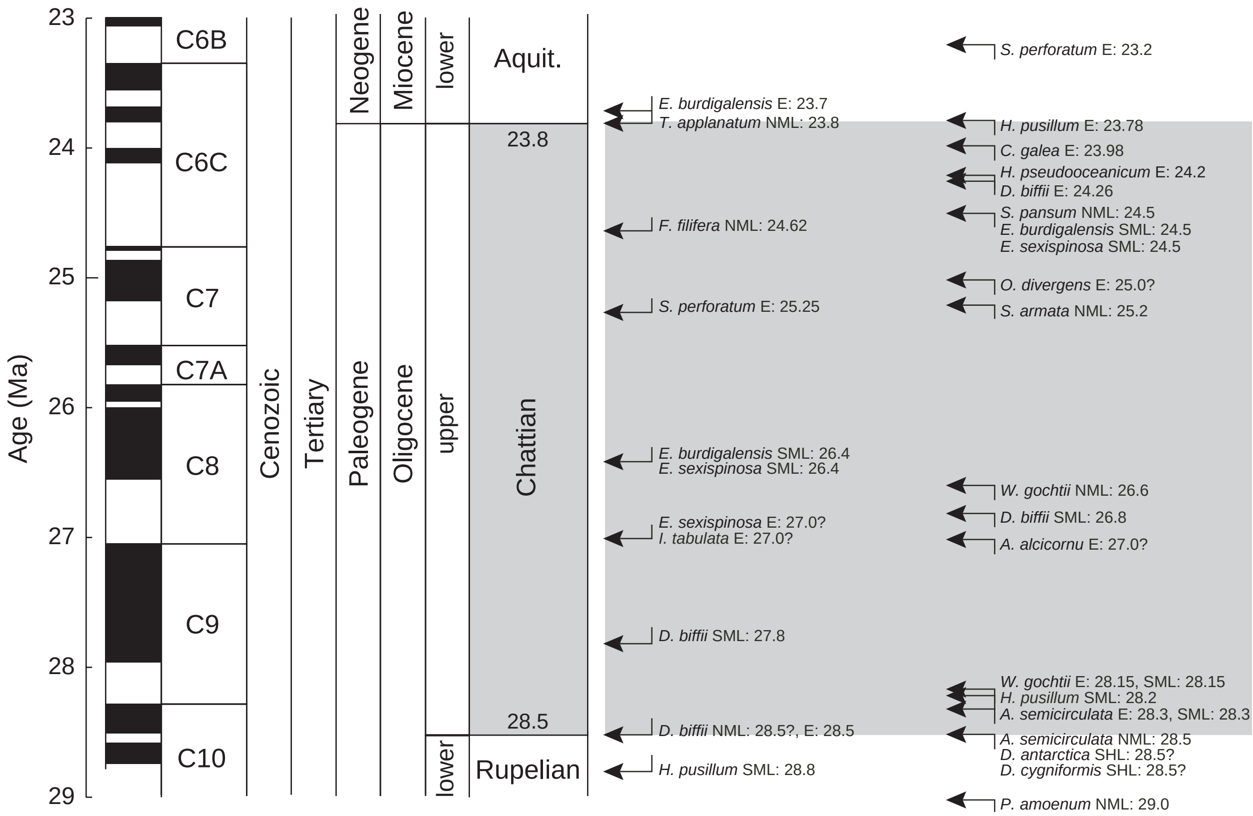


Figure F15. First and last occurrences of selected dinocyst taxa in the Aquitanian–Burdigalian. E = equatorial, NHL = Northern Hemisphere high latitudes, NML = Northern hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

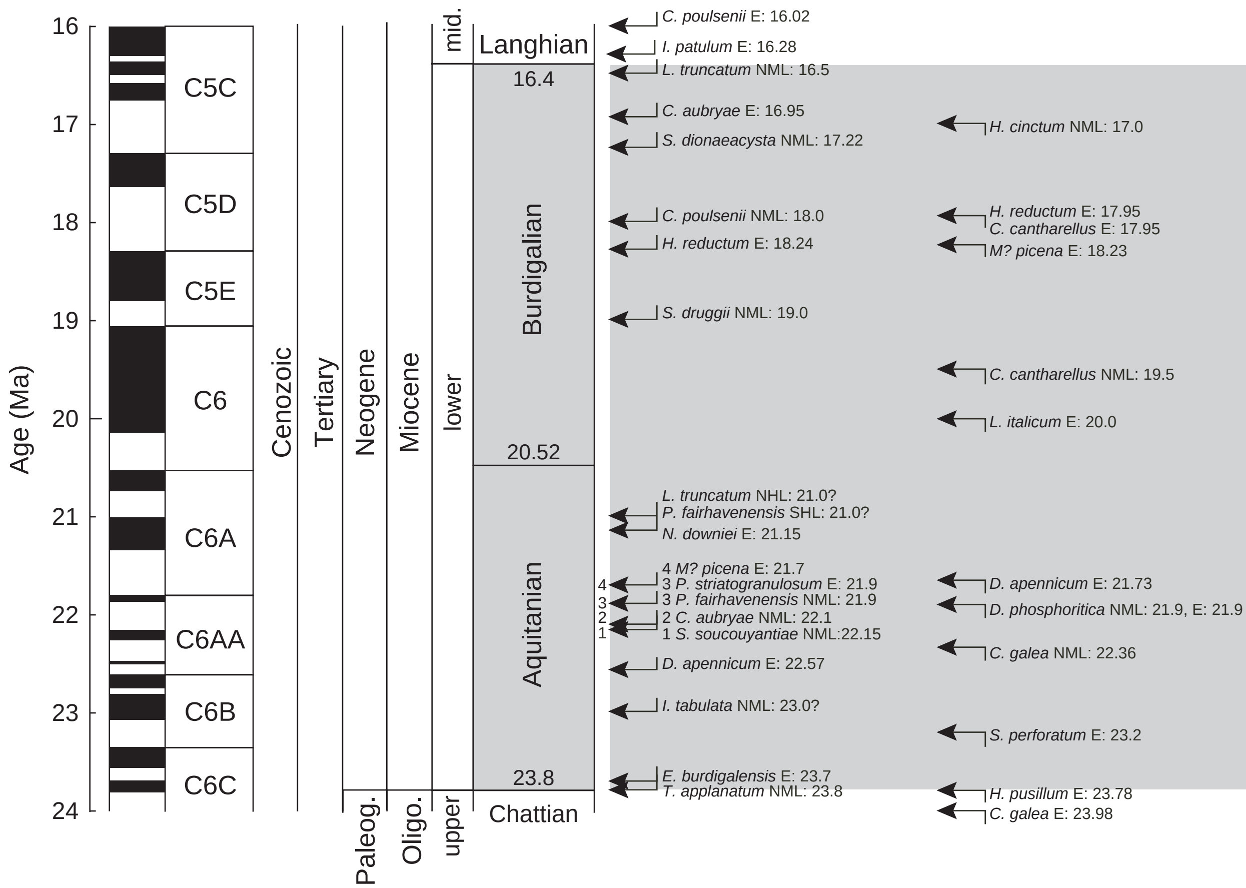


Figure F16. First and last occurrences of selected dinocyst taxa in the Langhian, Serravallian, Tortonian, and Messinian. E = equatorial, NML = Northern Hemisphere mid-latitudes, SHL = Southern Hemisphere high latitudes, SML = Southern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

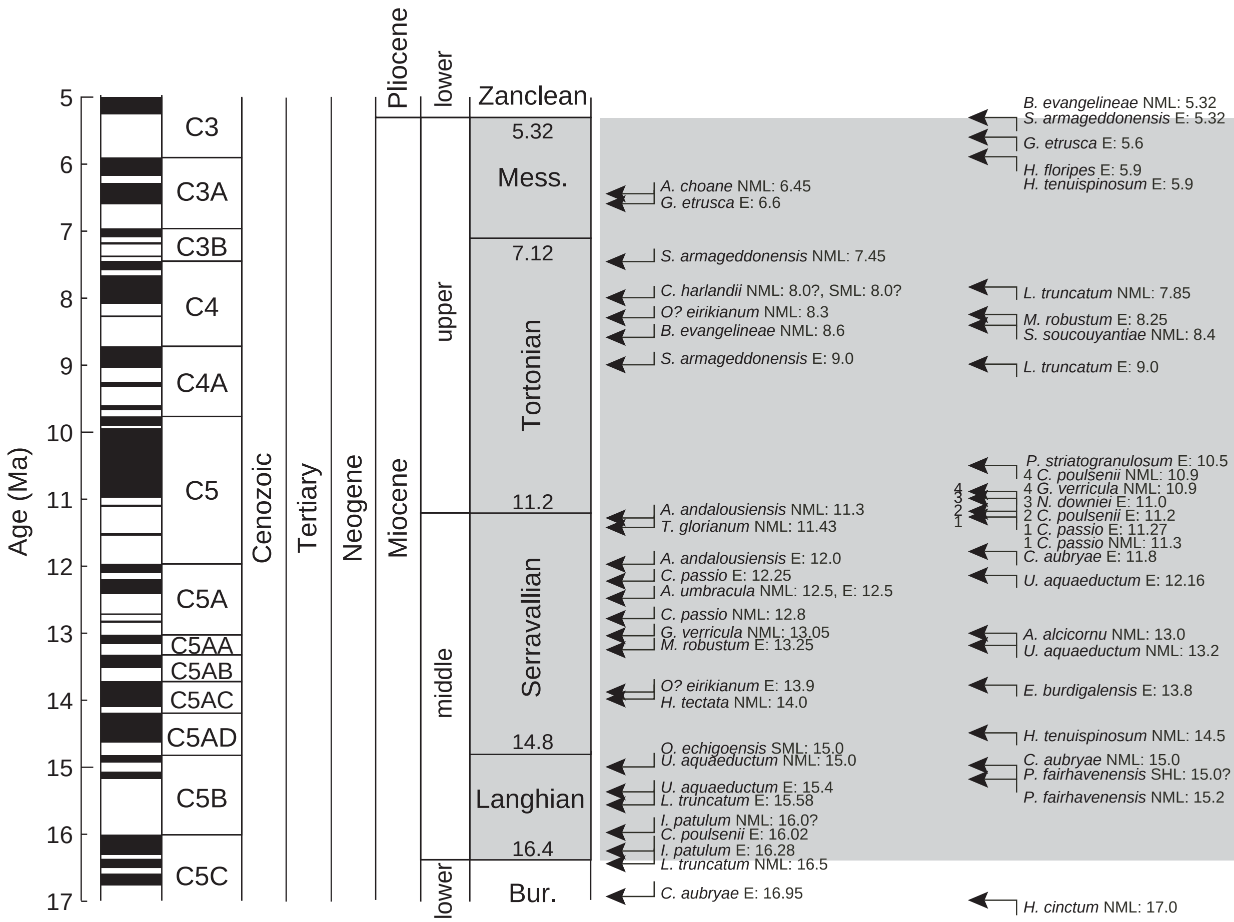


Figure F17. First and last occurrences of selected dinocyst taxa in the Pliocene, Pleistocene, and Holocene. E = equatorial, NML = Northern hemisphere mid-latitudes, SML = Southern Hemisphere mid-latitudes. Arrow with up bar = taxon first occurrence, arrow with down bar = taxon last occurrence.

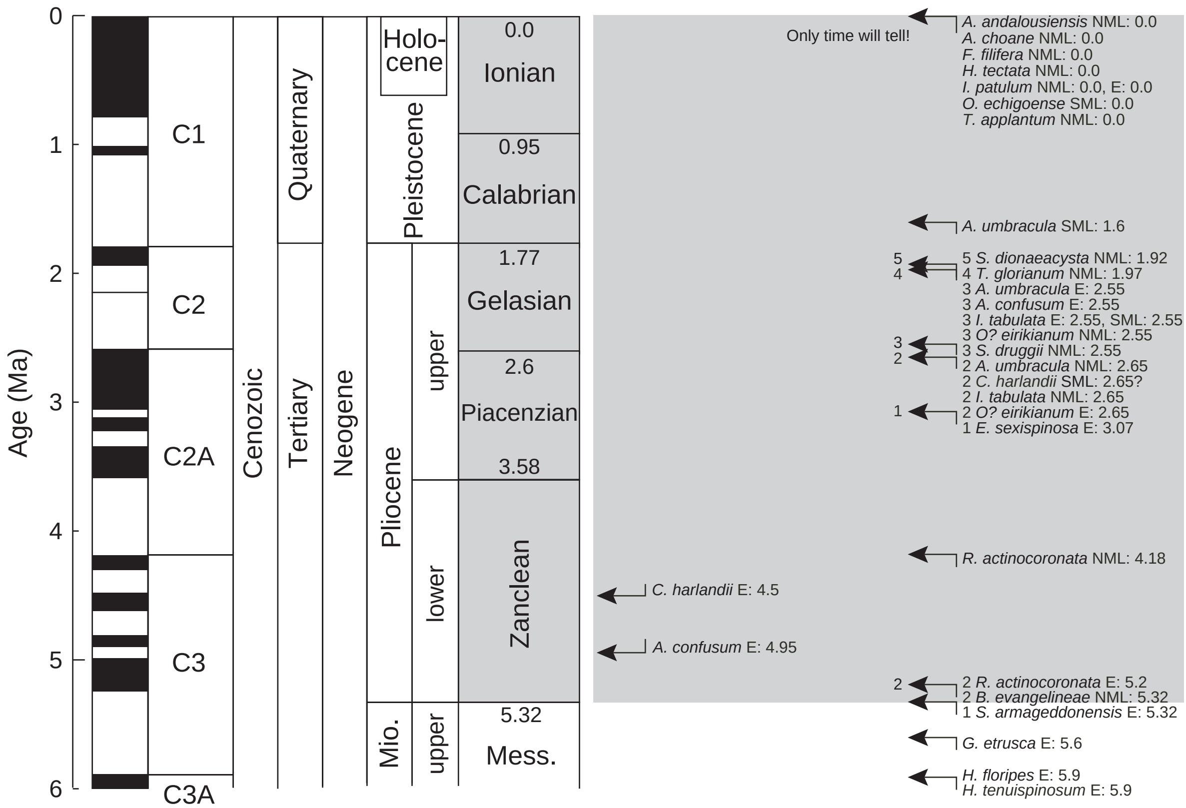


Table T1. Stratigraphic ranges, in millions of years, for selected Late Cretaceous–Cenozoic dinocyst species in the Northern and Southern Hemispheres. (This table is available in an **oversized format.**)

Table T2. Sequential listing of reference numbers, with accompanying citation.

Reference number	Reference	Geography	Realm	Calibration
1	Below 1981	Germany	Boreal	Biostratigraphy
2	Davey and Verdier 1971	Paris Basin	Boreal	Biostratigraphy
3	Davey and Verdier 1973	France	Boreal/Tethys	Biostratigraphy
4	Davey and Verdier 1974	France	Boreal/Tethys	Biostratigraphy
5	Davey 1979	England	Boreal	Biostratigraphy
6	Duxbury 1977	Speeton	Boreal	Biostratigraphy
7	Duxbury 1980	Speeton	Boreal	Biostratigraphy
8	Duxbury 1983	Isle of Wight	Boreal	Biostratigraphy
9	Head et al. 1989c	Labrador Sea	NH arctic	Extrapolated/Biostratigraphy
10	Foucher 1979	Paris Basin	Boreal	Biostratigraphy
11	Habib and Drugg 1983	France/Switzerland	Tethys	Biostratigraphy
12	De Graciansky et al. 1998	Europe	Boreal/Tethys	Biostratigraphy
13	Harding 1990	Germany/England	Boreal	Biostratigraphy
14	Hoedemaeker and Leereveld 1995	Southeast Spain	Tethys	Biostratigraphy
15	Hoek et al. 1996	Israel	Tethys	Biostratigraphy
16	Jarvis et al. 1988	England	Boreal	Biostratigraphy
17	Kirsch 1991	South Germany	Boreal	Biostratigraphy
18	Leereveld 1995	South Spain	Tethys	Biostratigraphy
19	Londeix 1990	South France	Tethys	Biostratigraphy
20	Roncaglia et al. 1999	New Zealand	Mid-latitude SH	Biostratigraphy
21	Monteil 1985	South France	Tethys	Biostratigraphy
22	Monteil 1992	South France	Tethys	Biostratigraphy
23	Pearce 2000	England	Boreal	Biostratigraphy
24	Powell 1992	United Kingdom	Boreal	Biostratigraphy
25	Prince et al 1999	Isle of Wight	Boreal	Biostratigraphy
26	Prössl 1990	North Germany	Boreal	Biostratigraphy
27	Robaszynski et al. 1982	Belgium	Boreal	Biostratigraphy
28	Brinkhuis and Schiøler 1996	Northwest Europe	Boreal	Biostratigraphy
29	Schiøler and Wilson 1993	Denmark	Boreal	Biostratigraphy
30	Tocher and Jarvis 1987	South England	Boreal	Biostratigraphy
31	Verdier 1975	North France	Boreal	Biostratigraphy
32	Wilpshaar 1995	South France	Tethys	Biostratigraphy
33	Wilson 1974	Northwest Europe	Boreal	Biostratigraphy
34	Xpert LPP/Williams/Pearce	Global	Global	Biostratigraphy
35	Williams et al. 1993	Global	Global	Extrapolated
36	de Verteuil and Norris 1996a	Northwest Atlantic	Mid-latitude NH	Extrapolated/Biostratigraphy
37	Powell et al. 1996	Northwest Europe	Mid-latitude NH	Magnetostratigraphy
38	Zevenboom 1995	South Europe	Low latitude NH	Magnetostratigraphy/Biostratigraphy
39	Bujak et al. 1980	Northwest Europe	Mid-latitude NH	Biostratigraphy
40	Bujak and Mudge 1994	Northwest Europe	Mid-latitude NH	Extrapolated
41	Mudge and Bujak 1996	Northwest Europe	Mid-latitude NH	Extrapolated
42	Heilmann-Clausen 1985	Northwest Europe	Mid latitude NH	Biostratigraphy
43	Köthe 1990	Northwest Europe	Mid-latitude NH	Extrapolated/Biostratigraphy
44	Wilson 1988	New Zealand	Mid-latitude SH	Extrapolated/Biostratigraphy
45	Stover and Hardenbol 1994	Northwest Europe	Mid-latitude NH	Biostratigraphy
46	McMinn 1992	Australia, ODP Leg 123	Low-latitude SH	Biostratigraphy
47	Heilmann-Clausen and Costa 1989	Northwest Europe	Mid latitude NH	Biostratigraphy
48	Brinkhuis and Biffi 1993	Italy	Low-latitude NH	Magnetostratigraphy
49	Wrenn and Hart 1988	Antarctica	High-latitude SH	Magnetostratigraphy/Biostratigraphy
50	Brinkhuis et al. 1998	Africa, Northwest Europe	Low-mid latitude NH	Biostratigraphy
51	Helby et al. 1987	Australia	Low-mid latitude SH	Biostratigraphy
52	Brinkhuis and Leereveld 1988	Africa	Low-latitude NH	Biostratigraphy
53	Brinkhuis and Zachariasse 1988	Africa	Low-latitude NH	Biostratigraphy
54	Raine et al. 1997	New Zealand	Mid-latitude SH	Extrapolated/Biostratigraphy
55	Wilpshaar et al. 1996	Italy	Low-latitude NH	Magnetostratigraphy
56	Stover and Williams 1995	Global	Global	Extrapolated/Biostratigraphy
57	Brinkhuis et al. 1992	Italy	Low-latitude NH	Magnetostratigraphy
58	**Brinkhuis, Sengers, et al.,** this volume	Offshore Tasmania	Low–mid latitude SH	Magnetostratigraphy/Biostratigraphy
59	**Brinkhuis, Munsterman, et al.,** this volume	Offshore Tasmania	High-latitude SH	Magnetostratigraphy/Biostratigraphy
60	Pearce et al. 2003	England	Boreal	Biostratigraphy
61	Prince 1997	England	Boreal	Biostratigraphy

Notes: Reference numbers are used in Table **T1**, p. 43. NH = Northern Hemisphere, SH = Southern Hemisphere.

Table T3. Alphabetic listing of reference numbers, with accompanying citation.

Reference number	Reference	Geography	Realm	Calibration
1	Below 1981	Germany	Boreal	Biostratigraphy
48	Brinkhuis and Biffi 1993	Italy	Low-latitude NH	Magnetostratigraphy
52	Brinkhuis and Leereveld 1988	Africa	Low-latitude NH	Biostratigraphy
28	Brinkhuis and Schiøler 1996	North West Europe	Boreal	Biostratigraphy
53	Brinkhuis and Zachariasse 1988	Africa	Low-latitude NH	Biostratigraphy
57	Brinkhuis et al. 1992	Italy	Low-latitude NH	Magnetostratigraphy
50	Brinkhuis et al. 1998	Africa, Northwest Europe	Low-mid-latitude NH	Biostratigraphy
58	**Brinkhuis, Sengers, et al.,** this volume	Offshore Tasmania	Low-mid-latitude SH	Magnetostratigraphy/Biostratigraphy
59	**Brinkhuis, Munsterman, et al.,** this volume	Offshore Tasmania	High-latitude SH	Magnetostratigraphy/Biostratigraphy
40	Bujak and Mudge 1994	Northwest Europe	Mid-latitude NH	Extrapolated
39	Bujak et al. 1980	Northwest Europe	Mid-latitude NH	Biostratigraphy
5	Davey 1979	England	Boreal	Biostratigraphy
2	Davey and Verdier 1971	Paris Basin	Boreal	Biostratigraphy
3	Davey and Verdier 1973	France	Boreal/Tethys	Biostratigraphy
4	Davey and Verdier 1974	France	Boreal/Tethys	Biostratigraphy
12	De Graciansky et al. 1998	Europe	Boreal/Tethys	Biostratigraphy
36	de Verteuil and Norris 1996a	Northwest Atlantic	Mid-latitude NH	Extrapolated/Biostratigraphy
6	Duxbury 1977	Speeton	Boreal	Biostratigraphy
7	Duxbury 1980	Speeton	Boreal	Biostratigraphy
8	Duxbury 1983	Isle of Wight	Boreal	Biostratigraphy
10	Foucher 1979	Paris Basin	Boreal	Biostratigraphy
11	Habib and Drugg 1983	France/Switzerland	Tethys	Biostratigraphy
13	Harding 1990	Germany/England	Boreal	Biostratigraphy
9	Head et al. 1989c	Labrador Sea	NH arctic	Extrapolated/Biostratigraphy
42	Heilmann-Clausen 1985	Northwest Europe	Mid-latitude NH	Biostratigraphy
47	Heilmann-Clausen and Costa 1989	Northwest Europe	Mid-latitude NH	Biostratigraphy
51	Helby et al. 1987	Australia	Low-mid-latitude SH	Biostratigraphy
14	Hoedemaeker and Leereveld 1995	Southeast Spain	Tethys	Biostratigraphy
15	Hoek et al. 1996	Israel	Tethys	Biostratigraphy
16	Jarvis et al. 1988	England	Boreal	Biostratigraphy
17	Kirsch 1991	South Germany	Boreal	Biostratigraphy
43	Köthe 1990	Northwest Europe	Mid-latitude NH	Extrapolated/Biostratigraphy
18	Leereveld 1995	South Spain	Tethys	Biostratigraphy
19	Londeix 1990	South France	Tethys	Biostratigraphy
46	McMinn 1992	Australia, ODP123	Low-latitude SH	Biostratigraphy
21	Monteil 1985	South France	Tethys	Biostratigraphy
22	Monteil 1992	South France	Tethys	Biostratigraphy
41	Mudge and Bujak 1996	Northwest Europe	Mid-latitude NH	Extrapolated
23	Pearce 2000	England	Boreal	Biostratigraphy
60	Pearce et al. 2003	England	Boreal	Biostratigraphy
24	Powell 1992	United Kingdom	Boreal	Biostratigraphy
37	Powell et al. 1996	Northwest Europe	Mid-latitude NH	Magnetostratigraphy
61	Prince 1997	England	Boreal	Biostratigraphy
25	Prince et al 1999	Isle of Wight	Boreal	Biostratigraphy
26	Prössl 1990	North Germany	Boreal	Biostratigraphy
54	Raine et al. 1997	New Zealand	Mid-latitude SH	Extrapolated/Biostratigraphy
27	Robaszynski et al. 1982	Belgium	Boreal	Biostratigraphy
20	Roncaglia et al. 1999	New Zealand	Mid-latitude SH	Biostratigraphy
29	Schiøler and Wilson 1993	Denmark	Boreal	Biostratigraphy
45	Stover and Hardenbol 1994	Northwest Europe	Mid-latitude NH	Biostratigraphy
56	Stover and Williams 1995	Global	Global	Extrapolated/Biostratigraphy
30	Tocher and Jarvis 1987	South England	Boreal	Biostratigraphy
31	Verdier 1975	North France	Boreal	Biostratigraphy
35	Williams et al. 1993	Global	Global	Extrapolated
32	Wilpshaar 1995	South France	Tethys	Biostratigraphy
55	Wilpshaar et al. 1996	Italy	Low-latitude NH	Magnetostratigraphy
33	Wilson 1974	Northwest Europe	Boreal	Biostratigraphy
44	Wilson 1988	New Zealand	Mid-latitude SH	Extrapolated/Biostratigraphy
49	Wrenn and Hart 1988	Antarctica	High-latitude SH	Magnetostratigraphy/Biostratigraphy
34	Xpert LPP/Williams Pearce	Global	Global	Biostratigraphy
38	Zevenboom 1995	South Europe	Low-latitude NH	Magnetostratigraphy/Biostratigraphy

Notes: Reference numbers are used in Table **T1**, p. 43. NH = Northern Hemisphere, SH = Southern Hemisphere.

Table T4. Ages for geochronologic divisions.

Stratigraphic unit	Age (Ma)	
	Top	Basis
Albian	98.94	112.18
Albian lower	106.18	112.18
Albian middle	102.12	106.18
Albian upper	98.94	102.12
Aptian	112.18	120.98
Aptian lower	117.07	120.98
Aptian upper	112.18	117.07
Aquitanian	20.52	23.8
Barremian	120.98	127.03
Barremian lower	124.76	127.03
Barremian upper	120.98	124.76
Bartonian	37	41.3
Berriasian	136.99	144.19
Bidentatum	120.98	121.11
Bowerbanki	117.07	118.05
Burdigalian	16.4	20.52
Calabrian	0.95	1.77
Campanian	71.29	83.46
Campanian lower	76.15	83.46
Campanian upper	71.29	76.15
Cenomanian	93.49	98.94
Cenomanian lower	95.84	98.94
Cenomanian middle	94.71	95.84
Cenomanian upper	93.49	94.71
Chattian	23.8	28.5
Coniacian	85.79	88.96
Coniacian lower	87.28	88.96
Coniacian upper	85.79	87.28
Danian	60.9	65
Dentatus	105.3	106.35
Deshayesi	118.05	119.02
Dispar	98.94	100
Dixoni	95.84	97.39
Dutempleana	108.47	110.06
Fissicostatus	120	120.98
Forbesi	119.02	120
Gelasian	1.77	2.6
Geslinianum	93.73	93.99
Gottschei	128.46	129.17
Guerangeri	93.99	94.71
Hauterivian upper	127.03	129.89
Holocene	0	0.01
Inflatum	100	102.12
Ionian	0	0.95
Juddi	93.49	93.73
Jukesbrownei	94.71	94.86
Langhian	14.8	16.4
Lautus	102.12	103.18
Loricatus	103.18	105.3
Lutetian	41.3	49
Maastrichtian	65	71.29
Maastrichtian lower	69.42	71.29
Maastrichtian upper	65	69.42
Mantelli	97.39	98.94
Marginatus	127.39	128.46
Martonoides	116.09	117.07
Messinian	5.32	7.12
Nutfieldensis	113.16	116.09
Piazencian	2.6	3.6
Priabonian	33.7	37
Rarocinctum	125.52	127.03
Raulinianus	106.35	108.47
Rhotomagense	94.86	95.84
Rudefissicostatum	121.11	125.52
Rupelian	28.5	33.7
Santonian	83.46	85.79
Santonian lower	84.6	85.79
Santonian upper	83.46	84.6
Selandian	57.9	60.9
Serravallian	11.2	14.8
Speetonensis	129.17	129.53
Tardefurcata	110.06	112.18
Thanetian	54.8	57.9
Tithonian	144.19	150.69
Tortonian	7.12	11.2
Turonian	88.96	93.49
Turonian lower	91.88	93.49
Turonian middle	90.36	91.88
Turonian upper	88.96	90.36
Variabilis	127.03	127.39
Ypresian	49	54.8
Zanclean	3.6	5.32

Note: Ages used to prepare Table T1, p. 43.

Plate P1. The modified Kofoid system (as outlined in Fensome et al., 1993b) is used in the labeling of individual plates for the gonyaulacaleans. The Kofoid system is used in the labeling of plates in the peridinialeans. The archeopyle location is denoted by diagonal lines. **1.** *Achilleodinium biformoides* (Eisenack 1954b) Eaton 1976. Ventral view. Holotype dimension: central body diameter = 50 µm. **2.** *Achomosphaera alcicornu* (Eisenack 1954b) Davey and Williams 1966a. Dorsal view. Holotype dimensions: overall diameter = 157 µm, central body diameter = 65 µm × 67 µm. **3.** *Achomosphaera andalousiensis* Jan du Chêne 1977. Dorsal view. Holotype dimensions: central body diameter = 35 µm × 40 µm, process length = 15 µm. **4.** *Adnatosphaeridium tutulosum* (Cookson and Eisenack 1960a) Morgan 1980. Holotype dimensions: overall diameter = 70 µm, central body diameter = 53 µm. **5.** *Alisocysta circumtabulata* (Drugg 1967) Stover and Evitt 1978. Ventral view. Range of type material: length = 37–47 µm, width = 36–47 µm. **6.** *Alisocysta margarita* (Harland 1979a) Harland 1979a. Ventral view. Holotype dimensions: length = 44 µm, width = 40 µm. **7.** *Alisocysta reticulata* Damassa 1979b. Ventral view. Average range of type material: length = 55 µm, width = 51 µm. **8.** *Alisogymnium euclaense* (Cookson and Eisenack 1970a) Lentin and Vozzhennikova 1990. Holotype dimensions: length = 34 µm, width = 22 µm. **9.** *Alterbidinium*? *distinctum* (Wilson 1967a) Lentin and Williams 1985. Dorsal view. Holotype dimensions: pericyst length = 118 µm, pericyst width = 61 µm, endocyst diameter 58 µm × 63 µm. **10.** *Amiculosphaera umbraculum* Harland 1979b. Dorsal view. Holotype dimensions: length = 80 µm, width = 86 µm. **11.** *Apectodinium augustum* (Harland 1979c) Lentin and Williams 1981. Dorsal view. Holotype dimensions: pericyst length (excluding horns) = 63.75 µm, pericyst width (excluding horns) = 66.25 µm. **12.** *Apteodinium deflandrei* (Clarke and Verdier 1967) Lucas-Clark 1987. Right lateral view. Holotype dimensions: overall length = 52 µm, overall width = 40 µm. (Continued on next page.)

