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VALANGINIAN MIOSPORE AND MICROPLANKTON ASSEMBLAGES FROM THE NORTHERN RICHARDSON MOUNTAINS, DISTRICT OF MACKENZIE, CANADA

D. J. McINTYRE
and
W. W. BRIDEAUX

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Preface

The Mackenzie Delta of northern Canada is one of the areas where significant hydrocarbon deposits have been discovered recently. Palynological studies have already contributed to the search for oil and gas in the area. They have assisted in providing the detailed stratigraphic control necessary to adequately define prospective strata and structures. The ultimate contribution of such palynological studies is to assist in estimation of potential abundance and probable distribution of energy resources available to Canada.

In this report the authors present the results of detailed palynological study of material from two outcrop sections north of the Richardson Mountains, west of Aklavik, District of Mackenzie. Although the interval studied encompasses only a small part of the Lower Cretaceous such detailed taxonomic and biostratigraphic studies, combined with other studies, form the foundation for precise dating and correlation of Cretaceous rocks both here and elsewhere in western Canada.

D.J. McLaren
Director General
Geological Survey of Canada

OTTAWA, January 1980

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VALANGINIAN MIOSPORE AND MICROPLANKTON ASSEMBLAGES FROM THE NORTHERN RICHARDSON MOUNTAINS, DISTRICT OF MACKENZIE, CANADA

Abstract

The taxonomy and biostratigraphy of pollen, spore, dinoflagellate and acritarch assemblages for the Bluish grey shale unit (lower to middle Valanginian) of the Lower sandstone division are described from two outcrop sections from the northern end of the Richardson Mountains, west of Aklavik, District of Mackenzie.

Fifty-five species of pollen and spores and forty-eight species of dinoflagellates and acritarchs are recognized. One new spore species, Triporoletes incertus, and ten new dinoflagellate species, Apteodinium apiatum, Apteodinium spongiosum, Millioudodinium saetigerum, Millioudodinium spinoreticulateum, Palaeostomocystis senilis, Cleistosphaeridium separatum, Cleistosphaeridium spissum, Ctenidodinium scissum, Gochteodinia judilentinae and Kallosphaeridium? agglutinatum, are described.

Résumé

Une étude faite à partir de deux coupes affleurant dans la partie nord des monts Richardson, à l'ouest d'Aklavik dans le district de Mackenzie permet de donner une description de la taxonomie et de la biostratigraphie des assemblages de pollen, de spores, de dinoflagellés et d'acritarches provenant de l'unité "Bluish grey shale" (Lower sandstone division) d'âge Valanginien inférieur à moyen.

Cinquante-cinq espèces de pollen et de spores ainsi que quarante-huit espèces de dinoflagellés et d'acritarches sont reconnues. La description d'une nouvelle espèce de spore, Triporoletes incertus, et de dix nouvelles espèces de dinoflagellés, Apteodinium apiatum, Apteodinium spongiosum, Millioudodinium saetigerum, Millioudodinium spinoreticulatum, Palaeostomocystis senilis, Cleistosphaeridium separatum, Cleistosphaeridium spissum, Ctenidodinium scissum, Gochteodinia judilentinae et Kallosphaeridium? agglutinatum, sont décrits dans le cadre de cette étude.

VALANGINIAN MIOSPORE AND MICROPLANKTON ASSEMBLAGES FROM THE NORTHERN RICHARDSON MOUNTAINS, DISTRICT OF MACKENZIE, CANADA

INTRODUCTION

This paper documents an abundant and varied lower to middle Valanginian assemblage of spores, pollen, dinoflagellate cysts and acritarchs from two surface sections sampled through the Bluish grey shale unit of the Lower sandstone division (Jeletzky, 1958, 1960, 1972). The taxonomy, biostratigraphic significance, and relation to contiguous miospore and microplankton assemblages, and other published assemblages of Valanginian age, are discussed in detail. This contribution represents the first comprehensive published report on Valanginian palynomorphs from North America (*see* Warren, 1967, unpublished) and is one of the first to describe Valanginian microplankton assemblages from northern Canada (*see* Pocock, 1967).

The palynomorph assemblages were recovered from rocks of early to middle Valanginian age exposed in sections along the south banks of Martin Creek and an unnamed creek, often referred to as "Grizzly Gorge" (Fig. 1). "Grizzly Gorge" creek flows in a northeasterly direction, entering the West Channel of the Mackenzie River delta system about 80 km (50 miles) west of Inuvik, northwestern District of Mackenzie. The samples used in this investigation were collected by one of the writers (WWB) in the 1973 and 1975 field seasons. Descriptions of the lithology for the parts of the two measured sections from which samples were taken are given in the Appendix. The early to middle Valanginian age of the Bluish grey shale unit in these sections is based on published information derived from macrofossil collections (Jeletzky, 1958, 1960, 1972, 1973, written com., 1976) and on macrofossil collections made by D.W. Myhr, Tripet Resources Limited (formerly of the Institute of Sedimentary and Petroleum Geology) and one of the writers (WWB) in the 1975 field season. These collections were reported on by Jeletzky (written com., 1976, 1977).

Curation of materials

All outcrop samples used in this study and also palynologic slides that do not contain holotypes or figured specimens are stored at the Institute of Sedimentary and Petroleum Geology, 3303 -33rd Street N.W., Calgary, Alberta, Canada T2L 2A7. Slides containing holotypes or figured specimens are stored in the collection of the Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada K1A 0E8.

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The writers thank N.S. Ioannides (I.S.P.G.) and G. Norris (University of Toronto) for constructive reviews and critiques of the original manuscript and A. Hedinger for assistance in the field. The excellent preparations of S. Pickering and E. O'Keefe of the Institute of Sedimentary and Petroleum Geology are the foundation for this work.

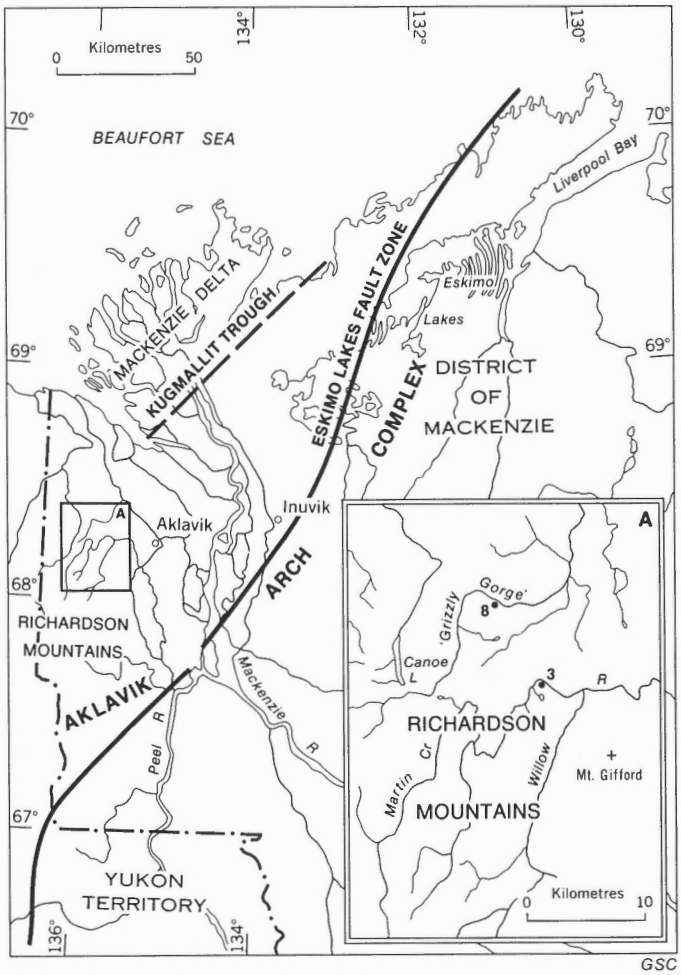


Figure 1. *Location of sections, geographic and geologic features mentioned in text.*

PREVIOUS WORK

Pollen and spores

Published information about North American Valanginian pollen and spore assemblages is extremely limited. McGregor (1965) has illustrated assemblages from the Richardson Mountains, N.W.T. and Williams (1975) has reported a few spore species from sediments from offshore Eastern Canada. Dörhöfer (in press) has summarized some of the available information and outlined the reasons for the scarcity of such information. Hopkins (1971) has illustrated spores and pollen from the Isachsen Formation, of Valanginian to Barremian age, on Melville Island and has noted the lack of significant variation in the microfloras from this formation.

Published information is available about Valanginian pollen and spore assemblages in Europe but much of this information is included in studies of Late Jurassic and Early Cretaceous microfloras. A few of the samples from southern England studied by Couper (1958) were of Valanginian age. Lantz (1958a) briefly reported on Valanginian spores and pollen from the island of Oleron and also (1958b) discussed some Lower Cretaceous assemblages from Dorset. Spores from Valanginian strata are included in the papers on Cicatricosisporites species by Hughes and Moody-Stuart (1969) and Hughes and Croxton (1973). Döring (1965), and earlier papers, included Valanginian age material in his detailed work on Jurassic-Cretaceous spores in the southern Mecklenburg-Brandenburg Basin and in 1966 summarized the Cretaceous microfloras studied. The work of Burger (1966) from the Lower Saxony Basin includes strata as young as Valanginian. Norris (1969) described the palynology of the Purbeck Beds of southern England. These included lowermost Valanginian strata, the microfloras from which are included in his zone C. Dörhöfer (1977) described pollen and spore assemblages, including some of early Valanginian age, from the Hils area, Lower Saxony Basin. Further discussion of the southern England and German assemblages is contained in a recent paper by Dörhöfer and Norris (1977) and comparisons and correlations are given. Dörhöfer (in press) has discussed in some detail the published work from Europe and has summarized the results.

Information on Valanginian pollen and spore assemblages in the U.S.S.R. is contained in papers by Malyavkina (1949, 1958), Bolkhovitina (1956), and Samoilovich (1961). More information is published but much of this is not readily accessible.

Australian spore and pollen assemblages were described by Balme (1957) including some of Valanginian age. Balme (1964) discussed Australian pre-Tertiary floras. Valanginian microfloras are included in his Lower Cretaceous Microcachryidites Assemblage. Detailed discussion and description of Early Cretaceous microfloras, including the Stylosus Assemblage of Valanginian age, were given by Dettmann (1963). Evans (1966) and Dettmann and Playford (1969) reviewed Australian Cretaceous microfloras and proposed more detailed zonations than that of Balme (1964). Burger (1973) discussed spore and pollen floras of the Neocomian of the Great Artesian Basin and introduced a palynologic zonation for this interval.

Microplankton

The literature treating Valanginian dinoflagellates is sparse. Assemblages from North America and contiguous regions have been reported by the following authors: Warren (1967) from the Sacramento Valley of California; Wiggins (1969) from Alaska; Habib (1972, 1973, 1974, 1975) from various localities in the western North Atlantic; Williams (1975) from the Atlantic continental margin, offshore eastern Canada; and Pocock (1976) from Arctic Canada. Elsewhere, Gocht (1957, 1959) reported on upper Valanginian assemblages from northwestern Germany; Alberti (1961) described assemblages from various Valanginian localities, principally in Germany but including several localities in Poland and Bulgaria; Millioud (1967, 1969) published data on assemblages from the Valanginian stratotype in Switzerland; Vozzhennikova (1967) described species from putative Valanginian strata from the Kostromsk region of the European U.S.S.R. and Tyumensk region of western Siberia; and Duxbury (1977) described a Valanginian assemblage from England.

Harker and Sarjeant (1975) suggest that information from Valanginian assemblages has been included by Vavrdova (1964). However, as Brideaux (1977, p. 42) notes, this information appears to be incorrect; Vavrdova (1964) treated only putative Barremian-Aptian strata from Czechoslovakia.

STRATIGRAPHY

Regional setting

The Bluish grey shale unit, as exposed along Martin Creek and "Grizzly Gorge", was deposited along the southeastern margin of the Kugmallit Trough (Fig. 1) adjacent to the southern flanks of the Eskimo Lakes Arch, which is associated with the Columbian orogeny, and later, the Eskimo Lakes Fault Zone, which is associated with the Laramide orogeny (Young et al., 1976, Figs. 2, 3). The presumed axis of the Kugmallit Trough lies to the west and northwest of the measured sections. The attitude of beds of the Bluish grey shale unit could not be measured, but sandstone beds of the underlying Buff sandstone unit and overlying White sandstone unit strike approximately north and dip 15° east (Brideaux, 1976).

Stratigraphic position, thickness and lithology

The Bluish grey shale unit, along Martin Creek and "Grizzly Gorge", is underlain conformably by the Buff sandstone unit (Brideaux, 1976, p. 116), and overlain conformably by the White sandstone unit. These three units comprise the Lower sandstone division as exposed along these two water courses. The Bluish grey shale unit is correlative, at least in part, with the shale unit of the subsurface "Parsons sandstone" of Cote et al. (1975) to the east and northeast on the eastern side of the Mackenzie River delta. Along Martin Creek the Bluish grey shale unit is 16.7 m (55.1 ft) thick at the measured section 75-BIA-003 (*see* Fig. 1; Appendix 1); along "Grizzly Gorge" the thickness at Section 75-BIA-008 (Fig. 1) was measured as 11.2 m (37 ft). In the central and western Richardson Mountains, 48 to 112 km (30-70 miles) west of the study area, the shale unit thickens considerably to 122 to 152.5 m (400-500 ft) and is termed the Bluish grey shale division (Jeletzky, 1961). The contacts between this shale division and the underlying Lower sandstone division and overlying White quartzite division are conformable and gradational. To the southeast of the study area along the front range of the Richardson Mountains, the Bluish grey shale unit can be recognized as a thin but persistent horizon [4.9-5.5 m (16-18 ft) thick] at the top of the Buff sandstone unit (Jeletzky, 1958, Section 11, p. 51, 52) but disappears farther south.

Along Martin Creek, the Bluish grey shale unit comprises dark grey, friable, silty shale with intercalated iron-rich concretionary beds from 0.1 to 0.2 m thick. Along "Grizzly Gorge", the lithology of the unit is similar except that the shale beds are often iron stained or yellow streaked and the iron-rich concretionary horizons are replaced for the most part by iron-rich, dark brown weathering silty shale or shale. One indurated iron-rich bed occurs near the top of the measured section. Along the front range of the Richardson Mountains, this lithology persists (Jeletzky, 1958, p. 51, 52). However, in the central and western Richardson Mountains, the lithology comprises bluish-grey and dark grey to black, indurated shales and, less commonly, silty or sandy shales, in places rich in concretions (Jeletzky, 1961).

Age

The Bluish grey shale unit in the study area falls within the Buchia keyserlingi Zone of early to middle Valanginian age (Jeletzky, 1961, 1972, 1973, written com., 1976). Jeletzky (written com., 1976) comments:

"In terms of the West European zones (*see* Jeletzky, 1973, Fig. 3, Column 1) this redefined boundary between the Buchia keyserlingi and Buchia ex gr. inflata-sublaevis Zones should correspond approximately with that between the Kilianella roubaudi and Saynoceras Zones. It also should correspond roughly with the boundary between Polyptychites-beds and Dichotomites-beds in northwestern Germany (*see* Jeletzky, 1973, Fig. 3, Column 4) and with the middle upper Valanginian boundary as defined in my paper . . .".

Jeletzky (op. cit.) observes also that this boreal Buchia keyserlingi Zone corresponds approximately with the Buchia tolmatschowi sensu lato and Buchia pacifica sensu lato Zones of western British Columbia.

The measured sections yielded only a few poorly preserved belemnites at the location along "Grizzly Gorge". However, a section of the Bluish grey shale unit measured along the north bank of Martin Creek (Lat. 68°12'20"N, Long. 135°34'35"W) by D.W. Myhr yielded well-preserved specimens of Buchia keyserlingi (Lahusen, 1888) forma typica (Jeletzky, pers. com., 1976).

Depositional environment

The Bluish grey shale unit in the study area belongs to the shale subfacies of the Pelitic Facies of Young et al. (1976, p. 18). These writers suggest that the shale subfacies was deposited in an open marine, neritic to bathyal setting which agrees essentially with the interpretation of Jeletzky (1974, Fig. 8, Columns G4, G5). The Bluish grey shale unit is underlain by littoral to inner neritic sandstones (Jeletzky, op. cit.), the shoreface deposits of Myhr and Young (1975) and Brideaux (1976, p. 118) of the Buff sandstone unit. The shale unit is overlain by the beach facies of Jeletzky (op. cit.), the nearshore sandstone facies of Young et al. (1976) of the White sandstone unit. The Bluish grey shale unit thus represents a brief marine incursion from the west into the predominantly shoreface to littoral or beach facies environment of the study area.

DISTRIBUTION

Pollen and spores

Local distribution

Fifty-five species of pollen grains and spores were identified from the Bluish grey shale unit. Four species occurred only along Martin Creek, six occurred only at "Grizzly Gorge", and forty-five occurred at both localities (Table 1).

In samples from both sections, species diversity varies between thirty-three and thirty-eight species per sample except at 11.5 to 11.7 m in the Martin Creek section where it declines to twenty species and at the base of the "Grizzly Gorge" section where twenty-three species were recorded.

Paleogeographic distribution

Only six species recorded from the Bluish grey shale unit do not occur elsewhere in strata of Valanginian age. Four of these six species have been recorded elsewhere from younger strata and the other two are at present known only from the Bluish grey shale unit.

The majority of the species recorded from both sections of the Bluish grey shale unit are forms with rather long ranges which also occur in Valanginian strata in Europe. Although European assemblages, as published (*see* section on previous work), appear to contain a greater diversity of pollen and spores, there is much similarity between the Valanginian assemblage from the Bluish grey shale unit and European assemblages. Twenty-one of the species recorded from the Bluish grey shale unit also occur in Australian Valanginian assemblages but many other species recorded from Australia have not been seen in the Canadian material.

Microplankton

Local distribution

Forty-eight species of dinoflagellate cysts, acritarchs and other marine microfossils were identified from the Bluish grey shale unit. Of these, twenty-one species occurred only along Martin Creek (Table 2), three occurred only at "Grizzly Gorge" and twenty-four occurred at both localities. Of the total assemblage for this region, forty-five species were identified along Martin Creek and only twenty-seven at "Grizzly Gorge".

Along Martin Creek, species diversity is greatest at the base (thirty) and at the top of the unit (twenty-six). The diversity declines above the basal bed, except at 7.5 to 8.5 m from the base of the unit where it rises to nineteen, and reaches a minimum of three species 11.5 to 11.7 m above the base of the unit. At "Grizzly Gorge" the greatest diversity occurs in the basal beds (eighteen) and declines to a relatively constant number thereafter (seven to eight).

Paleogeographic distribution

Seventeen species recorded from the Bluish grey shale unit occur elsewhere in Valanginian or putative Valanginian strata (Table 3). Valanginian assemblages from California (Warren, 1967) show ten species in common with those from northern Canada, closely followed by the nine species in common from the Speeton Clay of England (Duxbury, 1977). Five species occur in common with the limited Valanginian assemblage recorded by Pocock (1976) from northern Canada. Other regions show very little similarity in published assemblages with those from the Bluish grey shale unit. The ratio (Brideaux, 1976b, p. 124) of the number of species common to northern Canadian and Californian assemblages with the total number of species that occur in one or the other but not both assemblages is 0.103 (10/97) compared with the value of 0.048 (4/83) recorded from Berriasian assemblages from the same regions. The same ratio for Valanginian assemblages from Arctic Canada and from the Speeton Clay of England (Duxbury, 1977) is 0.13 (9/68) and for Berriasian assemblages from the same area, 0.08 (4/54). Published Valanginian assemblages from northern Canada therefore appear to show a slightly greater degree of similarity with those from England and northern California than published Berriasian assemblages from the same areas.

TABLE 1

Occurrence of pollen and spores in the Bluish grey shale unit along Martin Creek and "Grizzly Gorge", N.W.T.

LOCATION AND SECTION	MARTIN CREEK SECTION 75-BIA-003 (top part)							'GRIZZLY GORGE' SECTION 75-BIA-008 (basal part)				
BLUISH-GREY SHALE UNIT Height from base (m)	0.0-0.4	0.4-0.5	2.4-2.7	4.4-5.8	7.5-8.5	11.5-11.7	16.0-16.7	0.0-0.3	3.0-3.3	6.0-6.3	9.0-9.2	10.8-11.1
GSC LOC. NO.'S / TAXON (in order of appearance in text)	C-50866 C-29161	C-50867	C-29162	C-50868	C-50869	C-50870	C-50871 C-50854	C-50919	C-50920	C-50921	C-50922	C-50923
Aequitriradites spinulosus		×					×				×	
Appendicisporites potomacensis	×						×			×		
Baculatisporites comaumensis	×	×	×	×	×	×	×	×	×	×	×	×
Biretisporites potoniaei				×	×							×
Ceratosporites sp.		×	×							×	×	
Cicatricosisporites angicanalis									×			
Cicatricosisporites australiensis	×	×	×	×	×		×	×	×	×	×	×
Cicatricosisporites exilioides					×				×	×	×	×
Cicatricosisporites hallei							×		×	×		×
Cicatricosisporites hughesii	×	×	×	×	×		×	×	×	×	×	×
Cicatricosisporites myrtellii								×			×	
Cicatricosisporites potomacensis		×	×	×	×		×		×	×	×	×
Concavissimisporites punctatus								×	×	×	×	
Concavissimisporites variverrucatus	×	×	×	×	×					×	×	×
Contignisporites cooksonii		×	×		×		×			×		
Contignisporites dorsostriatus				×								
Cooksonites variabilis	×											
Coronatispora valdensis	×		×			×		×				
Crybelosporites vectensis	×		×	×	×				×	×	×	×
Deltoidospora spp.	×	×	×	×	×	×	×	×	×	×	×	×
Densoisporites velatus	×	×	×	×	×				×	×	×	×
Foraminisporis wonthaggiensis	×	×	×	×	×	×	×		×	×	×	
Gleicheniidites senonicus	×	×	×	×	×	×	×	×	×	×	×	×
Impardecispora apiverrucata									×			×
Januasporites spiniferus	×		×		×		×				×	
Klukisporites pseudoreticulatus	×	×	×	×	×	×	×	×	×	×	×	×
Krauselisporites hastilobatus											×	
Lycopodiumsporites austroclavatidites	×	×	×	×	×	×	×	×	×	×	×	×
Lycopodiumsporites marginatus	×	×	×	×	×		×	×	×	×	×	×
Neoraistrickia truncata	×	×		×			×		×	×		
Osmundacidites wellmanii	×	×	×	×	×	×	×	×	×	×	×	×
Pilosisporites trichopapillosus		×	×	×	×		×		×	×	×	
Polycingulatisporites reduncus		×		×						×		
Rogalskaisporites cicatricosus		×				×	×					
Rubinella major	×	×	×	×					×			
Sestrosporites psuedoalveolatus	×		×	×	×	×		×	×		×	
Stereisporites antiquasporites	×				×		×			×	×	×
Trilobosporites aornatus								×	×			×
Triporoletes incertus	×		×	×	×		×		×	×	×	×
Alisporites bilateralis	×	×	×	×	×	×	×	×	×	×	×	×
Alisporites grandis	×	×	×	×	×	×	×	×	×	×	×	×
Alisporites minutus	×	×	×	×	×		×			×	×	×
Cedripites cretaceus	×	×	×	×	×	×	×		×	×	×	×
Podocarpidites biformis	×	×	×	×	×	×	×	×	×	×	×	×
Podocarpidites canadensis	×	×	×	×	×		×				×	
Podocarpidites multesimus	×	×	×	×	×		×	×	×	×	×	×
Vitreisporites pallidus	×					×	×				×	
Callialasporites dampieri		×	×	×	×				×	×	×	×
Cerebropollenites mesozoicus	×	×	×	×	×	×	×	×	×	×	×	×
Classopollis classoides	×	×	×	×	×	×	×	×	×	×	×	×
Cycadopites nitidus	×	×	×	×	×	×	×	×	×	×	×	×
Eucommiidites troedssonii						×						
Exesipollenites tumulus	×	×	×	×	×	×	×	×	×	×		×
Perinopollenites elatoides	×	×	×	×	×		×		×	×		×
Taxodiaceaepollenites hiatus	×	×	×	×	×		×	×	×	×	×	×

GSC

That the greater degree of similarity is shown with Valanginian assemblages from Tethyan regions rather than boreal assemblages from Alaska and Russia may be due to the paucity of published information from the latter areas.

Eighteen species, including Apteodinium apiatum sp. nov., A. spongiosum sp. nov., Millioudodinium spinoreticulatum sp. nov., Palaeostomocystis senilis sp. nov., Bourkidinium sp. AE, Cleistosphaeridium spissum sp. nov., Gochteodinia judilentinae sp. nov. and Kallosphaeridium? agglutinatum sp. nov., have been recorded only from the Bluish grey shale unit. Fourteen other species have been recorded elsewhere in northern Canada (Brideaux, 1976a, 1977) from younger or older strata.

We concluded that little similarity existed between published Valanginian assemblages from northern Canada and elsewhere. Dinoflagellate assemblages from northern Canada exhibited a marked provinciality which began to decrease in degree only in the Hauterivian (Brideaux, 1977, unpubl. data).

POLLEN AND SPORE BIOSTRATIGRAPHY

Bluish grey shale unit

The majority of the fifty-five pollen and spore taxa recorded in the lower to middle Valanginian Bluish grey shale unit have long ranges extending above and below the Valanginian in Europe and North America and they are of no assistance in closely determining the age or correlation of the microfloras noted in this study. There has been insufficient detailed study of northern Canadian Lower Cretaceous pollen and spore assemblages to determine the exact ranges of the species in this area but there are indications (Brideaux and McIntyre, unpubl. data) that their local ranges are similar to those noted in other areas.

Only two species, Ceratosporites sp. and Triporoletes incertus sp. nov., are presently considered to be restricted to the Bluish grey shale unit which falls in the Buchia keyserlingi Zone of the northern Canadian mainland (Table 3). Four other species which occur in the Bluish grey shale unit have not previously been recorded in North America (to our knowledge) and do not appear later than the Valanginian in Europe (Dörhöfer, in press; Döring, 1966; Burger, 1966). These species are Cicatricosisporites angicanalis, C. myrtellii, Rubinella major and Trilobosporites aornatus.

Five species which are presently known to appear in northern Canada no earlier than the lower to middle Valanginian Bluish grey shale unit are Cicatricosisporites exilioides, C. potamacensis, Crybelosporites vectensis, Kraeuselisporites hastilobatus and Lycopodiumsporites marginatus. These species all occur higher in the Lower Cretaceous

TABLE 2

Occurrence of microplankton in the Bluish grey shale unit along Martin Creek and "Grizzly Gorge", N.W.T.

LOCATION AND SECTION	MARTIN CREEK SECTION 75-BIA-003 (top part)							'GRIZZLY GORGE' SECTION 75-BIA-008 (basal part)				
BLUISH-GREY SHALE UNIT Height from base (m)	0.0-0.4	0.4-0.5	2.4-2.7	4.4-5.8	7.5-8.5	11.5-11.7	16.0-16.7	0.0-0.3	3.0-3.3	6.0-6.3	9.0-9.2	10.8-11.1
TAXON \ GSC LOC. NO.'S	C-29161/ C-50866	C-50867	C-29162	C-50868	C-50869	C-50870	C-50871	C-50919	C-50920	C-50921	C-50922	C-50923
Apteodinium apiatum sp. nov.	×		×	×	×		×	×	×	×		
Apteodinium spongiosum sp. nov.							×					
Druggidinium? sp. AE							×					
Gonyaulacysta cretacea/helicoidea group	×			×	×			×	×			
Gonyaulacysta kostromiensis	×				×							
Impagidinium sp.	×							×				
Leptodinium hyalodermopsis		×			×		×	×				
Lunatadinium dissolutum	×								×			
Meiourogonyaulax sp. AE	×											
Millioudodinium saetigerum sp. nov.	×											
Millioudodinium spinoreticulatum sp. nov.		×		×	×			×		×	×	
Trichodinium castaneum	×						×	×				
Trichodinium sp. BE	×	×			×		×	×		×		
Canningia sp. CE	×						×					
Pareodinia ceratophora	×		×	×				×			×	
Batioladinium jaegeri		×	×		×						×	
Fromea amphora	×			×				×				
Fromea sp. cf. F. *fragilis*							×					
Horologinella spinosigibberosa	×											
Palaeostomocystis senilis sp. nov.					×		×					
Bourkidinium sp. AE	×	×										
Cleistosphaeridium araneosum	×						×					
Cleistosphaeridium polypes clavulum	×	×					×					
Cleistosphaeridium separatum sp. nov.	×					×		×				×
Cleistosphaeridium spissum sp. nov.	×				×			×	×			
Cleistosphaeridium sp. KE	×		×		×		×	×		×		
Ctenidodinium spissum sp. nov.							×	×				
Oligosphaeridium asterigerum							×		×			
Oligosphaeridium complex	×											
Oligosphaeridium vasiformum	×	×	×	×	×		×	×	×	×	×	×
Oligosphaeridium sp. GE	×		×	×	×		×		×		×	
Polysphaeridium sp. AE						×						
Tanyosphaeridium sp. DE of Brideaux, 1977		×										
Gochteodinia villosa	×	×					×	×				×
Gochteodinia judilentinae sp. nov.					×		×					
Sirmiodinium grossii	×		×				×	×				×
Tubotuberella rhombiformis	×		×		×		×		×	×	×	×
Dingodinium cerviculum				×	×		×					
Muderongia sp. cf. M. *simplex*												×
Caligodinium aceras	×											×
Kallosphaeridium agglutinatum sp. nov.	×	×	×	×	×		×	×	×	×		
Kallosphaeridium sp. AE		×	×		×							
Kallosphaeridium sp. BE					×		×					
Wallodinium lunum	×						×					
Pediastrum sp.											×	
Schizosporis reticulatus									×	×		
Veryhachium reductum 'forma' trispinoides	×		×			×						
Paragonyaulacysta borealis	×				×			×				

GSC

elsewhere in northern Canada (Brideaux and McIntyre, 1976). Cicatricosisporites exilioides has previously been recorded as early as the Valanginian in Europe (Dörhöfer, 1977) and Crybelosporites vectensis has been recorded from Bajocian-Bathonian strata from Norway (Vigran and Thusu, 1975; Birkelund et al., 1978).

