

Cannosphaeropsis quattrocchiae, a new species of dinoflagellate cyst from the mid Cenozoic of the Colorado Basin, Argentina

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ABSTRACT: *Cannosphaeropsis quattrocchiae* n. sp., from the Cenozoic of the Colorado Basin, resembles two other species, *Cannosphaeropsis utinensis* and *Cannosphaeropsis passio*, and has been confused with the former. However, separation of the three species, based in part on the location of the processes, allows for their use in refining Cenozoic stratigraphy and paleoecology. On present evidence, the last appearance datum of *Cannosphaeropsis quattrocchiae* appears to be early Miocene, whereas *Cannosphaeropsis passio* is known only from the mid Miocene. *Cannosphaeropsis utinensis*, primarily a late Cretaceous species, occurs occasionally in lower Paleocene sediments. Geographically, *Cannosphaeropsis utinensis* and *Cannosphaeropsis passio* are known only from the Northern Hemisphere, whereas *Cannosphaeropsis quattrocchiae* is known only from the Southern Hemisphere.

INTRODUCTION

Exploration for petroleum in the Colorado Basin, Argentina (text-fig. 1), began in 1959, with the drilling of nine onshore wells - seven by Shell Production Company of Argentina and Esso, and two by Yacimientos Petrolíferos Fiscales (Y.P.F.). Subsequently, a further eleven wells were drilled in the western offshore part of the Basin, three by Hunt Petroleum and nine by Phillips/AGIP. Most of the wells penetrated Mesozoic and Cenozoic strata, including the Phillips/AGIP Cx-1 well, from which the samples for this study were obtained. Exploratory drilling has also been carried out in the south-central part of the Colorado Basin, where Y.P.F. Puelche x-1 and Ranquel x-1 boreholes are located.

In this study, individual cuttings samples, each covering 5m, spanning the interval 200-1900 m from the Cx-1 well were processed for palynomorphs. The dinoflagellate cyst (dinocyst) assemblages are diverse and contain several undescribed taxa. The objective of this study is to describe one of these previously undescribed forms, *Cannosphaeropsis quattrocchiae* n. sp., and to comment on its stratigraphic significance. *Cannosphaeropsis quattrocchiae* is a particularly distinctive trabeculate species that occurs between 945 and 1200m. Previous authors have referred to this species as *Cannosphaeropsis utinensis* (Guerstein 1990b and Palamarczuk and Barreda 1998) and *Cannosphaeropsis* aff. *utinensis* (Gamerro and Archangelsky 1981). (Full citations of all species names mentioned in the text and table are given in the Appendix.)

MATERIALS AND METHODS

Cuttings samples from the Cx-1 well were processed for palynomorphs. Treatment included hydrofluoric and hydrochloric acid, mild oxidation (10% nitric acid for one minute) and a 10% ammonia hydroxide wash for one minute. The organic fraction was concentrated by separation in zinc bromide (specific gravity 2.0). Differential centrifuging was used to re-

move fine particles and the residues were sieved to concentrate the 10-180µm fraction. The residues were stained using Bismarck C and mounted and dried on coverslips in hydroxyethyl cellulose with ethylene glycol monomethyl ether as a dispersal agent. The coverslips were then glued onto the slides with elvacute.

Light microscopy was undertaken using Zeiss photomicroscopes at the Geological Survey of Canada (Atlantic). Microscope co-ordinates quoted are from the Vernier Scale of Zeiss Photomicroscope, serial no. 4660390. England Finder references are provided for illustrated specimens. None of the photomicrographs involve image-reversal. The line drawings were made using a camera lucida and always show external views. The type and figured specimens are housed in the Palynological Collection, Departamento de Geología de la Universidad Nacional del Sur, Bahía Blanca, Argentina.

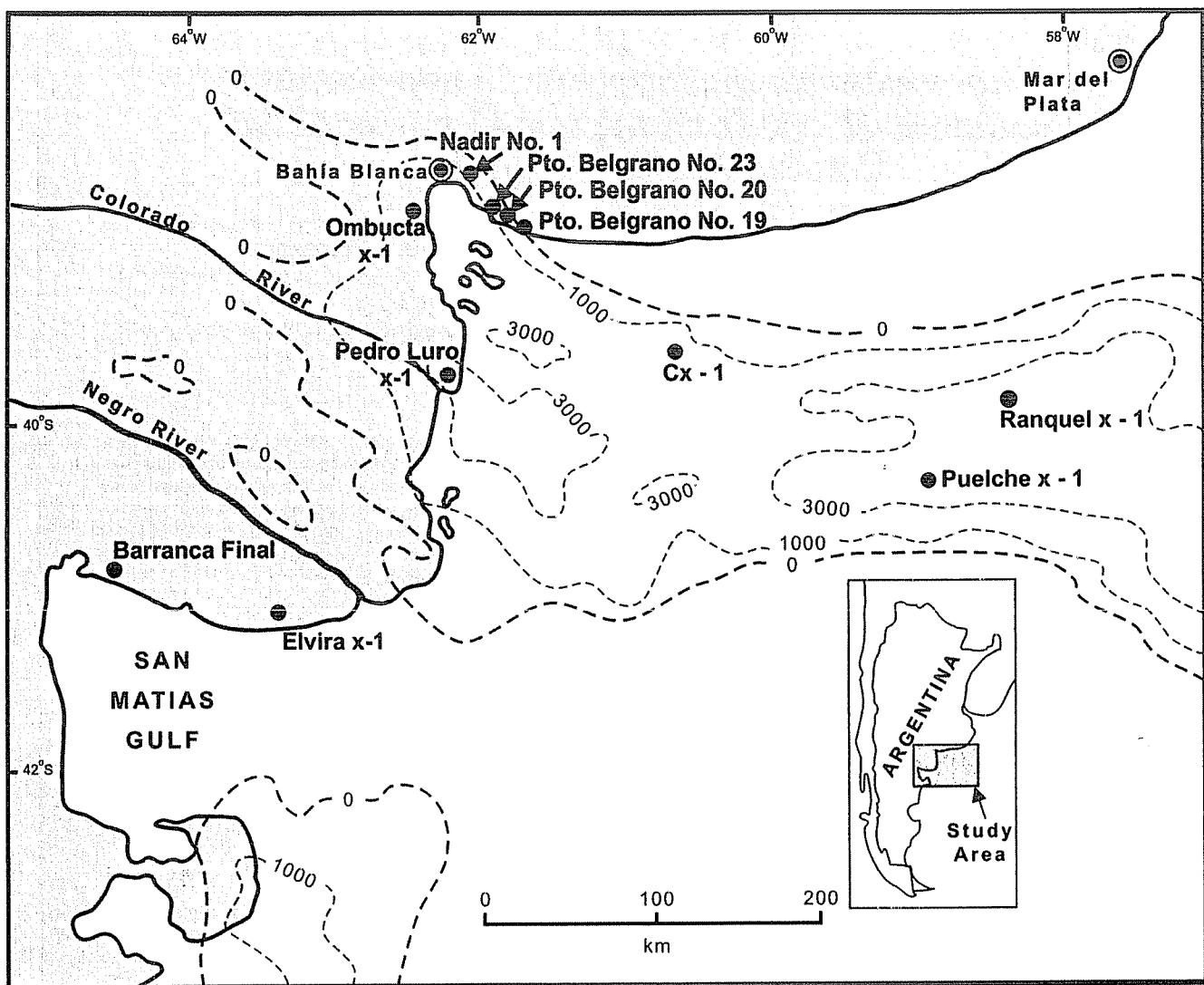
The ElectroScan E3 environmental scanning electron microscope (SEM) at the Geological Survey of Canada (Atlantic) was used under partial pressure water vapor. All the specimens were coated with gold prior to scanning.

STRATIGRAPHY

General Setting

The Colorado Basin is a rift basin formed in the late Jurassic, during the initial opening of the South Atlantic; it is aligned ESE-WNW, is situated between 38°S and 41.5°S and lies primarily offshore. Within the Basin, up to 7000m of Upper Jurassic-Cenozoic sediments unconformably overlie Permian strata that are significantly more compacted than the Mesozoic and Cenozoic deposits.

Fryklund et al. (1996) identified three "tecto-stratigraphic" sequences bounded by discordances or condensed sections: rift, sag and drift. These authors (Fryklund et al. 1996, fig. 5) recog-



TEXT-FIGURE 1

Map of the Colorado Basin showing the location of the wells, boreholes and sections mentioned in the text. The dashed lines indicate Cenozoic isopachs in meters. Land is shaded on main map. After Urien et al. (1981).