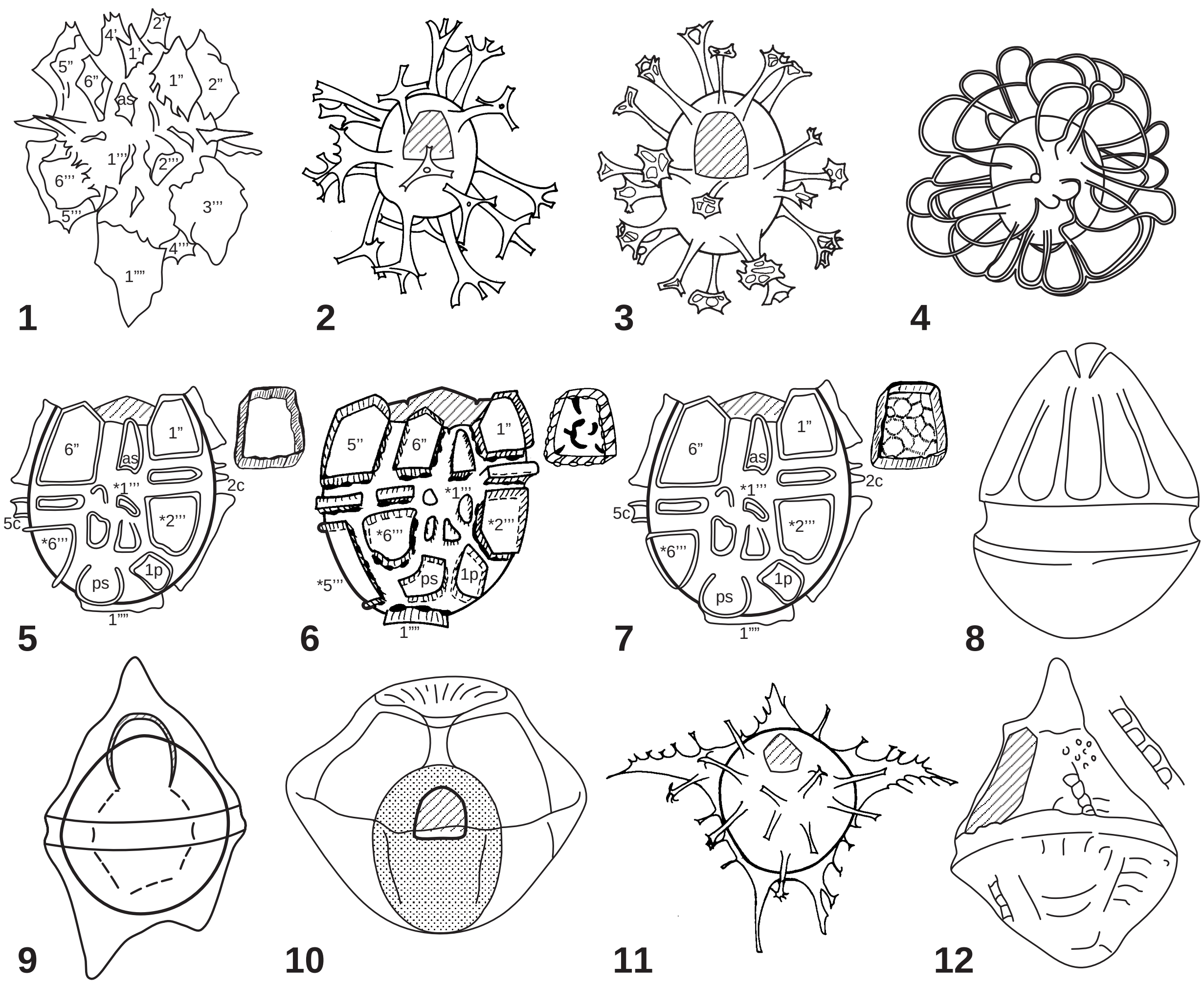


Plate P1 (continued). 13, 14. *Arachnodinium antarcticum* Wilson and Clowes 1982. Holotype dimensions: overall length (excluding operculum) = 105 µm, overall breadth = 96 µm, central body length (excluding operculum) = 58 µm, central body width = 48 µm, antapical process length = 22 µm; (13) lateral view; (14) apical view. **15.** *Areoligera gippingensis* Jolley 1992. Ventral view. Range of type material: overall length = 32–42 µm, overall width = 45–59 µm, process length = 15–33 µm. **16.** *Areosphaeridium diktyoplokum* (Klumpp 1953) Eaton 1971. Ventral view. Holotype dimensions: central body diameter = 48 µm. **17, 18.** *Areoligera semicirculata* (Morgenroth 1966b) Stover and Evitt 1978. Range of type material: central body length = 45–61 µm, central body width = 42–56 µm, central body height = 33–40 µm, process length = 5–33 µm; (17) ventral view; (18) antapical view. **19, 20.** *Ataxiodinium confusum* Versteegh and Zevenboom in Versteegh 1995. Holotype dimensions: overall diameter = 36 µm, endocyst diameter = 22 µm; (19) dorsal view; (20) lateral cross-section.

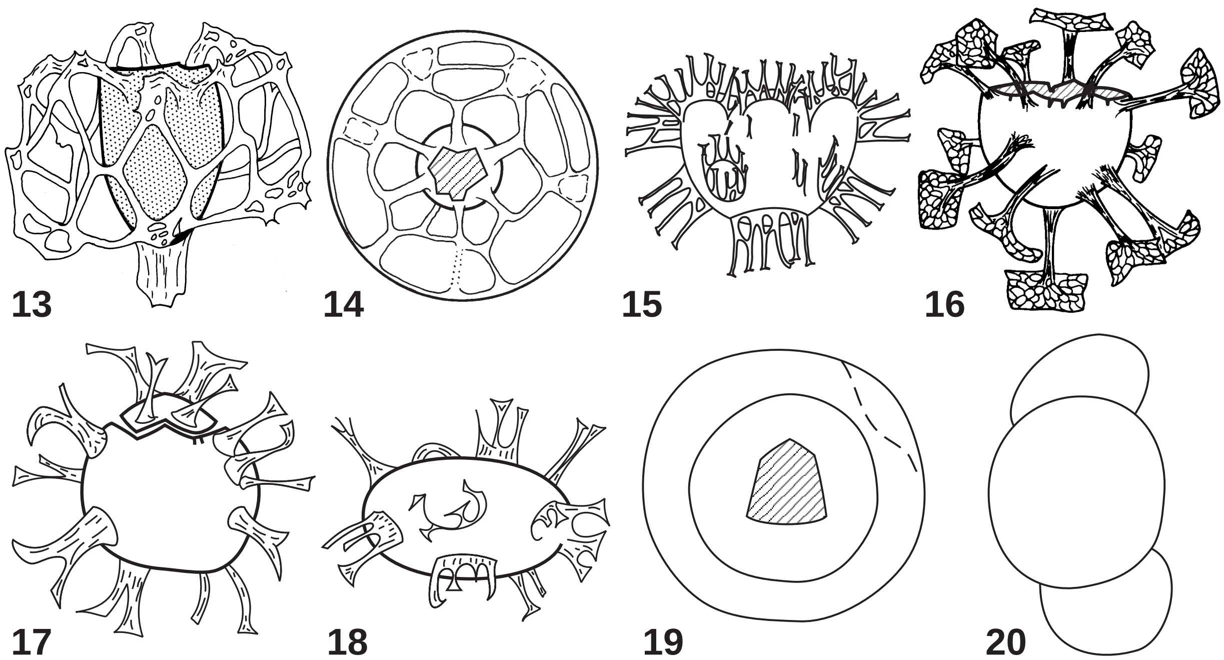


Plate P2. The modified Kofoid system (as outlined in Fensome et al., 1993b) is used in the labeling of individual plates for the gonyaulacaleans. The Kofoid system is used in the labeling of plates in the peridinialeans. The archeopyle location is denoted by diagonal lines. **1.** *Ataxiodinium choane* Reid 1974. Dorsal view. Holotype dimensions: overall diameter = 49 µm, endocyst diameter = 30 µm. **2.** *Barssidinium evangelineae* Lentin et al. 1994. Dorsal view. Holotype dimensions: cyst length = 99 µm, cyst width = 99 µm, process length up to 11 µm. **3.** *Biconidinium longissimum* Islam 1983c. Ventral view. Holotype dimensions: pericyst length = 140 µm, pericyst width = 51 µm, endocyst length = 57 µm, endocyst width = 49 µm. **4.** *Cannosphaeropsis passio* de Verteuil and Norris 1996a. Dorsal view. Holotype dimensions: overall length = 120 µm, overall width = 100 µm. **5, 6.** *Callaiosphaeridium asymmetricum* (Deflandre and Courteville 1939) Davey and Williams 1966b. Holotype dimensions: central body diameter = 40 µm, process length = 22–34 µm; (5) oblique apical view; (6) antapical view. **7.** *Cannosphaeropsis utinensis* O. Wetzel 1933b. Holotype dimensions: overall length = 116 µm, overall width = 88 µm, central body length = 44 µm, central body width = 36 µm. **8.** *Carpodinium obliquicostatum* Cookson and Hughes 1964. Ventral view. Holotype dimensions: length = 73 µm, width = 36 µm. **9, 10.** *Carpatella cornuta* Grigorovich 1969a. Holotype dimensions: length = 114 µm, width = 90 µm; (9) ventral view; (10) dorsal view. **11.** *Cassiculosphaeridia reticulata* Davey 1969a. Oblique ventral view. Holotype dimensions: diameter = 38 µm × 38 µm, crest height = 4–6 µm. **12.** *Cerebrocysta bartonensis* Bujak in Bujak et al. 1980. Dorsal view. Range of type material: overall diameter = 24 µm × 28 µm, crest height up to 2 µm. (Continued on next page.)

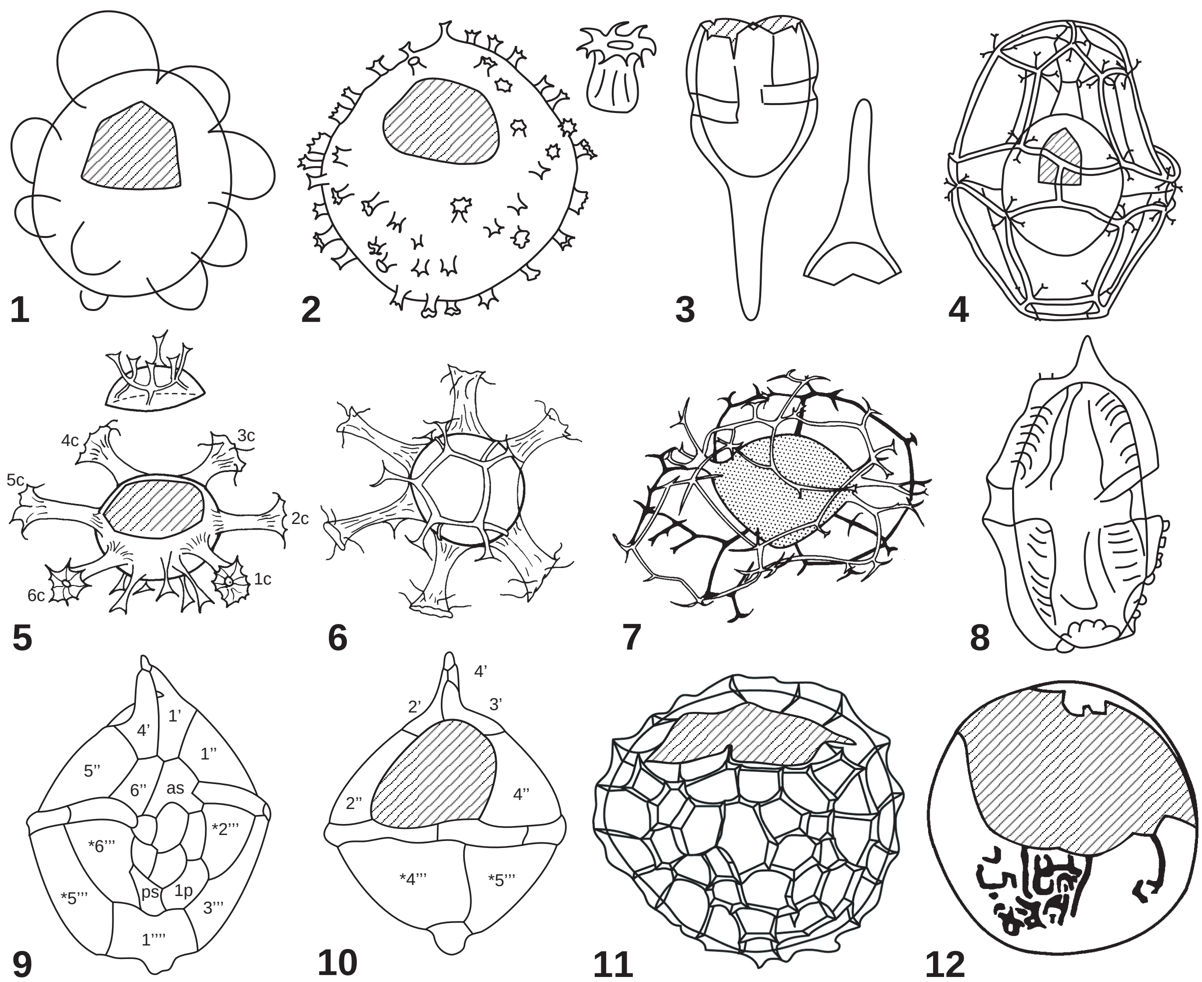


Plate P2 (continued). 13. *Cerebrocysta poulsenii* de Verteuil and Norris 1996a. Right lateral view. Holotype dimensions: length = 37 µm, width = 27 µm. **14.** *Cerodinium diebelii* (Alberti 1959b) Lentin and Williams 1987. Dorsal view. Holotype dimensions: pericyst length = 180 µm, pericyst width = 44 µm. **15.** *Cerodinium wardenense* (Williams and Downie 1966c) Lentin and Williams 1987. Dorsal view. Holotype dimensions: pericyst length = 57 µm, pericyst width = 46 µm, endocyst length = 36 µm, endocyst width = 43 µm. **16.** *Charlesdowniea crassiramosa* (Williams and Downie 1966b) Lentin and Vozzhennikova 1989. Dorsal view. Holotype dimensions: pericyst length = 125 µm, pericyst width = 122 µm, endocyst length = 80 µm, endocyst width = 71 µm. **17, 18.** *Charlesdowniea columna* (Michoux 1988) Lentin and Vozzhennikova 1990. Holotype dimensions: pericyst = 121 µm × 124 µm, archeopyle length = 21 µm, archeopyle width = 27 µm; (17) ventral view; (18) dorsal view. **19.** *Charlesdowniea edwardsii* (Wilson 1967c) Lentin and Vozzhennikova 1989. Dorsal view. Holotype dimensions: pericyst length = 96 µm, pericyst width = 107 µm, endocyst length = 50 µm, endocyst width = 58 µm, apical horn length = 16 µm, antiapical horn length = 19 µm, lateral horns length = 19 µm. **20.** *Chatangiella verrucosa* (Manum 1963) Lentin and Williams 1976. Dorsal view. Holotype dimensions: pericyst length = 134 µm, pericyst width = 83 µm.

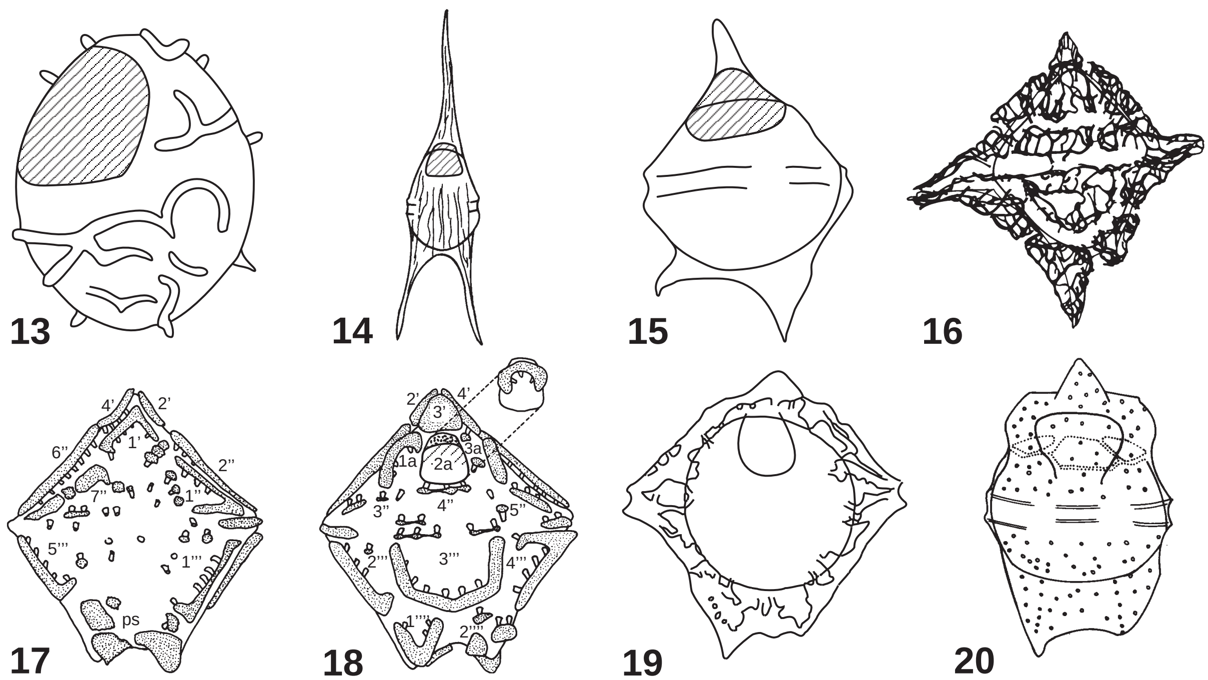


Plate P3. The modified Kofoid system (as outlined in Fensome et al., 1993b) is used in the labeling of individual plates for the gonyaulacaleans. The Kofoid system is used in the labeling of plates in the peridiniales. The archeopyle location is denoted by diagonal lines. **1.** *Chichaouadinium vestitum* (Brideaux 1971) Bujak and Davies 1983. Dorsal view. Holotype dimensions: overall length = 71 µm, overall width = 51 µm. **2.** *Chiropteridium galea* (Maier 1959) Sarjeant 1983. Ventral view. Holotype dimensions: central body height = 55 µm, central body width = 76 µm, overall width = 100 µm. **3.** *Conosphaeridium striatoconum* (Deflandre and Cookson 1955) Cookson and Eisenack 1969. Oblique apical view. Range of type material: central body diameter = 52–57 µm, process length = 12–18 µm. **4.** *Cordosphaeridium cantharellus* (Brosius 1963) Gocht 1969. Dorsal view. Holotype dimensions: central body diameter = 54 µm. **5.** *Cordosphaeridium funiculatum* Morgenroth 1966a. Dorsal view. Holotype dimensions: central body diameter = 57 µm. **6.** *Corrudinium harlandii* Matsuoka 1983b. Ventral view. Holotype dimensions: length = 46 µm, width 42 µm, height of septum up to 4 µm. **7.** *Corrudinium incompositum* (Drugg 1970b) Stover and Evitt 1978. Ventral view. Holotype dimensions: length = 40 µm, width 40 µm. **8.** *Cyclapophysis monmouthensis* Benson 1976. Dorsal view. Holotype dimensions: overall width = 135 µm, central body length = 75 µm, central body width = 65 µm. **9–11.** *Cousteaudinium aubryae* de Verteuil and Norris 1996a. All apical view. Holotype dimensions: endocyst length = 49 µm, endocyst width = 38 µm, process length = 6–32 µm. **12.** *Cyclonephelium filoreticulatum* (Slimani 1994) Prince et al. 1999. Ventral view. Holotype dimensions: overall length = 80 µm, overall width = 100 µm, endocyst length = 58 µm, endocyst width = 60 µm. (Continued on next page).

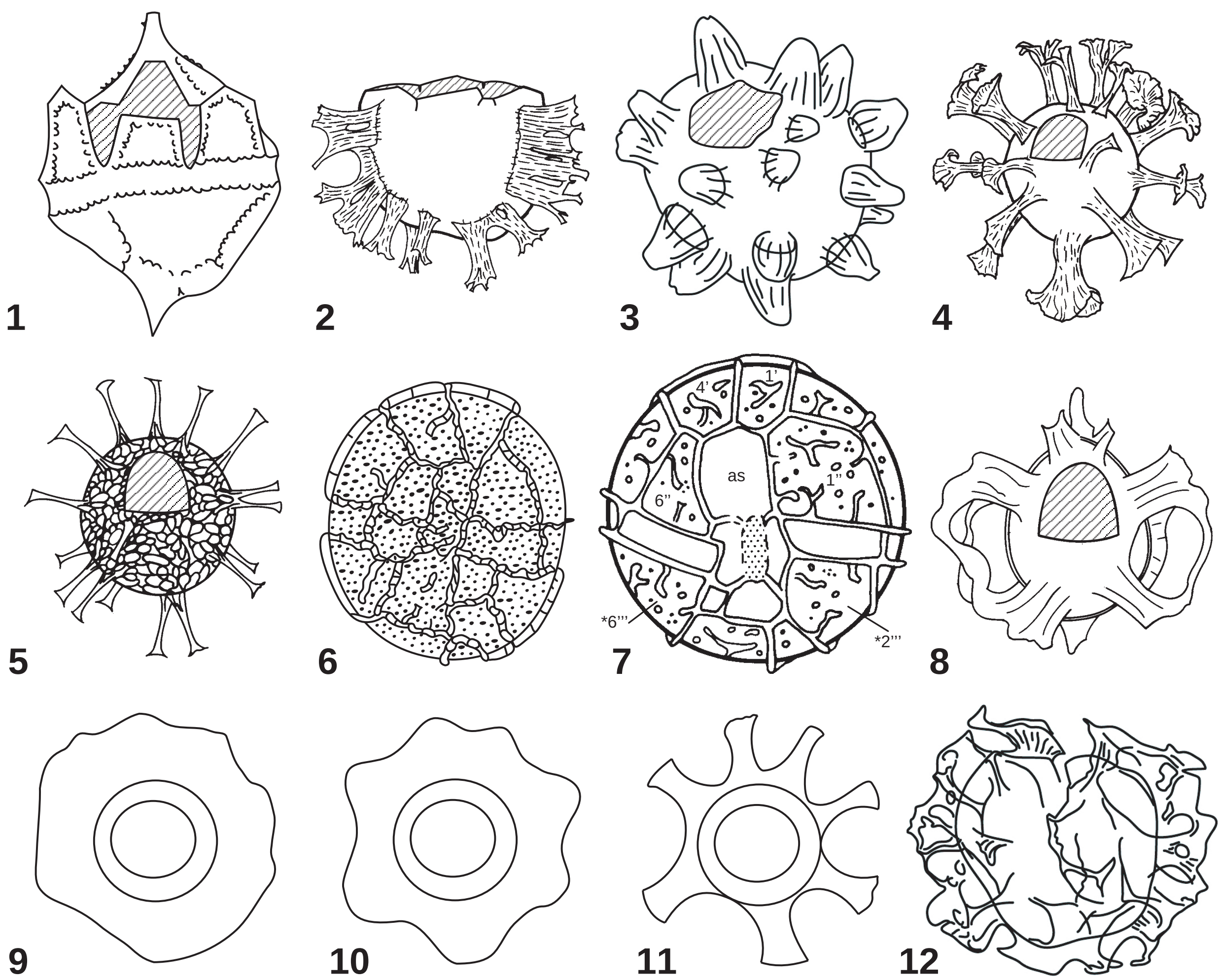


Plate P3 (continued). 13. *Cyclonephelium membraniphorum* Cookson and Eisenack 1962b. Ventral view. Holotype dimensions: overall length = 127 µm, overall breadth = 108 µm, membrane height = 6–22 µm. **14.** *Damassadinium californicum* (Drugg 1967) Fensome et al. 1993b. Ventral view. Range of type material: length = 61–103 µm, width = 44–66 µm. **15.** *Deflandrea antarctica* Wilson 1967a. Dorsal view. Holotype dimensions: pericyst length = 138 µm, pericyst width = 72 µm, endocyst diameter = 69 µm. **16.** *Deflandrea convexa* Wilson 1988. Dorsal view. Holotype dimensions: pericyst length = 93 µm, pericyst width = 76 µm, endocyst length = 76 µm, endocyst width = 76 µm. **17.** *Deflandrea cygniformis* Pöthe de Baldis 1966. Dorsal view. Holotype dimensions: overall length = 195.8 µm, overall width = 99 µm, epicyst length = 145 µm, hypocyst length = 50 µm, endocyst length = 85.8 µm, endocyst width = 102 µm (as stated by Pöthe de Baldis,1966, p. 221). **18.** *Deflandrea oebisfeldensis* Alberti 1959b. Dorsal view. Holotype dimensions: pericyst length = 150 µm, pericyst width = 88 µm. **19.** *Deflandrea phosphoritica* Eisenack 1938b. Dorsal view. Holotype dimensions: pericyst length = 116 µm. **20.** *Dinogymnium* sp. Lateral view. Dimension of holotype of type species, *Dinogymnium acuminatum*: length = 91 µm, width = 61 µm.

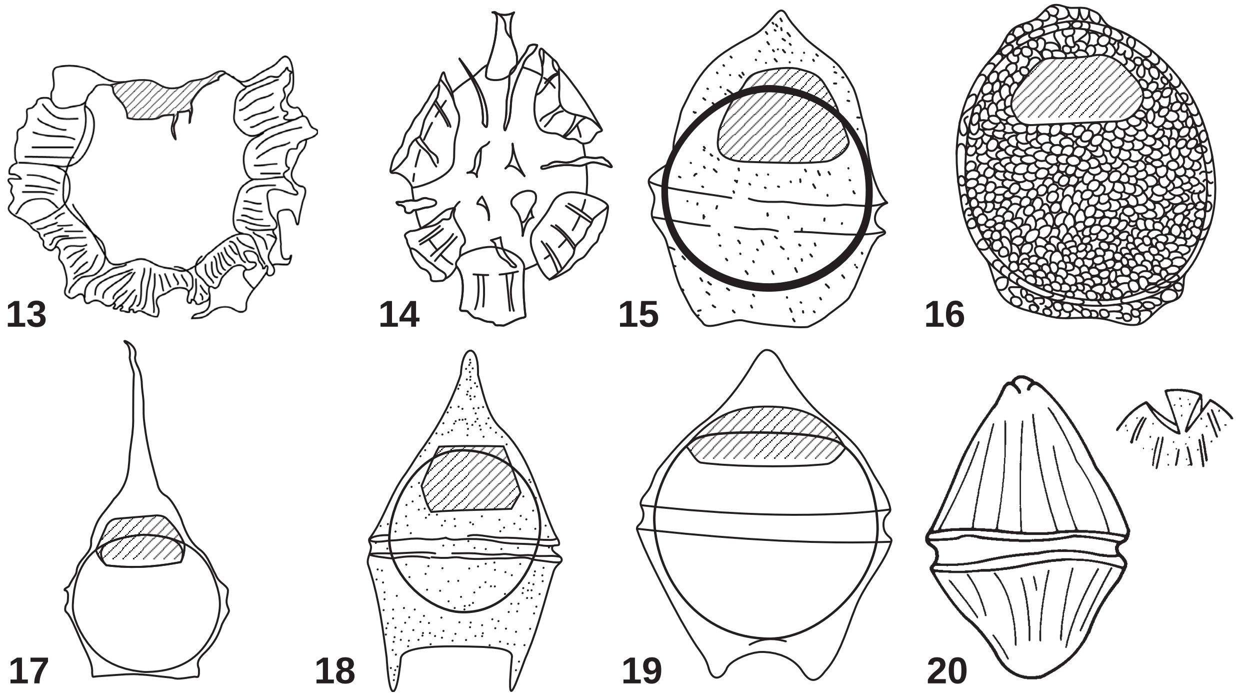


Plate P4. The modified Kofoid system (as outlined in Fensome et al., 1993b) is used in the labeling of individual plates for the gonyaulacaleans. The Kofoid system is used in the labeling of plates in the peridinialeans. The archeopyle location is denoted by diagonal lines. **1.** *Dinopterygium cladoides* Deflandre 1935. Ventral view. Range of type material: overall length = 65 µm, overall width = 75 µm, length (minus septa) = 40 µm, width (minus septa) = 50 µm. **2.** *Diphyes colligerum* (Deflandre and Cookson 1955) Cookson 1965a. Ventral view. Holotype dimensions: central body diameter = 33 µm. **3.** *Diphyes ficusoides* Islam 1983b. Ventral view. Holotype dimensions: central body diameter (without processes) = 28 µm × 36 µm, process length = 15–17 µm, antapical process length = 21 µm, antapical process maximum width = 20 µm. **4.** *Distatodinium apenninicum* Brinkhuis et al. 1992. Ventral view. Holotype dimensions: central body length = 52 µm, central body width = 29 µm, process length = 12 µm. **5.** *Distatodinium biffii* Brinkhuis et al. 1992. Ventral view. Holotype dimensions: central body length = 95 µm, central body width = 52 µm, process length = 45–55 µm. **6.** *Dracodinium condylos* (Williams and Downie 1966b) Costa and Downie 1979. Dorsal view. Holotype dimensions: pericyst length = 103 µm, pericyst width = 112.5 µm. **7.** *Dracodinium politum* Bujak et al. 1980. Dorsal view. Range of type material: pericyst length = 130–150 µm, pericyst width = 140–168 µm, endocyst length = 66–80 µm, endocyst width = 69–76 µm. **8.** *Dracodinium varielongitudum* (Williams and Downie 1966b) Costa and Downie 1979. Dorsal view. Holotype dimensions: pericyst length = 103 µm, pericyst width = 100 µm, endocyst length = 73 µm, endocyst width = 71 µm. **9.** *Dracodinium waipawaense* (Wilson 1967c) Costa and Downie 1979. Dorsal view. Holotype dimensions: pericyst length = 102 µm, pericyst width = 118 µm, endocyst length = 69 µm, endocyst width = 69 µm, apical horn length = 14 µm, right antapical horn length = 11 µm, lateral horn length = 22 µm. **10.** *Eatonicysta furensis* (Heilmann-Clausen in Heilmann-Clausen and Costa 1989) Stover and Williams 1995. Apical view. Holotype dimensions: overall length = 62 µm, overall width = 60 µm, central body length = 40 µm, central body width = 43 µm. **11.** *Eatonicysta pterococcoides* (O. Wetzel 1933b) Sarjeant 1985b. Lateral view. Range of type material: overall size = 64–68 µm, central body diameter = 32–40 µm. **12.** *Eatonicysta ursulae* (Morgenroth 1966a) Stover and Evitt 1978. Apical view. Holotype dimensions: central body diameter = 50 µm. (Continued on next page.)

