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D.C. McGregor and M. Camfield

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## Preface

Melville Island, in the southwestern corner of the Queen Elizabeth Islands, is underlain mainly by Devonian marine and continental strata. Since 1969 the area has been the site of intensive exploration for hydrocarbons with considerable attention being given to the Devonian rocks. Correlation of rock units is important in understanding geological relationships but in the Arctic Islands correlation has been impeded by the virtual absence of zonally significant faunas. Miospores, however, are abundantly distributed throughout the sequence. Although well suited to interfacies correlation, they had not, until the present study, been examined in detail in this region nor had correlations with marine biozones been established.

Field work for this study was carried out in 1968 and several interim reports were published in the following decade. This bulletin completes one phase of the study. The second phase, now underway, comprises the description of miospores from other Devonian formations from the same region. The study will be completed by the preparation of a report in which the stratigraphic and paleogeographic significance, the definition of miospore zones throughout the Middle and Upper Devonian of the region, and detailed comparisons of the assemblages with those from other parts of the world, will be described.

*R.A. Price*
Director General
Geological Survey of Canada

OTTAWA, January 1982

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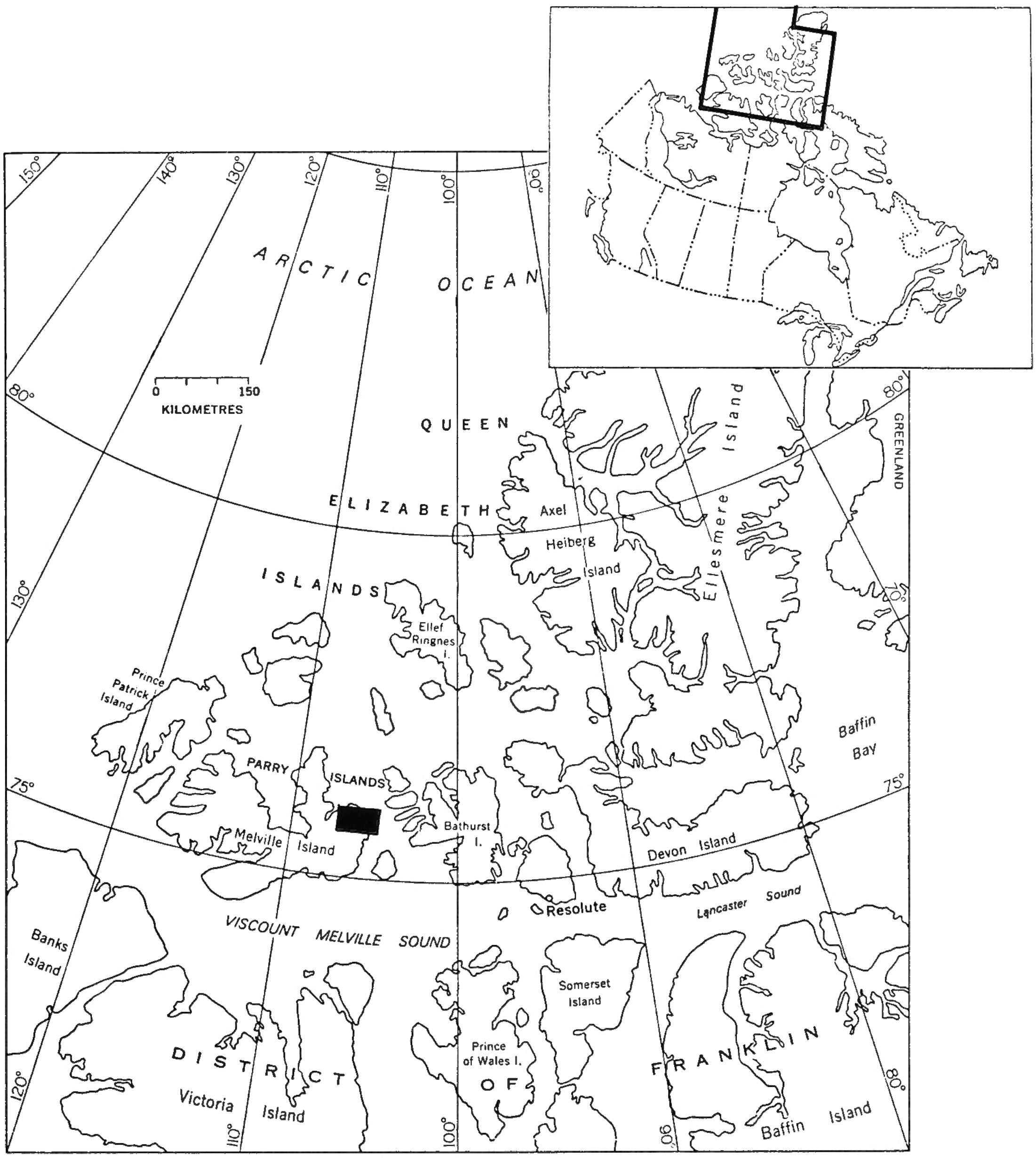



*Text-figure 1. Location of study area. Area of Text-figure 2 is shown by the black rectangle.*

## MIDDLE DEVONIAN MIOSPORES FROM THE CAPE DE BRAY, WEATHERALL, AND HECLA BAY FORMATIONS OF NORTHEASTERN MELVILLE ISLAND, CANADIAN ARCTIC


### *Abstract*

*Miospores are abundant and well-preserved in the type section of the Weatherall Formation and the underlying and overlying Cape De Bray and Hecla Bay formations east of Weatherall Bay, Melville Island. The spores and associated conodonts indicate that the Cape De Bray Formation and the lower Weatherall Formation in this section are early to middle Eifelian in age. Higher in the section, in the upper half of the Weatherall Formation and the lower two-thirds of Hecla Bay Formation, spores are the only stratigraphically useful fossils. They indicate a late Eifelian to probably mid-Givetian age, about half a stage older than previously thought. The spores provide a basis for direct correlation of continental and marine strata of the Franklinian "clastic wedge" of the Queen Elizabeth Islands with each other and with European standard stages. They represent part of the Old Red Sandstone flora that extends from eastern Alaska through arctic and eastern North America, western Europe and the central and northern USSR.*

*One hundred and sixteen taxa of miospores from these three formations are described herein, of which 12 are new species:* ***Apiculiretusispora leberidos, Camarozonotriletes laevigatus, Convolutispora porcata, Craspedispora arctica, Cymbosporites? opacus, Densosporites weatherallensis, Diatomozonotriletes franklinii, Dibolisporites farraginis, D. vegrandis, Grandispora uyenoi, G. variospinosa,*** *and* ***Perotrilites heclaensis****; two are new varieties:* ***Corystisporites multispinosus*** *var.* ***spinulosus*** *and* ***Geminospora tuberculata*** *var.* ***micrornata****; one is given a new name:* ***Grandispora tiwarii****; and 27 are new combinations.*

### *Résumé*

*Les miospores sont abondantes et bien conservées dans les sections-types de la formation de Weatherall, et les formations sous-jacentes et sus-jacentes de Cape De Bray et Hecla Bay respectivement, à l'est de la baie Weatherall, sur l'île Melville. Les spores et conodontes qui leur sont associés indiquent que dans cette section, la formation de Cape De Bray et la portion inférieure de la formation de Weatherall datent de l'Eifélien inférieur à moyen. Plus haut dans le profil, dans la moitié supérieure de la formation de Weatherall et les deux tiers inférieurs de la formation de Hecla Bay, les spores sont les seuls fossiles stratigraphiques présentant une utilité. Ils indiquent que ces niveaux datent de l'Eifélien supérieur au Givétien moyen (probablement), c'est-à-dire que dans la colonne stratigraphique, ils se situeraient un demi-étage plus bas qu'on ne le croyait auparavant. Les spores permettent d'établir une corrélation directe, dans les îles Reine-Elizabeth, des strates continentales et marines du "prisme clastique" du Franklinien les unes avec les autres, ainsi qu'avec les étages européens courants. Elles représentent une partie de la flore des Vieux grès rouges (Old red Sandstone), qui, à partir de l'est de l'Alaska, s'étendaient à travers les régions arctiques et l'est de l'Amérique du Nord, l'Europe de l'Ouest, et les régions septentrionales et centrales de l'U.R.S.S.*

*Dans le présent ouvrage, on décrit cent seize taxa de miospores prélevées dans ces trois formations, dont 12 représentent de nouvelles espèces:* ***Apiculiretusispora leberidos, Camarozonotriletes laevigatus, Convolutispora porcata, Craspedispora arctica, Cymbosporites? opacus, Densosporites weatherallensis, Diatomozonotriletes franklinii, Dibolisporites farraginis, D. vegrandis, Grandispora uyenoi, G. variospinosa,*** *et* ***Perotrilites heclaensis****; deux représentent des variétés nouvelles:* ***Corystisporites multispinosus*** *var.* ***spinulosus*** *et* ***Geminospora tuberculata*** *var.* ***micrornata****; l'une d'entre elles a reçu un nouveau nom:* ***Grandispora tiwarii****; et 27 représentent de nouvelles combinaisons.*

## INTRODUCTION

Melville Island is in the southwestern corner of the Queen Elizabeth Islands, District of Franklin (text-figure 1). Approximately four-fifths of the Island are underlain by Devonian marine and continental strata. These rocks were first described on a regional scale by Tozer and Thorsteinsson (1964). More recently Embry and Klovan (1976) studied the stratigraphy of the Middle and Upper Devonian clastic rocks of the Queen Elizabeth Islands, and revised the stratigraphic nomenclature (text-figure 2). Since 1969 the Devonian and other strata of this region, both outcrop and subsurface, have been subject to intensive investigation in connection with exploration for hydrocarbons.

Correlation of the Middle and Upper Devonian clastic rocks of the Arctic Islands has been impeded by the fact that zonally significant faunas are rare. Miospores occur abundantly throughout the sequence, and are well suited to interfacies correlation, as they are the only fossils commonly distributed abundantly in both continental and marine sediments. However, they have not been studied in detail in this region, or correlated with marine biozones.

This investigation is part of a comprehensive taxonomic and biostratigraphic study of the Devonian miospores of the Canadian Arctic Islands, begun in 1968. The overall objective of the study is to establish zonal standards for regional and intercontinental correlation of the Devonian marine and non-marine strata of the Arctic Islands using spores. In order that this may be accomplished, it is necessary to identify and describe the fossils, many of them new species, and to correlate their ranges with those of the faunas upon which the international biostratigraphic standards are presently based.

| SERIES | STAGE | EASTERN MELVILLE ISLAND: McGregor & Uyeno 1972 | EASTERN MELVILLE ISLAND: Chi & Hills 1976 | EASTERN MELVILLE ISLAND: This paper; McGregor (in press) |
|---|---|---|---|---|
| UPPER DEVONIAN | FAMENNIAN | | | |
| | | GRIPER BAY | PARRY ISLANDS | PARRY ISLANDS |
| | FRASNIAN | | BEVERLEY INLET | BEVERLEY INLET |
| | | HECLA BAY | | |
| MIDDLE DEVONIAN | GIVETIAN | | HECLA BAY | HECLA BAY |
| | | WEATHERALL | WEATHERALL | |
| | | | CAPE DE BRAY | WEATHERALL |
| | EIFELIAN | BLUE FIORD | BLUE FIORD | CAPE DE BRAY |
| | | | | BLUE FIORD |
| LOWER DEVONIAN | EMSIAN | | | |

*Text-figure 2: Age and stratigraphic nomenclature, Middle and Upper Devonian formations of eastern Melville Island. Solid vertical bar shows stratigraphic range of studied section. Broken vertical bar shows stratigraphic range of section north of Beverley Inlet, from which an investigation of the spores is in progress. Nomenclature in middle column is after Tozer and Thorsteinsson (1964); that in the two columns on the right is after Embry and Klovan (1976).*

This report completes the first phase of the investigation. It describes miospores of Eifelian and Givetian age from the type section of the Weatherall Formation and from the underlying and overlying Cape De Bray and Hecla Bay formations of northeastern Melville Island, and correlates the miospore assemblages with conodont assemblages collected at the same time by T.T. Uyeno in the lower part of the section.

We have a further investigation under way on the miospores in the Hecla Bay, Beverley Inlet, and Parry Islands formations from a stratigraphic section exposed on the south limb of the Robertson Point anticline, north of the head of Beverley Inlet, southeastern Melville Island (see figure 4, McGregor and Uyeno, 1972). This sequence includes the type sections of the Hecla Bay and Beverley Inlet formations. On its completion this investigation will complement the present one, and will provide a biostratigraphic standard for correlating and dating the whole of the Middle and Upper Devonian clastic wedge of the Canadian Arctic Islands, of middle Eifelian to early Famennian age.

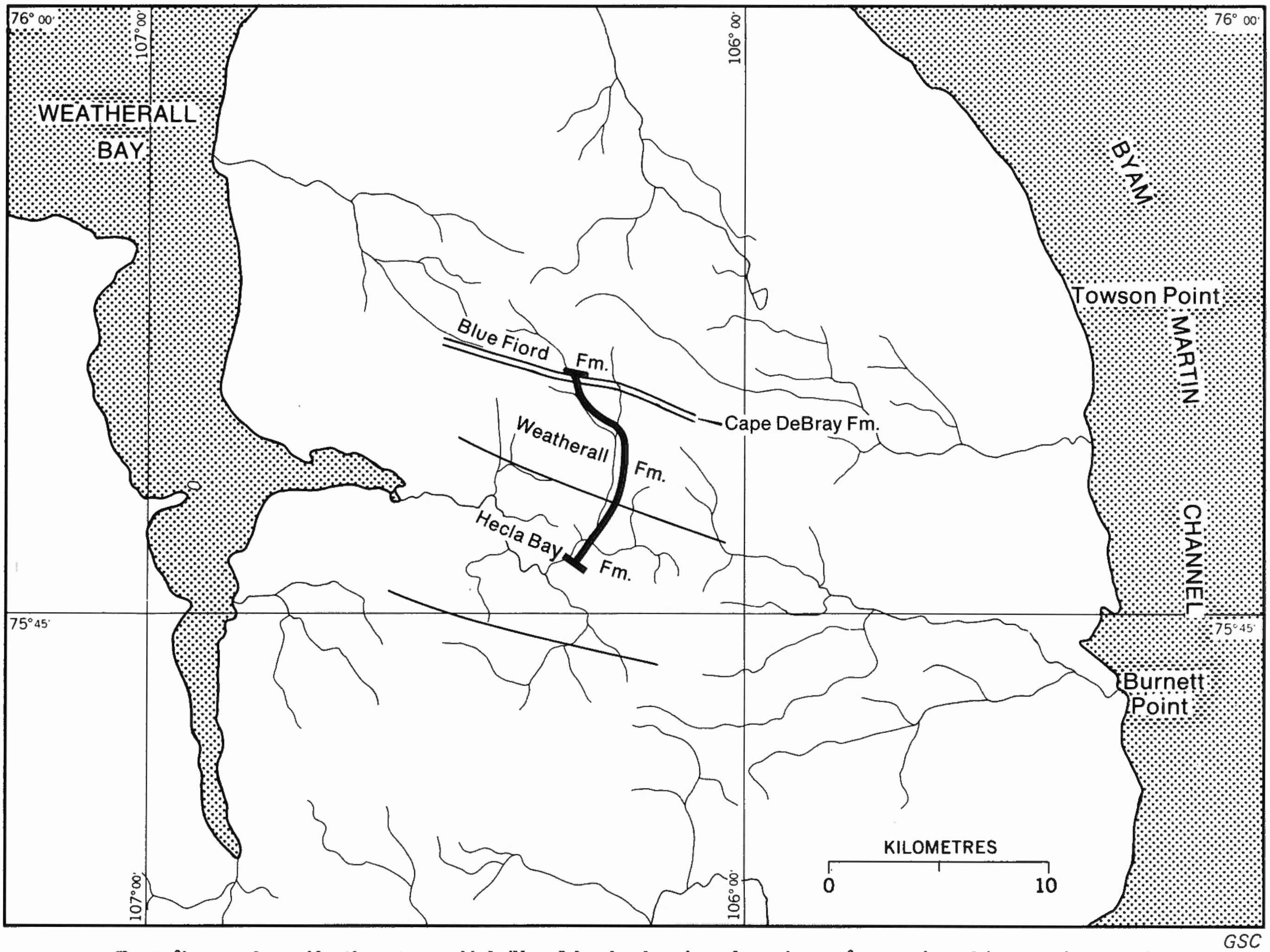
The final phase of the study of the miospores of the Arctic Islands will comprise an account of their stratigraphic and paleogeographic significance, the definition of miospore zones through the Middle and Upper Devonian of the region, and detailed comparison of the assemblages with those from other parts of the world. This concluding phase of the investigation will be the subject of a separate report, to follow after the spores have been described and their stratigraphic ranges have been determined.

### *Previous Studies Of Miospores in the Canadian Arctic Islands*

Investigation of Devonian spores of the Canadian Arctic was begun by one of us (DCM) in 1955. Miospores were extracted from four samples of Devonian age collected by the Geological Survey of Canada (GSC) on Ellesmere, Cornwallis, Melville, and Prince Patrick Islands (respectively GSC plant localities 4713, 7013, 5116, and 4428). Miospores and megaspores from the Melville Island locality (GSC 5116) were included in a doctoral thesis (McGregor, 1957) and subsequently published (McGregor, 1960). The rocks at this locality have been assigned to the Beverley Inlet Formation by Embry and Klovan (1976). This work was continued in 1956 at which time spores were recovered from five additional samples of Middle and Late Devonian age from Devon and Ellesmere Islands (GSC plant localities 4737, 4738, 4740, 4742, and 4747, McGregor, unpublished). Since then miospores have been discovered in all of the formations of the "clastic wedge" of the Arctic Islands.

The published information on Devonian miospores of the Canadian Arctic Islands is summarized in Table 1.

Five papers have been published on the miospores of the Cape De Bray, Weatherall, and Hecla Bay Formations of eastern Melville Island. McGregor and Owens (1966) published photographic illustrations of miospores and megaspores from the Weatherall Formation. The spores were obtained from GSC plant localities 7557 and 7560 in the lower member (lower 420 m) of the Weatherall Formation in the Robertson Point anticline, about 13 km northeast of the head of Beverley Inlet. Subsequently Owens (1971) formally described selected species from these two localities and from two plant localities in the upper member of the Weatherall Formation of the same section (GSC 7578 and 7579).




*Text-figure 3: Northeastern Melville Island showing location of stratigraphic section, and approximate lithostratigraphic boundaries.*

Palynological work was continued on the Beverley Inlet section, and was begun on the section east of Weatherall Bay, the subject of this report, by McGregor and Uyeno (1969) who collected samples for both palynomorph and conodont studies. McGregor (in McGregor and Uyeno, 1972) developed a preliminary zonation of the Weatherall, Hecla Bay, and Griper Bay Formations comprising four miospore-megaspore "assemblages" in the Beverley Inlet section.

Chi and Hills (1976) published a stratigraphic and taxonomic report on spores from Cape De Bray to Hecla Bay equivalent strata in six stratigraphic sections in the Arctic Islands including the Weatherall Bay and Beverley Inlet (Robertson Anticline) sections. Their report, ostensibly on megaspores, in fact also contains taxonomic descriptions and stratigraphic information on 15 species of miospores.

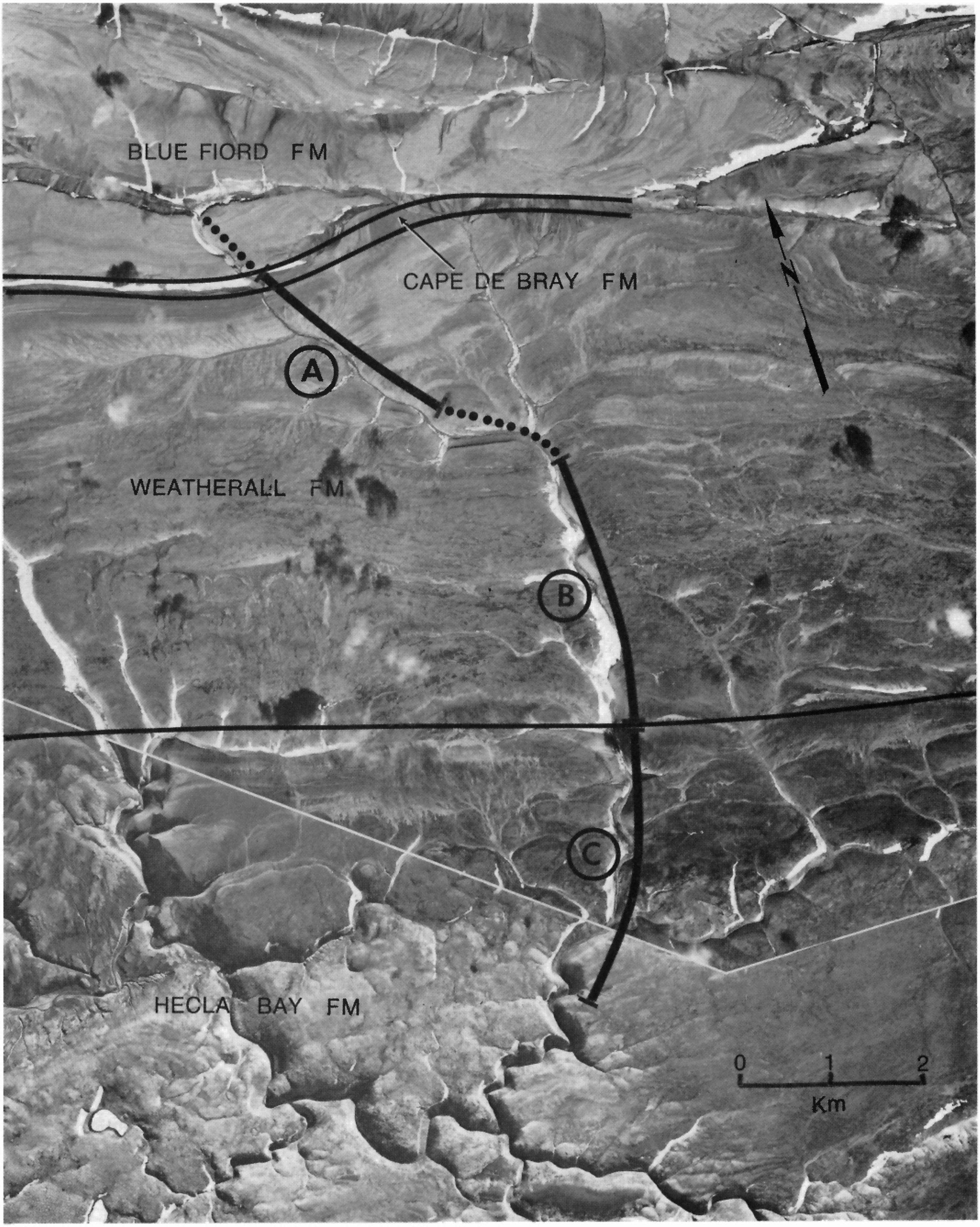
### *Field and Laboratory Work*

Field work for this investigation was carried out in the summer of 1968, by McGregor and T.T. Uyeno. The section east of Weatherall Bay, chosen for the present investigation, was one of four sections measured. The section was measured using a "pogo stick", a five-foot metal staff topped by a spirit level. Transportation from Resolute, Cornwallis Island, to the section and return was by casual charter from Atlas Aviation and Gateway Aviation.

The base of the section is 16.2 km east of the east arm of Weatherall Bay on the south side of the Towson Point anticline, in a small stream 7.3 km west of the eastern end of the prominent ridge of Blue Fiord limestone (text-figures 3 and 4). The measured section begins in a ravine 313.5 m below the top of the Blue Fiord Formation (text-figure 4). This location is probably close to, if not identical with, locality 27 of Tozer and Thorsteinsson (1964, p. 70).

Samples for palynomorphs and conodonts were collected at irregularly spaced stratigraphic intervals, at levels where lithology was judged to be appropriate for recovery of fossils. The stratigraphic position of the spore-bearing samples is given in Table 2. Conodonts occur near the base and the top of the Blue Fiord Formation, and in the lower 160 m of the Weatherall Formation (text-figures 5 and 6). The lowest spores were found in the basal exposure of the Cape De Bray Formation, on the east side of the stream below the limestone ridge, about 15 m downstream from the mouth of the canyon. Neither spores nor marine palynomorphs were recovered from the Blue Fiord Formation in this section, although several samples were taken. Text-figure 6 shows the location of spore-bearing and conodont-bearing samples on aerial photographs of the region.

Miospores were recovered from all of the samples collected in the Cape De Bray, Weatherall, and Hecla Bay formations. The samples represent a range of lithologic




*Text-figure 4: Vertical aerial photographs A16763-10 and A16766-156 of the study area showing approximate lithostratigraphic boundaries and extent of measured section. Wide solid bars indicate spore-bearing parts of the section. Dotted line indicates absence of spores. A, B, and C refer to parts of section shown in text-figure 6.*

Table 2

Stratigraphic position of spore samples

| Formation | GSC Plant Loc. | Metres Above Preceding Sample | Metres Above Base of Section | Formation | GSC Plant Loc. | Metres Above Preceding Sample | Metres Above Base of Section |
|---|---|---|---|---|---|---|---|
| Hecla Bay | 8342 | 12 | 1686 | Weatherall | 8320 | 0.1 | 963.6 |
| | 8341 | 18.5 | 1674 | | 8319 | 15 | 963.5 |
| | 8340 | 64 | 1655.5 | | 8318 | 18.5 | 948.5 |
| | 8339 | 71 | 1591.5 | | 8317 | 74.5 | 930 |
| | 8338 | 20 | 1520.5 | | 8316 | 10.5 | 855.5 |
| | 8337 | 7.5 | 1500.5 | | 8315 | 21.5 | 845 |
| | 8336 | 15 | 1493 | | 8314 | 9 | 823.5 |
| | 8335 | 9 | 1478 | | 8313 | 73.5 | 814.5 |
| | 8334 | 73 | 1469 | | 8312 | 6 | 741 |
| | 8333 | 38 | 1396 | | 8311 | 15 | 735 |
| | 8332 | 45.5 | 1358 | | 8310 | 102 | 720 |
| | 8331 | 38 | 1312.5 | | 8309 | 78.5 | 618 |
| | 8330 | 26.5 | 1274.5 | | 8308 | 3 | 539.5 |
| | 8329 | 37.5 | 1248 | | 8307 | 114.5 | 536.5 |
| | 8328 | 6 | 1210.5 | | 8306 | 56.5 | 422 |
| | 8327 | 44.5 | 1204.5 | | 8305 | 53.5 | 365.5 |
| | | | 1180 | | 8304 | 76 | 312 |
| Weatherall | 8326 | 30.5 | 1160 | | 8303 | 56 | 236 |
| | 8325 | 18 | 1129.5 | | 8302 | 46 | 180 |
| | 8324 | 27.5 | 1111.5 | | | | 160 |
| | 8323 | 94.5 | 1084 | Cape De Bray | 8301 | 94.5 | 134 |
| | 8322 | 15.5 | 989.5 | | 8300 | 33.5 | 39.5 |
| | 8321 | 10.4 | 974 | | 8299 | | 6 |

variation, and were taken from both the stream bottom and, where appropriate, high on the stream banks. Some minor excavation commonly was necessary to affect sampling of the more recessive beds.

Laboratory preparation of the palynomorph samples was done using standard chemical treatment, and concentration of the palynomorph residues using heavy liquid ($ZnBr_2$) and microsieves. Oxidation, either with concentrated nitric acid or with Schulze solution ($HNO_3 + KClO_3$), was carried out on all of the samples, to the point where the optimum clearing of the spores was obtained. Both miospores and megaspores were recovered by this process. Representative megaspores were picked out of each sample and stored separately, unmounted. Strew mounts were prepared from the miospore fraction, using either glycerine jelly sealed with "Cutex" fingernail polish, or the permanent clearcol and elvacite process described by Barss and Williams (1973). Selected single specimens were mounted in glycerine jelly and sealed under the coverglass with a ring of paraffin.

The present investigation involves only the miospores, the megaspores being retained for future study. We have adopted the generally accepted definition of miospores, i.e. those for which the mean diameter of known populations of the species is less than 200 μm in the equatorial plane.

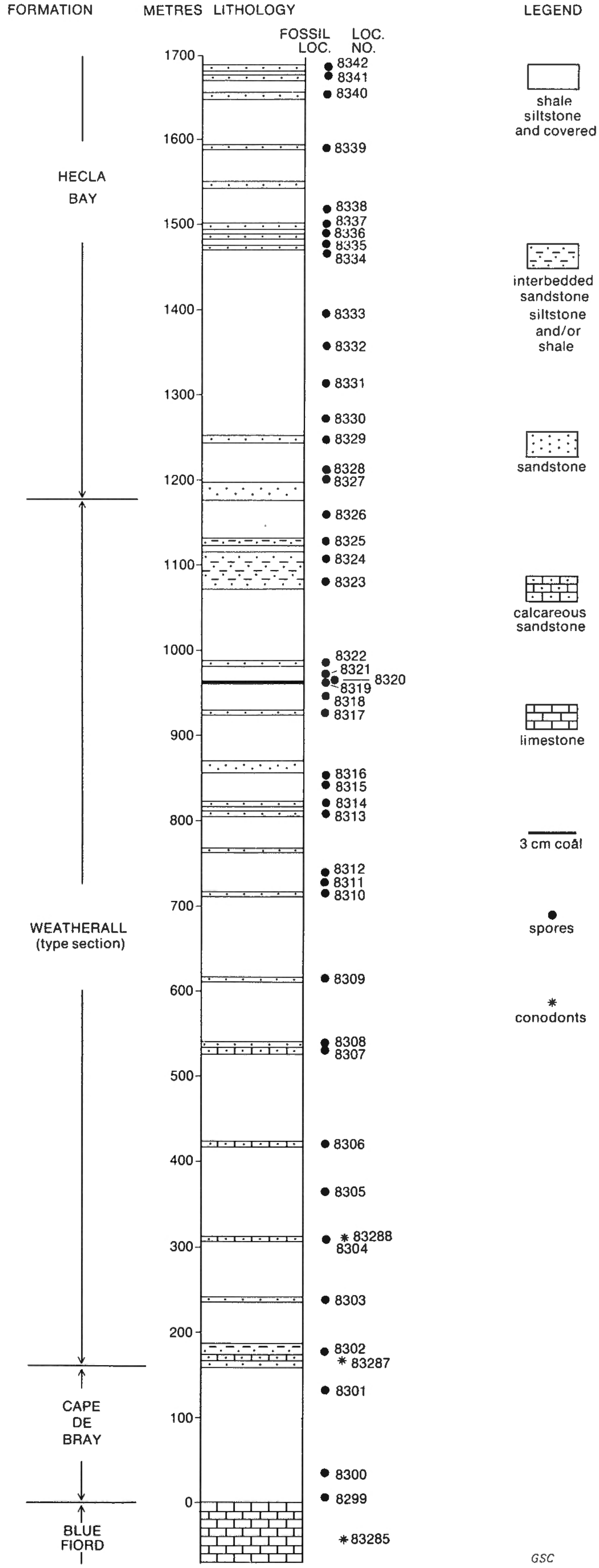
The initial planning of the project, and the field work, were done by McGregor in collaboration with T.T. Uyeno. The photographic plates and most of the text are by McGregor. Text-figures 8-97 were done cooperatively by Camfield and McGregor. The initial sample preparations, and the bulk of the extremely time-consuming reconnaissance and descriptive microscope work were accomplished by Camfield, under personal service contracts to the Department of Energy, Mines and Resources.

*Acknowledgments*

We are grateful to A.R. Sweet and T.T. Uyeno of the Geological Survey of Canada and J.B. Richardson of the British Museum (Natural History) for constructive comments on the manuscript; T.T. Uyeno for his cooperation in the field and for unpublished information on the conodonts; the Polar Continental Shelf Project for logistic support in the Arctic Islands; B. Owens of the Institute of Geological Sciences, Leeds, England, for assistance in collecting comparative material from the Old Red Sandstone of Scotland; W. Riegel of the University of Göttingen for the opportunity to examine type specimens of Middle Devonian spores from the Rhineland; J.E.A. Marshall of the University of Newcastle Upon Tyne and K.C. Allen of the University of Bristol for access to unpublished information on spores from Fair Isle, Shetland; and E. Erdmer for assistance in preparing photographs and drafting text-figures.

## GEOLOGICAL SETTING

The regional geology of the Canadian Arctic Islands has been described by many authors (e.g. Tozer and Thorsteinsson, 1964; Embry and Klovan, 1976; Trettin and Balkwill, 1979). The Middle Devonian strata of Melville Island are part of a belt of clastic sediments up to 3000 m thick occupying the Franklinian trough. Deposition of predominantly terrigenous sediments from the Peary and Caledonian Mountains and the Precambrian Shield of Greenland began in northern Ellesmere Island in Eifelian time and by late Frasnian time extended as far southwest as Banks Island. The Cape De Bray, Weatherall, and Hecla Bay formations represent respectively marine slope, deltaic and marine shelf, and braided stream deposits laid down successively as the coastal plain prograded southwestward (Embry and Klovan, 1976; also see Trettin, 1978, and Mayr, 1980). The entire belt was deformed during the Late Devonian to Early Mississippian Ellesmerian orogeny.




*Text-figure 5: Stratigraphic column and position of spore and conodont samples in studied section.*

### *Cape De Bray Formation*

The Cape De Bray Formation extends across southern Prince Patrick and Melville Islands into western Bathurst Island, and occurs in the subsurface over much of northern and eastern Banks Island (Miall, 1976; Embry and Klovan, 1976). It consists predominantly of medium to dark grey, noncalcareous shale.

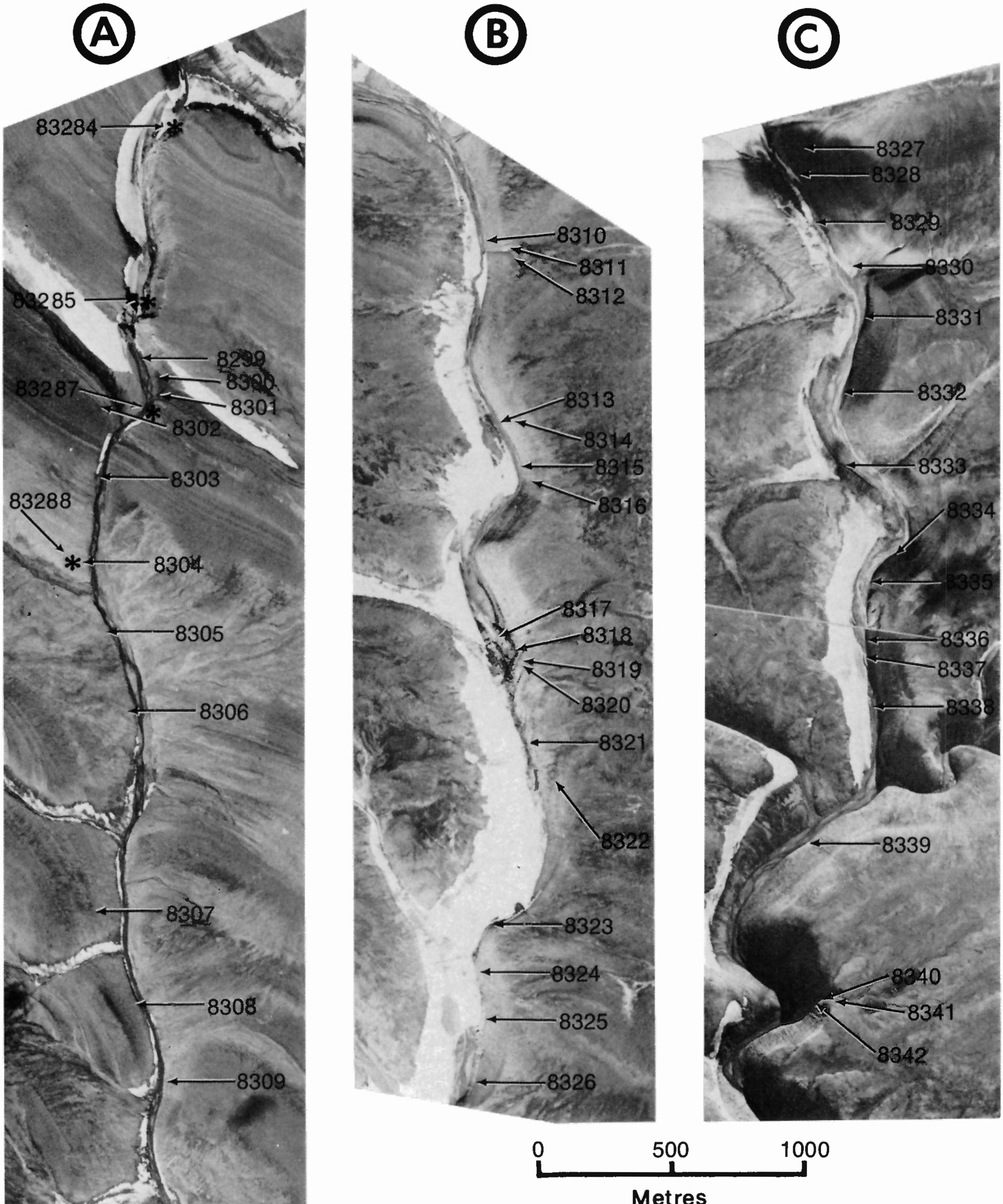
The Cape De Bray Formation as defined by Embry and Klovan (1976) includes the lower, shaly portion of the Weatherall Formation of Tozer and Thorsteinsson (1964). The type section is in the Canrobert Hills, northwestern Melville Island. According to Embry and Klovan the Cape De Bray is thickest (>900 m) in central and southern Melville Island, but only 100 m thick over the Blue Fiord carbonates east of Weatherall Bay. They define its upper contact with the Weatherall Formation as at the horizon above which resistant units of sandstone become common. We are able to locate this contact only approximately with reference to our measurements, made independently in 1968. At that time the beds now assigned to the Cape De Bray were included in the Weatherall Formation. We have placed the contact tentatively in the interval between our samples 8301 and 8302, about 160 m above the base. The discrepancy in thickness between the Cape De Bray as thus delimited and as defined by Embry and Klovan (1976) may be due in part to poor exposure of the shaly beds in this part of the section.

In the section east of Weatherall Bay, unidentifiable fragments of plants occur at intervals in the shale beds. In addition, Tozer and Thorsteinsson (1964, p. 73) reported **Tentaculites** sp. 25 ft. (7.6 m) above the base of the Cape De Bray (GSC loc. 37172), and a meagre fauna of Middle Devonian, probably Givetian age about 300 ft. (91.5 m) above the base (GSC loc. 37235). Embry and Klovan (1976) recorded "abundant atrypids" about 210 ft. (64 m) above the base, but did not comment upon their age significance. Chi and Hills (1976) attributed a Givetian age to the Cape De Bray at Weatherall Bay on the basis of the miospore **Grandispora velata** and the megaspores **Auroraspora macromanifesta** and **Enigmophytospora simplex.**

Elsewhere, marine faunules were obtained at unspecified levels in the type section of the Cape De Bray Formation on northwestern Melville Island (GSC locs. 24876-24879). These were assigned to the Middle Devonian (probably Givetian) by D.J. McLaren (in Tozer and Thorsteinsson, 1964, p. 77). Miospores and megaspores of suggested Givetian age were reported from approximately the upper half of the 915 m section of Cape De Bray Formation south of McCormick Inlet by Chi and Hills (1976).

The faunal and palynological evidence cited above is not sufficient to justify unquestioned assignment of a Givetian age to the Cape De Bray Formation east of Weatherall Bay. The Middle Devonian ("probably Givetian") fauna from this section, referred to above, occurs high in the section. Most of the formation lacks an age-diagnostic fauna. The miospores and megaspores reported by Chi and Hills (1976) from this section could be Eifelian or Givetian. Most of the spores reported from the section south of McCormick Inlet are either new species for which age control is absent, or are long-ranging in the Middle Devonian. Most if not all of the Cape De Bray at Weatherall Bay, and the lower beds of this formation at McCormick Inlet can therefore be regarded only as Eifelian or Givetian on the evidence cited above.

Conodonts collected and identified by T.T. Uyeno provide a more precise age determination for the Cape De Bray Formation east of Weatherall Bay. **Polygnathus costatus** cf. **costatus** Klapper, **P. costatus** cf. **partitus** Klapper, Ziegler and Mashkova, and **P. linguiformis** cf. **bultyncki** Weddige occur in the lowermost Weatherall, 169 m above the Blue




*Text-figure 6: Geographic location of spore- and conodont-bearing samples. Asterisks mark location of conodonts. For geographic and geologic context see text-figure 4.*

Fiord Formation (GSC loc. 83287). According to Uyeno (personal communication, 1979) the co-occurrence of these three forms strongly suggests their assignment to the **costatus costatus** Zone of early Eifelian age. Corals from about midway in the Blue Fiord Formation in the same section (GSC loc. 40806) are not known from rocks older than Eifelian, according to Pedder (in Uyeno and Mason, 1975), and conodonts from 297.2 m and 45.7 m below the top of the Blue Fiord Formation (GSC locs. 83284 and 83285 respectively) are close to the Emsian-Eifelian boundary according to Uyeno and Mason (1975), or about middle Emsian to early Eifelian (**inversus** to **costatus costatus** Zones) according to Uyeno (personal communication, 1979). The age of the Cape De Bray Formation in this section is therefore early Eifelian, bracketed by early Eifelian fossils below and above.

### *Weatherall Formation*

The areal distribution of the Weatherall Formation is in general similar to that of the Cape De Bray Formation, except that it is absent from Bathurst Island. It consists of repetitive, coarsening-upwards cycles of shale, siltstone and sandstone, with thick white sandstone units occurring toward the top of the formation (Embry and Klovan, 1976). The type section, established by Tozer and Thorsteinsson (1964) east of Weatherall Bay, is the subject of the present investigation. This section was diminished on revision by Embry and Klovan (1976), by the transference of the basal beds to the Cape De Bray Formation, and the inclusion of the upper 245 m (328 m according to measurement of McGregor and Uyeno) in the overlying Hecla Bay Formation. The thickness of the revised Weatherall Formation at the type section is 990 m (1020 m according to McGregor and Uyeno).

Conodonts near the base of the Weatherall Formation east of Weatherall Bay are probably early Eifelian (see above), and those found 143 m higher (GSC loc. 83288) are in the range **australis** Zone to Lower **varcus** Subzone, i.e. early Eifelian to early Givetian (Uyeno, personal communication, 1979).

Chi and Hills (1976) concluded on the basis of miospores and megaspores that the Weatherall Formation east of Weatherall Bay is entirely "Early(?)-Middle Givetian" (**macromanifestus** Zone). They were somewhat cautious in this age assignment, noting (op. cit., p. 678) that several of the spore species comprising the **macromanifestus** Zone also occur in the Eifelian, and concluding (op. cit., p. 679) only that "...the assignment of a Givetian age to the **Macromanifestus** zone is reasonable in the Canadian Arctic".

The most reasonable estimate of the age of the type section of the Weatherall Formation, prior to the present investigation, therefore is within the interval early Eifelian to middle Givetian.

### *Hecla Bay Formation*

East of the Cornwallis fold belt, the Hecla Bay Formation extends in an arc from north central Ellesmere Island southward and westward into northern Devon Island. West of the Cornwallis fold belt it occurs locally on Cornwallis Island and eastern Bathurst Island, and occupies most of western Bathurst, Byam Martin and southern Melville Islands. The base of the type section is 11.3 km northeast of Beverley Inlet, on southeastern Melville Island.

The Hecla Bay Formation consists predominantly of white or grey, quartzose, cross-bedded sandstone and unconsolidated sand. Siltstones and shales also occur at some places, such as in the lower few hundred metres east of Weatherall Bay. The Hecla Bay Formation conformably overlies the Strathcona Fiord Formation in the eastern Arctic, the Bird Fiord Formation on Bathurst Island, and the Weatherall Formation to the west. Embry and Klovan (1976) drew the basal contact at the level above which white, fine grained sandstone becomes common.

Plant fragments are common in the Hecla Bay Formation, particularly in the siltstones and shales. Most of them are fragmentary and of no use for age determination. No marine fossils have been found. According to Chi and Hills (1976) the Hecla Bay Formation east of Weatherall Bay contains spores of the **delicatus** Zone, to which they assign a Givetian age. As for the other ages based on the investigation of Chi and Hills, this one has a rather tenuous basis as most of their species are new, and spores with well-established stratigraphic ranges are not present.

## AGE AND CORRELATION OF SPORE ASSEMBLAGES

The biostratigraphic and paleogeographic significance of the Middle and Upper Devonian miospores of the Franklinian clastic belt will be discussed in detail in a later report. However, it seems appropriate to include here a summary of the ages and correlations indicated by the spores that are described in the present paper.

Text-figure 7 shows the stratigraphic ranges of all the taxa described herein in the section east of Weatherall Bay, and the samples from which each was recovered. Three broadly defined assemblages are apparent. The oldest occurs in the Cape De Bray Formation and the lower half of the Weatherall Formation. It is characterized by a complex of small-spined species of **Ancyrospora** that do not occur higher in the section, and that are similar to species described by Riegel (1973) from latest Emsian and early Eifelian strata of the Rhineland, e.g. **A.** sp. cf. **A. nettersheimensis, A. eurypterota**?, and **A. kedoae.**

In the same beds there are also many species of the typical Eifelian-Givetian Old Red Sandstone spore flora, e.g. **Grandispora velata, Rhabdosporites langii, Acinosporites acanthomammillatus, A. macrospinosus, Densosporites devonicus, Corystisporites multispinosus, Retusotriletes rugulatus,** and **Anapiculatisporites petilus.** These species enter the geological record in the early to middle Eifelian in the region extending from eastern Alaska through arctic and eastern Canada, western Europe and the central and northern European USSR. Together with the distinctive ancyrospores mentioned above, they are convincing evidence for an early Eifelian to mid-Eifelian age for the Cape De Bray Formation and the lower part of the Weatherall Formation east of Weatherall Bay.

In the upper ca. 450 m of the Weatherall Formation, and the lower ca. 400 m of the Hecla Bay Formation, the characteristic species of the Middle Devonian Old Red Sandstone spore assemblage persist. In addition, species of **Verrucosisporites (V. scurrus, V.premnus, V. tumulentis), Convolutispora (C. tegula, C. porcata, C. subtilis, C. crassata**?), and **Densosporites (D. concinnus, D. devonicus, D. inaequus)** are numerically dominant, and **Lophotriletes devonicus, Retispora archaelepidophyta, Camarozonotriletes** spp. and **Cristatisporites albus**? are common. The assemblage in this part of the section is clearly late Eifelian to early Givetian, based on comparison with remarkably similar assemblages of this age from eastern Canada (McGregor and Camfield, 1976), Scotland (Richardson, 1965), the Rhineland (Riegel, 1973 and personal communication; Tiwari and Schaarschmidt, 1975) and the European USSR (Arkhangelskaya, 1976).

In the type area of the Eifelian Stage, the Eifelian-Givetian boundary occurs well above the highest records of **Ancyrospora kedoae** and **A. eurypterota,** and the lowest records of **Acinosporites macrospinosus, Corystisporites**

**multispinosus**, and **Densosporites devonicus** (Riegel, 1973, 1975). On southeastern Melville Island it may occur close to, probably slightly below, the first records of **Cymbosporites magnificus** (= **C. cyathus**), according to McGregor (in press). Therefore, considering the ranges of these species to the east of Weatherall Bay, it seems reasonable to place the Eifelian-Givetian boundary provisionally high in the Weatherall Formation, as shown in text-figure 7.

The Weatherall Formation is thus largely, if not entirely, Eifelian on eastern Melville Island. This conclusion is at variance with the earlier opinions of McGregor and Uyeno (1972), Chi and Hills (1976) and others (see Table 1), but rests on more detailed evidence than was available to them.

A third distinct assemblage begins in the upper 100 m of the studied section, with the incoming of a flood of **Geminospora** spp. and a diversification of **Cymbosporites.** In other parts of the Old Red Sandstone region, geminospores of the **G. micromanifesta** (= **G. lemurata, G. svalbardiae**) type enter the geological record in the early Givetian (Raskatova, 1974; McGregor, 1979b). In the Robertson Anticline section of southeastern Melville Island, geminospores of this type begin in the highest beds of the Weatherall Formation, 157 m above mid to latest Eifelian conodonts, whereas the spores in the upper part of the overlying Hecla Bay Formation are close to the Givetian-Frasnian boundary in age (McGregor, in press). The part of the Hecla Bay Formation east of Weatherall Bay that we have studied represents about the lower two-thirds of the formation. Considering the above, it is probably early and middle Givetian in age.

In summary, the Cape De Bray, Weatherall and lower Hecla Bay formations east of Weatherall Bay represent an age range of early Eifelian to probably mid-Givetian. The Eifelian-Givetian boundary probably lies in the upper beds of the Weatherall Formation on eastern Melville Island.

## SYSTEMATIC PALEONTOLOGY

### *Preservation and Designation of Types*

Each type and figured specimen has been given a GSC type number, which appears in the text and the plate legends. Each slide bears a plant locality number (shown also in text-figures 5, 6 and 7) followed by either a slide number (e.g. 8299-1) or, for single specimen mounts, a letter designation (e.g. 8299-A). Locations given in text for specimens on strew slides (e.g. 58.3 x 128) refer to stage coordinates of Leitz Ortholux microscope 569332. Type and figured specimens are in the GSC Type Collection in Ottawa. All other specimens upon which the taxonomic descriptions are based are also in Ottawa and are available for examination.

### *Descriptive Procedure*

In this report we follow the practice begun in an earlier paper (McGregor and Camfield, 1976), that of arranging taxonomic descriptions alphabetically by genus rather than according to arbitrarily devised suprageneric categories.

New species are based on study of thirteen or more adequately preserved specimens. Specimen diameters are maximum diameters measured in the equatorial plane on intact, relatively undistorted spores, and unless stated to the contrary do not include the dimensions of equatorially projecting sculpture.

Throughout this study we have been conscious of the difficulty in discriminating between certain types of exinal corrosion and true sculpture. Some types of alteration, such as pyrite pitting, are relatively easily distinguished from reticulate sculpture, but other types, such as erosionally- or degradationally-induced surface granulation or punctation, may be virtually indistinguishable from granular, scabrate or foveolate sculpture unless only part of the wall is corroded (e.g. McGregor, 1977, pl. 2, fig. 12). Excessive laboratory treatment also may severely alter exinal sculpture (see Cramer, 1969, p. 436). We emphasize these effects because, although some workers have recognized and described the effects of physical damage, oxidation, or biological degradation on morphological features of palynomorphs (e.g. Neves and Sullivan, 1964; Havinga, 1971; Frederiksen, 1978), others have included corrosion-induced features or those suspected to be so in taxonomic descriptions, and new taxa have even been erected on the basis of specimens that appear to have been strongly altered (e.g. **Tholisporites punctatus** McGregor, 1960; **Dibrochosporites** Urban, 1968; **Radiatispinospora** Bharadwaj et al., 1973; **Dictyotriletes sphaericus** Kimyai, 1979). In this study we have not based new taxa primarily on specimens from the Cape De Bray Formation and the lowest beds of the Weatherall Formation, as spores in this part of the section are relatively poorly preserved. However, preservation commonly is good enough even in these beds to permit identification of existing species with confidence.

We have used a question mark to convey imprecision of identification, as follows: preceding the binomial, to indicate that the whole identification is questioned; following the generic name, to indicate that the generic assignment is in doubt; and following the trivial name, to indicate that the specific identification is questioned.

The subheading "Description" as used below signifies description of the taxonomically significant features of specimens recovered from the Weatherall Bay section. The subheading "Diagnosis" signifies statement of taxonomically significant features of new taxa only. We consider that a separate "Description" in addition to the diagnosis of new taxa, as practiced by some authors, is unnecessarily repetitive and contains information that could properly be included under "Diagnosis", "Comparisons", or "Remarks".

Incorrect orthography has been corrected, e.g. **Grandispora longus** has been changed to **G. longa,** except where use of the incorrect variant is necessary in the context or in synonymy.

The terms "intexine", "intexinal body", and "exoexine", used herein for convenience in the description of the walls of camerate spores, are applied without any implication of analogy or homology with the wall layers of Recent pollen or spores.

Stratigraphic ranges given in the pages that follow refer only to local ranges in the section east of Weatherall Bay.

### *List Of Species*

The following species have been identified in the section east of Weatherall Bay:

**Acinosporites acanthomammillatus** Richardson
**A. hirsutus** (Brideaux and Radforth) n. comb.
**A. lindlarensis** Riegel var. **lindlarensis**
**A. macrospinosus** Richardson
**Anapiculatisporites petilus** Richardson
**Ancyrospora ampulla**? Owens
**A. ancyrea** (Eisenack) Richardson var. **ancyrea**
**A. ancyrea** (Eisenack) Richardson var. **brevispinosa** Richardson
**A. angulata** (Tiwari and Schaarschmidt) n. comb.
**A. eurypterota**? Riegel
**A. kedoae** (Riegel) Turnau
**A. loganii** McGregor

**A. longispinosa** Richardson
**A.** sp. cf. **A. nettersheimensis** Riegel
**Apiculatasporites brevidenticulatus** (Chibrikova) n. comb.
**A. microconus** (Richardson) n. comb.
**A. perpusillus** (Naumova ex Chibrikova) McGregor
**Apiculiretusispora densiconata** Tiwari and Schaarschmidt
**A. leberidos** n. sp.
**Archaeozonotriletes timanicus** Naumova
**A. variabilis** Naumova emend. Allen
**Auroraspora micromanifesta** (Hacquebard) Richardson
**Baculatisporites semilucensis** (Naumova) n. comb.
**Calamospora atava** (Naumova) McGregor
**Camarozonotriletes antiquus** Kedo
**C. laevigatus** n. sp.
**C. mosolovicus** Naumova ex Kedo
**C.? notatus** (Owens) n. comb.
**C. parvus** Owens
**C. pusillus** Naumova ex Chibrikova
**Ceratosporites** sp. cf. **Acanthotriletes multisetus** (Luber) Richardson var. **multisetus**
**Convolutispora crassata**? (Naumova) n. comb.
**C. porcata** n. sp.
**C. subtilis** Owens
**C. tegula** Allen
?**Corystisporites collaris** Tiwari and Schaarschmidt
**C. multispinosus** Richardson var. **multispinosus**
**C. multispinosus** Richardson var. **spinulosus** n. var.
**C. serratus**? (Naumova) n. comb.
**C.** sp. cf. **Acanthotriletes horridus** Hacquebard
**Craspedispora arctica** n. sp.
**Cristatisporites albus**? (Arkhangelskaya) n. comb.
**C.** sp.
**Cyclogranisporites amplus**? McGregor
**Cymbosporites magnificus** (McGregor) n. comb.
**C.? opacus** n. sp.
**C.** sp. cf. **Retusotriletes tschibrikovii** Mikhailova
**C.** sp.
**Deltoidospora** sp.
**Densosporites concinnus** (Owens) n. comb.
**D. devonicus** Richardson
**D. inaequus** (McGregor) n. comb.
**D. weatherallensis** n. sp.
**Diatomozonotriletes franklinii** n. sp.
**D. oligodontus**? Chibrikova
**Dibolisporites antiquus**? (Naumova ex Kedo) n. comb.
**D. echinaceus** (Eisenack) Richardson
**D. farraginis** n. sp.
**D. uncatus** (Naumova) n. comb.
**D. vegrandis** n. sp.
**Emphanisporites annulatus**? McGregor
**E. rotatus** McGregor
**Geminospora? bislimbata** (Chibrikova) n. comb.
**G. micromanifesta** (Naumova) n. comb. var. **minor** Naumova
**G. micropaxilla** (Owens) n. comb.
**G. tuberculata** (Kedo) Allen var. **micrornata** n. var.
**G. tuberculata** (Kedo) Allen var. **tuberculata**
**G. venusta**? (Naumova) n. comb.
**G. verrucosa** Owens
**G.** sp.
**Grandispora douglastownense** McGregor
**G. eximia** (Allen) n. comb.
**G.** sp. cf. **G. eximia** (Allen) n. comb.
**G. inculta** Allen
**G. longa** Chi and Hills
**G. mammillata** Owens
**G. megaformis** (Richardson) McGregor
**G. protea** (Naumova) Moreau-Benoit
**G. tiwarii** n. name
**G. uyenoi** n. sp.
**G. variospinosa** n. sp.
**G. velata** (Eisenack) Playford
**G.** sp. 1
**G.** sp. 2
**G.** sp. 3
**Granulatisporites muninensis**? Allen
**G.** sp.
**Hystricosporites costatus** Vigran
**H. gravis** Owens
**H. setigerus**? (Naumova ex Kedo) Arkhangelskaya
**H.** sp. A of Owens
**Kraeuselisporites acerosus** (Arkhangelskaya) n. comb.
**K. ollii**? (Chibrikova) n. comb.
**K. rugosus** (Owens) n. comb.
**K. spinutissimus**? (Naumova ex Kedo) n. comb.
**Laevigatosporites** sp.
**Lophotriletes devonicus** (Naumova ex Chibrikova) n. comb.
**Perotrilites bifurcatus** Richardson
**P. ergatus**? Allen
**P. heclaensis** n. sp.
**P. selectus** (Arkhangelskaya) McGregor and Camfield
**Punctatisporites inspissatus** (Owens) n. comb.
**P.** sp. cf. **P. solidus** Hacquebard
**Retispora archaelepidophyta** (Kedo) n. comb.
**R** sp.
**Retusotriletes dubiosus** McGregor
**R. pychovii** Naumova
**R. rotundus** (Streel) Streel
**R. rugulatus** Riegel
**Rhabdosporites langii** (Eisenack) Richardson
**R.** sp. cf. **R. parvulus** Richardson
**R.** sp.
**Verruciretusispora dubia** (Eisenack) Richardson and Rasul
**Verrucosisporites premnus** Richardson
**V. scurrus** (Naumova) n. comb.
**V. tumulentis** Clayton and Graham

***Systematic Descriptions***

Genus **Acinosporites** Richardson 1965

Type species. **Acinosporites acanthomammillatus** Richardson 1965

The various forms of spinose spores without equatorial extensions that have been encountered in this investigation constitute an intergrading complex that is difficult to subdivide. **Acinosporites** and **Corystisporites,** the most appropriate genera to which specimens of the complex may be assigned, contain species with similarly constructed spines. Both include species with a high, membranous apical prominence. The "concertina-like folds" present on the holotypes of **A. acanthomammillatus** and **A. macrospinosus** were, justifiably, not included in the diagnosis of the genus by Richardson (1965), as they are not present in some species of **Acinosporites,** and they are commonly only discernible on the best-preserved specimens of species in which they do occur. The only feature explicit in the diagnosis of **Acinosporites** that serves to distinguish it from **Corystisporites** is the presence of distal exinal ridges.

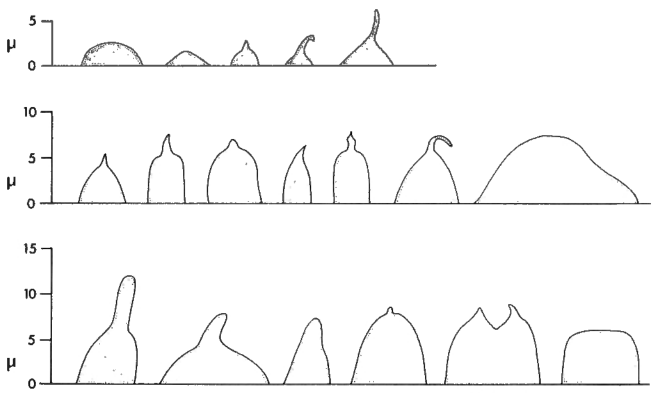
The Weatherall Bay section contains specimens with variably developed distal ridges, and those apparently without ridges, that appear otherwise identical. The presence and prominence of ridges apparently is to some degree a function of the spacing of the spines and of preservation, which further complicates the definition of genera and species within the complex.