Only eleven of the total miospore species identified in the Bluish grey shale unit are of use for precise age determination. Some are recorded for the first time in strata as old as Valanginian and for others it is the first recorded occurrence in North America, which places limitations on their value for age determination in the interval under discussion. Because of the meagre evidence of age provided by the few species noted earlier in this discussion of biostratigraphy, it is not possible to state with certainty that these species will provide good evidence of Valanginian age when discovered elsewhere in North America.

MICROPLANKTON BIOSTRATIGRAPHY

Bluish grey shale unit

Twenty-one of the forty-eight species treated in this paper are restricted, so far as is known, to the lower to middle Valanginian Bluish grey shale unit, which falls in the Buchia keyserlingi Zone of the northern Canadian mainland region (*see* Table 4).

These species include:

Apteodinium apiatum sp. nov.
A. spongiosum sp. nov.
Druggidium? sp. AE
Millioudodinium spinoreticulatum sp. nov.
Meiourogonyaulax sp. AE
Trichodinium sp. BE
Kallosphaeridium sp. BE
Fromea sp. cf. F. fragilis
Palaeostomocystis senilis sp. nov.
Cleistosphaeridium spissum sp. nov.
Ctenidodinium scissum sp. nov.
Oligosphaeridium sp. GE
Gochteodinia judilentinae sp. nov.
Kallosphaeridium? agglutinatum sp. nov.

Six species are not known to range above the Buchia keyserlingi Zone but do occur lower elsewhere in the northern Canadian mainland as indicated (Brideaux, 1976b, 1977, unpubl. data; Brideaux and Fisher, 1976):

Impagidinium sp. (upper Berriasian)
Paragonyaulacysta borealis (upper Oxfordian)
Cleistosphaeridium separatum sp. nov. (upper Berriasian)
Oligosphaeridium vasiformum (upper Berriasian)
Tubotuberella rhombiformis (upper Oxfordian)
Schizosporis reticulatus (lower Berriasian)

TABLE 3

Microplankton from the Bluish grey shale unit occurring at other Valanginian and putative Valanginian localities

TAXON \ LOCALITIES	1	2	3	4	5	6	7	8	9	10
Gonyaulacysta cretacea/helicoidea group			×			×				
Leptodinium hyalodermopsis			×							
Meiourogonyaulax sp. AE			×							
Lunatadinium dissolutum			×							
Gonyaulacysta kostromiensis		?		cf.						
Paragonyaulacysta borealis			×							
Pareodinia ceratophora	×				×		×			
Oligosphaeridium asterigerum			×					×		
Oligosphaeridium complex								×		×
Oligosphaeridium vasiformum	×									×
Gochteodinia villosa	×		×							×
Dingodinium cerviculum	×				×	×				×
Sirmiodinium grossii			×							×
Tubotuberella rhombiformis	×		×							×
Muderongia sp. cf. M. simplex									cf.	cf.
Wallodinium lunum			×			×				×

GSC

1. Pocock (1976), northern Canada
2. Wiggins (1972), Alaska
3. Warren (1967), California, U.S.A.
4. Vozzhennikova (1967), Kostromsk district, U.S.S.R.
5. Williams (1975), offshore eastern Canada
6. Habib (1972, 1974, 1975), western North Atlantic
7. Millioud (1967, 1969), Valanginian stratotype, Switzerland
8. Gocht (1959), Germany
9. Alberti (1961), Germany and Poland
10. Duxbury (1977), England

Eleven species are known not to range lower than the B. keyserlingi Zone (Brideaux and McIntyre, 1976; Brideaux, 1977; unpubl. data), but do range higher elsewhere in northern Canada:

Gonyaulacysta cretacea/helicoidea (Middle Albian)
Leptodinium hyalodermopsis (Middle Albian)
Millioudodinium saetigerum sp. nov. (Barremian-?Aptian)
Trichodinium castaneum (Santonian)
Kallosphaeridium sp. AE (?Hauterivian)
Batioladinium jaegeri (Middle Albian)
Fromea amphora (Middle Albian)
Oligosphaeridium complex (Middle Albian)
Dingodinium cerviculum (Middle Albian)
Caligodinium aceras (Campanian-Maastrichtian)
Wallodinium lunum (Barremian)

Nine other species occur in lower to middle Valanginian strata in the Buchia keyserlingi Zone, but also range higher and lower elsewhere in the northen Canadian mainland. A single specimen of Horologinella spinosigibberosa Brideaux and Fisher was observed in the Bluish grey shale unit and is considered to be derived from older strata. Other derived species include the common Middle and Upper Jurassic species, Gonyaulacysta cladophora (Deflandre) Dodekova, G. jurassica (Deflandre) Norris and Sarjeant and G. dualis (Brideaux and Fisher) Stover and Evitt.

Brideaux (1976b, p. 125) suggested that the occurrence of Paragonyaulacysta borealis in the Bluish grey shale unit was based on specimens derived from older strata. However, the excellent preservation of abundant specimens in samples from this unit indicates that the species is indigenous and that the range must be extended. A similar argument can be advanced for Tubotuberella rhombiformis Vozzhennikova emend. Brideaux. Other species, including Trichodinium castaneum, Batioladinium jaegeri, Fromea amphora, Dingodinium cerviculum and the Gonyaulacysta cretacea/heliocoidea group are confirmed in extension of their range into Valanginian strata [*see* also Habib (1972, 1975), Warren (1967), Pocock (1976)].

Recognition of basal Cretaceous stages - northern mainland

Berriasian and Valanginian

Ten species appear to be of value in recognizing the Berriasian stage in this region. Horologinella spinosigibberosa does not occur above the lower Berriasian Buchia okensis Zone (Brideaux, 1976b). The fossil of indeterminate affinity, "Organism" sp. AE of Brideaux (1976b), is known only from the upper Berriasian Buchia n. sp. aff. volgensis Zone (ibid., 1976b). Paragonyaulacysta capillosa is not known to range above the Berriasian (Brideaux and Fisher, 1976). Schizosporis reticulatus first appears in the Buchia okensis Zone. Cleistosphaeridium separatum sp. nov., Oligosphaeridium vasiformum, Scriniodinium? campanulum, Cyclonephelium distinctum, Impagidinium sp. and Tanyosphaeridium sp. DE of Brideaux (1977) first appear in the upper Berriasian Buchia n. sp. aff. volgensis Zone (ibid., 1976b) and range higher in the northern Canadian mainland.

Recognition of the Berriasian Stage and differentiation of this stage from the Valanginian Stage is more difficult in subsurface sections based on material from ditch cuttings samples. Only the last occurrence ("first occurrence downhole") of Paragonyaulacysta capillosa, Horologinella spinosigibberosa and "Organism" sp. AE are of use in that situation. The large number of species known so far only from Valanginian strata (*see* list above and Table 3) and several species, including Impagidinium sp., Paragonyaulacysta borealis and Tubotuberella rhombiformis, known to range no higher than the lower and middle Valanginian Buchia keyserlingi Zone, offer a substantial body of data with which to differentiate the Valanginian Stage from the Berriasian and undifferentiated Hauterivian Stages. However, this differentiation is again more difficult when ditch cuttings only are available in subsurface sections.

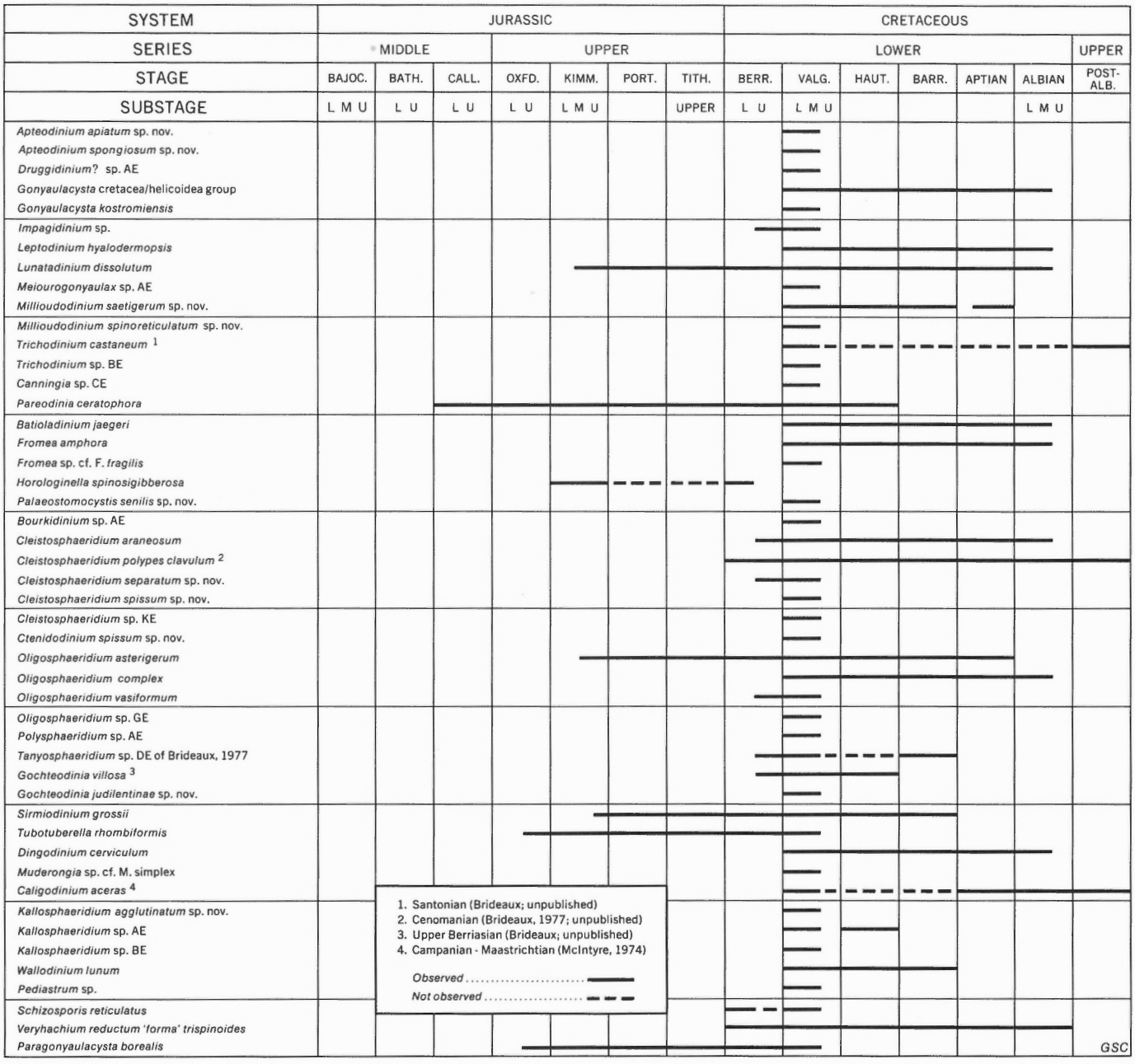
Hauterivian

Many dinoflagellate species are not known to range down into strata older than Hauterivian (Brideaux, 1977; unpubl. data). These species, most useful for differentiation of the Hauterivian from the Valanginian in outcrop sections and cored subsurface sections, include the following:

Achomosphaera neptunii (Eisenack) Davey and Williams, 1966
Coronifera oceanica Cookson and Eisenack, 1958
Cribroperidinium muderongensis (Cookson and Eisenack) Davey, 1969
Dimidiadinium uncinatum Brideaux, 1977
Palaeostomocystis expolita Brideaux, 1977
Batioladinium micropodum (Cookson and Eisenack) Brideaux, 1975
Canningia aspera Singh, 1971
Chlamydophorella nyei Cookson and Eisenack, 1958
Ellipsoidictyum imperfectum (Brideaux and McIntyre) Lentin and Williams 1977

TABLE 4

Known ranges of microplankton from the Bluish grey shale unit in the Mackenzie Delta-Arctic Archipelago regions based on published and unpublished data.



Microdinium opacum Brideaux, 1971
Odontochitina operculata (O. Wetzel) Deflandre and Cookson, 1955
Oligosphaeridium albertense (Pocock) Davey and Williams, 1966
Oligosphaeridium totum subsp. totum Brideaux, 1971
Palaeoperidinium cretaceum (Pocock ex Davey) Lentin and Williams, 1976
Pseudoceratium nudum Gocht, 1957

Studies are in progress (Brideaux, unpubl. data) of assemblages from rare productive horizons in the White sandstone unit along Martin Creek [late Valanginian age, Buchia ex gr. inflata-sublaevis Zone of Jeletzky (1973; written com., 1976)] and from the upper member of the sandstone-dominated Coal-bearing division along Martin Creek and "Grizzly Gorge" [middle Hauterivian age, Jeletzky (1960, p. 9, 1972, p. 25)]. These studies suggest that the species in the preceding list, locally in the Mackenzie Delta region, may not range below the middle Hauterivian.

Caution is necessary, however, in assessing apparently restricted ranges of microplankton species in this part of the column because of the strong paleoenvironmental control (*see* Brideaux and Myhr, 1976; Young et al., 1976). Some species seemingly restricted to the Valanginian may prove to range upward into lower Hauterivian strata elsewhere in the region where marine paleoenvironments prevailed. Similarly, some species known only from strata as old as middle Hauterivian may prove to range down into early Hauterivian or even older strata.

Valanginian microplankton biostratigraphy - other regions

Zonation schemes proposed by other workers applicable to Valanginian or putative Valanginian strata are discussed below for five other areas: northern Canada (Pocock, 1976); northern California (Warren, 1967); the western North Atlantic region (Habib, 1972, 1973, 1975); offshore eastern Canada (Williams, 1975); and the Speeton Clay of England (Duxbury, 1977). No discussion of possible correlation with Valanginian assemblages from other regions (Alaska, USSR, Europe; *see* Table 3) is attempted because of the almost total dissimilarity of the assembages with those from northern Canada.

Northern Canada

Pocock (1976) introduces and discusses a preliminary zonation, based on dinoflagellate cysts, for the uppermost Jurassic and Lower Cretaceous of northern Canada which includes two zones of Valanginian age (ibid., Fig. 1). The older, Biorbifera johnewingii Zone, is assigned an age no younger than early Valanginian based on association of its constituent species with the ammonite Thorsteinssonoceras ellesmerensis and the pelycypod Buchia keyserlingi. Jeletzky (1973, p. 63, 66, Fig. 3) places the T. ellesmerensis Subzone in the lower Valanginian within the lower to middle Valanginian Buchia keyserlingi Zone but this subzone has restricted geographic occurrence (Jeletzky, 1973) and Pocock (1976) does not specify a restricted occurrence for his Biorbifera johnewingii Zone. Therefore, the writers consider it more accurate to assign an early to middle Valanginian age to Pocock's zone. Constituent species of the zone, besides B. johnewingii are stated (Pocock, 1976, p. 104) to include: Druggidium deflandrei Habib, 1973, Diacanthum hollisteri Habib, 1972 and Gonyaulacysta (?= Leptodinium) sp. C. of Habib, 1972. Only Biorbifera johnewingii is shown on Pocock's range chart (ibid., Fig. 2). The writers have not observed any of the constituent species of this assemblage in strata on the northern Canadian mainland. The assemblage correlates best with the lower part of Habib's (1975) Druggidium deflandrei Zone of Valanginian to Valanginian or Hauterivian age described from western North Atlantic basins, a somewhat startling result in view of the difference in latitude of the two assemblages.

The younger, Pareodinia dasyforma [= Gochteodinia villosa (Vozzhennikova) Norris] "zone", occurs also within the Buchia keyserlingi Zone according to Pocock (1976, p. 105). Thus the age of strata within the zone is not younger than middle Valanginian, but presumably is younger than the age of the Biorbifera johnewingii Zone. The "zone" is characterized only by the extinction of Gochteodinia villosa and thus has no defined base. However, Pocock (1976, Fig. 2) shows this species as ranging into the lower Hauterivian, associated with Oligosphaeridium macrotubulum (Neale and Sarjeant) Davey and Williams, 1966 [= O. vasiformum (Neale and Sarjeant) Davey and Williams, 1966] and Dingodinium cerviculum Cookson and Eisenack, 1958 for at least part of their indicated ranges in northern Canada. In the opinion of the writers, the criterion for this "zone" is doubtful.

Of the other species mentioned or indicated by Pocock (1976) as occurring in Valanginian strata of northern Canada, only five occcur in the Bluish grey shale unit (*see* Table 3). Pseudoceratium regium Singh, 1971 [a junior synonym of Pseudoceratium expolitum Brideaux, 1971; *see* Harker and Sarjeant, 1975, p. 226; and Deflandrea terrula Davey, 1974 (=? Subtilisphaera terrula (Davey) Lentin and Williams, 1976, p. 119)] were also not observed in the Bluish grey shale unit. The former species has not been observed by the writers in strata older than Albian age. The latter species has not been observed anywhere in northern Canada by the authors. A closely comparable species, Subtilisphaera perlucida (Alberti) Jain and Millepied, 1973 is common to abundant in ?upper Hauterivian to Aptian strata throughout the northern Canadian mainland.

Northern California

Warren (1967) characterized two zones based on unpublished dinoflagellate taxonomy applicable in part or whole to Valanginian strata of northern California. The lower Dingodinium "conocornutum" zone was considered to be of latest Berriasian and Valanginian age and encompassed the topmost part of the local range of Buchia uncitoides and the total local ranges of B. tolmatschowi and B. pacifica. According to Jeletzky (1965, Fig. 1; 1973, Fig. 3), this would indicate a latest Berriasian to middle Valanginian age for Warren's (1967) zone. The zone is characterized (ibid., p. 379-381) by the last appearance of eleven species, the first appearance of one species and the restriction to the zone of fourteen species. Two subzones are defined: a lower Hystrichosphaeridium "polychonion" Subzone and an upper Pyxidiella "vermiculata" Subzone. Based on the interpretations of Jeletzky (1965, 1973), the lower subzone is latest Berriasian to earlier middle Valanginian in age and the upper subzone is later middle Valanginian age.

A younger unnamed zone was assigned a Valanginian to Hauterivian age by Warren (1967, p. 383-385) and encompassed the upper part of the local range of Buchia pacifica and the entire local range of B. inflata. According to Jeletzky (1965, 1973), this would indicate an age of middle and late Valanginian for all but the upper part of this zone. No species are restricted to this zone (Warren, 1967, p. 383-384), but at least sixteen species do not occur above this zone and two first appear in the zone.

Correlation of these zones with assemblages from the Bluish grey shale unit is difficult. Although ten species occur in common between northern California and northern Canadian mainland assemblages (Table 2), only two of these are short ranging in both regions. In California, Paragonyaulacysta borealis (= Pareodinia "albertii" in part) ranges into the basal part of the unnamed zone and overlaps the top of the Buchia pacifica and base of the B. inflata local ranges. In northern Canada, Paragonyaulacysta borealis does not range above the lower and middle Valanginian Buchia keyserlingi Zone. Also in northern California, Oligosphaeridium asterigerum first appears above the base of the local range of Buchia inflata; in northern Canada, the species appears first in the B. keyserlingi Zone. Thus this slim evidence suggests a possible correlation of Warren's (1967) "unnamed zone" with the assemblage of the Bluish grey shale unit and also suggests that Warren's "unnamed zone" may not extend into the Hauterivian.

Western North Atlantic

Habib (1972, 1973, 1974, 1975) described assemblages, in part of putative Valanginian age, from western North Atlantic basins. In ascending order, Habib (1975) outlined these zones: Biorbifera johnewingii Zone (Berriasian to either Berriasian or Valanginian); Druggidium apicopaucicum Zone (either Berriasian or Valanginian to Valanginian); Druggidium deflandrei (Valanginian to either Valanginian or Hauterivian); and the Oligosphaeridium complex Zone (either Valanginian or Hauterivian to Barremian or ?Aptian). Only three species (Table 3) occur in zones with some indication of Valanginian age in the western North Atlantic and in the lower to middle Valanginian Bluish grey shale unit. These three species occur in the western North Atlantic Druggidium apicopaucicum Zone. A single specimen referred to Druggidium? sp. AE recovered from the Bluish grey shale unit compares most favourably with D. apicopaucicum Habib, 1973. None of the other species in this western North Atlantic Zone occurs in the Bluish grey shale unit, although Scriniodinium? campanulum Gocht, 1959, and Cyclonephelium distinctum Deflandre and Cookson, 1955 occur in Berriasian and younger strata elsewhere in northern Canada (Brideaux, 1976b, 1977; Pocock, 1976). On this slim evidence rests a possible correlation between the assemblage of the Bluish grey shale unit (Buchia kerserlingi Zone of early and middle Valanginian age) with the Druggidium apicopaucicum Zone [given the somewhat confusing age assignment of ". . . either Berriasian or Valanginian to Valanginian . . ." by Habib (1975, p. 379)].

Offshore Eastern Canada

Williams (1975) proposed five assemblage zones for subsurface Lower Cretaceous strata of the Scotian Shelf and Grand Banks based on spore-pollen and dinoflagellate cyst assemblages. The Phoberocysta neocomica Assemblage Zone tentatively was assigned a Berriasian-Valanginian age based on the recognition of a Biorbifera johnewingii Subzone (non Habib, 1975; Pocock, 1976). The precise age of the zone could not be determined (Williams, 1975, p. 122). Unfortunately, only Pareodinia ceratophora and Dingodinium cerviculum occurred in common with assemblages from the Bluish grey shale unit. Therefore, correlation of this assemblage zone with the Bluish grey shale unit assemblage is not possible.

Speeton Clay of England

Duxbury (1977) proposed a zonation for Berriasian to Barremian rocks of the Speeton Clay of England based on observed species inception and extinction. Five zones were delineated of which two are Valanginian in part: Zone B (Berriasian and Lower Valanginian), and Zone C (Valanginian and lowermost Hauterivian). Nine species in the Valanginian of the Speeton Clay occur also in the lower and middle Valanginian Bluish grey shale unit of the northern Canadian mainland. Of these, only Tubotuberella rhombiformis Vozzhennikova emend. Brideaux (as Psaligonyaulax apatela) shows a restricted range in the Speeton Clay Valanginian, making its final appearance in the lower part of Duxbury's (1977) Zone C, presumably in some part of the lower Valanginian. This species is not known to range higher than the Buchia keyserlingi Zone in northern Canada. Aside from this, data are insufficient to establish correlation between the two sections.

SYSTEMATICS

Pollen and spores

Spore and pollen species identified in the Martin Creek and "Grizzly Gorge" sections are recorded in the following list. As most species have been described and illustrated in existing publications, a full systematic treatment is not necessary. The species in the following list appear in the same order as they appear in Table 1. Notes on morphology and stratigraphic range of some of the species are included in the following list.

(1) Aequitriradites spinulosus (Cookson and Dettmann) Cookson and Dettmann, 1961

(2) Appendicisporites potomacensis Brenner, 1963

Comments. Brenner (1963) recorded A. potomacensis in sediments as old as Barremian but Norris (1969) noted the occurrence of this species in his microfloral suite C which is of Berriasian age.

(3) Baculatisporites comaumensis (Cookson) Potonié, 1956

(4) Biretisporites potoniaei Delcourt and Sprumont, 1955

(5) Ceratosporites sp.

Plate 1, figures 1, 2

Description. Spores radiosymmetric, trilete, with spherical amb. Laesurae reaching to or almost to equator of spore body, narrow, straight or undulate, with slightly raised lips. Exine about 1.0 µm thick. Perine thin, about 0.5 µm thick, finely scabrate, closely attached to exine but folded into variously shaped projections on the distal surface and particularly in the equatorial region. Perinate projections are up to 9 µm long and range from hairlike to echinate to capitate or even shortly rugulate with serrate crests.

Dimensions. Spore body 44-48 µm; overall size 53-60 µm.

(6) Cicatricosisporties angicanalis Döring, 1965

Plate 1, figure 12

(7) Cicatricosisporites australiensis (Cookson) Potonié, 1956

Comments. Spores which are referred to this species are the most abundant of the various forms of Cicatricosisporites seen in the Bluish grey shale samples. There is variation among the grains assigned here to C. australiensis but in their morphologic features, such as size and shape, and the number, pattern and width of muri and lumina, they coincide with the description given by Dettmann (1963). Much of this apparent variation is probably caused by differences in orientation on the slides. It is possible that some of the spores included with C. australiensis could have been placed with C. mohriodes but this species, as described by Delcourt and Sprumont (1955) and Burger (1966) is rather similar to C. australiensis, a fact noted by Dettmann (1963). It is likely that these forms, and probably others, comprise a complex of similar types which can be separated only with great difficulty, if they are separable at all.

(8) Cicatricosisporites exiliodes (Maljavkina) Dörhöfer, 1977

Plate 1, figure 15

Comments. The spores here attributed to this species are similar to those illustrated by Singh (1971), Brideaux and McIntyre (1976) and Dörhöfer (1977); the latter having extended the range of the species down into the Valanginian in northwestern Germany. The presence of the species in the Martin Creek and "Grizzly Gorge" sections adds to the record of the lower end of its range.

(9) Cicatricosisporites hallei Delcourt and Sprumont, 1955

(10) Cicatricosisporites hughesii Dettmann, 1963

Plate 1, figure 14

Comments. This species was recorded originally in Aptian and Albian strata in Australia by Dettmann (1963) who noted that similar forms had been recorded in the uppermost Wealden of England, Lower Cretaceous of U.S.A. and Barremian-Albian of U.S.S.R. Burger (1973) recorded C. hughesii down to the base of his Cicatricosisporites australiensis subzone which he considered to be at least as old as Berriasian.

(11) Cicatricosisporites myrtellii Burger, 1966

Plate 1, figures 10, 11

(12) Cicatricosisporites potomacensis Brenner, 1963

Plate 1, figure 13

Comments. The earliest previous record of this species was in strata considered to be of Barremian age (Brenner, 1963). The specimens recovered from the Bluish grey shale unit appear to be identical with those described and illustrated by Brenner (ibid.) and mark a significant extension of the oldest occurrence of the species down into the Valanginian.

(13) Concavissimisporites punctatus (Delcourt and Sprumont) Brenner, 1963

(14) Concavissimisporites variverrucatus (Couper) Brenner, 1963

(15) Contignisporites cooksonii (Balme) Dettmann, 1963

(16) Contignisporites dorsostriatus (Bolkhovitina) Dettmann, 1963

(17) Cooksonites variabilis Pocock, 1962

(18) Coronatispora valdensis (Couper) Dettmann, 1963

(19) Crybelosporites vectensis Kemp, 1970

Plate 1, figures 6, 7

Comments. The specimens noted in this study are slightly larger than those recorded by Kemp (1970) and Brideaux and McIntyre (1976) but are identical in other respects. The occurrence of this species in the two sections examined shows that its range in northern Canada should be extended to include an earliest appearance in the Valanginian.

(20) Deltoidospora spp.

