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DEPARTMENT OF MINES
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BULLETIN 107

MIOSPORES FROM THE MISSISSIPPIAN HORTON GROUP, EASTERN CANADA

Geoffrey Playford

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PREFACE

Miospores from parts of the Horton Group had been studied by officers of the Geological Survey, who showed that further investigation was necessary for the successful subdivision and correlation of the stratigraphic units by this means.

The subject was suggested to Dr. Playford, then holding a postdoctorate fellowship awarded by the National Research Council of Canada, now with the Department of Geology and Mineralogy, University of Queensland, Brisbane, Australia.

His investigation has clearly indicated the value of miospores as a means of correlating the strata concerned, and is an important contribution to the knowledge of these tiny organisms.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, January 29, 1963

Bulletin 107 — Die Miosporen der Hortonschen Gruppe des Mississippian in Ost-Kanada. Von Geoffrey Playford

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Бюллетень 107 — Миоспоры из гортонской группы миссисипского периода Восточной Канады. Джеффри Плейфорд

MIOSPORES FROM THE MISSISSIPPIAN HORTON GROUP, EASTERN CANADA

Abstract

Fifty-three species of small spores, assigned to twenty-eight existing genera, are recorded from thirteen localities in the Horton Group. This group is a thick, non-marine sequence in eastern Canada and is of early Mississippian age. Twenty-one species are described as new. One of these, *Schopfites augustus* n. sp., represents the first record of *Schopfites* Kosanke in rocks of pre-Westphalian age. It is shown that two distinct assemblages of miospores are present in the Horton Group, which, in its type area, comprises the Horton Bluff Formation and the conformably overlying Cheverie Formation. One of the microfloras appears to be characteristic of the Horton Bluff, whereas the other younger assemblage has been encountered only in the type Cheverie. Stratigraphic implications of the microfloras are discussed, and the potential value of palynology in the resolution of Horton correlation problems is indicated. The Horton microfloras include certain species that occur in assemblages of comparable age from Russia, Britain, and Spitsbergen, but affiliations with previously described assemblages are not marked. The study constitutes an extension of Hacquebard's (1957) palynological investigation of two coals from the Horton Group, both of which contain the Horton Bluff microflora.

Résumé

Cinquante-trois espèces de petites spores appartenant à vingt-huit genres ont été trouvées dans 13 localités du groupe Horton. Ce groupe est une succession épaisse de roches non marines de l'Est du Canada et qui appartient au début du Mississippien. Vingt et une de ces espèces sont nouvelles. L'une d'entre elles, *Schopfites augustus* n. sp., représente la première découverte de *Schopfites* Kosanke dans des roches d'âge pré-Westphalien. Il existe deux assemblages distincts de miospores dans le groupe Horton qui, dans la région type, comprend la formation Horton Bluff recouverte en concordance par la formation Cheverie. L'un des assemblages de la microflore semble autochtone de la formation Horton Bluff tandis que l'autre, qui est plus récent, n'a été trouvé que dans la formation Cheverie. L'auteur examine les conséquences stratigraphiques de la microflore et détermine l'importance possible de la palynologie pour la solution des problèmes de corrélation du groupe Horton. La microflore du groupe Horton comprend certaines espèces que l'on trouve dans des assemblages d'âge analogue en URSS, au Royaume-Uni et au Spitzberg, mais la parenté avec les assemblages déjà décrits n'est pas prononcée. Cette étude est une continuation des recherches palynologiques effectuées par Hacquebard (1957) sur deux couches de houille du groupe Horton qui contiennent toutes deux la microflore de la formation Horton Bluff.

CONTENTS

Illustrations

INTRODUCTION

This study was undertaken to investigate systematically the *sporae dispersae* contained in various samples of the non-marine Horton Group; and, further, to explore the value of the fossil spores for purposes of stratigraphic correlation.

The Horton Group comprises a thick, continental sequence of conglomerates, sandstones, and shales, together with rare, thin intercalations of coal. Marked facies variations are characteristic of these strata, which are distributed widely in Nova Scotia and New Brunswick. The group reaches a maximum thickness of 9,000 feet and is thought to have resulted from mainly fluviatile, partly lacustrine, deposition. Details of Horton Group stratigraphy of Nova Scotia are to be found in publications by Bell (1929, 1960)[1] and Murray (1960). Gussow (1953) described the subdivisions of the Horton as developed in New Brunswick.

The Horton Group rests with pronounced unconformity upon Devonian or older metamorphic and igneous rocks and is overlain, generally conformably, by the marine Windsor Group, a predominantly calcareous sequence. Horton accumulation represents the first depositional phase to succeed the Acadian orogeny which, as discussed by Murray (1960, p. 9), "began in the early Devonian and probably increased in intensity to a maximum during the early Late Devonian". The type area of both the Horton and Windsor Groups is at the estuary of Avon River, Horton-Windsor district, Nova Scotia. Within the type area, Bell (1929) subdivided the Horton Group into two rock units, the Horton Bluff Formation and the overlying Cheverie Formation. The contact between the two is presumed to be conformable; the Horton Bluff Formation comprises by far the greater thickness.

According to Bell (1929, 1960), several attributes of the Cheverie Formation serve to distinguish it from the underlying unit. These include presence of fresh feldspar and biotite, sun-cracking and channelling phenomena, ferric iron oxide, and general paucity of organic material. Bell considered that such differences between the two formations constituted the manifestation of climatic changes: Horton Bluff time being one of abundant rainfall under cool conditions, whereas Cheverie climate was "temperate semi-arid . . . with a seasonal or periodic rainfall" (Bell, 1929, p. 44).

Stratigraphers working outside the type area have experienced difficulty in distinguishing Bell's biformational subdivision of the Horton. This is due principally to lack of sufficient diagnostic megafossils and to profound facies changes characteristic of the group. Accordingly, a prime objective of the present investigation has been the microfloral study of samples from the type Horton Bluff and Cheverie, as also of samples from undifferentiated developments of the Horton Group. It will

[1] Names and/or dates in parentheses are those of References cited at the end of this report.

be demonstrated subsequently that the Horton Bluff and Cheverie microfloras are sufficiently distinctive in themselves to enable correlation of widely scattered exposures of Horton Group strata. It must be emphasized, however, that further work on a much greater range of material will be necessary before the complete sequence of Horton microfloras is known. There seems little doubt that the palynological method offers unique advantages in the resolution of Horton correlation problems, as diverse and generally well-preserved miospore assemblages are recoverable from a wide variety of the constituent lithological types.

Megascopic plant remains are prevalent at many horizons of the Horton Group, particularly of the Horton Bluff Formation; these occur as both drift and in situ floras. The rather restricted fauna includes ostracoda and palaeoniscid fish remains (scales, spines, and teeth). Collections of plant megafossils (including two species of megaspores) and non-marine invertebrates have been described by Bell (1960). The fossils had been collected mainly from the type Horton-Windsor district, though Bell recorded their localities of occurrence elsewhere in the Maritime Provinces.

Lepidodendropsis corrugata (Dawson) is the predominant lycopodiaceous element of the Horton Bluff megaflora, which also includes abundant fragmentary foliage and rachises of the pteridosperm *Aneimites acadica* Dawson. Both species occur additionally in the Cheverie Formation and indeed comprise the most common and characteristic elements of the overall Horton megaflora. Two abundantly occurring megaspore types are of biostratigraphic interest in that one, *Triletes glaber* (Dawson), appears to be confined to the Horton Bluff Formation whereas the other, *Triletes cheveriensis* Bell, is known only from the Cheverie Formation and from the Albert Formation of New Brunswick (*see* Bell, 1960, pp. 28-29). From megafloral evidence Bell did not consider it justifiable to pronounce the existence of two distinct florules, characteristic of the Horton Bluff and Cheverie respectively. However he emphasized the fact that the younger unit does contain certain elements, viz. *Triphyllopteris* spp., *Sphenopteris* (*Aneimites*?) *strigosa* Bell, *Adiantites tenuifolius* Göppert, *Sphenopteridium macconochiei*? Kidston, and *Sphenopteridium* sp., which are unknown from the Horton Bluff Formation.

A comprehensive discussion of the age of the Horton Group was given recently by Bell (1960, pp. 14-17). He concluded that the megafloral composition of the Horton "represents only a Tournaisian part of Jongmans' widespread Lower Carboniferous *Triphyllopteris-Rhacopteris-Lepidodendropsis* flora", and has close affinities with the Pocono flora of the United States. Cessation of Horton deposition (specifically that of the Cheverie Formation) is dated as late Tournaisian on the grounds that the immediately overlying Windsor Group contains a marine fauna of early Viséan (late Meramecian) age. Thus a Mississippian age for the Horton Group seems well established, though its lower age limit is not precisely known.

The first and only previous palynological report dealing with the Horton Group is that of Hacquebard (1957) who presented a valuable and detailed description of the miospores present in two coal samples. One of the samples was from the type section of the Horton Bluff Formation at Blue Beach, near Horton Bluff; the other sample was collected from (undifferentiated) Horton Group exposed near West

Gore. The West Gore sample yielded a prolific and well-preserved microflora, most species of which were observed by Hacquebard as occurring also in the Blue Beach sample's comparatively poorly preserved assemblage. From the striking microfloral parallelism of the two samples, Hacquebard concluded that the West Gore material is of Horton Bluff age.

The present investigation constitutes an extension of Hacquebard's (1957) studies. It will be demonstrated that the miospore assemblage that he described is common to all samples examined herein, with the notable exception of those obtained from the Cheverie Formation as exposed in its type area.

Acknowledgments

This work was carried out in the laboratories of the Geological Survey of Canada during the tenure of a postdoctorate fellowship awarded by the National Research Council; grateful acknowledgment is here made to both institutions. The writer would like to express his sincere thanks to P. A. Hacquebard and M. S. Barss of the Geological Survey who suggested the subject. Hacquebard, in particular, from his knowledge of the Horton Group was able to direct the field collection to critical localities. Barss assisted with the palynological preparations and the photography, and made available information and slides of previously examined Horton Group samples.

Data on Samples Studied

The following is an index to the plant locality numbers, samples, and palynological preparations dealt with in this report. Further notes, relevant to the stratigraphy of the localities, are given subsequently.

Horton Group (Horton Bluff Formation)

813 Horton Bluffs at Avonport, Nova Scotia. Grey siltstone. Coll. L. M. Lambe, 1908. Preparation P272.

Horton Group (Undifferentiated)

6400 Mill Brook, 1 mile north of East Gore, Nova Scotia. Coal. Coll. P. A. Hacquebard and I. M. Stevenson, 1956. Preparations P266A-C, P289, P290.

6401 Three and a half miles south of Kennetcook, Nova Scotia. Impure coal. Coll. P. A. Hacquebard and G. Playford, 1962. Preparation P295.

6402 Little Ninemile River, 2 miles southeast of East Gore, Nova Scotia. Black carbonaceous shale. Coll. P. A. Hacquebard and G. Playford, 1962. Preparation P296.

6403 Big Marsh, 8½ miles north of Antigonish, Nova Scotia. Coal. Coll. B. C. Murray, 1955. Preparation P265.

6404 Hunters Mountain, 6 miles west of Baddeck, Nova Scotia. Coal. Coll. P. A. Hacquebard and M. S. Barss, 1956. Preparation P277A, B.

6405 Southeast Mabou River, 3¾ miles south of Brook Village, Nova Scotia. Dark grey, shaly siltstone. Coll. D. G. Kelley, 1960. Preparation P278.

6406 Mill Stream, 6 miles northwest of Sussex, New Brunswick. Coal. Coll. J. B. Hamilton, 1959. Preparation P276A, B.

Horton Group (Cheverie Formation)

6407 West shore of Avon River, Nova Scotia, 325 feet south of Blue Beach Fault. Dark grey, micaceous shale. Coll. W. A. Bell, 1913; P. A. Hacquebard and G. Playford, 1962. Preparations P270, P298.

6408 West shore of Avon River, Nova Scotia, 200 feet south of Blue Beach Fault. Dark grey, micaceous shale. Coll. P. A. Hacquebard and G. Playford, 1962. Preparation P297.

6409 Mouth of Avon River near Cheverie Point, Nova Scotia, 12 feet along shore southwest of Windsor contact. Grey siltstone. Coll. P. A. Hacquebard and G. Playford, 1962. Preparation P299.

6410 Mouth of Avon River near Cheverie Point, Nova Scotia, 1,750 feet along shore southwest of Windsor contact. Grey shale. Coll. P. A. Hacquebard and G. Playford, 1962. Preparation P300.

6411 Mouth of Avon River near Cheverie Point, Nova Scotia, 3,335 feet along shore southwest of Windsor contact. Grey shale. Coll. P. A. Hacquebard and G. Playford, 1962. Preparation P304.

Locality 813 is at the type section of the Horton Bluff Formation, but the sample examined is from an unspecified horizon in that unit.

Analytical details and economic prospects of the East Gore coal (locality 6400) are given by Stevenson (1959, pp. 64-65). From the map accompanying the latter publication, it is evident that the East Gore coal, the impure coal at locality 6401, and Hacquebard's (1957) West Gore coal occupy similar stratigraphic positions within the Horton sequence; i.e., they lie approximately on strike. Locality 6402 is also shown as a coal occurrence on Stevenson's (1959) map. It is separated from localities 6400 and 6401 by a tongue-shaped, northeasterly trending area composed of Meguma metasediments of older Palaeozoic age.

Locality 6403 is in the Big Marsh Member of the South Lake Creek Formation (*see* Murray, 1960, p. 34). On lithological criteria, Murray (loc. cit., fig. 13) correlated the Big Marsh Member in its entirety with the Horton Bluff Formation.

The Horton sequence of the Southwest Mabou River has been subdivided (Murray, 1960) into three formations. Locality 6405 lies within the lowest of the units, the Craignish Formation, approximately 750 feet stratigraphically below the base of the conformably overlying Strathlorne Formation. Murray considered that the Craignish Formation predates the Horton Bluff Formation.

The coal from locality 6404 (Hunters Mountain) is a minor constituent of strata that are regarded by D. G. Kelley (personal communication) as equivalent to the Strathlorne Formation.

According to J. B. Hamilton (personal communication), the coal of locality 6406 occurs in Horton strata that have been mapped as Albert Formation, though he considers that it is possibly representative of basal Moncton Group. Murray (1960) regarded the Albert Formation as a correlative of the Strathlorne and Horton Bluff Formations of the Nova Scotian Horton.

Localities 6407, 6408, 6409, 6410, and 6411 are all palynological sampling points in type (Avon River estuary) exposures of the Cheverie Formation. The first two localities are in the Blue Beach section, which according to Bell (1929, p. 40) and Murray (1960, p. 58), comprises basal Cheverie strata. These Blue Beach Cheverie beds terminate abruptly to the north in a prominent faulted contact (the Blue Beach Fault zone) with the Horton Bluff Formation. Localities 6409, 6410, and 6411 are situated on the opposite (east) side of the Avon River estuary,

where approximately 600 feet of upper Cheverie Formation are exposed along the Cheverie shore, southward from their contact with overlying Windsor limestones. The strata there are on the northern limb of a low anticline, the axis of which is at Cheverie Point. Details of this section are given by Bell (1929, pp. 40-41), who noted it subsequently (1960, p. 11) as the best exposure of the formation.

Recovery of miospores from the various samples was accomplished by means of the maceration techniques adopted earlier by the writer (1962, p. 570). Numerous representative slides were made and examined from each residue. In addition several hundreds of miospores were picked from residues and mounted individually. Glycerine jelly was used as mounting medium.

DESCRIPTION OF MIOSPORES

All type and other figured specimens of the present study are referred to by the preparation/slide number, followed by the 'east-west' and 'north-south' mechanical-stage readings, and then the Geological Survey of Canada plant type number. Stage coordinates are those of Leitz Dialux microscope No. 2 (serial No. 538214) in the coal research laboratories of the Geological Survey of Canada, Ottawa, where the material is retained.

In the systematic section below, citation of the geographical and stratigraphical occurrences of previously described species is confined mainly to those known hitherto from strata other than the Horton Group. Species present in the complementary Horton material studied by Hacquebard (1957) will be indicated subsequently in Table I.

Anteturma **SPORITES** H. Potonié, 1893

Turma **Triletes** (Reinsch) Potonié and Kremp, 1954

Subturma AZONOTRILETES Luber, 1935

Infraturma LAEVIGATI (Bennie and Kidston) R. Potonié, 1956

Genus ***Leiotriletes*** (Naumova) Potonié and Kremp, 1954

Type species. L. sphaerotriangulus (Loose) Potonié and Kremp, 1954.

Leiotriletes tortilis n. sp.

Plate I, figures 1–4

Diagnosis. Spores radial, trilete; amb subtriangular with rounded apices and strongly convex to almost straight sides. Laesurae well defined, usually distinctly sinuous; simple or accompanied by narrow lips, 1.5-2μ in both height and total width. Length of laesurae at least one half of the amb radius; often unequal on any one specimen. Exine 4-6.5μ thick, rarely folded; laevigate, or densely sculptured with minute grana which are discernible only with the oil immersion objective. Equatorial margin smooth.

Dimensions (25 specimens). Equatorial diameter 39-59μ (mean 48μ).

Types. Holotype, GSC No. 13052; paratypes, GSC Nos. 13051, 13053, 13054.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype roundly subtriangular, diameter 50μ; prominent, sinuous, unequal laesurae, length three quarters of, to almost equal to, amb radius; slight, narrow lip development; exine virtually laevigate, 4.5μ thick.