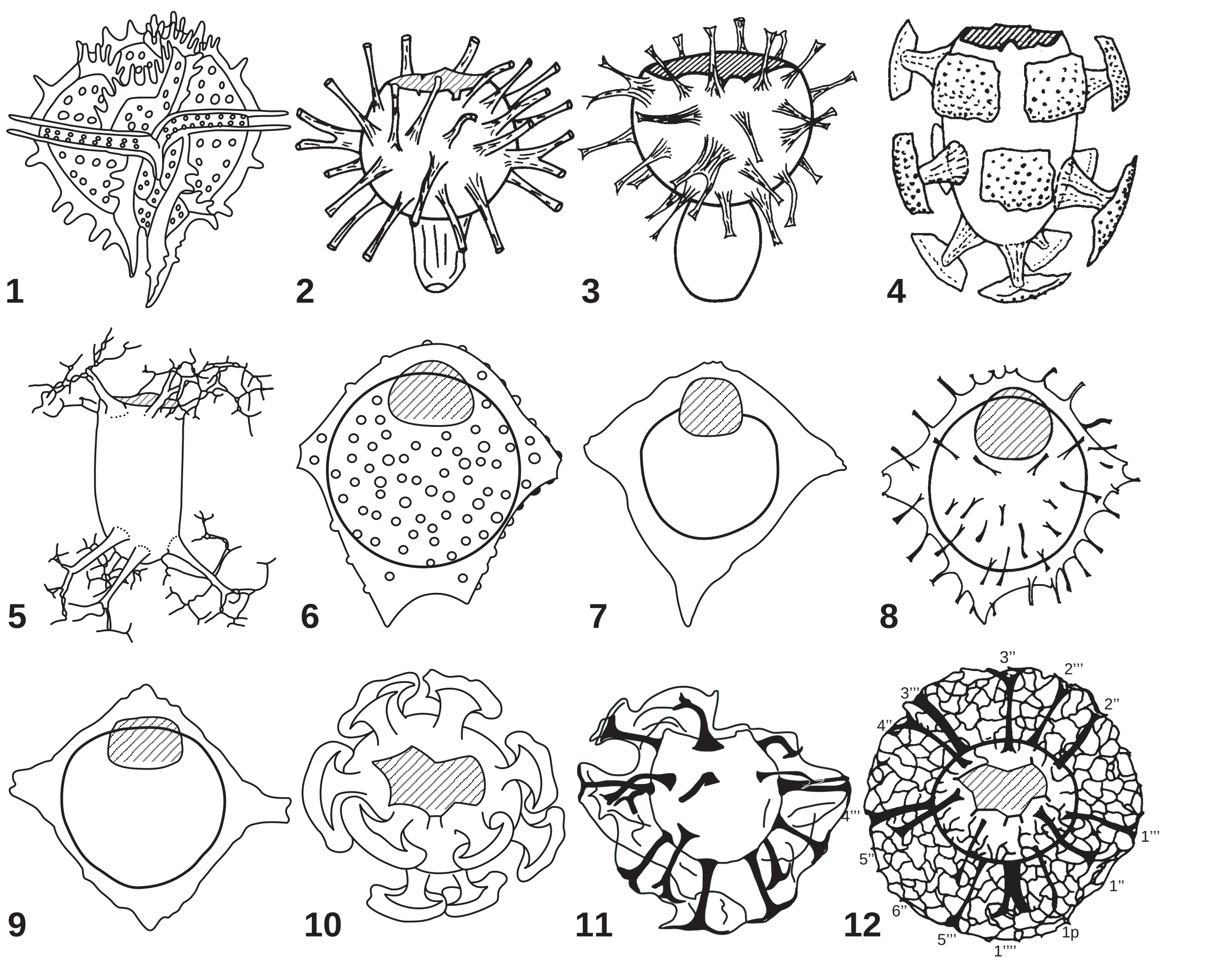


Plate P4 (continued). 13, 14. *Ectosphaeropsis burdigalensis* Londeix and Jan du Chêne 1988. Both right lateral view. Holotype dimensions: overall length = 112 µm, overall diameter = 64 µm, endocyst length = 52 µm, endocyst diameter = 39 µm, process length (excluding apical) = 22–25 µm, apical process length = 41 µm, apical protuberence height = 2.5 µm. **15.** *Edwardsiella sexispinosa* Versteegh and Zevenboom in Versteegh 1995. Dorsal view. Holotype dimensions: length = 55 µm, maximum diameter = 55 µm, process length = 39 µm, apical horn length = 11 µm, antapical horn length = 16 µm, membrane height on upper half of process = 5 µm. **16.** *Ellipsodinium rugulosum* Clarke and Verdier 1967. Oblique right lateral view. Holotype dimensions: length = 40 µm, breadth = 39 µm, ridge height = 1.5 µm. **17.** *Endoscrinium campanula* (Gocht 1959) Vozzhennikova 1967. Dorsal view. Holotype dimensions: overall length = 104 µm, overall width = 91 µm. **18.** *Enneadocysta partridgei* Stover and Williams 1995. Ventral view. Range of type material: overall length without opercula = 44–58 µm (specimens with opercula are 15–20 µm longer), overall width = 88–128 µm, process length = 18–32 µm. **19.** *Enneadocysta pectiniformis* (Gerlach 1961) Stover and Williams 1995. Ventral view. Holotype dimensions: diameter = 32 µm, process length = 13 µm. **20.** *Epelidosphaeridia spinosa* Cookson and Hughes 1964 ex Davey 1969a. Dorsal view. Holotype dimensions: overall length = 55 µm, overall width = 46 µm.

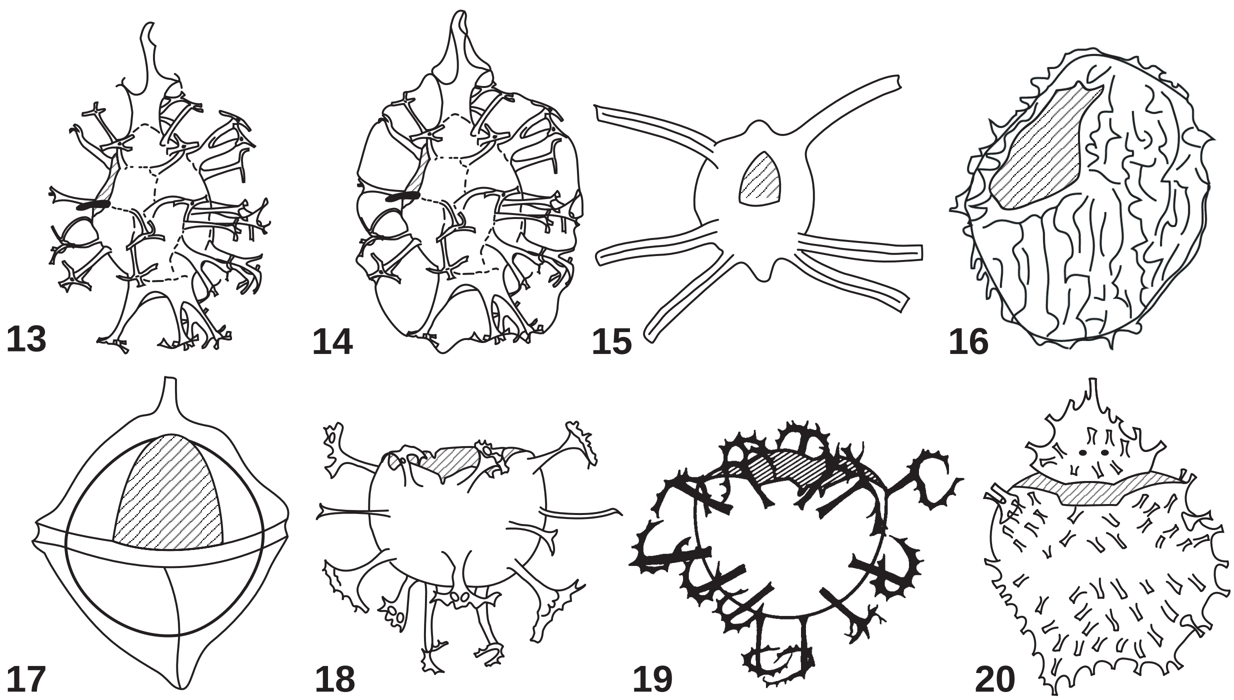


Plate P5. The modified Kofoid system (as outlined in Fensome et al., 1993b) is used in the labeling of individual plates for the gonyaulacaleans. The Kofoid system is used in the labeling of plates in the peridiniales. The archeopyle location is denoted by diagonal lines. **1.** *Filisphaera filifera* Bujak 1984. Dorsal view. Range of type material: length = 45–60 µm, width = 45–56 µm. **2.** *Florentinia mayii* Kirsch 1991. Dorsal view. Holotype dimensions: central body = 32 µm × 40 µm, broad processes, length and breadth = 19–23 µm × 18–21 µm, slender process length = 11 µm, spine length = 5 µm. **3.** *Galeacysta etrusca* Corradini and Biffi 1988. Right lateral view. Holotype dimensions: pericyst diameter = 78 µm × 80 µm, endocyst diameter = 52 µm × 66 µm. **4.** *Gerdiocysta conopeum* Liengjarern et al. 1980. Dorsal view. Holotype dimensions: central body length (excluding operculum) = 64 µm, central body width = 73 µm, process length up to 20 µm. **5.** *Glaphyrocysta semitecta* (Bujak in Bujak et al. 1980) Lentin and Williams 1981. Ventral view. Range of type material: central body length (without operculum) = 33–52 µm, central body width = 45–60 µm, maximum process length = 15–37 µm, maximum membrane height = 25–46 µm. **6.** *Gramocysta verricula* (Piasecki 1980) Lund and Lund-Christensen in von Daniels et al. 1990. Dorsal view. Holotype dimensions: length (excluding apical area) = 63 µm, width = 77 µm. **7.** *Habibacysta tectata* Head et al. 1989b. Dorsal view. Holotype dimensions: diameter = 33 µm. **8.** *Heterosphaeridium difficile* (Manum and Cookson 1964) Ioannides 1986. Ventral view. Holotype dimensions: diameter = 91 µm, process length = 25 µm. **9, 10.** *Hemiplacophora semilunifera* Cookson and Eisenack 1965a. Holotype dimensions: overall length = 62 µm, overall width = 57 µm; (9) ventral view; (10) dorsal view. **11, 12.** *Heteraulacacysta porosa* Bujak in Bujak et al. 1980. Holotype dimensions: overall diameter = 85 µm × 91 µm; (11) apical view; (12) antapical view. (Continued on next page.)

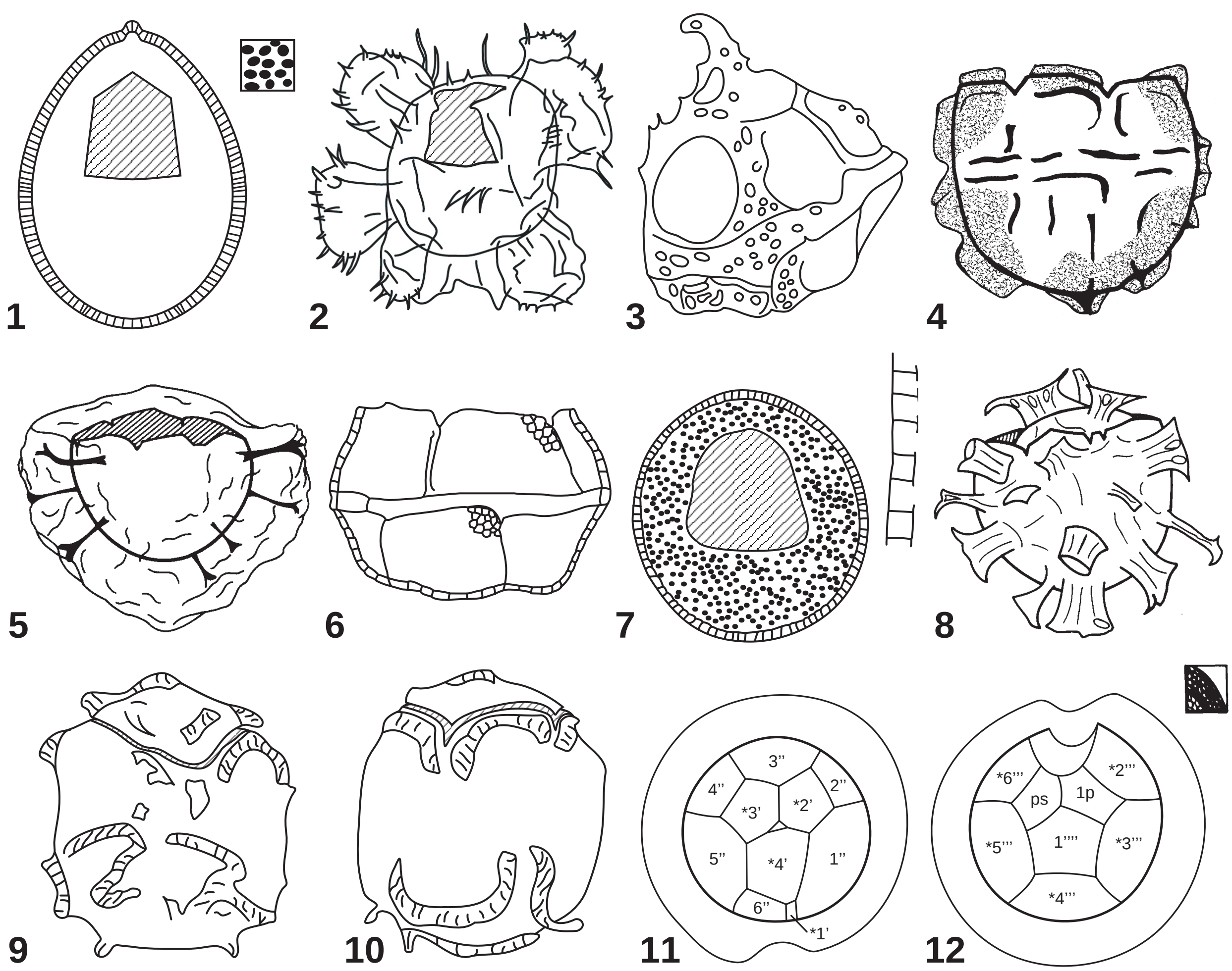


Plate P5 (continued). 13. *Homotryblium floripes* (Deflandre and Cookson 1955) Stover 1975. Antapical view. Range of type material: central body diameter = 45–72 µm × 32–59 µm, process length = 20–46 µm, process width = 3–28 µm. **14, 15.** *Homotryblium tenuispinosum* Davey and Williams 1966b. Holotype dimensions: central body diameter = 41 µm × 48 µm; (14) oblique ventral view; (15) oblique dorsal view. **16.** "*Hystrichokolpoma pseudooceanicum*" Zevenboom and Santarelli in Zevenboom 1995 (considered an unpublished manuscript name by the originating authors). Lateral view. Range of type material: central body length = 25–35 µm, central body width = 30–33 µm, process length = 12–15 µm. **17, 18.** *Hystrichokolpoma bulbosum* (Ehrenberg 1838) Morgenroth 1968. Dimensions of specimens examined by Morgenroth (1968): maximum body length = 31–43 µm, maximum body width = 25–33 µm, process length = 6–31 µm; (17) ventral view; (18) dorsal view. **19, 20.** *Hystrichokolpoma cinctum* Klumpp 1953. Holotype dimensions: central body diameter = 46 µm; (19) ventral view; (20) dorsal view.

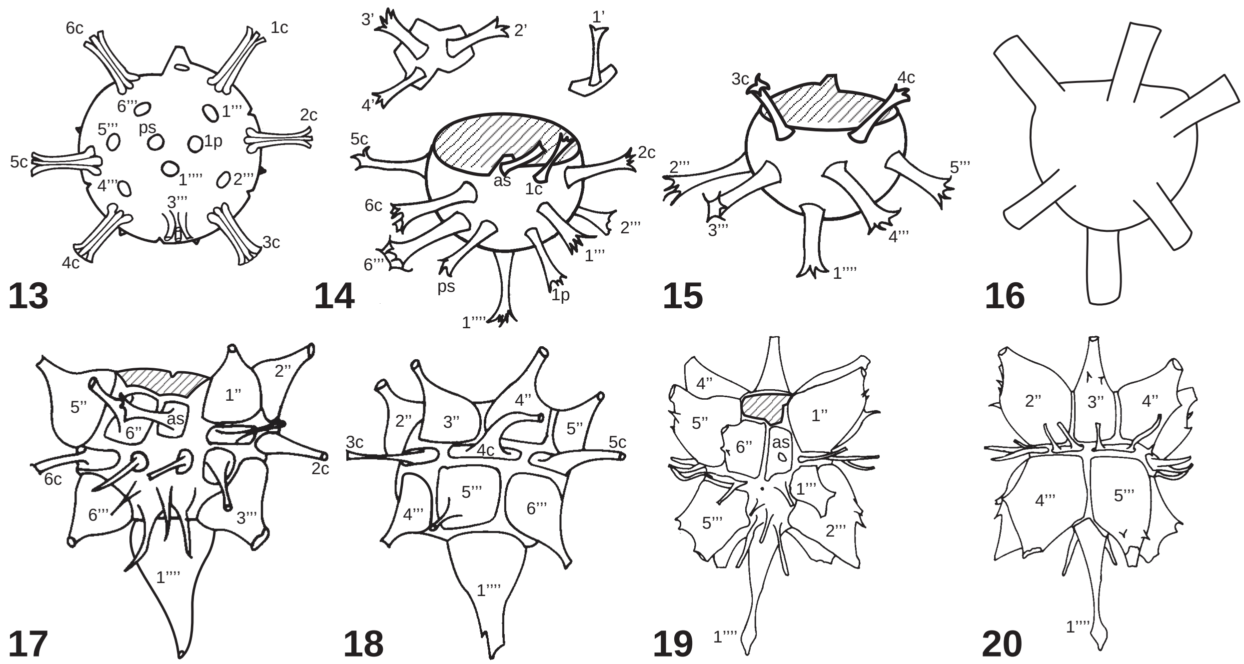


Plate P6. The modified Kofoid system (as outlined in Fensome et al., 1993b) is used in the labeling of individual plates for the gonyaulacaleans. The Kofoid system is used in the labeling of plates in the peridinialeans. The archeopyle location is denoted by diagonal lines. **1–3.** *Hystrichokolpoma pusillum* Biffi and Manum 1988. Holotype dimensions: central body length (with operculum) = 38 µm, central body length (excluding operculum) = 30 µm, central body width = 42 µm, large processes, length = 8–9 µm, large processes, breadth = 6–10 µm, antapical process length = 10 µm, slender processes, length = 8–9 µm; (1, 3) dorsal view; (2) ventral view. **4.** "*Hystrichokolpoma reductum*" Zevenboom and Santarelli in Zevenboom 1995 (considered an unpublished manuscript name by the originating authors). Dorsal view. Range of type material: central body length = 40–50 µm, central body width = 50–72 µm, process length = 30–40 µm. **5.** *Hystrichosphaeridium truswelliae* Wrenn and Hart 1988. Ventral view. Range of type material: overall diameter = 72–85 µm, central body diameter = 39–43 µm, process length = 8–15 µm, endophragm thickness < 1 µm, periphragm thickness < 1 µm. **6.** *Hystrichosphaeridium tubiferum* (Ehrenberg 1838) Deflandre 1937b, emended Davey and Williams 1966b. Apical view. Holotype dimensions: central body diameter = 33 µm × 34 µm. **7.** *Hystrichosphaeropsis quasicribrata* (O. Wetzel 1961) Gocht 1976. Dorsal view. Range of type material: overall size = 100 µm × 50 µm. **8.** *Impagidinium patulum* (Wall 1967) Stover and Evitt 1978. Ventral view. Holotype dimensions: diameter = ~55 µm. **9.** *Invertocysta tabulata* Edwards 1984. Ventral view. Holotype dimensions: length = 90 µm. **10, 11.** *Isabelidinium*? *viborgense* Heilmann-Clausen 1985. Holotype dimensions: pericyst length = 58 µm, pericyst width = 41 µm, endocyst length = 34 µm, endocyst width = 33 µm; (10) ventral view; (11) dorsal view. **12.** *Kleithriasphaeridium loffrense* Davey and Verdier 1976. Dorsal view. Holotype dimensions: central body diameter = 48 µm × 49 µm, process length = 31–34 µm. (Continued on next page.)

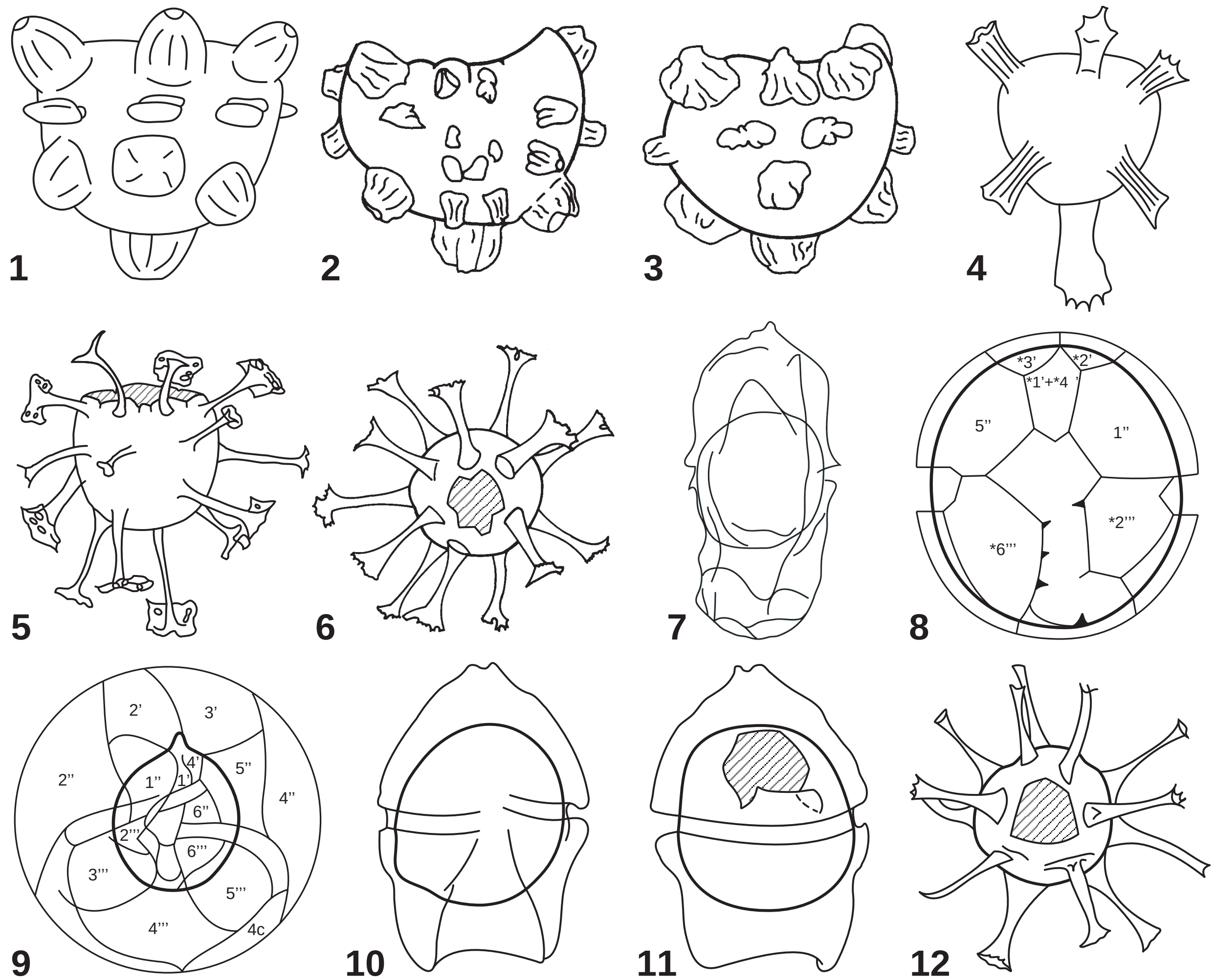
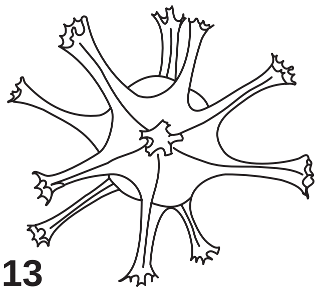


Plate P6 (continued). 13. *Kleithriasphaeridium readii* (Davey and Williams 1966b) Davey and Verdier 1976. Lateral view. Holotype dimensions: central body diameter = 41 µm × 45 µm, process length = 23–29 µm. **14.** *Labyrinthodinium truncatum* Piasecki 1980. Apical view. Holotype dimensions: diameter = 25 µm, process length = 5 µm. **15.** *Laciniadinium biconiculum* McIntyre 1975. Dorsal view. Holotype dimensions: length = 78 µm, width = 53 µm. **16.** *Leptodinium italicum* Biffi and Manum 1988. Dorsal view. Holotype dimensions: length (excluding septa) = 60 µm, width (excluding septa) = 52 µm, septa = 5–6 µm. **17, 18.** *Lentinia serrata* Bujak in Bujak et al. 1980. Holotype dimensions: pericyst length = 52 µm, pericyst width = 32 µm; (17) ventral view; (18) dorsal view. **19.** *Litosphaeridium siphonophorum* (Cookson and Eisenack 1958) Davey and Williams 1966b. Dorsal view. Holotype dimensions: overall diameter = 76 µm. **20.** *Manumiella seelandica* (Lange 1969) Bujak and Davies 1983. Dorsal view. Holotype dimensions: pericyst length = 106 µm, pericyst width = 71 µm.



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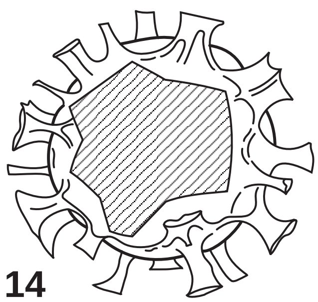

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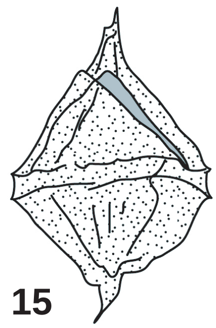

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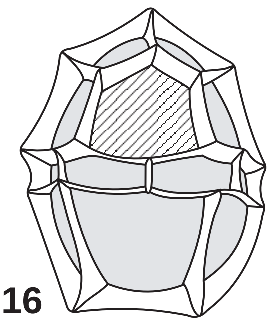

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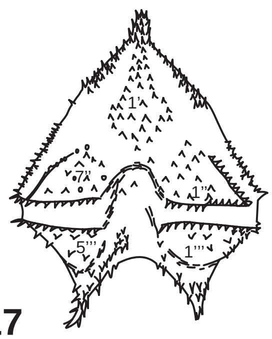

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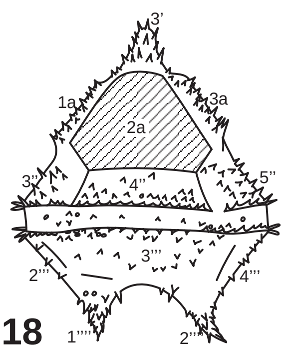

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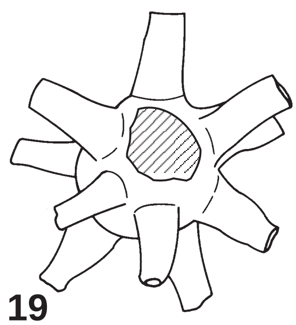

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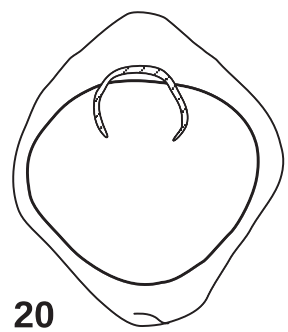

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Plate P7. The modified Kofoid system (as outlined in Fensome et al., 1993b) is used in the labeling of individual plates for the gonyaulacaleans. The Kofoid system is used in the labeling of plates in the peridinialeans. The archeopyle location is denoted by diagonal lines. **1.** *Melitasphaeridium pseudorecurvatum* (Morgenroth 1966a) Bujak et al. 1980. Dorsal view. Holotype dimensions: central body diameter = 34 µm. **2, 3.** *Membranilarnacia*? *picena* Biffi and Manum 1988. Holotype dimensions: overall width = 49 µm, central body length (excluding processes) = 40 µm, ectophragm separation = 8 µm; (2) apical view; (3) lateral view. **4.** *Membranophoridium perforatum* Wilson 1988. Ventral view. Holotype dimensions: overall length = 97 µm, overall width = 80 µm, endocyst length = 69 µm, endocyst width = 61 µm. **5.** "*Mendicodinium robustum*" Zevenboom and Santarelli in Zevenboom 1995 (considered an unpublished manuscript name by the originating authors). Ventral view of hypocyst. Range of type material: length = 80–90 µm, width = 80–90 µm, wall thickness = 5–6 µm. **6.** *Nematosphaeropsis downiei* Brown 1986. Dorsal view. Holotype dimensions: overall length = 95 µm, overall width = 88 µm, central body length = 65 µm, central body width = 60 µm, process length = 28–30 µm. **7.** *Octodinium askiniae* Wrenn and Hart 1988. Dorsal view. Range of type material: pericyst width = 21–39 µm, apical horn length up to 54 µm, antapical horn length up to 36 µm, endocyst length = 44–57 µm, endophragm thickness < 0.5 µm. **8.** "*Odontochitina diversa*" Pearce 2000 (unpublished thesis name). Lateral view. **9, 10.** *Odontochitina costata* Alberti 1961. Both dorsal view. Holotype dimensions: pericyst length = 522 µm, central body diameter = 88 µm. **11.** *Odontochitina operculata* (O. Wetzel 1933a) Deflandre and Cookson 1955. Dorsal view. Holotype dimensions: pericyst length = 210 µm, pericyst width = 170 µm. **12.** *Odontochitina porifera* Cookson 1956. Dorsal view. Holotype dimensions: pericyst length = 208 µm, pericyst width = 78 µm. (Continued on next page.)