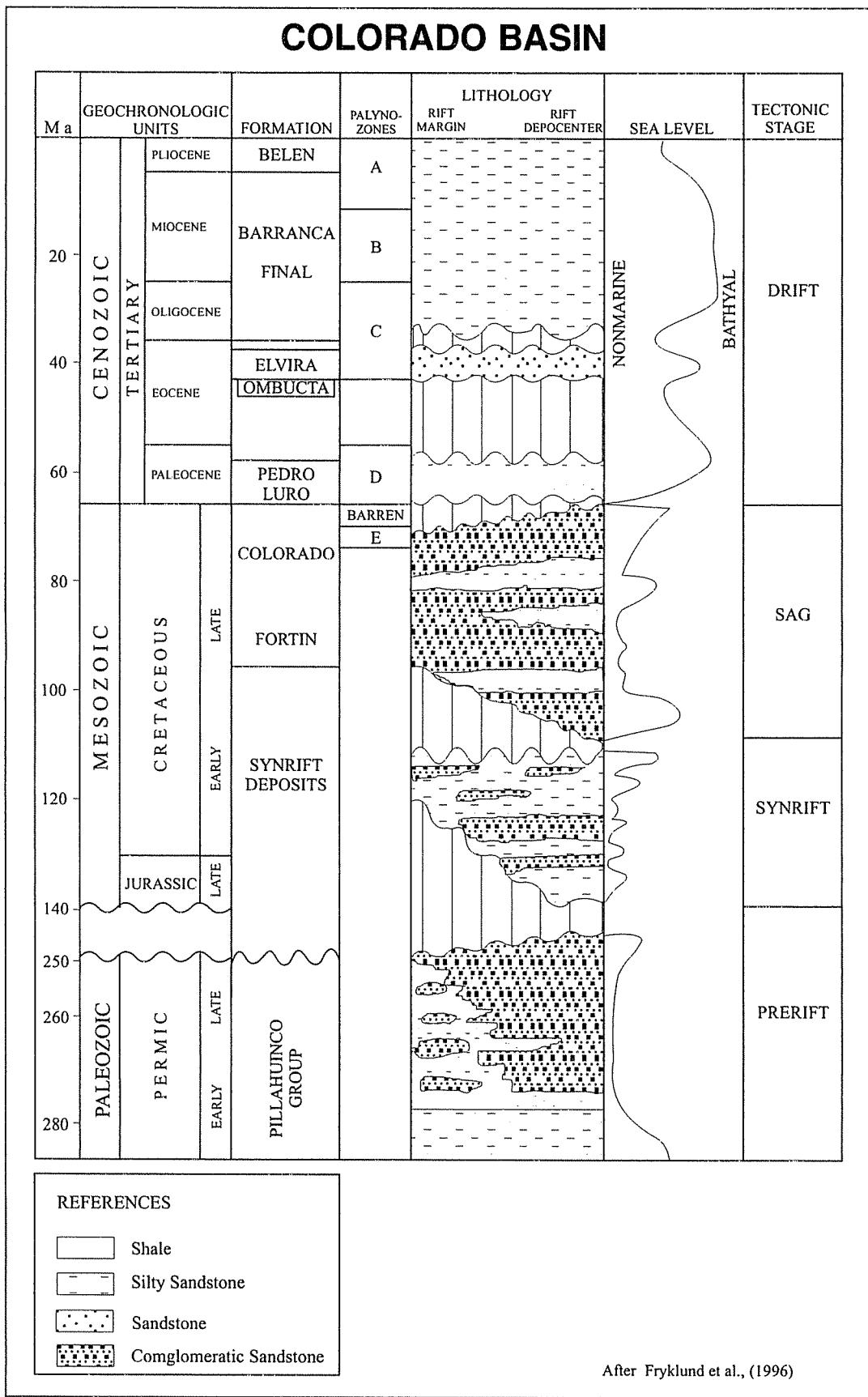
nized the following sedimentary sequences, from oldest to youngest (text-fig. 2): unnamed synrift deposits, representing the rift sequence (Late Jurassic and Early Cretaceous); Fortin and Colorado Formations, both corresponding to the sag sequence (Late Cretaceous); and Pedro Luro Formation (Paleocene), Ombucta and Elvira formations (mid and late Eocene), Barranca Final Formation (Oligocene to Pliocene) and Belén Formation (Pliocene), all representing the drift sequence.

The interval 945-1200m in Cx-1 well, from which specimens of *Cannospaeropsis quattrocciae* have been recovered, is from the Barranca Final Formation, which consists of sand and glauconitic sandstones with shale and limestone horizons (Urien et al. 1981).

The biostratigraphic subdivisions in the basin are based primarily on palynomorphs (mainly dinocysts) and foraminifers. In a study of offshore Ranquel x-1 and Puelche x-1 boreholes, Gamarro and Archangelsky (1981; text-fig. 2) defined five zones, designated E to A from oldest to youngest, based primar-

ily on dinocysts. The ages postulated for the zones were: E - Turonian-Campanian, D - Maastrichtian-Paleocene, C - Eocene-Oligocene, B - early to mid Miocene, A - late Miocene. An undated interval occurred between zones E and D (text-fig. 2). Foraminiferal data for Puelche x-1 more precisely delineated the Oligocene and Miocene (Becker and Bertels 1980).

Quattroccchio and Guerstein (1988) analyzed the Tertiary palynomorphs in two onshore sections in the Colorado Basin, Nadir No. 1 well and Puerto Belgrano No. 20 borehole. These authors presented a more detailed zonation, which they termed a climatic zonation (Quattroccchio and Guerstein, 1988, table IV). The zonation, based primarily on pollen and dinoflagellate species diversity, allowed subdivision of the Eocene, Oligocene and Miocene. Guerstein et al. (1995) further developed this zonation, recognizing the following subdivisions: C1 - Eocene, C2 - Eocene, C3 - late Eocene-early Oligocene, C4 - Oligocene, C5 - late Oligocene, B1 - early to mid Miocene, B2 - mid Miocene and B3 - mid to late Miocene. In other palynological studies: Guerstein (1990a, b) described Eocene-Miocene dinoflagellates,



TEXT-FIGURE 2

Stratigraphy of the Colorado Basin. Mainly after Fryklund et al. (1996), with palynozones from Gamarro and Archangelsky (1981). The sea level curve is after Fryklund et al (1996) and is presumably based on their data.

also from Nadir No. 1 and Puerto Belgrano No. 20; Quattrochio and Sarjeant (1996) studied the early Paleocene dinoflagellate cysts assemblages from Puerto Belgrano No. 20 borehole; and Ruiz and Quattrochio (1996, 1997a,b) examined miospore assemblages from the ?Maastrichtian to Paleocene from the onshore boreholes Puerto Belgrano 19, Puerto Belgrano 20, Ombucta x-1 and Pedro Luro x-1. Further discussion of the palynostratigraphy was presented by Archangelsky (1996).

Malumíán (1970, 1972) studied the foraminifers from the Paleocene-Miocene of onshore Puerto Belgrano No. 20 and 23 boreholes. Malumíán and Nafiez (1996) presented a discussion of the biostratigraphy based on calcareous microfossils and nannofossils. Malumíán et al. (1998 a and b) studied the foraminifer assemblages from the Elvira and Barranca Final Formations at their type localities, Elvira x-1 well and Barranca Final outcrop section respectively. They proposed the following ages: early Oligocene for the Elvira Formation and latest Oligocene ("Oligoceno cuspidal") to early Miocene for the basal part of Barranca Final Formation in Elvira x-1, and mid to late Miocene for the part of the Barranca Final Formation outcropping at Barranca Final.

PRESENT STUDY

The Cx-1 well, at 39°11'S 60°11'W, was drilled on the Argentine continental shelf in the western part of the Colorado Basin, reaching a total depth of 1950m. In the present study, dinocyst assemblages were analyzed to provide biostratigraphic control for the Cenozoic sediments in Cx-1 well. Since all the samples are cuttings, only highest occurrences (last appearance datums, or LADs) can be relied upon. The diverse, well-preserved dinoflagellates in the interval 200-1200m indicate an age range of possibly late Eocene to Miocene.

The last appearances of species in the interval 585-1100m are given in text-figure 3. According to Williams et al. 1998, *Pentadinium laticinctum* has an LAD at the top of the mid Miocene and *Distatodinium paradoxum* and *Cribroperidinium tenuitabulatum* both have LADs within the mid Miocene. However, there is only one previous Miocene record for *Emmetrocysta urniformis*, which is generally considered of Eocene age. Although the last observation is somewhat problematic, from the overall assemblage we conclude that the interval 945-1100m appears to be early to mid Miocene in age. There is no other age control for the Cx-1 well, but comparison with that for other sections may be helpful.

OTHER SECTIONS

Cannospaeropsis quattrochiae (as *Cannospaeropsis aff. utinensis*) was used by Gamerro and Archangelsky (1981) as one of the species marking the top of their Palynozone C in Puelche x-1 and Ranquel x-1 boreholes. These authors considered Palynozone C to be of Eocene-Oligocene age. Other species considered to mark the top of that zone were *Achromosphaera sagenda*, *Areoligera* sp. A, *Heterosphaeridium heteracanthum*, *Pentadinium taeniagerum*, *Spiniferites membranaceus*, *Systematophora placacantha* and *Trithyrodinium vermiculatum*. There are no other known occurrences of *Heterosphaeridium heteracanthum* and *Trithyrodinium vermiculatum* in the Cenozoic, and none of the other taxa identified to species level are known to be restricted to the Paleogene.

In Puelche x-1 borehole, the top of Palynozone C was placed at 1360m, which, as noted above, Gamerro and Archangelsky

considered to represent the top of the Oligocene. In their study of the foraminifers from Puelche x-1 borehole, Becker and Bertels (1980) considered the interval 1340-1380m to be early Miocene and placed the top of the Oligocene at 1420 m. Therefore, in Puelche x-1 borehole, the LAD of *Cannospaeropsis quattrochiae* at 1360m, if correlated with the foraminiferal data, is early Miocene. Thus, Palynozone C could extend into the early Miocene.

