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MIOSPORES AND MICROPLANKTON FROM APTIAN – ALBIAN ROCKS ALONG HORTON RIVER, DISTRICT OF MACKENZIE

W. W. Brideaux and D. J. McIntyre

1975

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PREFACE

This report describes spores, pollen, dinoflagellates and acritarchs from two Lower Cretaceous formations exposed in seven sections along Horton River, northwestern District of Mackenzie.

Such detailed paleontological studies provide data for the calibration of the geological time scale so necessary for the precise dating and correlation of the rocks that make up the geological framework of Canada.

D.J. McLaren,
Director General,
Geological Survey of Canada.

Ottawa, August 8, 1975

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ABSTRACT

In this paper are described the biostratigraphy, paleoecology and taxonomy of spores, pollen, dinoflagellate cysts and acritarchs from seven surface sections along Horton River, District of Mackenzie, Canada.

The Langton Bay Formation is composed of two members. The lower Gilmore Lake Member, is of Aptian age and predominantly nonmarine in origin except for a shallow-marine interval at the top of the type section. The upper, Crossley Lakes Member, is of Aptian age in the lower, nonmarine part, Early Albian age in the medial part, and Middle Albian age in the upper part. The medial part of the member is of shallow-marine, nearshore origin and the upper part is of shallow-water, but more open marine origin. The Horton River Formation is of Middle Albian age and was deposited in an open-marine, probably deeper water environment.

The composition of the dinoflagellate assemblages in the two formations is determined mainly by the local depositional environment, but secondary latitudinal influences cannot be ruled out.

One hundred and eight species of spores and pollen and 64 species and 2 subspecies of dinoflagellates and acritarchs are treated. One new bisaccate pollen species, *Parvisaccites hortonensis*, is described. A new dinoflagellate genus, *Luxadinium*, is described, as well as eight new species. These are: *Leptodinium cancellatum, Leptodinium modicum, Microdinium spinosum, Dictyopyxidia imperfecta, Pterodinium verrucosum, Scriniodinium rostratum, Senoniasphaera microreticulata* and *Luxadinium primulum*. A new species, *Luxadinium propatulum* gen. et sp. nov., is introduced.

RÉSUMÉ

Cette étude donne une description de la biostratigraphie, de la paléoécologie et de la description systematique des spores, du pollen, des thèques dinoflagellées et des acritarchs provenand de sept coupes en surface le long de la rivière Horton, dans le district de Mackenzie au Canada.

La formation de Langton Bay comprend deux niveaux. Le niveau inférieur, celui de Gilmore Lake date de l'Aptien et n'est pas d'origine marine pour la plus grande partie à l'exception d'un intervalle stratigraphique formé dans un environnement marin peu profond qui se trouve sur le dessus de la coupe type. Le niveau supérieur, celui de Crossley Lakes, date de l'Aptien en ce qui concerne sa partie inférieure qui n'est pas d'origine marine, du début de l'Albien dans sa partie médiane et de l'Albien moyen dans sa partie supérieure. La partie moyenne du niveau provient d'une sédimentation de mer peu profond et de zone littorale, la partie supérieure provient également d'une sédimentation de mer peu profond mais plus ouverte. La formation de Horton River date de l'Albien moyen et s'est déposée dans un environnement marin plus ouverte et probablement plus profond.

La composition des assemblages de dinoflagellés présents dans les deux formations est déterminée principalement par le milieu local de sédimentation cependant on ne peut exclure les effets latitudinaux.

On traite de 108 espèces de spores et de pollens et de 64 espèces et deux sous-espèces de dinoflagellés et d'acritarchs. On donne une description d'une nouvelle espèce de pollen bivésiculé, le *Parvisaccites hortonensis*. On propose un nouveau genre de dinoflagellés, *Luxadinium*, et huit nouvelles espèces. Ces espèces: *Leptodinium cancellatum, Leptodinium modicum, Microdinium spinosum, Dictyopyxidia imperfecta, Pterodinium verrucosum, Scriniodinium rostratum, Senoniasphaera microreticulata* et *Luxadinium primulum*. On présente un nouveau nom, *Luxadinium propatulum* gen. et nom. nov.

MIOSPORES AND MICROPLANKTON FROM APTIAN-ALBIAN ROCKS ALONG HORTON RIVER, DISTRICT OF MACKENZIE, CANADA

INTRODUCTION

The main purpose of this paper is to record the abundant and diverse assemblages of spores, pollen, dinoflagellates and acritarchs from seven stratigraphic sections of Lower Cretaceous rocks along Horton River, east of the main Mackenzie River delta. The biostratigraphic and paleoecologic significance of the assemblages is discussed in some detail, and the significance of these data in relation to other Lower Cretaceous assemblages described in the literature is assessed. This contribution is the first comprehensive report on Lower Cretaceous palynomorph assemblages from the northern Interior Plains and surrounding regions. It represents the results of part of a co-operative research project between the Geological Survey of Canada and Chevron Standard Limited.

The seven stratigraphic sections sampled are located along Horton River (Fig. 1), which flows in a northeasterly and then northerly direction through the northern portion of Anderson Plain, District of Mackenzie, before entering into Franklin Bay. The location and lithological description of each section are given in the Appendix. Lithologic columns for each section are given in Figure 2. Figure 3 is a table of formations, showing correlation of the formations dealt with in this paper with selected Lower Cretaceous formations of northern mainland Canada, the Arctic Islands, and parts of Alberta.

The samples used in this study are from stratigraphic sections described and collected by T.P. Chamney of the Institute of Sedimentary and Petroleum Geology in the summer field season of 1968 (Chamney, 1969a). The authors acknowledge his kind permission to use his field notes as the basis for lithologic columns and descriptions of the sections. These lithologic data constitute only a generalized description constructed in order to provide a geologic setting for the palynologic data presented herein.

The samples were collected as channel samples of the stated intervals (*see* Appendix). Palynologic preparation of the samples was carried out by Chevron Standard Limited, Calgary for all sections, with the exception of Section CR14A-68, which was processed by the Institute of Sedimentary and Petroleum Geology, Calgary. Samples and a set of slides for each sample from these sections are stored at the Institute of Sedimentary and Petroleum Geology, 3303 - 33 Street N.W., Calgary, T2L 2A7, Canada, and a duplicate set is stored at Chevron Standard Limited, 400 - 5 Avenue S.W., Calgary, T2P 0L7, Canada. Slides containing holotype and figured specimens are stored in the collection of the Geological Survey of Canada, 601 Booth Street, Ottawa, K1A 0E8, Canada.

Responsibility for examination and description of the miospore assemblages rests with D.J. McIntyre, and for the microplankton assemblages with W.W. Brideaux. However, the observations and conclusions expressed in the text are to be ascribed to both authors.

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PREVIOUS WORK

CRETACEOUS PALYNOLOGY

Relatively few taxonomic or biostratigraphic papers have been published on the Cretaceous palynology of the northern Interior Plains and the Canadian Arctic Archipelago. Most of the papers and short notes published have dealt with spore and pollen assemblages, but a few have included, or dealt exclusively with, dinoflagellate and acritarch assemblages. Papers describing Lower Cretaceous spores and pollen include: Hopkins (1971c) on the upper Valanginian-?Aptian Isachsen Formation of Melville Island; Hopkins (1974) on the Albian Christopher Formation of Melville, Amund Ringnes and Ellef Ringnes Islands; and Hopkins and Balkwill (1973) on the Upper Albian or Lower Cenomanian Hassel Formation of eastern Ellef Ringnes Island. Papers dealing with Upper Cretaceous palynology include: Manum (1963) and Manum and Cookson (1964) on dinoflagellate assemblages from Graham and Ellef Ringnes Islands (probably from the Santonian-Campanian Kanguk Formation or its lithologic correlatives); Felix and Burbridge (1973) on spores, pollen and dinoflagellates from sections of the Eureka Sound Formation of Maastrichtian age on Ellef Ringnes Island; McIntyre (1974) on spores, pollen and dinoflagellates, and McIntyre (1975) on new dinoflagellate taxa from the Santonian-Maastrichtian Amundsen Gulf Group; Yorath *et al.* (in press) on Horton River, District of Mackenzie; and Rouse and Srivastava (1972) on spores and pollen from the Bonnet Plume Formation, of Albian and Maastrichtian-Paleocene ages, in northeastern Yukon Territory.

Shorter papers and notes on Cretaceous palynology include: McGregor (1965) on spore and pollen

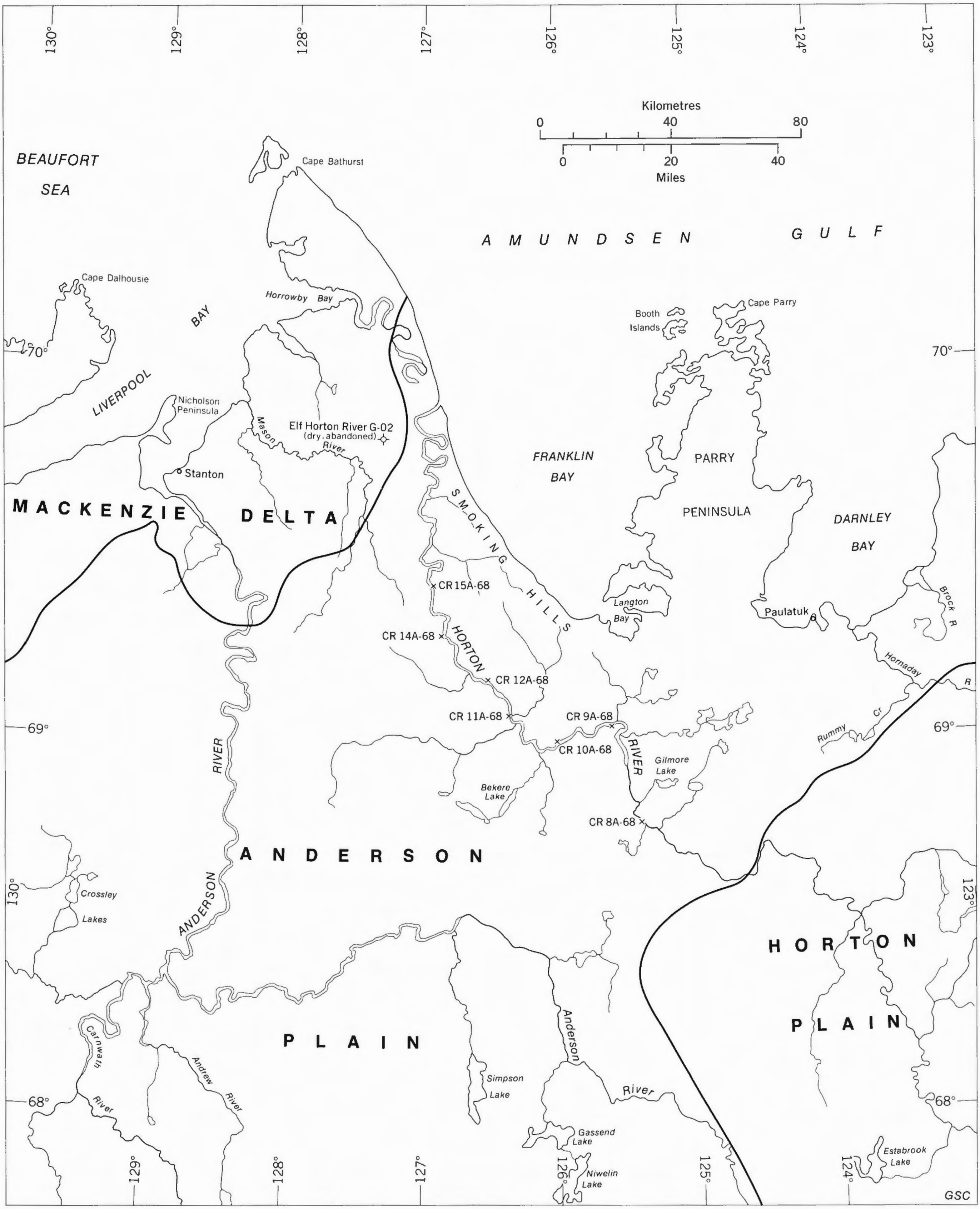

FIGURE 1. Location of sampled Lower Cretaceous sections on Horton River, District of Mackenzie

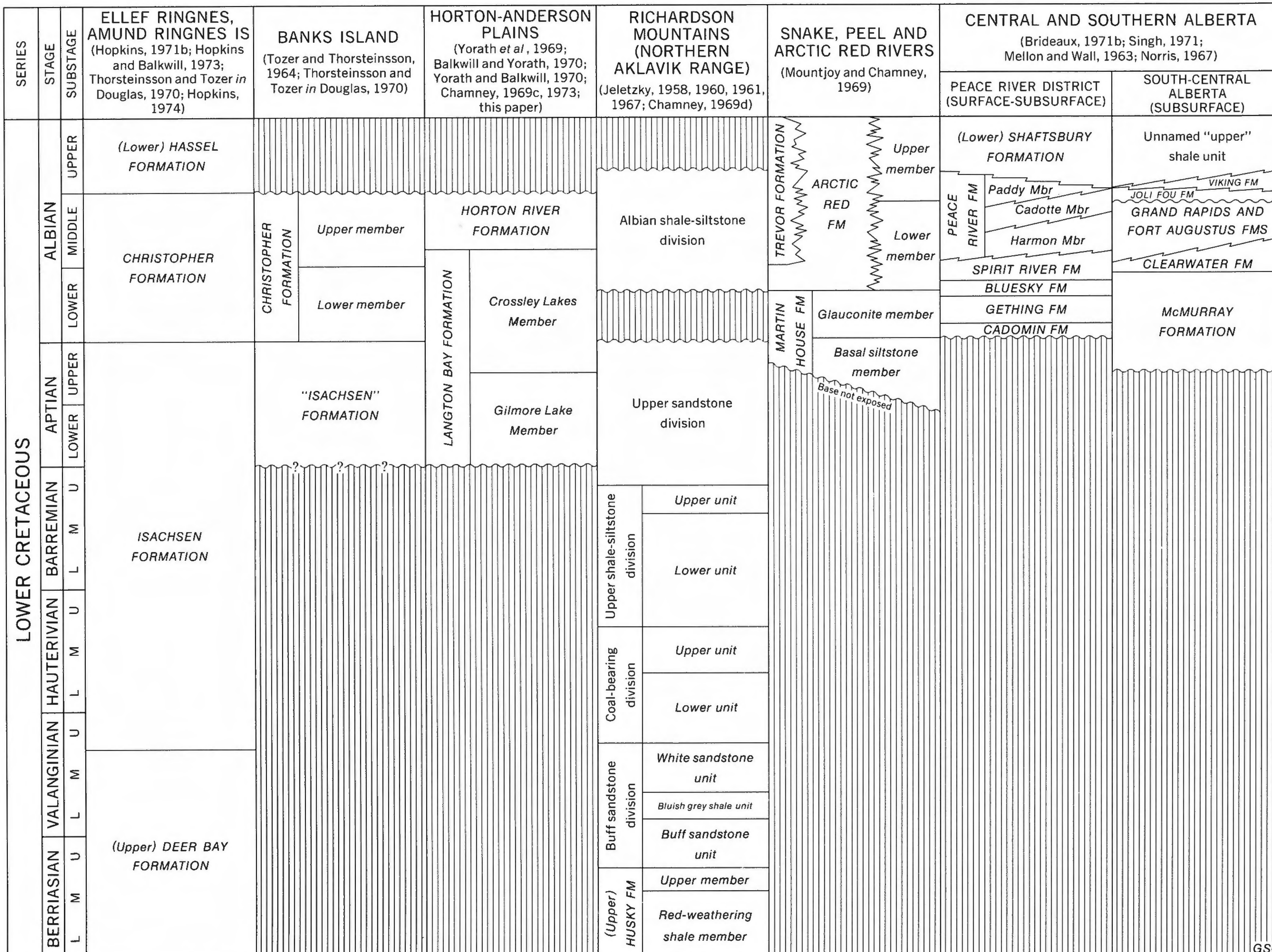

FIGURE 3. Correlations of Lower Cretaceous formations from selected regions of western and northern Canada. Relationship of lithologic and stage boundaries approximate. Data from various sources

assemblages from rocks of Triassic to Early Cretaceous age in the Arctic Islands; Hopkins (1969) on the Jurassic-Cretaceous boundary on northwest Melville Island based on spores and pollen; Hopkins (1971a) on the general palynology and paleoecology of the Albian spore and pollen assemblages from the Arctic Islands; Hopkins (1971b) and Hopkins *in* Dixon *et al.* (1973) on a spore, pollen and dinoflagellate assemblage from Cretaceous and/or Tertiary rocks on Somerset Island; Brideaux (1971a) on spores, pollen and dinoflagellates from the Campanian-?lower Maastrichtian East Fork and Little Bear Formations southwest of Fort Norman, in the upper Mackenzie River valley; and two taxonomic papers, the first by Hills and Wallace (1969) on a new Upper Cretaceous-Paleocene pollen genus, *Paraalnipollenites*, and the second by Brideaux and McIntyre (1973) on a new Lower Cretaceous dinoflagellate genus, *Lunatadinium*. Finally, Brideaux (1975) has outlined the current state of Mesozoic and Tertiary dinoflagellate studies in the delta and arctic regions, giving special emphasis to Cretaceous research and publications.

Brief reports and species lists of Cretaceous spores, pollen and dinoflagellates appear in Norford *et al.* (1970, 1971, 1973), Barnes *et al.* (1974), Thorsteinsson and Tozer (1962, p. 67) and Tozer and Thorsteinsson (1964, p. 152, 158).

This brief survey of previous work shows that publications have emphasized the spore and pollen assemblages from the northern mainland and Arctic Canada. There has not yet been published a comprehensive taxonomic and biostratigraphic study of Cretaceous dinoflagellate assemblages. The paper by Manum and Cookson (1964) described a varied and diverse assemblage of dinoflagellates, but precise information on the geographic location, lithologic units, and geologic age is lacking. The present contribution, consequently, is the first publication to document and describe Cretaceous dinoflagellate assemblages in northern Canada and to attempt to relate them to available geologic data.

CRETACEOUS STRATIGRAPHY - ANDERSON PLAIN

McGill and Loranger (1961) published the first micropaleontological report on Cretaceous strata along Anderson River, which crosses Anderson Plain (Fig. 1). The first informal division of Cretaceous lithologic units in the area, based on field studies conducted by J.C. Sproule and Associates, was described in an industrial report prepared in 1960 and released by the Department of Indian Affairs and Northern Development in 1963 (cited by Yorath *et al.*, 1969). In that report, Lower Cretaceous strata on Anderson Plain were subdivided into a lower "Silty Zone" and an upper "Bentonitic Zone". These units were adopted for use by Geological Survey personnel in reports arising from the field studies in this part of the District of Mackenzie connected with Operation Norman (Aitken *et al.*, 1969).

As a result of Operation Norman, several papers dealing with the Cretaceous stratigraphy of this area were published. Yorath *et al.* (1969) discussed in some detail the stratigraphy of Cretaceous rocks exposed along Horton and Anderson Rivers and in isolated outcrops on Anderson Plain. These authors described the lithology of the Cretaceous rocks, using the informal units proposed by Sproule and Associates, and discussed the age of the units and their relationship to correlative strata in the Canadian Arctic. Later papers (Balkwill and Yorath, 1970; Yorath and Balkwill, 1970) discussed, respectively, the Cretaceous stratigraphy of the Simpson Lake (NTS 97B), and Stanton (NTS 107D) map-areas. Age determinations of the Lower Cretaceous "Silty Zone" and "Bentonitic Zone" units, as well as the informal Upper Cretaceous units, are given by T.P. Chamney (1969a, 1969b, 1969c, 1973; and *in* Yorath *et al.*, 1969; Balkwill and Yorath, 1970; and Yorath and Balkwill, 1970).

Tassonyi (1969) discussed briefly the subsurface Cretaceous stratigraphy of two shallow wells drilled at Rond Lake in the southern extension of Anderson Plain. Yorath *et al.* (in press) discuss the subsurface section penetrated by the Elf Horton River G-02 well (Fig. 1) near the mouth of Horton River on Franklin Bay. Chamney (1973) discussed, in part, composite sections of the Cretaceous strata on Anderson and Horton Rivers and correlated these surface units lithologically and micropaleontologically with subsurface units in selected wells drilled in the Mackenzie Delta region.

Yorath *et al.* (in press) have proposed formal lithologic nomenclature for the "Silty Zone" and "Bentonitic Zone", as well as for the Upper Cretaceous "Pale Shale Zone" and "Bituminous Zone". These names are used in the brief discussion of stratigraphy to follow and in the systematic section where the occurrence of species is indicated.

STRATIGRAPHY OF LOWER CRETACEOUS ROCKS

DARNLEY BAY GROUP

The name, Darnley Bay Group, has been proposed by Yorath *et al.* (in press) for Lower Cretaceous sandstone, coal, shale and siltstone, outcropping on the flanks of the Coppermine Arch and on the Horton and Anderson Plains in the northern District of Mackenzie. The group is divided into a lower Langton Bay Formation, and an upper Horton River Formation (Yorath *et al.*, in press). These formations are identical with the informal units, "Silty Zone" and "Bentonitic Zone", respectively, used by earlier workers (Yorath *et al.*, 1969). The Darnley Bay Group unconformably overlies rocks of Proterozoic or early Paleozoic age and is overlain unconformably by rocks of the Upper Cretaceous Amundsen Gulf Group (Yorath *et al.*, in press). The discussion of the Darnley Bay Group that follows is summarized in large part from Yorath *et al.* (1969), Balkwill and Yorath (1970), Yorath and Balkwill (1970), and from field observations of T.P. Chamney kindly made available to the authors.

Langton Bay Formation

The name, Langton Bay Formation, was given by Yorath *et al.* (in press) to rocks assigned previously to the informal "Silty Zone" (Yorath *et al.*, 1969). The formation overlies unconformably Proterozoic and lower Paleozoic rocks and is overlain conformably by rocks of the Horton River Formation. Surface drift overlying much of the region between Anderson and

Horton Rivers precludes complete knowledge of the total area underlain by the Langton Bay Formation. Along Horton River, the formation disconformably overlies limestone of the Devonian Bear Rock Formation. The most complete section of the Langton Bay Formation is exposed along Horton River, although Yorath *et al.* (1969) list other isolated exposures and Balkwill and Yorath (1970) describe exposures in the Simpson Lake map-area to the north and west.

Yorath *et al.* (1969) measured a total thickness of 960 feet (288 m) in five sections of the Langton Bay Formation located along Horton River. These authors postulated a total composite thickness of the formation of 1,200 feet (366 m), based on a projection of the regional dip, which is 30 feet (9.1 m) per mile to the northwest.

In the Horton River area and in the vicinity of Brock and Hornaday Rivers (Fig. 1), the formation is divisible into a lower Gilmore Lake Member, and an upper Crossley Lakes Member (Yorath *et al.*, in press). The lithologies and thicknesses of these members are dealt with in the following sections. A discussion of previously published evidence for the correlation and geological age of the Langton Bay Formation then follows.

Gilmore Lake Member

The name Gilmore Lake Member has been introduced by Yorath *et al.* (in press) as a formal name for rocks previously referred to as the sandstone and coal division of the "Silty Zone" (Yorath *et al.*, 1969). At the type section, the Gilmore Lake Member rests disconformably on limestone of the Devonian Bear Rock Formation, and is overlain gradationally by siltstone and mudstone of the Crossley Lakes Member.

The thickness of the Gilmore Lake Member, as measured on Horton River, was given by Yorath *et al.* (1969) as 220 feet (66 m). This is the thickness of the measured Section YB-50 of Yorath *et al.* (in press) as illustrated *in* Balkwill and Yorath (1970, p. 8, Fig. 3) and described as Section CR8A-68 of T.P. Chamney (*see* Appendix). The lower beds of the Gilmore Lake Member consist of sandy mudstone containing angular limestone blocks derived from the Devonian Bear Rock Formation; the derived blocks decrease in size upward and eventually disappear. The contact with the Bear Rock Formation is irregular and these basal beds may vary in thickness along strike. The basal beds are succeeded by interbedded, light grey, fine- to medium-grained, friable quartz sandstone containing lignitic beds, then by friable quartz sandstone with minor amounts of interbedded mudstone. Thin gypsum laminae are present basally. Higher in the section, lesser amounts of shale-pebble conglomerate, sulphurous or marcasitic sandstone nodules, calcareous sandstone or sandy limestone concretions and wood fragments also occur.

Crossley Lakes Member

Yorath *et al.* (in press) have proposed the name Crossley Lakes Member for the 740 feet (226 m) of strata, exposed on Horton River, previously assigned to the informal siltstone and mudstone division of the "Silty Zone" (Yorath *et al.*, 1969). The Crossley Lakes Member is underlain gradationally by the Gilmore Lake Member and overlain conformably by the Horton River Formation. Yorath *et al.* (1969) established the contact of the Crossley Lakes Member with the overlying Horton River Formation ("Bentonitic Zone") at the base of a well-developed and laterally persistent cone-in-cone limestone concretionary bed. This bed occurs in Section CR12A-68 of Chamney (=Section YB-56 of Yorath) at a point 180 feet (55 m) above the base of the section. Thus, the Crossley Lakes Member, in this paper, comprises the 140 feet (43 m) of Section CR9A-68 (=Section YB-51), the 280 feet (85 m) of Section CR10A-68 (=Section YB-52), the 72.5 feet (22 m) of Section CR11A-68, and the 180 feet (55 m) of section below the cone-in-cone marker bed of Section CR12A-68 (=Section YB-56 of Yorath). The uppermost 15 feet (4.6 m) of Section CR9A-68 is correlated lithologically, in part, with the lower 30 feet (9.1 m) of Section CR10A-68. Hence the total measured thickness of the Crossley Lakes Member (comprising sections collected along Horton River by T.P. Chamney) is 657.5 feet (200 m). Yorath *et al.* (in press) give a thickness of 160 feet (49 m) at their Section YB-55, measured at a slightly different location to that of Section CR11A-68 of Chamney. This accounts for the different thickness of the member recorded in this paper, compared with that of Yorath *et al.* (1969).

The lower 125 feet (38 m) of Section CR9A-68 (=Section YB-51) comprise increasing amounts upward of light to dark grey shale or mudstone, and decreasing amounts upward of light grey sandstone or siltstone. Lignite beds and woody fragments also occur with decreasing frequency upward in the section. The last prominent sandstone unit occurs between 115 and 125 feet (35 and 38 m).

This 125-foot (38 m) unit is succeeded in the uppermost 15 feet (4.6 m) of Section CR9A-68 and the basal 30 feet (9.1 m) of Section CR10A-68 by grey shale, lesser amounts of yellow-stained (?jarositic) siltstone, and minor interbeds of jarositic clay and calcareous concretions, the latter weathering dull red to yellow. Chamney (*see* Appendix) mentions in field notes that a distinctive "mahogany banding" occurs at 125 to 128 feet (38 to 39 m) in Section CR9A-68 and in the basal 5 feet of Section CR10A-68. Thus, based on lithology, the uppermost 15 feet of Section CR9A-68, and the basal 15 feet of Section CR10A-68, appear to overlap.

The remainder of Section CR10A-68, all of Section CR11A-68, and the basal 25 feet (7.6 m) of Section CR12A-68, consist of grey to dark grey, fissile to plastic shale. Minor amounts of yellow-stained (?jarositic) shale and calcareous to dolomitic concretionary beds also occur. Comminuted pelycypod coquina beds, limy or marcasitic concretions, goethite rosettes (*fide* Chamney, Appendix), and rare shale-pebble beds also were observed in this part of the Crossley Lakes Member on Horton River.

In Section CR12A-68, from 25 feet (7.6 m) above the base of the section to the base of the cone-in-cone marker bed, the strata consist of grey to greyish brown, fissile shale and blocky weathering mudstone, interbedded grey-brown shale and siltstone, with minor greyish brown, very fine grained sandstone, and sporadic limestone or ironstone concretionary beds. Interbedded grey shale and pale yellow siltstone occur at the top of this 155-foot (47 m) interval. Comminuted pelycypod coquina beds, large wood fragments, and goethite rosettes also were observed.

Age and correlation

Yorath *et al.* (1969) correlated the Gilmore Lake Member of the Langton Bay Formation (sandstone and coal division of the "Silty Zone") with the Isachsen Formation on Banks Island (Thorsteinsson and Tozer, 1962) because of similar lithology and stratigraphic position. Yorath *et al.* (1969) also noted that the Crossley Lakes Member (siltstone and mudstone division of the "Silty Zone") showed lithological similarity to the lower part of the Christopher Formation (Fig. 3) on Banks Island (Thorsteinsson and Tozer, 1962). Balkwill and Yorath (1970) repeat these observations.

Jeletzky (*in* Thorsteinsson and Tozer, 1962) determined the age of the basal beds of the Isachsen Formation on Ellef Ringnes Island and Axel Heiberg Island as Valanginian based on the pelecypod *Buchia*. Beds assigned to the Isachsen Formation on Banks Island (Miall, 1974), and the strata of the Gilmore Lake Member on Horton River, are without macrofossil remains. They are considerably younger in age, however, than the Isachsen of the central Arctic (H.R. Balkwill, pers. com., 1974). The lower part of the Christopher Formation in the central Arctic (Jeletzky *in* Thorsteinsson and Tozer, 1962) yielded diagnostic ammonite faunas of late Early to Middle Albian age. Yorath *et al.* (1969) concluded from this evidence that the Langton Bay Formation ("Silty Zone") was probably late Early Cretaceous in age.

Hopkins (1971c), in a report on the palynology of the Isachsen Formation (Fig. 3) on Melville Island, cites evidence which brackets the age of the formation as late Valanginian to Barremian and possibly Aptian. Hopkins (1971a) cites the age of the Christopher Formation (Fig. 3) on Ellef Ringnes and Melville Islands as Albian, based on data from spore and pollen assemblages as well as previous work. Because no angiosperm pollen are noted by Hopkins (1971a), the age of these rocks is probably pre-Late Albian. Chamney (1973, Table I, p. 175) lists the "?Upper Silty Zone" (=?Crossley Lakes Member of the Langton Bay Formation) and a "SS. facies to the NE=Isachsen Fm." as having a provisional age of late Aptian to Early Albian.

In a later part of this paper, data are presented in support of the determination of an Aptian age for the Gilmore Lake Member and an Aptian to Middle Albian age for the Crossley Lakes Member, based on an analysis of the miospore and microplankton assemblages.

Horton River Formation

The name Horton River Formation was proposed by Yorath *et al.* (in press) for rocks assigned previously to the informal "Bentonitic Zone" (Yorath *et al.*, 1969). The formation is underlain conformably by rocks of the Crossley Lakes Member of the Langton Bay Formation. The contact was chosen at the base of a persistent cone-in-cone limestone concretionary bed, recognized in Horton River valley, and in the regions of the Smoking Hills and Brock and Hornaday Rivers (Yorath *et al.*, 1969). This marker horizon is not present on Anderson River and, at that location, the contact was placed at the base of a pale yellow weathering concretionary bed which occurs at a distinct break in lithology and slope (Yorath *et al.*, 1969). The Horton River Formation is overlain unconformably by the Santonian-Campanian Smoking Hills Formation ("Bituminous Zone") (McIntyre, 1974) of the Amundsen Gulf Group (Yorath *et al.*, in press). The contact on Horton River is marked by a sudden change in lithology from grey shale to a pebble-conglomerate.

Yorath *et al.* (1969) measured a composite thickness of 350 feet (107 m) for the Horton River Formation on Horton River. However, these authors estimated the total composite thickness of the formation along Horton River to be between 500 and 600 feet (152 and 183 m) based on regional attitudes. In this paper, the uppermost 10 feet (3 m) of Section CR12A-68 (=Section YB-56 of Yorath), the exposed 125 feet (38 m) and maximum covered interval of 70 feet (21 m) in Section CR14A-68, and the 140 feet (43 m) of Section CR15A-68, are included in the Horton River Formation. Thus, the total measured composite thickness for the formation as reported in this paper is 345 feet (105 m).

The basal beds of the Horton River Formation consist of grey shale, weathering rusty brown and containing scattered ironstone concretions. These are succeeded in Section CR14A-68 by grey, plastic shale with a few ironstone concretionary beds and with some pale yellow, silty clay interbeds near the top of the section. A maximum of 70 feet (21 m) of the uppermost part of Section CR14A-68 and a further 30 feet (9.1 m) below the exposed base of Section CR15A-68 are covered, giving a total covered interval of 100 feet (30 m). The remaining 110 feet (33 m) of Section CR15A-68 consist of light grey to grey shale, in part plastic or flaggy, weathering grey to greyish brown or pale orange-yellow, with a few limestone concretionary beds or concretion rows, and a few beds containing ammonites. The contact with the overlying Amundsen Gulf Group is marked in this section by 6 feet (1.8 m) of pebble-conglomerate.

A more generalized description of the lithology of the Horton River Formation is given by Yorath *et al.* (1969) and additional information is given in Yorath and Balkwill (1970). Balkwill and Yorath (1970) note that glacial drift covers areas probably underlain by the Horton River Formation in the Simpson Lake map-area.

Age and correlation

Yorath *et al.* (1969) tentatively correlated the Horton River Formation, on the Horton and Anderson Plains, with the upper member of the Christopher Formation on Banks Island on the basis of strikingly similar lithologies. They note, also, that their approach provides only an indirect assessment of the age of the Horton River Formation on Horton River. Jeletzky (*in* Thorsteinsson and Tozer, 1962, p. 65) stated the following concerning the age of the upper member of the Christopher Formation based on ammonites: "....two faunal zones are reported in the collection from Banks Island. The collections with *Beaudanticeras*...represent the *Beaudanticeras affine* or *Lemuroceras* zone, of late lower and early Middle Albian age. The collection with *Gastroplites*...is dated as latest Middle Albian ...". Thus the age of the upper member of the Christopher Formation on Banks Island is late Early to latest Middle Albian (*see* also Jeletzky, 1968, for further discussion of the age significance of these faunal zones). Hopkins (1971a) has reported an Albian, likely pre-Late Albian age for the Christopher Formation on Melville and Ellef Ringnes Islands. More direct evidence for the age of the Horton River Formation is presented by T.P. Chamney (*in* Balkwill and Yorath, 1970), who reports the identification of Middle Albian glomospirellid foraminifers from upper beds of the Horton River Formation ("Bentonitic Zone").

Chamney (*see* Appendix) reports the occurrence of a few, fragmented, immature ammonite specimens from 50 feet (15 m) above the base of Section CR14A-68 and between 8 and 20 feet (2.4 and 6.1 m) and at 23 feet (7.0 m) above the base of Section CR15A-68. Jeletzky (1969, p. 1, unpubl. internal report) states that the bed yielding the ammonite fauna in Section CR14A-68, "Possibly represents the late lower or early Middle Albian '*Lemuroceras*' *irenense* zone of the Canadian Western Interior standard sequence...but cannot be dated definitely because of an extremely poor preservation of the only ammonite fragment available ...". For the samples from Section CR15A-68, Jeletzky (ibid., p. 1, 2) states, "Presumably from some part of the *Lemuroceras* (now *Arcthoplites*) or *Beaudanticeras affine* zone and of the early middle or late lower Albian age in terms of international standard stages...".

Chamney (1973, Table I, p. 175) lists the formation (as "Bentonitic Zone") as being of Early to ?Middle Albian age.

It may be concluded with caution then, from macrofaunal and microfaunal evidence available, that the Horton River Formation is, in part, Middle Albian in age, but may be as old in part as Early Albian. In a later part of this paper, evidence is presented in support of a Middle Albian age for the whole of the Horton River Formation on Horton River. This determination is based on analyses of dinoflagellate, spore and pollen assemblages recovered from strata of this formation, exposed along Horton River.

BIOSTRATIGRAPHY

SPORES AND POLLEN

Langton Bay Formation

Gilmore Lake Member

One hundred and eight pollen and spore species were recorded in the Lower Cretaceous sections on Horton River and sixty-three of these make their appearance in Section CR8A-68 which represents the Gilmore Lake Member. Many of these pollen and spore species are long-ranging Jurassic and Cretaceous forms and these are not considered further during discussion of the age of the Horton River section.

The following species with known first appearances in the Aptian were identified in Section CR8A-68 (Figs. 4a, b):

Costatoperforosporites fistulosus
Crybelosporites vectensis
Lycopodiumsporites marginatus
Microreticulatisporites uniformis
Trilobosporites trioreticulosus

Thus the spore evidence shows that, at the surface, the Gilmore Lake Member is no older than Aptian. No species whose last appearances are of Aptian age occur in Section CR8A-68 and the only two species which make their last appearance in this section are *Coptospora* sp. and *Costatoperforosporites fistulosus* with ranges of Aptian to Middle Albian (Deák, 1963; Singh, 1971). Therefore, it is not possible to determine an upper age limit for the Gilmore Lake Member based on the spore and pollen assemblages. However, evidence discussed in the section on dinoflagellates shows that the Gilmore Lake Member is not younger than Aptian. Therefore, this member is assigned an Aptian age.

Two species, *Cicatricosisporites augustus* and *Appendicisporites bifurcatus*, which first appear in the Middle Albian in Alberta (Singh, 1971), occur in Section CR8A-68, as also does a species similar to the Middle Albian species *Coptospora williamsii*. These occurrences indicate that these species have longer ranges than previously reported. Because so little data exist for Aptian and Early Albian microfloras in North America, it is probable that many other species will prove to range into strata older than Middle Albian.

Crossley Lakes Member

Twenty-nine of the pollen and spore species, recorded in sections along Horton River, make their first appearances in Section CR9A-68 in the lower part of the Crossley Lakes Member, which must be Aptian or younger in age, as the underlying Gilmore Lake Member is of Aptian age. The following species, which are not known to occur in rocks older than Aptian (Brenner, 1963; Dettmann, 1963; Singh, 1971) make their appearances in Section CR9A-68:

Contignisporites glebulentus
Costatoperforosporites foveolatus
Costatoperforosporites sp. cf. *Anemia perforata*
Parvisaccites rugulatus
Trilobosporites apibaculatus
Trilobosporites perverulentus

No upper age limit for the lower part of the Crossley Lakes Member can be determined from the pollen and spores present. Evidence presented in the discussion of the dinoflagellate assemblages, however, supports an Aptian age for this part of the member.

Krauselisporites hastilobatus, a species previously recorded only from the Middle Albian in Saskatchewan (Playford, 1971), appears in Section CR9A-68. Therefore, its lower age limit should be extended down to the Aptian.

Only three spore species make their first appearance in Sections CR10A-68 and CR11A-68. No determination of the age of the middle part of the Crossley Lakes Member is possible based on the spore and pollen assemblages. The few species which make their last appearances in this part of the member are not significant in determining upper age limits in the Crossley Lakes Member. Evidence discussed below from the ranges of dinoflagellate species indicates that the age of the middle part of the Crossley Lakes Member is Early Albian.

In the upper part of the Crossley Lakes Member, the first tricolpate angiosperm pollen species, *Retitricolpites prosimilis*, appears at the 10- to 20-foot (3.0 to 6.1 m) level of Section CR12A-68. Therefore, this part of the section is not older than Middle Albian, as *R. prosimilis* first appears in the Middle Albian (Norris, 1967; Singh, 1971; Brideaux, 1971b), and tricolpate angiosperm pollen grains in North America are recorded definitely only in Middle Albian and younger strata (Norris, 1967; Brideaux, 1971b). The Valanginian-Middle Albian species *Cooksonites variabilis* (Dettmann, 1963; Singh, 1964) makes its last appearance in the Horton River section at the 170- to 180-foot (52 to 55 m) level of Section CR12A-68. The upper portion of the Crossley Lakes Member, therefore, is considered to be of Middle Albian age based on this evidence. The Lower Albian-Middle Albian boundary has been placed immediately below the first appearance of tricolpate angiosperm pollen, but there is no definitive evidence for the exact position of this boundary.