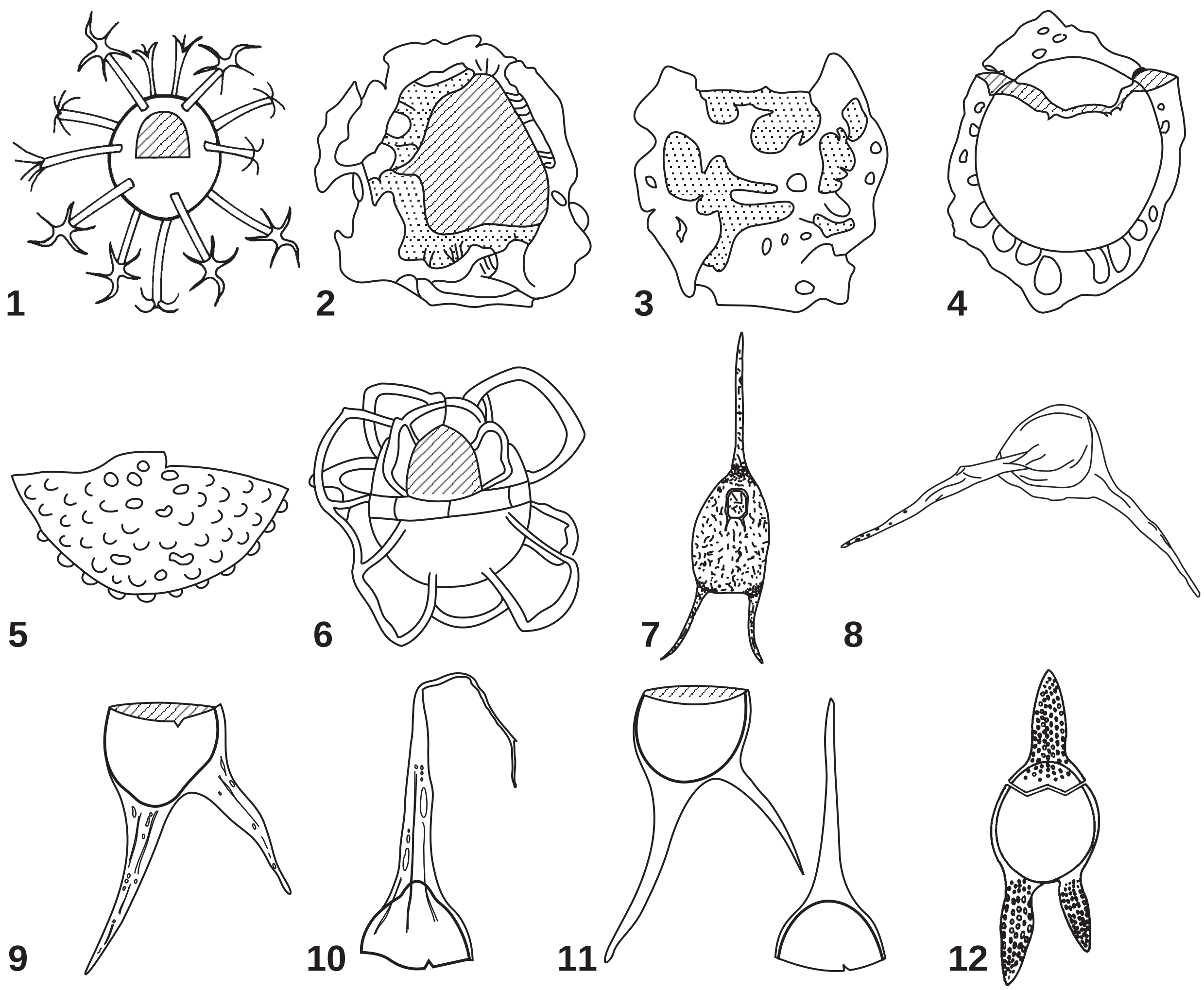

Plate P7 (continued). 13. *Oligosphaeridium poculum* Jain 1977b. Oblique apical view. Holotype dimensions: central body diameter (excluding processes) = 80 µm, process length = 6 µm, process width proximally = up to 16 µm, process width distally = up to 24 µm. **14.** *Oligosphaeridium pulcherrimum* (Deflandre and Cookson 1955) Davey and Williams 1966b. Dorsal view. Holotype dimensions: overall diameter = 118 µm, central body diameter = 47 µm × 61 µm, process length = 26–38 µm. **15.** *Oligosphaeridium* sp. Oblique apical view. **16.** *Operculodinium divergens* (Eisenack 1954b) Stover and Evitt 1978. Dorsal view. Holotype dimensions: overall diameter = 124 µm, central body diameter = 71 µm. **17.** *Operculodinium echigoense* Matsuoka 1983b. Dorsal view. Holotype dimensions: central body diameter = 72 µm, process length = 12 µm. **18.** *Operculodinium*? *eirikianum* Head et al. 1989b. Dorsal view. Holotype dimensions: central body diameter = 34 µm, process length = 8–9 µm. **19.** *Ovoidinium verrucosum* (Cookson and Hughes 1964) Davey 1970. Dorsal view. Holotype dimensions: overall length = 52 µm, overall width = 32 µm. **20.** *Palaeocystodinium bulliforme* Ioannides 1986. Dorsal view. Range of type material: pericyst length (excluding end spine) = 179–240 µm, pericyst width = 64–120 µm, endocyst length = 80–125 µm, endocyst width = 60–102 µm, end spine = up to 7 µm long, pericoel width = up to 6 µm × 28 µm at base of horns, periphragm thickness = up to 1.5 µm.

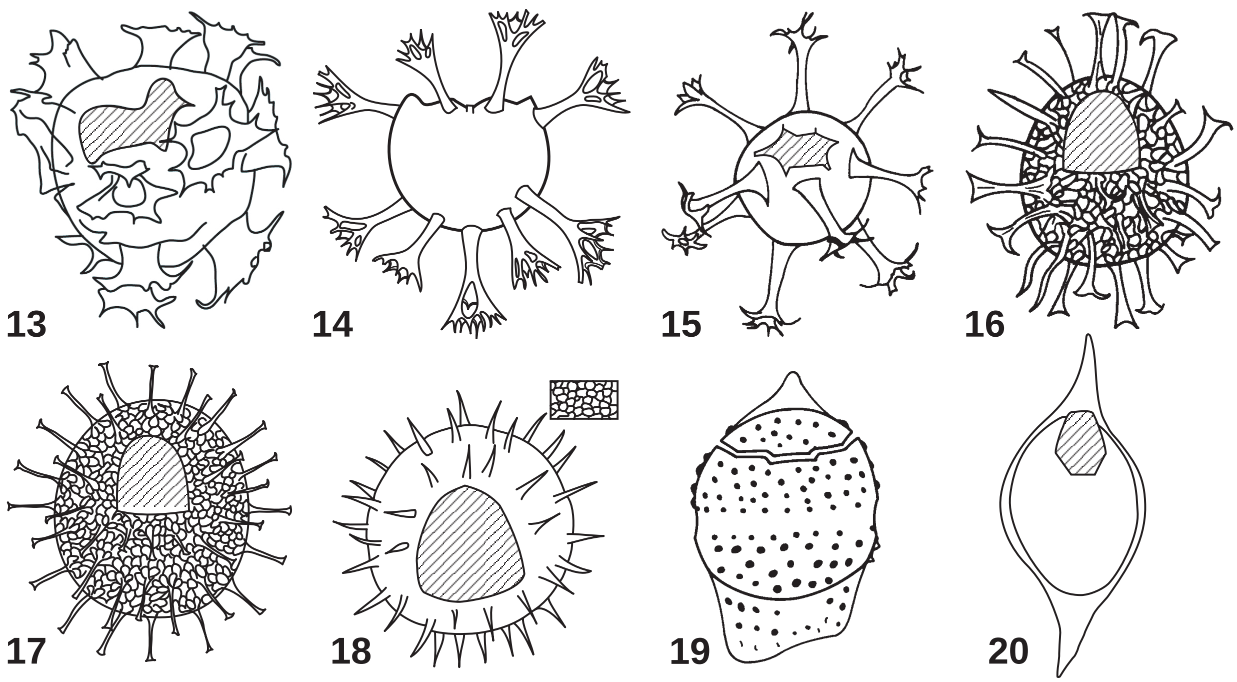

Plate P8. The modified Kofoid system (as outlined in Fensome et al., 1993b) is used in the labeling of individual plates for the gonyaulacaleans. The Kofoid system is used in the labeling of plates in the peridiniales. The archeopyle location is denoted by diagonal lines. **1.** "*Palaeocystodinium striatogranulosum*" Zevenboom and Santarelli in Zevenboom 1995 (considered an unpublished manuscript name by the originating authors). Dorsal view. Range of type material: pericyst length = 125–170 µm, pericyst width = 20–32 µm, endocyst length = 30–45 µm, endocyst width = 20–30 µm. **2.** *Palaeohystrichophora infusorioides* Deflandre 1935. Dorsal view. Holotype dimensions: overall length (without processes) = 35 µm, overall width (without processes) = 23 µm. ***3.*** *Palaeoperidinium pyrophorum* (Ehrenberg 1838 ex O. Wetzel 1933a) Sarjeant 1967b. Dorsal view. Holotype dimensions: length = 92 µm, width = 74 µm. **4.** *Palaeotetradinium silicorum* Deflandre 1936b. Dorsal view. Holotype dimensions: length = 47 µm, width = 40 µm. **5, 6.** *Palynodinium grallator* Gocht 1970a. Holotype dimensions: overall diameter (with processes) = 106 µm; (5) ventral view; (6) dorsal view. **7.** *Phthanoperidinium amoenum* Drugg and Loeblich 1967. Dorsal view. Holotype dimensions: length = 38 µm, width = 35 µm. **8.** *Phthanoperidinium distinctum* Bujak 1994. Dorsal view. Range of type material: pericyst length = 37–50 µm, pericyst width = 38–46 µm, apical horn length = <2 µm. **9.** *Pyxidinopsis fairhavenensis* de Verteuil and Norris 1996a. Dorsal view. Holotype dimensions: length = 30 µm, width = 25 µm. **10.** *Raetiaedinium truncigerum* (Deflandre 1937b) Kirsch 1991. Dorsal view. Holotype dimensions: central body diameter = 42 µm. **11.** *Raphidodinium fucatum* Deflandre 1936b. Range of type material: cyst length (excluding processes) = 28–30 µm, cyst width = 14–20 µm, process length = 40–50 µm, overall diameter = 110–115 µm. **12.** *Renidinium rigidum* Prince et al., 1999. Ventral view. Holotype dimensions: ectocyst length = 86 µm, ectocyst width = 73 µm, endocyst length = 62 µm, endocyst width = 58 µm, cavities = 2–40 µm. (Continued on next page.)

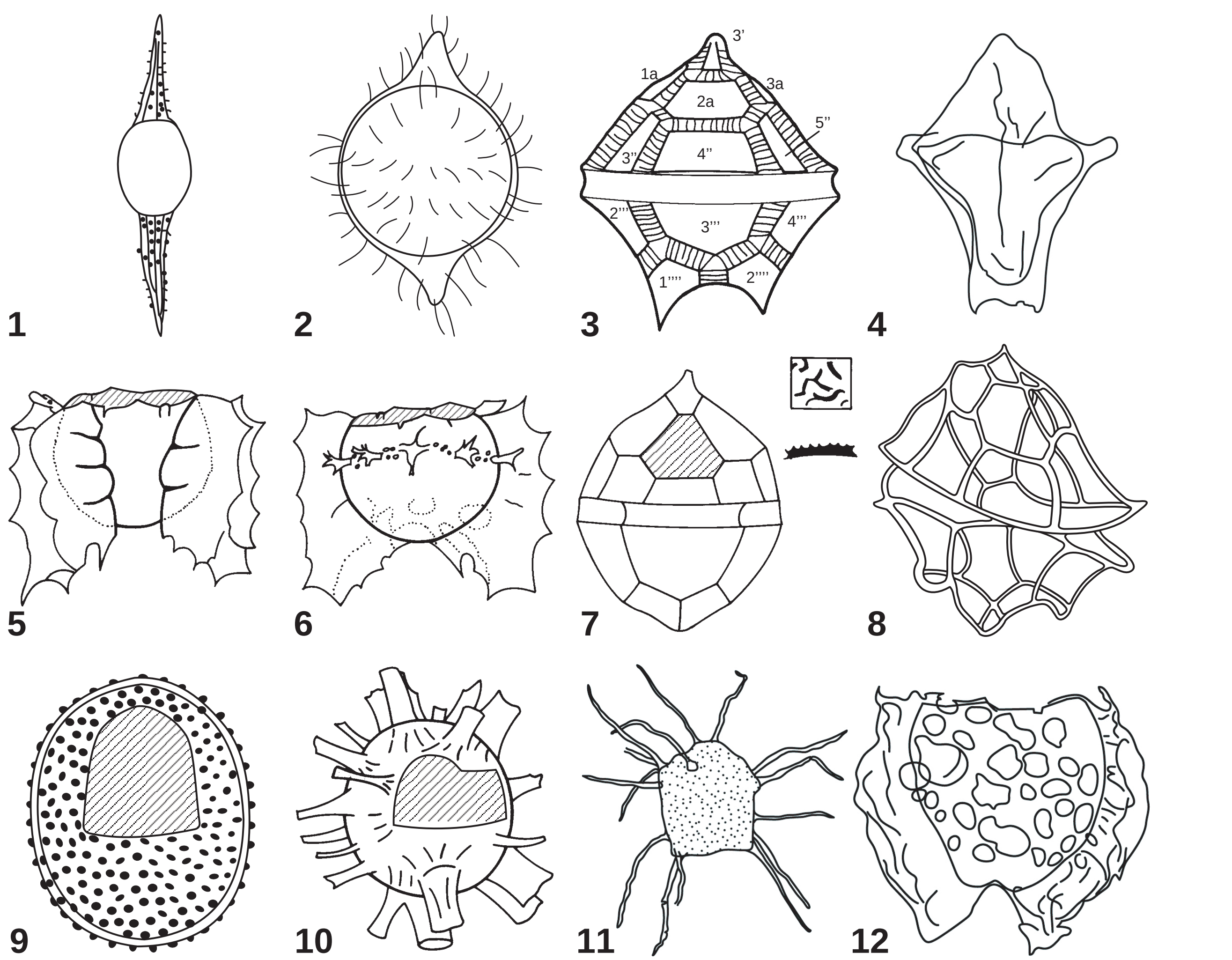

Plate P8 (continued). 13. *Reticulatosphaera actinocoronata* (Benedek 1972) Bujak and Matsuoka 1986. Oblique dorsal view. Holotype dimensions: central body diameter = 14 µm. **14.** *Rhombodinium draco* Gocht 1955. Dorsal view. Holotype dimensions: pericyst length = 150 µm, pericyst width = 158 µm. **15.** *Rhombodinium perforatum* (Jan du Chêne and Châteauneuf 1975) Lentin and Williams 1977b. Dorsal view. Holotype dimensions: pericyst length = 94 µm, pericyst width = 120 µm, apical horn length = 12 µm, left antapical horn length = 10 µm, right antapical horn length = 6 µm, lateral horn length = 22 µm, endocyst length = 70 µm, endocyst width = 84 µm. **16.** *Rhombodinium porosum* Bujak 1979. Dorsal view. Holotype dimensions: pericyst length = 138 µm, pericyst width = 145 µm. **17, 18.** *Saturnodinium pansum* (Stover 1977) Brinkhuis et al. 1992. Range of type material: overall size in apical-antapical view = 64 µm × 66–82 µm × 84 µm, endocyst diameter = 38–50 µm; (17) apical view; (18) dorsal view. **19.** *Saturnodinium perforatum* Brinkhuis et al. 1992. Dorsal view. Holotype dimensions: pericyst length = 71 µm, pericyst width = 51 µm, endocyst length = 25 µm, endocyst width = 22 µm. **20.** *Schematophora speciosa* Deflandre and Cookson 1955. Ventral view. Holotype dimensions: overall diameter = 54 µm × 51 µm. **21.** *Selenopemphix armageddonensis* de Verteuil and Norris 1992. Apical view. Holotype dimensions: major equatorial diameter (excluding processes) = 35 µm, minor equatorial diameter (excluding processes) = 30 µm, process width (based on 13 specimens) = 4–20 µm, process length (based on 13 specimens) = 4–7 µm.

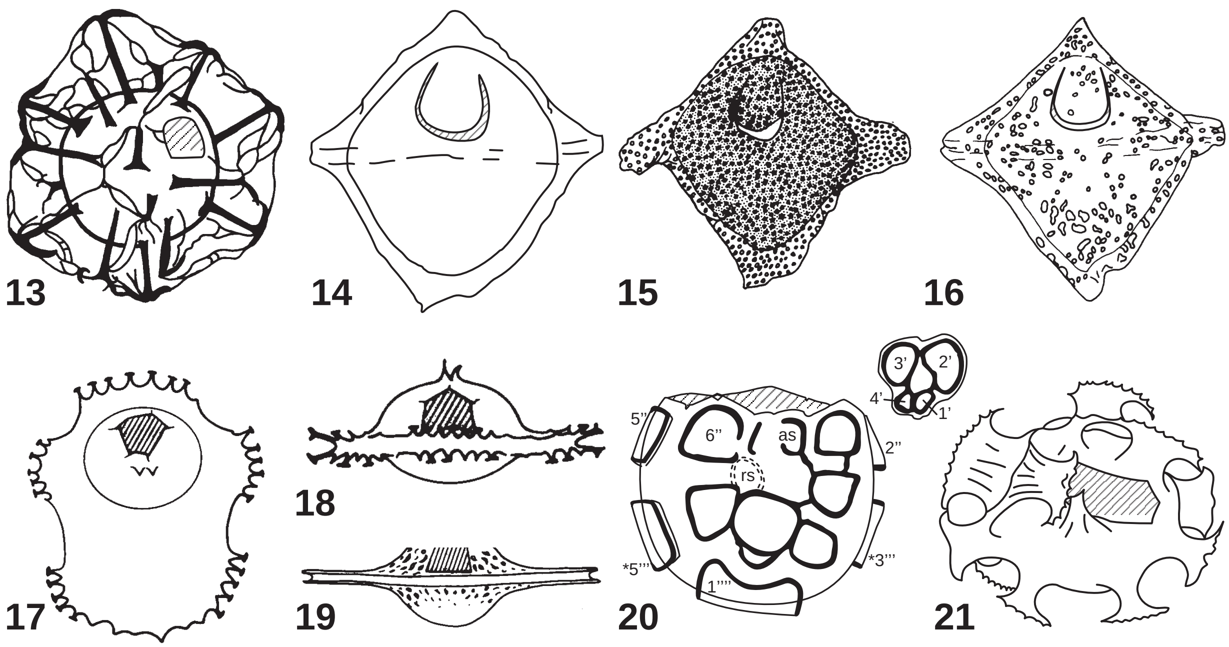

Plate P9. The modified Kofoid system (as outlined in Fensome et al., 1993b) is used in the labeling of individual plates for the gonyaulacaleans. The Kofoid system is used in the labeling of plates in the peridinialeans. The archeopyle location is denoted by diagonal lines. **1.** *Selenopemphix armata* Bujak in Bujak et al., 1980. Apical view. Range of type material: autocyst thickness (excluding processes) = 26–43 µm, autocyst width (excluding processes) = 24–45 µm, process length = 9–17 µm. **2.** *Selenopemphix dionaeacysta* Head et al. 1989b. Apical view. Holotype dimensions: maximum length (excluding processes) = 38 µm, process length (based on 17 specimens) = 4–8 µm. **3.** *Senoniasphaera inornata* (Drugg 1970b) Stover and Evitt 1978. Ventral view. Holotype dimensions: overall length (with operculum) = 118 µm, overall width = 100 µm. **4.** *Senoniasphaera protrusa* Clarke and Verdier 1967. Ventral view. Holotype dimensions: overall length = 100 µm, overall width = 71 µm, endocyst length = 66 µm, endocyst width = 60 µm, apical horn length = 18 µm, antapical horn length = 12 µm, cingulum width = 6–7 µm. **5, 6.** *Senoniasphaera rotundata* Clarke and Verdier 1967. Ventral view. Holotype dimensions: overall length = 92 µm, overall width = 67 µm, endocyst length = 71 µm, endocyst width = 60 µm, apical horn length = 14 µm, antapical horn length = 8 and 2 µm, cingulum width = 3 µm. **7.** *Senoniasphaera rotundata* subsp. *alveolata* Pearce et al. 2003. **8.** *Spinidinium echinoideum* (Cookson and Eisenack 1960a) Lentin and Williams 1976. Ventral view. Holotype dimensions: pericyst length = 80 µm, pericyst with = 57 µm, endocyst diameter = 43 µm. **9.** *Spinidinium macmurdoense* (Wilson 1967a) Lentin and Williams 1976. Dorsal view. Holotype dimensions: pericyst length = 99 µm, pericyst width = 72 µm × 63 µm. **10.** *Spiniferites porosus* (Manum and Cookson 1964) Harland 1973. Showing single plate 4″ and processes. Holotype dimensions: central body diameter = 66 µm × 75 µm, process length = 17–23 µm. **11.** *Spiniferites ramosus* subsp. *maeandriformis* (Corradini 1973) Lentin and Williams 1975. Showing single plate 4‴ and processes. Holotype dimensions: central body diameter = 60 µm × 60 µm, process length = 18–25 µm. **12.** *Spiniferites*? *velatus* (Clarke and Verdier 1967) Stover and Evitt 1978. Ventral view. Holotype dimensions: overall diameter = 100 µm, central body diameter = 55 µm, process length plus ledge = maximum of 32 µm, height of ledges = maximum of 20 µm. (Continued on next page.)

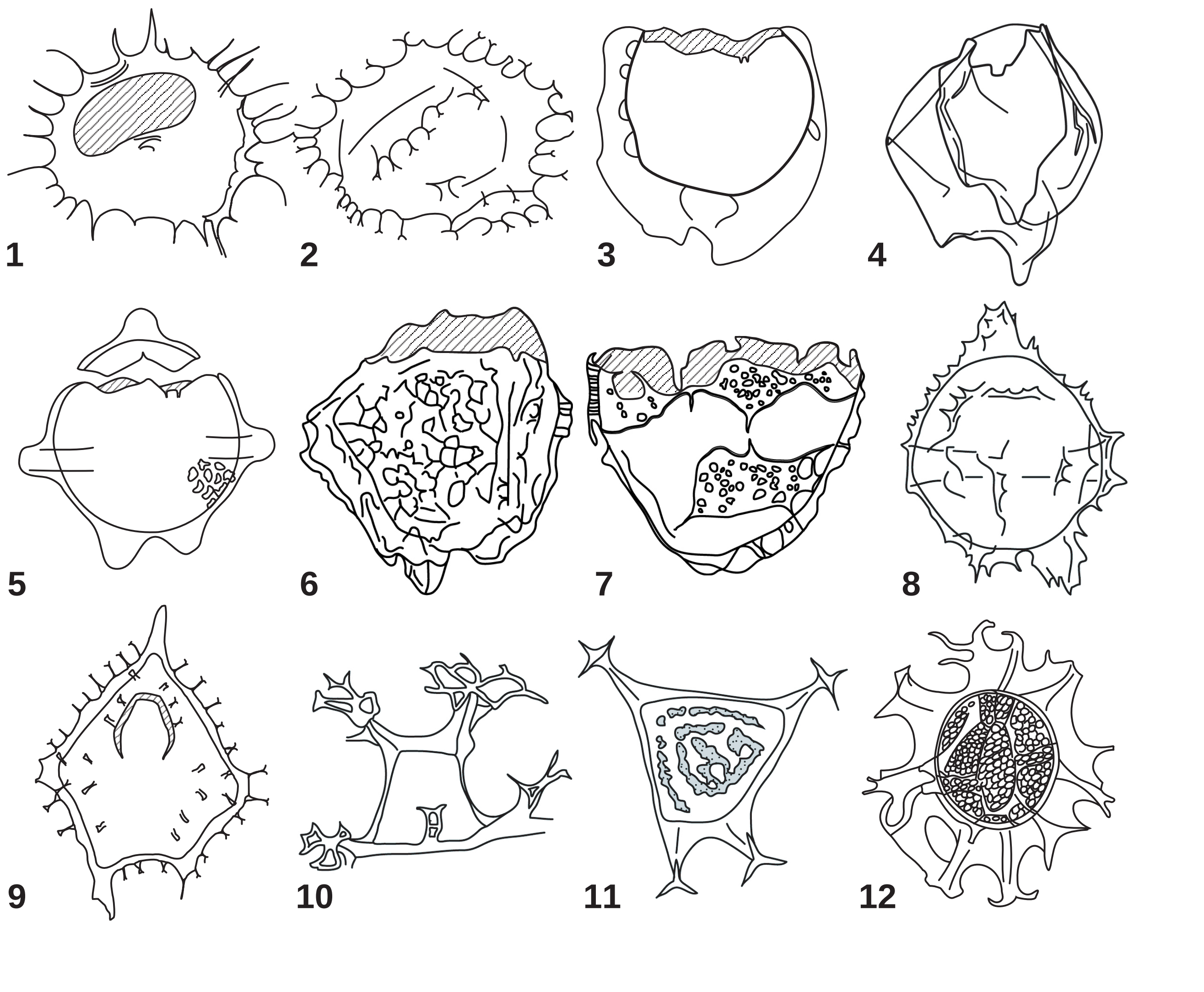

Plate P9 (continued). 13. *Spongodinium delitiense* (Ehrenberg 1838) Deflandre 1936b. Dorsal view. Dimensions of specimens examined by Deflandre (1936b): length = 75–130 µm, width = 70–112 µm. **14, 15.** *Stephodinium coronatum* Deflandre 1936a. Holotype dimensions: equatorial diameter of pericyst = 72 µm, endocyst diameter = 43 µm × 55 µm; (14) dorsal view; (15) apical view. **16.** *Sumatradinium druggii* Lentin et al. 1994. Dorsal view. Holotype dimensions: autocyst length = 76 µm, autocyst width = 70 µm, process length = up to 15 µm. **17, 18.** *Stoveracysta kakanuiensis* Clowes 1985. Holotype dimensions: overall length = 70 µm, length from archeopyle margin to antapex = 49 µm, overall width = 62 µm, archeopyle diameter = 46 µm, cingulum width = 5 µm; (17) ventral view; (18) oblique dorsal view. **19, 20.** *Stoveracysta ornata* (Cookson and Eisenack 1965a) Clowes 1985. Holotype dimensions: length = 70 µm, width = 57 µm; (19) ventral view; (20) dorsal view.

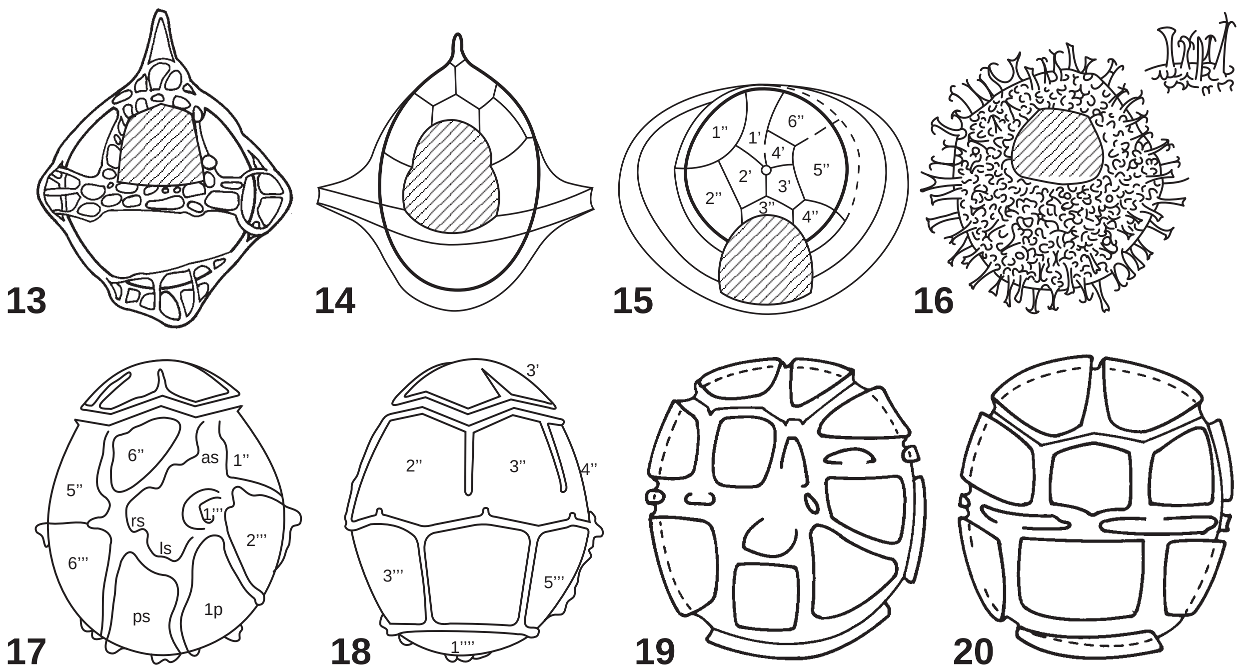

Plate P10. The modified Kofoid system (as outlined in Fensome et al., 1993b) is used in the labeling of individual plates for the gonyaulacaleans. The Kofoid system is used in the labeling of plates in the peridinialeans. The archeopyle location is denoted by diagonal lines. **1.** *Sumatradinium soucouyantiae* de Verteuil and Norris 1992. Dorsal view. Holotype dimensions: mid-body length (excluding processes) = 87 µm, equatorial diameter = 75 µm, process length (based on 15 specimens) = 6–15 µm. **2.** *Surculosphaeridium*? *longifurcatum* (Firtion 1952) Davey et al. 1966. Oblique apical view. Holotype dimensions: central body diameter = 41 µm, process length = 20 µm. **3.** *Thalassiphora delicata* Williams and Downie 1966c. Dorsal view. Holotype dimensions: overall diameter = 74 µm × 75 µm, endocyst diameter = 34 µm × 43 µm. **4.** *Thalassiphora*? *spinosa* (Clarke and Verdier 1967) Foucher 1975. Holotype dimensions: overall diameter = 93 µm, endocyst diameter = 38 µm, process length = 5–12 µm. **5.** *Triblastula utinensis* O. Wetzel 1933b. Dorsal view. Range of type material: length = 100–112 µm, width = 45–50 µm. **6.** *Trichodinium castanea* Deflandre 1935 ex Clarke and Verdier 1967. Dorsal view. Holotype dimensions: overall length = 89 µm, overall width = 73 µm, apical horn length = 11 µm. **7.** *Trigonopyxidia ginella* (Cookson and Eisenack 1960a) Downie and Sarjeant 1965. Lateral view. Holotype dimensions: pericyst diameter = 50 µm, endocyst diameter = 30 µm. **8.** *Trinovantedinium applanatum* (Bradford 1977) Bujak and Davies 1983. Dorsal view. Holotype dimensions: overall length = 78 µm, overall width = 74 µm, distance between antapical horns (distally) = 25 µm, maximum height of processes = 2.5 µm. **9.** *Trinovantedinium glorianum* (Head et al. 1989b) de Verteuil and Norris 1992. Dorsal view. Holotype dimensions: pericyst length (including processes) = 63 µm, endocyst length = 52 µm, process length (based on 12 specimens) = 2.5–8 µm. **10.** *Trithyrodinium evittii* Drugg 1967. Dorsal view. Range of type material: cyst length = 75–95 µm, cyst width = 60–80 µm. **11.** *Trithyrodinium suspectum* (Manum and Cookson 1964) Davey 1969b. Dorsal view. Holotype dimensions: overall length = 118 µm, endocyst diameter = 73 µm. **12.** *Unipontidinium aquaeductum* (Piasecki 1980) Wrenn 1988. Dorsal view. Holotype dimensions: overall length = 39 µm, overall width = 38 µm, central body length = 27 µm, central body width = 26 µm. (Continued on next page.)