Guerstein and Quattrochio (1988) compared the palynological assemblages from the onshore boreholes Nadir 1 and Puerto Belgrano 20 with the results from previous studies carried out in the offshore part of the Colorado Basin. In Puerto Belgrano 20, they found that *Cannospaeropsis quattrochiae* (as *Cannospaeropsis utinensis*) is common and has an LAD at the top of Palynozone C of Gamerro and Archangelsky. In Nadir 1, only one specimen of *Cannospaeropsis quattrochiae* was recorded from sediments interpreted as lower Miocene, though other specimens were recorded at lower levels.

Palamarczuk and Barreda (1998) studied the dinoflagellate cysts from the Chenque Formation outcropping in the San Jorge Basin (Chubut Province, Argentina). This formation has been interpreted as being of late Oligocene?- early Miocene (most probably early Miocene) in age, based on non-marine palynomorphs (Barreda, 1996). Palamarczuk and Barreda (1998, fig. 3) found *Cannospaeropsis quattrochiae* (as *Cannospaeropsis utinensis*), together with *Systematophora placacantha*, *Reticulatosphaera actinocoronata*, *Lingulodinium hemicyustum*, *Tuberculodinium vancampoae* and *Hystrichosphaeropsis obscura*. Based on this assemblage, especially the presence of *Systematophora placacantha*, Palamarczuk and Barreda concluded that the age of the section is early to mid Miocene.

SYSTEMATIC PALEONTOLOGY

Division Dinoflagellata (Bütschli 1885) Fensome et al. 1993

Class Dinophyceae Pascher 1914

Order Gonyaulacales Taylor 1980

Family Gonyaulacaceae Lindemann 1928

Genus *Cannospaeropsis* O. Wetzel 1933

Cannospaeropsis quattrochiae Guerstein et al. n. sp.

Plate 1, figures 1-12; plate 2, figures 1-8; text-figures 4a-h.

Cannospaeropsis aff. *utinensis* O. Wetzel 1933. — GAMERRO and ARCHANGELSKY 1981, pl. 4, fig. 14.

Cannospaeropsis utinensis O. Wetzel 1933. — GUERSTEIN 1990b, pl. 2, figs. 1-2, 5. — PALMARCZUK and BARREDA 1998, pl. 2, figs. 2, 6; pl. 6, figs. 3, 5-6.

Etymology: The species is named after the stratigraphic palynologist Mirta Quattrochio.

Holotype: Specimen illustrated in Plate 1, figures 7-8; text-figures 4e-f. Location: LPUNS Slide No. P34432-0 1, coordinates: 6.6/104.4 (England Finder reference: 34F); Palynological Collection, Departamento de Geología de la Universidad Nacional del Sur, Bahía Blanca, Argentina.

Type locality: Cx-1 well, 1045-1050m depth, 39°11'S, 60°11'W, Colorado Basin, Argentina.

Diagnosis: A species of *Cannospaeropsis* with a smooth-walled central body surrounded by a complete ectophragmal trabecular network. Trabeculae ribbon-like, bearing a thin fibrous crest, supported only by two robust processes, one on the

Cx - 1 WELL				
Depth (metres)	Epoch	Fm.	Sample number	Selected dinoflagellate dy st last occurrences (LADs)
600	Late Miocene	B	-P34416	<i>Invertocysta lacrymosa</i>
			-P34417	<i>Nematosphaeropsis rigida</i>
			-P34418	
		A	-P34419	
		R	-P34420	<i>Labyrinthodinium truncatum</i> subsp. <i>truncatum</i>
		R	-P34421	
		A	-P34422	<i>Selenopemphix dionaeacysta</i>
		N	-P34423	<i>Hystrichosphaeropsis obscura</i>
		C	-P34424	
		A	-P34425	<i>Systematophora ancyrea</i>
				<i>Xenicodinium conispinum</i>
		F	-P34426	<i>Dapsilidinium pseudocolligerum</i>
		I	-P34427	<i>Xenicodinium echiniferum</i>
		N	-P34428	<i>Cannosphaeropsis quattrochiae</i>
1000	Early Miocene	A	-P34429	<i>Criroperidinium tenuitabulatum</i>
		L	-P34430	<i>Distatodinium paradoxum</i> , <i>Pentadinium laticinctum</i>
		A	-P34431	<i>Cordosphaeridium minimum</i>
		-P34432		
		-P34433		
		-P34434		
		-P34435		
				<i>Emmetrocysta urniformis</i>
				<i>Melitasphaeridium pseudorecurvatum</i> , <i>Lejeuneacysta fallax</i>
				<i>Batiacasphaera sphaerica</i>

TEXT-FIGURE 3

Selected last appearance datums (LADs) for dinocysts in Cx-1 well, plotted against depth, age, lithostratigraphic and sample information.

dorsal anterior part of the epicyst, the other on the dorsal posterior part of the hypocyst.

Description

Shape: Cysts proximochorate to chorate. Central body subspherical to slightly elongate with complex dorsal anterior and posterior processes towards the poles that support the surrounding trabeculate network. Paracingulum delineated in the ectophragm by two, more or less parallel, but widely spaced trabecula (pl. 1, figs. 7-8; text-figs. 4e-f).

Wall relationships: Autophragm surrounded by a trabeculate ectophragm supported only by single apical and antapical processes.

Wall features: Autophragm smooth, bearing two thick, membranous processes, one on the dorsal epicyst and the other on the dorsal hypocyst. These processes connect the autophragm that forms the central body with the ectophragmal trabecula (pl. 1, figs. 10-11; pl. 2, figs. 4-6; text-figs. 4g-h). The epicystal

process is located anterior to paraplate 3"; and the hypocystal process is located at the 3"/4"/1"" triple junction. The epicystal process may be branched (pl. 2, fig. 5). Autophragm 1µm thick. Ectophragm consisting of a complete, ribbon-like trabeculate network, with trabecula up to 4µm wide and bearing a thin crest that gives a fibrous appearance (pl. 1, figs. 1-3; pl. 2, figs. 1-3, 7-8). Thickness of the trabecula increases toward gonal intersections, where platforms and trifurcate projections occur; these are formed from each of the three distal bifurcations of the processes. Tips of trifurcations bifurcate. Platform-like structures have one or two circular perforations up to 3µm in diameter. Platform surface is usually microperforate (pl. 2, fig. 3).

Paratabulation: Since the paratabulation can only be inferred from the trabeculate network, which is usually collapsed, it is difficult to determine. The study of the holotype and a few well-preserved specimens reflects a gonyaulaccean sexiform tabulation (text-figs. 4a-h). Apical series arranged around a small preapical paraplate (pr in text-fig. 4f). In some cases 1' and 4' are fused (text-figs. 4b,f). Paraplate 6" generally reduced

and triangular in shape, reminiscent of its configuration in *Spiniferites*.

Paracingulum. Six cingular paraplates, with 3c, 4c and 5c being broad.

Parasulcus. Sulcal region elongate and clearly defined, with a large area defined by trabecula posterior to anterior sulcal paraplate. This large sulcal area presumably incorporates the right, left and posterior sulcal paraplates.

Archeopyle. Precingular, type P (3"); operculum simple, free.

Size. Holotype: maximum diameter of the central body: 30 μm ; overall diameter: 67-80 μm . Range of 22 specimens: diameter of the central body: 28-40 μm ; overall diameter: 50-85 μm .

Age: LAD probably early Miocene. FAD not ascertained.

Comparison: *Cannosphaeropsis quattrocciae* is very similar to the type of *Cannosphaeropsis*, *Cannosphaeropsis utinensis* O. Wetzel 1933. Both species have a smooth central body, a complete trabeculate ectophragm and robust polar processes that connect the autophragm to the ectophragm. *Cannosphaeropsis quattrocciae* differs from the type species, however, in having the following characteristics: a) ribbon-like trabecula with a thin sinuous crest rather than simple, solid, circular trabecula; b) perforate gonal platforms with several projections instead of simple gonal trifurcations and intergonal bifurcations; and c) the epicystal process that supports the ectophragmal trabecula is dorsally rather than ventrally offset. As noted by de Verteuil and Norris (1996), *Cannosphaeropsis utinensis* is characterized by: an autophragm and/or trabecula that are never alveolate; one of the processes supporting the trabecular network is situated on the anterior sulcal area (near as/i'), and the other process, when present, is situated on paraplate 4"; and intergonal bifurcations. According to Sarjeant (1985), in *Cannosphaeropsis utinensis* the processes branch

secondarily into three spines with bifurcate tips. In addition, the trabecula commonly have a pair of spines (trabecular spines) that lie usually midway between gonal positions. *Cannosphaeropsis quattrocciae* shows a very different style of branching with no trabecular spines.

Cannosphaeropsis passio de Verteuil and Norris 1996 differs from *Cannosphaeropsis quattrocciae* in having an apical boss on the central body and in having trabecula supported by cingular processes only. *Cannosphaeropsis passio* also has an alveolate trabeculate ectophragm, with gonal trifurcations rotationally offset with respect to triple junction boundaries. The trabecula are solid and cylindrical. The central body and the ectophragm are connected by thin cylindrical cingular appendages only.

Cannosphaeropsis franciscana Damassa 1979 differs from *Cannosphaeropsis quattrocciae* by having regular gonal processes connecting the central body to the trabeculate ectophragm. The ectophragmal network, formed by cylindrical to flattened trabecula in *Cannosphaeropsis franciscana*, is not complete on the dorsal surface and forms a single long projection at the apex.