For example, specimens like **Acinosporites macrospinosus,** but in which the ridges are intermittently developed or not clearly defined intergrade with large-spined forms of **Corystisporites multispinosus** var. **multispinosus.** We have attempted to follow Richardson (1965) as closely as possible, but the problems of speciation within this complex are still not satisfactorily resolved.

**Acinosporites acanthomammillatus** Richardson
Plate 1, figures 1-6, text-figure 8

1965 **Acinosporites acanthomammillatus** Richardson, p. 577, Pl. 91, figs. 1, 2, text-fig. 6.
1972 ?**Spelaeotriletes** sp.; McGregor and Uyeno, Pl. 2, fig. 8.
non 1977 **Acinosporites acanthomammillatus** Richardson; Stapleton, p. 434, Pl. 2, fig. 5.

Description. Spores trilete with rounded subtriangular or subcircular amb. In lateral compression, proximal side flattened, distal side ±hemispherical. Laesura arms hidden by straight or sinuous, membranous, triradiate ridges up to 28 μm high at the pole, tapering toward the equator. Contact areas thin, and levigate or minutely scabrate. Proximal-equatorial and distal regions of considerable (but undetermined) thickness, bearing verrucae and biform elements 2-10 μm (rarely up to 13 μm) in length and basal width. Most sculptural elements surmounted by a cone or spine 0.5-5 μm long. Ornaments of fairly uniform size on each specimen, closely crowded, commonly fused basally into anastomosing ridges, may be more loosely spaced at the equator, but tend to be joined at the outer extremity of the contact areas (= the "concertina-like folds" of Richardson, 1965, p. 577). A thin central body is visible in some specimens (Pl. 1, fig. 4).




*Text-figure 8: Sculptural elements of* ***Acinosporites acanthomammillatus****, lateral view. This figure, like text-figures 9-97, is a composite based on several specimens. It is not intended to represent the range of sculpture observed on any single designated specimen.*

Diameter. 65-142 μm, mean 96 μm (79 specimens).

Occurrence. Figured specimens: Plate 1, figure 1, loc. 8321, slide 2, 65.4 x 125.6, GSC 66187; Plate 1, figures 2, 3, loc. 8318, slide 1, 51.2 x 116.2, GSC 66188; Plate 1, figure 4, loc. 8321, slide 2, 42.7 x 127.5, GSC 66189; Plate 1, figures 5, 6, loc. 8334, slide A, GSC 66272. Stratigraphic range, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 42).

Remarks. In his description of **A. acanthomammillatus**, Richardson (1965) says: "Exine . . .bears contorted anastomosing ridges . . .Superimposed on the ridges are rounded verrucae . . .surmounted by slender cones or spines . . .". We have interpreted the sculpture of the Weatherall specimens as primarily of verrucae, the bases of which commonly are confluent, forming ridges. Text-fig. 6 of Richardson (1965) does not appear inconsistent with this interpretation. This difference in interpretation is entirely a matter of emphasis; we see the verrucae, not the ridges, as the primary sculptural type, an interpretation gained from the several species without ridges that intergrade with extreme forms of **A. acanthomammillatus**.

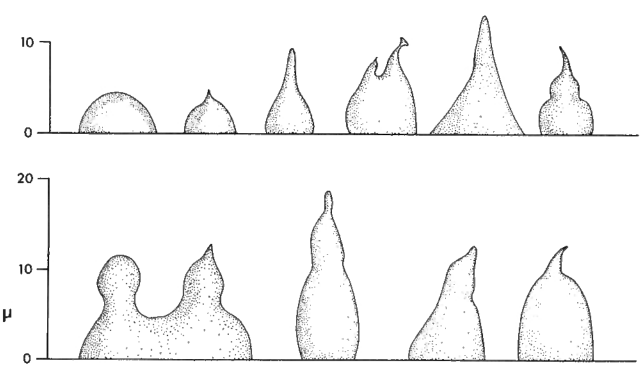
Comparisons. The sculptural elements of **Acinosporites hirsutus** are longer than those of **A. acanthomammillatus** and are mostly longer than wide. Those of **Cymbosporites magnificus** are smaller and of lower equatorial profile. Extreme forms of both species intergrade with extremes of **Acinosporites acanthomammillatus. Samarisporites hesperus** Allen (1965) is smaller and is described as cingulate. The cingulum is not visible in Allen's photographs (his Pl. 98, figs. 12-15) however, and **S. hesperus** at least superficially resembles small-sculptured variants of **Acinosporites acanthomammillatus.**

**Cristatisporites albus**? (Arkhangelskaya) n. comb. has a dark concentric ring and an equatorial extension. However, extreme forms of **C. albus**? with a relatively narrow equatorial extension and an indistinct concentric ring form an intergradational link with extreme variants of **A. acanthomammillatus.**

**Acinosporites hirsutus** (Brideaux and Radforth) n. comb.
Plate 1, figures 7, 8, 12, 13, text-figure 9

1965 **Acinosporites** sp. A; Richardson, p. 579, Pl. 91, fig. 9.
1970 **Corystisporites hirsutus** Brideaux and Radforth (pars), p. 36, fig. 19.
? 1974 **Acinosporites** sp., aff. **A. macrospinosus** Richardson; Bär and Riegel, Pl. 1, fig. 6.

Description. Spores trilete with subcircular, subtriangular, or oval amb. In lateral plane, distal side subhemispherical, proximal side flattened. Thin inner body present but indistinct in most specimens. Trilete mark paralleled and hidden by a membranous triradiate apical prominence up to 20 μm high. Exoexine as much as 10 μm thick equatorially, and of considerable (but undetermined) thickness distally. Exoexine levigate, scabrate or minutely granulate proximally, with low and narrow ±radially oriented ridges or folds occupying the interradial sectors of some specimens. Distal and equatorial regions densely set with ornaments that are joined in ridges and vary greatly in form and size. A specimen may bear mammae, verrucae, coni, or ±parallel-sided ornaments, most of them surmounted by a small cone, spine, bulbous thickening, or anchor-tipped extension. Sculptural elements range from 4 μm to 21 μm in total length and from 3.5 μm to 10 μm wide at base. Most are longer than their basal width. The largest elements commonly occur at or near the equator.




*Text-figure 9: Sculptural elements of* ***Acinosporites hirsutus****, lateral view.*

Diameter. 59-113 μm, mean 86 μm (28 specimens).

Occurrence. Figured specimens: Plate 1, figures 7, 8, 13, loc. 8320, slide 1, 34.2 x 123.5, GSC 66190; Plate 1, figure 12, loc. 8319, slide 0, GSC 66191. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 71).

Table 3

Descriptive parameters of **Acinosporites macrospinosus** Richardson (1965) and morphologically related species, according to original diagnosis

| | | | Spines | | | | |
|---|---|---|---|---|---|---|---|
| Species | Y-mark | Diameter (µm) excl. spines | length (µm) | spacing (µm) | other | Other ornamentation | Other features |
| **Acinosporites macrospinosus** Richardson 1965 | membranous apical prominence 21-52 µm high | 80-160 | 10-50 | | stout often swollen bases, pointed apices | anastomosing convolute ridges | concertina-folds around contact areas |
| **Corystisporites hirsutus** Brideaux & Radforth 1970 | sinuous low membranous ridges | 58-110 | 10-30 | may be joined at base | irregular in shape, may be expanded at base or near tip | may bear low scattered convolute ridges with small spines | |
| **Corystisporites multispinosus** Richardson 1965 | contorted membranous ridges 20-32 µm high | 70-144 | 6-13 (15-18 on holotype) | 20-53 at equ., in ±concentric rows, may be fused in groups | often swollen at base; tips pointed, blunt or slightly expanded | | |
| **Corystisporites collaris** Tiwari & Schaarschmidt 1975 | raised to form elevation (12-18 µm high in holotype) | 54-75 | 10-24 | close | pointed, most with swelling about mid-length | | |
| **Corystisporites robustus** Brideaux & Radforth 1970 | folded membranous ridges up to 20 µm high | 66-135 | 10-60 | | pointed, usually basally bulbous, gradually tapered, may be in clusters | low interconnected ridges | |

Comparisons. The holotype of **Corystisporites hirsutus** Brideaux and Radforth (1970) is identical to the specimens assigned to this species from Melville Island. The specimen illustrated in figure 17 of Brideaux and Radforth (1970) is **Acinosporites macrospinosus** Richardson.

**A. hirsutus** is intermediate in structure between **A. acanthomammillatus** and **A. macrospinosus.** It appears to lack the "concertina-like folds" evident at the equator of these species. It is further distinguished from **A. acanthomammillatus** by its more elongate spines, and from **A. macrospinosus** by its shorter, less uniformly tapered spines and its more prominently developed equatorial and distal ridges (see also Riegel, 1973, p. 90).

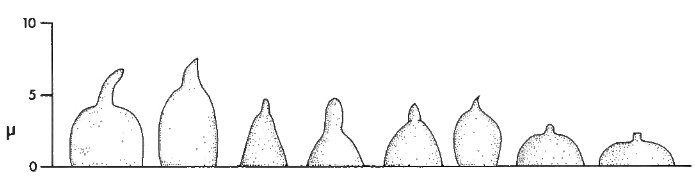
**Acanthotriletes bucerus** Chibrikova (1959) is smaller, and lacks folds along the triradiate mark.

**Acinosporites lindlarensis** Riegel var. **lindlarensis**
Plate 1, figures 9, 10, text-figure 10

1968 **Acinosporites lindlarensis** Riegel, p. 89, Pl. 19, figs. 11-16.
? 1975 **Cymbosporites cyathus** Allen; Tiwari and Schaarschmidt (pars), Pl. 15, fig. 4.

For additional synonymy see McGregor and Camfield (1976), p. 6.

Description. Trilete, camerate miospores with subcircular or oval, rarely rounded subtriangular amb. Exoexine closely appressed to, or slightly separated from, the intexine. Laesura arms extend to or almost to equator, simple or with narrow lips or folds about 2 µm in total width at pole, tapered toward equator. Intexine levigate. Exoexine proximally levigate or with small coni 0.5-1.5 µm at base, about 1 µm high, the larger ones occurring toward the outer extremity of the contact area. Sculptural elements of equatorial and distal regions biform, with roundly expanded or conical bases 1.5-6 µm wide, up to 7 µm long, tapered gradually or abruptly into a spine or baculum 1-4 µm long, or more commonly rounded at the apex and surmounted by a granule or cone, rounded or polygonal in plan view, discrete and closely spaced, or joined at base to adjacent elements forming ridges of varied length. The largest sculptural elements occur subequatorially at the outer limit of the contact areas. Size of sculptural elements fairly constant on any one specimen.




*Text-figure 10: Equatorial and distal sculptural elements of* ***Acinosporites lindlarensis*** *var.* ***lindlarensis.***

Diameter. 58-112 µm, mean 82 µm (19 specimens).

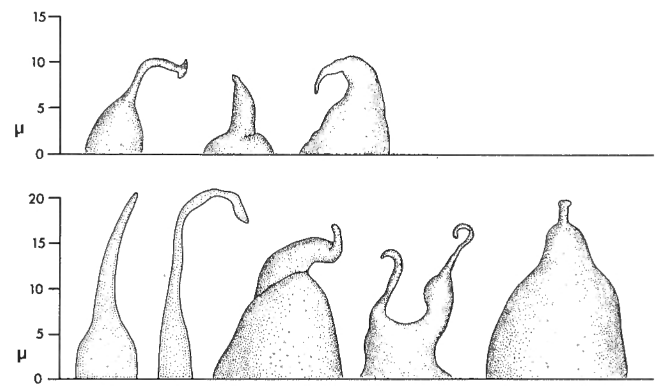
Occurrence. Figured specimen, loc. 8321, slide 2, 36.9 x 110.2, GSC 66192. Stratigraphic range, Cape De Bray, Weatherall, and lower Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 17).

Remarks. See discussion of this species in McGregor and Camfield (1976), p. 6-7.

**Acinosporites macrospinosus** Richardson
Plate 1, figures 11, 14, 15, 16, text-figure 11

1965 **Acinosporites macrospinosus** Richardson, p. 578, Pl. 91, figs. 3-6.
1970 **Corystisporites robustus** Brideaux and Radforth, p. 35, fig. 18.
1970 **Corystisporites hirsutus** Brideaux and Radforth (pars), p. 36, fig. 17.
? 1973 **Corystisporites multispinosus** Richardson; Riegel, p. 86, Pl. 11, fig. 12.
? 1975 **Corystisporites multispinosus** Richardson; Tiwari and Schaarschmidt (pars), p. 27, Pl. 5, fig. 6.
? 1975 **Corystisporites collaris** Tiwari and Schaarschmidt, p. 28, Pl. 6, figs. 2-5.

Description. Trilete spores with subtriangular to subcircular amb. Trilete rays extend to equator, accompanied by a membranous apical prominence that is highest at the proximal pole and tapers toward the equator. Proximal area apparently levigate but difficult to see owing to the coarse distal sculpture. Distal and equatorial regions with irregularly shaped spines, about 2-15 µm wide at base, about 10-40 µm long, tapered gradually or abruptly to a fine point or hair-like tip or, rarely, a minute bifurcation. Some spines are slightly constricted at about the mid-point of their length, and some bear a node-like swelling near the tip. Spines closely spaced with bases confluent, especially at the outer edges of the contact areas (= the 'concertina' folds of Richardson, 1965), or more widely spaced with their bases discrete or joined by low ridges that form a loose, irregularly reticulate pattern.




*Text-figure 11: Sculptural elements of* ***Acinosporites macrospinosus,*** *lateral view.*

Diameter. 63-126 µm, mean 91 µm (10 specimens).

Occurrence. Figured specimens: Plate 1, figure 11, loc. 8308, slide 2, 38.5 x 111.9, GSC 66193; Plate 1, figure 14, loc. 8308, slide 12, 54.8 x 115.5, GSC 66194; Plate 1, figures 15, 16, loc. 8311, slide J, GSC 66195. Stratigraphic range, Weatherall and lower Hecla Bay formations, mid-Eifelian to lower Givetian (Fig. 7, no. 58).

Comparisons. Selected descriptive parameters of **Acinosporites macrospinosus** and morphologically related species are compared in Table 3. From this comparison we conclude that **Corystisporites robustus** is in practice indistinguishable from **A. macrospinosus.** Some of the original specimens of **A. hirsutus** (Brideaux and Radforth) n. comb. are more appropriately assignable to **A. macrospinosus,** as confirmed by examination of the specimen illustrated in fig. 17 of Brideaux and Radforth (1970).

**Corystisporites multispinosus** bears shorter, commonly more slender, less variously-shaped spines. Most specimens of **C. multispinosus** may be distinguished from **A. macrospinosus** by the lack of distal exinal ridges, but some bear ridge-like interconnections of spine-bases (cf. Richardson, 1965, p. 570), and are thus intergradational with **A. macrospinosus.** We have assigned such specimens to **C. multispinosus** on the basis of their shorter spines. At least some of the specimens assigned to **C. multispinosus** by Riegel (1973) evidently are of this transitional character.

Genus **Anapiculatisporites** Potonié and Kremp 1954

Type species. **Anapiculatisporites isselburgensis** Potonié and Kremp 1954.

According to the commonly accepted generic diagnosis of Potonié and Kremp (1954), **Anapiculatisporites** differs from **Acanthotriletes** principally in that the sculpture of the distal face rarely protrudes at the equator. The diagnoses of the two genera therefore overlap, as spores with equatorially-projecting sculpture would be acceptable in both. The diagnosis of **Anapiculatisporites** does however allow for a slightly broader range of sculptural variation than that of **Acanthotriletes,** in permitting both cones and spines rather than only spines (see Potonié and Kremp, 1954, p. 133).

Smith and Butterworth (1967, p. 160) attempted to eliminate the overlap in the definitions of these genera by emending **Anapiculatisporites.** However, in doing so, they departed rather significantly from the original diagnosis (see discussion in Playford, 1971, p. 16). Nevertheless, their diagnosis might be considered an acceptable resolution to the problem of distinguishing **Anapiculatisporites** from **Acanthotriletes** were it not for the fact that the status of the genus **Acanthotriletes** has recently been called into question by Jansonius (in Jansonius and Hills, 1976). According to Jansonius, the correct type species of the genus, "by combined description", is **Acanthotriletes primigenus** Naumova (1949), an acritarch, and not **A. ciliatus,** the neotype (a species of trilete spores) chosen by Potonié and Kremp (1954) without having examined Naumova's original material. Chibrikova (1963, p. 103) has confirmed that the supposed Cambrian trilete spores reported by Naumova (1949), and to which the name **Acanthotriletes** was first applied, are not trilete, and are probably planktonic (i.e. acritarchs). As the type species of **Acanthotriletes** is an acritarch, it follows that the original diagnosis, which stated that constituents of the genus are trilete, was based on a misinterpretation of the structure of the type material. The genus **Acanthotriletes** therefore needs to be redefined to conform with the structure of the type, and can no longer be applied to trilete spores. Accepting the above argument, one must find another generic repository for species heretofore placed in **Acanthotriletes.**

In fact, from the purist point of view, many if not most of the several dozen species that have been assigned to **Acanthotriletes** do not correspond to the genus as diagnosed either by Naumova (1949) or by Potonié and Kremp (1954). Both diagnoses stated that the wall is covered on all sides (including the contact areas) by closely-spaced spines. Few if any of the species of **Acanthotriletes** meet this requirement. In practice, most workers have ignored this aspect of the diagnosis, presumably on the tacit understanding that most trilete spores by virtue of their developmental history have either greatly reduced ornament or none in the contact areas.

The taxonomy of simple spinose spores in general is in a rather chaotic state. Taxonomic consideration of this problem should include assessment of all species now in **Acanthotriletes** and other genera of similar circumscription, e.g. **Ceratosporites** Cookson and Dettmann (1958); **Echinatisporis** Krutzsch (1959); **Saxosporis** Krutzsch (1963); **Acanthosporis** Madler (1964); **Spinosisporites** Luber (in Pokrovskaya, 1966). Such an undertaking is appropriate for a special study and is beyond the scope of this paper.

As the name **Acanthotriletes** is no longer available for trilete spores, we accept the diagnosis of **Anapiculatisporites** by Potonié and Kremp (1954) and the placement in it of species formerly included in **Acanthotriletes,** until such time as the whole problem of the taxonomy of simple spinose spores is resolved.

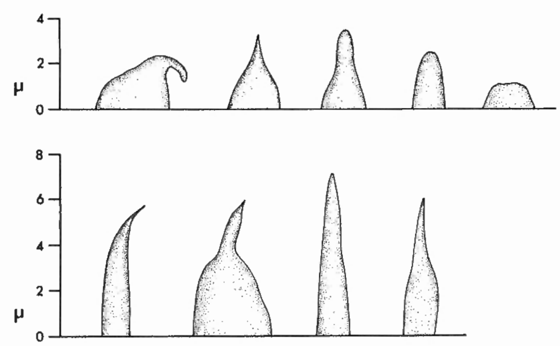
**Anapiculatisporites petilus** Richardson
Plate 2, figures 1, 2, text-figure 12

1965 **Anapiculatisporites petilus** Richardson, p. 571, Pl. 89, fig. 11.

1966 **Retusotriletes hastatus** Nadler, p. 58, Pl. 1, fig. 5.

non 1976 **Anapiculatisporites petilus** Richardson; Massa and Moreau-Benoit, Pl. 3, fig. 4.

Expanded diagnosis. Trilete spores with broadly subtriangular or subcircular amb. Trilete mark simple or with folds 2-3 μm wide and high bordering the laesura. Laesura arms 1/2-7/8 the radius in length. Contact areas levigate or scabrate, distal and equatorial regions bearing regularly-spaced, broad- or narrow-based spines that commonly are pointed at the tip. Spines 1-7 μm (commonly 2-4 μm) high, 0.5-1.5 μm (rarely up to 3 μm) wide at base, 2-6 μm apart. About 15-30 spines at equator. Wall 3-6 μm thick at equator and distally.




*Text-figure 12: Sculptural elements of **Anapiculatisporites petilus**, lateral view.*

Diameter. 36-68 μm, mean 50 μm (28 specimens).

Occurrence. Figured specimen, loc. 8321, slide 2, 57.5 x 121.8, GSC 66196. Stratigraphic range, Cape De Bray, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 21).

Comparisons. The specimens in the Weatherall Bay section differ from **A. petilus** as described by Richardson (1965, p. 571) in the base of some spines being as much as 2 μm wide, and in having more than 15 sculptural elements at the equator. Nevertheless, our specimens do conform to the formal diagnosis given by Richardson, and so we feel justified in including them in **A. petilus. Dibolisporites eifeliensis** (Lanninger) McGregor is thinner-walled and has commonly blunt or bifurcate-tipped sculpture.

Genus **Ancyrospora** Richardson 1960 emend. Richardson 1962

Type species. **Ancyrospora grandispinosa** Richardson 1960.

This genus has been emended by Richardson (1962) and Urban (1969), and "extended" by Turnau (1974). In this paper we follow Richardson's emendation, as we find that of Urban too detailed and restrictive. Turnau's interpretation

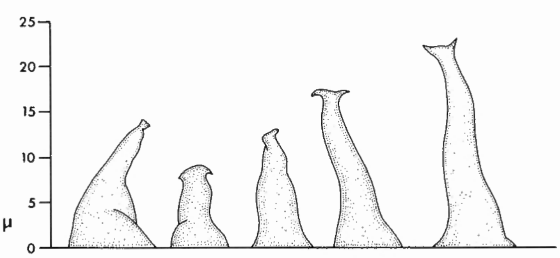
(1974, p. 151) may nevertheless be correct for some species now included in **Ancyrospora.** We agree with Urban that there has been an over-proliferation of species within this genus, and within the whole complex of spores with bifurcating processes. There are now about 35 species and varieties of **Ancyrospora** and about an equal number published in open nomenclature; more than 60 species of **Archaeotriletes** (mostly in Russian literature); at least 26 species of **Hystricosporites** and about an equal number in open nomenclature; and about 50 species of bifurcate-spined spores variously assigned to **Acanthotriletes, Archaeozonotriletes, Azonotriletes, Calyptosporites, Densosporites, Dicrospora, Grandispora, Hymenozonotriletes, Nikitinsporites, Ocksisporites, Perotrilites, Samarisporites,** and other genera.

A working group of the Commission Internationale de Microflore du Paléozoique is engaged in a study of all genera and species of anchor-spined spores, with the objectives of synthesizing the taxonomy of the group and clarifying the stratigraphic ranges of the constituent species. Because this working group is active, we believe it would be premature to enter into detailed discussion of synonymy or to attempt any taxonomic emendations here.

**Ancyrospora ampulla**? Owens
Plate 2, figures 3, 4, text-figure 13

? 1971 **Ancyrospora ampulla** Owens, p. 73, Pl. 24, figs. 1-4, text-fig. 13.

Description. Trilete, zonate spores with rounded subtriangular amb and intexinal body. Laesura arms obscured by high triradiate folds that extend nearly to the equator. Thickness of intexine and exoexine undetermined. Distal and equatorial regions bear prominent spinose processes with bifurcate tips. Processes 7-22 μm long, 4-9 μm wide at their base, mostly 4-10 μm apart, less commonly more closely spaced, rarely basally confluent with one or more adjacent processes. Processes evenly tapered from the base to 1-2.5 μm wide just below the tip, surmounted by a rather flat bifurcation 1.5-4 μm wide, less commonly sharply constricted in width just below the expanded anchor-tip. Processes compressed on the surface of the spore may appear to possess a bulbous base.




*Text-figure 13: Sculptural elements of* ***Ancyrospora ampulla*****?***, lateral view.*

Diameter. 144 μm; intexine 103 μm. (One specimen only.)

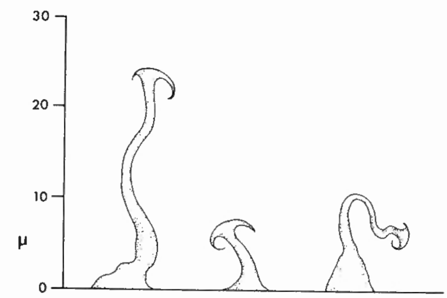
Occurrence. Loc. 8341, slide 8, 59.1 x 119.1, GSC 66197. Hecla Bay Formation, mid-Givetian (Fig. 7, no. 111).

Comparisons. Identity with **A. ampulla** Owens is questioned because the specimen lacks small spines between the processes, and the zona is not appreciably thickened adjacent to the intexine.

**Ancyrospora ancyrea** (Eisenack) Richardson var. **ancyrea**
Plate 2, figures 5, 6, text-figure 14

1962 **Ancyrospora ancyrea** (Eisenack) Richardson var. **ancyrea**, Richardson, p. 177, Pl. 25, figs. 6, 7, text-figs. 5, 6, 9C, 9E, 10B.

Description. Trilete, zonate spores with rounded subtriangular to subcircular amb. In lateral compression, proximal face flattened-pyramidal, distal hemisphere strongly convex. Laesura arms straight, about 1/2 the radius in length, commonly hidden by triradiate folds that form an apical prominence up to 29 μm high at the pole and taper toward the equator. Intexine not visible. Exoexine about 8-12 μm thick distally, extended laterally at the equator as a flange of varied width with a broadly scalloped margin, as if developed from the confluence of the broad-based equatorial spines. Distal and equatorial regions bear prominent spinose processes that bifurcate at their tips. Processes 6-40 μm (commonly 18-25 μm) long, arising from gently tapered or wide-conical (or less commonly from rounded) bases up to 8 μm wide, becoming slender and less strongly tapered toward the laterally extended, reflexed bifurcation at their tip.




*Text-figure 14: Sculptural elements of* ***Ancyrospora ancyrea*** *var.* ***ancyrea****, lateral view.*

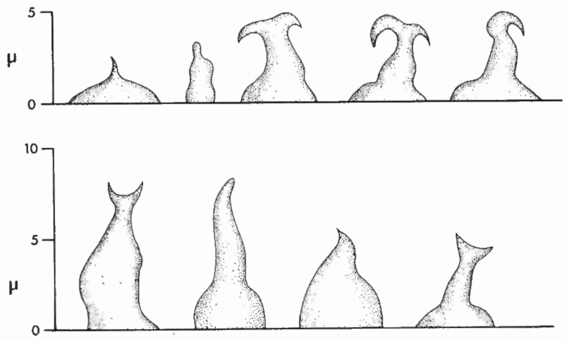
Diameter. 110-179 μm, mean 150 μm (7 specimens).

Occurrence. Figured specimens: Plate 2, figure 5, loc. 8331, slide 1, 43.2 x 121.8, GSC 66198; Plate 2, figure 6, loc. 8321, slide 1, 34.1 x 110.3, GSC 66199. Stratigraphic range, Weatherall and lower Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 33).

**Ancyrospora ancyrea** (Eisenack) Richardson
var. **brevispinosa** Richardson
Plate 2, figure 7, text-figure 15

1962 **Ancyrospora ancyrea** (Eisenack) Richardson var. **brevispinosa** Richardson, p. 179, Pl. 25, fig. 8, text-fig. 9A.

Description. Trilete, zonate spores with rounded subtriangular to subcircular amb. In lateral compression, proximal face flattened-pyramidal, distal face subhemispherical. Laesura arms 1/4 to 1/2 the radius in length, commonly hidden by fold-like lips about 2 μm in total width, up to 6 μm high at proximal pole. Intexine not visible. Exoexine dark, 4-9 μm thick, extended laterally at equator as a flange 2-10 μm wide. Flange of undetermined thickness, apparently thin but relatively rigid, rarely folded. Sculptural elements at equator on flange, and distally, consist of discrete processes 3-15 μm long, the longest near the distal pole, commonly 5-8 μm long at equator. Processes arise from a tapered or bulbous base up to 6 μm wide, or less commonly only slightly tapered from a base 1.5-2 μm wide. Tip of process pointed, or surmounted by a laterally extended bifurcation up to 6 μm wide. About 20-28 processes at equator.




*Text-figure 15: Sculptural elements of* ***Ancyrospora ancyrea*** *var.* ***brevispinosa****, lateral view.*

Diameter. 84-99 μm, mean 95 μm (9 specimens).

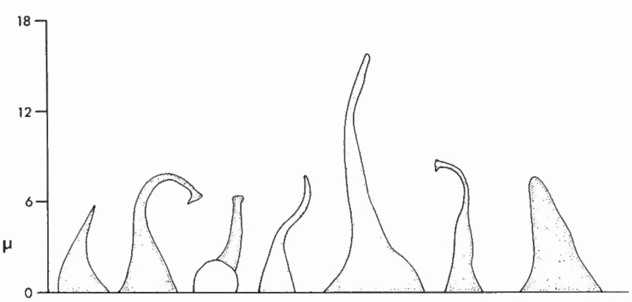
Occurrence. Figured specimen, Plate 2, figure 7, loc. 8335, slide 4, 68 x 116.4, GSC 66200. Stratigraphic range, upper Weatherall Formation and Hecla Bay Formation, upper Eifelian and lower Givetian (Fig. 7, no. 92).

Comparisons. **Perotrilites bifurcatus** Richardson has a thinner, less rigid zona and narrow-based processes.

**Ancyrospora angulata** (Tiwari and Schaarschmidt) n. comb.
Plate 2, figure 8, text-figure 16

1975 **Calyptosporites angulatus** Tiwari and Schaarschmidt, p. 44, Pl. 26, figs. 4, 5; Pl. 27, fig. 1; text-fig. 33.

Description. Trilete, zonate spores with subtriangular amb and subcircular intexinal body. Laesura arms paralleled and obscured by prominent triradiate folds of the exoexine that commonly extend beyond the body onto the zona. Exoexine extended laterally in the equatorial plane as a zona. Zona about two to four times wider opposite the rays than interradially. Intexinal wall commonly obscured by folding of the exoexine and concentration of sculpture at the inner edge of the zona. Contact areas levigate. Proximal-equatorial and distal regions bear spines 5-20 μm long, mostly 2-6 μm in basal width, and either so closely spaced that their bases are confluent, or up to 10 μm apart. Most spines evenly tapered from base to tip. Spine tips pointed, or bearing a minute anchor-like bifurcation 1-1.5 μm wide.




*Text-figure 16: Sculptural elements of* ***Ancyrospora angulata****, lateral view.*

Diameter. 103-154 μm (6 specimens).

Occurrence. Figured specimen, loc. 8308, slide 12, 60 x 121.4, GSC 66201. Stratigraphic range, sample 8308, lower Weatherall Formation, ?mid Eifelian (Fig. 7, no. 56).

Comparisons. **Ancyrospora** sp. cf. **A. nettersheimensis** (this paper) and **A. nettersheimensis** Riegel (1973) differ from **A. angulata** in the less pronounced differential width of the zona opposite the rays, the on average more widely spaced spines, and larger bifurcations on the spine tips. **A. nettersheimensis** differs additionally in possessing a faint equatorial limbus. **Hymenozonotriletes argutus** Naumova in Lanninger (1968) is at least superficially like **A. angulata** but lacks bifurcate spine-tips. **A. kedoae** (Riegel) Turnau (1974) has more broadly-based spines and a more pronouncedly scalloped zonal margin, and lacks radial widening of the zona.

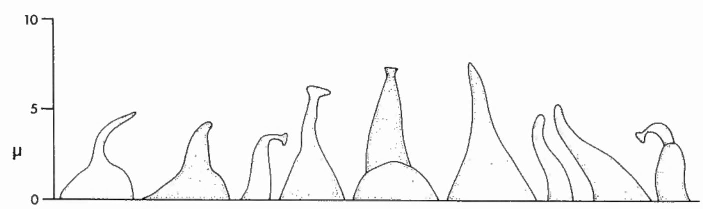
We wish to emphasize the gradational nature of the differences between **A. angulata** and structurally similar species such as **A.** sp. cf. **A. nettersheimensis.** We found too few specimens of these forms in the Weatherall Bay section to permit us to circumscribe precise specific differential diagnoses.

**Ancyrospora eurypterota**? Riegel
Plate 2, figures 11, 12, text-figure 17

? 1973 **Ancyrospora eurypterota** Riegel, p. 100, Pl. 17, figs. 1-5.

Description. Trilete, zonate spores with broadly convex-triangular amb. Laesura arms obscured by prominent triradiate fold-like lips of undetermined height, 8-14 μm wide, that extend radially essentially untapered onto the inner edge of the zona. Intexinal body thin, its outline commonly obscured by thickened wall and concentration of sculptural elements at inner edge of zona. Exoexine extended laterally at the equator as a zona about 1/3 radius in width, slightly wider radially than interradially, rarely folded, on some specimens bordered by a narrow exinal fold or limbus.

Sculpture confined to distal and equatorial regions, consists of spines 3-10 μm long, 2-9 μm wide at base, the longest and broadest-based occurring at the inner edge of the flange. Some spines bear minute, laterally expanded tips. Spines about 7-20 μm apart at equator, more closely spaced distally, and closely crowded in an imbricating ring at the inner edge of the flange.




*Text-figure 17: Sculptural elements of* ***Ancyrospora eurypterota****?, lateral view.*

Diameter. 124-220 μm, mean 156 μm (16 specimens).

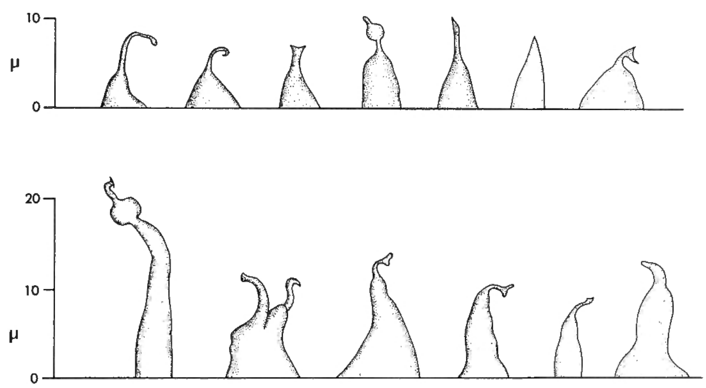
Occurrence. Figured specimens: Plate 2, figure 11, loc. 8308, slide 11, 58.1 x 128.9, GSC 66204; Plate 2, figure 12, loc. 8308, slide 7, 58.8 x 126.2, GSC 66205. Stratigraphic range, Cape De Bray Formation and lower Weatherall Formation, Eifelian (Fig. 7, no. 26).

Comparisons. The specimens from Melville Island differ from **A. eurypterota** from the Eifel region described by Riegel (1973) in having slightly larger sculptural elements that are most closely-spaced at the inner edge of the flange. **Calyptosporites microspinosus** Richardson (1962) has a less rigid exine that commonly bears folds that do not affect the intexine. It therefore appears to differ rather fundamentally from **Ancyrospora eurypterota**? in the manner of attachment of the intexine to the exoexine, and in the thickness of the exoexine (?"inner and outer sculptine" of Allen, 1965).

**Ancyrospora kedoae** (Riegel) Turnau
Plate 2, figures 9, 10, 13, text-figure 18

1968 **Hymenozonotriletes argutus** Naumova; Lanninger, p. 144, Pl. 24, fig. 15.
Non 1953 Naumova, p. 41, Pl. 4, fig. 10, or p. 67, Pl. 9, fig. 9.
1973 **Hymenozonotriletes kedoae** Riegel, p. 94, Pl. 15, figs. 1-3.
1974 **Ancyrospora kedoae** (Riegel) Turnau, p. 152, Pl. 4, figs. 1-3, 6, 7.

Description. Trilete, zonate miospores with subtriangular to subcircular amb. In lateral compression, proximal face flattened pyramidal, distal face rounded. Trilete laesura hidden by an apical prominence up to 15 μm high at the pole and 2-4 μm wide, extending to equator. Intexinal body darker than exoexine, visible in most specimens, levigate. Exoexine thin, extended laterally to form an equatorial zona with a strongly indented margin of varied width. Exoexine levigate proximally, drawn up equatorially and distally into broad based processes, most of which taper gradually or abruptly into one (rarely two) delicate apical extensions about 1-2 μm wide and 1-10 μm long, each with a pointed or minutely bifurcate tip. Sculptural processes 3-20 μm (most 4-10 μm) wide at base, and about 5-25 μm (most 8-14 μm) in total length (including apical extension), some with bulbous thickening in the upper half. The broadened bases of the processes are commonly joined to form the zona ("pseudoflange") equatorially and a loose reticulum of ridges distally.




*Text-figure 18: Sculptural elements of* ***Ancyrospora kedoae,*** *lateral view.*

Diameter. 85-206 μm, mean 124 μm (24 specimens).

Occurrence. Figured specimens: Plate 2, figures 9, 10, loc. 8311, slide C, GSC 66202; Plate 2, figure 13, loc. 8310, slide 1, 41.2 x 124.6, GSC 66203. Stratigraphic range, lower Weatherall Formation, Eifelian (Fig. 7, no. 44).

Comparisons. Not all of our specimens are flattened on one side in polar outline in the manner described by Riegel (1973). In other respects their similarity to **A. kedoae** is sufficiently close to justify inclusion in that species. **Acinosporites macrospinosus** rarely has bifurcate-tipped ornaments, and lacks an equatorial extension (zona). **Ancyrospora angulata** (Tiwari and Schaarschmidt, 1975) n. comb. is distinguished by "...the tendency of the angular development of the saccus," (op. cit. p. 45), a feature which however is not evident on all specimens of that species (op. cit. Pl. 26, fig. 5).

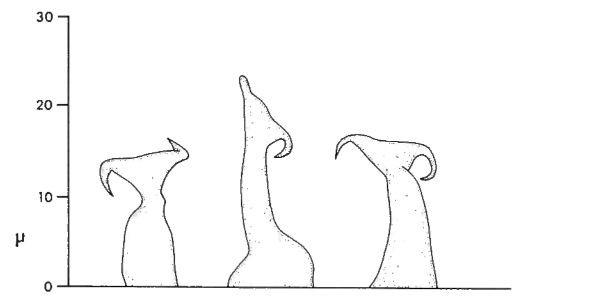
Remarks. It may be appropriate to separate generically forms such as **Ancyrospora kedoae,** with flange-like confluent spine bases (the "pseudoflange" of Richardson, 1962, p. 175), from those with a well-defined equatorial extension, such as **A. eurypterota.** Riegel (1973, p. 94) implied recognition of this difference by assigning the former to **Hymenozonotriletes.** We prefer not to use the name **Hymenozonotriletes,** however, because of the confusion surrounding its definition and application (see Playford, 1976, p. 36; Jansonius and Hills, 1976). Except for their flange-like confluent spine bases, species assigned here to **A. kedoae** are similar in general constitution to **Acinosporites.**

**Ancyrospora loganii** McGregor
Plate 3, figure 1, text-figure 19

1973 **Ancyrospora loganii** McGregor, p. 65, Pl. 9, figs. 6, 7, 10-12, text-fig. 38.

For additional synonymy, see McGregor (1973), p. 65.

Description. Trilete, zonate spores with subtriangular amb and subcircular inner body (intexine). Exoexine extended at the equator as a continuous zona 20-23 μm wide opposite the trilete rays. Intexine thin, darker than flange, its margin indistinct. Trilete mark not well defined. Distal and equatorial regions bear scattered, gently tapered processes 13-23 μm long, 2.5-5 μm (rarely up to 8 μm) wide at base, each process terminated by an expanded, laterally extended, and reflexed bifurcate tip 1/2 to 4/5 as wide as the total length of the process on which it is borne.




*Text-figure 19: Sculptural elements of* ***Ancyrospora loganii,*** *lateral view.*

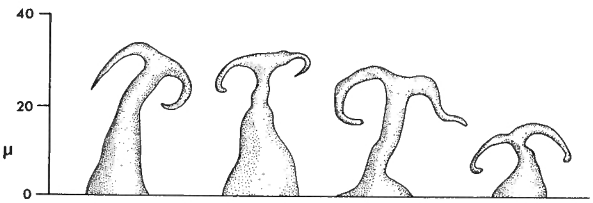
Diameter. 177 μm (one specimen).

Occurrence. Loc. 8300, slide 10, 37.8 x 122.9, GSC 66206, Cape De Bray Formation, lower Eifelian (Fig. 7, no. 11).

**Ancyrospora longispinosa** Richardson
Plate 3, figure 2, text-figure 20

1962 **Ancyrospora longispinosa** Richardson, p. 181, Pl. 26, figs. 1-3, text-fig. 8.

Description. Spores trilete with broadly subtriangular or subcircular amb. Laesura arms long, commonly obscured by prominent, convolute, fold-like labra that are up to 14 μm high at the pole and taper in width and height toward the equator. Intexine thin, indistinct in most specimens. The exoexine bears a deeply incised equatorial flange-like structure ("pseudoflange") of varied prominence, composed of the coalescent bases of the prominent spinose processes. Processes occur equatorially and distally, the coalescence of their bases commonly giving the impression of concentric arrangement. Individual processes are 10-33 μm wide at their base, up to 48 μm (commonly about 20-25 μm) long, typically tapered to their tip or to a relatively slender untapered shaft about 4-7 μm wide and terminated by a laterally extended, reflexed bifurcation 10-30 μm wide. Exoexine, including spine-bases, "spongy" (cf. Urban, 1969) or undifferentiated.




*Text-figure 20:* *Sculptural elements of* ***Ancyrospora longispinosa****, lateral view.*

Diameter. 130-195 μm, mean 156 μm (7 specimens).

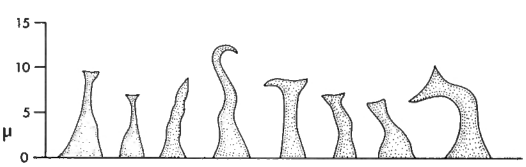
Occurrence. Figured specimen, loc. 8339, slide 4, 58.6 x 127.3, GSC 66207. Stratigraphic range, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 36).

Remarks. The exoexine may lack structural differentiation, or may have a sponge-like texture or a composition of coarse or fine subparallel, anastomosing rods, especially prominent in the spine-bases. Similar spongy and rod-like structure has been observed by others in several species of **Ancyrospora** (e.g. Guennel, 1963, p. 257; Vigran, 1964, p. 25-26), and has been incorporated into an emended diagnosis of the genus by Urban (1969). Whether this exinal composition is primary structure or the result of degradation is debatable. Some of the specimens we have assigned to **A. longispinosa** show it clearly; others show it prominently on some parts of the spore only; and others bear scarcely a trace of such texture. If it is a preservational feature, there seems no doubt that many species of **Ancyrospora** with a "pseudoflange" share the tendency to corrode in this characteristic fashion.

**Ancyrospora** sp. cf. **A. nettersheimensis** Riegel
Plate 3, figure 3, text-figure 21

cf. 1973 **Ancyrospora nettersheimensis** Riegel, p. 100, Pl. 17, figs. 6-8.

Description. Trilete, zonate miospores with subcircular or broadly subtriangular amb and central body. Laesura arms accompanied by an apical prominence that is up to 30 m high at the pole, and extends, decreasing in height, to or almost to the equator. Exoexine extended equatorially to form a zona about 1/4 to 1/3 the radius of the central body interradially, and somewhat wider at the ends of the rays. Proximal surface levigate or scabrate. Equatorial and distal regions ornamented with ±parallel-sided or moderately tapered spines 1-2.5 μm wide, commonly arising from a strongly tapered base up to 5 μm wide. Spines 5-15 μm long, most bearing a minute bifurcate termination about 2-5 μm wide. Spines 3-20 μm apart, and about the same size equatorially and distally, their broad basal portions imparting a slightly crenulate appearance to the equatorial outline.




*Text-figure 21:* *Sculptural elements of* ***Ancyrospora*** *sp. cf.* ***A. nettersheimensis****, lateral view.*

Diameter. 98-142 μm, mean 121 μm (12 specimens).

Occurrence. Figured specimen, loc. 8308, slide 11, 43.6 x 122.1, GSC 66208. Stratigraphic range, Cape De Bray and lower Weatherall formations, Eifelian (Fig. 7, no. 12).

Comparisons. **A. eurypterota**? is larger and bears smaller sculptural elements relative to the diameter of the spore. The specimens from the Weatherall Bay section are smaller than **A. nettersheimensis** Riegel (1973) and lack the faint limbus and foveolate to microreticulate sculpture of that species. In practice, however, it is difficult to separate the less well preserved specimens from **A. nettersheimensis**. **A. loganii** is larger with on average larger processes. In **A. angulata** the spines are smaller and more closely spaced, and the zona is markedly wider opposite the rays than interradially.

Genus **Apiculatasporites** Potonié and Kremp 1956

Type species. **Apiculatasporites spinulistratus** (Loose) Ibrahim 1933.

The genus **Apiculatasporites** has been subject to a number of interpretations, as a consequence of differing conceptions of the structure of the type species, and varied opinions as to its position vis-à-vis other genera (see Potonié, 1960, p. 38; Visscher, 1966, p. 328). **Apiculatasporites** Ibrahim (1933) sensu Potonié (1960) does not differ significantly from **Apiculatisporis** Potonié and Kremp (1956).

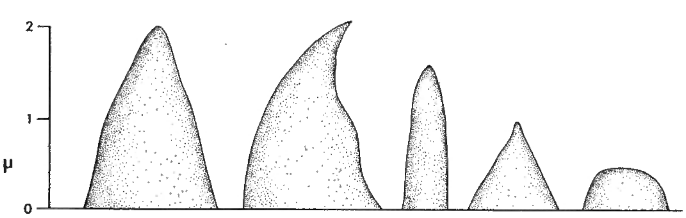
Visscher (1966) emended **Apiculatasporites** to include only specimens with sculptural elements 0.5-1.5 μm high, and in the process provided the first diagnosis of the genus since the original, now inappropriate, diagnosis of Ibrahim (1933). Nevertheless, as Visscher did not specifically distinguish it from **Apiculatisporis**, the confusion between the two genera remained. Smith and Butterworth (1967, p. 176) in a subsequent emendation of **Apiculatasporites** (without reference to that of Visscher, 1966) noted that the size of its sculptural elements is "...less than that of the ornament of **Apiculatisporis**", but did not state the size limits of the coni in either genus.

To be precise about the difference between these genera, we propose a differential diagnosis based on acceptance of the emendation of Visscher (1966), as well as the intent of Smith and Butterworth (1967). We accept both **Apiculatasporites** and **Apiculatisporis** as genera of subcircular, trilete spores bearing sculpture of rather regularly spaced coni. The character by which we propose to distinguish the two genera is the height of the majority of sculptural elements per specimen, 0.5-1.5 μm in **Apiculatasporites** and greater than 1.5 μm in **Apiculatisporis**.

**Apiculatasporites brevidenticulatus** (Chibrikova) n. comb.
Plate 3, figures 4, 5, text-figure 22

1962 **Retusotriletes brevidenticulatus** Chibrikova, p. 407, Pl. 5, fig. 7.

Description. Trilete spores with rounded subtriangular amb. Laesura arms 1/2 to 4/5 the radius in length, simple or accompanied by lips 0.5 to 1.5 μm in combined width, typically wider at the ends of rays than at pole. Curvaturae defined by faint arcuate ridges or proximal limit of sculpture. Wall about 1 μm thick, commonly with one or more arcuate folds. Contact areas levigate; distal and proximal-equatorial regions bearing grana, coni and small spinae 0.5-1.5 μm (less commonly 2 μm) high, 1.5 μm or less in basal width, 1-3 μm apart. Coni are the most common sculptural type.




*Text-figure 22:* *Sculptural elements of* ***Apiculatasporites brevidenticulatus****, lateral view.*

Diameter. 35-62 µm, mean 45 µm (30 specimens).

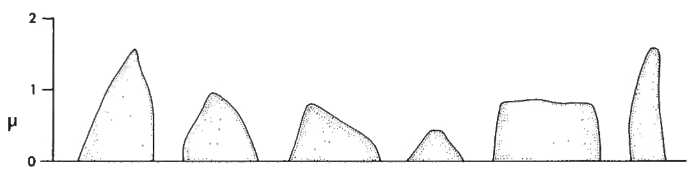
Occurrence. Figured specimen, loc. 8336, slide 1, 36.7 x 110.7, GSC 66209. Stratigraphic range, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 45).

Comparison. **Dibolisporites quebecensis** McGregor (1973) has predominantly biform sculptural elements, whereas the specimens we have assigned to **Apiculatasporites brevidenticulatus** have non-biform sculpture. Also, **D. quebecensis** has on average slightly larger sculptural elements. **Retusotriletes divulgatus** Chibrikova (1962) has larger ornaments that do not broaden toward the base. **R. aculeolatus** Chibrikova (1962) has smaller, apparently more closely-set sculptural elements.

**Apiculatasporites microconus** (Richardson) n. comb.
Plate 3, figure 10, text-figure 23

1965 **Apiculatisporis microconus** Richardson, p. 566, Pl. 89, fig. 3.
1967 **Apiculiretusispora microconus** (Richardson) Streel, p. 34.
1971 **Apiculatisporis microechinatus** Owens, p. 14, Pl. 2, figs. 4, 6, 7.

Expanded diagnosis. Trilete miospores with rounded subtriangular or subcircular amb. Laesura arms 1/2 to 3/4 radius in length, simple or with narrow lips. Wall about 1-1.5 µm thick, commonly folded. Contact area levigate, delimited by proximal limit of sculpture or rarely by faintly discernible curvatural ridges. Proximal-equatorial and distal regions bear grana, coni and spinae 0.5-1.5 µm high, 0.5-1.5 µm wide, about 1-2 µm apart.




*Text-figure 23: Sculptural elements of* ***Apiculatasporites microconus****, lateral view.*

Diameter. 68-160 µm, mean 109 µm (86 specimens).

Occurrence. Figured specimen, loc. 8320, slide M, GSC 66215. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 22).

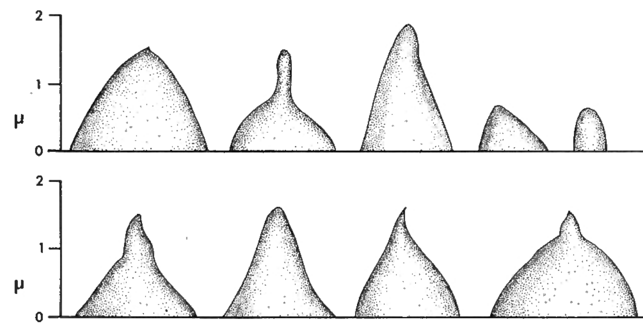
Comparisons. The holotype of **Apiculatisporis microechinatus** Owens is 112 µm in diameter, considerably larger than the stated range of diameter of that species. It can be accommodated well within the circumscription of **Apiculatasporites microconus.** We have found it impossible to distinguish other specimens of **Apiculatisporis microechinatus,** some with slightly larger sculpture, from **Apiculatasporites microconus** as defined, and prefer to include them in **A. microconus.** The diagnosis of **A. microconus** is accordingly expanded so as to include specimens with sculptural elements slightly exceeding 1 µm in size. **Retusotriletes aculeolatus** var. **major** Chibrikova (1962) is closely comparable to **Apiculatasporites microconus.** A possible difference, according to the description in Chibrikova (1962, p. 400), may be the greater prominence of its contact areas.

**Apiculatasporites perpusillus**
(Naumova ex Chibrikova) McGregor
Plate 3, figures 6, 7, text-figure 24

1959 **Acanthotriletes perpusillus** Naumova ex Chibrikova, p. 42, Pl. 1, fig. 9.

For additional synonymy, see McGregor (1973), p. 23.

Description. Trilete spores with rounded subtriangular to subcircular amb. Laesura arms 1/2-4/5 the radius in length, simple, commonly gaping. Wall 1-2 µm thick, commonly slightly thicker interradially, dark along rays in most specimens. Contact area levigate or with minute grana. Proximal-equatorial and distal regions with discrete blunt or pointed coni 0.5-2 µm apart, mostly less than 1.5 µm wide and high, less commonly up to 2 µm wide at their base. Sculptural elements largest near distal pole on some specimens.




*Text-figure 24: Sculptural elements of* ***Apiculatasporites perpusillus****, lateral view.*

Diameter. 19-30 µm, mean 23 µm (50 specimens).

Occurrence. Figured specimen, loc. 8335, slide 3, 42.8 x 112.7, GSC 66210. Stratigraphic range, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 35).

Comparisons. **Granulatisporites muninensis** Allen (1965) differs in possessing grana as well as coni, that are smaller and more closely spaced. **Lophotriletes devonicus** (Chibrikova) n. comb. is subtriangular with concave, straight, or only slightly convex interradial margins, and has larger sculptural elements.

Genus **Apiculiretusispora** Streel 1964 emend. Streel 1967

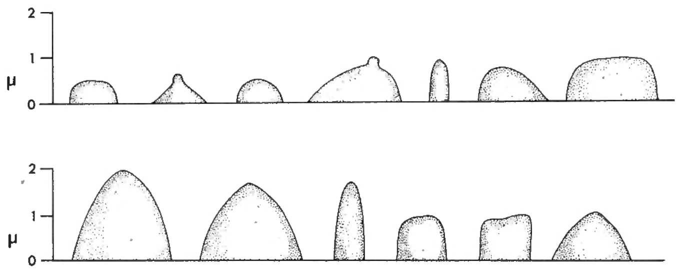
Type species. **Apiculiretusispora brandtii** Streel 1964.

**Apiculiretusispora densiconata** Tiwari and Schaarschmidt
Plate 3, figure 9, text-figure 25

? 1955 **Retusotriletes verrucosus** Naum. in litt.; Kedo, p. 22, Pl. 1, fig. 17.
1975 **Apiculiretusispora densiconata** Tiwari and Schaarschmidt, p. 20, Pl. 4, fig. 7, Pl. 5, figs. 1, 2.

Description. Trilete miospores with subcircular amb. Laesura arms 1/2 to 4/5 the radius in length, straight, bordered by prominent, straight or slightly sinuous, untapered labra 2-6 µm (commonly about 3 µm) in combined width, up to 6 µm (commonly 2-3 µm) high. Contact areas defined by limit of proximal encroachment of coarser sculpture, or by faintly discernible complete or incomplete curvatural ridges.

Wall of about uniform thickness, 1-2 µm thick, rigid in appearance. Contact areas scabrate or minutely granulate. Proximal-equatorial and distal regions bear closely spaced grana and coni 0.5-1.5 µm (commonly about 1 µm, rarely as much as 2 μm) high, 0.5-1.5 μm (rarely up to 2 μm) wide at base, round to polygonal in plan view, rarely with a minute apical granule. Sculptural elements so closely spaced that others of equal size would not fit between them.



*Text-figure 25: Sculptural elements of* ***Apiculiretusispora densiconata****, lateral view.*

Diameter. 51-94 μm, mean 71 μm (60 specimens).

Occurrence. Figured specimen, loc. 8320, slide 1, 42.3 x 122.7, GSC 66214. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 7).

Comparisons. **Apiculiretusispora granulata** Owens (1971) has distinct curvaturae perfectate, a thicker wall, smaller sculpture, and lips that taper in height and width toward the equator. **Apiculatasporites microconus** (Richardson) n. comb. is larger, has more widely spaced sculpture, commonly lacks curvaturae, and has a less rigid wall that is subject to folding. **A. brandtii** Streel (1964) has a characteristic dark, triangular "promontory" at the proximal pole, and lacks the prominent lips of **A. densiconata. Retusotriletes verrucosus** Kedo (1955) appears to be closely comparable to **Apiculiretusispora densiconata** except for possibly more prominent curvatural ridges. **Retusotriletes** sp. cf. **R. devonicus** Naumova, in de Jersey (1966), has prominent, wide curvaturae and apparently exclusively granulate sculpture. **Apiculatasporites elegans** (McGregor) n. comb. (basionym **Apiculatisporis elegans** McGregor, 1960, p. 30) lacks tecta. **Dibolisporites echinaceus** (Eisenack) Richardson (1965) has larger, biform sculpture.

**Apiculiretusispora leberidos** n. sp.
Plate 3, figures 8, 11, 12

Diagnosis. Trilete spores with convex-subtriangular amb. Trilete rays simple, 1/4 to 1/2 the radius in length. Faintly discernible radial prolongations of the laesura arms commonly extend about 4/5 the distance to the equator and merge with dark but indistinctly delimited curvaturae. Some specimens bear ornament of very fine grana or coni, about 0.5 μm high and wide, that are close-packed or up to 1 μm apart, in the distal and proximal-equatorial regions. In some specimens, however, part or all of the ornamentation is missing. The unsculptured wall is 1.5-3 μm thick interradially, slightly thinner opposite the rays, rigid in appearance, rarely folded, and dark interradially close to the proximal pole.

Diameter. 30-50 μm, mean 38 μm (27 specimens).

Occurrence. Holotype, Plate 3, figure 8, loc. 8335, slide 1, 66.6 x 117.7. GSC 66211. Paratypes: Plate 3, figure 11, slide 8337-6, 36.3 x 120.9, GSC 66212; Plate 3, figure 12, slide 8337-6, 58 x 113.6, GSC 66213. Stratigraphic range, Weatherall and Hecla Bay formations, Givetian (Fig. 7, no. 87).

Derivation of name. Gr. **leberis,** sloughed skin.

Comparisons. **A. plicata** (Allen) Streel (1967) is on average larger, is thinner-walled, and has longer laesura arms. **A. pygmaea** McGregor (1973) is smaller and thinner, with a consistently intact sculptured layer.

Genus **Archaeozonotriletes** Naumova emend. Allen 1965

Type species. **Archaeozonotriletes variabilis** Naumova emend. Allen 1965

**Archaeozonotriletes timanicus** Naumova
Plate 3, figures 13, 14, 15

1953 **Archaeozonotriletes timanicus** Naumova, p. 81, Pl. 12, fig. 14.
? 1959 **Archaeozonotriletes polymorphus** Naumova var. **takatinicus** Chibrikova, p. 58, Pl. 7, figs. 2, 3.
? 1962 **Archaeozonotriletes timanicus** Naumova var. **radiatus** Chibrikova, p. 412, Pl. 7, fig. 1.
1965 **Archaeozonotriletes ignoratus** Naumova; Hemer, second plate (unnumbered).
1965 **Archaeozonotriletes timanicus** Naumova var. no. 1; Nazarenko, Pl. 1, figs. 49, 50.
? 1965 **Tholisporites ancylus** Allen (pars), Pl. 101, fig. 5.
? 1966 **Archaeozonotriletes laticolaris** Mikhailova, p. 209, Pl. 3, fig. 4.
1967 **Lophozonotriletes media** Taugourdeau-Lantz, p. 52, Pl. 2, fig. 6.
1980 **Densosporites** cf. **anulatus** (Loose) Potonié and Kremp; Moreau-Benoit, p. 24, Pl. 13, fig. 7.

Description. Trilete, acamerate, patinate spores with rounded subtriangular or subcircular amb. Laesura arms straight, simple, extending to or almost to the inner edge of the patina. Contact areas thin, equatorial and distal regions enclosed by a patina about 4.5-16 μm thick, about the same thickness equatorially and distally. Patina dissected into irregularly distributed, relatively large, broad based, low, rounded or flat-topped verrucae or ridges, commonly of irregular shape in plan view.

Diameter. 54-91 μm, mean 73 μm (28 specimens).

Occurrence. Figured specimens: Plate 3, figures 13, 14, loc. 8333, slide D, GSC 66216; Plate 3, figure 15, loc. 8335, slide 10, 58.4 x 111.2, GSC 66217. Stratigraphic range, Hecla Bay Formation, lower Givetian (Fig. 7, no. 102).

Comparison. Poorly preserved specimens with relatively little sculptural dissection could be confused with highly corroded specimens of **A. variabilis.** However, in well-preserved material the two species are easily distinguished. **A. asymmetricus** Panshina (1971) appears to be of similar basic construction but its large, flat, irregular tubercles are larger toward the equator where they commonly are fused with one another. **Convolutispora crassata**? (Naumova) n. comb. is not patinate.