Horton River Formation

In Section CR14A-68, fourteen pollen and spore species make their first appearance and two more species appear in Section CR15A-68, which represents the top of the Horton River Formation. Species which make their first appearance in the Horton River Formation (Figs. 4b, 6) and are not known elsewhere in strata older than Middle Albian (Norris, 1967; Singh, 1971) are:

Appendicisporites cristatus
Cicatricosisporites sp. cf. *Anemia exilioides*
Fraxinoipollenites venustus
Retitricolpites georgensis

The tricolpate angiosperm pollen species, *R. georgensis* and *F. venustus*, occur rarely in the Horton River Formation, but their occurrence is particularly significant because they occur only in Middle Albian and younger strata in North America (Norris, 1967; Brideaux, 1971b, Singh, 1971). The presence of these two species, and the determination of a Middle Albian age for the top of the Crossley Lakes Member, shows that the Horton River Formation is not older than Middle Albian in sections on Horton River.

In Sections CR14A-68 and CR15A-68, some species, which are not known to occur in strata younger than Middle Albian (Brenner, 1963; Dettmann, 1963; Kemp, 1970; Singh, 1971; Playford, 1971), make their last appearances below the top of the Horton River Formation. These species are:

Cicatricosisporites potomacensis
Contignisporites glebulentus
Crybelosporites vectensis
Dictyotriletes granulatus
Foraminisporis asymmetricus
Januasporites spiniferus
Pilosisporites trichopapillosus
Pilosisporites verus
Reticulisporites vermiformis
Triporoletes radiatus
Triporoletes reticulatus
Triporoletes simplex

The age of the Horton River Formation in the Horton River section is considered to be Middle Albian based on evidence from the pollen and spore assemblages. No species indicative of a Late Albian age are present, and there is no evidence to suggest that any part of the formation is younger than Middle Albian in outcrops along Horton River. This conclusion is supported by the evidence from dinoflagellate assemblages to be discussed below.

DINOFLAGELLATES AND ACRITARCHS

Langton Bay Formation

Gilmore Lake Member

Except for the rare occurrence of *Lunatadinium dissolutum* (Valanginian-Middle Albian) at the 83- to 104-foot (25 to 32 m) level of Section CR8A-68, a dinoflagellate assemblage occurs first in the topmost sample from this section, and therefore at the top of the member (Figs. 5, 6). Species that first appear here are:

Astrocysta cretacea (Valanginian-Upper Cretaceous)
Batioladinium jaegeri (Hauterivian-Middle Albian)
Cleistosphaeridium multispinosum (Hauterivian-Cenomanian)
Cyclonephelium distinctum (Berriasian-Upper Cretaceous)
Dingodinium cerviculum (Hauterivian-Upper Albian)
Microdinium opacum (Hauterivian-Upper Albian)
Odontochitina operculata (Hauterivian-Upper Cretaceous)
Oligosphaeridium complex (Valanginian-Upper Cretaceous)
Oligosphaeridium? sp. A. of Brideaux, 1971b (Hauterivian-Upper Albian)
Pterospermopsis australiensis (Upper Jurassic-Cretaceous)

The known ranges of these species in North America, Eurasia, and Australasia are given in brackets. These ranges are based on published and unpublished data. Some of the unpublished data will appear in manuscripts in preparation by the present authors and by other workers (Brideaux, 1975).

Thus, the age of uppermost part of the Gilmore Lake Member at the type section is no older than Hauterivian, based on dinoflagellates. A precise upper age limit based on dinoflagellate assemblages cannot be placed on this part of the section, but the interval cannot be younger than Aptian, as later evidence will show. This is confirmed by the spore and pollen assemblages as discussed earlier in this paper.

Crossley Lakes Member

Dinoflagellates are not present in preparations from the basal 60 feet (18 m) of this member, as sampled in Section CR9A-68; they occur first at the 60- to 70-foot (18 to 21 m) level (Figs. 5, 6). The following species, listed in order of appearance (Fig. 5), first appear in the interval between 60 and 110 feet (18 and 33 m):

Oligosphaeridium sp. AB (Hauterivian-Upper Albian)
Oligosphaeridium irregulare (Hauterivian-Upper Albian)
Tenua hystrix (Upper Hauterivian-Lower Albian)
Muderongia sp. A (pre-Aptian?-Aptian-Lower Albian)
Oligosphaeridium anthophorum (Upper Jurassic-Campanian)
Oligosphaeridium pulcherrimum (Upper Jurassic-Santonian)

Between 88 and 128 feet (27 and 39 m) in Section CR9A-68, the following species make their final appearance in Lower Cretaceous rocks on Horton River in the order listed (Fig. 5):

Oligosphaeridium irregulare
Oligosphaeridium anthophorum
Oligosphaeridium pulcherrimum

The uppermost 15 feet (4.6 m) of Section CR9A-68 tentatively have been correlated lithologically in part with the lowermost 30 feet (9.1 m) of Section CR10A-68. Palynologic evidence suggests that only the basal 10 feet (3 m) of CR10A-68 are correlative. Two new species and the first acanthomorph acritarchs appear for the first time 10 feet (3 m) above the base of Section CR10A-68. These species are not present in the upper 15 feet (4.6 m) of Section CR9A-68. The species that first appear are:

Muderongia tetracantha (Hauterivian-Aptian)
Oligosphaeridium totum subsp. *totum* (Hauterivian-Upper Albian)

Within the next 30 feet (9.1 m) of section, the following species make their first appearance in the order listed (Fig. 5):

Gardodinium eisenackii (Hauterivian-Upper Albian)
Palaeostomocystis fragilis (Hauterivian-Upper Cretaceous)
Leiofusa jurassica (Upper Carboniferous-Oligocene)

Oligosphaeridium? sp. A. of Brideaux, 1971b, last occurs at the 30- to 40-foot (9.1 to 12.2 m) level (Fig. 5) and *Muderongia tetracantha* last occurs in this section at the 50- to 60-foot (15 to 18 m) level. Beyond this point, only a few species appear or make their final appearance in the sampled sections on Horton River assigned to the Crossley Lakes Member. The following species first appear at the stated levels in these sections:

Chlamydophorella nyei - Section CR10A-68, 95 to 100 feet (29 to 30 m) (Hauterivian-Santonian)
Dictyopyxidia imperfecta sp. nov. Section CR10A-68, 130 to 140 feet (40 to 43 m) (Hauterivian-Middle Albian)
Micrhystridium sp. A. - Section CR12A-68, 100 to 110 feet (30 to 33 m) (Middle Albian)
Senoniasphaera microreticulata sp. nov. - Section CR12A-68, 150 to 160 feet (46 to 49 m) (Middle Albian)

Two species make final appearances in this interval. These are *Muderongia* sp. A. [Section CR11A-68 at 40 to 50 feet (12 to 15 m)] and *Oligosphaeridium totum* subsp. *totum* [Section CR12A-68 at 20 to 30 feet (6.1 to 9.1 m)].

The age of the basal part of the Crossley Lakes Member [Section CR9A-68 between 60 and 140 feet (18 and 43 m)], based on the dinoflagellate assemblages could be as old as Hauterivian and as young as Aptian. Of the seven species making their first appearance in this interval, only *Tenua hystrix* (Upper Hauterivian-Lower Albian) and *Muderongia* sp. A. (pre-Aptian?-Lower Albian) have relatively restricted ranges in northern Canada and elsewhere. The upper limit of the age for this portion of the section, and hence for the total sequence below it, including the Gilmore Lake Member, is Aptian. *Muderongia tetracantha* (Hauterivian-Aptian) makes its final appearance at 50 to 60 feet (15 to 18 m) in Section CR10A-68. *Tenua* sp. A. first appears 20 feet (6.1 m) lower in that section, and is not known to range into rocks older than Aptian in northern Canada and Alberta. Thus, the lower part of the Crossley Lakes Member is as old as Hauterivian and no younger than Aptian, based on dinoflagellates. However, the evidence from pollen and spore assemblages indicates an Aptian age for the underlying Gilmore Lake Member. Thus, the age of the lower part of the Crossley Lakes Member must be Aptian.

The age of the Crossley Lakes Member, above the 60-foot (18 m) level in Section CR10A-68, is no older than Early Albian and can be only as young as Middle Albian; for, as will be shown later, the age of the Horton River Formation is Middle Albian, based on dinoflagellate assemblages. This determination has been supported by the spore and pollen assemblages. As noted in discussion of the spore and pollen assemblages, tricolpate angiosperm species appear first at the 10- to 20-foot (3.0 to 6.1 m) level of Section CR12A-68. Based on these data, the boundary between Lower and Middle Albian rocks along Horton River has been placed at this level. Assuming this to be correct, the upper limit of the range of *Muderongia* sp. A. in Lower Cretaceous rocks along Horton River is Early Albian, and the upper limit of the known range of *Tenua hystrix* in the northern Canadian mainland is also Early Albian.

Thus the medial portion of the Crossley Lakes Member is Early Albian in age and the upper portion [above the 20-foot (6.1 m) level of Section CR12A-68] is Middle Albian in age.

Horton River Formation

Dinoflagellate assemblages in this formation are characterized by a marked influx of species new to the Darnley Bay Group, although many of them may have longer ranges elsewhere. Nineteen species make their first appearance in the uppermost 15 feet (4.6 m) of Section CR12A-68 and the basal 30 feet (9.1 m) of Section CR14A-68. Thirteen of these appear first in a sample at 10 to 20 feet (3.0 to 6.1 m) in Section CR14A-68. Many of these species have short ranges in the Horton River Formation, but are longer ranging elsewhere; some are known only from this formation. Many other species, present throughout the Langton Bay Formation, make final appearances in the upper part of the Horton River Formation, well below the uppermost beds. Of twenty-six species making their final appearance in Section CR14A-68, however, only three species, *Dingodinium cerviculum*, *Oligosphaeridium* sp. AB and *Senoniasphaera reticulata* sp. nov., had occurred in rocks underlying the Horton River Formation on Horton River.

The following species appear first in the upper 15 feet (4.6 m) of Section CR12A-68 just above the cone-in-cone marker bed in the order listed (Fig. 5). Species asterisked are restricted to the Horton River Formation on Horton River:

Cleistosphaeridium polypes subsp. *polypes** (Aptian-Cenomanian)
Tanyosphaeridium sp. B of Brideaux, 1971b* (Middle Albian-Upper Albian)
Microdinium spinosum sp. nov.* (Middle Albian)

The following species appear first in the basal sample from Section CR14A-68:

*Apteodinium maculatum** (Barremian-Middle Albian)
*Cleistosphaeridium ancoriferum** (Middle Albian-Cenomanian)
Gonyaulacysta helicoidea (Barremian-Middle Albian)
*Gonyaulacysta hyalodermopsis** (Barremian-Middle Albian)
*Hystrichokolpoma ferox** (Aptian-Santonian)
Leptodinium cancellatum sp. nov.* (Middle Albian)
*Leptodinium delicatum** (Middle Albian-Cenomanian)
Leptodinium modicum sp. nov. (pre-Middle Albian?-Middle Albian)
Luxadinium primulum gen. et sp. nov.* (Middle Albian)
*Oligosphaeridium asterigium** (Valanginian-Middle Albian)
Pterodinium verrucosum sp. nov.* (Middle Albian)
Pterodinium sp. cf. *P. aliferum** (Aptian?-Middle Albian)
Pterodinium sp. A * (Middle Albian)

Nineteen other species make their first appearance in the order listed (Fig. 5) in the next 80 feet (24 m) of section, including:

Cleistosphaeridium polypes subsp. *clavulum** (Middle Albian-Cenomanian)
Cleistosphaeridium? sp. AE* (Middle Albian)
Kalyptea sp. A of Brideaux, 1971b* (Middle Albian-Upper Albian)
Scriniodinium rostratum sp. nov.* (Middle Albian)
Palaeoperidinium sp. A of Brideaux, 1971b* (Middle Albian-Upper Albian)
*Canningia minor** (Lower Albian-Cenomanian)
*Canningia ringnesii** (Middle Albian-Upper Cretaceous)
Imbatodinium sp. A * (Middle Albian)
*Lecaniella foveata** (Middle Albian-Upper Albian)

In the upper part of the Horton River Formation, represented in Section CR15A-68, three species make their first appearance in the order listed (Fig. 5):

Cleistosphaeridium? *aciculare* (Middle Albian-Cenomanian)
Scriniodinium campanula (Valanginian-Turonian)
Oligosphaeridium? sp. B of Brideaux, 1971b (Middle Albian-Upper Albian)

In this section also, several species make their final appearance in its lower portion, including:

Lunatadinium dissolutum
Micrhystridium sp. A
Tanyosphaeridium sp. C
Tenua sp. A

Near the top of Section CR15A-68, *Imbatodinium* sp. A. makes its final appearance, and is not known to range higher elsewhere in northern Canada. A number of other species, which make their final appearance in Section CR15A-68 below the topmost beds, are known to range higher in northern Canada and elsewhere.

The age of the Horton River Formation on Horton River is considered to be Middle Albian based on evidence from the dinoflagellate and acritarch assemblages. This is confirmed by the pollen and spore assemblages as discussed earlier in this paper. *Tanyosphaeridium* sp. B, *Kalyptea* sp. A, *Palaeoperidinium* sp. A and *Oligosphaeridium*? sp. B (all of Brideaux, 1971b), and *Canningia ringnesii* have not been recorded elsewhere in rocks older than Middle Albian (Brideaux, 1971b; Singh, 1971; unpublished data). There is also no evidence, based on the dinoflagellate and spore and pollen assemblages (*see* preceding discussions), to suggest that any part of the formation is younger than Middle Albian in age.

Thus, the following new taxa have a documented range (this paper) of Middle Albian, although later they may be found to range into younger or older rocks elsewhere:

Cleistosphaeridium? sp. AE
Conosphaeridium sp. A
Imbatodinium sp. A
Leptodinium cancellatum sp. nov.
Luxadinium primulum gen. et sp. nov.
Micrhystridium sp. A
Microdinium spinosum sp. nov.
Pterodinium verrucosum sp. nov.
Pterodinium sp. A
Scriniodinium rostratum sp. nov.

Senoniasphaera microreticulata sp. nov.

In addition, the known upper range limit of the following species is considered to be Middle Albian, although later work may extend this range:

Apteodinium maculatum
Dictyopyxidia imperfecta sp. nov.
Gonyaulacysta helicoidea
Leptodinium modicum sp. nov.
Lunatadinium dissolutum
Oligosphaeridium asterigium
Pterodinium sp. cf. *P. aliferum*
Tenua sp. A

The limit of the known lower range of the following species must also be extended downwards to at least Middle Albian:

Cleistosphaeridium? *aciculare*
Cleistosphaeridium ancoriferum
Cleistosphaeridium polypes subsp. *clavulum*
Lecaniella foveata
Leptodinium delicatum

COMPARISON WITH SELECTED ASSEMBLAGES

DINOFLAGELLATE AND ACRITARCH ASSEMBLAGES

Dinoflagellate-acritarch assemblages from Aptian to Middle Albian rocks have been reported previously from many localities (Downie and Sarjeant, 1965; Singh, 1971; Brideaux, 1971b; Davey and Verdier, 1971,1974). Many of these are short communications and are of little value in comparing assemblages. Some, especially those reports from Australasia, are descriptions of assemblages from rocks, the ages of which are insufficiently documented for accurate comparisons. Thus, the comparison of assemblages has been limited to seven papers (Fig. 7) from Germany, France, and Alberta, Canada (*see* addendum). The results are tabulated in Figure 7.

Reference to Figure 7 will support the following observations. Three species have not been recorded in previously published papers from rocks of Aptian to Middle Albian age. These are: *Oligosphaeridium* sp. AB, *Muderongia* sp. A, and *Tenua* sp. A. One species, *Dictyopyxidia imperfecta* sp. nov. has not been recorded previously from rocks of Early and Middle Albian age. Eleven species, including seven species proposed in this paper, have not been reported previously from rocks of Middle Albian age.

Twenty-two species occur in rocks of Aptian age on Horton River. Only seven of these occur also in rocks of Aptian age from Germany (Eisenack, 1958; Alberti, 1961). Five species occurring in German Aptian rocks do not occur in Aptian rocks on Horton River.

Seventeen species occur in rocks of Early Albian age on Horton River. Four species occur in common when compared with assemblages from central Alberta (Pocock, 1962; Singh, 1964) and four in assemblages from the Paris Basin (Davey and Verdier, 1971). Nine species reported from the Paris Basin do not occur at Horton River.

Fifty-seven species are recorded in Middle Albian rocks along Horton River. Thirty-six of these occur also in rocks of Middle Albian age in central and west-central Alberta (Pocock, 1962; Singh, 1964, 1971; Brideaux, 1971b). Only four species that occur in Alberta do not occur at Horton River. Sixteen species occur in common in Middle Albian rocks of Horton River and the Paris Basin (Davey and Verdier, 1971).

The validity of comparisons between assemblages of Aptian and Early Albian ages along Horton River and elsewhere is lessened by two factors: only a few previously reported assemblages can be used in such a comparison; and rocks of this age along Horton River are not particularly rich in dinoflagellates. Nevertheless, there does appear to be only a small number of species in common. Six species are endemic to the region and have been recorded elsewhere only in the Mackenzie Delta region (unpublished data).

On the other hand, previous sufficiently documented reports of Middle Albian dinoflagellate assemblages also are few in number, but Middle Albian rocks on Horton River contain a diverse assemblage in contrast to Aptian and Lower Albian rocks. A greater number of species occurs in common with assemblages of Middle Albian age in Alberta than with those of the Paris Basin. Only eleven species reported in Middle Albian rocks of the Paris Basin occur also in rocks of Middle Albian age in Alberta, five fewer than at Horton River. Although no attempt has been made to compare quantitatively assemblages from Horton River with those reported from Aptian and Albian rocks of Australasia by Cookson and Eisenack (1958, 1960a, 1962, 1968, 1969), a cursory examination shows little resemblance beyond the common occurrence of such ubiquitous species as *Dingodinium cerviculum*, *Odontochitina operculata* and commonly occurring upper Lower Cretaceous species of *Oligosphaeridium* (*O. anthophorum*, *O. complex*, *O. pulcherrimum*) and *Cyclonephelium* (*C. distinctum*, *C. compactum*).

Thus, there is some basis for postulating a boreal dinoflagellate realm, at least between Aptian and Middle Albian time. This boreal dinoflagellate realm contains a number of endemic elements, but includes also species which appear to be ubiquitous to most marine deposits of Aptian to Middle Albian age in Europe, North America and Australasia. Work in progress and unpublished data on other dinoflagellate assemblages in the Mackenzie Delta tends to support this hypothesis. In connection with this discussion, it is unfortunate that Vozzhennikova (1967) does not include data on Aptian and Albian dinoflagellate assemblages in her treatment of Soviet material.

PALEOECOLOGY

EVIDENCE FROM SPORE-POLLEN AND DINOFLAGELLATE-ACRITARCH ASSEMBLAGES

Spore and pollen floras of the Gilmore Lake Member are dominated by bisaccate and inaperturate Taxodiaceae pollen; *Classopollis* pollen is common in a few samples. Species diversity is small but increases in the upper part of the member (top of

	GEOLOGIC AGE AND LOCATION / TAXON	APTIAN				EARLY ALBIAN				MIDDLE ALBIAN					
		1	2	8	9	1	3	4	7	1	3	4	5	6	7
1	*Lunatadinium dissolutum*	×				×				×					
2	*Batioladinium jaegeri*	×				×	×		×	×	×	×	×	×	×
3	*Cleistosphaeridium multispinosum*	×				×				×		×	×	×	
4	*Cyclonephelium distinctum*	×			×				×	×			×	×	×
5	*Dingodinium cerviculum*	×		×		×				×			×	×	
7	*Microdinium opacum*	×				×				×		×		×	
8	*Odontochitina operculata*	×	×	×	×	×	×	×	×	×	×	×	×	×	×
9	*Oligosphaeridium complex*	×	×		×	×			×	×			×	×	×
10	*Oligosphaeridium*? sp. A of Brideaux, 1971b	×												×	
11	*Astrocysta cretacea*	×			×	×	×		×	×	×	×	×	×	×
12	*Pterospermopsis australiensis*	×								×			×	×	
13	*Oligosphaeridium* sp. AB	×								×					
14	*Oligosphaeridium irregulare*	×						×			×	×		×	
15	*Tenua hystrix*	×	×			×									
16	*Oligosphaeridium anthophorum*	×	×	×									×	×	
17	*Oligosphaeridium pulcherrimum*	×	×										×	×	
18	*Muderongia* sp. A	×				×									
20	*Muderongia tetracantha*	×													
21	*Oligosphaeridium totum* subsp. *totum*	×				×				×			×	×	
22	*Tenua* sp. A	×				×				×					
23	*Gardodinium eisenackii*	×		×	×	×				×			×	×	
24	*Palaeostomocystis fragilis*					×				×			×	×	
25	*Leiofusa jurassica*					×				×			×	×	
26	*Chlamydophorella nyei*				×	×				×			×	×	
27	*Dictyopyxidia imperfecta* sp. nov.					×				×					
28	*Micrhystridium* sp. A									×					
29	*Senoniasphaera microreticulata* sp. nov.									×					
30	*Cleistosphaeridium polypes* subsp. *polypes*				×				×	×			×		×
31	*Tanyosphaeridium* sp. B of Brideaux, 1971b									×				×	
32	*Microdinium spinosum* sp. nov.									×					
33	*Apteodinium maculatum*									×					
34	*Cleistosphaeridium ancoriferum*				×				×	×				×	
35	*Gonyaulacysta helicoidea*				×					×			×		×
36	*Gonyaulacysta hyalodermopsis*									×					
37	*Hystrichokolpoma ferox*		×							×			×		
38	*Leptodinium cancellatum* sp. nov.									×					
39	*Leptodinium delicatum*									×					
40	*Leptodinium modicum* sp. nov.									×					
41	*Oligosphaeridium asterigium*									×					
42	*Pterodinium verrucosum* sp. nov.									×					
43	*Pterodinium* sp. cf. *P. aliferum*		?						?	×					?
44	*Pterodinium* sp. A									×					
45	*Luxadinium primulum* gen. et sp. nov.									×					
46	*Cleistosphaeridium polypes* subsp. *clavulum*				×					×					×
47	*Cleistosphaeridium* sp. AE									×					
48	*Tanyosphaeridium* sp. A of Brideaux, 1971b									×			×	×	
49	*Kalyptea* sp. A of Brideaux, 1971b									×				×	
50	*Scriniodinium rostratum* sp. nov.									×					
51	*Microdinium*? *crinitum*				×				×	×					×
52	*Tanyosphaeridium* sp. C								?	×					?
53	*Cyclonephelium compactum*									×				×	
54	*Spiniferites ramosus*		×		×				×	×			×	×	×
55	*Palaeoperidinium* sp. A of Brideaux, 1971b									×				×	
56	*Canningia minor*				×				×	×				×	×
57	*Conosphaeridium* sp. A									×					
58	*Fromea amphora*			×	×				×	×			×	×	×
59	*Polysphaeridium laminaspinosum*				×				×	×					×
60	*Canningia ringnesii*									×				?	
61	*Kalyptea monoceras*		×							×				×	
62	*Imbatodinium* sp. A									×					
63	*Lecaniella foveata*									×			×		
64	*Cleistosphaeridium*? *aciculare*									×				×	
65	*Scriniodinium campanula*								×	×			×	×	×
66	*Oligosphaeridium*? sp. B of Brideaux, 1971b									×				×	

1 This paper
2 Eisenack (1958), North Germany
3 Pocock (1962), Alberta
4 Singh (1964), central Alberta
5 Singh (1971), west-central Alberta
6 Brideaux (1971b), central Alberta
7 Davey and Verdier (1971), Paris Basin
8 Alberti (1961), Germany
9 Davey and Verdier (1974), SE France

GSC

FIGURE 7. Comparison of dinoflagellate-acritarch species occurrence in Aptian-Middle Aptian sections along Horton River with other selected localities of comparable age

Section CR8A-68). The spore and pollen assemblages in the Gilmore Lake Member are sparse and the grains are usually corroded and poorly preserved. Dinoflagellates occur only in the topmost beds of the member. A nonmarine depositional environment is indicated for the Gilmore Lake Member except for a brief shallow-water marine or brackish interval at the top of the member (Section CR8A-68, 220.5-230 ft, 66-69 m) where eleven dinoflagellate species occur.

Dinoflagellates are absent in the basal 60 feet (18 m) of the Crossley Lakes Member (Section CR9A-68). Within this stratigraphic interval, 18 pollen and spore species make their appearance in the microfloras, which are slightly more diverse and contain more abundant grains than those of the Gilmore Lake Member. Preservation also is somewhat better. A return to nonmarine conditions is indicated for the basal part of the Crossley Lakes Member.

Seven species of dinoflagellates appear between 60 and 100 feet (18 and 33 m) in Section CR9A-68, just below the interval comprising sulphur-rich clay and grey shale of the Crossley Lakes Member. Five of these species belong to the gonyaulacacean genus *Oligosphaeridium* which dominates dinoflagellate assemblages in the lower part of the Crossley Lakes Member. Ten spore and pollen species also make their appearance in this part of the section. The spore and pollen assemblages in Section CR9A-68 continue to be dominated by bisaccate pollen and contain abundant inaperturate pollen of Taxodiaceae indicating a predominantly coniferous forest vegetation in the region.

Five more dinoflagellate species appear in the sulphur-rich strata at the base of Section CR10A-68, but only four species appear between here and the uppermost beds of the Crossley Lakes Member. Samples from the medial part of the Crossley Lakes Member (Sections CR10A-68, CR11A-68), and the lower 100 feet (30 m) of CR12A-68 yield a low diversity of dinoflagellate species and often are barren of dinoflagellates. The most persistent forms are *Odontochitina operculata*, *Oligosphaeridium complex* and *Astrocysta cretacea*, species which probably show considerable tolerance to conditions unfavourable for diverse dinoflagellate assemblages. These species show a similar occurrence pattern in dinoflagellate assemblages of low diversity in shallow-marine rocks of the Lower Colorado Group of Central Alberta (Brideaux, 1971b). *Odontochitina operculata* and *Astrocysta cretacea* occur rarely in samples from the basal 100 feet (30 m) of Section CR12A-68. In this interval, *Gardodinium eisenackii* and *Chlamydophorella nyei* become more common in the low diversity assemblages. This dinoflagellate-impoverished interval is coincident with a number of pelecypod debris rich beds (*see* Appendix).

The only significant change in the spore and pollen assemblages in Sections CR10A-68, CR11A-68 and CR12A-68 is the appearance of the tricolpate angiosperm pollen species *Retitricolpites prosimilis* in CR12A-68. Only three other species first appear in this part of the Crossley Lakes Member. Various bisaccate pollen species and pollen of Taxodiaceae continue to dominate the low diversity spore and pollen assemblages of the Crossley Lakes Member. Detrital plant material continues to be abundant as in the lower part of the section. The land plant evidence plus the dinoflagellate evidence indicate a relatively shallow, nearshore environment of deposition.

In the interval 90 to 110 feet (27 to 33 m) of Section CR12A-68, *Astrocysta cretacea* again becomes common in the dinoflagellate assemblages, along with *Gardodinium eisenackii*, *Chlamydophorella nyei* and acanthomorph acritarchs, mainly *Micrhystridium* sp. A. In this interval, *Senoniasphaera microreticulata* makes its first appearance. This association persists in the uppermost 15 feet (4.6 m) of Section CR12A-68 which are assigned to the Horton River Formation and lie above the cone-in-cone marker bed. The return of relatively more diverse dinoflagellate assemblages and the abundance of acanthomorph acritarchs probably reflects a more open, although still shallow, marine environment of deposition (Wall, 1965; Brideaux, 1971a; 1971b). The spore and pollen assemblages become even less diverse, perhaps reflecting the more open marine conditions, or indicating that conditions were unsuitable for the transportation of spores and pollen to the site of deposition.

In the basal 20 feet (6.1 m) of Section CR14A-68, a marked influx of species signals a definite change to relatively deeper water, open-marine conditions. Acanthomorph acritarchs are rare or absent. At the top of this section, maximum species diversity occurs for dinoflagellate assemblages from Lower Cretaceous rocks along Horton River. Particularly evident, in the assemblages of this lower part of the Horton River Formation, are species of the gonyaulacacean genera *Cleistosphaeridium*, *Gonyaulacysta*, *Leptodinium* and *Pterodinium*. This contrasts with the dominance of the *Astrocysta cretacea*, pseudoceratiacean and cavate cyst associations of the medial and upper parts of the Crossley Lakes Member, and the dominance of species of *Oligosphaeridium* in the lower part of that member.

The spore and pollen assemblages of Section CR14A-68 contain abundant bisaccate grains and inaperturate Taxodiaceae pollen. The grains in this part of the Horton River section are less corroded and generally much better preserved than in the rest of the section. A feature of the spore floras of Section CR14A-68 is the abundance of spores of the genera *Appendicisporites*, *Cicatricosisporites* and *Triporoletes*. Species of other spore genera also are more common than in the Langton Bay Formation. The greater diversity and abundance of spores and pollen in the lower part of the Horton River Formation may indicate more favourable conditions for the growth of the terrestrial flora of the region, or it may indicate that the depositional environment at the time was more suitable for the survival and preservation of land-derived palynomorphs. The spores and pollen in assemblages from Section CR15A-68 are abundant, but species diversity is less than in the lower part of the Horton River Formation.

Many of the gonyaulacacean species disappear from the section at or near the top of Section CR14A-68 and species diversity is approximately halved in the upper part of the Horton River Formation as sampled in Section CR15A-68. Other gonyaulacacean forms such as *Spiniferites ramosus* and species of *Microdinium* attain prominence along with *Astrocysta cretacea, Batioladinium jaegerii, Cleistosphaeridium multispinosum, Cyclonephelium distinctum* and *Imbatodinium* sp. A. Polygonomorphid and pteromorphid acritarchs of the genera *Veryhachium* and *Pterospermopsis* occur together with this dinoflagellate association. This change in the composition of the assemblages is thought to indicate continuance of open-marine conditions but no conclusions can be made about relative water depths.

The available evidence suggests that the composition of the dinoflagellate assemblages in Lower Cretaceous rocks along the Horton River has been influenced considerably by paleoecologic conditions. This does not invalidate the basic biostratigraphic conclusions noted earlier, but it does support the contention that many species with short ranges in the Horton River section will be found elsewhere to have more extensive geologic ranges.

Gonyaulacacean genera tend to dominate the dinoflagellate assemblages from Lower Cretaceous rocks on Horton River, with the exception of the medial part of the Crossley Lakes Member, where pseudoceratiacean genera and peridiniacean (*Astrocysta cretacea*) forms are prominent. The pseudoceratiacean forms belong to the genus *Tenua* and latterly to *Senoniasphaera* with species of *Cyclonephelium* occurring throughout. *Astrocysta cretacea* is replaced as the dominant peridiniacean form by *Luxadinium primulum* in the lower part of the Horton River Formation but returns to prominence in the upper part. Despite the ubiquity of *Astrocysta cretacea*, peridiniacean species are relatively rare in numbers throughout these sections. Rare also are species of the gonyaulacean genera *Spiniferites* and *Gonyaulacysta*, common elsewhere in rocks of this age (Aptian-Albian) as for example in Middle and Upper Albian rocks of central and west-central Alberta (Brideaux, 1971b; Singh, 1971). Brideaux (1975) speculates on apparent differences in assemblages of Early Cretaceous age in the delta region (based in part on unpublished data) and concludes that, although local depositional environment has had some effect on dinoflagellate assemblages, there is evidence to suggest that secondary latitudinal influence has been superimposed. This possibility is discussed also in the preceding section of this paper.

SYSTEMATIC PALYNOLOGY

SPORES AND POLLEN

Spore and pollen species identified in the sections on Horton River are recorded in the following list. The number preceding each species refers to the corresponding number on Figures 4a, 4b and 6. As most species have been described and figured in existing publications, a full descriptive and systematic coverage has not been considered necessary. Three species, one new, are described in detail following this list. The suprageneric categories, under which species are grouped, follow the usage of Potonié (1956) and the revisions published by Dettmann (1963). It should be noted that these categories have no standing under the International Code of Botanical Nomenclature (ICBN) (Stafleu *et al.*, 1972) and hence no dates of publication are given.

Anteturma SPORITES H. Potonié

Turma TRILETES Reinsch emend. Dettmann

Suprasubturma ACAVATITRILETES Dettmann

Subturma AZONOTRILETES Luber emend. Dettmann

Infraturma LAEVIGATI Bennie and Kidston emend. R. Potonié

1 *Biretisporites potoniaei* Delcourt and Sprumont, 1955 (Pl. 1, fig. 1)

30 *Cyathidites australis* Couper, 1953 (Pl. 1, fig. 2)

2 *Cyathidites minor* Couper, 1953 (Pl. 1, fig. 3)

31 *Deltoidospora juncta* (Kara-Mursa) Singh, 1964 (Pl. 1, fig. 4)

39 *Todisporites minor* Couper, 1958 (Pl. 1, fig. 5)

12 *Stereisporites antiquasporites* (Wilson and Webster) Dettmann, 1963 (Pl. 1, fig. 6)

Infraturma APICULATI Bennie and Kidston emend. R. Potonié

78 *Leptolepidites verrucatus* Couper, 1953 (Pl. 1, figs. 8, 9)

41 *Concavissimisporites punctatus* (Delcourt and Sprumont) Brenner, 1963 (Pl. 1, fig. 7)

17 *Concavissimisporites variverrucatus* (Couper) Brenner, 1963 (Pl. 1, fig. 10)

64 *Acanthotriletes varispinosus* Pocock, 1962 (Pl. 1, fig. 13)

18 *Baculatisporites comaumensis* (Cookson) R. Potonié, 1956 (Pl. 1, fig. 12)

13 *Osmundacidites wellmanii* Couper, 1953 (Pl. 1, fig. 11)

19 *Pilosisporites trichopapillosus* (Thiergart) Delcourt and Sprumont, 1955 (Pl. 1, fig. 14)

42 *Pilosisporites verus* Delcourt and Sprumont, 1955 (Pl. 1, fig. 15)

67 *Kuylisporites lunaris* Cookson and Dettmann, 1958 (Pl. 1, fig. 16)

102 *Dictyotriletes granulatus* Pocock, 1962 (Pl. 1, figs. 17, 18)

Infraturma MURORNATI R. Potonié and Kremp

73 *Lycopodiacidites intraverrucatus* Brenner, 1963 (Pl. 1, figs. 19, 20)

3 *Lycopodiumsporites austroclavatidites* (Cookson) R. Potonié, 1956 (Pl. 1, fig. 21)

22 *Lycopodiumsporites marginatus* Singh, 1964 (Pl. 1, fig. 22)

55 *Microreticulatisporites uniformis* Singh, 1964 (Pl. 1, figs. 23, 24)

43 *Reticulisporites vermiformis* Kremp, 1970 (Pl. 1, figs. 25, 26)

23 *Klukisporites areolatus* Singh, 1971 (Pl. 1, fig. 27)

79 *Klukisporites pseudoreticulatus* Couper, 1958 (Pl. 1, fig. 28)

105 *Foveotriletes subtriangularis* Brenner, 1963 (Pl. 1, fig. 29)

32 *Tigrisporites scurrandus* Norris, 1967 (Pl. 1, figs. 30-32)

24 *Cicatricosisporites annulatus* Archangelsky and Gamerro, 1966 (Pl. 1, figs. 33, 34)

44 *Cicatricosisporites augustus* Singh, 1971 (Pl. 1, figs. 35, 36)

45 *Cicatricosisporites australiensis* (Cookson) R. Potonié, 1956 (Pl. 1, fig. 37)

97 *Cicatricosisporites* sp. cf. *Anemia exilioides* (Maljavkina) Bolkhovitina, 1953 (Pl. 1, figs. 39-41)

46 *Cicatricosisporites hallei* Delcourt and Sprumont, 1955 (Pl. 1, fig. 38)

47 *Cicatricosisporites hughesii* Dettmann, 1963 (Pl. 1, fig. 42)

72 *Cicatricosisporites ludbrooki* Dettmann, 1963 (Pl. 1, fig. 43)

33 *Cicatricosisporites potomacensis* Brenner, 1963 (Pl. 1, fig. 44)

20 *Cicatricosisporites pseudotripartitus* (Bolkhovitina) Dettmann, 1963 (Pl. 2, figs. 1, 2)

96 *Cicatricosisporites* sp. cf. *C. subrotundus* Brenner, 1963 (Pl. 2, fig. 3)

65 *Cicatricosisporites venustus* Deák, 1963 (Pl. 2, figs. 4, 5)

60 *Costatoperforosporites fistulosus* Deák, 1962 (Pl. 2, figs. 6, 7)

83 *Costatoperforosporites foveolatus* Deák, 1962 (Pl. 2, fig. 9)

74 *Costatoperforosporites* sp. cf. *Anemia perforata* Baranov, Nemkova and Kondratiev, 1957 (Pl. 2, fig. 8)

Subturma ZONOTRILETES Waltz

Infraturma AURICULATI Schopf emend. Dettmann

62 *Appendicisporites bifurcatus* Singh, 1964 (Pl. 2, fig. 10)

106 *Appendicisporites bilateralis* Singh, 1971 (Pl. 2, fig. 11)

103 *Appendicisporites cristatus* (Markova) Pocock, 1964 (Pl. 2, figs. 14, 15)

100 *Appendicisporites erdtmanii* Pocock, 1964 (Pl. 2, figs. 16, 17)

75 *Appendicisporites potomacensis* Brenner, 1963 (Pl. 2, figs. 12, 13)

84 *Appendicisporites* sp. cf. *Anemia trichacantha* (Maljavkina) Markova *in* Ivanov and Markova, 1961 (Pl. 2, fig. 18)

80 *Trilobosporites apibaculatus* Brenner, 1963 (Pl. 2, fig. 19)

48 *Trilobosporites marylandensis* Brenner, 1963 (Pl. 2, fig. 20)

70 *Trilobosporites perverulentus* (Verbitskaya) Dettmann, 1963 (Pl. 2, figs. 21, 22)

61 *Trilobosporites trioreticulosus* Cookson and Dettmann, 1958 (Pl. 2, fig. 23)

Infraturma TRICRASSATI Dettmann

4 *Gleicheniidites senonicus* Ross, 1949 (Pl. 2, fig. 28)

91 *Ornamentifera baculata* Singh, 1971 (Pl. 2, fig. 29)

40 *Sestrosporites pseudoalveolatus* (Couper) Dettmann, 1963 (Pl. 2, fig. 24)

68 *Coronatispora valdensis* (Couper) Dettmann, 1963 (Pl. 2, figs. 26, 27)

89 *Camarozonosporites ambigens* (Fradkina) Playford, 1971 (Pl. 2, fig. 25)

Infraturma CINGULATI R. Potonié and Klaus emend. Dettmann

95 *Polycingulatisporites reduncus* (Bolkhovitina) Playford and Dettmann, 1965

76 *Foraminisporis asymmetricus* (Cookson and Dettmann) Dettmann, 1963 (Pl. 2, figs. 30, 31)

49 *Foraminisporis wonthaggiensis* (Cookson and Dettmann) Dettmann, 1963 (Pl. 2, figs. 32, 33)

56 *Contignisporites cooksonii* (Balme) Dettmann, 1963 (Pl. 2, figs. 41, 42)

88 *Contignisporites glebulentus* Dettmann, 1963 (Pl. 2, figs. 37-39)

34 *Cingutriletes clavus* Dettmann, 1963 (Pl. 2, fig. 34)

94 *Distaltriangulisporites perplexus* (Singh) Singh, 1971 (Pl. 2, fig. 40)