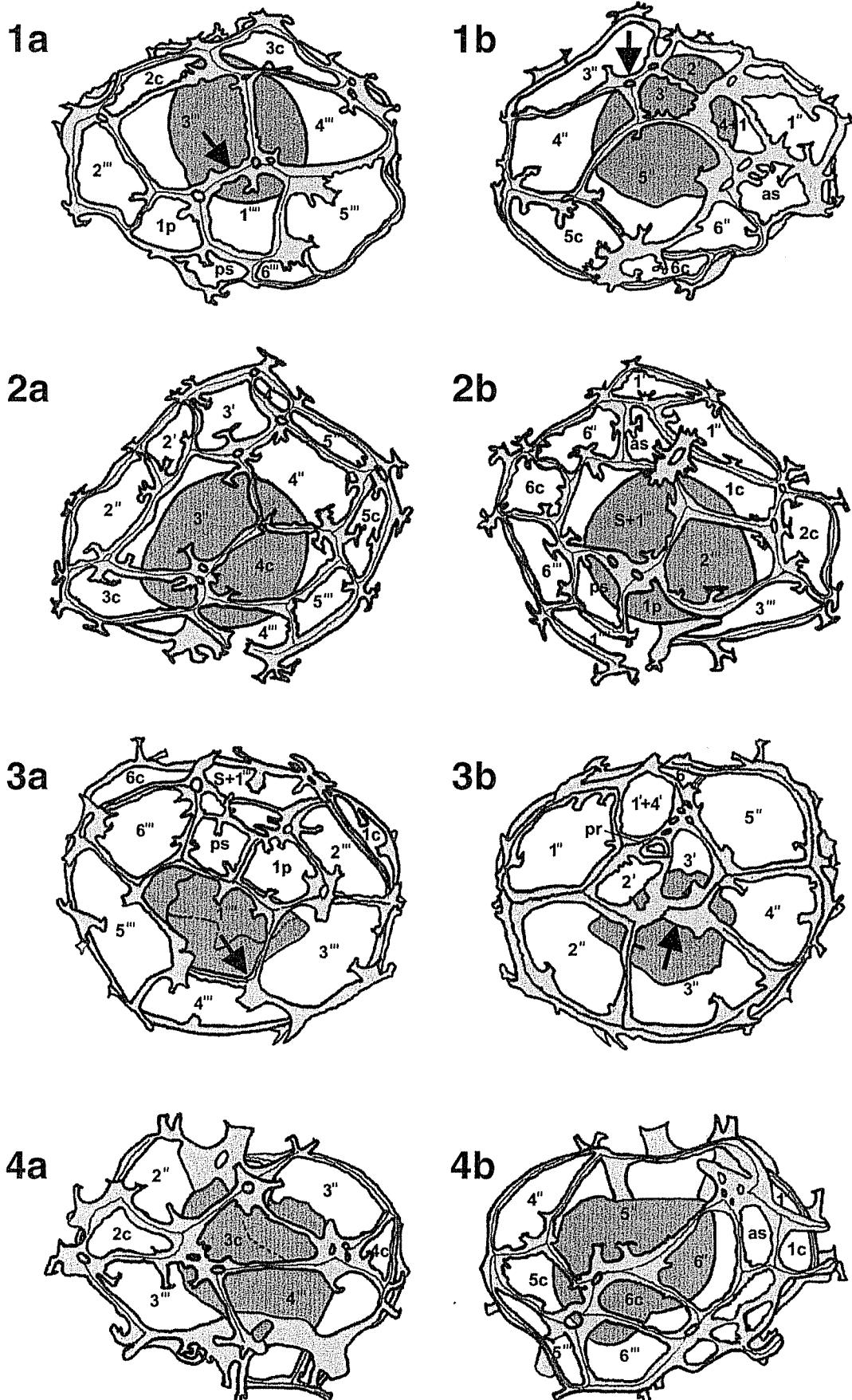
DISCUSSION

The stratigraphic range of *Cannosphaeropsis quattrocciae* is difficult to determine, in part because of the similarity to *Cannosphaeropsis utinensis*. The latter, according to Stover et al. (1996), has a stratigraphic range from late Santonian to mid-late Maastrichtian. There are several records of *Cannosphaeropsis utinensis* in the Tertiary, especially in the Danian (e.g. Corradini 1973; Riegel 1974; Williams 1975; Bujak and Williams 1978; Hansen 1979), but few can be substantiated. However, Hansen (1979) recorded the species from the type Danian of Denmark, citing it as one of the 40 most abundant dinoflagellates. Few authors citing Danian occurrences, including Hansen (1979), provide illustrations.

TEXT-FIGURE 4

Cannosphaeropsis quattrocciae sp. nov., line sketches of external views showing the paratabulation as expressed by the trabecula. Arrows show the position of the processes connecting the autophragm with the trabecular network. For each specimen the sample number, slide number, depth (in parentheses), co-ordinates (on Zeiss photomicroscope serial no. 4660390) and England Finder reference are given respectively. The following abbreviations are used: cbd = central body diameter; od = overall diameter.

- a-b Specimen in dorso-apical orientation: a, antapical posterior paratabulation; b, apical anterior paratabulation. Slide no. P34437-01 (1145-1150 m), 20/91.8, England Finder reference 21T/3; cbd = 37 μm ; od = 80 x 65 μm . See also P1. 1, figs. 1-2.
- c-d Specimen in oblique dorsal orientation: c, dorsal paratabulation; d, ventral paratabulation. Slide no. P34429-01 (985-990 m), 7/107.2, England Finder reference 37G; cbd = 32 μm ; od = 68 x 60 μm . See also P1. 1, figs. 4-6.
- e-f Holotype in apical-antapical orientation: e, antapical paratabulation; f, apical paratabulation. Slide no. P34432-01 (1045-1050 m), 6.6/104.4, England Finder reference 34F; cbd = 30 μm ; od = 80 x 67 μm . See also P1. 1, figs. 7-8.
- g-h Specimen in dorso-ventral orientation: g, dorsal paratabulation; h, ventral paratabulation. Slide no. P34430-01 (1005-1010 m), 15/106.6, England Finder reference 39P/4; cbd = 40 μm ; od = 83 x 63 μm . See also P1. 1, figs. 10-11.



Post-Paleocene records of *Cannosphaeropsis utinensis* or *Cannosphaeropsis* cf. *utinensis* are usually one of two other species, *Cannosphaeropsis quattrocchiae* or *Cannosphaeropsis passio*. As noted previously, Gamerro and Archangelsky (1981) recorded *Cannosphaeropsis* aff. *utinensis* from the Eocene-Oligocene of Argentina. Guerstein and Quattrocchio (1988, 1991) extended the range of *Cannosphaeropsis utinensis* into the Eocene-Oligocene and Miocene respectively. As noted previously, however, the specimens identified as *Cannosphaeropsis utinensis* by these authors are assignable to *Cannosphaeropsis quattrocchiae*. There are no other known Southern Hemisphere occurrences of *Cannosphaeropsis utinensis* or *Cannosphaeropsis quattrocchiae*.

Thus, it appears that: (1) *Cannosphaeropsis utinensis* does not occur in the Southern Hemisphere; (2) *Cannosphaeropsis utinensis*, a predominantly late Cretaceous species, may extend up into the Danian but, if found in sediments younger than Danian, it is probably reworked or misidentified; and (3) *Cannosphaeropsis quattrocchiae* is, as currently known, a Southern Hemisphere species possibly restricted to the Eocene-early Miocene.

What of the records of *Cannosphaeropsis utinensis* from the Tertiary of the Northern Hemisphere? De Coninck (1975, pl. 21, figs. 26-27) found one specimen in the Ypresian that, from examination of the figures, may be *Cannosphaeropsis utinensis*; but most of the specimen is obscured by debris. De Coninck (1980, p. 1, figs. 7-8) recorded a more convincing specimen from the Ypresian of Belgium, noting that the species represented less than 0.1% of the assemblage. Other isolated reportings of *Cannosphaeropsis utinensis* in the Eocene are by Schumacker-Lamby (1978) and Strel et al. (1977). Invariably there are few specimens; for example, Schumacker-Lamby (1978), who recorded and illustrated a single specimen.

The low number of occurrences of *Cannosphaeropsis utinensis* in the Eocene strongly suggests that the specimens are reworked or misidentified. However, there are also several records of this species from the Miocene. Brown and Downie (1984) recorded *Cannosphaeropsis utinensis* from the Eocene and Miocene of DSDP Site 548A, the Goban Spur. However, the specimen illustrated is *Cannosphaeropsis passio*, as is the specimen illustrated in Powell (1992, pl. 4-11, fig. 14) from the Miocene. Another Miocene record is in Manum et al. (1989, pl. 4, figs. 5-6), but their two specimens do not appear assignable to either *Cannosphaeropsis passio* or *Cannosphaeropsis utinensis*. In summary, our observations that most Neogene records of so-called *Cannosphaeropsis utinensis* are referable to *Cannosphaeropsis passio* support the conclusions of de Verteuil and Norris (1996), who provided a synonymy for *Cannosphaeropsis passio*.