Comparison. This species shows some similarity to *Cyclogranisporites flexuosus* Playford, 1962 (p. 585; pl. 79, figs. 13-16), which differs however in possessing much more prominent laesurate lips, distinctly granulate sculpture, and usually circular amb. *Leiotriletes directus* Balme and Hennelly, 1956 (p. 244, pl.

1, figs. 1-4) is smaller than *L. tortilis* n. sp., and has a much thinner, commonly folded exine.

Genus ***Punctatisporites*** (Ibrahim) Potonié and Kremp, 1954

Type species. P. punctatus Ibrahim, 1933.

Punctatisporites debilis Hacquebard, 1957

Plate I, figure 6

Dimensions (25 specimens). Equatorial diameter 40-62μ (mean 50μ).

Types. Hypotype, GSC No. 13056.

Punctatisporites irrasus Hacquebard, 1957

Plate I, figure 5

Dimensions (25 specimens). Equatorial diameter 62-85μ (mean 73μ).

Types. Hypotype, GSC No. 13055.

Punctatisporites limbatus Hacquebard, 1957

Plate I, figures 7, 8

Description of specimens. Spores radial, trilete; amb subcircular to oval. Distinct, straight laesurae extend one half to three quarters of the distance to the equatorial margin; bordered by perceptible to well developed, slightly elevated lips extending 2-6μ on either side. Exine thickness (measured at equator) 4-8μ; probable contact areas marked by considerably thinner exine in subcircular proximal interradial regions. Exine laevigate to finely infragranulate; large-scale folds common.

Dimensions (26 specimens). Equatorial diameter 78-180μ (mean 127μ). This extends by 33μ the lower limit of the size range stated by Hacquebard (1957, p. 308).

Types. Hypotypes, GSC Nos. 13057, 13058.

Punctatisporites planus Hacquebard, 1957

Plate I, figures 9, 10

Dimensions (25 specimens). Equatorial diameter 51-70μ (mean 59μ).

Types. Hypotypes, GSC Nos. 13059, 13060.

Punctatisporites solidus Hacquebard, 1957

Plate I, figure 12

Description of specimens. Spores radial, trilete; amb roundly subtriangular. Laesurae distinct, more or less straight; length, often unequal on a single specimen,

ranges from two thirds to three quarters of amb radius. Lips usually clearly defined, irregularly developed; total width 2-4μ. Exine 3-4.5μ thick; laevigate to indistinctly infrapunctate. Equatorial margin smooth.

Dimensions (20 specimens). Equatorial diameter 50-72μ (mean 60μ).

Types. Hypotype, GSC No. 13062.

Comparison. Spores comparable with *Punctatisporites solidus* have been recorded by Balme and Hassell (1962, pp. 5-6; pl. 1, fig. 4) from the Upper Devonian of Western Australia. However, as indicated by the authors, these spores have stronger lip development which, coupled with their more circular amb, suggests that they probably represent a species distinct from *P. solidus*.

Punctatisporites viriosus Hacquebard, 1957

Plate I, figure 11

Dimensions (20 specimens). Equatorial diameter 65-82μ (mean 75μ).

Types. Hypotype, GSC No. 13061.

Genus ***Gulisporites*** Imgrund, 1960

Type species. G. cochlearius (Imgrund) Imgrund, 1960.

Gulisporites torpidus n. sp.

Plate I, figures 13, 14

Diagnosis. Spores radial, trilete; amb subtriangular with rounded apices and convex to slightly concave sides. Laesurae strongly tectate, length approximately equal to amb radius. Lips dark, rarely dehiscent, often partly or totally obscure the commissures; elevated (4-8μ high), especially in polar region. Total width of lips 9-27μ; often broadest at equator. Exine 3-4.5μ thick; laevigate to finely, irregularly granulate. Equatorial margin smooth.

Dimensions (15 specimens). Equatorial diameter 56-85μ (mean 70μ).

Types. Holotype, GSC No. 13063; paratype, GSC No. 13064.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype 84μ, subtriangular with convex to almost straight sides; conspicuously lipped, non-dehiscent laesurae; lips 5μ high and 9-11μ wide at proximal pole, becoming broader (18-21μ) and cushion-like towards equator, exine 3μ thick, practically laevigate.

Remarks. On the basis of shape, strongly developed laesurate lips, and sculptural characteristics, this species finds suitable inclusion within *Gulisporites* Imgrund. However, no specimens have yet been observed as dehiscent in the manner illustrated by Imgrund (1960, p. 152, fig. 1) for the type species.

Genus *Retusotriletes* Naumova, 1953

Type species. R. simplex Naumova, 1953.

Discussion. This genus is characterized by prominent contact areas which are delimited by perfect or imperfect curvaturae. Potonié (1958) included *Retusotriletes* within the Infraturma Laevigati; certainly the type species, as designated by Potonié, is laevigate, though many of the species ascribed to the genus by Naumova and subsequent Russian authors are conspicuously sculptured with grana, verrucae, coni, &c. Under these circumstances, it may well prove desirable to create a separate suprageneric category to incorporate such azonate miospores, in which the most salient common feature is curvaturate development.

Retusotriletes avonensis n. sp.

Plate I, figures 15, 16; Plate II, figures 1, 2

Diagnosis. Spores radial, trilete; amb subtriangular to somewhat quadrangular. Laesurae extend between three fifths and three quarters of the distance to the equatorial margin and are accompanied by more or less distinct, slightly elevated, sinuous lips that vary from 1.5 to 6μ in overall width. Curvaturae usually clearly developed about radial termini of laesurae but in general are less well defined interradially. Equatorial region thicker than contact areas though not to the extent of constituting a well-defined cingulum. Mesosporoid vaguely evident in some specimens. Exoexine finely and densely infragranulate overall. Periphery smooth. Relatively thin contact areas often folded, especially along lipped laesurae and curvaturate margins.

Dimensions (30 specimens). Equatorial diameter 62-104μ (mean 79μ).

Types. Holotype, GSC No. 13068; paratypes, GSC Nos. 13065, 13066, 13067.

Locus typicus. Horton Group (Cheverie Formation), Nova Scotia, GSC loc. 6408.

Description. Holotype 76μ in diameter; amb subtriangular with rounded apices and convex sides; narrowly lipped laesurae equal three fifths of spore radius, radial termini flanked by distinct curvaturae which become less clearly delineated in interradial areas; thickened equatorial region approximately 10μ broad; exine infragranulate, conspicuously folded along margin of one contact area; mesosporoid vaguely discernible, roughly conformable with limit of contact areas.

Remarks. The possession of curvaturae renders appropriate the inclusion of this species in *Retusotriletes*. Staplin (1960, p. 21) has already noted that many species of the genus show equatorial thickening; such is the case in, for example, *R. semilucensis* Naumova, 1953, *R. sterlibaschevensis* Chibrikova, 1959, *R. crispus* Chibrikova, 1959, and *R. golatensis* Staplin, 1960. Assignment to *Asterocalamotriletes* (Luber) Potonié, 1958 or *Cadiospora* Kosanke, 1950 was considered but rejected because the Canadian species is not cingulate, i.e., it does not exhibit an abrupt, well-defined equatorial thickening of the exoexine, and moreover its laesurae are not terminally forked as is so characteristic of *Cadiospora*.

Representatives of *Retusotriletes* are numerically and stratigraphically important in Devonian strata and are particularly well known from Givetian-Famennian deposits of the Soviet Union (*see* Naumova, 1953; Kedo, 1955, 1957a; Chibrikova, 1959). In contrast, the genus appears to be a relatively trivial component of microfloras of Lower Carboniferous age.

Comparison. *Retusotriletes avonensis* n. sp. shows some similarity to *Euryzonotriletes glabellus* (Waltz) Ishchenko, 1956 (p. 56, pl. 10, fig. 116) which was described from the Lower Carboniferous (Viséan) of the U.S.S.R. The Russian species differs from *R. avonensis* in being smaller and in possessing a clearly delineated spore body bounded equatorially by a thickened girdle ('otorochka').

Genus ***Leiozonotriletes*** Hacquebard, 1957

Type species. *L. insignitus* Hacquebard, 1957.

Discussion. Potonié (1960, pp. 64-65) stated that *Leiozonotriletes* is synonymous with his (1958, p. 28) restricted circumscription of *Archaeozonotriletes* Naumova (type species—*A. variabilis* Naumova). However, the latter genus is cingulate according to Potonié and is thus clearly different from Hacquebard's genus which characteristically shows a mesosporoid enclosed by exoexine that is not equatorially thickened.

Geminospora Balme, 1962 (pp. 4-5, pl. 1, figs. 5-10) appears to differ from *Leiozonotriletes* in possessing distal sculpture of 'close packed grana, short cones and infrabaculae'.

Leiozonotriletes insignitus Hacquebard, 1957

Plate II, figures 14, 15

Leiozonotriletes insignitus Hacquebard, 1957, p. 315, pl. 3, fig. 1.
Leiozonotriletes sp. cf. *Archaeozonotriletes primarius* Naumova, 1953; Hacquebard, 1957, p. 315, pl. 3, fig. 4.
Archaeozonotriletes insignitus (Hacquebard) Potonié, 1960, p. 65.

Description of specimens. Spores radial, trilete; amb roundly subtriangular to subcircular or oval. Laesurae with prominent lip development which is particularly pronounced in proximal polar region; lips thickened, elevated, often sinuous, 3-8μ in overall width. Laesurae approximately two thirds to four fifths of amb radius, i.e., extending to periphery of mesosporoid. Exoexine thick; finely and densely infragranulate to almost laevigate. Intexine, usually distinctly separated from outer layer, forming thin mesosporoid (or 'central body'), the outline of which is roughly conformable with equator.

Dimensions (18 specimens). Overall equatorial diameter 82-145μ (mean 110μ); diameter of mesosporoid 58-105μ (mean 77μ).

Types. Hypotypes, GSC Nos. 13080, 13081.

Remarks. The above specimens extend the lower limit of the size-range of *Leiozonotriletes insignitus*, which thus now incorporates the specimen described

and figured by Hacquebard (1957) as *L.* sp. cf. *Archaeozonotriletes primarius* Naumova, 1953.

Comparison. Hacquebard (loc. cit.) has already noted the similarity between *L. insignitus* and *Archaeozonotriletes primarius* Naumova, 1953 (pp. 34, 83, pl. 3, fig. 8 and pl. 13, fig. 11). Naumova's species has longer laesurae and a further distinction lies in its sculpture of very small, closely packed tubercles.

Infraturma APICULATI (Bennie and Kidston) R. Potonié, 1956

Subinfratuma GRANULATI Dybová and Jachowicz, 1957

Genus ***Granulatisporites*** (Ibrahim) Potonié and Kremp, 1954

Type species. G. granulatus Ibrahim, 1933.

Granulatisporites crenulatus n. sp.

Plate II, figures 8–10

Diagnosis. Spores radial, trilete; amb subtriangular with rounded apices and convex to straight, rarely concave, sides. Laesurae distinct, straight, simple or occasionally with faint lip development; length at least three quarters of amb radius. Exinal sculpture consists of closely spaced grana having rounded to polygonal bases, 0.5-2μ in greatest diameter (average 1μ); height of grana about 0.5μ. Sculpture often considerably diminished in proximal polar region. Exine 2-3.5μ thick, rarely folded.

Dimensions (40 specimens). Equatorial diameter 36-54μ (mean 44μ).

Types. Holotype, GSC No. 13076; paratypes, GSC Nos. 13074, 13075.

Locus typicus. Horton Group (Craignish Formation), Nova Scotia, GSC loc. 6405.

Description. Holotype 48μ, amb subtriangular with rounded apices and irregularly convex sides; simple, straight laesurae extend four fifths of the distance to the equatorial margin; exine 2.5μ thick; dense, comprehensive, granulate sculpture, finer proximally than on distal surface; grana average 1μ in greatest diameter; one minor peripheral fold. Characteristic of specimens included within this species is the more or less continuous, negative microreticulum separating the densely distributed sculpturing elements.

Comparison. In comparison with *Granulatisporites crenulatus* n. sp., *G. microrugosus* Staplin, 1960 (p. 15, pl. 3, fig. 14) has more diverse sculpture, shorter laesurae, and seemingly thinner exine. *Cycadofilicitriletes scrupeus* Luber, 1955 (p. 52, pl. 2, figs. 32, 33) appears to be similar but is said to possess an equatorial structure; its sculpture is termed 'rough-punctate' and this brief description does not enable accurate comparison with *Granulatisporites crenulatus*.

Granulatisporites inspissatus n. sp.

Plate II, figures 6, 7

Diagnosis. Spores radial, trilete; amb subtriangular with straight to convex sides and rounded apices. Laesurae distinct, simple, straight or broadly undulating;

length two thirds to three quarters of amb radius. Exine 2-3μ thick; comprehensive sculpture of fine, densely distributed grana which are just visible at equatorial margin and do not exceed 0.5μ in any dimension. Fairly well defined, dark, presumably thickened, interradial (contact?) area on proximal surface; margin of area conforms with equator, its triangular apices are marked by the ends of the laesurae.

Dimensions (15 specimens). Equatorial diameter 46-57μ (mean 51μ).

Types. Holotype, GSC No. 13072; paratype, GSC No. 13073.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype roundly subtriangular, diameter 52μ; laesurae two thirds of amb radius; exine 2μ thick, finely granulate; conspicuous, darkened, proximal interradial area, 34μ in diameter.

Comparison. Zonotriletes punctulosus Luber (*in* Luber and Waltz, 1938, pp. 26-27, pl. 6, fig. 79) is superficially similar, but is larger, has longer laesurae, and is perhaps zonate or cingulate; its description, however, is insufficiently detailed for precise comparison.

Genus ***Cyclogranisporites*** Potonié and Kremp, 1954

Type species. C. leopoldi (Kremp) Potonié and Kremp, 1954.

Cyclogranisporites commodus n. sp.

Plate II, figures 3–5

Diagnosis. Spores radial, trilete, originally spherical; amb subcircular to oval. Laesurae distinct, simple, straight; length about two thirds of amb radius. Exine about 1μ thick. Proximal and distal hemispheres sculptured with closely spaced (0.5-1μ apart), minute grana having circular to polygonal bases up to 1.5μ (usually 0.5-1μ) in greatest diameter; height of grana averages 0.5μ. Proximal polar sculpture often relatively finer than that of distal surface. Peripheral, arcuate folding common. Equatorial margin finely notched.

Dimensions (20 specimens). Equatorial diameter 32-52μ (mean 41μ).

Types. Holotype, GSC No. 13069; paratypes, GSC Nos. 13070, 13071.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype 42μ, amb subcircular; distinct, straight laesurae extend slightly over three fifths of the distance to the equatorial margin; comprehensive, fine, dense, granulate sculpture; grana about 0.5μ high, up to 1.5μ in basal diameter (average 1μ); exine 1μ thick; one conspicuous peripheral fold.

Comparison. Of previously described species, *Cyclogranisporites minutus* Bhardwaj, 1957a (pp. 83-84, pl. 22, figs. 22, 23) appears to be the most closely comparable; it differs from *C. commodus* n. sp. in possessing shorter and unequal laesurae and probably finer sculpture having a pitted appearance in surface view. *C. leopoldi* (Kremp) Potonié and Kremp (1955, p. 62, pl. 13, figs. 174-178) is generally smaller than *C. commodus* and has less distinct, shorter laesurae; *Granulatisporites frustulentus* Balme and Hassell, 1962 (p. 6, pl. 1, figs. 8, 9) is roundly triangular and has weakly developed laesurae together with a generally

thicker, more strongly granulate exine. The spore figured by Butterworth and Williams (1958, pl. 1, fig. 20: no description) as *Cyclogranisporites* sp., from the Scottish Namurian A, seems close to *C. commodus*.

Subinfraturma VERRUCATI Dybová and Jachowicz, 1957

Genus ***Verrucosisporites*** (Ibrahim) Potonié and Kremp, 1954

Type species. V. verrucosus Ibrahim, 1932.

Verrucosisporites congestus n. sp.

Plate II, figures 11–13

Diagnosis. Spores radial, trilete, originally spherical; amb subcircular to oval. Laesurae distinct to perceptible, simple, straight; length one half to two thirds of amb radius. Strongly developed, comprehensive verrucate sculpture comprising large, usually irregular, mainly discrete verrucae, which are rounded in cross-section. Height of verrucae 3-7μ; bases subcircular to polygonal, 3-25μ in greatest diameter (average 11μ); shape and dimensions variable on any one specimen. Verrucae non-overlapping, usually closely spaced, rarely as much as 10μ apart. Surface of verrucae smooth, or rough due to minute undulations. Exine very thick (6-11.5μ, including sculpture).

Dimensions (62 specimens). Equatorial diameter (including sculpture) 56-101μ (mean 82μ).

Types. Holotype, GSC No. 13078; paratypes, GSC Nos. 13077, 13079.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype subcircular, overall diameter 80μ; simple laesurae extend two thirds of the distance to the equatorial margin; coarse verrucate sculpture; verrucae very closely spaced, 4-6μ high, 7-21μ in basal diameter (average 15μ); fourteen verrucae visible at equator; exine thickness 11μ (inclusive of sculpture). The sculpturing elements of this species are developed similarly on proximal and distal surfaces and at equator.