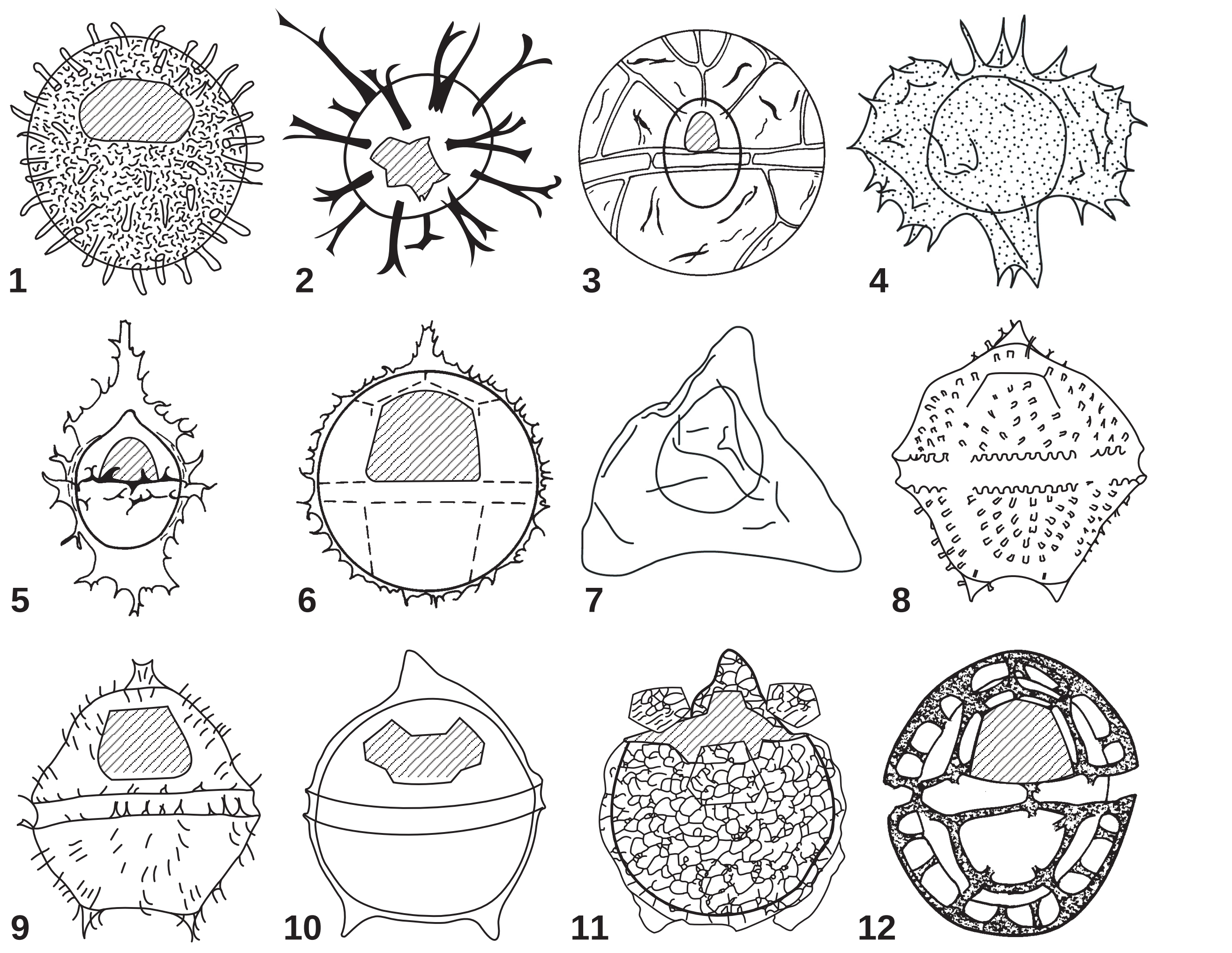

Plate P10 (continued). 13. *Wetzeliella gochtii* Costa and Downie 1976. Dorsal view. Holotype dimensions: pericyst length = 113 µm, pericyst width = 108 µm, endocyst length = 97 µm, endocyst width = 93 µm, apical horn length = 0 µm, lateral horn length = 6 µm, right antapical horn length = 10 µm, left antapical horn length = 6 µm, process length = 6–15 µm. **14.** *Wetzeliella meckelfeldensis* Gocht 1969. Dorsal view. Holotype dimensions: pericyst length = 151 µm, pericyst width = 140 µm, endocyst diameter = 83.75 µm. **15, 16.** *Wilsonidium echinosuturatum* (Wilson 1967c) Lentin and Williams 1976. Holotype dimensions: pericyst length = 149 µm, pericyst width = 143 µm, endocyst diameter = 99 µm × 91 µm, apical horn length = 14 µm, left antapical horn length = 11 µm, right antapical horn length = 22 µm, lateral horns = 16 µm; (15) ventral view; (16) dorsal view. **17, 18.** *Xenascus ceratioides* (Deflandre 1937b) Lentin and Williams 1973. Holotype dimensions: pericyst length = 172 µm; (17) ventral view; (18) dorsal view. **19.** *Xiphophoridium alatum* (Cookson and Eisenack 1962b) Sarjeant 1966b. Dorsal view. Holotype dimensions: overall length = 125 µm, overall width = 96 µm, length (not including ornamentation) = 70 µm, width (not including ornamentation) = 52 µm.

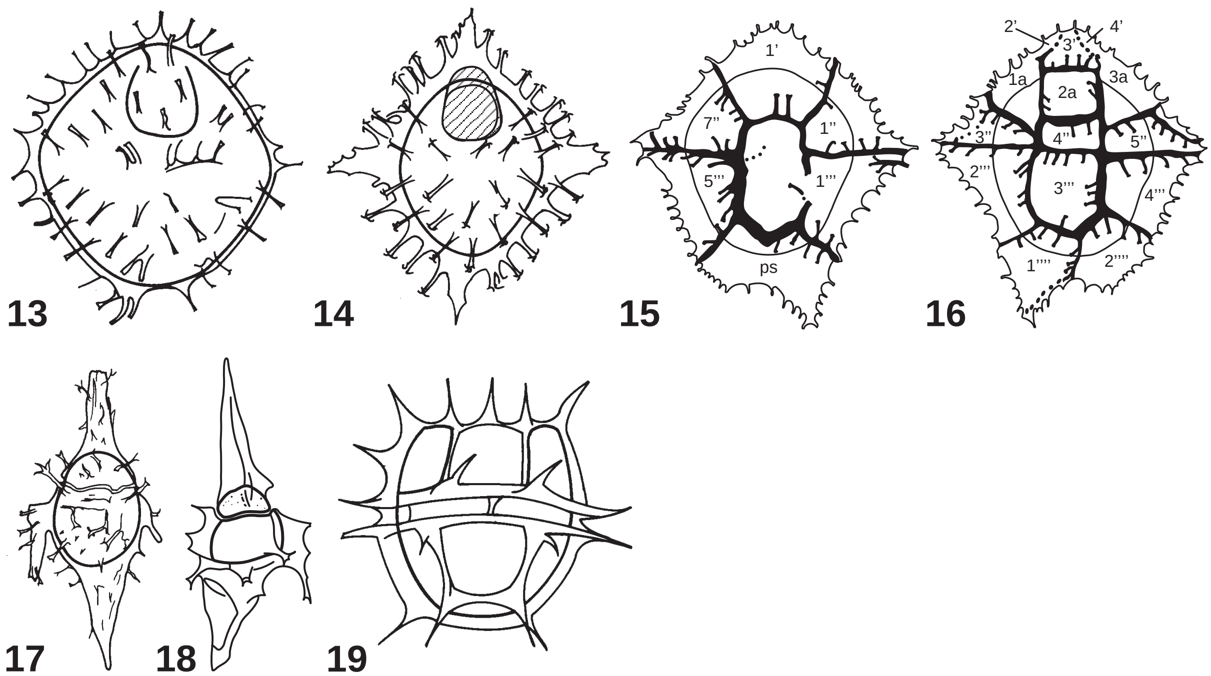

Plate P11. 1, 2. *Achilleodinium biformoides* (Eisenack 1954b) Eaton 1976; (1) dorsal view of dorsal surface (500×); (2) dorsal view of ventral surface (500×). Courtesy of S.P. Damassa. **3, 4.** *Achomosphaera alcicornu* (Eisenack 1954b) Davey and Williams 1966a; (3) ventral view of dorsal surface (300×); (4) ventral view of ventral surface (300×). **5.** *Achomosphaera andalousiensis* Jan du Chêne 1977. Left lateral view of left lateral surface (500×). **6.** *Adnatosphaeridium tutulosum* (Cookson and Eisenack 1960a) Morgan 1980 (500×). **7.** *Alisocysta circumtabulata* (Drugg 1967) Stover and Evitt 1978. Oblique apical surface (700×). **8.** *Alisocysta margarita* (Harland 1979a) Harland 1979a. Oblique apical surface (700×). (Continued on next page.)

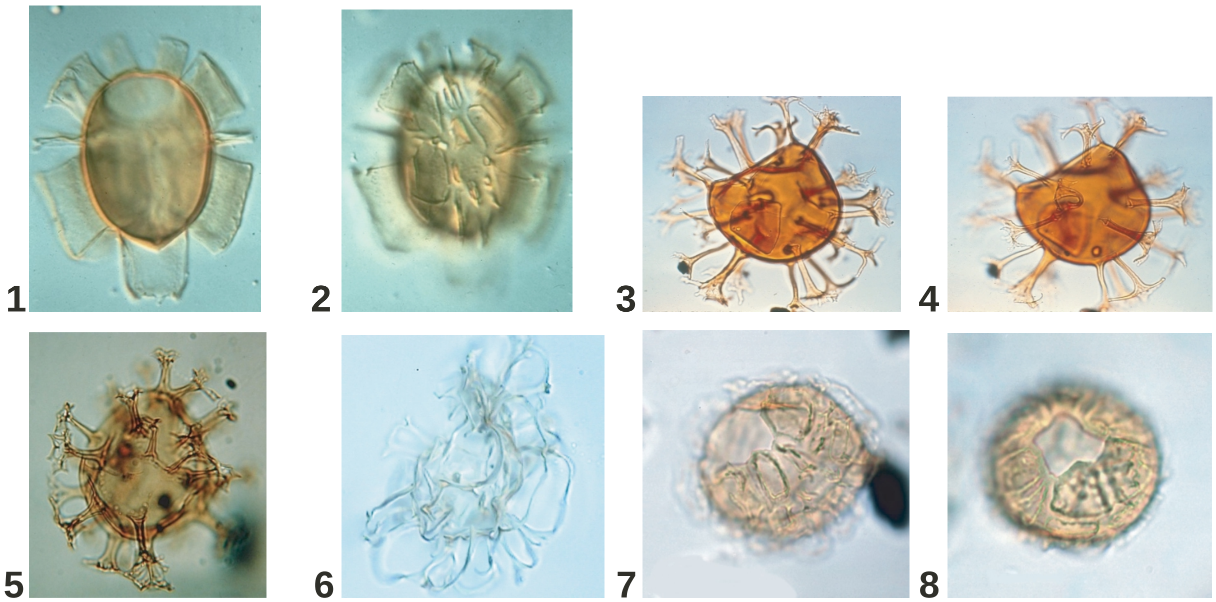

Plate P11 (continued). **9.** *Alisocysta reticulata* Damassa 1979b. Right lateral surface (550×). **10, 11.** *Alisogymnium euclaense* (Cookson and Eisenack 1970a) Lentin and Vozzhennikova 1990; (10) 850×; (11) 1000×. **12–14.** *Alterbidinium*? *distinctum* (Wilson 1967a) Lentin and Williams 1985; (12) ventral view of optical section (400×); (13) ventral view of dorsal surface (400×); (14) right lateral view of right lateral surface (400×). **15, 16.** *Amiculosphaera umbraculum* Harland 1979b; (15) oblique lateral surface (400×); (16) optical section (400×). Courtesy of R. Harland. **17.** *Apectodinium augustum* (Harland 1979c) Lentin and Williams 1981. Ventral view of dorsal surface (300×). **18.** *Apteodinium deflandrei* (Clarke and Verdier 1967) Lucas-Clark 1987. Dorsal view of dorsal surface (700×). **19, 20.** *Arachnodinium antarcticum* Wilson and Clowes 1982; (19) ventral surface (300×); (20) optical section (300×).

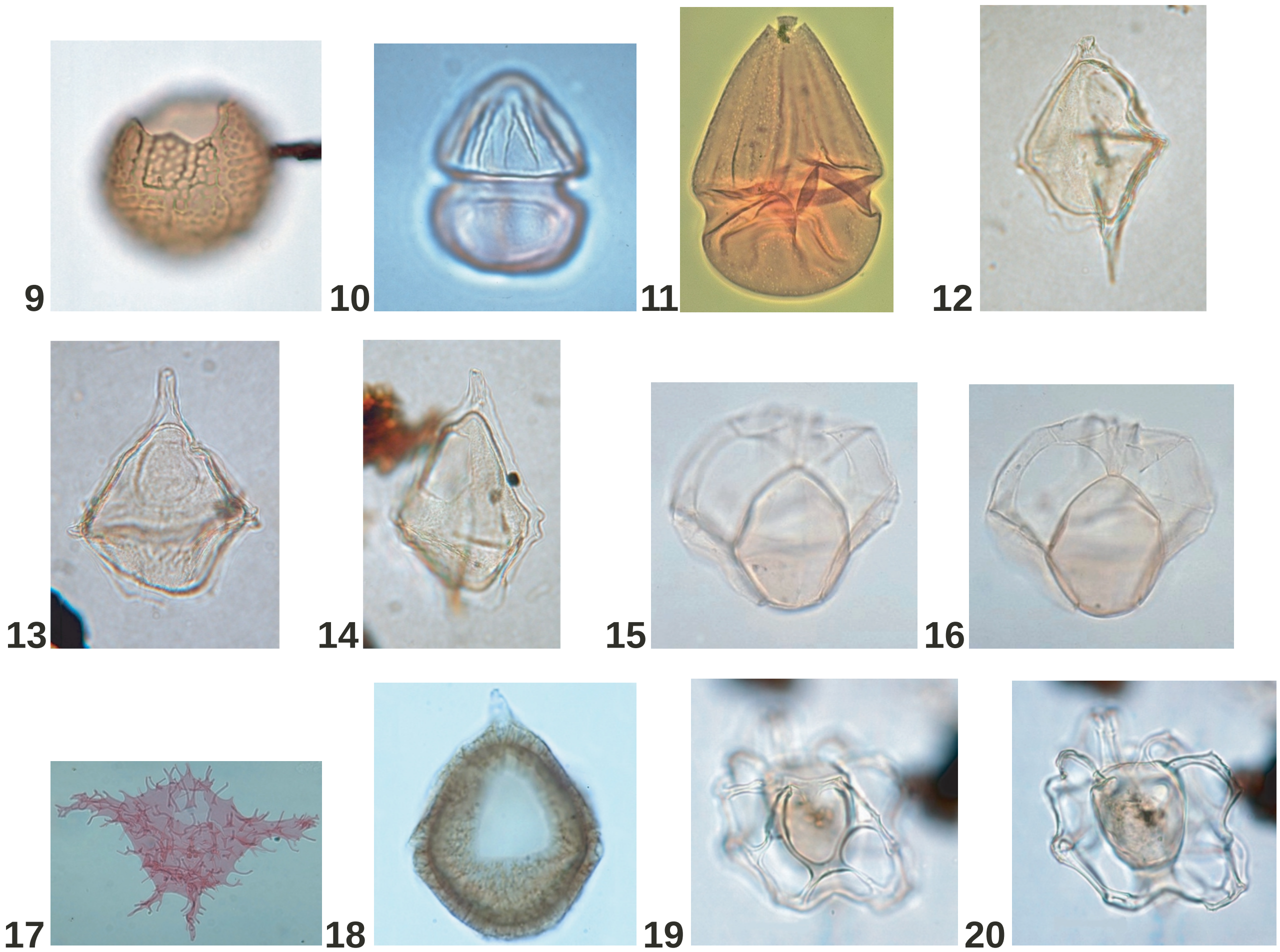

Plate P12. 1–4. *Arachnodinium antarcticum* Wilson and Clowes 1982; (2) upper surface (300×); (3) same specimen as 2, optical section (300×); (3) same specimen as 2, lower surface (300×). **5, 6.** *Areoligera gippingensis* Jolley 1992; (5) ventral surface (600×); (6) oblique apical view (600×). **7, 8.** *Areoligera semicirculata* (Morgenroth 1966b) Stover and Evitt 1978; (7) dorsal surface (450×); (8) ventral view of optical section (450×). (Continued on next page.)

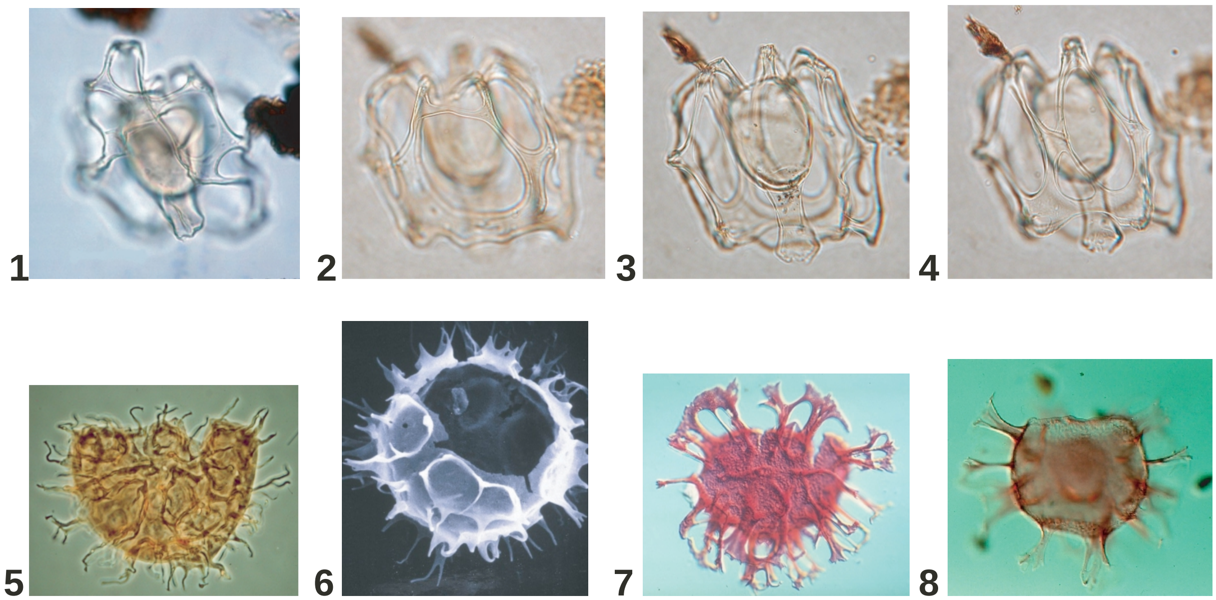

Plate P12 (continued). 9, 10. *Areosphaeridium diktyoplokum* (Klumpp 1953) Eaton 1971; (10) dorsal surface. Both 350×. **11.** *Ataxiodinium choane* Reid 1974. Courtesy of Dan Zevenboom. 700×. **12, 13.** *Ataxiodinium confusum* Versteegh and Zevenboom in Versteegh 1995; (12) dorsal surface (800×); (13) ventral cross-section (800×). **14, 15.** *Barssidinium evangelineae* Lentin et al. 1994; (14) dorsal surface (300×); (15) optical section (300×). **16.** *Biconidinium longissimum* Islam 1983c. 400×. **17, 18.** *Callaiosphaeridium asymmetricum* (Deflandre and Courteville 1939) Davey and Williams 1966b. Both polar views (500×). **19, 20.** *Cannosphaeropsis passio* de Verteuil and Norris 1996a; (19) optical section (350×); (20) dorsal surface (350×).

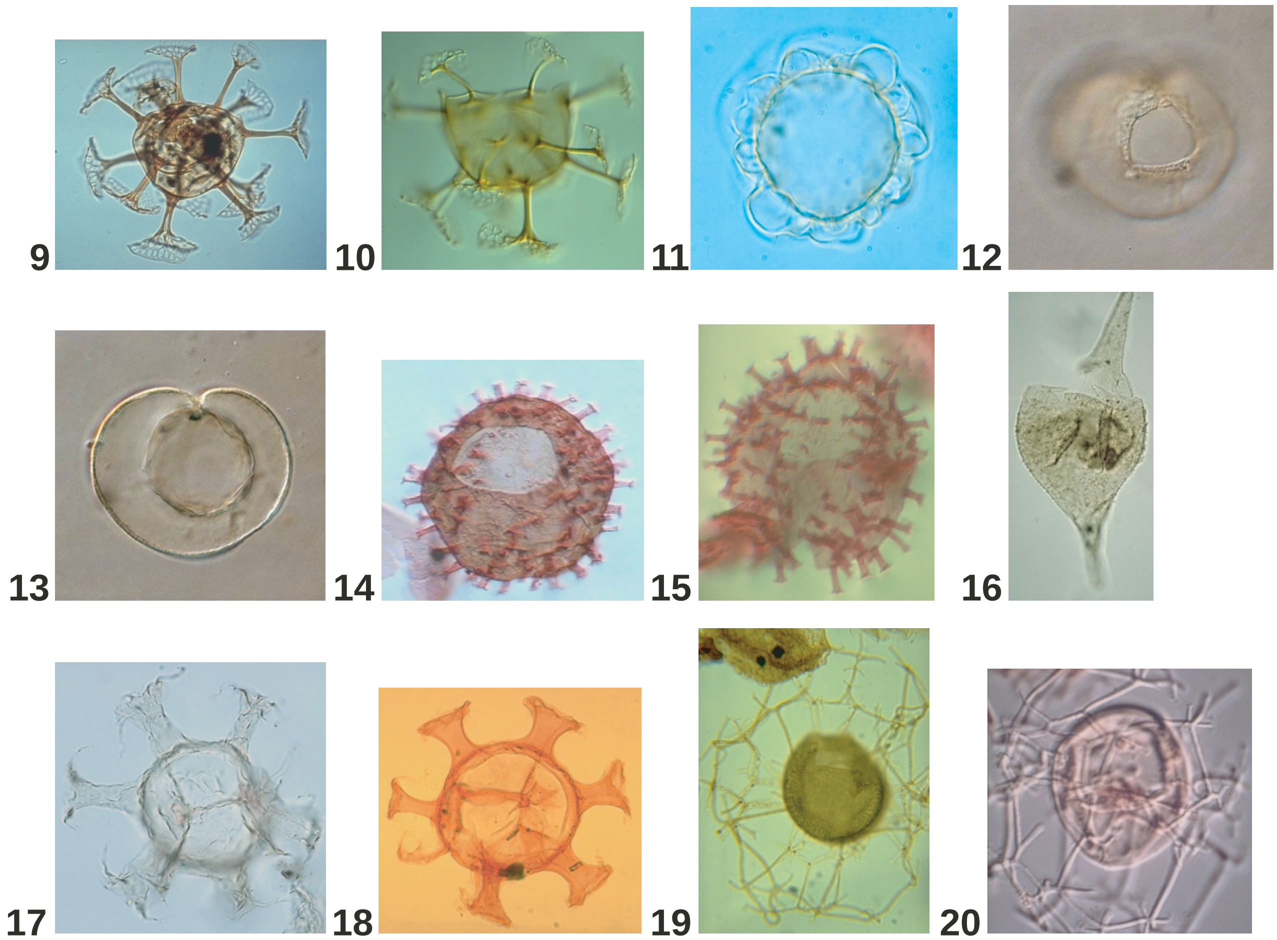

Plate P13. 1, 2. *Cannosphaeropsis utinensis* O. Wetzel 1933b. Same specimen (350×). **3–5.** *Carpatella cornuta* Grigorovich 1969a. Courtesy of S.P. Damassa; (3) scanning electron micrograph (SEM), ventral surface (450×); (4) SEM, dorsal surface (450×); (5) light micrograph, optical section (450×). **6.** *Carpodinium obliquicostatum* Cookson and Hughes 1964. 550×. **7.** *Cassiculosphaeridia reticulata* Davey 1969a. Courtesy of J.P. Verdier. 750×. **8, 9.** *Cerebrocysta bartonensis* Bujak in Bujak et al. 1980; (8) dorsal surface (900×); (9) right lateral view (900×). **10, 11.** *Cerebrocysta poulsenii* de Verteuil and Norris 1996a; (10) optical section of the holotype (750×); (11) ventral view of dorsal surface of the holotype (750×), courtesy of L. de Verteuil. **12, 13.** *Cerodinium diebelii* (Alberti 1959b) Lentin and Williams 1987. 250×. (Continued on next page.)

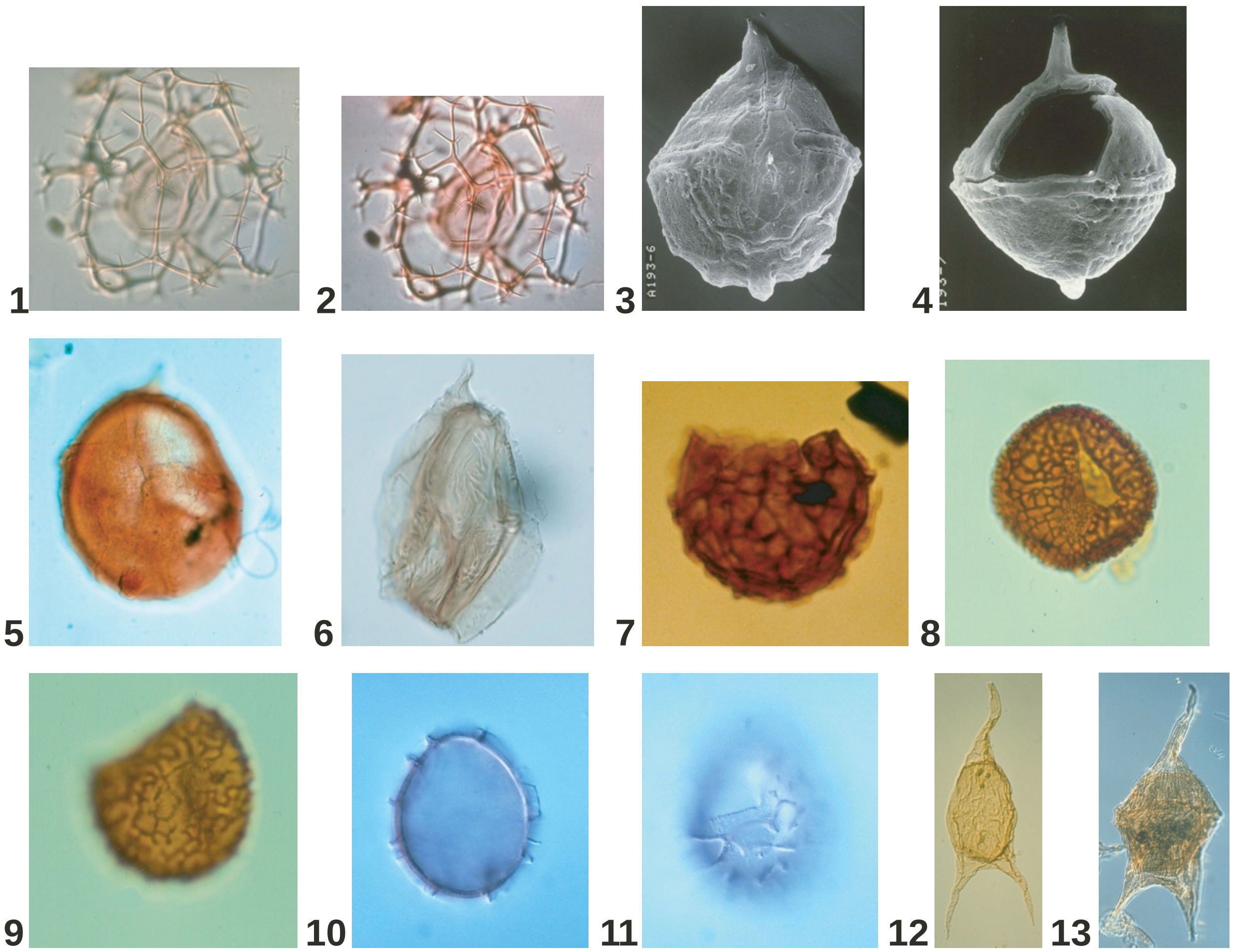

Plate P13 (continued). 14. *Cerodinium wardenense* (Williams and Downie 1966c) Lentin and Williams 1987. Dorsal surface (650×). **15, 16.** *Charlesdowniea columna* (Michoux 1988) Lentin and Vozzhennikova 1990; (15) dorsal view of dorsal surface (350×); (16) SEM, dorsal surface (350×). **17, 18.** *Charlesdowniea crassiramosa* (Williams and Downie 1966b) Lentin and Vozzhennikova 1989; (17) dorsal view of dorsal surface (700×); (18) operculum (350×). **19.** *Charlesdowniea edwardsii* (Wilson 1967c) Lentin and Vozzhennikova 1989. Ventral view of dorsal surface (400×). **20.** *Chatangiella verrucosa* (Manum 1963) Lentin and Williams 1976. Dorsal view of dorsal surface (300×). **21.** *Chichaouadinium vestitum* (Brideaux 1971) Bujak and Davies 1983. Ventral view of dorsal surface (725×). Holotype. Courtesy of W.W. Brideaux.

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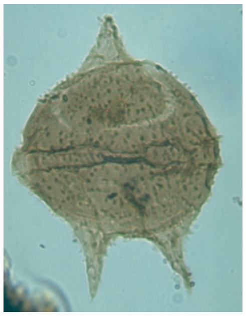
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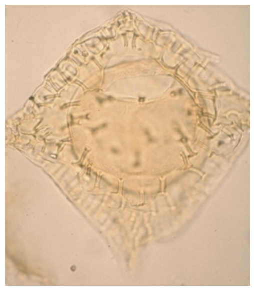
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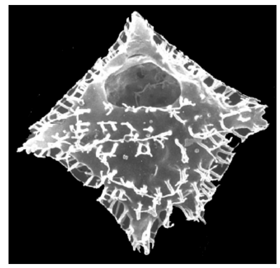
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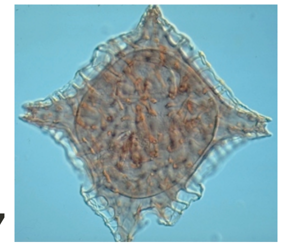
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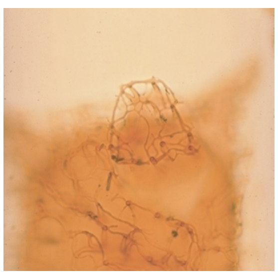
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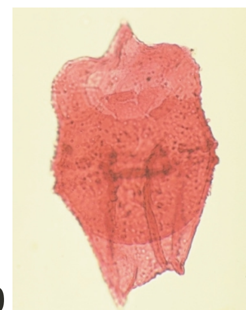
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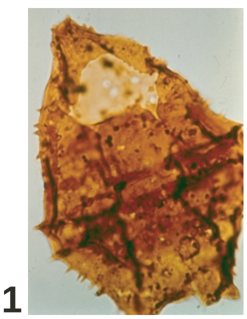

Plate P14. **1.** *Chichaouadinium vestitum* (Brideaux 1971) Bujak and Davies 1983. Dorsal view of dorsal surface (600×). **2, 3.** *Chiropteridium galea* (Maier 1959) Sarjeant 1983; (2) ventral view, optical section (325×); (3) dorsal view of ventral surface (325×). **4.** *Conosphaeridium striatoconum* (Deflandre and Cookson 1955) Cookson and Eisenack 1969. Oblique antapical surface (550×). **5, 6.** *Cordosphaeridium cantharellus* (Brosius 1963) Gocht 1969. Courtesy of S.P. Damassa; (5) optical section (350×); (6) dorsal surface (350×). **7, 8.** *Cordosphaeridium funiculatum* Morgenroth 1966a; (7) dorsal view of dorsal surface, courtesy of S.P. Damassa. Both 400×. (Continued on next page.)

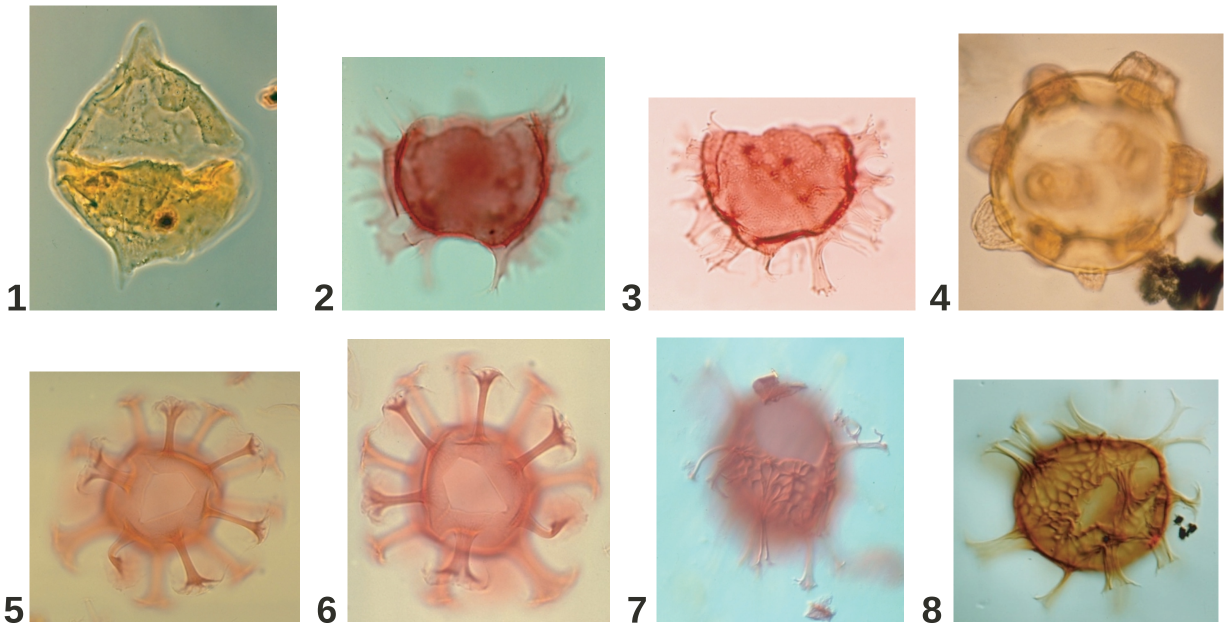

Plate P14 (continued). 9–11. *Corrudinium harlandii* Matsuoka 1983b. Holotype; (9) dorsal view (650×); (10, 11) optical sections (650×), courtesy of K. Matsuoka. **12–14.** *Corrudinium incompositum* (Drugg 1970b) Stover and Evitt 1978; (12) scanning electron micrograph (SEM), oblique apical view (750×); (13) right lateral surface (750×); (14) left lateral surface (750×). **15–17.** *Cousteaudinium aubryae* de Verteuil and Norris 1996a; (15) left ventro-lateral view of left ventro-lateral surface (450×); (16) left ventro-lateral view in optical section (450×). Figures 15, 16 courtesy of L. de Verteuil. **18.** *Cyclapophysis monmouthensis* Benson 1976 (300×). **19.** *Cyclonephelium filoreticulatum* (Slimani 1994) Prince et al., 1999. 450×. **20.** *Cyclonephelium membraniphorum* Cookson and Eisenack 1962b. 300×.