De Verteuil and Norris (1996) did not comment on geographic occurrences of *Cannosphaeropsis passio* and *Cannosphaeropsis utinensis*, since all are from the Northern Hemisphere. However, such occurrences are important when comparing the two species with *Cannosphaeropsis quattrocchiae*. *Cannosphaeropsis utinensis* and *Cannosphaeropsis passio* appear to be Northern Hemisphere taxa; *Cannosphaeropsis quattrocchiae* is known only from the Southern Hemisphere. The three taxa have restricted stratigraphic ranges. *Cannosphaeropsis utinensis* may extend into the Danian but is predominantly a late Cretaceous species. *Cannosphaeropsis quattrocchiae* appears to have an LAD in the early Miocene,

and *Cannosphaeropsis passio* occurs in the mid Miocene (de Verteuil and Norris 1996).

CONCLUSIONS

Cannosphaeropsis quattrocchiae is characterized by an ectophragmal network formed from ribbon-like trabecula which bear a thin crest and are perforate. The trabecula are supported by two processes, both dorsally located. The tabulation is similar to that of *Gonyaulax* and, as in that genus, the first and fourth apicals are sometimes fused.

The most similar species to *Cannosphaeropsis quattrocchiae* is *Cannosphaeropsis utinensis*, which differs most notably in the nature of the trabecula and supporting processes. *Cannosphaeropsis passio* is unique in that the trabecular network is supported by cingular processes.

The LAD of *Cannosphaeropsis quattrocchiae* appears to be early Miocene, but this needs confirmation through analyses of surface sections, where the FAD could be determined as well. *Cannosphaeropsis quattrocchiae* is a Southern Hemisphere form, unlike *Cannosphaeropsis utinensis* and *Cannosphaeropsis passio*. The geographic occurrences and restricted stratigraphic ranges of the three species make them ideal for detailed biostratigraphic work.

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REFERENCES

- ARCHANGELSKY, S., 1996. Palinoestratigrafía de la Plataforma Continental. In: Ramos, V. A. and Turic, M. A., Eds., Geología y recursos naturales de la Plataforma Continental Argentina; XIIIº Congreso Geológico Argentino y IIIº de Exploración de Hidrocarburos (Buenos Aires, 1996), Relatorio, 4: 67-72.
- ARTZNER, D. G. and DORHOFER, G., 1978. Taxonomic note: *Lejeuneacysta* nom. nov. pro *Lejeunia* Gerlach 1961 emend. Lentin and Williams 1976 - dinoflagellate cyst genus. Canadian Journal of Botany, 56: 1381-1382.
- BARREDA, V. D., 1996. Bioestratigrafía de polen y esporas de la Formación Chenque, Oligoceno tardío-Mioceno de las provincias de Chubut y Santa Cruz, Patagonia, Argentina. Ameghiniana, 33(1): 35-56.
- BECKER, D. and BERTELS, A., 1980. Micropaleontología de la secuencia terciaria de la perforación Puelche (margen continental argentino). In: II Congreso Argentino de Paleontología y Bioestratigrafía y I Congreso Latinoamericano de Paleontología, 2: 315-3133, pl. 1-7.