Comparison. This species is similar to *Verrucosisporites eximius* Playford, 1962 (p. 587, pl. 80, figs. 5-8, text-fig. 5d) but differs in possessing simple, shorter laesurae and rounded verrucae which do not delimit a continuous negative microreticulum. *V. perverrucosus* (Loose) Potonié and Kremp, 1955 (p. 68, pl. 13, fig. 194) lacks distinct trilete sutures, and its sculptural elements are more loosely distributed than in *V. congestus* n. sp. *V. firmus* Loose, 1934 (*see* Potonié and Kremp, 1955, p. 67, pl. 13, figs. 203, 204) is indistinctly trilete and has finer, partly pilate, verrucate sculpture. *Filicitriletes phaleratus* Luber, 1955 (p. 62, pl. 3, fig. 76) exhibits diverse sculpture of "numerous irregular tubercular and rod-like protuberances", some conical in lateral view; moreover, its laesurae appear longer than those of *V. congestus* and are partly obscured by the sculpture.

Verrucosisporites nitidus n. name

Plate III, figures 3–6

Lophotriletes grumosus Naumova, 1953, p. 57, pl. 7, figs. 14, 15.
Lophotriletes aff. *grumosus* Naumova; Ishchenko, 1956, p. 40, pl. 7, fig. 74.

Diagnosis. As given by Naumova (1953, p. 57).

Amplification of diagnosis. Spores radial, trilete; amb circular, subcircular, or roundly subtriangular. Laesurae simple, straight to sinuous, perceptible to obscure (often semi-hidden by sculpture); length one half to four fifths of amb radius. Comprehensive, relatively coarse sculpture consisting of numerous, smooth, discrete, non-overlapping verrucae that are rounded in lateral view and possess circular to roundly polygonal basal outlines. Height of verrucae 1-3μ, greatest basal diameter 2-12μ (average 5μ). Verrucae typically closely spaced, thus separated by a more or less regular and continuous negative microreticulum which is usually sharply defined in low focus. Exine thickness (including sculpture) 2-4μ.

Dimensions (55 specimens). Equatorial diameter (including projections) 28-55μ (mean 41μ). Naumova (1953) and Ishchenko (1956) stated respectively 40-64μ and 30-60μ as size range for this species.

Types. Holotype, as designated by Naumova (1953, p. 57) for *Lophotriletes grumosus* (IGN No. 3450/3612). Unfortunately, Naumova does not indicate which of the two figures (pl. 7, figs. 14, 15) depicts the holotype; hypotypes, GSC Nos. 13084, 13085, 13086, 13087.

Locus typicus. Petino Beds (Upper Frasnian); Petino, Voronezh region, U.S.S.R. (*after* Naumova, loc. cit.).

Remarks. Lophotriletes grumosus Naumova is not conformable with the genus *Lophotriletes* Naumova as emended by Potonié and Kremp (1954), since the latter incorporates miospores of subtriangular shape possessing prominent conate sculpture (as in *Apiculatisporis* Potonié and Kremp, 1956). On the other hand, the species finds suitable inclusion within the genus *Verrucosisporites* (Ibrahim) Potonié and Kremp, 1954. *Lophotriletes grumosus* Naumova, 1953 is a later homonym of *Lophotriletes grumosus* (Ibrahim) Ishchenko, 1952, which is a clearly different species more recently (Potonié and Kremp, 1955) assigned to *Apiculatisporites* (al. *Apiculatisporis*). In any case, combination of *L. grumosus* Naumova with *Verrucosisporites* would be inadmissible owing to the existence of the previously and validly published binary name *Verrucosisporites grumosus* Ibrahim, 1933. Hence the formal proposal herein of the new epithet, *nitidus,* for Naumova's species.

Previous records. Verrucosisporites nitidus n. name has been recorded previously from Upper Devonian and Lower Carboniferous strata of the U.S.S.R. Described initially (Naumova, 1953) from the Upper Frasnian of the Voronezh region, it was recorded subsequently (Ishchenko, 1956) in Tournaisian (possibly also Viséan-Namurian) deposits of the western extension of the Donetz Basin.

Verrucosisporites papulosus Hacquebard, 1957

Plate III, figures 1, 2

Description of specimens. Spores radial, trilete, originally spherical; amb circular to oval. Laesurae distinct to perceptible, simple, straight; length one half

to two thirds of spore radius. Comprehensive exinal sculpture consisting of discrete, low verrucae having rounded to slightly flattened apices; grana sometimes additionally present but in strictly minor proportions. Verrucae up to 2μ high (usually about 1.5μ), 0.5-4μ apart. Bases of verrucae circular, roundly polygonal, or elongate; maximum diameter 1-5μ (average 2μ). Sculpture often conspicuously finer on proximal than on distal hemisphere. Exine 1.5-2μ thick, exclusive of sculpture; peripheral arcuate folding uncommon.

Dimensions (50 specimens). Equatorial diameter 49-66μ (mean 57μ).

Types. Hypotypes, GSC Nos. 13082, 13083.

Genus ***Converrucosisporites*** Potonié and Kremp, 1954

Type species. C. triquetrus (Ibrahim) Potonié and Kremp, 1954.

Converrucosisporites parvinodosus n. sp.

Plate III, figures 7–9

Diagnosis. Spores radial, trilete; amb subtriangular with rounded apices and convex sides. Laesurae distinct, more or less straight; rare, minor lip development. Length of laesurae four fifths of, to almost equal to, amb radius. Exine sculptured with numerous, discrete, low, smooth verrucae that are broadly rounded in cross-section and subcircular to irregularly polygonal in basal outline. Verrucae closely spaced, delimiting continuous, fine, negative microreticulum. Height of verrucae 0.5-1.5μ, more or less uniform on any one specimen; basal diameter 1-6μ. Exine occasionally folded, thickness 2-3μ. Equatorial margin finely notched.

Dimensions (15 specimens). Equatorial diameter 32-51μ (mean 41μ).

Types. Holotype, GSC No. 13089; paratypes, GSC Nos. 13088, 13090.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype roundly subtriangular, 34μ in diameter; laesurae distinct, simple, straight, extending four fifths of the distance to the equatorial margin; exine 2.5μ thick, densely and comprehensively sculptured with low, rounded verrucae, 1-4μ (average 2.5μ) in maximum basal diameter; more or less regular and continuous network of fine channels separate sculpturing elements. The verrucate sculpture of this species is usually somewhat finer proximally than on distal surface.

Comparison. Granulatisporites crenulatus n. sp. closely resembles *Converrucosisporites parvinodosus* n. sp., but differs in possessing distinctly finer (granulate) sculpture. In comparison with *C. parvinodosus, C. sulcatus* (Wilson and Kosanke, 1944, fig. 4) Potonié and Kremp, 1955 is more coarsely verrucate, and *Verrucosisporites pseudoreticulatus* Balme and Hennelly, 1956 (p. 250, pl. 4, figs. 42-44) is much larger and often subcircular in equatorial outline. *Converrucosisporites parvinodosus* is similar to, perhaps conspecific with, *Azonotriletes ruboides* Waltz (*in* Luber and Waltz, 1941), but the latter seems more coarsely sculptured and has shorter laesurae; closer comparison is not possible from the single drawing (pl. 2, fig. 27) and brief description (pp. 16-17) given by Waltz.

Subinfraturma NODATI Dybová and Jachowicz, 1957

Genus ***Anapiculatisporites*** Potonié and Kremp, 1954

Type species. A. isselburgensis Potonié and Kremp, 1954.

Anapiculatisporites ampullaceus (Hacquebard) n. comb.

Plate III, figures 16, 17

Raistrickia ampullacea Hacquebard, 1957, p. 310, pl. 1, figs. 21, 22.
Raistrickia sp. A Hacquebard, 1957, p. 311, pl. 2, fig. 3.

Description of specimens. Spores radial, trilete; amb convexly subtriangular to subcircular or oval. Laesurae simple, more or less straight, indistinct to perceptible; at least two thirds amb radius, often extending to equatorial margin. Prominent distal and equatorial sculpture consisting of long, broad-based, discrete, essentially spinose projections. The upper (narrower) parts of the spinae are frequently broken, in which case the terminations are truncate and the sculpture thus appears partly baculate. Processes characteristically flask-shaped in lateral view; bases subcircular, 2-5μ in diameter, 1.5-8μ apart (average 4μ). Length of (unbroken) spinae 4-9μ. Between nine and twenty processes are visible at equator. Exine of remainder of distal surface and whole of proximal surface laevigate to finely, irregularly granulate; thickness about 2μ.

Dimensions (30 specimens). Equatorial diameter (excluding projections) 40-61μ (mean 52μ).

Types. Hypotypes, GSC Nos. 13097, 13098.

Remarks. Study of numerous specimens in various states of preservation indicates that the two species described by Hacquebard (1957) as *Raistrickia ampullacea* and *R.* sp. A are conspecific. The exclusively distal and equatorial sculpture of essentially spinose processes warrants the assignment of the specimens to the genus *Anapiculatisporites.*

Anapiculatisporites hystricosus n. sp.

Plate III, figures 13–15

Diagnosis. Spores radial, trilete; amb convexly subtriangular. Laesurae more or less straight, distinct to perceptible, extending to equatorial margin or almost so; accompanied by relatively dark, slightly elevated lips that are 3-4μ in overall width. Proximal surface laevigate. Whole of distal surface prominently sculptured with broadly based spinae and coni; sculpturing elements mainly discrete but sometimes fused in groups of up to three individuals. Bases of spinae-coni subcircular in surface view, 1-4μ (average 2.5μ) in diameter, up to 7μ apart. Spinae taper abruptly from their broad, conical, somewhat bulbous bases, thus possessing sharp, slender, apical portions; overall length of spinae 3-6μ. Coni are identical to basal parts of spinae; in lateral view, coni are rounded to slightly pointed, 1-2.5μ (average 1.5μ) in height. Approximately 15-28 coni and spinae project from equatorial margin. Exine 1.5-2.5μ thick, excluding sculpture.

Dimensions (25 specimens). Equatorial diameter (excluding projections) 38-58μ (mean 47μ).

Types. Holotype, GSC No. 13096; paratypes, GSC Nos. 13094, 13095.

Locus typicus. Horton Group (Cheverie Formation), Nova Scotia, GSC loc. 6408.

Description. Holotype roundly subtriangular, diameter 43μ; distinct, straight, conspicuously lipped laesurae attain equatorial margin; distal surface and much of equator bear closely spaced spinae and a few coni; sculptural elements often coalescent at bases, otherwise separated by as much as 5μ; spinae and coni 3-4μ and 1.5-2.5μ high respectively; exine 2.5μ thick; prominent peripheral fold. Spinae/coni ratio is variable in this species, but spinae always predominate in well-preserved specimens. This, together with the obvious conformity of the coni with the prominent, robust, basal parts of the spinae, suggests that the coni probably result from severance of the relatively slender, hence delicate, upper parts of the spinae.

Comparison. Anapiculatisporites ampullaceus (Hacquebard) n. comb. differs from *A. hystricosus* n. sp. in possessing simple indistinct laesurae, together with processes which have thicker upper parts and which appear flask-shaped in lateral view especially when truncated near their apices.

Anapiculatisporites tersus n. sp.

Plate III, figures 10–12

Diagnosis. Spores radial, trilete; amb subtriangular with rounded apices and convex sides. Laesurae perceptible to distinct, simple, more or less straight; length four fifths of, to almost equal to, spore radius. Contact areas usually indistinct; curvaturae imperfectae developed about one or more of the radial termini of the laesurae. Sparsely distributed spinose sculpture restricted to distal surface and equator. Slender, gradually tapering, often bent spinae have subcircular bases and are 2-9μ apart. Length of spinae 1-3.5μ, basal diameter about 0.5μ (rarely as much as 1μ). Rare, minute coni sometimes additionally present. Exine otherwise laevigate, 2-3μ in thickness.

Dimensions (15 specimens). Equatorial diameter 39-56μ (mean 46μ).

Types. Holotype, GSC No. 13091; paratypes, GSC Nos. 13092, 13093.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype convexly subtriangular, diameter 43μ; perceptible, straight laesurae equal four fifths of amb radius; contact areas poorly defined; curvaturae imperfectae extend from distal limit of one laesura; sculpture confined to distal and equatorial regions; spinae 1.5-3.5μ long, 2-8μ apart, *ca.* 0.5μ in basal diameter; ten spinae visible at equatorial margin; few scattered minute coni also present; exine averages 2μ in thickness. The species is characterized by fine, loosely distributed, spinose sculpturing elements, extensive laesurae, and development of imperfect curvaturae.

Comparison. Acanthotriletes tenuispinosus Naumova var. *famenensis* Naum-

ova, 1953 (p. 106, pl. 16, fig. 18) is smaller (20-30μ) and has denser sculpture.

Genus ***Apiculatasporites*** Ibrahim, 1933 *sensu* Potonié, 1960

Type species. A. spinulistratus (Loose) Ibrahim, 1933.

Apiculatasporites compactus n. sp.

Plate III, figures 21, 22

Diagnosis. Spores radial, trilete; amb circular to subcircular or oval. Laesurae simple, straight or slightly sinuous, distinct to perceptible; length two fifths to one half of amb radius. Exine densely sculptured with pointed to slightly rounded coni that are circular to roundly polygonal in basal outline; sculpture usually comprehensive but sometimes relatively minor or absent in proximal, interradial (contact) areas. Coni 1-2.5μ high, 1-3.5μ in basal diameter; mainly discrete and up to 3μ apart. Exine about 2.5μ thick, rarely folded.

Dimensions (25 specimens). Equatorial diameter 62-92μ (mean 78μ).

Types. Holotype, GSC No. 13102; paratype, GSC No. 13103.

Locus typicus. Horton Group (Cheverie Formation), Nova Scotia, GSC loc. 6407.

Description. Holotype 79μ in diameter, subcircular; leasurae equal two fifths of spore radius; proximal and distal hemispheres uniformly sculptured with small, closely spaced, rarely coalescent coni of which seventy-eight are visible along the equator; coni average 1μ apart. The coni of this species are often sufficiently closely spaced to delimit a fine, more or less regular, negative microreticulum.

Comparison. Acanthotriletes trichacanthus (Luber *in* Luber and Waltz, 1941, p. 55, pl. 12, fig. 188) Ishchenko, 1956 (p. 28, pl. 4, fig. 38) has sculpture similar to *Apiculatasporites compactus* n. sp., but is typically roundly triangular and possesses longer laesurae. The species was described and illustrated further by Luber (1955, pp. 52-53, pl. 2, figs. 39-41) as *Angaropteritriletes trichacanthus* (Luber), which possesses a central body (?mesospore) and considerable sculptural diversity, neither of which is an attribute of *Apiculatasporites compactus.* In comparison with *A. compactus, Apiculatisporites subspinosus* Artüz, 1957 (p. 245, pl. 3, fig. 16) has less densely distributed coni, longer laesurae, and a thinner, frequently folded exine.

Genus ***Pustulatisporites*** (Potonié and Kremp) Imgrund, 1960

Type species. P. pustulatus Potonié and Kremp, 1954.

Pustulatisporites gibberosus (Hacquebard) n. comb., emend.

Plate III, figures 18–20

Raistrickia? gibberosa Hacquebard, 1957, p. 310, pl. 2, fig. 1.

Emended diagnosis. Spores radial, trilete; amb roundly subtriangular to subcircular. Laesurae distinct to indistinct, simple, straight; length two thirds of, to almost equal to, spore radius. Apart from proximal interradial (contact) areas,

exine bears prominent, rather loosely distributed, smooth verrucae together with subordinate blunt coni. Sculpturing elements 1-8μ high, 1.5-15μ in maximum basal diameter, 1-10μ apart (usually about 5μ); bases circular to roundly elongate in surface view. Nine to seventeen elements project from equator. Sides of verrucae parallel or upwardly convergent; tops flat or broadly rounded. Exine otherwise infragranulate to almost laevigate; thickness 1.5-3μ.

Dimensions (24 specimens). Equatorial diameter (excluding projections) 43-65μ (mean 53μ). The holotype (*see* Hacquebard, 1957, pl. 2, fig. 1) measures 64μ, exclusive of projections.

Types. Hypotypes, GSC Nos. 13099, 13100, 13101.

Remarks. The above emendation is based upon study of numerous specimens from the Horton Group, additional to that described by Hacquebard (1957). The original tentative assignment to *Raistrickia* is not endorsed because the height of the sculptural elements is exceeded, often considerably, by their diameter. Moreover, the mixed, not closely spaced, sculpture (verrucae and coni) is not conformable with *Verrucosisporites* (or *Converrucosisporites*) but is more in accord with *Pustulatisporites* to which the species is consequently here allocated.

Comparison. Pustulatisporites gibberosus (Hacquebard) n. comb., emend. closely resembles the Russian Lower Carboniferous species *Azonotriletes raritubercula*tus Sadkova (*in* Luber and Waltz, 1941, p. 56, pl. 11, fig. 191), which was described subsequently by Ishchenko (1956, p. 41, pl. 6, fig. 78) as *Lophotriletes raritubercula*tus (Sadkova). However, the latter is larger (75-85μ) with consistently circular amb and typically has shorter laesurae extending only one third of the distance to the equator.

Pustulatisporites pretiosus n. sp.