Remarks. Allen's (1965) emendation of **Archaeozonotriletes,** strictly applied, does not allow for spores with the type of dissected-verrucose sculpture possessed by **A. timanicus.** However, other genera of spores with coarse-sculptured patina are not appropriate: **Chelinospora** Allen emend. McGregor and Camfield (1976) lacks verrucae; **Cyrtospora** Winslow (1962) has a strongly extended tuberculose distal thickening; **Patellasporites** Groot and Groot emend. Kemp (1970) has narrow canals separating "islands" of varied shape and size.

**Tholisporites** Butterworth and Williams (1958) may be appropriate, as there are no sculptural specifications contained in the diagnosis. As this genus is defined, it can include all spores in which the patina is thickest in the equatorial region regardless of their sculpture, and it therefore overlaps both **Chelinospora** and **Patellasporites.** Allen (1965) and McGregor (1973) have attempted to distinguish **Tholisporites** from **Archaeozonotriletes** on the relative thickness of the patina equatorially and distally, but this practice has been questioned (e.g. Owens, 1971) and has not been widely accepted. It may not be possible to determine the degree of differentiation in thickness of the patina, and this parameter may therefore not be taxonomically useful. Furthermore, the relative equatorial/distal thickness of the patina in Naumova's original material of **A. variabilis** is not determinable from her description or illustrations, so **A. variabilis** itself may be **Tholisporites**-like.

Considering the above we prefer not to use **Tholisporites** in this report. We prefer to leave the present species in **Archaeozonotriletes,** and stress the need for a comprehensive revision of the genera of patinate spores.

**Archaeozonotriletes variabilis** Naumova emend. Allen
Plate 3, figures 18-20

1953 **Archaeozonotriletes variabilis** Naumova, p. 30, Pl. 2, figs. 12, 13; p. 80, Pl. 12, figs. 8-11; p. 83, Pl. 13, figs. 7-9.
1960 **Densosporites crassus** McGregor, p. 36, Pl. 13, fig. 8.
1965 ?**Archaeozonotriletes variabilis** Naumova; Kerr, McGregor and McLaren, Pl. 4, fig. 13.
1965 **Archaeozonotriletes variabilis** Naumova emend. Allen, p. 721, Pl. 100, figs. 3-6.
non 1975 **Archaeozonotriletes variabilis** Naumova emend. Allen; Tiwari and Schaarschmidt, p. 33, Pl. 14, fig. 8; Pl. 15, figs. 1-3.

Description. Trilete, acamerate, patinate spores with rounded subtriangular, subcircular, or irregular amb. In lateral compression, proximal area flat or slightly convex, distal side strongly convex owing to thickness of patina. Laesura arms straight, simple, extend to or almost to inner proximal edge of patina. In polar view, the patina extends symmetrically or asymmetrically 4-18 µm equatorially and encloses a subcircular central area. Patina may extend, with diminished thickness, proximally onto the outer part of the contact area (Pl. 3, fig. 19). Exine levigate, commonly corroded to form a scabrate, punctate, or pseudoverrucose pattern (Pl. 3, fig. 20).

Diameter. 44-88 µm, mean 62 µm (15 specimens).

Occurrence. Figured specimens: Plate 3, figure 18, loc. 8334, slide 12, 42.3 x 111.6, GSC 66220; Plate 3, figure 19, loc. 8332, slide 2, 58.7 x 109.9, GSC 66221; Plate 3, figure 20, loc. 8325, slide 8, 58.2 x 121.1, GSC 66222. Stratigraphic range, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 88).

Comparisons. **Densosporites crassus** McGregor (1960) must be considered no longer valid, as it is based on three corroded specimens of **Archaeozonotriletes variabilis. Tholisporites punctatus** McGregor (1960) was also erected on the basis of corrosion mistaken for sculpture, and is therefore invalid. Some specimens of **T. punctatus** may be **Archaeozonotriletes variabilis,** others **Tholisporites densus** McGregor. **T. densus** itself bears a rather close resemblance to **A. variabilis,** differing in having a thin, veil-like structure over the contact areas. The proximal veil is distinctive, but the possibility should be considered that it is an artifact caused by overmaceration of the specimens.

Genus **Auroraspora** Hoffmeister, Staplin and Malloy 1955 emend. Richardson 1960

Type species. **Auroraspora solisorta** Hoffmeister, Staplin and Malloy 1955

**Auroraspora micromanifesta** (Hacquebard) Richardson
Plate 3, figure 16

1957 **Endosporites micromanifestus** Hacquebard, p. 317, Pl. 3, fig. 16.
1960 **Auroraspora micromanifestus** (Hacquebard) Richardson, p. 51.

Description. Trilete, zonate spores with rounded subtriangular amb and subcircular central body. Laesura arms extend to or nearly to body margin, accompanied by prominent fold-like labra, up to 11 µm high at the pole, that extend, decreasing in height, to the outer edge of the zona. Body about 2 µm thick, darker than zona. Zona thin, 1/3 to 2/5 the radius in width, widest opposite the trilete rays. Zona attached to body proximally and distally, commonly with numerous radially oriented folds that do not extend onto the body.

Diameter. 69 µm and 78 µm (2 specimens).

Occurrence. Figured specimen, loc. 8317, slide 1, 44.7 x 110.4, GSC 66218. Stratigraphic range, middle of Weatherall Formation, ?upper Eifelian (Fig. 7, no. 89).

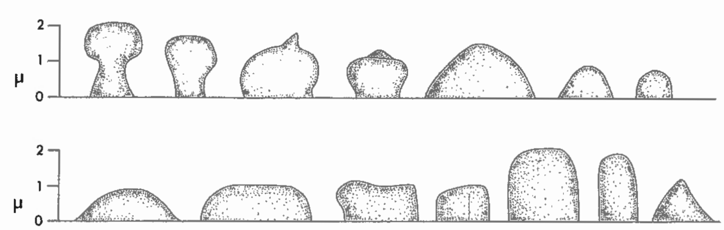
Genus **Baculatisporites** Pflug and Thomson 1953

Type species. **Baculatisporites primarius** (Wolff) Pflug and Thomson 1953

**Baculatisporites semilucensis** (Naumova) n. comb.
Plate 3, figure 17, text-figure 26

1953 **Lophotriletes semilucensis** Naumova, p. 54, Pl. 7, fig. 2.

Description. Trilete miospores with subcircular or rounded subtriangular amb. Laesura arms simple, commonly indistinct, 2/3-4/5 the radius in length. Wall 1-2 µm thick, commonly folded. Distal and proximal-equatorial sculpture consists of bacula 1-2 µm high, 1-2 µm wide at base; flat-topped or rounded verrucae and coni 1-3 µm at base, 0.5-1.5 µm high; and pila 0.5-1 µm wide at base, with expanded tip up to 2 µm wide. Elements commonly as wide as, or wider than, high. Minute coni and grana may occur among other ornaments. Bacula are the most common sculpture type. Elements subcircular, elongate or irregularly rounded in plan view, about 0.5-1 µm apart. Sculpture of contact areas similar or slightly reduced in size.




*Text-figure 26: Sculptural elements of* ***Baculatisporites semilucensis,*** *lateral view.*

Diameter. 41-72 µm, mean 57 µm (23 specimens).

Occurrence. Figured specimen, loc. 8319, slide 10, 52.6 x 111.5, GSC 66219. Stratigraphic range, Weatherall and lower Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 53).

Remarks. The small, "bastion-like" sculptural elements conform more closely to the sculpture of **Baculatisporites** than to that of any of the several other genera of baculate spores. Pila, grana, and biform ornaments may also occur in this species but do not constitute the most common form of sculpture.

Comparisons. Naumova (1953, p. 54, Pl. 7, fig. 2) did not describe the sculpture of **Lophotriletes semilucensis** in detail. However, her illustration leaves litle doubt that the species includes forms similar to those from Melville Island. **L. semilukensis** Naumova var. **zonalis** Kedo (1955) is thicker and has shorter trilete rays. **L. fastuosus** Naumova (1953) is subtriangular with rounded sculptural elements. **Verrucosisporites polygonalis** Lanninger (1968) has broader sculptural elements that are greatly reduced in the contact areas.

Genus **Calamospora** Schopf, Wilson and Bentall 1944

Type species. **Calamospora hartungiana** Schopf, Wilson and Bentall 1944

**Calamospora atava** (Naumova) McGregor
Plate 3, figure 21

1953 **Leiotriletes atavus** Naumova, p. 22, 103, Pl. 1, fig. 8, Pl. 16, fig. 3.

For additional synonymy see McGregor (1973), p. 13.

Description. Trilete miospores with subcircular or rounded subtriangular amb. Laesura arms simple, straight, 1/4 to 1/2 the radius in length. Wall 1-2 µm thick at equator and distally, levigate, commonly wrinkled and folded. Exine in the proximal polar region perceptibly or conspicuously darkened (?thickened) in a subtriangular or subcircular area that may extend to the ends of rays. Dark region may extend to pole, or may surround a lighter polar region.

Diameter. 38-88 µm, mean 57 µm (41 specimens).

Occurrence. Figured specimen, loc. 8333, slide G, GSC 66223. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 4).

Remarks and comparisons. Good (1977), in a study of in situ spores from several Carboniferous calamitean cones, observed that specimens of **Calamospora** from the same cone species, and even from the same cone, may display a wide variation in wall thickness and orientation of folding, length of trilete arms, spore diameter, and degree of exinal darkening in the pyramic region. It seems reasonable to suspect that intraspecific variation of similar order may occur within the sporangia of Devonian plants that produced **Calamospora**, even though their phyletic position may be quite different from those of the Carboniferous. This appears to be contradicted by the findings of Nadler (1966) in which aggregates of **Calamospora** from sporangia of the Lower Devonian plant **Protobarinophyton obrutschevii** Ananiev show a relatively narrow range of variation in all of the above-mentioned features. On the other hand, specimens of **Calamospora** from sporangia of **Sawdonia acanthotheca** Gensel, Andrews, and Forbes (1975) are in fact nearly as varied in these features as those reported by Good (1977). Other genera of in situ spores from sporangia of Devonian age show comparable variation in wall thickness, length of trilete rays, and the size, shape, and distinctness of the darkened pyramic area (Gensel, 1980).

The degree of intraspecific variation displayed by spores of some species of cones seems to justify the inclusion of the present specimens in the form species **Calamospora atava**, in spite of the rather wide variation in the distinctness and shape of their proximal darkened region and the fact that the wall is slightly thicker than that of spores commonly assigned to that species.

Accepting this rather broad range of minor structural variation as intraspecific and therefore also intrageneric, the present spores could not be assigned to **Phyllothecotriletes** Luber ex Potonié (1958). If non-curvaturate (sensu Potonié, 1958; Staplin, 1960; and others), **Phyllothecotriletes** is a junior synonym of **Calamospora;** if curvaturate (sensu Streel, 1964, 1967), it is a junior synonym of **Retusotriletes.** It is perhaps not appropriate to consider problems surrounding the circumscription of **Phyllothecotriletes** further here, except to point out that Luber's figure of **P. nigritellus,** the lectogenotype of Potonié (1958), shows what appear to be curvaturae, but this feature is not mentioned in the description given by Luber (1955, p. 37).

**Calamospora atava** has not been differentiated satisfactorily from **C. nigrata** (Naumova) Allen, despite the fact that the drawings and descriptions of these species in Naumova (1953), Kedo (1955) and others suggest a separation on the basis of exinal sculpture and/or wall thickness. See for example discussion in McGregor (1964, p. 7), Allen (1965, p. 693), and de Jersey (1966, p. 6).

For additional discussion see McGregor (1973, p. 13).

Genus **Camarozonotriletes** Naumova 1939 ex Ishchenko 1952

Type species. **Camarozonotriletes devonicus** Naumova 1953

This genus was regarded by Potonié (1958, p. 31) as comprising cingulate spores with small sculptural elements on the equatorial part of the cingulum. However, there is a discrepancy between the illustration and the description of **C. devonicus**, the lectogenotype designated by Potonié (1958), in Naumova (1953, p. 89 and Pl. 14, fig. 9 or 9a). In Naumova's diagnosis, the wall of **C. devonicus** is described as smooth, whereas the specimen illustrated (fig. 9 according to the text, fig. 9a according to the plate legend) is distinctly sculptured. The sculptural characteristics of the genotype therefore are uncertain, and can only be determined by examination of type material. Even if the genotype is sculptured, there seems to be no compelling reason to restrict the generic circumscription to sculptured forms. No such restriction seems intended in Soviet usage (e.g. Naumova, 1939, p. 355; Kedo, 1955, p. 41). In this paper we regard **Camarozonotriletes** as encompassing both levigate and sculptured forms.

**Camarozonotriletes** is at least superficially similar to **Rotaspora** Schemel (1950), and several authors have placed them in synonymy (see summary in Playford, 1976, p. 24). We do not believe that synonymy is established although further study may prove it to be so. The drawings of **Camarozonotriletes** spp. in Soviet literature, including that of **C. devonicus** Naumova (1953, pl. 14, ?fig. 9) designated by Potonié as the genotype (but see above), show a rather uniformly darkened peripheral structure, commonly but not invariably slightly darker than the central region. On the other hand, illustrations of the various species of **Rotaspora** by non-Soviet workers, including that of the genotype, **R. fracta** by Schemel (1950, Pl. 40, figs. 8 and 9), commonly although not invariably show the equatorial structure as lighter than the body, or even, as in **R. fracta,** suggestive of bizonate structure. These distinctions in relative density of the body and the equatorial structure, and of the equatorial structure itself, do not apply to all species (compare **R. ergonulii** (Agrali) Sullivan and Marshall (1966), and some specimens of **Camarozonotriletes** figured by Kedo (1955). Nevertheless they do suggest that the type species of the two genera, at least, may be sufficiently different to warrant generic separation. The discontinuous stratigraphic ranges of the two genera is another reason for suspicion that there may be a structural basis for their separation, although of course it is not in itself sufficient reason to maintain the taxonomic distinction.

**Camarozonotriletes antiquus** Kedo
Plate 3, figures 22, 23

1955 **Camarozonotriletes antiquus** Naum. in litt.; Kedo, p. 41, Pl. 6, fig. 5.

Description. Trilete, cingulate miospores with subtriangular amb. Laesura arms 3/4 radius in length, simple, gaping. Wall 2 µm thick equatorially at corners, up to 4 µm thick interradially. No appreciable difference in optical density between body and cingulum. Contact areas levigate, with a dark (?thickened) subtriangular region around the pole and, on one specimen, a lighter zone close to and paralleling the rays. Proximal-equatorial and distal regions bear minute, closely spaced coni less than 1 µm high and less than 1 µm in basal width.

Diameter. 42-54 µm (4 specimens).

Occurrence. Figured specimen, loc. 8319, slide 1, 63.4 x 127.9, GSC 66224. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 94).

Comparison. **C. parvus** Owens (1971) is smaller. **C. pusillus** Naumova ex Chibrikova (1959) is smaller and has coarser sculpture.

**Camarozonotriletes laevigatus** n. sp.
Plate 4, figures 1, 2

Diagnosis. Trilete, cingulate miospores. Amb subtriangular with rounded corners and straight or slightly convex interradial margins. Laesura arms simple, 2/3-4/5 radius in length. Proximal face darkened (?thickened) in angles of rays on most specimens. Equatorial cingulum 2-3 µm wide at midpoint of interradial margins, decreasing in width toward radial angles where it is about 1 µm wide. Central area (?contact area), enclosed by inner edge of cingulum, subtriangular with slightly concave or ±straight interradial margins. Cingulum commonly slightly darker than central area. Wall levigate proximally and distally.

Diameter. 25-38 µm, mean 30 µm (14 specimens).

Occurrence. Holotype, loc. 8332, slide C, GSC 66225. Stratigraphic range, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 86).

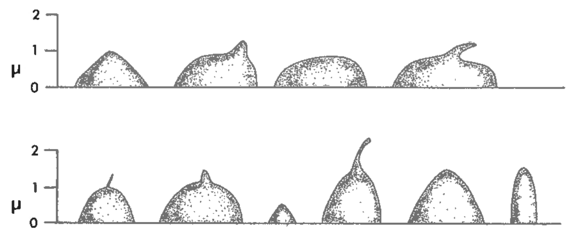
Derivation of name. L. **laevigatus,** smooth.

Comparison. This species is identical to **C. parvus** Owens except for lack of sculpture. **C. minutus** Naumova ex. Chibrikova (1959) is shagreen but otherwise closely resembles **C. laevigatus.**

**Camarozonotriletes mosolovicus** Naumova ex Kedo
Plate 4, figures 3-6, text-figure 27

1955 **Camarozonotriletes mosolovicus** Naum. in litt.; Kedo, p. 42, Pl. 6, fig. 8.
1955 **Camarozonotriletes obtusus** Naum.; Kedo, p. 42, Pl. 6, fig. 9.

Description. Trilete, cingulate miospores with subtriangular amb, rounded corners, and convex interradial margins. Laesura arms 1/2-7/8 the radius in length, simple or with narrow lips. Equatorial cingulum 3-4 µm wide at midpoint of interradial margins, decreasing to 1-2.5 µm wide opposite the ends of the rays, commonly slightly darker than central area. Central area enclosed by inner edge of cingulum subtriangular with straight or convex interradial margins. Central proximal area levigate, equatorial and distal regions bearing coni, mammillate biform elements, and grana that may encroach slightly onto the proximal face interradially. Sculptural elements 1-2 µm (rarely 3 or 4 µm) high, 0.5-3 µm (mostly 1-2 µm) wide at their base, commonly largest interradially and toward the distal pole; rounded or polygonal in plan view, commonly discrete, 2 µm or less apart, may be surmounted by a minute hair-like extension.




*Text-figure 27: Sculptural elements of* ***Camarozonotriletes mosolovicus****, lateral view.*

Diameter. 36-44 µm, mean 40 µm (8 specimens).

Occurrence. Figured specimens: Plate 4, figures 3, 4, loc. 8329, slide A, GSC 66226; Plate 4, figures 5, 6, loc. 8321, slide 1, 61.5 x 122.3, GSC 66227. Stratigraphic range, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 72).

Comparison. **C. sextantii** McGregor and Camfield (1976) has a distinctive dark ray-border and proximal curvaturae, and commonly shows evidence of separation of inner and outer wall layers. **C. parvus** is smaller and has much finer sculpture. **C. pusillus** is smaller, has smaller sculpture, and may be darkened at the proximal pole.

**Camarozonotriletes? notatus** (Owens) n. comb.
Plate 4, figure 14

1971 **Stenozonotriletes notatus** Owens, p. 36, Pl. 10, figs. 2, 5, 9.

Description. Trilete, ?cingulate, levigate miospores with rounded subtriangular or subcircular amb. Central area enclosed by ?cingulum rounded subtriangular, with an ill-defined triangular region centred at the proximal pole and extending to or nearly to the ends of the rays. This region may be slightly darkened, or of the same optical density as the rest of the proximal face but outlined by faintly discernible dark lines. Laesura arms straight, simple or with low, narrow labra; long, may extend beyond the central area forming shallow v-shaped re-entrants in the inner proximal edge of the ?cingulum. Cingulum-like structure 8-12 µm in maximum width interradially, reduced to 2-4.5 µm wide opposite the ends of the rays.

Diameter. 52, 67, and 76 µm (three specimens).

Occurrence. Figured specimen, loc. 8339, slide 4, 66.7 x 111.6, GSC 66231. Stratigraphic range, Hecla Bay Formation, lower Givetian (Fig. 7, no. 100).

Remarks. Only three specimens were seen, all in polar compression. The equatorial structure is darker than the central area, which, together with the preference for polar orientation, suggests that the spores may be cingulate or only weakly patinate. They may be basically similar in structure to **?Stenozonotriletes furtivus** Allen, of McGregor and Camfield (1976), differing in the more pronounced narrowing of the equatorial structure radially. As applied in the Soviet Union (e.g. by Kedo, 1955) **Camarozonotriletes** seems to include spores in which the cingulum is continuous around the equator, albeit significantly narrower radially, as well as those in which the equatorial crassitude is essentially restricted to the interradial position. Accordingly we prefer to place this species in **Camarozonotriletes** rather than in **Stenozonotriletes.**

There is no discernible wall separation, and no curvaturae were seen, as were reported for some specimens of **S. notatus** by Owens (1971). However, these features are not diagnostic for the species, as not all of the specimens studied by Owens show them.

Parts of the wall of our specimens have fine to dense "punctation" similar to that of the type and figured specimens described by Owens (1971). Because of the appearance and somewhat irregular distribution of this punctation, especially at the spore margin, it seems reasonable to regard it as a product of corrosion.

Comparison. ?**Stenozonotriletes inequaemarginalis** Richardson (1965) may be similar to **Camarozonotriletes**? **notatus,** but it has a slightly narrower equatorial crassitude.

**Camarozonotriletes parvus** Owens
Plate 4, figures 7-11

1966 **Camarozonotriletes** sp. cf. **C breviculus** Ishchenko, 1958; McGregor and Owens, Pl. 9, fig. 5.
1971 **Camarozonotriletes parvus** Owens, p. 40, Pl. 11, figs. 1-4.
1972 **Camarozonotriletes** n. sp., McGregor and Uyeno, Pl. 2, fig. 2.

Description. Trilete, cingulate miospores with subtriangular amb, rounded corners, and slightly concave, straight, or slightly convex interradial margins. Laesura arms simple, straight, 2/3 to 4/5 the radius in length, commonly slightly gaping. Wall darker along rays, forming a vaguely defined ±triangular zone around the proximal pole. Equatorial cingulum 2.5-5 µm (commonly 3 µm) in maximum width interradially, reduced to 1.5-2.5 µm at corners. Exine levigate proximally, minutely conate-granulate equatorially and distally. Sculptural elements less than 1 µm wide, less than 0.5 µm high, closely spaced. In some specimens they can be distinguished only under oil immersion.

Diameter. 22-39 µm, mean 31 µm (122 specimens).

Occurrence. Figured specimens: Plate 4, figures 7-9, loc. 8329, slide B, GSC 66228; Plate 4, figures 10, 11, loc. 8319, slide A, GSC 66229. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 38).

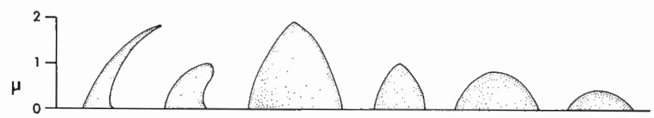
Comparison. **Camarozonotriletes minutus** Naumova ex Chibrikova (1959) is described as shagreen. In all other respects it appears identical to **C. parvus. Camarozonotriletes laevigatus** n. sp. is unsculptured.

Remarks. McGregor and Camfield (1976, p. 13) detected two wall layers in the type specimens of **C. parvus,** the inner wall unsculptured and interradially thickened at the equator, and the outer wall sculptured and closely appressed to the inner. In the present investigation we have not seen two walls in **C. parvus.** Their evidence in the type specimens of Owens (1971) may be owing to the dissociation of two normally undetached layers owing to excessive maceration.

**Camarozonotriletes pusillus** Naumova ex Chibrikova
Plate 4, figures 12, 13, text-figure 28

1953 **Camarozonotriletes pusillus** Naumova, Pl. 22, fig. 97 (nomen nudum).
1959 **Camarozonotriletes pusillus** Naum. in litt.; Chibrikova, p. 81, Pl. 14, fig. 8.
1972 **Camarozonotriletes mosolovicus** Naumova; McGregor and Uyeno, Pl. 1, fig. 13.

Description. Trilete, cingulate miospores with convex-subtriangular or subcircular amb. Laesura arms simple, straight, 1/2-4/5 radius in length, commonly gaping, some specimens bordered by an indistinctly delimited dark zone between the rays. Cingulum about 3 µm in maximum width at the interradial margins, reduced to 1-2 µm opposite the rays. Central area enclosed by cingulum subtriangular with slightly concave, straight, or slightly convex interradial margins. Wall levigate proximally, ornamented distally and equatorially by minute coni, grana, and rare small spinae. Sculptural elements mostly about 0.5-1 µm (rarely exceeding 1.5 µm) wide at their base, up to 1.5 µm (rarely 2 µm) high, closely crowded or up to 2 µm apart, reduced in size at corners on some specimens.




*Text-figure 28: Sculptural elements of **Camarozonotriletes pusillus**, lateral view.*

Diameter. 23-42 µm, mean 33 µm (26 specimens).

Occurrence. Figured specimen, loc. 8335, slide 10, 41 x 110.5, GSC 66230. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 54).

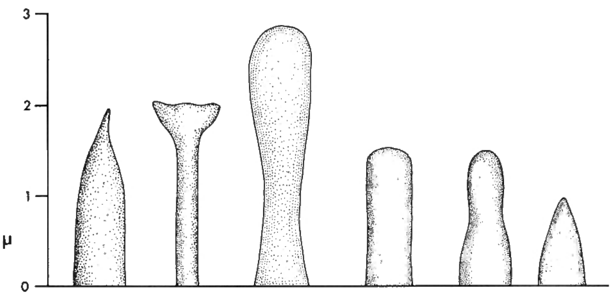
Comparisons. **C. giveticus** Kedo (1955) is larger and, judging from the illustration (op. cit., Pl. 6, fig. 6), has smaller sculptural elements. **C. mosolovicus** is larger, has larger sculptural elements that may be biform, and is not darkened at the proximal pole.

Genus **Ceratosporites** Cookson and Dettmann 1958

Type species. **Ceratosporites equalis** Cookson and Dettmann 1958

**Ceratosporites** sp. cf. **Acanthotriletes multisetus** (Luber) Potonié and Kremp var. **multisetus**
Plate 4, figures 15-17, text-figure 29

Description. Trilete miospores with rounded subtriangular or subcircular amb. Wall 1-2 µm thick. Laesura arms simple or with low, indistinct lips, straight, 1/2-4/5 radius in length. Contact areas levigate or scabrate. Proximal-equatorial and distal regions with small, closely spaced spinae, bacula, pila, and coni, 1-2 µm (rarely up to 4 µm) long, 0.5-2 µm wide at their base, more than twice as long as wide, subcircular in plan view. The sculpture, although varied, consists predominantly of spinae and bacula. Spinae may be pointed, blunt, or expanded at the tip.




*Text-figure 29: Sculptural elements of **Ceratosporites** sp. cf. **Acanthotriletes multisetus**, lateral view.*

Diameter. 48-66 μm, mean 55 μm (10 specimens).

Occurrence. Figured specimens: Plate 4, figure 15, loc. 8308, slide 7, 49 x 112.9, GSC 66232; Plate 4, figures 16, 17, loc. 8308, slide 7, 43.5 x 119, GSC 66233. Stratigraphic range, lower Weatherall Formation, ?mid-Eifelian (Fig. 7, no. 57).

Comparison. Richardson (1965, p. 567) described **Acanthotriletes multisetus** var. **major** from Givetian strata of the Orcadian Basin, believing it to be identical, except for larger size, to **Azonotriletes multisetus** Luber (in Luber and Waltz, 1938). The sculptural elements on Luber's specimens are longer than on those of Richardson (5 μm vs. 2-4 μm) although the specimens themselves are only about half the size. Considering these differences, and uncertainty as to the precise form of the "seta" of the Russian specimens, we do not regard the synonymy given by Richardson as securely established. The specimens from the Weatherall Formation are smaller than those from the Orcadian Basin, and do not appear to have the two separated wall layers reported by Richardson. Our specimens may therefore represent a new species. Nevertheless, we prefer to leave the nomenclature open until we have examined relevant specimens from the Karaganda and Orcadian Basins.

In **Baculatisporites semilucensis** the sculptural elements are less than twice as long as wide, and commonly less regular in plan view.

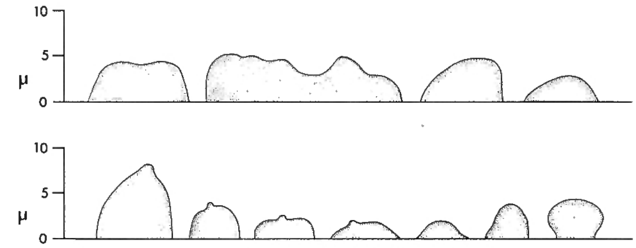
Genus **Convolutispora** Hoffmeister, Staplin and Malloy 1955

Type species: **Convolutispora florida** Hoffmeister, Staplin and Malloy 1955

**Convolutispora crassata**? (Naumova) n. comb.
Plate 4, figures 18-20, Plate 18, figure 23, text-figure 30

? 1953 **Lophozonotriletes crassatus** Naumova, p. 76, Pl. 11, fig. 14.
1960 **Convolutispora flexuosa** forma **minor** Hacquebard; McGregor, p. 34, Pl. 12, fig. 4.

Description. Trilete miospores with subcircular or rounded subtriangular amb. In lateral compression, proximal surface flattened pyramidal, distal surface ±hemispherical. Laesura arms simple, straight or somewhat sinuous, 1/2-4/5 radius in length. Wall 3-12 μm thick distally and only slightly thinner proximally. Contact areas levigate or scabrate, or with widely spaced, low grana or coni. Proximal-equatorial and distal regions bear closely spaced verrucae and convolute or irregularly anastomosing ridges 3-12 μm wide at their base, 1-8 μm (commonly 2-5 μm) high at equator, many of which are surmounted by one or more coni or grana about 0.5 μm wide and high. Sculptural elements extremely variable in size and shape on each specimen.




*Text-figure 30: Transverse-sectional outline of sculptural elements of **Convolutispora crassa**?.*

Diameter. 39-69 μm, mean 46 μm (97 specimens).

Occurrence. Figured specimens: Plate 4, figures 18 and 19, loc. 8312, slide K, GSC 66234; Plate 4, figure 20, loc. 8320, slide J, GSC 66235. Stratigraphic range, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 41).

Comparison. Assignment to **C. crassata** is questioned because it is not known whether that species is cingulate or comprehensively thickened. **Verrucosisporites scurrus** (Naumova) n. comb. differs in having predominantly discrete sculptural elements, including a proportion of ±flat-topped bacula. Extreme forms of **V. scurrus** intergrade with **Convolutispora crassata**? however, and the two species evidently are members of an intergrading complex of spores with convolute and verrucose sculpture, including **Convolutispora tegula** Allen, **Dibolisporites uncatus** (Naumova) n. comb., and several species of **Verrucosisporites** that occur in Givetian strata. **Archaeozonotriletes timanicus** differs in being larger and patinate, and in having broader, shallower sculpture. The sculpture of **Convolutispora florida** Hoffmeister, Staplin and Malloy (1955) consists solely of ridges.

Remarks. Some specimens (Plate 18, figure 23) show a pattern of corrosion similar to that of some specimens of **Verrucosisporites scurrus**, and like the characteristic pattern of **Geminospora verrucosa** Owens. See comments under **Verrucosisporites scurrus**.

**Convolutispora porcata** n. sp.
Plate 4, figure 21

Diagnosis. Trilete spores with subcircular, oval, or convex-subtriangular amb. In profile, spores proximally flattened-pyramidal, distally rounded. Laesura arms straight, 1/2 to full radius in length, simple or paralleled by an unsculptured region up to 5 μm wide on each side of the rays. Wall 4-11 μm thick at equator and distally, and only slightly thinner proximally. Proximal and distal regions, including contact areas, sculptured by closely spaced, rounded or flat-topped ridges and verrucae separated by narrow light channels forming an imperfect reticulum. Ridges and verrucae 1-2 μm high, ridges 1-3 μm wide and of varied length, verrucae 1-7 μm wide. Sculptural elements of varied and irregular outline in plan view. Sculpture may be slightly reduced in size on proximal face.

Diameter. 70-131 μm, mean 100 μm (38 specimens).

Occurrence. Holotype, Plate 4, figure 21, loc. 8331, slide 1, 34.6 x 128.1, GSC 66236. Stratigraphic range, upper Weatherall Formation and Hecla Bay Formation, ?upper Eifelian and lower Givetian (Fig. 7, no. 84).

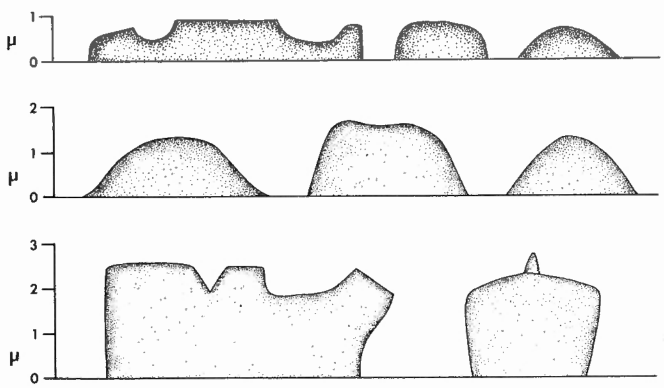
Derivation of name. L. **porca**, ridge between two furrows.

Comparison. **Archaeozonotriletes semanticus** Chibrikova (1962) is larger and has sculpture of narrow-based tubercles, some of which are surmounted by a small spine. The form assigned to **Reticulatisporites textilis** Balme and Hassell by Moreau-Benoit (1979) is similar to **Convolutispora porcata** except for the presence of dark curvaturae.

**Convolutispora subtilis** Owens
Plate 4, figures 22, 23, text-figure 31

1969 **Convolutispora** sp., Lele and Streel, p. 100, Pl. 3, fig. 53.
1971 **Convolutispora subtilis** Owens, p. 35, Pl. 9, figs. 3-6.
1972 **Convolutispora** n. sp., McGregor and Uyeno, Pl. 2, fig. 11.

Description. Trilete miospores with subcircular amb. In lateral compression, proximal hemisphere flattened-convex, distal hemisphere ±hemispherical. Laesura arms straight, simple, 1/2-4/5 the radius in length, commonly of unequal length. Wall 2-6 µm thick at equator and distally, slightly thinner proximally, rarely folded. Contact areas levigate or scabrate. Proximal-equatorial and distal regions with crowded grana, coni or small verrucae, discrete or more commonly joined in convolute ridges or groups, 0.5-1.5 µm (rarely up to 3.5 µm) wide at base, about as high as wide, separated by narrow channels. Some sculptural elements may be flat-topped, and some may be surmounted by a minute apicula. Verrucae up to 3 µm wide and up to 2.5 µm high may occur with other sculptural elements, especially at equator.




*Text-figure 31: Transverse-sectional outline of sculptural elements of* ***Convolutispora subtilis.***

Diameter. 40-66 µm, mean 54 µm (40 specimens).

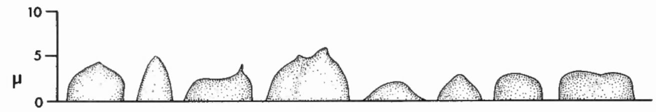
Occurrence. Figured specimen, loc. 8319, slide B, GSC 66237. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 75).

Comparison. Owens' (1971) specimens of **C. subtilis** differ only in the rarity of discrete sculptural elements among the convolute ridges.

**Convolutispora tegula** Allen
Plate 4, figures 24-27, text-figure 32

1965 **Convolutispora tegula** Allen, p. 705, Pl. 97, figs. 4-8.

Description. Trilete miospores with subcircular, rounded subtriangular, or oval amb. In lateral compression, proximal hemisphere ±flattened convex, distal hemisphere strongly convex. Laesura arms indistinct, straight, simple, longer than 1/2 radius in length. Wall 5-10 µm thick equatorially and distally including sculpture, may be slightly thinner proximally. Contact area indistinct, levigate or with verrucae about 2 µm high, 2-4 µm wide. Proximal-equatorial region and distal hemisphere with crowded, broadly rounded or ±flat-topped, irregularly convolute, partly anastomosing muri, separated by narrow light channels. Discrete verrucae and coni may occur among the muri, but are not the dominant sculptural type. Sculptural elements 2-8 µm wide, 2-5 µm (rarely up to 7 µm) high, some bearing minute grana or spinae on top.




*Text-figure 32: Transverse-sectional outline of sculptural elements of* ***Convolutispora subtilis.***

Diameter. 43-84 µm, mean 59 µm (68 specimens).

Occurrence. Figured specimens: Plate 4, figures 24, 25, loc. 8334, slide H, GSC 66238; Plate 4, figures 26, 27, loc. 8335, slide 2, 53 x 112.2, GSC 66239. Stratigraphic range, Weatherall and Hecla Bay formations, ?upper Eifelian and lower Givetian (Fig. 7, no. 85).

Comparison. **Archaeozonotriletes gravis** Arkhangelskaya (in Filimonova and Arkhangelskaya, 1963) is asymmetrically thickened and has sculpture consisting of closely spaced "tubercles", not muri.

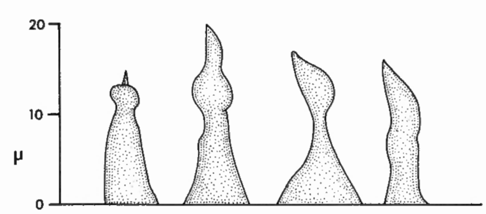
Genus **Corystisporites** Richardson 1965

Type species: **Corystisporites multispinosus** Richardson 1965

**?Corystisporites collaris** Tiwari and Schaarschmidt
Plate 4, figures 30-32, text-figure 33

? 1975 **Corystisporites collaris** Tiwari and Schaarschmidt, p. 28, Pl. 6, figs. 2-5, text-fig. 18.

Description. Spores trilete with rounded triangular or subcircular amb. Wall thickness undetermined. Trilete laesura arms obscured by membranous lips up to 16 µm high, highest at proximal pole. Ornamentation of the contact areas not distinguishable. Equatorial and distal sculpture consists of irregularly tapered, mostly broad-based spines, some of which bear a darkened collar-like bulge about 2-4 µm long and wide in the upper half of the spine. Spines 6-23 µm long, 2-8 µm wide at their base, tapered to a point, or blunt-tipped and surmounted by a delicate spine. Spines close together or up to 5 µm apart.




*Text-figure 33: Sculptural elements of* ***?Corystisporites collaris****, lateral view.*

Diameter. 63, 86 and 97 µm (3 specimens)

Occurrence. Figured specimen, loc. 8306, slide 1, 58.7 x 109.2, GSC 66243. Stratigraphic range, Weatherall Formation, upper Eifelian and lower Givetian (Fig. 7, no. 52).

Remarks. The most significant distinguishing characteristic of this species is the collar-like thickening on some of the spines (Tiwari and Schaarschmidt, 1975, p. 28). There is some doubt as to the taxonomic significance of this feature, as it occurs sporadically in other species as well, e.g. **Calyptosporites microspinosus** (Richardson) Tiwari and Schaarschmidt (1975, p. 44-45). Commonly, only a few spines on each specimen possess this thickening.

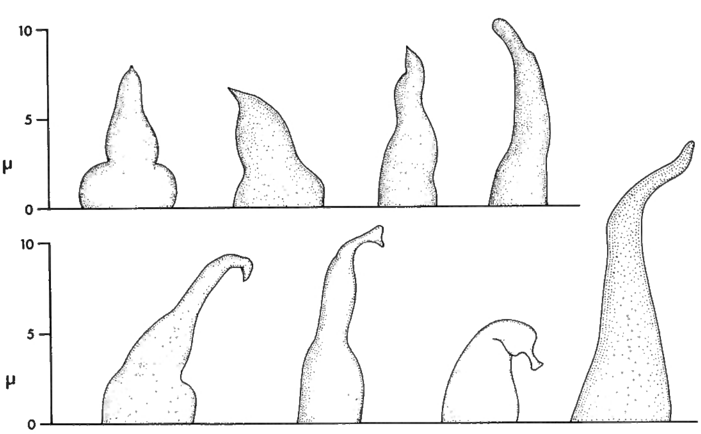
**Corystisporites multispinosus** Richardson

Remarks. There is considerable variation in the diameter of the spores, the length of their spines, and the ratio of spine length to spore diameter among specimens of this species. Extreme variants within this complex appear rather different from one another (e.g. Plate 5, figures 1, 3, and 4). We have attempted to divide the complex in various ways, none of which resulted in mutually exclusive groups, or species. The most reasonable subdivision seems to be one based primarily on the size of the spores, as high values for the ratio spore radius/spine length are more common amongst the smaller spores. Accordingly we propose a new variety, **spinulosus**, for these smaller spores. Establishment of this new variety results in another varietal name, to include the holotype of the species, being set up automatically with the same epithet as the species. Both varieties include specimens with a rather broad range of spine length. On study of additional specimens it may be possible to subdivide this group further, or in a more appropriate way.

**Corystisporites multispinosus** Richardson var. **multispinosus**
Plate 5, figures 1, 2, text-figure 34

1965 **Corystisporites multispinosus** Richardson (pars), p. 570, Pl. 89, fig. 10.

Diagnosis. Trilete miospores with rounded subtriangular or subcircular amb. In lateral compression, proximal surface flattened, distal region strongly rounded. Laesura arms hidden by prominent triradiate, fold-like lips that may be as much as 25 μm high at the proximal pole, and taper in width and height toward the equator. Exine proximally scabrate, distally and equatorially spinose, the spines closely crowded, each arising from a slightly tapered or bulbous base, may be fused basally into groups. Spines 3.5-20 μm (commonly 5-12 μm) long, 2-8 μm wide at their base, may be drawn out to a delicate, pointed, blunt, or rarely slightly expanded or anchor-like tip. Ratio of spore radius/average length of spines per specimen, 5.5-11.




*Text-figure 34: Sculptural elements of **Corystisporites multispinosus** var. **multispinosus**, lateral view.*

Diameter. 126-172 μm, mean 149 μm (12 specimens).

Holotype. Specimen designated by Richardson (1965, p. 570).

Occurrence. Figured specimen, loc. 8331, slide 1, 38 x 110.3, GSC 66244. Stratigraphic range, upper Weatherall Formation and Hecla Bay Formation, upper Eifelian and lower Givetian (Fig. 7, no. 67).

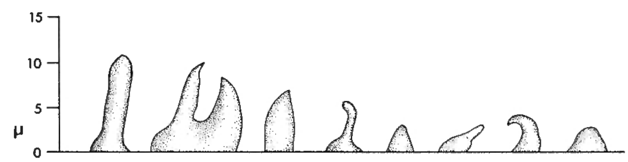
Comparisons. This variety intergrades with small-spined forms of **Acinosporites macrospinosus**. Discrimination between them may be especially difficult with poorly preserved or distorted specimens, in which the "concertina folds" around the contact areas may not be visible.

Remarks. This variety includes those specimens of Richardson's (1965) original material that are 126 μm or more in maximum equatorial diameter.

**Corystisporites multispinosus** Richardson
var. **spinulosus** n. var.
Plate 5, figures 3, 4, text-figure 35

1965 **Corystisporites multispinosus** Richardson (pars), p. 570, text-fig. 4.
1966 ?**Corystisporites multispinosus** Richardson; McGregor and Owens, Pl. 7, fig. 1.
1977 **Acinosporites macrospinosus** Richardson; McGregor, p. 129, Pl. 1, figs. 13, 14. (See McGregor, 1979, Pl. 1, fig. 20).
non 1975 **Corystisporites multispinosus** Richardson; Tiwari and Schaarschmidt, p. 27, Pl. 5, fig. 6, Pl. 6, fig. 1.

Diagnosis. As for **C. multispinosus** var. **multispinosus** except that spinae are 2.5-11.5 μm (commonly 2.5-7 μm) long, and the ratio of spore radius/average length of spines per specimen is 5.5-16.5.




*Text-figure 35: Sculptural elements of **Corystisporites multispinosus** var. **spinulosus**, lateral view.*

Diameter. 73-118 μm, mean 102 μm (31 specimens).

Occurrence. Holotype, Plate 5, figure 3, loc. 8334, slide 1, 42 x 123.8, GSC 66245. Paratype, Plate 5, figure 4, loc. 8323, slide 12, 33 x 111.2, GSC 66246. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 16).

Derivation of name. L. **spinula**, small thorn.

Comparisons. This variety is smaller than var. **multispinosus.** It overlaps var. **multispinosus** in total range of spine length, but on most specimens the spines are shorter on average, and shorter relative to the total diameter of the spore.

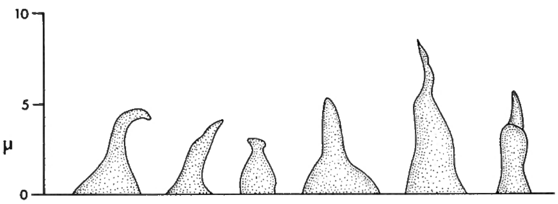
Extreme forms of **Kraeuselisporites acerosus** with large sculptural elements and a poorly developed zona intergrade with small-sculptured forms of **Corystisporites multispinosus** var. **spinulosus.** However most specimens of **K. acerosus** have distinctly smaller and more closely spaced sculptural elements, and a prominent subequatorial zona.

**Corystisporites serratus**? (Naumova) n. comb.
Plate 4, figures 28, 29, 33, 34, text-figure 36

? 1953 **Acanthotriletes serratus** Naumova, p. 25, Pl. 1, figs. 19, 20.

? 1959 **Acanthotriletes hirsutus** Chibrikova, p. 42, Pl. 1, fig. 10.
1964 "Grupo T1-sp", Regali, p. 170, fig. 2, no. 11.

Description. Trilete miospores with rounded subtriangular or subcircular amb, commonly distorted by folding. In lateral compression, proximal side flattened, distal region strongly convex. Trilete mark accompanied by membranous triradiate lips about 8-10 μm high that extend nearly to the equator, commonly obscured by exinal folds and the densely spinose distal sculpture. Proximal face levigate or scabrate, equatorial and distal regions bearing closely spaced spines. Spines 2.5-9 μm long, each arising from a strongly tapered or less commonly rounded base 2.5-4 μm wide, less sharply tapered toward the tip, pointed or rarely blunt or splayed at the tip. Wall relatively thin, but exact thickness not determined.



*Text-figure 36: Sculptural elements of **Corystisporites serratus?**, lateral view.*

Diameter. 46-83 μm, mean 64 μm (20 specimens).

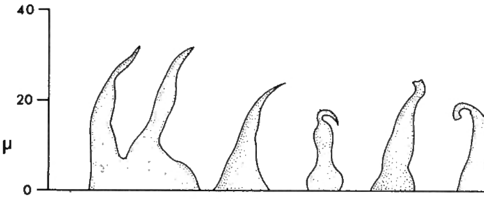
Occurrence. Figured specimens: Plate 4, figure 28, loc. 8321, slide 5, 58.3 x 109.1, GSC 66240; Plate 4, figure 29, loc. 8311, slide 3, 63.7 x 109.3, GSC 66241; Plate 4, figures 33, 34, loc. 8335, slide 10, 56 x 111.1, GSC 66242. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 59).

Comparison. **Corystisporites multispinosus** is much larger. **Acinosporites hirsutus** (Brideaux and Radforth) n. comb. bears longer, more varied, commonly biform spines that are joined to one another at their bases into ridges. **Acanthotriletes serratus** has strongly developed triradiate folds along the rays, according to the original illustrations of the species, in Naumova (1953). Its wall is "thick", according to the original description, and for this reason the identity of **A. serratus** with the present species is questioned. Whether or not they prove to be identical, there seems little doubt that the genus **Corystisporites** is appropriate for both.

**Corystisporites** sp. cf. **Acanthotriletes horridus** Hacquebard
Plate 5, figure 11, text-figure 37

cf. 1957 **Acanthotriletes horridus** Hacquebard, p. 309, Pl. 1, fig. 20.
1970 **Acanthotriletes** sp. A, Brideaux and Radforth, p. 34, Pl. 2, fig. 14.
1972 **Acanthotriletes horridus** Hacquebard; Mortimer and Chaloner, Pl. 4, fig. 2.

Description. Trilete miospores with rounded subtriangular amb. Laesura arms hidden by prominent triradial fold-like labra forming an apical prominence that extends to the equator of the spore. In lateral compression, proximal face flattened, distal side strongly convex. Wall about 2 μm thick, proximally scabrate, equatorially and distally bearing spines that arise from a gently tapered or bulbous base and taper gradually to a delicate, pointed tip. Rarely, a spine may terminate in a minute anchor-like bifurcation. Spines 2.5-10 μm wide at their base, 10-40 μm long, closely spaced or up to 18 μm apart. Pairs of adjacent elements rarely adjoined at their base.



*Text-figure 37: Sculptural elements of **Corystisporites** sp. cf. **Acanthotriletes horridus**, lateral view.*

Diameter. 87-142 μm (7 specimens).

Occurrence. Figured specimen, loc. 8331, slide 1, 42.8 x 110.1, GSC 66254. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 60).

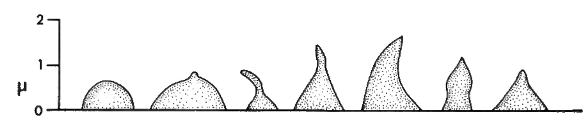
Comparisons. Except for the absence of a central body, and the rare occurrence of minute anchor-like spine tips, this species is identical to **Grandispora ?naumovii** (Kedo) McGregor (1973). **Acanthotriletes horridus** Hacquebard (1957) lacks a fold-like apical prominence, and has more space between spines distally than equatorially. **Acinosporites macrospinosus** Richardson (1965) has more closely crowded processes, and anastomosing ridges connecting the bases of the processes. **Archaeotriletes laetus** Sergeeva (in Nazarenko et al., 1971) has shorter spines and is thicker-walled. **Acanthotriletes** cf. **horridus** Hacquebard, of Richardson (1965), apparently lacks elevated lips.

Genus **Craspedispora** Allen 1965

Type species. **Craspedispora craspeda** Allen 1965.

**Craspedispora arctica** n. sp.
Plate 5, figures 5-9, text-figure 38

Diagnosis. Trilete, zonate spores with rounded subtriangular or suboval amb. Laesura arms 2/3 radius in length, bordered by distinct or indistinct dark lips that are individually 2.5-4 μm wide at the pole and become slightly narrower toward the tips of the rays. Wall of spore body 3-5 μm thick interradially at equator, slightly thinner opposite rays. Zona equatorial and 1.2-5 μm wide interradially; distinctly narrower or absent radially; if present radially, may be deflected onto proximal face opposite one or more of the rays. Proximal face levigate or minutely sculptured; distal region and equator, including zona, bears broad-based coni and/or truncate coni, and rare grana and small spinae, about 1-1.5 μm in height and basal width, about 1-2 μm apart.



*Text-figure 38: Sculptural elements of **Craspedispora arctica**, lateral view.*

Diameter. 49-59 μm, mean 52 μm (13 specimens).

Occurrence. Holotype, Plate 5, figures 5-7, loc. 8339, slide 7, 54.8 x 112.2, GSC 66247. Paratype, Plate 5, figures 8, 9, loc. 8312, slide 1, 68.7 x 126.2, GSC 66248. Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 61).

Derivation of name. Gr. **arktos**, bear, north.

Remarks. The dark ring, interpreted as reflecting the thickness of the spore body wall, appears to be internal. The distal and proximal surfaces of the spore run smoothly across it to form the equatorial structure here interpreted as a zona. This interpretation is open to question, however, and we cannot eliminate the possibility that these spores are camerate.

Comparisons. **C. craspeda** Allen has a wider, levigate or sparsely sculptured zona. **Camarozonotriletes paraexinus** Chibrikova (1962) bears slender confluent spinae that form a fimbriate rim at the equator. **C. sextantii** McGregor and Camfield (1976) commonly has straight or concave interradial margins and a more pronounced thinning of the equatorial wall radially, lacks a zona, and has its largest sculptural elements at the equator interradially.

Genus **Cristatisporites** Potonié and Kremp 1954 emend. Butterworth et al. in Staplin and Jansonius 1964

Type species. **Cristatisporites indignabundus** (Loose) Potonié and Kremp 1954.

1964 **Asperispora** Staplin and Jansonius, p. 107.
1965 **Samarisporites** Richardson (pars), p. 581; p. 583, **S. orcadensis.**

The various emendations of **Cristatisporites** are summarized in Table 4 and compared with the original diagnosis of the genus by Potonié and Kremp (1954). The two nearly-identical diagnoses of Butterworth et al. (in Butterworth, 1964, and in Staplin and Jansonius, 1964), like that of Bharadwaj and Venkatachala (1962), recognize the "cingulate" (or zonate) nature of the genus, and distinguish **Cristatisporites** from **Densosporites** by its less massive "cingulum", its apiculate-tipped sculptural elements, and the fact that the sculpture is (or may be) homogeneous over the whole distal region. Other features, such as the loose ring of sculpture or pits around the contact area, the cristate arrangement of the distal sculpture, and the internal foveolae or vacuolae, are optional according to the diagnoses of Butterworth et al. (in Butterworth, 1964, and in Staplin and Jansonius, 1964) and therefore are not useful for differentially diagnosing the genus.

The specimens described below are best accommodated in **Cristatisporites** as emended by Butterworth et al. (in Staplin and Jansonius, 1964), although these authors do not mention cristae as a sculptural option. The emended diagnosis of Butterworth et al. (in Butterworth, 1964) does include reference to cristae and it seems reasonable to assume that cristae are a viable sculptural option in either emendation. Cristae or coalesced sculpture is characteristic of **Asperispora** Staplin and Jansonius (1964), but as can be seen from Table 4, this genus is not clearly distinguishable from **Cristatisporites** as emended in the same paper.

**Samarisporites** Richardson (1965), proposed nearly simiItaneously with, and independently of, the emendations of **Cristatisporites** by Butterworth et al., is distinguished from the latter only by the requirement that spores in it have an unsculptured proximal face. This distinction is taxonomically trivial, and is especially difficult to maintain for those species that have dense, prominent distal sculpture that tends to obscure the details of the proximal face (see also Playford, 1971, p. 40). We have not used **Samarisporites** for this reason, and because it contains some species (e.g. **S. megaformis** Richardson, 1965) that may be placed more conveniently in **Grandispora** (see McGregor, 1973). **Cingulizonates** (Dybova and Jachowicz, 1957) emend. Butterworth et al. (in Staplin and Jansonius, 1964) is bizonate, but has two distal zones of sculpture and, as interpreted, a raised proximal annular "cuesta".

Many of the Devonian specimens that have been assigned by various authors to **Cristatisporites, Asperispora, Cingulizonates, Samarisporites, Hymenozonotriletes,** and **Densosporites** apparently have basically similar structure and sculpture (see Staplin and Jansonius, 1964; Richardson, 1965). The group clearly needs to be revised, and the diagnoses of its constituent genera made more precise, with reference both to the type material of the various species contained in them, and the practical aspects of differential diagnosis. It seems unlikely that as many as six genera are necessary to accommodate this complex.

With respect to these genera, our usage in this paper is as follows: those specimens of the complex with prominent, closely crowded, at least partly confluent (cristate) distal sculpture, e.g. **Cristatisporites albus**? (Arkhangelskaya) n. comb., we place in **Cristatisporites** emend. Butterworth et al. (in Staplin and Jansonius, 1964). Those with discrete distal sculptural elements are assigned to **Kraeuselisporites** Leschik emend. Scheuring (1974). Those with a prominent annular dark ring, e.g. **Densosporites devonicus,** we place in **Densosporites** Berry emend. Potonié and Kremp (1954) in nomenclatural conformance with the generally accepted usage established by Richardson (1965), noting however that neither this emendation nor others that have been proposed are entirely appropriate for optically "bizonate" spores of this type.

Accordingly, the following Devonian species are transferred to **Cristatisporites:**

1. **Cristatisporites albus** (Arkhangelskaya) n. comb. Basionym: **Hymenozonotriletes albus:** Arkhangelskaya, 1963, p. 26, Pl. 11, figs. 1-4.
2. **Cristatisporites praetervisus** (Naumova) n. comb. Basionym: **Hymenozonotriletes praetervisus** Naumova, 1953, p. 40, Pl. 4, fig. 8.
3. **Cristatisporites orcadensis** Richardson, 1960, p. 58, = **Samarisporites orcadensis** (Richardson) Richardson, 1965, p. 583.
4. **Cristatisporites conannulatus** Richardson 1960, p. 60, = **Samarisporites conannulatus** (Richardson) Richardson, 1965, p. 583.
5. **Cristatisporites mediconus** Richardson, 1960, p. 60, = **Samarisporites mediconus** (Richardson) Richardson, 1965, p. 583.
6. **Cristatisporites naumovae** (Staplin and Jansonius) n. comb. Basionym: **Asperispora naumovae** Staplin and Jansonius, 1964, p. 107, Pl. 19, figs. 5, 6, 10, 11, text-fig. 2h.
7. **Cristatisporites hesperus** (Allen) n. comb. Basionym: **Samarisporites hesperus** Allen, 1965, p. 715, Pl. 98, figs. 12-16.
8. **Cristatisporites triangulatus** (Allen) n. comb. Basionym: **Samarisporites triangulatus** Allen, 1965, p. 716, Pl. 99, figs. 1-6.
9. **Cristatisporites inusitatus** (Allen) n. comb. Basionym: **Samarisporites inusitatus** Allen, 1965, p. 717, Pl. 99, figs. 7-9.
10. **Cristatisporites euglyphus** (Taugourdeau-Lantz) n. comb. Basionym: **Samarisporites euglyphus** Taugourdeau-Lantz, 1967, p. 52, Pl. 2, figs. 7 and 8.

Other species that may be **Cristatisporites** but need further study before nomenclatural transfer: **Hymenozonotriletes polystichus** Naumova (1953), **H. deliquescens** Naumova (1953), **H. tichomirovii** Naumova (1953), and **Calyptosporites decorus** Tiwari and Schaarschmidt (1975).

**Cristatisporites albus**? (Arkhangelskaya) n. comb.
Plate 5, figures 10, 12-16, text-figure 39

? 1963 **Hymenozonotriletes albus** Arkhangelskaya, p. 26, Pl. 11, figs. 1-4.

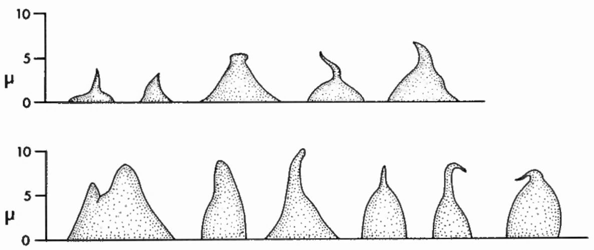
Table 4

Comparative summary of diagnoses of **Asperispora** and **Cristatisporites**

| | | | | Exoexinal Sculpture | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | AMB | Y | Wall | Proximal | Distal | Special | Cingulum | Zona | Other | Distinguishing Features |
| **Asperispora** 1964 (Staplin & Jansonius) | subtriangular or subcircular | sutural ridges distinct | 2 layers; inner indistinct | smooth or faintly sculptured | glandulose-apiculose-verrucose, [all] mammoid or with setose tips and in part coalesced | | | relatively narrow | | uniformly sculptured proximally, has distinct sutural ridges, lacks internal foveolation and vacuolation |
| **Cristatisporites** 1954 (Potonié & Kremp) | | often indistinct | | thickly covered with coni or spinae, merged row-like at bases as ridges ± parallel or spiral to equator | | | | | | |
| 1962 (Bharadwaj & Venkatachala) | triangular or subcircular | to equator | | regular or irregular cristae of spinae, verrucae or coni | | | thick, wedge-shaped | | | |
| 1964 (Butterworth et al., in Butterworth) | subtriangular, circular or oval | often indistinct, simple or with lips, extends to "ring" or equator | 2 layers; inner ± smooth, often indistinct; outer thick distally, much thinner proximally | minute sculpture in contacts; cingulum smooth, granular or apiculate | mammoid; or with verrucae, some setose tips; may be in rows parallel to equator; same on cingulum and central area | usually a loose ring of setae, apiculae, granules or pits around contacts | margin irregular or strongly incised | | inner surface of exoexine may be minutely foveolate or vacuolate | Prominent distal sculpture |
| 1964 (Butterworth et al., in Staplin & Jansonius) | subtriangular or subcircular | often indistinct, ridges or grooves, extends to "ring" | 2 layers; inner ± smooth, often indistinct | minute sculpture in contacts; zona smooth, granulose, or apiculate | prominent, mammoid, or with warts, some with setose tip; may be same at equator | usually a loose ring of setae, apiculae, grana, or small pits around contacts | | not raised above central proximal not bizonate (Staplin & Jansonius 1964, Table 1); margin irregular or strongly incised | inner surface of exoexine may be minutely foveolate or vacuolate | has differentiated proximal and internal sculpture and structure, and proportionally wider zona than **Asperispora** |

Description. Trilete, zonate spores with subcircular or subtriangular amb. In lateral compression, proximal side flattened, distal region strongly convex. Laesura arms extend to margin of central region, commonly obscured by triradiate fold-like labra about 4-12 μm high at the pole that extend, decreasing in height, to or nearly to the equator. A thin inner body may be visible on some specimens. Outer wall differentiated into a central broadly subtriangular or subcircular region and an equatorial extension (zona) about 1/5 to 1/3 the radius in width. Central region thin proximally, slightly thicker distally except at its margin where it commonly is significantly thicker (darker) internally in a concentric ring at the inner limit of the zona.