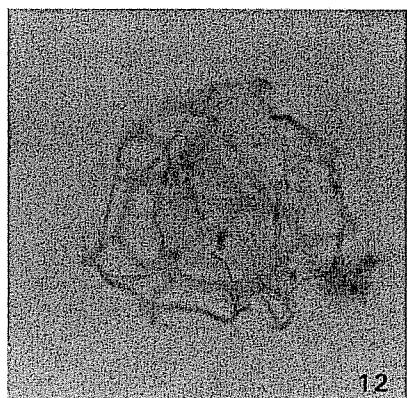
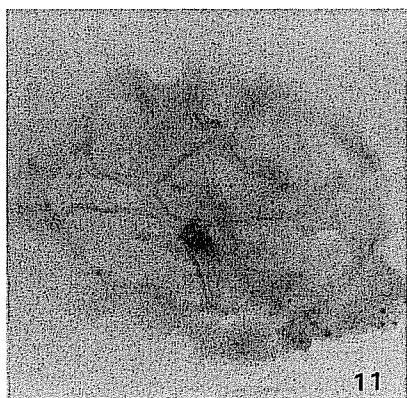
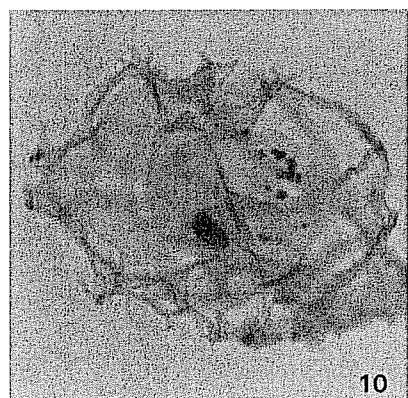
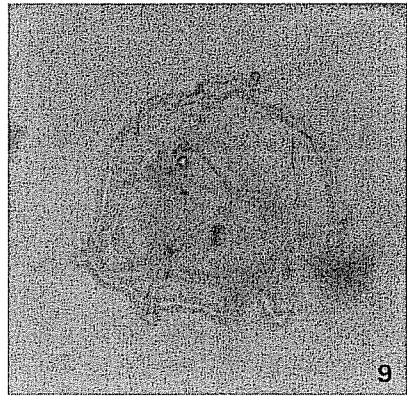
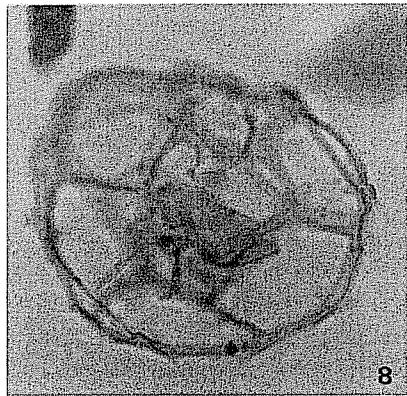
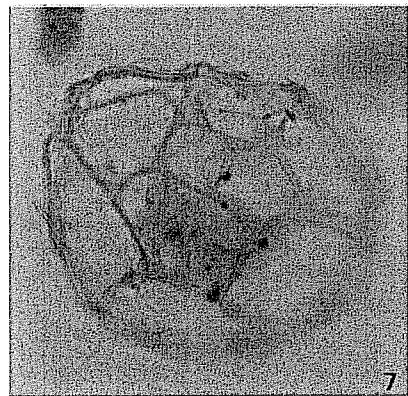
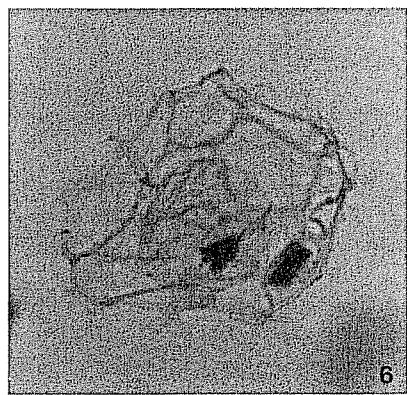
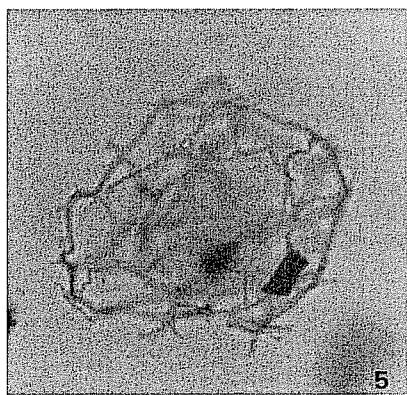
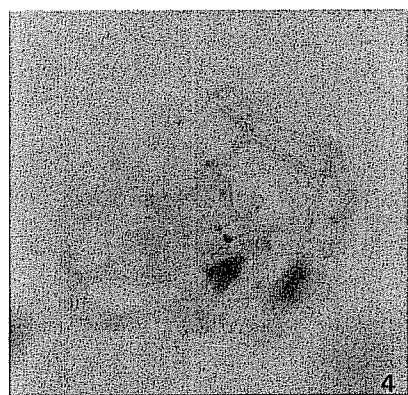
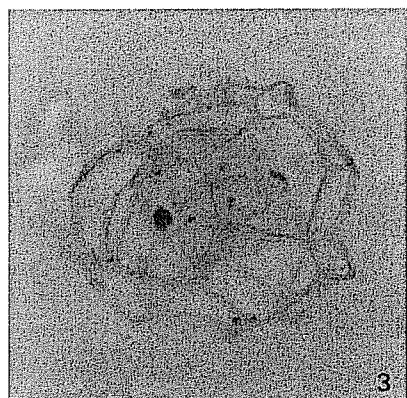
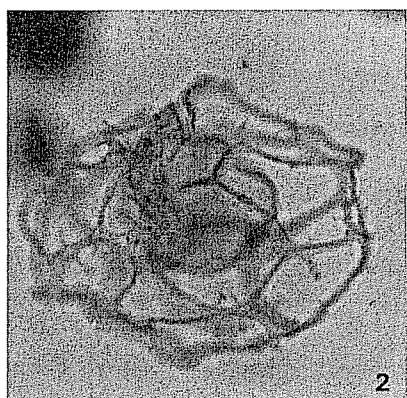
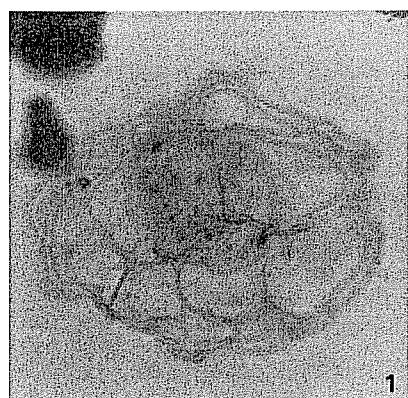
- BENEDEK, P.N., 1972. Phytoplankton aus dem Mittel- und Oberoligozän von Thönisberg (Niederrheingebiet). *Palaeontographica, Abteilung B*, 137: 1-71, pl.1-16.
- BROSNIUS, M., 1963. Plankton aus dem nordhessischen Kasseler Meeressand (Oberoligozän). *Zeitschrift der Deutschen Geologischen Gesellschaft*, 114 (1):32-56, pl. 1-8.
- BROWN, S. and DOWNIE, C., 1984. 20. Dinoflagellate cyst stratigraphy of Paleocene to Miocene sediments from the Goban Spur (Sites 548-550, Leg 80. Initial Reports of the Deep Sea Drilling Project, Washington, 80: 643-651, pl.1-4.
- BUJAK, J. P. and MATSUOKA, K., 1986. Late Cenozoic dinoflagellate cyst zonation in the western and northern Pacific. *American Association of Stratigraphic Palynologists, Contributions Series*, 17: 7-25, pl. 1-3.
- BUJAK, J. P. and WILLIAMS, G. L., 1978. Cretaceous palynostratigraphy of offshore southeastern Canada. *Geological Survey of Canada, Bulletin*, no. 297: 19p., 3 pl.
- BUJAK, J. P., DOWNIE, C., EATON, G. L. and WILLIAMS, G. L., 1980. Dinoflagellate cysts and acritarchs from the Eocene of southern England. *Special Papers in Palaeontology*, no. 24: 100 p., 22 pl.
- BÜTSCHLI, O., 1885. Erster Band. *Protozoa*. In: Dr. H. G. Brönn's Klassen und Ordnungen des Thier-Reichs, wissenschaftlich dargestellt in Wort und Bild, p. 865-1088; C. F. Winter'sche Verlagshandlung, Leipzig and Heidelberg, Germany.
- COOKSON, I.C., 1953. Records of the occurrence of *Botryococcus braunii*, *Pediastrum* and the *Hystrichosphaeridae* in Cainozoic deposits of Australia. *National Museum, Melbourne, Memoir*, no.18: 107-123, pl. 1-2.
- COOKSON, I.C. and EISENACK, A., 1961. Upper Cretaceous microplankton from the Belfast No. 4 Bore, southwestern Victoria. *Proceedings of the Royal Society of Victoria*, 74(1): 69-76, pl. 11-12.
- 1965. Microplankton from the Browns Creek Clays, southwestern Victoria. *Proceedings of the Royal Society of Victoria*, 79: 119-131, pl. 11-15.
- CORRADINI, D., 1973. Non-calcareous microplankton from the Upper Cretaceous of the northern Apennines. *Bollettino della Società paleontologica italiana*, 11: 119-197, p.19-39.
- DAMASSA, S. P., 1979. Danian dinoflagellates from the Franciscan Complex, Mendocino County, California. *Palynology*, 3 :191-207, p.1-5.
- DAVEY, R. J. and WILLIAMS, G. L., 1966. IV. The genera *Hystrichosphaera* and *Achomosphaera*. In: Davey, R. J., Downie, C., Sarjeant, W. A. S. and Williams, G. L., *Studies on Mesozoic and Cainozoic dinoflagellate cysts*; British Museum (Natural History) Geology, Bulletin, Supplement 3: 28-52.
- DAVEY, R. J., DOWNIE, C., SARJEANT, W. A. S. and WILLIAMS, G. L., 1969. Generic reallocations. In: Davey, R. J., Downie, C., Sarjeant, W. A. S. and Williams, G. L., Appendix to "Studies on Mesozoic and Cainozoic dinoflagellate cysts"; British Museum (Natural History) Geology, Bulletin, Appendix to Supplement 3: 15-17.
- DE CONINCK, J., 1975. Microfossiles à paroi organique de l'Yprésien du Bassin Belge. *Service géologique de Belgique, Professional Paper* 1975, no.12: 1-15 1, pl. 1-22.
- , 1980. Organic walled microfossils in the clay of leper in the Overijse Borehole. *Bulletin de la Société belge de géologie*, 89(4): 201-215, pl. 1-2.
- DEFLANDRE, G. and COOKSON, I. C., 1955. Fossil microplankton from Australian late Mesozoic and Tertiary sediments. *Australian Journal of Marine and Freshwater Research*, 6 (2): 242-3 13, pl. 1-9.
- DE VERTEUIL, L. and NORRIS, G., 1996. Miocene dinoflagellate stratigraphy and systematics of Maryland and Virginia. *Micropaleontology*, 42, Supplement: I-VIII, 1-172, pl. 1-18.
- EATON, G. L., 1976. Dinoflagellate cysts from the Bracklesham Beds (Eocene) of the Isle of Wight, southern England. *British Museum (Natural History) Geology, Bulletin*, 26: 227-332, pl. 1-21.
- EDWARDS, L. E. 1984. Miocene dinocysts from Deep Sea Drilling Project Leg 81, Rockall Plateau, eastern North Atlantic Ocean. In: Roberts, D. G. et al., Deep Sea Drilling Project, Washington, Initial Reports, 81: 581-594, pl. 1-5.
- EISENACK, A. and KJELLSTRÖM, G., 1972. *Katalog der Fossilien Dinoflagellaten, Hystrichosphären und Verwandten Mikrofossilien. Band II. Dinoflagellaten. III + 1132 p.*; E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, Germany. (Cover date 1971, issue date 1972.)
- FENSOME, R. A., TAYLOR, F. J. R., NORRIS, G., SARJEANT, W. A. S., WHARTON, D. I. and WILLIAMS, G. L., 1993. A classification of fossil and living dinoflagellates. *Micropaleontology Press Special Publication*, no. 7: 351 p.
- FRYKLUND, R., MARSHALL, A. and STEVES, J., 1996. La Cuenca del Colorado: una actualización de exploración. In: Ramos, V.A. and Turic, M.A., Eds., *Geología y recursos naturales de la Plataforma Continental Argentina; XIIIº Congreso Geológico Argentino y IIIº de Exploración de Hidrocarburos* (Buenos Aires, 1996), Relatorio, 8: 135-158.
- GAMERO, J. C. and ARCHANGELSKY, S., 1981. Palinozonas Neocretácicas y Terciarias de la plataforma continental Argentina en la Cuenca del Colorado. *Revista española de micropaleontología*, 13(1): 119-140, pl. 1-4.
- GERLACH, E., 1961. Mikrofossilien aus dem Oligozän und Miozän Nordwestdeutschlands, unter besonderer Berücksichtigung der Hystrichosphären und Dinoflagellaten. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 112 (2): 143-228, pl. 25-29.
- GUERSTEIN, G. R., 1990a. Palinología estratigráfica del Terciario de la Cuenca del Colorado, República Argentina. Parte II: especies marinas de la perforación Nadir No. 1. *Revista española de micropaleontología*, 22(2): 167-182, pl. 1-5.
- , 1990b. Palinología estratigráfica del Terciario de la Cuenca del Colorado, República Argentina. Parte III: estudio sistemático de la perforación Puerto Belgrano No. 20. *Revista Española de Micropaleontología*, 22(3): 459-480, pl. 1-2.
- GUERSTEIN, G. R. AND QUATTROCCHIO, M., 1988. Palinozonas e interpretación estratigráfica mediante análisis de agrupamiento del Terciario de la Cuenca del Colorado, República Argentina. 2º Jornadas geológicas bonaerenses, Actas: 27-35.
- , 1991. Datos paleoambientales basados en el estudio estadístico de las palinofloras de la perforación Nadir No 1 (Eoceno-Mioceno) Cuenca del Colorado. *Revista de la Asociación geológica Argentina*, 46(1-2): 136-149.
- GUERSTEIN, G. R., QUATTROCCHIO, M.E., DESCHAMPS, C. and RUIZ, L., 1995. Cenozoic (pre-Pliocene) paleoenvironmental trends based on palynomorphs from the Colorado Basin, Argentina. *Asociación paleontológica Argentina, Publicación especial*, 3: 63-73.