Plate IV, figures 5–7; Plate V, figure 1; Figure 1a

Diagnosis. Spores radial, trilete; amb subtriangular with rounded apices and convex to almost straight sides. Laesurae extend to equatorial margin or almost so; often totally obscured by conspicuous, elevated, flexuous lips. Distal surface exhibits diverse sculpture of mainly verrucae, accompanied by subordinate grana

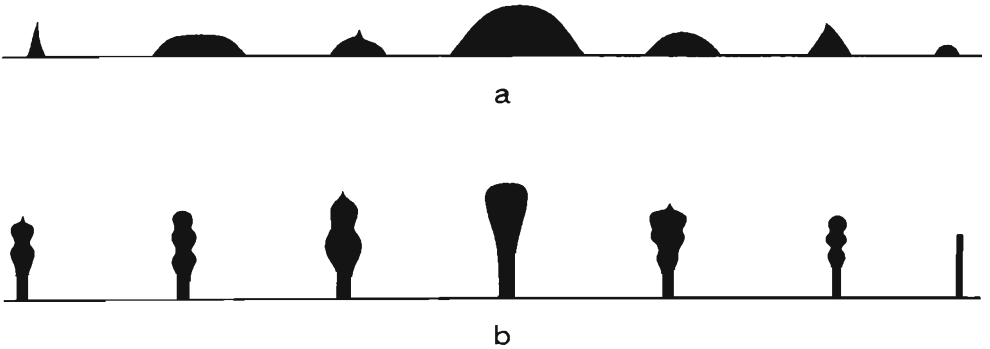

FIGURE 1. Illustrating the diversity of the sculptural elements (as seen in lateral view) characteristic of (a) *Pustulatisporites pretiosus* n. sp., and (b) *Raistrickia abstrusa* n. sp. Approximate magnification ×3,500.

and coni and, less frequently, by small spinae. Sculpture usually sparsely and irregularly distributed, often evident at equatorial margin. Verrucae relatively low, broadly rounded, sometimes bearing a single minute conus or spina. Bases of verrucae subcircular, usually discrete but may be fused in groups of up to three individuals. Basal width of verrucae 1.5-8μ, height 1-4μ. Apart from distal sculpturing elements, exine is finely and densely infragranulate, 2-3μ thick. Irregular secondary folding common. Mesosporoid occasionally perceptible as an ill-defined, darker, 'central body' which is more or less conformable with equator and is roughly three quarters of overall diameter.

Dimensions (115 specimens). Equatorial diameter 98-195μ (mean 149μ).

Types. Holotype, GSC No. 13109; paratypes, GSC Nos. 13108, 13110, 13111.

Locus typicus. Horton Group (Cheverie Formation), Nova Scotia, GSC loc. 6407.

Description. Holotype subtriangular, diameter 156μ; laesurae almost attain equatorial margin; prominent, sinuous lips 2-5μ in overall width; distal surface bears sparsely, irregularly distributed, mainly discrete verrucae, together with a few grana and rare coni; verrucae 1.5-7μ in basal diameter; some verrucae possess small spinose terminations; remainder of distal surface and whole of proximal surface finely and densely infragranulate; exine *ca.* 3μ thick; minor peripheral folding associated with radial terminus of one laesura; mesosporoid not represented. The distal sculpture of some specimens is concentrated in distal polar region such that projections are not visible equatorially. Laesurate lips are often partly lost in preservation and/or preparation.

Comparison. Angaropteritriletes pallens Luber, 1955 (p. 53, pl. 2, fig. 42) is much smaller (60μ) and possesses fine, dense, entirely spinose sculpture.

Remarks. The nature and diversity of the exinal sculpture of this species are in accord with the genus *Pustulatisporites*. The occasional presence of a mesosporium-like body is an interesting, though hardly diagnostic, feature of *P. pretiosus* n. sp.

Genus ***Acanthotriletes*** (Naumova) Potonié and Kremp, 1954

Type species. A. ciliatus (Knox) Potonié and Kremp, 1954.

Acanthotriletes hacquebardii n. sp.

Plate IV, figures 1–4

Diagnosis. Spores radial, trilete; amb circular, subcircular, or broadly roundly subtriangular. Laesurae obscure to perceptible, simple, more or less straight; length two fifths to one half of spore radius. Exine 3-4.5μ thick; conspicuous, spinose sculpture developed uniformly on both proximal and distal surfaces. Spinae taper uniformly, or somewhat irregularly, to sharply pointed apices, which however are often broken, thus truncate, in poorly preserved specimens. Spinae often bent, usually closely spaced and discrete; sometimes fused in pairs—at bases only, or for some distance along their length. Dimensions of spinae characteristically

variable: length 4-20μ, basal diameter 1.5-8μ. Bases of spinae subcircular in surface view, up to 8μ (average 4μ) apart. Small, strictly subordinate coni sometimes additionally present. Sixteen to thirty-six elements project from the equatorial margin. Apart from spinae and rare coni, exine is laevigate.

Dimensions (55 specimens). Equatorial diameter (excluding sculpture) 62-103μ (mean 81μ).

Types. Holotype, GSC No. 13105; paratypes, GSC Nos. 13104, 13106, 13107.

Locus typicus. Horton Group (Cheverie Formation), Nova Scotia, GSC loc. 6408.

Description. Holotype subcircular, 97μ in diameter; laesurae almost entirely obscured by sculpture, length about one half of amb radius; overall, dense, spinose sculpture; spinae non-coalescent, basal diameter 2-5μ, length 5-12μ, spacing 2-8μ; no coni present; thirty-two spinae project from equator; exine 3.5μ thick. Amongst specimens included within this species, considerable variation in both size and spacing of the spinose elements often occurs. This variation is observed to be continuous in any given sample; hence there is no warranty for the recognition of more than one species, or even for subspecific subdivision.

Comparison. Acanthotriletes macrurus (Luber) Ishchenko var. *giganteus* Ishchenko, 1952 (p. 29, pl. 6, fig. 68), which was described from the Middle Carboniferous of the Donetz Basin, seems very similar to, perhaps conformable with, *A. hacquebardii* n. sp. Ishchenko (loc. cit.) states a clear, if restricted, diagnosis for his new variety but does not indicate its relationship, seemingly remote, with Luber's species *A. macrurus*, which is also present in his Donetz Basin microfloras. The latter species has been assigned to another genus, *Apiculatisporis* (*al. Apiculatisporites*), by Potonié and Kremp (1955); on the other hand, Ishchenko's variety *giganteus* seems clearly conformable with *Acanthotriletes* and thus probably represents a distinct species. It is noteworthy that forms approaching Luber's species have not yet been observed in the Horton Group material, either separately or in association with the albeit variable *A. hacquebardii.* Because of the uncertainty regarding circumscription and specific relationship of the Russian variety, it is not here placed in synonymy with *A. hacquebardii.* Future work may well justify such a procedure.

A. galeritus Ishchenko, 1956 (p. 30, pl. 4, fig. 44) is generally smaller (60-65μ) and has longer laesurae together with irregularly distributed spinae. The closely related Namurian species described by Neves (1961) as *Ibrahimispores brevispinosus* and *I. magnificus* differ from *A. hacquebardii* in possessing hollow spinae that are apically thickened; the laesurae of *I. brevispinosus* are considerably longer than those of *A. hacquebardii.*

Remarks. The species is assigned to *Acanthotriletes* (Naumova) on the basis of its prominent spinose sculpture. It is noteworthy that Potonié and Kremp (1954) did not specify either triangular or circular amb as diagnostic of the genus, and indeed assigned to it species of both, and intermediate, shapes.

It appears difficult to distinguish *Ibrahimispores* Artüz 1957 from *Acanthotriletes*, and unfortunately Artüz did not compare the two genera. Perhaps the

'fine and thick punctation' and loosely distributed spinae of *Ibrahimispores* may prove to be meaningful criteria.

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

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

Grandispora echinata Hacquebard, 1957

Plate V, figure 2

Dimensions (32 specimens). Overall equatorial diameter 59-96μ (mean 73μ); diameter of mesosporoid 42-76μ (mean 58μ).

Types. Hypotype, GSC No. 13112.

Remarks. To the specific diagnosis given by Hacquebard (1957, p. 317) the following observations can be added. The laesurae are usually accompanied by elevated, sinuous lips, which may simulate exinal folds and are of variable width (up to 7μ overall). The holotype (*see* Hacquebard, 1957, pl. 3, fig. 17) shows irregular lip development. The spinose/conate sculpture of the exoexine is confined mainly to the distal surface and proximal equatorial region. In most specimens, the exoexine of proximal interradial (contact) areas is infragranulate. The mesosporoid is not always clearly defined.

Genus ***Spinozonotriletes*** Hacquebard, 1957

Type species. *S. uncatus* Hacquebard, 1957.

Spinozonotriletes conspicuus n. sp.

Plate V, figures 3, 4

Diagnosis. Spores radial, trilete; amb roundly subtriangular. Laesurae straight, perceptible to distinct, simple or accompanied by minor, narrow lip development; extending to, or just beyond, margin of intexine. Exine differentiated, the relatively thick (2-4μ), sculptured exoexine enclosing a thin (less than 1μ), intexinal 'central body' (mesosporoid), the outline of which is not always distinct but is generally conformable with equator. Prominent, coarse, spinose sculpture restricted to distal surface and equator. Spinae taper uniformly from broad bases to pointed apices; often curved or broken. Spinae scattered to closely spaced, sometimes fused in pairs at bases only; length 9-24μ, basal diameter 4-13μ. Apart from large spinae, exoexine finely and densely infragranulate-punctate; sometimes additionally bearing a few small coni/spinae around equator.

Dimensions (28 specimens). Overall equatorial diameter (excluding spinae) 76-110μ (mean 92μ); diameter of mesosporoid 49-80μ (mean 65μ).

Types. Holotype, GSC No. 13114; paratype, GSC No. 13113.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype subtriangular with rounded apices and convex sides, diameter 99μ; mesosporoid perceptible, margin conformable with equator, 79μ in diameter; distinct, simple, straight laesurae extend to mesosporoid margin; finely

infrapunctate-granulate exoexine, 2-3μ thick, bearing large, loosely distributed (3-30μ apart) spinae on distal surface and around equator; basal diameter of spinae 5-12μ, length 13-21μ; other very small spinae/coni (up to 2μ in basal diameter and 3μ in length) developed on part of equator. Characteristic of specimens assigned to this species are the long and robust spinae which show notable variation in both size and density of distribution.

Comparison. Spinozonotriletes conspicuus n. sp. shows some resemblance to *Archaeotriletes incompositus* Chibrikova, 1959 (pp. 44-45, pl. 3, fig. 1) which was described from Givetian strata of Bashkiria, U.S.S.R. However, the latter species is generally smaller than *S. conspicuus*, its spinae are frequently longer and crowded at the 'thickened' periphery, and its, often indiscernible, laesurae do not attain the body margin. Chibrikova does not specify whether the spinose sculpture of *A. incompositus* is developed on both or only one of the surfaces.

S. conspicuus differs from *S. uncatus* Hacquebard, 1957 in lacking elevated, flange-like lips; and from *S. tenuispinus* Hacquebard, 1957 in having much coarser spinose projections.

Spinozonotriletes tenuispinus Hacquebard, 1957

Plate V, figures 6, 7

Dimensions (6 specimens). Overall equatorial diameter (excluding spinae) 87-127μ (mean 104μ); diameter of mesosporoid 57-94μ (mean 74μ).

Types. Hypotypes, GSC Nos. 13116, 13117.

Spinozonotriletes uncatus Hacquebard, 1957

Plate V, figure 5

Dimensions (21 specimens). Overall equatorial diameter (excluding spinae) 75-152μ (mean 109μ); diameter of mesosporoid 59-114μ (mean 83μ).

Types. Hypotype, GSC No. 13115.

Remarks. Dettmann and Playford (1963, p. 680, pl. 96, figs. 6-9) have discussed and illustrated structural and morphological details of this species as revealed by sections cut at 3μ intervals transverse to the equatorial plane. These sections indicate that the thin, homogeneous intexine, which constitutes the mesospore, is loosely enveloped by the much thicker, spinose-sculptured exoexine, which is itself composed of granules and forms the elevated laesurate lips.

Previous records. Spinozonotriletes uncatus appears to be a species of considerable stratigraphical value. Following its initial description (Hacquebard, 1957) from the West Gore and Blue Beach samples of the Horton Group, *S. uncatus* was reported as a diagnostic element of the Rarituberculatus Assemblage (Tournaisian), the older of two microfloras delineated by Playford (1963) in the Lower Carboniferous sequence of Spitsbergen.

Subinfraturma BACULATI Dybová and Jachowicz, 1957

Genus ***Raistrickia*** (Schopf, Wilson, and Bentall) Potonié and Kremp, 1954

Type species. R. grovensis Schopf *in* Schopf, Wilson, and Bentall, 1944.

Raistrickia abstrusa n. sp.

Plate VI, figures 1–3; Figure 1b

Diagnosis. Spores radial, trilete; amb subtriangular with broadly rounded apices and convex, occasionally almost straight, sides. Laesurae distinct to perceptible, straight or slightly curved, simple; length two fifths to one half of amb radius. Exine sculptured with loosely and rather irregularly distributed, small, often bent processes that are 0.5-1μ in basal diameter, 2-5μ long, and 2-8μ apart. Processes typically spatulate or sub-spatulate in lateral aspect, but sides often show a series of minute subsidiary rounded nodes that give a transversely segmented appearance. Tops of processes diverse-truncate, slightly rounded, sometimes bearing a minute pointed conus or spina. Minute rodlets sometimes additionally present, but in minor proportions. Sculpture often considerably diminished to absent in proximal polar region. Exine otherwise laevigate or very finely and irregularly granulate; thickness 1.5-2μ. Exinal folding minor or absent.

Dimensions (15 specimens). Equatorial diameter 54-69μ (mean 62μ).

Types. Holotype, GSC No. 13118; paratypes, GSC Nos. 13119, 13120.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype broadly roundly subtriangular, 64μ in diameter; laesurae simple, straight, not well defined, extending about one half of the distance to the equatorial margin; processes of distal and equatorial regions are more or less spatulate in lateral view, uniformly or irregularly tapering—basal diameter 0.5-1μ, diameter at top 1-1.5μ, length 2-3μ, spacing 2-8μ; seventeen processes visible along equatorial margin; proximal surface bears minute bacula; exine otherwise laevigate, 1μ thick. Nature and diversity of the sculpturing elements characteristic of this species are evident only with the oil immersion objective.

Remarks. Distribution, small size, and character of the sculptural processes serve to distinguish this species from previously described representatives of the genus.

Raistrickia baculosa Hacquebard, 1957

Plate VI, figure 4

Dimensions (20 specimens). Equatorial diameter (excluding projections) 64-91μ (mean 77μ).

Types. Hypotype, GSC No. 13121.

Raistrickia clavata Hacquebard, 1957, here emended

Plate VI, figures 5–10

Raistrickia clavata Hacquebard, 1957, p. 310, pl. 1, fig. 25.
Raistrickia pistillata Hacquebard, 1957, pp. 310-311, pl. 2, fig. 2.

Emended diagnosis. Spores radial, trilete; amb roundly subtriangular, oval, subcircular, or circular. Laesurae usually distinct, simple, more or less straight; length, often unequal on same specimen, ranges from one half to nine tenths of spore radius. Prominent, comprehensive, pilate sculpture consisting of crowded to loosely distributed, smooth, discrete, club- or mushroom-shaped processes; small, pointed to rounded coni and some verrucae often additionally present in minor proportions. Basal diameter of processes 1-6μ, length 2.5-12μ, width of (expanded) heads 2.5-10μ. Sculptural elements vary in size and shape on any given specimen; sculpture generally coarser and denser on distal surface and equator than on proximal surface. Eight to twenty-two processes developed at equator. Exine (excluding sculpture) 1.5-3μ thick.

Dimensions (140 specimens). Equatorial diameter (excluding projections) 48-85μ (mean 67μ).

Types. Hypotypes, GSC Nos. 13122, 13123, 13124, 13125, 13126, 13127.

Remarks. The species described above is only sparingly represented in the Horton Group (West Gore) sample investigated by Hacquebard (1957), and its original separation into two specific taxa—*Raistrickia clavata* and *R. pistillata*—seemed reasonable. However, the present writer's observations on a large number of these distinctively sculptured spores provide ample evidence that they are representative of a single species (as diagnosed above) which exhibits continuous, but not extreme, morphological variation in shape and sculptural characteristics.

Raistrickia ponderosa n. sp.

Plate VI, figures 11, 12; Plate VII, figure 1

Diagnosis. Spores radial, trilete, originally spherical; amb circular to subcircular. Laesurae simple, straight, usually obscured by sculpture; length one half to three quarters of amb radius. Proximal and distal hemispheres sculptured densely and uniformly with numerous, mostly discrete, smooth, stout, pila- and bacula-like processes, together with some verrucae and rare coni. Bases and tops of processes have more or less circular outline in surface view. Processes either show some convergence upwards to truncated tops, or, more typically, expand slightly near apices to form rounded heads. Length of processes 3.5-11μ; basal diameter 2.5-7μ. Exine very thick (4-7μ, excluding projections).

Dimensions (36 specimens). Equatorial diameter (excluding projections) 69-115μ (mean 90μ).

Types. Holotype, GSC No. 13129; paratypes, GSC Nos. 13128, 13130.