(21) Densoisporites velatus Weyland and Krieger, 1953

(22) Foraminisporis wonthaggiensis (Cookson and Dettmann) Dettmann, 1963

(23) Gleicheniidites senoninicus Ross, 1949

(24) Impardecispora apiverrucata (Couper) Venkatachala et al., 1968

(25) Januasporites spiniferus Singh, 1964

(26) Klukisporites pseudoreticulatus Couper, 1958

(27) Kraeuselisporites hastilobatus Playford, 1971

Plate 1, figure 3

Comments. The specimens of this species are slightly smaller than those described by Playford (1971) but are otherwise similar in their morphology. The record of this species in the Martin Creek and "Grizzly Gorge" sections indicates a significant downward extension of its range from the Albian occurrence noted by Playford (1971) and the Aptian occurrence recorded by Brideaux and McIntyre (1976).

(28) Lycopodiumsporites austroclavatidites (Cookson) Potonié, 1956

(29) Lycopodiumsporites marginatus Singh, 1964

Plate 1, figures 8, 9

Comments. The identification of this species in the Bluish grey shale unit indicates that its lower range is at least as old as Valanginian rather than Aptian as recorded by Singh (1971). Difficulty was experienced in assigning some specimens to either L. austroclavatidites or L. marginatus as the main point of identification is the height of the muri and many specimens are somewhat intermediate between the two species in this character. Lycopodiumsporites marginatus is definitely present as is L. austroclavatidites but the many intermediate forms indicate that the two spore species are part of a morphologic continuum.

(30) Neoraistrickia truncata (Cookson) Potonié, 1956

(31) Osmundacidites wellmanii Couper, 1953

(32) Pilosisporites trichopapillosus (Thiergart) Delcourt and Sprumont, 1955

(33) Polycingulatisporites reduncus (Bolkhovitina) Playford and Dettmann, 1965

(34) Rogalskaisporites cicatricosus (Rogalska) Danzé-Corsin and Laveine, 1963 in Briche et al., 1963

(35) Rubinella major (Couper) Norris, 1969

Plate 1, figure 4

(36) Sestrosporites pseudoalveolatus (Couper) Dettmann, 1963

(37) Stereisporites antiquasporites (Wilson and Webster) Dettmann, 1963

(38) Trilobosporites aornatus Döring, 1965

Plate 1, figure 5

Genus Triporoletes Mtchedlishvili 1969 emend. Playford, 1971, p. 551.

1960 Triporoletes Mtchedlishvili in Mtchedlishvili and Samoilovich, p. 127-128.

1962 Rouseisporites Pocock, p. 52-53.

(39) Triporoletes incertus sp. nov.

Plate 1, figures 16, 26

Holotype. GSC 58571; Slide P1102-4D, 19.6 x 96.8; Lower sandstone division, Bluish grey shale unit, Buchia keyserlingi Zone, Section 75-BIA-008, 9.0-9.2 m, along "Grizzly Gorge", District of Mackenzie, GSC loc. C-50922, lower to middle Valanginian. Equatorial diameter, 70 µm.

Description. Spores subtriangular to circular in equatorial outline; trilete mark generally present but often weakly or incompletely developed, laesurae when fully developed extending to equator of spore and becoming narrower; sometimes laesurae are particularly pronounced at the polar area and show a gaping commissure rimmed by a margo; laesurae are not seen on some spores. Sclerine three-layered; two layers of exine each about 0.75 µm, usually distinct and up to 1.0 µm apart, perine about 0.5 µm thick, membraneous, zonate, reticulate on both distal and proximal surfaces, finely scabrate to laevigate, sometimes incompletely present. Zona 3-5 µm wide, some specimens with a shallow invagination at each equatorial apex. Proximal reticulum irregular in shape, connected to tetrad mark, lumina generally 10-12 µm in maximum diameter but occasional lumina as small as 5 µm. Reticulum of distal surface has large irregularly shaped lumina up to 25 µm long and about half that width; the lumina often contain incomplete ridges which are not as high as the muri enclosing them. Distal and proximal reticulum generally extend to margins of spores and are composed of ridges 1-2 µm wide and about 2 µm high formed by folds in the perine.

Dimensions. Equatorial diameter, 52-76 µm, 14 specimens measured.

Comparison. Triporoletes incertus sp. nov. differs from T. reticulatus (Pocock) Playford in having much larger proximal lumina, smaller and more irregular distal lumina and equatorial radial invaginations which are not readily observed or are absent.

Occurrence. Bluish grey shale unit (lower to middle Valanginian).

(40) Alisporites bilateralis Rouse, 1959

(41) Alisporites grandis (Cookson) Dettmann, 1963

(42) Alisporites minutus Rouse, 1959

(43) Cedripites cretaceous Pocock, 1962

(44) Podocarpidites biformis Rouse, 1957

(45) Podocarpidites canadensis Pocock, 1962

(46) Podocarpidites multesimus (Bolkhovitina) Pocock, 1962

(47) Vitreisporites pallidus (Reissinger) Nilsson, 1958

(48) Callialasporites dampieri (Balme) Dev, 1961

(49) Cerebropollenites mesozoicus (Couper) Nilsson, 1958

(50) Classopollis classoides Pflug emend. Pocock and Jansonius, 1961

(51) Cycadopites nitidus (Balme) Norris, 1969

(52) Eucommiidites troedssonii Erdtman, 1948

(53) Exesipollenites tumulus Balme, 1957

(54) Perinopollenites elatoides Couper, 1958

(55) Taxodiaceaepollenites hiatus (Potonié) Kremp, 1950

Dinoflagellates*

Proximate cysts

Gonyaulacacean cysts

Genus Apteodinium Eisenack, 1958, p. 385.

(56) Apteodinium apiatum sp. nov.

Plate 2, figures 1-7

Holotype GSC 58577; Slide P1101-6C, 35.3 x 125.4; Lower sandstone division, Bluish grey shale unit, Buchia keyserlingi Zone, Section 75-BIA-003, 16.0-16.7 m, along Martin Creek, District of Mackenzie, GSC loc. C-50871, lower to middle Valanginian. Pericyst length, 95 µm; pericyst width, 78 µm; apical horn, 5 µm.

Diagnosis.

Shape. Pericyst - Ambitus rounded-rhombic to subovoid, longer than broad; prolonged into a short apical horn, apparently solid and distally rounded, 4-10 µm in length. Slight dorsoventral compression.

Endocyst - Ambitus rounded-rhombic to subovoid; apex and antapex rounded. Similar compression.

Pericoels - Pericyst and endocyst in close contact except at the apex where the apical horn, formed by the pericyst, projects above the endocyst.

Phragma. Periphragm - 0.5-1.0 µm thick, commonly much folded. Surface ornament of low, pustulate elements, 0.5-1.0 µm high and wide, verrucate in profile, but open to the endophragm in plan view in places on some specimens. Periphragm smooth or scabrate between pustules.

*(1) Where the periphragm and endophragm are appressed in the vicinity of the archeopyle, there is no separation of perioperculum and endooperculum. Hence there is effectively only one archeopyle and one operculum and these are treated as such.

(2) Unless otherwise stated the species described below come from the Lower sandstone division, Bluish grey shale unit, Buchia keyserlingi Zone, lower to middle Valanginian.

Endophragm - Less than 0.5 µm thick, commonly much folded. Surface smooth or scabrate.

Paratabulation. Pericyst - A few specimens bear indistinct markings which appear parasutural; paratabulation otherwise indeterminable except in the vicinity of the archeopyle.

Pericingulum - Faint markings and/or folds delimit the pericingulum of the dorsal pericyst and, less distinctly on the ventral pericyst.

Perisulcus - Not observed.

Endocyst - Paratabulation not observed.

Archeopyle. Precingular, type P(3"). Operculum simple, free, rounded-polygonal and somewhat elongate in shape.

Variation. Density of the pustules on the periphragm variable; periphragm sculpture strongly reduced on some specimens. The morphology of the pustules suggests that they may have borne small apiculate extensions which have been removed by mechanical or chemical means.

Dimensions. Pericyst length - 95-110 µm, width - 80-90 µm. 40 specimens measured.

Comparison. The granular periphragm of Apteodinium maculatum Eisenack and Cookson (1960, p. 4, Pl. 2, fig. 1) bears variably grouped maculate sculpture elements. The pustulate sculpture elements on the smooth to scabrate periphragm of Apteodinium apiatum sp. nov. are variable in density but evenly spaced.

(57) Apteodinium spongiosum sp. nov.

Plate 2, figures 8-12

Holotype. GSC 58584; Slide P1101-6C, 34.5 x 128.5; Lower sandstone division, Bluish grey shale unit, Buchia keyserlingi Zone, Section 75-BIA-003, 16.0-16.7 m, along Martin Creek, District of Mackenzie, GSC loc. C-50871, lower to middle Valanginian. Pericyst length, 92 µm; pericyst width, 70 µm; apical horn, 18 µm.

Diagnosis.

Shape. Pericyst - Ambitus ovoid, elongated longitudinally; prolonged into a stout apical horn, 11-18 µm long. Slight dorsoventral compression.

Endocyst - Ambitus ovoid, elongate longitudinally, rounded apically or with a very small apical prominence. Slight dorsoventral compression.

Pericoels - Pericyst and endocyst in close contact except at the position of the apical horn.

Phragma. Periphragm - Variable thickness, sponge-like thickenings forming a complex scrollwork projecting up to 2.0 µm above the endophragm, set off by narrow, twisting channels of thinner periphragm; scrollwork absent on the apical horn.

Endophragm - About 0.5 µm thick, apparently smooth.

Paratabulation. Pericyst - Scrollwork pattern appears to bear no relation to paratabulation.

Pericingulum - Observed on only a few specimens; denoted by a broad band of semi-aligned ridges of raised periphragm, up to 12 µm wide, the band offset about one half a pericingulum width.

Perisulcus - Observed on only a few specimens; denoted by a reduction or absence of raised periphragm, this region narrow anteriorly, widening posteriorly.

Endocyst - Paratabulation not observed.

Archeopyle. Precingular, Type P(3"). Operculum simple, free, rounded-polygonal and somewhat elongate in shape.

Dimensions. Percyst length - 80-118 µm, width - 63-75 µm. 18 specimens measured.

Comparison. Concerning Apteodinium granulatum, Eisenack, (1958, p. 386, translation) comments that its wall is ". . .± strongly granulated, varying in thickness, thin to moderately thick, up to 4 µm . . .; The granulation of the wall appears to be produced by an alveolar structure . . .". From this description it appears that Apteodinium spongiosum sp. nov. and Apteodinium granulatum Eisenack, 1958 are similar in wall structure and general morphology. Apteodinium spongiosum sp. nov. differs, however, in possessing an elaborate scrollwork pattern of raised periphragm and also is larger.

Genus Druggidium Habib, 1972, p. 49.

(58) Druggidium? sp. AE

Plate 3, figure 1

Description.

Shape. Pericyst - Ambitus elongate, without apical or antapical horns; profile rounded. Dorsoventral compression.

Endocyst - As for the pericyst.

Pericoels - Not developed.

Phragma. Periphragm - 1.5-2.0 µm thick. Intratabular surface scabrate between raised, sinuous, irregularly shaped ridges, the ridges punctate to finely alveolar and bearing, in places, intergonal distally bifid processes projecting up to 2.0 µm above the ridges; ridges from 1.5-2.0 µm high and wide. Parasutural ridges of similar morphology.

Endophragm - Not clearly distinguishable even in optical section; presumably thin and smooth.

Paratabulation. Pericyst - Paratabulation determined in part as ?', 6", 6c, 5" '-?6" ', 1" ", ?p.

Pericingulum - Helicoidal, indented; denoted by parasutural ridges of morphology similar to those elsewhere on the pericyst.

Perisulcus - Present, difficult to determine details on available specimen.

Endocyst - Paratabulation not observed.

Archeopyle. Not clearly observed. Available specimen is broken and shows an apical disruption which may be mechanical in origin.

Dimensions. Pericyst length - 68 µm, width - 48 µm. 1 specimen measured.

Comparison. Druggidium? sp. AE bears some similarity to Druggidium apicopaucicum Habib (1973, p. 49, Pl. 1, figs. 1-3, Fig. 3), but differs in being larger and possessing intratabular ridges. The specimen questionably is assigned to the genus because of the absence of a well-defined archeopyle.

Genus Gonyaulacysta Deflandre ex Norris and Sarjeant, 1965 emend. Stover and Evitt, 1978, p. 157.

(59) Gonyaulacysta spp. (cretacea/helicoidea group)

Plate 3, figures 5, 6

Discussion. The writers find difficulty in distinguishing Gonyaulacysta cretacea (Neale and Sarjeant) Sarjeant, 1969 from Gonyaulacysta helicoidea (Eisenack and Cookson) Sarjeant, 1966a (*see* also Brideaux, 1977, p. 6). However, in view of studies in progress based on the holotypes and topotype material of the two species (Sarjeant, written com., 1976), the writers offer only a brief discussion based on analysis of published data and do not propose any new taxonomy.

Dimensions. For Gonyaulacysta helicoida, Pericyst length 62-86 µm (holotype, 78 µm), width - 48-67 µm (holotype, 56 µm). For Gonyaulacysta cretacea. Pericyst length - 35-50 µm (holotype, 46.5 µm), other holotype dimensions - Pericyst width, 30 µm; endocyst length, 35 µm.

Sarjeant (1966a, p. 117) suggests that G. cretacea ". . . differs from G. helicoidea only in having a more markedly polygonal outline and in lacking tubercules". However, scrutiny of Sarjeant's (1966a, Pl. 13, figs. 7, 8, Pl. 15, figs. 8, 9, Fig. 26) drawings and photos of G. helicoidea and comparison with illustrations of G. cretacea (Neale and Sarjeant, 1962, Pl. 19, figs. 1,2, Fig. 2) does not bear this out with regard to polygonality. If anything, G. cretacea seems less polygonal in shape than G. helicoidea. It appears, from published descriptions, that the only difference other than size between the two species lies in the periphragm sculpture.

E.J. Kidson (written com., 1976) suggests that there are differences in the structure of the apical horn in the two species. Gonyaulacysta helicoidea is considered to possess a subconical horn and G. cretacea to possess an elongate, digit-like horn. The holotype of G. cretacea does possess a broadly conical horn, but the paratype (Eisenack and Cookson, 1960, Pl. 1, fig. 8) appears to have a more tubular shaped horn, closer in shape to the holotype of G. cretacea (Neale and Sarjeant, 1962, Pl. 19, figs. 1, 2) and to the figured material assigned to G. helicoidea by Sarjeant (1966a).

The matter of size also merits discussion. Specimens assigned to G. helicoidea by Sarjeant (1966a) are smaller than those described by Eisenack and Cookson (1960) from Australia. Sarjeant's (1966a) size range compares more closely with the size range of specimens assigned to G. cretacea by Neale and Sarjeant (1962). For comparative purposes, it may be noted that specimens tentatively assigned to G. helicoidea by the writers during this study have the following size ranges: Pericyst length - 50-70 µm, width - 40-58 µm. 6 specimens measured.

These specimens possess tubercules, although the number and density may vary considerably. Other specimens, without tubercules and tentatively assigned to G. cretacea, from the Bluish grey shale unit, have the following size range: Pericyst length - 45-70 µm, width - 35-58 µm. 7 specimens measured.

Similar observations about size apply to specimens assigned to these two species by Brideaux (1977, p. 6).

These observations suggest that:

(a) The shape of the apical horn, and the presence or absence of tubercules on the periphragm and the polygonality of the specimens are not consistent.

(b) Apart from these characteristics, the specimens assigned by Sarjeant (1966a) to G. helicoidea may represent a population of generally smaller size.

(c) Gonyaulacysta cretacea is a junior synonym of G. helicoidea except for possible ?subspecific differences in sizes of members of a population.

Occurrence. Gonyaulacysta cretacea is recorded from the Hauterivian of England (Neale and Sarjeant, 1962; Duxbury, 1977) and the Barremian of the northern Canadian mainland (Brideaux, 1977). Gonyaulacysta helicoidea is reported from Barremian to middle Albian strata of England, Australia and northern Canada (*see* Brideaux, 1977, p. 6; Duxbury, 1977).

(60) Gonyaulacysta sp. cf. G. kostromiensis (Vozzhennikova) Sarjeant, 1969, p. 10

Plate 4, figures 2-5

cf. 1967 Gonyaulax kostromiensis Vozzhennikova, p. 85, Pl. 26, figs. 1-6, Pl. 27, figs. 1, 2.

cf. 1969 Gonyaulacysta kostromiensis (Vozzhennikova) Sarjeant, p. 10.

?1972Nelchinopsis kostromiensis (Vozzhennikova) Wiggins, p. 301, Pl. 1A-F, Fig. 2.

1977 Gonyaulacysta kostromiensis (Vozzhennikova) Sarjeant; Duxbury, p. 37.

Discussion. The morphology of the few specimens available for study by the writers is essentially similar to those illustrated by Wiggins (1972) and by Vozzhennikova (1967). However, the writers differ in their interpretation of the paratabulation, particularly in the apical region of the cyst. Specimens from along Martin Creek exhibit the following paratabulation denoted by smooth, low ridges or spiny to denticulate parasutural crests: ?1pr, 4', 6", 6c, ?5" ', 1p, 1" ",Xs. The writers can find no evidence for Wiggins' (1972, p. 301) paratabulation formula which includes 5', 6a-7a and perhaps 7c paraplates. Careful study of illustrations of the species (Wiggins, 1972, Pl. 1A-F) appears to support this revised interpretation. The supposed parasutures described by Wiggins (1972) as delineating a sequence of intercalary paraplates appear to be artifacts induced by refraction of parasutural crests at differing focal levels. A similar situation was noted on the writers' specimens but careful tracing of parasutural crests through differing focal levels revealed only the typical gonyaulacoid-type apical paratabulation of four apical paraplates. Unfortunately Vozzhennikova's (1967) illustrations give no clear indication of the apical part of the cyst. Duxbury's (1977) interpretation of the situation appears identical to that of the writers. Certainly his material appears identical with that from the Valanginian Bluish grey shale unit. It is clear from this discussion that the writers do not accept the interpretation of Stover and Evitt (1978, p. 215, 216) regarding paratabulation and archeopyle type.

If the material described in this paper and that of Duxbury (1977) is identical to that described by Vozzhennikova (1967), the writers would agree with Duxbury that the species kostromiensis should be retained in Gonyaulacysta. If the material described by Wiggins (1972) is also identical then the genus, Nelchinopsis is superfluous and a junior synonym of Gonyaulacysta. If Wiggins' (1972) material is different, then the genus Nelchinopsis should be retained, but the material would need to be assigned a new specific epithet. There is no need for a new genus such as Duxbury (1977, p. 37) proposes. Duxbury's genus Alaskadinium is therefore a junior synonym of Nelchinopsis if that genus is retained, or of Gonyaulacysta if Wiggins' material is shown to belong within the circumscription of the species, kostromiensis. A direct comparison of material from each of these populations would be necessary to resolve this matter. This species is retained provisionally in Gonyaulacysta because of the high spinose crests, paratabulation and apical horn. The archeopyle type, however, is still unknown.

Occurrence. Hauterivian of England (Duxbury, 1977); probably from the Valanginian of the Kostromskaya district, U.S.S.R. (Vozzhennikova, 1967); possibly from the Valanginian or early Hauterivian of the Alaska Peninsula, U.S.A. (Wiggins, 1972).

Genus Impagidinium Stover and Evitt, 1978, p. 165.

(61) Impagidinium sp.

Plate 4, figures 1, 6, 7

1976b Leptodinium sp. EE of Brideaux, p. 118, Pl. 1, fig. 1.

Description.

Shape. Pericyst - Ambitus subcircular, the length slightly greater than the width; epipericyst and hypopericyst length approximately equal; slight dorsoventral compression.

Endocyst - As for the pericyst.

Pericoels - None developed.

Phragma. Periphragm - About 1.0 µm thick; scabrate and with randomly distributed intratabular spines and coni 1-2 µm high and about 0.5-1.0 µm wide basally, and parasutural crests, 2-4 µm high, the crests entire-margined or slightly serrated or crenulated and with minute, variably developed perforations.

Endophragm - Difficult to differentiate, probably less than 0.5 µm thick, presumably smooth.

Paratabulation. Pericyst - Parasutural crests denote a paratabulation of 4', 6", 6c, 5"'-?6"', 1p, 1"", Xs. Apical paraplates are difficult to observe because of folding. Of postcingular paraplates, 2"', 3"' and 4"' are the largest. Paraplate 1p is small and subquadrate; paraplate 1"" is quadrate and relatively large.

Endocyst - Paratabulation not observed except in the vicinity of the archeopyle.

Pericingulum - Present, distinct, 3-5 µm wide, helicoid, displaced up to four cingular widths, typically one to two; cingular parasutures delineate six cingular paraplates.

Perisulcus - Present, not always visible; sinuous S-shaped depression of variable width, widest posteriorly; sulcal paraplates not visible on material available.

Archeopyle. Precingular, Type P(3"). Operculum free, simple, slightly to distinctly longer than broad.

Dimensions. Pericyst length - 37-55 µm, width - 38-48 µm. 11 specimens measured.

Comparison. Impagidinium alectrolophum (Sarjeant) Stover and Evitt, 1978 possesses a granulate periphragm and higher, eccentrically developed parasutural crests. Impagidinium verrucosum (Brideaux and McIntyre) Stover and Evitt, 1978 possesses much higher parasutural crests, larger more densely distributed intratabular apiculae and is larger overall.

Occurrence. Upper Berriasian (Buchia n. sp. aff. volgensis Zone) of the northern Canadian mainland (Brideaux, 1976b).

Genus Leptodinium Klement, 1960 emend. Sarjeant, 1969, p. 11.

(62) Leptodinium hyalodermopsis (Cookson and Eisenack) Stover and Evitt, 1978, p. 170.

Occurrence. Neocomian and Aptian of Western Australia (Cookson and Eisenack, 1958); Berriasian to Hauterivian of California, U.S.A. (Warren, 1967); Middle Albian (Brideaux and McIntyre, 1976) and Barremian of the northern Canadian mainland (Brideaux and Myhr, 1976).

Genus Lunatadinium Brideaux and McIntyre, 1973

(63) Lunatadinium dissolutum Brideaux and McIntyre, 1973

Occurrence. Middle Kimmeridgian to Middle Albian of the northern Canadian mainland region, and Canadian Arctic Archipelago (Brideaux and McIntyre, 1973, 1976; Brideaux and Fisher, 1976; Brideaux and Myhr, 1976; Brideaux, 1976b, 1977). Tithonian to Valanginian of the Sacramento Valley, California, U.S.A. (Warren, 1967).

Genus Meiourogonyaulax Sarjeant, 1966a, p. 144.

(64) Meiourogonyaulax sp. AE

Plate 4, figures 8, 9, 11

Description.

Shape. Pericyst - Ambitus ovoid; rounded; longer than broad; epipericyst length less than hypopericyst length; apical portion missing on specimens available for study. Compression dorsoventral.

Endocyst - Closely appressed to the pericyst except in the region of parasutural crest development; separation greatest in the vicinity of the hypocystal crests and along the pericingulum. Compression dorsoventral.

Pericoels - Developed along parasutural crests, especially in the vicinity of the pericingulum and on the hypocyst. No regular ambital or hypopericoels developed.

Phragma. Periphragm - 0.50-0.75 µm thick, surface sculpture pattern of densely spaced minute punctae; structure that of a perforate tectum, analagous to that of a pollen sexine.

Endophragm - Less than 0.25 µm thick; presumably smooth; visible only in optical section or at the development of parasutural crests.

Paratabulation. Pericyst - Denoted by parasutural crests and, in addition on the epipericyst, by accessory ?archeopyle sutures; determined as ?4', 5"-?6", Xc, 5" ', 1p, 1" ", Xs. Of the precingular paraplates, 2"-5" are the most clearly delineated by parasutural crests and accessory parasutures, and 1" and 6" are difficult to observe; of the postcingular paraplates, 3" ' is the largest and trapezoid in shape, and 1" ' is very small; paraplate 1p is L-shaped.

Endocyst - Evidence for paratabulation lacking except in the vicinity of the archeopyle.

Pericingulum - Present, moderately indented, width 4-6 µm; planar to slightly helicoid; delineated by pericingular parasutures up to 3.0 µm high.

Perisulcus - Present, indistinct; delineated by parasutural crests.

Archeopyle. Presumably apical, Type A(?1-4). Operculum not observed.

Variation. Some variation exists in degree of separation of pericyst and endocyst in the vicinity of parasutural development on the few specimens available for study.

Dimensions. Pericyst length - 40 µm, 44 µm, width - 36 µm, 39 µm. Endocyst length - 39 µm, 36 µm, width - 33 µm, 35 µm. 2 specimens measured; pericyst dimensions include parasutural extensions.

Comparison. No comparable species have been reported in published literature. The specimens encountered in this study and assigned to Meiourogonyaulax sp. AE appear identical to the unpublished species "Seriniodiniopsis variabilis" of Warren (1967, p. 105, Pl. 7, figs. 1-12, Figs. 15, 16 and especially to the specimens illustrated on Pl. 7, figs. 1, 2, 4, 5).

Occurrence. Tithonian to Barremian of California, U.S.A. (Warren, 1967).

Genus Millioudodinium Stover and Evitt, 1978, p. 173.

(65) Millioudodinium saetigerum sp. nov.

Plate 3, figures 2, 3, 7

1977 Gonyaulacysta sp. A. Brideaux, p. 7, Pl. 1, fig. 7.

Holotype. GSC 58586; Slide P1101-1D, 22.5 x 127.9; Lower sandstone division, Bluish grey shale unit, Buchia keyserlingi Zone, Section 75-BIA-003, 0.0-0.3 m, along Martin Creek, District of Mackenzie, C-50866, lower to middle Valanginian. Pericyst length, 70 µm; pericyst width, 67 µm; apical horn, 11 µm.

Diagnosis.

Shape. Pericyst - Ambitus subcircular to ovoid; a short apical horn, 6-11 µm in length, with a distal, notched outline; antapex rounded. Dorsoventral compression.

Endocyst - Ambitus subcircular to ovoid; apical prominence absent; antapex rounded. Dorsoventral compression.

Pericoels - Developed only where the pericyst projects above the endocyst to form an apical horn.

Phragma. Periphragm - About 1 µm thick, punctate, bearing small, scattered intratabular apiculate sculpture elements and densely spaced parasutural apiculae about 0.5-1.0 µm high.

Endophragm - About 1.0 µm thick, surface presumably smooth or scabrate.

Paratabulation. Pericyst - Parasutural apiculae denote a paratabulation of 4', 6", 6c, 5" '-?6" ', ?1p, 1" ".

Endocyst - Paratabulation not observed.

Pericingulum - Helicoid, displaced one pericingular width (5-7 µm), slightly indented; six cingular paraplates denoted by parasutural apiculae.

Perisulcus - Present; denoted by a shallow S-shaped depression, narrow anteriorly, broadening posteriorly on the hypopericyst, and widest at the posterior end.

Archeopyle. Precingular, Type P(3"). Operculum free, simple, longer than broad, rounded-polygonal.

Variation. Periphragm of an amorphous consistency, apparently degraded, obscuring details of paratabulation particularly at the apex and antapex.

Dimensions. Pericyst length, 70-87 µm, width 51-70 µm. 10 specimens measured (including 8 specimens reported by Brideaux, 1977).

Comparison. Millioudodinium episomum (Sarjeant) Stover and Evitt, 1978 has thin parasutural spinelets connected distally by trabecula; Gonyaulacysta microceras Eisenack, 1958 has low, narrow crests, in places bearing small spines; Apteodinium nuciforme (Deflandre) Stover and Evitt, 1978 is very coarsely granular and thick walled; and Millioudodinium pallum (Sarjeant) Stover and Evitt, 1978 has paratabulation denoted by very short spines arising from low ridges.

Occurrence. Barremian and ?Aptian rocks of the northern Canadian mainland (Brideaux, 1977).

(66) Millioudodinium spinoreticulatum sp. nov.

Plate 3, figures 4, 8-12

Holotype. GSC 58587; Slide P1102-1C, 31.0 x 122.6; Lower sandstone division, Bluish grey shale unit, Buchia keyserlingi Zone, Section 75-BIA-008, 0.0-0.3 m, along "Grizzly Gorge", District of Mackenzie, GSC loc. C-50919, lower to middle Valanginian. Pericyst length, 73 µm; pericyst width, 58 µm; apical horn, 7 µm.

Diagnosis.

Shape. Pericyst - Ambitus ovoid to rounded-pentagonal, longer than broad; apical horn, 7-16 µm in length, with a distal notched cap. Dorsoventral compression.

Endocyst - Commonly present, but difficult to delineate; everywhere closely appressed to the pericyst; apical horn as for pericyst; dorsoventral compression.

Pericoels - absent.