57 *Rogalskaisporites cicatricosus* (Rogalska) Danzé-Corsin and Laveine, 1963 *in* Briche *et al.*, 1963 (Pl. 2, fig. 35)

25 *Cirratriradites teter* Norris, 1967 (Pl. 2, fig. 36)

Subturma ZONOLAMINATITRILETES Smith and Butterworth

Infraturma CINGULICAVATI Smith and Butterworth

77 *Krauselisporites hastilobatus* Playford, 1971 (Pl. 3, figs. 1-3)

66 *Densoisporites microrugulatus* Brenner, 1963 (Pl. 3, fig. 4)

Suprasubturma PERINOTRILETES Erdtman emend. Dettmann

38 *Crybelosporites vectensis* Kremp, 1970 (Pl. 3, figs. 5-7)

Turma MONOLETES Ibrahim

Suprasubturma ACAVATOMONOLETES Dettmann

Subturma AZONOMONOLETES Luber

Infraturma LAEVIGATOMONOLETI Dybova and Jachowicz

58 *Laevigatosporites ovatus* Wilson and Webster, 1946 (Pl. 3, fig. 8)

Infraturma SCULPTATOMONOLETI Dybova and Jachowicz

108 *Verrucatosporites chaloneri* (Brenner) Kremp, 1970 (Pl. 3, fig. 9)

Turma HILATES Dettmann

59 *Aequitriradites spinulosus* (Cookson and Dettmann) Cookson and Dettmann, 1961 (Pl. 3, fig. 19)

93 *Triporoletes radiatus* (Dettmann) Playford, 1971 (Pl. 3, figs. 10-12)

50 *Triporoletes reticulatus* (Pocock) Playford, 1971 (Pl. 3, figs. 13, 14)

90 *Triporoletes simplex* (Cookson and Dettmann) Playford, 1971 (Pl. 3, fig. 15)

98 *Triporoletes singularis* Mtchedlishvili *in* Mtchedlishvili and Samoilovich, 1960 (Pl. 3, figs. 16-18)

85 *Cooksonites variabilis* Pocock, 1962 (Pl. 3, figs. 20, 21)

63 *Coptospora* sp. cf. *C. williamsii* Playford, 1971 (Pl. 3, figs. 22, 23)

26 *Coptospora* sp. of Brideaux and McIntyre, this paper (Pl. 3, figs. 24, 25)

99 *Januasporites spiniferus* Singh, 1964 (Pl. 3, figs. 26, 27)

Anteturma POLLENITES R. Potonié

Turma SACCITES Erdtman

Subturma MONOSACCITES Chitaley emend. R. Potonié and Kremp

Infraturma SACCIZONATI Bhardwaj

5 *Cerebropollenites mesozoicus* (Couper) Nilsson, 1958 (Pl. 3, figs. 35, 36)

35 *Callialasporites dampieri* (Balme) Dev, 1961 (Pl. 3, fig. 28)

Subturma DISACCITES Cookson

Infraturma DISACCIASTRILETI Leschik emend. R. Potonié

51 *Vitreisporites pallidus* (Reissinger) Nilsson, 1958 (Pl. 3, fig. 30)

6 *Alisporites bilateralis* Rouse, 1959 (Pl. 3, fig. 32)

7 *Alisporites grandis* (Cookson) Dettmann, 1963 (Pl. 3, fig. 29)

71 *Alisporites minutus* Rouse, 1959 (Pl. 3, fig. 31)

27 *Cedripites canadensis* Pocock, 1962 (Pl. 3, fig. 37)

14 *Cedripites cretaceus* Pocock, 1962 (Pl. 3, figs. 33, 34)

8 *Podocarpidites biformis* Rouse, 1957 (Pl. 4, figs. 5, 6)

28 *Podocarpidites canadensis* Pocock, 1962 (Pl. 4, fig. 2)

15 *Podocarpidites multesimus* (Bolkhovitina) Pocock, 1962 (Pl. 4, figs. 3, 4)

9 *Parvisaccites radiatus* Couper, 1958 (Pl. 4, fig. 9)

82 *Parvisaccites rugulatus* Brenner, 1963 (Pl. 4, fig. 10)

21 *Parvisaccites hortonensis* sp. nov. (Pl. 4, figs. 11-14)

81 cf. *Podocarpus tricocca* (Maljavkina) Bolkhovitina, 1953 (Pl. 4, fig. 1)

Turma ALETES Ibrahim

Subturma AZONOLETES Luber emend. R. Potonié and Kremp

Infraturma PSILONAPITI Erdtman

10 *Taxodiaceaepollenites hiatus* (Potonié) Kremp, 1950 (Pl. 4, fig. 19)

107 *Laricoidites magnus* (Potonié) Potonié, Thomson and Thiergart, 1950 (Pl. 4, fig. 7)

69 *Inaperturopollenites limbatus* Balme, 1957 (Pl. 4, fig. 8)

Infraturma GRANULONAPITI Cookson

36 *Araucariacites australis* Cookson, 1947 (Pl. 4, fig. 15)

Infraturma RETICULONAPITI

86 *Reticulatasporites dupliexinous* Brenner, 1963 (Pl. 4, figs. 20, 21)

Subturma ZONALETES Luber

11 *Perinopollenites elatoides* Couper, 1958 (Pl. 4, figs. 22, 23)

Turma PLICATES Naumova emend. R. Potonié

Subturma PRAECOLPATES R. Potonié and Kremp

52 *Eucommiidites minor* Groot and Penny, 1960 (Pl. 4, figs. 17, 18)

Subturma POLYPLICATES Erdtman

53 *Equisetosporites multicostatus* (Brenner) Norris, 1967 (Pl. 4, fig. 16)

Subturma MONOCOLPATES Iversen and Troels-Smith

87 *Clavatipollenites hughesii* Couper emend. Kemp, 1968 (Pl. 4, fig. 30)

16 *Cycadopites nitidus* (Balme) Norris, 1969 (Pl. 4, fig. 24)

Subturma TRIPTYCHES Naumova

104 *Retitricolpites georgensis* Brenner, 1963 (Pl. 4, figs. 31, 32)

92 *Retitricolpites prosimilis* Norris, 1967 (Pl. 4, figs. 33, 34)

101 *Fraxinoipollenites venustus* Singh, 1971 (Pl. 4, figs. 35-37)

Turma POROSES Naumova emend. R. Potonié

Subturma MONOPORINES Naumova

29 *Exesipollenites tumulus* Balme, 1957 (Pl. 4, fig. 29)

54 *Circulina parva* Brenner, 1963 (Pl. 4, figs. 27, 28)

37 *Classopollis classoides* Pflug emend. Pocock and Jansonius, 1961 (Pl. 4, figs. 25, 26)

(63) Genus *Coptospora* Dettmann

1962 *Cooksonites* Pocock (partim), p. 54.
1963 *Coptospora* Dettmann, p. 88.

Coptospora sp. cf. *C. williamsii* Playford

Plate 3, figures 22, 23

cf. 1971 *Coptospora williamsii* Playford, p. 551, Pl. 106, figs. 8-13.

Discussion. The specimens recorded from Section CR9A-68 along Horton River are morphologically similar to those described by Playford (1971). However, the Horton River specimens have a diameter of 65-70μ and are smaller than the size range of 82-140μ noted by Playford (1971) for his specimens from the Swan River Group.

Occurrence. Langton Bay Formation, Gilmore Lake Member; similar forms recorded by Playford (1971) from upper Middle Albian or lowermost Upper Albian strata assigned to the upper part of the Swan River Group of southwestern Manitoba.

(26) *Coptospora* sp.

Plate 3, figures 24, 25

Description. Spores are hilate, spheroidal, and have a subtriangular to circular amb. The exine is 2.5μ thick, the ectexine 2μ thick and the endexine, about 0.5μ thick. The sculpture is verrucate, except at one pole where the hilum is developed. The verrucae are low, rounded on top, 2-4μ wide basally, often elongated across the equator, and closely spaced with grooves 1μ wide between sculpture elements.

Dimensions. Equatorial diameter, 53-60μ.

Discussion. The species has not been named formally because only a few specimens were recovered. A similar form, *Coptospora* sp. A of Dettmann (1963, p. 89, Pl. 20, figs. 6-8), is larger than *Coptospora* sp. and has a thicker exine which has a radially striated inner surface.

Genus *Parvisaccites* Couper

1958 *Parvisaccites* Couper, p. 154.

(21) *Parvisaccites hortonensis* sp. nov.

Plate 4, figures 11-14

Holotype. GSC No. 34159, Slide 6745/A1, 26.7 x 114.6; Langton Bay Formation, Gilmore Lake Member, Section CR8A-68, 30-33 feet (9.1-10.1 m); GSC loc. C-8440; Aptian. Dimensions: Breadth of grain, 44μ; depth of grain, including sacci, 32μ.

Description. The pollen grains are disaccate. The sacci are small and narrow and either project laterally or are distally pendant. They are shorter than the corpus. The sacci vary in size depending on the amount of separation of the endexine and ectexine. The sacci are finely reticulate and usually have a radiate appearance because of the conspicuous baculae which fill the sacci. The proximal cap is scabrate and has an LO pattern. The cap grades into the sacci and no marginal crest is visible. The exine of the cap is 2μ thick. The endexine is 0.5μ thick and the ectexine including the baculae 1.5μ thick. A wide sulcus, almost the full length of the corpus, is usually present on the distal surface between the sacci.

Dimensions. Length of grain, 32-55μ; breadth of grain, 34-60μ; depth of grain, including sacci, 23-35μ.

Comparison. *Parvisaccites hortonensis* sp. nov. has similarities with *Punctabivesiculites parvus* Pierce (1961, p. 37, Pl. 2, fig. 48) and *Retibivesiculites parvus* Pierce (1961, p. 38, Pl. 2, figs. 51, 52) from Cenomanian strata in Minnesota. However, these two species are larger than *Parvisaccites hortonensis* sp. nov. and have more pronounced sacci.

DINOFLAGELLATES AND ACRITARCHS

Division PYRROPHYTA Pascher

Class DINOPHYCEAE Pascher

Order PERIDINIALES Schütt

Discussion. The material treated in this section consists of fossilized remains of the cyst stage of motile, unicellular dinoflagellates (Evitt, 1961). These cyst forms have been classified into approximately 300 genera (Lentin and Williams, 1973). Several suprageneric classifications based on fossil cysts have been proposed (Deflandre, 1952; Eisenack, 1961, 1964; Norris and Sarjeant, 1965; Vozzhennikova, 1965; and Sarjeant and Downie, 1966, 1974). Some of these suprageneric groups are typified by the motile thecal stage of a genus of modern dinoflagellates. Genera based on fossil cysts often are assigned to them because of their morphological similarity to thecate forms. Many other groups proposed are typified by a genus based on fossil material. For this, and other reasons, Sarjeant and Downie (1966) proposed that genera based on fossil dinoflagellate cysts be classified in what they termed 'cyst-families'. These authors redefined many established families with reference to dinoflagellate cyst morphology and proposed several new cyst-families. More recently, Sarjeant and Downie (1974) have revised their earlier work and dropped the prefix 'cyst'.

Wall and Dale (1968) objected to the classification developed by Eisenack (1961, 1964) on the grounds that many genera of fossil dinoflagellate cysts were excluded from the scheme. These authors objected also to the 'cyst-family' concept of Sarjeant and Downie (1966) on the grounds that such a scheme was nonbiological and non-evolutionary. Wall and Dale (1968) also raised serious doubt as to the validity of many generic names for fossil cysts in view of certain provisions of the International Code of Botanical Nomenclature (ICBN) (Stafleu *et al.*, 1972). Readers may refer to Wall and Dale (1968) for details of their discussion.

In that paper are mentioned also a number of gonyaulacacean and peridiniacean dinoflagellate lineages (Wall and Dale, 1968, Table 2, Textfig. 5), of which the gonyaulacoid-hystrichosphaericoid, pseudoceratioid-areoligeroid and peridinioid-deflandreoid lineage groupings are relevant to this discussion.

Evitt's (1972) informal groups of "G-cysts", "K-cysts" and "P-cysts" correspond in principle to those lineages cited above. Evitt (1972) further groups the cyst genera in each category into "complexes" based on similarities in reflected tabulation, archeopyle structure and morphologic features of lesser taxonomic value. Evitt (1972) and Wall and Dale (1968) overlap in their assignments of cyst genera to the various "complexes" and lineage groups. Wall and Dale (op. cit.) differ also from Evitt (op. cit.) in that they assign their aeroligeroid and pseudoceratioid lineage groups to the gonyaulacacean and peridinioid lineages, respectively, whereas Evitt places these in his "K-cyst" category.

Because of the objections raised by Wall and Dale (1968), and the inconsistencies inherent in earlier familial schemes, the present authors prefer to use a more informal grouping of genera below the level of order. Thus, the simplified scheme of Evitt (1972) is followed in this paper, except that "G-cysts" are described as gonyaulacacean cysts, "K-cysts" as pseudoceratiacean cysts, and "P-cysts" as peridiniacean cysts. Those cysts that do not readily fit into these groups are arranged alphabetically in the category of unassigned cysts.

It is convenient also to be able to group genera, from the various categories, which have grossly similar surface sculpture or wall structure, under one heading. Therefore, the authors treat each of the major categories in turn under the general headings of proximate, chorate and cavate cysts and, within these headings, in alphabetical order. The authors agree with the opinion expressed by Wall and Dale (1968, p. 291) on the validity of the hypothesis of contractional growth, with which these terms are associated, and use the terminology only in a gross morphologic sense.

Following is a list of the taxa treated in the systematic section dealing with dinoflagellates and acritrachs. The taxa are arranged alphabetically under the categories discussed above and follow in that order in the text. The numbers correspond to numbers assigned on Textfigures 5, 6 and 7.

Proximate gonyaulacacean cysts

33 *Apteodinium maculatum* Eisenack and Cookson, 1960.

35 *Gonyaulacysta helicoidea* (Eisenack and Cookson) Sarjeant, 1966a.

36 *Gonyaulacysta hyalodermopsis* (Cookson and Eisenack) Sarjeant, 1966a.

38 *Leptodinium cancellatum* sp. nov.

39 *Leptodinium delicatum* (Davey) Sarjeant, 1969.

40 *Leptodinium modicum* sp. nov.

1 *Lunatadinium dissolutum* Brideaux and McIntyre, 1973.

51 *Microdinium? crinitum* Davey, 1969.

7 *Microdinium opacum* Brideaux, 1971b.

32 *Microdinium spinosum* sp. nov.

Proximate pseudoceratiacean cysts

2 *Batioladinium jaegeri* (Alberti) Brideaux in press.

56 *Canningia minor* Cookson and Hughes, 1964.

60 *Canningia ringnesii* Manum and Cookson, 1964.

15 *Tenua hystrix* Eisenack, 1958.

22 *Tenua* sp. A of Brideaux and McIntyre, this paper.

Proximate unassigned cysts

27 *Dictyopyxidia imperfecta* sp. nov.

58 *Fromea amphora* Cookson and Eisenack, 1958.

24 *Palaeostomocystis fragilis* Cookson and Eisenack, 1962.

Chorate gonyaulacacean cysts

64 *Cleistosphaeridium? aciculare* Davey, 1969.

34 *Cleistosphaeridium ancoriferum* (Cookson and Eisenack) Davey *et al.*, 1966.

3 *Cleistosphaeridium multispinosum* (Singh) Brideaux, 1971b.

30 *Cleistosphaeridium polypes* (Cookson and Eisenack) Davey subsp. *polypes* Davey, 1969.

46 *Cleistosphaeridium polypes* subsp. *clavulum* (Davey) Lentin and Williams, 1973.

47 *Cleistosphaeridium?* sp. AE of Brideaux and McIntyre, this paper.

57 *Conosphaeridium* sp. A of Brideaux and McIntyre, this paper.

37 *Hystrichokolpoma ferox* (Deflandre) Davey, 1969.

16 *Oligosphaeridium anthophorum* (Cookson and Eisenack) Davey, 1969.

41 *Oligosphaeridium asterigium* (Gocht) Davey and Williams *in* Davey *et al.*, 1969.

9 *Oligosphaeridium complex* (White) Davey and Williams, 1966.

14 *Oligosphaeridium irregulare* (Pocock) Davey and Williams, 1966.

17 *Oligosphaeridium pulcherrimum* (Deflandre and Cookson) Davey and Williams, 1966.

21 *Oligosphaeridium totum* Brideaux subsp. *totum* Brideaux, 1971b.

13 *Oligosphaeridium* sp. AB of Brideaux and McIntyre, this paper.

10 *Oligosphaeridium?* sp. A of Brideaux, 1971b.

66 *Oligosphaeridium?* sp. B of Brideaux, 1971b.

59 *Polysphaeridium laminaspinosum* Davey and Williams, 1966.

42 *Pterodinium verrucosum* sp. nov.

43 *Pterodinium* sp. cf. *P. aliferum* Eisenack, 1958.

44 *Pterodinium* sp. A of Brideaux and McIntyre, this paper.

54 *Spiniferites ramosus* (Ehrenberg) Mantell, 1854.

48 *Tanyosphaeridium* sp. A of Brideaux, 1971b.

31 *Tanyosphaeridium* sp. B of Brideaux, 1971b.

52 *Tanyosphaeridium* sp. C of Brideaux and McIntyre, this paper.

Chorate pseudoceratiacean cysts

53 *Cyclonephelium compactum* Deflandre and Cookson, 1955.

4 *Cyclonephelium distinctum* Deflandre and Cookson, 1955.

Chorate unassigned cysts

62 *Imbatodinium* sp. A of Brideaux and McIntyre, this paper.

Cavate gonyaulacacean cysts

23 *Gardodinium eisenackii* Alberti, 1961.

65 *Scriniodinium campanula* Gocht, 1959.

50 *Scriniodinium rostratum* sp. nov.

Cavate pseudoceratiacean cysts

20 *Muderongia tetracantha* (Gocht) Alberti, 1961.

18 *Muderongia* sp. A of Brideaux and McIntyre, this paper.

8 *Odontochitina operculata* (O. Wetzel) Deflandre, 1946.

29 *Senoniasphaera microreticulata* sp. nov.

Cavate peridiniacean cysts

11 *Astrocysta cretacea* Pocock ex Davey, 1969

45 *Luxadinium primulum* gen. et sp. nov.

Luxadinium propatulum comb. et sp. nov.

55 *Palaeoperidinium* sp. A of Brideaux, 1971b.

Cavate unassigned cysts

26 *Chlamydophorella nyei* Cookson and Eisenack, 1958.

5 *Dingodinium cerviculum* Cookson and Eisenack, 1958.

61 *Kalyptea monoceras* Cookson and Eisenack, 1960b.

49 *Kalyptea* sp. A of Brideaux, 1971b.

Group ACRITARCHA

63 *Lecaniella foveata* Singh, 1971.

25 *Leiofusa jurassica* Cookson and Eisenack, 1958.

28 *Micrhystridium* sp. A of Brideaux and McIntyre, this paper.

12 *Pterospermopsis australiensis* Deflandre and Cookson, 1955.

19 *Veryhachium collectum* Wall, 1965.

19 *Veryhachium reductum* "forma" *trispinoides* de Jekhowsky, 1961.

Proximate gonyaulacacean cysts

Genus *Apteodinium* Eisenack

1958 *Apteodinium* Eisenack, p. 385.

(33) *Apteodinium maculatum* Eisenack and Cookson

Plate 5, figures 1, 2

1960 *Apteodinium maculatum* Eisenack and Cookson, p. 4, Pl. 2, figs. 1-3.
1966b *Apteodinium maculatum* Eisenack and Cookson; Sarjeant, p. 205, Pl. 22, fig. 1, Textfig. 54.

Description. The periblast outline is subcircular to ovoid; the apex is prolonged into an apical horn, 5-13μ long, and the antapex is rounded. The cyst wall is two layered. The endophragm is thin, and about 0.5μ thick in optical section; the periphragm is formed of short pila or rods arising from the inner surface and coalescing to form a microreticulate surface pattern. These elements are about 0.5μ high and the lumina of the surface microreticulum are about 0.2-0.5μ in maximum diameter. The periblast forms the apical horn, and the endoblast protrudes slightly into the apical pericoel.

The archeopyle is precingular trapezoidal in outline, and formed by the loss of a single reflected precingular plate, probably 3". The operculum is generally detached, but may be partially attached and is found in several specimens inside the endocoel. The operculum includes both wall layers. The cingulum and sulcus cannot be distinguished on the specimens from Horton River material, although the cingulum is distinctly visible on the holotype illustrated by Eisenack and Cookson (1960, Pl. 2, fig. 1). Both cingulum and sulcus are sketched by Sarjeant (1966b, Textfig. 54), but are not clearly visible in the illustration (Sarjeant, 1966b, Pl. 22, fig. 1).

The "small thickened areas with circular outlines" scattered over the periphragm (Eisenack and Cookson, 1960, p. 5) are not recorded by Sarjeant (1966b, p. 205), nor are they seen on material from the Horton River. These may be preservation phenomena.

Dimensions. (18 measured specimens) - Length, 75-90μ; width, 60-78μ.

Occurrence. Horton River Formation (Middle Albian); recorded previously from the lower Barremian of England (Sarjeant, 1966b) and the Aptian and Albian of Australia (Eisenack and Cookson, 1960).

Genus *Gonyaulacysta* Deflandre ex Norris and Sarjeant, 1965 emend. Sarjeant

1964 *Gonyaulacysta* Deflandre, p. 5.
1965 *Gonyaulacysta* Deflandre; Norris and Sarjeant, p. 65.
1966a *Gonyaulacysta* Deflandre emend. Sarjeant, p. 111.
1969 *Gonyaulacysta* Deflandre emend. Sarjeant *in* Davey *et al.*, p. 7.

(35) *Gonyaulacysta helicoidea* (Eisenack and Cookson) Sarjeant

Plate 5, figure 3

1960 *Gonyaulax helicoidea* Eisenack and Cookson, p. 2, Pl. 1, figs. 4, 9.
1966a *Gonyaulacysta helicoidea* (Eisenack and Cookson) Sarjeant, p. 116, Pl. 13, figs. 7, 8, Pl. 15, figs. 8, 9, Textfig. 26.

Dimensions. (3 specimens) - Length, 50-53μ; width, 42-48μ.

Occurrence. Horton River Formation; recorded previously from the lower Barremian of England (Sarjeant, 1966a), the Aptian of South Australia (Eisenack and Cookson, 1960) and the Middle Albian of west-central Alberta, Canada (Singh, 1971).

(36) *Gonyaulacysta hyalodermopsis* (Cookson and Eisenack) Sarjeant

Plate 5, figures 4, 5

1958 *Gonyaulax hyalodermopsis* Cookson and Eisenack, p. 34, Pl. 3, figs. 11, 12, Textfigs. 5, 6.

1966a *Gonyaulacysta hyalodermopsis* (Cookson and Eisenack) Sarjeant, p. 131 (nom. nud.).

1969 *Gonyaulacysta hyalodermopsis* (Cookson and Eisenack) Sarjeant, p. 10.

Description. The outline of the periblast is pentagonal with an interruption in the outline at the apex which is prolonged into an apical horn 7-11μ in length. The antapex is somewhat flattened. The wall of the cyst is two layered. The endoblast outline is pentagonal and does not protrude at the apex. The periblast is appressed closely to the endoblast except where it is prolonged, forming the truncated conical apical horn, and where it forms sutural crests 3-6μ high. The surfaces of both layers are smooth or scabrate.

The cingulum is outlined by parallel crests and is sinistral, displaced one and one-half to two cingulum widths; the width of the cingulum ranges between 4 and 7μ. The sulcus is visible on most specimens as a ventral, medial depression in the periphragm; the depression is bordered anteriorly by the reflected apical plate 1' and posteriorly by the reflected antapical plate 1''''. It is widest at the posterior end, narrowing to the width of the reflected plate 1' anteriorly.

The archeopyle is precingular, formed by the loss of a single reflected precingular plate 3" in both wall layers. The operculum is "hoof-shaped", the flatter edge corresponding to the posterior junction with the cingular suture. The operculum is generally detached, rarely partly attached along its posterior margin, but may be found lying in the endocoel.

Reflected tabulation, as determined by the presence of the sutural ridges is as follows: 4', 6", 6c, 5''', 1p, 1''''. Reflected plate 1' is long and narrow. Reflected plate 4' is reduced to a narrow strip, 3-5μ wide, and often not clearly distinguishable on many specimens. The antapical reflected plate 1'''' is quadrate.

Dimensions. (27 measured specimens) - Length, 55-92μ; width, 56-82μ.

Discussion. The description above is not intended to be complete, but rather to elucidate certain aspects of the wall structure and tabulation absent from the original description of Cookson and Eisenack (1958, p. 34). The tabulation as shown by Cookson and Eisenack (1958, Figs. 5, 6) is essentially correct except for details of the apical reflected series and postulation of strongly reduced reflected plates corresponding to 1''' and 6'''. There are only five postcingular reflected plates, with reflected plate 5''' being somewhat smaller than the others in the series, at least on specimens from Horton River.

Occurrence. Horton River Formation (Middle Albian); recorded previously from the upper Neocomian and Aptian of West Australia (Cookson and Eisenack, 1958) and from the Berriasian to Hauterivian of the Sacramento Valley, California, U.S.A. (Warren, 1967, p. 147).

Genus *Leptodinium* Klement emend. Sarjeant

1960 *Leptodinium* Klement, p. 45.
1966a *Leptodinium* Klement emend. Sarjeant, p. 133.
1967 *Leptodinium* Klement emend. Wall, p. 104.
1969 *Leptodinium* Klement emend. Sarjeant *in* Davey *et al.*, p. 11.

(38) *Leptodinium cancellatum* sp. nov.

Plate 5, figures 7-9

Holotype. GSC No. 34146, Slide P851-3A, 20.5 x 129.5; Horton River Formation, Section CR14A-68, 30 to 37 feet (9.1 to 11.1 m), GSC loc. C-8534; Middle Albian. Length, 75μ (right lateral view).

Diagnosis. Circular or subcircular outline; length to width ratio close to 1.0. Wall two-layered, the periphragm forming low sutural ridges reflecting a tabulation of 4', 6", 6c, 5''', 1'''', 1p, 5s, and also forming the intratabular apiculate to vermiculate sculpture. Reflected plate 1' elongate and narrow, 4' considerably larger than 1'. Cingulum offset 1 to 1-1/2 cingular widths; sulcus nearly straight, with reflected sulcul tabulation often developed. Archeopyle precingular, formed by loss of reflected plate 3"; operculum detached.

Description. The cyst outline is circular or subcircular. The ratio of epitract to hypotract length is close to 1.0. Both apex and antapex are rounded.

The cyst wall is two layered. The endophragm is smooth and thin, less than 0.5μ thick in optical section. The periphragm is about 1.0μ thick in optical section and forms the low sutural crests and intratabular sculpture. The two layers are in contact except at the sutures and the intratabular ridges. The periphragm is finely granular between the major sculpture. Intratabular sculpture is variable, even on a given specimen, and ranges from granulate to vermiculate or vermiculate-reticulate, forming a trellis-like pattern. The intratabular sculpture may connect with the sutural ridges. Intratabular sculpture is less than 1.0μ in height and from 0.5 to 2.0μ in width.

The archeopyle is precingular and formed by the loss of reflected plate 3". The operculum is detached and rounded-trapezoidal in shape.

The cingulum is well marked by a pair of cingular ridges, which are similar to the sutural ridges and connect with them. Cross-sutures delimit six precingular reflected plates. The cingulum is from 4.0 to 7.0μ wide, sinistral, and displaced one to one and one-half cingular widths. The sulcus is narrow anteriorly, where the reflected anterior sulcal plate adjoins 1', and widens posteriorly to meet the reflected antapical plate 1''''. Some, or all, of the sulcal reflected plates (anterior sulcal, left anterior sulcal, right sulcal, left sulcal and posterior sulcal) are visible on a given specimen. A central area located between the reflected anterior and posterior sulcal plates is probably the reflected site of the insertion of the longitudinal flagellum.

Reflected tabulation correspond to the formula 4', 6", 6c, 6''', 1p, 5s, 1''''. Reflected plate 1' is narrow posteriorly and is widest just below the apex; reflected plate 4' is much larger than 1';

reflected plate 1p is trapezoidal in shape. The reflected tabulation is outlined by low, narrow, sutural ridges, 1-2μ wide, by irregularly dissected sutural ridges, or by sutural rows of basally connected pila or coni, 1-2μ high. The sutures often are crenulated.

Dimensions. (30 measured specimens) - Length, 57-77μ; width, 52-67μ.

Comparison. The intratabular sculpture of *Leptodinium cancellatum* sp. nov. serves to distinguish the species from others described in the literature.

Occurrence. Horton River Formation (Middle Albian).

(39) *Leptodinium delicatum* (Davey) Sarjeant

Plate 5, figure 6

1969 *Gonyaulacysta delicata* Davey, p. 123, Pl. 1, figs. 7, 8, Figs. 10A, B.
1969 *Leptodinium delicatum* (Davey) Sarjeant, p. 12.

Dimensions. (12 measured specimens) - Maximum diameter, 50-62μ.

Discussion. Davey (1969) remarks on the fragile nature of the cyst wall of this species. This characteristic is well shown in specimens recorded from Horton River material; as a result, a maximum diameter is recorded rather than a length and width. Davey (1969, p. 124) also notes the restricted distribution of this species in his Saskatchewan material and suggests that it might have been recycled into Cenomanian strata.

Occurrence. Horton River Formation (Middle Albian); recorded previously from Cenomanian strata of Saskatchewan (Davey, 1969) at a depth of 835 feet (254.6 m) in International Yarbo No. 17 borehole.

(40) *Leptodinium modicum* sp. nov.

Plate 5, figures 10-15

Holotype. GSC No. 34147, Slide P851-2A, 32.6 x 117.0; Horton River Formation, Section CR14A-68, 20 to 30 feet (6.1 to 9.1 m), GSC loc. C-8533; Middle Albian. Length, 45μ; width, 50μ (excluding crests; dorsal surface uppermost, specimen tilted).

Diagnosis. Pentagonal, but rounded, outline; length to width ratio close to 1.0. Two smooth wall layers; periphragm thin, forming entire, low sutural crests reflecting a tabulation of 4', 6'', 6c, 5''', 1p, 1''''; reflected plate 1' elongate; 4' elongate and small. Cingulum offset two to three cingular widths; sulcus sinuous and inclined to the right. Archeopyle precingular, formed by loss of reflected plate 3''; operculum detached.

Description. The periblast outline is pentagonal, but rounded; the rounded apex is without an apical horn or prominence. The antapex is slightly flattened. The total length to width ratio of the periblast, excluding crests, is close to 1.0. The epitract length is equal to or slightly less than that of the hypotract. Two wall layers are present. The endophragm is smooth and thin, about 1μ thick in optical section. The periphragm is smooth, thin, and closely appressed to the endophragm, except where the periphragm forms low, entire crests along the reflected plate boundaries and at the periphery of the cingular and sulcal regions. The crests are 3 to 6μ high and often so strongly folded as to make determination of reflected tabulation almost impossible.

The archeopyle is precingular and is formed by loss of reflected plate 3''. The operculum, detached in archeopyle formation, is trapezoidal with somewhat rounded corners.

The sinistral cingulum varies from 4 to 6μ in width and is outlined by a pair of cingular sutures; six reflected precingular plates are present. Where the cingulum is interrupted by the sulcus, the ends of the cingulum are offset from 2 to 3 cingular widths. The sulcus is sinuous, a shallow S in shape, and inclined from left to right. Anteriorly, the sulcus reaches about halfway onto the epitract where it narrows and meets reflected plate 1'. Posteriorly, the sulcus widens somewhat and extends almost to the antapex where it meets reflected plate 1''''.

The reflected tabulation is difficult to demonstrate on a single specimen because of the strongly folded and contorted sutural crests. From composite observations, the reflected tabulation is determined as: 4', 6'', 6c, 5''', 1p, 1''''. Reflected plate 1' is elongate and 4' is narrow and reduced; of the precingular series, reflected plate 5''' is the smallest. Reflected plate 1'''' is quadrate to trapezoidal in shape.

Dimensions. (20 measured specimens) - Periblast length, 50-65μ; periblast width, 53-58μ; endoblast length, 45-58μ; endoblast width, 48-50μ.

Comparison. *Leptodinium modicum* sp. nov. differs from other species placed in *Leptodinium* (Davey *et al.*, 1969) in that it possesses low, entire crests, an offset cingulum, inclined sulcus and distinct reflected tabulation pattern.

Occurrence. Horton River Formation (Middle Albian).

Genus *Lunatadinium* Brideaux and McIntyre

1973 *Lunatadinium* Brideaux and McIntyre, p. 396.

(1) *Lunatadinium dissolutum* Brideaux and McIntyre

1973 *Lunatadinium dissolutum* Brideaux and McIntyre, p. 396, Pl. 1, figs. 1-13.

Occurence. Langton Bay and Horton River Formations (Aptian to Middle Albian); recorded previously from various surface and subsurface sections on the northern Canadian mainland in Hauterivian to Middle Albian strata (Brideaux and McIntyre, 1973), and strata of the Lower Sandstone Division (Middle Valanginian) at Martin Creek, Aklavik Range, District of Mackenzie (Brideaux, unpublished).

Genus *Microdinium* Cookson and Eisenack

1960a *Microdinium* Cookson and Eisenack, p. 6.
1966a *Microdinium* Cookson and Eisenack; Sarjeant *in* Davey *et al.*, p. 148.

(51) *Microdinium*? *crinitum* Davey

Plate 6, figure 6

1967 *Cometodinium obscurum* Clarke and Verdier, p. 35, Pl. 10, fig. 3, Pl. 11, fig. 9; *auct. non* Deflandre and Courteville, 1939, p. 99.
1969 ?*Microdinium crinitum* Davey, p. 137, Pl. 2, figs. 7, 8.
1971 ?*Microdinium crinitum* Davey; Davey and Verdier, p. 25.

Dimensions. (2 measured specimens) - Width, 35 and 38μ; processes, 6 to 8μ.

Discussion. As described in Davey (1969, p. 137), the processes are peritabular and the periblast bears small intratabular granules. One specimen possesses what is interpreted as an apical archeopyle. The number of reflected plates lost in archeopyle formation cannot be determined, but is probably four.

Occurrence. Horton River Formation (Middle Albian); recorded previously from the Albian to basal Turonian (Clarke and Verdier, 1967), the Cenomanian of France and Saskatchewan, Canada (Davey, 1969), and the Albian of the Paris Basin (Davey and Verdier, 1971).

(7) *Microdinium opacum* Brideaux

Plate 6, figures 1, 2

1961 Forma A Evitt, p. 390, Pl. 1, fig. 14, Pl. 2, fig. 7.
?1964 Dinoflagellate gen. et. sp. indet. forma E, Vavrdova, p. 100, figs. 4a, b.
1971b *Microdinium opacum* Brideaux, p. 76, Pl. 21, figs. 19-22, Textfigs. 7d, e.

Occurrence. Langton Bay and Horton River Formations (Aptian to Middle Albian); recorded previously from the Grand Rapids Formation, the Lower Colorado Group, the Peace River and lower Shaftesbury Formations below the Fish Scale Zone in central Alberta, Canada (Middle and Upper Albian; Brideaux, 1971b); doubtfully from the Lower Cretaceous of Czechoslovakia (Vavrdova, 1964).

(32) *Microdinium spinosum* sp. nov.

Plate 6, figures 3-5

Holotype. GSC No. 34148; Slide 6884-2, 13.4 x 133.2; Horton River Formation, Section CR15A-68, 30 to 37 feet (9.1 to 11.1 m), GSC loc. C-8534; Middle Albian. Length, 28μ (archeopyle present); width, 28μ.

Diagnosis. Proximate dinoflagellate cyst; thin walled; tabulation, ?4', 6'', 6c, 5''', 1p, 1'''', 1-4s; low sutural crests bearing spinulose processes, or sutural rows of coni or pila outline the reflected tabulation. Cingulum slightly sinistral; sulcus S-shaped. A nearly circular darkened spot always present at latitude of reflected plate 3'''.

Description. The preferred orientation of the cyst is always dorso-ventral. The outline is roughly hexagonal, but not strongly angular; the antapex is gently rounded. The epitract length is always distinctly less than the hypotract length. The overall length to width ratio is very close to 1.0 with the greatest width occurring just below the latitude of the cingulum. The wall is about 1.0μ thick in optical section. Intertabular crests bearing small spinulose processes, about 0.5 to 1.0μ high, or rows of coni or pila, 0.5 to 1.5μ high, outline the reflected tabulation. The intratabular wall surface is generally scabrate, although well-preserved specimens possess a fine microgranulate design of great complexity on some reflected plates. A central darkened region is present on all specimens encountered, lying in the latitude of reflected plate 3''' and extending into the cingular region. The wall does not appear to be thicker in this darkened area. All specimens are dark brown to brownish yellow in colour.

The archeopyle is apical and possibly composed of four apical reflected plates. It is difficult, however, to confirm this from the Horton Rvier specimens. The operculum is absent or, when present, is detached but lies in the archeopyle. It is never well preserved and appears to have undergone chemical degradation. The tabulation pattern has been determined as ?4', 6'', 6c, 5''', 1p, 1'''', 1-4s. Four reflected sulcul plates, the anterior, left, right, and posterior, are distinguishable. Precingular reflected plates 3'' and 4'' are quite small and nearly rectangular. The postcingular reflected plates 1''' to 5''' and reflected plates 1p and 1'''' are quite large compared to the precingular series. Cingular reflected plates are defined by very low, fine ridges and are somewhat rectangular. The anterior sulcal reflected plate may or may not be delimited from the rest of the sulcus, and is harp-shaped, the narrower end towards the antapex. The cingulum is slightly sinistral. The sulcus is S-shaped, widest at the boundary with reflected plate 1'''', narrowing at the base of the anterior sulcal reflected plate and widening slightly before reaching the edge of the archeopyle.

Dimensions. (18 measured specimens) - Length, 25-32μ; width, 25-34μ.

Comparison. *Microdinium spinosum* sp. nov. differs from *M. ornatum* Cookson and Eisenack (1960a, p. 5) in its reflected tabulation pattern and possession of a circular darkened area, from *M.* sp. cf. *M. ornatum* Cookson and Eisenack (*in* Sarjeant, 1966a, p. 149) in its reflected tabulation and possession of a darkened patch, and from *M. setosum* Sarjeant (1966a, p. 151) in details of reflected tabulation and the possession of smaller sutural crests or spine rows and a central darkened region.

Microdinium opacum Brideaux (1971b, p. 76) most closely resembles *M. spinosum* sp. nov. Both species have a central darkened patch, similar reflected sulcal tabulation, archeopyle and operculum structure. But *M. spinosum* possesses reflected tabulation delimited by rows of coni, pila, or spinulose crests, whereas *M. opacum* shows smooth low ridges or crests. Furthermore, *M. spinosum* possesses only five reflected postcingular plates, in contrast to six for *M. opacum*, and differs in the shapes of the six reflected precingular plates.

Glyphanodinium facetum Drugg (1964, p. 238) possesses a faint central darkened area but differs from *M. spinosum* in several respects, notably in its markedly pentagonal outline and possession of six postcingular reflected plates.

Occurrence. Horton River Formation (Middle Albian).

<u>Proximate pseudoceratiacean cysts</u>

Genus *Batioladinium* Brideaux

in press *Batioladinium* Brideaux.

(2) *Batioladinium jaegeri* (Alberti) Brideaux

Plate 6, figures 7, 10, 11

1961 *Broomea jaegeri* Alberti, p. 26, Pl. 5, figs. 1-7.
in press *Batioladinium jaegeri* (Alberti) Brideaux.