Locus typicus. Horton Group (Cheverie Formation), Nova Scotia, GSC loc. 6408.

Description. Holotype subcircular, diameter 87μ; laesurae partly obscured, length approximately one half of spore radius; crowded, occasionally coalescent, subcylindrical projections, 5-10μ long, 3-7μ broad at base; twenty-eight elements project at equator; exine otherwise laevigate, 6μ thick.

Remarks. This species appears intermediate between the genera *Verrucosi-*

sporites and *Raistrickia*. It is assigned to the latter on the grounds that its predominant sculptural elements have the proportions of bacula-pila and not of verrucae.

Comparison. *Verrucosisporites tuberosus* (Knox, 1950, p. 319, pl. 17, fig. 236) Potonié and Kremp, 1955 appears similar but has shorter laesurae together with sculptural elements that do not appear to show apical expansion. *Lophotriletes atratus* Naumova, 1953 (p. 123, pl. 18, fig. 17), described also by Ishchenko (1956, p. 41, pl. 6, fig. 77), resembles *Raistrickia ponderosa* n. sp. but differs in its smaller size (40-55μ), longer laesurae, and finer sculpture. In comparison with *R. clavata* Hacquebard, emend., *R. ponderosa* is generally larger and possesses a thicker, more uniformly sculptured exine and consistently circular (or subcircular) amb.

Genus ***Schopfites*** Kosanke, 1950

Type species. *S. dimorphus* Kosanke, 1950.

Schopfites augustus n. sp.

Plate VII, figures 2–7; Figure 2

Diagnosis. Spores radial, trilete; amb circular, subcircular, or broadly roundly subtriangular. Laesurae straight or slightly curved, distinct, simple; extending three fifths to four fifths of the distance to the equatorial margin. Proximal surface laevigate. Whole or most of distal surface conspicuously sculptured with sparsely distributed to closely packed projections of variable shape and size; low, rounded to pointed coni and small verrucae often additionally present, usually in equatorial region. In general, sculptural elements increase progressively, in size and density of distribution, from the equatorial margin (where they are either absent or inconspicuous) to the distal polar region (where they are very large, usually closely spaced, and often basally coalescent). Processes subcircular to polygonal in basal outline; variable outline in lateral view with parallel, upwardly convergent, or upwardly divergent sides and rounded, truncated, roundly pointed, or irregular tops. Processes thus include bacula, pila, blunt spinae, and narrow ridge-like elevations; height 2.5-17μ, basal diameter 1-10μ, diameter at top 2-13μ. Sculptural diversity evident on any given specimen. Exine thickness 2-4μ; thicker on distal surface than proximally. One or two large-scale folds often present on proximal surface.

Dimensions (70 specimens). Equatorial diameter 54-122μ (mean 85μ).

FIGURE 2. Diagrammatic lateral view of sculptural elements characteristic of the distal surface of *Schopfites augustus* n. sp. Approximate magnification ×1,000.

Types. Holotype, GSC No. 13138; paratypes, GSC Nos. 13137, 13139, 13140, 13141.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype subcircular, 92μ in diameter; laesurae two thirds amb radius; relatively thin, laevigate, proximal surface conspicuously folded about one laesura; most of distal surface bears closely spaced, large projections of diverse size and shape; a few small verrucae and low rounded coni in distal equatorial region. Amongst specimens included within this variable species, there is no general correlation between spore diameter and size/spacing of sculptural elements.

Comparison. The consistently circular *Schopfites dimorphus* Kosanke, 1950 (pp. 52-53, pl. 13, figs. 1-3) has less diverse sculptural elements which appear to be distributed more or less evenly on the distal surface and which are usually clearly evident at the equator, especially interradially. *S. colchesterensis* Kosanke, 1950 (p. 53, pl. 13, fig. 4) differs from *S. augustus* n. sp. in possessing shorter and more uniform projections which "frequently ..... extend well onto the proximal surface".

Infraturma MURORNATI Potonié and Kremp, 1954

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

Type species. C. florida Hoffmeister, Staplin, and Malloy, 1955.

Convolutispora cf. *finis* Love, 1960

Plate VIII, figures 1, 2

Description of specimens. Spores radial, trilete; amb circular to broadly roundly subtriangular. Laesurae perceptible to distinct, simple, straight; length two thirds to three quarters of amb radius. Comprehensive rugulate sculpture comprising relatively fine, low, smooth, sinuous muri, which both ramify and terminate freely. Muri closely spaced but non-overlapping; tops rounded to somewhat flattened. Lumina, where delimited, are of highly irregular shape and size. Muri 1-3μ high, 1-5μ broad. Exine 3.5-5μ thick (including muri); occasionally showing large-scale compression folds. Equatorial margin finely notched.

Dimensions (25 specimens). Equatorial diameter 77-113μ (mean 94μ).

Types. Hypotypes, GSC Nos. 13144, 13145.

Comparison. The specimens described above seem very close to *Convolutispora finis* Love, 1960 (pp. 115-116, pl. 1, fig 7, text-fig. 5) which was reported from the Pumpherston Shell Bed (Viséan) of Scotland. However, the Canadian specimens appear to possess a slightly coarser rugulate sculpture.

Convolutispora vermiformis Hughes and Playford, 1961

Plate VII, figures 8, 9

Convolutispora flexuosa forma *minor* Hacquebard, 1957, p. 312, pl. 2, fig. 10.

Dimensions (20 specimens). Equatorial diameter 56-77μ (mean 66μ).

Types. Hypotypes, GSC Nos. 13142, 13143.

Remarks. The present writer (1962) considered *Convolutispora flexuosa* forma *minor* Hacquebard, 1957 to be conformable with the species *C. vermiformis* Hughes and Playford, 1961 (p. 30, pl. 1, figs. 2-4). This is confirmed by direct comparison of representatives of these two Lower Carboniferous taxa from respectively the Horton Group of Nova Scotia and the Billefjorden Sandstones of Spitsbergen. Because specific, rather than infraspecific, ranking is considered more justified and appropriate for the spores, the specific epithet given by Hughes and Playford is adopted.

Previous records. Described initially from the Mississippian Horton Group of Nova Scotia (Hacquebard, 1957), this species was reported subsequently from probable Frasnian coal of Melville Island, Canadian Arctic Archipelago (McGregor, 1960) and from the Lower Carboniferous of Spitsbergen (Hughes and Playford, 1961; Playford, 1962).

Genus ***Microreticulatisporites*** (Knox) Potonié and Kremp, 1954

Type species. M. lacunosus (Ibrahim) Knox, 1950.

Microreticulatisporites hortonensis n. sp.

Plate VIII, figures 3, 4

Microreticulatisporites sp. A of Hacquebard, 1957, p. 311, pl. 2, fig. 6.

Diagnosis. Spores radial, trilete; amb circular, subcircular, or broadly roundly subtriangular. Laesurae distinct to perceptible, simple, straight, often unequal; length one half to four fifths amb radius. Microreticulate sculpture developed on both proximal and distal surfaces. Lumina 1-5μ apart, sharply defined in low focus; shape irregular on same specimen, ranging from circular (diameter 0.5-2μ) to narrowly, sinuously, sometimes dichotomously, elongate (up to 6μ long). Muri smooth, relatively broad; average height 1μ. Exine 1.5-2.5μ thick (including muri).

Dimensions (25 specimens). Equatorial diameter 41-58μ (mean 49μ).

Types. Holotype, GSC No. 13146; paratype, GSC No. 13147.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype oval, 48μ in diameter; distinct, simple laesurae equal approximately one half of spore radius; comprehensively microreticulate; lumina somewhat larger proximally than on distal hemisphere; one marginal fold; exine 2μ thick; equatorial margin undulating to notched.

Comparison. The sculpture of *Microreticulatisporites hortonensis* n. sp. is not unlike that exhibited by representatives of the genus *Foveolatisporites* Bhardwaj, 1955. However the 'apical lid' structure characteristic of the latter (*see* Bhardwaj, 1957b, pp. 119-120) is not developed in the Horton species, which is thus conformable with *Microreticulatisporites* (Knox) Potonié and Kremp, 1954 (*non* Bhardwaj, 1955, p. 127). *M. hortonensis* differs from *Foveosporites insculptus* Playford, 1962 (p. 601, pl. 85, figs. 3-5) in its smaller size, thinner exine, and sculptural characteristics (i.e. microreticulate rather than punctate/vermiculate).

Genus ***Dictyotriletes*** (Naumova) Potonié and Kremp, 1954

Type species. D. bireticulatus (Ibrahim) Potonié and Kremp, 1954.

Dictyotriletes admirabilis n. sp.

Plate VIII, figures 5–8

Diagnosis. Spores radial, trilete, originally spherical; amb circular to subcircular. Laesurae simple or with narrow sinuous lips, distinct, more or less straight, often unequal on same specimen; length ranges from one half of, to almost equal to, amb radius. Broadly meshed reticulate sculpture developed on both proximal and distal hemispheres. Sparse, very low, narrow, gently curving muri enclose large lumina of variable shape. Muri rarely exceed 0.5μ in either height or width, but are usually well defined. Muri often join in vicinity of equator; occasional slight expansion at junctions. Apart from muri, exine is laevigate to finely and densely granulate, and 3-4μ thick. Peripheral folding often associated with muri.

Dimensions (55 specimens). Equatorial diameter 50-75μ (mean 63μ).

Types. Holotype, GSC No. 13148; paratypes, GSC Nos. 13149, 13150, 13151, 13152, 13153, 13154, 13155.

Locus typicus. Horton Group, Nova Scotia, GSC loc. 6400.

Description. Holotype subcircular, 64μ in diameter; distinct, simple laesurae extend one half to two thirds of the distance to the equatorial margin; comprehensive, very fine, open-meshed reticulum with broadly curved, thread-like muri; exine additionally bears minute, closely spaced grana and is 3μ thick. Some specimens possess more or less symmetrically disposed muri prescribing, for instance, a quadrangular, concavely-sided lumen on each surface (*see* Pl. VIII, fig. 7). In many examples, however, mural arrangement is irregular.

Comparison. This species resembles *Reticulatisporites scrobiculatus* Kosanke, 1950 (p. 27, pl. 4, fig. 6) but is considerably smaller and has finer muri and non-punctate exine.

Dictyotriletes submarginatus n. sp.

Plate VIII, figures 9–13

Diagnosis. Spores radial, trilete; amb subtriangular with convex sides and rounded or slightly pointed apices. Laesurae straight to sinuous, distinct, extending almost to equator; accompanied by conspicuous, elevated, thickened lips that are 1-3μ in overall width and merge into the thickened equatorial region. Distal surface reticulate, subreticulate, to rugulate, with low, smooth, narrow, sinuous muri which may both anastomose and terminate freely. Muri 1-2.5μ high, 1-4μ broad, rounded to pointed in lateral aspect. Lumina, where delimited, are usually of highly irregular shape and size (range 1-11μ in greatest dimension). More or less distinct and continuous 'pseudocingulum' is frequently present; caused by slight expansion and/or partial fusion of muri in distal equatorial region which consequently appears relatively darker and thicker. Proximal surface usually entirely

laevigate, although some specimens show strictly marginal encroachment of muri thus enhancing the cingulate effect. Equatorial margin irregularly undulating to incised.

Dimensions (30 specimens). Equatorial diameter 53-70μ (mean 62μ).

Types. Holotype, GSC No. 13156; paratypes, GSC Nos. 13157, 13158, 13159, 13160.

Locus typicus. Horton Group (Cheverie Formation), Nova Scotia, GSC loc. 6407.

Description. Holotype roundly subtriangular, 68μ in diameter; laesurae prominently and narrowly lipped, almost attaining equatorial margin; distal surface imperfectly reticulate; muri 1-4μ wide, 1-2μ high; lumina 3-10μ in longest diameter; darker equatorial region 8-10μ wide, inner margin poorly defined.

Remarks. This species is assigned to the genus *Dictyotriletes* on the basis of its reticulate-rugulate sculpture, the muri of which are low and do not possess the membranous connections frequently observed in representatives of the genus *Reticulatisporites*. An unusual feature of the species is the apparent peripheral structure resulting from congregation of the distal muri in the equatorial region. In this respect an analogy may be drawn with the genus *Secarisporites* Neves, 1961, although the overlapping, 'lobate outgrowths' composing the discontinuous, deeply incised, peripheral rim of the latter genus are not exhibited by *Dictyotriletes submarginatus* n. sp.

Comparison. D. submarginatus shows sculptural and structural similarity to *D. nigratus* Naumova, 1953 (p. 28, pl. 2, fig. 8) which was described from Givetian strata of the Russian Platform. However, Naumova's species is smaller and appears to have a regular reticulum in which the lumina are 10μ in diameter; Naumova does not indicate whether the sculpture is developed on both or only on one of the surfaces.

Genus ***Reticulatisporites*** (Ibrahim) Potonié and Kremp, 1954

Type species. R. reticulatus Ibrahim, 1933.

Reticulatisporites cheveriensis n. sp.

Plate IX, figures 1–3

Diagnosis. Spores radial, trilete; amb circular, subcircular, or roundly subtriangular. Laesurae obscure to perceptible, simple, straight; length approximately one half to three quarters of spore radius. Proximal and distal surfaces have prominent, irregular, reticulate sculpture with high, narrow, membranous muri enclosing large polygonal lumina. Muri 6-16μ high, producing conspicuous 'pseudoflange' at margin. Muri usually highly contorted due to compression, frequently partly lost in preservation and/or preparation. Sides of muri tapering, tops more or less sharply pointed; mural junctions thickened. Lumina irregular in shape and size, ranging from 6 to 30μ in greatest diameter. Exine 2.5-5μ thick, excluding muri.

Dimensions (15 specimens). Equatorial diameter (exclusive of muri) 69-130μ (mean 103μ).

Types. Holotype, GSC No. 13162; paratypes, GSC Nos. 13163, 13164.

Locus typicus. Horton Group (Cheverie Formation), Nova Scotia, GSC loc. 6408.

Description. Holotype 106μ in diameter, amb circular; laesurae obscured by sculpture; muri 8-14μ high; lumina 8-20μ in longest diameter; margin discontinuously flange-like, irregularity due to partial destruction of muri.

Comparison. This species probably includes the specimen described by Love (1960, p. 117, pl. 1, fig. 11, text-fig. 7) as *Reticulatisporites* type B, from the Burdiehouse Limestone (Viséan) of Scotland. *R. cheveriensis* n. sp. and *R.*? sp. of Playford (1962, p. 600, pl. 85, figs. 1, 2) possess similar sculpture, but the latter species is smaller with concavely subtriangular amb and generally much higher muri. *R. muricatus* Kosanke, 1950 (p. 27, pl. 4, fig. 7) has distinct laesurae and somewhat coarser and more regularly distributed muri.

Genus ***Camptotriletes*** (Naumova) Potonié and Kremp, 1954

Type species. C. corrugatus (Ibrahim) Potonié and Kremp, 1954.

Camptotriletes verrucosus Butterworth and Williams, 1958

Plate IX, figures 6, 7

Description of specimens. Spores radial, trilete; amb circular to broadly roundly subtriangular. Laesurae usually distinct, simple, straight, length approximately one half to three quarters of amb radius. Proximal and distal surfaces sculptured with poorly defined, relatively low, smooth rugulae (or ridges) that are rather loosely and irregularly distributed and of variable width. Ridges locally expanded, thus suggesting a verrucate sculpture especially when the spores are examined under low magnification. Ridges anastomose in places but do not show any tendency to form a reticulum. In lateral view, ridges are broadly rounded; height 1-2.5μ, width 2-6μ. Exine 2-2.5μ thick, excluding rugulae. Equatorial margin irregular to undulating.

Dimensions (18 specimens). Equatorial diameter 55-71μ (mean 62μ).

Types. Hypotypes, GSC Nos. 13167, 13168.

Remarks. The Canadian specimens described above conform very closely with the diagnosis of *Camptotriletes verrucosus* Butterworth and Williams, 1958 (pp. 368-369) and especially with the holotype (pl. 2, fig. 2).

Previous records. C. verrucosus was originally described from the Limestone Coal Group (Namurian A) of Scotland (Butterworth and Williams, 1958). Subsequently, Butterworth and Millott (1960) applied the species name to their oldest microspore zone which embraces coal seams occurring within the Scremerston Coal Group and Lower Limestone Group of Northumberland, both of Viséan age. Neves (1961) has noted *C. verrucosus* as a rare constituent of Lower Namurian A assemblages from the southern Pennines region of England.

Thus the species has not been reported previously either from outside Britain or in rocks as old as the Horton Group.

Camptotriletes sp.

Plate IX, figure 4

Description of specimens. Spores radial, trilete; amb subtriangular with convex sides and rounded apices. Laesurae distinct, simple, straight; length one half to three fifths of amb radius. Exine sculptured, on both proximal and distal surfaces, with long, low, anastomosing ridges that are smooth, non-overlapping, and 1-4μ apart. Ridges conical to rounded in cross-section; height 0.5-1μ, basal width 1-3.5μ. Ridges show distinct tendency for concentric disposition in equatorial region (i.e., arranged subparallel to equator). Exine about 1μ thick, excluding ridges. One or two secondary folds sometimes present.

Dimensions (6 specimens). Equatorial diameter 59-71μ (mean 65μ).

Types. Hypotype, GSC No. 13165.