Phragma. Periphragm - 0.5-1.0 µm thick; surface sculpture consists of parasutural ridges together with an irregularly anastomosing or more regular system of low

ridges which may form an imperfect to perfect reticulum; ridges less than 0.5 µm high and less than 0.25 µm wide; bearing spines, from 1.0-2.0 µm high (typically about 1.0 µm) distributed randomly on the ridges and on more prominent parasutural ridges.

Endophragm - Less than 0.5 µm thick, commonly obscure; presumably smooth.

Paratabulation. Pericyst - Parasutural ridges denote a paratabulation determined approximately as 4', ?6", ?6c, ?6" ', ?1p, 1" ". Parasutural ridges are obscured in places by the intratabular reticulum.

Endocyst - Paratabulation not observed.

Pericingulum - Present, distinct, slightly indented, helicoid; with ?six cingular paraplates.

Perisulcus - Present as a shallow depression, the details difficult to delineate; narrow anteriorly, widest posteriorly; extending about one-third of the way up the epipericyst.

Archeopyle. Precingular, Type P(3"). Operculum free, simple, longer than broad, strongly rounded, gibbous-shaped.

Variation. The degree of reticulation is more or less constant for a given specimen, but varies widely between specimens; in places on a given specimen, the spines may be discrete.

Dimensions. Pericyst length - 70-87 µm, width - 55-70 µm. 9 specimens measured.

Comparison. The intratabular spine-bearing network of low ridges distinguishes this species from other similar species of Millioudodinium. See also remarks for Millioudodinium saetigerum sp. nov.

Genus Tichodinium Eisenack and Cookson, 1960 emend. Clarke and Verdier, 1967, p. 18.

(67) Trichodinium castaneum (Deflandre) Clarke and Verdier, 1967, p. 19.

Plate 4, figures 10, 12, 13

Synonymy. Clarke and Verdier (1967, p. 19) give a comprehensive synonymy which introduces variation in the circumscription of the species. For that reason the writers give a comprehensive description of T. castaneum collected from along Martin Creek.

Description.

Shape. Pericyst - Ambitus ovoid, longer than broad; compression dorsoventral.

Endocyst - Commonly indistinct, when visible, closely appressed to pericyst; compression dorsoventral.

Pericoels - Not developed.

Phragma. Periphragm - About 1.0 µm thick; sculpture of non-tabular, evenly and densely spaced, discrete acuminate spines, 2-4 µm in length, with an apical crownlet of similar spines up to 5 µm long; periphragm otherwise scabrate to punctate between spines; structure spongy or "tectate", in the sense of a pollen grain sexine.

Endophragm - Very thin, less than 0.25 µm thick.

Paratabulation. Pericyst - Not evident except in the vicinity of the archeopyle.

Endocyst - Not evident except in the vicinity of the archeopyle.

Pericingulum - Present, indistinct; indicated in places on some specimens by a parallel alignment of spines along precingular parasutures.

Perisulcus - Denoted on some specimens by a shallow, nearly straight-sided depression within which spine sculpture is reduced or absent.

Archeopyle. Precingular, Type P(3"). Operculum free, simple, the shape broader than long, slightly polygonal, but well rounded.

Dimensions. Pericyst length - 70-83 µm, width - 62-66 µm. 9 specimens measured.

Occurrence. Upper Hauterivian to Senonian, various localities in England, France, Germany and Australia (Clarke and Verdier, 1967; Davey, 1969; Verdier, 1975), Turonian and Coniacian of France (Foucher, 1971, 1975) and Turonian to lower Campanian of the Canadian Atlantic continental margin (Williams, 1975; Williams and Brideaux, 1975).

(68) Trichodinium sp. BE

Plate 4, figure 12

Description.

Shape. Pericyst - Ambitus ovoid; length of complete specimens nearly equal to or greater than the width; apex and antapex rounded. Moderate lateral compression.

Endocyst - Commonly indistinct and closely appressed to the pericyst. Moderate lateral compression.

Pericoels - Not developed.

Phragma. Periphragm - About 0.5 µm thick; densely spaced but discrete sculpture of coni, papillae or distally finely bifid elements; non-tabular.

Endophragm - Obscure, very thin, less than 0.25 µm thick; presumably smooth.

Paratabulation. Pericyst - Shape of the archeopyle and weakly developed accessory parasutures denote an epiparatabulation of 4', 6". Evidence for hypoparatabulation not observed.

Endocyst - No indication of paratabulation observed except in the vicinity of the archeopyle.

Pericingulum - No indication of pericingulum.

Perisulcus - No indication of perisulcus.

Archeopyle. Precingular, Type P(3"). Operculum simple, free, longer than broad, roughly of triangular shape, but broadly rounded at the apex.

Variation. Periphragm sculpture constant for a given specimen, but variable in density between specimens.

Dimensions. Pericyst length - 63-90 µm, width - 65-75 µm. 18 specimens measured.

Comparison. Specimens assigned to Trichodinium castanum (Deflandre) Clarke and Verdier from samples of the Bluish grey shale unit differ in their possession of a periphragm sculpture of acuminate spines and show a preference for dorsoventral rather than lateral compression. Other species of Trichodinium differ in type or density of ornament.

Cyclonepheloid Cysts

Discussion. Wall and Evitt (1975) speak of an Areoligera-Cyclonephelium complex related to a ceratioid lineage of gonyaulacinian affinity. This includes the genus Canningia, treated here, and similar genera. See also the discussion in Brideaux (1977, p. 10).

Genus Canningia Cookson and Eisenack, 1960b, p. 251.

(69) Canningia sp. CE

Plate 5, figures 2, 3

Description.

Shape. Pericyst - Ambitus of incomplete specimens hemispherical, the antapex rounded, the morphology of the apex not observed; complete specimens probably ovoid, the length nearly equal to or less than the width. Moderate dorsoventral compression.

Endocyst - Essentially as for the pericyst.

Pericoels - Not developed.

Phragma. Periphragm - About 0.75 µm thick; surface sculpture pattern punctate to microreticulate, the lumina variously formed and typically about 0.5 µm in diameter or less; structure alveolate.

Endophragm - About 0.25 µm thick; presumably smooth.

Paratabulation. Pericyst - Epiparatabulation of 4', 6", 0c, denoted by shape of the apical archeopyle and accessory parasutures. Evidence of hypoparatabulation not observed.

Endocyst - Evidence of paratabulation not observed.

Pericingulum - Not observed.

Perisulcus - Not observed.

Archeopyle. Apical, Type A(1'-4'). Operculum not observed, presumably free and probably simple.

Dimensions. Pericyst length - (maximum observed) 62-87 µm, width - 70-112 µm. 5 specimens measured.

Comparison. Canningia spumosa Brideaux, 1977 differs in possessing a thicker periphragm with apiculate sculpture.

Pareodinioid Cysts

Genus Pareodinia Deflandre, 1947 emend. Stover and Evitt, 1978, p. 116 (restricted).

Discussion. The genus Pareodinia is restricted to include only species with simple, smooth, low sculpture elements on the periphragm and to exclude those species bearing spinose or chorate processes of the type found on Gochteodinia villosa (Vozzhennikova) Norris, Gochteodinia judilentinae sp. nov. treated later in this paper, and any similar forms.

(70) Pareodinia ceratophora Deflandre, 1947 emend. Gocht, 1970, p. 154.

Occurrence. Lower Jurassic (Toarcian) to Lower Cretaceous (Barremian) rocks, worldwide (Riley and Sarjeant, 1972; Sarjeant, 1975; Millioud et al., 1975); ?Bathonian-Callovian to Kimmeridgian-lower Volgian rocks on the Canadian Arctic Archipelago (Johnson and Hills, 1973; Tan and Hills, 1978) and middle Kimmeridgian to Hauterivian rocks on the northern Canadian mainland (Brideaux and Myhr, 1976; Brideaux, 1976b, 1977).

Unassigned Cysts

Genus Batioladinium Brideaux, 1975, p. 1241 (June).

1975 Necrobroomea Wiggins, p. 111 (July).

(71) Batioladinium Jaegeri (Alberti) Brideaux, 1975, p. 1240-1241.

Plate 5, figures 6, 8, 11

Occurrence. Valanginian to Albian of Germany, France and England (see Brideaux and McIntyre, 1976; Brideaux, 1975; Duxbury, 1977); Upper Albian and ?lower Cenomanian of England (Cookson and Hughes, 1964); Barremian to Albian on the northern Canadian mainland (Brideaux and Myhr, 1976; Brideaux, 1977); Santonian-Campanian of the Anderson Plain region, northern Canadian mainland (McIntyre, 1974).

Genus Fromea Cookson and Eisenack, 1958.

(72) Fromea amphora Cookson and Eisenack, 1958, p. 56

Plate 5, figure 5

Occurrence. Aptian to Cenomanian of Australia (Cookson and Eisenack, 1958); Upper Cretaceous of the Canadian Arctic Archipelago (Manum and Cookson, 1964); Upper Albian and ?lower Cenomanian (Cookson and Hughes, 1964), Valanginian to Barremian (Duxbury, 1977) and upper Barremian (Sarjeant, 1966b) of England; Cenomanian of England and France (Davey, 1969); the Barremian of Germany (Alberti, 1961); Upper Albian of Rumania (Baltes, 1967); Middle and Upper Albian of central Alberta, Canada (Singh, 1971; Brideaux, 1971); the Barremian to Middle Albian of the northern Canadian mainland (Brideaux and McIntyre, 1976; Brideaux, 1977); the Albian of the Paris Basin, France (Davey and Verdier, 1971) and the Upper Cretaceous of the U.S.S.R. (Vozzhennikova, 1967).

(73) Fromea sp. cf. F. fragilis (Cookson and Eisenack) Stover and Evitt, 1978, p. 48

Plate 5, figure 9

Description.

Shape. Autocyst - Ambitus ovoid, the length/width ratio varying from 1.24 to 2.14 (mean, 1.76); apex and antapex rounded, maximum diameter at or near the mid-latitude of the autocyst; extreme compression.

Phragma. Autophragm - About 0.5 µm thick; surface sculpture smooth or scabrate; autophragm folded and crumpled; no distinct lineation or pattern to folding.

Paratabulation. Autocyst - Sculpture, structure or lineation denoting paratabulation absent.

Autocingulum - Not observed.

Autosulcus - Not observed.

Archeopyle. Apical, Type A (?1'-4'). Operculum not observed, presumably free and? simple.

Dimensions. Autocyst length - 130-193 µm (mean, 161.5 µm), width - 70-118 µm (mean, 85.2 µm). 12 specimens measured (many more observed, unsuitable for measurement).

Comparison. Fromea sp. cf. F. fragilis differs from F. fragilis Cookson and Eisenack in possessing no defined folding lineation suggesting a pericingular or perisulcal region and in having a generally larger overall size. Cookson and Eisenack (1962, p. 487) record for F. fragilis an autocyst length of 70-105 µm. Singh (1971, p. 428) reports an autocyst length of 72-145 µm (mean, 108 µm) and Brideaux (1971, p. 80) records 60-140 µm.

Genus Horologinella Cookson and Eisenack, 1962, p. 271

(74) Horologinella spinosigibberosa Brideaux and Fisher, 1976, p. 22

Discussion. A single specimen found in the basal 0.4 m of the Bluish grey shale unit, along Martin Creek, is considered to have been derived from older rocks. The species occurs in the basal part of the Buchia okensis Zone of early Berriasian age (Brideaux, 1976b), but does not occur higher in the Berriasian. The authors do not agree with Stover and Evitt (1978, p. 54) that this species is an acritarch.

Occurrence. Upper Oxfordian to ?Portlandian of the northern Canadian mainland and Canadian Arctic Archipelago (Brideaux and Fisher, 1976; Brideaux, 1977; Tan and Hills, 1978) and the basal beds of the Lower Berriasian Buchia okensis Zone on the northern Canadian mainland (Brideaux, 1976b).

Genus Palaeostomocystis Deflandre, 1937 emend. Deflandre, 1966, p. 6.

(75) Palaeostomocystis senilis sp. nov.

Plate 5, figure 12, Plate 6, figure 1

Holotype. GSC 58604; Slide P1101-6C, 43.6 x 131.4; Lower sandstone division, Bluish grey shale unit, Buchia keyserlingi Zone, Section 75-BIA-003, 16.0-16.7 m, along Martin Creek, District of Mackenzie, GSC loc. C-50871, lower to middle Valanginian. Autocyst length, 212 µm; autocyst width, 156 µm; length/width ratio, 1.36.

Diagnosis.

Shape. Autocyst - Ambitus ovoid, the length/width ratio from 1.11 to 1.96 (mean 1.54); apex and antapex rounded, maximum diameter at or near mid-latitude of autocyst; extreme compression.

Phragma. Autophragm - About 0.5 µm thick; surface sculpture pattern a complex densely spaced anastomosing network of minute folds or obvermiculate ridges from 2-12 µm long and up to 0.5 µm wide and high.

Paratabulation. Autophragm - Evidence for paratabulation lacking except in the vicinity of the archeopyle where faint indications are denoted by weakly developed angularity and, in places on some specimens, weakly developed accessory ?precingular parasutures.

Autocingulum - Present, denoted by a peristent pattern of several major folds near the mid-latitude of the autocyst; folds on some specimens pass laterally into an ill-defined pair of parasutural ridges near the ambitus of the autocyst, and on several specimens the folds are associated with slight invaginations of the autocyst at the periphery.

Autosulcus - Not observed.

Archeopyle. Apical, Type A(?1'-4'). Operculum not observed, presumably simple and free.

Dimensions. Autocyst length - 108-212 µm (mean, 157 µm), width - 90-156 µm (mean, 110 µm). 11 specimens measured.

Comparison. Fromea fragilis (Cookson and Eisenack) Stover and Evitt, 1978, differs in possessing a smooth or scabrate autophragm, generally has a smaller mean length and width and does not exhibit the consistent set of transverse folds in the latitude of the autocingulum.

Genus Paragonyaulacysta Johnson and Hills, 1973, p. 207

(76) Paragonyaulacysta borealis (Brideaux and Fisher) Stover and Evitt, 1978, p. 116

Discussion. Six specimens of this species were noted in samples from the Bluish grey shale unit, five of them in the basal 0.3 m of the unit. Brideaux (1967b) suggests that these occurrences represent derived specimens, but the writers now consider that these occurences represent an extension of the range of this species into at least the lower part of the Valanginian Buchia keyserlingi Zone.

Occurrence. Various surface and subsurface sections on the northern Canadian mainland and Arctic Archipelago in upper Oxfordian to middle Valanginian strata (Brideaux and Fisher, 1976; Brideaux, 1976b, 1977; Tan and Hills, 1978).

Chorate cysts

Gonyaulacacean cysts

Genus Bourkidinium Morgan, 1975, p. 160

(77) Bourkidinium sp. AE

Plate 6, figures 2, 3

Description.

Shape. Pericyst - Ambitus elongate, the observed length averaging about twice the width, apex somewhat truncated by the formation of an apical archeopyle, antapex rounded; dorsoventral compression.

Endocyst - Indistinct, smooth, closely appressed to the pericyst throughout; visible at the base of processes.

Pericoels - Not developed.

Phragma. Periphragm - About 0.25 µm thick; surface sculpture of densely spaced discrete granules about 0.25 µm or less in width and height. Periphragm forms apical and antapical concentrations of processes which are tubular, smooth, distally open and slightly or not at all flared, 9-12 µm long and 1.5-2.5 µm wide; 10-11 processes apically, 25-30 processes nearer the antapex and one process medially on one specimen.

Endophragm - Visible only where processes arise from the periphragm; apparently smooth, less than 0.25 µm thick.

Paratabulation. Pericyst - Epiparatabulation of ?4', 5-6", indicated by weakly developed angularity and accessory sutures along apical archeopyle; processes not relatable to a process formula on specimens available for study.

Endocyst - Paratabulation indicated as for pericyst.

Pericingulum - Not indicated.

Perisulcus - On one specimen, three or? four processes are thinner than the rest and may indicate presence of sulcal processes.

Archeopyle. Apical, Type A (?1'-4'). Operculum not observed, probably free and simple.

Dimensions. Pericyst length - 70 µm, 39 µm, width - 28 µm, 23 µm. 2 specimens measured.

Comparison. Bourkidinium sp. AE differs from Bourkidinium granulatum Morgan, 1975 (late Aptian-Albian) in possessing nearly double the number of processes at the apical and antapical poles of the cyst and in possessing processes that are not flared distally and are shorter by half than those on B. granulatum.

Genus Cleistosphaeridium Davey, Downie, Sarjeant Williams, 1966, p. 166

(78) Cleistosphaeridium araneosum Brideaux, 1977

Plate 6, figure 6

1971 Cleistosphaeridium sp. A of Brideaux, p. 94, Pl. 27, fig. 80.

1976 Cleistosphaeridium? sp. AE of Brideaux and McIntyre, p. 26, Pl. 7, fig. 13, 14.

1976 Cleistosphaeridium sp. AR of Brideaux and Myhr, p. 243, Fig. 43.3.

1976b Cleistosphaeridium sp. JE of Brideaux, p. 118, Pl. 23.1, figs. 5, 6.

1977 Cleistosphaeridium araneosum Brideaux, p. 22, Pl. 9, figs. 1-3.

Diagnosis. Essentially as reported by Brideaux (1977, p. 22) but with this revision concerning the phragma:

Periphragm - Less than 0.5 µm thick; bearing non-tabular acuminate, distally pointed or bifid processes from 6-12 µm long and 0.5-1.5 µm wide basally, or flattened processes, wider basally, tapering, distally bifid or capitate up to 12 µm long and up to 2.0 µm wide basally; processes may or may not arise from an apparently non-tabular quasi-reticulate network of very low, narrow ridges, the basally joined processes on some specimens confined to cingular parasutures; processes variable in density.

Endophragm - Less than 1.0 µm thick; smooth; not readily distinguishable.

Dimensions. Pericyst length - 50-87 µm (all specimens, 45-95 µm), width - 52-78 µm (all specimens, 40-78 µm), process length - 7-14 µm (all specimens, 6-15 µm). 9 specimens measured from the Bluish grey shale unit; measurements for all specimens compiled from Brideaux, 1971, 1976b, 1977; Brideaux and McIntyre, 1976; and this paper.)

Occurrence. Upper Berriasian and Hauterivian to Middle Albian of the northern Canadian mainland (Brideaux, 1976b, 1977; Brideaux and McIntyre, 1976; Brideaux and Myhr, 1976); Middle and Upper Albian of central Alberta (Brideaux, 1971).

(79) Cleistosphaeridium polypes (Cookson and Eisenack) Davey subsp. clavulum Lentin and Williams, 1973, p. 30

Dimensions. Pericyst length - 38-45 µm, width - 40-42 µm, process length - 2-6 µm, typically 3-5 µm. 4 specimens measured (pericyst length excludes processes and includes specimens with apical archeopyles).

Comparison. Specimens from Arctic Canada assigned to this subspecies by Brideaux and McIntyre (1976) and Brideaux (1976b, 1977, this paper) exhibit a greater range in length, width and larger mean pericyst dimensions but have a much smaller mean length of processes and much smaller ratio of process length to pericyst dimensions. These specimens are otherwise similar in morphology. Although this Arctic population may be better regarded as a third subspecies of the species polypes, the authors prefer to treat it as a variant group within the subspecies clavulum.

Occurrence. Aptian to lower Cenomanian of northern Canada, England and France (*see* Davey and Verdier, 1971, 1974; Brideaux and McIntyre, 1976; Brideaux, 1977) and Berriasian of the northern Canadian mainland (Brideaux, 1976b).

(80) Cleistosphaeridium separatum sp. nov.

Plate 6, figures 4-8

1977 Cleistosphaeridium sp. BE of Brideaux, p. 24, Pl. 9, figs. 7, 8, 10, 11.

Holotype. GSC 58606; ARCO Slide 10614-A2, 17.1 x 125.7; Upper shale-siltstone division equivalent, Banff-Aquitaine-Arco Rat Pass K-35 well, sidewall core, 487.7 m, GSC loc. C-12624, Hauterivian. Pericyst length excluding operculum, approximately 23 µm; pericyst width, 38 µm; processes, 3-7 µm long.

Diagnosis.

Shape. Pericyst - Complete pericyst not observed, the remaining portion nearly hemispherical; antapex rounded. Dorsoventral compression.

Endocyst - Commonly obscure, closely appressed to the pericyst.

Pericoels - Not observed.

Phragma. Periphragm - About 0.5 µm thick; surface sculpture of fine granulate to echinate elements less than 0.5 µm high; processes arising from periphragm closed, distally bifid to finely branched, 2-8 µm long (typically 4-7 µm) and about 1 µm wide; in places on some specimens, processes concentrated in penetabular position on paraplates and reduced in density or absent in the interior of paraplates; 15-20 processes per paraplate.

Endophragm - Commonly obscure, less than 0.5 µm thick; presumably smooth.

Paratabulation. Pericyst - Marked development of accessory parasutures in the vicinity of the archeopyle and penetabular concentration of processes denote an epiparatabulation of 4', Oa, 6" and ?c; less pronounced penetabular concentration of processes denotes a hypoparatabulation of ? (5" '-6" ', 1" ", ?p).

Endocyst - Paratabulation not observed.

Pericingulum - Not observed.

Perisulcus - Present on one specimen, position denoted by distinct sulcal notch; parasulcal processes discrete and apparently parasutural, denoting an anterior sulcal paraplate and one or more sulcal paraplates.

Archeopyle. Apical, Type A(1'-4'). Operculum free and? simple.

Dimensions. Pericyst length - 23-42 µm (archeopyle developed); width - 30-52 µm. 11 specimens measured (includes five specimens reported in Brideaux, 1977 and one specimen recently identified from the Buff sandstone unit of the Lower sandstone division).

Comparison. Cleistosphaeridium separatum sp. nov. differs from Cleistosphaeridium huguoniotii (Valensi) Davey, 1969 in possessing marked accessory parasutures and narrower processes which are commonly penetabular.

Occurrence. Buff sandstone unit, near base of unit, upper part of Buchia n. sp. aff. volgensis Zone, Upper Berriasian (cf. Brideaux, 1976b), a single specimen, and northern Canadian mainland, Hauterivian (Brideaux, 1977).

(81) Cleistosphaeridium spissum sp. nov.

Plate 7, figures 1-9

Holotype. GSC 58609; Slide P1102-2C, 12.5 x 122.6; Lower sandstone division, Bluish grey shale unit, Buchia keyserlingi Zone, section 75-BIA-008, 3.0-3.3 m above base of unit, along "Grizzly Gorge", District of Mackenzie, GSC loc. C-50920, lower to middle Valanginian. Maximum pericyst dimension, 110 µm; minimum pericyst dimension, 83 µm.

Diagnosis.

Shape. Pericyst - Ambitus ovoid, elongate, length/width ratio greater than 1.0; apical and antapical horns absent; dorsoventral compression.

Endocyst - Ambitus as for pericyst; closely appressed throughout.

Pericoels - Absent.

Phragma. Periphragm - Less than 0.5 µm thick; bearing hundreds of densely distributed processes of two main types: the most common type, very thin walled, tubular but flattened, wider basally, tapering slightly distally; distally trifurcate with stout aculei, partly open or? closed, in places distinctly connected basally by a reticulate network of very low ridges, in places apparently discrete; a second less common type, observed along what are interpreted as cingular parasutures, thin-columned, acuminate or distally slightly clavate, closed, joined basally by a system of low ridges. Length of all types, from 5-15 µm, typically 7-10 µm.

Endophragm - Indistinct, very thin, smooth.

Paratabulation. Pericyst - Paratabulation indeterminate.

Endocyst - Paratabulation absent.

Pericingulum - On some specimens, rows of acuminate processes, seemingly connected basally, may represent pericingular parasutures.

Perisulcus - Not observed.

Archeopyle. Not observed.

Dimensions. Maximum pericyst diameter - 30-110 µm, maximum width - 19-83 µm. 16 specimens measured.

Variation. Orientation of many specimens uncertain; some smaller specimens may be orientated in the apical-antapical view, maximum dimensions thus representing compressed widths and depths.

(82) Cleistosphaeridium sp. KE

Plate 8, figures 1-5

Description.

Shape. Pericyst - Ambitus ovoid to subcircular, the length nearly equal to or distinctly greater than the width. Moderate to extreme dorsoventral compression.

Endocyst - As for the pericyst.

Pericoels - Absent.

Phragma. Periphragm - About 0.5 µm thick. Dense cover formed of three types of processes arising from the periphragm: simple, slender, distally acuminate to capitate, 8 to 15 µm long; broad-based, tapering, elongate, distally capitate to bifid, up to 2.0 µm wide basally and 15 µm in length; and less commonly, relatively shorter, stout processes which bifuracte to form two distinct branches, themselves distally bifurcated or bifid, up to 3.0 µm wide basally and up to 12 µm in length.

Endophragm - Less than 0.5 µm thick; commonly indistinct.

Paratabulation. Pericyst - Epipericyst paratabulation of 4', 6", 0c, observed only in the vicinity of the archeopyle and in places on some specimens faintly indicated by presumed pandasutural gaps in spine cover.

Endocyst - Not observed.

Pericingulum - Not clearly observed; may be indicated in places on some specimens by a gap in the process cover.

Perisulcus - Not observed.

Archeopyle. Apical, Type A(1'-4'). Operculum free, simple.

Dimensions. Pericyst length - 59-95 µm, width - 49-79 µm. 16 specimens measured (many more observed).

Comparison. Cleistosphaeridium sp. KE differs from Cleistosphaeridium araneosum Brideaux in variety and density of process cover and lack of basal processes connections,

from Cleistosphaeridium aciculare Davey, 1969, in having basally widened processes and a variety of process types, and from Cleistosphaeridium multifurcatum (Deflandre) Davey et al., 1969 in the absence of a fine surface reticulation on the periphragm and in the variety of process types.

Genus Ctenidodinium Deflandre, 1938 emend. Gocht, 1970

(83) Ctenidodinium scissum sp. nov.

Plate 8, figures 6-9, Plate 9, figures 1-6

Holotype. GSC 58616; Slide P1101-6D, 27.5 x 130.0; Lower sandstone division, Bluish grey shale unit, Buchia keyserlingi Zone, section 75-BIA-003, 16.0-16.7 m, along Martin Creek, District of Mackenzie, GSC loc. C-50871, lower to middle Valanginian. Pericyst length, 63 µm; pericyst width, 61 µm; parasutural crests up to 22 µm high.

Diagnosis.

Shape. Pericyst - Ambitus subcircular; apical and antapical prominences absent; ambitus of the envelope formed by projecting parasutural crests ovoid to subcircular. Compression slight to moderate dorsoventral.

Endocyst - Ambitus subcircular; apical and antapical prominences absent. Slight to moderate dorsoventral compression.

Pericoel - Absent.

Phragma. Periphragm - About 0.25 µm thick; surface sculpture scabrate; periphragm forming membranous, finely folded parasutural crests from 10-22 µm high, typically 10-18 µm high, the crests scabrate, weakly striate or wrinkled basally in places, distally entire or weakly crenulated.

Endophragm - 0.5-0.75 µm thick; surface sculpture microreticulate, in places granulate or microrugulate.

Paratabulation. Pericyst - Paratabulation of ?4', 6", ?6c, 5" '-?6" ', 1p, 1" ". Apical paraplate 1' is elongate; of the precingular paraplates, 2"-4" are largest and polygonal and 6" is the smallest; of the postcingular paraplates, 2" '-4" ' are the largest and are subquadrate to pentagonal; 1p is small relative to 2" '-4" ' and is subquadrate.

Endocyst - Paratabulation not evident.

Pericingulum - Denoted by cingular parasutures of equal width; slightly helicoid, displaced about one-half to one cingulum width (5-7 µm); six? cingular paraplates.

Perisulcus - Denoted by low parasutural crests; wider on the hypopericyst, narrowing and extending onto the epipericyst only a short distance, terminated adjacent to the first apical paraplate; sulcal paraplates present but difficult to distinguish.

Archeopyle. Epicystal, Type AP?a(1'-4', 1"-6"). Operculum simple and partially detached or free.

Dimensions. Pericyst length - 51-67 µm, width - 50-69 µm. 23 specimens measured (many more observed).

Variation. Only a few specimens have been found with complete detachment of the operculum. The majority show only partial detachment or an incipient separation along the pericingulum.

Comparison. Ctenidodinium spissum sp. nov. differs from other species assigned to the genus in possessing entire-margined parasutural crests and a microreticulate endophragm.

Genus Oligosphaeridium Davey and Williams, 1966, p. 70

(84) Oligosphaeridium asterigerum (Gocht) Davey and Williams, 1969, p. 5

Plate 10, figure 5

Occurrence. Valanginian and Hauterivian of Germany (Gocht, 1959); middle Kimmeridgian to Middle Albian of the northern Canadian mainland (Brideaux and McIntyre, 1976; Brideaux and Myhr, 1976; Brideaux, 1977).