Occurrence. Langton Bay and Horton River Formations (Aptian to Middle Albian); recorded previously from the upper Barremian of Haverlahwiese (Salzgitter), Germany (Alberti, 1961), the Albian of Alberta, Canada (Pocock, 1962; Singh, 1964, 1971; Brideaux, 1971b), and of the Côtes Noires de Moeslains and Vallentigny, France (Davey and Verdier, 1971) and the Upper Albian and? lower Cenomanian of England (Cookson and Hughes, 1964) and as derived? material from the Santonian and Campanian of the Anderson Plain, northern Canadian mainland (McIntyre, 1974).

Genus *Canningia* Cookson and Eisenack

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

(56) *Canningia minor* Cookson and Hughes

Plate 6, figure 8

1964 *Canningia minor* Cookson and Hughes *in* Manum and Cookson, p. 15, Pl. 2, fig. 9 (nom. nud.).
1964 *Canningia minor* Cookson and Hughes, p. 43, Pl. 8, figs. 1-3, 5.

Discussion. The paper by Manum and Cookson (1964) was published on February 28th, 1964. At that time the authors gave no diagnosis or description of the species (ICBN, Art. 32) and did not indicate the nomenclatural type (ICBN, Art. 37). The species was published validly only in April, 1964 (Cookson and Hughes, 1964, p. 43).

Comparison. *Canningia* sp. cf. *C. minor* Cookson and Hughes *in* Brideaux (1971b, p. 78, Pl. 22, figs. 30, 34) differs from *Canningia minor* in having a much thicker, scabrate to granulate wall, rather than a thin, smooth or faintly scabrate wall.

Occurrence. Horton River Formation (Middle Albian); recorded previously from Graham and Ellef Ringnes Islands, Canadian Arctic Archipelago (Upper Cretaceous) by Manum and Cookson (1964), from the Upper Gault and Cambridge Greensand, England (Upper Albian and? lower Cenomanian) by Cookson and Hughes (1964) and the Côtes Noires de Moeslains, Courcelles and Vallentigny, France (Albian) by Davey and Verdier (1971).

(60) *Canningia ringnesii* Manum and Cookson

Plate 6, figure 9

1964 *Canningia ringnesii* Manum and Cookson, p. 15, Pl. 2, fig. 10.
1971b *Canningia* sp. A Brideaux, p. 80, Pl. 22, figs. 31, 32.

Comparison. *Canningia* sp. A of Brideaux (1971b, p. 80) possesses closely spaced setae and papillae and has an overlapping size range with *C. ringnesii*. The two forms are considered here to be conspecific.

Occurrence. Horton River Formation (Middle Albian); recorded previously from the Upper Cretaceous of Ellef Ringnes Island, Canadian Arctic Archipelago (Manum and Cookson, 1964) and from the Lower Colorado Group and lower Shaftesbury Formation below the Fish Scale Beds (Middle and Upper Albian) by Brideaux (1971b).

Genus *Tenua* Eisenack

1958 *Tenua* Eisenack, p. 410.
1968 *Tenua* Eisenack emend. Sarjeant, p. 230.
1972 *Tenua* Eisenack; Pocock, p. 94 (pars.).

Discussion. Sarjeant (1968, p. 230) emended the genus *Tenua* Eisenack (1958) to include reference to possession of an apical archeopyle and varied ornamentation of the cyst wall. But he essentially retained Eisenack's (1958) description of shape, adding only spheroidal and ellipsoidal, to ovoidal. No mention was made of the development of antapical prominences nor was a comment made on the presence of an offset sulcal notch and the probable pseudoceratiacean affinity of the genus. Specimens in this paper assigned to the type species, *T. hystrix* Eisenack, show a gradation from those forms illustrated by Eisenack (1958, Pl. 23, figs. 1-4) and Eisenack and Kjellström (1971, Pl. 6, figs. 10-12), to those possessing strongly indented antapices with one or two antapical prominences and an offset sulcal region.

(15) *Tenua hystrix* Eisenack

Plate 6, figures 12, 13

1958 *Tenua hystrix* Eisenack, p. 410, Pl. 23, figs. 1-4.
1958 *Tenua hystricella* Eisenack, p. 411, Pl. 23, figs. 5-7.
1971 *Tenua hystrix* Eisenack; Eisenack and Kjellström, p. 1039, Pl. 6, figs. 10-12.

Description. Complete specimens were not observed. The remaining portion of the cyst body, comprising the precingular reflected plate series of the epitract and the hypotract, is rounded to strongly indented antapically with one, or more rarely two, unequal antapical prominences developed. Where two prominences are developed, the left is always more strongly developed. The archeopyle is apical; the zig-zag margin and development of secondary sutural notches indicate the presence of six precingular reflected plates. A vaguely defined cingulum is outlined by parallel rows of processes. The sulcus, the position of which is indicated by the reduction of, or absence of, processes, is offset to the left. Its presence is especially marked on those specimens showing strong development of antapical prominences. The cyst wall is densely ornamented with spines, bacula, and bifid processes, 5 to 13µ in length; the longer elements occur at or about the latitude of the presumed cingulum.

Dimensions. (15 measured specimens, many more observed) - Length, 68-82µ; width, 82-95µ.

Occurrence. Langton Bay Formation, Gilmore Lake and lower and middle parts of the Crossley Lakes Member (Aptian to Lower Albian); recorded previously from the Aptian (Eisenack, 1958; Eisenack and Kjellström, 1971), the upper Hauterivian (Gocht, 1959), and probably as a derived species in Middle Oligocene to Middle Miocene rocks (Gerlach, 1961), all from northwest Germany.

(22) *Tenua* sp. A.

Plate 6, figures 14-16

Description. The overall shape of the complete cyst is pentagonal, although the outline is somewhat asymmetrical, the left side of the hypotract being more prolonged than the right side. This basic outline is interrupted at several points: where the archeopyle is developed on incomplete specimens; at the antapex where a prominent indentation occurs; and at the latitude of the cingulum where pronounced cingular prominences occur. On one complete specimen the apex is prolonged about 12µ, forming an apical prominence. The antapex possesses two distinct prominences, equal or unequal in length; when unequal, the left antapical prominence is the longer. In extreme cases, the two prominences may be more aptly termed antapical horns. This situation pertains also to the cingular prominences where the left cingular prominence is more pronounced than that of the right side.

The autocyst is 1 to 2µ thick in optical section. The autophragm is scabrate and bears spines, pila, and spatulate to bifid processes which, rarely, are connected basally. The sculpture is reduced in the sulcal region and, on some specimens, in what appears to be the inner portion of reflected precingular plates. Sculpture also is reduced on the inner part of the reflected apical plates on the one complete specimen. Sculpture elements are developed most strongly in the latitude of the cingulum, toward the periphery of the reflected precingular plates, on the reflected apical plates on the single complete specimen, and variably developed elsewhere. The elements are 3 to 6µ long and from 1 to 2µ in maximum width.

The cingulum is outlined on many specimens by parallel rows of processes, but distortion of the specimen or reduction of the processes renders its position difficult to discern in some instances. The cingulum is sinistral, displaced about one and one half to two cingulum widths and is about 6 to 8µ wide. The position of the sulcus is defined by a broad, parallel-sided band where processes are absent or strongly reduced. The sulcus interrupts the cingulum below a sulcal notch offset to the left and the sulcus follows a slanted path from left to right ending at the antapex.

The archeopyle is apical and has a zig-zag margin with a sulcal notch offset to the left and secondary sutural notches; the archeopyle is formed by the loss of the reflected apical plate series. The operculum is detached, except on the complete specimen, where it remains attached along part of the ventral surface. No opercula have been recognized on the slide. The reflected tabulation pattern of the epitract consists of four reflected apical plates and six reflected precingular plates, as determined by the distribution of processes and the secondary sutural notches. Details of the hypotractal reflected tabulation are obscure, but a few specimens suggest that at least five postcingular reflected plates and one or two? antapical reflected plates are present.

Dimensions. (12 measured specimens) - Length of complete specimen, 130µ; others, 87-103µ; width, 90-115µ.

Occurrence. Langton Bay and Horton River Formations (Aptian to Middle Albian).

<u>Proximate unassigned cysts</u>

Genus *Dictyopyxidia* Eisenack

1960b *Dictyopyxis* Cookson and Eisenack, p. 255 (*nom. van.*) *non Dictyopyxis* Ehrenberg (diatom).
1961 *Dictyopyxidia* Eisenack, p. 316 (*nom. subst. pro Dictyopyxis* Cookson and Eisenack, 1960b).

(27) *Dictyopyxidia imperfecta* sp. nov.

Plate 7, figures 1-5

Holotype. GSC No. 34149; Slide P851-5A, 38.1 x 130.0; Horton River Formation, Section CR14A-68, 45 to 50 feet (13.5 to 15.2 m), GSC loc. C-8536; Middle Albian. Length, 50µ (operculum detached), width, 58µ.

Diagnosis. Subcircular to oval proximate dinoflagellate cyst. Wall two-layered; endophragm simple; periphragm forming a low, perfect to imperfect, reticulate network, the lumina highly variable in size and shape; a sinistral cingulum, and sulcal region, outlined respectively by a transverse, elongate pair of low ridges and an absence or reduction of the reticulum. Archeopyle apical, operculum simple and free, polygonal; tabulation not determinable.

Description. The proximate cyst generally is oriented dorsoventrally on the slide. The overall outline of the cyst is subcircular to oval, although some specimens may be slightly angular. The apex and antapex are gently rounded and possess no prominences. The length of the epitract is equal to or slightly less than the hypotract. The greatest width of the cyst occurs at or near the latitude of the cingulum.

The wall is two layered. The endophragm is about 1.0μ thick in optical section. The periphragm forms a very low, perfect to imperfect reticulum. The muri are 0.5 to 1.0μ high and from 1.0 to 1.5μ wide and enclose ovoid to polygonal lumina of variable maximum diameter. On rare specimens, the muri become partly detached and may be up to 4μ high. The structure of the muri appears to be somewhat fibrous. A curious condition occurs in many specimens from Section CR14A-68 (Horton River Formation). The reticulate layer is severely reduced over the whole of the cyst so that only low, flattened, papillate-like processes, alone, or in combination with patchy remnants of reticulum remain.

The cingulum is distinct on most specimens, sinistral, displaced from one to two cingulum widths and 5 to 8μ wide. It is formed by a pair of slightly more prominent, transversely oriented low sutures, interconnected with the main reticulum. This pair of ridges is interrupted on the ventral surface by the sulcal region, defined by a marked reduction or complete absence of a reticulum. Rare, low ridges connect the main cingular ridges, but no angular reflected tabulation is evident. The sulcus is terminated at the antapex by the reticulum and on the epitract by a prominent sulcul notch. The position of the notch and the course of the sulcus indicate that the sulcus is not offset.

The archeopyle is apical and formed by the loss of the reflected plates of the apical series. The outline is variably zig-zag and includes the distinct sulcal notch. The operculum is simple, free, and is rarely found in place or partially attached. It is visible in a few instances and is five sided and angular in outline suggesting four reflected apical plates, and bears a similar low reticulum to that of the main cyst body. Individual reflected plates are not determinable.

The tabulation of the species, with the exception of the apical series, is not determinable; the low reticulum does not appear sufficiently differentiated to permit the recognition of a reflected tabulation pattern.

Dimensions. (54 measured specimens) - Length, 45-68μ; width, 40-62μ.

Comparison. *Dictyopyxidia imperfecta* sp. nov. differs from *D. circulata* Clarke and Verdier (1967, p. 67) in the presence of a relatively pronounced cingulum and distinct sulcal region, in having an imperfect to severely reduced reticulum, and in being of generally larger size. *Dictyopyxidia imperfecta* sp. nov. differs from the type species *D. aerolata* (Cookson and Eisenack) Eisenack in being more or less equidimensional rather than distinctly elongate, in having a low, imperfect, rather than regular, distinct reticulum, in having a defined rather than indistinct cingulum, and in being of generally smaller size.

Occurrence. Langton Bay and Horton River Formations (Aptian to Middle Albian).

Genus *Fromea* Cookson and Eisenack

1958 *Fromea* Cookson and Eisenack, p. 55.

(58) *Fromea amphora* Cookson and Eisenack

Plate 7, figure 6

1958 *Fromea amphora* Cookson and Eisenack, p. 56, Pl. 5, figs. 10, 11.

Occurrence. Horton River Formation (Middle Albian); recorded previously from the Aptian to Cenomanian of Australia (Cookson and Eisenack, 1958), the Upper Cretaceous of the Canadian Arctic Archipelago (Manum and Cookson, 1964), the Upper Albian and? Lower Cenomanian (Cookson and Hughes, 1964) and Upper Barremian (Sarjeant, 1966b) of England, the Cenomanian of England and France (Davey, 1969), the Barremian of Germany (Alberti, 1961), the Upper Albian of Rumania (Baltes, 1967), the Middle and Upper Albian of central Alberta, Canada (Singh, 1971; Brideaux, 1971b), the Albian of the Paris Basin, France (Davey and Verdier, 1971), the Upper Cretaceous of the U.S.S.R. (Vozzhennikova, 1967) and along Horton River, N.W.T. (McIntyre, 1974).

Genus *Palaeostomocystis* Deflandre

1935 *Palaeostomocystis* Deflandre, p. 234 (nom. nud.).
1937 *Palaeostomocystis* Deflandre, p. 52.

(24) *Palaeostomocystis fragilis* Cookson and Eisenack

1962 *Palaeostomocystis fragilis* Cookson and Eisenack, p. 496, Pl. 7, figs. 10, 11.

Occurrence. Langton Bay Formation, Gilmore Lake Member and Horton River Formation (Aptian and Middle Albian); recorded previously from the Aptian? to Cenomanian of Australia (Cookson and Eisenack, 1962), the Upper Cretaceous along Horton River, N.W.T. (McIntyre, 1974) and on Graham and Ellef Ringnes Islands, Canadian Arctic Archipelago (Manum and Cookson, 1964), and the Middle and Upper Albian of central Alberta, Canada (Brideaux, 1971b; Singh, 1971).

Chorate gonyaulacacean cysts

Genus *Cleistosphaeridium* Davey *et al.*

1966 *Cleistosphaeridium* Davey *et al.*, p. 166.

(64) *Cleistosphaeridium? aciculare* Davey

Plate 7, figure 7

1969 *Cleistosphaeridium? aciculare* Davey, p. 158, Pl. 6, fig. 12 (non fig. 11).

Discussion. Brideaux (1971b, p. 94) discusses the similarity between *C.? aciculare* and *C. multispinosum* (Singh) Brideaux (1971b). The former species seems characterized by acuminate processes, and the latter species has processes that are thin and parallel-sided.

Dimensions. (2 measured specimens) - Maximum diameter, 40μ, 43μ; processes, 6-12μ.

Occurrence. Horton River Formation (Middle Albian); recorded previously from the Upper Albian and Lower Cenomanian of Saskatchewan, Canada (Davey, 1969).

(34) *Cleistosphaeridium ancoriferum* (Cookson and Eisenack) Davey *et al.* emend. Cookson and Eisenack

Plate 7, figures 10, 11

Brief synonymy.

1960a *Hystrichosphaeridium ancoriferum* Cookson and Eisenack, p. 8, Pl. 2, fig. 11.
1966 *Cleistosphaeridium ancoriferum* (Cookson and Eisenack) Davey *et al.*, p. 167, Pl. 9, fig. 1.
1968 *Cleistosphaeridium ancoriferum* (Cookson and Eisenack) Davey *et al.* emend. Cookson and Eisenack, p. 119, Figs. 6A-G.

Discussion. Specimens from the Horton River Formation conform to the emended diagnosis given by Cookson and Eisenack (1968, p. 119, 120). Groups of processes, perhaps corresponding to intratabular groups reflecting tabulation, are joined by a thin, distal membrane. There is no continuous membrane, as in specimens with similar but thinner and undifferentiated processes, assigned to *Chlamydophorella nyei* Cookson and Eisenack. (*See* also discussions by Davey *et al.*, 1966, p. 168; and Davey, 1969, p. 155, 156).

This species may be synonymous with *Cleistosphaeridium huguonioti* (Valensi) Davey. The processes appear to be similar (Valensi, 1955, p. 38, Fig. 2a), but the authors feel that specimens described as belonging to one or the other of these two species should be compared before a final assessment of synonymy is made. In connection with this, the reader is referred to other discussions by Clarke and Verdier (1967, p. 54) and Davey (1969, p. 155, 156).

Occurrence. Horton River Formation (Middle Albian); recorded previously from the Albian and Cenomanian of Australia (Cookson and Eisenack, 1960a, 1968) and, doubtfully (according to Cookson and Eisenack, 1968, p. 120), from the Cenomanian of England by Davey *et al.* (1966).

(3) *Cleistosphaeridium multispinosum* (Singh) Brideaux

Plate 7, figure 12

1964 *Baltisphaeridium multispinosum* Singh, p. 141, Pl. 20, figs. 1, 2.
1969 ?*Cleistosphaeridium aciculare* Davey, p. 158, Pl. 6, fig. 11 (non fig. 12).
1971b *Cleistosphaeridium multispinosum* (Singh) Brideaux, p. 93, Pl. 27, figs. 77-79.
1971 *Baltisphaeridium multispinosum* Singh, p. 395, Pl. 73, fig. 6.

Discussion. The reader is referred to the remarks of Brideaux (1971, p. 94) and Singh (1971, p. 395).

Occurrence. Langton Bay and Horton River Formations (Aptian to Middle Albian); recorded previously from Middle and Upper Albian surface and subsurface rocks of central and west-central Alberta (Singh, 1964, 1971; Brideaux, 1971b), Upper Albian and Lower Cenomanian rocks of Saskatchewan (in part, Davey, 1969) and in Middle and Upper Albian rocks of Maryland, U.S.A. (Brideaux, unpublished data).

(30) *Cleistosphaeridium polypes* (Cookson and Eisenack) Davey subsp. *polypes*

Plate 7, figure 9

1962 *Hystrichosphaeridium recurvatum* subsp. *polypes* Cookson and Eisenack, p. 491, Pl. 4, figs. 11-13.
1969 *Cleistosphaeridium polypes* (Cookson and Eisenack) Davey, p. 154, Pl. 6, figs. 7, 8.
1971 *Cleistosphaeridium polypes* (Cookson and Eisenack) Davey var. *polypes* Davey; Davey and Verdier, p. 15, Pl. 2, figs. 2-5.
1971 *Cleistosphaeridium polypes* (Cookson and Eisenack) Davey; Singh, p. 324, Pl. 50, figs. 4, 5.

Comparison. Specimens from the Horton River Formation have shorter processes (6 to 10μ) than those described by Davey (1969, p. 154), but are otherwise comparable.

Occurrence. Horton River Formation (Middle Albian); besides the occurrences from Aptian to Cenomanian rocks cited by Singh (1971, p. 324), recorded also from the Lower and Middle Albian of the Paris Basin (Davey and Verdier, 1971).

(46) *Cleistosphaeridium polypes* subsp. *clavulum* (Davey) Lenten and Williams, 1973

Plate 7, figure 8

1964 *Hystrichosphaeridium recurvatum* subsp. *polypes* Cookson and Eisenack; Cookson and Hughes, p. 47, Pl. 9, fig. 14.
1969 *Cleistosphaeridium polypes* var. *clavulum* Davey, p. 154, Pl. 6, figs. 9, 10.
1971 *Cleistosphaeridium polypes* var. *clavulum* Davey; Davey and Verdier, p. 15, Pl. 2, fig. 11.

Discussion. The few specimens from the Horton River material have smaller processes (5 to 10μ) than those recorded by Davey (1969, p. 154) but are otherwise comparable.

Occurrence. Horton River Formation (Middle Albian); recorded previously from Upper Albian and Lower Cenomanian rocks of England and France (Cookson and Hughes, 1964; Davey, 1969; Davey and Verdier, 1971).

(47) *Cleistosphaeridium*? sp. AE

Plate 7, figures 13, 14

Description. The cyst is subcircular. The wall is two layered; the endophragm is about 1.0μ thick in optical section and the thin periphragm forms the processes and connecting ridges. The processes are hollow, acuminate or bifid, and up to 8μ high. Many processes are interconnected basally by low irregular ridges about 0.5 to 1.0μ high. There is a suggestion of arrangement in groups, perhaps reflecting tabulation, but it is not possible to determine any reflected tabulation pattern. The periphragm, between the processes, is punctate. An apical archeopyle is present with the operculum partly attached on specimens available for study.

The cingulum is visible as a band devoid of processes and up to 7μ wide, and its course is highlighted by a parallel alignment of processes along the periphery. The cingulum is offset about one-half its width. A sulcal area is not discernible.

Dimensions. (3 measured specimens) - Length, 51-62μ; width, 52-61μ.

Occurrence. Horton River Formation (Middle Albian).

Genus *Conosphaeridium* Cookson and Eisenack

1969 *Conosphaeridium* Cookson and Eisenack, p. 5.

(57) *Conosphaeridium* sp. A.

Plate 7, figures 17, 18

Description. The cyst is subcircular and possesses a two-layered wall. The endophragm is thin and smooth. The periphragm is thin, microrugulate and forms the processes. The processes are entire, hollow, distally open, cylindrical or sub-conical, with a striated surface that is an extension of the microrugulate periphragm pattern, and are from 12 to 22μ in length. A polygonal archeopyle is present, formed presumably by the loss of the apical reflected plates. The several specimens available for study are so oriented that a reflected tabulation pattern cannot be determined.

Dimensions. (2 measured specimens) - Width, respectively, 50μ, 63μ.

Comparison. Other species assigned to *Conosphaeridium* by Cookson and Eisenack (1969) have a smooth periphragm between processes.

Occurrence. Horton River Formation (Middle Albian).

Genus *Hystrichokolpoma* Klumpp emend. Williams and Downie

1953 *Hystrichokolpoma* Klumpp, p. 388.
1966 *Hystrichokolpoma* Klumpp emend. Williams and Downie, p. 176.

(37) *Hystrichokolpoma ferox* (Deflandre) Davey

Plate 7, figures 15, 16

1937 *Hystrichosphaeridium ferox* Deflandre, p. 72, Pl. 14, figs. 3, 4.
1963 *Baltisphaeridium ferox* (Deflandre) Downie and Sarjeant, p. 91.
1969 *Hystrichokolpoma ferox* (Deflandre) Davey, p. 159, Pl. 9, figs. 5-7.

Occurrence. Horton River Formation (Middle Albian); recorded previously from upper Aptian (Eisenack, 1958) to Danian strata (Drugg, 1967) and from various localities in Europe, Britain, Australia and North America (Singh, 1971).

Genus *Oligosphaeridium* Davey and Williams

1966 *Oligosphaeridium* Davey and Williams *in* Davey *et al.*, p. 70.

(16) *Oligosphaeridium anthophorum* (Cookson and Eisenack) Davey

Plate 8, figures 12, 13

1958 *Hystrichosphaeridium anthophorum* Cookson and Eisenack, p. 43, Pl. 11, figs. 12, 13, 16-18.
1969 *Oligosphaeridium anthophorum* (Cookson and Eisenack) Davey, p. 147, Pl. 5, figs. 1-3.

Occurrence. Langton Bay Formation, Gilmore Lake Member (Aptian); recorded previously by many authors in Upper Jurassic to Campanian rocks (Cookson and Eisenack, 1958; Eisenack, 1958; Alberti, 1961; Davey, 1969; Brideaux, 1971b; Singh, 1971; McIntyre, 1974).

(41) *Oligosphaeridium asterigium* (Gocht) Davey and Williams

Plate 8, figure 1

1959 *Hystrichosphaeridium asterigium* Gocht, p. 67, Pl. 3, fig. 1, Pl. 7, figs. 1-4.
1969 ?*Oligosphaeridium asterigium* (Gocht) Davey and Williams, p. 5, *in* Davey *et al.*

Discussion. Brideaux (1971b, p. 89) considered this species to be a synonym of *Oligosphaeridium complex* (White) Davey and Williams (1966). The authors feel, however, that Gocht's original distinction (Gocht, 1959, p. 67, 68) was a valid one and retain *O. asterigium* as a distinct species.

Occurrence. Horton River Formation (Middle Albian); recorded previously from the Valanginian and Hauterivian of Germany (Gocht, 1959).

(9) *Oligosphaeridium complex* (White) Davey and Williams

Plate 8, figure 2

1842 *Xanthidium tubiferum complex* White, p. 39, Pl. 4, div. 3, fig. 11.
1946 *Hystrichosphaeridium complex* (White) Deflandre, p. 11.
1966 *Oligosphaeridium complex* (White) Davey and Williams, p. 71, Pl. 7, figs. 1, 2, Pl. 10, fig. 3, Textfig. 14.

Occurrence. Langton Bay and Horton River Formations (Aptian to Middle Albian); widely distributed in Cretaceous and Tertiary rocks (Davey and Williams, 1966; Brideaux, 1971b; Singh, 1971; McIntyre, 1974).

(14) *Oligosphaeridium irregulare* (Pocock) Davey and Williams

Plate 8, figures 3, 6

1962 *Hystrichosphaeridium irregulare* Pocock, p. 82, Pl. 15, figs. 228, 229.
1969 ?*Oligosphaeridium irregulare* (Pocock) Davey and Williams, p. 5, *in* Davey *et al.*
1971b *Oligosphaeridium irregulare* (Pocock) Davey and Williams; Brideaux, p. 90, Pl. 26, fig. 62.

Comparison. This species is distinguished by the possession of highly variable processes which have biconcave to tubular columns and open, complexly flared distal extremities (*see* also the remarks of Singh, 1964, and Brideaux, 1971b).

Occurrence. Langton Bay Formation, Gilmore Lake Member (Aptian); recorded previously from the Lower and Middle Albian of western Canada (Pocock, 1962; Singh, 1964; Brideaux, 1971b).

(17) *Oligosphaeridium pulcherrimum* (Deflandre and Cookson) Davey and Williams

Plate 8, figure 4

1955 *Hystrichosphaeridium pulcherrimum* Deflandre and Cookson, p. 270, Pl. 1, fig. 8, Textfigs. 21, 22.
1966 *Oligosphaeridium pulcherrimum* (Deflandre and Cookson) Davey and Williams, p. 75, Pl. 10, fig. 9, Pl. 11, fig. 5.
1971b *Oligosphaeridium* sp. cf. *O. pulcherrimum* (Deflandre and Cookson) Davey and Williams; Brideaux, p. 90, Pl. 25, figs. 60, 61.

Discussion. Eocene forms reported by Davey and Williams (1966, p. 76) are probably derived.

Occurrence. Langton Bay Formation, Gilmore Lake Member (Aptian); recorded previously from the Middle and Upper Albian of Alberta, Canada (Singh, 1971; Brideaux, 1971b), the Cenomanian to Coniacian of Alabama, U.S.A. (Leopold and Pakiser, 1964) and of England (Clarke and Verdier, 1967), the Lower Cretaceous of Belgium (Delcourt and Sprumont, 1957) and Australia (Deflandre and Cookson, 1955), the Coniacian and Santonian "A" of the Grand Banks, Atlantic continental margin (Williams and Brideaux, 1975), the Santonian and Campanian along Horton River, N.W.T. (McIntyre, 1974) and the Cretaceous of France (Valensi, 1955).

(21) *Oligosphaeridium totum* Brideaux subsp. *totum*

Plate 8, figure 10

1971b *Oligosphaeridium totum* var. *totum* Brideaux, p. 88, Pl. 25, figs. 53, 55 (October, 1971).
1971 *Oligosphaeridium diastema* Singh, p. 337, Pl. 55, figs. 4, 5, Pl. 56, figs. 1, 2 (December, 1971).
1973 *Oligosphaeridium totum* Brideaux subsp. *totum;* Lentin and Williams, p. 100.

Discussion. Dr. C. Singh (pers. com.) agrees with the authors on the question of the synonymy of *O. diastema* Singh and *O. totum* (subsp.) *totum* Brideaux.

Occurrence. Langton Bay Formation (Aptian to Middle Albian); recorded previously from Middle and Upper Albian strata of central and west-central Alberta (Brideaux, 1971b; Singh, 1971).

(13) *Oligosphaeridium* sp. AB

Plate 8, figure 9

Description. The complete cyst is subcircular or somewhat ovoid in shape and possesses a two-layered wall. The periphragm is punctate and forms the processes; the endophragm is smooth and thin. The combined periphragm and endophragm thickness in optical section is 1.0μ or less.

The processes are intratabular in position and represent a reflected tabulation formula of 4', 6", 0c, 5"', 1"", 0-1p, 0-1ps. The processes are widened proximally, narrowed somewhat along the columns, and then flared slightly at their distal portion. The apices are open, occasionally entire, but most often slightly serrate or irregularly dissected, with short acuminate or spatulate projections. The columns are faintly striated and, rarely, possess one or two deep dissections part way down their length. The processes are variable in length, from 15 to 35μ, typically 20 to 30μ.

The archeopyle is formed by the loss of the reflected apical plates, and the operculum is irregularly polygonal in shape and often partially attached. Of the four processes representing the apical reflected plates, that process assigned to reflected plate 2' is the largest and that of 4' is the smallest. No other differentiation of processes was observed consistently. Cingular and sulcal processes are absent. Complete specimens possess from 16 to 18 processes, and those with apical archeopyles may have 12 to 14.

Dimensions. (6 measured specimens) - Width, 45-60μ.

Comparison. The processes of *Oligosphaeridium totum* Brideaux (1971b) are entire-margined at the apices and buccinate. Those of *Oligosphaeridium albertense* (Pocock) Davey and Williams, 1969, appear to be, from published descriptions (Pocock, 1962; Singh, 1964), distinctly biconcave and distally more complex.

Occurrence. Langton Bay Formation, Crossley Lake Member, and Horton River Formation (Aptian to Middle Albian).

(10) *Oligosphaeridium*? sp. A of Brideaux

Plate 8, figure 7

1971b *Oligosphaeridium*? sp. A Brideaux, p. 91, Pl. 26, fig. 66.

Discussion. Two specimens from the Horton River material are referred to this taxon. The illustrated specimen is similar in most respects to other specimens of this form encountered, but differs in that some of the precingular processes are connected basally by a thin membrane.

Occurrence. Langton Bay Formation, Gilmore Lake Member (Aptian); recorded previously from Middle and Upper Albian rocks of central and west-central Alberta, Canada (Brideaux, 1971b).

(66) *Oligosphaeridium*? sp. B of Brideaux

Plate 8, figure 11

1971b *Oligosphaeridium*? sp. B Brideaux, p. 91, Pl. 26, figs. 63-65.

Discussion. One specimen was recovered from Horton River strata. It possesses a small, bifurcated anterior sulcal process, the tips of which are bifid. A process interpreted as corresponding to reflected process 1p is smaller than the six precingular and five postcingular processes present on the specimen.

Occurrence. Horton River Formation (Middle Albian); recorded previously from Middle and Upper Albian rocks of central and west-central Alberta, Canada (Brideaux, 1971b).

Genus *Polysphaeridium* Davey and Williams

1966 *Polysphaeridium* Davey and Williams, p. 91.

(59) *Polysphaeridium laminaspinosum* Davey and Williams

Plate 8, figure 14

1966 *Polysphaeridium laminaspinosum* Davey and Williams, p. 94, Pl. 8, fig. 8.
1971 *Polysphaeridium laminaspinosum* Davey and Williams; Davey and Verdier, p. 27, Pl. 5, figs. 4, 6.

Dimensions. (1 measured specimen) - Diameter, 30μ; length of processes, 8-10μ.

Occurrence. Horton River Formation (Middle Albian); recorded previously from the Albian of the Paris Basin (Davey and Verdier, 1971) and the Cenomanian of England (Davey and Williams, 1966) and France (Davey, 1969).

Genus *Pterodinium* Eisenack

1958 *Pterodinium* Eisenack p. 395.

(42) *Pterodinium verrucosum* sp. nov.

Plate 9, figures 1-8

Holotype. GSC No. 34150, Slide P851-4A, 39.8 x 118.8; Section CR14A-68, Horton River Formation, 37 to 45 feet (11.1 to 13.6 m); GSC loc. C-8535. Total length, 62μ; total width, 61μ (including sutural crests).

Diagnosis. Subcircular to ovoid cysts; two-layered wall, the periphragm bearing intratabular apiculate sculpture and forming high, thin, entire sutural crests, outlining a reflected tabulation of 4', 6", 6c, 5"', 1"", 1p, 5s. Cingulum sinistral, displaced up to three cingular widths; sulcus with full tabulation, sinuous in outline. Archeopyle precingular, formed by loss of reflected plate 3", operculum detached.

Description. The periblast is subcircular or ovoid. The ratio of epitract to hypotract length is close to 1.0. The apex is rounded; the antapex is rounded or slightly flattened.

The cyst is two layered. The endophragm is thin, less than 1.0μ thick in optical section, and smooth. The periphragm is as thin as the endophragm and forms the sutural crests. The two layers are in contact except along these crests. The periphragm bears apiculate sculpture in intratabular regions that varies from grana to coni or irregular "wart-like" elements, from 1.0 to 3.0μ high, typically 2.0μ and 1.0 to 2.0μ wide. The apiculate elements, as many as 40 per reflected plate, are concentrated in the central intratabular regions, reduced or absent nearer the margins, and absent in the cingular region.

The archeopyle is precingular and formed by the loss of reflected plate 3". The operculum is detached.

The reflected tabulation pattern is determined as 4', 6", 6c, 5"', 1"", 1p, 5s, and is outlined by smooth, entire, sutural crests from 5 to 12μ , but typically from 6 to 8μ high. These crests often may be so folded or flattened, particularly in the apical region, as to obscure the details of tabulation. The crests are corroded occasionally and appear granulose or finely punctate.

The cingulum is outlined by cingular crests, similar in construction to the sutural crests. It is sinistral, 5-7μ in width, and offset up to three cingular widths, but typically one and one-half to two widths. Six reflected cingular plates are present. The sulcus follows a somewhat sinuous course and exhibits a full complement of reflected sulcal plates. The reflected anterior sulcal plate is large; the reflected left sulcal plate is narrow, elongate and rectangular; the reflected right anterior sulcal and right sulcal plates are small by comparison and polygonal; the reflected posterior sulcal plate is larger and ovoid. A central elongate ovoid region is interpreted as the position of emplacement of the longitudinal flagellum of the thecal stage.

Dimensions. (37 measured specimens) - Periblast length, 58-80μ; periblast width, 53-72μ; endoblast length, 48-73μ; endoblast width, 48-65μ.

Occurrence. Horton River Formation (Middle Albian).

(43) *Pterodinium* sp. cf. *P. aliferum* Eisenack

Plate 8, figures 15, 16

1958 cf. *Pterodinium aliferum* Eisenack, p. 395, Pl. 24, fig. 6, Textfig. 6.
1971 cf. *Pterodinium aliferum* Eisenack; Davey and Verdier, p. 30, Pl. 6, figs. 4, 6.

Description. The periblast outline is hexagonal to rounded-hexagonal; the apex is flattened or slightly pyramidal and the antapex is flattened. The length is generally greater than the width and the epitract is slightly shorter than the hypotract.

The wall is two layered. The endophragm is thin, less than 1.0μ thick in optical section, and smooth. The periphragm is also thin, about 1.0μ thick in optical section, and punctate to alveolate and forms the sutural crests.

The archeopyle is precingular and formed by the loss of reflected plate 3". The operculum is detached and somewhat hoof shaped or rounded-trapezoidal.

The cingulum is marked by high, thin crests which are often highly folded and flattened making recognition of the six reflected cingulum plates difficult. The cingulum is 4 to 6μ wide, sinistral, and displaced from one to two cingular widths. The sulcus is often difficult to discern because of the folded or flattened sutural crests, which tend to obscure its course. It is narrowest at the latitude of the cingulum, widening both anteriorly and posteriorly, sinuous in course and its length is divided equally between epitract and hypotract. The sulcus is terminated anteriorly by reflected plate 1' and posteriorly by 1''''.

Reflected tabulation corresponds to the formula: 4', 6'', 6c, 5''', 1'''', 1p. Reflected plate 1p is somewhat triangular to trapezoidal in shape. The reflected tabulation is outlined by high, thin, sutural crests which are densely punctate to alveolate and serrated along the top. The crests are up to 12μ high, but generally are 5-8μ high. They are often flattened or so strongly folded as to obscure the details of reflected tabulation.

Dimensions. (21 measured specimens) - Periblast length, 58-80μ; periblast width, 40-75μ; endoblast length, 40-73μ; endoblast width, 40-65μ.

Comparison. *Pterodinium* sp. cf. *P. aliferum* Eisenack is smaller and lacks the marked serrations and indentations of *P. aliferum* Eisenack. The crests of *Pterodinium* sp. A are smooth, almost hyaline.

Occurrence. Horton River Formation (Middle Albian); a similar species (as *Pterodinium aliferum*) recorded previously from the Aptian of Germany (Eisenack, 1958) and the Lower and Middle Albian of the Côtes Noire des Moeslains (Davey and Verdier, 1971).

(44) *Pterodinium* sp. A

Plate 9, figure 9

Description. The periblast outline is ovoid or rounded-hexagonal. The ratio of periblast length to width is greater than 1.0. The ratio of the epitract to hypotract length is less than 1.0. The apex is rounded or slightly peaked and the antapex is flat or slightly rounded. The endophragm is thin, less than 0.5μ thick in optical section and in contact with the periphragm in intratabular areas. The periphragm also is thin, less than 1.0μ thick in optical section, and forms the cingular and sutural crests.

The archeopyle is precingular and formed by the loss of reflected plate 3''. The operculum is detached and is longitudinally elongate and trapezoidal in shape.

The cingulum is 6-8μ wide, bordered by high cingular crests which often are so crumpled as to obscure the six reflected cingular plates. The cingulum is sinistral and displaced from one to one and one-half cingular widths. The sulcus follows a more or less straight course and is little differentiated; it is distributed equally on the epitract and hypotract.

Reflected tabulation is determined as 4', 6'', 6c, 5''', 1'''', 1p. The reflected tabulation is outlined by high, thin, smooth, almost hyaline, sutural crests, from 6-12μ, but typically 6-8μ high, and highly folded and crumpled, sometimes obscuring the tabulation, particularly in the apical area.

Dimensions. (8 measured specimens) - Periblast length, 68-80μ; periblast width, 50-68μ; endoblast length, 55-63μ; endoblast width, 50-62μ.

Occurrence. Horton River Formation (Middle Albian).

Genus *Spiniferites* Mantell emend. Sarjeant

1850 *Spiniferites* Mantell, p. 191.
1933 *Hystrichosphaera* O. Wetzel, p. 78.
1970 *Spiniferites* Mantell emend. Sarjeant, p. 75.

Discussion. The name *Spiniferites* Mantell emend. Sarjeant is used in this paper, although the authors agree with the views of Sarjeant (1967a, p. 245) and those of Brideaux (1971b, p. 95). In view of Sarjeant's (1967a) arguments, the most logical step would have been to conserve the name *Hystrichosphaera* O. Wetzel, 1933.

(54) *Spiniferites ramosus* (Ehrenberg) Mantell

Plate 9, figure 10

Brief synonymy.

1838 *Xanthidium ramosum* Ehrenberg, p. 47.
1854 *Spiniferites ramosus* (Ehrenberg) Mantell, p. 239.
1937 *Hystrichosphaera ramosa* (Ehrenberg) Deflandre, p. 64, Pl. 11, figs. 5, 7.
1966 *Spiniferites ramosus* (Ehrenberg) Mantell; Loeblich Jr. and Loeblich III, p. 56.

Occurrence. Horton River Formation (Middle Albian); recorded previously from Upper Jurassic to Holocene rocks worldwide (Sarjeant, 1967a).

Genus *Tanyosphaeridium* Davey and Williams

1966 *Tanyosphaeridium* Davey and Williams, p. 98.