Comparison. The morphography of this species appears closely comparable with that of *Azonotriletes grandicornis* Luber (*in* Luber and Waltz, 1938, p. 24, pl. 5, fig. 66) but insufficient specimens have been found in the Horton material to warrant their definite assignment. It can be noted, however, that the Canadian forms possess distinctly shorter laesurae than are shown in the drawings representative of Luber's species. Luber (1955, p. 57) transferred *A. grandicornis* to the broad category *Filicitriletes* Luber, 1955 which, as Potonié (1958, p. 35) has argued, is an unsatisfactory taxonomic unit lacking type-species designation. Potonié and Kremp (1955, p. 104) considered *A. grandicornis* to be a probable representative of *Camptotriletes*.

Previous records. The closely similar, if not identical, species *Azonotriletes grandicornis* Luber is well known from Lower Carboniferous strata of the Karaganda Basin, U.S.S.R. (Luber and Waltz, 1938, 1941; Luber, 1955).

Subturma PERINOTRILITES Erdtman, 1947

Genus ***Perotrilites*** Erdtman ex Couper, 1953

Type species. P. granulatus Couper, 1953.

Perotrilites magnus Hughes and Playford, 1961

Plate IX, figure 5

Dimensions (40 specimens). Equatorial diameter (excluding perine) 97-167μ (mean 130μ).

Types. Hypotype, GSC No. 13166.

Previous records. Described initially from the Lower Carboniferous of Spitsbergen (Hughes and Playford, 1961; Playford, 1962).

Perotrilites perinatus Hughes and Playford, 1961
Plate X, figure 5

Dimensions (10 specimens). Equatorial diameter (excluding perine) 57-87μ (mean 78μ).

Types. Hypotype, GSC No. 13173.

Previous records. Known hitherto from the Lower Carboniferous of Spitsbergen (Hughes and Playford, 1961; Playford, 1962).

Turma ZONALES (Bennie and Kidston) R. Potonié, 1956
Subturma ZONOTRILETES Waltz, 1935
Infraturma CINGULATI Potonié and Klaus, 1954
Genus ***Stenozonotriletes*** (Naumova) Potonié, 1958

Type species. S. conformis Naumova, 1953.

Stenozonotriletes extensus var. *major* Naumova, 1953
Plate VIII, figure 14

Dimensions (10 specimens). Overall equatorial diameter 57-74μ (mean 64μ); width of cingulum 4-5μ.

Types. Hypotype, GSC No. 13161.

Previous records. This form was recorded earlier from the Horton Group (Hacquebard, 1957), and was first described by Naumova (1953) from Middle and Upper Devonian strata of the Russian Platform.

Stenozonotriletes sp.
Plate X, figure 9

Description. Spore radial, trilete; amb subtriangular with convex sides and rounded to slightly pointed apices. Periphery smooth to broadly undulating. Laesurae perceptible, simple, straight, extending approximately four fifths of the distance to the equatorial margin. Spore body surrounded equatorially by relatively narrow, dark cingulum. Body virtually laevigate to finely, irregularly punctate; the latter probably due to slight corrosion. Cingulum uniform, laevigate; inner margin conformable with equator.

Dimensions (single specimen). Overall equatorial diameter 101μ; width of cingulum 6μ.

Types. Hypotype, GSC No. 13177.

Comparison. This form does not seem to bear any obvious resemblance to previously described species of the *Stenozonotriletes* type. *S. grandiculus* Ishchenko, 1952 (p. 59, pl. 16, fig. 144) and *S. forticulus* Balme and Hassell, 1962 (p. 14, pl. 3, figs. 5-7) are both smaller than the Canadian specimen and have shorter laesurae. *Ambitisporites avitus* Hoffmeister, 1959 (p. 332, pl. 1, figs. 1-8) is smaller and its laesurae extend to the inner margin of the cingulum.

Genus *Lycospora* (Schopf, Wilson, and Bentall) Potonié and Kremp, 1954

Type species. *L. micropapillata* (Wilson and Coe) Schopf, Wilson, and Bentall, 1944.

Lycospora magnifica McGregor, 1960

Plate X, figures 1–4

Lycospora magnifica McGregor, 1960, p. 35, pl. 12, fig. 5 and pl. 13, figs. 2-4.
Lycospora magnifica var. *endoformis* McGregor, 1960, p. 36, pl. 12, figs. 9, 10.

Description of specimens. Spores radial, trilete; amb convexly subtriangular or, less frequently, subcircular. Laesurae straight or sinuous, extending to inner margin of cingulum; accompanied by slightly elevated, thickened lips that are 2.5-6μ in overall width and have straight to irregularly undulating outer margins. Lips sometimes show lateral expansion at radial termini—such divergence giving the effect of curvaturae imperfectae. Exine scabrate to finely punctate/vermiculate overall. Verrucae, together with minor coni and rare grana, are developed additionally on distal surface and cingulum, and, less commonly, on proximal interradial regions. Verrucae sparse to closely spaced; bases rounded to roundly elongate (sausage-like); usually discrete on distal surface and basally coalescent on cingulate border. Verrucae broadly rounded in lateral aspect, sometimes bearing minute apical spinae. Height of verrucae and coni 1-3μ, basal diameter 1.5-6.5μ (average 3μ). Exine more or less continuously and uniformly thickened on outer part of proximal face to comprise a distinct, relatively narrow, subequatorial cingulum (4-8.5μ wide), which is sculptured, usually densely, with the verrucate/conate elements so characteristic of the distal surface. Exine 2-3μ thick on distal surface and non-cingulate proximal surface. Mesosporoid vaguely to clearly discernible in some specimens.

Dimensions (45 specimens). Overall equatorial diameter 60-94μ (mean 75μ).

Types. Hypotypes, GSC Nos. 13169, 13170, 13171, 13172.

Remarks. D. C. McGregor and the present writer have made detailed comparisons between the Horton Group specimens (described above) and the type and other original specimens upon which the species was first diagnosed. As a result it is agreed that no obvious morphographical difference exists between the specimens from these two sources.

Comparison. *Lycospora magnifica* resembles a form that is said to be widespread in Lower Carboniferous (Viséan) deposits of Kazachstan, viz. *Zonotriletes subtriquetrus* Luber (*in* Luber and Waltz, 1941, p. 45, pl. 9, fig. 146), described later by Luber (1955, p. 42, pl. 5, figs. 95, 97) as *Lepidozonotriletes subtriquetrus.* The principal differences, however, lie in the smaller size (30-50μ) of the Russian species and its possession of simple, not lipped, laesurae.

Previous records. The species was initially described (McGregor, 1960) from Canadian sediments of somewhat greater age than the Horton Group; i.e., from probable Frasnian coal of Melville Island, Canadian Arctic Archipelago.

Lycospora torulosa Hacquebard, 1957
Plate X, figure 6

Description of specimens. Spores radial, trilete; amb subtriangular with convex to almost straight sides and rounded to somewhat pointed apices. Laesurae, often obscure when viewed from distal side, attain inner margin of cingulum and are accompanied by faint, slightly elevated lips that are about 2μ in overall width. Proximal surface of spore body delicate (frequently torn and folded); laevigate or sculptured sparsely with grana and small verrucae. Distal surface of body conspicuously sculptured with discrete, closely spaced grana and verrucae having subcircular to polygonal bases up to 6μ in maximum diameter. Distal sculpturing elements often show gradual increase in size towards polar region. Cingulum fairly uniform in both width (4-6μ) and thickness; inner margin sometimes irregularly pitted (?corrosion). Cingulum laevigate or bearing scattered minute coni or spinae which, under high magnification, are just visible at the periphery.

Dimensions (28 specimens). Overall equatorial diameter 40-54μ (mean 48μ).

Types. Hypotype, GSC No. 13174.

Remarks. L. torulosa undoubtedly bears a close morphographical relationship to the two species of *Vallatisporites* (recorded below), with which it is invariably associated.

Genus ***Vallatisporites*** Hacquebard, 1957

Type species. V. vallatus Hacquebard, 1957.

Vallatisporites vallatus Hacquebard, 1957
Plate X, figure 7

Dimensions (35 specimens). Overall equatorial diameter 52-71μ (mean 62μ); width of flange 6.5-14μ (mean 10μ).

Types. Hypotype, GSC No. 13175.

Comparison. A very closely comparable species is *Hymenozonotriletes pusillites* Kedo (1957b, p. 22, fig. 1) which is said to be restricted vertically to the lower horizons of the Malevka-Murayevnya beds (Lower Tournaisian) of the Pripyat Basin, Byelorussian S.S.R. Kedo reports that the species occurs prolifically in these strata, often comprising more than 50 per cent of the microfloral assemblages. The Russian species and *Vallatisporites vallatus* appear to be distinguishable mainly on the basis of laesurate character. In the latter species the laesurae are flanked by usually distinct lips and extend on to the cingulum, whereas *H. pusillites* possesses simple laesurae which do not extend beyond the inner margin of the cingulum.

Vallatisporites verrucosus Hacquebard, 1957
Plate X, figure 8

Dimensions (40 specimens). Overall equatorial diameter 48-69μ (mean 58μ); width of flange 7-13μ (mean 10μ).

Types. Hypotype, GSC No. 13176.

Genus ***Cristatisporites*** Potonié and Kremp, 1954

Type species. C. indignabundus (Loose) Potonié and Kremp, 1954.

Cristatisporites aculeatus (Hacquebard) Potonié, 1960

Plate XI, figures 3–5

Lepidozonotriletes aculeatus Hacquebard, 1957, p. 316, pl. 3, figs. 11-12.
Cristatisporites aculeatus (Hacquebard) Potonié, 1960, pp. 63-64.

Description of specimens. Spores radial, trilete; amb roundly subtriangular. More or less straight laesurae approximately equal to amb radius; bordered by elevated, thickened lips, individually 2.5-7μ wide. Flange/central-area margin often indistinct. Proximal surface finely and densely granulate. Composite sculpture on whole of distal surface, clearly evident at equatorial margin, consisting of: a) scalloped, imbricating, plate-like elevations or ridges that are especially large and closely spaced (often coalescent) in equatorial region; b) spinae and coni developed conspicuously on tops of elevations and, less commonly, directly on the exine between the ridges. Ridges narrow, often arranged in concentric rows more or less parallel with equator; width of individual units 5-15μ, height 4-16μ. Spinae/coni 1-9μ long, 1-5μ broad at base. Flange 12-28μ wide.

Dimensions (30 specimens). Equatorial diameter (excluding projections) 87-184μ (mean 132μ).

Types. Hypotypes, GSC Nos. 13181, 13182, 13183.

Remarks. The additional specimens from the Horton Group, although lowering the size-range by 16μ, conform well with those described initially by Hacquebard (1957) from his West Gore sample. Potonié (1960) has noted the preoccupation of the generic name *Lepidozonotriletes* (*see* Luber, 1955); his allocation of *L. aculeatus* Hacquebard to *Cristatisporites* seems appropriate.

Cristatisporites echinatus Playford, 1963

Plate X, figure 10

Dimensions (4 specimens). Overall equatorial diameter 58-96μ (mean 79μ).

Types. Hypotype, GSC No. 13178.

Remarks. This distinctive species is characterized by long laesurae flanked by elevated, thickened lips, together with conspicuous spinose-conate sculpture which is confined to the distal surface and equator (*see* Playford, 1963, p. 637, pl. 91, figs. 1-4, text-fig. 10f; Dettmann and Playford, 1963, p. 680, pl. 96, figs. 3-5). Only a few Canadian representatives have been observed; their morphography is closely conformable with that of the Spitsbergen specimens from which *Cristatisporites echinatus* was diagnosed. However, in the Horton specimen illustrated herein (Pl. X, fig. 10) the spinae attain a slightly greater length (maximum 8μ, at equator) and are more frequently coalescent on the cingulum than is usual in the Spitsbergen examples.

Previous records. C. echinatus was known hitherto only from the Lower

Carboniferous of Spitsbergen, where it is restricted to the Rarituberculatus Assemblage of probable Tournaisian age (*after* Playford, 1963).

Anteturma **POLLENITES** R. Potonié, 1931

Turma **Saccites** Erdtman, 1947

Subturma MONOSACCITES (Chitaley) Potonié and Kremp, 1954

Infraturma TRILETESACCITI Leschik, 1955

Subinfraturma INTRORNATI Butterworth and Williams, 1958

Genus ***Endosporites*** Wilson and Coe, 1940

Type species. *E. ornatus* Wilson and Coe, 1940.

Endosporites macromanifestus Hacquebard, 1957

Plate XI, figure 1

Dimensions (8 specimens). Overall equatorial diameter 110-159μ (mean 138μ); diameter of central body 60-96μ (mean 81μ).

Types. Hypotype, GSC No. 13179.

Previous records. Hacquebard (1957) described this species from the Horton Group (West Gore sample). It has been recorded also from the Middle Old Red Sandstone of Scotland by Lang (1925) and Richardson (1960) as, respectively, Spore-type A and *Auroraspora macromanifestus* (Hacquebard).

Endosporites micromanifestus Hacquebard, 1957

Plate XI, figure 2

Dimensions (12 specimens). Overall equatorial diameter 64-100μ (mean 84μ); spore body diameter 41-62μ (mean 51μ).

Types. Hypotype, GSC No. 13180.

Comparison. As stated by Hacquebard (1957, p. 317), *Endosporites micromanifestus* is distinguishable from *E. macromanifestus* by its smaller size and more distinctly infragranulate bladder.

Previous records. Hacquebard (loc. cit.) described *E. micromanifestus* from the West Gore and Blue Beach samples of the Horton Group. The species has been reported subsequently from the Lower Oil-shale Group (Viséan) of Scotland (Love, 1960) and throughout the Lower Carboniferous sequence of Spitsbergen (Hughes and Playford, 1961; Playford, 1963). The miospores described by Ishchenko (1956, p. 62, pl. 9, figs. 129, 130) as *Hymenozonotriletes* aff. *variabilis* Naumova are considered to be identical with the Canadian species (*see* Hughes and Playford, 1961, p. 44); Ishchenko indicated distribution throughout the Tournaisian/Viséan/Namurian succession of the Donetz Basin's western extension.

STRATIGRAPHIC SIGNIFICANCE OF THE MIOSPORES

Composition and Correlative Value of Assemblages

The fifty-three miospore forms documented above include twenty-one new species, and two types that are specifically unnamed because of their insufficient representation. The remaining thirty species are all referable to previously described types, of which two are newly combined and one is newly named. Distribution and relative abundance of the spores observed in material from each of the thirteen sampling localities are shown in Table I. Spores that occur also in one or both of Hacquebard's (1957) samples are indicated in this table.

Table I

Miospore Distribution in Horton Group Samples

	HORTON GROUP												
	Horton Bluff Fm.	Undifferentiated Horton Group							Cheverie Formation				
Locality / Species	813	6400	6401	6402	6403	6404	6405	6406	6407	6408	6409	6410	6411
Leiotriletes tortilis		C											
*Punctatisporites debilis**	R	C	R	R	A	C	R	C					
*Punctatisporites irrasus**		R		C	C			R					
*Punctatisporites limbatus**	R	C			R	R							
*Punctatisporites planus**	R	C		R	C	R	R	R					
*Punctatisporites solidus**		R				R		R					
*Punctatisporites viriosus**	R	R		R		R							
Gulisporites torpidus		R		R			R	R					
*Leiozonotriletes insignitus**		R		R									
Granulatisporites inspissatus		R											
Cyclogranisporites commodus		C	R	R				R					
*Verrucosisporites papulosus**		C	C	C		R	R	R					
*Anapiculatisporites ampullaceus**	R	R	R			R							
Anapiculatisporites tersus		R											
*Pustulatisporites gibberosus**		C	R	R									
*Grandispora echinata**		R			R	R		R					
*Spinozonotriletes conspicuus**		R											
*Spinozonotriletes tenuispinus**		R											
*Spinozonotriletes uncatus**	R	R	C	R		R		C					
Raistrickia abstrusa		R											
*Raistrickia baculosa**		R	R	R									
*Schopfites augustus**		C	R	C		R		R					
Dictyotriletes admirabilis		C											
Camptotriletes verrucosus		R											
Camptotriletes sp.		R											
Perotrilites magnus		R		R									
Perotrilites perinatus		R											
Stenozonotriletes extensus var. *major**		R		R	R	R							
Lycospora magnifica	R	C	R	R				R					
*Lycospora torulosa**	R	C	C	A	R	R	R	C					
*Vallatisporites vallatus**	R	A	A	A	R	C	C	A					

	HORTON GROUP												
	Horton Bluff Fm.	Undifferentiated Horton Group							Cheverie Formation				
Species \ Locality	813	6400	6401	6402	6403	6404	6405	6406	6407	6408	6409	6410	6411
*Vallatisporites verrucosus**	R	A	A	A	R	C	C	A					
*Cristatisporites aculeatus**		C		R									
Cristatisporites echinatus		R											
*Endosporites macromanifestus**		R											
Granulatisporites crenulatus		R					A			R		R	
Verrucosisporites congestus	R	C		R				R	C	C			R
Converrucosisporites parvinodosus	R	R				R		R	R				
*Raistrickia clavata**	R	A	R	C		R		R	R				
Raistrickia ponderosa		R							C	C			R
*Convolutispora vermiformis**	R	R		R		R		R	R	R			R
*Microreticulatisporites hortonensis**	R	R							R	R			
*Endosporites micromanifestus**		R	R	R				R	R	R		R	
Retusotriletes avonensis									C	C			
Verrucosisporites nitidus									C	C	R	C	R
Anapiculatisporites hystricosus									R	C		R	
Apiculatasporites compactus									R	R			
Pustulatisporites pretiosus									A	A	C	C	A
Acanthotriletes hacquebardii									R	C			
Convolutispora cf. *finis*									C	R			C
Dictyotriletes submarginatus									R	C	C		
Reticulatisporites cheveriensis									R	R			
Stenozonotriletes sp.										R			

A = abundant; C = common; R = rare

* Indicates species present in Blue Beach sample (Horton Bluff Formation) and/or West Gore sample (Horton Group, probably Horton Bluff Formation) both of which were investigated by Hacquebard (1957).