(85) Oligosphaeridium complex (White) Davey and Williams, 1966, p. 71

Occurrence. Widely distributed in Cretaceous and Tertiary rocks (see Brideaux, 1977; Brideaux and Myhr, 1976).

(86) Oligosphaeridium vasiformum (Neale and Sarjeant) Davey and Williams, 1966, p. 74

Plate 10, figures 1-4, 7, 8, 12

1962 Hystrichosphaeridium macrotubulum Neale and Sarjeant, p. 452, Pl. 20, figs. 7, 8a

1966 Oligosphaeridium macrotubulum (Neale and Sarjeant) Davey and Williams, p. 75, Pl. 9, fig. 4.

1967 Hystrichosphaeridium sp. Warren, p. 219, Pl. 19, figs. 5, 6, 9.

1976b Oligosphaeridium sp. FE, Brideaux, p. 119, Pl. 23.2, fig. 7.

Discussion. The holotype of O. vasiformum was figured by Neale and Sarjeant (1962, Pl. 20, fig. 1) and re-illustrated by Davey and Williams (1966, Pl. 10, fig. 1). A second specimen, designated as the holotype by Davey and Williams (1966, Pl. 9, fig. 7), is the paratype specimen drawn by Neale and Sarjeant (1962, Textfig. 8b). Davey and Williams (1966, Pl. 9, fig. 7) also reverse the image.

A process formula for O. vasiformum has been determined as 4', 6", 5" ', 1" ", 1p. 0-1s. Of the precingular processes, 3" and 4" are the largest and 6" is the shortest. Of the postcingular processes, 3" ' and 4" ' are the more robust. Process 1p is relatively small compared to all but the sulcal process. Process 1" " in places exhibits the most complex distal terminations, but is commonly not particularly differentiated. The sulcal process is reduced in length and may in places depart from the typical distal morphology of the other processes.

The pitting of the periphragm is highly variable, being pronounced on some specimens and not on others and is probably controlled by the preservation. Processes are commonly elongate and narrow, but occasional specimens bear a shorter and stouter complement. The distal part of the processes is commonly quadrate or sub-quadrate with four or five blunted aculei, but the number of aculei may be as high as six and these may be more elongate.

Dimensions. Pericyst width - 50-105 µm (excluding processes); process length - 22-50 µm (excluding sulcal process). 40 specimens measured, many more observed.

Comparison. The quadrate to subquadrate distal terminations of the processes and the blunted aculei, typically four or five in number, distinguish this species from the closely comparable species, Oligosphaeridium complex (White) Davey and Williams.

Occurrence. Middle Hauterivian of England (Neale and Sarjeant, 1962; Davey and Williams, 1966); lower? Berriasian of California (Warren, 1967, p. 219). Warren (1967, p. 219) incorrectly cites the occurrence as Valanginian.

(87) Oligosphaeridium sp. GE

Plate 10, figures 6, 9-11

Description.

Shape. Pericyst - Complete pericyst rarely observed; amb subcircular. Slight dorsoventral compression.

Endocyst - Commonly obscure, closely appressed to the pericyst.

Pericoels - Not developed.

Phragma. Periphragm - 0.5 to 1.0 µm thick; surface sculpture scabrate to punctate; intratabular processes arising from periphragm short, stout, hollow, open distally, the distal parts quadrate to subquadrate, slightly flared and produced into four to six, typically five, blunt extensions; processes on some specimens approaching an infundibular outline with more pronounced distal flaring; length 12-30 µm, typically 15-25 µm.

Endophragm - Commonly obscure, less than 0.5 µm thick; presumably smooth.

Paratabulation. Pericyst - Process formula of 4', 6", 0c, 5" ', 1p, 1" ", 0-1s; of the apical processes, 2' is the largest, pentagonal and transversely elongate and 3' is the smallest. Of the precingular and postcingular processes, 3", 4", 3" ' and 4" ' are the larger; the shape of the operculum and the weak development of accessory parasutures denote the presence of four apical paraplates and six precingular paraplates.

Endocyst - Not observed.

Pericingulum - Position denoted by the absence of processes.

Persulcus - Not observed.

Archeopyle. Apical, Type A(1'-4'). Operculum free, simple.

Dimensions. Pericyst length - 62-68 µm (complete specimens not measurable), width - 65-85 µm. 12 specimens measured.

Comparison. Oligosphaeridium sp. GE has processes which are similar in distal construction to those of Oligosphaeridium vasiformum (Neale and Sarjeant) Davey and Williams, but which are shorter and stouter and possess shorter and blunter extensions. The tendency of some specimens of Oligosphaeridium sp. GE to display processes which approach an infundibular outline recalls the morphology of processes of Hystrichosphaeridium sp AE of Brideaux, 1977, but that species displays also cingular processes.

Genus Polysphaeridium Davey and Williams, 1966, p. 91

(88) Polysphaeridium sp. AE

Plate 11, figures 1-3

Description.

Shape. Pericyst - Amb subcircular; ?dorsoventral compression.

Endocyst - Commonly obscure; closely appressed to pericyst.

Pericoels - Not developed.

Phragma. Periphragm - About 1.0-1.5 µm thick; surface sculpture scabrate to granulate; non-tabular processes arising from periphragm greater than fifty in number, hollow, open or closed distally, the latter in the minority; closed processes tubular and distally bifid; open processes ± tubular or tapering, rarely subconical; length, 2-4 µm, width 1-3 µm.

Endophragm - Commonly obscure, less than 0.5 µm thick; presumably smooth.

Paratabulation. Pericyst - Presence denoted only by the archeopyle outline which suggests 4', 6".

Endocyst - Not observed.

Pericingulum - Not observed.

Perisulcus - Not observed.

Archeopyle. Apical, Type A(1'-4'). Operculum not observed, presumably free.

Dimensions. Pericyst length - 30, 35 µm (no complete specimens observed), width - 45, 35 µm. 2 specimens measured.

Comparison. This species resembles Hystrichosphaeridium arundum Eisenack and Cookson (1960, p. 8, Pl. 3, figs. 7-9) but differs in possessing smaller, much more numerous processes. The processes are also shorter than those of Conosphaeridium sp. B of Brideaux (1977, p. 24, Pl. 9, figs. 4, 6) and differ in having a majority of tubular processes rather than subconical to lagenate processes.

Genus Tanyosphaeridium Davey and Williams, 1966, p. 98

(89) Tanyosphaeridium sp. DE of Brideaux, 1977, p. 32

Dimensions. Pericyst length - 42 µm (archeopyle present), width - 24 µm, process length - 5-8 µm. 1 specimen observed.

Occurrence. Upper Berriasian and Barremian of the northern Canadian mainland (Brideaux, 1976b, 1977).

Pareodinioid cysts

Genus Gochteodinia Norris, 1978, p. 7

Type species. Gochteodinia villosa (Vozzhennikova, 1967, p. 56, Pl. 12, figs. 1-3, Pl. 13, figs. 1-3, Pl. 14, figs. 1, 2, Pl. 15, figs. 1, 2) Norris, 1978, p. 7.

Diagnosis. (Amplified after Norris, 1978, p. 7.)

Shape. Pericyst - Ambitus elongate; apical horn of variable length, commonly elongate, tapering and sometimes bearing a solid distal part; remaining part of the pericyst pyriform, the antapex commonly rounded and without indentations or prominences developed. Slight to moderate dorsoventral compression.

Endocyst - Commonly obscure and closely appressed to the pericyst.

Pericoels - Absent.

Phragma. Periphragm - Commonly of constant thickness, except for distal thickening of the apex. Surface sculpture variable and including smooth, punctate, scabrate or apiculate elements. Periphragm forming non-tabular processes of variable morphology and length, typically one-quarter the diameter of the pericyst; processes commonly hollow and tubular, the bases entire or splayed, the distal parts variable in morphology, open or closed, and including simple, bifid, anchor-shaped and aculeate terminations among others. Processes present, reduced or absent on the apical horn and reduced to absent in places on the remaining part of the periphragm.

Endophragm - Commonly obscure, of constant thickness; visible beneath origin of hollow processes on the periphragm; smooth or scabrate.

Paratabulation. Pericyst - Denoted in the vicinity of the archeopyle and by arrangement of processes in circumferential clusters on some species indicative of apical or? intercalary, precingular and postcingular groupings.

Endocyst - Indicated only in the vicinity of the archeopyle.

Pericingulum - Position suggested on some species by absence of processes in a circumferential belt below the mid-latitude of the pericyst.

Perisulcus - Not indicated

Archeopyle. Intercalary, Type 2I or 3I. Operculum free, commonly compound.

Comparison. Gochteodinia Norris, 1978 is distinguished from Pareodinia Deflandre, 1947 emend. Wiggins, 1975, restricted herein, by possession of tubular processes arising from the periphragm, and from Paranetrelytron Sarjeant, 1966b, p. 201, in the presence of processes and the absence of a kalyptra and developed pericoels.

Other species. Gochteodinia judientinae sp. nov. Gochteodinia sp. A of Brideaux and McIntyre, 1976 (= Imbatodinium sp. A of Brideaux and McIntyre, 1976, p. 32, Pl. 9, figs. 14-16).

(90) Gochteodinia villosa (Vozzhennikova) Norris, 1978, p. 7

Plate 11, figure 10, Plate 12, figure 1

1967 Imbatodinium villosum Vozzhennikova, p. 56, Pl. 12, figs. 1-3, Pl.-13, figs. 1-3, Pl. 14, figs. 1, 2, Pl. 15, figs. 1, 2.

1975 Pareodinia dasyforma Wiggins, p. 107, Pl. 5, figs. 3, 4 (nom. subst. pro Pareodinia villosa Vozzhennikova non Pareodinia villosa Tasch, 1964).

1976 Imbatodinium villosum Vozzhennikova; Bjaerke; Edwards and Thusu; Pl. 1, fig. 3.

1977 Pareodinia dasyforma Wiggins; Duxbury, p. 56, Pl. 14, figs. 1-3.

Holotype. IGiG SO AN prep. 308P - 447/4; Upper Jurassic, well 50, Kuntsevo (Moscow region), U.S.S.R. Pericyst length, 108 µm; pericyst width, 30 µm; apical horn length, 21.6 µm.

Diagnosis.

Shape. Pericyst - Ambitus elongate; apical horn variable in length and distally solid, the distal extremity capitate; remaining pericyst pyriform with convex sides; antapex rounded; slight dorsoventral compression.

Endocyst - Commonly obscure, appressed closely to pericyst.

Pericoels - Absent.

Phragma. Periphragm - 0.5-1.0 µm thick; except the distally solid apical horn; surface sculpture smooth or scabrate; periphragm forming hollow, tubular processes, their density and development variable, the distal parts clavate, bifid or hooked, rarely complex with aculei; processes reduced or absent on the apical horn; base of processes entire.

Endophragm - Commonly obscure, less than 0.5 µm thick; presumably smooth.

Paratabulation. Pericyst - Denoted only in the vicinity of the archeopyle.

Endocyst - Indications of paratabulation absent.

Pericingulum - Not indicated.

Perisulcus - Not indicated.

Archeopyle. Intercalary, Type 2I(2a, 3a). Operculum free, compound.

Dimensions. From Vezzhennikova, 1967, p. 56: pericyst length - 70.5-108.0 µm, pericyst width - 27.0-40.5 µm, process length - 10.5-13.5 µm, more than 30 specimens. Encountered in present study; pericyst length - 82-130 µm, pericyst width - 38-48 µm, process length - 4-20 µm, typically 10-15 µm, length of solid apical horn - 5-8 µm. 10 specimens measured.

Discussion. Specimens from the Bluish grey shale unit are typically somewhat larger, have a shorter solid part of the apical horn and show a greater variety of distal termination of the processes than specimens of this species described by Vozzhennikova (1967, p. 56).

Occurrence. Upper Jurassic of the Moscow region (Vozzhennikova, 1967); upper Berriasian to middle Hauterivian of California (Warren, 1967); Upper Jurassic (uppermost Kimmeridgian to Portlandian) of Great Britian (Riley and Sarjeant, 1972); Neocomian of Alaska, U.S.A. (Wiggins, 1975); undifferentiated upper Jurassic or? lower Cretaceous of Spitsbergen (Bjaerke et al., 1976).

(91) Gochteodinia judilentinae sp. nov.

Plate 11, figures 4-9

Holotype. GSC 58632; Slide P1101-6C, 32.3 x 124.3; Lower sandstone division, Bluish grey shale unit, Buchia keyserlingi Zone, section 75-BIA-003, 16.0-16.7 m, along Martin Creek,

District of Mackenzie, GSC loc. C-50871, lower to middle Valanginian. Pericyst length, 118 µm; maximum pericyst width, 38 µm.

Diagnosis

Shape. Pericyst - Ambitus elongate; apical horn variable in length, distal part solid, and terminated by an apiculate process, 5-12 µm long; remaining pericyst pyriform with convex sides; antapex rounded; slight dorsoventral compression.

Endocyst - Commonly obscure, visible under the origins of processes; closely appressed to the pericyst.

Pericoels - Absent.

Phragma. Periphragm - Less than 1.0 µm thick; except the distal solid part of the apical horn; surface sculpture smooth or scabrate; periphragm forming hollow, tubular processes, open distally, the margins flared slightly and in places thickened, projecting into long aculei, typically eight in number on well preserved processes; aculei 4-8 µm long; processes 12 to 24 in number and 10-20 µm in length; processes reduced or absent on the apical horn; processes on the epiperiphragm dividing basally, the slightly thickened splays diverging and then merging with the smooth periphragm.

Endophragm - Commonly obscure, less than 0.5 µm thick; presumably smooth.

Paratabulation. Pericyst - Denoted only in the vicinity of the intercalary archeopyle. Processes on some specimens show a distinct circumferential clustering suggesting apical or? intercalary, precingular and postcingular groupings.

Endocyst - Indication of paratabulation absent except in vicinity of the archeopyle.

Pericingulum - Position on some specimens indicated by an absence of processes in a circumferential belt below the mid-latitude of the pericyst, or by reduction of the number and morphology of the processes to one or two thin, acuminate, distally closed examples.

Perisulcus - Not indicated.

Archeopyle. Intercalary, Type 2I(2a, 3a). Operculum free, compound, observed opercular pieces bearing one process each.

Dimensions. Pericyst length - 105-124 µm, width (maximum width) - 28-46 µm. 9 specimens measured.

Comparison. Gochteodinia judilentinae sp. nov. differs from Gochteodinia villosa (Vozzhennikova) Norris in possession of slightly flared processes with distal aculeate extensions and processess which are splayed basally on the epiperiphragm.

Cavate cysts

Gonyaulacacean cysts

Genus Sirmiodinium Alberti emend. Warren, 1973, p. 104

(92) Sirmiodinium grossii Alberti emend. Warren, 1973, p. 104

Occurrence. Upper Tithonian to Hauterivian of California (Warren, 1967); upper Kimmeridgian to Barremian of Great Britain and Europe (*see* Brideaux, 1977); middle? and upper Kimmeridgian to Barremian of the northern Canadian mainland and Arctic Archipelago (Brideaux and Fisher, 1976; Brideaux, 1976a, b, Brideaux, 1977).

Genus Tubotuberella Vozzhennikova emend. Brideaux, 1977, p. 36

1967 Tubotuberella Vozzhennikova, p. 180.

1977 Tubotuberella Vozzhennikova emend. Brideaux, p. 36.

(93) Tubotuberella rhombiformis Vozzhennikova emend. Brideaux, 1977, p. 36

Plate 12, figure 3

1967 Tubotuberella rhombiformis Vozzhennikova, p. 180, Pl. 101, figs. 1, 2, Pl. 102, figs. 1-3, Pl. 104, figs. 1-3.

1976 Scriniodinium apatelum Bjaerke et al., Pl. 1, figs. 2, 4 only, auct. non (Cookson and Eisenack) Sarjeant.

1977 Tubotuberella rhombiformis Vozzhennikova emend. Brideaux, p. 36, Pl. 14, figs. 10, 11, Pl. 15, fig. 1.

1977 Psaligonyaulax apatela Duxbury, p. 47, auct. non (Cookson and Eisenack) Sarjeant.

Discussion. Stover and Evitt (1978, p. 197) contend that Vozzhennikova (1967, p. 180) designated more than one specimen as holotype. However, Vozzhennikova (1967, p. 180) clearly cites the holotype specimen as that illustrated on Plate 101, figure 2a, b and Plate 104, figure 2 and so indicates in the plate legends for Plates 101, 104. Careful comparison of the drawings (op. cit., Pl. 101, fig. 2a, b) with the photograph (op. cit., Pl. 104, fig. 2) shows that they are indeed the same specimen. Therefore, the correct citation, in the writers' opinion, is that given here and in Brideaux (1977, p. 36).

Dimensions. Pericyst length - 80-118 µm, width - 48-72 µm, Endocyst length - 45-82 µm.

Comparison. Tubotuberella rhombiformis Vozzhennikova emend. Brideaux differs from Glabridinium apatelum (Cookson and Eisenack) Brideaux, 1977 in possessing parasutural crests and in lacking defined apical horns, and from Tubotuberella sp. cf. T. rhombiformis Vozzhennikova emend. Brideaux (Brideaux, 1976b) in possessing parasutural crests. Of the specimens illustrated by Bjaerke et al. (1976), the specimen on Plate 1, figure 5 seems more closely allied to Glabridinium apatelum (Vozzhennikova) Brideaux. Bjaerke et al. (1976, p. 66, footnote) refer to the taxonomic problems occasioned by this group and discussed by Brideaux (1977) in part.

Occurrence. Upper Jurassic (Upper Volgian) of the Moscow region, U.S.S.R. (Vozzhennikova, 1967); upper Oxfordian to Kimmeridgian and Berriasian of the northern Canadian mainland (Brideaux, 1976b, 1977); Berriasian and Valanginian of England (Duxbury, 1977); undifferentiated Upper Jurassic or Lower Cretaceous of Spitsbergen (Bjaerke et al., 1976).

Peridiniacean cysts

Genus Dingodinium Cookson and Eisenack, 1958, p. 39

(94) Dingodinium cerviculum Cookson and Eisenack, 1958, p. 40

Plate 12, figure 2

Dimensions. Pericyst length, 55-78 µm, width - 45-60 µm, Endocyst length, 39-58 µm. 5 specimens measured.

Occurrence. Upper Hauterivian to Albian of Germany, France, England, Roumania, Australia, western North Atlantic and Canada (*see* Davey, 1974; Habib, 1975; Brideaux and McIntyre, 1976; Brideaux, 1977).

Pseudoceratiacean cysts

Genus Muderongia Cookson and Eisenack, 1958, p. 40

(95) Muderongia sp. cf. M. simplex Alberti, 1961, p. 12

Plate 12, figure 4

Comment. A few poorly preserved specimens are assigned provisionally to this species, first described from the Valanginian and Barremian of Germany by Alberti (1961).

Unassigned cysts

Genus Caligodinium Drugg, 1970, p. 814

(96) Caligodinium aceras (Manum and Cookson) Lentin and Williams, 1973, p. 21

Occurrence. Berriasian (Brideaux, 1976b), Santonian-lower Campanian (Brideaux and Myhr, 1976) and Campanian-Maastrichtian (McIntyre, 1974) from the northern Canadian mainland; Upper Cretaceous of the Canadian Arctic Archipelago (Manum and Cookson, 1964; *see* also Felix and Burbridge, 1976).

Genus Kallosphaeridium De Coninck, 1969, p. 44

(97) Kallosphaeridium? agglutinatum sp. nov.

Plate 12, figures 5-12

Holotype. GSC 58642; P1101-3C, 43.7 x 128.4; Lower sandstone division, Bluish grey shale unit, Buchia keyserlingi Zone, Section 75-BIA-003, 4.4-5.8 m, along Martin Creek, District of Mackenzie, GSC loc. C-50868, lower to middle Valanginian. Maximum pericyst width, 71 µm; kalyptra present, extending 2 µm; apical archeopyle present.

Diagnosis.

Shape. Autocyst - Ambitus ovoid to subcircular; apical and antapical prominences absent. Compression variable. Surrounding flocculent material extending from 2-22 µm, typically 5-15 µm beyond autocyst.

Pericoels - Absent.

Phragma. Autophragm - Less than 1.0 µm thick; surface sculpture of irregularly but densely spaced grana or, less commonly, short rugulate elements up to 1.0 µm high and 0.5 to 1.0 µm wide. Amorphous sheath (kalyptra) commonly with entrained mineral matter.

Paratabulation. Autocyst - Epiparatabulation of 4', 6" denoted in the vicinity of the archeopyle by archeopyle outline and development in places of accessory archeopyle sutures.

Autocingulum - Not indicated.

Autosulcus - Not indicated.

Archeopyle. Apical, Type A?a(1'-4'). Operculum simple, free or partially attached on some specimens along the posterior parasuture of paraplate 1'.

Dimensions. Autocyst diameter (maximum) - 55-90 µm (32 specimens measured), width - 56-83 µm (9 specimens measured). 41 specimens measured, many more observed; orientation possible only on 9 measured specimens.

Discussion. Caligodinium Drugg, 1970 was diagnosed as possessing an apical archeopyle formed by the loss of three apical paraplates, an interpretation supported by Stover and Evitt, 1978. Kallosphaeridium? agglutinatum sp. nov. possesses an apical archeopyle formed by loss of four apical paraplates, but possesses an autophragm with surrounding flocculent material. For this reason the authors prefer a provisional assignment to Kallosphaeridium.

Comparison. Kallosphaeridium? agglutinatum sp. nov. differs from K.? granulatum (Norvick in Norvick and Burger) Stover and Evitt, 1978 in being larger and possessing a dense granulate to microrugulate ornament compared to the granulate, baculate or clavate ornament of the latter.

(98) Kallosphaeridium sp. AE

Plate 5, figures 1, 4

1976a Canningia sp. AE Brideaux, p. 256, Pl. 44.2, fig. 8.

Description.

Shape. Autocyst - Ambitus ovoid; length of complete specimens less than width; apex and antapex rounded. Moderate dorsoventral compression.

Phragma. Autophragm - About 0.5 µm thick; surface sculpture of non-tabular densely spaced, but discrete coni or papillae, up to 1.5 µm high, typically 1.0 µm high and 0.5 µm wide.

Paratabulation. Autocyst - Archeopyle shape and weakly developed accessory parasutures denote an epiparatabulation of 4', 6", 0c. Evidence for hypoparatabulation absent.

Autocingulum - Not observed.

Autosulcus - Not observed except in vicinity of a weakly defined sulcal notch on some specimens.

Archeopyle. Apical, Type Aa(1'-4'). Operculum simple, attached along the posterior parasuture of paraplate 1'.

Dimensions. Autocyst length - 50-60 µm, width - 65-70 µm. 3 specimens measured.

Comparison. Canningia ringnesiorum Manum and Cookson, 1964 differs in possessing a free operculum. Kallosphaeridium sp. BE of McIntyre and Brideaux (this paper) possesses granulate sculpture.

Occurrence. Valanginian?-Hauterivian, subsurface of northern Canadian mainland (Brideaux and Myhr, 1976; Brideaux, 1976a).

(99) Kallosphaeridium sp. BE

Plate 5, figures 7, 10

Description.

Shape. Autocyst - Ambitus ovoid; length of complete specimens nearly equal to width; apex and antapex rounded. Moderate dorsoventral compression.

Phragma. Autophragm - About 0.5 µm thick; non-tabulate surface sculpture of moderate to densely spaced grana about 0.5 µm high and 0.5-1.0 µm wide.

Paratabulation. Autocyst - Shape of archeopyle and weakly to distinctly developed accessory sutures denote an epiparatabulation of 4', 6", 0c. Evidence for hypoparatabulation absent.

Autocingulum - Not observed.

Autosulcus - Not observed except in the vicinity of an offset sulcal notch on some specimens.

Archeopyle. Apical, Type Aa(1'-4'). Operculum simple, attached along the posterior parasuture of paraplate 1'.

Dimensions. Autocyst length - 60-70 µm (5 complete specimens), width - 57-68 µm. 8 specimens measured.

Comparison. Batiacasphaera macrogranulata Morgan, 1975 possesses larger grana which may coalesce to form short rugulae and has a simple, free operculum. Kallosphaeridium sp. AE differs only in possessing a sculpture of coni or papillae.

Genus Wallodinium Loeblich and Loeblich, 1968, p. 212

(100) Wallodinium lunum (Cookson and Eisenack) Lentin and Williams, 1973, p. 140

Occurrence. Lower Hauterivian to Cenomanian of England, France, Germany, Australia and the Atlantic continental margin of the United States (Cookson and Eisenack, 1960; Alberti, 1961; Cookson and Hughes, 1964; Habib, 1972; Davey and Verdier, 1974; Davey, 1974); in Canada, from Hauterivian and Barremian (Brideaux, 1977) and Santonian-Campanian (McIntyre, 1974) of the northern Canadian mainland; Senonian of the Canadian Arctic (Manum and Cookson, 1964); Lower Turonian of Saskatchewan (Davey, 1970).

Other algal microfossil groups

Genus Pediastrum Meyen, 1829

(101) Pediastrum sp.

Plate 12, figure 13

Comment. A single specimen referable to this genus was recovered from the Bluish grey shale unit exposed along "Grizzly Gorge". Evitt (1963) discusses the provenance of this form and notes that, although it is considered a freshwater form, fossil occurrences have been reported from a number of obviously marine paleoenvironments.

Occurrence. Evitt (1963) reports fossil occurrences of this genus from Lower and Upper Cretaceous marine rocks in Pakistan, and in California and the Rocky Mountains region (Lewis shale) of the U.S.A., and cites previous reports of Tertiary and Quaternary occurrences in probable freshwater paleoenvironments.

Genus Schizosporis Cookson and Dettmann emend. Pierce, 1976, p. 27

(102) Schizosporis reticulatus Cookson and Dettmann emend. Pierce, 1976, p. 27

Comment. Pierce (1976) discusses the morphology, affinity and habitat of this species, referring it to the Acritarcha and suggesting that it may have occupied a freshwater paleoenvironment. However, Pierce (1976, p. 29, 30) lists a number of reported occurrences which are undoubtedly from marine paleoenvironments.

Occurrence. Berriasian to Turonian from various localities in United States, Canada, southern Australia, England and Czechoslovakia (Pierce, 1976, p. 25, 29, 30) to which may be added the lower Berriasian of northern mainland Canada (Brideaux, 1976b).

Genus Veryhachium Deunff emend. Downie and Sarjeant, 1963, p. 93

(103) Veryhachium reductum 'forma' trispinoides de Jekhowsky, 1961, p. 210

Occurrence. Permo-Triassic to Upper Albian from Europe, Africa, Britain and Canada (Brideaux and McIntyre, 1976, p. 39; Brideaux, 1976b).

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APPENDIX

Description of sections

Section 75-BIA-003 (Martin Creek) Lat. 68°12'10"N, Long. 135°34'50"W.

The Bluish grey shale unit at this location is overlain by more than 8.6 m of the White sandstone unit which is not described in this paper.

Lower sandstone division

Bluish grey shale unit	Unit Thickness (m)	Height above base (m)
Dark grey, friable, silty shale	5.0	05.0
Ironstone bed, maroon weathering	0.2	05.2
Dark grey, friable, silty shale	7.0	12.2
Ironstone concretionary band	0.1	12.3
Dark grey, friable, silty shale	3.9	16.2
Ironstone concretionary band, discontinuous	0.1	16.3
Dark grey, friable, silty shale	0.4	16.7

The unit is underlain by 78 m assigned to the Buff sandstone unit, which is not described in this paper.

Section 75-BIA-008 ('Grizzly Gorge') Lat. 68°15'49"N, Long. 135°40'59"W.

The Bluish grey shale unit at this location is overlain by 53 m of the White sandstone unit which is not described in this paper.

Dark grey to black carbonaceous shale	0.1	00.1
Rusty weathered iron-rich bed	0.1	00.2
Dark grey shale, more friable, yellow stained to rusty weathered in bands or beds	5.8	06.0
Rusty weathered shale with an ironstone bed in the middle of the unit, gradational change upward and downward from ironstone to shale	0.7	06.7
Grey shale	0.6	07.3
Rusty weathered iron-rich bed	0.2	07.5
Grey shale, yellow weathered and streaked	0.7	08.2
Rusty weathered grey shale with poorly preserved belemnites	0.2	08.4
Dark grey shale, silty at the base, 0.4 m of rusty weathered shale, 0.3 m from base	2.8	11.2

Contact with Buff sandstone unit taken at the top of the last sandy bed. An estimated 3.0 m of Buff sandstone unit is exposed below the base of the Bluish grey shale unit and is not described in this paper.