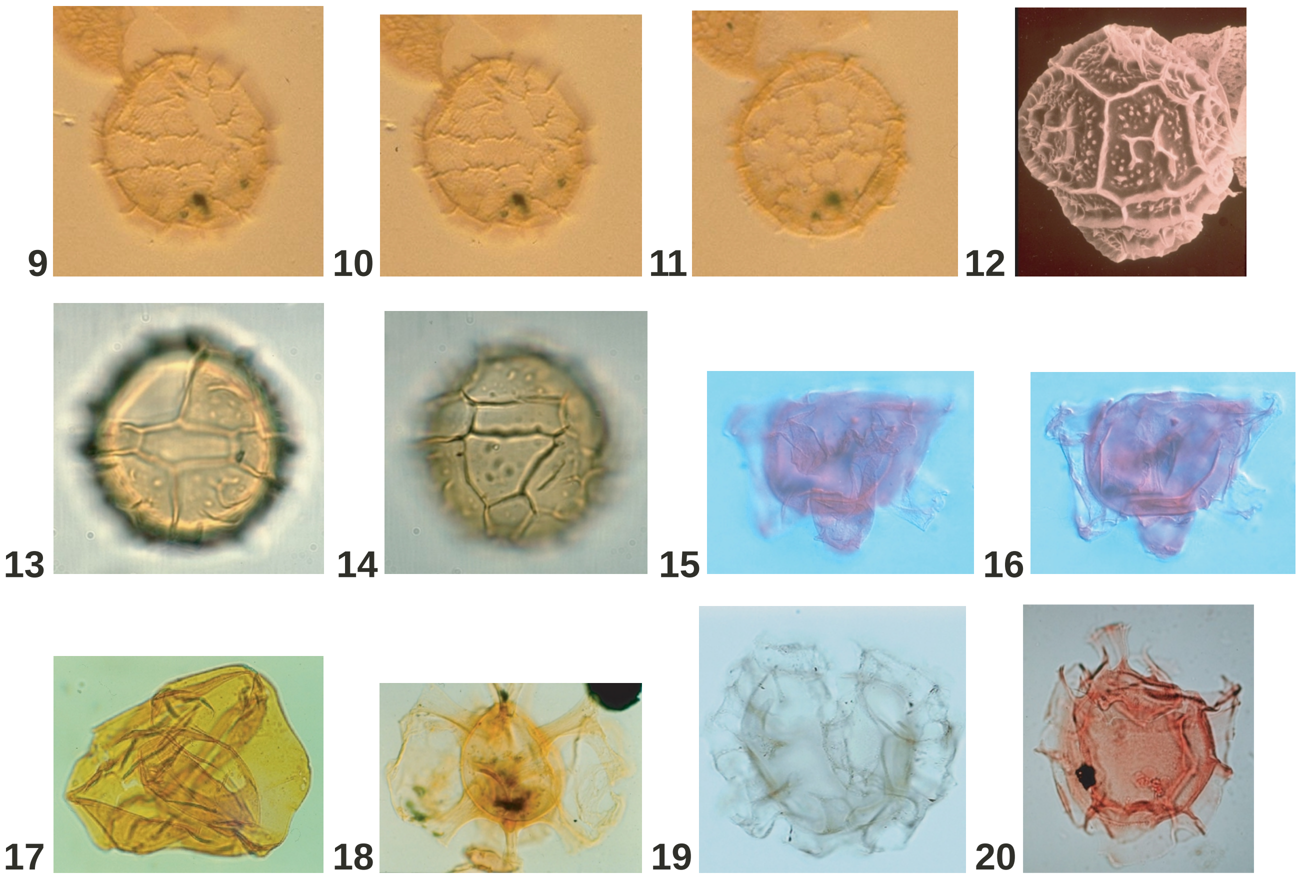

Plate P15. **1, 2.** *Cyclonephelium membraniphorum* Cookson and Eisenack 1962b. Both ventral surface (350×). **3, 4.** *Damassadinium californicum* (Drugg 1967) Fensome et al., 1993b; (3) right lateral surface (425×); (4) optical section (425×). **5–8.** *Deflandrea antarctica* Wilson 1967a; (5) dorsal surface (300×); (6) same specimen as 5, optical section (300×); (7) dorsal surface (300×); (8) same specimen as 7, ventral surface (300×). **9–12.** *Deflandrea convexa* Wilson 1988; (9) dorsal surface (450×); (10) optical section of holotype (450×); (11) dorsal surface (300×); (12) same specimen as 11, ventral surface (300×). Figures 9, 10 courtesy of G.J. Wilson. (Continued on next page.)

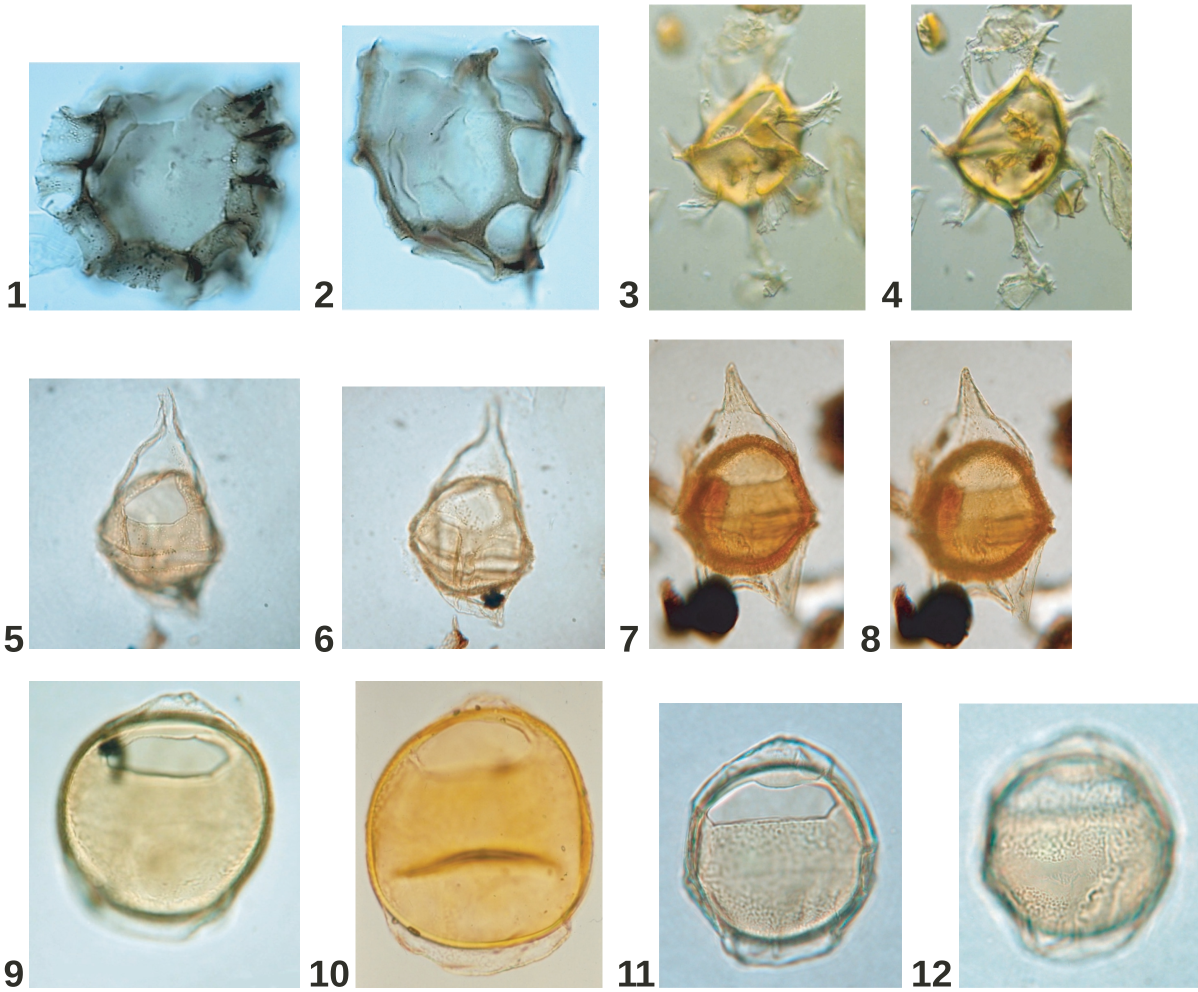

Plate P15 (continued). **13.** *Deflandrea cygniformis* Pöthe de Baldis, 1966. 250×. **14, 15.** *Deflandrea oebisfeldensis* Alberti 1959b. 300×. **16.** *Deflandrea phosphoritica* Eisenack 1938b. Optical section (300×). **17.** *Dinogymnium* sp. 900×. **18.** *Dinopterygium cladoides* Deflandre 1935. 375×. **19, 20.** *Diphyes colligerum* (Deflandre and Cookson 1955) Cookson 1965a; (20) optical section. Both 600×.

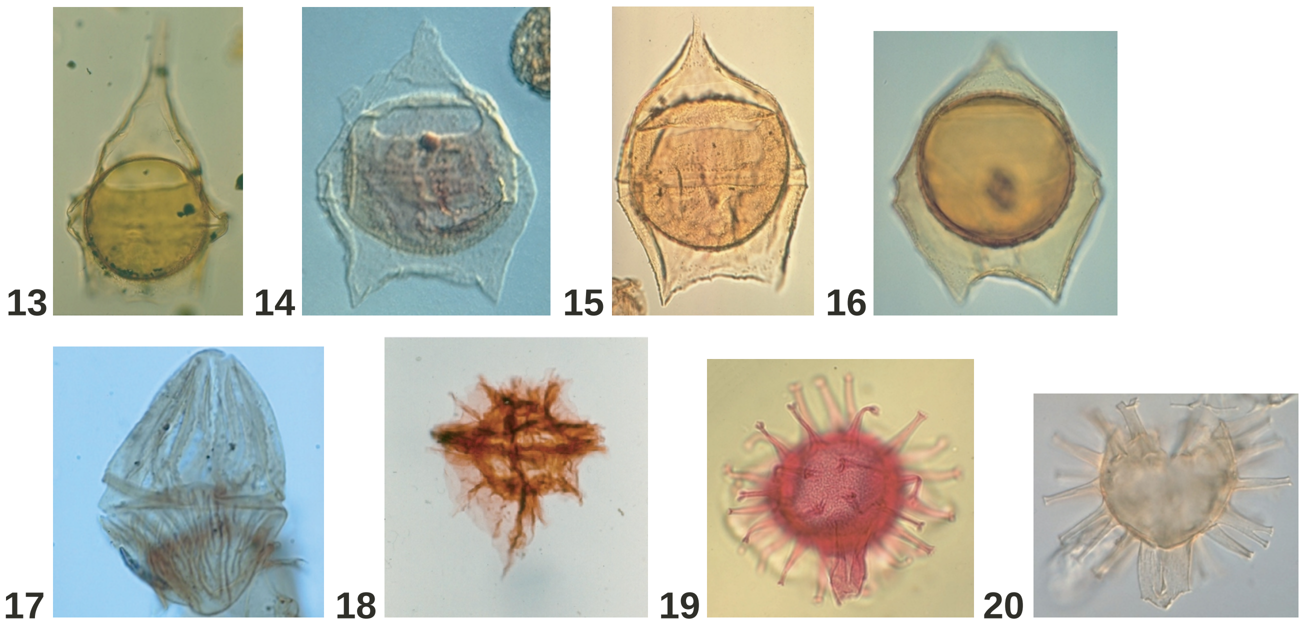

Plate P16. 1–3. *Diphyes ficusoides* Islam 1983b; (3) with operculum in place. All (550×). **4, 5.** *Distatodinium apenninicum* Brinkhuis et al. 1992; (4) ventral surface (500×); (5) dorsal surface (500×). **6, 7.** *Distatodinium biffii* Brinkhuis et al. 1992. 250×. **8, 9.** *Dracodinium condylos* (Williams and Downie 1966b) Costa and Downie 1979; (8) optical section in dorsal view (300×); (9) ventral surface in ventral view (300×). **10.** *Dracodinium politum* Bujak et al. 1980. Optical section in dorsal view (250×). **11, 12.** *Dracodinium varielongitudum* (Williams and Downie 1966b) Costa and Downie 1979; (11) optical section in ventral view (350×); (12) dorsal surface (300×). (Continued on next page.)

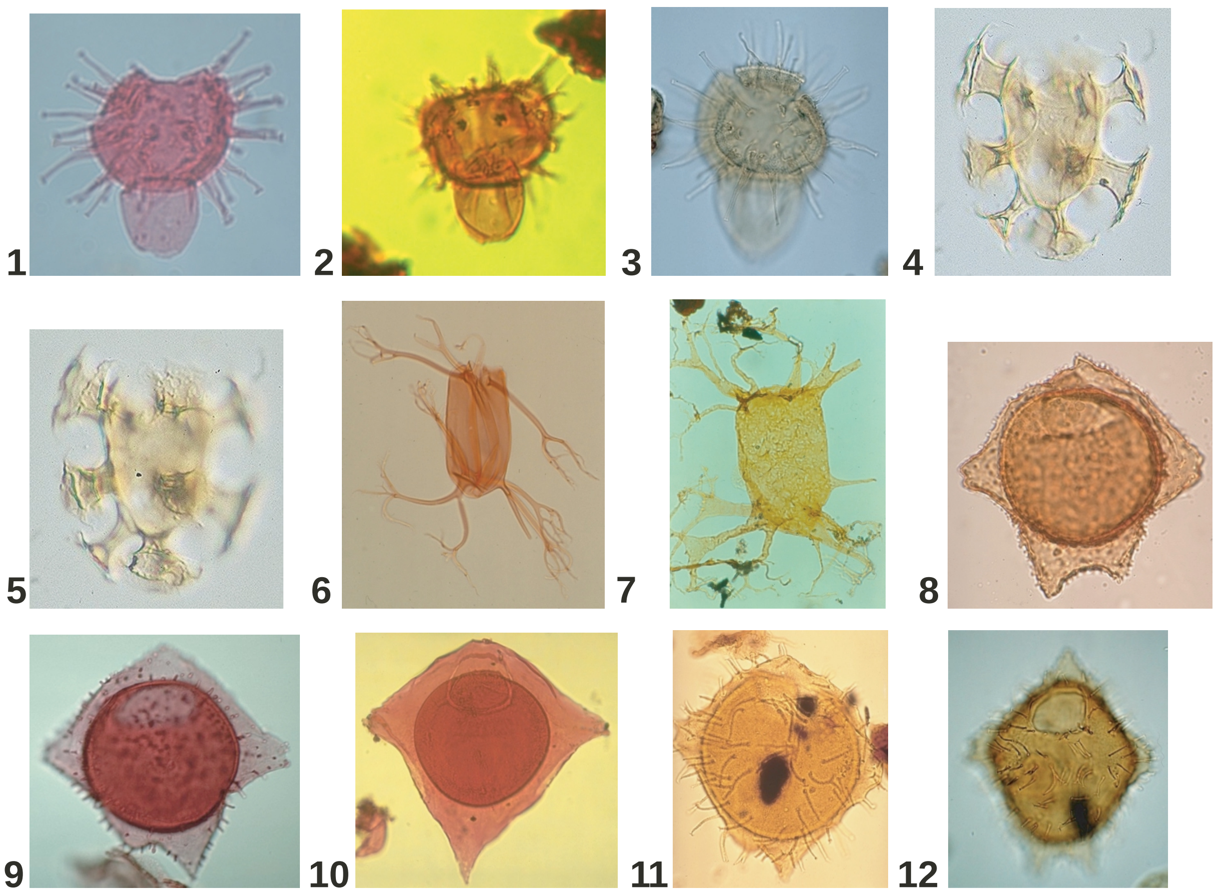

Plate P16 (continued). 13. *Dracodinium waipawaense* (Wilson 1967c) Costa and Downie 1979. Ventral view of dorsal surface (250×). **14.** *Eatonicysta furensis* (Heilmann-Clausen in Heilmann-Clausen and Costa 1989) Stover and Williams 1995. Ventral surface (500×). **15.** *Eatonicysta pterococcoides* (O. Wetzel 1933b) Sarjeant 1985b. 550×. **16–18.** *Eatonicysta ursulae* (Morgenroth 1966a) Stover and Evitt, 1978; (17) with operculum (400×); (18) oblique apical view (400×); (19) oblique ventral view (400×). **19.** *Ectosphaeropsis burdigalensis* Londeix and Jan du Chêne 1988. Dorsal surface (300×).

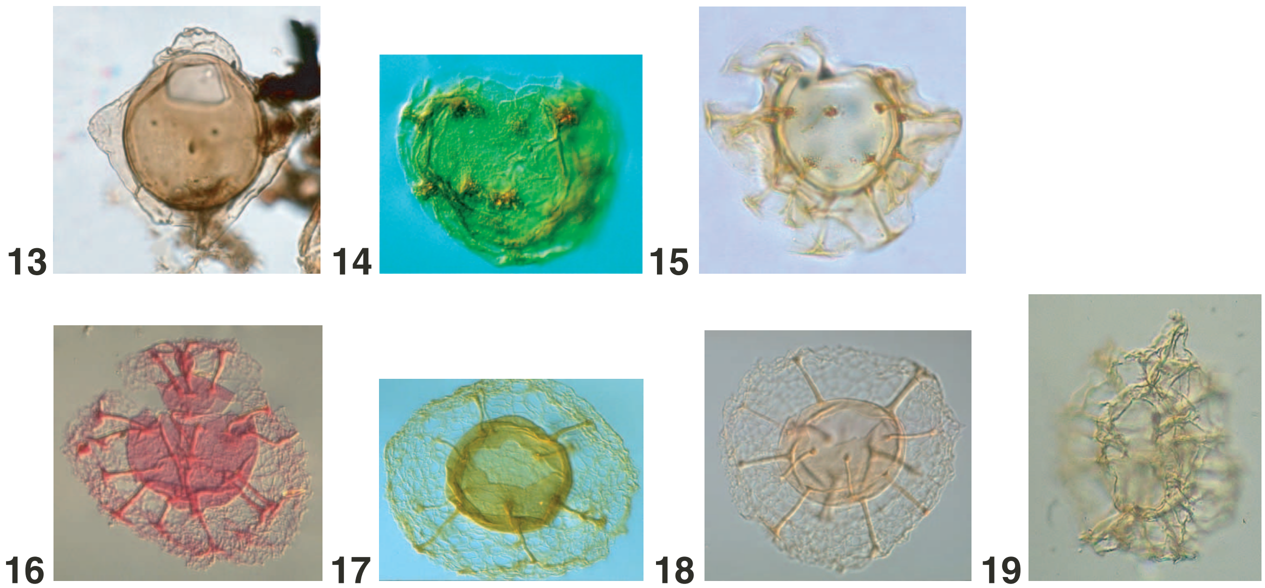

Plate P17. 1–3. *Edwardsiella sexispinosa* Versteegh and Zevenboom in Versteegh 1995; (1, 2) optical sections (300×); (3) dorsal surface (300×), courtesy of G.J.M. Versteegh. **4.** *Ellipsodinium rugulosum* Clarke and Verdier 1967. Right lateral surface (950×). **5, 6.** *Endoscrinium campanula* (Gocht 1959) Vozzhennikova 1967; (5) dorsal surface (350×); (6) scanning electron micrograph (SEM), dorsal surface (300×), courtesy of E.J. Kidson. **7, 8.** *Enneadocysta partridgei* Stover and Williams 1995; (8) same specimen as 7 showing operculum inside. Both (300×). **9–12.** *Enneadocysta pectiniformis* (Gerlach 1961) Stover and Williams 1995; (9, 10). same specimen (500×); (11) dorsal surface (500×); (12) same specimen as 11, ventral surface (500×). (Continued on next page.)

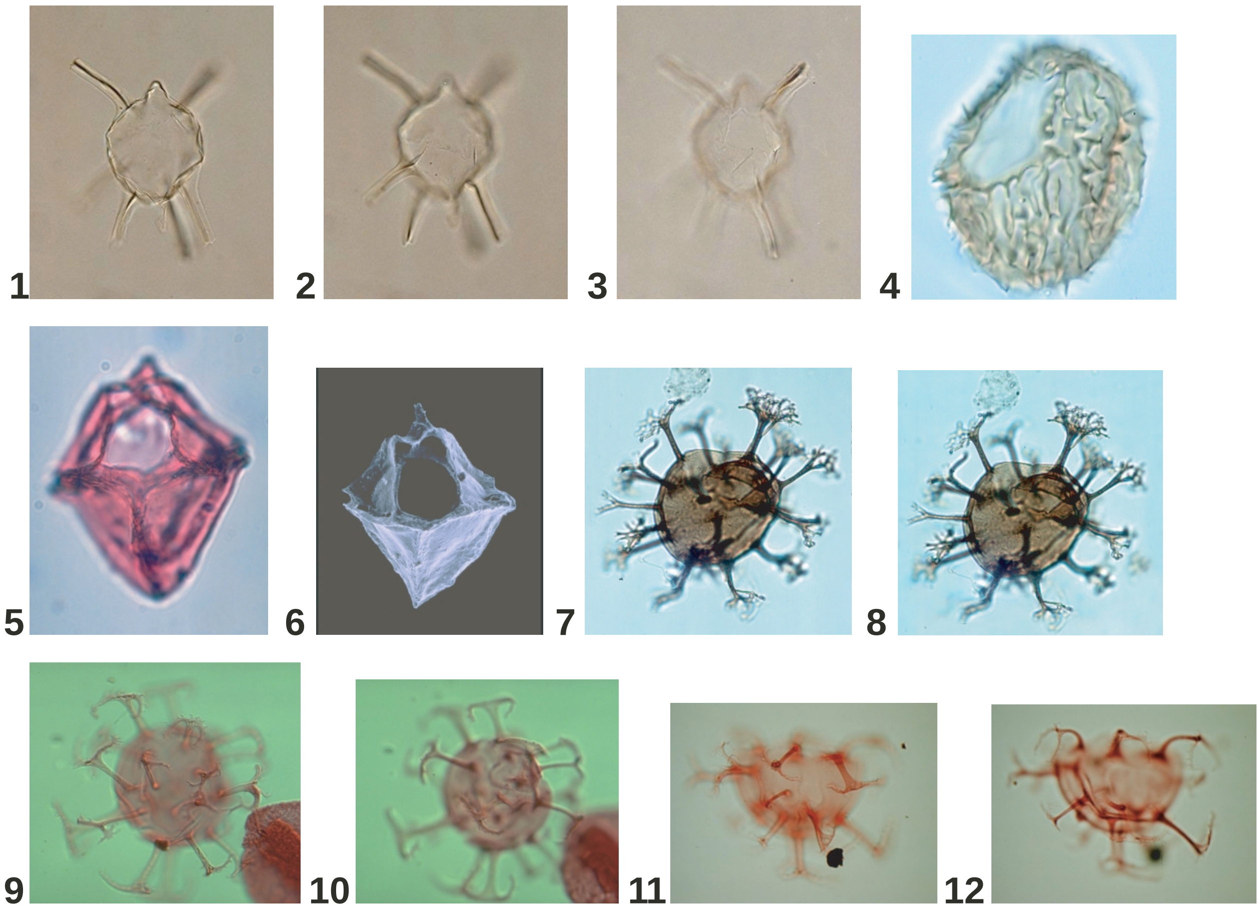

Plate P17 (continued). 13, 14. *Epelidosphaeridia spinosa* Cookson and Hughes 1964 ex Davey 1969a; (13) dorsal view of dorsal surface (700×); (14) ventral view (550×). **15, 16.** *Filisphaera filifera* Bujak 1984; (15) dorsal surface (650×); (16) optical section (650×). **17.** *Florentinia mayii* Kirsch 1991. 600×. **18, 19.** *Galeacysta etrusca* Corradini and Biffi 1988. Holotype; (18) ventral view of dorsal surface (400×); (19) ventral view of ventral surface (400×). **20.** *Gerdiocysta conopeum* Liengjarern et al. 1980. 400×.

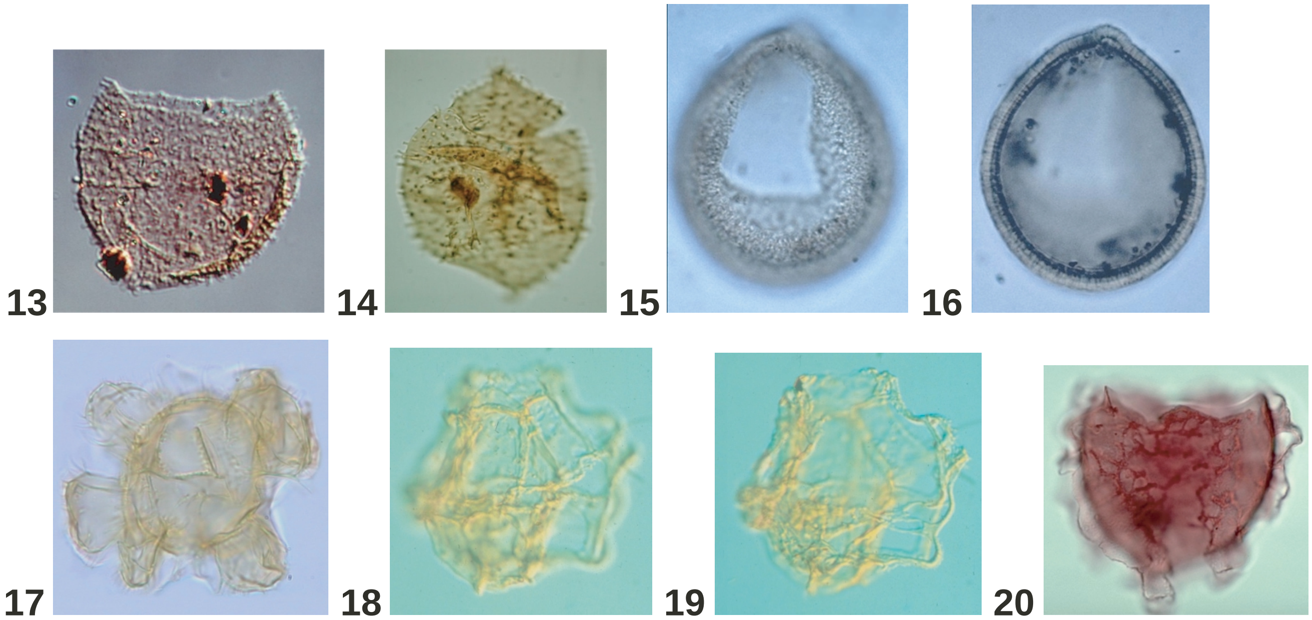

Plate P18. 1. *Gerdiocysta conopeum* Liengjarern et al. 1980. Dorsal view of dorsal surface (400×). **2–4.** *Glaphyrocysta semitecta* (Bujak in Bujak et al. 1980) Lentin and Williams 1981. (2) ventral surface (400×); (3) same specimen as 2, optical section (400×); (4) same specimen as 2, dorsal surface (400×). **5.** *Gramocysta verricula* (Piasecki 1980) Lund and Lund-Christensen in von Daniels et al. 1990. 425×. **6.** *Habibacysta tectata* Head et al. 1989b. Dorsal surface (900×). **7, 8.** *Hemiplacophora semilunifera* Cookson and Eisenack 1965a; (7) operculum (900×); (8) ventral view of dorsal surface plus operculum (500×). (Continued on next page).

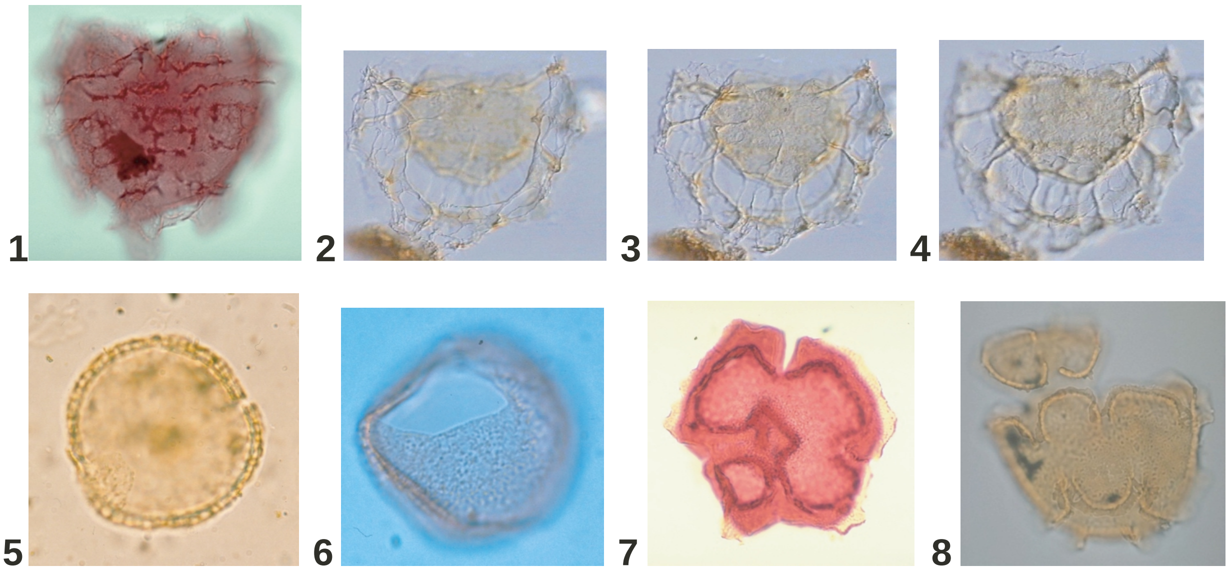

Plate P18 (continued). **9.** *Heteraulacacysta porosa* Bujak in Bujak et al. 1980. 350×. **10, 11.** *Heterosphaeridium difficile* (Manum and Cookson 1964) Ioannides 1986. Both 400×. **12–16.** *Homotryblium floripes* (Deflandre and Cookson 1955) Stover 1975; (12) antapical view of antapical surface (350×); (13) same specimen as 12, antapical view of postcingular processes (350×); (14) same specimen as 12, antapical view of cingular processes (350×); (15) antapex (350×); (16) antapex (400×). **17, 18.** *Homotryblium tenuispinosum* Davey and Williams 1966b; (17) lateral view (450×), courtesy of J.P. Bujak; (18) ventral surface showing sulcal tongue (450×). **19, 20.** *Hystrichokolpoma bulbosum* (Ehrenberg 1838) Morgenroth 1968; (19) optical section (800×); (20) same specimen as 19, ventral surface in focus (800×), courtesy of S.P. Damassa.