Proximal face levigate or scabrate, distal and equatorial regions with comprehensive sculpture of coni and verrucae 2-9 μm wide at their base and 2-7 μm (rarely as much as 10 μm) high. Most sculptural elements surmounted by a minute spina or baculum with a pointed or less often blunt or spreading tip. Verrucae more numerous than coni in central distal region. Sculptural elements discrete or joined in subconcentric, sinuous, or subreticulate groups (cristae). Incidence of sculptural confluence commonly greatest in central distal region.




*Text-figure 39: Sculptural elements of **Cristatisporites albus**?, lateral view.*

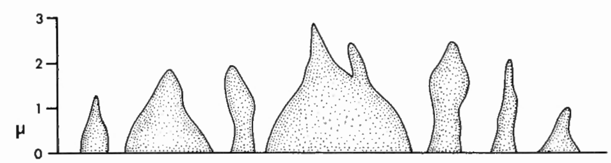
Diameter. 76-135 μm, mean 101 μm (72 specimens).

Occurrence. Figured specimens: Plate 5, figure 10, loc. 8320, slide G, GSC 66249; Plate 5, figures 12, 13, loc. 8320, slide 1, 34.6 x 120.5, GSC 66250; Plate 5, figure 14, loc. 8309, slide 1, 33 x 122, GSC 66251; Plate 5, figure 15, loc. 8317, slide 1, 67.1 x 109.8, GSC 66252; Plate 5, figure 16, loc. 8311, slide B, GSC 66253. Stratigraphic range, Weatherall and Hecla Bay formations, ?upper Eifelian and lower Givetian (Fig. 7, no. 74).

Comparisons. **Cristatisporites albus** has only slightly developed labra, according to the illustrations in Arkhangelskaya (1963), and is larger, but in other respects it appears to be like our species. **C. orcadensis** Richardson may be distinguishable by a more consistently subtriangular amb and lesser incidence of basal interconnection of sculptural elements. These differences are difficult to maintain however, as they are gradational. We prefer to be cautious in drawing comparisons with **C. albus** and **C. orcadensis**, as we have not examined the type material of either species. Extreme variants of **C. albus**? intergrade with **Acinosporites acanthomammillatus**. **Cristatisporites** sp. of Scott and Doher (1967, fig. 2c) and **Samarisporites** sp. of Grey (1974, fig. 61p,q) seem similar to **C. albus**? but, as neither is described, it is not possible to make precise comparisons. **Spelaeotriletes** sp. of Peppers and Damberger (1969) has sculpture predominantly of verrucae that are only rarely joined at their bases. **Hymenozonotriletes polystichus** Naumova (1953) has rounded sculpture and simple trilete rays.

**Cristatisporites** sp.
Plate 6, figure 1, text-figure 40

Description. Trilete, zonate spore with subtriangular amb and strongly convex interradial margins. Laesura arms simple, about 2/3 the body radius in length. Intexine thin, concentrically folded. Exoexine closely appressed to intexine, thin and levigate in contact areas, thicker and convex distally, extended equatorially as a zona about 1/3 the radius in width, slightly wider at corners than interradially. Equatorial and distal regions of exoexine bear minute sculpture of varied form, consisting of mammae, coni, spinae, and rare bacula and pila. Sculptural elements 1-3 μm long, 0.5-3 μm wide, mostly longer than wide, at the equator adjoining at the base or up to 7 μm apart, showing progressively greater incidence of basal fusion toward the distal pole where the fused bases form irregularly disposed, closely spaced cristae. Cristae arranged more or less concentrically at inner limit of zona.




*Text-figure 40: Sculptural elements of **Cristatisporites** sp., lateral view.*

Diameter. 148 μm (one specimen only).

Occurrence. Loc. 8311, slide H, GSC 66255, Weatherall Formation, upper Eifelian (Fig. 7, no. 76).

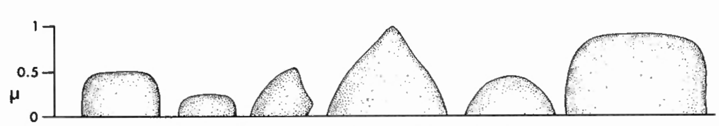
Genus **Cyclogranisporites** Potonié and Kremp 1954

Type species. **Cyclogranisporites leopoldi** (Kremp) Potonié and Kremp 1954

**Cyclogranisporites amplus**? McGregor
Plate 6, figures 2, 3, text-figure 41

? 1960 **Cyclogranisporites amplus** McGregor, p. 29, Pl. 11, fig. 8.

Description. Trilete spores with subcircular amb and profile. Laesura arms 1/2 to 3/4 the radius in length, simple, straight, commonly of unequal length. Wall sculptured proximally and distally with closely spaced grana, baculo-grana, and rare coni less than 1.5 μm (mostly less than 1 μm) wide and high. Wall 1-3 μm thick, of about constant thickness overall on each specimen, rarely folded.




*Text-figure 41: Sculptural elements of **Cyclogranisporites amplus**?, lateral view.*

Diameter. 40-77 μm, mean 53 μm (31 specimens).

Occurrence. Figured specimens: Plate 6, figure 2, loc. 8320, slide 1, 56.7 x 119.8, GSC 66256; Plate 6, figure 3, loc. 8333, slide C, GSC 66257. Stratigraphic range, Weatherall Formation, upper Eifelian and ?lower Givetian (Fig. 7, no. 77).

Comparison. These spores differ from **Cyclogranisporites amplus** only in their smaller size. **Apiculiretusispora nitida** Owens has distinct curvaturae delimiting levigate contact areas, and coni as well as grana. **Lophotriletes rotundus** Naumova ex. Kedo (1955) resembles **C. amplus**?, but the description and illustration lack sufficient precision for detailed comparison.

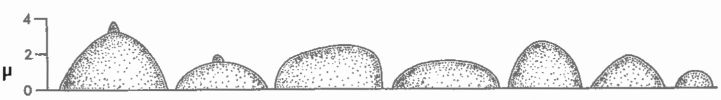
Genus **Cymbosporites** Allen 1965

Type species. **Cymbosporites magnificus** (McGregor 1960) n. comb.

**Cymbosporites magnificus** (McGregor) n. comb.
Plate 6, figures 4, 5, text-figure 42

1960 **Lycospora magnifica** McGregor, p. 35, Pl. 13, figs. 2-4.
1960 **Lycospora magnifica** forma **endoformis** McGregor, p. 36, Pl. 12, figs. 9, 10.
? 1964 **Lycospora rugulatus** Vigran, p. 23, Pl. 1, figs. 17, 18, Pl. 2, fig. 15.
1965 **Cymbosporites cyathus** Allen, p. 725, Pl. 101, figs. 8-11.
1971 **Verruciretusispora magnifica** (McGregor) Owens var. **magnifica** emend. Owens, p. 22, Pl. 5, figs. 1-6.
1971 **Verruciretusispora magnifica** var. **endoformis** (McGregor) Owens, p. 24, Pl. 5, fig. 7.
? 1977 **Archaeozonotriletes vorobjensis** Naumova; Chibrikova, Pl. 14, fig. 2.

Description. Trilete, patinate miospores with subcircular or rounded subtriangular amb. In lateral compression, proximal face poleward from inner edge of patina flattened or depressed, distal hemisphere strongly rounded. Contact areas levigate or scabrate, well defined in most specimens by lateral confluence of equatorial sculpture forming arcuate ridges separating the thin proximal face from the thickened equatorial and distal regions. Wall about 1-3 µm thick proximally, about 6-12 µm thick at equator and distally. Laesura arms 3/4 to full radius in length, accompanied by straight or sinuous labra about 2-4 µm wide and high, or less commonly by higher fold-like labra that are fused radially with the arcuate ridges. Proximal-equatorial and distal regions sculptured with verrucae, mammae, and rounded coni of low relief, 1-4 µm high, 2-6 µm wide at their base, discrete and closely spaced, or joined laterally into short irregularly-trending ridges.




*Text-figure 42: Sculptural elements of **Cymbosporites magnificus**, lateral view.*

Diameter. 66-107 µm, mean 82 µm (35 specimens).

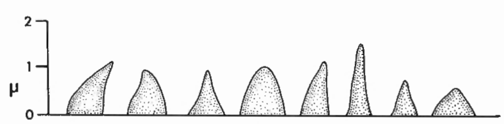
Occurrence. Figured specimen, loc. 8342, slide 3, 34 x 122.4, GSC 66258. Stratigraphic range, Hecla Bay Formation, lower Givetian (Fig. 7, no. 101).

Comparisons. Having re-examined the types of **Verruciretusispora magnifica** (McGregor) Owens, we find no significant difference between them and the specimens we have assigned to this species from Melville Island. We also believe, as suggested elsewhere (Owens, 1971, p. 24; McGregor, 1979, p. 33) that **Cymbosporites cyathus** Allen (1965) is similar, and accordingly place it in synonymy. Some of the present specimens are identical to **Cymbosporites magnificus (C. cyathus)** as originally described by McGregor (1960) and Allen (1965). Others show a greater tendency toward fusion of sculptural elements on the distal face, and/or development of an apical prominence, which are features that characterize **Acinosporites acanthomammillatus** Richardson (1965). The latter and **Cymbosporites magnificus** are of basically similar construction, but are distinguished by the more prominent labra and sculptural ridges and the larger, more prominently-projecting verrucate-mammillate sculpture of **A. acanthomammillatus**. In including specimens from some basal fusion of sculpture, we take a somewhat broader circumscription of **Cymbosporites magnificus (C. cyathus)** than does Allen (1965). Specimens we have assigned to **C. magnificus** are clearly part of a morphologically intergrading complex, that also includes **Acinosporites acanthomammillatus, A. hirsutus** and **Cristatisporites albus**?.

**Archaeozonotriletes vorobjensis** Naumova, in Chibrikova (1977, Pl. 14, fig. 2) is at least superficially like **C. magnificus**. We have not been able to locate a description of that species so cannot make further comparison.

**Cymbosporites? opacus** n. sp.
Plate 6, figures 6, 9, 10, text-figure 43

Diagnosis. Trilete, ?patinate and ?camerate miospores with subcircular amb. In lateral profile, proximal face flattened pyramidal, distal region subhemispherical. Laesura arms obscured by convoluted fold-like lips up to 10 µm high and wide that extend to or almost to the equator, and are of about the same width and height from the pole to their distal extremities, or are wider toward the equator. Intexine thin, smooth, rarely folded or distorted, commonly but not invariably approximately concentric with the amb, separated from the outer rim of the exoexine distally and equatorially by a distance equal to about 1/3 to 1/4 the radius. Optical density of spore about the same on both sides of the intexinal boundary. Exoexine thick, exact thickness not determined, porous-infragranulate ("spongy") in texture, commonly distorted at the equator by coarse, indistinct, low folds. Most specimens bear coarse, radially oriented, weakly or strongly delimited proximal thickenings or folds 3.5-7 µm wide that extend from slightly poleward of the equator to within a few microns of the proximal pole. Exoexine bears discrete coni and small spine 0.5-1 (rarely up to 1.5) µm long, 0.5-1 µm wide, and 2-4 µm apart equatorially and distally.




*Text-figure 43: Sculptural elements of **Cymbosporites? opacus**, lateral view.*

Diameter. 72-149 µm, mean 102 µm (35 specimens).

Occurrence. Holotype, Plate 6, figure 10, loc. 8342, slide 3, 33.9 x 129, GSC 66261. Paratypes: Plate 6, figure 6, loc. 8342, slide 3, 58.8 x 128.5, GSC 66259; Plate 6, figure 9, loc. 8339, slide 4, 40 x 127.6, GSC 66260. Stratigraphic range, Hecla Bay Formation, lower Givetian (Fig. 7, no. 108).

Derivation of name. L. **opacus**, dark.

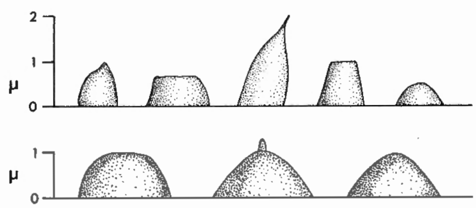
Remarks. The structure of this species is difficult to interpret. The dark and rigid appearance of the exoexine suggests that it is relatively thick, but no wall thickness feature has been observed. The feature interpreted as the intexinal wall is more or less centrally located relative to the proximal pole on all specimens, as would be the case if it were firmly attached to the exoexine proximally. On some specimens its contour does not parallel that of the outer limit of the exoexine in polar compression, which suggests that it is not closely appressed to the inner surface of a thick exoexinal wall. The "spongy" appearance of the wall may be a result of degradation.

Comparisons. Like **Cymbosporites? opacus**, **Archaeozonotriletes meandricus** Allen (1965) has sinuous, elevated lips and a thick, infragranulate wall, and one of the specimens illustrated by Allen (1965, Pl. 100, fig. 13) evidently has vaguely defined, radially disposed proximal "ridges". However, **A. meandricus** lacks sculpture and according to Allen is "probably one-layered". **Periplecotriletes tortus** Egorova (1974) bears randomly disposed ridges but no other sculpture, and apparently is not camerate. **Archaeozonotriletes primarius** Naumova (1953) may be similar in basic structure to **Cymbosporites? opacus** but lacks convolute lips and the radially disposed pattern.

**Cymbosporites** sp. cf. **Retusotriletes tschibrikovii** Mikhailova
Plate 6, figures 7, 8, 11, 12, text-figure 44

cf. 1966 **Retusotriletes tschibrikovii** Mikhailova, p. 203, Pl. 2, fig. 5.

Description. Trilete, patinate miospores with rounded subtriangular or subcircular amb. Laesura arms extend to or almost to equator, straight or slightly sinuous near pole, simple or with narrow, low labra 1-2 μm wide and high. Wall significantly thicker at equator and distally than proximally, but precise thickness not determined. Contact areas levigate or scabrate, thin, with concentric compression folds on some specimens. Proximal-equatorial and distal regions with grana, coni, and short bacula 1-2 μm in height and basal width, round or polygonal in plan view, closely crowded or up to 2.5 μm apart.




*Text-figure 44: Sculptural elements of* ***Cymbosporites*** *sp. cf.* ***Retusotriletes tschibrikovii****, lateral view.*

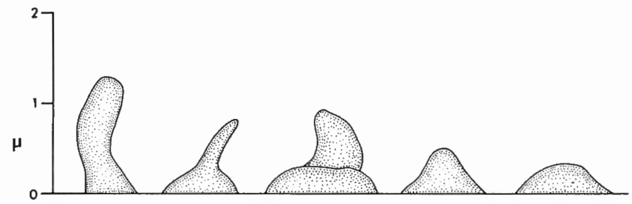
Diameter. 73-94 μm (5 specimens).

Occurrence. Figured specimens: Plate 6, figures 7, 8, loc. 8339, slide 4, 64.4 x 128.9, GSC 66262; Plate 6, figures 11, 12, loc. 8338, slide 4, 36 x 122, GSC 66263. Stratigraphic range, Hecla Bay Formation, lower Givetian (Fig. 7, no. 103).

Comparison. If patinate, **Retusotriletes tschibrikovii** Mikhailova (1966) would resemble the specimens from the Hecla Bay Formation except for its smaller diameter and distinct curvaturae.

**Cymbosporites** sp.
Plate 6, figures 16, 17, text-figure 45

Description. Trilete, patinate spores with rounded-subtriangular or subcircular amb. Laesura arms extend to the inner edge of the patina, accompanied by an elevated, fold-like triradiate prominence up to 10 μm wide that may extend beyond the arms of the laesura onto the patina. In polar view the patina is symmetrical or slightly asymmetrical and about 3.5-9 μm wide, enclosing a broadly subtriangular or subcircular central area. Proximal central area thin, levigate. Patina bears grana, coni, and biform ornaments 0.5-2 μm high and wide, rather widely spaced at the equator and closely spaced over the distal side. Proximal part of patina levigate or sparsely sculptured.




*Text-figure 45: Sculptural elements of* ***Cymbosporites*** *sp., lateral view.*

Diameter. 46-55 μm (4 specimens).

Occurrence. Figured specimen, loc. 8342, slide 3, 54.6 x 125.4, GSC 66268. Found only in topmost sample of Hecla Bay Formation, ?mid-Givetian (Fig. 7, no. 116).

Genus **Deltoidospora** Miner 1935

Type species. **Deltoidospora hallii** Miner 1935.
For synonymy, see McGregor (1973), p. 15.

**Deltoidospora** sp.
Plate 6, figure 15

Description. Trilete miospores with subtriangular amb and straight or convex interradial margins. Laesura arms straight, 3/4 to 4/5 radius in length. Rays commonly accompanied by labra about 2 μm wide and high. Wall 2-3 μm thick, levigate or minutely scabrate.

Diameter. 21-36 μm, mean 29 μm (8 specimens).

Occurrence. Figured specimen, loc. 8337, slide 9, 64.2 x 111.8, GSC 66269. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 81).

Genus **Densosporites** Berry emend. Potonié and Kremp 1954

Type species. **Densosporites covensis** Berry 1937.

We believe the dark ring visible at the outer edge of the central body of the species of **Densosporites** described herein is not a cingulum. Rather, it is an optical effect resulting from proximal-distal compression of the thick, strongly convex equatorial-distal region of the exoexine, accentuated by the tendency for concentration and fusion of sculpture at the outer limit of the contact areas. This interpretation is supported by the thick wall of the specimen of **D. devonicus** shown in microtome section by Allen (1965, Pl. 98, fig. 6). It is also consistent with the observation that the "cingulum" does not extend all the way around the body on some specimens. Such discontinuity could result if the distal wall were distorted to one side during compression.

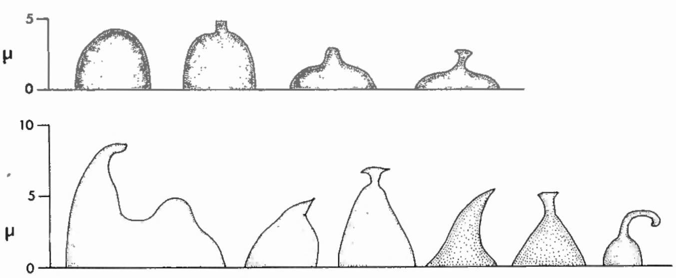
Assuming this interpretation to be correct, we refer to these Devonian species of **Densosporites** as zonate rather than cingulizonate. The zone itself may be quite thick, as in the above-mentioned specimen of Allen (1965; see also his Pl. 99, figs. 11, 12, **Cirratriradites avius** Allen), or only moderately thick as seen in some laterally compressed specimens from Melville Island (e.g. Pl. 6, fig. 21). Thus interpreted, these spores are rather different in structure from typical Carboniferous representatives of the genus. It may be appropriate to consider assigning them to a new genus, characterized by "pseudobizonate" structure and somewhat thickened, rarely folded "light zone" or equatorial extension.

Further work is necessary, perhaps including thin sectioning and SEM studies, to clarify the structure of the spores herein assigned to **Densosporites**, and the whole complex of "zonate" Middle Devonian spores placed by various authors in **Kraeuselisporites, Samarisporites,** and **Cristatisporites.**

**Densosporites concinnus** (Owens) n. comb.
Plate 6, figures 13, 14, 18, 19, text-figure 46

1971 **Samarisporites concinnus** Owens, p. 45, Pl. 12, figs. 7-9, Pl. 13, figs. 1-3.
1972 **Samarisporites** n. sp., McGregor and Uyeno, Pl. 2, fig. 3.
1975 **Densosporites devonicus** Richardson; Tiwari and Schaarschmidt, p. 31, Pl. 14, figs. 1-3.

Description. Trilete, zonate miospores with rounded subtriangular or subcircular amb. In lateral view, proximal face flattened or low-pyramidal, distal surface strongly convex. Laesura arms 1/2-4/5 radius in length, commonly obscured by high, triradiate fold-like labra that extend, tapered in width and height, to or almost to the equator. Intexine thin, commonly not distinguishable. Exoexine thin in contact areas, up to 6 µm thick distally, extended laterally as a zona. Zona appears to consist of two parts, an inner, thickened, dark ring 5-13 µm wide, 1/5 to 1/3 the radius in width, adjacent to and commonly overlapping the equatorial margin of the intexine; and an outer, thinner, usually narrower flange-like extension. The inner and outer margins of the thickened ring commonly are not sharply delimited. Equatorial and distal regions of the exoexine bear coni and spinae that taper gradually or abruptly toward their tip, and less commonly mammoid ornaments. Tips of sculptural elements pointed, blunt, or rarely bearing a minute widened or anchor-like termination. Sculptural elements are of same dimensions equatorially and distally, or smaller toward the distal pole. Sculptural elements 1-10 µm (mostly 2-5 µm) in basal width, 2-9 µm (mostly 3-6 µm) high, closely crowded, or up to 10 µm apart.



*Text-figure 46: Sculptural elements of **Densosporites concinnus**, lateral view.*

Diameter. 53-96 µm, mean 72 µm (137 specimens).

Occurrence. Figured specimens: Plate 6, figure 13, loc. 8332, slide B, GSC 66264; Plate 6, figure 14, loc. 8331, slide 3, 41.3 x 114, GSC 66265; Plate 6, figure 18, loc. 8333, slide K, GSC 66266; Plate 6, figure 19, loc. 8331, slide 1, 34.6 x 119.5, GSC 66267. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 23).

Comparisons. Spores of this type are common in the Eifelian and Givetian of Arctic Canada and have been reported from other parts of the world by several authors. Extreme variants of **Densosporites concinnus** intergrade with **D. devonicus** and **D. inaequus.** The two last-mentioned species may be distinguished from **D. concinnus** by their larger size, by the more elongate, predominantly bifurcate sculpture of **D. devonicus,** and by the larger, broader-based, less densely distributed sculpture of **D. inaequus.**

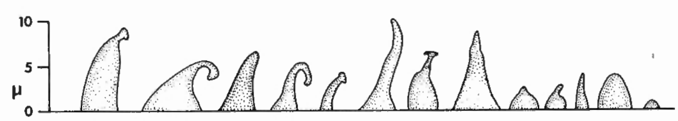
**Hymenozonotriletes tichomirovii** Naumova in Andreeva et al. (1967, fig. 19), **H. argutus** Naumova in Tuzova (1959, Pl. 6, fig. 7), and the spore figured but undescribed by Regali (1964, fig. 2, no. 16) may be **D. concinnus,** but synonymy cannot be confirmed from the published information. **Hymenozonotriletes pachyacanthus** Naumova ex Kedo (1955) is much larger, but apparently a smaller version of this species, perhaps like **D. concinnus,** was described previously but not published by Naumova. (See Kedo, 1955, p. 31.)

**Hymenozonotriletes polyacanthus** Naumova (1953) is well within the size range of **D. concinnus,** but includes some specimens with larger spines, judging from Naumova's illustrations (op. cit., Pl. 4, figs. 11, 12). The Soviet concept of this species may include a wider range of morphology than either **D. concinnus** or **D. devonicus** (cf. Kedo, 1955, Pl. 3, figs. 5, 6) but may embrace specimens assignable to both. Naumova (1953) does not specify which of her figured specimens is the holotype, so without further information on the Soviet material it seems impossible to resolve either the nomenclatural or the taxonomic disposition of **H. polyacanthus** vis-à-vis **D. concinnus** and **D. devonicus.**

**Densosporites devonicus** Richardson
Plate 6, figures 20, 21, text-figure 47

1960 **Densosporites devonicus** Richardson, p. 57, Pl. 14, figs. 10 and 11, text-fig. 7.
1965 **Densosporites orcadensis** Richardson, p. 580, Pl. 92, figs. 1 and 2.
1976 **Hymenozonotriletes propolyacanthus** Arkhangelskaya, p. 55, Pl. 10, figs. 3, 4.
1976 **Densosporites orcadensis** Richardson; McGregor and Camfield, p. 17, Pl. 6, fig. 3.
non 1975 **Densosporites devonicus** Richardson; Tiwari and Schaarschmidt, p. 31, Pl. 14, figs. 1-3.

Description. Trilete, zonate miospores with rounded-subtriangular or subcircular amb. In lateral compression, proximal face flattened-pyramidal, distal region strongly rounded. Laesura arms extend 2/3 to full distance to inner edge of equatorial extension (zona), commonly obscured by fold-like labra about 5-13 µm in height and combined width, that extend to the inner edge of the zona or beyond. Intexinal body thin, commonly not distinguishable. Exoexine thin in contact areas, considerably thicker distally, extended laterally as a zona. Dark inner part of the equatorial extension about 10-28 µm wide, overlaps central area, and is bounded equatorially by an outer, less thickened, flange-like light zone up to about 24 µm wide. Dark zone may be narrower, equal to, or wider than light zone. Distal and proximal-equatorial regions bear spinae or coni that taper gradually to the tip, or taper sharply and are surmounted by a slender extension. Sculptural elements pointed or with a minutely expanded or bifurcate tip. Elements 1-12 µm long, 1-5 µm wide at the base, and about 1-7 µm apart, the smallest commonly occurring in the distal polar region. Mammillate biform elements, blunt cones, and small verrucae may also be present, especially toward the distal pole. Sculptural elements mostly discrete except at the outer edge of the dark zone proximally, where their bases tend to coalesce.



*Text-figure 47: Sculptural elements of **Densosporites devonicus**, lateral view.*

Diameter. 91-179 μm, mean 117 μm (63 specimens).

Occurrence. Figured specimens: Plate 6, figure 20, loc. 8320, slide L, GSC 66270; Plate 6, figure 21, loc. 8320, slide 1, 66 x 111, GSC 66271. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 46).

Comparisons. The main criterion used by Richardson (1965) for differentiating **D. devonicus** from **D. orcadensis** is the width of the "light zone" compared to that of the "dark zone" of the equatorial extension. Forms like **D. orcadensis**, in which the width of the light zone is equal to or greater than that of the dark zone, occur in this section and others in the Canadian Arctic Islands, but they intergrade with **devonicus**-like forms in such a way that it seems impractical to separate them.

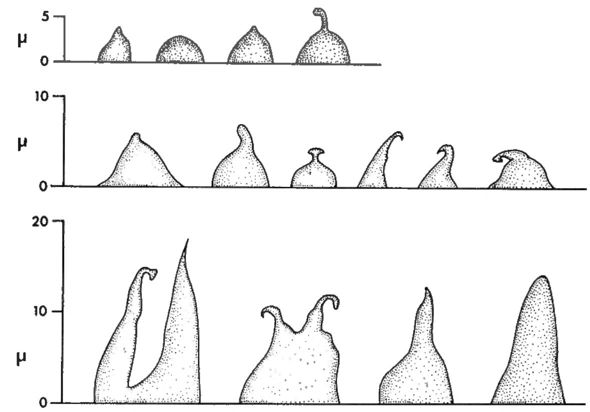
Certain of the specimens assigned to **Hymenozonotriletes polyacanthus** Naumova (1953, Pl. 4, fig. 11; also Kedo, 1955, Pl. 3, fig. 6) possibly would be accommodated by our definition of **Densosporites devonicus**. **H. polyacanthus** of Soviet palynologists seems to include spores similar to both **D. devonicus** and **D. concinnus**.

**D. weatherallensis** n. sp. differs from **D. devonicus** in its broader spines that rarely expand at the tip, in the close spacing or basal fusion of its sculpture toward the distal pole, and its less conspicuous "dark zone". **Hymenozonotriletes spinuliferus** Naumova var. **major** Pychova (1960, Pl. 3, fig. 6, nomen nudum) appears from the illustrations to have broader-based sculptural elements than **D. devonicus**.

**Densosporites inaequus** (McGregor) n. comb.
Plate 7, figures 1-6, text-figure 48

1953 **Hymenozonotriletes argutus** Naumova, p. 67, Pl. 9, fig. 9; (non p. 41, Pl. 4, fig. 10).
1955 **Hymenozonotriletes argutus** Naumova; Kedo, p. 32, Pl. 4, fig. 4.
1960 **Hymenozonotriletes inaequus** McGregor, p. 37, Pl. 13, fig. 5.
1971 **Samarisporites inaequus** (McGregor) Owens, p. 43, Pl. 12, figs. 1, 2, 4.
1971 **Samarisporites galeatus** Owens, p. 44, Pl. 12, figs. 3, 5, 6.
non 1967 **Hymenozonotriletes argutus** Naumova; Cramer, p. 268, Pl. 3, fig. 73 and Pl. 4, fig. 74.
non 1969 **Calyptosporites argutus** (Naumova) Cramer, p. 436, Pl. 3, fig. 33.
non 1973 **Hymenozonotriletes argutus** Naumova; Konior and Turnau, Pl. 26, fig. 3.

Description. Trilete, zonate miospores with rounded subtriangular or subcircular amb. In lateral view, proximal face flattened-pyramidal, distal surface subhemispherical. Laesura arms 1/2 to full radius, straight, commonly hidden by fold-like lips that are 2-8 μm in combined width and up to 17 μm high at the pole, and extend to or beyond the inner edge of the zona. Intexinal body thin, commonly not visible. Exoexine thin in contact areas, thicker distally, extended equatorially to form a zona that is thickened in a dark ring 8-18 μm wide adjacent to the margin of the central body, bounded equatorially by a less thickened, flange-like lateral extension narrower (rarely wider) than inner dark zone. The inner and outer margins of the dark ring are indistinctly delimited on most specimens, being gradational with the outer, thinner part of the equatorial extension on the one side and with the exoexine around the distal pole on the other. Contact areas levigate or scabrate, commonly with narrow sub-concentric compression folds near their outer limits. Distal and proximal-equatorial regions with broad-based coni and spinae each with an attenuated, pointed tip or a delicate anchor-like termination. Sculptural elements 2.5-14 μm wide at base, 2.5-19 (commonly 8-12) μm high, the larger sculptural elements occurring near the equator where they commonly are fused in groups of two or more, especially proximally at the outer edge of the dark zone. Near distal pole, sculptural elements tend to be more widely spaced, about 2-12 μm apart, and verrucae may occur as well as coni and spinae.



*Text-figure 48: Sculptural elements of **Densosporites inaequus**, lateral view. Two upper rows show elements in the vicinity of the distal pole.*

Diameter. 75-154 μm, mean 101 μm (68 specimens).

Occurrence. Figured specimens: Plate 7, figure 1, loc. 8320, slide N, GSC 66273; Plate 7, figure 2, loc. 8320, slide K, GSC 66274; Plate 7, figure 3, loc. 8320, slide 1, 56.2 x 121.7, GSC 66275; Plate 7, figures 4, 5, loc. 8314, slide 2, 58.6 x 119.8, GSC 66276; Plate 7, figure 6, loc. 8312, slide L, GSC 66277. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 73).

Remarks. Although Naumova (1953, p. 41) provided the first valid description of this species, the name she applied to it, **argutus**, is a junior homonym of a species with a different circumscription, based on a different type, described on page 67 of the same publication, and therefore is not legitimate. McGregor (1960) was the first to provide a new trivial name, **inaequus**, for this species. He suggested, but did not formally propose, synonymy with Naumova's species.

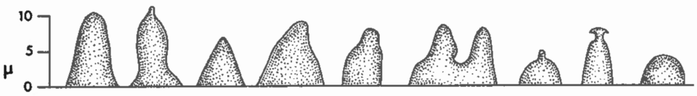
Comparisons. Having examined the type and figured specimens of **Samarisporites galeatus** Owens (1971), we believe that this species was based on overmacerated specimens of **Densosporites inaequus** and accordingly must be placed in synonymy with it.

**Hymenozonotriletes argutus** Naumova, of Tuzova (1959, p. 146, Pl. 13, fig. 3) and **H. spinuliferus** Naumova (1953, p. 41, Pl. 4, fig. 13) may be closely comparable to **Densosporites inaequus**, but the drawings and brief descriptions provided by these authors are not sufficient for detailed comparison.

**Densosporites weatherallensis** n. sp.
Plate 7, figures 7, 8, 9, 14, text-figure 49

Diagnosis. Trilete, zonate miospores with subtriangular or subcircular amb and intexinal body. Laesura arms 3/4 to full radius of body in length, commonly hidden by prominent triradiate exoexinal folds that are up to 14 μm high at proximal pole and extend to or nearly to the equator.

Intexine 0.5-2.5 μm thick, levigate, its boundary distinct or indistinct. Exoexine thin in contact areas, thicker distally, extended laterally in equatorial plane as a zone about equal in width to the radius of the intexine. Dark ring with indistinct inner and outer limits may be visible around inner edge of zona. Contact areas levigate. Equatorial and distal regions of exoexine bear coni, verrucae, and ±parallel-sided or tapered processes 3-7 μm wide at base and 2-12 μm long, pointed or rounded, many surmounted by a minute spine that may (rarely) be expanded or bifurcate at the tip. Sculptural elements closely spaced at distal pole, may be joined basally in groups or short rows, commonly slightly more widely spaced toward equator.




*Text-figure 49: Sculptural elements of **Densosporites weatherallensis**, lateral view.*

Diameter. 80-135 μm, mean 112 μm (34 specimens).

Occurrence. Holotype, Plate 7, figures 7, 14, loc. 8320, slide 1, 36.2 x 116.9, GSC 66278. Paratype, Plate 7, figures 8, 9, loc. 8320, slide 4, 53.5 x 124.7, GSC 66279. Stratigraphic range, Weatherall Formation and lower Hecla Bay Formation, upper Eifelian and lower Givetian (Fig. 7, no. 70).

Derivation of name. After Weatherall Bay, northeastern Melville Island.

Comparison. **Densosporites devonicus** has less broadly based, more widely spaced, often bifurcate sculptural elements. **D. inaequus** has more broadly based, commonly strongly tapered sculptural elements, and widely spaced distal sculpture. **Hymenozonotriletes spinuliferus** Naumova (1953) has more widely spaced sculpture and the intexinal body is "not much smaller than the perispore". **H. spinuliferus** var. **major** Pychova (1960, Pl. 3, fig. 6, nomen nudum) has more widely spaced distal sculpture. **H. laciniosus** Naumova (1953) has larger sculptural elements.

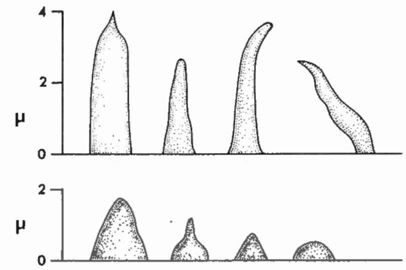
Genus **Diatomozonotriletes** Naumova emend. Playford 1963

Type species. **Diatomozonotriletes saetosus** (Hacquebard and Barss) Hughes and Playford 1961.

**Diatomozonotriletes franklinii** n. sp.
Plate 7, figures 10-13, text-figure 50

1966 **Diatomozonotriletes devonicus** Naumova; Mikhailova, Pl. 1, fig. 2.
1972 **Diatomozonotriletes devonicus** Naumova; McGregor and Uyeno, Pl. 2, fig. 6.
non 1959 **Diatomozonotriletes devonicus** Naum. in litt.; Chibrikova, p. 80, Pl. 14, fig. 4.

Diagnosis. Trilete miospores with subtriangular amb, rounded corners, and convex, straight, or slightly concave interradial margins. Wall 1-1.5 μm thick, may be slightly thicker interradially, may be darkened proximally between rays. Laesura arms 2/3-5/6 the radius in length, simple or with narrow labra. Proximal face levigate or scabrate, or with scattered small grana. Sculpture at the equator interradially consists of closely spaced spinae 0.5-1 μm wide at base, 2.5-4 μm long in the middle of the interradial margins, diminishing in length toward the radial angles. Radial extremities levigate or with sculpture like that of distal region. Distal hemisphere bears small evenly distributed grana and coni less than 2 μm (mostly less than 1 μm) wide and high, commonly less than 1 μm apart, polygonal or subcircular in plan view.




*Text-figure 50: Sculptural elements of **Diatomozonotriletes franklinii**, lateral view. Upper row shows sculpture of the interradial equatorial region.*

Diameter. 26-38 μm, mean 31 μm (28 specimens).

Occurrence. Holotype, Plate 7, figures 10, 11, loc. 8318, slide B, GSC 66280. Paratype, Plate 7, figures 12, 13, loc. 8335, slide 2, 59.3 x 113.4, GSC 66281. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 80).

Derivation of name. After 19th century arctic explorer Sir John Franklin.

Comparisons. **Diatomozonotriletes oligodontus**? Chibrikova (1962) has predominantly wider, less closely spaced sculptural elements.

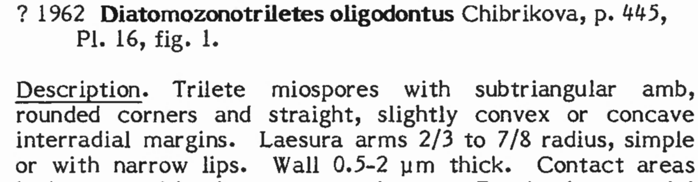
**D. devonicus** Naumova, illustrated but not described by Mikhailova (1966), appears identical to the specimens from Melville Island. **D. devonicus** Naumova ex Chibrikova (1959), on the other hand, has a quite different appearance and description, and is evidently another species (see p. 54). No description of a species of this name was ever published by Naumova, as far as we are aware.

**Diatomozonotriletes** sp. of Allen (1965), based on 3 specimens, resembles **D. franklinii** closely, except possibly for a greater tendency toward concave-triangular amb.

**Diatomozonotriletes oligodontus**? Chibrikova
Plate 7, figures 15-17, text-figure 51

? 1962 **Diatomozonotriletes oligodontus** Chibrikova, p. 445, Pl. 16, fig. 1.

Description. Trilete miospores with subtriangular amb, rounded corners and straight, slightly convex or concave interradial margins. Laesura arms 2/3 to 7/8 radius, simple or with narrow lips. Wall 0.5-2 μm thick. Contact areas levigate or with minute scattered grana. Proximal-equatorial and distal regions with coni, spinae and grana, 0.5-2.5 μm wide at base, up to 3 μm long, some surmounted by a minute hair-like extension. Sculptural elements longest equatorially at the mid-point of the sides, shorter toward the corners, and reduced in size or lacking opposite the rays. Sculptural elements 0.5-2 μm apart distally, less than 1 μm apart interradially.




*Text-figure 51: Sculptural elements of the interradial equatorial region of **Diatomozonotriletes oligodontus**?, lateral view.*

Diameter. 21-38 μm, mean 30 μm (23 specimens).

Occurrence. Figured specimens: Plate 7, figures 15, 16, loc. 8319, slide C, GSC 66282; Plate 7, figure 17, loc. 8335, slide 3, 54.6 x 112.1, GSC 66283. Stratigraphic range, Cape De Bray, Weatherall, and lower Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 15).

Comparisons. **D. oligodontus** Chibrikova has variably developed curvaturae perfectae, but in other respects appears similar. **D. franklinii** has longer and narrower interradial spines, and narrower and more closely spaced sculpture distally. One of the specimens of **Acanthotriletes** sp. 2 of Jardiné and Yapaudjian (1968, Pl. 1, fig. 17) and **Diatomozonotriletes** sp. of Massa and Moreau-Benoit (1976, Pl. 4, fig. 6) resemble the present species but cannot be compared in detail because neither was described. The figured specimen of **Diatomozonotriletes** sp. no. 2911 of Lanzoni and Magloire (1969), also not described, is larger.

Genus **Dibolisporites** Richardson 1965

Type species. **Dibolisporites echinaceus** (Eisenack) Richardson 1965.

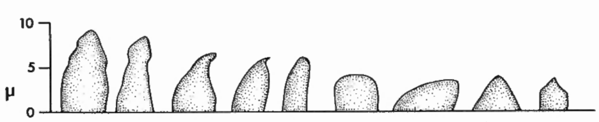
For synonymy, see Playford (1976), p. 14.

Remarks. Playford (1976) has provided an expanded, more detailed diagnosis of this genus, and has defined precisely the term "biform" as applied to the form of its sculptural elements.

**Dibolisporites antiquus**? (Naumova ex Kedo) n. comb.
Plate 8, fig. 1, text-fig. 52

? 1955 **Retusotriletes antiquus** Naum. in litt.; Kedo, p. 22, Pl. 1, fig. 20.

Description. Trilete miospores with rounded subtriangular or subcircular amb. Laesura arms with prominent untapered labra extending to outer limit of contact areas. contact areas scabrate, their outer limits sharply defined by curvaturate limits of proximal encroachment of distal-equatorial sculpture. Proximal-equatorial and distal regions with prominent sculpture of closely spaced elongate verrucae, broad-based coni, and blunt spinae 4-11 μm long and 3-7 μm in basal width. Sculptural elements commonly surmounted by a minute spine or cone.




*Text-figure 52: Sculptural elements of **Dibolisporites antiquus?**, lateral view.*

Diameter. 96, 108, 124, and 138 μm (4 specimens).

Occurrence. Figured specimen, loc. 8309, slide 4, 50 x 111.2, GSC 66284. Stratigraphic range, Weatherall Formation and basal Hecla Bay Formation, upper Eifelian and lower Givetian (Fig. 7, no. 69).

Comparisons. Based on their sculpture, these spores could be accommodated within the upper limit of the sculptural size range of **Dibolisporites echinaceus** Richardson (1965). However, the overall size of the spores is small relative to the dimensions of the sculptural elements, and for this reason we suggest that these spores be treated as a species separate from **D. echinaceus.** They are quite distinct from the specimens of **D. echinaceus** in the Weatherall Bay section. Their identity with **Retusotriletes antiquus** Kedo is questioned because the shape of the sculptural elements of that species was not described in detail.

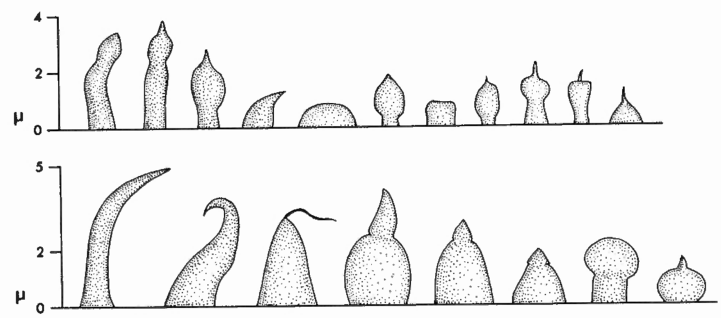
**Retusotriletes tamilii** Phil. in Mikhailova (1966, Pl. 1, fig. 1, undescribed) may be smaller and apparently lacks labra. **Lophotriletes indigensis** Pasch. sp. nov. in Andreeva et al. (1967, Pl. 1, fig. 4, undescribed) according to the illustration lacks curvaturae and has less crowded sculpture. **Dibolisporites** sp. of Arkhangelskaya (1976, Pl. 7, fig. 6, undescribed) may have curvatural ridges and smaller sculptural elements. As none of these forms have been described, further comparison with **Dibolisporites antiquus**? is not possible.

**Dibolisporites echinaceus** (Eisenack) Richardson
Plate 8, figure 2, text-figure 53

1965 **Dibolisporites echinaceus** (Eisenack) Richardson, p. 568, Pl. 89, figs. 5, 6, text-fig. 3B-3D.
1966 Spores of **Calamophyton bicephalum** Leclercq and Andrews 1960; Bonamo and Banks, p. 788, figs. 25, 27-30.
1968 **Dibolisporites** sp. A, Riegel, p. 84, Pl. 17, figs. 8, 9.
? 1972 **Acanthotriletes submutabilis** Chibrikova, p. 95, Pl. 1, figs. 8a, 8b.
1973 **Dibolisporites bullatus** (Allen) Richardson; Riegel, p. 84, Pl. 10, figs. 10-12, Pl. 11, figs. 1, 2.
1975 **Dibolisporites triangulatus** Tiwari and Schaarschmidt, p. 21, Pl. 7, figs. 3a, 3b, 4, Pl. 8, figs. 1, 2a, 2b, text-fig. 9

For additional synonymy see McGregor (1973), p. 29.

Description. Trilete miospores with rounded subtriangular or subcircular amb. Laesura arms 1/2 to 4/5 radius in length, with labra each 0.5-2 μm wide. Curvaturae visible on some specimens, defined by the limit of proximal encroachment of the distal-equatorial sculpture, or by narrow arcuate ridges. Wall about 0.5-2 μm thick proximally and distally. Contact areas levigate or scabrate. Proximal-equatorial and distal regions with coni, pila, and biform spinae and verrucae, 1-5 μm (commonly 1.5-3.5 μm) long, 0.5-2 μm wide at their base, and 0.5-1.5 μm apart. Sculptural elements commonly surmounted by a delicate apical spine.




*Text-figure 53: Sculptural elements of **Dibolisporites echinaceus**, lateral view.*

Diameter. 71-135 μm, mean 105 μm (52 specimens).

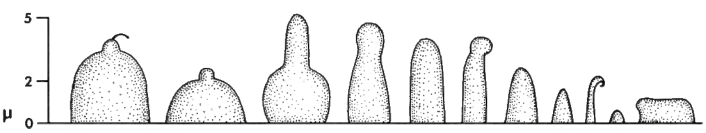
Occurrence. Figured specimen, loc. 8313, slide A, GSC 66285. Stratigraphic range, Cape De Bray, Weatherall, and lower Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 3).

Comparisons. In this section, as in the Gaspé Sandstone (McGregor, 1973), **Dibolisporites echinaceus** includes forms with a broad range of sculpture size. Specimens in which the sculpture is 2-3 µm high are common. This range is precisely in the size interval between **D. echinaceus** and **D.** cf. **gibberosus** var. **major** according to Richardson (1965). Specimens with larger sculptural elements, and those with smaller ones, occur as well, and the most reasonable course seems to be to combine them as **D. echinaceus** (see also McGregor, 1973). In the Orcadian Basin, this complex apparently is readily divisible into two species (Richardson, 1965), and the same may prove to be true for some other regions.

**D. triangulatus** Tiwari and Schaarschmidt (1975) does not differ from **D. echinaceus** in any significant way. Three other new species proposed by Tiwari and Schaarschmidt (op. cit.) display minor differences. **D. pseudoreticulatus** has relatively high, wide curvatural ridges; **D. radiatus** has relatively large sculptural elements "...disposed in a regular radial pattern" (op. cit., p. 23); and **D. varius** has baculate sculpture.

**Dibolisporites farraginis** n. sp.
Plate 8, figures 3, 4, text-figure 54

Diagnosis. Trilete miospores with subcircular amb. Laesura arms 1/2-3/4 the radius in length, simple, may be obscured by exinal folds. Wall 1.5-3 µm thick, commonly with one or two major taper-pointed folds. Equatorial and distal regions bear a heterogeneous mixture of spinae, coni and verrucae, 1-3 (rarely 4-5) µm long and 0.5-3 µm (rarely 4 µm) in basal width, some of which may be surmounted by a fine hairlike termination. Grana and bacula may occur interspersed with other sculpture. Sculptural elements densely distributed or up to 8 µm apart. Contact areas with similarly shaped but smaller and more widely scattered sculpture.




*Text-figure 54: Equatorial and distal sculptural elements of* ***Dibolisporites farraginis****, lateral view.*

Diameter. 43-85 µm, mean 60 µm (25 specimens).

Occurrence. Holotype, Plate 8, figure 4, loc. 8342, slide 3, 65.4 x 112.8, GSC 66287. Paratype, Plate 8, figure 3, loc. 8335, slide 4, 42.6 x 121.7, GSC 66286. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 66).

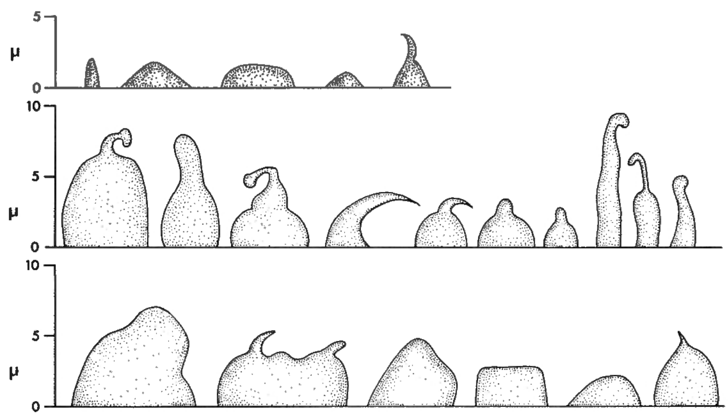
Derivation of name. L. **farrago**, medley, mixture.

Comparisons. **Dibolisporites farraginis** is distinguished from **D. uncatus** (Naumova) n. comb. by its smaller sculptural elements, from **D. vegrandis** n. sp. by larger, more elongate, and commonly less densely distributed sculptural elements, and from **D.** cf. **correctus** (Naumova) Richardson (1965) by relatively narrower based, more varied sculptural elements.

**Dibolisporites uncatus** (Naumova) n. comb.
Plate 8, figures 5, 6, 11, text-figure 55

1953 **Acanthotriletes uncatus** Naumova, p. 26, 28, Pl. 1, figs. 23, 24, Pl. 5, fig. 36.
1960 **Verrucosisporites variabilis** McGregor, p. 30, Pl. 11, fig. 15.
1964 **Lophotriletes uncatus** (Naumova) Vigran, p. 13, Pl. 1, figs. 3, 4.
1964 Unnamed, Regali, fig. 2, no. 6.
1965 **Verrucosisporites** cf. (al. **Acanthotriletes**) **uncatus** (Naumova) Richardson, p. 572, Pl. 89, fig. 13.
1967 **Raistrickia** sp., Scott and Doher, fig. 3m.
1971 **Dibolisporites variabilis** (McGregor) Smith, p. 83.
non 1971 **Verrucosisporites variabilis** McGregor; Owens, Pl. 4, fig. 9.

Description. Trilete miospores with subcircular amb. In lateral compression, proximal face flattened pyramidal, distal region ±hemispherical. Wall 1.5-4 µm thick, about the same thickness proximally and distally. Laesura arms indistinct in most specimens, 2/3 to full radius, simple. Contact areas levigate or with sculpture like that of distal face but greatly reduced in size. Proximal-equatorial and distal regions with a mixture of grana; spinae with blunt, pointed, or widened tips, some with one or two constrictions along their length; coni, some surmounted by a minute apiculate extension up to 2 µm long; and verrucae with or without an apical extension. Sculptural elements 1-9 µm (commonly 3-5 µm) in basal width, up to 10 µm long, mostly longer than wide, subcircular or irregular in plan view, may be adjoined at base but mostly discrete and 1-6 µm apart. Most specimens carry more spinae than verrucae and coni.




*Text-figure 55: Sculptural elements of* ***Dibolisporites uncatus****, lateral view. Upper row shows sculpture of contact areas.*

Diameter. 31-85 µm, mean 59 µm (77 specimens).

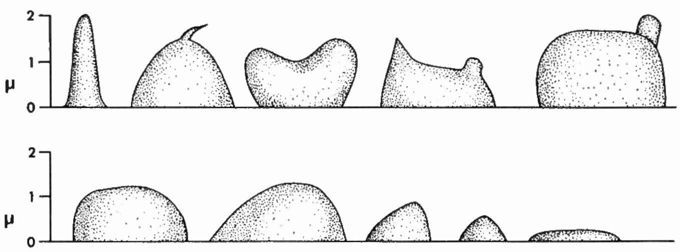
Occurrence. Figured specimens: Plate 8, figure 5, loc. 8311, slide G, GSC 66288; Plate 8, figure 6, loc. 8311, slide M, GSC 66289; Plate 8, figure 11, loc. 8338, slide 1, 46.2 x 121.6, GSC 66290. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 55).

Comparisons. **Dibolisporites uncatus** could perhaps be placed in **Verrucosisporites** with equal justification. The "biform" or ±mammoid type of sculpture present in this species also occurs, but with different dimensions, in **V. scurrus** and **V. tumulentis.**

**Verrucosisporites scurrus** has larger, more closely spaced sculptural elements, a greater proportion of them flat-topped, and a thicker wall. **V. premnus** has much larger, mostly ±flat-topped, non-biform verrucae and bacula. **Convolutispora ?crassata** has larger, commonly more closely crowded sculptural elements fused into ridges. **Dibolisporites farraginis** has smaller sculptural elements.

### **Dibolisporites vegrandis** n. sp.
Plate 8, figures 9, 10, text-figure 56

Diagnosis. Trilete miospores with rounded subtriangular or subcircular amb. Laesura arms straight, simple, 3/4 to full radius in length. In lateral compression the proximal hemisphere slightly rounded, distal hemisphere strongly convex. Wall 2-5 µm thick, rather rigid, commonly with one to several crescentic compression folds. Contact areas bear minute, scattered grana. Proximal-equatorial and distal regions with grana, coni and rare spinae 0.5-2 µm high, commonly 0.5-1.5 µm wide at base, that intergrade in shape and size with verrucae and coni up to 3 µm (rarely 4 or 5 µm) in diameter, and up to 3 µm high. The larger sculptural elements surmounted by 1 to 4 minute grana or hair-like extensions. Sculptural elements close together or up to 3 µm apart. Some specimens bear grana only, others have grana, verrucae and coni. Most specimens bear a variety of sculptural types and sizes.




*Text-figure 56: Sculptural elements of **Dibolisporites vegrandis**, lateral view.*

Diameter. 43-84 µm, mean 65 µm (27 specimens).

Occurrence. Holotype, Plate 8, figures 9, 10, loc. 8337, slide 2, 57.5 x 124.4, GSC 66293. Stratigraphic range, upper Weatherall Formation and lower Hecla Bay Formation, upper Eifelian and lower Givetian (Fig. 7, no. 91).

Derivation of name. L. **vegrandis**, not large, little.

Comparisons. Extreme variants of **D. vegrandis** intergrade with **D. farraginis**. Both are characterized by a variety of sculptural size and form. Typically, **D. vegrandis** is thicker-walled and smaller, with less-elongate sculpture.

### Genus **Emphanisporites** McGregor 1961

Type species. **Emphanisporites rotatus** McGregor 1961.

### **Emphanisporites annulatus**? McGregor
Plate 8, figure 8

? 1961 **Emphanisporites annulatus** McGregor, p. 3, Pl. 1, figs. 5, 6.

Description. Trilete spore with subcircular amb. Trilete mark simple, rays extend almost to equator. Wall thickness undetermined. Proximal face with 5 or 6 radially disposed exinal ridges in each interradial sector, extending from the equator nearly to the proximal pole. Ridges 2.5-4.5 µm wide at equator, narrower toward the pole. Distal region unsculptured, with a vaguely defined dark annular ring (?thickening) about 4 µm wide, situated about 1/3 the distance toward the distal pole.

Diameter. 51 µm (one specimen).

Occurrence. Loc. 8300, slide 10, 58 x 120.7, GSC 66292, Cape De Bray Formation, lower Eifelian (Fig. 7, no. 10).

Remarks. The specimen bears a vaguely defined annular structure suggestive of the distal annulus of **E. annulatus.** The structure may however be an accident of preservation. If so the specimen would be a robust-ribbed specimen of **E. rotatus.**

### **Emphanisporites rotatus** McGregor
Plate 8, figure 7

1974 **Emphanisporites** sp., Clayton, Higgs, Gueinn and van Gelder, Pl. 6, fig. 2.
1975 **Emphanisporites densus** Tiwari and Schaarschmidt, p. 24, Pl. 10, figs. 6-9.
1978 **Emphanisporites robustus** McGregor; Arkhangelskaya, Pl. 12, fig. 1.

For additional synonymy, see McGregor (1973), p. 46.

Dimensions. 32-64 µm, mean 43 µm (8 specimens).

Occurrence. Figured specimen, loc. 8300, slide 3, 34.1 x 114.9, GSC 66291. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 10).

Remarks. As is usual for this species, the specimens represent a wide variation in diameter, wall thickness, and dimensions and prominence of the proximal ribs. McGregor and Camfield (1976) concluded on examination of nearly 900 specimens that because of intergradations, taxonomic subdivision of the species was not practical. Such a range of form as is presently encompassed by this species is perhaps unfortunate from the standpoint of biostratigraphy. Nevertheless any subdivisions that are proposed will have to be recognizable consistently in large populations or the taxonomic exercise will be only academic. Some species proposed up to now, e.g. **E. robustus** McGregor (1961), **E. spinaeformis** Schultz (1968), **E. densus** Tiwari and Schaarschmidt (1975), and **Emphanizonosporites radiatus** Schultz (1968), established on the basis of few specimens, as defined can be recognized only as end-members in a morphologically gradational series. The same may prove to be true of **Emphanisporites hibernicus** Clayton et al. (1977). It seems reasonable to include all of this range of variation within **E. rotatus** at present. Eventually, suitable ways may be found to subdivide the species, perhaps by biometric analysis of large numbers of specimens from Siegenian-Emsian strata, where this species is most abundant.

### Genus **Geminospora** Balme emend. Owens 1971

Type species. **Geminospora lemurata** Balme 1962.

Since it was described by Balme (1962), this genus has come to be recognized in practice on somewhat different criteria than set out in the original diagnosis. The difference in thickness between the proximal and distal regions of the outer wall, emphasized by Balme, may be difficult to determine, but in at least some species the proximal and distal facies are about equally thick. Allen (1965) has noted that the proximal-distal difference in thickness may not be appreciable and the genus cannot be regarded as patinate. Studies of the Canadian arctic material tend to bear out this observation. Thus, even though the type species may be differentially thickened to some extent, more practical distinguishing criteria have proven to be the presence of a moderate to heavy thickening of the outer wall (herein referred to as the exoexine) as seen at the equator, and a thin inner wall ("mesosporoid" of Balme, 1962, herein termed the intexine) that is slightly or considerably separated from the exoexine. These features are observable in any compressional orientation. Owens (1971) broadened the diagnosis of the genus to include a wider range of exoexinal sculpture. **Geminospora** is distinguished from **Grandispora** and **Rhabdosporites** by its relatively thick exoexine, and from **Cymbosporites** by the absence of a patina and the consistent presence of a detectable intexinal body. The distinction between **Geminospora** and **Rhabdosporites** is discussed further under **Geminospora micropaxilla** (Owens) n. comb. (p. 41).

**Geminospora? bislimbata** (Chibrikova) n. comb.
Plate 8, figures 12, 13

1959 **Archaeozonotriletes bislimbatus** Chibrikova, p. 63, Pl. 8, fig. 8.
1966 Unidentified, McGregor and Owens, Pl. 24, figs. 5, 6.

Description. Trilete, camerate miospores with subcircular amb. Laesura arms 1/2-4/5 the radius of the central body, simple, straight or slightly undulating. Intexinal body 1-1.5 μm thick, located symmetrically or asymmetrically within the surrounding wall (inner part of exoexine?), commonly folded. ?Inner exoexine 2-4 μm thick, proximally levigate or scabrate. A thin sculptured layer, here interpreted as the outer part of the exoexine, covers the distal region, extends onto the proximal face about 1/3 the distance toward the pole, and projects laterally, commonly asymmetrically, slightly or considerably beyond the margin of the ?exoexine. Sculptured layer with narrow, closely spaced, rather vaguely delimited, ±radial ribs or creases, the equatorial ends of which impart slight, rounded irregularities about 0.5-3 μm wide and high at the periphery.

Diameter. 96-150 μm, mean 114 μm (18 specimens).