The single sample from the Horton Bluff Formation, together with the seven samples indicated in Table I as 'undifferentiated Horton Group', all yielded a microfloral assemblage that is strikingly similar to that reported by Hacquebard (1957). One of Hacquebard's samples was also from the type section of the Horton Bluff Formation, and the other, containing a specifically almost identical assemblage, came from undifferentiated Horton strata exposed near West Gore. It seems reasonable, therefore, to attribute all the 'undifferentiated' samples to the Horton Bluff Formation, as was indeed suggested earlier by Hacquebard for his West Gore sample. Moreover, this correlation is supported by the fact that the overlying Cheverie Formation (*see* Table I) contains a uniform microflora which is clearly different from the Horton Bluff assemblage.

It is noteworthy that hystrichosphaerids have not been encountered in any of the residues.

Microflora of the Horton Bluff Formation and Probable Equivalents

This prolific and highly varied assemblage is marked by abundant representatives of the two species of *Vallatisporites* described by Hacquebard (1957)—*V.*

vallatus and *V. verrucosus*—and also of *Lycospora torulosa* Hacquebard. Other, commonly prominent constituents include *Punctatisporites* spp., *Verrucosisporites papulosus* Hacquebard, *Pustulatisporites gibberosus* (Hacquebard) n. comb., emend., *Spinozonotriletes uncatus* Hacquebard, *Schopfites augustus* n. sp., *Raistrickia clavata* Hacquebard, emend., and *Lycospora magnifica* McGregor. A total of thirty-five species is apparently confined to the assemblage (*see* Table I). Of these, twenty constitute forms described earlier by Hacquebard.

The Horton Bluff assemblage is prolifically represented in the East Gore coal (locality 6400), which contains, in addition, a number of distinctive forms that were not encountered in the other material—viz., *Leiotriletes tortilis* n. sp., *Granulatisporites inspissatus* n. sp., *Anapiculatisporites tersus* n. sp., *Spinozonotriletes conspicuus* n. sp. (present also in Hacquebard's West Gore coal), *Dictyotriletes admirabilis* n. sp., *Camptotriletes verrucosus* Butterworth and Williams, *Perotrilites perinatus* Hughes and Playford, and *Cristatisporites echinatus* Playford. It is obviously impossible at this stage to assess the stratigraphic value of these types within the confines of the Horton Group, but it can be noted that they do occur in a sample that is eminently representative of the Horton Bluff microflora.

From Table I it is evident that eight species have been observed as common to both the Horton Bluff and Cheverie assemblages. However, two of these, *Raistrickia clavata* Hacquebard, emend., and *R. ponderosa* n. sp., appear to be almost mutually exclusive—the former being much more characteristic of the Horton Bluff assemblage, and the latter of the younger, Cheverie florule.

Microflora of the Cheverie Formation

In comparison with the older (Horton Bluff) assemblage, the Cheverie microflora is notably less diverse (*see* Table I). Moreover, its constituent miospores are generally less well preserved, a circumstance which is perhaps the result of different climatic orders during Horton Bluff and Cheverie times. According to Bell (1929), the latter was an oxidizing environment, being characterized by temperate semi-aridity with alternating wet and dry seasons.

Of the ten species observed only in the Cheverie Formation, one, *Pustulatisporites pretiosus* n. sp., is overwhelmingly the most abundant and characteristic. As such, it may well qualify as the key species of the Cheverie Formation. Other forms, which are apparently restricted vertically to the Cheverie, include *Retusotriletes avonensis* n. sp., *Verrucosisporites nitidus* n. name, *Anapiculatisporites hystricosus* n. sp., *Acanthotriletes hacquebardii* n. sp., *Convolutispora* cf. *finis* Love, *Dictyotriletes submarginatus* n. sp., and *Reticulatisporites cheveriensis* n. sp. A striking feature is the absence of so many of the forms characteristic of the Horton Bluff microflora. A few poorly preserved specimens that are almost certainly assignable to *Vallatisporites* have been observed in the Cheverie sample, and this is in marked contrast to the profuse occurrence of that genus in the older microflora. It has been noted previously that *Raistrickia ponderosa* n. sp. is common to both assemblages but is much more characteristic of the Cheverie florule. *Punctatisporites* is a minor component of the Cheverie samples.

Stratigraphic Implications

As discussed earlier, two samples (Hacquebard's Blue Beach coal and the siltstone of locality 813) from the type Horton Bluff Formation contain essentially the same miospore assemblage that was recovered also from Hacquebard's West Gore coal and from strata designated in Table I as 'undifferentiated Horton Group'. This common microfloral denominator indicates a similar age, corresponding to Horton Bluff time, for all these samples. Thus, the present study endorses and strengthens Hacquebard's (1957, p. 302) correlation of the West Gore and Blue Beach samples, and moreover suggests attribution of additional material (from localities 6400, 6401, 6402, 6403, 6404, 6405, and 6406) to the Horton Bluff Formation.

Localities 6400, 6401, and 6402, together with the West Gore locality, are all stratigraphically close to the basement complex. The fact that they contain the Horton Bluff microflora argues against Murray's (1960) postulation of Cheverie overlap along the margin of the Minas Basin. The spore content of the coal from locality 6403 verifies Murray's correlation of the Big Marsh Member with the Horton Bluff Formation. The downward stratigraphic limits of the known Horton Bluff species are, of course, not yet established. From one sample at least, obtained at locality 6405, it is known that several of these species range as far down as the upper part of the Craignish Formation. Therefore, Murray's opinion, that the Craignish Formation is older than the Horton Bluff Formation may be only partly correct. The coal from locality 6406 is ample evidence of the New Brunswick occurrence, in either the Albert Formation or the lower Moncton Group, of the Horton Bluff microflora.

The younger microflora has been documented from samples of both lower and upper strata of the Cheverie Formation, as developed in its type area. The distinctive aspect of the Cheverie assemblage suggests its value in the elucidation of correlation problems within the Horton Group. Of Horton strata occurring outside the type Horton-Windsor area, none so far examined contains the Cheverie microflora.

The present investigation establishes the existence of two distinct microfloras within the Horton Group, but undoubtedly much further work remains to be done before the full sequence of Horton microfloras is known. Perhaps the greatest need is for a detailed examination of a representative, relatively undisturbed section that could serve as a standard reference column of Horton miospore assemblages. Murray's (1960) Southwest Mabou River section might well serve this purpose.

Comparison with Microfloras of Other Regions

The microfloras of the Horton Group do not closely resemble previously described Lower Carboniferous assemblages. However, a number of the species discussed below are either identical with or closely related to certain types recorded earlier from Upper Devonian and/or Lower Carboniferous strata. As discussed by Hacquebard (1957, p. 306), the Horton Bluff assemblage appears to show

more general affinity to Upper Devonian microfloras, chiefly those described by Naumova (1953) from the Russian Platform, than to known Lower Carboniferous assemblages. The extensive northern floral province, implied by the remarkably similar Tournaisian microfloras of Russia and Spitsbergen (*see* Playford, 1962, 1963), evidently did not encompass eastern Canada, though Viséan microfloras of western Canada, Russia, and Spitsbergen are very closely parallel. Knowledge of the lateral extent of the Horton Bluff and Cheverie microfloras necessarily awaits palynological investigation of Kinderhookian-Osagean strata elsewhere in North America, for example, the Banff Formation of western Canada.

The Horton Bluff microflora contains four species that have been recorded (Playford, 1962, 1963) from the Lower Carboniferous of Spitsbergen: *Spinozonotriletes uncatus* Hacquebard, *Cristatisporites echinatus* Playford, *Perotrilites magnus* Hughes and Playford, and *P. perinatus* Hughes and Playford. The first two named are confined in Spitsbergen to the Rarituberculatus Assemblage of probable Tournaisian age. One of the most characteristic and abundant elements of the Horton Bluff microflora, *Vallatisporites vallatus* Hacquebard, is morphographically very close to *Hymenozonotriletes pusillites* Kedo which occurs prolifically in the Lower Tournaisian of White Russia (Kedo, 1957b). Other forms encountered only in the Horton Bluff microflora include *Camptotriletes verrucosus* Butterworth and Williams, which was known hitherto only from Viséan-Namurian rocks of Britain (Butterworth and Williams, 1958; Butterworth and Millott, 1960; Neves, 1961); *Stenozonotriletes extensus* var. *major* Naumova, which occurs in Russian strata of Middle and Upper Devonian age (Naumova, 1953); *Lycospora magnifica* McGregor, the predominant species of an Upper Devonian coal from Melville Island, Canadian Arctic (McGregor, 1960); and *Endosporites macromanifestus* Hacquebard, which Lang (1925) and Richardson (1960) recorded from the Middle Old Red Sandstone of Scotland. *Pustulatisporites gibberosus* (Hacquebard) n. comb., emend. and *Camptotriletes* sp. are respectively very similar to the Russian Lower Carboniferous species *Azonotriletes rarituberculatus* Sadkova and *A. grandicornis* Luber. The genus *Schopfites* Kosanke has been reported hitherto from exclusively Westphalian D strata of Illinois (Kosanke, 1950), Oklahoma (Wilson and Hoffmeister, 1956), the Canadian Maritime Provinces (Somers, 1952; Hacquebard, Barss, and Donaldson, 1960; Barss, Hacquebard, and Howie, 1963), and Germany (Bhardwaj, 1960); and also from the Westphalian C-D of Britain (Butterworth and Millott, 1960). Hence, *Schopfites augustus* n. sp., which is apparently confined to the Horton Bluff microflora, is of particular interest as the oldest known representative of the genus. Of similar significance is *Gulisporites torpidus* n. sp.; until now that genus has been reported only from the Permian of the Kaipang Basin (Imgrund, 1960).

The Cheverie microflora includes *Verrucosisporites nitidus* n. name, which was described earlier (Naumova, 1953; Ishchenko, 1956) from Upper Devonian and Lower Carboniferous rocks of the U.S.S.R.; *Acanthotriletes hacquebardii* n. sp., which closely resembles the Russian Middle Carboniferous form *A. macrurus* (Luber) Ishchenko var. *giganteus* Ishchenko; and *Reticulatisporites cheveriensis* n. sp., which probably includes Love's (1960) *Reticulatisporites* type B of the

Scottish Viséan. A form closely comparable with *Convolutispora finis* Love is also represented in the Cheverie Formation.

Endosporites micromanifestus Hacquebard and *Convolutispora vermiformis* Hughes and Playford, which are common to both the Horton Bluff and Cheverie microfloras, occur throughout the Lower Carboniferous (Tournaisian-Viséan) sequence of Spitsbergen (Playford, 1962, 1963). *Converrucosisporites parvinodosus* n. sp. has also been encountered in the two formations of the Horton Group; a very similar species, *Azonotriletes ruboides* Waltz, is known from the Russian Lower Carboniferous (Luber and Waltz, 1941).

REFERENCES

Artüz, S.

1957: Die Sporae Dispersae der Türkischen Steinkohle vom Zonguldak-Gebiet; *Istanbul Üniv. fen Fak. Mecmuasi*, ser. B, cilt 22, sayi 4, pp. 239-263.

1959: Zonguldak Bölgesindeki Alimolla, Sulu ve Büjük Kömur Damarlarinin Sporolojik Etüdü; *Istanbul Üniv. fen Fak. Monograf.*, sayi 15, 73 pp.

Balme, B. E.

1962: Upper Devonian (Frasnian) Spores from the Carnarvon Basin, Western Australia; *The Palaeobotanist*, vol. 9, No. 1 and 2, pp. 1-10.

Balme, B. E., and Hassell, C. W.

1962: Upper Devonian Spores from the Canning Basin, Western Australia; *Micropaleontology*, vol. 8, No. 1, pp. 1-28.

Balme, B. E., and Hennelly, J. P. F.

1956: Trilete Sporomorphs from Australian Permian Sediments; *Austral. J. Bot.*, vol. 4, No. 3, pp. 240-260.

Barss, M. S., Hacquebard, P. A., and Howie, R. D.

1963: Palynology and Stratigraphy of some Upper Pennsylvanian and Permian Rocks of the Maritime Provinces, Canada; *Geol. Surv., Can.*, Paper 63-3.

Bell, W. A.

1929: Horton-Windsor District, Nova Scotia; *Geol. Surv., Can.*, Mem. 155, 268 pp.

1960: Mississippian Horton Group of Type Horton-Windsor District, Nova Scotia; *Geol. Surv., Can.*, Mem. 314, 58 pp.

Bhardwaj, D. C.

1955: The Spore Genera from the Upper Carboniferous Coals of the Saar and their Value in Stratigraphical Studies; *The Palaeobotanist*, vol. 4, pp. 119-150.

1957a: The Palynological Investigations of the Saar Coals (Part I—Morphography of *Sporae Dispersae*); *Palaeontographica*, B, vol. 101, pp. 73-125.

1957b: The Spore Flora of Velener Schichten (Lower Westphalian D) in the Ruhr Coal Measures; *Palaeontographica*, B, vol. 102, pp. 110-138.

1960: Sporological Evidence on the Boundaries of the Stratigraphical Subdivisions in the Upper Pennsylvanian Strata of Europe and North America; *4me Congr. Avanç. Études Strat. Géol. Carb., Compte Rendu*, vol. 1, pp. 33-39.

Butterworth, M. A., and Millott, J. O'N.

1960: Microspore Distribution in the Coalfields of Britain; *Proc. Int. Committee for Coal Petrol.*, No. 3, pp. 157-163.

Butterworth, M. A., and Williams, R. W.

1958: The Small Spore Floras of Coals in the Limestone Coal Group and Upper Limestone Group of the Lower Carboniferous of Scotland; *Trans. Roy. Soc. Edinburgh*, vol. 63, pt. 2 (No. 17), pp. 353-392.

Chibrikova, E. V.

1959: Spores from the Devonian and Older Rocks of Bashkiria; *Akad. Nauk SSSR, Bashkir filial,* Data on Palaeont. and Stratig. of Dev. and Older Depos. Bashkiria, pp. 3-116, Moscow.

Dettmann, M. E., and Playford, G.

1963: Sections of Some Spores from the Lower Carboniferous of Spitsbergen; *Palaeontology*, vol. 5, pt. 4, pp. 679-681.

Gussow, W. C.
1953: Carboniferous Stratigraphy and Structural Geology of New Brunswick, Canada; *Bull. Am. Assoc. Petrol. Geol.*, vol. 37, No. 7, pp. 1713-1816.

Hacquebard, P. A.
1957: Plant Spores in Coal from the Horton Group (Mississippian) of Nova Scotia; *Micropaleontology*, vol. 3, No. 4, pp. 301-324.

Hacquebard, P. A., Barss, M. S., and Donaldson, J. R.
1960: Distribution and Stratigraphic Significance of Small Spore Genera in the Upper Carboniferous of the Maritime Provinces of Canada; *4me Congr. Avanç. Études Strat. Géol. Carb., Compte Rendu*, vol. 1, pp. 237-245.

Hoffmeister, W. S.
1959: Lower Silurian Plant Spores from Libya; *Micropaleontology*, vol. 5, No. 3, pp. 331-334.

Hoffmeister, W. S., Staplin, F. L., and Malloy, R. E.
1955: Mississippian Plant Spores from the Hardinsburg Formation of Illinois and Kentucky; *J. Pal.*, vol. 29, No. 3, pp. 372-399.

Hughes, N. F., and Playford, G.
1961: Palynological Reconnaissance of the Lower Carboniferous of Spitsbergen; *Micropaleontology*, vol. 7, No. 1, pp. 27-44.

Imgrund, R.
1960: Sporae Dispersae des Kaipingbeckens, ihre paläontologische und stratigraphicshe Bearbeitung im Hinblick auf eine Parallelisierung mit dem Ruhrkarbon und dem Pennsylvanian von Illinois; *Geol. Jahrb.*, vol. 77, pp. 143-204.

Ishchenko, A. M.
1952: Atlas of Microspores and Pollen of the Middle Carboniferous of the Western Part of the Donetz Basin; *Akad. Nauk Ukr. SSR, Inst. Geol. Nauk*, 83 pp., Kiev.
1956: Spores and Pollen of the Lower Carboniferous Deposits of the Western Extension of the Donetz Basin and their Stratigraphic Importance; *Akad. Nauk Ukr. SSR, Tr. Inst. Geol. Nauk*, Ser. Stratig. and Palaeont., No. 11, 185 pp., Kiev.
1958: Sporo-Pollen Analysis of the Lower Carboniferous Sediments of the Dnieper-Donetz Basin; *Akad. Nauk Ukr. SSR, Tr. Inst. Geol. Nauk*, Ser. Stratig. and Palaeont., No. 17, 188 pp., Kiev.