PLATE LEGENDS

In the explanation of figures the species name is followed by the GSC locality number, the slide number, stage co-ordinates, an explanation (if necessary) of the focus level and orientation of the specimen, the GSC type number and the magnification. IC refers to Interference Contrast; other figures are photographed in bright field illumination.

For Plate 1, stage co-ordinates are for Leitz Orthoplan Microscope No. 860360 at Geological Research and Services, PetroCanada, Calgary. For Plates 2-12 stage co-ordinates are for Reichert Zetopan Microscope No. 56395 at the Institute of Sedimentary and Petroleum Geology, Calgary.

PLATE 1

Figures 25, 26 x 780, all others x500

Figures 1, 2. Ceratosporites sp

1. C-50922, P1102-4D, 13.0 x 102.0, GSC 58557

2. C-50922, P1102-4F, 17.3 x 104.6, GSC 58558

Figure 3. Kraeuselisporites hastilobatus C-50922, P1102-4D, 34.3 x 114.2, distal focus, GSC 58559

Figure 4. Rubinella major C-50866, P1101-1A, 30.3 x 95.3, GSC 58560

Figure 5. Trilobosporites aornatus C-50920, P1102-2F, 17.3 x 95.0, GSC 58561

Figures 6, 7. Crybelosporites vectensis

6. C-50922, P1102-4D, 45.7 x 104.3, lateral view, GSC 58562

7. C-50920, P1102-2F, 20.8 x 93.0, proximal focus, GSC 58563

Figures 8, 9. Lycopodiumsporites marginatus

8. C-50868, P1101-3F, 45.5 x 93.7, GSC 58564

9. C-50869, P1101-4F, 26.7 x 106.0, GSC 58565

Figures 10, 11. Cicatricosisporites myrtellii C-50919, P1102-1D, 31.1 x 100.4, (10) proximal view at lo-focus, (11) distal view at hi-focus, GSC 58566

Figure 12. Cicatricosporites angicanalis C-50920, P1102-2D, 25.0 x 94.0, GSC 58567

Figure 13. Cicatricosisporites potomacensis C-50869, P1101-4D, 37.5 x 98.7, GSC 58568

Figure 14. Cicatricosisporites hughesii C-50922, P1102-4F, 16.7 x 96.3, GSC 58569

Figure 15. Cicatricosisporites exilioides C-50921, P1102-3H, 16.8 x 102.8, GSC 58570

Figures 16-26. Triporoletes incertus sp. nov.

Figures 16, 17. Holotype, C-50922, P1102-4D, 19.6 x 96.8, (16) distal view, (17) proximal view, IC, GSC 58571

18, 19. C-50922, P1102-4F, 21.8 x 107.3, (18) proximal view (19) distal view, GSC 58572

20, 21. C-50922, P1102-4D, 30.7 x 107.0, (20) proximal view, IC (21) distal view, GSC 58573

22. C-50869, P1101-4F, 18.5 x 96.2, GSC 58574

23. C-50868, P1101-3D, 31.5 x 98.9, GSC 58575

24. C-50921, P1102-3D, 17.3 x 106.9, GSC 58576

25, 26. Holotype, C-50922, P1102-4D, 19.6 x 96.8, (25) proximal view, (26) distal view, GSC 58571

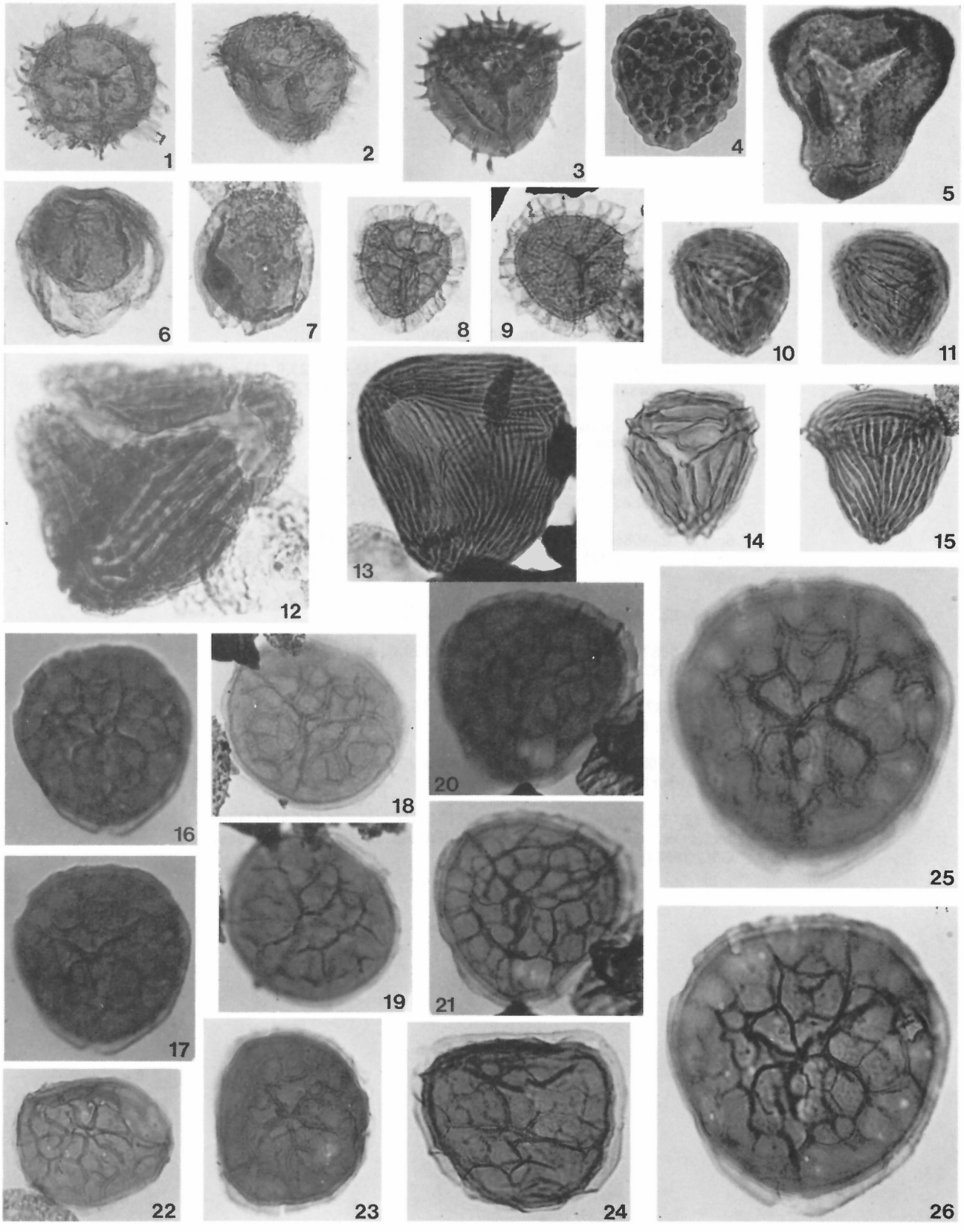
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PLATE 2

Figures 1-7. Apteodinium apiatum sp. nov.

1, 2. Holotype. C-50871, Slide 1101-6C, 35.3 x 125.4 (1) lo-focus on dorsal surface and archeopyle, IC, GSC 58577, x500

3. C-50869, Slide 1101-4C, 43.2 x 120.0, lateral view, mid-focus, GSC 58578, x500

4, 5. C-50869, Slide 1101-4A, 47.2 x 118.1, (4) lo-focus on dorsal surface, (5) hi-focus on ventral surface, GSC 58579, x500

6, 7. C-50867, Slide 1101-2C, 21.9 x 116.8, (6) hi-focus on dorsal surface, (7) lo-focus on ventral surface, IC, GSC 58580, x500

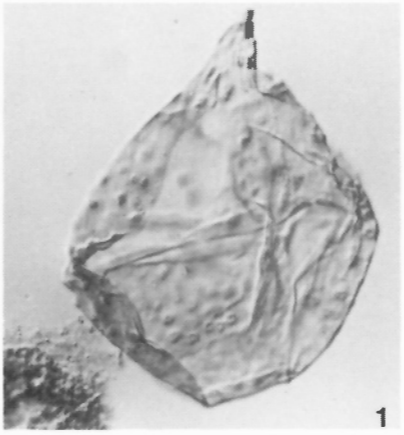
Figures 8-12. Apteodinium spongiosum sp. nov.

8. C-50871, Slide 1101-6C, 21.7 x 123.6, hi-focus on ventral surface, IC, GSC 58581, x1000

9. C-50871, Slide 1101-6C, 43.2 x 116.6, detail of periphragm structure, GSC 58582, x1000

10. C-50871, Slide 1101-6C, 38.0 x 128.1, hi-focus on right lateral surface, GSC 58583, x500

11, 12. Holotype. C-50871, Slide 1101-6C, 34.5 x 128.5, (11) lo-focus on dorsal surface, (12) hi-focus on ventral surface, GSC 58584, x500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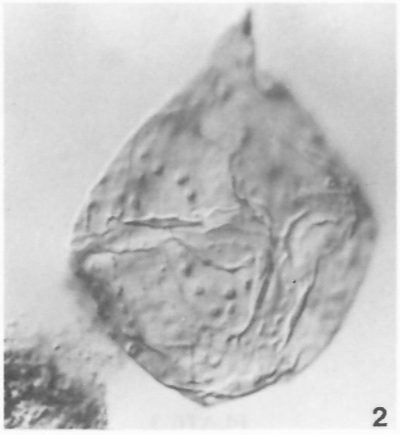
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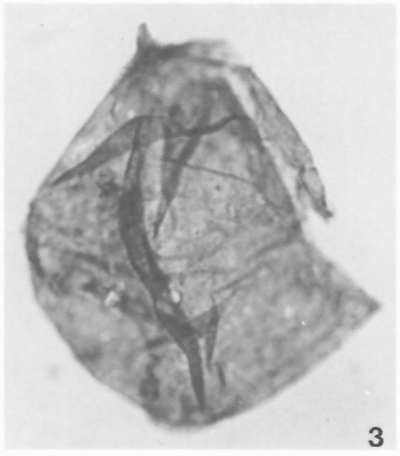
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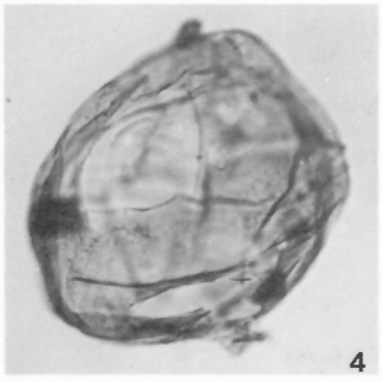
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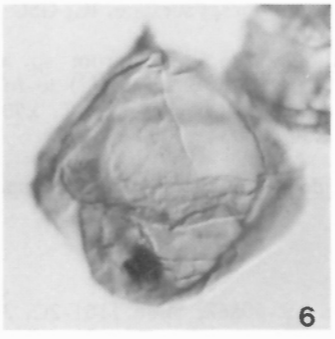
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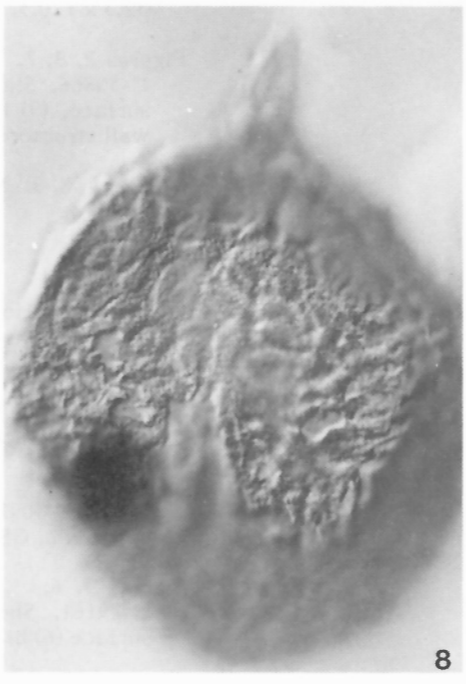
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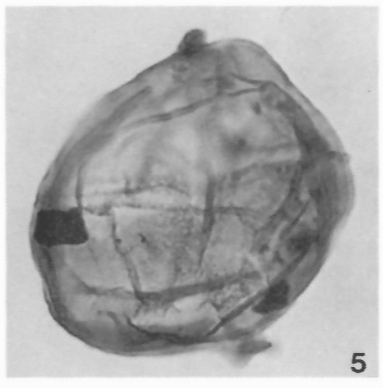
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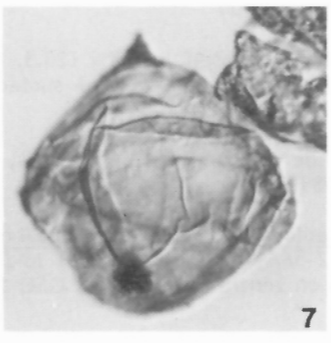
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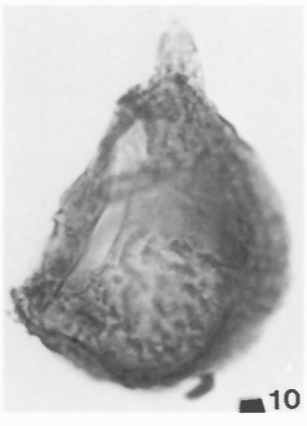
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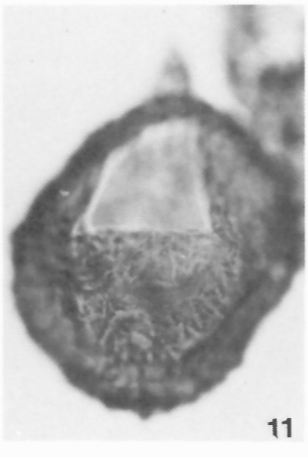
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PLATE 3

Figure 1. Druggidium? sp. AE C-50871, Slide 1101-6C, 32.5 x 120.5, hi-focus on dorsal surface, IC, GSC 58585, x1000

Figures 2, 3, 7. Millioudinium saetigerum sp. nov. Holotype. C-50866, Slide 1101-1D, 22.5 x 127.9, (2) lo-focus on ventral surface, (3) hi-focus on dorsal surface, IC, x500, (7) focus on wall structure, IC, GSC 58586, x1000

Figures 4, 8, 9. Millioudodinium spinoreticulatum sp. nov.

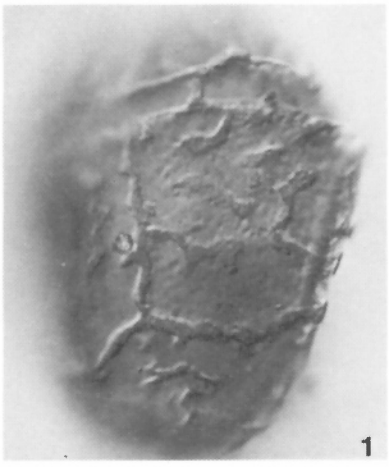
10-12.

4, 9, 12. Holotype. C-50867, Slide 1101-2C, 31.0 x 122.6, (4) lo-focus on ventral surface, (9) hi-focus on dorsal surface (12) mid-focus, GSC 58587, x1000

8, 11. C-50922, Slide 1102-4C, 27.8 x 123.3, (8) hi-focus on dorsal surface, (11) lo-focus on ventral surface, GSC 58588, x1000

10. C-50921, Slide 1102-3C, 16.6 x 132.4, mid-focus on reticulum, GSC 58589, x1000

Figures 5, 6. Gonyaulacysta spp. (cretacea/helicoidea group) C-29161, Slide 912-56A, 22.7 x 126.3, (5) lo-focus on dorsal surface (6) hi-focus on ventral surface, IC, GSC 58590, x500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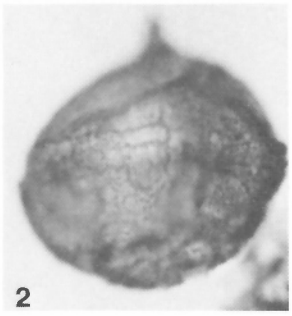
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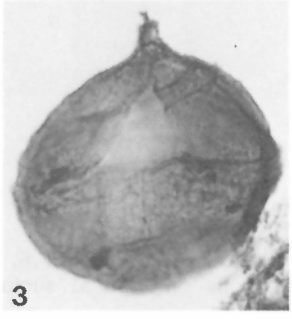
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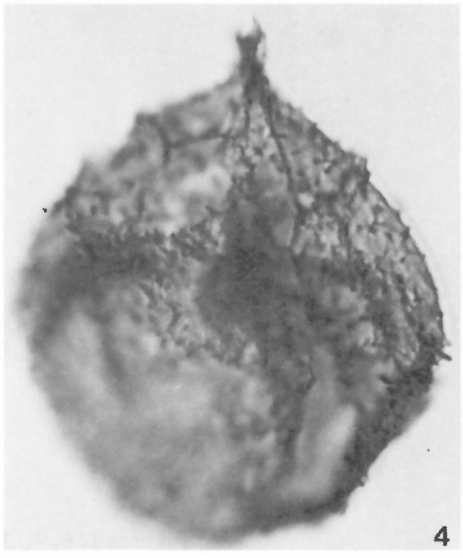
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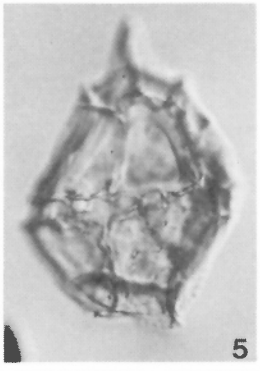
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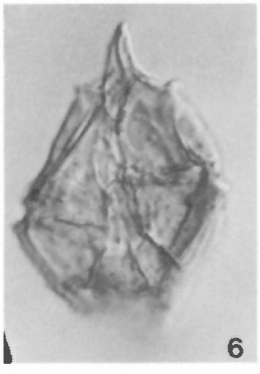
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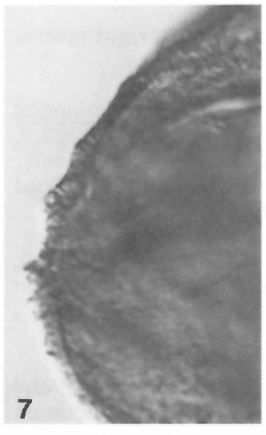
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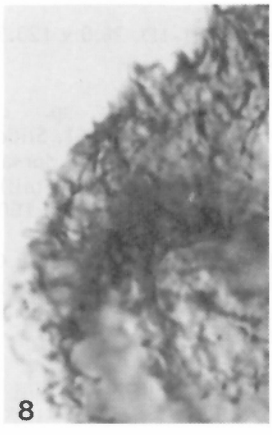
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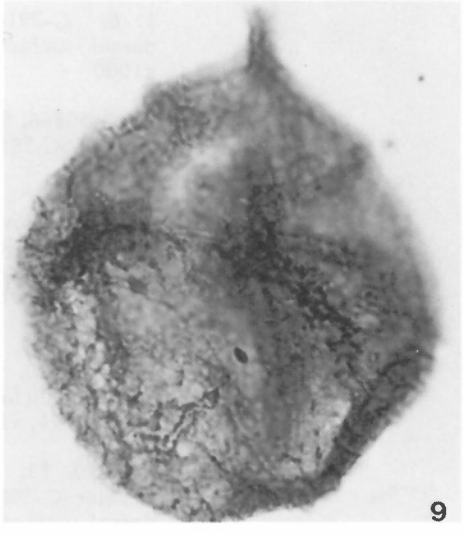
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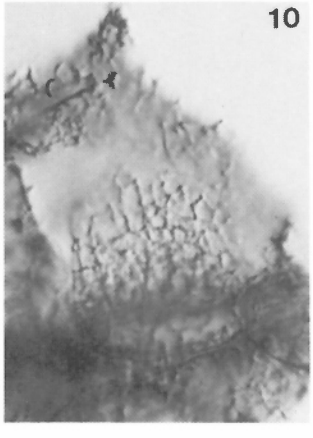
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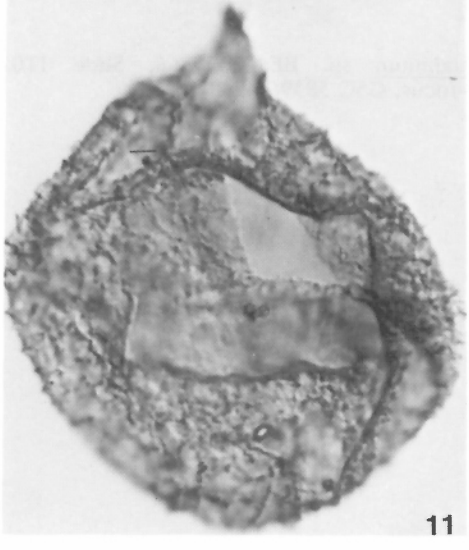
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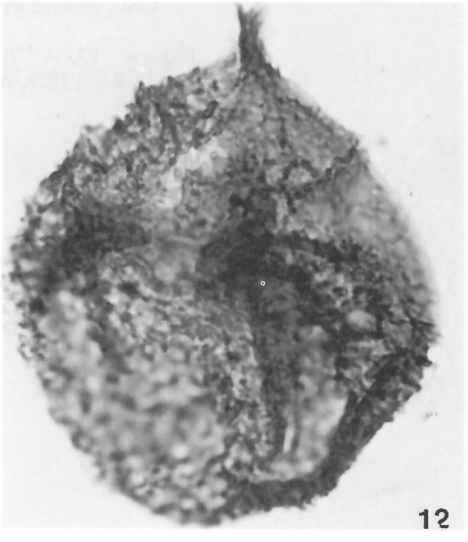
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PLATE 4

Figures 1, 6, 7. Impagidinium sp.

1. 6. C-29161, Slide 912-56D, 23.0 x 127.6, (1) hi-focus on dorsal surface, (6) lo-focus on ventral surface, GSC 58591, x1000

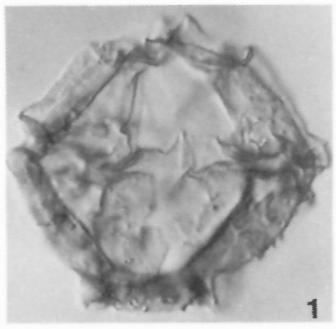
7. C-50866, Slides 1101-1D, 26.0 x 123.3, hi-focus, right lateral view, GSC 58592, x1000

Figures 2-5. Gonyaulacysta sp. cf. G. kostromiensis (Vozzhennikova) Sarjeant C-29161, Slide 912-56A, 20.5 x 123.9, (2, 3) hi and lo foci on ventral and dorsal surfaces respectively, IC, x500, (4, 5) hi and lo foci (detail) of ventral and dorsal apices respectively, IC, GSC-58593, x1000

Figures 8, 9, 11. Meiourogonyaulax sp. AE C-29161, Slide 912-56G, 32.6 x 127.0, (8) hi-focus on dorsal surface, (9) lo-focus on ventral surface, (11) lo-lo-focus on ventral surface, IC, GSC 58594, x1000

Figures 10, 13. Trichodinium castaneum (Deflandre) Clarke and Verdier C-50866, Slide 1101-6C, 41.7 x 122.3, (10) hi-focus on dorsal surface and archeopyle, (13) lo-focus on ventral surface, GSC 58595, x1000

Figure 12. Trichodinium sp. BE C-50866, Slide 1101-6C, 38.2 x 120.3, mid-focus, GSC 58596, x500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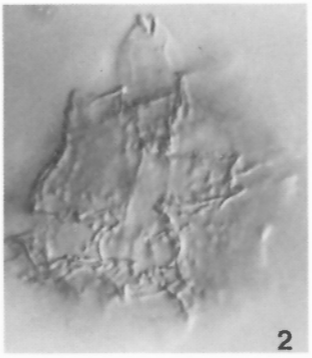
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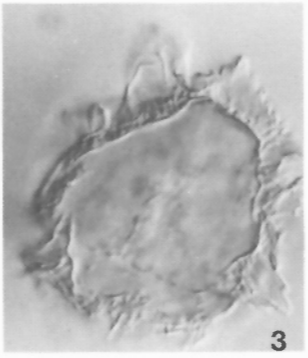
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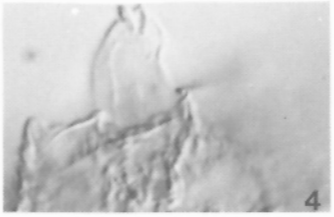
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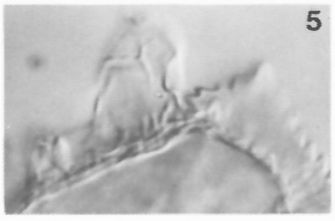
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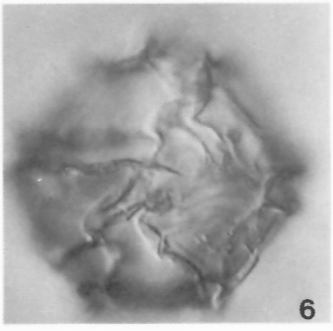
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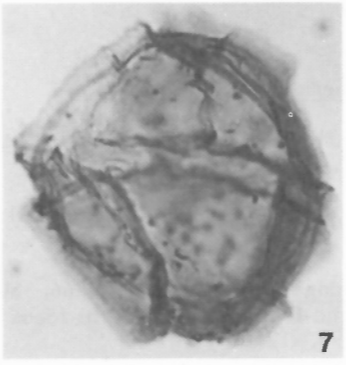
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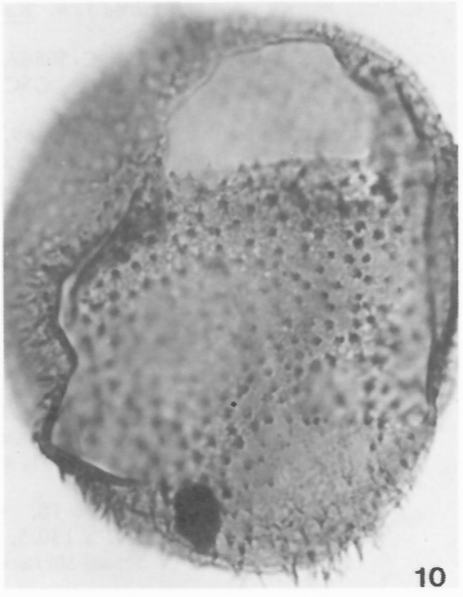
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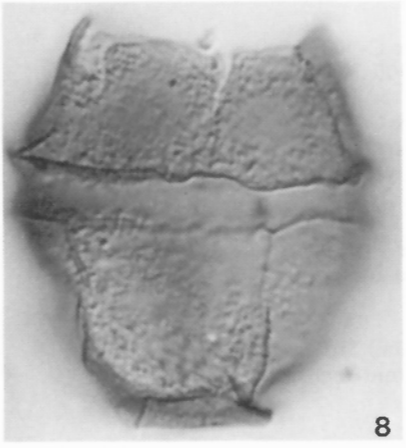
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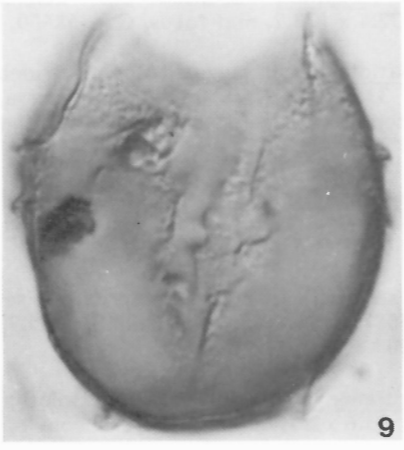
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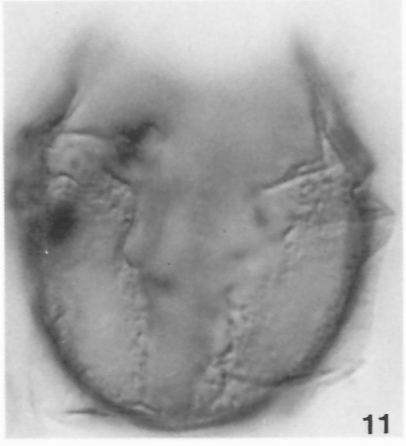
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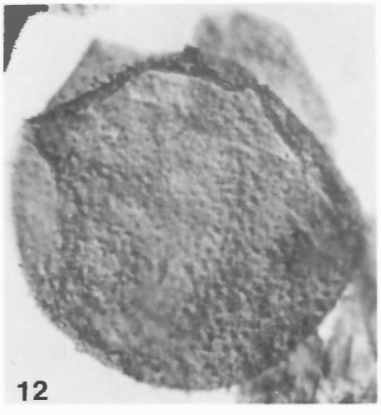
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PLATE 5