Occurrence. Figured specimens: Plate 8, figure 12, loc. 8342, slide 3, 59.7 x 127.6, GSC 66294; Plate 8, figure 13, loc. 8339, slide 4, 33.7 x 122.1, GSC 66295. Stratigraphic range, Hecla Bay Formation, mid-Givetian (Fig. 7, no. 110).

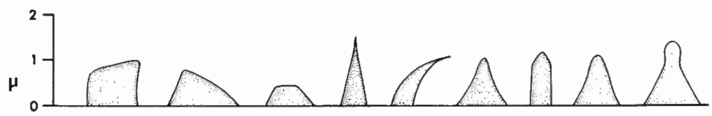
Remarks and comparisons. This species is questionably assigned to **Geminospora** because of uncertainty as to the nature of the outer sculptured layer.

The specimens of **G.? bislimbata** described from the Soviet Union (Chibrikova, 1959) are smaller (60-80 μm) but in all other respects appear identical to those from Melville Island. **Archaeozonotriletes bublitschenko** Mikhailova (1966) has sculpture resolvable as closely crowded, elongate spines. **Geminospora(?) membrana** Sanders (1968) is surrounded by a filamentous membrane studded with sharp spines, or composed of a "mesh" of filaments. **Archaeozonotriletes comans** Chibrikova (1959) has relatively short, discrete sculpture.

**Geminospora micromanifesta** (Naumova) n. comb.
var. **minor** Naumova
Plate 8, figures 14, 15, 19-22, text-figure 57

1953 **Archaeozonotriletes micromanifestus** Naumova var. **minor** Naumova, p. 32, Pl. 2, fig. 19.
? 1955 **Archaeozonotriletes micromanifestus** Naumova var. **minor** Naumova; Kedo, p. 34, Pl. 4, fig. 11.
1959 **Archaeozonotriletes micromanifestus** Naumova var. **crispus** Chibrikova, p. 70, Pl. 11, fig. 1.
1962 **Geminospora lemurata** Balme, p. 5, Pl. 1, figs. 5-10.
1962 **Archaeozonotriletes micromanifestus** Naumova var. **microtuberculatus** Chibrikova, p. 414, Pl. 7, fig. 5.
? 1964 **Lycospora svalbardiae** Vigran (pars), holotype, p. 23, Pl. 3, figs. 4, 5.
? 1965 **Geminospora svalbardiae** (Vigran) Allen (pars), p. 696, Pl. 94, figs. 14, 15.
1965 **Geminospora tuberculata** (Kedo) Allen, p. 696, Pl. 94, figs. 10, 11.
1966 ?**Archaeozonotriletes plicatus** Naum. in litt.; McGregor and Owens, Pl. 23, fig. 17.
1966 ?**Geminospora**, McGregor and Owens, Pl. 23, fig. 19.
1967 **Geminospora maculata** Taugourdeau-Lantz, p. 49, Pl. 2, fig. 11.

Description. Trilete, camerate miospores with subcircular or rounded subtriangular amb. Proximal face shallow-convex, distal hemisphere strongly convex in lateral compression. Laesura arms simple or with low, narrow lips, straight, 1/2-5/6 radius in length, rarely extend beyond equator of intexinal body. Curvaturae delimited by proximal limit of sculpture, commonly not distinguishable. Intexinal body subcircular or broadly subtriangular, about 0.5-1 μm thick, attached to exoexine in proximal polar region, situated symmetrically or asymmetrically with respect to the exoexine, commonly with one or more taper-pointed folds. Exoexine distally and equatorially 1.5-4 μm thick, somewhat thinner proximally. Contact areas minutely scabrate; proximal-equatorial and distal regions with grana, coni, bacula, or minute spinae 0.5-1 μm (rarely 1.5 μm) long, 0.5-1 μm wide at base. Sculptural elements about 0.5-1.5 μm (rarely 2 μm) apart.




*Text-figure 57: Sculptural elements of **Geminospora micromanifesta** var. **minor**, lateral view.*

Diameter. 40-82 μm, mean 56 μm (54 specimens). Diameter of intexinal body 60-90% of total spore diameter.

Occurrence. Figured specimens: Plate 8, figures 14, 15, loc. 8342, slide 3, 62 x 110.1, GSC 66296; Plate 8, figures 19, 20, loc. 8342, slide 3, 39.3 x 112.5, GSC 66297; Plate 8, figures 21, 22, loc. 8341, slide B, GSC 66298. Stratigraphic range, Hecla Bay Formation, mid-Givetian (Fig. 7, no. 113).

Comparisons. Balme (1962) remarked on the rather wide variation in morphology of specimens of **G. lemurata**. **G. tuberculata** (Kedo) Allen (1965) (non Kedo, 1955) is thinner-walled than **G. lemurata** but shows a comparable range of variation in size and spacing of sculpture and presence or absence of labra. The suite of specimens of **Geminospora micromanifesta** var. **minor** from the Hecla Bay Formation (this study) includes those that possess a spectrum of morphological variation comparable to both **G. lemurata** and **G. tuberculata** sensu Allen (1965).

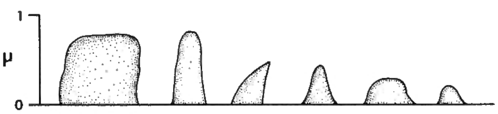
**Lycospora svalbardiae** Vigran (1964) apparently comprises spores with an even broader range of variation, some of which are **Geminospora**, some not. The holotype of **L. svalbardiae** (op. cit., Pl. 3, figs. 4, 5) may be closely comparable to **G. micromanifesta** var. **minor**, whereas the other specimen figured (op. cit., Pl. 4, figs. 1, 2) may be **Apiculatasporites**. **Geminospora svalbardiae** (Vigran) Allen comprises specimens rather similar to the holotype but includes some with slightly finer sculpture and, according to the description, some with a thicker wall than we have seen in specimens from Melville Island. **G. plicata** Clayton and Graham (1974; non **G. plicata** Owens, 1971) has smaller, more closely spaced sculptural elements and a thicker exoexine than our specimens, and, like the finer-sculptured specimens of Allen (1965, cf. Pl. 94, figs. 12, 13), may be excluded from **G. micromanifesta** var. **minor**. The specimen figured by Kedo (1955, Pl. 4, fig. 11) is also thicker equatorially (and distally?) than those from the Hecla Bay Formation, but appears otherwise identical.

**Stenozonotriletes bellus** Guennel has smaller, more closely spaced sculptural elements and is described as cingulate.

**Geminospora micropaxilla** (Owens) n. comb.
Plate 8, figures 16-18, Plate 9, figures 1-3, text-figure 58

1971 **Rhabdosporites micropaxillus** Owens (pars), p. 49, Pl. 15, figs. 4 (holotype), 6.

Description. Trilete, camerate miospores with subcircular or rounded subtriangular amb and central body. Laesura arms 1/2-5/6 radius of central body, simple or with narrow labra. Intexine levigate, 1-2.5 µm thick, commonly folded, attached to exoexine proximally. Exoexine 2-5 µm thick equatorially and distally, rarely folded, may be same thickness or thinner proximally. Contact areas levigate or scabrate, the rest of exoexine with coni, bacula, and grana that are less than 1 µm (commonly less than 0.5 µm) in width and length and are so small on some specimens that they form a scabrate texture.




*Text-figure 58: Sculptural elements of* ***Geminospora micropaxilla****, lateral view.*

Diameter. 83-133 µm, mean 111 µm (23 specimens). Diameter of intexinal body 69-88% of total spore diameter.

Occurrence. Figured specimens: Plate 8, figures 16-18, loc. 8340, slide 3, 39.4 x 126.3, GSC 66299; Plate 9, figures 1, 2, loc. 8337, slide 5, 56.9 x 111.7, GSC 66300; Plate 9, figure 3, loc. 8339, slide 4, 56 x 109, GSC 66301. Stratigraphic range, upper Weatherall Formation and Hecla Bay Formation, upper Eifelian and lower Givetian (Fig. 7, no. 96).

Comparisons and remarks. The structure of **Geminospora micropaxilla** is rather closely comparable to that of **Rhabdosporites langii.** A major point of difference is the more rigid, less profusely folded exoexine of **G. micropaxilla,** a condition that presumably is owing to the characteristic wall-thickness feature that in optical section in polar view could be mistaken for an equatorial limbus. This species does not agree precisely with the diagnostic requirements of **Rhabdosporites,** to which it obviously is structurally related, as the exoexine is significantly thickened relative to the intexine. Marshall and Allen (in press) have chosen a different course from that followed here, by placing **R. micropaxillus** Owens in synonymy with **R. langii,** and making the consequently required emendations of **Rhabdosporites** to include spores with a "limbus".

**Archaeozonotriletes micromanifestus** Naumova (1953) var. **micromanifestus** may have larger sculptural elements and a slightly smaller intexine/exoexine size ratio (see Naumova, 1953, Pl. 2, fig. 18 and Pl. 12, figs. 2-4; and Kedo, 1955, Pl. 5, fig. 1).

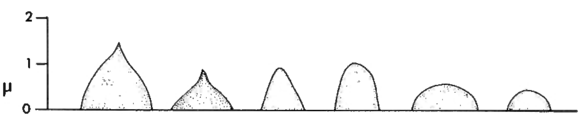
**Rhabdosporites minutus** Tiwari and Schaarschmidt (1975) is much smaller according to the diagnosis, but one of the specimens illustrated by these authors (Pl. 21, fig. 6) apparently is 85 µm in diameter, within the size range of **G. micropaxilla.** Some of the specimens illustrated by Owens (1971, Pl. 15, figs. 3, 5, 6) under the name **Rhabdosporites micropaxillus** are assigned herein to **R.** sp. because of their coarse ornamentation and absence of a wall-thickness feature. We emphasize however that the presence of a wall-thickness feature in itself may not be a good systematic criterion, as it may be obliterated in some preservational states, or simulated by concentric folding of the exoexine.

The rather tenuous morphographic distinction between some species of **Geminospora** and **Rhabdosporites,** exemplified by **G. micropaxilla,** is also apparent in the fact that in situ spores assignable to these genera occur in closely related gymnospermous plants (Allen, 1980).

**Geminospora tuberculata** (Kedo) Allen var. **micrornata** n. var.
Plate 9, figures 4, 5, text-figure 59

? 1965 **Archaeozonotriletes comptus** Naum. var. **expletivus** Chibr.; Nazarenko, Pl. 1, fig. 47.

Description. Trilete, camerate miospores with amb and intexinal body subcircular or rounded subtriangular. Laesura arms simple, straight, extend 1/2 to full distance to equator of intexinal body. Intexine levigate, 1-1.5 µm thick, attached to exoexine in proximal polar region. Exoexine 2-4 µm thick. Contact areas levigate or minutely scabrate, proximal-equatorial and distal regions with coni and grana 0.5-1.5 µm in length and basal width, some joined in groups of 2 or 3, or more commonly up to 5 µm apart giving the impression of relatively widely spaced sculpture. Concentric and radial folds may occur on intexine and exoexine.




*Text-figure 59: Sculptural elements of* ***Geminospora tuberculata*** *var.* ***micrornata****, lateral view.*

Diameter. 66-99 µm, mean 80 µm (39 specimens). Diameter of intexinal body 70-90% of total spore diameter.

Occurrence. Holotype, loc. 8342, slide 3, 35.4 x 127, GSC 66302. Stratigraphic range, upper Hecla Bay Formation, mid-Givetian (Fig. 7, no. 109).

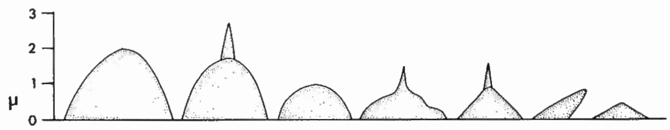
Comparisons. This variety differs from var. **tuberculata** only in its smaller sculptural elements.

**Geminospora tuberculata** (Kedo) Allen var. **tuberculata**
Plate 9, figures 6, 7, 10-13, text-figure 60

1953 **Archaeozonotriletes meonacanthus** Naumova, nomen nudum, Pl. 22, fig. 100.
1955 **Archaeozonotriletes tuberculatus** Kedo, p. 35, Pl. 5, figs. 6, 7.
? 1959 **Archaeozonotriletes meonacanthus** Naumova ex Chibrikova, p. 58, Pl. 7, fig. 4.
1959 **Archaeozonotriletes comptus** Naumova var. **expletivus** Chibrikova, p. 59, Pl. 7, fig. 6.
? 1959 **Archaeozonotriletes micromanifestus** Naumova; Tuzova, p. 125, Pl. 5, figs. 4, 5.
1965 **Archaeozonotriletes meonacanthus** Naumova; Nazarenko, Pl. 1, figs. 32-34.
1966 **Archaeozonotriletes comptus** Naumova var. **expletivus** Chibrikova; Mikhailova, Pl. 1, fig. 12.
non 1965 **Geminospora tuberculata** (Kedo) Allen, p. 696, Pl. 94, figs. 10, 11.

Description. Trilete, camerate miospores with amb and intexinal body subcircular or rounded subtriangular. In lateral compression, proximal side flattened-pyramidal, distal region strongly rounded. Laesura arms simple, straight, extend 2/3 to 7/8 the distance to equator of intexinal body.

Intexine commonly with minor folds, levigate, 0.5-1.5 μm thick distally, may be slightly thicker proximally, attached to exoexine in proximal polar region. Exoexine 3-5 μm thick equatorially and distally, slightly thinner proximally. Contact areas levigate or scabrate, proximal-equatorial and distal regions with grana, coni, and/or mammae 1-3 μm wide at base, 0.5-2.5 μm long, subcircular in plan view, may be rather irregularly distributed in rows or clumps, closely adjacent to one another or up to 5 μm apart, giving an overall impression of rather widely spaced sculpture.




*Text-figure 60: Sculptural elements of **Geminospora tuberculata** var. **tuberculata**, lateral view.*

Diameter. 74-120 μm, mean 93 μm (23 specimens). Diameter of intexinal body 55-90% of total spore diameter.

Occurrence. Figured specimens: Plate 9, figures 6, 7, loc. 8342, slide 3, 45.6 x 110.8, GSC 66303; Plate 9, figures 10, 11, loc. 8342, slide 3, 36.9 x 114.1, GSC 66304; Plate 9, figures 12, 13, loc. 8342, slide 3, 49.5 x 115, GSC 66305. Stratigraphic range, two uppermost samples of Hecla Bay Formation, mid-Givetian (Fig. 7, no. 112).

Remarks. Allen's identification of specimens from Spitsbergen as **Geminospora tuberculata** (Kedo) Allen is incorrect in our opinion. As indicated elsewhere in this report, we believe the correct assignment of the Spitsbergen specimens is to **Geminospora micromanifesta** (Naumova) n. comb. var. **minor** Naumova. The nomenclatural recombination **G. tuberculata** (Kedo) Allen is correct, however, as the original material described by Kedo (1955) is **Geminospora.**

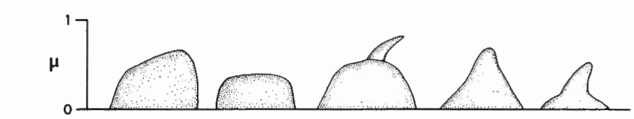
Comparisons. Several taxa of camerate spores with a thin intexinal body separated from a thickened outer wall, and with relatively widely spaced small sculpture (**Geminospora**) have been described as species of **Archaeozonotriletes** by Naumova (1953), Kedo (1955), and Chibrikova (1959, 1962) (see synonymy). These taxa are characterized by their authors on the basis of spore size, wall thickness, diameter of body relative to that of the "perispore", and spacing, size, and shape of the sculptural elements. However none of the authors provide objective, measurable limits for any parameter except spore size. As a result, it is impossible from the descriptions and illustrations provided to differentiate the species from one another consistently. Based on the published descriptions and illustrations, the specimens from the USSR, like those from Arctic Canada, seem quite variable and difficult to differentiate as form species. For example, the single specimen of **Archaeozonotriletes meonacanthus** figured (but not described) by Naumova (1953) is practically identical in appearance to one of the figured specimens of **A. tuberculatus** Kedo (1955, Pl. 5, fig. 6). **A. meonacanthus** Naum. figured by Chibrikova (1959, Pl. 7, fig. 4) however has a much thicker outer wall. **A. comptus** Naum. var. **expletivus** Chibrikova of Mikhailova (1966, Pl. 1, fig. 12) appears identical to **A. tuberculatus** Kedo, except for pointed rather than rounded sculptural elements (see also Chibrikova, 1959, Pl. 7, fig. 6). In our material, pointed and rounded elements (coni and grana) may occur on the same specimen, and in fact coni may be preservationally altered to grana. The most reasonable course rather than establishing a new species and thereby further complicating an already confused situation, is to gather the above-mentioned species into one manageable species. Most of the Russian forms are smaller than those in the Weatherall Bay section, but we do not regard this difference alone as sufficient for taxonomic separation at the species level.

**Geminospora tuberculata** var. **micrornata** n. var. also has widely spaced sculptural elements, but they are smaller than those of **G. tuberculata** var. **tuberculata. G. micromanifesta** (Naumova) n. comb. var. **minor** Naumova has smaller, more closely spaced sculpture. In **Archaeozonotriletes meonacanthus** var. **denticulatus** Chibrikova (1962) the intexinal body nearly fills the exoexinal cavity.

**Geminospora venusta**? (Naumova) n. comb.
Plate 9, figures 14, 15, text-figure 61

? 1953 **Archaeozonotriletes venustus** Naumova, p. 32, Pl. 2, fig. 21.
1955 **Archaeozonotriletes venustus** Naumova; Kedo, p. 35, Pl. 5, figs. 4, 5.

Description (one specimen): Trilete, camerate miospore with intexinal body and amb rounded subtriangular. Laesura arms simple, straight, extend to equator of body. Intexine 1 μm thick, with minor folds, attached to exoexine proximally. Exoexine 2-2.5 μm thick equatorially and distally. Contact areas levigate, proximal-equatorial and distal regions with grana, mammae and coni 0.5-1 μm long, 0.75-1.5 μm wide, and 0.5-1 μm apart.




*Text-figure 61: Sculptural elements of **Geminospora venusta**?, lateral view.*

Diameter. 53 μm, intexinal body 41 μm.

Occurrence. Loc. 8342, slide 4, 68 x 119.5, GSC 66307, Hecla Bay Formation, mid-Givetian (Fig. 7, no. 114).

Comparisons. This specimen appears identical to the two figured by Kedo (1955, Pl. 5, figs. 4, 5). However, Naumova's (1953) figure of **Archaeozonotriletes venustus** is somewhat different, and for that reason assignment of our specimen to this species is questioned. **Geminospora tuberculata** var. **tuberculata** has more widely spaced sculptural elements and, in the Weatherall Bay section, is larger. **G. micromanifesta** var. **minor** has smaller sculptural elements.

**Geminospora verrucosa** Owens
Plate 9, figure 16

1965 Unidentified, Kerr, McGregor, and McLaren, 1965, Pl. 4, fig. 11.
1967 **Foveosporites pertusus** Vigran; McGregor, Pl. 1, fig. 18.
1971 **Geminospora verrucosa** Owens, p. 63, Pl. 19, figs. 10-12.

Description. Trilete, ?camerate miospores with subcircular amb. In lateral compression ±isopolar, both proximal and distal regions subhemispherical. Laesura arms straight, simple, 4/5-7/8 radius. Intexine not observed. Exoexine, including sculpture, 3-7 μm thick equatorially and (?)distally, of undetermined thickness proximally. Exoexine perforated proximally and distally by densely distributed punctations 1 μm or less wide, about 0.5-3 μm apart. Wall at equator penetrated by very close, fine, radially aligned perforations, representing the punctations in longitudinal section, some of which apparently pass completely through the exoexine.

Exoexine locally thickened equatorially and distally by broad-based verrucae and coni 2-6 μm high, about 4-7 μm wide at base, discrete or basally confluent with adjacent elements to form irregularly anastomosing ridges.

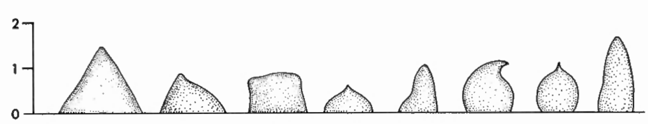
Diameter. 45-73 μm (5 specimens).

Occurrence. Figured specimen, loc. 8322, slide 9, 37.7 x 111.6. Stratigraphic range, upper Weatherall Formation and Hecla Bay Formation, upper Eifelian and lower Givetian (Fig. 7, no. 97).

Remarks. Some or all specimens of other thick-walled species may bear partial or complete punctation similar to, or less pronounced than, that of **G. verrucosa**, e.g. **Verrucosisporites tumulentis** (Pl. 18, fig. 21); **V. scurrus** (Pl. 18, fig. 22); and **Convolutispora crassata**? (Pl. 18, fig. 23) in the present study; and **Lophozonotriletes scurrus** var. **jugomaschevensis** Chibrikova (1962, Pl. 15, figs. 5, 6); **Foveosporites pertusus** Vigran (1964, Pl. 4, figs. 3, 4, Pl. 5, figs. 1, 2); **Geminospora punctata** Owens (1971, Pl. 19, figs. 1-9); and **Lophozonotriletes plumosus** Raskatova (1973, Pl. 15, fig. 9). This observation leads us to believe that the punctations of **G. verrucosa** and the other species mentioned above may be preservationally induced, the exine perhaps being structurally or chemically predisposed to this type of corrosion (see also Allen, 1973, p. 47). As the punctate pattern of **G. verrucosa** is present on many specimens, from numerous localities and several depositional basins, and is easily recognizable, its inclusion as a taxonomically diagnostic feature may be justified. Allen (1965) followed a similar course in recognizing corrosion as a diagnostic feature of **Tholisporites ancylius.**

**Geminospora** sp.
Plate 9, figures 8, 9, text-figure 62

Description. Trilete, camerate miospores with subcircular or rounded subtriangular amb. Laesura arms straight, simple, 2/3 to 7/8 radius of intexine. Intexine about 1 μm thick, commonly folded. Exoexine 4-5 μm thick. Proximal face of exoexine minutely scabrate, distal region with coni, spinae, and rare bacula 0.5-2.0 μm high, 0.5-1.0 μm (rarely 2.0 μm) at base.




*Text-figure 62: Sculptural elements of **Geminospora** sp., lateral view.*

Diameter. 83-152 μm (4 specimens). Diameter of intexinal body 66-74% of total spore diameter.

Occurrence. Figured specimen, loc. 8342, slide 4, 50.6 x 110.5, GSC 66306. Found only in the uppermost sample of the Hecla Bay Formation, mid-Givetian (Fig. 7, no. 115).

Comparisons. **Geminospora micromanifesta** var. **minor** is much smaller and commonly has a relatively larger intexinal body. **G. micropaxilla** has smaller sculptural elements and a more rigid exoexine, but tends to intergrade with **G.** sp.

Genus **Grandispora** Hoffmeister, Staplin and Malloy 1955 emend. McGregor 1973

Type species. **Grandispora spinosa** Hoffmeister, Staplin and Malloy 1955.

For synonymy see Playford (1971), p. 45.

Playford (1971) and McGregor (1973) independently advocated the synonymy of **Grandispora, Calyptosporites,** and **Spinozonotriletes.** McGregor's (1973) emendation of **Grandispora,** used in this report, includes a broader range of sculptural variation than allowed by Playford. We do not accept Neves and Owens' (1966) emendation of this genus because of the restriction placed by the need to observe the extent of attachment of the intexine and exoexine. On the other hand, we now believe that McGregor (1973) was incorrect in regarding **Samarisporites** as a junior synonym of **Grandispora.** As we indicated earlier (p. 29), the genotype of **Samarisporites, S. orcadensis** (Richardson) Richardson (1965), appears to be similar in sculpture and basic construction to **Cristatisporites** (Potonié and Kremp) emend. Butterworth et al. (in Butterworth, 1964, and in Staplin and Jansonius, 1964), and fundamentally different from **Grandispora** in being zonate rather than camerate (see also Allen, 1980, p. 265). Richardson (1965, p. 582) differentiated **Samarisporites** from **Cristatisporites** by the restriction of the sculpture in the former genus to the distal surface of the exoexine, but according to the emendation of **Cristatisporites** by Butterworth et al. (in Butterworth, 1964) this does not appear to allow a clear-cut distinction.

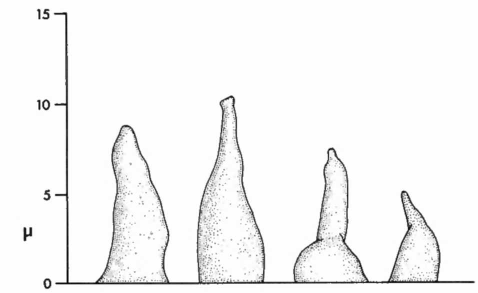
Although we agree that the difference between zonate and camerate structure is generically significant in principle, we return to the point made by McGregor (1973, p. 58) that in practice it may be difficult or even impossible using conventional light microscopy to discriminate between the two conditions, and especially between camerate and zonate-camerate forms, in species that occur predominantly in polar compression. The absence of distal exoexinal folds that do not affect the intexinal body does not prove that the spores in question are not camerate, or that the exoexine and intexine are attached to one another distally. On the other hand, folding of the exoexine independently of the intexine does indicate camerate condition, as pointed out by Richardson (1965, p. 583). In the present paper those species of the **Grandispora-(Samarisporites)-Cristatisporites** complex that are demonstrably camerate are placed in **Grandispora. Grandispora** as used here therefore may include spores of the Subturmae Solutitriletes and Membranatitriletes of Neves and Owens (1966). Zonate species with discrete distal sculptural elements are assigned to **Kraeuselisporites** Leschik emend. Scheuring (1974) and **Densosporites** Berry emend. Potonié and Kremp (1954). Zonate-camerate forms with a diaphanous exoexine are placed in **Perotrilites** Couper emend. Evans (1970), although their distinction from **Grandispora** is not satisfactorily defined.

**Geminospora** differs from **Grandispora** in that the exoexine is markedly thicker than the intexine. **Rhabdosporites** has minute sculpture that is at least in part baculate.

**Grandispora douglastownense** McGregor
Plate 10, figure 1, text-figure 63

1973 **Grandispora douglastownense** McGregor, p. 62, Pl. 8, figs. 8, 9, 12-14, text-fig. 35.

Description. Trilete, camerate miospores with rounded subtriangular amb and irregularly rounded intexinal body. Thickness of intexine and exoexine undetermined. Trilete rays, seen on one specimen, consist of convoluted fold-like labra that extend nearly to the equator. Proximal face levigate. Distal side and equator with prominent widely spaced spines. Spines 4.5-11.5 μm long, 2.5-5 μm wide at their base, about 2-4 times as long as basal width, parallel-sided in the lower part of their length or gently tapered for most of their length, or less commonly arising from a bulbous base, and blunt, acute, or slightly expanded at the tip.




*Text-figure 63:* *Sculptural elements of* ***Grandispora douglastownense****, lateral view.*

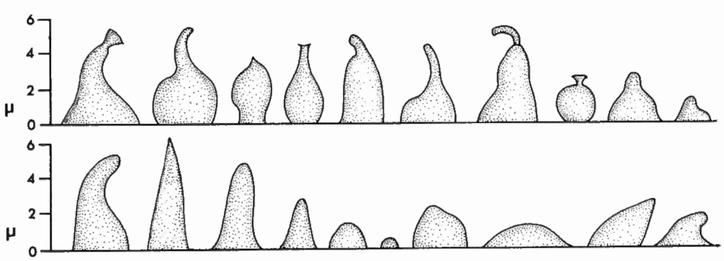
Diameter. 150 μm (intexinal body 110 μm) and 158 μm (intexinal body 130 μm), two specimens only.

Occurrence. Figured specimen, loc. 8306, slide 2, 62.8 x 125.2, GSC 66309, Weatherall Formation. Stratigraphic distribution: Weatherall Formation, upper Eifelian (Fig. 7, no. 51).

**Grandispora eximia** (Allen) n. comb.
Plate 10, figures 2, 6, 7, text-figure 64

1965 **Perotrilites eximius** Allen, p. 731, Pl. 102, figs. 11-13.

Description. Trilete, camerate miospores with rounded subtriangular or subcircular amb. Laesura arms straight, 1/2 to full radius of intexinal body in length, obscured by prominent, commonly convolute, triradiate labra or exoexinal folds that reach the equator of the intexine and may extend onto the equatorial extension. Intexinal body 5-12 μm thick proximally and distally, dark, its outline conformable to that of the exoexine. Exoexine separated from intexine equatorially and distally, laterally extended at the equator. Contact areas levigate or scabrate. Equatorial and distal regions of exoexine with coni, verrucae, spinae and biform sculptural elements, 1-7 μm (commonly 2-4 μm) wide at base and 1-8 μm (commonly 3-5 μm) long. Sculptural elements rarely terminated by an expanded or minutely bifurcate tip. Grana less than 1 μm wide and high may also occur interspersed with the larger elements. Sculptural elements 2-14 μm (commonly 5-10 μm) apart.




*Text-figure 64:* *Sculptural elements of* ***Grandispora eximia****, lateral view.*

Diameter. 110-205 μm, mean 158 μm (73 specimens). Diameter of intexinal body in polar view 63-93% of total spore diameter.

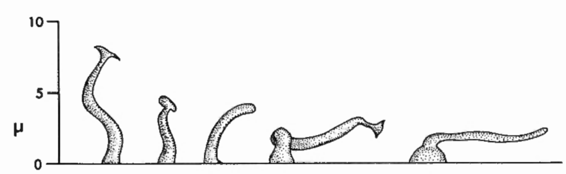
Occurrence. Figured specimens: Plate 10, figure 2, loc. 8334, slide D, GSC 66310; Plate 10, figure 6, loc. 8334, slide E, GSC 66311; Plate 10, figure 7, loc. 8335, slide 2, 59 x 109.8, GSC 66312. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 63).

Remarks. The intexine appears to be attached to the exoexine in a small area at the proximal pole, delimited by small, irregular, concentric folds. Obliquely preserved specimens (e.g. Plate 10, figure 7) show two wall layers 2-8 μm apart over the distal hemisphere, even though no independent exinal folds were observed to extend across the margin of the intexinal body. The exoexine is laterally extended as a two-layered zona at the outer extremity of the proximal face, and the zona is confluent with the trilete, fold-like structures. This interpretation agrees to some extent with the structural interpretation of **Perotrilites eximius** given by Allen (1965) based on thin sections. We have not detected any thin inner layer analogous to the "inner sculptine" of Allen's **P. eximius**, which according to Allen (1965) is only visible in specimens that have been sectioned. A wide variety of sculptural form particularly characterizes this species.

Comparisons. **Archaeozonotriletes adultus** Chibrikova (1962) is much larger. **Hymenozonotriletes melanidus** Naumova var. **calceolicus** Chibrikova (1962) and **H. endemicus** Chibrikova (1959) have a dark ring at the outer edge of the inner body.

**Grandispora** sp. cf. **G. eximia** (Allen) n. comb.
Plate 10, figures 3, 4, text-figure 65

Description. Trilete, zonate (-?camerate) miospores with rounded subtriangular or subcircular amb and intexinal body. In lateral compression, proximal area ±flat, distal hemisphere strongly rounded. Laesura arms 1/2-3/4 radius in length, accompanied by prominent folds 10-25 μm high that taper in height and width toward equator. Intexine 8-12 μm thick distally, only slightly thinner proximally, darkened at proximal pole. Zona attached proximally near equator, as if representing an extension of the curvaturae. Exoexine proximally levigate, in some specimens with sinuous wrinkles 1-6 μm wide along outer edge of contact areas. Exoexine distally with fine spinae, 0.5-1.5 μm (rarely 2 μm) wide at base, 2-9 μm (commonly 3-6 μm) high, with or without spreading tips. Sculptural elements fairly regularly spaced, 2-9 μm apart.




*Text-figure 65:* *Sculptural elements of* ***Grandispora*** *sp. cf.* ***G. eximia****, lateral view.*

Diameter. 95-121 μm, mean 105 μm (7 specimens). Intexinal body in polar view 79-93% of total spore diameter.

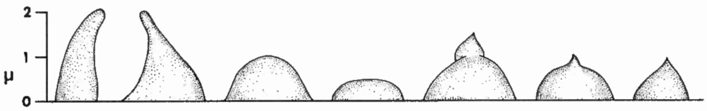
Occurrence. Figured specimens: Plate 10, figure 3, loc. 8331, slide 3, 49.5 x 109.6, GSC 66313; Plate 10, figure 4, loc. 8331, slide 3, 66.3 x 112, GSC 66314. Stratigraphic range, upper Weatherall Formation and lower Hecla Bay Formation, upper Eifelian and lower Givetian (Fig. 7, no. 98).

Comparisons. This form differs from **G. eximia** in its distinctive narrow and elongate sculptural elements, and slightly smaller size.

**Grandispora inculta** Allen
Plate 11, figures 2, 3, text-figure 66

1965 **Grandispora inculta** Allen, p. 734, Pl. 103, fig. 7-9.
1979 **Perotrilites conatus** Richardson; McGregor, Pl. 3, fig. 10.

Expanded diagnosis. Trilete, camerate miospores with subtriangular or subcircular amb. Intexinal body situated concentrically within exoexine, levigate or scabrate, about 2 µm thick, bearing simple laesura with arms 1/2-4/5 radius in length. Trilete rays of exoexine 1/2 to full radius in length, commonly hidden by triradiate folds up to 3 µm in total width and up to 4 µm high at the pole. Exoexine about 1 µm thick, levigate or scabrate in contact areas, sculptured proximal-equatorially and distally with coni, mammillate biform elements, and grana 0.5-2 µm wide at base and 0.5-2 µm high. Sculptural elements closely spaced, joined in groups or more commonly 1-2 µm apart.




*Text-figure 66: Sculptural elements of* ***Grandispora inculta****, lateral view.*

Diameter. 61-105 µm, mean 74 µm (28 specimens). Diameter of intexinal body 47-86% (commonly about 75%) of total spore diameter.

Occurrence. Figured specimens: Plate 11, figure 2, loc. 8320, slide C, GSC 66317; Plate 11, figure 3, loc. 8331, slide 1, 53.5 x 110.6, GSC 66318. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 49).

Comparisons. In his description of the sculpture of **Grandispora inculta,** Allen (1965) mentioned only coni. Some of the specimens from Melville Island bear coni only, but others bear both coni and grana, and less commonly mammoid elements. All are like **G. inculta** in other respects. It seems reasonable to include them in that species by expanding the diagnosis to include grana and small mammoid elements as well as coni.

**Perotrilites conatus** Richardson (1965) has a larger size range (60-132 µm) and sculpture of either coni 1 µm or less high, or spines 3-4 µm long. The holotype is 80 µm in diameter and appears to be conate, and may be conspecific with **Grandispora inculta.** If it is, **conatus** (Richardson, January 1965) would have nomenclatural priority over **inculta** (Allen, December 1965). Spinose specimens of **Perotrilites conatus** may be separable as another form species.

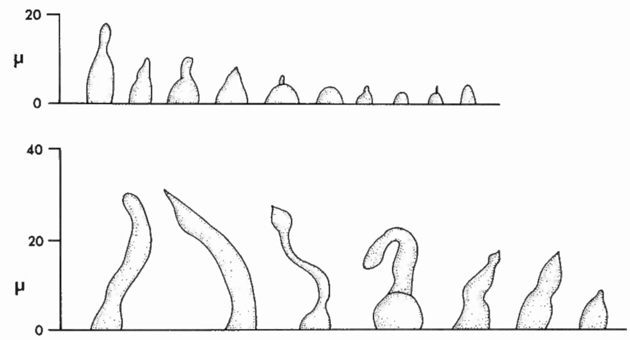
Loboziak and Streel (1980, and in Brice et al., 1979) believe **Endosporites globosus** Taugourdeau-Lantz (1967) to be synonymous with **Perotrilites conatus.** On the basis of the published information only, this conclusion is questionable, as **E. globosus** is considerably larger, and baculate.

Remarks. This species is retained in **Grandispora** on the strength of Allen's excellent thin section (1965, Pl. 103, fig. 9) which shows the camerate condition clearly.

**Grandispora longa** Chi and Hills
Plate 10, figure 5, Plate 11, figure 1, text-figure 67

1966 **Calyptosporites** sp., McGregor and Owens, Pl. 13, figs. 1, 2.
1971 ?**Spinozonotriletes** sp. A, Owens, p. 58, Pl. 18, fig. 2.
1976 **Grandispora longus** Chi and Hills (pars), p. 752, Pl. 14, figs. 1 (holotype), 2, text-figs. 95, 96.

Description. Trilete, camerate spores with subcircular or rounded subtriangular amb. Laesura arms hidden by triradiate fold-like labra that are highest at proximal pole, and extend with decreasing height to or nearly to the equator. Intexinal body about 1.5-2.5 µm thick, levigate, its outline in polar view conforming to that of the exoexine. Exoexine thin, levigate proximally, projects in the equatorial plane as a two-layered lateral extension. Sculptural elements longest toward the distal pole where they consist of prominent spinae 12-35 µm long, most of them at least four times as long as wide, arising directly from exoexine or from a bulbous base. Spinae 2-12 µm (commonly 4-7 µm) wide at their base, tapered for their entire length or constricted at about the middle and/or in the upper part, terminating in a fine point, or blunt and surmounted by a minute spine, cone, or mammoid biform process. A few stout biform elements and coni, 5-9 µm wide at base, 5-10 µm high, may occur among the spinae in the distal polar region. Sculptural elements near distal pole adjoining or up to about 8 µm apart. Those on the equatorial extension are smaller and consist of coni, mammoid elements, verrucae and grana, 0.5-6 µm (rarely up to 8 µm) in height and width, and on some specimens spinae most of which are smaller than those in the distal region, i.e. not more than 17 µm long and 4 µm wide at base. Sculptural elements on equatorial extension more widely spaced than those toward the distal pole, commonly 5-10 µm apart.




*Text-figure 67: Sculptural elements of* ***Grandispora longa****, lateral view. Lower row shows elements in vicinity of distal pole.*

Diameter. 145-286 µm, mean 179 µm (33 specimens). Diameter of intexinal body 40-70% of total spore diameter.

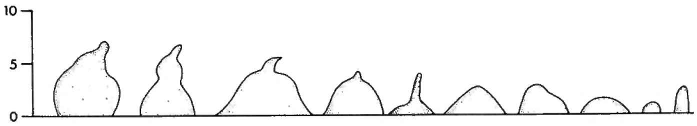
Occurrence. Figured specimens: Plate 10, figure 5, loc. 8323, slide 5, 47.1 x 113, GSC 66315; Plate 11, figure 1, loc. 8334, slide C, GSC 66316. Stratigraphic range, uppermost Cape De Bray Formation to lower Hecla Bay Formation, Eifelian and lower Givetian (Fig. 7, no. 31).

Remarks. Short-spined forms have been separated from **G. longa** as a new species, **G. variospinosa,** in which the length of the longest spines rarely exceeds 12 µm.

**Grandispora mammillata** Owens
Plate 11, figures 4-6, text-figure 68

1966 **Grandispora** sp., McGregor and Owens, Pl. 13, figs. 3-5, Pl. 14, figs. 1, 2.
1971 **Grandispora mammillata** Owens, p. 48, Pl. 14, figs. 1-4.
1972 **Grandispora** n. sp., McGregor and Uyeno, Pl. 2, fig. 5.

Description. Trilete, camerate miospores with subcircular to rounded subtriangular amb and body. Laesura arms 2/3-7/8 radius in length, simple or hidden by straight or sinuous triradiate folds 1-2.5 µm wide, commonly highest (up to about 10 µm) near proximal pole. Intexine levigate, 1.5-5 µm (commonly 2.5 µm) thick. Exoexine 1-2.5 µm thick, proximally levigate or scabrate, attached to intexine proximally. Exoexine sculptured equatorially and distally with verrucae 1-8 µm (commonly about 3 µm) wide at base, up to 6 µm high; grana and minute spinae 0.5 µm wide at base, less than 2 µm high; and less abundant biform sculptural elements consisting of a conate or verrucate base 3-7 µm wide and high, surmounted by a small cone or spine. Sculptural elements 0.5-6 µm apart, commonly most widely spaced toward the equator. Characteristically, the sculptural elements of the distal surface are joined basally in rows of two or more by irregularly oriented folds about 1.5-4 μm wide.




*Text-figure 68: Sculptural elements of* ***Grandispora mammillata****, lateral view.*

Diameter. 77-167 μm, mean 113 μm (111 specimens). Diameter of intexinal body 50-90% (commonly about 75%) of total spore diameter.

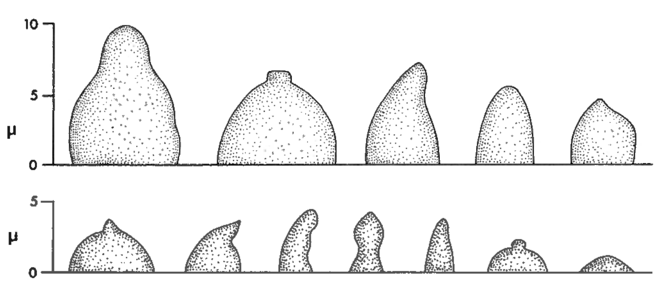
Occurrence. Figured specimens: Plate 11, figure 4, loc. 8312, slide G, GSC 66319; Plate 11, figures 5, 6, loc. 8335, slide 4, 36.9 x 126.2, GSC 66320. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 43).

Comparison. **Grandispora eximia** has a thicker intexine, and commonly more widely spaced sculptural elements that are not adjoined basally.

**Grandispora megaformis** (Richardson) McGregor
Plate 11, figures 7-9, text-figure 69

1965 **Samarisporites megaformis** Richardson, p. 582, Pl. 92, fig. 6.
1971 **Calyptosporites** sp. A, Owens, p. 48, Pl. 13, fig. 8.
1973 **Grandispora megaformis** (Richardson) McGregor, p. 60, Pl. 8, figs. 6, 7.

Description. Trilete, camerate spores with rounded subtriangular or subcircular amb and intexinal body. Laesura arms obscured by triradiate exoexinal folds that are up to 15 μm high at pole, and extend to or almost to the equator. Intexinal body levigate, 1-4.5 μm thick, its shape in polar view conformable to that of the exoexine. Exoexine 2-3 μm thick, with minor proximal and distal folds that commonly are ±radially directed. Contact areas levigate. Distal central area of exoexine ornamented with coni and/or verrucae 2-10 μm wide at their base, 3-16 μm long, subcircular in basal outline, closely crowded or less commonly up to 8 μm apart. Sculptural elements smaller and more sparsely distributed on the equatorial extension, where they consist of mammoid biform elements, verrucae, coni, and spinae up to 20 μm apart; mammoid elements, verrucae and coni 1.5-5 μm wide at base, 2-6 μm long; spinae 0.5-2 μm wide at base, 1.5-5 μm long.




*Text-figure 69: Sculptural elements of* ***Grandispora megaformis****, lateral view. Upper row shows elements of distal polar region.*

Diameter. 154-236 μm, mean 180 μm (13 specimens). Diameter of intexinal body 55-75% of total spore diameter.

Occurrence. Figured specimens: Plate 11, figures 7, 8, loc. 8334, slide 3, 70.5 x 122, GSC 66321; Plate 11, figure 9, loc. 8331, slide 2, 66.2 x 123.4, GSC 66322. Stratigraphic range, Weatherall Formation and lower Hecla Bay Formation, upper Eifelian and lower Givetian (Fig. 7, no. 28).

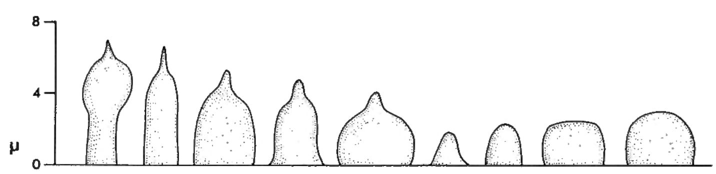
Comparisons. This species differs from **G. variospinosa** in the sculptural elements of the central distal region being more closely spaced, and less than twice as long as wide, i.e. not spinose. It has larger sculptural elements than **G. protea,** and a size differentiation between those on the central area and those on the equatorial extension.

**Hymenozonotriletes macrotuberculatus** Arkhangelskaya (1963) is distinguished from **Grandispora megaformis** by its more densely packed (equatorial?) sculptural elements, according to Richardson (1965, p. 582). Spore type B of Owens (1971) has more numerous short radial exoexinal folds, but is like **G. megaformis** in other respects. In **Spinozonotriletes mammillatus** Moreau-Benoit (1967) the sculptural elements are wider than high, and widely spaced and apparently of equal size over the whole spore. **Hymenozonotriletes verrucosus** Menendez and Pothe de Baldis (1967) is smaller but otherwise like **Grandispora megaformis.**

**Grandispora protea** (Naumova) Moreau-Benoit
Plate 11, figure 10, Plate 12, figure 1, text-figure 70

1953 **Hymenozonotriletes proteus** Naumova, p. 40, Pl. 4, fig. 5.
1965 **Calyptosporites proteus** (Naumova) Allen, p. 735, Pl. 103, figs. 10, 11.
1967 (?)**Hymenozonotriletes proteus** Naumova; McGregor, 1967, Pl. 1, fig. 16.
1980 **Grandispora protea** (Naumova) Moreau-Benoit, p. 37, Pl. 11, fig. 6.
non 1965 **Hymenozonotriletes proteus** Naumova; Tilina-Stanichnikova, Pl. 2, fig. 2.
non 1974 **Calyptosporites proteus** (Naumova) Allen; Hamid, Pl. 9, figs. 8, 9.

Description. Trilete, camerate spores with rounded subtriangular amb. Laesura arms hidden by elevated triradial exoexinal folds, highest at proximal pole, tapered toward equator. Intexine distinct, levigate, about 1.5 μm thick. Exoexine about 1-2 μm thick, commonly with minor wrinkles and folds, proximally levigate, equatorially and distally bearing verrucae, rounded coni, and rare spinae and biform elements, 1-5 μm at base, 1-8 μm high, and 2-9 μm apart. Sculptural elements may be surmounted by a fine cone or spine. On some specimens the smallest sculptural elements occur at the equator, but commonly those on flange and toward the distal pole are of about the same size.




*Text-figure 70: Sculptural elements of* ***Grandispora protea,*** *lateral view.*

Diameter. 112-229 μm, mean 148 μm (28 specimens). Diameter of intexinal body 40-60% of total spore diameter.

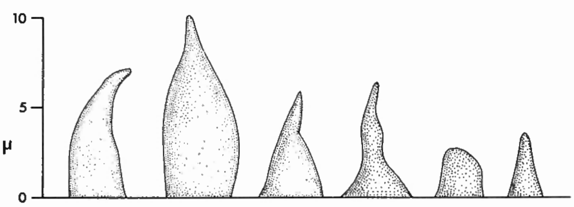
Occurrence. Figured specimens: Plate 11, figure 10, loc. 8317, slide 1, 60.8 x 119.1, GSC 66323; Plate 12, figure 1, loc. 8311, slide E, GSC 66324. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 27).

Comparisons. **Grandispora protea** differs from **G. velata** only in its larger and more round-topped sculptural elements. Extreme forms of these two species intergrade. **Spinozonotriletes echinatus** Moreau-Benoit has broader based, predominantly pointed sculptural elements. **Spinozonotriletes** sp. A of Turnau (1974) is smaller and has exclusively biform ornaments. **Calyptosporites** cf. **domanicus** (Naumova) Cramer (1969, fig. 39) is at least superficially like **G. protea**, but as it is not described in detail and we have not examined the specimens, closer comparison is not possible at this time. **Spinozonotriletes** cf. **echinatus** Moreau-Benoit, of Bar and Riegel (1974), has slightly larger sculpture. **Grandispora rarispinosa** Massa and Moreau-Benoit ex Moreau-Benoit (1980) is smaller and has less densely distributed sculpture.

**Grandispora tiwarii** n. name
Plate 12, figures 2, 4, text-figure 71

1975 **Calyptosporites spinosus** Tiwari and Schaarschmidt, p. 43, Pl. 24, figs. 4a-5, Pl. 25, figs. 1, 2, text-fig. 31.
non 1955 **Grandispora spinosa** Hoffmeister, Staplin and Malloy, p. 388, Pl. 39, figs. 10, 14.

Description. Trilete, ?camerate spores with rounded subtriangular or subcircular amb and intexinal body. Laesura arms indistinct, obscured by triradiate exoexinal folds that extend to the equator. Intexinal body darker than exoexine, of undetermined thickness, its radius about half that of the exoexine. Exoexine thin, proximally levigate, distally and equatorially with rather loosely distributed spinae about 1-8 µm apart. Spinae narrow- or broad-based, 1.5-3.5 µm wide at base, 2.5-7 µm (rarely up to 10 µm) long, of about the same size over all of the distal region.




*Text-figure 71: Sculptural elements of **Grandispora tiwarii**, lateral view.*

Diameter. 114-194 µm (5 specimens).

Occurrence. Figured specimen, loc. 8300, slide 10, 62.1 x 112.6, GSC 66325. Stratigraphic range, Cape De Bray Formation and lower Weatherall Formation, Eifelian (Fig. 7, no. 2).

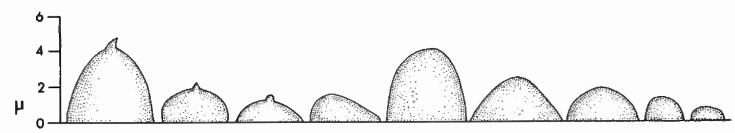
Derivation of name. After R.S. Tiwari, who with F. Schaarschmidt originally described this species.

Remarks. On transfer of the specific epithet to **Grandispora**, the nomenclatural combination becomes a junior homonym of **Grandispora spinosa** Hoffmeister, Staplin and Malloy (1955). A new trivial name, **tiwarii**, is therefore given to this species, in accordance with the requirements of the International Code of Botanical Nomenclature, Art. 64.

Comparisons. **Hymenozonotriletes spinulosus** Naumova (1953) is smaller, and may have smaller sculptural elements. **Grandispora spinosa** Hoffmeister, Staplin and Malloy (1955) has more widely spaced sculptural elements, and no triradiate exoexinal folds. **G. protea** bears verrucae, rounded coni and biform elements, and only rare spinae. **Calyptosporites microspinosus** (Richardson) Richardson (1965) has bifurcate-tipped spines. **C.** sp. nov. of Riegel (1968) is smaller, and has a relatively narrower equatorial exinal extension. **Hymenozonotriletes** sp. 31 of Tilina-Stanichnikova (1965) and the unnamed specimen illustrated in fig. 17 of Regali (1964) are at least superficially like **Grandispora tiwarii**, but as neither is described, further comparison is not possible.

**Grandispora uyenoi** n. sp.
Plate 12, figures 3, 7, text-figure 72

Diagnosis. Trilete, camerate miospores with subcircular amb. In lateral compression, proximal surface flattened pyramidal, distal surface rounded. Laesura arms 1/2-4/5 radius in length, simple, or may be paralleled by triradiate exoexinal folds. Intexinal body levigate, about 1 µm thick, commonly folded, may be indistinct. Exoexine 2-5 µm thick. Contact areas levigate or scabrate, delimited by thin, low curvaturae. Proximal-equatorial and distal surfaces ornamented with verrucae and/or coni 2-6 µm in height and basal width. On most specimens some verrucae bear a minute granum or cone on top. Sculptural elements subcircular or polygonal in plan view, closely spaced, occasionally joined in groups of two or three.




*Text-figure 72: Sculptural elements of **Grandispora uyenoi**, lateral view.*

Diameter. 89-177 µm, mean 128 µm (20 specimens). Diameter of intexinal body 65-90% (commonly about 80%) of total spore diameter.

Occurrence. Holotype, Plate 12, figures 3, 7, loc. 8309, slide 1, 52.3 x 112, GSC 66326. Stratigraphic range, lower Weatherall Formation, mid-Eifelian (Fig. 7, no. 68).

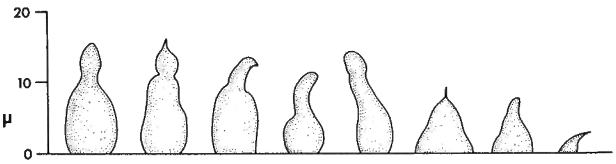
Derivation of name. After T.T. Uyeno of the Geological Survey of Canada, who spent two field seasons with the senior author in the Arctic Islands.

Comparisons. **Archaeozonotriletes tuberculosus** Raskatova (1973) is smaller and has tubercles that commonly are of irregular shape. **Grandispora mammillata** Owens of Massa and Moreau-Benoit (1976, Pl. 5, fig. 1) is smaller and has a more prominent intexinal body.

**Grandispora variospinosa** n. sp.
Plate 12, figures 5, 6, text-figure 73

1972 **Spinozonotriletes** sp. A, McGregor and Uyeno, Pl. 2, fig. 1.
1976 **Grandispora longus** Chi and Hills (pars), p. 752, Pl. 14, figs. 3-6.

Diagnosis. Trilete, zonate-?camerate spores with rounded subtriangular or subcircular intexinal body and amb. Laesura arms obscured by prominent fold-like labra that are 10-20 µm high at pole and extend beyond the body margin, commonly to the equator of the spore. Intexinal body subcircular, commonly concentric with exoexine, levigate or scabrate, about 1-3 µm thick, with distinct or indistinct margin. Exoexine thin, of about uniform thickness, commonly with minor folds that only rarely run across the body. Exoexine projects in the equatorial plane as a lateral extension 1/4-1/2 the radius in width. Proximal hemisphere levigate. Distal and equatorial regions with spinae and/or biform elements, some with an expanded base, commonly tapered to a delicate point or surmounted by a small cone or spine, rarely with a minute anchor-like bifurcation. Spines may be constricted in one or more places along their length. Spinae and biform elements are the predominant type of sculpture over the body region, with the longest toward the distal pole. Sculptural elements up to 20 µm (mostly 4-12 µm) long and 2.5-6 µm wide at base, most 2-4 times as long as wide, may be as small as 1 µm long and wide at the equator. Sculptural elements 2-7 µm apart over the body, never close-packed, more widely spaced on the equatorial extension.




*Text-figure 73: Sculptural elements of* ***Grandispora variospinosa****, lateral view.*

Diameter. 117-218 µm, mean 168 µm (27 specimens).

Occurrence. Holotype, Plate 12, figure 6, loc. 8338, slide 4, 38.6 x 119.1, GSC 66328. Paratype, Plate 12, figure 5, loc. 8309, slide 1, 39.6 x 124.2, GSC 66327. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 37).

Derivation of name. L. **varius**, different + **spinosus**, thorny.

Remarks. It has not been possible to determine whether these spores are camerate. The body is concentric with the exoexine in all specimens. However, some minor radially-directed exinal folds in addition to those associated with the trilete rays were observed to run across the intexinal margin on some specimens. This observation suggests that the intexine is detached from the exoexine over at least part of its distal side and perhaps on part of its proximal side as well. No specimens were observed in lateral compression.

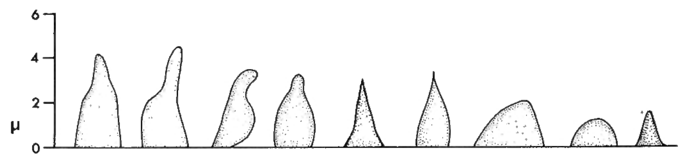
Comparison. **Grandispora longa** Chi and Hills (1976) has larger distal spines. Extreme forms intergrade with **G. variospinosa**, and Chi and Hills' (1976) population of **G. longa** includes both species. Intermediate forms are rare in the Weatherall Bay section, which suggests that division of the complex into two species is justified. **G. megaformis** has more robust, less elongate, commonly more closely spaced sculptural elements in the distal polar region.

**Cirratriradites** cf. **avius** of Tiwari and Schaarschmidt (1975) is smaller, has rounded cones rather than spines, and according to the description, its sculptural elements fall into two distinct size ranges. **Pustulatisporites pretiosus** Playford in Scott and Doher (1967), not described, is smaller, and also has rounded sculpture (?verrucae). **Calyptosporites decorus** Tiwari and Schaarschmidt (1975) is smaller, has a thick, "leathery" exoexine, and sculptural elements that are closely spaced on the body and especially densely concentrated in a ring at the body margin. Spore type B of Owens (1971) has closely spaced distal verrucae and characteristic radial exoexinal folds.

**Grandispora velata** (Eisenack) Playford
Plate 12, figure 8, text-figure 74

1944 **Triletes velatus** Eisenack (pars), p. 108, Pl. 1, figs. 1-3.
1955 **Hymenozonotriletes echiniformis** Kedo, p. 31, Pl. 4, fig. 1.
1960 **Cosmosporites velatus** (Eisenack) Richardson, p. 52, Pl. 14, fig. 4, text-fig. 3.
1962 **Calyptosporites velatus** (Eisenack) Richardson, p. 192.
1971 **Grandispora velata** (Eisenack) Playford, p. 47.
1973 **Grandispora velata** (Richardson) McGregor, p. 61, Pl. 8, figs. 10, 11, text-fig. 34.
non 1967 **Calyptosporites velatus** (Eisenack) Richardson; Moreau-Benoit, p. 231, Pl. 4, fig. 57.
non 1980 **Grandispora velata** (Eisenack) McGregor; Moreau-Benoit, Pl. 12, fig. 3.

Description. Trilete, camerate miospores with rounded subtriangular amb and intexinal body. Laesura arms about 1/2-2/3 radius in length, characteristically hidden by prominent triradial exoexinal folds that extend to or almost to the equator. Intexine about 1 µm thick, levigate. Exoexine less than 2 µm thick, proximally levigate, equatorially and distally with spinae, coni and rare grana, 1-3 µm wide at base, 1-4.5 µm high and 2-8 µm apart. Most sculptural elements taper gradually or abruptly to an acute tip.




*Text-figure 74: Sculptural elements of* ***Grandispora velata****, lateral view.*

Diameter. 119-265 µm, mean 162 µm (51 specimens). Diameter of intexinal body 40-65% of total spore diameter.

Occurrence. Figured specimen, loc. 8318, slide 1, 42.9 x 113.5, GSC 66329. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 9).

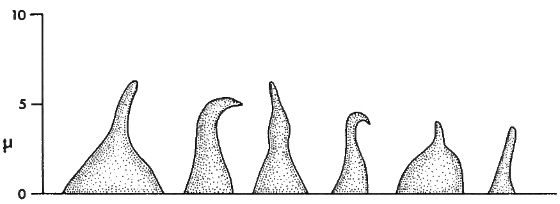
Comparisons. **Hymenozonotriletes tener** Chibrikova (1959) and **H. tener** var. **concinnus** Chibrikova (1962) are smaller, but in other respects similar to **Grandispora velata. Calyptosporites** sp. A of Daemon et al. (1967) is smaller, with more closely spaced sculptural elements. The specimen illustrated by Moreau-Benoit (1980, Pl. 12, fig. 3) has more closely crowded sculptural elements and a darker body than forms heretofore assigned to **G. velata.** On these grounds we prefer to exclude it from **G. velata.**

Large-sculptured forms of **G. velata** intergrade with **G. protea.**

**Grandispora** sp. 1
Plate 12, figure 10, text-figure 75

Description. Trilete, ?camerate miospores with rounded subtriangular amb and intexinal body. Laesura arms 4/5 radius of intexine in length, paralleled by triradiate exoexinal folds that extend to or nearly to the equator. Intexinal body dark, of undetermined thickness, its margin not sharply defined. Exoexine apparently thin, extended laterally in equatorial plane as a flange about 1/3 the radius in width.

Contact areas levigate, equatorial and distal regions of exoexine spinose. Spines 3-7 μm long, 1-5.5 μm wide at their base, about 3-15 μm apart on each specimen, about the same spacing at the equator and toward the pole.




*Text-figure 75: Sculptural elements of **Grandispora** sp. 1, lateral view.*

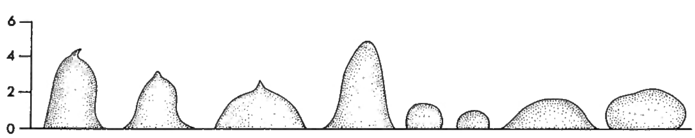
Diameter. 128 and 150 μm (2 specimens only).