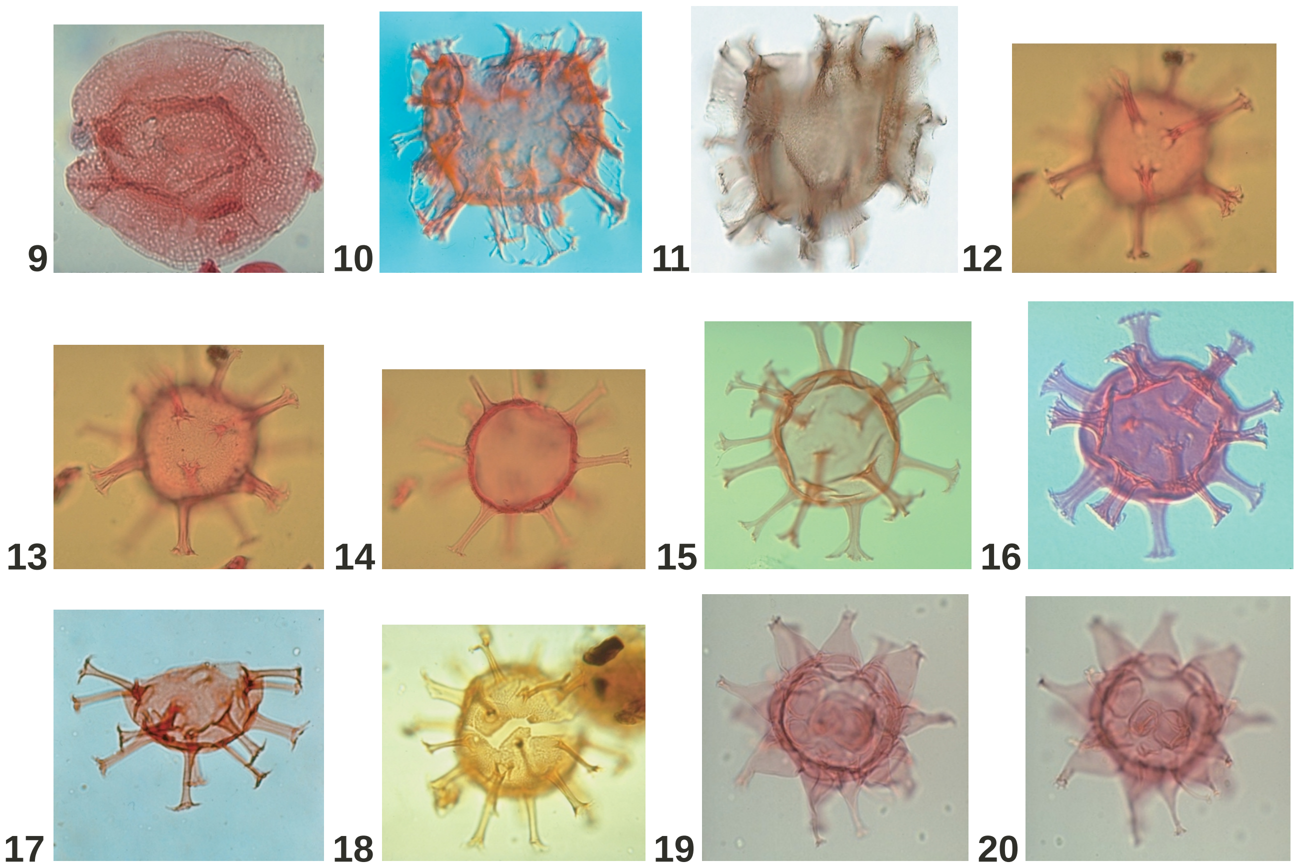

Plate P19. 1. *Hystrichokolpoma bulbosum* (Ehrenberg 1838) Morgenroth 1968. Same specimen as Pl. P18, p. 81, figs. 19, 20. Dorsal surface (800×), courtesy of S.P. Damassa. **2–5.** *Hystrichokolpoma cinctum* Klumpp 1953; (2) optical section (300×); (3) same specimen as 2, ventral surface (300×); (4) same specimen as 2, dorsal survace (300×); (5) dorsal surface (450×), courtesy of S.P. Damassa. **6.** "*Hystrichokolpoma pseudooceanicum*" Zevenboom and Santarelli in Zevenboom 1995 (considered an unpublished manuscript name by the originating authors). 750×. **7.** *Hystrichokolpoma pusillum* Biffi and Manum 1988. Series of successive foci on same specimen (300×), courtesy of S.P. Damassa. **8.** "*Hystrichokolpoma reductum*" Zevenboom and Santarelli in Zevenboom 1995 (considered an unpublished manuscript name by the originating authors). 400×. (Continued on next page.)

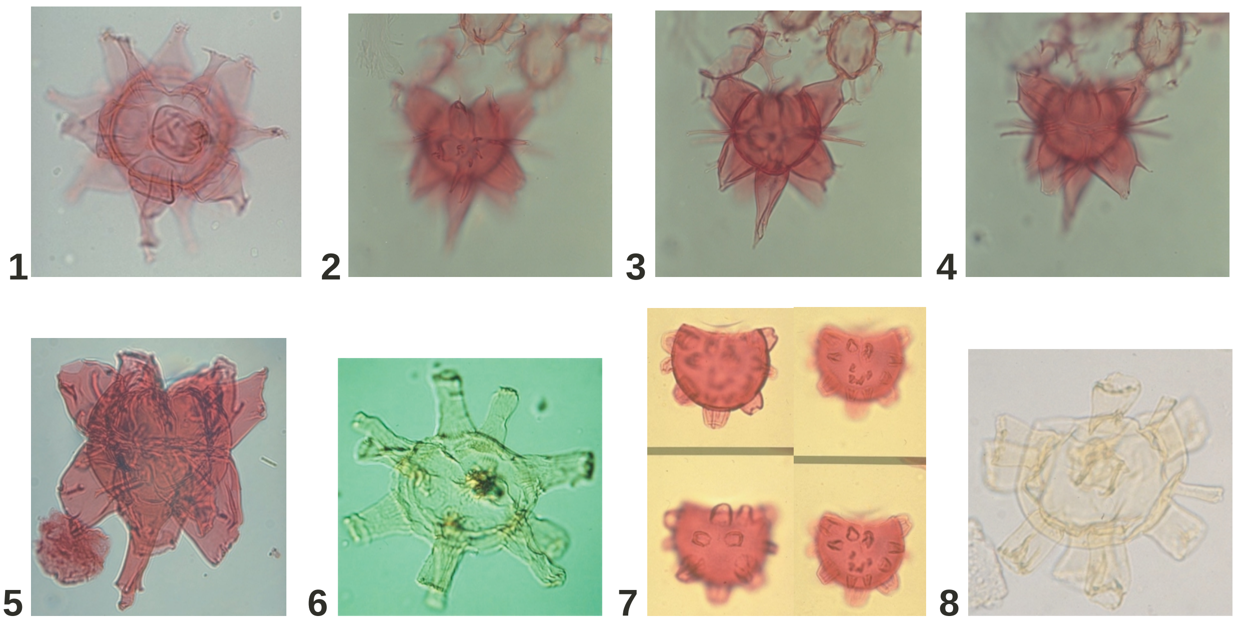

Plate P19 (continued). 9–11. *Hystrichosphaeridium truswelliae* Wrenn and Hart 1988. Same specimen at different focal depths (400×). **12, 13.** *Hystrichosphaeridium tubiferum* (Ehrenberg 1838) Deflandre 1937b, emended Davey and Williams 1966b; (12) apical surface (350×); (13) same specimen as 12, antapical surface (350×). **14.** *Hystrichosphaeropsis quasicribrata* (O. Wetzel 1961) Gocht 1976. 450×. **15, 16.** *Impagidinium patulum* (Wall 1967) Stover and Evitt 1978; (15) dorsal view of ventral surface (500×); (16) same specimen as 15, dorsal view of dorsal surface (500×). **17, 18.** *Invertocysta tabulata* Edwards 1984; (18) Holotype, courtesy of L.E. Edwards. Both 375×. **19.** *Isabelidinium*? *viborgense* Heilmann-Clausen 1985. Courtesy of C. Heilmann-Clausen. 700×. **20.** *Kleithriasphaeridium loffrense* Davey and Verdier 1976. 400×.

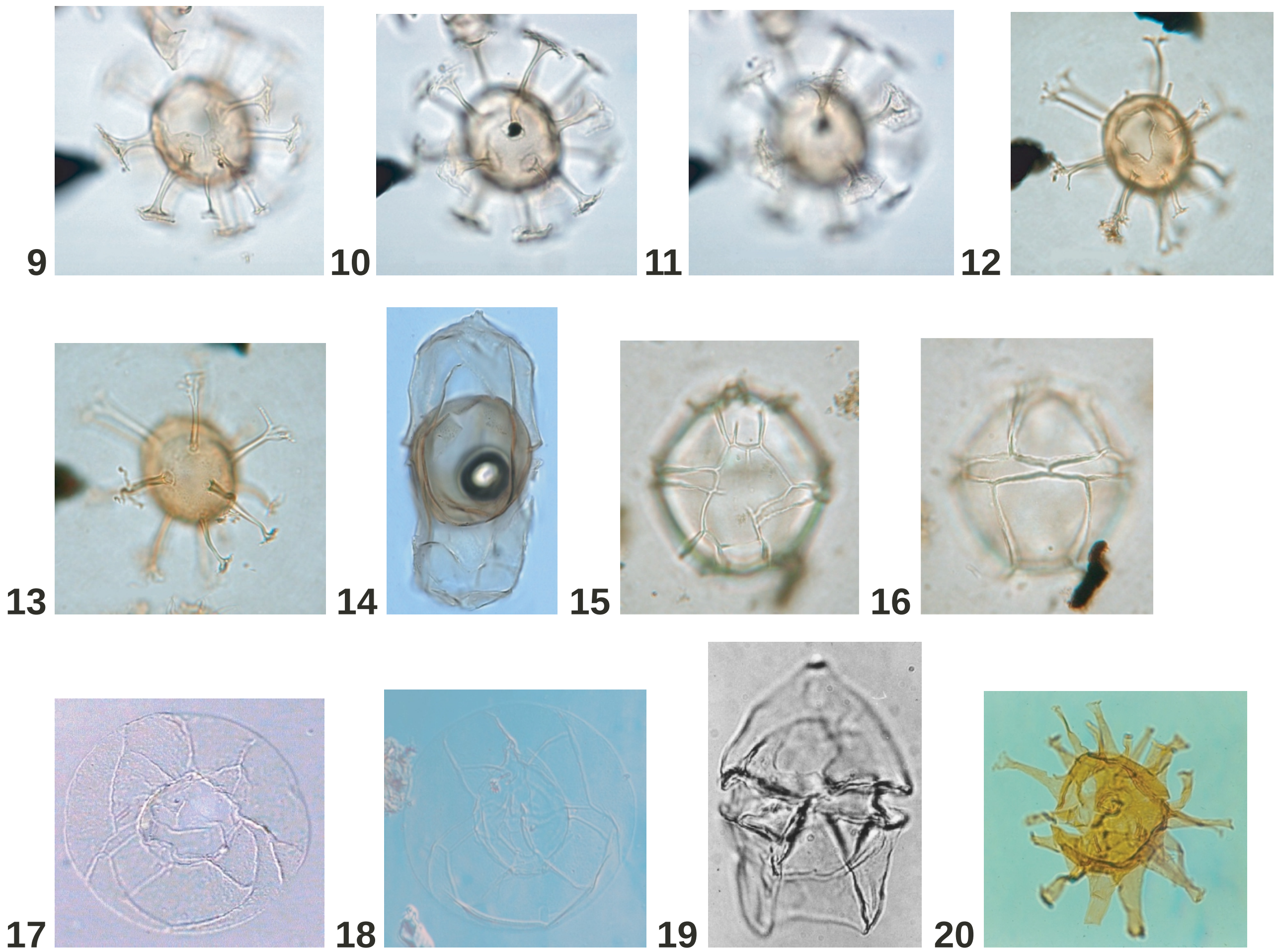

Plate P20. 1, 2. *Kleithriasphaeridium loffrense* Davey and Verdier 1976. Both 400×. **3.** *Kleithriasphaeridium readii* (Davey and Williams 1966b) Davey and Verdier 1976. 300×. **4–6.** *Labyrinthodinium truncatum* Piasecki 1980; (4) antapical surface; (6) archeopyle margin in focus. Courtesy of L. de Verteuil. All 800×. **7–10.** *Laciniadinium biconiculum* McIntyre 1975; (7) optical section in dorsal view (500×); (8) same specimen as 7, dorsal view (500×); (9, 10). Same specimen in dorsal view (500×). **11.** *Lentinia serrata* Bujak in Bujak et al. 1980. Optical section of holotype (650×). (Continued on next page.)

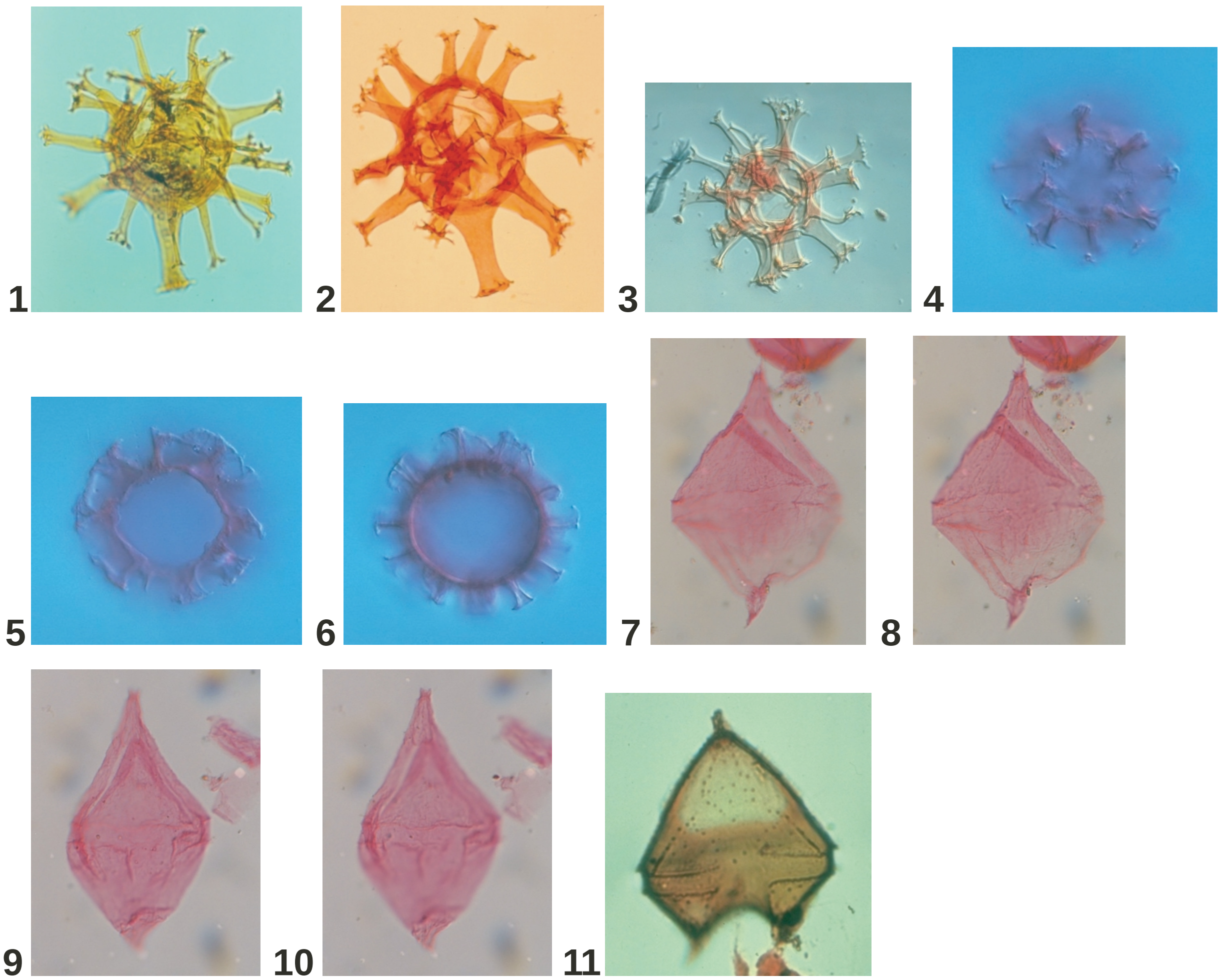

Plate P20 (continued). 12–14. *Leptodinium italicum* Biffi and Manum 1988; (12) scanning electron micrograph (SEM), ventral surface (625×); (13) dorsal view of ventral surface (625×); (14) same specimen as 13, dorsal view of dorsal surface (625×). **15–17.** *Litosphaeridium siphonophorum* (Cookson and Eisenack 1958) Davey and Williams 1966b; (15) SEM (450×), courtesy of E.J. Kidson; (16) 450×; (17) 500×. **18.** *Manumiella seelandica* (Lange 1969) Bujak and Davies 1983. 425×. **19.** *Melitasphaeridium pseudorecurvatum* (Morgenroth 1966a) Bujak et al. 1980. Optical section (525×). **20.** *Membranilarnacia*? *picena* Biffi and Manum 1988. Optical section (675×).

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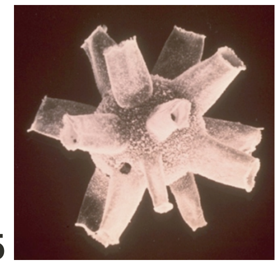

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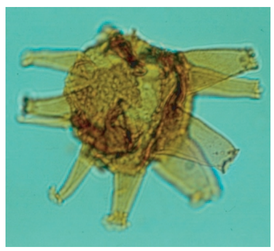

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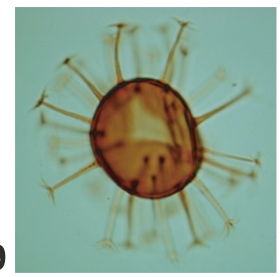

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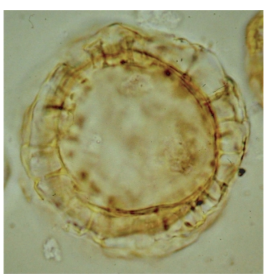

Plate P21. **1, 2.** *Membranophoridium perforatum* Wilson 1988. Holotype, courtesy of G.J. Wilson; (1) 300×; (2) 400×. **3.** "*Mendicodinium robustum*" Zevenboom and Santarelli in Zevenboom 1995 (considered an unpublished manuscript name by the originating authors). 400×. **4.** *Nematosphaeropsis downiei* Brown 1986. 400×. **5, 6.** *Octodinium askiniae* Wrenn and Hart 1988; (5) 300×; (6) 375×. ***7.*** *Odontochitina costata* Alberti 1961. Dorsal view (275×). **8.** *Odontochitina operculata* (O. Wetzel 1933a) Deflandre and Cookson 1955. Ventral view (275×). (Continued on next page.)

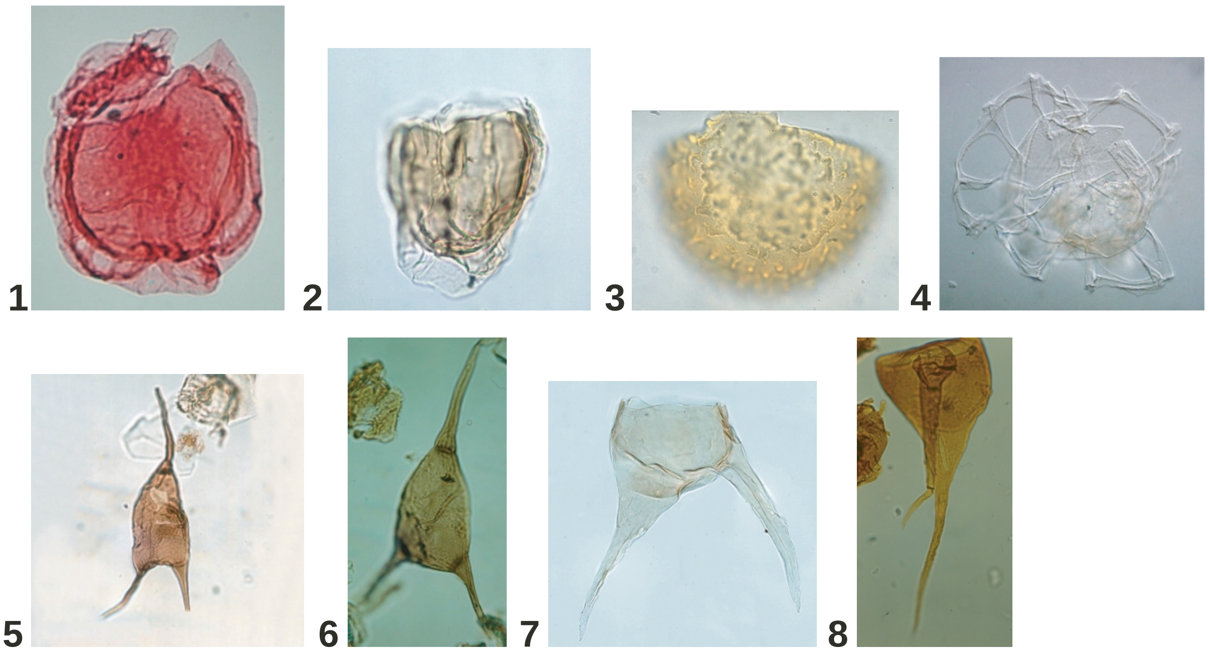

Plate P21 (continued). 9. "*Odontochitina diversa*" Pearce 2000 unpublished thesis name. 300×. **10–12.** *Odontochitina porifera* Cookson 1956; (10, 11) same specimen in ventral view. All 225×. **13.** *Oligosphaeridium poculum* Jain 1977b. 325×. **14, 15.** *Oligosphaeridium pulcherrimum* (Deflandre and Cookson 1955) Davey and Williams 1966b; (14) ventral surface. Both × 325. **16–18.** *Oligosphaeridium* spp. All 325×. **19, 20.** *Operculodinium divergens* (Eisenack 1954b) Stover and Evitt 1978; (20) courtesy of S.P. Damassa. Both 350×.

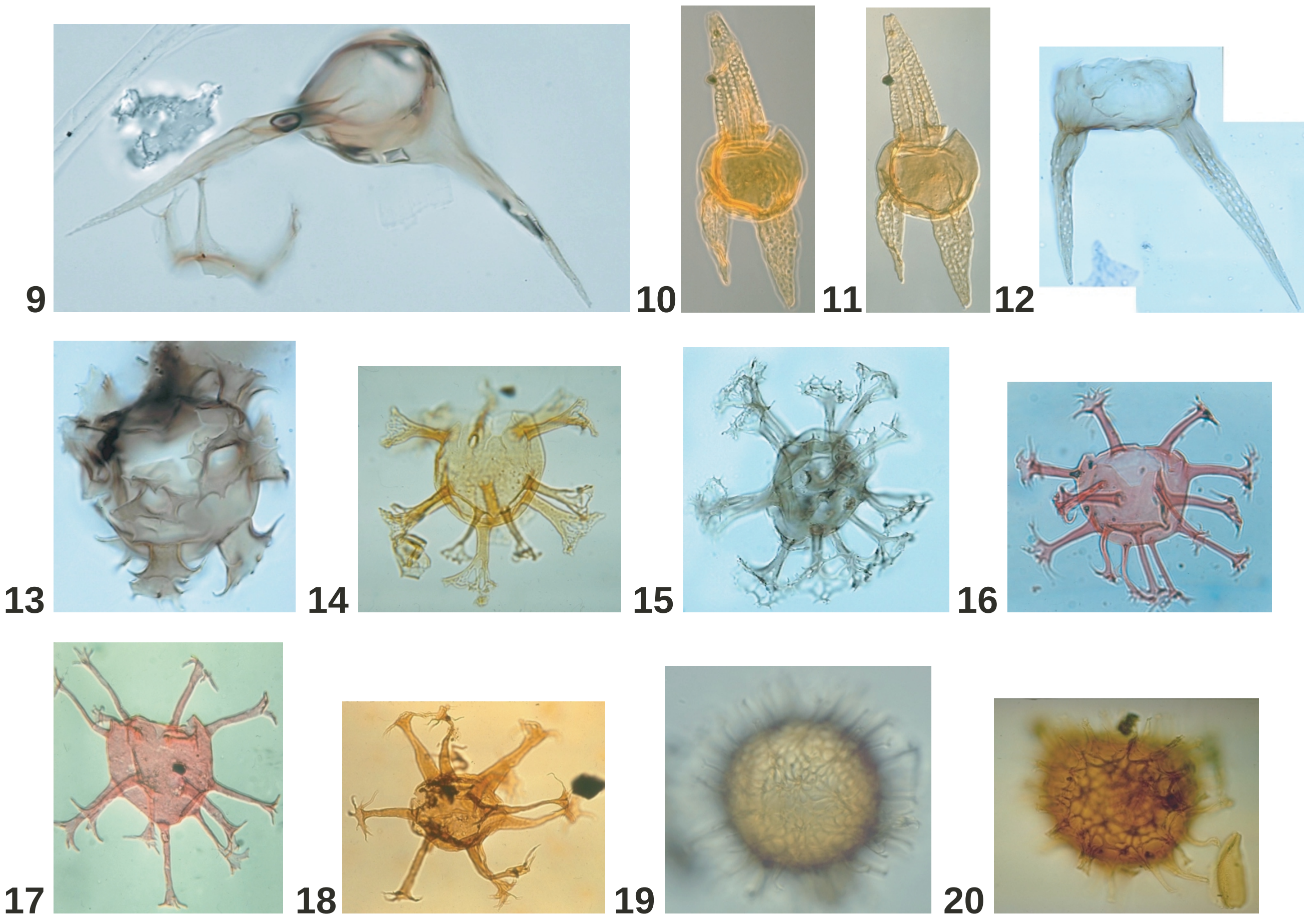

Plate P22. 1, 2. *Operculodinium echigoense* Matsuoka 1983b; (2) courtesy of K. Matsuoka. Both 400×. **3.** *Operculodinium*? *eirikianum* Head et al. 1989b. 700×. **4.** *Ovoidinium verrucosum* (Cookson and Hughes 1964) Davey 1970. Ventral view (700×). **5, 6.** *Palaeocystodinium bulliforme* Ioannides 1986. Both 250×. **7.** "*Palaeocystodinium striatogranulosum*" Zevenboom and Santarelli in Zevenboom 1995 (considered an unpublished manuscript name by the originating authors). 300×. **8.** *Palaeohystrichophora infusorioides* Deflandre 1935. Ventral view of dorsal surface (900×). **9, 10.** *Palaeoperidinium pyrophorum* (Ehrenberg 1838 ex O. Wetzel 1933a) Sarjeant 1967b. Dorsal view of dorsal surface; (9) 400×; (10) 450×. **11–13.** *Palynodinium grallator* Gocht 1970a; (11) with operculum (325×); (12) dorsal view of ventral surface (325×); (13) dorsal surface (325×). (Continued on next page).

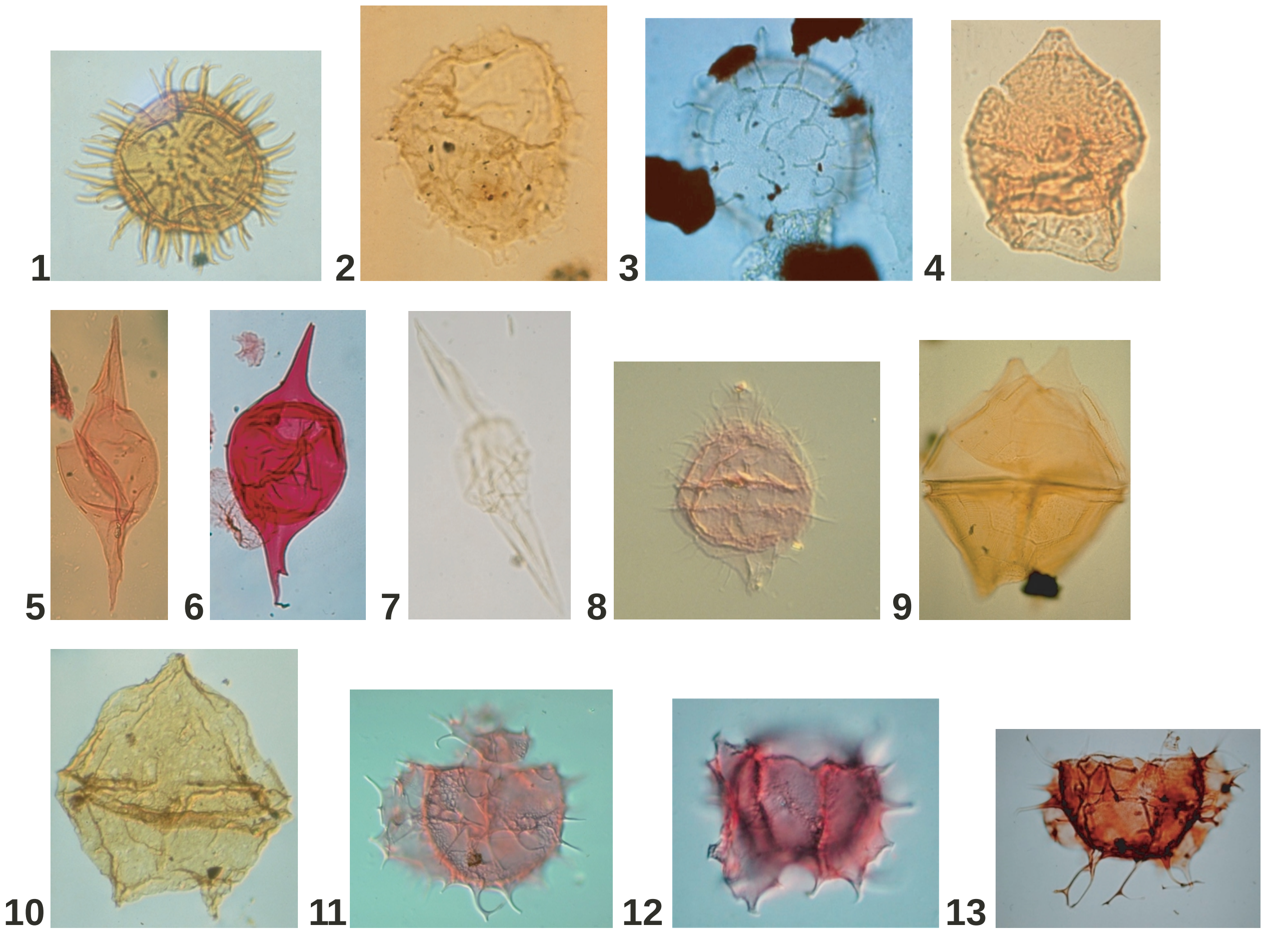

Plate P22 (continued). 14. *Phthanoperidinium amoenum* Drugg and Loeblich 1967. Dorsal view of dorsal surface (850×). **15.** *Phthanoperidinium distinctum* Bujak 1994. Paratype (750×), courtesy of J.P. Bujak. **16–18.** *Pyxidinopsis fairhavenensis* de Verteuil and Norris 1996a; (16, 17) same specimen, dorsal view of dorsal surface (825×); (18) same specimen as 16, optical section (825×), courtesy of L. de Verteuil. **19.** *Raetiaedinium truncigerum* (Deflandre 1937b) Kirsch 1991. Dorsal view of dorsal surface (550×). **20.** *Raphidodinium fucatum* Deflandre 1936b. 400×. **21.** *Renidinium rigidum* Prince et al. 1999. 500×.