- HABIB, D., 1972. Dinoflagellate stratigraphy Leg 11, Deep Sea Drilling Project. In: Hollister, C.D. et al., Deep Sea Drilling Project, Washington, Initial Reports, 11: 367-425.
- HANSEN, J. M., 1979. A new dinoflagellate zone at the Maastrichtian/Danian boundary in Denmark. Geological Survey of Denmark, Yearbook, 1978: 131-140.
- HEAD, M. J., NORRIS, G. and MUDIE, P. J., 1989. New species of dinocysts and a new species of acritarch from the upper Miocene and lowermost Pliocene, ODP Leg 105, Site 646, Labrador Sea. In: Srivastava, S. P. et al., Ocean Drilling Program, Proceedings, Scientific Results, Leg 105: 453-466, pl. 1-5.
- HELENES, J., 1984. Morphological analysis of Mesozoic-Cenozoic *Cribroperidinium* (Dinophyceae), and taxonomic implications. Palynology, 8:107-137, pl.1.1 -5.
- LENTIN, J. K. and WILLIAMS, G. L., 1976. A monograph of fossil peridinioid dinoflagellate cysts. Bedford Institute of Oceanography, Report Series, no. BI-R-75-16, 237 p.
- LINDEMANN, E., 1928. Abteilung Peridineae (Dinoflagellatae). In: Engler, A. and Prantl, K., Eds., Die Natürlichen Pflanzenfamilien nebst ihren Gattungen und wichtigeren Arten insbesondere den Nutzpflanzen. Zweite stark vermehrte und verbesserte Auflage herausgegeben von A. Engler. 2 Band: 3-104; Wilhelm Engelmann, Leipzig, Germany.
- MALUMIÁN, N., 1970. Bioestratigrafía del Terciario marino del subsuelo de la provincia de Buenos Aires, Argentina. Ameghiniana, 7(2): 173-204.
- , 1972. Foraminíferos del Oligoceno y Mioceno del subsuelo de la provincia de Buenos Aires. Ameghiniana, 9(2): 97-137.
- MALUMIÁN, N. and NAÑEZ, C., 1996. Microfósiles y nanofósiles calcáreos de la Plataforma Continental. In: Ramos, V.A. and Turic, M.A., Eds., Geología y recursos naturales de la Plataforma Continental Argentina; XIIIº Congreso Geológico Argentino y IIIº de Exploración de Hidrocarburos (Buenos Aires, 1996), Relatorio, 5: 74-93.
- MALUMIÁN, N., NAÑEZ, C. and JANNOU, G., 1998. La Formación Elvira en su localidad tipo. Foraminíferos y edad. Mioceno inferior, cuenca del Colorado. X Congreso Latinoamericano de Geología y VI Congreso Nacional de Geología Económica, Buenos Aires, Actas, 1: 114-119.
- MALUMIÁN, N., SURIANO, J. M. and COBOS, J. C., 1998. La Formación Barranca Final en su localidad tipo. Mioceno, Cuenca del Colorado. X Congreso Latinoamericano de Geología y VI Congreso Nacional de Geología Económica, Buenos Aires, Actas, 1:125-130.
- MANUM, S. B., BOULTER, M. C., GUNNARSDOTTIR, H., RANGNES, K. and SCHOLZE, A. 1989. 32. Eocene to Miocene palynology of the Norwegian Sea (ODP Leg 104). In: Eldholm, O. et al., Ocean Drilling Program, Proceedings, Scientific Results, Leg 104, 104: 611-639, pl. 1-23.
- MCMINN, A., 1991. Recent dinoflagellate cysts from estuaries on the central coast of New South Wales, Australia. Micropaleontology, 37(3): 269-287, pl. 1-5.
- MORGENROTH, P., 1966a. Mikrofossilien und Konkretionen des nordwesteuropäischen Untereozans. Palaeontographica, Abteilung B, 119 (1-3): 1-53, pl. 1-11.

PLATE 1

Cannosphaeropsis quattrochiae sp. nov. For each specimen the sample number, slide number, co-ordinates (on Zeiss photomicroscope serial no. 4660390) and England Finder reference are given respectively. The following abbreviations are used:
cbd = central body diameter; od = overall diameter; all specimens about x700.

- 1-2 Specimen in antapical view: 1, high focus on antapical posterior paratabulation; 2, low focus on apical anterior paratabulation. Slide no. P34437-01 (1145-1150m), 20/91.8, England Finder reference 21T/3; cbd = 37 μ m; od = 80 x 65 μ m. See also text-fig. 4a-b.
- 3 Specimen in antapical view, high focus on antapical posterior paratabulation. Slide no. P34431-01 (1025-1030m), 17/19.8, England Finder reference 40R/3; cbd = 41 μ m; od = 77 x 64 μ m.
- 4-6 Specimen in dorsal view: 4, high focus on dorsal paratabulation; 5, low focus on ventral paratabulation; 6, mid focus showing the polar process connecting the autophragm with the trabecular network. Slide no. P34429-01 (985-990m), 7/107.2, England Finder reference 37G; cbd = 32 μ m; od = 68 x 69 μ m. See also text-fig. 4c-d.
- 7-8 The holotype, specimen in antapical view: 7, high focus on antapical paratabulation; 8, low focus on apical paratabulation. Slide no. P34432-01 (1045-1050m), 6.6/104.4, England Finder reference 34F; cbd = 30 μ m; od = 80 x 6 μ m. See also text-fig. 4e-f.
- 9,12 Specimen in antapical view: 9, low focus on apical area; 12, high focus on antapical area. Slide no. P34429-01 (985-990m), 2.5/94.2, England Finder reference 23M/2; cbd = 35 μ m; od = 60 μ m.
- 10-11 Specimen in dorsal view: 10, mid focus showing the archeopyle and the polar processes connecting the autophragm with the ectophragm; 11, high focus on dorsal paratabulation. Slide no. P34430-0 1 (1005-1010m, 15/106.6, England Finder reference 39P/4; cbd = 40 μ m; od = 83 x 63 μ m. See also text-fig. 4g-h.



- , 1966b. Neue in organischer Substanz erhaltene Mikrofossilien des Oligozans. Neues Jahrbuch für Geologie und Palaontologie, Abhandlungen, 127: 1-12, pl. 1-2.
- PALAMARCUK, S. and BARREDA, V. D., 1998. Bioestratigrafía en base a quistes de dinoflagelados de la Formación Chenque (Miocene), Provincia del Chubut, Argentina. *Ameghiniana*, 35(4): 415-126, p1. 1-6.
- PASCHER, A., 1914. Über Flagellaten und Algen. Deutsche Botanische Gesellschaft, Berichte, 32: 136-160.
- PIASECKI, S., 1980. Dinoflagellate cyst stratigraphy of the Miocene Hodde and Gram Formations, Denmark. Geological Society of Denmark, Bulletin, 29: 53-76, pl. 1-6.
- POWELL, A. J., 1992. Dinoflagellate cysts of the Tertiary System. In: Powell, A. J., Ed., A stratigraphic index of dinoflagellate cysts: 155-229, pl. 4.1-4.11. British Micropaleontological Society, Publication Series, Chapman and Hall, London, U.K.
- QUATTROCCHIO, M. E. and GUERSTEIN, G. R., 1988. Evaluación paleoambiental y paleoclimática del Terciario de la Cuenca del Colorado, República Argentina. Palinofloras. Asociacion Geológica Argentina, Revista, 43 (3): 375-387.
- QUATTROCCHIO, M. E. and SARJEANT, W. A. S., 1996. Early Paleocene (Danian) dinoflagellates from the Colorado Basin, Argentina. *Revista española de micropaleontología*, 28(3): 111-138, pl. 1-5.
- RIEGEL, W., 1974. New forms of organic-walled microplankton from an Upper Cretaceous assemblage in southern Spain. *Revista española de micropaleontología*, 6(3): 347-366, pl. 1-3.
- ROSSIGNOL, M., 1962. Analyse pollinique de sédiments marins quaternaires en Israël II.- Sédiments pléistocènes. *Pollen et Spores*, 4(1): 121-148, pl. 1-2.
- , 1964. Hystrichosphères du Quaternaire en Méditerranée orientale, dans les sédiments Pléistocènes et les boues marines actuelles. *Revue de micropaléontologie*, 7 (2): 83-99, pl. 1-3.
- RUIZ, L. C. and QUATTROCCHIO, M. E., 1996. Stratigraphic palynology of the Pedro Luro Formation (?Maastrichtian-Paleocene), Colorado Basin, Argentina. In: *Géologie de l'Afrique et de l'Atlantique Sud; Actes Colloques Angers*, 1994: 361-371, p1.1-2.
- , 1997a. Estudio palinológico de la Formación Pedro Luro (?Maastrichtiano-Paleoceno) en la Cuenca del Colorado, República Argentina. Parte 1: esporas Triletes, Laevigati, Murornati, Tricassati, Cingulati y Zonati. *Revista española de micropaleontología*, 29(1): 13-29.
- , 1997b. Estudio palinológico de la Formación Pedro Luro (?MaastrichtianoPaleoceno) en la Cuenca del Colorado, República Argentina. Parte 2: turna Saccites, Plicates, Poroses e incertae sedis. *Revista Española de Micropaleontología*, 29(2): 115-137.
- SARJEANT, W. A. S., 1970. The genus *Spiniferites* Mantell, 1850 (Dinophyceae). *Grana*, 10: 74-78.
- , 1985. A restudy of some dinoflagellate cyst holotypes in the University of Kiel collections: VI. Late Cretaceous dinoflagellate cysts and other palynomorphs in the Otto Wetzel collection. *Meyniiana*, 37: 129-185, p1. 1-7.
- SHUMACKER-LAMBRY, J., 1978. Palynologie du Landenien inférieur (Paléocène) à Gelinden-Overbroek/Belgique. Relations entre les microfossiles et le sédiment. 157 p., 18 pl.; Université de Liège, Laboratoire de Paléobotanique et de Paléopalynologie, Liège, Belgium. (Published thesis.)
- STOVER, L. E., 1975. Observations on some Australian Eocene dinoflagellates. *Geoscience and Man*, 11: 35-45, pl. 1-3.
- , 1977. Oligocene and Early Miocene dinoflagellates from Atlantic Corehole 5/5B, Blake Plateau. American Association of Stratigraphic Palynologists, Contributions Series, no. SA: 66-89, pl. 1-3.
- STOVER, L. E. and HARDENBOL, J., 1994. Dinoflagellates and depositional sequences in the Lower Oligocene (Rupelian) Boom Clay Formation, Belgium. *Bulletin de la Société belge de géologie*, 102 (1-2): 5-77, pl. 1-13. (Cover date 1993, issue date 1994.)
- STOVER, L. E., BRINKHUIS, H., DAMASSA, S. P., DE VERTEUIL, L., HELBY, R. J., MONTEIL, E., PARTRIDGE, A. D., POWELL, A. J., RIDING, J. B., SMELROR, M., and WILLIAMS, G. L., 1996. 19. Mesozoic-Tertiary dinoflagellates, acritarchs and prasinophytes. In: Jansonius, J. and McGregor, D.C., Eds., *Palynology: Principles and Applications*, Volume 2, p. 641-750. American Association of Stratigraphic Palynologists Foundation, Dallas, U.S.A.
- STREEL, M., BICK, H., FAIRON-DEMARET, M., SHUMACKER-LAMBRY, J. and VANGUESTAINE, M., 1977. Macro- et microfossiles végétaux dans le contexte litho- et biostratigraphique du Senonien-Paléocène de la rive gauche de la meuse au Nord de Liège, Belgique. APLF-Meeting Liège. 19-23 Sept 77. Excursion. 1 Guidebook.
- TAYLOR, F. J. R., 1980. On dinoflagellate evolution. *BioSystems*, 13: 65-108.
- URIEN, C. M., ZAMBRANO, J. J. and MARTINS, L. R., 1981. The basins of southeastern South America (southern Brazil, Uruguay and eastern Argentina) including the Malvinas Plateau and southern South Atlantic paleogeographic evolution. Comité Sudamericano del Jurásico y Cretácico: Cuencas sedimentarias del Jurásico y Cretácico de América del Sur, 1: 45-125.
- WALL, D., 1967. Fossil microplankton in deep-sea cores from the Caribbean Sea. *Palaeontology*, 10(1):95-123, pl. 14-16.
- WETZEL, O., 1933. Die in organischer Substanz erhaltenen - Mikrofossilien des baltischen Kreide-Feuersteins mit einem sediment-petrographischen und stratigraphischen Anhang. *Palaeontographica*, Abteilung A, 78: 1-110, pl.1-7.
- WILLIAMS, G. L., 1975. Dinoflagellate and spore stratigraphy of the Mesozoic-Cenozoic, offshore eastern Canada. *Geological Survey of Canada, Paper 74-30(2)*: 107-161.
- WILLIAMS, G. L., BRINKHUIS, H., BUJAK, J. P., DAMASSA, S. P., HOCHULI, P. A., DE VERTEUIL, L. and ZEVENBOOM, D., 1998. Dinoflagellate cysts. In: "Appendix to: Hardenbol J., Thierry J., Farley M. B., Jacquin Th., de Graciansky P. C. and Vail P. R. Mesozoic and Cenozoic sequence chronostratigraphic framework of European basins." In: de Graciansky, P.C., Hardenbol, Jacquin, T. and Vail, P. R., Mesozoic and Cenozoic sequence stratigraphy of European basins. Society of Sedimentologists and Geologists, Special Publication, 60: 764-765.
- WRENN, J. H., 1988. Differentiating species of the dinoflagellate cyst genus *Nematosphaeropsis* Deffandre & Cookson 1955. *Palynology*, 12: 129-150, pl. 1-7.