Figures 1, 4. Kallosphaeridium sp. AE

1. C-50867, Slide 1101-2C, 38.1 x 122.9, lo-focus on ventral surface, GSC 58597, x1000

4. C-50869, Slide 1101-4C, 38.3 x 130.6, detail of ornament, GSC 58598, x1250

Figures 2, 3. Canningia sp. CE C-50866, Slide 1101-1D, 38.5 x 134.4, (2) mid-focus, x1000 (3) hi-focus on detail of ornament, GSC 58599, x1250

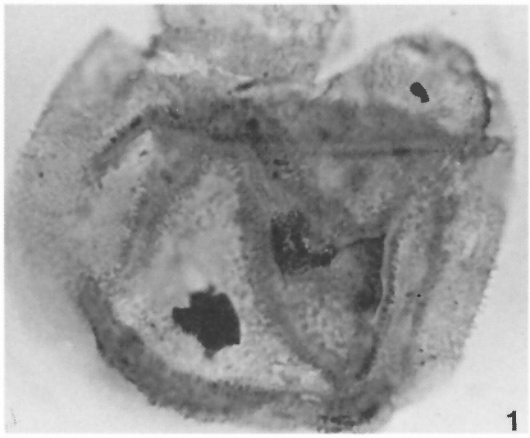
Figure 5. Fromea amphora Cookson and Eisenack C-50866, Slide 1101-1C, 32.4 x 123.2, mid-focus, GSC 58600, x500

Figures 6, 8, 11. Batioladinium jaegeri (Alberti) Brideaux C-50867, Slide 1101-2D, 33.6 x 125.7, (6) hi-focus on dorsal archeopyle trace, (8) mid-focus, (11) lo-focus on ventral archeopyle trace, GSC 58601, x1000

Figures 7, 10. Kallosphaeridium sp. BE C-50869, Slide 1101-4C, 34.1 x 130.5, (7) hi-focus on ventral surface, (10) lo-focus on dorsal surface, IC, GSC 58602, x1000

Figure 9. Fromea sp. cf. F. fragilis (Cookson and Eisenack) Stover and Evitt C-50871, Slide 1101-6C, 23.0 x 125.9, mid-focus, GSC 58603, x500

Figure 12. Palaeostomocystis senilis sp. nov. Holotype. C-50871, Slide 1101-6C, 43.6 x131.4, focus on archeopyle, GSC 58604, x1000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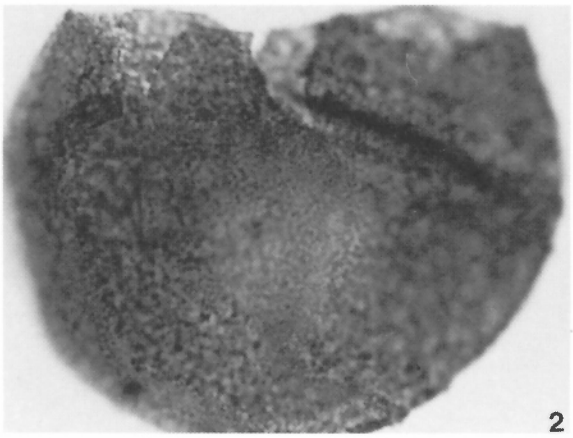
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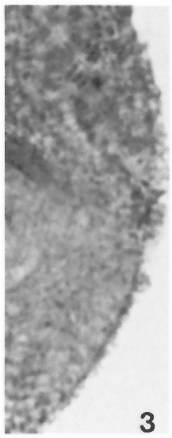
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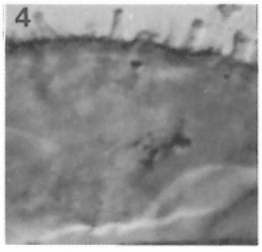
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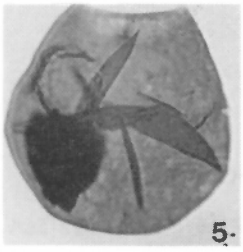
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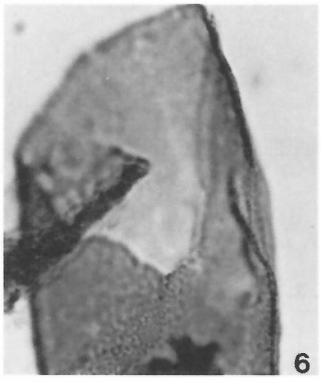
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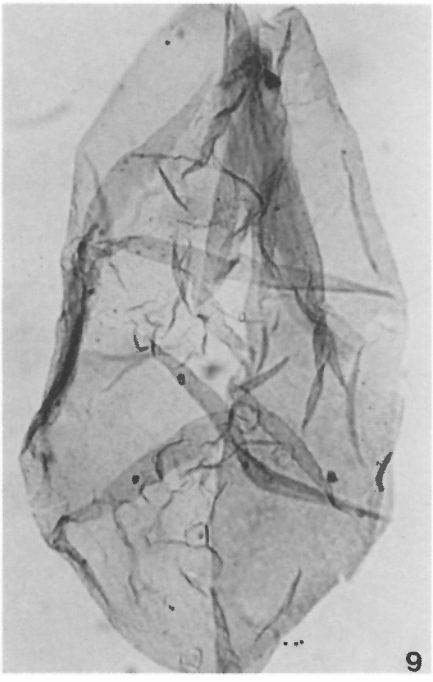
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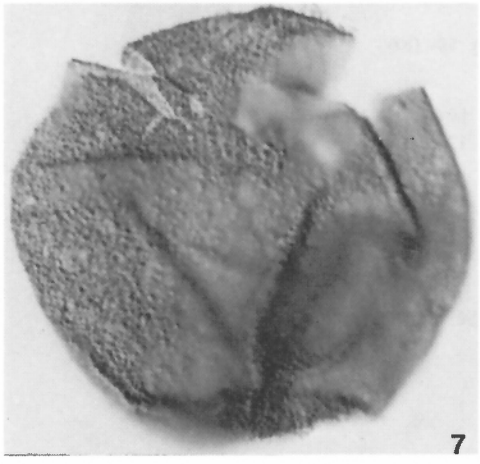
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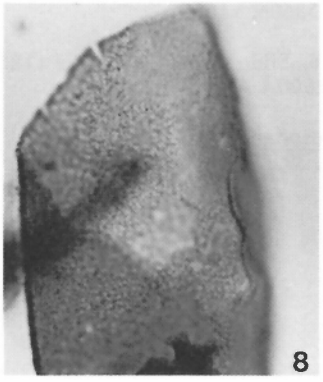
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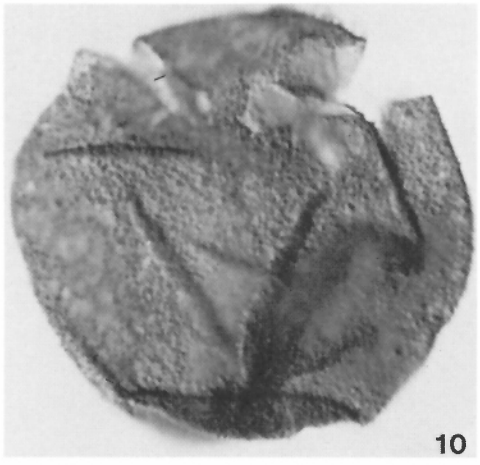
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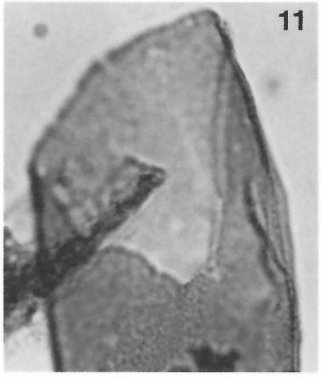
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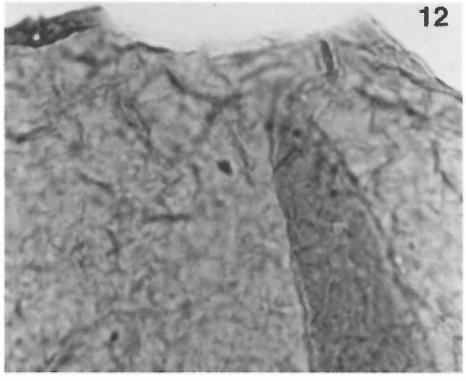
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PLATE 6

Figure 1. Palaeostomocystis senilis sp. nov. Holotype. C-50871, Slide 1101-6C, 43.6 x 134.1, mid-focus, GSC 58604, x300

Figures 2, 3. Bourkidinium sp. AE C-29161, Slide 912-56A, 42.5 x 122.7, mid and lo foci, IC, GSC 58605, x1000

Figures 4, 5, 7, 8. Cleistosphaeridium separatum sp. nov.

4, 5. Holotype. C-12624, ARCO Slide 10614 A2, Banff-Aquitaine-Arco Rat Pass K-35 well, 17.1 x 125.7, hi and mid foci, IC, GSC 58606, x1000

7, 8. C-50866, Slide 1101-1D, 17.3 x 118.0, hi and lo foci, IC, GSC 58607, x1000

Figure 6. Cleistosphaeridium araneosum Brideaux C-50871, Slide 1101-6C, 39.7 x 131.4, mid-focus, IC, GSC 58608, x500


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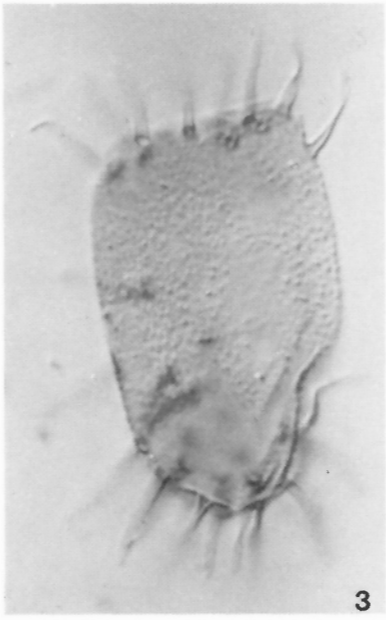
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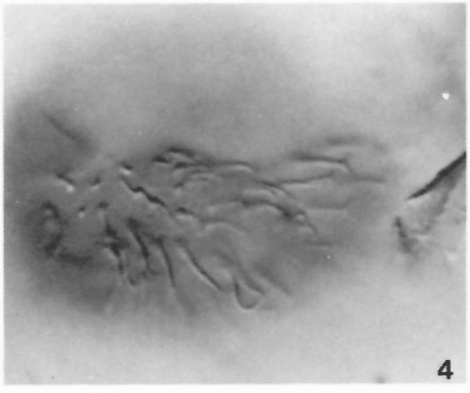
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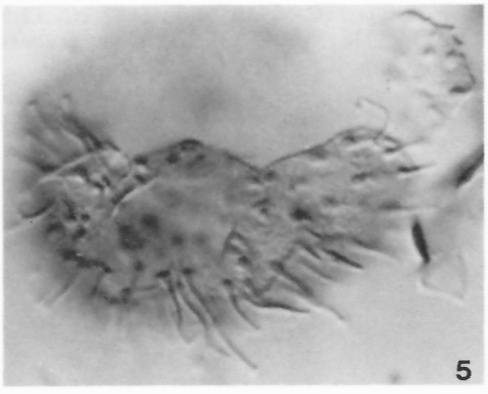
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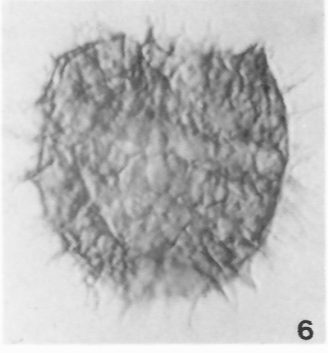
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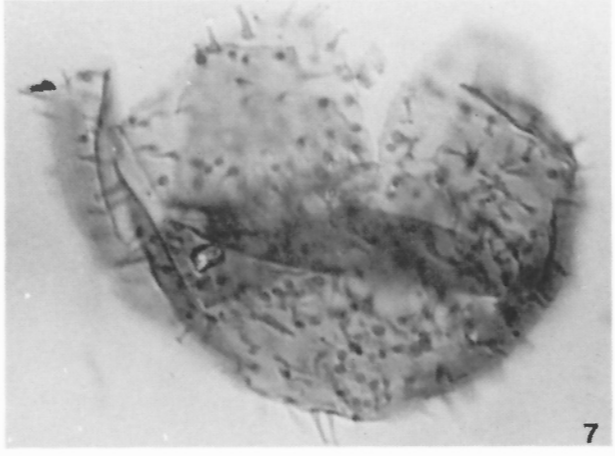
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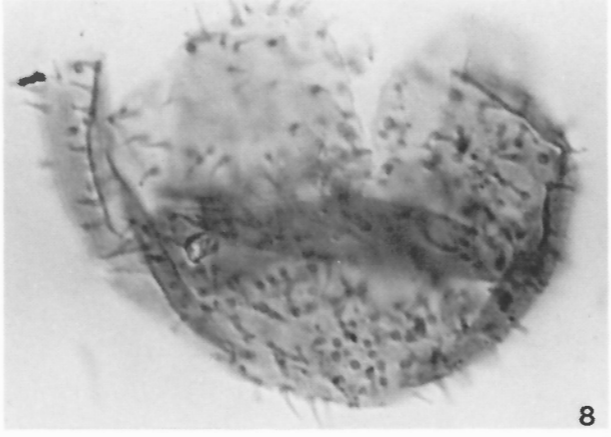
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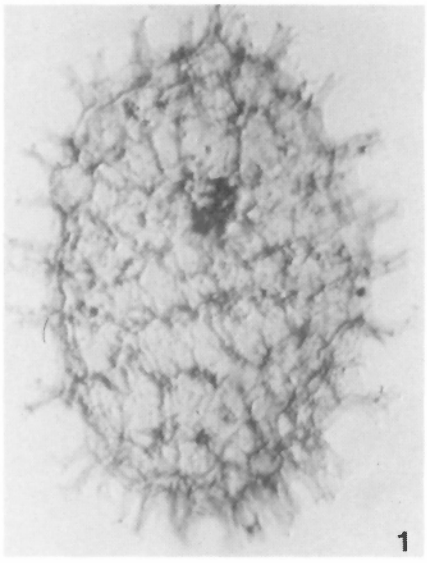
PLATE 7

Figures 1-9. Cleistosphaeridium spissum sp. nov.

1-4. Holotype. C-50920, Slide 1102-2C, 12.5 x 122.6, (1, 2) hi and lo foci IC, x500, (3) focus on processes, (4) focus on ?pericingulum, IC, x1000, GSC 58609

5, 6. C-50919, Slide 1102-1C, 23.2 x 132.6, hi and mid foci on processes, IC, GSC 58610, x1000

7-9. C-50919, Slide 1102-1C, 40.5 x 127.6, hi-mid and lo foci, IC, GSC 58611, x1000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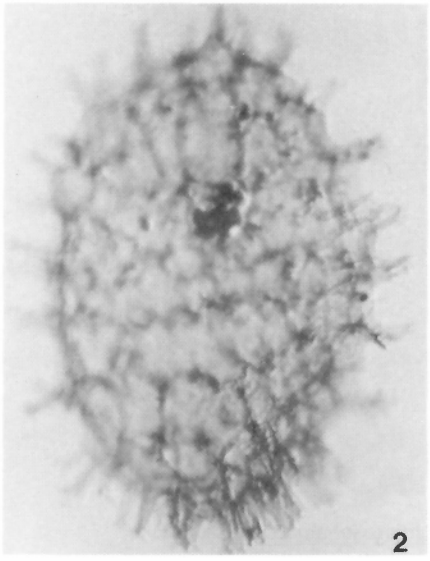
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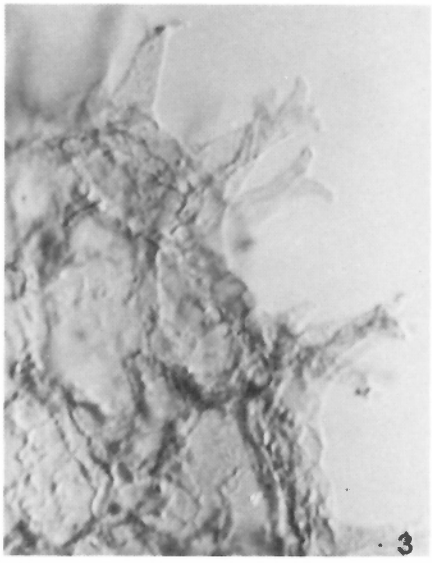
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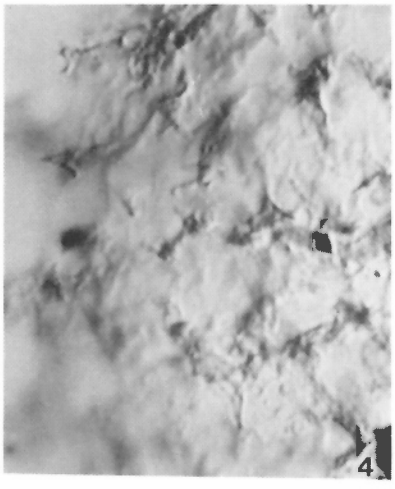
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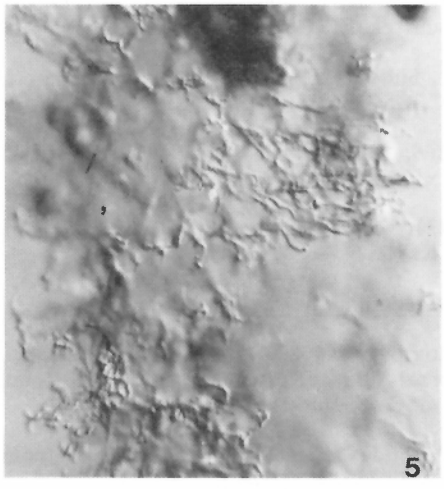
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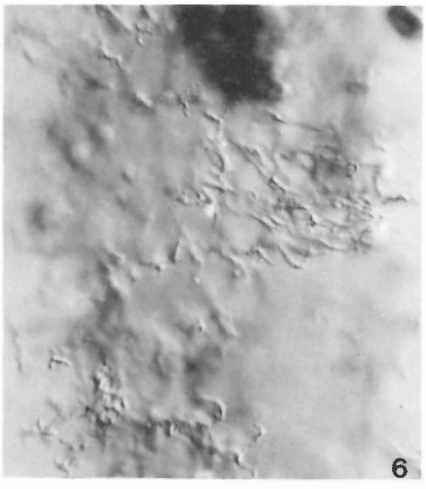
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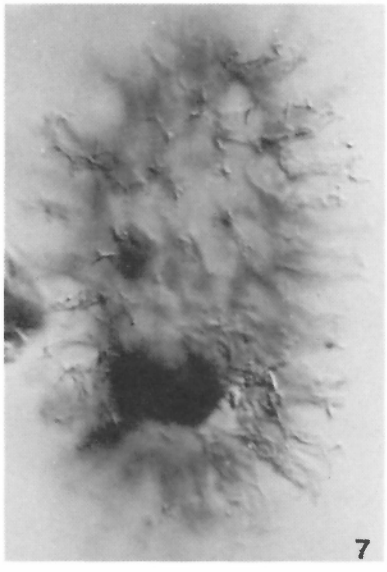
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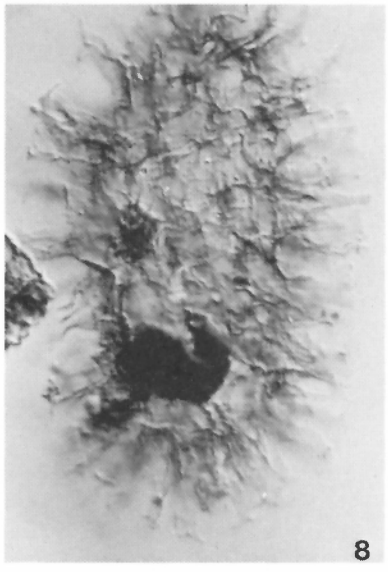
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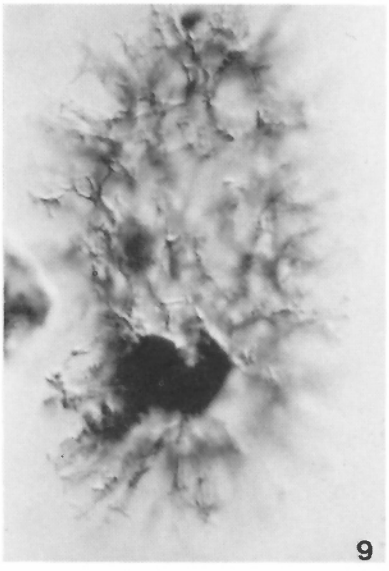
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PLATE 8

Figures 1-5. Cleistosphaeridium sp. KE

1, 2. C-29145, Slide 912-40C, 40.7 x 119.2, (1) hi-focus, (2) mid-focus on processes, IC, GSC 58612, x1000

3. C-29161, Slide 912-56A, 14.9 x 134.4, focus on pericingular processes, IC, GSC 58613, x1000

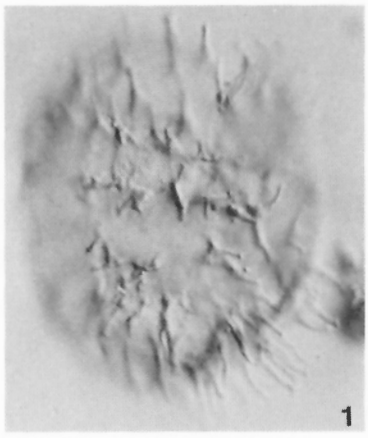
4. C-50866, Slide 1101-1D, 34.7 x 122.8, lo-focus, IC, GSC 58614, x1000

5. C-50871, Slide 1101-6C, 43.7 x 125.3, mid-focus on archeopyle, IC, GSC 58615, x1000

Figures 6-9. Ctenidodinium scissum sp. nov.

6, 8, 9. Holotype. C-50871, Slide 1101-6D, 27.5 x 130.0, (6) hi-focus on dorsal surface, (8) mid-focus, (9) lo-focus on ventral surface, IC, GSC 58616, x1000

7. C-50871, Slide 1101-6C, 24.8 x 116.0, hi-focus on ventral surface, IC, GSC 58617, x1000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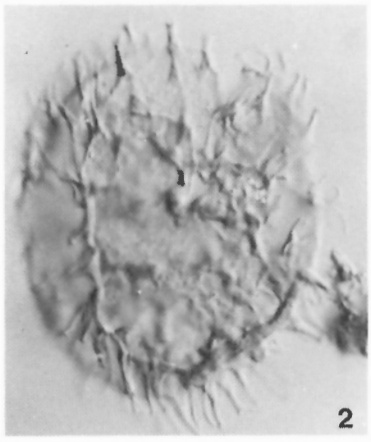
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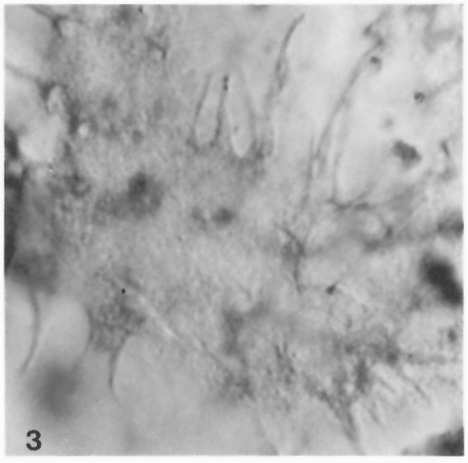
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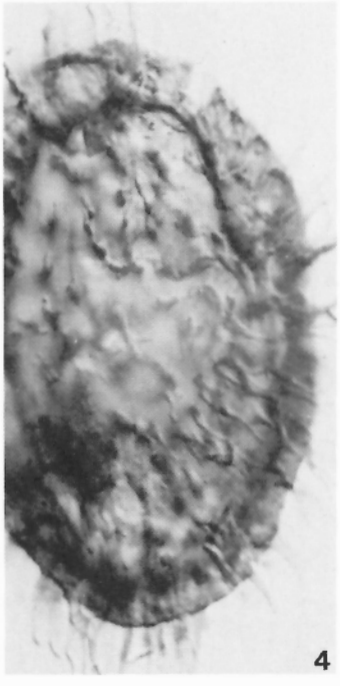
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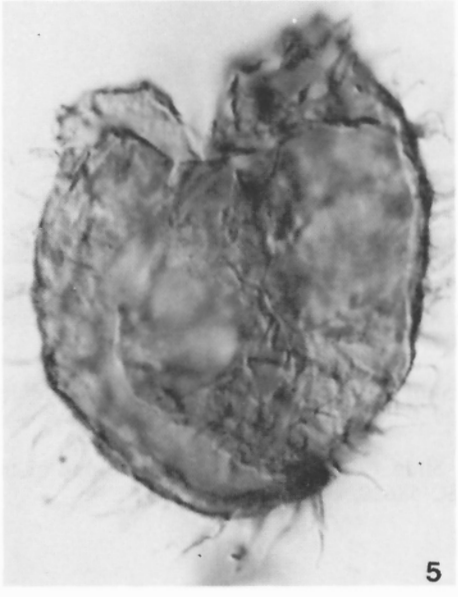
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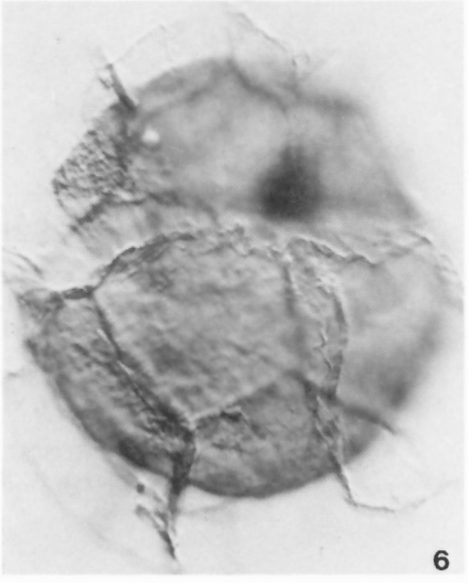
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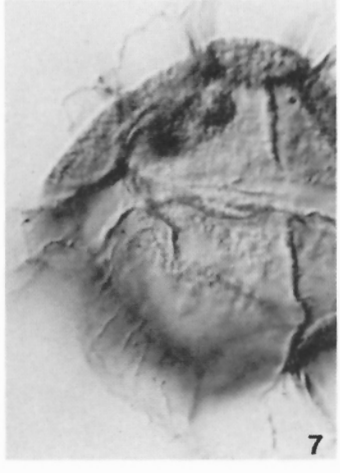
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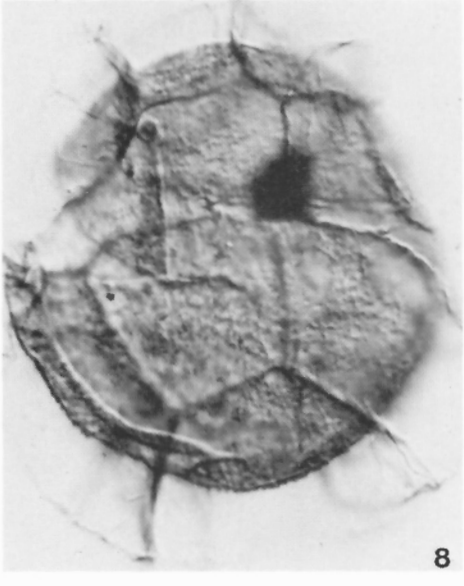
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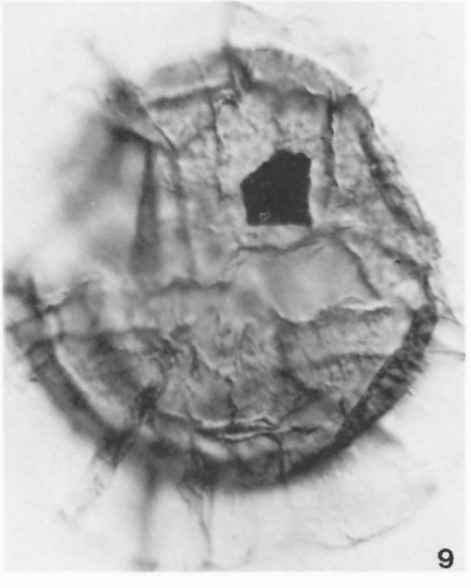
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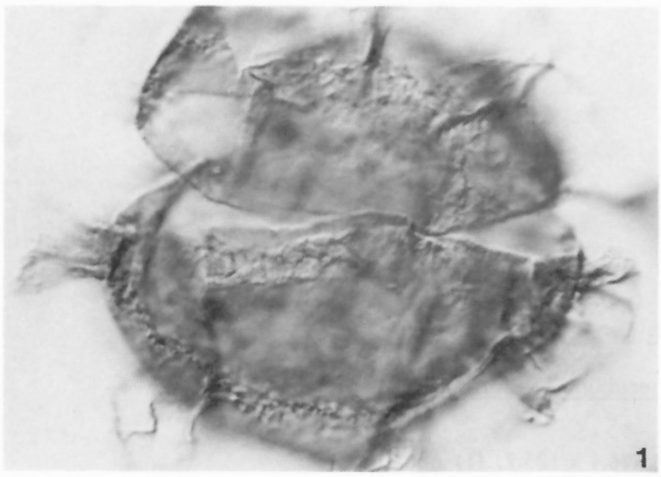
PLATE 9

Figures 1-6. Ctenidodinium scissum sp. nov.