Occurrence. Figured specimen, loc. 8334, slide 3, GSC 66331. Hecla Bay Formation, lower Givetian (Fig. 7, no. 104).

Comparisons. This species bears a close resemblance to **Ancyrospora nettersheimensis** except that the spines are not bifurcate.

**Grandispora** sp. 2
Plate 13, figure 1, text-figure 76

Description. Trilete, camerate spores with rounded subtriangular amb. Laesura arms simple, about 1/2-5/6 radius of intexine in length, commonly obscured by high triradiate exoexinal folds that extend to or nearly to the equator. Intexinal body distinct, 4-5.5 μm thick, levigate or scabrate. Exoexine thin, attached to intexine proximally, levigate or minutely granulate in contact areas. Distal and proximal-equatorial regions of exoexine comprehensively sculptured with verrucae, conical verrucae, and short spines, some of which may be surmounted by a minute cone. Sculptural elements 1.5-5 μm in basal width, 1-5 μm in total height, subcircular in plan view, ±regularly spaced, some joined in groups of two, but mostly discrete and 1-6 μm apart. Folds on intexine and exoexine common.




*Text-figure 76: Sculptural elements of **Grandispora** sp. 2, lateral view.*

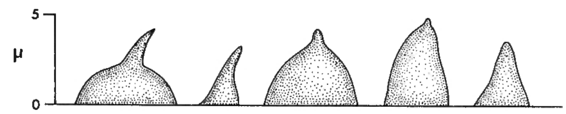
Diameter. 165-220 μm, mean 190 μm (7 specimens). Diameter of intexinal body 58-75% of total spore diameter.

Occurrence. Figured specimen, loc. 8338, slide 4, 61.1 x 112.3, GSC 66332. Stratigraphic range, Hecla Bay Formation, lower Givetian (Fig. 7, no. 105).

Comparisons. **Grandispora uyenoi** is smaller and more densely sculptured. **G. eximia** has predominantly conate and spinose sculpture, less closely spaced, and a thicker intexine. **G. ?macrotuberculata** (Arkhangelskaya) McGregor is smaller, with elongate, more strongly tapered sculptural elements. **Spinozonotriletes** cf. **echinatus** Moreau-Benoit of Bar and Riegel (1974) has larger, more widely spaced sculpture.

**Grandispora** sp. 3
Plate 12, figure 9, text-figure 77

Description. Trilete, camerate miospores with rounded subtriangular or subcircular amb and intexinal body. Laesura arms simple, about 3/4 the body radius in length, may be obscured by triradiate exinal folds. Intexinal body about 1 μm thick, levigate, its diameter about 1/2-2/3 that of the exoexine, commonly with concentric and transverse folds. Exoexine very thin in contact areas, slightly thicker equatorially and distally, commonly folded, comprehensively scabrate, and bearing mammae, verrucae and coni in the proximal-equatorial and distal regions. Sculptural elements 3-5 μm high, 1.5-5 μm wide at base, adjoining or up to 7 μm apart, the spacing being about the same over the entire surface of the exoexine outside the contact areas.




*Text-figure 77: Sculptural elements of **Grandispora** sp. 3, lateral view.*

Diameter. 81, 107, and 110 μm (3 specimens only).

Occurrence. Figured specimen, loc. 8337, slide 10, 47.3 x 114.9, GSC 66330. Hecla Bay Formation, lower Givetian (Fig. 7, no. 107).

Remarks. All three specimens are comprehensively scabrate except for the sculptural elements, which are clear. The scabrate pattern may be a corrosion effect.

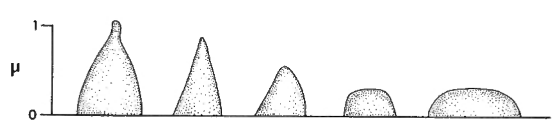
Genus **Granulatisporites** Ibrahim emend. Potonié and Kremp 1954

Type species. **Granulatisporites granulatus** Ibrahim 1933.

**Granulatisporites muninensis**? Allen
Plate 13, figures 5-11, text-figure 78

? 1965 **Granulatisporites muninensis** Allen, p. 693, Pl. 94, fig. 3-5.

Description. Trilete miospores with subtriangular amb and straight or convex interradial margins. In lateral compression, proximal face flattened, distal region strongly convex. Laesura arms straight, 7/8 to full radius in length, simple or with labra 0.5-2.5 μm in height and combined width. Wall 1-2.5 μm thick, slightly thinner at corners than interradially. Contact areas levigate, the rest of the spore bearing coni and grana less than 1 μm (commonly about 0.5 μm) in width and height, subcircular in plan view, close-packed or up to 1 μm apart. Sculptural elements of about the same size on each specimen, or slightly smaller equatorially opposite the rays.




*Text-figure 78: Sculptural elements of **Granulatisporites muninensis**?, lateral view.*

Diameter. 17-40 μm, mean 28 μm (90 specimens).

Occurrence. Figured specimens: Plate 13, figures 5-7, loc. 8333, slide A, GSC 66334; Plate 13, figures 8, 9, loc. 8336, slide 5, 59.7 x 119.2, GSC 66335; Plate 13, figures 10, 11, loc. 8312, slide 1, 65.2 x 121.9, GSC 66336. Stratigraphic range, Cape De Bray, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 20).

Comparisons. According to Allen (1965, p. 693) **G. muninensis** is granulate, not conate. On this basis he distinguishes it from **Anapiculatisporites devonicus** var. **azonatus** (Chibrikova) Vigran (1964) which bears coni. The latter has slightly larger sculptural elements than the Melville Island specimens, but the ranges of sculptural size in the two species overlap. The dimensions of the sculpture in **G. muninensis** are not explicitly given by Allen (1965), but from the illustrations of the holotype they appear to be 0.5 μm or less in size. At this scale it is difficult to resolve the shape of the smallest sculptural elements in profile, and coni and grana may appear indistinguishable. Nevertheless, as grana are distinguishable on only some of our specimens it seems best to question the identification.

**Apiculatasporites davenportensis** Peppers (in Peppers and Damberger, 1969) is subcircular and thinner. **A. perpusillus** (Naumova) McGregor is subcircular and has larger, more widely spaced sculpture consisting only of coni.

**Granulatisporites** sp.
Plate 13, figures 2-4

Description. Trilete miospores with subtriangular amb and convex interradial margins. Laesura arms 3/4-7/8 radius in length, with lips 1-2 μm in combined width. Wall rarely folded, about 3 μm thick, may be slightly thinner equatorially opposite rays, and in the contact areas. Contact areas levigate or scabrate, proximal-equatorial and distal regions with closely spaced grana and coni about 0.5-0.75 μm wide and high, may be slightly larger near distal pole on some specimens.

Diameter. 24-39 μm, mean 30 μm (17 specimens).

Occurrence. Figured specimen, loc. 8336, slide 5, 37.8 x 111, GSC 66333. Stratigraphic range, upper Cape De Bray Formation, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 32).

Comparisons. **Granulatisporites muninensis** Allen (1965) is thinner-walled.

Genus **Hystricosporites** McGregor 1960

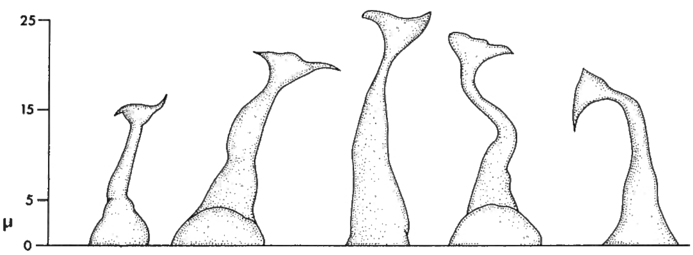
Type species. **Hystricosporites delectabilis** McGregor 1960

See remarks under **Ancyrospora** on p. 000 of this paper, and in Playford (1976, p. 32-33).

**Hystricosporites costatus** Vigran
Plate 13, figure 12, text-figure 79

1964 **Hystricosporites costatus** Vigran, p. 14, Pl. 5, figs. 3-5.
1971 **Hystricosporites delectabilis** McGregor; Taugourdeau-Lantz, p. 32, Pl. 2, fig. 18.

Description. Trilete, camerate miospores with subcircular amb. Laesura arms simple, about 4/5 the radius in length, accompanied by convoluted triradiate folds that are highest at the pole. A thin, concentrically folded, subcircular inner body is visible on some specimens. Exoexine about 6-9 μm thick equatorially and distally, comprehensively scabrate except for the bifurcate appendages, which are clear. Contact areas bear thickened, radially oriented, closely spaced ribs about 3-4.5 μm wide, number of ribs per interradial sector undetermined. The distal region and the proximal face outside the contact areas bear prominent, relatively widely spaced processes 12-28 μm long with laterally extended bifurcate tips. Processes commonly most closely spaced at the outer extremity of the contact areas. Most processes arise from a conical or bulbous base 3-14 μm wide, and taper gradually to 1-2.5 μm wide just below a triangular, laterally extended bifurcate tip 6-12 μm wide.




*Text-figure 79: Sculptural elements of **Hystricosporites costatus**, lateral view.*

Diameter. 110, 117, and 137 μm exclusive of processes (3 specimens only).

Occurrence. Figured specimen, loc. 8332, slide 1, 44.5 x 122.8, GSC 66337. Stratigraphic range, upper Weatherall Formation and Hecla Bay Formation, upper Eifelian and lower Givetian (Fig. 7, no. 95).

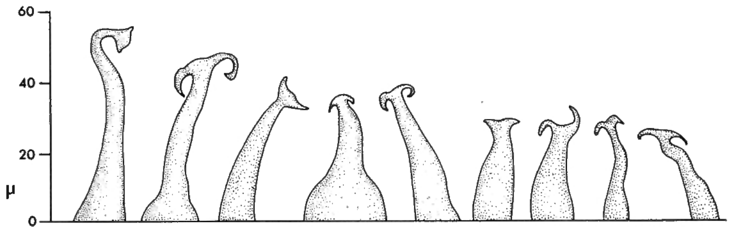
Comparisons. **Hystricosporites delectabilis** McGregor (1960) is larger and bears processes that have predominantly reflexed bifurcate terminations. **H. reflexus** Owens (1971) has coarser proximal ribs, and reflexed bifurcate terminations on the processes. Both of these species have much in common with **H. costatus** however. The taxonomic value of both size and the extent of flexure of the bifurcate terminations may be questioned.

**H. porcatus** (Winslow) Allen (1965) has more strongly elevated lips and wide curvaturae. **H. gravis** has longer processes and a thicker exoexine.

**Hystricosporites gravis** Owens
Plate 13, figures 15, 16, text-figure 80

1966 **Hystricosporites** sp., McGregor and Owens, Pl. 9, fig. 7.
1971 **Hystricosporites gravis** Owens, p. 31, Pl. 8, figs. 1-3, text-fig. 9.
1972 **Hystricosporites** n. sp. 1, McGregor and Uyeno, Pl. 2, fig. 12.

Description. Trilete, camerate spores with rounded triangular or subcircular amb. In lateral compression, proximal side flattened and distal region strongly rounded. Laesura arms commonly hidden by high, triradiate, flexuous folds. Thin, concentrically folded inner body visible on some specimens. Exoexine 8-16 μm thick equatorially and distally, thinner in contact areas, scabrate except for processes, most of which are clear. Contact areas bordered by raised, commonly poorly defined curvatural ridges, and bear radially oriented ribs 3-10 μm wide, some bifurcate, extending untapered or only slightly tapered in width from the curvaturae to the proximal pole, 5-8 ribs in each interradial sector. Proximal-equatorial and distal regions bear prominent anchor-tipped processes 25-80 μm long, rarely longer, commonly about as long as the radius of the spore, each arising from a tapered or bulbous base 9-26 μm wide. Bases of some processes may be dissected by ±radially oriented ribs and channels. Processes slightly tapered, may be almost parallel-sided in the upper half of their length where they are 3-8 µm wide, may be slightly constricted below the anchor-loke bifurcate tip. Tips laterally extended, straight or slightly reflexed. Number of processes projecting at equator, 16-37.




*Text-figure 80:* *Sculptural elements of* ***Hystricosporites gravis****, lateral view.*

Diameter. 74-178 µm, mean 123 µm (86 specimens).

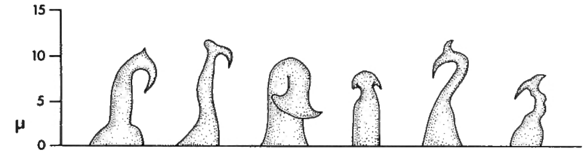
Occurrence. Figured specimens: Plate 13, figure 15, loc. 8319, slide F, GSC 66340; Plate 13, figure 16, loc. 8319, slide E, GSC 66341. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 47).

Remarks. Several of the many named and unnamed forms of **Hystricosporites** and **Archaeotriletes** in the literature may be synonymous with **H. gravis.** Sorting out the systematics of this group is a major project requiring extensive study, and is outside the objectives of this report. One of the most neglected aspects of comparison of the various species of **Hystricosporites,** and in fact of the whole complex of anchor-spined spores, is assessment of the effects of preservational alteration on the sculpture and structure of the wall. We suspect that confusion between inherent and induced features is a principal cause of overspeciation in the group. For example, **Acanthotriletes crassus** Naumova (1953) and **Archaeotriletes ancylius** Naumova ex Kedo (1955) may be based on poorly preserved specimens of **H. gravis.**

**Hystricosporites setigerus**? (Naumova ex Kedo) Arkhangelskaya
Plate 13, figures 13, 14, text-figure 81

? 1955 **Archaeotriletes setigerus** Naum. in litt.; Kedo, p. 25, Pl. 2, fig. 9.
1972 **Hystricosporites** n. sp. 3, McGregor and Uyeno, Pl. 4, fig. 2 (non **Hystricosporites furcatus** Owens, p. 28, Pl. 6, figs. 7-9).
? 1976 **Hystricosporites setigerus** (Kedo) Arkhangelskaya, p. 48, Pl. 5, fig. 6.

Description. Trilete miospores with rounded subtriangular or subcircular amb. In lateral compression proximal surface flattened, distal surface ±hemispherical. Laesura arms hidden by prominent triradiate folds 15-22 µm high that extend to or nearly to the equator. The equatorial extremities of the triradiate folds are connected by curvatural ridges that mark the outer edge of the thin wall of the contact areas. Contact areas levigate. Remainder of spore surface 2.5-4 µm thick, bearing relatively small, widely spaced processes with anchor-like, laterally extended, mostly reflexed bifurcate tips 3-7 µm wide. Processes 5-20 µm (commonly 8-14 µm) long, 2-6 µm wide at their base, each arising from a gently tapered or bulbous base, and tapered gradually toward the expanded tip. About 9-27 processes project at the periphery.




*Text-figure 81:* *Sculptural elements of* ***Hystricosporites setigerus****?, lateral view.*

Diameter. 73-117 µm, mean 95 µm (16 specimens).

Occurrence. Figured specimens: Plate 13, figure 13, loc. 8328, slide 6, 43.3 x 110.7, GSC 66338; Plate 13, figure 14, loc. 8308, slide 5, 36 x 124.4, GSC 66339. Stratigraphic range, Cape De Bray, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 5).

Comparisons. According to the expanded description of **Hystricosporites setigerus** by Arkhangelskaya (1976), it differs from the present specimens only in a slightly thicker wall and the rare presence of multifurcate-tipped processes. **H. microancyreus** Riegel (1973) has more closely spaced processes that are longest in the equatorial region, and constricted immediately below their bifurcate tip. **H. reflexus** Owens and **H. furcatus** Owens have radially oriented ribs in the contact areas, and a thicker wall equatorially and distally. **H. porcata** (Balme and Hassell) Allen (1965) has smaller processes and a thicker wall.

Remarks. This species occurs in about equal numbers in polar and in lateral compression. No evidence of two wall layers was observed. The scabrate or spongy texture and the channelled spine-bases characteristic of the wall of many specimens of **H. gravis** and other species of anchor-spined spores was not seen in any specimens of **H. setigerus**?.

**Hystricosporites** sp. A. of Owens
Plate 14, figure 1

1971 **Hystricosporites** sp. A., Owens, p. 33, Pl. 8, fig. 4.

Description. Trilete spore with rounded subtriangular amb. Laesura arms hidden by high, triradiate folds that extend, decreasing in height, to the equator. Contact areas with radially oriented ridges 5-10 µm wide, closely spaced, 4-6 ridges per sector. Remainder of wall bears large, prominent spinose processes 50-80 µm long, that are tapered gradually from 10-35 µm wide at their base to 7-10 µm wide, and expanded at the tip into triangular, laterally extended, bifurcate terminations 17-26 µm wide. Narrow longitudinal ribs are discernible at the base of some of the processes. Equatorial region of body, and approximately the lower half of the processes apparently enveloped by a diaphanous, folded structure (?exoexine).

Diameter. 119 µm (one specimen).

Occurrence. Loc. 8335, slide 1, 55.3 x 116, GSC 66342, Hecla Bay Formation, lower Givetian (Fig. 7, no. 106).

Remarks. The nature and extent of the diaphanous structure that appears to envelop the equatorial region has not been determined. This structure is not apparent on the single specimen described by Owens (1971) that is identical to ours in other respects. One of the specimens of **H. grandis** figured by Owens (1971, Pl. 7, fig. 5) possesses an apparently similar diaphanous structure.

Genus **Kraeuselisporites** Leschik emend. Scheuring 1974

Type species. **Kraeuselisporites dentatus** Leschik 1956

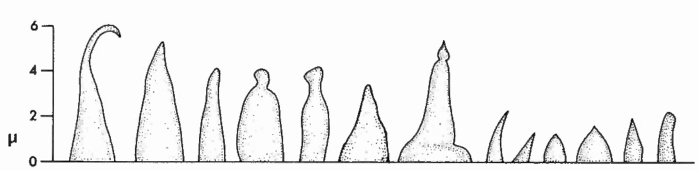
1956 **Kraeuselisporites** Leschik, p. 36.
1958 **Styxisporites** Cookson and Dettmann, p. 114.
1962 **Kraeuselisporites** Leschik emend. Jansonius, p. 46.
1974 **Kraeuselisporites** Leschik emend. Scheuring, p. 199.

Remarks. Several authors have discussed the circumscription and taxonomic relationships of **Kraeuselisporites.** Scheuring (1974) provided the most thorough discussion of the genus, based on examination of the type specimens of Leschik (1956). He concluded that it should contain only "acavate" spores and those with distinct sculpture on the distal hemisphere, but could include those with an unsculptured zona. According to this interpretation **Styxisporites** Cookson and Dettmann (1958) (which however, contrary to Scheuring, may include specimens with a distally sculptured zona), is a junior synonym, and **Indotriletes** Tiwari (1964), which is camerate, is excluded. We accept Scheuring's version of the genus, but note that it may be difficult to maintain a clear distinction between the camerate and acamerate conditions within this spore complex. The use of these conditions for generic separation using conventional light microscopy therefore may be impractical for some members of the group (see Playford and Helby, 1968, p. 112, and discussion on p. 43 of this paper).

**Kraeuselisporites acerosus** (Arkhangelskaya) n. comb.
Plate 14, figures 6, 7, 9, 10, text-figure 82

1963 **Hymenozonotriletes acerosus** Arkhangelskaya, p. 25, Pl. 10, figs. 1-5.

Description. Trilete, zonate miospores with subcircular or rounded subtriangular amb. In lateral profile, proximal face flattened, distal region strongly rounded. Wall thin proximally, 3.5-9 µm thick distally. Laesura arms obscured by prominent, straight or more commonly sinuous triradiate fold-like lips that extend with some decrease in height from the pole toward the equator, and merge with the curvaturae. Curvaturae equatorial or slightly proximal to the equator, raised as an ?exoexinal extension that on compression extends laterally as a thin zona of varied width, scarcely detectable in polar compression on some specimens, wider on others, may be slightly wider opposite the rays. Widest zona observed, 14 µm. A dark ring of irregular width, commonly with poorly defined margins, may be present around the spore at the inner edge of the zona. Contact areas scabrate or levigate, rarely with radial, discontinuous folds. Equatorial and distal regions bear spinae, less commonly coni, and rare biform sculptural elements 0.5-5 µm (commonly 1-3 µm) apart, 0.5-3 µm in basal width, 0.5-4 µm (rarely up to 6.5 µm) long, most more than twice as long as basal width.




*Text-figure 82: Sculptural elements of **Kraeuselisporites acerosus**, lateral view.*

Diameter. 61-138 µm, mean 97 µm (155 specimens).

Occurrence. Figured specimens: Plate 14, figure 6, loc. 8311, slide F, GSC 66347; Plate 14, figure 7, loc. 8335, slide 1, 38 x 120, GSC 66348; Plate 14, figures 9, 10, loc. 8335, slide 1, 52 x 126.6, GSC 66349. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 8).

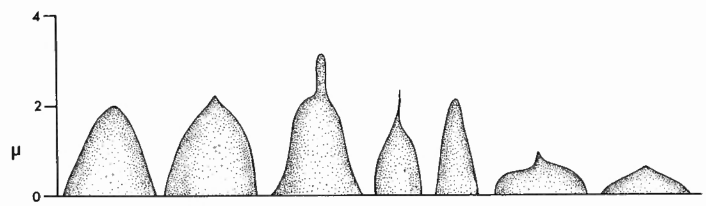
Remarks. None of the specimens we have assigned to this species show clear evidence of camerate structure. The dark, partial or complete annulus observed on some specimens may be a manifestation of effects of compression on the thick, originally convex distal region (cf. **Densosporites**).

Comparisons. **Samarisporites amoenus** Arkhangelskaya (1976) has a wider zona.

**Kraeuselisporites ollii**? (Chibrikova) n. comb.
Plate 14, figures 2-5, 8, text-figure 83

1972 ?**Archaeozonotriletes arduus** Arkhangelskaya; McGregor and Uyeno, Pl. 2, fig. 4 (refigured in McGregor, 1979b, Pl. 2, fig. 11).
? 1972 **Hymenozonotriletes ollii** Chibrikova, p. 147, Pl. 9, figs. 5-7.

Description. Trilete, zonate miospores with subcircular amb. In lateral profile, proximal area ±flat, distal region strongly rounded. Wall about 1 µm thick proximally, 2-4 µm thick distally. Laesura arms hidden by prominent, convolute triradiate fold-like lips about 5-25 µm high and 4-13 µm wide at the proximal pole, extending to or nearly to the equator, where they appear on some specimens to be continuous with the zona. Zona membranous, 1-15 µm (commonly 5-10 µm) wide. Contact areas levigate or scabrate, with numerous sinuous, more or less radially oriented folds, 2-6 µm wide and high, that may be densely crowded and fill the entire contact region. Equatorial extension and distal hemisphere bear coni, some terminated by a minute spine, and rare grana and spinae. Sculptural elements 0.5-2.5 µm wide, 0.5-3 µm long, and 0.5-3 µm apart. On some specimens the bases of adjacent sculptural elements are fused in the distal polar region.




*Text-figure 83: Sculptural elements of **Kraeuselisporites ollii**?, lateral view.*

Diameter. 64-133 µm, mean 92 µm (80 specimens).

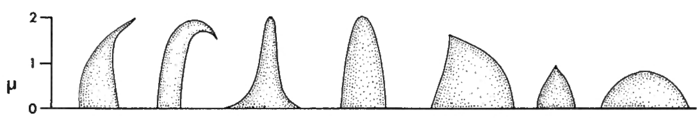
Occurrence. Figured specimens: Plate 14, figure 2, loc. 8331, slide 3, 49.5 x 126.8, GSC 66343; Plate 14, figure 3, loc. 8331, slide 1, 58.5 x 125.5, GSC 66344; Plate 14, figure 4, loc. 8320, slide D, GSC 66345; Plate 14, figures 5, 8, loc. 8331, slide 3, 70 x 113.8, GSC 66346. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 25).

Comparisons. **Kraeuselisporites ollii** (Chibrikova) n. comb. has more widely spaced, slightly larger sculptural elements. These rather minor differences may not be sufficient in themselves to separate it taxonomically from the Melville Island species. Chibrikova's illustrations (1972, Pl. 9, figs. 5-7) do not show the proximal sinuous folds clearly, although they are described in the text of her paper. **K. acerosus** has a less incised zonal margin and narrower-based, more elongate sculpture, and lacks prominent proximal radiating folds. **Camptozonotriletes asaminthus** Allen (1965) bears a slightly larger sculpture of verrucae, and is thicker distally. **Archaeozonotriletes arduus** Arkhangelskaya (1963) has larger sculptural elements that are largest at the equator where, by their serial arrangement, they create the appearance of a narrow fringe.

**Kraeuselisporites rugosus** (Owens) n. comb.
Plate 14, figures 11, 12, text-figure 84

1971 ?**Spinozonotriletes rugosus** Owens, p. 57, Pl. 17, fig. 6, Pl. 18, fig. 1.
1972 ?**Spinozonotriletes** n. sp., McGregor and Uyeno, Pl. 1, figs. 19, 20.

Description. Trilete, zonate miospores with subcircular or rounded subtriangular amb. In lateral compression, proximal surface flattened pyramidal, distal region ±hemispherical. Laesura arms hidden by elevated, contorted, triradiate fold-like lips that are highest and widest at the pole and extend to or nearly to the equator. Wall thin proximally, 1.5-3.5 μm thick distally, extended in the equatorial plane as a relatively thin zona about 1/5 the radius in width. Proximal region tightly folded in a triangular area about 1/3-1/2 the distance to the equator of the body, enclosing an unwrinkled area in the angles of the triradiate lips. Less densely distributed folds may occur proximally outside this triangular area, except on the zona, which commonly has relatively few folds. Wall proximally levigate, distally and equatorially bearing coni, spinae, and rare grana 0.5-2 μm wide at base, 0.25-3 μm high, and up to 3 μm apart.



Text-figure 84: *Sculptural elements of **Kraeuselisporites rugosus**, lateral view.*

Diameter. 83-139 μm, mean 112 μm (74 specimens).

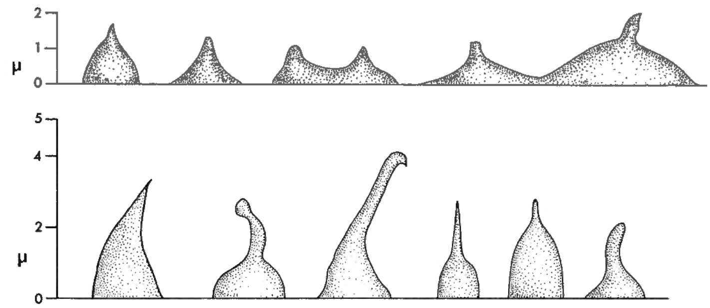
Occurrence. Figured specimens: Plate 14, figure 11, loc. 8333, slide 3, 47.7 x 117.8, GSC 66350; Plate 14, figure 12, loc. 8334, slide G, GSC 66351. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 50).

Remarks. We were not able to distinguish any clear evidence of separation of the zona into two layers. On the other hand, the intense folding of the exoexine on the proximal face indicates some separation in that region.

**Kraeuselisporites spinutissimus**? (Naumova ex Kedo) n. comb.
Plate 15, figures 1, 2, text-figure 85

? 1955 **Hymenozonotriletes spinutissimus** Naum. in litt.; Kedo, p. 27, Pl. 2, fig. 16.

Description. Trilete, zonate miospores with subcircular or rounded subtriangular amb. Laesura arms 2/3 to full radius in length, commonly obscured by straight or sinuous triradiate folds 1-4 μm in total width and about 6 μm high at proximal pole. Intexine distinct, dark. Exoexine distally about 4 μm thick, ?thinner proximally, extended equatorially as a narrow zona about 10-13 μm wide. Contact areas levigate. Equatorial and distal regions bear small coni, spinae and biform sculptural elements, the latter consisting of a small cone, spine or pilum arising from a conical or bulbous base. Sculptural elements 1-3 μm wide at base, 0.5-6 μm (commonly 1-3 μm) in total height, adjoined at base or up to 3 μm apart.



Text-figure 85: *Sculptural elements of **Kraeuselisporites spinutissimus**?, lateral view.*

Diameter. 65-80 μm (6 specimens).

Occurrence. Figured specimen, loc. 8301, slide 5, 41 x 111.5, GSC 66352. Stratigraphic range, Cape De Bray Formation, lower Eifelian (Fig. 7, no. 1).

Comparison. **Hymenozonotriletes spinutissimus** Kedo (1955) from the Luga-Oredezh beds of Byelorussia is slightly smaller, 40-65 μm in diameter, but in other respects is similar. Another Russian form, **H. serratus** Naumova of Pychova (1960, Pl. 4, fig. 2, and Pl. 6, fig. 7, not described) appears identical to **H. spinutissimus.** Both of these forms are illustrated by line drawings that depict little or no difference in optical density between the body of the spore and the equatorial extension. In the spores from Melville Island, on the other hand, the body is much darker than the zona.

Genus **Laevigatosporites** Ibrahim 1933

Type species. **Laevigatosporites vulgaris** (Ibrahim) Ibrahim 1933.

**Laevigatosporites** sp.
Plate 15, figures 3, 4.

1972 "Azonomonoletes" sp., McGregor and Uyeno, Pl. 1, fig. 16.
? 1977 **Azonomonoletes usitatus** Chibrikova, Pl. 13, figs. 19, 39, 45.
non 1962 **Azonomonoletes usitatus** Chibrikova, p. 451, Pl. 16, figs. 15, 16.

Description. Monolete miospores with oval amb and reniform profile in lateral compression. Ratio of length to width 1.7-1.8. Wall 1.5-3 μm thick, levigate. Laesura straight, simple, extends about 1/2-5/6 longest diameter of spore, may be bordered by an indistinct darkened area. Low curvaturae with indistinctly delimited margins present at equator, commonly only visible on laterally compressed specimens.

Diameter. 36-60 μm (8 specimens).

Occurrence. Figured specimens: Plate 15, figure 3, loc. 8320, slide 2, 67.4 x 111, GSC 66353; Plate 15, figure 4, loc. 8322, slide 8, 35 x 111.5, GSC 66354. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 93).

Comparisons. **Azonomonoletes usitatus** Chibrikova (1962) is punctate or shagreen according to the description. However, the specimens illustrated by Chibrikova (1977, Pl. 13, figs. 19, 39, 45) appear to be smooth and may be conspecific with **Laevigatosporites** sp. from Melville Island. The single specimen of "Azonomonoletes" sp. illustrated by McGregor and Uyeno (1972, Pl. 1, fig. 16) is identical to the present specimens except for patches of corrosion that superficially resemble microsculpture. The "sculpture" on the specimens of Chibrikova (1962) also may be a product of diagenetic alteration of a smooth exine, in which case these specimens would be indistinguishable from **Laevigatosporites** sp.

**Azonomonoletes laevis** Chibrikova (1959) lacks curvaturae. **Laevigatosporites** sp. of de Jersey (1966) is smaller.

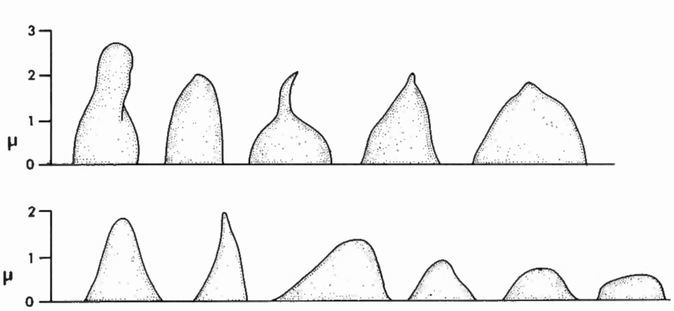
Genus **Lophotriletes** Naumova 1959 ex Ishchenko 1952

Type species. **Lophotriletes gibbosus** (Ibrahim) Potonié and Kremp 1954.

**Lophotriletes devonicus** (Naumova ex Chibrikova) n. comb.
Plate 15, figures 5-11, text-fig. 86

1959 **Diatomozonotriletes devonicus** Naum. in litt.; Chibrikova, p. 80, Pl. 14, fig. 4.
1962 **Diatomozonotriletes devonicus** Naum. var. **contractus** Chibrikova, p. 447, Pl. 16, fig. 3.
1962 **Diatomozonotriletes devonicus** Naum. var. **azonatus** Chibrikova, p. 447, Pl. 16, fig. 5 (non fig. 4).
1972 **Lophotriletes** sp., McGregor and Uyeno, Pl. 2, fig. 10.
1976 **Anapiculatisporites devonicus** var. **azonatus** Chibrikova; Massa and Moreau-Benoit, Pl. 3, fig. 2.

Description. Trilete miospores with subtriangular amb and slightly convex, straight, or slightly concave interradial margins. In lateral compression, proximal face flat-pyramidal, distal region strongly convex. Laesura arms 2/3 to 7/8 radius in length, simple or bordered by dark folds or lips up to 3 µm in total width that are widest at the pole. Wall 1-2.5 µm thick at equator and distally, about 1 µm thick proximally. Proximal face levigate or more commonly with grana less than 1 µm (commonly less than 0.5 µm) wide, and 1-2 µm apart. Distal and equatorial regions with coni and truncated coni 1.5-2.5 µm wide and high, less commonly grana or bacula of about the same dimensions, and rarely verrucae and biform elements 1.5-3 µm (rarely up to 4.5 µm) wide and high. Sculptural elements may be largest toward distal pole, coni most common equatorially. Sculptural elements somewhat irregularly spaced, 0.5-2.5 µm apart, commonly reduced in size or lacking at the apices.



*Text-figure 86: Equatorial and distal sculptural elements of **Lophotriletes devonicus**, lateral view.*

Diameter. 27-43 µm, mean 35 µm (74 specimens).

Occurrence. Figured specimens: Plate 15, figures 5, 6, 11, loc. 8329, slide 1, 51 x 121.7, GSC 66355; Plate 15, figures 7, 8, loc. 8323, slide 5, 47.6 x 115.6, GSC 66356; Plate 15, figures 9, 10, loc. 8319, slide G, GSC 66357. Stratigraphic range, Weatherall and lower Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 79).

Remarks. The distal sculptural elements of this species commonly resemble small verrucae in plan view. In lateral compression, however, most prove to be broad-based, blunt coni in profile. The combination of predominantly conate or modified-conate sculpture and the distinctly triangular amb makes **Lophotriletes** the most appropriate generic assignment. No other genus seems appropriate to accommodate the full range of variation of structure and sculpture observed in this species. Nevertheless there are certain features in common with **Planisporites** (Knox) Potonié (1960), **Procoronaspora** Butterworth and Williams (1958), **Tuberositriletes** Döring (1964), and **Tricidarisporites** Sullivan and Marshall emend. Gueinn, Neville and Williams (in Neves et al., 1973). Based on a few specimens only, some of the more extreme variants within this complex could have been apportioned confidently to these genera. Given the large number of specimens available however, division of the complex is not practical along the lines specified in the circumscriptions of any of them.

Comparisons. Chibrikova (1962) indicated that both **Diatomozonotriletes devonicus** var. **contractus** and **D. devonicus** var. **azonatus** display considerable variation in equatorial wall thickness, in disposition of the sculptural elements, and in the curvature of the interradial margins. However, neither these two varieties nor **D. devonicus** Naumova ex Chibrikova (1959) possess the distinctive elongate equatorial-interradial sculpture characteristic of **Diatomozonotriletes** Naumova emend. Playford (1963). They appear to agree in all respects with those specimens from Melville Island herein assigned to **Lophotriletes devonicus** that have sculpture at the lower end of the size range, i.e. those with sculptural elements about 1.5-2 µm in diameter. Those with larger sculptural elements are included in the same species for the reasons given above.

**Anapiculatisporites devonicus** var. **azonatus** (Chibrikova) Vigran (1964) has slightly smaller sculptural elements. **Lophotriletes** sp. 9 of Mikhailova and Fradkina (1966), illustrated but not described, is larger and bears evenly distributed, more or less isodiametric sculptural elements that are not reduced in size at the apices. **Acanthotriletes** sp. 2 of Jardiné and Yapaudjian (1968, Pl. 1, figs. 13, 14, 17) has rather small, closely spaced sculpture but the specimen shown in figure 14, at least, may be assignable to **Lophotriletes devonicus**. **Lophotriletes viluicus** Pashkevich (1971) is larger and has smaller sculptural elements.

Genus **Perotrilites** Couper emend. Evans 1970

Type species. **Perotrilites granulatus** Couper 1953.

1964 **Indotriradites** Tiwari, p. 251, Pl. 1, figs. 4, 4a, 5, 6.

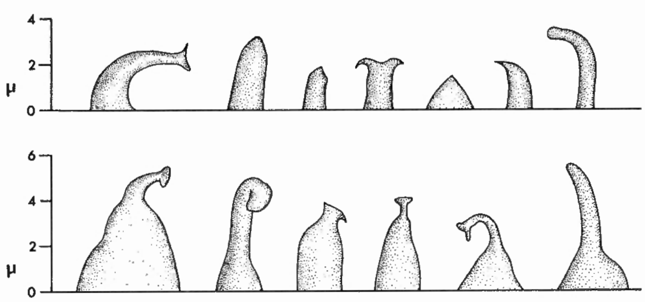
Remarks. Evans (1970) concluded that the holotype and other specimens of **P. granulatus** are double-layered and possess a single-layered zona. This interpretation is in accord with our interpretation of the structure of specimens from Melville Island that we have assigned to **Perotrilites.** Following this interpretation, **Perotrilites** differs from **Kraeuselisporites** Leschik emend. Scheuring in being distally two-layered, whereas according to Scheuring (1974, p. 200) ". . .none of Leschik's types [of **Kraeuselisporites**] shows a distinctly detached intexine." On the other hand, Jansonius (1962) and Segroves (1970) regarded **Kraeuselisporites** as encompassing both camerate and acamerate forms. For the present, to preserve nomenclatural stability until a thorough morphologic study can be done, we accept the distinction proposed by Evans and Scheuring. We have not seen clear evidence of distally camerate or double layered condition in specimens here assigned to **Kraeuselisporites**, whereas **Perotrilites** spp. herein appear to be two-layered (camerate) as well as zonate.

As defined by Evans, **Perotrilites** is distinguishable from **Grandispora** by its single layered equatorial extension (zona) and close-fitting exoexine. In practice however it may be difficult to separate these two genera using these criteria, for the reasons stated by Playford (1971, p. 45) and McGregor (1973, p. 58) in their discussion of **Grandispora** vis-à-vis **Spinozonotriletes** and **Calyptosporites**. For further discussion see p. 43 (this paper).

**Perotrilites bifurcatus** Richardson
Plate 15, figures 13-15, text-figure 87

1962 **Perotrilites bifurcatus** Richardson, p. 174, Pl. 25, figs. 4, 5, text-fig. 3.
1966 ?**Perotrilites** sp., McGregor and Owens, Pl. 9, fig. 6.
non 1968 **Perotriletes bifurcatus** Richardson 1962; Lanninger, p. 155, Pl. 26, fig. 5.

Description. Trilete, zonate-camerate miospores with rounded subtriangular or subcircular amb. Intexinal body levigate, dark, 5-9 µm thick equatorially and distally. Exoexine diaphanous, closely appressed to body distally, extended in equatorial plane in the form of a flange of varied width, about 1/5-1/3 the body radius in width, commonly bearing a few irregularly disposed folds on the proximal face. Laesura arms 1/2-3/4 the radius, obscured by straight or sinuous lips or folds that may extend to the equator of the body. Contact areas levigate, may be darkened close to the pole. Equatorial and distal regions bear delicate spinae, bacula and rare coni about 3-9 µm apart, 2-7 µm long, that taper gently from base 1-4 µm wide, and terminate either in an acute tip or in a minute anchor-like bifurcation.



*Text-figure 87: Sculptural elements of **Perotrilites bifurcatus**, lateral view.*

Diameter. 62-122 µm, mean 83 µm (69 specimens).

Occurrence. Figured specimens: Plate 15, figure 13, loc. 8312, slide A, GSC 66360; Plate 15, figures 14, 15, loc. 8311, slide P, GSC 66361. Stratigraphic range, Cape De Bray, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 18).

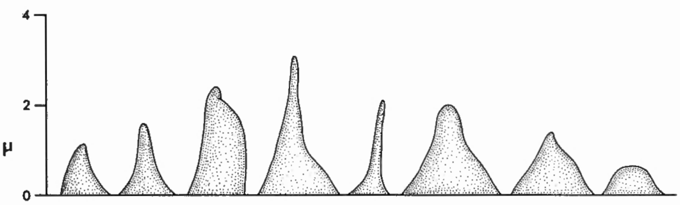
Comparisons. **Perotrilites selectus** (Arkhangelskaya) McGregor and Camfield (1976) is profusely wrinkled proximally, has shorter, undivided, commonly more widely spaced sculptural elements, and is not darkened at the pole. **Hymenozonotriletes spinosus** Naumova (1953) is larger, with simple laesura, and apparently non-bifurcate spinae.

**Hymenozonotriletes meonacanthus** Naumova (1953) appears to be basically similar in construction but lacks bifurcate spines. Detailed comparison of this species with **Perotrilites bifurcatus** is not possible from the limited information provided by Naumova (1953). It should be noted that some specimens from Melville Island, otherwise similar to **P. bifurcatus**, bear only undivided spines or shorter, blunt processes and thus seem to resemble **Hymenozonotriletes meonacanthus** rather closely. They are judged to be specimens of **P. bifurcatus** in which the spines have been preservationally altered.

**Perotrilites ergatus**? Allen
Plate 15, figures 12, 16, 17, text-figure 88

? 1965 **Perotrilites ergatus** Allen, p. 731, Pl. 102, figs. 16-20.

Description. Trilete, zonate-camerate miospores with rounded subtriangular or subcircular amb. Laesura arms 1/2-3/4 radius, commonly hidden by high triradiate folds that taper toward equator. Intexinal body thick, levigate. Exoexine thin and diaphanous, commonly folded, proximally levigate, commonly with wrinkles 1-2 µm wide. Equatorial extension and distal hemisphere of exoexine with gently or sharply tapered spinae and/or coni 1-3.5 µm long and 0.5-2 µm in basal width, and rare grana about 1-1.5 µm wide and high. Sculptural elements 1-6 µm (commonly 3-5 µm) apart. Distally, sculptural elements may be interconnected by wrinkle-like folds about 1-2 µm wide and high that on some specimens form an imperfect reticulum.



*Text-figure 88: Sculptural elements of **Perotrilites ergatus**?, lateral view.*

Diameter. 71-131 µm, mean 97 µm (46 specimens); intexinal body 58-88 µm.

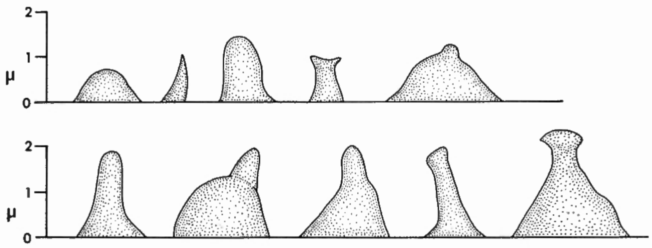
Occurrence. Figured specimens: Plate 15, figure 12, loc. 8308, slide 10, 67.4 x 123.2, GSC 66358; Plate 15, figures 16, 17, loc. 8308, slide 10, 41.1 x 110.3, GSC 66359. Stratigraphic range, Cape De Bray and Weatherall formations, Eifelian (Fig. 7, no. 13).

Comparisons. On most specimens of this species the inner edge of the intexine ("inner sculptine" of Allen, 1965) is not visible, so we have been unable to determine whether the intexine is as thick (6-10 µm) as that of **P. ergatus** Allen. In other morphological features there is close agreement with **P. ergatus.**

**Grandispora mammillata** Owens (1971) is larger, has larger sculptural elements with more robust interconnecting folds, and a thicker and more rigid two-layered equatorial extension.

**Perotrilites heclaensis** n. sp.
Plate 15, figures 18-21, text-figure 89

Diagnosis. Trilete, zonate-camerate miospores with subcircular or rounded subtriangular amb. In lateral compression, proximal face flattened pyramidal, distal side strongly rounded. Laesura arms 1/3-7/8 radius, commonly accompanied by narrow, straight or sinuous triradiate folds that are up to 2-6 µm high at pole and taper toward equator. Intexine levigate, dark, commonly darkest near proximal pole, 2-8 µm thick at equator interradially, may be slightly thinner at corners. Exoexine thin, diaphanous, proximally levigate, with small wrinkles on some specimens along outer edge of contact area. Exoexine forms a narrow, continuous or discontinuous equatorial extension but closely envelops the intexine proximally and distally. Exoexine sculptured at equator and distally with grana and broad-based coni 1-3 µm (rarely as much as 5 µm) wide and about as high or slightly less, that may be surmounted by a small baculum with or without spreading tip. Slender spines and bacula 0.5-1 µm wide and 2-3 µm high, may also occur. Sculptural elements 2-6 µm apart, may be most closely spaced and largest toward distal pole, or relatively small both distally and equatorially.




*Text-figure 89: Sculptural elements of* ***Perotrilites heclaensis****, lateral view.*

Diameter. 40-71 µm, mean 59 µm (69 specimens).

Occurrence. Holotype, Plate 15, figure 18, loc. 8335, slide 1, 50.7 x 120.2, GSC 66362. Paratypes: Plate 15, figure 19, loc. 8333, slide B, GSC 66363; Plate 15, figures 20, 21, loc. 8334, slide 3, 43.6 x 120.3, GSC 66364. Stratigraphic range, Hecla Bay Formation, lower Givetian (Fig. 7, no. 99).

Derivation of name. After the Hecla Bay Formation.

Comparisons. **Hymenozonotriletes suppletus** Chibrikova (1959) is similar, to the extent that comparison can be made from the description and illustration given by Chibrikova. More detailed comparison depends on an understanding of the nature of the thin equatorial extension in that species, and would require examination of the type material which is not available to us.

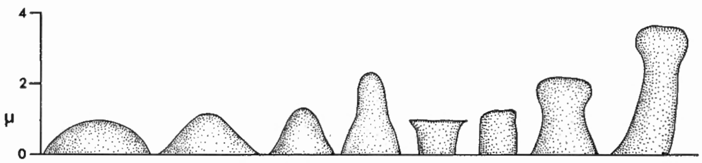
**Perotrilites bifurcatus** is larger, bears longer, typically bifurcate sculptural elements, and has a relatively narrower and often discontinuous zona.

**Hymenozonotriletes meonacanthus** Naumova (1953) is larger, bears sculpture of "sparse, thin spinules" [translation from Russian], and a continuous equatorial extension of about constant width.

**Perotrilites selectus** (Arkhangelskaya) McGregor and Camfield
Plate 15, figures 22, 23, text-figure 90

1960 **Perotrilites** sp., McGregor, p. 35, Pl. 12, fig. 8.
1963 **Hymenozonotriletes selectus** Arkhangelskaya; Filimonova and Arkhangelskaya, p. 35, Pl. 3, fig. 5, Pl. 4, figs. 1-4.
1964 **Perotrilites** cf. **perinatus** Hughes and Playford; Vigran, p. 19, Pl. 3, figs. 7, 8.
1971 **Perotrilites aculeatus** Owens, p. 65, Pl. 20, figs. 4-7.
1976 **Perotrilites selectus** (Arkhangelskaya) McGregor and Camfield, p. 25, Pl. 8, figs. 7, 8.
non 1976 **Perotrilites** (?) **aculeatus** Arkhangelskaya, p. 52, Pl. 8, fig. 2.

Description. Trilete, zonate-camerate miospores with rounded subtriangular amb. Laesura arms 1/3-4/5 radius, straight, simple or with sinuous triradiate folds about 2 µm wide at pole, tapered toward equator. Intexine dark, levigate, 4-6 µm thick interradially, may be slightly thinner at corners. Exoexine about 1 µm thick, transparent, extended equatorially as a zona of rather narrow but varied width, distally closely appressed to or slightly separated from the exoexine (Pl. 15, fig. 23), proximally levigate, distally with relatively widely spaced bacula, coni and grana 0.5-3.5 µm (commonly 1 µm) long, 1-2 µm (rarely 3-4 µm) wide at base. Sculptural elements 2-10 µm (commonly 4-8 µm) apart. Wrinkles 0.5-1.5 µm wide, straight or convolute, occur on the exoexine proximally, in great concentration on some specimens.




*Text-figure 90: Sculptural elements of* ***Perotrilites selectus****, lateral view.*

Diameter. 66-110 µm, mean 84 µm (28 specimens).

Occurrence. Figured specimens: Plate 15, figure 22, loc. 8342, slide 3, 57.7 x 126, GSC 66365; Plate 15, figure 23, loc. 8320, slide 1, 56.7 x 116.8, GSC 66366. Stratigraphic range, upper Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 82).

Comparisons. Specimens from the Russian Platform (Filimonova and Arkhangelskaya, 1963) and the Moose River Basin (McGregor and Camfield, 1976) are larger but as no other difference is apparent they are judged to be the same species as those from Melville Island. **Perotrilites aculeatus** Owens (1971) is similar in all respects, including size. **Hymenozonotriletes meonacanthus** var. **rugosus** Kedo (1955) has simple laesura, sparse "fine spinules" [translation from Russian] and, judging by the illustration (Kedo, 1955, Pl. 2, fig. 19) less profuse proximal folding. **Kraeuselisporites ?ollii** is not detectably camerate, has prominent strongly elevated labra and more closely spaced sculptural elements, and bears wider proximal folds that tend to be radially oriented.

Genus **Punctatisporites** Ibrahim 1933

Type species. **Punctatisporites punctatus** (Ibrahim) Ibrahim 1933.

**Punctatisporites inspissatus** (Owens) n. comb.
Plate 16, figures 1, 2

1971 **Stenozonotriletes inspissatus** Owens, p. 37, Pl. 10, figs. 3, 6, 10.

Description. Trilete miospores with subcircular or rounded subtriangular amb. Laesura arms simple or with narrow lips, straight, 2/3-7/8 radius. Wall 3-8 µm thick, rigid, levigate.

Diameter. 45-108 µm, mean 65 µm (32 specimens).

Occurrence. Figured specimens: Plate 16, figure 1, loc. 8331, slide 1, 26.2 x 19.4, GSC 66367; Plate 16, figure 2, loc. 8320, slide 1, 50.3 x 124.1, GSC 66368. Stratigraphic range, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 48).

Remarks. Spores assigned to this species herein and in Owens (1971) have a comprehensively thickened wall, not a zona. The distal face is slightly thicker than the proximal, but in our opinion not sufficiently thicker to constitute a patina. The specimens are therefore reassigned to **Punctatisporites.** One may conclude from eccentrically compressed specimens illustrated by Naumova (1953, e.g. Pl. 3, fig. 15; Pl. 10, figs. 9, 12, 16) and other Soviet workers, that some species assigned to **Stenozonotriletes** by them (including the type species, **S. conformis**) are not cingulate, and the present specimens may be basically similar to them in structure. Thorough examination of the type species of **Stenozonotriletes** may eventually show that it is synonymous with **Punctatisporites.**

The granulose "ornament" reported by Owens (1971) in his original description of this species has been induced by corrosion, in our opinion. The holotype is in fact levigate. Some of our specimens bear ?corrosion-induced "sculpture" to varying degrees (e.g. Pl. 16, fig. 1).

The narrow, optically light feature observed at the inner edge of the wall is interpreted provisionally as an optical manifestation of the curved inner surface of the exoexine, and not as a space separating two wall layers. We have not been able to see unequivocal evidence of two walls. We should note, however, that **P. inspissatus** is similar in many respects to **Geminospora punctata** Owens (1971) which has a punctate wall. Some specimens of **G. punctata** (e.g. Owens, 1971, Pl. 19, figs. 5-9) display rather convincing evidence of two walls.

Comparisons. Numerous species similar in varied degrees to **P. inspissatus** have been described from rocks of Devonian to Tertiary age, and have been assigned to various genera, e.g. **Callumispora, Psilatriletes, Punctatisporites,** and **Stenozonotriletes.** Among those that have been reported from Devonian strata, **Stenozonotriletes laevigatus** Naumova (1953) is closely comparable (if comprehensively thickened; see comments above) except for slightly shorter trilete rays. **S. extensus** var. **major** Naumova (1953) is "shagreen". **S. clarus** Ishchenko (1958), reported also by Hughes and Playford (1961) and others outside the USSR, is described as cingulate. In polar compression, apparently the only orientation in which it is preserved, **S. clarus** bears a close resemblance to **Punctatisporites inspissatus.**

**Punctatisporites** sp. cf. **P. solidus** Hacquebard
Plate 16, figure 3

cf. 1957 **Punctatisporites solidus** Hacquebard, p. 308, Pl. 1, fig. 13.

Description. Trilete miospores with subcircular, oval, or rounded subtriangular amb. Laesura arms 1/2 to full radius in length, accompanied by conspicuous triradiate folds about 2-8 µm in total width at proximal pole, tapering toward equator. Indistinct, low, narrow curvaturae imperfectae visible in some specimens. Wall 1-3 µm thick, levigate or minutely scabrate.

Diameter. 54-121 µm, mean 78 µm (26 specimens).

Occurrence. Figured specimen, Plate 16, figure 3, loc. 8311, slide K, GSC 66369. Stratigraphic range, Weatherall and Hecla Bay formations, ?upper Eifelian and Givetian (Fig. 7, no. 83).

Remarks. **Punctatisporites solidus** has a thicker wall.

Genus **Retispora** Staplin 1960

Type species. **Retispora lepidophyta** (Kedo) Playford 1976.

**Retispora archaelepidophyta** (Kedo) n. comb.
Plate 16, figures 4-7, 10

1955 **Hymenozonotriletes archaelepidophytus** Kedo, p. 30, Pl. 3, fig. 9.

Description. Trilete, camerate miospores with rounded subtriangular or subcircular body and amb. Laesura arms 1/3-4/5 radius, simple, may be obscured by triradiate exoexinal folds. Intexinal body levigate, 2-5 µm thick, rarely folded, on some specimens darkened (thickened?) in a subtriangular area in the angles of the rays. Exoexine thin, commonly folded, apparently attached to the intexine proximally and distally, but extending beyond the body in the equatorial plane as a two-layered flange-like structure. Exoexine proximally levigate, equatorially and distally with a network of irregularly rounded lumina about 1-13 µm in greatest dimension, separated by levigate strips of wall about 0.5-2 µm wide. Smaller and larger lumina apparently randomly intermixed from the distal pole to the edge of the body, but lumina tend on some specimens to be smaller and most irregular in shape on the equatorial extension.

Diameter. 83-143 µm, mean 110 µm (46 specimens). Diameter of intexinal body 56-73% of total spore diameter.

Occurrence. Figured specimens: Plate 16, figures 4, 5, loc. 8334, slide F, GSC 66370; Plate 16, figures 6, 7, loc. 8320, slide E, GSC 66371; Plate 16, figure 10, loc. 8342, slide 4, 35 x 125.2, GSC 66372. Stratigraphic range, Weatherall and Hecla Bay formations, mid-Eifelian to lower Givetian (Fig. 7, no. 64).

Comparisons. **Retispora lepidophyta** (Kedo) Playford differs in possessing conspicuous lips, a thinner intexine, a more rigid exoexine and commonly more regular lumina. Some specimens of **R. lepidophyta** bear minute sculptural elements on the muri, whereas this condition was not observed on any specimens of **R. archaelepidophyta. Hymenozonotriletes cassiculus** Higgs (1975) has flexuous triradiate folds, curvaturae, thinner intexine, and may bear exoexinal sculpture of small coni or spinae.

**Retispora** sp.
Plate 16, figures 8, 9

Description. Trilete, camerate miospores with subcircular body and amb. Laesura arms on intexinal body long and simple, commonly obscured by coarse exoexinal reticulum. Intexine levigate, about 2 µm thick. Exoexinal attachment to intexine suggested by central position of intexinal body, but exact locus or loci of attachment undetermined. Exoexine consists of an irregularly divided and interconnected reticulum of bars about 1-3.5 µm wide enclosing rounded polygonal and subcircular lumina about 2-15 µm in greatest dimension. Exoexinal bars bear irregularly spaced, inconspicuous coni less than 1 µm wide and high. Reticulum extends over entire distal face and encroaches onto the proximal-equatorial region.

Diameter. 121-165 µm (5 specimens). Diameter of intexinal body 44-59% of total spore diameter.

Occurrence. Figured specimen, loc. 8334, slide 1, 60 x 119.3, GSC 66373. Stratigraphic range, upper Weatherall and lower Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 90).

Genus **Retusotriletes** Naumova emend. Streel 1964

Type species. **Retusotriletes simplex** Naumova 1953

**Retusotriletes dubiosus** McGregor
Plate 16, figure 11

1944 **Triletes dubius** Eisenack, p. 115 (pars).
1965 **Retusotriletes dubius** (Eisenack) Richardson, p. 564 (pars), Pl. 88, fig. 5.

1973 **Retusotriletes dubiosus** McGregor, p. 21, Pl. 2, fig. 1.
non 1959 **Retusotriletes dubius** Chibrikova, p. 50, Pl. 5, fig. 3.

Description. Trilete miospores with rounded triangular or subcircular amb. In lateral compression, proximal surface ±flat, distal surface rounded. Laesura arms simple, straight, 1/2 to full radius in length. Curvaturae perfectae about 1 μm wide, 0.5-3 μm high, commonly in part coincident with equator interradially. Wall 1.5-4.5 μm thick equatorially and distally, the thickness augmented slightly interradially where curvaturae lie at equator; thinner in contact areas, rarely folded, levigate, darkened at apex in a triangular area of varied prominence.

Diameter. 49-88 μm, mean 70 μm (18 specimens).

Occurrence. Figured specimen, loc. 8333, slide J, GSC 66374. Stratigraphic range, Cape De Bray, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 29).

**Retusotriletes pychovii** Naumova
Plate 16, figure 12

1953 **Retusotriletes pychovii** Naumova, p. 88, 110, 123, Pl. 14, fig. 5, Pl. 16, fig. 41, Pl. 18, fig. 18.

Description. Trilete miospores with subcircular amb. In lateral compression, proximal surface flat, distal surface rounded. Laesura arms simple, 5/6 to full radius in length. Curvaturae perfectae 1-2 μm high, may be accompanied by compression folds along part of their length. The darkened curvaturae characteristically have a sharply defined inner limit and a less sharply defined outer limit. Wall 2-3.5 μm thick equatorially and distally, slightly thinner in contact areas, levigate or minutely scabrate.

Diameter. 37-50 μm, mean 44 μm (9 specimens).

Occurrence. Figured specimen, loc. 8319, slide H, GSC 66375. Stratigraphic range, Weatherall and lower Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 34).

**Retusotriletes rotundus** (Streel) Streel
Plate 16, figure 13

For synonymy see McGregor (1973), p. 20 and McGregor and Camfield (1976), p. 26.

Description. Trilete miospores with subcircular or rounded subtriangular amb. Laesura arms simple, straight, 1/3-4/5 radius. Contact areas delimited by proximally situated curvaturae perfectae about 1-2 μm wide and high, commonly partly obscured by abundant compression folds. Apical region dark (?thickened) in circular or rounded triangular zone extending about 1/3 to 1/2 the distance to the outer extremity of the contact areas, may enclose a lighter zone around the pole. Limits of dark apical zone (and its inner light zone where present) sharply or indistinctly defined. Wall 1-2 μm thick, levigate.

Diameter. 43-97 μm, mean 66 μm (51 specimens).

Occurrence. Figured specimen, loc. 8310, slide 1, 49.8 x 114.7, GSC 66376. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 24).