(48) *Tanyosphaeridium* sp. A of Brideaux

Plate 9, figure 11

1971b *Tanyosphaeridium* sp. A of Brideaux, p. 93, Pl. 26, fig. 71.
1971 *Tanyosphaeridium* sp. Singh, p. 344, Pl. 57, fig. 7.

Discussion. The form is distinct from *Tanyosphaeridium variecalamum* Davey and Williams (1966) in possessing processes which, distally, are entire and buccinate.

Dimensions. (2 measured specimens) - Length, 28 and 33μ (both possess apical archeopyles).

Occurrence. Horton River Formation (Middle Albian); recorded previously from Middle and Upper Albian rocks of central and west-central Alberta (Brideaux, 1971b; Singh, 1971).

(31) *Tanyosphaeridium* sp. B of Brideaux

Plate 9, figure 12

1971b *Tanyosphaeridium* sp. B Brideaux, p. 93, Pl. 27, fig. 75.

Discussion. A few poorly preserved specimens were found in samples from the Horton River region. A relatively large number of processes distinguishes this species from *Tanyosphaeridium* sp. A of Brideaux, 1971b.

Occurrence. Horton River Formation (Middle Albian); recorded previously from Middle and Upper Albian rocks of central and west-central Alberta (Brideaux, 1971b).

(52) *Tanyosphaeridium* sp. C.

Plate 9, figure 13

Description. The cyst is longer than broad. The periphragm is granular and forms smooth truncated processes with more or less tubular columns and entire or minutely serrated distal extremities. Processes are 10 to 14μ in length and number 24 on the complete specimen with attached operculum, and 20 on the other, which possesses an apical archeopyle.

Dimensions. (2 measured specimens) - Length, 25 and 30μ; width, 21 and 23μ, respectively.

Comparison. These specimens most closely resemble *Tanyosphaeridium variecalamum* Davey and Williams, 1966, but are too poorly preserved to permit definite identification.

Occurrence. Horton River Formation (Middle Albian). A similar form (as *T. variecalamum* Davey and Williams) is recorded from the Cenomanian of England (Davey and Williams, 1966).

Chorate pseudoceratiacean cysts

Genus *Cyclonephelium* Deflandre and Cookson emend. Cookson and Eisenack

1955 *Cyclonephelium* Deflandre and Cookson, p. 285.
1962 *Cyclonephelium* Deflandre and Cookson emend. Cookson and Eisenack, p. 493.

(53) *Cyclonephelium compactum* Deflandre and Cookson

Plate 9, figure 17

1955 *Cyclonephelium compactum* Deflandre and Cookson, p. 285, Pl. 2, figs. 11-13.
1962 *Cyclonephelium compactum* Deflandre and Cookson; Cookson and Eisenack, p. 494, Pl. 5, figs. 1-3 (holotype refigured as fig. 1).

Occurrence. Horton River Formation (Middle Albian); recorded previously from Aptian to Campanian strata (*see* Sarjeant, 1967b, Table VII; Brideaux, 1971b).

(4) *Cyclonephelium distinctum* Deflandre and Cookson

Plate 9, figure 18

1955 *Cyclonephelium distinctum* Deflandre and Cookson, p. 285, Pl. 2, fig. 14; Textfigs. 47, 48.
1961 *Circulodinium deflandrei* Alberti, p. 29, Pl. 4, figs. 7-13.
1971b *Cyclonephelium* sp. A Brideaux, p. 97, Pl. 28, fig. 88.

Occurrence. Langton Bay Formation, Gilmore Lake Member and Horton River Formation (Aptian to Middle Albian); recorded previously from Cretaceous and lower Paleocene rocks (Deflandre and Cookson, 1955; Clarke and Verdier, 1967; Drugg, 1967; Millioud, 1969; Singh, 1971; Brideaux, 1971b; McIntyre, 1974).

Chorate unassigned cysts

Genus *Imbatodinium* Vozzhennikova

1967 *Imbatodinium* Vozzhennikova, p. 52.

Discussion. *Imbatodinium*, according to Vozzhennikova (1967, p. 52), possesses an apical archeopyle. Her illustrations (op. cit., Pls. 11-15) suggest, however, that the genus possesses an intercalary archeopyle formed by the loss of two reflected intercalary plates. This is particularly well demonstrated for *Imbatodinium villosum* Vozzhennikova, 1967, Pl. 13, figs. 1a-e, and *I. verrucosum* Vozzhennikova, 1967, Pl. 12, fig. 6, but less so for *I. kondratjevi* Vozzhennikova, 1967, Pl. 11, figs. 2b, 3.

(62) *Imbatodinium* sp. A

Plate 9, figures 14-16

Description. The cyst outline is subcircular to ovoid, rounded antapically, but prolonged apically into an apical horn, which often terminates in a club-shaped process. The endophragm is smooth and thin, less than 1.0μ thick in optical section; the periphragm is also thin, and is ornamented with apiculate elements.

The elements are commonly slender, acuminate, or more rarely distally bifid or, still more rarely, broadly flattened and ending in two, long, fimbriate projections directed more or less perpendicularly to each other. Several of these broad projections may be fused at the antapex. The elements with acuminate projections may or may not be present part way along the apical horn. The position of the acuminate and the more complex processes cannot be related to a reflected tabulation pattern. The length of the processes ranges from 5 to 11μ, typically 6-8μ.

The archeopyle, based on examination of several poorly oriented specimens, seems to be formed by the loss of at least one, and probably two intercalary reflected plates. The loss of these plates allows the specimen to be deformed so that the apical region is twisted or bent into the archeopyle, making interpretation difficult.

Dimensions. (9 measured specimens) - Length, 70-80μ; apical horn length, 7-12μ.

Comparison. This species resembles *Imbatodinium villosum* Vozzhennikova (1967), but differs in the possession of a variety of apiculate elements and the pronounced distal club-shaped termination of the apical horn.

Occurrence. Horton River Formation (Middle Albian).

Cavate gonyaulacacean cysts

Genus *Gardodinium* Alberti

1961 *Gardodinium* Alberti, p. 18.
1967 non *Gardodinium* (Eisenack) Alberti; Clarke and Verdier, p. 26.

Discussion. Alberti (1961, p. 18) did not indicate the type of archeopyle for *Gardodinium*. Clarke and Verdier (1967, p. 27) describe *Gardodinium deflandrei* Clarke and Verdier, 1967, p. 25, Pl. 3, figs. 10-12, Textfig. 10, and diagnose the species as possessing a precingular archeopyle. This feature is illustrated (op. cit.) in Plate 3, figure 12 and Textfigure 10. The authors also state that unpublished material of Early Cretaceous age, attributed to *Gardodinium* Alberti, 1961, also exhibits a precingular archeopyle.

Material from Horton River, however, clearly attributable to *Gardodinium eisenackii* Alberti, 1961, possesses a clearly defined apical archeopyle with accessory archeopyle sutures. Specimens exhibit a range of preservation from completeness to those with incipient archeopyle formation, and partial to complete detachment of the operculum (Pl. 10, figs. 1-4). The operculum consists clearly of the apical reflected plate series and includes the long apical horn formed from the periblast and the portion of the endoblast that projects into the apical pericoel of the periblast. On favourable specimens, the apiculate processes, arising from the endophragm, appear peritabular, conforming to the outline of the reflected plate. On other specimens the processes are too crowded to assess their relation to reflected tabulation patterns.

It is entirely possible, as well, that *Gardodinium* sensu Alberti (1961) and *Chlamydophorella* Cookson and Eisenack, 1958, p. 56, are synonymous. Both genera possess similar morphology and specimens referable to them have apical archeopyles. Only thorough revision of the original material of Alberti (1961) and Cookson and Eisenack (1958) can answer this question; therefore, *Gardodinium* and *Chlamydophorella* are maintained as distinct genera in this paper. A second possibility exists that *Gardodinium* sensu Alberti (1961) does possess a precingular archeopyle and that *Gardodinium* Alberti sensu Clarke and Verdier (1967) does belong with that form. But if this is so, then *Gardodinium* approaches the concept of *Scriniodinium* Klement, 1957, p. 409, and, should the two genera prove to be synonymous, then *Gardodinium* Alberti would become a junior synonym of *Scriniodinium* Klement.

(23) *Gardodinium eisenackii* Alberti

Plate 10, figures 1-4

1961 *Gardodinium eisenackii* Alberti, p. 18, Pl. 3, figs. 8-13.
1971 *Gardodinium eisenackii* Alberti; Singh, p. 380, Pl. 68, figs. 1, 2.
1971 *Gardodinium elongatum* Singh, p. 381, Pl. 68, figs. 3, 4.

Discussion. *Gardodinium elongatum* Singh (1971, p. 381) is based on two specimens and is characterized as differing from *G. eisenackii* Alberti by possession of an elongate, narrow cyst body. Specimens from Horton River strata show great variations in the ratio of length to width and length of apical horn, encompassing specimens such as those described by Singh (1971, p. 382). The two species are considered herein to be synonymous.

Occurrence. Langton Bay and Horton River Formations (Aptian to Middle Albian); recorded previously from Middle and Upper Albian rocks of west-central Alberta (Singh, 1971) and, presumably, from Hauterivian to Aptian rocks of Germany (Alberti, 1961) and middle Hauterivian to lower Barremian rocks of England (Sarjeant, 1966b).

Genus *Scriniodinium* Klement

1957 *Scriniodinium* Klement, p. 409.

(65) *Scriniodinium campanula* Gocht

Plate 10, figure 5

1959 *Scriniodinium campanula* Gocht, p. 61, Pl. 4, fig. 6, Pl. 5, fig. 1.
1967 *Endoscrinium campanula* (Gocht) Vozzhennikova, p. 175.
1971b *Gonyaulacysta fragosa* Brideaux, p. 83, Pl. 23, fig. 42, Pl. 24, figs. 44, 45, Textfigs. 8c-d.

Dimensions. (1 measured specimen) - Length, 105μ; width, 83μ.

Occurrence. Horton River Formation (Middle Albian); recorded previously from Middle and Upper Albian rocks of central and west-central Alberta (Singh, 1971; Brideaux, 1971b), from Valanginian to Aptian rocks of Germany (Gocht, 1959; Alberti, 1961), from Albian rocks of Roumania (Baltes, 1967) and the Paris Basin (Davey and Verdier, 1971), Upper Albian and Lower Cenomanian rocks (Cookson and Hughes, 1964) and Cenomanian and Turonian rocks (Clarke and Verdier, 1967; Davey, 1970) of England.

(50) *Scriniodinium rostratum* sp. nov.

Plate 10, figures 6-14; Plate 11, figures 1-3

Holotype. GSC No. 34151, Slide 851-4A, 36.3 x 122.5; Horton River Formation, Section CR14A-68, 37 to 45 feet (11.1 to 13.5 m), GSC loc. C-8535; Middle Albian. Periblast length, 65μ; periblast width, 55μ; endoblast length, 50μ; endoblast width 51μ.

Diagnosis. Periblast outline ovoid, with a distinctive, beak-like, apical prominence, and flattened antapically; wall two layered, with a precingular archeopyle developed in both layers; cingulum offset one cingular width; reflected tabulation outlined by low sutural ridges and corresponding to the scheme, 1pr, ?4', 6'', 6c, 5'''-?6''', 1'''', ?1p.

Description. The periblast is ovoid, the length greater than the width. The epitract and hypotract are of equal or approximately equal size. The apical region tapers rapidly to form a shoulder-like outline, but is prolonged into an apical prominence. The prominence is slightly thickened at the apex and is distinctively "beak-like" in appearance (Pl. 10, fig. 13). The antapex is flattened.

The periphragm is thin, less than 0.5μ thick in optical section, often strongly folded, finely granulose, and bears low, narrow sutural ridges which often are obscured by folding. The endoblast is ovoid, the length greater than the width. The endophragm is smooth and does not appear to be in close contact with the periphragm.

The periarcheopyle is precingular and formed by the loss of reflected plate 3". The peri-operculum is free. The endarcheopyle is similar to the periarcheopyle in shape and position and probably is also precingular. On one specimen the peri-operculum is still partially attached but, where observed in several other specimens, the peri-operculum is free.

The periphragm bears evidence of reflected tabulation in the form of sutural ridges, less than 0.5μ wide and high, which outline a reflected tabulation determined as 1pr, ?4', 6", 6c, 5-?6"', 1"", ?1p. The tabulation scheme is difficult to determine accurately because the periphragm tends to fold along the sutural ridges and secondarily across the reflected plates. This is the case particularly for the apical region, where reflection tabulation has been observed only imperfectly on a few specimens. The small depression at the apex, surrounded by the thickened apical prominence is interpreted as a reflected pre-apical plate (pr). The endophragm shows no signs of tabulation other than presence of an archeopyle.

Ridges similar to the sutural ridges outline a cingulum and its six reflected plates. The cingulum, where visible, is 5 to 7μ wide and offset about one cingulum width. A sulcal area is indistinctly visible on several specimens, but folds obscure its course. The sulcus appears to follow a slightly sinuous path and extends a short distance onto the epitract.

Dimensions. (35 measured specimens) - Periblast length, 53-75μ; periblast width, 50-65μ; endoblast length, 45-60μ; endoblast width, 38-50μ.

Occurrence. Horton River Formation (Middle Albian).

<u>Cavate pseudoceratiacean cysts</u>

Genus *Muderongia* Cookson and Eisenack

1958 *Muderongia* Cookson and Eisenack, p. 40.

(20) *Muderongia tetracantha* (Gocht) Alberti

Plate 11, figure 6

1957 *Pseudoceratium? tetracanthum* Gocht, p. 168, Pl. 18, figs. 7-9.
1961 *Muderongia tetracantha* (Gocht) Alberti, p. 14, Pl. 2, figs. 14-18.

Dimensions. (3 measured specimens) - Antapical horn, 40-64μ; lateral postcingular horns, 44-58μ; maximum cyst width excluding horns, 45-60μ.

Occurrence. Langton Bay Formation, Gilmore Lake Member (upper Aptian); recorded previously from the Upper Hauterivian of Germany (Gocht, 1957), from the Valanginian to Lower Barremian of Germany and Poland (Alberti, 1961) and the Aptian of Australia (Cookson and Eisenack, 1958). M. Millioud (pers. com., 1973) states that he has found no species of this type in post-Barremian strata in Europe. G. L. Williams (pers. com., 1973) states that he has found no species of this type in post-Aptian strata. These statements about the range of *Muderongia* exclude forms like *Muderongia* sp. A described below.

(18) *Muderongia* sp. A

Plate 11, figures 4, 5

Description. Complete specimens were not observed. The remaining periblast exhibits a trapezoidal outline. A reconstructed outline which includes the missing apical portion probably would result in an overall rhombic outline for the complete periblast. Two closed postcingular and two closed antapical horns are present. The presumed left antapical horn is the longer, often two to three times as long as the shorter right antapical horn. If this interpretation is correct, then the left postcingular horn is the shorter of the two postcingular horns. The right postcingular horn is broad at the base, but tapers abruptly at about half its length. The other horns taper smoothly from broad bases.

The periblast extends to form the horns. The endoblast outline parallels the periblast except in the regions of the postcingular and antapical horns, where pericoels are formed. The periphragm surface is smooth or faintly granulose; the endophragm is smooth.

The archeopyle is apical with a zig-zag margin indicating the presence of reflected tabulation. The operculum consists presumably of the apical reflected plate series and the apical portion of the endoblast. Opercula have not been observed. Other indications of reflected tabulation, and the presence of a cingulum and sulcus, were not observed on specimens available for study.

Dimensions. (8 measured specimens) - Maximum periblast width, 44-70μ; left postcingular horn, 11-28μ; right postcingular horn, 28-44μ; left antapical horn, 28-44μ; right antapical horn, 12-27μ.

Discussion. Three species of *Muderongia, M. mcwhaei* Cookson and Eisenack, 1958, *M. perforata* Alberti, 1961 and *M. simplex* Alberti, 1961, show some tendency to the development of a second antapical horn. In all cases, however, the second horn is very small and may be absent. In no case is the second antapical horn developed as strongly as in *Muderongia* sp. A. Vozzhennikova (1967, Pl. CXV, fig. 3) figures, but does not describe or otherwise characterize, a specimen which appears identical in morphology with *Muderongia* sp. A. Davis (1963, unpublished) illustrates and describes a form, as *Pseudoceratium* sp. A, from Middle and Upper Albian rocks of northern Wyoming, U.S.A. Davis' form may be conspecific with *Muderongia* sp. A described in this paper, but this requires confirmation.

Occurrence. Langton Bay Formation, Gilmore Lake Member and lower part of the Crossley Lakes Member (Aptian and Lower Albian).

Genus *Odontochitina* Deflandre

1935 *Odontochitina* Deflandre, p. 234.

(8) *Odontochitina operculata* (O. Wetzel) Deflandre

1933 *Ceratium (Euceratium) operculatum* O. Wetzel, p. 170, Pl. 2, figs. 21, 22.
1935 *Odontochitina silicorum* Deflandre, p. 234, Pl. 9, figs. 8-10.
1946 *Odontochitina operculata* (O. Wetzel) Deflandre (card nos. 1016-1019).

Occurrence. Langton Bay and Horton River Formation (Aptian to Middle Albian); recorded previously from many localities worldwide (Singh, 1971; Brideaux, 1971b) in rocks of Hauterivian to Maastrichtian age.

Genus *Senoniasphaera* Clarke and Verdier

1967 *Senoniasphaera* Clarke and Verdier, p. 61.

(29) *Senoniasphaera microreticulata* sp. nov.

Plate 11, figures 7-12; Plate 12, figures 1-8

Holotype. GSC No. 34152, Slide P851-1A, 35.9 x 121.3; Section CR14A-68, Horton River Formation, 10 to 20 feet (3.0 to 6.1 m), GSC loc. C-8532. Dimensions: Periblast, 123μ x 118μ; endoblast 105μ x 105μ.

Diagnosis. Cyst two layered; the periphragm microreticulate and generally closely appressed to the thicker microreticulate endophragm. One apical prominence, and a rounded or asymmetrically developed antapex, and with cingular bulges. Archeopyle apical; operculum simple and detached or partially attached ventrally. Reflected tabulation, 4', 6'', 0c, 5-?6''', 1''''. Cingulum displaced one to two cingular widths; sulcus offset to the left.

Description. The periblast outline is subcircular to ovoid with one apical prominence, a slight lateral bulging at the cingulum, and a rounded to asymmetrically developed antapex. Where asymmetrical development of the antapex occurs, the left antapical prominence is more pronounced. The periblast and endoblast are somewhat dorso-ventrally flattened.

The cyst possesses two distinct wall layers which, in well-preserved specimens, are closely appressed except at the apex, the cingular region, and at the antapical prominences. Specimens damaged by maceration, or by natural preservational processes, may show moderate to extreme detachment of the two layers.

The periphragm is a thin microreticulate layer which may be folded or otherwise produced so as to outline reflected tabulation. These folds lie along the course of raised and thickened microreticulate ridges on the underlying endophragm. In specimens from which the periphragm has been stripped, the endophragm can be seen to possess a variable microreticulate to microfossulate sculpture, and occasionally may bear apiculate sculpture. The periphragm, in damaged or degraded specimens, may appear to be connected to the endophragm by a network of fibrous processes. Well-preserved material dispels this impression.

The archeopyle is apical and has a zig-zag margin, indicating the presence of reflected tabulation. The operculum is simple, and may be detached and preserved separately, but is often found close to or partially attached ventrally to the rest of the cyst. The operculum is formed of apical reflected plates 1' to 4' in both the periblast and endoblast (Pl. 11, fig. 11).

The reflected tabulation pattern is not clear in all details on each specimen, particularly in the case of the postcingular series. The scheme, as derived from a study of all available material, is: 4', 6'', 0c, 5-?6''', 0p, 1''''. The presence of five postcingular reflected plates is confirmed on all well-preserved specimens. A sixth postcingular reflected plate appears to be present on a few specimens, but is not clearly shown.

A cingulum and sulcus are evident on all but the most poorly preserved material. The cingulum follows a slightly sinuous path and is displaced one to two cingular widths on the ventral surface. The sulcus is displaced to the left at its posterior end, is narrow anteriorly, and widens posteriorly at its junction with the antapical reflected plate.

Dimensions. (40 measured specimens, many more observed) - Periblast: length, 112-140μ; width, 75-126μ; endoblast: length, 105-118μ; width, 75-123μ.

Discussion. *Senoniasphaera* sp. of Davey and Verdier, 1971, p. 31, Pl. 6, figs. 7-9, is much smaller. Coming from the Upper Albian of Vallentigny, in northeastern France, it represents the only other Albian occurrence of the genus. The other published species of *Senoniasphaera* occur in rocks of Late Cretaceous age (Clarke and Verdier, 1967; Williams and Brideaux, 1975).

Occurrence. Langton Bay Formation, uppermost part of the Crossley Lakes Member, Horton River Formation (Lower and Middle Albian).

Cavate peridiniacean cysts

Genus *Astrocysta* Davey

1967a *Astrocysta* Sarjeant, p. 243 (nom. nud.).
1970 *Astrocysta* Davey, p. 359.

Discussion. Davey (1970, p. 359) diagnosed the genus, *Astrocysta*, as possessing an intercalary archeopyle. Norris and Hedlund (1972) re-examined the holotype specimen of *Astrocysta cretacea* Pocock ex Davey and found it to possess a transapical archeopyle with the operculum still attached. Observations by W.W. Brideaux, on material assigned to *A. cretacea* from several localities in North America (unpublished material), support the interpretation advanced by Norris and Hedlund for material other than the holotype. Brideaux (1971b) suggested tentatively that the archeopyle of *Astrocysta* might be formed by the loss of a single intercalary reflected plate and rejected the possibility that an epitractal archeopyle was involved. The authors must reject herein the concept of an intercalary archeopyle as advanced by Davey (1970) and Brideaux (1971b).

Astrocysta Davey appears, therefore, to belong to that group of cavate peridinioid cysts in which the archeopyle is formed by the loss of one apical reflected plate, three reflected intercalary and three reflected precingular plates. Comments by the authors (this paper, p. 37) in connection with a discussion of the new genus *Luxadinium* gen. nov. also apply here.

(11) *Astrocysta cretacea* Pocock ex Davey

Plate 14, figure 3

1962 *Palaeoperidinium cretaceum* Pocock, p. 80, Pl. 14, figs. 219-221.
1970 *Astrocysta cretacea* Pocock ex Davey, p. 359, Pl. 2, fig. 4.
1971b *Lejeunia? cretacea* (Pocock) Brideaux, p. 86, Pl. 24, figs. 46, 47.
1971 *Palaeoperidinium? cretaceum* Pocock; Singh, p. 385, Pl. 68, figs. 9-11.
1972 *Astrocysta cretacea* Pocock ex Davey; Norris and Hedlund, p. 51, Pl. 2, fig. 6 (re-illustration of the holotype specimen).

Discussion. The name, *Palaeoperidinium*, was introduced by Deflandre (1934, p. 968) but constituted a *nomen nudum*. Sarjeant (1967a, p. 246) subsequently validly and effectively published the name. The species *cretaceum* was effectively published by Pocock (1962, p. 80) but was not validly published because the genus to which it was assigned was not validly published (I.C.B.N., Art. 43). Hence the species name was validated first by Davey (1970, p. 359) and should be cited as *Astrocysta cretacea* Pocock ex Davey.

Occurrence. Langton Bay and Horton River Formation (Aptian to Middle Albian); recorded previously from the Albian of Alberta (Pocock, 1962; Singh, 1964, 1971; Brideaux, 1971b) and Saskatchewan (Davey, 1970), the Lower Cenomanian of Montana and Wyoming (as Dinoflagellate A, Burgess, 1971), and the Upper Cretaceous (probably Santonian-Campanian) of Graham and Ellef Ringnes Islands (Manum and Cookson, 1964); observed in samples of Barremian to Campanian age on the Atlantic Coastal Plain of Maryland, U.S.A., and in rocks of Hauterivian to Albian age in the Mackenzie Delta region, District of Mackenzie, Canada (Brideaux, unpublished data); reported Upper Jurassic occurrences (Pocock, 1962) appear questionable.

Genus *Luxadinium* gen. nov.

Type species. *Luxadinium primulum* sp. nov. (here designated).

Diagnosis. Cavate peridinioid dinoflagellate cyst. Periblast broadly pentagonal, generally as long or longer than broad; possessing an apical horn or prominence and one or two antapical prominences, of which the left one is the longer; the periphragm thin, often much thinner than the endophragm, smooth, or with minor and variable ornamentation that may or may not be related to reflected tabulation. Endoblast subcircular or distinctly longer than broad; the apex rounded or with a distinct apical prominence which projects into the apical pericoel; the antapex flattened to rounded, rarely extended to form a left antapical prominence; the endophragm smooth, or with minor and variable sculpture that may or may not be related to reflected tabulation. Periphragm and endophragm not in contact and forming a single pericoel or, in contact at the mid-region of the cyst and forming an apical pericoel, a right antapical pericoel and, occasionally, a much reduced left antapical pericoel.

Periarcheopyle and endarcheopyle formed by the loss of three reflected intercalary plates (1a to 3a) and three reflected precingular plates (3'' to 5''). Endoperculum simple or compound and, where compound, composed of up to six endopercular pieces; perioperculum simple or compound, and presumably paralleling the endoperculum for the particular species; opercula not attached.

Reflected tabulation distinct or poorly developed to absent; where distinct, indicated by the shape of the archeopyle, intertabular growth areas and/or intratabular ornamentation; reflected tabulation scheme, 4', 3a, 7'', 0c, 5'', 2''''.

Cingulum distinct and displaced from one-half to two cingular widths; sulcus generally distinct, extending onto the epitract anteriorly and widening slightly posteriorly.

Discussion. Fossil peridinioid dinoflagellate cysts that possess archeopyles in one or both wall layers formed by the loss of three reflected intercalary and three reflected precingular plates, show considerable variation in the form of operculum derived from the endoblast. Furthermore, the form of the operculum derived from reflected plates of the periblast in such forms is not known definitely mainly because of the often very thin and fragile structure of the periphragm.

W.R. Evitt (pers. com. 1973) observed that, although two new genera might have to be established to accommodate fossil peridinioid cysts with a simple 3I3P operculum, and those with compound 3I + 3P opercula, practical considerations dictated that perhaps one new genus might be proposed to include both of these types. When clear criteria could be established for the separation of the two forms in the absence of opercular pieces two generic taxa might be proposed. The authors had, independently, come to a similar conclusion and circumscribe the new genus, *Luxadinium*, so as to include forms with both types of 3I + 3P opercula.

In addition to the type species, *Luxadinium primulum* sp. nov., a second species belongs in the genus as circumscribed. The authors refer to the taxon, *Scriniodinium eurypylum auct. non* Manum and Cookson, 1964 *in* Brideaux (1971b, p. 99, Pl. 29, figs. 97, 98) and *in* Singh (1971, p. 364, Pl. 62, figs. 6-10). The operculum of this species is not known definitely to be simple or compound in either wall layer. The archeopyle is formed in both layers by the loss of three reflected intercalary plates and three reflected precingular plates. The archeopyle of *Scriniodinium eurypylum* Manum and Cookson, 1964, p. 20, Pl. 4, figs. 7-13, is formed by the loss of these six reflected plates and, in addition, at least one of the apical plates (observations of the authors; W.R. Evitt, pers. com.).

The following new species is thus introduced: *Luxadinium propatulum* sp. nov., = *Scriniodinium eurypylum auct. non* Manum and Cookson, 1964 *in* Brideaux, 1971, p. 99, Pl. 29, figs. 97, 98 and *in* Singh, 1971, p. 364, Pl. 62, figs. 6-10. The holotype chosen is the specimen illustrated *in* Singh (1971, Pl. 62, fig. 8); that specimen shows clearly an archeopyle formed by the loss of three reflected intercalary plates and three reflected precingular plates in both the periphragm and endophragm. The holotype comes from Sample No. 3-S-5, Section 3, of the lower Shaftesbury Formation (sec. 11, tp. 83, rge. 22, W5M, west-central Alberta) at the base of the measured section, and is found on Slide No. 3-S-5 Micro. 137 at co-ordinates 11.8 x 42.9 on the Carl Zeiss Polarizing Photomicroscope at the Research Council of Alberta, Edmonton, Alberta, Canada. The holotype specimen is refigured in this paper on Plate 13, figures 9-11 and a second specimen is figured on Plate 13, figure 12 and Plate 14, figures 1, 2.

Except for designation of the archeopyle form as consisting of 3I + 3P, or 3I3P, the descriptions and comments of the two authors (Brideaux, 1971b, p. 99; Singh 1971, p. 364, 365) suffice for other morphological details.

The assertion by Davey and Verdier (1973, p. 199 and p. 210) that the specimen illustrated as *Scriniodinium eurypylum* Manum and Cookson (= *Luxadinium propatulum* sp. nov.) by Brideaux (1971b, Pl. 29, fig. 97) possesses an apical archeopyle and belongs to *Ovoidinium verrucosum* var. *ostium* Davey and Verdier, 1973, is incorrect. Davey (pers. com., 1974) agrees with this assessment. Furthermore, the range of *Luxadinium propatulum* sp. nov. does extend into the Cenomanian (unpublished data of the authors) contrary to the opinions expressed by Davey and Verdier (1973, p. 210). W.W. Brideaux has observed the species in Cenomanian material from Saskatchewan kindly loaned by R.J. Davey.

Other groups of peridinioid cysts, in which the operculum either remains attached (i.e.: 3I3Pa) or involves the additional loss of one or more reflected plates of the apical series, also exist (W.R. Evitt, pers. com.) and also show considerable variation in the form of the operculum. These groups include, in part, some species assigned to the genera, *Palaeoperidinium* Deflandre ex Sarjeant and *Astrocysta* Davey (*see* also Norris and Hedlund, 1972). W.R. Evitt (pers. com., 1973) plans a more comprehensive treatment of some or all of these forms, and the authors therefore propose no further changes in nomenclature and taxonomy in this contribution.

(45) *Luxadinium primulum* sp. nov.

Plate 12, figures 9-12; Plate 13, figures 1-8

Holotype. GSC No. 34153, Slide P851-2A, 29.2 x 134.5; Section CR14A-68, Horton River Formation, 20 to 30 feet (6.1 to 9.1 m); GSC loc. C-8533. Dimensions: Periblast, 70μ x 62μ; endoblast, 61μ x 62μ.

Diagnosis. Peridinioid cavate cyst; the periphragm thin, of pentagonal outline, and with an apical and one left antapical prominence. Endophragm slightly thicker, closely appressed to periblast but lacking apical and antapical extensions, bearing intratabular apiculae delimiting reflected tabulation of 4', 3a, 7'', 0c, 5''', 2''''. Archeopyle in both layers, formed by loss of three reflected intercalaries and three precingular plates. Endoperculum and? perioperculum compound, and composed of six reflected plates 1a to 3a and 3'' to 5''. Cingulum distinct and displaced up to one and one-half cingular widths; sulcus generally well defined, wider posteriorly.

Description. The basic outline of the pericyst is pentagonal with well-rounded corners. The cyst length is always greater than the width, with the maximum width occurring at the cingulum. The periblast tapers apically to a well-rounded prominence. The left side of the periblast is produced antapically to form a small, pointed prominence; the right side is rounded or, occasionally, is produced to form a much-reduced right antapical prominence. The endoblast is similar in shape and outline, but is not extended apically, and is almost completely flattened antapically.

The periphragm is smooth, very thin, almost veil-like, and is often stripped away. The endophragm is thicker, about 1.0μ thick in optical section, with intratabular apiculae, 0.25 to 0.5μ high and wide. The apiculae are absent in the intertabular regions and their absence marks the position of reflected sutural lines. The periphragm and endophragm are in contact except at the apical prominence and where antapical prominences occur. There exist, therefore, an apical pericoel, a smaller left antapical pericoel and, occasionally, a much reduced right antapical pericoel.

The archeopyle is formed by the loss of three intercalary and three precingular reflected plates (1a to 3a and 3'' to 5'') in the periphragm and endophragm. No specimen has been observed in which the archeopyle is developed only in the periphragm. The sweeping arc of the anterior margin of the archeopyle is broken only by the characteristic "tongue" of the margin of reflected plate 3' projecting into the opening. The operculum is compound and has been observed, in most cases, as a group of disconnected reflected plates. Most common is the association of the large reflected plate 2a together with one or more of the reflected precingular plates 3'' to 5''. Several specimens have the intercalaries missing with the detached precingular group intact within the endocoel. Rare specimens, including the holotype, show only incipient principal sutural breaks between reflected plates forming the opercula. It is probable that all six plates separate along principal sutures although, occasionally, some may remain attached. Presumably, the respective reflected plates of both wall layers separate as units.

Reflected tabulation is defined on the endophragm by intratabular clusters of apiculate sculpture separated by smooth intertabular regions. The latter mark the reflected courses of the probable growth areas between plates of the thecal stage. The reflected tabulation scheme can be summarized as 4', 7'', 0c, 5'', 2''''. The two reflected antapical plates are discernable only on a few specimens. Reflected tabulation is not exhibited on the periphragm.

The cingulum is outlined on the endophragm by two low parallel ridges which may or may not bear apiculae or, more rarely, by rows of discrete apiculae. The cingulum is displaced from one to one and one-half cingular widths. On the periphragm, two low folds, identical in position to the ridges or apiculate rows of the endophragm, outline the cingulum.

The sulcus is reflected on the endophragm by a shallow indentation, narrower anteriorly, and widening posteriorly to meet the antapical reflected plates. The course of the sulcus also is defined by the sharp borders of the intratabular apiculae outlining reflected plates 1''' and 5'''. On the periphragm, the sulcus is reflected as a similarly shaped shallow depression flanked by folds of the periphragm that parallel the edges of the sulcus on the endophragm. On one specimen, the reflected position of the flagellar pore is well preserved.

Dimensions. (40 measured specimens) - Periblast length, 50-70μ; periblast width, 43-62μ; endoblast length, 42-62μ; endoblast width, 43-62μ.

Comparison. *Luxadinium primulum* sp. nov. is distinguished from *Luxadinium propatulum* sp. nov., nom. nov. by possession of a distinctive intratabular apiculate ornament on the endophragm and smooth periphragm, and by the lack of a distinct apical prominence developed on the endoblast.

Occurrence. Horton River Formation, lower part (Middle Albian).

Genus *Palaeoperidinium* Deflandre ex Sarjeant

1934 *Palaeoperidinium* Deflandre, p. 968 (*nom. nud.*)
1967a *Palaeoperidinium* Deflandre ex Sarjeant, p. 246.

(55) *Palaeoperidinium* sp. A of Brideaux

Plate 14, figure 4

1971b *Palaeoperidinium* sp. A Brideaux, p. 87, Pl. 25, fig. 52.

Dimensions. (3 specimens, 2 measurable) - length, 90μ and 100μ; width, both 70μ.

Discussion. One of the specimens exhibits a poorly defined transapical archeopyle. The specimen illustrated by Brideaux (1971b, Pl. 25, fig. 52) also possesses a transapical archeopyle, but the photograph does not possess sufficient contrast to exhibit this clearly.

Occurrence. Horton River Formation (Middle Albian); recorded previously from the Middle and Upper Albian of central and west-central Alberta (Brideaux, 1971b).

Cavate unassigned cysts

Genus *Chlamydophorella* Cookson and Eisenack

1958 *Chlamydophorella* Cookson and Eisenack, p. 56.

(26) *Chlamydophorella nyei* Cookson and Eisenack

Plate 14, figure 9

1958 *Chlamydophorella nyei* Cookson and Eisenack, p. 56, Pl. 11, figs. 1-3.

Occurrence. Langton Bay and Horton River Formations (Aptian to Middle Albian); recorded previously from Aptian to Maastrichtian rocks (Cookson and Eisenack, 1958; Singh, 1971; Brideaux, 1971b; McIntyre, 1974).

Genus *Dingodinium* Cookson and Eisenack

1958 *Dingodinium* Cookson and Eisenack, p. 39.

(5) *Dingodinium cerviculum* Cookson and Eisenack

Plate 14, figure 5

1958 *Dingodinium cerviculum* Cookson and Eisenack, p. 40, Pl. 1, figs. 12, 14.

Occurrence. Langton Bay Formation, Gilmore Lake and lower part, Crossley Lakes Member (Aptian and Lower Albian); recorded previously from the upper Neocomian to Aptian of Australia (Cookson and Eisenack, 1958; Evans, 1966; Haskell, 1969), the Middle and Upper Albian of central Alberta (Singh, 1971; Brideaux, 1971b), the Albian of Roumania (Baltes, 1967) and the Hauterivian to lower Turonian of Germany (Alberti, 1961). Alberti (1961, p. 17) remarks that his Turonian specimens may be reworked (*see* also Brideaux, 1971b, p. 102).

Genus *Kalyptea* Cookson and Eisenack

1960b *Kalyptea* Cookson and Eisenack, p. 256.

(61) *Kalyptea monoceras* Cookson and Eisenack

Plate 14, figure 6

1960b *Kalyptea monoceras* Cookson and Eisenack, p. 256, Pl. 39, figs. 2, 3.

Occurrence. Horton River Formation (Middle Albian), one specimen; recorded previously from the Upper Jurassic of Australia and Papua (Cookson and Eisenack, 1960b), the Middle and Upper Albian of central Alberta (Brideaux, 1971b), the Upper Albian and Lower Cenomanian of England (Cookson and Hughes, 1964), and the Santonian-Campanian along Horton River (McIntyre, 1974).

(49) *Kalyptea* sp. A of Brideaux

Plate 14, figure 8

1971b *Kalyptea*? sp. A Brideaux, p. 98, Pl. 29, fig. 96.

Dimensions. (9 measured specimens) - Maximum diameter of kalyptra, 50-95μ; maximum diameter of inner layer, 32-63μ.

Discussion. The ratio of maximum dimensions of the specimens from Horton River strata exhibits the same wide variation as those from the Middle and Upper Albian of central Alberta (Brideaux, 1971b, p. 99). The dimensions of the Horton River specimens extend the observed maximum diameter of the inner layer from 62μ to 63μ. The observed maximum diameter of the kalyptra is 43-101μ, and of the inner layer, 25-63μ.

Comparison. *Kalyptea* sp. A is similar in organization to *Kalyptea aceras* Manum and Cookson, 1964, p. 27, Pl. 6, figs. 9-11, but has a thinner wall, a much wider range in maximum diameter, and does not possess microreticulate sculpture on the inner layer.

Occurrence. Langton Bay Formation, Gilmore Lake Member, and Horton River Formation (Aptian to Middle Albian); recorded previously from Middle and Upper Albian rocks of central Alberta (Brideaux, 1971b).

Group ACRITARCHA Evitt

Genus *Lecaniella* Cookson and Eisenack

1962 *Lecaniella* Cookson and Eisenack, p. 269.

(63) *Lecaniella foveata* Singh

Plate 14, figures 10, 11

1971 *Lecaniella foveata* Singh, p. 426, Pl. 79, figs. 5-10, Pl. 80, fig. 1.

Dimensions. (3 measured specimens) - Maximum diameter, 63-67μ; diameter of outer rim, 3μ.

Occurrence. Horton River Formation (Middle Albian); recorded previously from the Upper Albian of west-central Alberta (Singh, 1971).

Genus *Leiofusa* Eisenack

1938 *Leiofusa* Eisenack, p. 12.

(25) *Leiofusa jurassica* Cookson and Eisenack

1958 *Leiofusa jurassica* Cookson and Eisenack, p. 51, Pl. 10, figs. 3, 4.

Occurrence. Langton Bay and Horton River Formations (Aptian to Middle Albian); recorded previously from Upper Carboniferous to Oligocene rocks (Combaz *et al.*, 1967, Fig. 3; other authors); the Lower Jurassic of Britain (Wall, 1965); the Middle and Upper Albian of central and west-central Alberta (Brideaux, 1971b; Singh, 1971).