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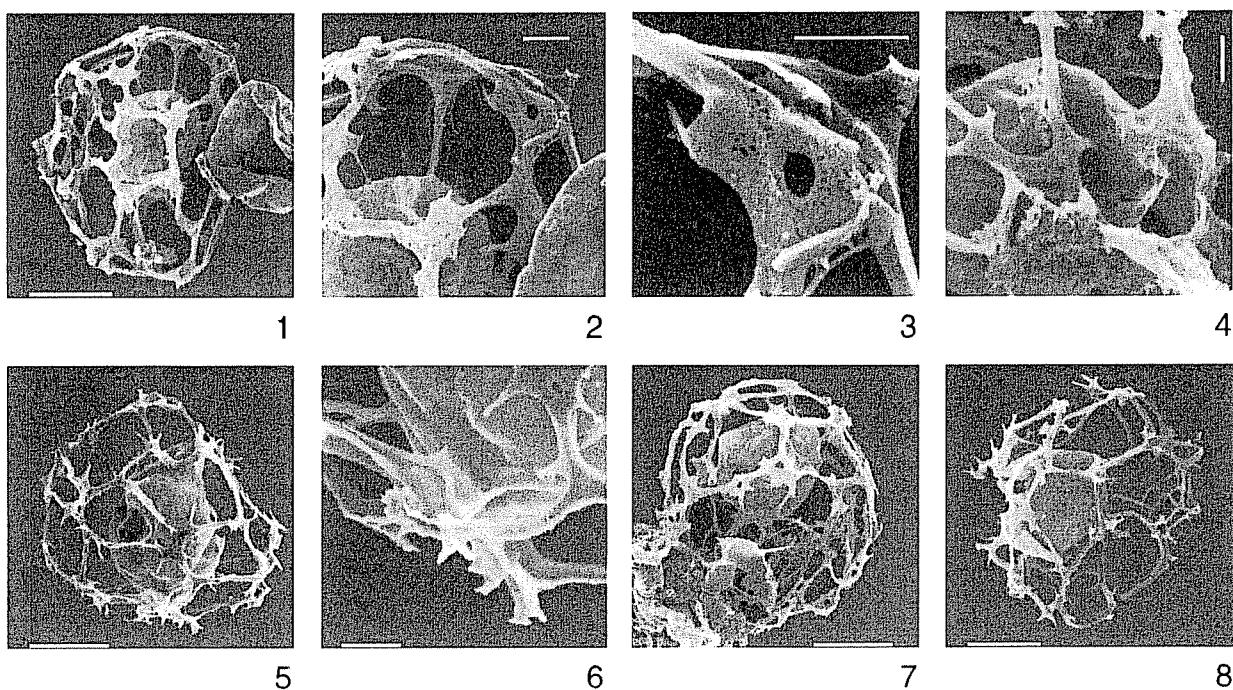


PLATE 2

Cannosphaeropsis quattrocciae sp. nov.: scanning electron photomicrographs at various magnifications.
Scale bars represent 20 μ m in figures 1, 5, 7-8, and 5 μ m in figures 2-4, 6.

- 1-3 Specimen from the type material: 1, antapical view; 2, detail showing the ribbon-like-trabecula and the fibrous crest; 3, detail of the microperforate platforms. GSC Atlantic preparation P34440 (1195-1200m), stub no. 34440-1, GSC specimen no. 118296.
- 4 Detail of the dorsal view of a specimen from the type material showing connection between central body and trabecular network. GSC Atlantic preparation P34434 (1085-1090m), stub no. 34434-2, GSC specimen no. 118297.
- 5-6 Specimen from the type material: 4, dorsal view showing the polar processes supporting the ectophraginal network; 5, detail of the apical process connecting the autophragm with the trabecular network. GSC Atlantic preparation P34440 (1085-1090m), stub no. 34440-9, GSC specimen no. 118298.
- 7 Apparent apical view of a specimen from the type material. GSC Atlantic preparation P34440 (1195-1200m), stub no. 34440-05, GSC specimen no. 118299.
- 8 Dorsal view of a specimen from the type material. GSC Atlantic preparation P34432 (1045-1050m), stub no. 34432-10, GSC specimen no. 118300.

APPENDIX I

List of species and subspecies names cited in the text

Achomosphaera sagena Davey and Williams 1966
Batiacasphaera sphaerica Stover 1977
Cannosphaeropsis franciscana Damassa 1979
Cannosphaeropsis passio de Verteuil and Norris 1996
Cannosphaeropsis quattrocciae n. sp. herein
Cannosphaeropsis utinensis O. Wetzel 1933
Cordosphaeridium minimum (Morgenroth 1966a) Benedek 1972
Cribroperidinium tenuitabulatum (Gerlach 1961) Hellenes 1984
Dapsilidinium pseudocolligerum (Stover 1977) Bujak et al. 1980
Distatodinium paradoxum (Brosius 1963) Eaton 1976
Emmetrocystis uriformis (Cookson 1953) Stover 1975
Heterosphaeridium heteracanthum (Deflandre and Cookson 1955)
Eisenack and Kjellström 1972
Hystrichosphaeropsis obscura Habib 1972
Invertocysta lacrymosa Edwards 1984
Labyrinthodinium truncatum Piasecki 1980 subspecies *truncatum* (autonym)
Lejeuneacystafallax (Morgenroth 1966b) Aitzner and Dorhofer 1978

Lingulodinium hemicyustum McMinn 1991
Melitasphaeridium pseudorecurvatum (Morgenroth 1966a) Bujak et al. 1980
Nematosphaeropsis rigida Wrenn 1988
Pentadinium laticinctum Gerlach 1961
Pentadinium taeniagerum Gerlach 1961
Reticulatosphaera actinocoronata (Benedek 1972) Bujak and Matsuoka 1986
Selenopemphix dionaeacysta Head et al. 1989
Spiniferites membranaceus (Rossignol 1964) Sarjeant 1970
Systematophora aencyrea Cookson and Eisenack 1965
Systematophora placacantha (Deflandre and Cookson 1955) Davey et al. 1969
Trityrodinium vermiculatum (Cookson and Eisenack 1961) Lentin and Williams 1976
Tuberculodinium vancampoae (Rossignol 1962) Wall 1967
Xenicodinium conispinum Stover and Hardenbol 1994
Xenicodinium echiniferum Stover and Hardenbol 1994