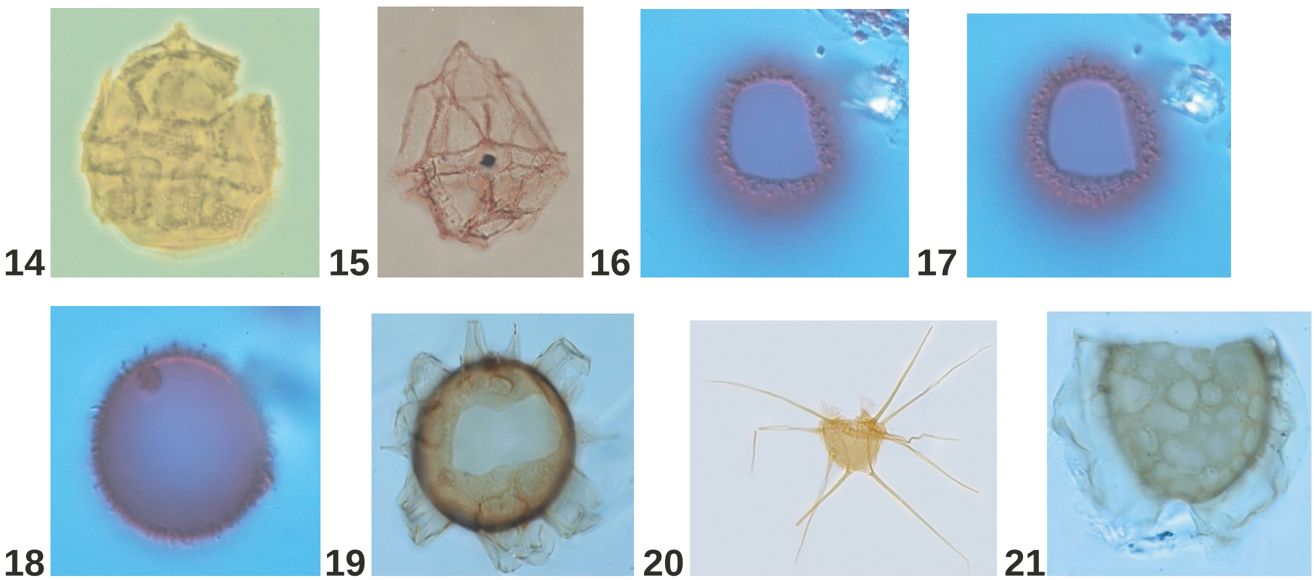

Plate P23. **1.** *Renidinium rigidum* Prince et al., 1999. Same specimen as Pl. P22, p. 89, fig. 21. Optical section (500×). **2, 3.** *Reticulatosphaera actinocoronata* (Benedek 1972) Bujak and Matsuoka 1986. Both 850×. **4.** *Rhombodinium draco* Gocht 1955. Dorsal view of ventral surface (300×). **5.** *Rhombodinium perforatum* (Jan du Chêne and Châteauneuf 1975) Lentin and Williams 1977b. Dorsal view of dorsal surface (300×). **6–8.** *Rhombodinium porosum* Bujak 1979; (6) dorsal view, optical section (275×); (7, 8) dorsal view of dorsal surface (275×). **9, 10.** *Saturnodinium pansum* (Stover 1977) Brinkhuis et al. 1992. Apical view; (10) holotype. Both 450×. **11, 12.** *Saturnodinium perforatum* Brinkhuis et al. 1992; (11) scanning electron micrograph (SEM), apical surface. Both 600×. (Continued on next page.)

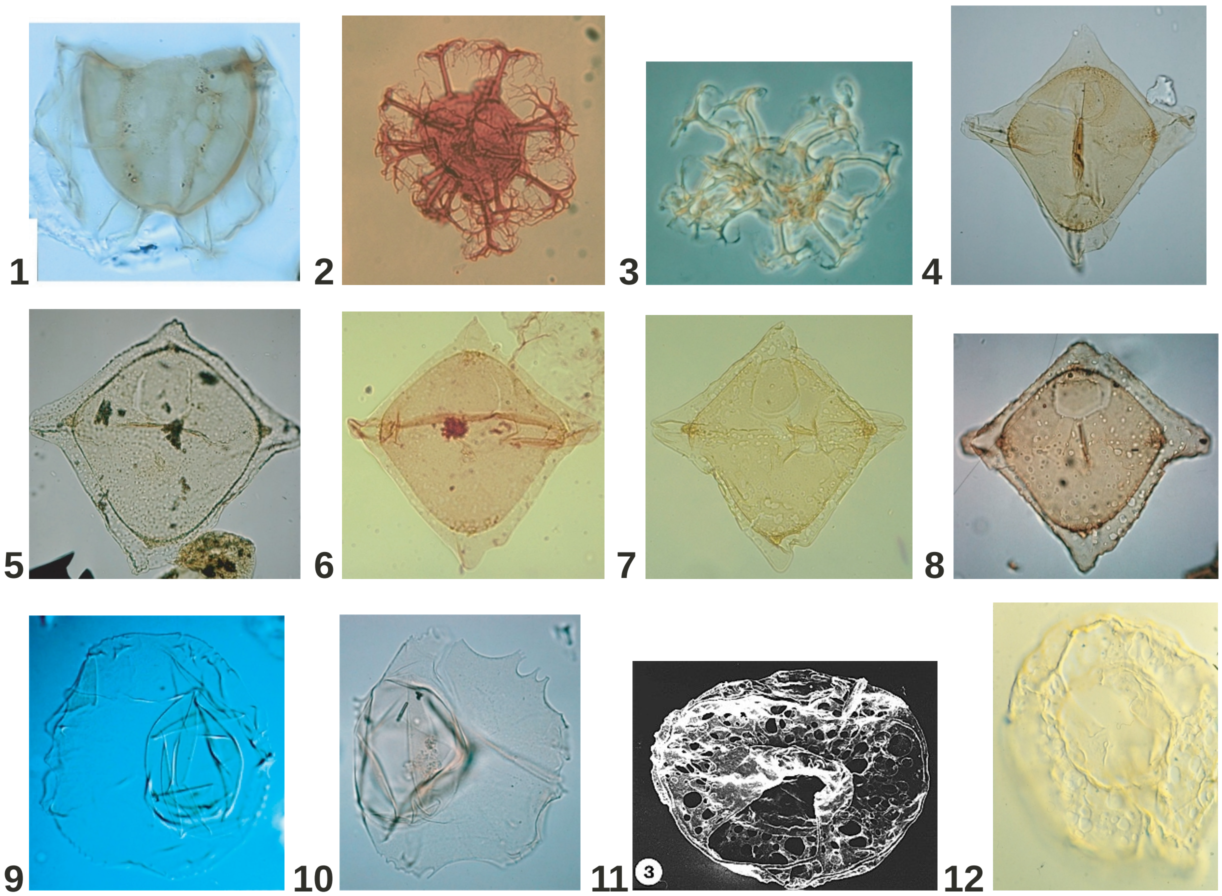

Plate P23 (continued). 13–16. *Schematophora speciosa* Deflandre and Cookson 1955; (13) operculum (950×); (14) dorsal surface (625×); (15) dorsal view of ventral surface (625×); (16) ventral surface (625×). **17, 18.** *Selenopemphix armageddonensis* de Verteuil and Norris 1992; (17) apical view of apical surface (750×); (18) same specimen as 17, apical view of antapical surface (750×), courtesy of L. de Verteuil. **19.** *Selenopemphix armata* Bujak in Bujak et al. 1980. Holotype (575×), courtesy of J.P. Bujak. **20.** *Selenopemphix dionaeacysta* Head et al. 1989b. Courtesy of D. Zevenboom. 750×.

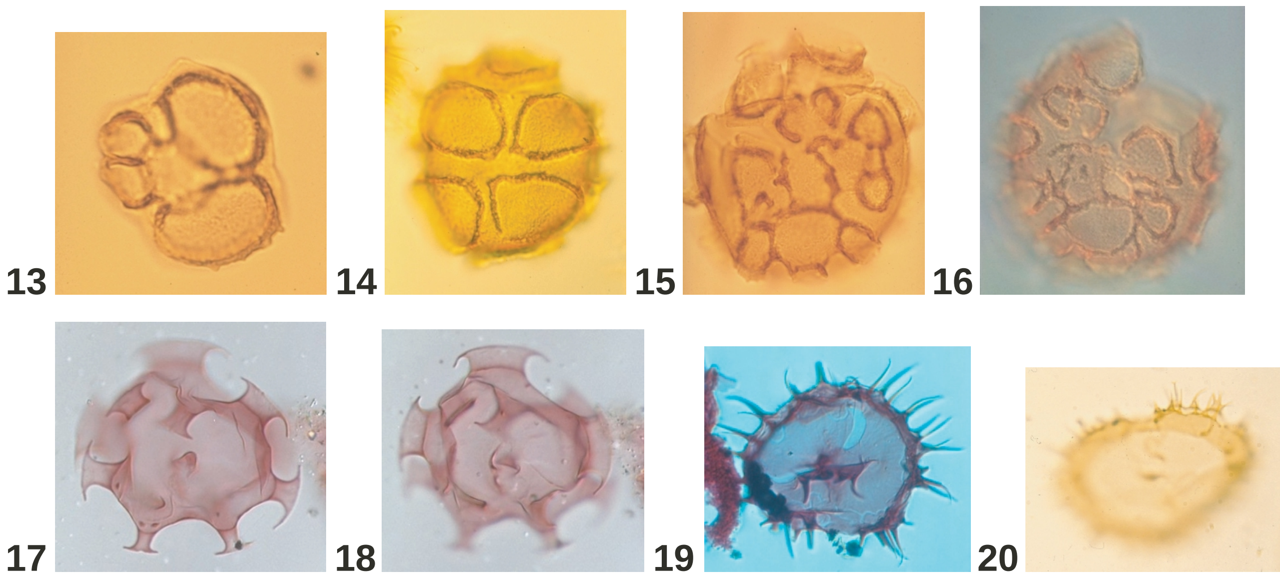

Plate P24. **1.** *Selenopemphix dionaeacysta* Head et al. 1989b. Courtesy of M.J. Head. 750×. **2–4.** *Senoniasphaera inornata* (Drugg 1970b) Stover and Evitt 1978; (2) ventral view of ventral surface (350×); (3, 4) dorsal surface (350×). **5.** *Senoniasphaera protrusa* Clarke and Verdier 1967 (475×). **6, 7.** *Senoniasphaera rotundata* Clarke and Verdier 1967; (6) dorsal view of dorsal surface (500×); (7) same specimen as 6, dorsal view, optical section (500×). **8, 9.** *Senoniasphaera rotundata* subsp. *alveolata* Pearce et al. 2003; (8) dorsal surface (500×); (9) same specimen as 8, ventral surface (500×). **10.** *Spinidinium echinoideum* (Cookson and Eisenack 1960a) Lentin and Williams 1976. Holotype (550×), from the L.E. Stover Collection. (Continued on next page).

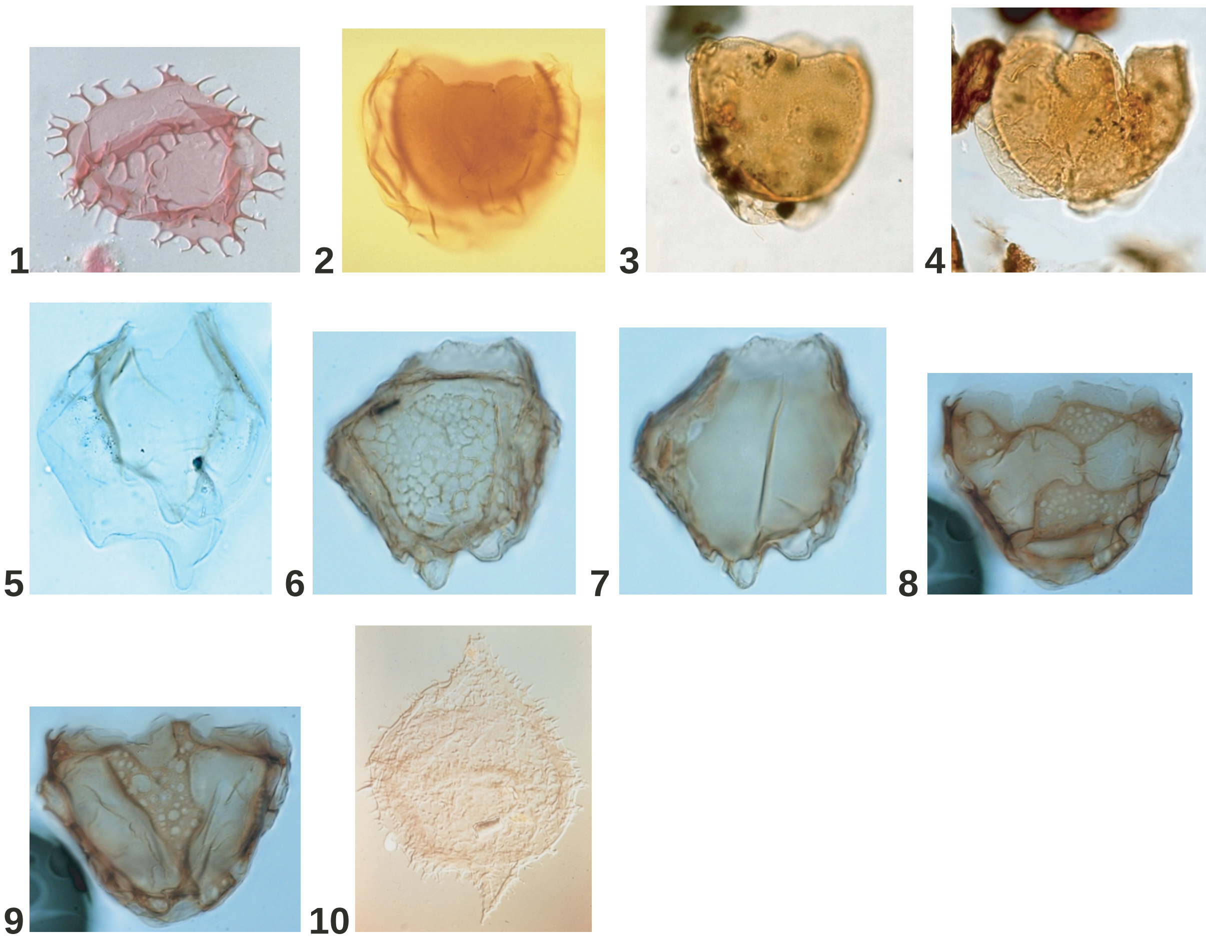

Plate P24 (continued). 11–14. *Spinidinium macmurdoense* (Wilson 1967a) Lentin and Williams 1976; (11) ventral view, optical section (400×); (12) dorsal view of dorsal surface (350×); (13) dorsal view, optical section (400×); (14) ventral view of ventral surface (350×). **15.** *Spiniferites porosus* (Manum and Cookson 1964) Harland 1973. Right lateral view showing right lateral surface (325×). **16.** *Spiniferites ramosus* subsp. *maeandriformis* (Corradini 1973) Lentin and Williams 1975. Left lateral view (425×). **17, 18.** *Spiniferites*? *velatus* (Clarke and Verdier 1967) Stover and Evitt 1978. Both 375×. **19, 20.** *Spongodinium delitiense* (Ehrenberg 1838) Deflandre 1936b; (19) oblique right view of right lateral surface (300×); (20) same specimen as 19, oblique right lateral view of left lateral surface (300×).

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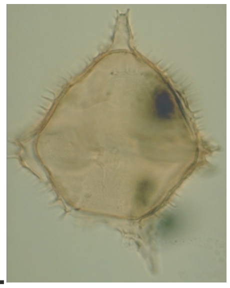
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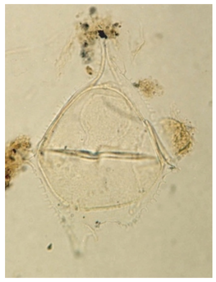
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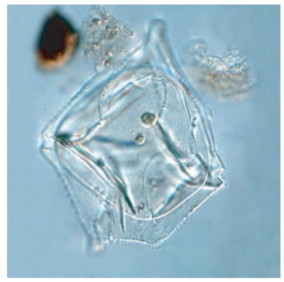
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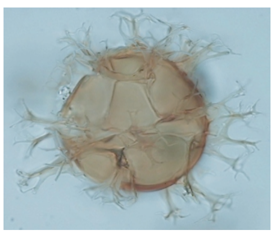
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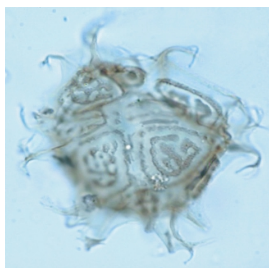
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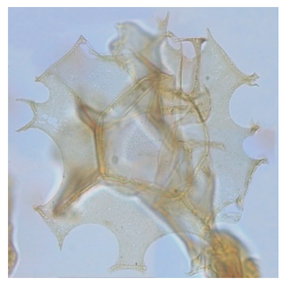
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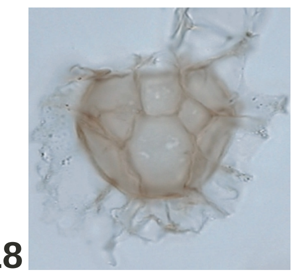
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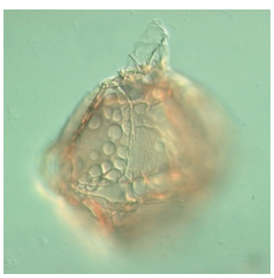
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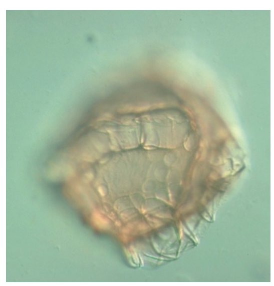

Plate P25. 1, 2. *Spongodinium delitiense* (Ehrenberg 1838) Deflandre 1936b; (1) ventral surface (300×); (2) dorsal surface (350×). **3, 4.** *Stephodinium coronatum* Deflandre 1936a; (3) scanning electron micrograph (SEM), dorsal surface (500×), courtesy of E.J. Kidson; (4) apical surface (500×). **5–10.** *Stoveracysta ornata* (Cookson and Eisenack 1965a) Clowes 1985; (5) dorsal surface (350×); (6) specimen with operculum in place (350×); (7) dorsal surface (350×); (8) same specimen as 7, ventral surface (350×); (9) dorsal surface (350×); (10) same specimen as 9, ventral surface (350×). **11.** *Sumatradinium druggii* Lentin et al. 1994. 275×. **12–14.** *Sumatradinium soucouyantiae* de Verteuil and Norris 1992; (14) dorsal surface. All 350×. **15–17.** *Surculosphaeridium? longifurcatum* (Firtion 1952) Davey et al. 1966. All 500×. **18–20.** *Thalassiphora delicata* Williams and Downie 1966c. All 400×.

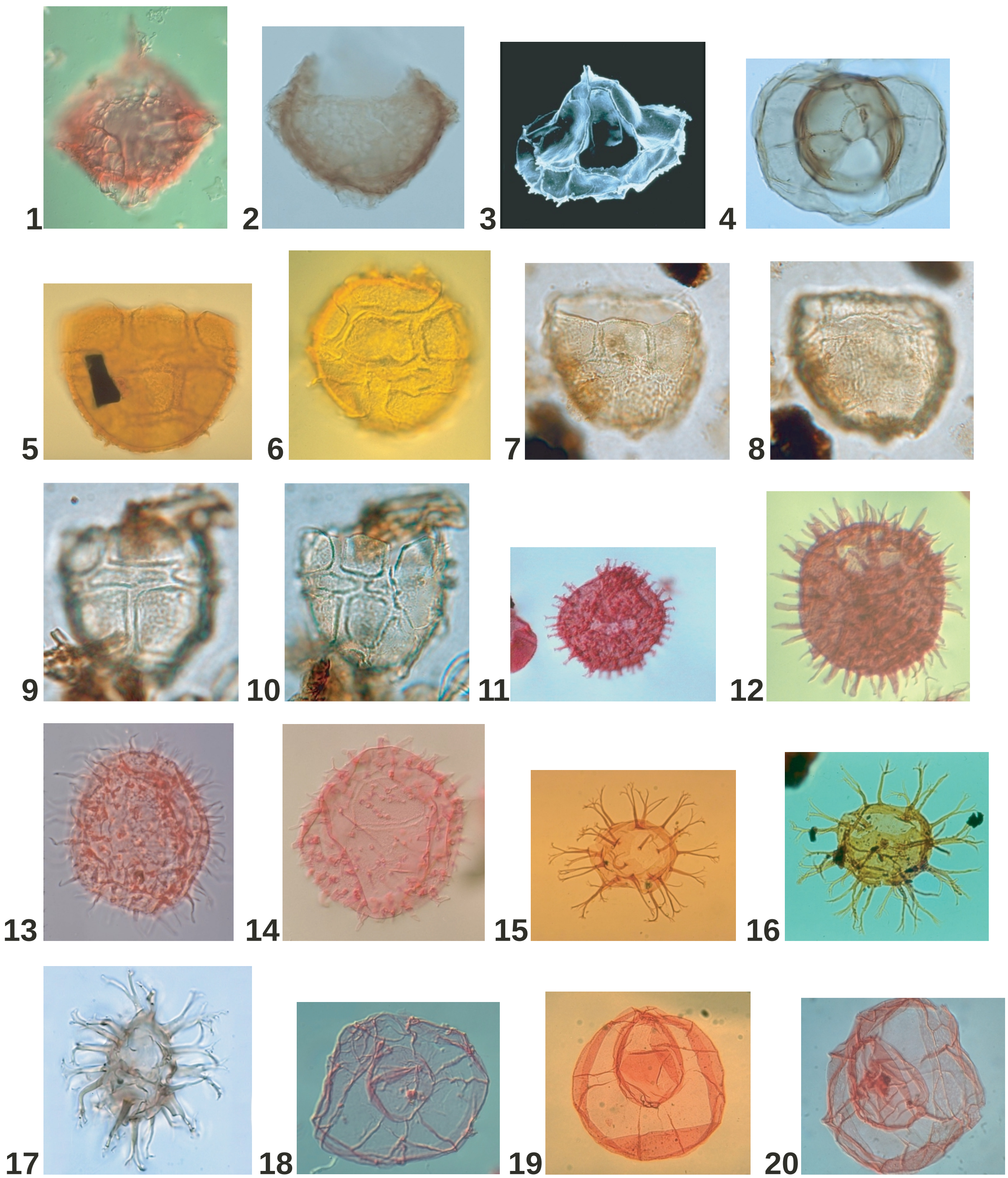

Plate P26. **1.** *Thalassiphora delicata* Williams and Downie 1966c. 350×. **2.** *Thalassiphora*? *spinosa* (Clarke and Verdier 1967) Foucher 1975. 350×. **3, 4.** *Triblastula utinensis* O. Wetzel 1933b; (4) left lateral view. Both 350×. **5.** *Trichodinium castanea* Deflandre 1935 ex Clarke and Verdier 1967. 400×. **6.** *Trigonopyxidia ginella* (Cookson and Eisenack 1960a) Downie and Sarjeant 1965. 550×. **7.** *Trinovantedinium applanatum* (Bradford 1977) Bujak and Davies 1983; dorsal view (450×), courtesy of M.R. Bradford. **8.** *Trinovantedinium glorianum* (Head et al. 1989b) de Verteuil and Norris 1992. Ventral view of dorsal surface. Holotype (450×), courtesy of M.J. Head. (Continued on next page).

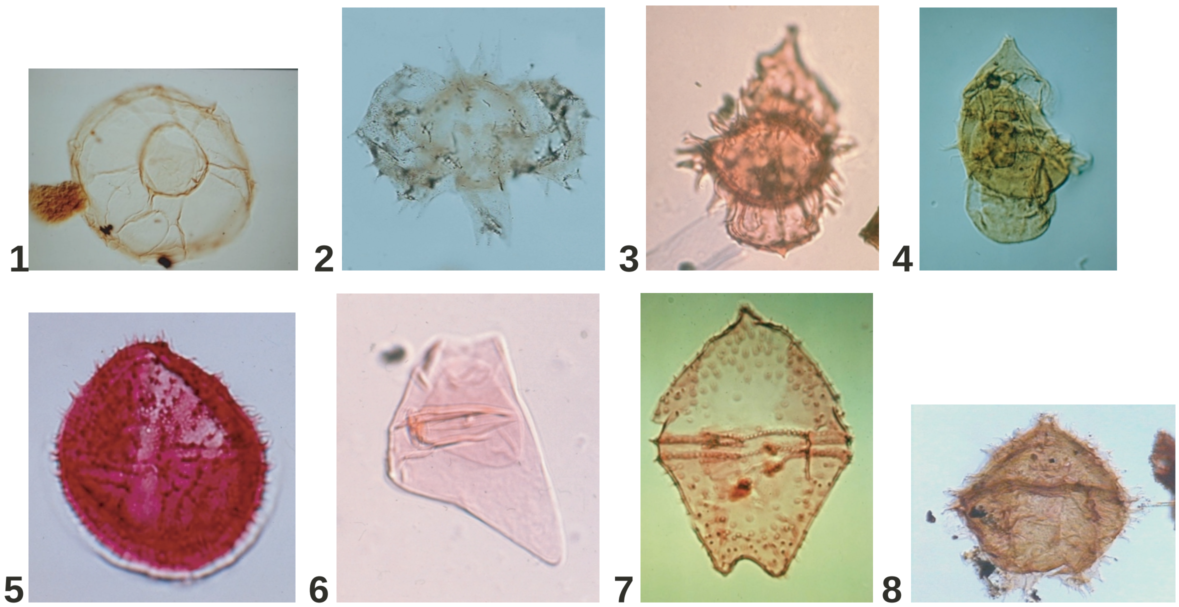

Plate P26 (continued). **9.** *Trithyrodinium evittii* Drugg 1967. 400×. **10, 11.** *Trithyrodinium suspectum* (Manum and Cookson 1964) Davey 1969b; (10) 425×; (11) optical section (500×). **12–14.** *Unipontidinium aquaeductum* (Piasecki 1980) Wrenn 1988; (12) scanning electron micrograph (SEM), dorsal surface (850×); (13) dorsal view of ventral surface (750×); (14) dorsal view of dorsal surface (850×). **15–18.** *Wetzeliella gochtii* Costa and Downie 1976; (15) dorsal view of dorsal surface (300×); (16) same specimen as 15, dorsal view of ventral surface (300×); (17) ventral view of ventral surface (300×); (18) same specimen as 17, ventral view of dorsal surface (300×). **19, 20.** *Wetzeliella meckelfeldensis* Gocht 1969; (19) ventral view of ventral surface (250×); (20) same specimen as 19, ventral view of dorsal surface (250×).

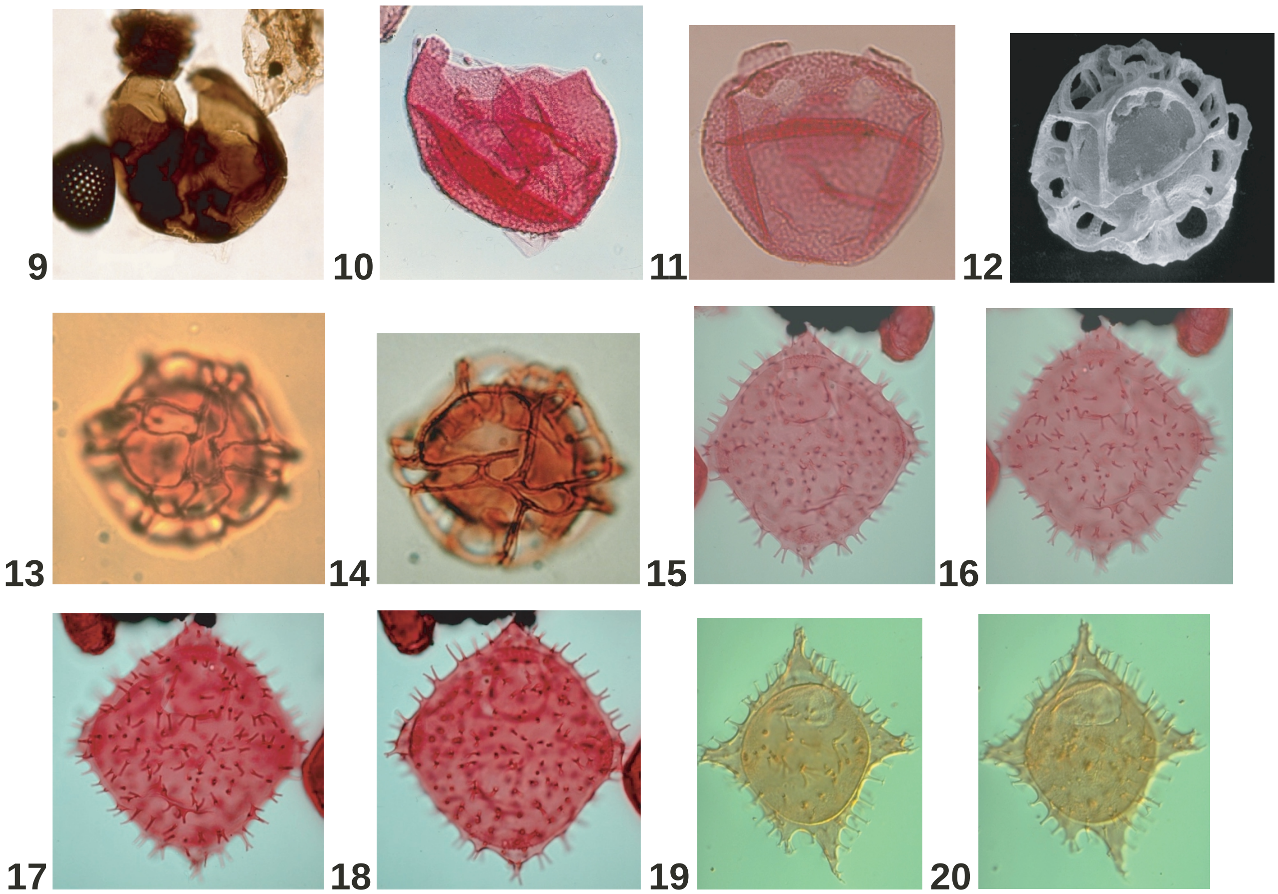

Plate P27. 1–3. *Wilsonidium echinosuturatum* (Wilson 1967c) Lentin and Williams 1976; (1) dorsal view of dorsal surface, holotype (275×); (2) same specimen as 1, ventral surface (250×); (3) same specimen as 1, dorsal surface (250×), courtesy of G.J. Wilson. **4, 5.** *Xenascus ceratioides* (Deflandre 1937b) Lentin and Williams 1973. Same specimen in ventral view, both showing dorsal surface (both 250×). **6–8.** *Xiphophoridium alatum* (Cookson and Eisenack 1962b) Sarjeant 1966b; (7, 8) dorsal views. All 400×. **9, 10.** *Stoveracysta kakanuiensis* Clowes 1985; (9) dorsal surface (475×); (10) dorsal view of ventral surface (475×).