Genus *Micrhystridium* Deflandre emend. Lister

1937 *Micrhystridium* Deflandre, p. 79.
1963 *Micrhystridium* Deflandre emend. Downie and Sarjeant, p. 92.
1970 *Micrhystridium* Deflandre emend. Lister, p. 77.

(28) *Micrhystridium* sp. A.

Plate 14, figures 12, 13

Description. The test outline is circular to subcircular. The wall is thin, apparently formed of a single layer or two highly appressed layers. The outer layer is smooth or faintly granulose and gives rise to six to twelve processes. The processes are as long or longer than the test diameter, are slightly wider basally, and narrow distally, ending in a very small pilate tip.

Dimensions. (14 measured specimens) - Test diameter 12.5 to 22.5μ; process length, 7.5 to 38μ, typically 15-25μ.

Occurrence. Langton Bay Formation, upper part of Crossley Lakes Member, and Horton River Formation (Lower and Middle Albian).

Genus *Pterospermopsis* W. Wetzel

1952 *Pterospermopsis* W. Wetzel, p. 411.

(12) *Pterospermopsis australiensis* Deflandre and Cookson

Plate 14, figure 7

1955 *Pterospermopsis australiensis* Deflandre and Cookson, p. 286, Pl. 3, figs. 4, 52, 53.

Occurrence. Langton Bay Formation, Gilmore Lake Member, and Horton River Formation (Aptian to Middle Albian); recorded previously from Lower Cretaceous to Paleocene rocks (Deflandre and Cookson, 1955; Stanley, 1965; Baltes, 1965; Singh, 1971; Brideaux, 1971b).

Genus *Veryhachium* Deunff emend. Downie and Sarjeant

1954 *Veryhachium* Deunff, p. 306.
1963 *Veryhachium* Deunff emend. Downie and Sarjeant, p. 93.

(19) *Veryhachium collectum* Wall

1965 *Veryhachium collectum* Wall, p. 159, Pl. 3, figs. 11-14, Pl. 8, fig. 6.
1971 *Veryhachium* cf. *V. collectum* Wall; Brideaux, p. 74, Pl. 21, fig. 10.

Occurrence. Langton Bay Formation, Crossley Lakes Member and Horton River Formation (Lower and Middle Albian); recorded previously from the Lower Jurassic of Britain (Wall, 1965) and the Middle and Upper Albian of central Alberta (Brideaux, 1971b; Singh, 1971).

(19) *Veryhachium reductum* "forma" *trispinoides* de Jekhowsky

1961 *Veryhachium reductum* forma *trispinoides* de Jekhowsky, p. 210, Pl. 2, figs. 32-37.

Occurrence. Langton Bay Formation, Crossley Lakes Member and Horton River Formation (Lower and Middle Albian); recorded previously from the Permo-Triassic of Europe and Africa (de Jekhowsky, 1961), the Lower Jurassic of Britain (Wall, 1965) and the Middle and Upper Albian of central Alberta (Brideaux, 1971b; Singh, 1971).

ADDENDUM

Davey and Verdier (1974) have reported on dinoflagellate cyst assemblages from the Aptian type sections at Gargas and La Bédoule in southeastern France. Their important paper came to the authors' attention after completion of the text for this paper. A number of comments occasioned by Davey and Verdier's (1974) paper, therefore, are appended.

Of the twenty-three species and subspecies recorded in Aptian rocks along Horton River, only five species occur also in the Aptian type section (Fig. 7). Ten other species and subspecies occurring in the Aptian type section occur only in Albian rocks along Horton River. As mentioned previously, in discussing the paleoecology of the assemblages, the absence of those species in Aptian rocks along Horton River is probably a function of unfavourable paleoenvironments resulting in the impoverished assemblage recorded in the Aptian Gilmore Lake Member.

Davey and Verdier (1974, p. 650) suggest that some of the species reported by Singh (1971) "... strongly suggest an Aptian age for the lower part of the section...". Although Davey and Verdier (op. cit.) do not specify which part of the section they mean, they presumably are referring to Section 8 of Singh (1971) from the upper part of the Loon River Formation. Davey and Verdier (op. cit.) also suggest that some species recorded by Singh (1971) from higher parts of the sections (Peace River and lower Shaftesbury Formations) are reworked from the presumed Aptian samples. Concerning the age of the sampled (upper) part of the Loon River Formation, Singh (1971, p. 25) writes: "The Loon River microflora is associated with the *Subarcthoplites-Beudanticeras* fauna of Middle Albian age...". Singh (1971, p. 11) notes also that the lower part of the Loon River Formation carries the *Cleoniceras* ammonite fauna of Early Albian age. The work of Mellon and Wall (1963) on the Blairmore Group and equivalent strata, Mellon (1967) on the Blairmore and Mannville Groups of the Alberta plains and foothills, and Williams (1960, 1963) on the Mannville Group is pertinent here also. These papers summarize the evidence for the age of formations assigned to these groups, based on known microfaunal (foraminifera, ostracodes) and macrofaunal (ammonites, pelecypods) evidence, and show that the age of these groups in central and southern Alberta is not older than Early Albian. Finally, the species cited as evidence for the assertions by Davey and Verdier (1974, p. 650) range throughout the later Neocomian, Aptian and Albian of Alberta and the northern Canadian mainland (Singh, 1964, 1971; Brideaux, 1971b; Brideaux and McIntyre, this paper; Brideaux, unpublished data). Thus, evidence cited by Davey and Verdier (op. cit.) does not appear to warrant the conclusions of those authors and the present writers cannot agree with their assertions. Similar observations apply to the remarks made by Davey and Verdier (op. cit.) regarding so-called reworked Aptian species in subsurface Middle and Upper Albian rocks of central and west-central Alberta recorded by Brideaux (1971b).

Several taxonomic points raised by Davey and Verdier (1974, op. cit.) also merit discussion. The synonymy of the species, *Spinidinium vestitum* Brideaux (1971b, p. 99, Pl. 29, figs. 99-103, Text-figs. 10a, d) should be as follows:

1970 *Deflandrea echinoidea* Davey, p. 339; Pl. 1, fig. 5; *auct. non* Cookson and Eisenack, 1960, p. 2, Pl. 1, figs. 5, 6.

1970 *Deflandrea* cf. *echinoidea* Cookson and Eisenack; Davey, p. 339; Pl. 1, fig. 6, Pl. 2, fig. 2.

1971 *Deflandrea limpida* Singh, p. 359; Pl. 61, figs. 1-12 (Dec. 1971).

1974 *Deflandrea echinoidea* Sverdlove and Habib, p. 58; Pl. 1, figs. 1-6; Textfig. 2a, b; *auct. non* Cookson and Eisenack, 1960, p. 2, Pl. 1, figs. 5, 6.

non Deflandrea vestita (Brideaux) Sverdlove and Habib, 1974, p. 59; Pl. 1, figs. 7-12; Textfig. 2c, d.

Davey and Verdier (1973, p. 196) place *Deflandrea* cf. *echinoidea* Cookson and Eisenack in Davey (1970, p. 339) in synonymy with *Deflandrea gallia* Davey and Verdier, 1973, p. 196, Pl. 3, figs. 1-4. The present writers are not in agreement with this view. The form cited as *Deflandrea vestita* (Brideaux) Sverdlove and Habib, 1974, belongs neither in *Deflandrea* nor in *Spinidinium*, but is probably a species of *Ginginodinium* Cookson and Eisenack, 1960.

Singh (pers. com.) agrees that *Deflandrea limpida* (publication date, Dec. 1971) is a junior synonym of *Spinidinium vestitum* (publication date, Sept. 1971). Davey and Verdier (1973, p. 197) stated incorrectly that Brideaux (1971b, p. 101) attributed a Saskatchewan occurrence of *D.* cf. *echinoidea* (as *Spinidinium vestitum*) to Davey (1970). More correctly, Brideaux (1971b, p. 101) stated only that *S. vestitum* was "...observed...in early Cenomanian material from Saskatchewan provided by Dr. R.J. Davey...".

Finally, *Dinopterygium* sp. A (Brideaux, 1971b, p. 97, Pl. 28, figs. 89-92) is most certainly not attributable to the genus *Gonyaulacysta*, and neither does it appear to be synonymous with *Gonyaulacysta* sp. of Davey and Verdier (1974, p. 632, Pl. 93, fig. 5) as asserted by Davey and Verdier (1974, p. 532, 650). *Dinopterygium* sp. A of Brideaux (1971b) differs from *Gonyaulacysta* sp. of Davey and Verdier in the absence of spiny processes, microgranulate ornament, and in the presence of wider (14-16μ) singular sutures.

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APPENDIX

The following descriptions of sections on Horton River, collected by T.P. Chamney in 1968, are based directly on field notes by T.P. Chamney and edited mainly for purposes of continuity. All thicknesses are given in feet (metres).

Section CR15A-68 (=Section YB-36 *in* Yorath *et al.*, in press).
Latitude 69°27'30"N, Longitude 126°54'W.
Datum = River level.

Description	Thickness	Height Above Base
AMUNDSEN GULF GROUP (Upper Cretaceous)		
SMOKING HILLS FORMATION		
About 6 ft (1.8 m) of pebble-conglomerate overlying the uppermost shale of the Horton River Formation at this location. This belongs to the Smoking Hills Formation.		
DARNLEY BAY GROUP (Lower Cretaceous)		
HORTON RIVER FORMATION		
Shale, dark grey, plastic; iron concretions at 130-140 ft (39-42 m)	80 (24.4)	140 (42.7)
Shale, light grey, grey weathering, platy to flaggy	22 (6.7)	60 (18.3)
Highly calcareous ironstone concretionary bed (impure limestone)	1 (0.3)	38 (11.6)
Shale, grey, weathers grey-brown with slight rusty stain or pale orange-yellow	7 (2.1)	37 (11.3)
Covered interval (slumping)	30 (9.0)	30 (9.0)

Section CR14A-68 (=Section YB-35 *in* Yorath *et al.*, in press).
Latitude 69°19'N, Longitude 126°50'W.
Datum = River level.

Shale, grey-brown weathered, blocky with thin-bedded, pale yellow silty clay	15 (4.6)	125 (38.1)
Shale, dark grey, plastic; at 90-100 ft (27.4-30.5 m), pale yellow ?silty clay beds increase; at 90 ft (27.4 m), noncalcareous ironstone concretions; at 60 ft (18.3 m), ammonites; at 37 ft (11.3 m), iron concretionary horizon	100 (30.5)	110 (33.5)
Covered interval (slumping)	10 (3.0)	10 (3.0)

Section CR12A-68 (=Section YB-56 *in* Yorath *et al.*, in press).
Latitude 69°12'30"N, Longitude 126°17'W.
Datum = River level.

Slumped interval in part	5 (1.5)	195 (59.4)
Shale, grey, weathering rusty brown; scattered ironstone concretions common	3.5 (1.1)	190 (57.9)

Description	Thickness	Height Above Base
Limestone, cone-in-cone concretionary horizon	1.5 (0.5)	186.5 (56.8)
LANGTON BAY FORMATION		
Crossley Lakes Member		
Shale and siltstone as below but more plastic	5 (1.5)	185 (56.4)
Basal ironstone concretionary bed succeeded by interbedded grey shale and pale yellow siltstone	8 (2.4)	180 (54.9)
Section resumes about 1/4 mile (0.4 km) (west) downstream.		
Limestone, white weathering	2 (0.6)	172 (52.4)
Mudstone (silty clay-shale), rubbly weathering; goethite rosettes and pelecypod fragments	60 (18.3)	170 (51.8)
Shale and silt interbedded with pelecypods; wood common, 1 ft (0.3 m) in diameter; at 100-110 ft (30.4-33.5 m), slightly more indurated, more silty, and with very fine grained sandstone beds	30 (9.1)	110 (33.5)
Shale and silt interbedded. Silt, pale grey-brown; shale, grey-brown; pelecypods at 75 ft (22.9 m)	10 (3.0)	80 (24.4)
Shale, medium dark grey, weathering grey, fissile, slightly blocky, plastic, bentonitic	20 (6.1)	70 (21.3)
Shale and silt as below, weathers pale grey-brown. At 49.5-50 ft (15.1-15.2 m), coquina of pelecypod shells, comminuted	10 (3.0)	50 (15.2)
Shale and silt alternate, thin bedded as below. Abundant pelecypod shells, wood, ?vertebrate bone	10 (3.0)	40 (12.2)
Shale, as below, with scattered limestone-dolomite concretions, approximately 1.5 ft (0.5 m) in length; large dolomite crystals; goethite rosettes common. Coquinoid bed, 3 in (0.08 m) thick, of comminuted white pelecypod shells	10 (3.0)	30 (9.1)
Shale as below, increase in thin-bedded, pale yellow-brown silt; at 12-20 ft (3.7-6.1 m), shell coquina of pelecypods, 1.5 in (0.04 m) thick. Goethite rosettes common	10 (3.0)	20 (6.1)
Shale, grey-brown, slightly calcareous, rusty red, with thin-bedded, pale yellow silty clay	5 (1.5)	10 (3.0)
Covered interval	5 (1.5)	5 (1.5)

Section CR11A-68
Latitude 69°07'30"N, Longitude 126°20'W. West bank, Horton River, opposite mouth of Coal Creek.
Datum = River level.

Limestone, clay-iron, weathering pale yellow	2.5 (0.7)	72.5 (22.1)
Shale as below, but more rubbly weathering	20 (6.1)	70 (21.3)
Shale, dark grey, noncalcareous, silty and sandy, blocky, weathers grey; thin beds of pale yellow silty clay	20 (6.1)	50 (15.2)

Description	Thickness	Height Above Base
Shale as below; at 24 ft (7.2 m), alternating beds, 6 in (0.15 m) thick, of dark grey shale and pale yellow silty clay; at 28.5-30 ft (8.6-9.1 m), pale yellow silt capped by ferruginous stained clay pebbles; very irregular upper surface	10 (3.0)	30 (9.1)
Shale as below, some thin-bedded, pale yellow silty clay	10 (3.0)	20 (6.1)
Shale, dark grey-red-brown stained; highly calcareous, weathering grey, rubbly	5 (1.5)	10 (3.0)
Slump-covered	5 (1.5)	5 (1.5)

Section CR10A-68 (*see* also Section YB-52 *in* Yorath *et al.*, in press).
Latitude 64°01'30"N, Longitude 126°02'W.
Datum = River level.

Description	Thickness	Height Above Base
Shale, grey-brown, earthy weathering underlying moss and tree-covered slope at top of section	6 (1.8)	309 (94.2)
Massive, clay-iron concretionary bed, calcareous, with abundant fossil material	3 (0.9)	303 (92.3)
Shale and pale yellow jarositic silty clay	50 (15.2)	300 (91.4)
Shale, pale yellow, crumbly with coxcomb and dolomite crystals *in situ*. Broken pelecypod shells at 245 ft (74.7 m)	10 (3.0)	250 (76.2)
Shale, grey, blocky and silty, with scattered iron concretions and common thin-bedded pale yellow silt (?jarositic). Iron concretions weathered and broken into large dolomite-like crystals at 240 ft (73.1 m)	10 (3.0)	240 (73.1)
Shale, as below, with increasing silt, upper 8 in (0.2 m) of pale grey soft silt, broken pelecypod bed at 225 ft (68.6 m)	10 (3.0)	230 (70.1)
Shale, grey, interbedded with pale yellow silt, increasing silty content upwards	3 (0.9)	220 (67.0)
Iron concretionary bed	2 (0.6)	217 (66.1)
Shale, as below, with a slight increase in pale yellow jarositic clay beds, some scattered ammonite shell fragments at 200-210 ft (60.9-64.0 m)	25 (7.6)	215 (65.5)
Shale, blocky to platy weathering, grey-brown, with 3 in (0.08 m) of pale yellow jarosite clay at top	30 (9.0)	190 (57.9)
Covered interval	10 (3.0)	160 (48.8)
Shale, dark grey, weathering light grey to grey, blocky; ammonite shell fragments scattered throughout, with some clay iron concretions	30 (9.1)	150 (45.7)
Slump assumed to be shale as below	20 (6.1)	120 (36.6)
Shale, medium grey, weathering grey-brown, fissile to blocky, plastic	5 (1.5)	100 (30.4)
Shale, grey, hackly with thin beds of pale yellow jarosite	18 (5.5)	95 (28.9)

Description	Thickness	Height Above Base
Limestone, concretionary bed, highly calcareous; slightly unconsolidated, with swash marks, and less calcareous at top	2 (0.6)	77 (23.4)
Shale, grey and dark grey banded; slightly thinner bedded pale yellow silt	5 (1.5)	75 (22.8)
Shale, as below; a few thin-bedded, pale yellow, silty clay beds	10 (3.0)	70 (21.3)
Shale, dark grey, plastic, non-calcareous, marcasite concretions at base	10 (3.0)	60 (18.3)
Shale, as below, with increase in pale yellow silty clay to pure silt	10 (3.0)	50 (15.2)
Shale as below; increase in pale yellow ?jarositic beds; at 30-31.5 ft (9.1-9.6 m), scattered iron concretions, calcareous, weathering pale yellow	10 (3.0)	40 (12.2)
Shale, grey, with thin-bedded, pale yellow (sulphur?) silty clay, weathering hackly, "mahogany" banded; at 25 ft (7.8 m), ?jarositic bed, 1.5 in (0.04 m) thick; some dull red-brown limestone iron-rich beds, 2 in (0.05 m) thick	10 (3.0)	30 (9.1)
Scree and slump-covered	20 (6.1)	20 (6.1)

Section CR9A-68 (*see* also Section YB-51 *in* Yorath *et al.*, in press).
Latitude 69°04'N, Longitude 125°51'W.
Datum = River level.

Interbedded light grey silt and dark grey silty clay	5 (1.5)	140 (42.6)
Silt, soft, white, very thin bedded, dark clay and yellow ?sulphur clay	7 (2.1)	135 (41.1)
Shale, dark grey, black, weathering to grey, "mahogany" banding with very thin bedded, pale yellow sulphur clay	3 (0.9)	128 (39.0)
Silt, and sand, very fine-grained, grey-brown, weathering light grey, ferruginous "flow casts"; micromicaceous	10 (3.0)	125 (38.1)
Sand, medium grey-brown, argillaceous	5 (1.5)	115 (35.1)
Scree and slump-covered	10 (3.0)	110 (33.5)
Sand; light brown, very fine to fine grained, alternating with beds of shale, dark grey, grading into light grey silt at top. Fossilized wood fragments	12 (3.7)	100 (30.5)
Shale, dark grey to black, weathering silvery grey, fissile, ?carbonaceous at base	1.5 (0.5)	88 (26.9)
Silt; white, soft, yellow-weathering. Marcasite nodules and odd-shaped forms	3.5 (1.1)	86.5 (26.4)
Limestone, highly arenaceous and fossiliferous with ripple-marks on upper surface	3 (0.9)	83 (25.3)
Slumpy soft white silt, as below, to very fine sand, clean with slight ferruginous streaks. Strewn with blocks of ferruginous red-brown "cap-rock" at top of unit	15 (4.6)	80 (24.3)

Description	Thickness	Height Above Base
Silt, light grey, unconsolidated, blocky, soft, crossbedded, low angle, non-calcareous	15 (4.6)	65 (19.8)
Sand and shale as below, predominantly very fine grained sand and silt, pale grey with dark grey, very thin bedded clay	26 (7.9)	50 (15.2)
Lignite seam	0.5 (0.15)	24 (7.3)
Shale, grey, blocky weathering, non-calcareous. Thin sand beds, grey-brown at 12, 15 and 22 ft (3.7, 4.6 and 6.7 m); dark grey clay partings	13.5 (4.1)	23.5 (7.2)
Silt, very fine sand and clay shale, alternating light grey (silt) and dark grey carbonaceous (clay); interbedded, slightly crossbedded and lenticular. Sand fine to medium grained, scattered, coloured mafics; non-calcareous	5 (1.5)	10 (3.0)
Covered interval	5 (1.5)	5 (1.5)

<u>Section CR8A-68</u> (=Section YB-50 *in* Yorath *et al.*, in press).
Latitude 68°50'N, Longitude 125°24'W.
Datum = River level.

<u>Gilmore Lake Member</u>

Description	Thickness	Height Above Base
Unconsolidated brown sand, with chert pebbles	9.5 (2.9)	230 (70.1)
Shale, blocky to fissile, medium grey, weathering grey-brown	5.5 (1.7)	220.5 (67.2)
Sandstone, very fine grained, to pale grey siltstone, slightly consolidated, vertical cliff-former of blocky siltstone slabs; interbedded at top with grey argillaceous silt. 2 ft (0.6 m) of massive, grey siltstone at top of unit	45 (13.7)	215 (65.5)
Sandstone, brown, crossbedded	10 (3.0)	170 (51.8)
Shale, dark grey, fissile to blocky	10.5 (3.2)	160 (48.8)
Sandstone, very fine grained to siltstone; soft, white	4.5 (1.4)	149.5 (45.6)
Concretionary bed of iron-stained crystalline limestone, and arenaceous, red-brown, orange-weathering, to calcareous sandstone	5 (1.5)	145 (44.2)
Sandstone, very fine grained and siltstone, light grey, poorly consolidated but some indurated silty concretions forming resistant caps on pinnacles (minor hoodoos)	36 (11.0)	140 (42.7)
Dark grey lignitic shale, interbedded with light grey silty clay	21 (6.4)	104 (31.7)
Silty shale (mudstone), as below, grey	8 (2.4)	83 (25.3)
Mudstone, medium grey with marcasite balls about 0.5 in (0.02 m) in diameter	5 (1.5)	75 (22.9)
Sandstone, pale grey-brown, massive bedding, ledge former	2 (0.6)	70 (21.3)
Mudstone, medium grey, soft, blocky	8 (2.4)	68 (20.7)
Sand, grey-brown, soft, unconsolidated; very fine to silty	5 (1.5)	60 (18.3)

Description	Thickness	Height Above Base
Coal, lignitic in part, to shiny black; with dark grey siltstone below the coal, and pale grey clay with silt above	5 (1.5)	55 (16.8)
Siltstone, white; mudstone, grey; banded, with light brown siltstone, resistant and vertically fractured	5 (1.5)	50 (15.2)
Mudstone to siltstone, fissile shale as below with white silt bands, all weather light grey. Top 8 in (0.2 m), lignitic coal bed with carbonized wood fragments	5 (1.5)	45 (13.7)
Mudstone, medium to dark grey, poorly consolidated. Carbonized plant remains common; alternating 3 in (0.1 m) bands of white silt; top 8 in (0.2 m), lignitic coal	7 (2.1)	40 (12.2)
Silt to very fine sand, white, poorly consolidated	13 (4.0)	33 (10.1)
Shale, pale green-grey, laterally thickening to include a white siltstone lens about 1.5 ft (0.46 m) thick	4 (1.2)	20 (6.1)
Shale, medium grey, clayey with pyritic, orange limestone boulders and orange ferruginous streaks	1 (0.3)	16 (4.9)
BEAR ROCK FORMATION (Middle Devonian)		
Limestone, very finely crystalline, highly pyritic with marcasite nodules, balls, tubes; fetid odour when struck. Variable thickness along strike--up to 20 ft (6.1 m) thick	1.5 (0.46)	15 (4.6)
Rock flour and crushed surface, grey-brown, weathers orange-brown	0.5 (0.15)	13.5 (4.15)
Limestone, as below, more thinly bedded	3 (0.9)	13 (4.0)
Limestone, grey to pale grey-brown, very finely crystalline, stylolitic surfaces; slight sulphide odour when broken	10 (3.0)	10 (3.0)

PLATES 1 - 4

All figures x500 except Plate 4, figures 31-37 which are x1000. All pollen and spore specimens illustrated in this paper (Pls. 1-14) are deposited in type collections of the Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada.

In the figure explanations, the species name is followed by the GSC (I.S.P.G.) Location Number, the slide number, the stage co-ordinates for Leitz Ortholux microscope No. 646441 at Chevron Standard Limited, Calgary, Alberta, the GSC Type Number and the page reference for species described in the systematics section.

PLATE 1

Fig. 1. *Biretisporites potoniaei*. C-8536, P851-5A, 27.3 x 105.9, GSC No. 42389 (p. 14)

Fig. 2. *Cyathidites australis*. C-8470, 6774-A1, 15.1 x 114.6, GSC No. 42390 (p. 14)

Fig. 3. *Cyathidites minor*. C-8548-9, 6888-A1, 23.2 x 116.0, GSC No. 42391 (p. 14)

Fig. 4. *Deltoidospora juncta*. C-8548-9, 6888-A1, 29.6 x 112.2, GSC No. 42392 (p. 14)

Fig. 5. *Todisporites minor*. C-8456, 6760-A1, 41.1 x 105.4, GSC No. 42393 (p. 14)

Fig. 6. *Stereisporites antiquasporites*. C-8547, 6887-A1, 32.3 x 114.9, GSC No. 42394 (p. 14)

Fig. 7. *Concavissimisporites punctatus*. C-8536, P851-5A, 24.0 x 119.7, GSC No. 42395 (p. 14)

Figs. 8, 9. *Leptolepidites verrucatus*. C-8459, 6763-A1, 28.0 x 115.5, GSC No. 42396 (p. 14)

Fig. 10. *Concavissimisporites variverrucatus*. C-8464, 6767-A1, 35.6 x 109.6, GSC No. 42397 (p. 14)

Fig. 11. *Osmundacidites wellmanii*. C-8478, 6782-A1, 38.9 x 110.2, GSC No. 42398 (p. 14)

Fig. 12. *Baculatisporites comaumensis*. C-8544, 6884-A1, 37.7 x 112.0, GSC No. 42399 (p. 14)

Fig. 13. *Acanthotriletes varispinosus*. C-8464, 6767-A1, 25.7 x 105.5, GSC No. 42400 (p. 14)

Fig. 14. *Pilosisporites trichopapillosus*. C-8538, P851-7A, 28.8 x 108.8, GSC No. 42401 (p. 14)

Fig. 15. *Pilosisporites verus*. C-8540, P851-9A, 12.1 x 111.0, GSC No. 42402 (p. 14)

Fig. 16. *Kuylisporites lunaris*. C-8454, 6759-A1, 24.5 x 112.9, GSC No. 42403 (p. 14)

Fig. 17. *Dictyotriletes granulatus*. C-8538, P851-7A, 24.2 x 110.3, GSC No. 42404 (p. 14)

Fig. 18. *Dictyotriletes granulatus*. C-8540, P851-9A, 30.0 x 117.5, GSC No. 42405 (p. 14)

Fig. 19. *Lycopodiacidites intraverrucatus*. C-8458, 6762-A1, 23.1 x 115.3, GSC No. 42406 (p. 14)

Fig. 20. *Lycopodiacidites intraverrucatus*. C-8476, 6780-A1, 22.7 x 109.3, GSC No. 42407 (p. 14)

Fig. 21. *Lycopodiumsporites austroclavatidites*. C-8533, P851-2A, 22.5 x 113.0, GSC No. 42408 (p. 15)

Fig. 22. *Lycopodiumsporites marginatus*. C-8460, 6764-A1, 14.7 x 101.6, GSC No. 42409 (p. 15)

Fig. 23. *Microreticulatisporites uniformis*. C-8461, 6765-A1, 30.4 x 105.0, GSC No. 42410 (p. 15)

Fig. 24. *Microreticulatisporites uniformis*. C-8460, 6764-A1, 38.2 x 115.9, GSC No. 42411 (p. 15)

Fig. 25. *Reticulisporites vermiformis*. C-8524, 6846-A1, 31.3 x 102.7, GSC No. 42412 (p. 15)

Fig. 26. *Reticulisporites vermiformis*. C-8536, P851-5B, 09.8 x 111.0, GSC No. 42413 (p. 15)

Fig. 27. *Klukisporites areolatus*. C-8445, 6750-A1, 15.0 x 116.0, GSC No. 42414 (p. 15)

Fig. 28. *Klukisporites pseudoreticulatus*. C-8524, 6846-A1, 35.0 x 101.4, GSC No. 42415 (p. 15)

Fig. 29. *Foveotriletes subtriangularis*. C-8538, P851-7A, 22.4 x 108.5, GSC No. 42416 (p. 15)

Fig. 30. *Tigrisporites scurrandus*. C-8534, P851-3B, 22.1 x 108.8, GSC No. 42417 (p. 15)

Fig. 31. *Tigrisporites scurrandus*. C-8533, P851-2A, 32.7 x 108.9, GSC No. 42418 (p. 15)

Fig. 32. *Tigrisporites scurrandus*. C-8533, P851-2B, 24.7 x 110.6, GSC No. 42419 (p. 15)

Figs. 33, 34. *Cicatricosisporites annulatus*. C-8468, 6772-A4, 31.0 x 120.3, GSC No. 42420. (p. 15)

Fig. 35. *Cicatricosisporites augustus*. C-8457, 6761-A1, 12.7 x 112.6, GSC No. 42421 (p. 15)

Fig. 36. *Cicatricosisporites augustus*. C-8459, 6763-A1, 22.8 x 115.5, GSC No. 42422 (p. 15)

Fig. 37. *Cicatricosisporites australiensis*. C-8436, P851-5A, 15.6 x 109.5, GSC No. 42423 (p. 15)

Fig. 38. *Cicatricosisporites hallei*. C-8462, 6766-A2, 15.1 x 109.3, GSC No. 42424 (p. 15)

Figs. 39, 40. *Cicatricosisporites* sp. cf. *Anemia exilioides*. C-8552, 6891-A1, 42.7 x 117.1, GSC No. 42425 (p. 15)

Fig. 41. *Cicatricosisporites* sp. cf. *Anemia exilioides*. C-8537, P851-6A, 33.2 x 108.9, GSC No. 42426 (p. 15)

Fig. 42. *Cicatricosisporites hughesii*. C-8532, P851-1A, 30.2 x 104.2, GSC No. 42427 (p. 15)

Fig. 43. *Cicatricosisporites ludbrooki*. C-8457, 6761-A1, 25.4 x 111.7, GSC No. 42428 (p. 15)

Fig. 44. *Cicatricosisporites potomacensis*. C-8458, 6762-3, 27.5 x 112.8, GSC No. 42429 (p. 15)

PLATE 1

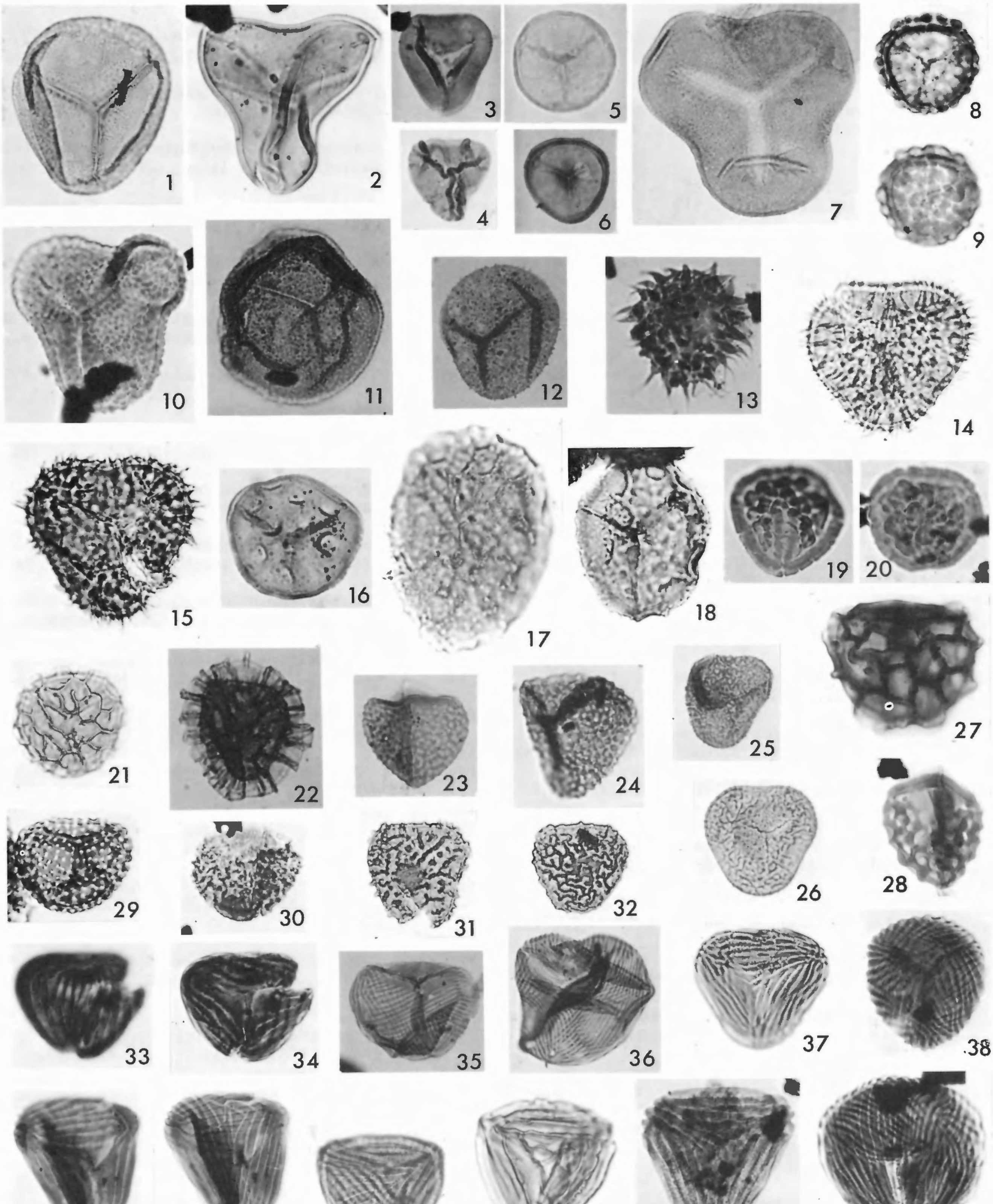
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PLATE 2

Fig. 1. *Cicatricosisporites pseudotripartitus.* C-8502, 6807-A1, 37.7 x 105.8, GSC No. 42430 (p. 15)

Fig. 2. *Cicatricosisporites pseudotripartitus.* C-8453, 6758-A2, 21.4 x 107.5, GSC No. 42431 (p. 15)

Fig. 3. *Cicatricosisporites* sp. cf. *C. subrotundus.* C-8534, P851-3A, 16.8 x 111.3, GSC No. 42432 (p. 15)

Fig. 4. *Cicatricosisporites venustus.* C-8460, 6764-A1, 39.2 x 118.7, GSC No. 42433 (p. 15)

Fig. 5. *Cicatricosisporties venustus.* C-8453, 6758-A2, 39.4 x 100.2, GSC No. 42434 (p. 15)

Figs. 6, 7. *Costatoperforosporites fistulosus.* C-8461, 6765-A1, 45.5 x 101.3, GSC No. 42435 (p. 15)

Fig. 8. *Costatoperforosporites* sp. cf. *Anemia perforata.* C-8458, 6762-A1, 27.3 x 114.3, GSC No. 42436 (p. 15)

Fig. 9. *Costatoperforosporites foveolatus.* C-8451, 6756-A1, 38.5 x 114.1, GSC No. 42437 (p. 15)

Fig. 10. *Appendicisporites bifurcatus.* C-8471, 6775-A1, 19.2 x 104.6, GSC No. 42438 (p. 15)

Fig. 11. *Appendicisporites bilateralis.* C-8542, P851-11A, 35.6 x 111.7, GSC No. 42439 (p. 15)

Fig. 12. *Appendicisporites potomacensis.* C-8458, 6762-A1, 25.2 x 107.7, GSC No. 42440 (p. 15)

Fig. 13. *Appendicisporites potomacensis.* C-8459, 6763-A1, 13.8 x 115.3, GSC No. 42441 (p. 15)

Fig. 14. *Appendicisporites cristatus.* C-8543, P851-12A, 25.8 x 107.8, GSC No. 42442 (p. 15)

Fig. 15. *Appendicisporites cristatus.* C-8542, P851-11A, 18.1 x 110.6, GSC No. 42443 (p. 15)

Fig. 16. *Appendicisporites erdtmanii.* C-8533, P851-2A, 13.3 x 110.1, GSC No. 42444 (p. 15)

Fig. 17. *Appendicisporites erdtmanii.* C-8541, P851-10A, 19.3 x 114.2, GSC No. 42445 (p. 15)

Fig. 18. *Appendicisporites* sp. cf. *Anemia trichacantha.* C-8463, 6767-A1, 18.9 x 99.7, GSC No. 42446 (p. 15)

Fig. 19. *Trilobosporites apibaculatus.* C-8460, 6764-A1, 35.7 x 111.0, GSC No. 42447 (p. 15)

Fig. 20. *Trilobosporites marylandensis.* C-8463, 6767-A1, 32.5 x 107.8, GSC No. 42448 (p. 15)

Fig. 21. *Trilobosporites perverulentus.* C-8538, P851-7A, 28.8 x 108.8, GSC No. 42449 (p. 15)

Fig. 22. *Trilobosporites perverulentus.* C-8459, 6763-A1, 16.0 x 108.5, GSC No. 42450 (p. 15)

Fig. 23. *Trilobosporites trioreticulosus.* C-8457, 6761-A1, 10.2 x 105.0, GSC No. 42451 (p. 15)

Fig. 24. *Sestrosporites pseudoalveolatus.* C-8509, 6831-A1, 25.7 x 113.0, GSC No. 42452 (p. 15)

Fig. 25. *Camarozonosporites ambigens.* C-8484, 6788-3, 20.8 x 108.3, GSC No. 42453 (p. 15)

Fig. 26. *Coronatispora valdensis.* C-8472, 6776-A1, 11.2 x 115.8, GSC No. 42454 (p. 15)

Fig. 27. *Coronatispora valdensis.* C-8540, P851-9A, 26.1 x 110.1, GSC No. 42455 (p. 15)

Fig. 28. *Gleicheniidites senonicus.* C-8547, 6887-A1, 28.8 x 112.3, GSC No. 42456 (p. 15)

Fig. 29. *Ornamentifera baculata.* C-8506, 6828-A1, 17.3 x 111.7, GSC No. 42457 (p. 15)

Fig. 30. *Foraminisporis asymmetricus.* C-8533, P851-2A, 26.4 x 107.3, GSC No. 42458 (p. 15)

Fig. 31. *Foraminisporis asymmetricus.* C-8459, 6763-A2, 20.4 x 108.3, GSC No. 42459 (p. 15)

Fig. 32. *Foraminisporis wonthaggiensis.* C-8521, 6843-A1, 24.6 x 108.1, GSC No. 42460 (p. 15)

Fig. 33. *Foraminisporis wonthaggiensis.* C-8460, 6764-A1, 14.1 x 108.4, GSC No. 42461 (p. 15)

Fig. 34. *Cingutriletes clavus.* C-8534, P851-3B, 26.6 x 106.1, GSC No. 42462 (p. 16)

Fig. 35. *Rogalskaisporites cicatricosus.* C-8479, 6783-A1, 23.3 x 116.9, GSC No. 42463 (p. 16)

Fig. 36. *Cirratriradites teter.* C-8516, 6838-A1, 27.0 x 119.1, GSC No. 42464 (p. 16)

Figs. 37, 38. *Contignisporites glebulentus.* C-8478, 6782-A1, 33.9 x 115.0, GSC No. 42465 (p. 15)

Fig. 39. *Contignisporites glebulentus.* C-8466, 6770-A1, 34.4 x 113.8, GSC No. 42466 (p. 15)

Fig. 40. *Distaltriangulisporites perplexus.* C-8533, P851-2A, 17.7 x 104.8, GSC No. 42467 (p. 16)

Figs. 41, 42. *Contignisporites cooksoni.* C-8450, 6755-A1, 23.1 x 104.2, GSC No. 42468 (p. 15)