1, 2. C-50871, Slide 1101-6C, 18.4 x 126.9, (1) lo-focus on archeopyle, (2) hi-focus on attached part of epicyst, IC, GSC 58618, x1000

3-4. C-50871, Slide 1101-6C, 25.3 x 128.4, hi and lo foci, IC. GSC 58619, x1000

5, 6. C-50871, Slide 1101-6C, 20.5 x 133.8, lo and hi focus on hypocyst, IC, GSC 58620, x1000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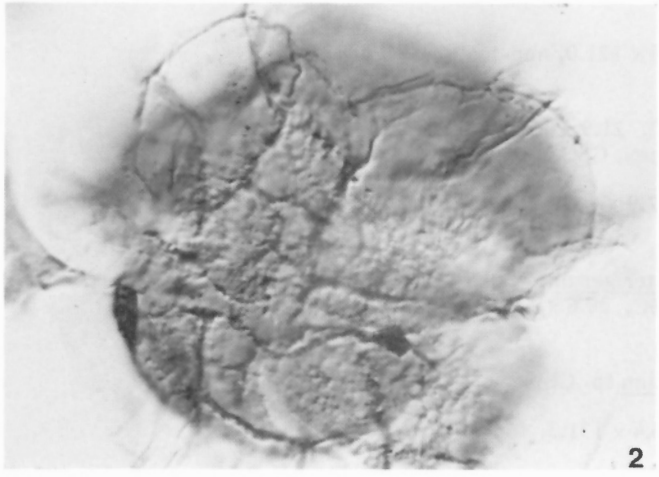
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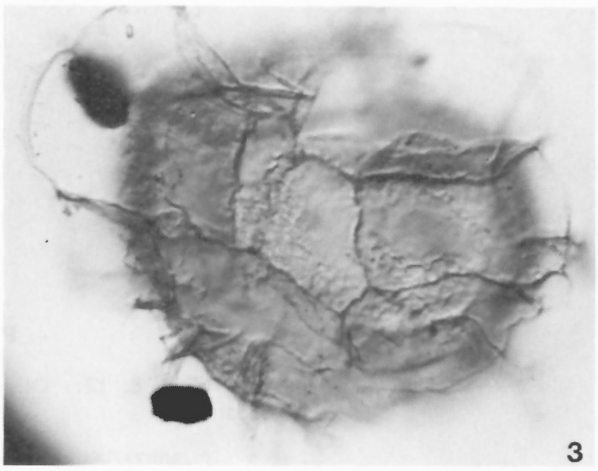
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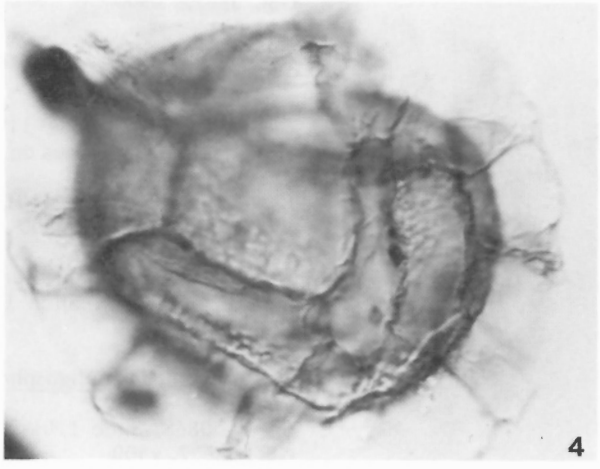
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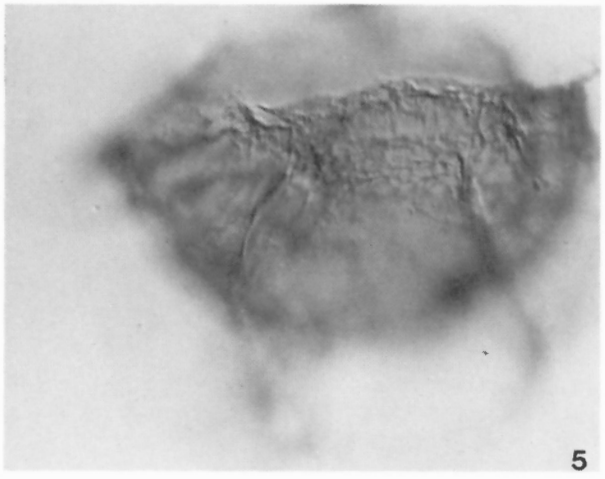
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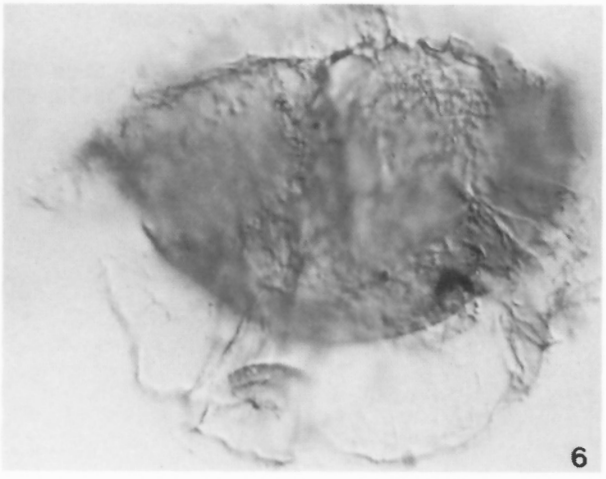
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PLATE 10

Figures 1-4, 7, 8, 12. Oligosphaeridium vasiformum Neale and Sarjeant

1, 2. C-50871, Slide 1101-6C, 46.1 x 123.7, (1) mid-focus on archeopyle, (2) lo-focus on ventral surface, with processes 5", 6" at top right, GSC 58621, x300

3. C-50868, Slide 1101-3C, 42.4 x 123.5, focus on archeopyle, GSC 58622, x300

4. C-50867, Slide 1101-2C, 43.5 x 121.0, mid-focus, GSC 58623, x300

7, 8. C-50868, Slide 1101-3C, 21.9 x 126.3, (7) lo-focus on archeopyle, (8) hi-focus on antapex, GSC 58624, x300

12. C-50866, Slide 1101D, 27.9 x 119.4, hi-focus on ventral surface, GSC 58625, x300

Figure 5. Oligosphaeridium asterigerum (Gocht) Davey and Williams C-50871, Slide 1101-6C, 20.6 x 123.4, mid-focus, IC, GSC 58626, x300

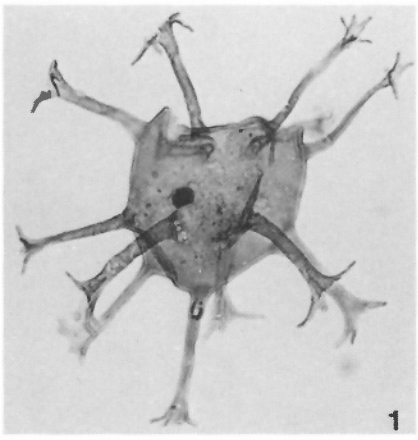
Figures 6, 9, 10, 11. Oligosphaeridium sp. GE

6. C-50868, Slide 1101-3C, 30.4 x 131.3, focus on archeopyle, GSC 58627, x500

9. C-50869, Slide 1101-4A, 45.6 x 133.2, hi-focus interior view of operculum, GSC 58628, x500

10. C-50871,Slide 1101-6D, 46.9 x 123.6, mid-focus, GSC 58629, x500

11. C-50869, Slide 1101-4A, 38.3 x 130.4, mid-focus on operculum, GSC 58630, x500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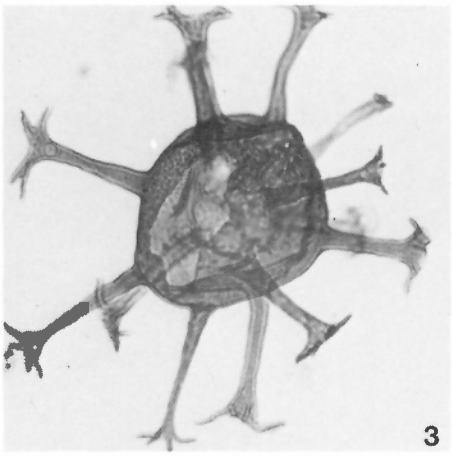
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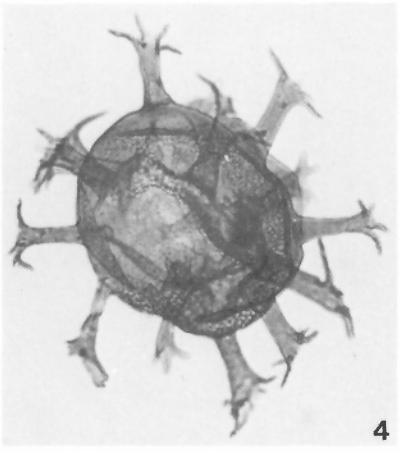
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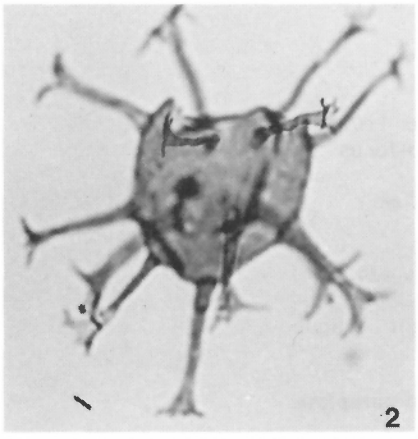
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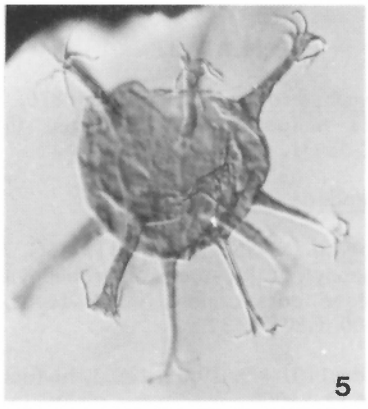
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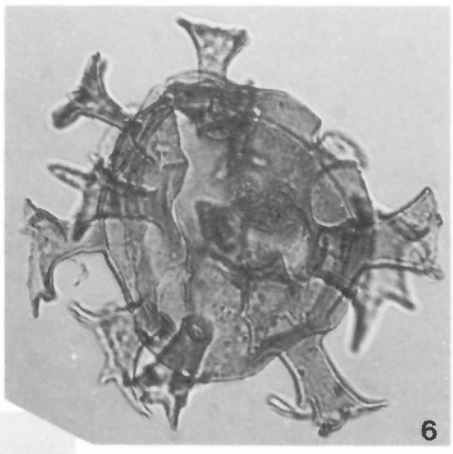
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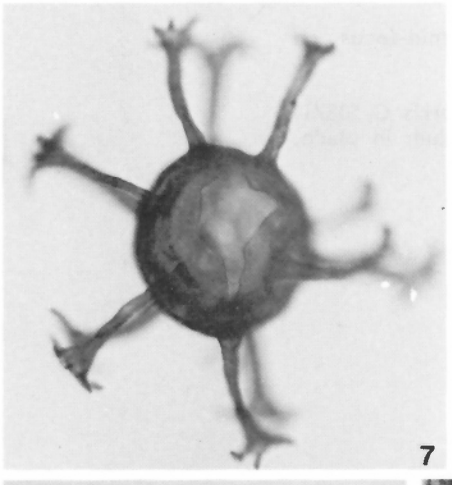
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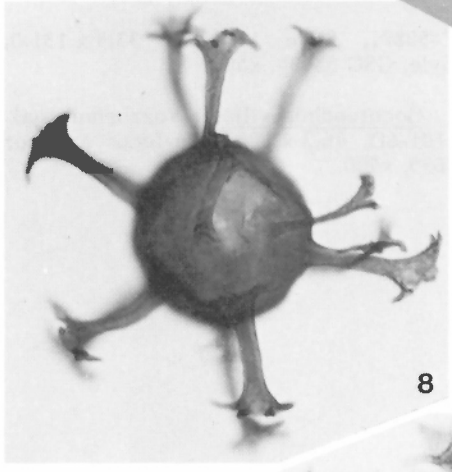
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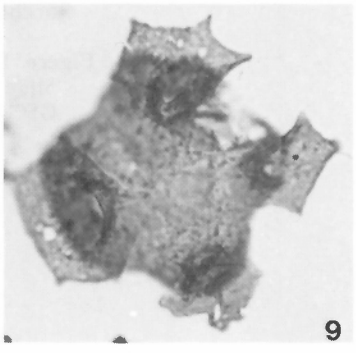
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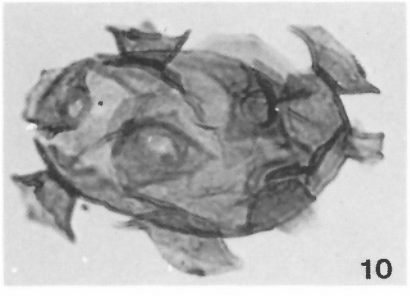
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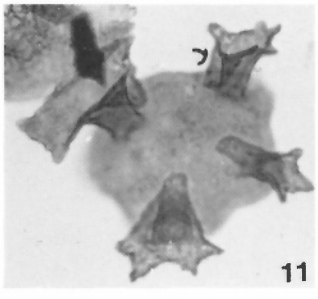
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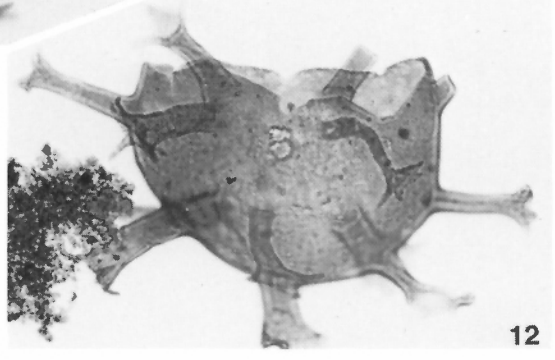
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PLATE 11

Figures 1-3. Polysphaeridium sp. AE C-50870, Slide 1101-5C, 24.0 x 125.7, (1) hi-focus, (2) mid-focus, (3) lo-focus on archeopyle, GSC 58631, x1000

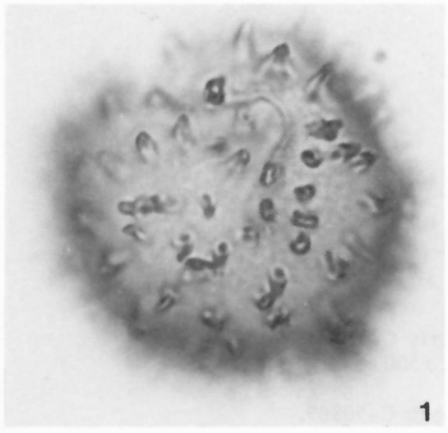
Figures 4-9. Gochteodinia judilentinae sp. nov.

4, 5, 7, 8. Holotype. C-50871, Slide 1101-6C, 32.3 x 124.3, (4) hi-focus on archeopyle, (5) lo-focus on archeopyle, x1000, (7) hi-focus, left oblique dorsal view, (8) lo-focus, right oblique ventral view, x500, GSC 58632

6. C-50869, Slide 1101-4D, 19.6 x 120.3, hi-focus on paraplate process, GSC 58633, x1000

9. C-50871, Slide 1101-6D, 33.3 x 131.0, mid-focus on archeopyle, GSC 58634, x500

Figure 10. Gochteodinia villosa (Vozzhennikova) Norris C-50871, Slide 1101-6D, 46.2 x 124.8, hi-focus on operculum in place, GSC 58635, x500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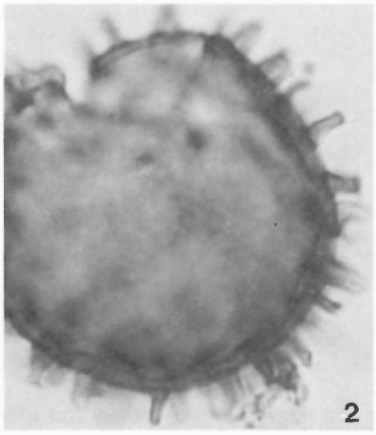
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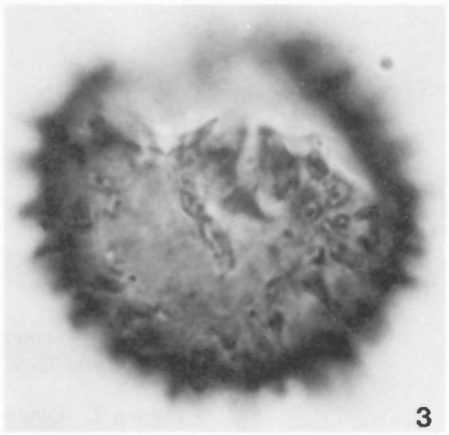
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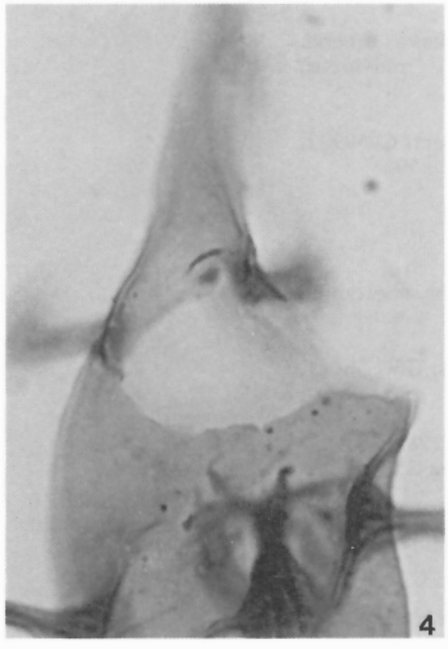
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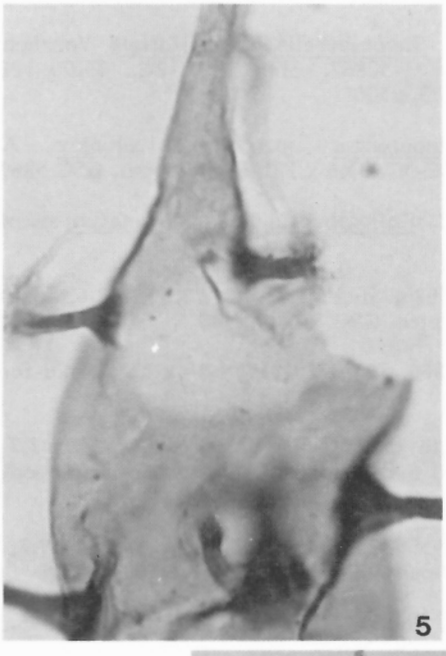
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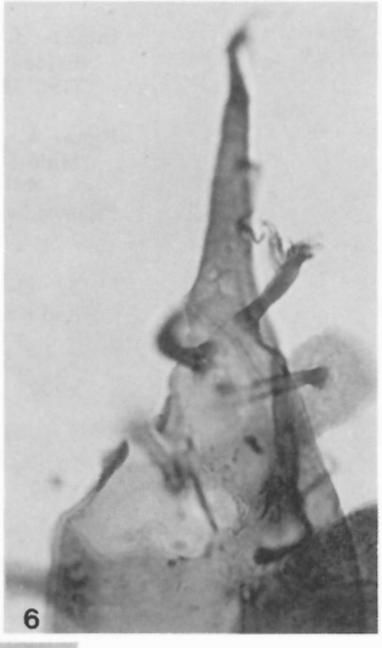
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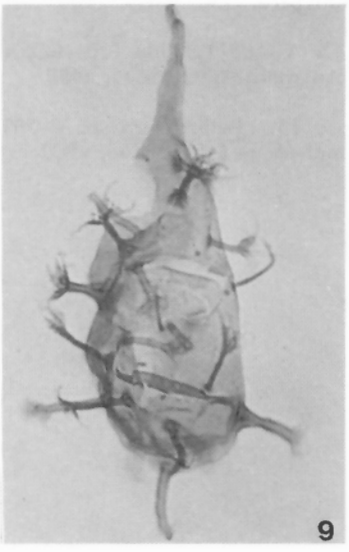
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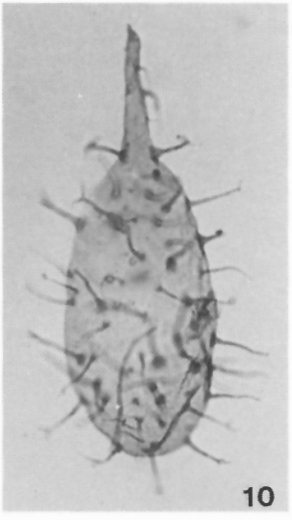
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PLATE 12

Figure 1. Gochteodinia villosa (Vozzhennikova) Norris C-50923, Slide 1102-5C, 27.7 x 130.5, mid-focus, GSC 58636, x500

Figure 2. Dingodinium cerviculum Cookson and Eisenack C-50869, Slide 1101-4F, 14.7 x 127.3, mid-focus, GSC 58637, x1000

Figure 3. Tubotuberella rhombiformis Vozzhennikova emend. Brideaux C-50867, Slide 1101-2C, 35.0 x 122.5, mid-focus, GSC 58638, x500

Figure 4. Muderongia sp. cf. M. simplex Alberti C-50923, Slide 1102-5C, 35.6 x 121.2, mid-focus, GSC 58639, x500

Figures 5-12. Kallosphaeridium? agglutinatum sp. nov.

5. C-50920, Slide 1102-2C, 22.5 x 118.6, focus on operculum and Kalyptra, GSC 58640, x500

6. C-50866, Slide 1101-1B, 12.4 x 131.2, mid-focus, GSC 58641, x500

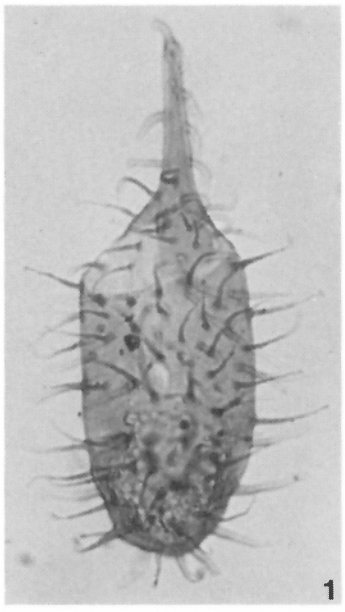
7-9. Holotype. C-50868, Slide 1101-3C, 43.7 x 128.4, (7) hi-focus, (8) mid-lo-focus, (9) lo-focus on archeopyle, GSC 58642, x500

10. C-50920, Slide 1102-2C, 38.3 x 119.7, mid-focus on attached operculum, GSC 58643, x500

11. C-50868, Slide 1101-3C, 42.8 x 124.6, mid-focus on kalyptra, GSC 58644, x500

12. C-50871, Slide 1101-6C, 40.6 x 125.6, focus on periphragm ornament, GSC 58645, x500

Figure 13. Pediastrum sp. C-50922, Slide 1102-4C, 33.8 x 131.7, mid-focus, GSC 58646, x500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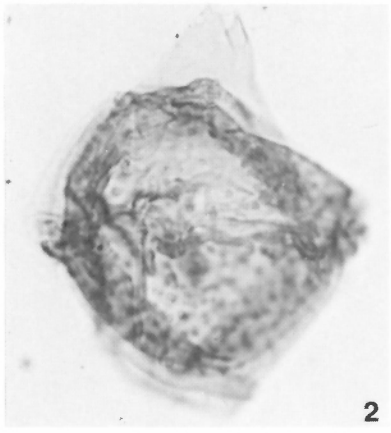
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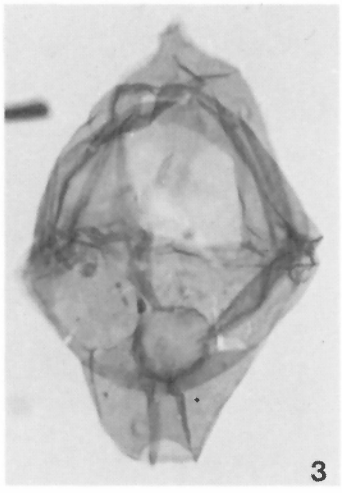
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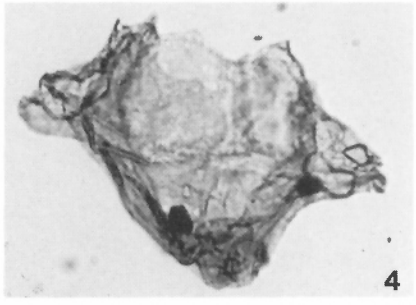
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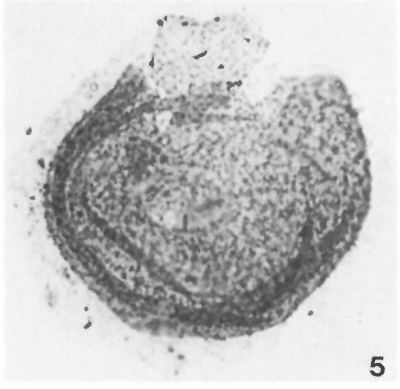
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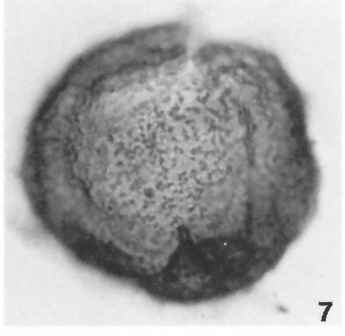
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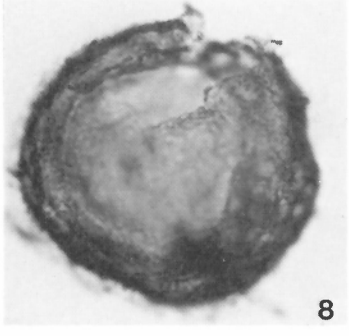
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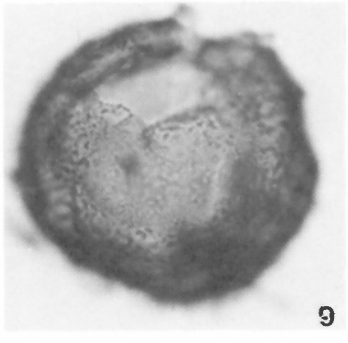
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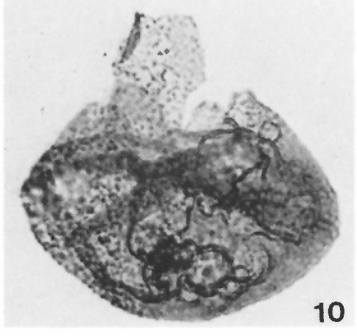
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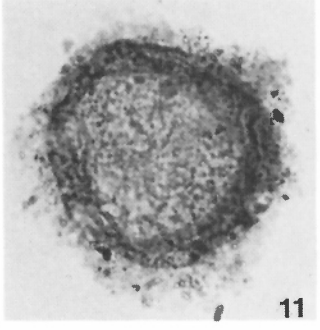
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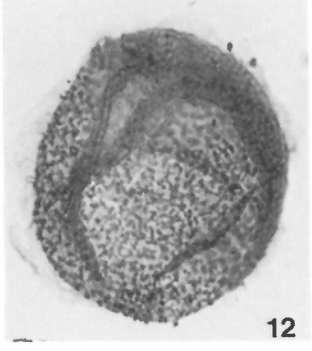
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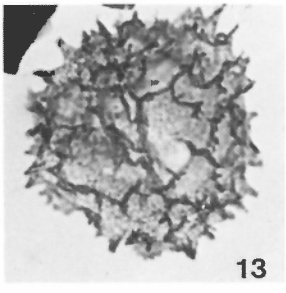
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