Comparisons. Specimens of **R. rotundus** from Gaspé have "The ends of rays connected to one another by low curvatural ridges. . ." (McGregor, 1973, p. 20). On some of the present specimens the rays are clearly discernible only part of the way to the curvaturae (cf. Lele and Streel, 1959, p. 95, **R. triangulatus**). Specimens so strongly folded that curvaturae are hidden are indistinguishable from **Calamospora atava** (Naumova) McGregor. In fact, evidence indicates that **C. atava** and **R. rotundus** were both produced by at least one Devonian plant, **Sawdonia acanthotheca** (Gensel et al., 1975).

For further comparative discussion see McGregor (1973), p. 20-21.

Remarks. In our view, variations in the shape and distinctness of the darkened region at the juncture of the trilete rays are not important systematically. This was the position taken by McGregor (1973), and it is supported by reports of the recovery of in situ spores of **Psilophyton princeps** in which the darkened area may be either triangular or subcircular (Gensel, 1980, p. 115), or in situ spores of **P. forbesii** Andrews (Gensel, 1979, p. 91), **Sawdonia acanthotheca** Gensel, Andrews and Forbes (1975, p. 56) and a variety of Carboniferous calamitean cone species (Good, 1977) in which only some specimens from a sporangium are darkened apically. See "remarks and comparisons" under **Calamospora atava.**

**Retusotriletes rugulatus** Riegel
Plate 17, figures 1-5

1965 **Retusotriletes dubius** (Eisenack) Richardson (pars), p. 564, Pl. 88, fig. 6.
1966 **Retusotriletes** sp., McGregor and Owens, Pl. 9, fig. 2.
1967 **Retusotriletes** sp. 1, Hemer and Nygreen, Pl. 2, fig. 6.
1971 **Retusotriletes dubius** (Eisenack) Richardson; Owens (pars), p. 12, Pl. 1, fig. 10.
1973 **Retusotriletes rugulatus** Riegel, p. 82, Pl. 10, figs. 2-5.
1974 **Stenozonotriletes extensus** Naumova; Hamid, Pl. 10, fig. 3.

Description. Trilete miospores with subcircular or rounded subtriangular amb. In lateral compression, proximal surface ±flat, distal surface rounded. Laesura arms simple, 2/3-7/8 radius in length. Wall 1.5-3 μm (rarely 4 μm) thick proximally and distally, rarely folded. Curvaturae perfectae distinct, wedge-like in profile, about 1 μm wide and high, may be confluent with equator for part of their length. Proximal polar region with dark subtriangular area of varied prominence. Entire contact region bears fine, more or less radially oriented rugulate or subreticulate ribs or wrinkles, less than 1 μm wide and high. Remainder of exine levigate.

Diameter. 44-96 μm, mean 64 μm (64 specimens).

Occurrence. Figured specimens: Plate 17, figure 1, loc. 8319, slide J, GSC 66377; Plate 17, figure 2, loc. 8339, slide 4, 46.4 x 127.8, GSC 66378; Plate 17, figure 3, loc. 8339, slide 4, 42.6 x 111, GSC 66379; Plate 17, figure 4, loc. 8319, slide 1, 62.3 x 115, GSC 66380; Plate 17, figure 5, loc. 8338, slide 8, 32.1 x 112.1, GSC 66381. Stratigraphic range, Cape De Bray, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 30).

Remarks. A coarse and irregular pattern occurs on the proximal face of some specimens (Pl. 17, figs. 4, 5). It has been observed only on specimens that have an overall deteriorated appearance, and is judged to have been caused by corrosion.

Comparisons. **Emphanisporites** sp. of Tiwari and Schaarschmidt (1975, p. 25) appears identical to **Retusotriletes rugulatus** except for its "prominent elevated lips". The undescribed specimen figured by Kosanke (1964, fig. 7) may be **R. rugulatus. Hymenozonotriletes biformis** Arkhangelskaya (1963) has thick radial ridges and furrows on the proximal face. **Retusotriletes biarealis** McGregor (1964) is thinner walled and bears a relatively faintly defined radial pattern in the contact areas.

Genus **Rhabdosporites** Richardson 1960

Type species. **Rhabdosporites langii** (Eisenack) Richardson 1960.

Remarks. The generic diagnosis of Rhabdosporites limits the exoexinal sculpture to "...closely packed rods which are parallel sided elements and have truncate tips", i.e. bacula (Richardson 1960). Nevertheless, various authors have assigned to the genus species that bear other types of sculpture, either in addition to or in the absence of bacula, i.e. grana (**R. scamnus** Allen 1965), coni (**R. micropaxillus** Owens 1971), grana and spinae (**R. cuvillieri** Taugourdeau-Lantz 1967), "vermiculate ridgelets" (**R. firmus** Guennel 1963), and "sinuous muroid folds" (**R. cymatilus** Allen 1965).

Specimens referred to the type species, **R. langii**, commonly are described as baculate, e.g. in Bonamo and Banks (1967); Sanders (1968); Owens (1971); Chi and Hills (1976); Bonamo (1977). On the other hand, some workers have noted various other types of microsculpture on specimens that appear to be identical in all other respects to **R. langii**. Riegel (1968, p. 92) commented that "...die Skulptur nicht aus Stäbchen besteht, die Richardson (1960) in seiner Gattungs- und Artdiagnose angibt und im normalen Durchlichtbild häufig vorgetäuscht werden, sondern aus einer dichten Granulierung durch teils kegelförmige, teils parallelseitige, abgestumpfte Elemente...". Tiwari and Schaarschmidt (1975, p. 39) record both bacula and grana. Lele and Streel (1969, p. 102) note that specimens from Goé "...show mostly cones and seldom bacula...", and that specimens from Cromarty, the type region, bear coni as well as bacula. Similarly, specimens from New York State are both conate and baculate (Streel, 1972, p. 210).

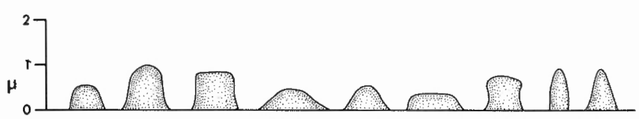
One of us (DCM) has examined specimens of **R. langii** from Edderton Burn and Coal Heugh (localities 10 and 13 of Richardson, 1965) and agrees with Richardson (1965) that the predominant sculptural type is minute bacula. Grana, coni and truncated coni do occur in some specimens from these localities however, and a similar range of sculpture occurs in **R. langii** from the Canadian Arctic.

Expanded diagnosis. In view of the foregoing we expand the diagnosis of **Rhabdosporites** by adding the following after the description of the exoexinal ornamentation: "Grana, coni and minute spinae may also occur, but in well preserved specimens they do not constitute the most abundant sculptural types." The same qualifiction is added to the diagnosis of the type species.

**Rhabdosporites langii** (Eisenack) Richardson
Plate 17, figures 6-11, 13, text-figure 91

1925 Spore-type B, Lang, p. 256, Pl. 1, figs. 3-6.
1944 **Triletes langi** Eisenack, p. 112, Pl. 2, fig. 4.
1953 **Hymenozonotriletes polymorphus** Naumova, Pl. 22, fig. 106 (nomen nudum).
1955 **Hymenozonotriletes polymorphus** Naum. in litt.; Kedo, p. 30, Pl. 3, fig. 8.
1960 **Rhabdosporites langi** (Eisenack) Richardson, p. 54, Pl. 14, figs. 8, 9, text-figures 4, 6B.
1967 Spores of **Tetraxylopteris schmidtii** Beck, 1957; Bonamo and Banks, p. 765, figs. 34-36, 38, 40.
1969 ? **Rhabdosporites Langi** (Eisenack) Richardson; Lele and Streel, p. 102, Pl. 3, fig. 65.
1971 Spores of **Milleria ( Protopteridium) thomsonii** (Dawson) Lang, 1926; Leclercq and Bonamo, p. 98, figs. 24-33. (See also Obrhel, 1959, p. 387, Pl. 2, fig. 6).
1973 **Rhabdosporites langii** (Eisenack) Richardson; McGregor, p. 63, Pl. 9, figs. 4, 9.
1974 **Calyptosporites proteus** (Naumova) Allen; Hamid, Pl. 9, fig. 8.
1975 **Rhabdosporites** sp., Tiwari and Schaarschmidt, p. 40, Pl. 21, fig. 7.
1977 Spores of **Rellimia thomsonii** (Dawson) Leclercq and Bonamo, 1973; Bonamo, p. 1277, figs. 6, 7.

Description. Trilete, camerate spores with subcircular or rounded triangular amb and body outline. Laesura arms equal to radius of intexine or less, simple or with low, dark lips up to 8 μm in total width, may be obscured by triradiate folds of the exine that parallel the rays. Intexinal body levigate, distinct, 1-3 μm (rarely as much as 4.5 μm) thick, commonly with subconcentric compression folds, may be excentrically placed in polar compression. Exoexine thin, commonly showing no wall-thickness feature, with few to many concentrically or irregularly disposed folds. A limbus-like equatorial fold may be present around part or all of the circumference. Contact areas levigate or scabrate. Proximal-equatorial and distal regions bear closely spaced bacula, coni, truncated coni, or grana that rarely exceed 1 μm in width and height.




*Text-figure 91: Sculptural elements of* ***Rhabdosporites langii****, lateral view.*

Diameter. 90-245 μm, mean 133 μm (150 specimens). Diameter of intexinal body 52-86% (mean 71%) of total spore diameter. One specimen 357 μm in diameter (slide 8309-4, 40.3 x 112).

Occurrence. Figured specimens: Plate 17, figures 6, 7, 10, loc. 8321, slide 2, 37.9 x 120.5, GSC 66382; Plate 17, figure 8, loc. 8339, slide 4, 69.6 x 117.5, GSC 66383; Plate 17, figure 9, loc. 8321, slide 1, 66.2 x 124.4, GSC 66384; Plate 17, figure 11, loc. 8313, slide B, GSC 66385; Plate 17, figure 13, loc. 8331, slide 1, 57 x 125.8, GSC 66386. Stratigraphic range, Cape De bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 6).

Comparisons. **H. polymorphus** Naumova ex Kedo (1955) was equated with **Rhabdosporites langii** without qualification by Arkhangelskaya (1976, p. 44). Neither Arkhangelskaya nor any other palynologist has to our knowledge published a detailed description of the sculpture of **H. polymorphus** however. Our acceptance of the synonymy of **H. polymorphus** and **R. langii** therefore is based on the tacit assumption that Arkhangelskaya, having access to Kedo's material, has determined the presence in the Russian specimens of the typical sculpture of **R. langii. Hymenozonotriletes mesodevonicus** Naumova (1953) resembles **H. polymorphus** except for its apparently greatly thickened body.

**Dibrochosporites nodosus** Urban (1968) is camerate, of similar size to **R. langii**, and bears sculpture that appears at the margin as short, blunt rods. It differs from **R. langii** in the directiculate nature of the exoexine.

**Rhabdosporites** sp. A of Richardson (1965) is like **R. langii** except that it has what appear to be three wall layers. **Hymenozonotriletes facetus** Arkhangelskaya (1963) has a well-defined exoexinal wall thickness feature, and undulating ridges in the vicinity of the proximal pole.

**Rhabdosporites** (?) **vermiculatus** Sanders (1964) also has a vermiculate pattern near the proximal pole and in addition has a retusoid intexine that according to Sanders (1964, p. 30) is identical to a spore (?**Retusotriletes rugulatus**) figured by Kosanke (1964, fig. 7). **Rhabdosporites firmus** Guennel (1963) may be synonymous with **R. langii**, if the "distinctly granulose" sculpture can be shown to fit within the broader range of sculpture now known to occur in **R. langii**. We do not regard the rounded triangular shape of the intexinal body of **R. firmus** as sufficient by itself to separate that species from **R. langii**.

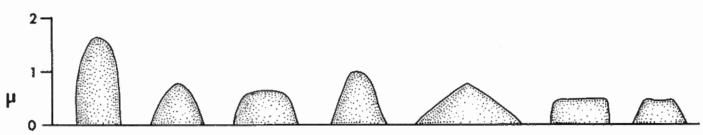
**R. cuvillieri** Taugourdeau-Lantz (1967) differs from **R. langii** in being distinctly curvaturate. It also lacks bacula, which would be an unusual circumstance for **R. langii**, most specimens of which possess at least some bacula. One of Taugourdeau-Lantz's figured specimens (1967, Pl. 3, fig. 3), the only one examined by one of us (DCM), is in fact **Contagisporites optivus** (Chibrikova) Owens var. **optivus**.

See also "Comparisons and remarks" under **Geminospora micropaxilla**.

**Rhabdosporites** sp. cf. **R. parvulus** Richardson
Plate 17, figure 12, text-figure 92

cf. 1965 **Rhabdosporites parvulus** Richardson, p. 588, Pl. 93, figs. 5, 6.

Description. Trilete, camerate miospores with rounded subtriangular amb. Intexinal body distinct, rounded subtriangular and relatively dark. Laesura arms 1/2 to total body radius in length, simple or with low, narrow lips, or accompanied by triradiate folds that may extend to the periphery of the spore. Intexine and exoexine about 1.5-3 μm thick. Intexine levigate. Contact areas of exoexine levigate or scabrate, remainder of exoexine sculptured with closely spaced coni, bacula and grana rarely exceeding 1 μm in width or height.




*Text-figure 92: Sculptural elements of **Rhabdosporites** sp. cf. **R. parvulus**, lateral view.*

Diameter. 75-108 μm, mean 93 μm (15 specimens). Diameter of intexinal body 63-80% of total spore diameter.

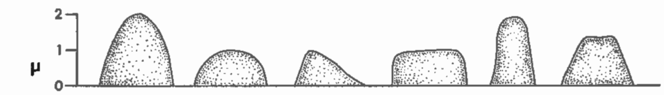
Occurrence. Figured specimen, loc. 8318, slide 1, 69.8 x 111.1, GSC 66387. Stratigraphic range, Weatherall and Hecla Bay formations, upper Eifelian and lower Givetian (Fig. 7, no. 62).

Comparisons. The distinctly subtriangular amb distinguishes these spores from most specimens of **Rhabdosporites langii**. They are also smaller than **R. langii** on average, and the intexinal body is consistently more or less concentric with the exoexine. These differences may prove sufficient for clear separation from **R. langii** when more specimens have been found upon which to establish their range of morphographic variation. They differ from **R. parvulus** in the smaller ratio of body diameter to total spore diameter, and the subconcentric and commonly distinct body. They lack the distinctive radially directed exoexinal folds and exclusively granulate sculpture of **R. scamnus** Allen (1965).

**Rhabdosporites** sp.
Plate 18, figures 1-3, text-figure 93

1971 **Rhabdosporites micropaxillus** Owens (pars), Pl. 15, figs. 5, 7.

Description. Trilete, camerate miospores with subcircular amb and body outline. Laesura arms commonly indistinct, straight, about 2/3 radius in length, simple, may be paralleled by triradiate exoexinal folds up to about 8 μm high that continue to the equator or terminate at the outer ends of rays. Intexine indistinct, thin, levigate. Exoexine of undetermined thickness, lacks conspicuous wall-thickness feature, scabrate in contact areas, the remainder with closely spaced coni, grana and bacula 1-2 μm in basal width and height. Subconcentric and transverse exoexinal folds common.




*Text-figure 93: Sculptural elements of **Rhabdosporites** sp., lateral view.*

Diameter. 112-165 μm (6 specimens).

Occurrence. Figured specimens: Plate 18, figures 1, 2, loc. 8323, slide 5, 39.5 x 110, GSC 66388; Plate 18, figure 3, loc. 8312, slide D, GSC 66389. Stratigraphic range, Weatherall Formation, upper Eifelian and ?lower Givetian (Fig. 7, no. 78).

Comparisons. **R. langii** and **R.** sp. cf. **R. parvulus** have smaller sculptural elements and a more distinct intexine, and **R.** sp. cf. **R. parvulus** is smaller. **Grandispora uyenoi** n. sp. has larger, commonly biform sculptural elements. **Geminospora micropaxilla** has smaller sculptural elements, a conspicuous exoexinal wall-thickness feature, and a more rigid, less commonly folded exoexine.

Genus **Verruciretusispora** Owens 1971

Type species. **Verruciretusispora dubia** (Eisenack) Richardson and Rasul 1978.

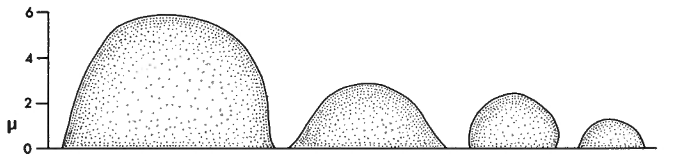
**Verruciretusispora dubia** (Eisenack) Richardson and Rasul
Plate 18, figures 4-7, text-figure 94

1944 **Triletes dubius** Eisenack, p. 115 (pars), Pl. 2, fig. 7, text-fig. 14.
1971 **Verruciretusispora robusta** Owens, p. 21, Pl. 4, figs. 7, 8, 10, 11.
1972 "New genus n. sp.", McGregor and Uyeno, Pl. 1, fig. 11.
1973 **Verruciretusispora multituberculata** (Lanninger) McGregor, p. 36, Pl. 4, figs. 13, 14.
1978 **Verruciretusispora dubia** (Eisenack) Richardson and Rasul, p. 443, Pl. 1, fig. 6.
non 1977 cf. **Verruciretusispora robusta** Stapleton, p. 432, Pl. 2, fig. 1.
non 1979 **Verruciretusispora multituberculata** (Lanninger) McGregor; Moreau-Benoit, p. 44, Pl. 6, fig. 4.

For additional synonymy see McGregor (1973), p. 36.

Description. Trilete miospores with rounded triangular or subcircular amb. In lateral compression, proximal face flattened, distal region subhemispherical. Laesura arms 4/5 to 7/8 the radius in length, simple or with low, narrow lips. Curvaturae perfectae clearly defined, about 1-2 μm wide and high, commonly coincident with equator interradially, and invaginating proximally to join the extremities of the rays. Wall 1-2.5 μm thick distally and equatorially opposite rays, 2.5-4 μm thick interradially where curvaturae lie at equator.

Wall may be darkened in a subtriangular area around the proximal pole. Contact areas levigate, wall outside curvaturae proximally and distally densely or sparsely ornamented with verrucae 1.5-10 μm wide, 1-6 μm high, commonly irregularly spaced, may be of various sizes on each specimen. Verrucae subcircular in plan view, subhemispherical in profile.




*Text-figure 94: Sculptural elements of* ***Verruciretusispora dubia****, lateral view.*

Diameter. 46-96 μm, mean 70 μm (50 specimens).

Occurrence. Figured specimens: Plate 18, figure 4, loc. 8313, slide 2, 51.8 x 129.2, GSC 66390; Plate 18, figure 5, loc. 8319, slide Q, GSC 66391; Plate 18, figure 6, loc. 8335, slide 2, 36.5 x 124.5, GSC 66392; Plate 8, figure 7, loc. 8331, slide 1, 43.9 x 120.1, GSC 66393. Stratigraphic range, Cape De Bray, Weatherall, and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 19).

Remarks. In his original circumscription of **Triletes dubius,** Eisenack (1944) included specimens subsequently assigned to **Retusotriletes dubiosus** McGregor, **Retusotriletes rugulatus** Riegel, and **Verruciretusispora dubia** (Eisenack) Richardson and Rasul. The specimen that he designated as the type (Eisenack, 1944, p. 115, Pl. 2, fig. 7) bears the characteristic scattered warts and other diagnostic features of the present species. In addition according to Eisenack (1944, p. 115) the same specimen possesses "...eine blattaderähnliche Riefung der Kontaktfläche..." which, however, is not evident on the published photograph. Evidently the latter feature is very faintly defined, unlike the prominent rugulate ribs or wrinkles of **Retusotriletes rugulatus.**

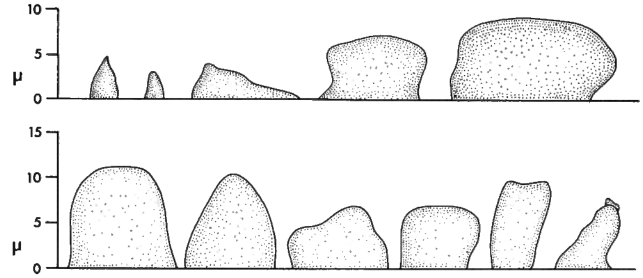
Genus **Verrucosisporites** Ibrahim emend. Smith 1971

Type species. **Verrucosisporites verrucosus** (Ibrahim) Ibrahim 1933.

**Verrucosisporites premnus** Richardson
Plate 18, figures 8, 9, text-figure 95

1965 **Verrucosisporites premnus** Richardson, p. 572, Pl. 90, figs. 1, 2.
1965 **Raistrickia** sp. A, Richardson, p. 574, Pl. 90, fig. 3.
1965 **Raistrickia** cf. **clavata** Hacquebard; Richardson, p. 575, Pl. 90, fig. 5.

Description. Trilete miospores with subcircular or rounded subtriangular amb. Outline in lateral compression subcircular. Laesura arms simple, 4/5 to full radius in length. Wall, excluding sculpture, 3-6 μm thick distally and equatorially, thinner proximally. Contact areas levigate or with rare, scattered grana. Sculpture of equatorial and distal regions consists mostly of prominent bacula, verrucae and spatulate sculptural elements with flattened or less commonly rounded tops, greatly varied in size and shape on each specimen, 3-16 μm high and 3-15 μm wide at base, lower or higher than wide. Some are narrower at base than at the top. Rare coni or truncated coni also occur. In plan view, sculptural elements subcircular or irregular. The largest sculptural elements commonly occur at the equator, and may be distributed asymmetrically in polar view. Sculptural elements widely or closely spaced, discrete or joined in small groups.




*Text-figure 95: Equatorial and distal sculptural elements of* ***Verrucosisporites premnus****, lateral view.*

Diameter. 32-91 μm, mean 54 μm (25 specimens).

Occurrence. Figured specimens: Plate 18, figure 8, loc. 8333, slide F, GSC 66394; Plate 18, figure 9, loc. 8342, slide 3, 57.4 x 115.8, GSC 66395. Stratigraphic range, Weatherall and Hecla Bay formations, mid-Eifelian to lower Givetian (Fig. 7, no. 65).

Comparisons. **Raistrickia** sp. A and **R.** cf. **clavata** Hacquebard of Richardson have most morphographic features in common with **V. premnus.** The major point of difference between these forms and **V. premnus** is that they may bear spatulate or club-shaped sculptural elements in addition to bacula. Given the variation allowed according to the diagnosis of **V. premnus,** it is difficult to maintain taxonomic separation on this basis. The concept of **V. premnus** adopted here therefore includes specimens such as those segregated as **Raistrickia** sp. A and **R.** cf. **clavatus** by Richardson.

**Verrucosisporites tuberculatus** Moreau-Benoit (1966) has smaller, predominantly verrucate sculptural elements. **Clivosispora tuberculata** (Moreau-Benoit) Taugourdeau-Lantz (1971) has closely packed verrucate sculptural elements that are largest equatorially. **Lophozonotriletes notabilis** Zhdanova (in Nazarenko et al., 1971) is smaller, with smaller "spines and tubercles". **Verrucosisporites scurrus** (Naumova) n. comb. has smaller sculptural elements, according to the illustrations in Naumova (1953, Pl. 3, fig. 22) and Kedo (1955, Pl. 6, figs. 10, 11), that commonly are tapered in profile, and may be biform.

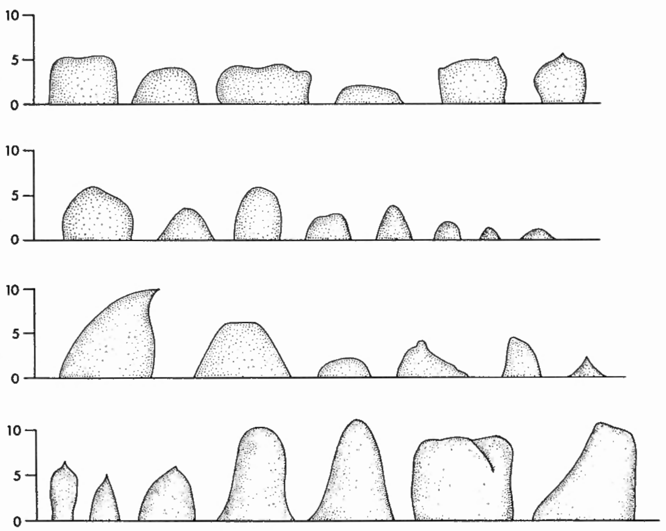
Remarks. Because of the relatively large proportion of bacula on most specimens, this species perhaps could be placed justifiably in **Raistrickia.** Both Richardson (1965, p. 572) and Smith (1971, p. 79) questioned its assignment to **Verrucosisporites.** Nevertheless the distinction between these spores and **Verrucosisporites** as defined by Smith (1971) is not clear-cut. We prefer assignment to **Verrucosisporites** as it emphasizes the evident morphographic relationships between this species and **V. scurrus.** Specimens with high, flat-topped sculptural elements, alluded to but not figured by Allen (1965) in remarks following his description of **Raistrickia aratra,** may be assignable to **Verrucosisporites premnus.**

**Verrucosisporites scurrus** (Naumova) n. comb.
Plate 18, figures 10-17, 22, text-figure 96

1953 **Lophozonotriletes scurrus** Naumova, p. 38, Pl. 3, figs. 22, 23.
1955 **Lophozonotriletes grumosus** Naumova; Kedo, p. 43, Pl. 6, fig. 12.
1957 **Lophozonotriletes proscurrus** Kedo, p. 33, Pl. 4, figs. 17-19.
1963 **Verrucosisporites monticulatus** Guennel, p. 252, fig. 5.
1963 **Lophozonotriletes malevkensis** Naumova ex Kedo (pars), Pl. 10, fig. 242.

1963 **Lophozonotriletes bellus** Kedo, p. 87, Pl. 10, figs. 243, 244.
1963 **Lophozonotriletes excisus** Naumova; Kedo, Pl. 11, fig. 256.
1964 **Raistrickia** cf. **clavata** Hacquebard; Vigran, p. 16, Pl. 2, fig. 10.
1965 **Verrucosisporites** cf. **proscurrus** Kedo; Richardson, p. 573, Pl. 90, figs. 10, 11.
1965 **Raistrickia aratra** Allen, p. 701, Pl. 96, figs. 3, 4.
1967 **Lophozonotriletes** sp. 1, Hemer and Nygreen, Pl. 2, fig. 3.

Description. Trilete miospores with subcircular, less commonly rounded subtriangular amb. In lateral compression, distal region subhemispherical, proximal face less strongly rounded. Laesura arms simple, 2/3 to full radius in length. Wall 2-5 µm thick (rarely thicker) distally and equatorially, slightly thinner proximally. Contact areas levigate or with greatly reduced sculpture. Equatorial and distal regions bear a varied sculpture of verrucae, rounded and flat-topped bacula, coni, and truncated coni 2-12 µm (commonly 4-7 µm) wide and high, most about as high as their basal width, that may be surmounted by a small granule or cone. Spatulate elements are rare. Sculptural elements may be evenly or asymmetrically distributed, discrete and as much as 7 µm apart, densely spaced, or less commonly joined in groups to form short, irregular rugulae. Sculptural elements rounded, subrugulate or irregular in plan view.




*Text-figure 96: Equatorial and distal sculptural elements of* ***Verrucosisporites scurrus****, lateral view.*

Diameter (excluding sculpture). 30-86 µm, mean 57 µm (175 specimens).

Occurrence. Figured specimens: Plate 18, figures 10, 11, loc. 8312, slide J, GSC 66396; Plate 18, figure 12, loc. 8312, slide C, GSC 66397; Plate 18, figures 13, 14, loc. 8319, slide M, GSC 66398; Plate 18, figure 15, loc. 8311, slide L, GSC 66399; Plate 18, figures 16, 17, loc. 8319, slide L, GSC 66400. Stratigraphic range, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 40).

Comparisons. Specimens herein assigned to **Verrucosisporites scurrus** (Naumova) n. comb. form an intergrading series from those with predominantly flat-topped sculptural elements (cf. **Lophozonotriletes scurrus** Naumova in Kedo, 1955, Pl. 6, figs. 10, 11) to those with predominantly conate and verrucose sculpture, and conform rather closely to the diagnosis of **Raistrickia aratra** Allen (1965, p. 701). The specimens of **Raistrickia aratra** illustrated by Allen (1965) bear a relatively large proportion of rounded and elongate sculptural elements. However, the sculpture of **R. aratra** is very variable, and flat-topped bacula are a significant feature of some specimens.

Extreme forms of this species intergrade with **Dibolisporites uncatus** (Naumova) n. comb., **Verrucosisporites premnus** Richardson, **V. tumulentis** Clayton and Graham, and **Convolutispora tegula** Allen. Typically **D. uncatus** has predominantly somewhat smaller and less crowded conate, spinose and biform sculpture; **V. premnus** has larger, predominantly flat-topped, baculate-spatulate sculpture; **C. tegula** has predominantly convolute sculpture and a thicker wall.

**Lophozonotriletes gibberulus** Naumova (1953) has larger tubercles and may be thicker-walled. **L. excisus** Naumova (1953) has predominantly flat-topped, apparently larger sculptural elements. **L.** cf. **excisus** of Menendez and Pothe de Baldis (1967) may have larger sculptural elements. **L. grumosus** Naumova (1953) has rounded, close-packed, more or less isodiametric sculptural elements (not as in Kedo, 1955, Pl. 6, fig. 12). **L. scurrus** Naumova var. **jugomaschevensis** Chibrikova (1962) bears relatively large "mushroom-shaped" sculptural elements wider than high, and smaller punctate-microtubercular ornament. **L. notabilis** Zhdanova in Nazarenko et al. (1971) is smaller and has spines and flattened tubercles.

**Raistrickia nigra** Love (1960) bears more regularly spaced ornaments of about the same size on each specimen. **Raistrickia** sp. of Jardiné and Yapaudjian (1968) has more widely spaced, baculate ornament. **Pustulatisporites gibberosus** (Hacquebard) Playford (1964) bears more or less evenly spaced sculptural elements that are wider than high and subcircular in surface view. **Acanthotriletes dentatus** Naumova (1953) has more elongate sculpture.

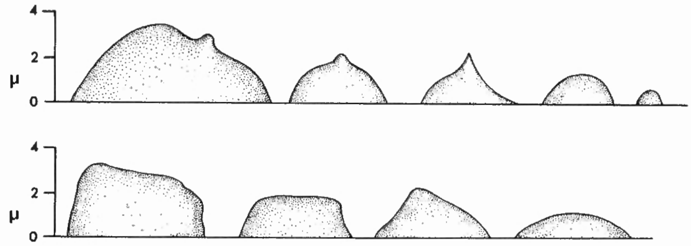
In **Heterotriletes** de Jersey (1966) the sculptural elements attain their greatest size in the equatorial region, and include a significant proportion of rugulate.

The concept of **Lophozonotriletes bellus** Kedo expressed by van der Zwan (1980) overlaps that applied here to **Verrucosisporites scurrus.** The specimens illustrated in figs. 3a, 3b, 5, 6a, 6b of van der Zwan may be assignable to **V. scurrus.**

**Verrucosisporites tumulentis** Clayton and Graham
Plate 18, figures 18-21, text-figure 97

1974 **Verrucosisporites tumulentis** Clayton and Graham, p. 574, Pl. 1, figs. 12-14.

Description. Trilete miospores with subcircular amb and profile. Wall 2-3.5 µm (rarely 4 µm) thick, about as thick proximally and equatorially as distally. Laesura arms simple, straight, 1/2-4/5 radius. Contact areas levigate, scabrate or with coni about 1-2 µm wide and high toward outer edge. Proximal-equatorial and distal regions bear relatively low verrucae, about 1-4 µm high, up to 9 µm wide at base, flat-topped or rounded, that may be surmounted by one or more minute coni or grana. Coni of about the same dimensions may occur among the verrucae, especially adjacent to the contact areas. Sculptural elements mostly discrete, less commonly adjoined to form short rugulae.



*Text-figure 97: Equatorial and distal sculptural elements of* ***Verrucosisporites tumulentis****, lateral view.*

Diameter. 43-73 μm, mean 59 μm (47 specimens).

Occurrence. Figured specimens: Plate 18, figure 18, loc. 8320, slide 1, 53.7 x 124, GSC 66401; Plate 18, figure 19, loc. 8318, slide 1, 35.3 x 127, GSC 66402; Plate 18, figure 20, loc. 8319, slide 10, 28.9 x 128, GSC 66403; Plate 18, figure 21, loc. 8319, slide 10, 30.5 x 127, GSC 66404. Stratigraphic range, Weatherall and Hecla Bay formations, Eifelian and lower Givetian (Fig. 7, no. 39).

Comparisons. **Camptotriletes verrucosus** Butterworth and Williams (1958) is sufficiently like this species that it may be impractical to separate them. At present we prefer to maintain the distinction on the basis of the common occurrence of discrete verrucae in **Verrucosisporites tumulentis.** The specimens described by Clayton and Graham (1974) are slightly thinner-walled than most specimens from Melville Island, but we do not regard this difference as sufficient justification in itself for taxonomic separation.

**Verrucosisporites scurrus** (Naumova) n. comb. typically has broader, higher verrucae. **Lophozonotriletes curvatus** Naumova (1953) includes specimens apparently similar to **Verrucosisporites tumulentis,** but consists mainly of spores with a different, highly varied range of sculpture (e.g. Naumova, 1953, Pl. 19, figs. 25-30). **V. pulvinatus** de Jersey (1966) is thin proximally and bears subhemispherical processes at the ends of the trilete rays.

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## PLATE 1
(All figures X500)

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| Figures | 1-6. | **Acinosporites acanthomammillatus** Richardson; 1, specimen with relatively small sculptural elements, GSC 66187; 2, 3, proximal and distal views, GSC 66188; 4, broken specimen showing thin central body, GSC 66189; 5, 6, proximal and distal views, GSC 66272. |
| | 7,8,12,13. | **Acinosporites hirsutus** (Brideaux and Radforth) n. comb., 7, 8, 13, equatorial, proximal, and distal views respectively, GSC 66190; 12, specimen gradational to **A. microspinosus**, GSC 66191. |
| | 9,10. | **Acinosporites lindlarensis** Riegel var. **lindlarensis**, equatorial and distal views, GSC 66192. |
| | 11,14,15,16. | **Acinosporites macrospinosus** Richardson; 11, specimen in distal focus showing irregular reticulum, GSC 66193; 14, specimen with closely spaced spines, GSC 66194; 15, 16, proximal and distal views of specimen with poorly developed reticulum, GSC 66195. |

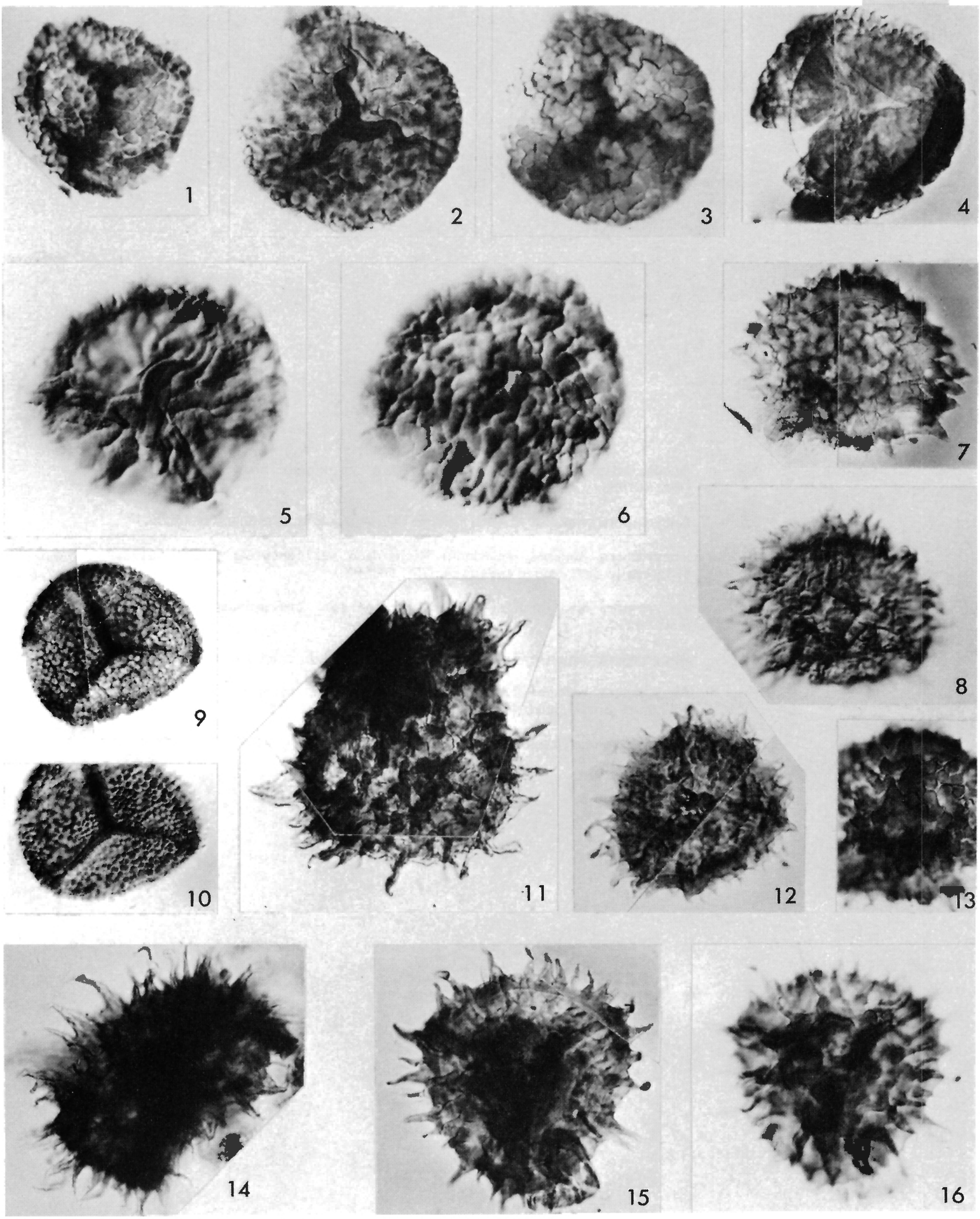
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PLATE 2
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Figures 1,2. **Anapiculatisporites petilus** Richardson; proximal and distal views, GSC 66196.

3,4. **Ancyrospora ampulla**? Owens, GSC 66197. 4, sculptural elements, X1000.

5,6. **Ancyrospora ancyrea** (Eisenack) Richardson var. **ancyrea**; 5, GSC 66198; 6, laterally compressed specimen, GSC 66199.

7. **Ancyrospora ancyrea** (Eisenack) Richardson var. **brevispinosa** Richardson, GSC 66200.

8. **Ancyrospora angulata** (Tiwari and Schaarschmidt), n. comb., GSC 66201.

9,10,13. **Ancyrospora kedoae** (Riegel) Turnau; 9, 10, proximal and distal views of specimen with subcircular amb, GSC 66202; 13, GSC 66203.

11,12. **Ancyrospora eurypterota**? Riegel; 11, GSC 66204; 12, GSC 66205.

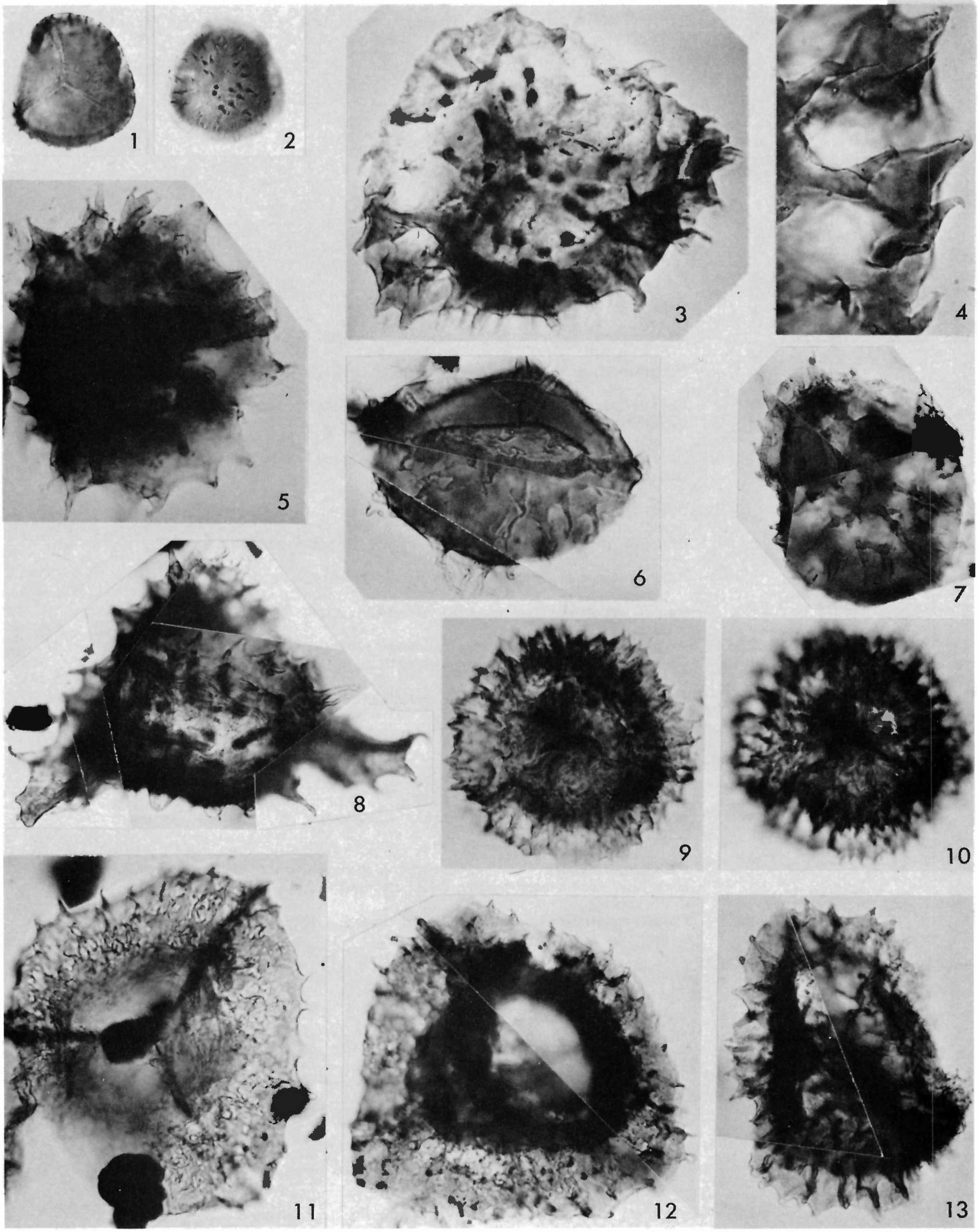
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PLATE 3
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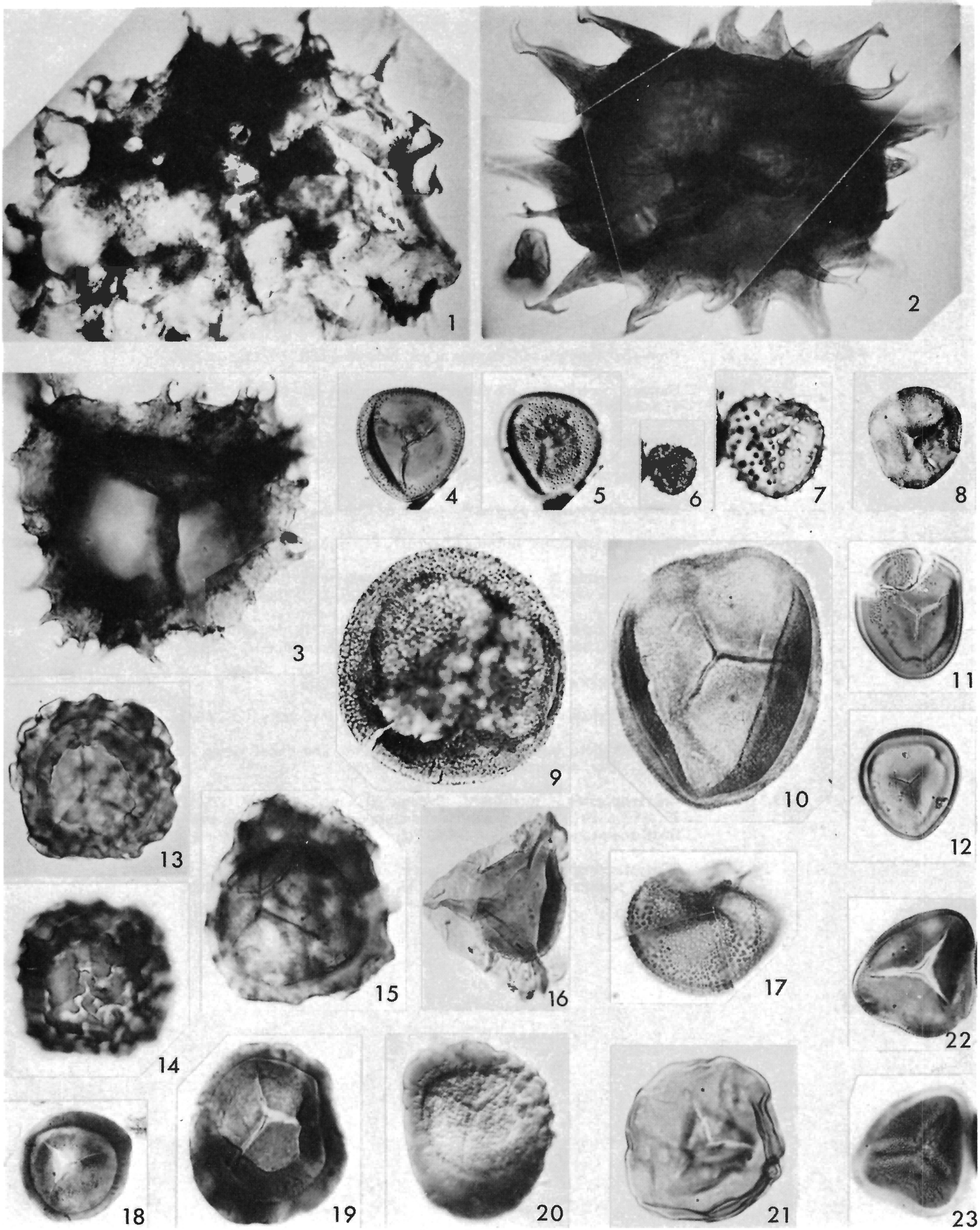
|---|---|---|
| Figure | 1. | **Ancyrospora loganii** McGregor, GSC 66206. |
| | 2. | **Ancyrospora longispinosa** Richardson, GSC 66207. |
| | 3. | **Ancyrospora** sp. cf. **A. nettersheimensis** Riegel, GSC 66208. |
| | 4,5. | **Apiculatasporites brevidenticulatus** (Chibrikova) n. comb., proximal and distal views, GSC 66209. |
| | 6,7. | **Apiculatasporites perpusillus** (Naumova ex Chibrikova) McGregor, GSC 66210; 7, X1000. |
| | 8,11,12. | **Apiculiretusispora leberidos** n. sp.; 8, holotype, with the sculptured layer nearly intact, GSC 66211; 11, paratype with vestige of sculptured layer, GSC 66212; 12, paratype without sculpture **(Retusotriletes)**, GSC 66213. |
| | 9. | **Apiculiretusispora densiconata** Tiwari and Schaarschmidt, GSC 66214. |
| | 10. | **Apiculatasporites microconus** (Richardson) n. comb., GSC 66215. |
| | 13,14,15. | **Archaeozonotriletes timanicus** Naumova; 13, 14, equatorial and distal views, GSC 66216; 15, specimen with asymmetrical patina, GSC 66217. |
| | 16. | **Auroraspora micromanifesta** (Hacquebard) Richardson, GSC 66218. |
| | 17. | **Baculatisporites semilucensis** (Naumova) n. comb., laterally compressed specimen, GSC 66219. |
| | 18-20. | **Archaeozonotriletes variabilis** Naumova emend. Allen; 18, small specimen with asymmetrical patina, GSC 66220; 19, specimen with patina encroaching onto outer part of contact areas, GSC 66221; 20, corroded specimen, GSC 66222. |
| | 21. | **Calamospora atava** (Naumova) McGregor, specimen with inner light zone and outer dark zone around the proximal pole, GSC 66223. |
| | 22,23. | **Camarozonotriletes antiquus** Kedo, proximal and distal views, GSC 66224. |

# PLATE 3



## PLATE 4
(Figures X500 unless noted)

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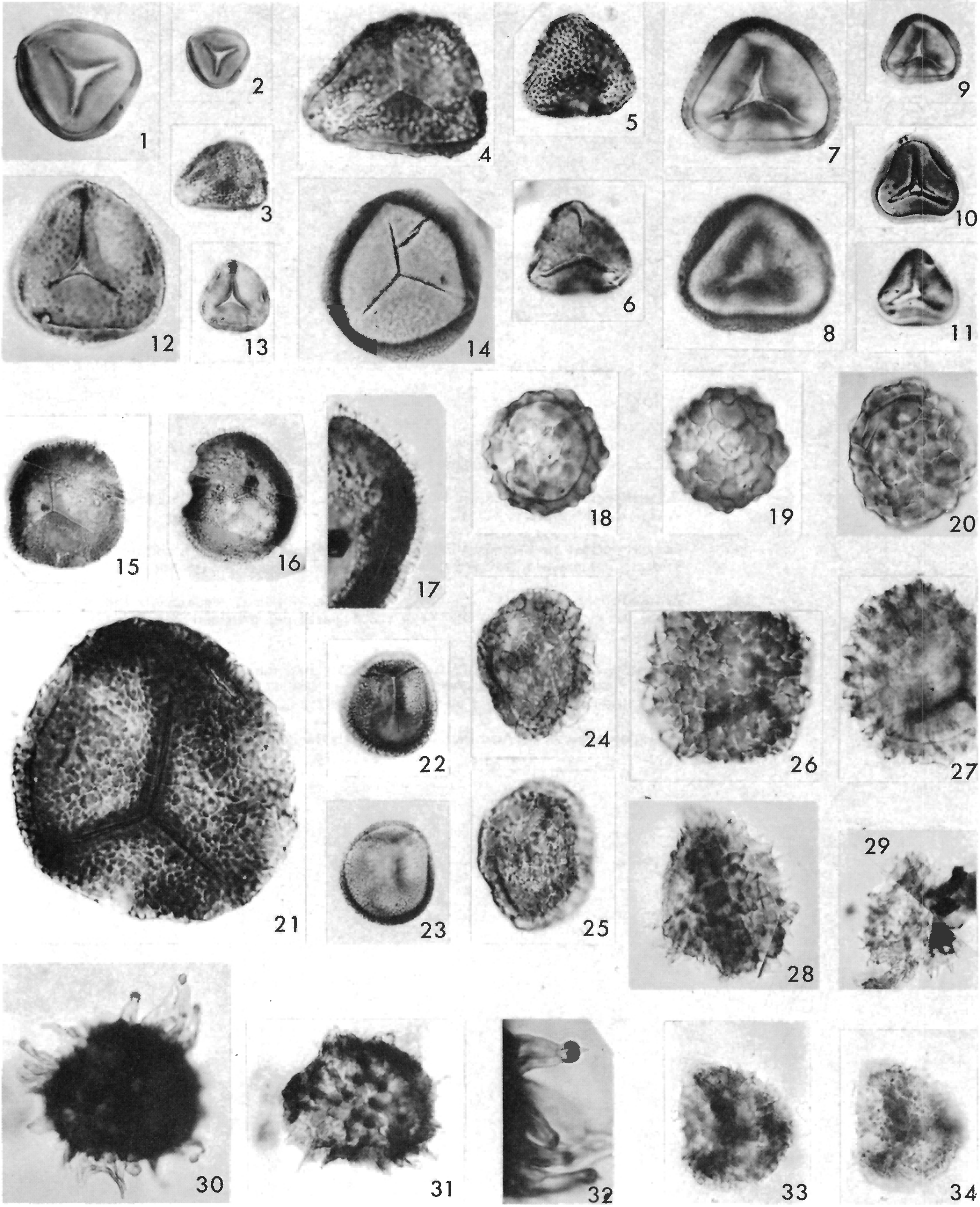
|---|---|---|
| Figures 1,2. | **Camarozonotriletes laevigatus** n. sp., holotype, GSC 66225; 1, X1000. |
| 3-6. | **Camarozonotriletes mosolovicus** Naumova ex Kedo; 3, 4, GSC 66226; 4, X1000; 5, 6, GSC 66227. |
| 7-11. | **Camarozonotriletes parvus** Owens; 7-9, GSC 66228; 7, 8, proximal and distal views, X1000; 10, 11, specimen with concave interradial body margin, proximal and distal views, GSC 66229. |
| 12,13. | **Camarozonotriletes pusillus** Naumova ex Chibrikova, GSC 66230; 12, X1000. |
| 14. | **Camarozonotriletes? notatus** (Owens) n. comb., GSC 66231. |
| 15-17. | **Ceratosporites** sp. cf. **Acanthotriletes multisetus** (Luber) Richardson var. **multisetus**; 15, GSC 66232; 16, 17, GSC 66233; 17, X1000. |
| 18-20. | **Concolutispora crassata**? (Naumova) n. comb.; 18, 19, proximal and distal views, GSC 66234; 20, laterally compressed specimen, GSC 66235. |
| 21. | **Convolutispora porcata** n. sp., holotype, GSC 66236. |
| 22,23. | **Convolutispora subtilis** Owens, proximal and distal views, GSC 66237. |
| 24-27. | **Convolutispora tegula** Allen; 24, 25, proximal and distal views, GSC 66238; 26, 27, distal and proximal views, GSC 66239. |
| 28,29,33,34. | **Corystisporites serratus**? (Naumova) n. comb.; 28, GSC 66240; 29, GSC 66241; 33, 34, proximal and distal views of specimen with relatively small sculptural elements, GSC 66242. |
| 30-32. | ?**Corystisporites collaris** Tiwari and Schaarschmidt, GSC 66243; 30, 31, equatorial and distal views; 32, sculptural elements, X1000. |

PLATE 4



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## PLATE 5
(Figures X500 unless noted)

Figures

1,2. **Corystisporites multispinosus** Richardson var. **multispinosus,** GSC 66244; 2, equatorial sculpture, X1000.

3,4. **Corystisporites multispinosus** Richardson var. **spinulosus** n. var.; 3, holotype, laterally compressed, GSC 66245; 4, paratype, small specimen, GSC 66246.

5-9. **Craspedispora arctica** n. sp.; 5, 6, 7, holotype, proximal, equatorial, and distal views respectively, GSC 66247; 8, 9, paratype, proximal and distal views, GSC 66248.

10,12-16. **Cristatisporites albus**? (Arkhangelskaya) n. comb.; 10, GSC 66249; 12, 13, distal and proximal-equatorial views, GSC 66250; 14, GSC 66251; 15, 16, laterally compressed specimens, GSC 66252 and 66253 respectively.

11. **Corystisporites** sp. cf. **Acanthotriletes horridus** Hacquebard, GSC 66254.

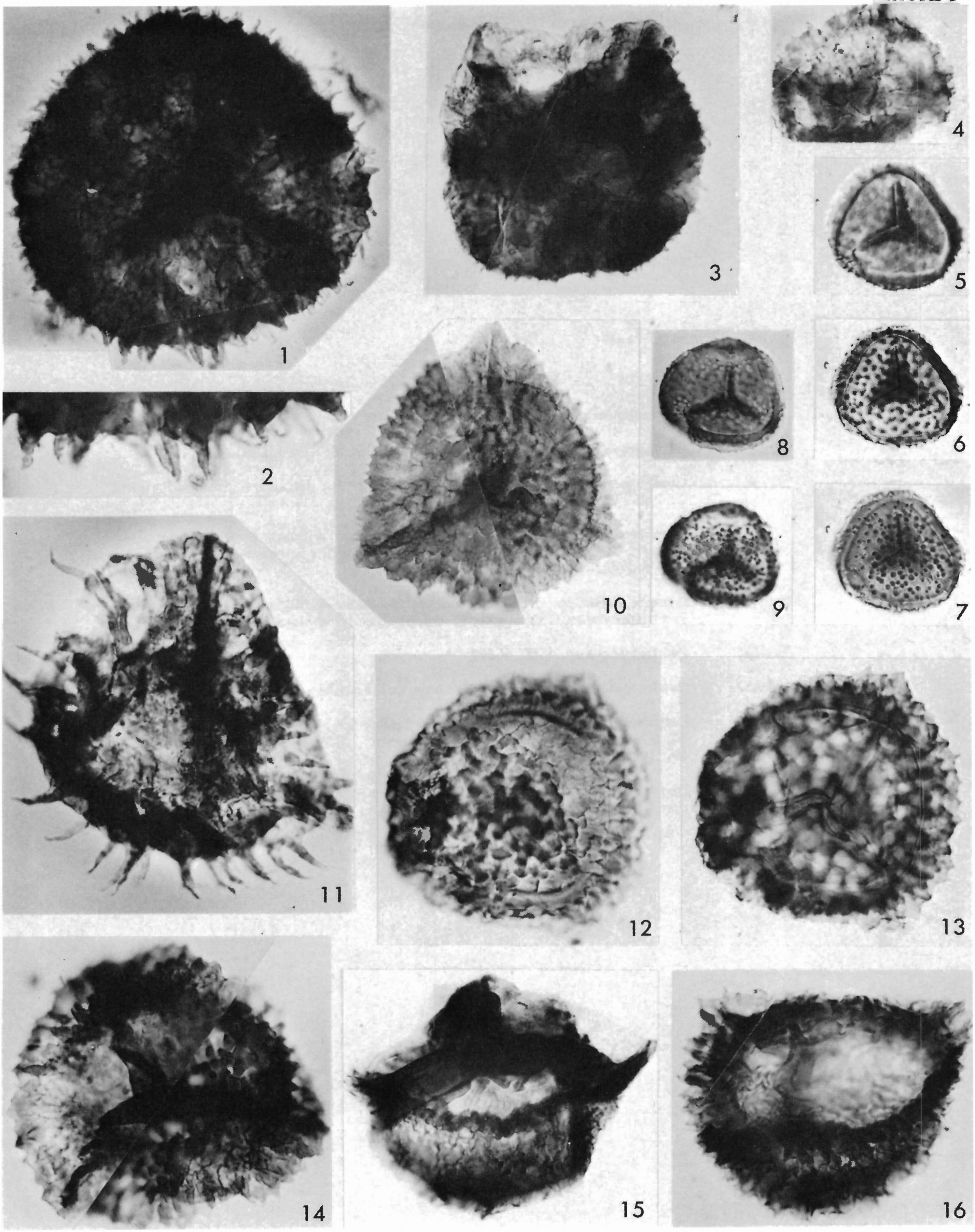
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PLATE 6
(All figures X500)

Figure 1. **Cristatisporites** sp., GSC 66255.

2,3. **Cyclogranisporites amplus**? McGregor; 2, GSC 66256; 3, GSC 66257.

4,5. **Cymbosporites magnificus** (McGregor) n. comb., distal and proximal views, GSC 66258.

6,9,10. **Cymbosporites? opacus** n. sp.; 6, paratype, without proximal radiating pattern, GSC 66259; 9, paratype, with well-defined proximal radiating ribs, GSC 66260; 10, holotype, GSC 66261.

7,8,11,12. **Cymbosporites** sp. cf. **Retusotriletes tschibrikovii** Mikhailova; 7, 8, proximal and distal views, GSC 66262; 11, 12, proximal and distal views, GSC 66263.

15. **Deltoidospora** sp., GSC 66269.

16,17. **Cymbosporites** sp., proximal and equatorial-distal views, GSC 66268.

13,14,18,19. **Densosporites concinnus** (Owens) n. comb.; 13, small specimen, GSC 66264; 14, laterally compressed specimen, GSC 66265; 18, GSC 66266; 19, GSC 66267.

20,21. **Densosporites devonicus** Richardson; 20, GSC 66270; 21, laterally compressed specimen, GSC 66271.