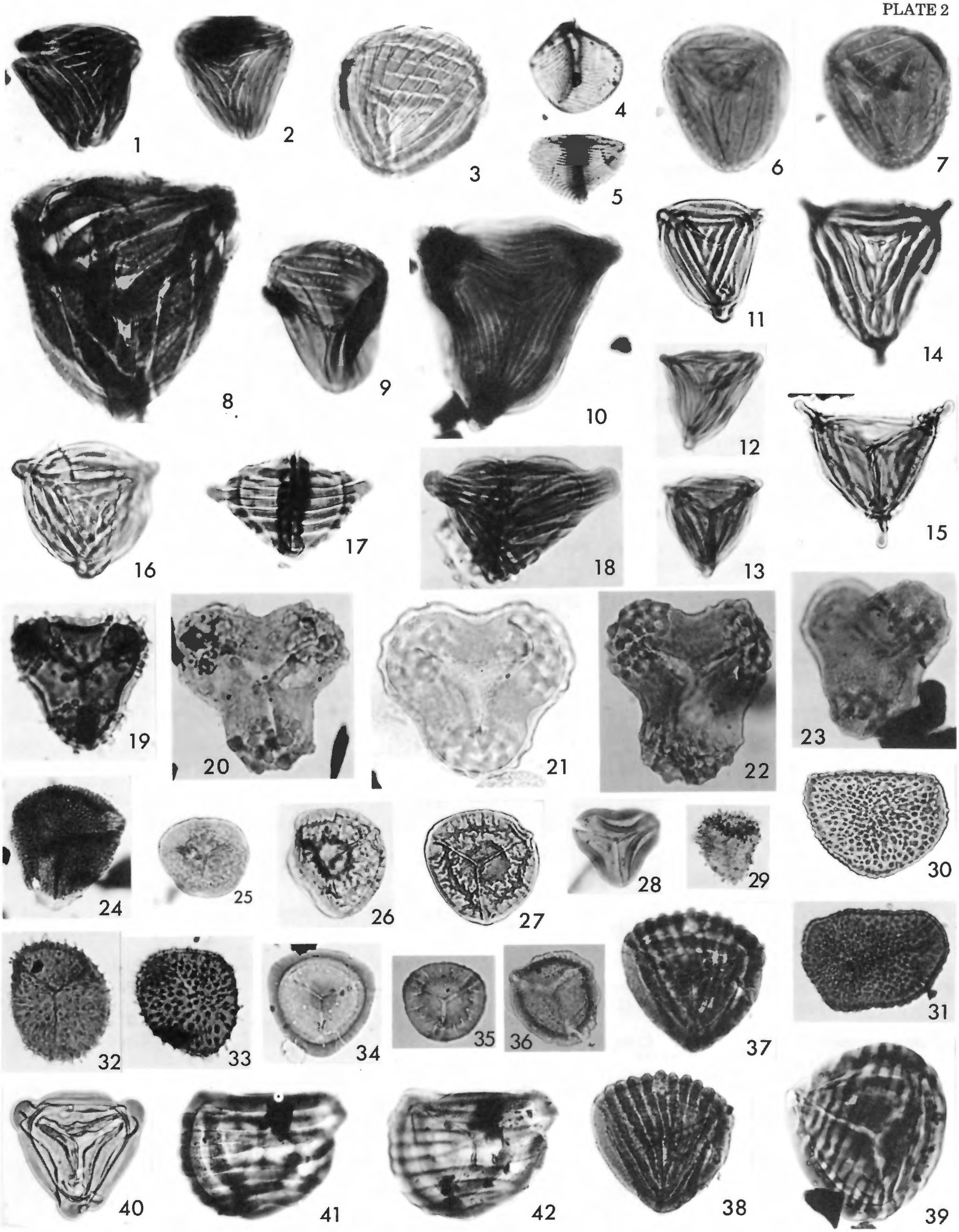
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PLATE 3

Figs. 1, 2, 3. *Krauselisporites hastilobatus*. C-8458, 6762-6, 23.7 x 110.4, GSC No. 42469 (p. 16)

Fig. 4. *Densoisporites microrugulatus*. C-8454, 6759-A1, 13.3 x 105.2, GSC No. 42470 (p. 16)

Fig. 5. *Crybelosporites vectensis*. C-8541, P851-10A, 32.2 x 108.7, GSC No. 42471 (p. 16)

Fig. 6. *Crybelosporites vectensis*. C-8472, 6776-A1, 33.2 x 113.8, GSC No. 42472 (p. 16)

Fig. 7. *Crybelosporites vectensis*. C-8472, 6776-A1, 30.7 x 115.7, GSC No. 42473 (p. 16)

Fig. 8. *Laevigatosporites ovatus*. C-8545, 6885-A1, 39.7 x 106.8, GSC No. 42474 (p. 16)

Fig. 9. *Verrucatosporites chalonerii*. C-8545, 6885-A1, 24.6 x 111.0, GSC No. 42475 (p. 16)

Fig. 10. *Triporoletes radiatus*. C-8543, P851-12A, 25.8 x 107.8, GSC No. 42476 (p. 16)

Fig. 11. *Triporoletes radiatus*. C-8535, P851-4A, 35.4 x 110.0, GSC No. 42477 (p. 16)

Fig. 12. *Triporoletes radiatus*. C-8541, P851-10A, 13.8 x 117.8, GSC No. 42478 (p. 16)

Fig. 13. *Triporoletes reticulatus*. C-8451, 6756-A1, 11.5 x 100.7, GSC No. 42479 (p. 16)

Fig. 14. *Triporoletes reticulatus*. C-8536, P851-5A, 30.5 x 113.8, GSC No. 42480 (p. 16)

Fig. 15. *Triporoletes simplex*. C-8535, P851-4A, 33.9 x 108.2, GSC No. 42481 (p. 16)

Fig. 16. *Triporoletes singularis*. C-8540, P851-9A, 38.6 x 115.1, GSC No. 42482 (p. 16)

Fig. 17. *Triporoletes singularis*. C-8533, P851-2A, 34.0 x 106.1, GSC No. 42483 (p. 16)

Fig. 18. *Triporoletes singularis*. C-8534, P851-3A, 34.6 x 107.8, GSC No. 42484 (p. 16)

Fig. 19. *Aequitriradites spinulosus*. C-8541, P851-10A, 32.6 x 105.1, GSC No. 42485 (p. 16)

Fig. 20. *Cooksonites variabilis*. C-8454, 6759-A1, 28.9 x 111.3, GSC No. 42486 (p. 16)

Fig. 21. *Cooksonites variabilis*. C-8464, 6768-A1, 45.8 x 99.6, GSC No. 42487 (p. 16)

Fig. 22. *Coptospora* sp. cf. *C. williamsii*. C-8532, P851-1A, 38.5 x 106.1, GSC No. 42488 (p. 16, 17)

Fig. 23. *Coptospora* sp. cf. *C. williamsii*. C-8452, 6757-A2, 17.1 x 106.4, GSC No. 42489 (p. 16, 17)

Fig. 24. *Coptospora* sp., C-8450, 6755-A1, 29.2 x 115.7, GSC No. 42490 (p. 16, 17)

Fig. 25. *Coptospora* sp., C-8451, 6756-A1, 30.5 x 109.7, GSC No. 42491 (p. 16, 17)

Fig. 26. *Januasporites spiniferus*. C-8539, P851-8B, 12.7 x 107.1, GSC No. 42492 (p. 16)

Fig. 27. *Januasporites spiniferus*. C-8541, P851-10A, 25.4 x 103.1, GSC No. 42493 (p. 16)

Fig. 28. *Callialasporites dampierii*. C-8446, 6751-1, 23.2 x 100.6, GSC No. 42494 (p. 16)

Fig. 29. *Alisporites grandis*. C-8471, 6775-A1, 25.6 x 102.0, GSC No. 42495 (p. 16)

Fig. 30. *Vitreisporites pallidus*. C-8545, 6885-A1, 14.6 x 113.0, GSC No. 42496 (p. 16)

Fig. 31. *Alisporites minutus*. C-8524, 6846-A1, 36.8 x 107.3, GSC No. 42497 (p. 16)

Fig. 32. *Alisporites bilateralis*. C-8534, P851-3A, 19.6 x 116.6, GSC No. 42498 (p. 16)

Fig. 33. *Cedripites cretaceus*. C-8555, 6894-A1, 38.7 x 112.8, GSC No. 42499 (p. 16)

Fig. 34. *Cedripites cretaceus*. C-8551, 6890-A1, 32.3 x 102.4, GSC No. 42500 (p. 16)

Fig. 35. *Cerebropollenites mesozoicus*. C-8445, 6750-A1, 29.3 x 106.0, GSC No. 42501 (p. 16)

Fig. 36. *Cerebropollenites mesozoicus*. C-8469, 6773-A2, 43.4 x 115.5, GSC No. 42502 (p. 16)

Fig. 37. *Cedripites canadensis*. C-8461, 6765-A1, 28.0 x 115.5, GSC No. 42503 (p. 16)

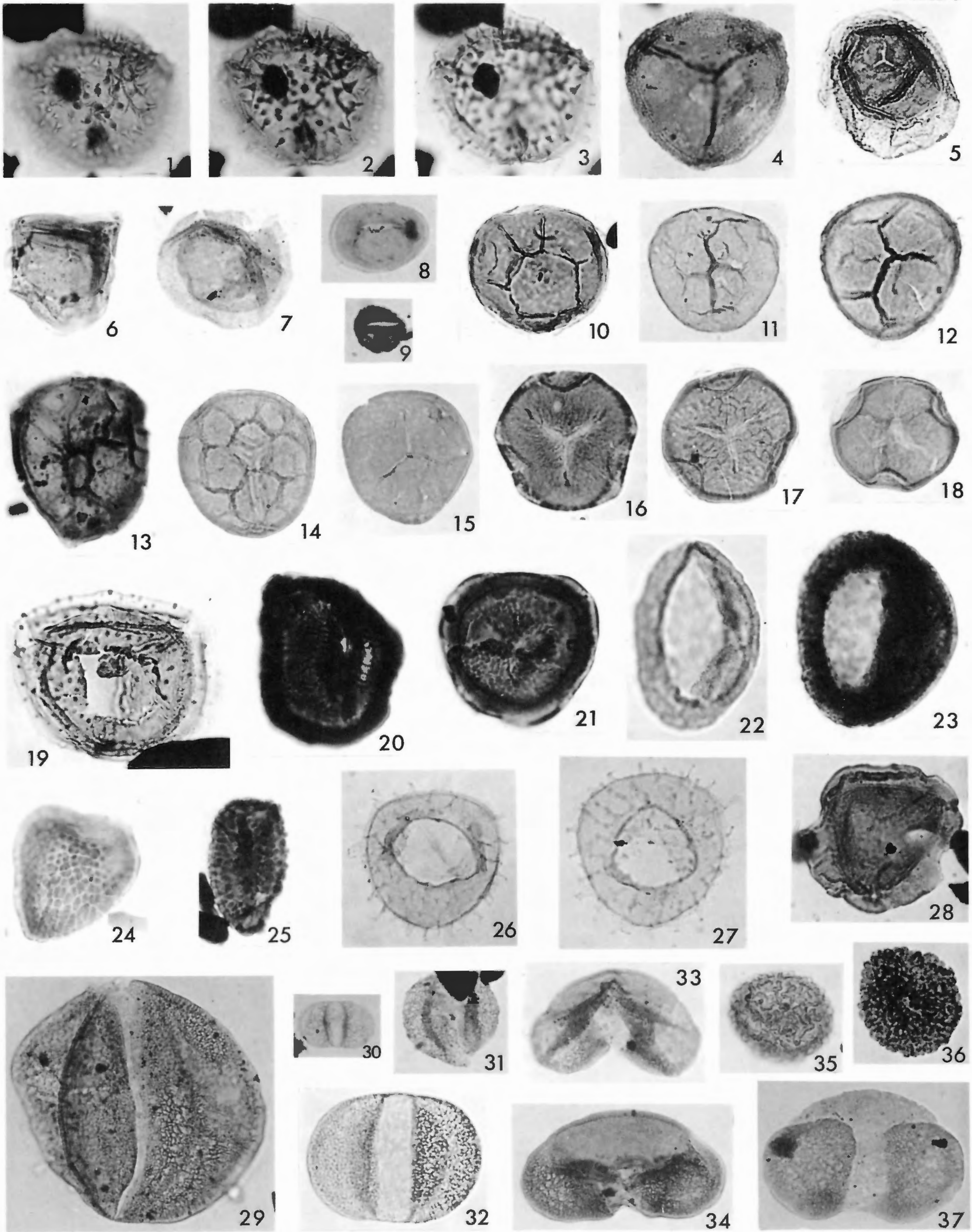
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PLATE 4

Fig. 1. cf. *Podocarpus tricocca*. C-8460, 6764-A1, 41.0 x 105.3, GSC No. 42504 (p. 16)

Fig. 2. *Podocarpidites canadensis*. C-8445, 6750-A1, 38.3 x 114.0, GSC No. 42505 (p. 16)

Fig. 3. *Podocarpidites multesimus*. C-8554, 6893-A1, 22.5 x 103.3, GSC No. 42506 (p. 16)

Fig. 4. *Podocarpidites multesimus*. C-8503, 6825-A1, 26.7 x 114.0, GSC No. 42507 (p. 16)

Fig. 5. *Podocarpidites biformis*. C-8533, P851-2A, 23.2 x 115.0, GSC No. 42508 (p. 16)

Fig. 6. *Podocarpidites biformis*. C-8536, P851-5A, 31.3 x 118.5, GSC No. 42509 (p. 16)

Fig. 7. *Laricoidites magnus*. C-8545, 6885-A1, 25.5 x 108.2, GSC No. 42510 (p. 17)

Fig. 8. *Inaperturopollenites limbatus*. C-8454, 6759-A1, 19.1 x 107.0, GSC No. 42511 (p. 17)

Fig. 9. *Parvisaccites radiatus*. C-8470, 6774-A2, 34.0 x 108.4, GSC No. 42512 (p. 16)

Fig. 10. *Parvisaccites rugulatus*. C-8460, 6764-A1, 34.9 x 112.0, GSC No. 42513 (p. 16)

Fig. 11. *Parvisaccites hortonensis* sp. nov., holotype. C-8440, 6745-A1, 26.7 x 114.6, GSC No. 34159 (p. 16, 17)

Fig. 12. *Parvisaccites hortonensis*. C-8446, 6751-A1, 29.3 x 101.4, GSC No. 42514 (p. 16, 17)

Fig. 13. *Parvisaccites hortonensis*. C-8440, 6745-A1, 17.2 x 102.3, GSC No. 42515 (p. 16, 17)

Fig. 14. *Parvisaccites hortonensis*. C-8443, 6748-A2, 28.7 x 100.8, GSC No. 42516 (p. 16, 17)

Fig. 15. *Araucariacites australis*. C-8533, P851-2A, 20.5 x 106.6, GSC No. 42517 (p. 17)

Fig. 16. *Equisetosporites multicostatus*. C-8458, 6762-A1, 38.9 x 110.5, GSC No. 42518 (p. 17)

Fig. 17. *Eucommiidites minor*. C-8554, 6893-A1, 41.2 x 106.4, GSC No. 42519 (p. 17)

Fig. 18. *Eucommiidites minor*. C-8539, P851-8C, 35.2 x 118.5, GSC No. 42520 (p. 17)

Fig. 19. *Taxodiaceaepollenites hiatus*. C-8456, 6760-A1, 21.1 x 104.0, GSC No. 42521 (p. 17)

Figs. 20, 21. *Reticulatasporites dupliexinous*. C-8464, 6768-A1, 43.7 x 11.1, GSC No. 42522 (p. 17)

Fig. 22. *Perinopollenites elatiodes*. C-8548-9, 6888-A1, 31.8 x 110.6, GSC No. 42523 (p. 17)

Fig. 23. *Perinopollenites elatoides*. C-8465, 6769-A1, 42.7 x 110.7, GSC No. 42524 (p. 17)

Fig. 24. *Cycadopites nitidus*. C-8474, 6778-A1, 48.0 x 103.3, GSC No. 42525 (p. 17)

Fig. 25. *Classopollis classoides*. C-8458, 6762-A1, 24.2 x 102.5, GSC No. 42526 (p. 17)

Fig. 26. *Classopollis classoides*. C-8520, 6842-A1, 28.1 x 108.9, GSC No. 42527 (p. 17)

Fig. 27. *Circulina parva*. C-8458, 6762-A1, 27.8 x 109.4, GSC No. 42528 (p. 17)

Fig. 28. *Circulina parva*. C-8462, 6766-A2, 19.6 x 104.9, GSC No. 42529 (p. 17)

Fig. 29. *Exesipollenites tumulus*. C-8546, 6886-A1, 27.4 x 117.8, GSC No. 42530 (p. 17)

Fig. 30. *Clavatipollenites hughesii*. C-8464, 6768-A1, 40.9 x 110.0, GSC No. 42531 (p. 17)

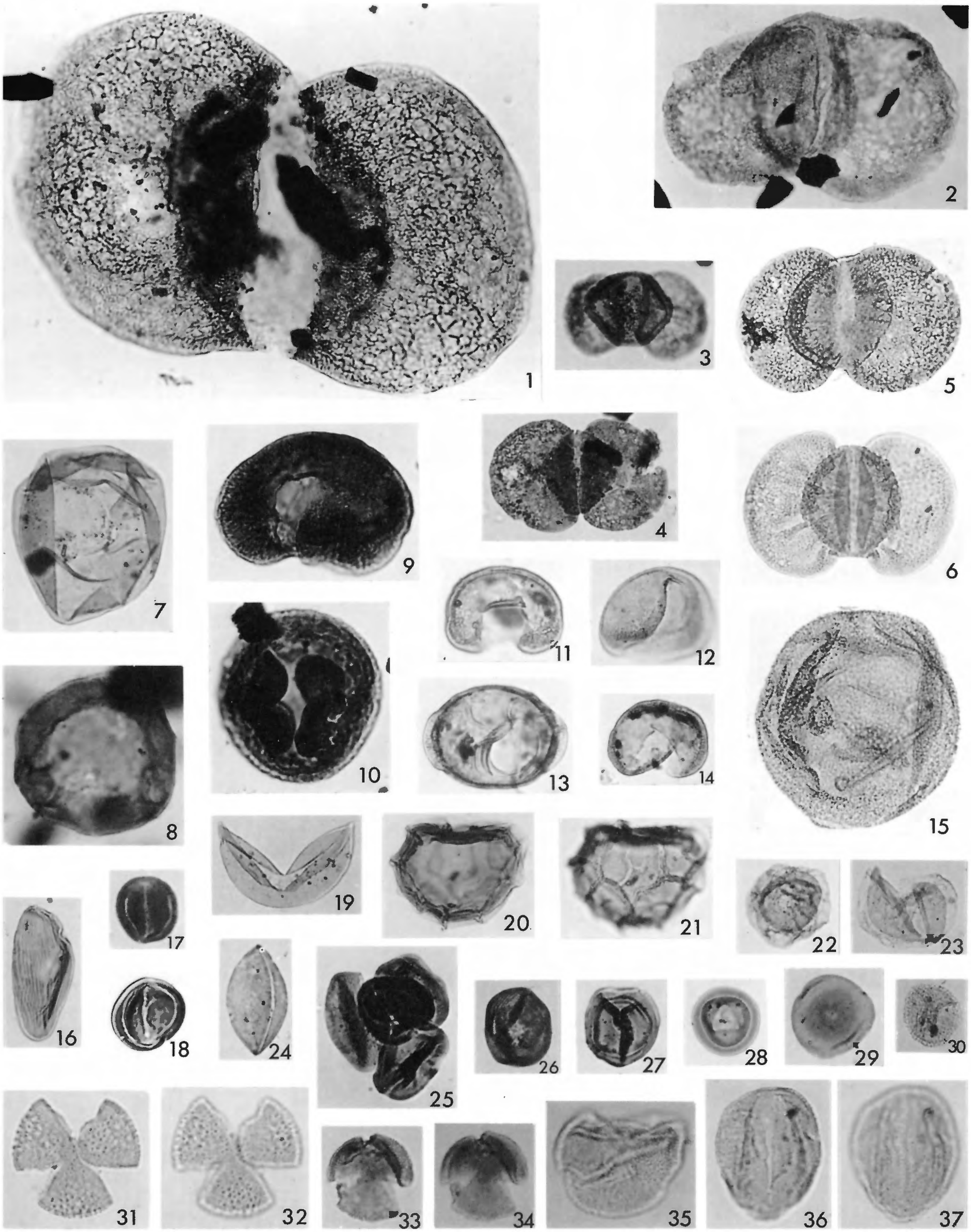
Figs. 31, 32. *Retitricolpites georgensis*. C-8538, P851-7C, 31.7 x 111.8, GSC No. 42532. x1000 (p. 17)

Figs. 33, 34. *Retitricolpites prosimilis*. C-8511, 6833-A1, 32.3 x 106.2, GSC No. 42533. x1000 (p. 17)

Fig. 35. *Fraxinoipollenites venustus*. C-8535, P851-4B, 36.0 x 115.0, GSC No. 42534. x1000 (p. 17)

Figs. 36, 37. *Fraxinoipollenites venustus*. C-8535, P851-4B, 16.8 x 104.2, GSC No. 42535. x1000 (p. 17)

PLATE 4



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PLATES 5 - 14

In the figure explanations, the species name is followed by the GSC (I.S.P.G.) Location Number, the slide number, the stage co-ordinates for Reichert Zetopan microscope No. 56 395 at the Institute of Sedimentary and Petroleum Geology, Calgary, Alberta, an explanation of the orientation and focus level, if needed, the GSC Type Number, the magnifications and the page reference for species described in the systematics section. IC refers to Interference Contrast, and PC refers to Phase Contrast. All other figures are taken in Brightfield.

PLATE 5

Figs. 1, 2. *Apteodinium maculatum*. C-8533, Slide P851-2A, 37.3 x 120.8, IC, GSC No. 41475. (1) x325, (2) x1250 (p. 18, 20)

Fig. 3. *Gonyaulacysta helicoidea*. C-8533, Slide P851-2A, 23.6 x 121.6, GSC No. 41476. x500 (p. 18, 20)

Figs. 4, 5. *Gonyaulacysta hyalodermopsis*. (p. 19, 20)

4. C-8534, Slide P851-3A, 32.7 x 120.8, dorsal view at hi-focus, IC, GSC No. 41477. x500

5. C-8533, Slide P851-2A, 12.1 x 116.3, ventral view at hi-focus, IC, GSC No. 41478. x500

Fig. 6. *Leptodinium delicatum*. C-8534, Slide P851-3A, 34.1 x 116.7, GSC No. 41479. x500 (p. 19, 22)

Figs. 7-9. *Leptodinium cancellatum* sp. nov. (p. 19, 21)

7. C-8535, Slide P851-4A, 28.4 x 129.3, antapical view at lo-focus, GSC No. 41480. x500

8. Holotype, C-8534, Slide P851-3A, 20.5 x 129.5, right lateral view at hi-focus, GSC No. 34146. x500

9. C-8535, Slide P851-4A, 41.8 x 126.9, surface detail, GSC No. 41481. x1250

Figs. 10-15. *Leptodinium modicum* sp. nov. (p. 19, 22)

10-13. Holotype, C-8533, Slide P851-2A, 32.6 x 117.0, (10, 11) dorsal view at hi- and mid-focus respectively, (12, 13) ventral view at lo-focus, IC, GSC No. 34147. x900

14, 15. C-8534, Slide P851-3A, 25.9 x 118.8, (14) antapical view at hi-focus, (15) apical view at lo-focus, GSC No. 41482. x900

PLATE 5

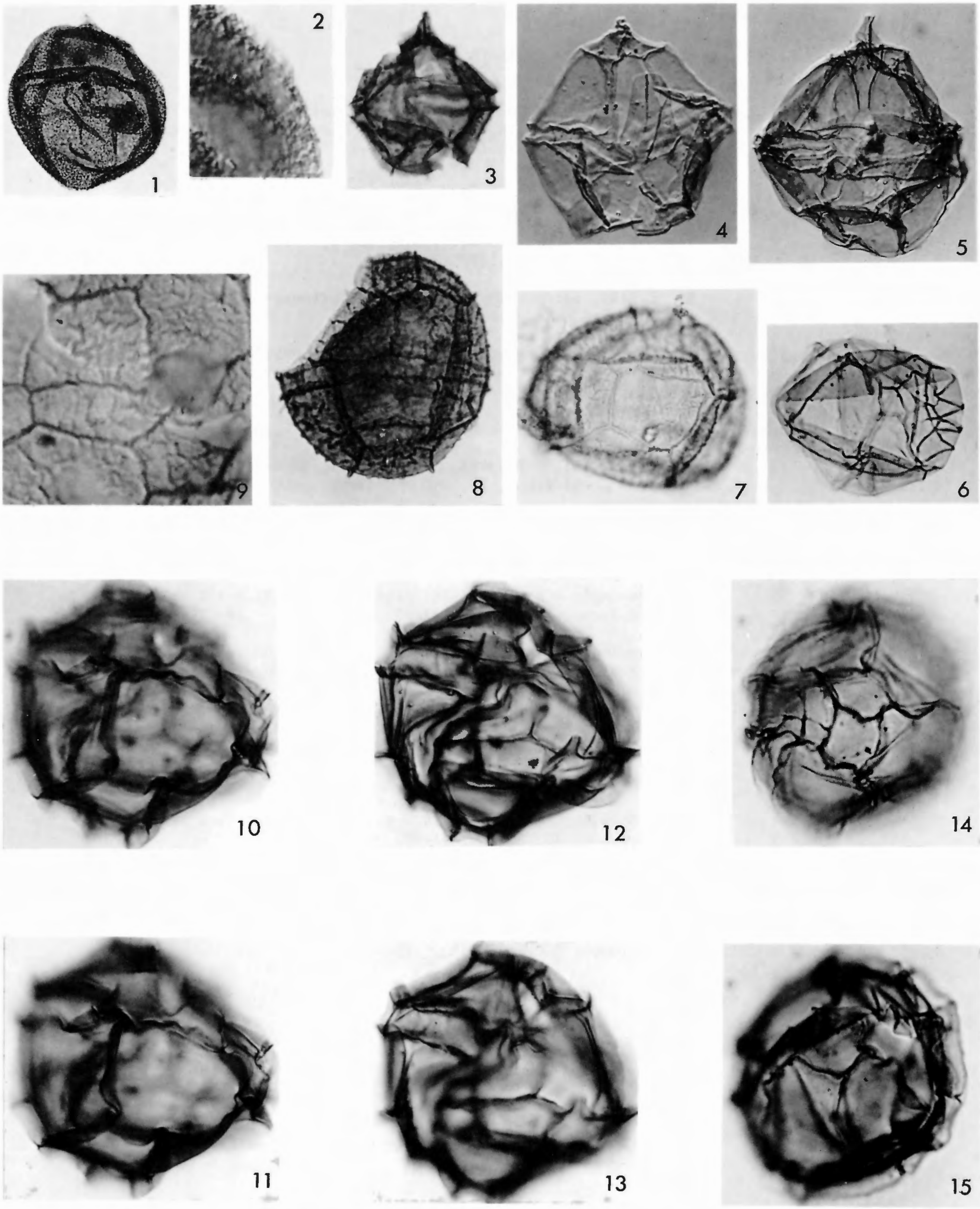

PLATE 6

Figs. 1, 2. *Microdinium opacum*. The holotype refigured, Slide BW 134/1, 54.6 x 116.4, (1) ventral view at hi-focus, (2) dorsal view at lo-focus. x1250 (p. 19, 23)

Figs. 3-5. *Microdinium spinosum* sp. nov. (p. 19, 23)

3, 4. Holotype, C-8480, Slide 6884-2, 13.9 x 110.4, (3) dorsal view at lo-focus, (4) ventral view at hi-focus, IC, GSC No. 34148. x1250

5. C-8481, Slide 6885-2, 08.9 x 126.7, ventral view at hi-focus, GSC No. 41483. x1250

Fig. 6. *Microdinium? crinitum*. C-8535, Slide P851-4A, 35.7 x 126.2, oblique apical view at hi-focus, IC, GSC No. 41484. x900 (p. 19, 23)

Figs. 7, 10, 11. *Batioladinium jaegeri* (p. 19, 24)

7. C-8539, Slide P851-8A, 15.9 x 124.1, oblique ventral view at hi-focus, IC, GSC No. 41485. x500

10-11. C-8538, Slide P851-7B, 38.3 x 126.4, left lateral view (10) at hi-focus and (11) lo-focus, GSC No. 41486. x500

Fig. 8. *Canningia minor*. C-8538, Slide P851-7A, 41.8 x 133.1, mid-focus, IC, GSC No. 41487. x500 (p. 19, 24)

Fig. 9. *Canningia ringnesii*. C-8540, Slide P851-9A, 24.3 x 128.8, mid-focus, IC, GSC No. 41488. x500 (p. 19, 24)

Figs. 12, 13. *Tenua hystrix*. C-8460, Slide 6764-1, 41.4 x 124.4, (12) dorsal view at hi-focus, (13) ventral view at lo-focus, GSC No. 41489. x500 (p. 19, 24)

Figs. 14-16. *Tenua* sp. A (p. 19, 25)

14. C-8539, Slide P851-8A, 14.0 x 130.8, ventral view at lo-focus, IC, GSC No. 41490. x500

15. C-8474, Slide 6778-A3, 13.4 x 122.2, ventral view at lo-focus, IC, GSC No. 41491. x500

16. C-8506, Slide 6828-A4, 27.7 x 117.4, ventral view at lo-focus, GSC No. 41492. x500

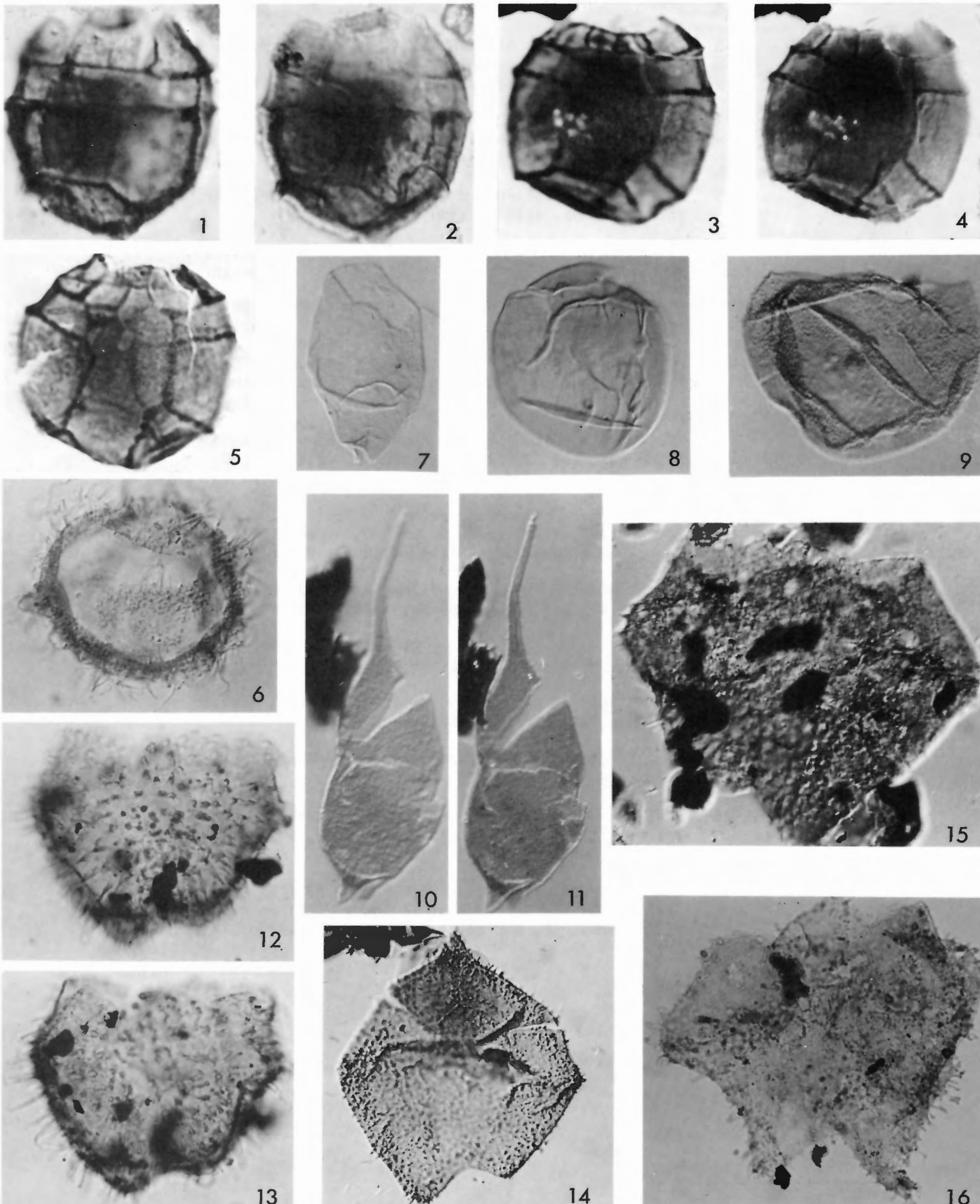
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PLATE 7

Figs.	1-5.	*Dictyopyxidia imperfecta* sp. nov.	(p. 19, 25)
	1-3.	Holotype, C-8536, Slide P851-5A, 38.1 x 130.0, (1) dorsal view at lo-focus and (2) ventral view at hi-focus, (3) mid-focus on operculum, GSC No. 34149. (1, 2) x900, (3) x500	
	4.	C-8537, Slide P851-6A, 18.6 x 131.8, ventral view at hi-focus, GSC No. 41493. x500	
	5.	C-8537, Slide P851-6A, 27.9 x 129.0, dorsal view at hi-focus, GSC No. 41494. x500	
Fig.	6.	*Fromea amphora*. C-8540, Slide P851-9A, 24.3 x 124.7, IC, GSC No. 41495. x500	(p. 19, 26)
Fig.	7.	*Cleistosphaeridium*? *aciculare*. C-8552, Slide 6891-2, 41.3 x 123.9, IC, GSC No. 41496. x500	(p. 19, 26)
Fig.	8.	*Cleistosphaeridium polypes* (subsp.) *clavulum*. C-8534, Slide P851-3A, 09.7 x 122.5, GSC No. 41497. x500	(p. 19, 27)
Fig.	9.	*Cleistosphaeridium polypes* (subsp.) *polypes*. C-8539, Slide P851-8A, 33.0 x 126.1, GSC No. 41498. x500	(p. 19, 27)
Figs.	10, 11.	*Cleistosphaeridium ancoriferum*. C-8532, Slide P851-1A, 33.9 x 129.4, (10) lo-focus on archeopyle, (11) hi-focus on antapex, IC, GSC No. 41499. x900	(p. 19, 27)
Fig.	12.	*Cleistosphaeridium multispinosum*. C-8542, Slide P851-11A, 33.4 x 118.9, IC, GSC No. 41500. x500	(p. 19, 27)
Figs.	13, 14.	*Cleistosphaeridium* sp. AE	(p. 19, 27)
	13.	C-8533, Slide P851-2A, 17.4 x 122.8, ventral view at lo-focus, IC, GSC No. 41501. x900	
	14.	C-8535, Slide P851-4A, 44.2 x 117.5, dorsal view at hi-focus, IC, GSC No. 41502. x900	
Figs.	15, 16.	*Hystrichokolpoma ferox*. C-8539, Slide P851-8A, 22.6 x 131.4, (15) hi-focus and (16) mid-focus, IC, GSC No. 41503. x500	(p. 19, 28)
Figs.	17, 18.	*Conosphaeridium* sp. A. C-8538, Slide P851-7A, 36.1 x 118.4, (17) ventral view at lo-focus, (18) dorsal view at hi-focus, IC, GSC No. 41504. x500	(p. 19, 28)

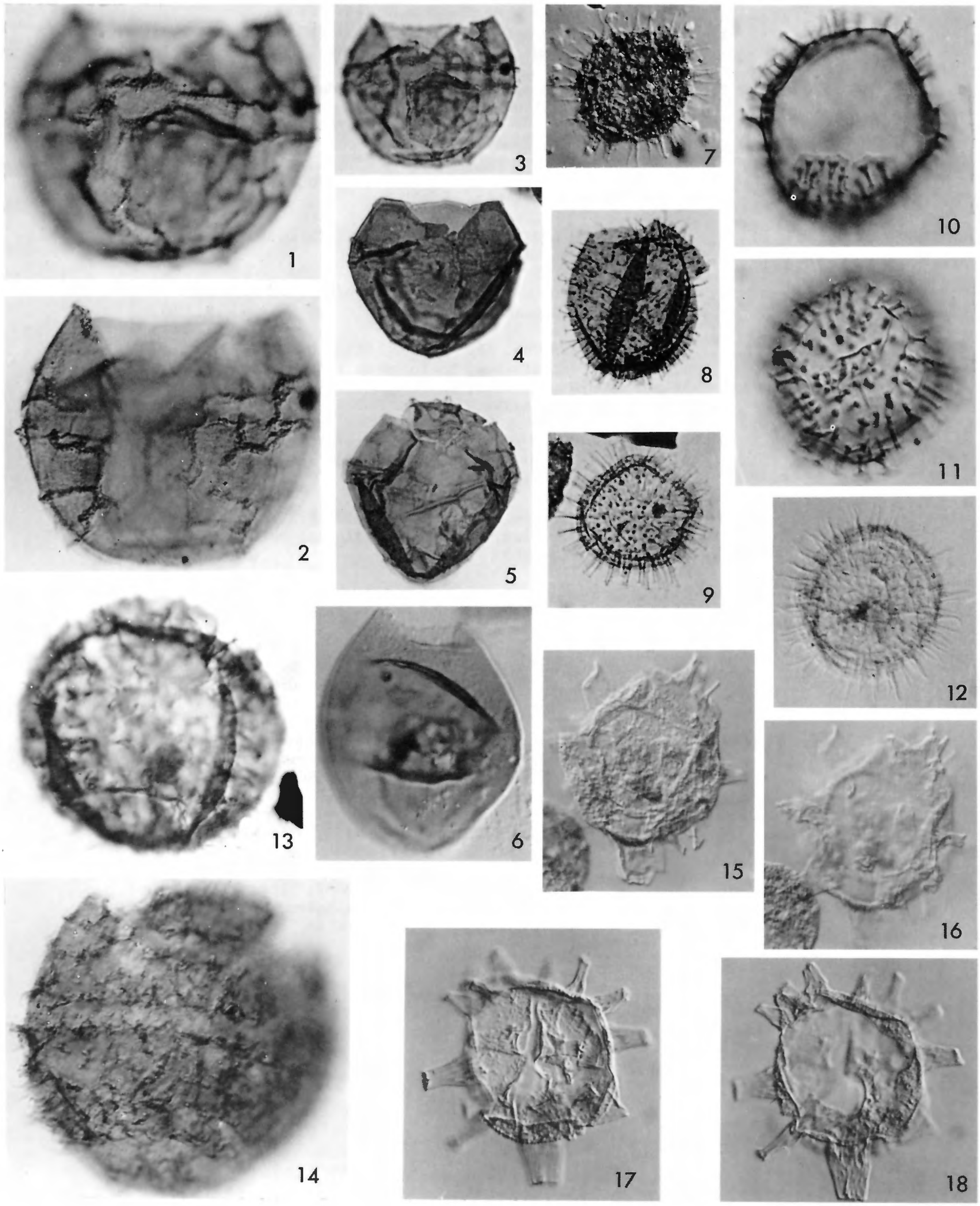
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PLATE 8