PLATE 6

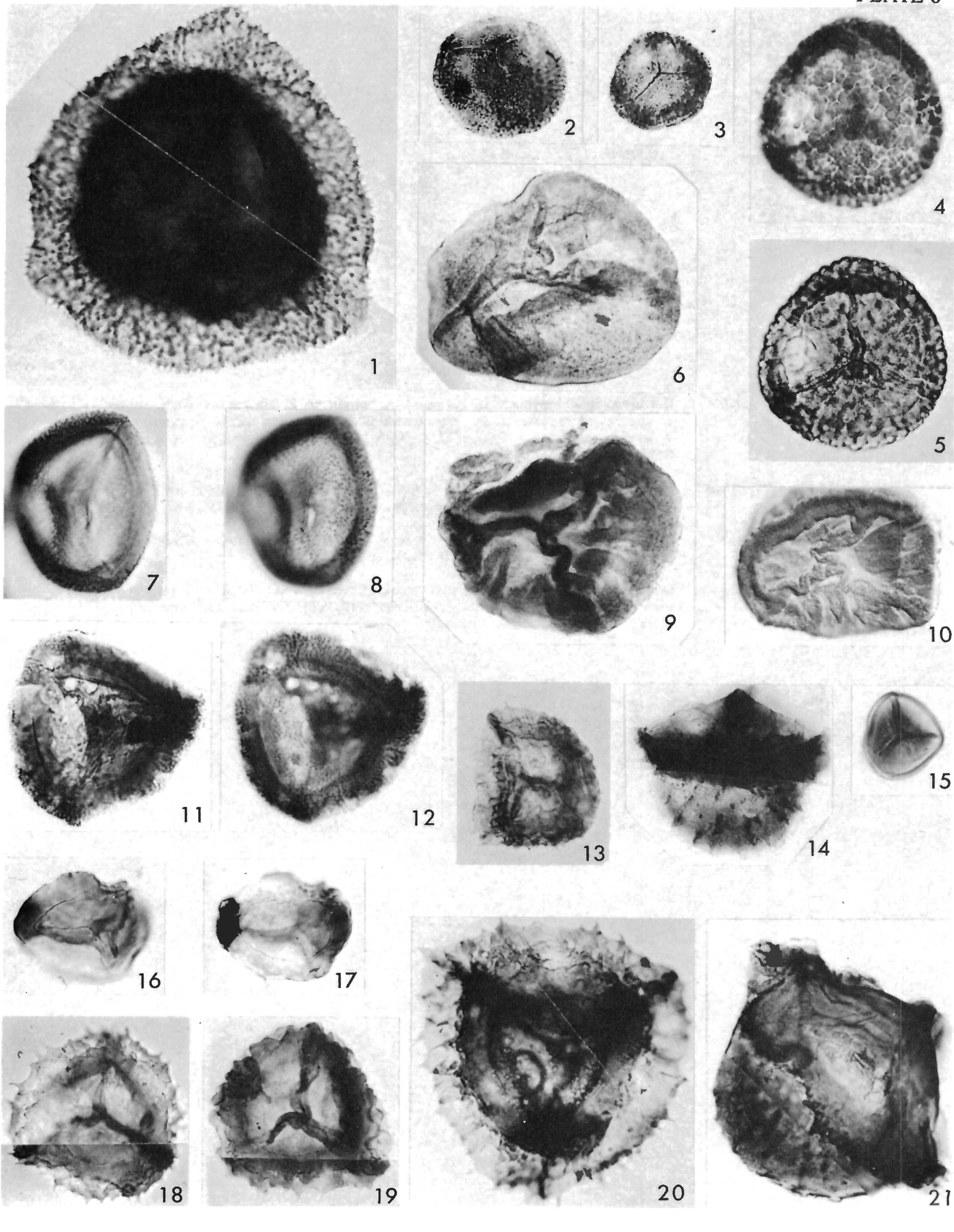

PLATE 7

(Figures X500 unless noted)

Figures 1-6. **Densosporites inaequus** (McGregor) n. comb.; 1, 2, specimens with small sculptural elements, cf. **D. concinnus**, GSC 66273 and 66274 respectively; 3, large specimen, GSC 66275; 4, 5, laterally compressed specimen, GSC 66276; 6, GSC 66277.

7,8,9,14. **Densosporites weatherallensis** n. sp.; 7, 14, holotype, proximal and distal views, GSC 66278; 8, 9, paratype, proximal and distal views, GSC 66279.

10-13. **Diatomozonotriletes franklinii** n. sp.; 10, 11, holotype, GSC 66280; 12, 13, paratype, GSC 66281; 10, 12, X1000.

15-17. **Diatomozonotriletes oligodontus**? Chibrikova; 15, 16, distal and proximal views, GSC 66282; 17, small specimen with slightly concave interradial margins, GSC 66283; 16, X1000.

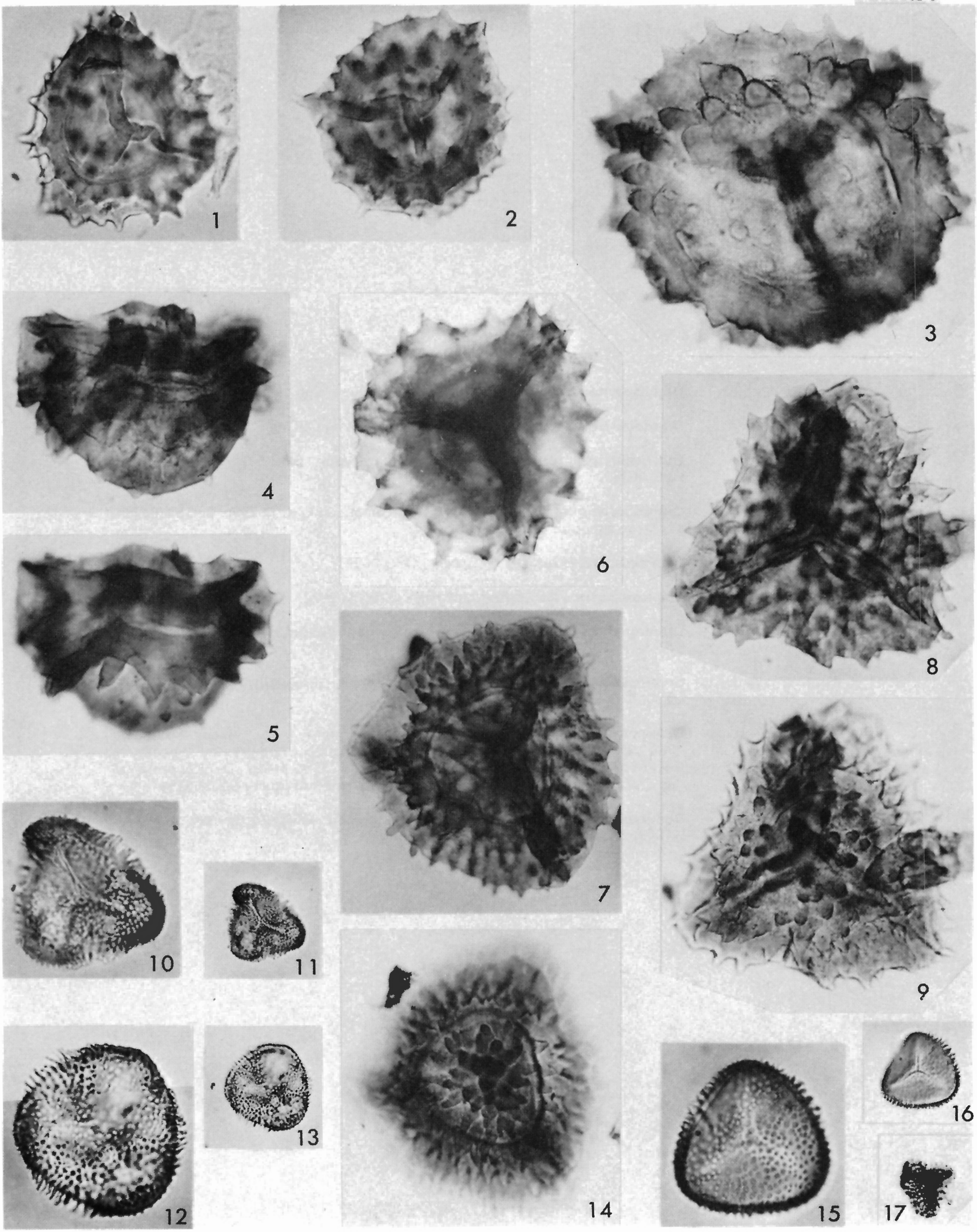
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PLATE 8

(Figures X500 unless noted)

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|---|---|---|
| Figure | 1. | **Dibolisporites antiquus**? (Naumova ex Kedo) n. comb., GSC 66284. |
| | 2. | **Dibolisporites echinaceus** (Eisenack) Richardson, GSC 66285. |
| | 3,4. | **Dibolisporites farraginis** n. sp.; 3, paratype, GSC 66286; 4, holotype, GSC 66287. |
| | 5,6,11. | **Dibolisporites uncatus** (Naumova) n. comb.; 5, GSC 66288; 6, GSC 66289; 11, large specimen, GSC 66290. |
| | 7. | **Emphanisporites rotatus** McGregor, GSC 66291. |
| | 8. | **Emphanisporites annulatus**? McGregor, GSC 66292. |
| | 9,10. | **Dibolisporites vegrandis** n. sp., holotype, proximal and distal views, GSC 66293. |
| | 12,13. | **Geminospora**? **bislimbata** (Chibrikova) n. comb.; 12, GSC 66294; 13, GSC 66295. |
| | 14,15,19-22. | **Geminospora micromanifesta** (Naumova) n. comb. var. **minor** Naumova; 14, 15, proximal and distal views of obliquely compressed specimen, GSC 66296; 19, 20, proximal and distal views, GSC 66297; 21, 22, proximal and distal views of specimen with relatively fine sculpture, GSC 66298. |
| | 16-18. | **Geminospora micropaxilla** (Owens) n. comb., GSC 66299; 16, sculpture, X1000, 17, 18, distal and proximal views. |

PLATE 8

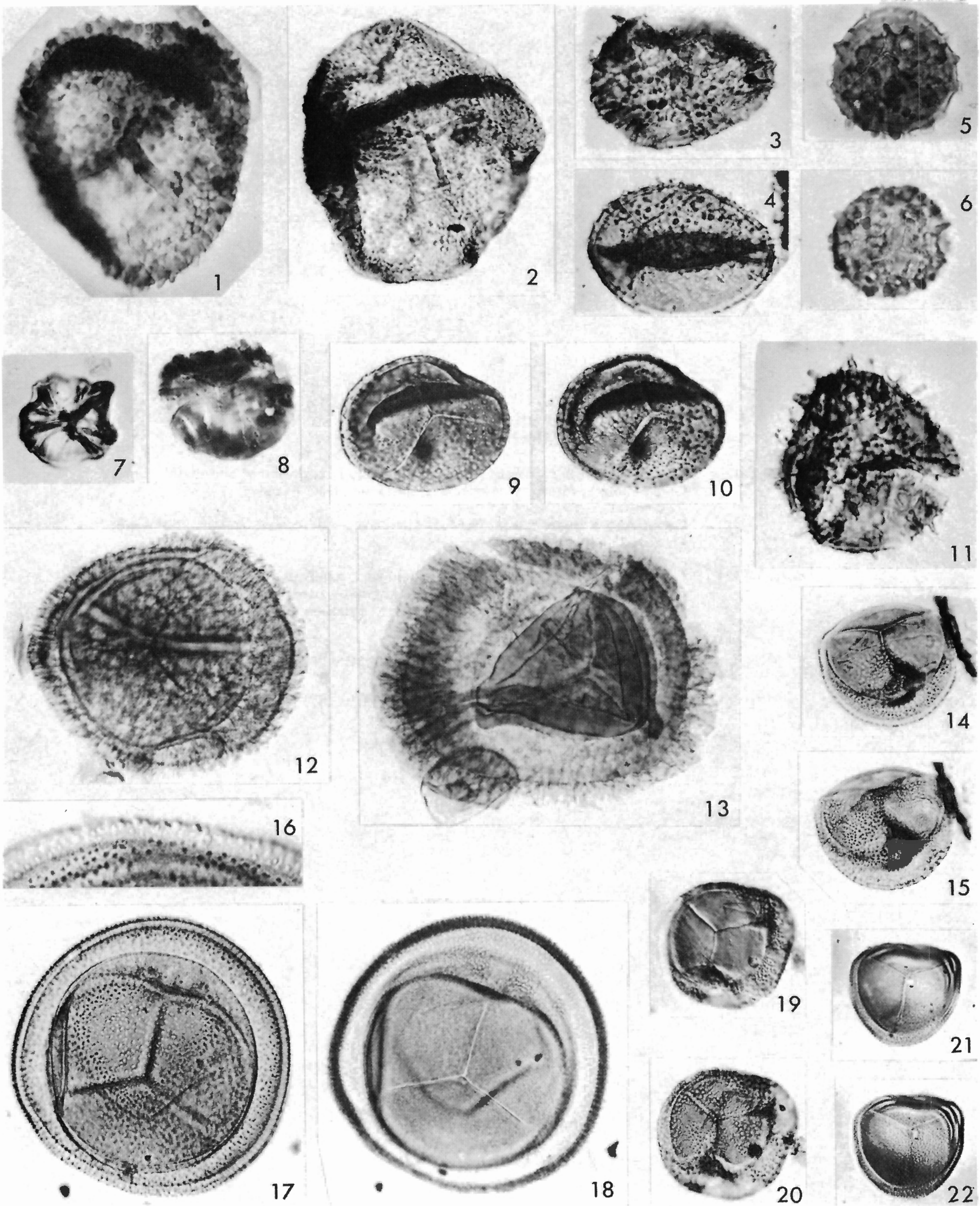

PLATE 9

(All figures X500)

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| Figures 1-3. | **Geminospora micropaxilla** (Owens) n. comb.; 1, 2, proximal and distal views, GSC 66300; 3, laterally compressed specimen, GSC 66301. |
| 4,5. | **Geminospora tuberculata** (Kedo) Allen var. **micrornata** n. var.; holotype, proximal and equatorial views, GSC 66302. |
| 6,7,10-13. | **Geminospora tuberculata** (Kedo) Allen var. **tuberculata**; 6, 7, proximal and distal views, GSC 66303; 10, 11, laterally compressed specimen, GSC 66304; 12, 13, proximal and distal views of obliquely compressed specimen, GSC 66305. |
| 8,9. | **Geminospora** sp., proximal and distal views, GSC 66306. |
| 14,15. | **Geminospora venusta**? (Naumova) n. comb., proximal and distal views, GSC 66307. |
| 16. | **Geminospora verrucosa** Owens, GSC 66308. |

PLATE 9

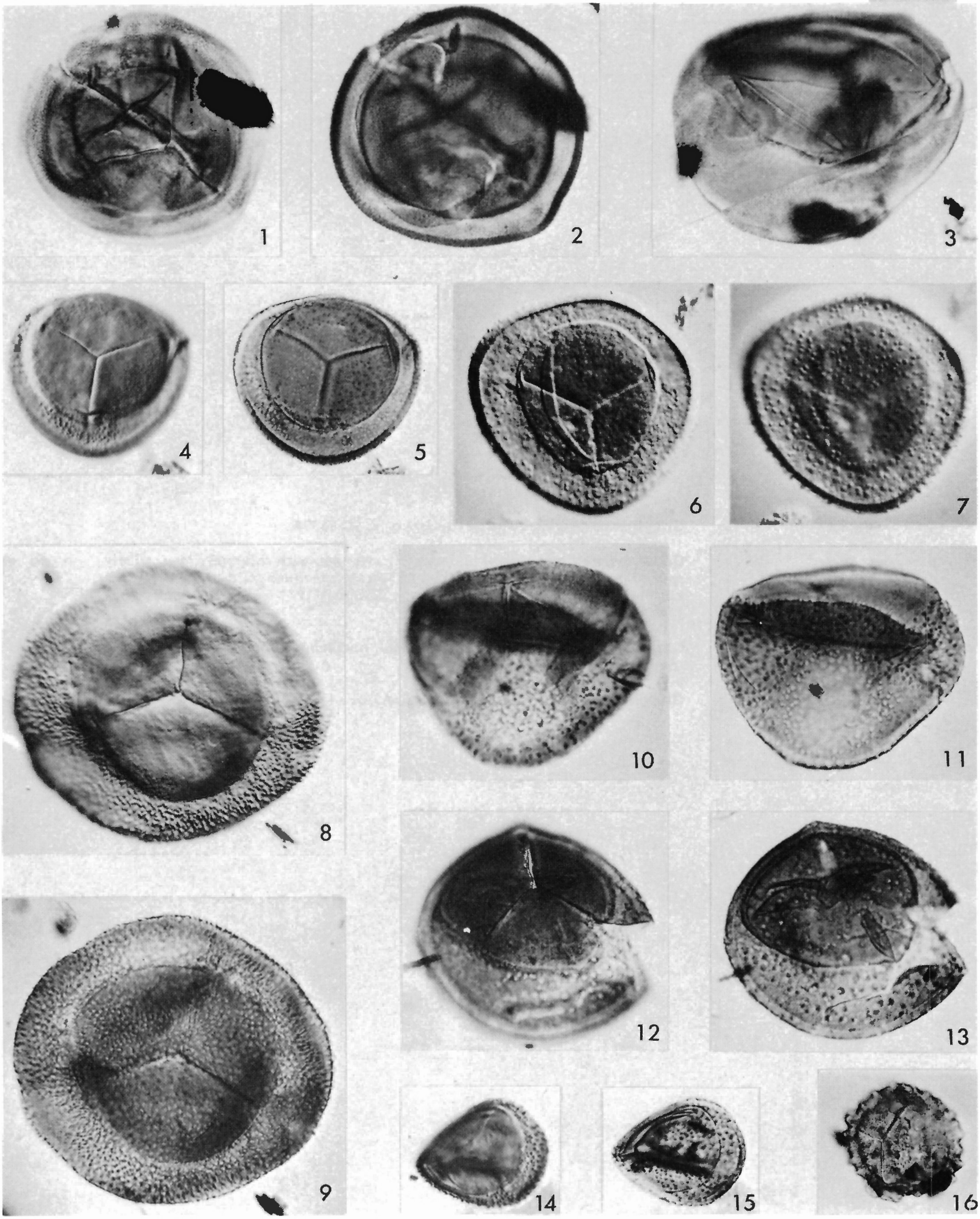

PLATE 10
(All figures X500)

Figure 1. **Grandispora douglastownense** McGregor, GSC 66309.

2,6,7. **Grandispora eximia** (Allen) n. comb.; 2, specimen with relatively long, widely spaced sculptural elements, GSC 66310; 6, specimen with shorter, more closely spaced sculptural elements, GSC 66311; 7, obliquely compressed specimen, GSC 66312.

3,4. **Grandispora** sp. cf. **G. eximia** (Allen) n. comb.; 3, obliquely compressed specimen, GSC 66313; 4, GSC 66314.

5. **Grandispora longa** Chi and Hills, GSC 66315.

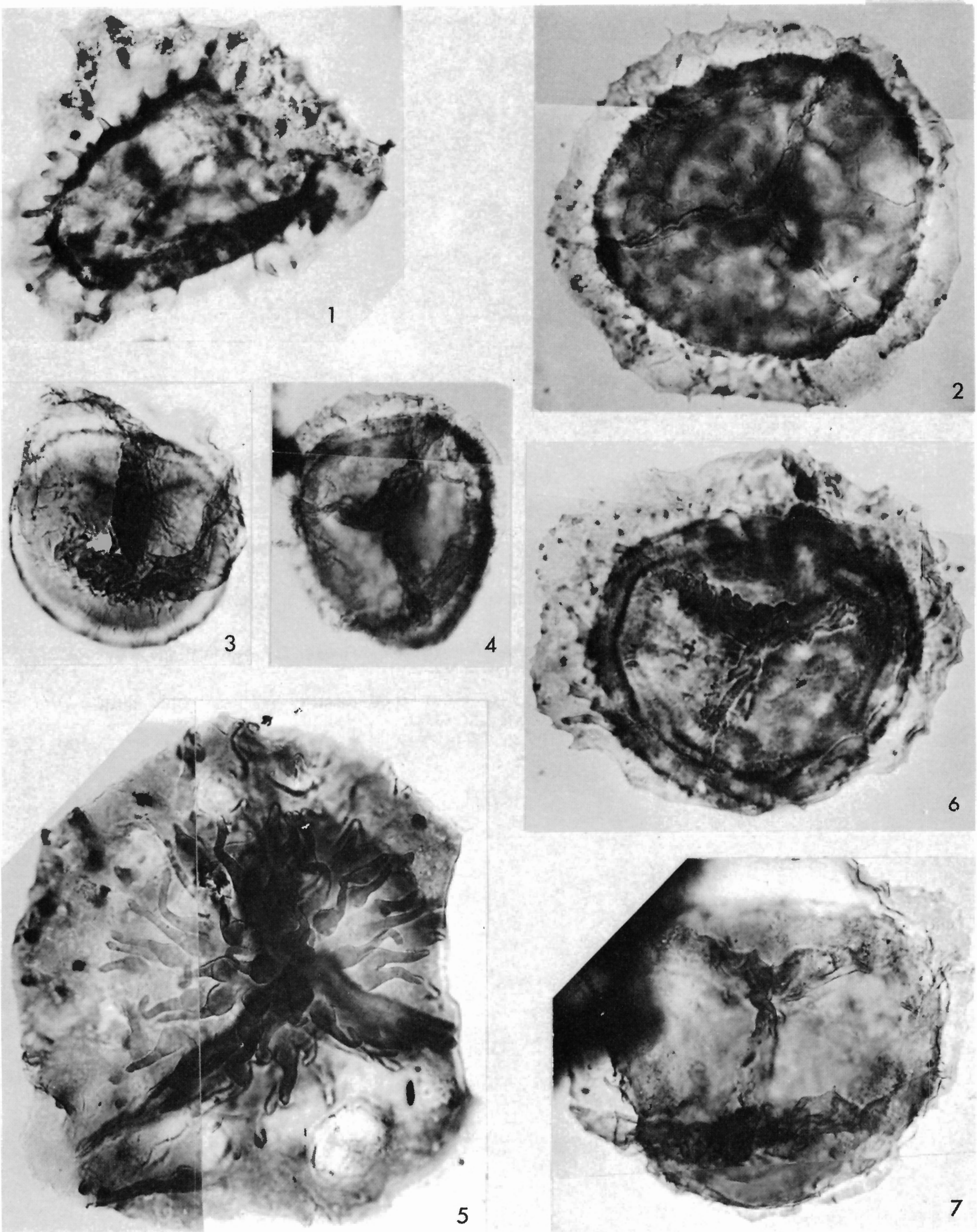
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PLATE 11
(All figures X500)

Figure 1. **Grandispora longa** Chi and Hills, GSC 66316.

2,3. **Grandispora inculta** Allen; 2, specimen bearing coni and grana, GSC 66317; 3, specimen with coni only, GSC 66318.

4-6. **Grandispora mammillata** Owens; 4, GSC 66319; 5, 6, distal and proximal views, GSC 66320.

7-9. **Grandispora megaformis** (Richardson) McGregor; 7, 8, proximal and distal views, GSC 66321; 9, GSC 66322.

10. **Grandispora protea** (Naumova) Moreau-Benoit, specimen with small sculpture, cf. **G. velata**, GSC 66323.

PLATE 11

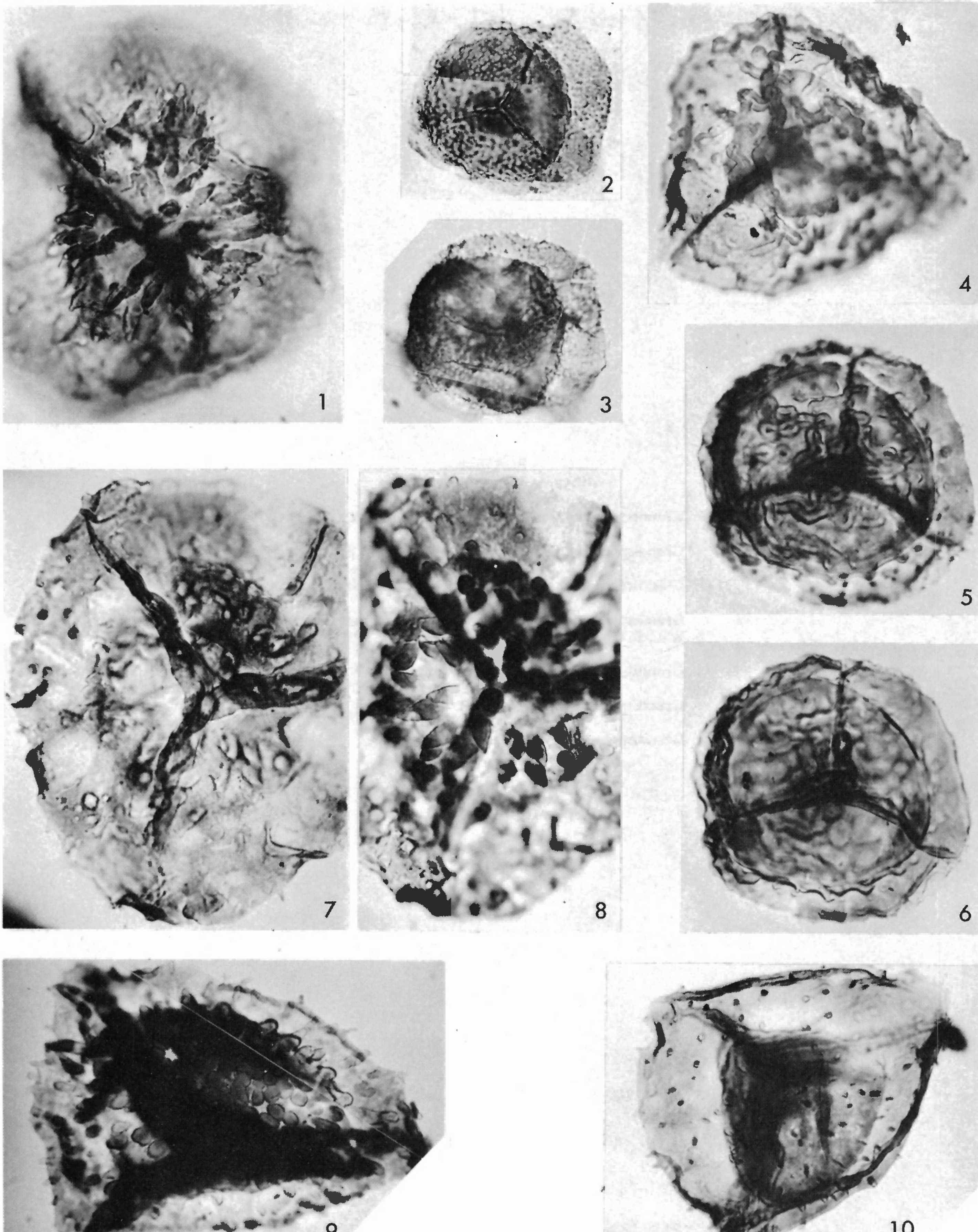


PLATE 12
(Figures X500 unless noted)

Figure 1. **Grandispora protea** (Naumova) Moreau-Benoit, GSC 66324.

2,4. **Grandispora tiwarii** n. name, GSC 66325; 4, equatorial sculpture, X1000.

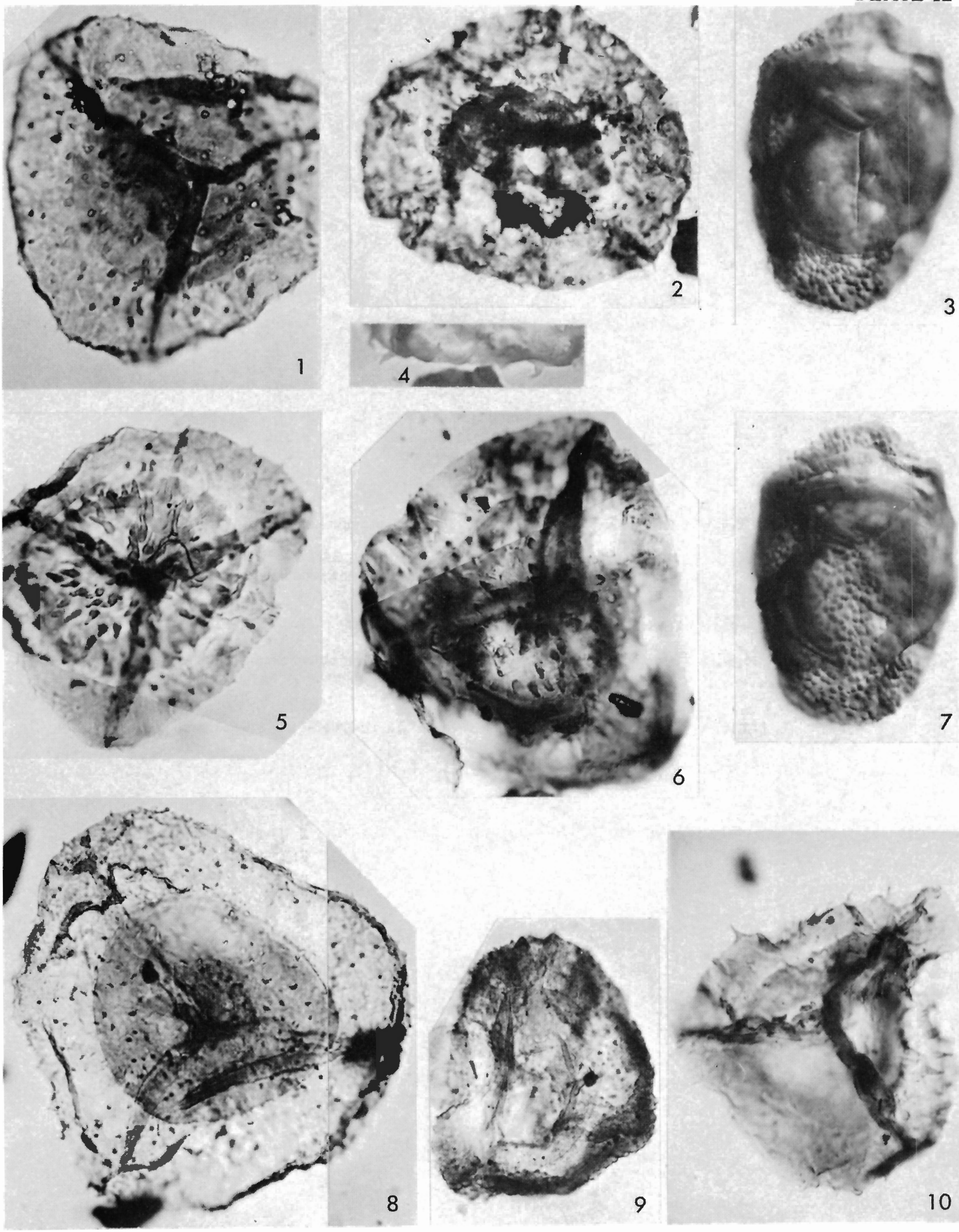
3,7. **Grandispora uyenoi** n. sp., holotype, proximal and distal views, GSC 66326.

5,6. **Grandispora variospinosa** n. sp.; 5, paratype, GSC 66327; 6, holotype, GSC 66328.

8. **Grandispora velata** (Eisenack) Playford, GSC 66329.

9. **Grandispora** sp. 3, GSC 66330.

10. **Grandispora** sp. 1, GSC 66331.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## PLATE 13
(Figures X500 unless noted)

Figure 1. **Grandispora** sp. 2, GSC 66332.

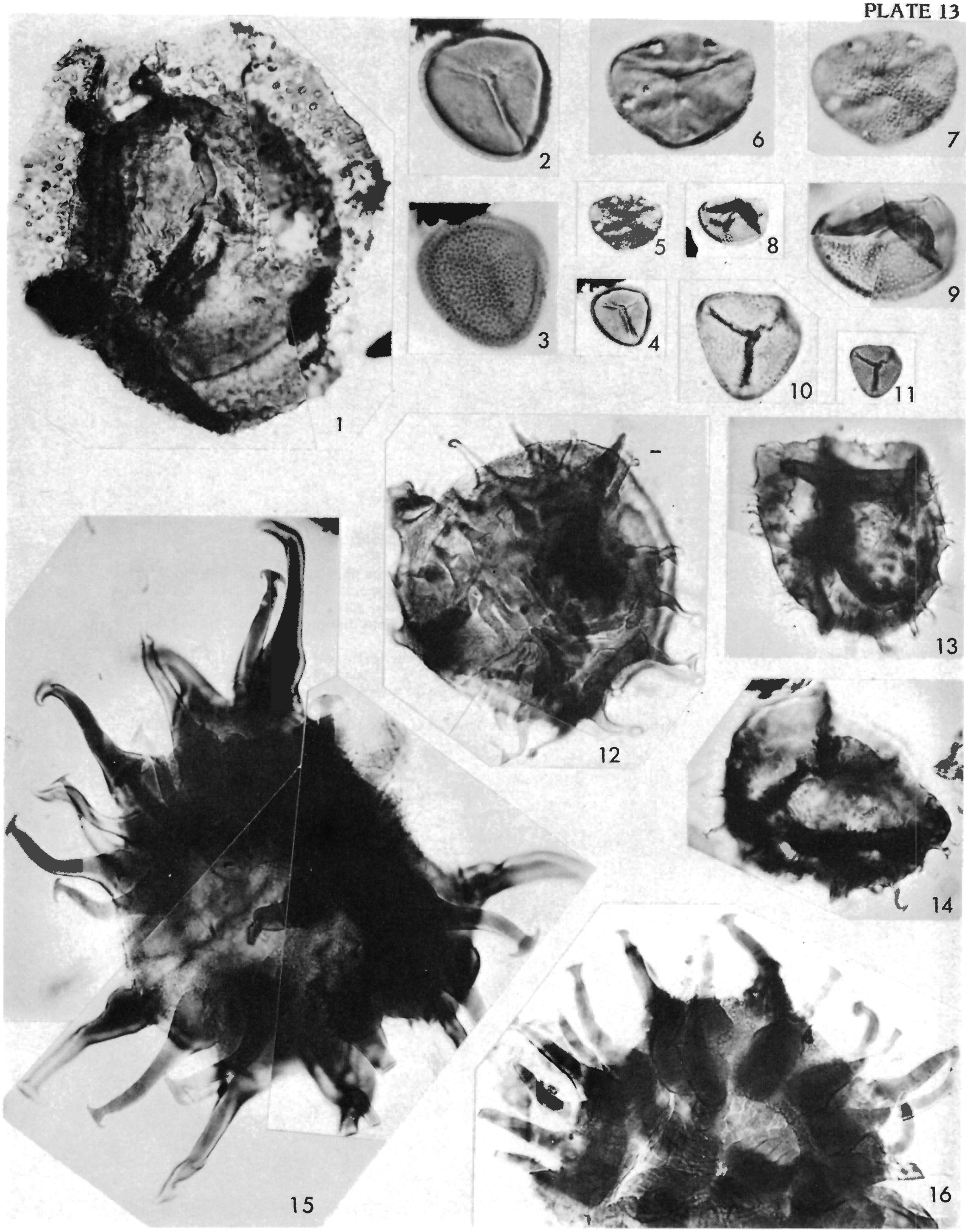
2-4. **Granulatisporites** sp., GSC 66333; 2, 3, proximal and distal views, X1000.

5-11. **Granulatisporites muninensis**? Allen; 5-7, GSC 66334; 6, 7, proximal and distal views, X1000; 8, 9, laterally compressed specimen, GSC 66335; 9, X1000; 10, 11, GSC 66336; 10, X1000.

12. **Hystricosporites costatus** Vigran, GSC 66337.

13,14. **Hystricosporites setigerus**? (Naumova ex Kedo) Arkhangelskaya; 13, laterally compressed specimen, GSC 66338; 14, obliquely compressed specimen, GSC 66339.

15,16. **Hystricosporites gravis** Owens; 15, GSC 66340; 16, specimen showing proximal radiating ribs, GSC 66341.



## PLATE 14
(All figures X500)

Figure 1. **Hystricosporites** sp. A of Owens, GSC 66342.

2,3,4,5,8. **Kraeuselisporites ollii**? (Chibrikova) n. comb.; 2, specimen with wide zona, GSC 66343; 3, laterally compressed specimen, GSC 66344; 4, obliquely compressed specimen with rudimentary zona, GSC 66345; 5, 8, distal and proximal views of specimen with confluent distal sculpture, GSC 66346.

6,7,9,10. **Kraeuselisporites acerosus** (Arkhangelskaya) n. comb.; 6, obliquely compressed specimen, GSC 66347; 7, specimen with large sculpture, GSC 66348; 9,10, proximal and distal views, GSC 66349.

11,12. **Kraeuselisporites rugosus** (Owens) n. comb.; 11, GSC 66350; 12, GSC 66351.

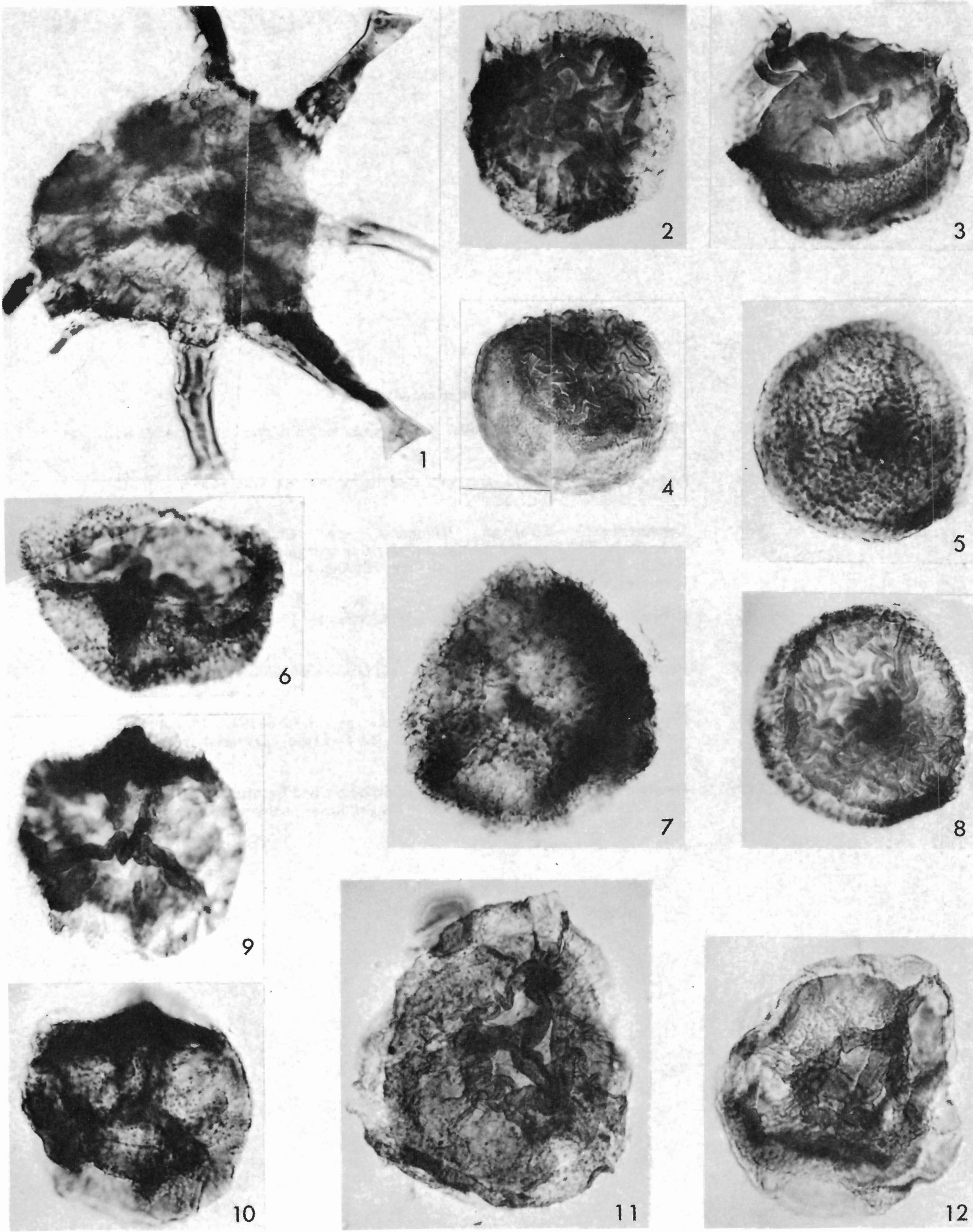

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PLATE 15

(Figures X500 unless noted)

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| Figures | 1,2. | **Kraeuselisporites spinutissimus**? (Naumova ex Kedo) n. comb., equatorial and distal views, GSC 66352. |
| | 3,4. | **Laevigatosporites** sp.; 3, specimen showing curvaturae, GSC 66353; 4, thick-walled specimen, GSC 66354. |
| | 5-11. | **Lophotriletes devonicus** (Naumova ex Chibrikova) n. comb.; 5, 6, 11, specimen with concave interradial margins, GSC 66355; 6, 11, X1000; 7, 8, GSC 66356; 7, distal view, X1000; 9, 10, laterally compressed specimen, GSC 66357; 10, X1000. |
| | 12,16,17. | **Perotrilites ergatus**? Allen; 12, GSC 66358; 16, 17, proximal and distal views, GSC 66359. |
| | 13-15. | **Perotrilites bifurcatus** Richardson; 13, GSC 66360; 14, 15, proximal and distal views, GSC 66361. |
| | 18-21. | **Perotrilites heclaensis** n. sp.; 18, holotype, GSC 66362; 19, paratype, laterally compressed, GSC 66363; 20, 21, paratype, proximal and distal views, GSC 66364. |
| | 22,23. | **Perotrilites selectus** (Arkhangelskaya) McGregor and Camfield; 22, specimen with narrow zona, GSC 66365; 23, obliquely compressed specimen, GSC 66366. |

PLATE 15

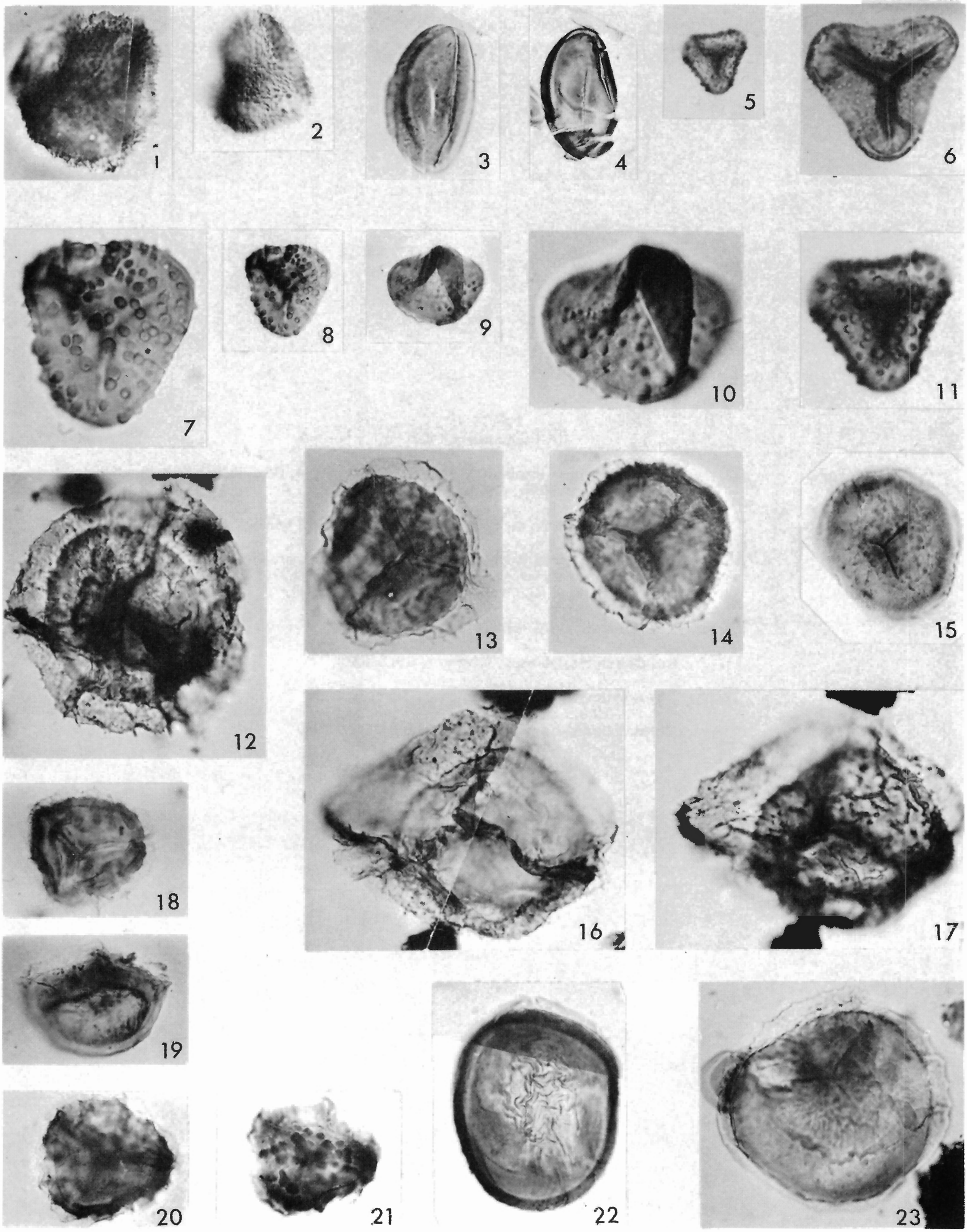


PLATE 16
(All specimens X500)

Figures 1,2. **Punctatisporites inspissatus** (Owens) n. comb.; 1, GSC 66367; 2, laterally compressed specimen, GSC 66368.

3. **Punctatisporites** sp. cf. **P. solidus** Hacquebard, GSC 66369.

4-7,10. **Retispora archaelepidophyta** (Kedo) n. comb.; 4, 5, proximal and distal views of specimen with strongly folded exoexine, GSC 66370; 6, 7, equatorial and distal views, GSC 66371; 10, distal view, GSC 66372.

8,9. **Retispora** sp., GSC 66373.

11. **Retusotriletes dubiosus** McGregor, GSC 66374.

12. **Retusotriletes pychovii** Naumova, GSC 66375.

13. **Retusotriletes rotundus** (Streel) Streel, GSC 66376.

PLATE 16

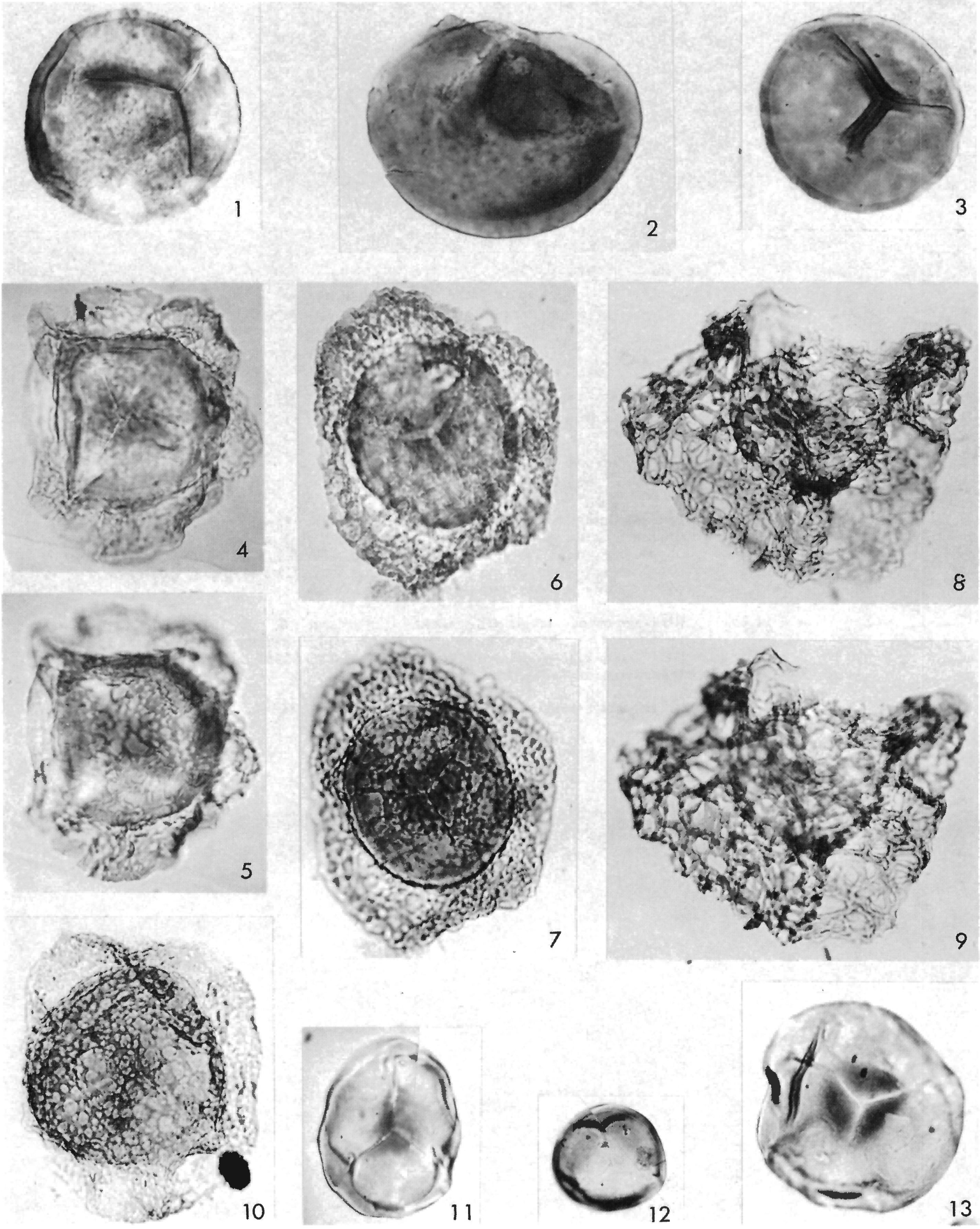


PLATE 17
(Figures X500 unless noted)

Figures 1-5. **Retusotriletes rugulatus** Riegel; 1, GSC 66377; 2, obliquely compressed specimen with numerous closely spaced proximal wrinkles, GSC 66378; 3, specimen with closely spaced proximal wrinkles, GSC 66379; 4, large specimen with coarsely patterned proximal face, GSC 66380; 5, specimens with coarsely patterned proximal face, GSC 66381.

6-11,13. **Rhabdosporites langii** (Eisenack) Richardson; 6, 7, 10, GSC 66382; 6, 7, sculpture, X1000; 8, specimen with concentrically folded margin, GSC 66383; 9, minutely sculptured specimen, GSC 66384; 11, strongly folded specimen, GSC 66385; 13, GSC 66386.

12. **Rhabdosporites** sp. cf. **R. parvulus** Richardson, GSC 66387.

PLATE 17

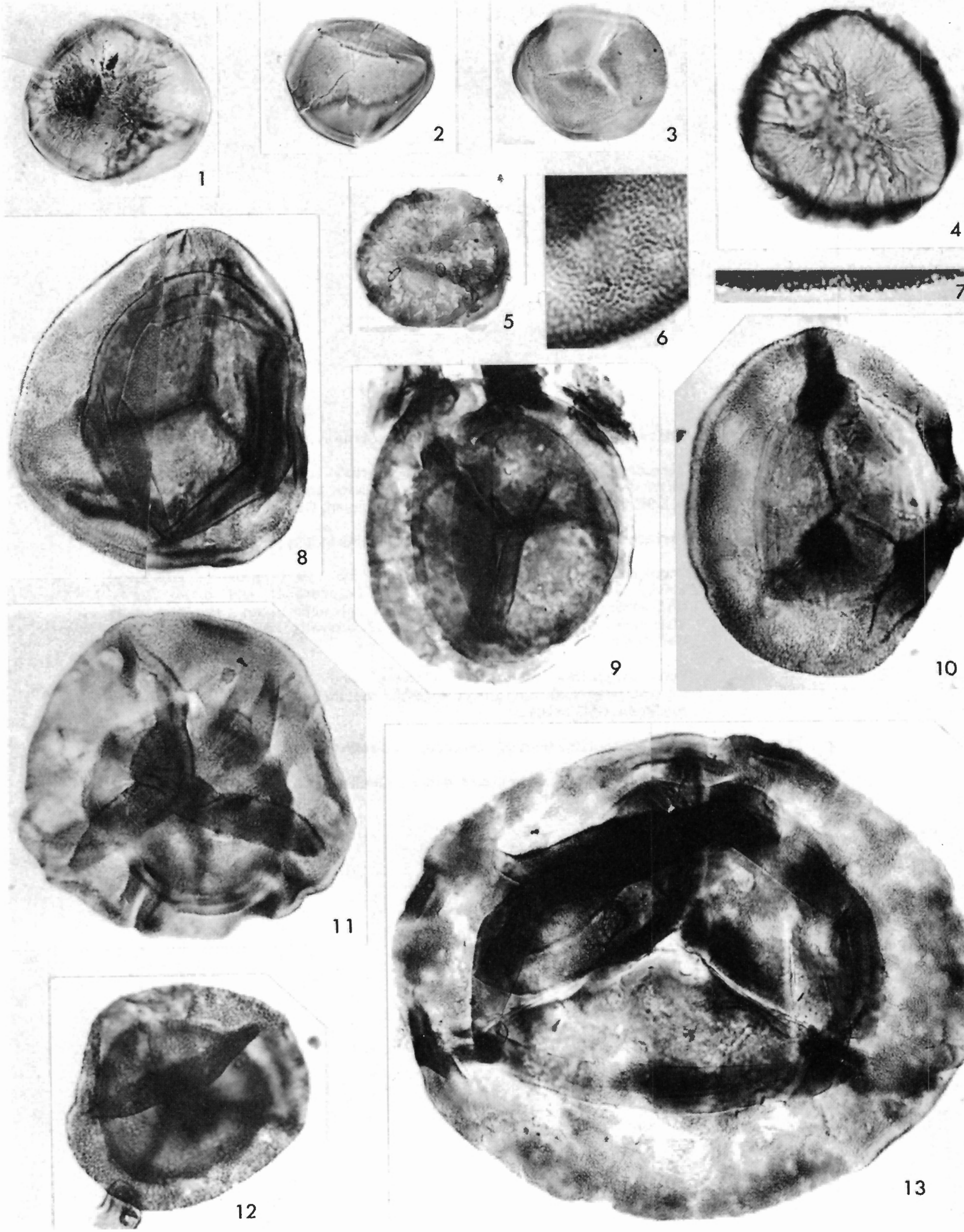


PLATE 18
(Figures X500 unless noted)

Figures

1-3. **Rhabdosporites** sp.; 1,2, GSC 66388; 2, sculpture, X1000; 3, GSC 66389.

4-7. **Verruciretusispora dubia** (Eisenack) Richardson and Rasul; 4, specimen with large verrucae, GSC 66390; 5, specimen with small verrucae, GSC 66391; 6, GSC 66392; 7, laterally compressed specimen, GSC 66393.

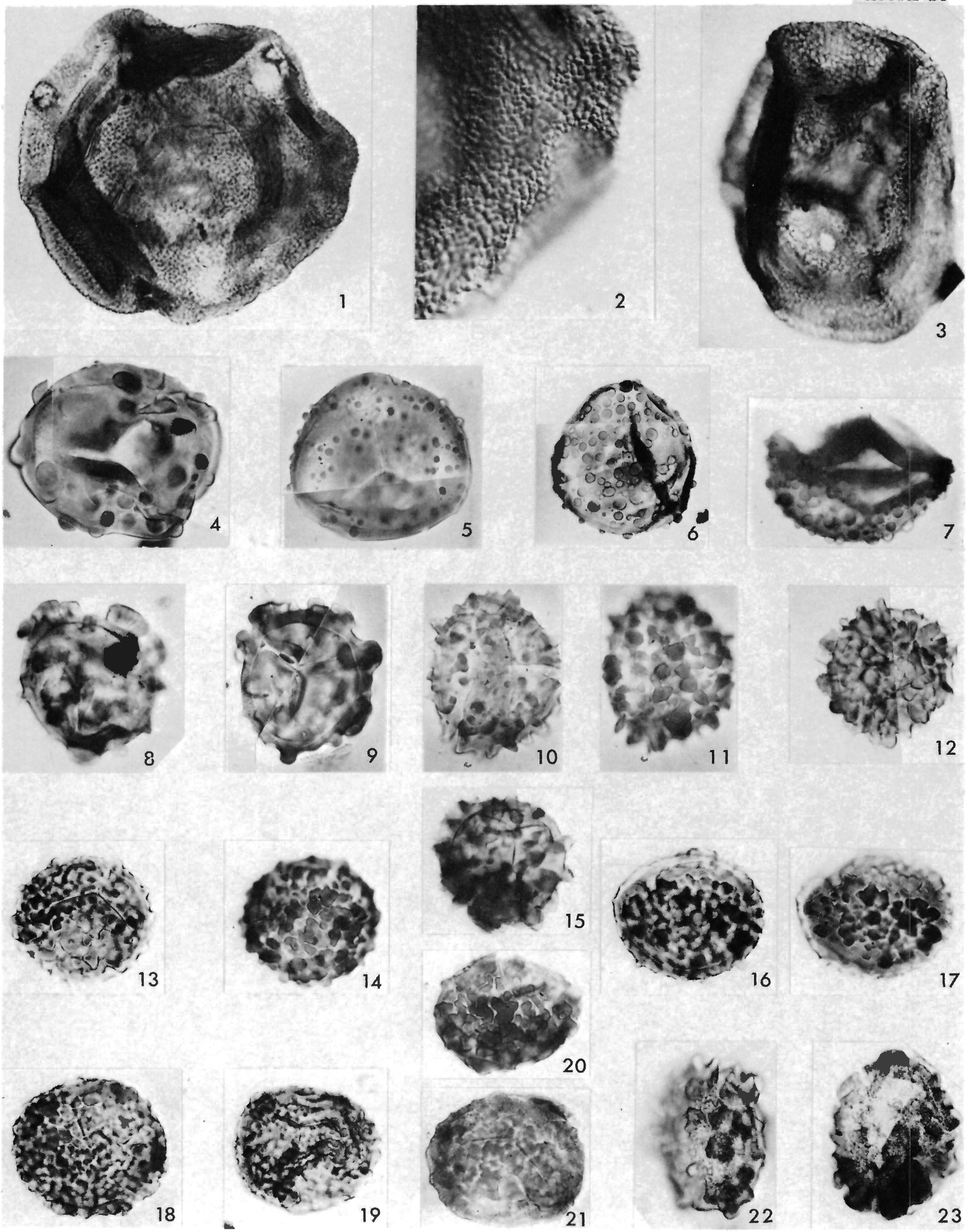
8,9. **Verrucosisporites premnus** Richardson; 8, GSC 66394; 9, GSC 66395.

10-17. **Verrucosisporites scurrus** (Naumova) n. comb.; 10, 11, proximal and distal views, GSC 66396; 12, GSC 66397; 13, 14, proximal and distal views, GSC 66398; 15, obliquely compressed specimen with asymmetrically distributed sculpture, GSC 66399; 16, 17, laterally compressed specimen, GSC 66400.

18-21. **Verrucosisporites tumulentis** Clayton and Graham; 18, GSC 66401; 19, GSC 66402; 20, laterally compressed specimen, GSC 66403; 21, corroded specimen, GSC 66404.

22. **Verrucosisporites scurrus,** corroded, cf. **Geminospora verrucosa,** GSC 66405.

23. **Convolutispora crassata**?, corroded, cf. **Geminospora verrucosa,** GSC 66406.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