Fig. 1. *Oligosphaeridium asterigium*. C-8532, Slide P851-1A, 32.2 x 118.8, mid-focus, GSC No. 41505. x500 (p. 19, 28)

Fig. 2. *Oligosphaeridium complex*. C-8540, Slide P851-9A, 17.9 x 123.6, GSC No. 41506. x325 (p. 19, 28)

Figs. 3, 6. *Oligosphaeridium irregulare* (p. 19, 28)

3. C-8467, Slide 6771-1, 23.5 x 124.8, hi-focus on archeopyle, IC, GSC No. 41507. x500

6. C-8467, Slide 6771-1, 33.4 x 128.5, hi-focus on operculum, IC, GSC No. 41508. x500

Fig. 4. *Oligosphaeridium pulcherrimum*. C-8467, Slide 6771-1, 30.7 x 122.4, GSC No. 41509. x500 (p. 19, 29)

Figs. 5, 8. *Oligosphaeridium* sp. AB. C-8532, Slide P851-1A, 39.6 x 125.9, (5) ventral view, lo-focus on reflected processes 1" and 6" and operculum, (8) hi-focus on part of dorsal surface, GSC No. 41510. x500 (p. 19, 29)

Fig. 7. *Oligosphaeridium*? sp. A of Brideaux, 1971b. C-8452, Slide 6757-2, 17.2 x 126.0, hi-focus on archeopyle, IC, GSC No. 41511. x1250 (p. 19, 29)

Fig. 9. *Oligosphaeridium* sp. AB. C-8538, Slide P851-7A, 36.2 x 131.7, the operculum, lo-focus on external surface, IC, GSC No. 41512. x500 (p. 19, 29)

Fig. 10. *Oligosphaeridium totum* (subsp.) *totum*. C-8474, Slide 6778-3, 36.1 x 121.5, IC, GSC No. 41513. x500 (p. 19, 29)

Fig. 11. *Oligosphaeridium*? sp. B of Brideaux, 1971b. C-8556, Slide 6895-2, 25.7 x 121.3, hi-focus, IC, GSC No. 41514. x500 (p. 19, 29)

Figs. 12, 13. *Oligosphaeridium anthophorum*. C-8466, Slide 6770-3, 15.5 x 127.3, the operculum, (12) lo-focus on external surface, (13) hi-focus on external surface, IC, GSC No. 41515. x500 (p. 19, 28)

Fig. 14. *Polysphaeridium laminaspinosum*. C-8538, Slide P851-7A, 34.4 x 122.3, IC, GSC No. 41516. x500 (p. 19, 30)

Figs. 15, 16. *Pterodinium* sp. cf. *P. aliferum*. C-8537, Slide P851-6A, 15.3 x 119.5, (15) ventral view at hi-focus, x900, (16) dorsal view at lo-focus, x500, IC, GSC No. 41517 (p. 19, 30)

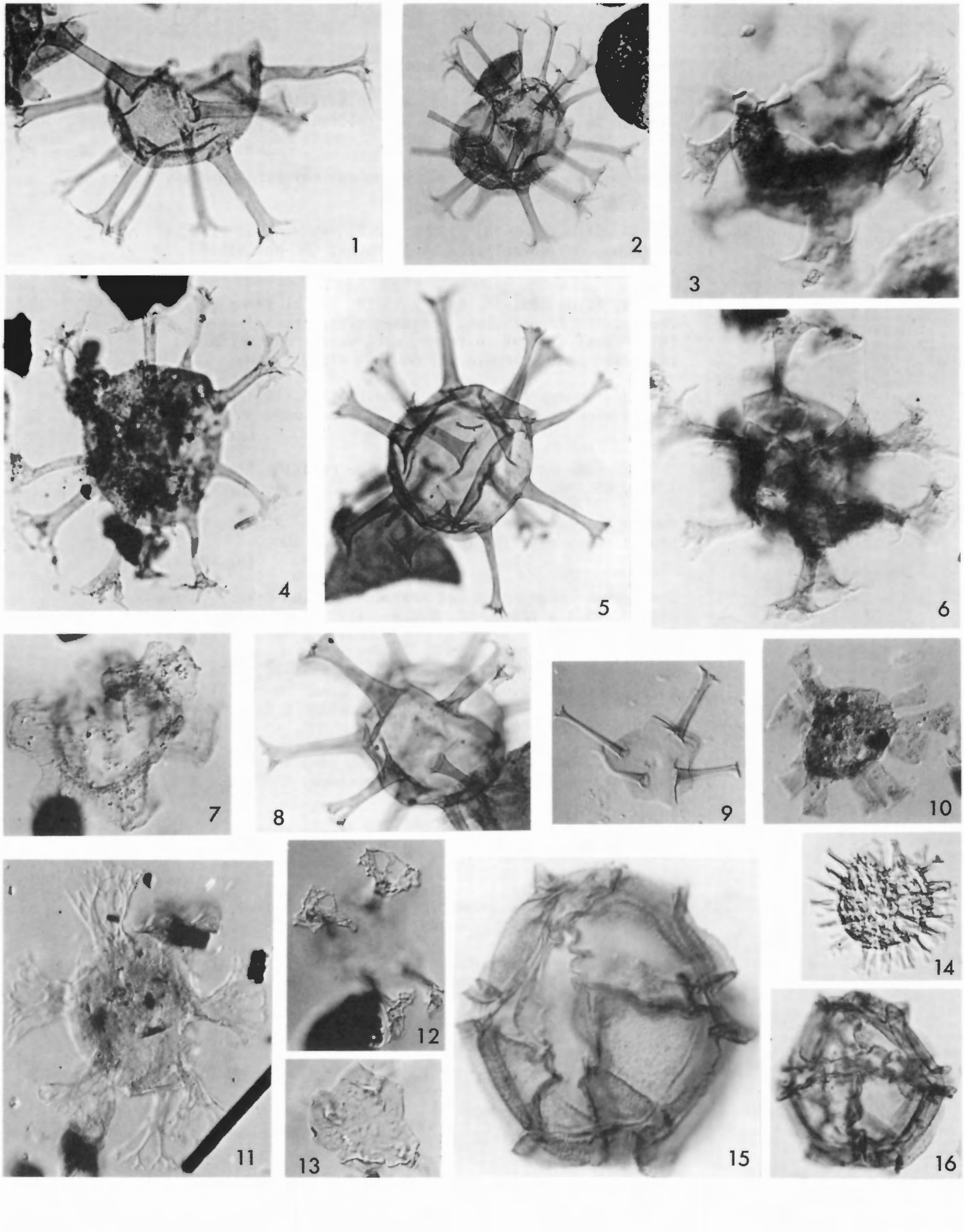
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PLATE 9

Figs. 1-8. *Pterodinium verrucosum* sp. nov. (p. 19, 30)

1-3. Holotype, C-8535, Slide P851-4A, 39.8 x 118.8, (1) dorsal view at lo-focus, (2) mid-focus, (3) ventral view at hi-focus, IC, GSC No. 34150. x900

4. Holotype, as above, hi-focus on sulcal reflected plates, IC, GSC No. 34150. x1250

5, 6. C-8533, Slide P851-2A, 27.8 x 120.7, (5) ventral view at hi-focus, (6) dorsal view at lo-focus, GSC No. 41518. x500

7, 8. C-8534, Slide P851-3A, 38.3 x 131.9, (7) hi-focus on archeopyle in dorsal view, specimen tilted towards apex, (8) ventral view at lo-focus, with sulcal and antapical reflected plates prominent, GSC No. 41519. x500

Fig. 9. *Pterodinium* sp. A. C-8534, Slide P851-3A, 14.4 x 122.1, dorsal view at lo-focus, GSC No. 41520. x500 (p. 19, 31)

Fig. 10. *Spiniferites ramosus*. C-8541, Slide P851-10A, 28.3 x 134.4, GSC No. 41521. x500 (p. 19, 31)

Fig. 11. *Tanyosphaeridium* sp. A of Brideaux, 1971b. C-8554, Slide 6893-2, 33.5 x 127.3, IC, GSC No. 41522. x500 (p. 19, 31)

Fig. 12. *Tanyosphaeridium* sp. B of Brideaux, 1971b. C-8555, Slide 6894-2, 25.4 x 122.2, IC, GSC No. 41523. x500 (p. 19, 31)

Fig. 13. *Tanyosphaeridium* sp. C. C-8535, Slide P851-4A, 35.6 x 117.2, IC, GSC No. 41524. x900 (p. 19, 32)

Figs. 14-16. *Imbatodinium* sp. A (p. 19, 32)

14, 15. C-8540, Slide P851-9A, 27.9 x 118.3, (14) lateral view at hi-focus, x500, (15) detail of processes, x900, IC, GSC No. 41525

16. C-8553, Slide 6892-2, 41.8 x 122.6, lateral view, focus on intercalary archeopyle, IC, GSC No. 41526. x500

Fig. 17. *Cyclonephelium compactum*. C-8537, Slide P851-6A, 20.0 x 129.0, GSC No. 41527. x325 (p. 19, 32)

Fig. 18. *Cyclonephelium distinctum*. C-8556, Slide 6895-2, 29.2 x 124.5, ventral view at hi-focus, IC, GSC No. 41528. x500 (p. 19, 32)

PLATE 9

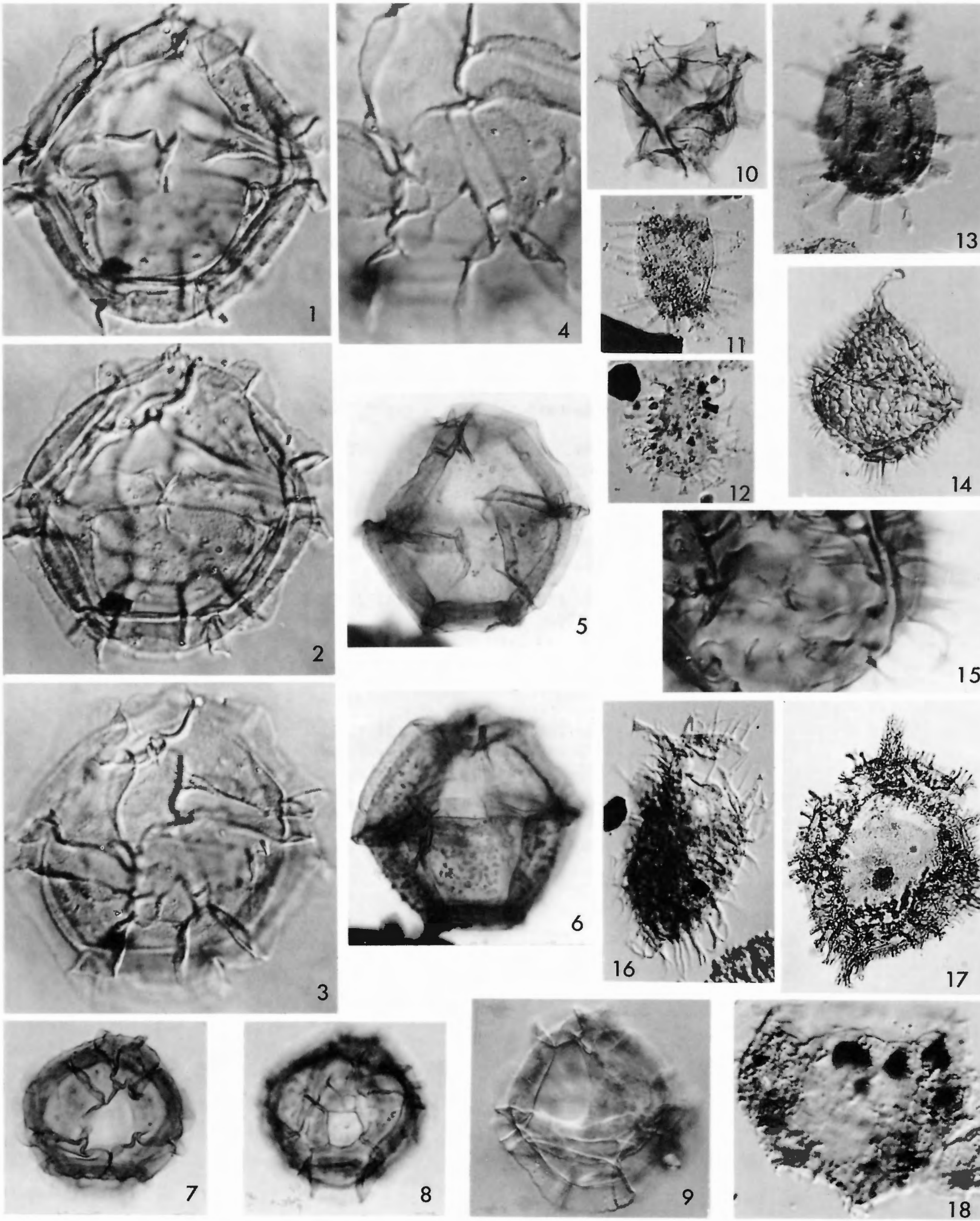

PLATE 10

Figs. 1-4. *Gardodinium eisenackii* (p. 19, 33)

1. C-8532, Slide P851-1A, 21.5 x 122.8, lateral view at lo-focus, IC, GSC No. 41529. x500

2. C-8534, Slide P851-3A, 16.4 x 126.4, lo-focus on apical archeopyle, IC, GSC No. 41530. x500

3. C-8533, Slide P851-2A, 07.7 x 121.3, mid-focus on principal archeopyle sutures, IC, GSC No. 41531. x900

4. C-8534, Slide P851-3A, 21.5 x 131.7, GSC No. 41532. x500

Fig. 5. *Scriniodinium campanula*. C-8552, Slide 6891-4, 16.7 x 128.7, IC, GSC No. 41533. x325 (p. 19, 33)

Fig. 6-14. *Scriniodinium rostratum* sp. nov. (p. 19, 34)

6. C-8540, Slide P851-9A, 11.5 x 130.0, right lateral view at hi-focus, IC, GSC No. 41534. x500

7. C-8539, Slide P851-8A, 12.3 x 124.7, mid-focus, IC, GSC No. 41535. x500

8, 9. C-8537, Slide P851-6A, 41.3 x 118.6, (8) lo-focus on the apex, (9) hi-focus on the antapex, IC, GSC No. 41536. x500

10, 11. C-8542, Slide P851-11A, 40.4 x 134.1, (10) right lateral view at hi-focus, (11) right lateral view at lo-focus, IC, GSC No. 41537. x900

12-14. Holotype, C-8535, Slide P851-4A, 36.3 x 122.4, (12) ventral view at hi-focus, (13) mid-focus, (14) lo-focus on dorsal surface, IC, GSC No. 34151. x900

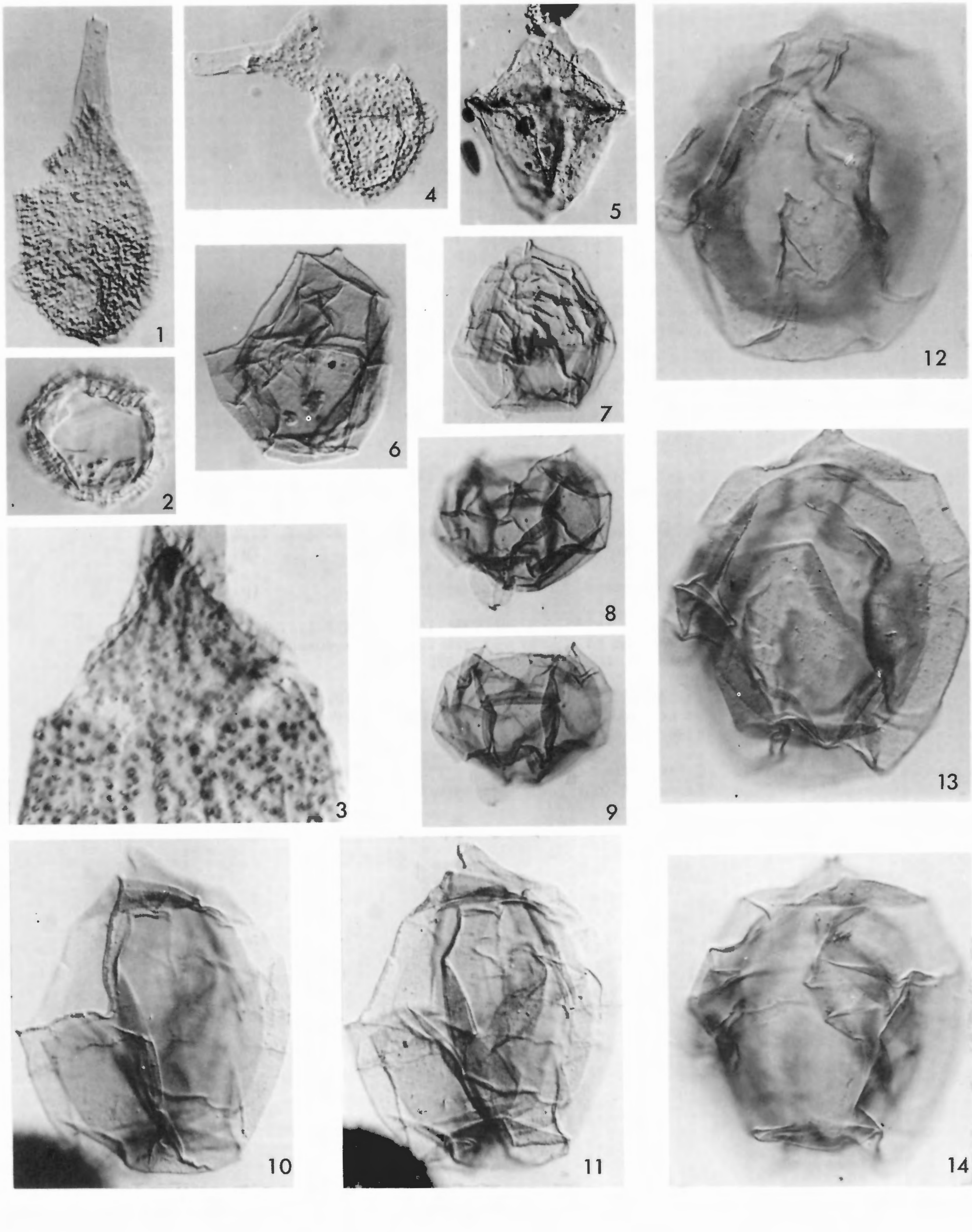
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PLATE 11

Figs. 1-3. *Scriniodinium rostratum* sp. nov. C-8535, P851-4A, 40.7 x 134.3, (1) dorsal view at lo-focus, (2) mid-focus, (3) ventral view at hi-focus, IC, GSC No. 41538. x900 (p. 19, 34)

Figs. 4, 5. *Muderongia* sp. A (p. 19, 34)

4. C-8474, Slide 6788-3, 14.8 x 123.7, PC, GSC No. 41539. x500

5. C-8474, Slide 6778-3, 11.1 x 132.4, PC, GSC No. 41540. x500

Fig. 6. *Muderongia tetracantha.* C-8474, Slide 6778-3, 22.1 x 120.0, IC, GSC No. 41541. x500 (p. 19, 34)

Fig. 7-12. *Senoniasphaera microreticulata* sp. nov. (p. 20, 35)

7-9. Holotype, C-8532, Slide P851-1A, 35.9 x 121.3, (7) ventral surface at hi-focus, (8) mid-focus, (9) dorsal surface at lo-focus, GSC No. 34152. x325

10-12. C-8540, Slide P851-9A, 24.1 x 126.5, (10) ventral surface at hi-focus, (12) dorsal surface at lo-focus, IC, GSC No. 41542. x325

11. C-8446, Slide 6851-2, 20.2 x 133.8, detached operculum formed of four reflected apical plates, IC, GSC No. 41543. x500

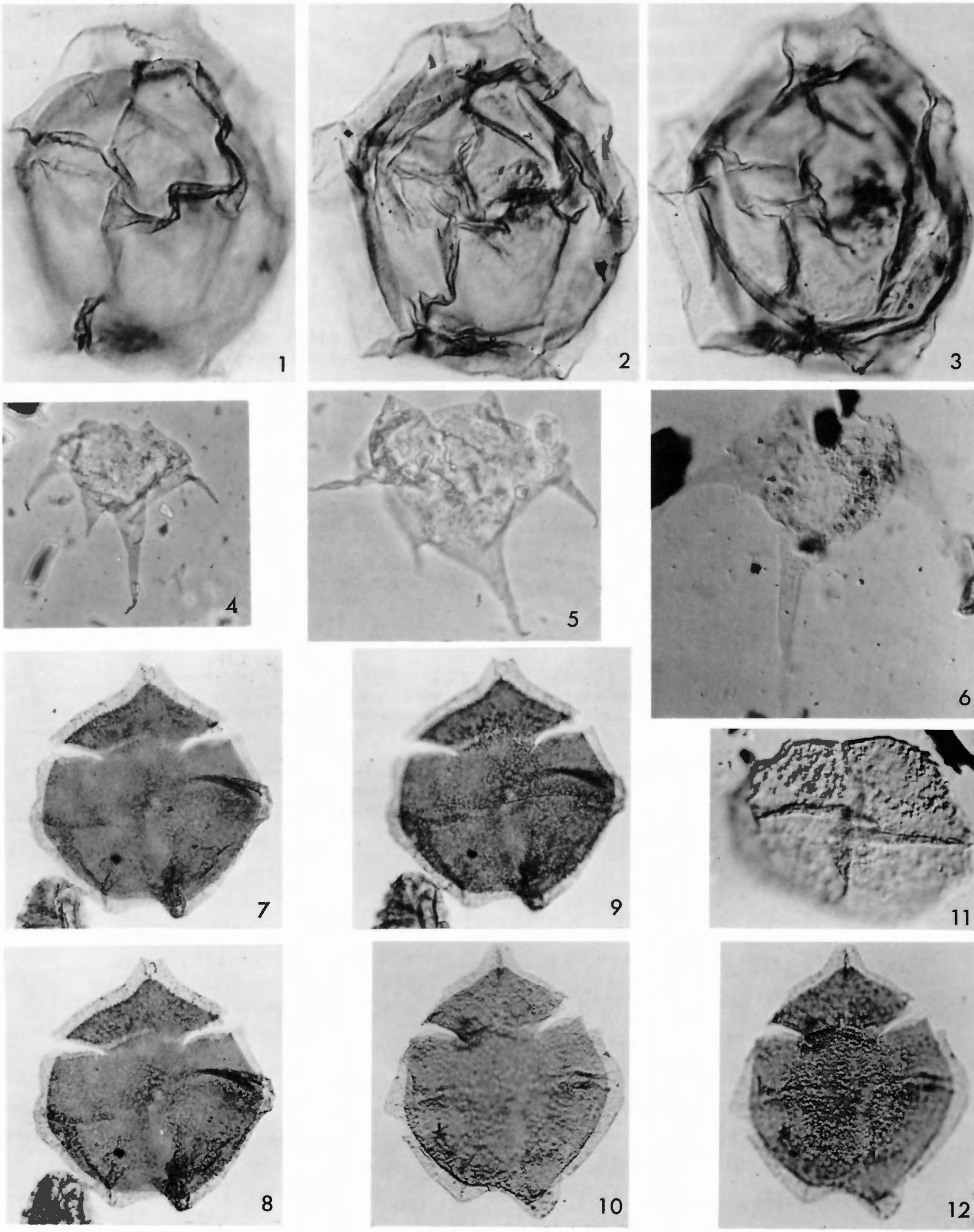

PLATE 12

Figs. 1-8. *Senoniasphaera microreticulata* sp. nov. (p. 20, 35)

1. Holotype, C-8532, Slide P851-1A, 35.9 x 121.3, ventral view at hi-focus, IC, GSC No. 34152. x500

2. C-8543, Slide P851-12A, 28.0 x 124.5, mid-focus, specimen showing marked separation of periphragm and endophragm, GSC No. 41544. x325

3, 4. C-8534, Slide P851-3A, 28.2 x 121.0, the endoblast, (3) dorsal view at hi-focus, (4) ventral view at lo-focus, GSC No. 41545. x500

5, 6. C-8540, Slide P851-9A, 24.1 x 126.5, (5) hi-focus on left ventral periphragm surface, (6) lower focus on part of ventral endophragm surface, IC, GSC No. 41543. x900

7, 8. C-8532, Slide P851-1A, 20.0 x 126.3, (7) isolated endoblast, dorsal view at hi-focus, (8) ventral view at lo-focus, GSC No. 41547. x500

Figs. 9-12. *Luxadinium primulum* gen. et sp. nov. (p. 20, 37)

9. Holotype, C-8533, Slide P851-2A, 29.2 x 134.5, mid-focus with apex tilted towards viewer--ventral surface in focus, dorsal surface in focus by transparency, IC, GSC No. 34153. x900

10-12. C-8538, Slide P851-7A, 19.8 x 123.7, (10) hi-focus on ventral surface, (11) mid-focus on anterior dorsal surface, (12) lo-focus on posterior dorsal surface, IC, GSC No. 41548. x900

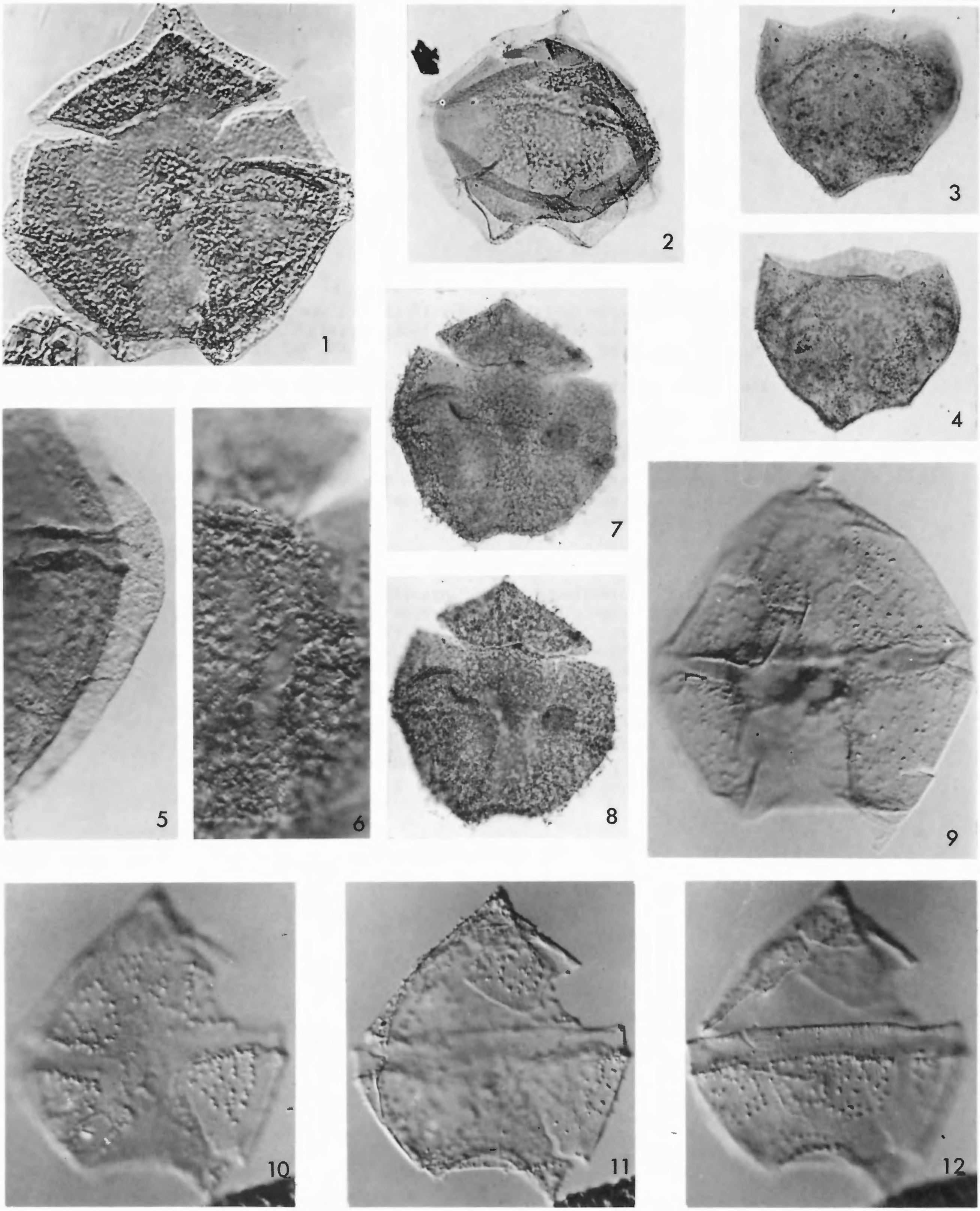
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PLATE 13

Figs. 1-8. *Luxadinium primulum* gen. sp. nov. (p. 20, 37)

1-3. C-8532, Slide P851-1A, 29.8 x 129.3, (1) ventral surface at hi-focus, (2) mid-focus on projecting reflected plate 3', (3) lo-focus on dorsal archeopyle, IC, GSC No. 41549. x900

4-6. C-8532, Slide P851-1A, 25.6 x 125.0, (4) ventral surface at hi-focus, (5) dorsal surface at mid-lo-focus, (6) anterior dorsal surface at lo-focus, IC, GSC No. 41550. x900

7, 8. C-8544, Slide P851-10A, 38.4 x 123.9, (7) mid-focus on parts of the endopercula lying in the endocoel (reflected plates 1a and 2a), (8) dorsal endarcheopyle at hi-focus, IC, GSC No. 41551. x900

Figs. 9-12. *Luxadinium propatulum* gen. et sp. nov. (p. 37)

9-11. Holotype, refigured after Singh (1971, Pl. 62. fig. 8), Research Council of Alberta Sample No. 3-S-5, Slide No. 3-S-5-Micro. 137, 12.3 x 125.4, (9) hi-focus on dorsal archeopyle, with projected reflected plate 3' clearly visible in periblast and endoblast, (10) mid-focus, (11) ventral surface at lo-focus by transparency, IC, x900

12. Research Council of Alberta Sample No. 3-S-5, Slide No. 3-S-5-Micro. 136, 12.6 x 125.5, mid-focus on projecting reflected plate 3' in periblast and endoblast, IC, x1250

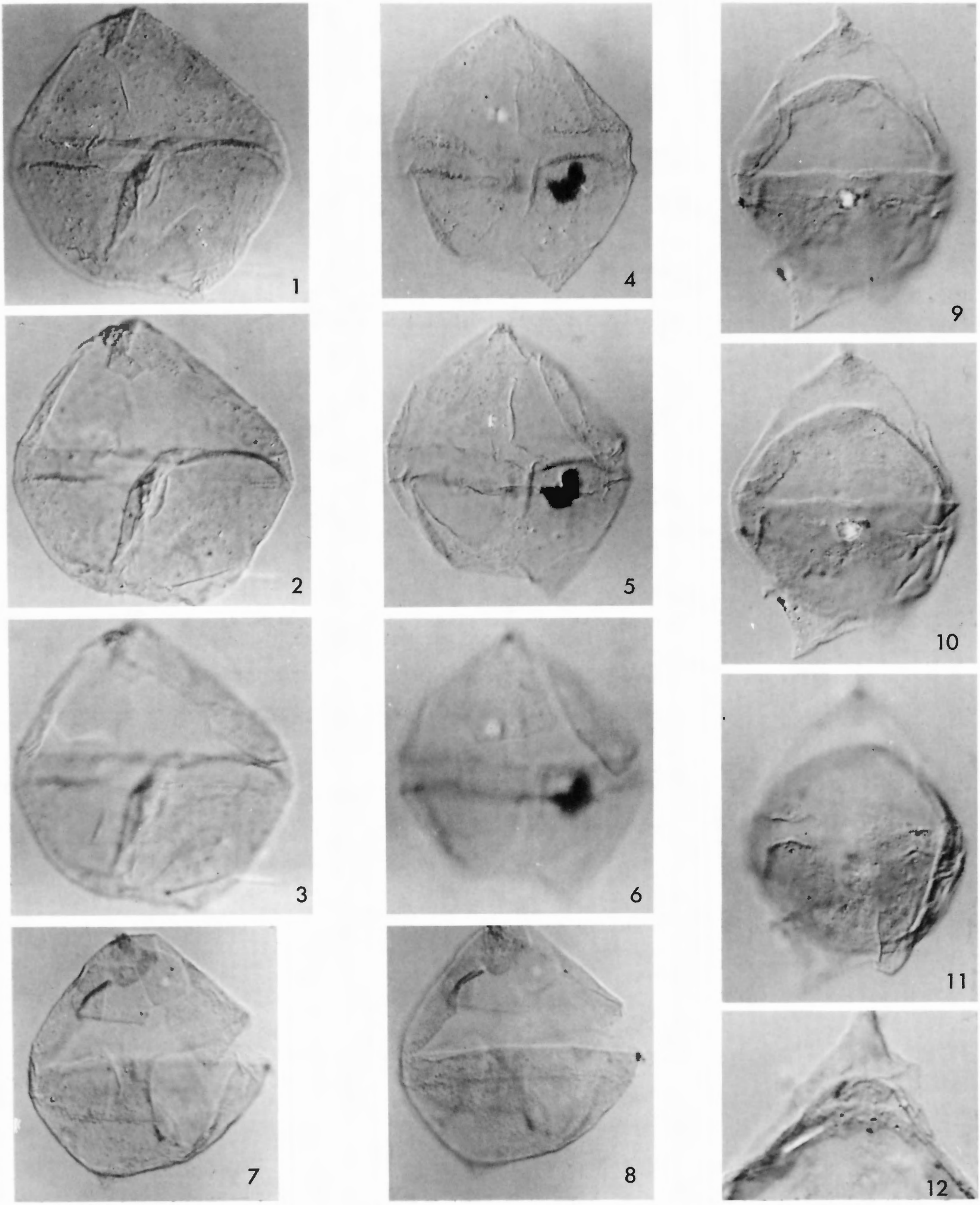


PLATE 14

Figs. 1, 2. *Luxadinium propatulum* gen. et sp. nov. Research Council of Alberta Sample No. 3-S-5, Slide No. 3-S-5-Micro. 136, 12.6 x 125.5, (1) dorsal view at lo-focus, (2) ventral view at hi-focus, IC, x900 (p. 37)

Fig. 3. *Astrocysta cretacea*. C-8554, Slide 6893-2, 27.1 x 127.3, mid-focus, GSC No. 41552. x500 (p. 20, 36)

Fig. 4. *Palaeoperidinium* sp. A of Brideaux, 1971. C-8537, Slide P851-6A, 25.9 x 133.2, IC, GSC No. 41553. x500 (p. 20, 38)

Fig. 5. *Dingodinium cerviculum*. C-8538, Slide P851-7A, 25.8 x 124.6, IC, GSC No. 41554. x1250 (p. 20, 38)

Fig. 6. *Kalyptea monoceras*. C-8539, Slide P851-8A, 39.8 x 123.9, IC, GSC No. 41555. x500 (p. 20, 38)

Fig. 7. *Pterospermopsis australiensis*. C-8446, Slide 6851-2, 26.3 x 121.3, IC, GSC No. 41556. x500 (p. 20, 39)

Fig. 8. *Kalyptea* sp. A of Brideaux, 1971b. C-8535, Slide No. P851-4A, 26.3 x 121.3, IC, GSC No. 41557. x500 (p. 20, 38)

Fig. 9. *Chlamydophorella nyei*. C-8543, Slide P851-12A, 23.6 x 125.3, hi-focus, IC, GSC No. 41558. x1250 (p. 20, 38)

Figs. 10, 11. *Lecaniella foveata* (p. 20, 39)

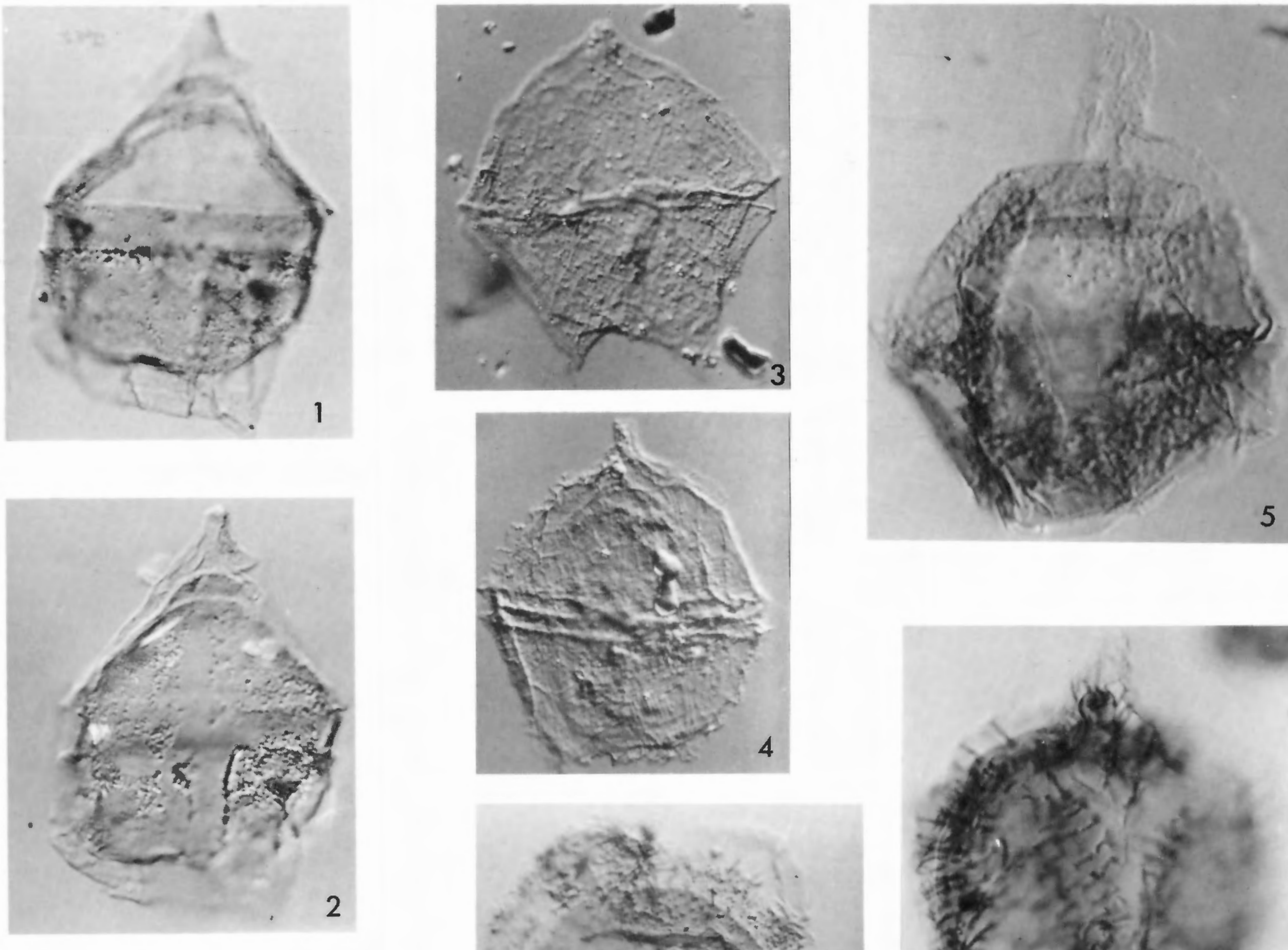
10. C-8542, Slide P851-11A, 20.5 x 126.1, IC, GSC No. 41559. x500

11. C-8543, Slide P851-12B, 29.5 x 126.3, lo-focus on line of separation, IC, GSC No. 41560. x500

Figs. 12, 13. *Micrhystridium* sp. A (p. 20, 39)

12. C-8443, Slide 6848-2, 15.4 x 127.1, IC, GSC No. 41561. x900

13. C-8442, Slide 6847-1, 19.1 x 115.7, GSC No. 41546. x900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