Kedo, G. I.
1955: Spores of the Middle Devonian of the Northeastern Byelorussian S.S.R.; *Akad. Nauk BSSR, Inst. Geol. Nauk*, Palaeont. and Stratig. BSSR, No. 1, pp. 5-59, Minsk.
1957a: Spores from the Supra-Salt Devonian Deposits of the Pripyat Basin and their Stratigraphic Significance; *Akad. Nauk BSSR, Inst. Geol. Nauk*, Palaeont. and Stratig. BSSR, No. 2, pp. 3-43, Minsk.
1957b: Stratigraphic Significance of *Hymenozonotriletes pusillites* sp. n.; *Dokl. Akad. Nauk BSSR*, vol. 1, No. 1, pp. 21-23.

Knox, E. M.
1950: The Spores of *Lycopodium, Phylloglossum, Selaginella,* and *Isoetes* and their Value in the Study of Microfossils of Palaeozoic Age; *Trans. Bot. Soc. Edinburgh,* vol. 35, pt. 3, pp. 209-357.

Kosanke, R. M.
1950: Pennsylvanian Spores of Illinois and their Use in Correlation; *Illinois State Geol. Surv.*, Bull. 74, 128 pp.

Lang, W. H.
1925: Contributions to the Study of the Old Red Sandstone Flora of Scotland. I. On Plant-Remains from the Fish-Beds of Cromarty; *Trans. Roy. Soc. Edinburgh*, vol. 54, pt. 2, No. 2, pp. 253-272.

Love, L. G.
1960: Assemblages of Small Spores from the Lower Oil-shale Group of Scotland; *Proc. Roy. Soc. Edinburgh*, B, vol. 67, pt. 2, No. 7, pp. 99-126.

Luber, A. A.
1955: Atlas of Spores and Pollen Grains of the Palaeozoic Deposits of Kazachstan; *Akad. Nauk Kazach. SSR*, 128 pp., Alma-Ata.

Luber, A. A., and Waltz, I. E.
1938: Classification and Stratigraphic Value of Spores of Some Carboniferous Coal Deposits in the U.S.S.R.; *Trans. Cent. Geol. Prosp. Inst.*, fasc. 105, 45 pp., Moscow.
1941: Atlas of Microspores and Pollen of the Palaeozoic of the U.S.S.R.; *Tr. All-Union Geol. Sci. Res. Inst.* (*VSEGEI*), Bull. 139, 107 pp., Moscow.

McGregor, D. C.
1960: Devonian Spores from Melville Island, Canadian Arctic Archipelago; *Palaeontology*, vol. 3, pt. 1, pp. 26-44.

Murray, B. C.
1960: Stratigraphy of the Horton Group in Parts of Nova Scotia; *N. S. Research Foundation*, 128 pp., Halifax.

Naumova, S. N.
1953: Sporo-Pollen Complexes of the Upper Devonian of the Russian Platform and their Stratigraphic Significance; *Tr. Inst. Geol. Nauk, Akad. Nauk SSSR*, vol. 143 (Geol. Ser. 60), 204 pp., Moscow.

Neves, R.
1961: Namurian Plant Spores from the Southern Pennines, England; *Palaeontology*, vol. 4, pt. 2, pp. 247-279.

Playford, G.
1962: Lower Carboniferous Microfloras of Spitsbergen—Part One; *Palaeontology*, vol. 5, pt. 3, pp. 550-618.
1963: Lower Carboniferous Microfloras of Spitsbergen—Part Two; *Palaeontology*, vol. 5, pt. 4, pp. 619-678.

Potonié, R.
1956: Synopsis der Gattungen der Sporae dispersae. I. Teil: Sporites; *Beih. Geol. Jahrb.*, vol. 23, 103 pp.
1958: Synopsis der Gattungen der Sporae dispersae. II. Teil: Sporites (Nachträge), Saccites, Aletes, Praecolpates, Polyplicates, Monocolpates; *Beih. Geol. Jahrb.*, vol. 31, 114 pp.
1960: Synopsis der Gattungen der Sporae dispersae. III. Teil: Nachträge Sporites, Fortsetzung Pollenites. Mit Generalregister zu Teil I-III; *Beih. Geol. Jahrb.*, vol. 39, 189 pp.

Potonié, R., and Kremp, G.
1954: Die Gattungen der paläozoischen Sporae dispersae und ihre Stratigraphie; *Geol. Jahrb.*, vol. 69, pp. 111-194.

Potonié, R., and Kremp, G. (cont'd)
1955: Die Sporae dispersae des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebiete und Zeitabschnitte—Teil I; *Palaeontographica*, B, vol. 98, No. 1-3, pp. 1-136.

Richardson, J. B.
1960: Spores from the Middle Old Red Sandstone of Cromarty, Scotland; *Palaeontology*, vol. 3, pt. 1, pp. 45-63.

Schopf, J. M., Wilson, L. R., and Bentall, R.
1944: An Annotated Synopsis of Paleozoic Fossil Spores and the Definition of Generic Groups; *Illinois State Geol. Surv.*, Rept. Inv. 91, 72 pp.

Somers, G.
1952: A Preliminary Study of the Spores from the Phalen Seam in the New Waterford District, Sydney Coalfield, Nova Scotia; *N.S. Dept. Mines and N.S. Research Foundation*, Second Conference on the Origin and Constitution of Coal, pp. 219-247.

Staplin, F. L.
1960: Upper Mississippian Plant Spores from the Golata Formation, Alberta, Canada; *Palaeontographica*, B, vol. 107, No. 1-3, pp. 1-40.

Stevenson, I. M.
1959: Shubenacadie and Kennetcook Map-Areas, Colchester, Hants and Halifax Counties, Nova Scotia; *Geol. Surv., Can.*, Mem. 302, 88 pp.

Wilson, L. R., and Hoffmeister, W. S.
1956: Plant Microfossils of the Croweburg Coal; *Okla. Geol. Surv.*, Circ. 32, 57 pp.

Wilson, L. R., and Kosanke, R. M.
1944: Seven New Species of Unassigned Plant Microfossils from the Des Moines Series of Iowa; *Proc. Acad. Sci. Iowa*, vol. 51, pp. 329-333.

PLATES I to XI

PLATE I

(All figures $\times 500$, and from unretouched negatives)

Figures 1–4 *Leiotriletes tortilis* n. sp. (Page 6)
1, proximal surface, preparation P266C/5, 26.3×111.5, GSC No. 13051; 2, holotype, proximal surface, preparation P266C/163, 36.3×101.6, GSC No. 13052; 3, proximal surface, preparation P266C/197, 33.9×102.1, GSC No. 13053; 4, proximal surface, preparation P266C/208, 38.0×104.3, GSC No. 13054.

Figure 5 *Punctatisporites irrasus* Hacquebard, 1957. (Page 7)
Proximal surface, preparation P266C/88, 28.6×105.1, GSC No. 13055.

Figure 6 *Punctatisporites debilis* Hacquebard, 1957. (Page 7)
Proximal surface, preparation P266/C108, 22.1×98.1, GSC No. 13056.

Figures 7, 8 *Punctatisporites limbatus* Hacquebard, 1957. (Page 7)
7, proximal surface, preparation P226C/12, 36.3×101.2, GSC No. 13057; 8, proximal surface, preparation P266C/49, 33.6×106.1, GSC No. 13058.

Figures 9, 10 *Punctatisporites planus* Hacquebard, 1957. (Page 7)
9, proximal surface, preparation P266C/61, 33.2×103.0, GSC No. 13059; 10, proximal surface, preparation P266C/79, 29.5×98.3, GSC No. 13060.

Figure 11 *Punctatisporites viriosus* Hacquebard, 1957. (Page 8)
Distal surface, preparation P266C/144, 33.4×106.2, GSC No. 13061.

Figure 12 *Punctatisporites solidus* Hacquebard, 1957. (Page 7)
Proximal surface, preparation P290/13, 38.6×104.3, GSC No. 13062.

Figures 13, 14 *Gulisporites torpidus* n. sp. (Page 8)
13, holotype, proximal surface, preparation P290/34, 33.4×101.7, GSC No. 13063; 14, proximal surface, preparation P290/212, 39.6×103.8, GSC No. 13064.

Figures 15, 16 *Retusotriletes avonensis* n. sp. (Page 9)
15, proximal surface, preparation P270/2, 19.7×103.2, GSC No. 13065; 16, proximo-lateral view, preparation P270/2, 13.5×101.6, GSC No. 13066.

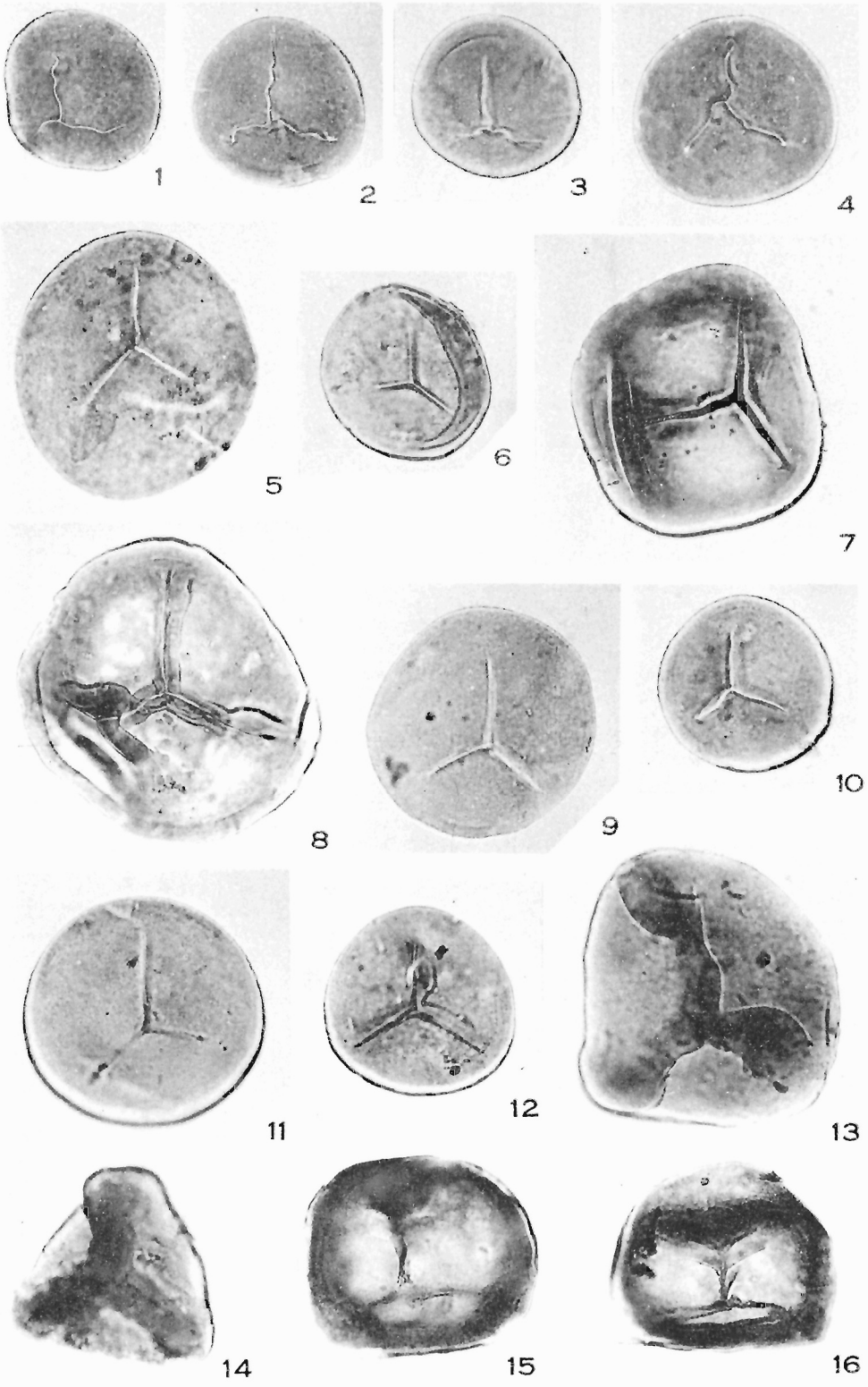
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PLATE II

(All figures $\times 500$, and from unretouched negatives)

Figures 1, 2 *Retusotriletes avonensis* n. sp. (Page 9)
1, proximo-lateral view, preparation P270/23, 42.7×95.7, GSC No. 13067; 2, holotype, proximal surface, preparation P297/59, 36.8×105.1, GSC No. 13068.

Figures 3–5 *Cyclogranisporites commodus* n. sp. (Page 12)
3, holotype, proximal surface, preparation P266C/230, 23.0×92.8, GSC No. 13069; 4, distal surface, preparation P266A/1, 22.7×98.5, GSC No. 13070; 5, proximal surface, preparation P266B/4, 25.4×104.6, GSC No. 13071.

Figures 6, 7 *Granulatisporites inspissatus* n. sp. (Page 11)
6, holotype, proximal surface, preparation P266C/1, 20.1×111.5, GSC No. 13072; 7, proximal surface, preparation P290/182, 36.9×100.7, GSC No. 13073.

Figures 8–10 *Granulatisporites crenulatus* n. sp. (Page 11)
8, proximal surface, preparation P278/1, 38.5×99.2, GSC No. 13074; 9, proximal surface, preparation P278/9, 37.2×103.0, GSC No. 13075; 10, holotype, proximal surface, preparation P278/22, 35.5×101.9, GSC No. 13076.

Figures 11–13 *Verrucosisporites congestus* n. sp. (Page 13)
11, subpolar view, preparation P270/94, 39.4×100.2, GSC No. 13077; 12, holotype, subpolar view, preparation P266C/5, 53.6×104.3, GSC No. 13078; 13, subpolar view, preparation P266C/167, 39.8×97.3, GSC No. 13079.

Figures 14, 15 *Leiozonotriletes insignitus* Hacquebard, 1957. (Page 10)
14, distal surface, preparation P266C/15, 35.9×101.2, GSC No. 13080; 15, proximal surface, preparation P266C/214, 37.8×102.3, GSC No. 13081.


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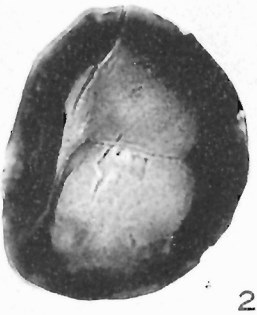
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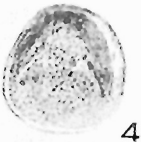
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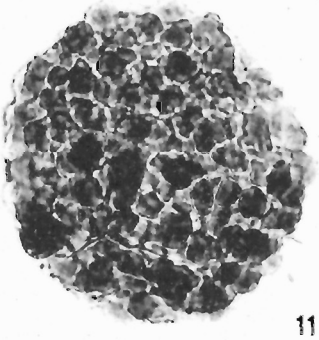
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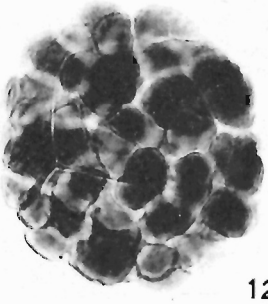
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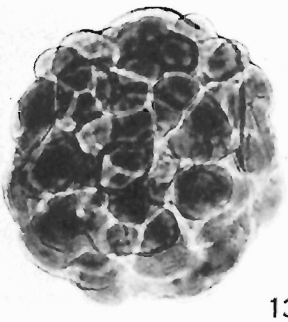
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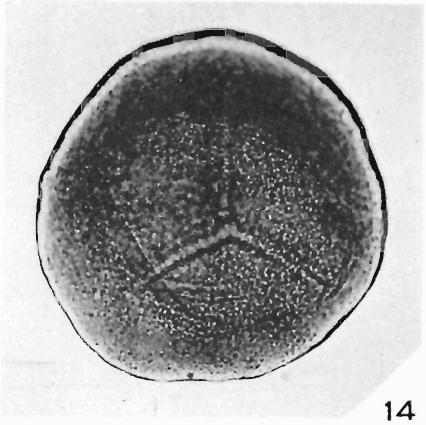
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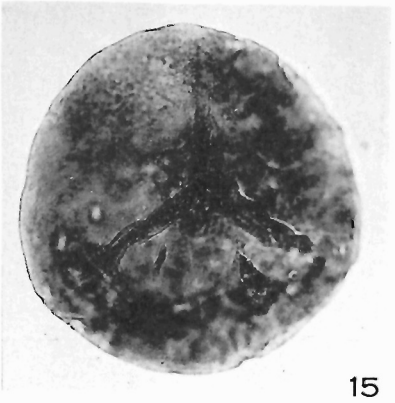
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PLATE III

(All figures ×500, and from unretouched negatives)

Figures 1, 2 *Verrucosisporites papulosus* Hacquebard, 1957. (Page 14)
1, subpolar view, preparation P266C/181, 35.6×103.2, GSC No. 13082; 2, subpolar view, preparation P290/145, 35.8×97.2, GSC No. 13083.

Figures 3–6 *Verrucosisporites nitidus* n. name. (Page 13)
3, distal surface, preparation P270/1, 43.3×101.8, GSC No. 13084; 4, proximal surface, preparation P270/63, 40.5×105.0, GSC No. 13085; 5, proximal surface, preparation P270/6, 51.9×109.6, GSC No. 13086; 6, proximal surface, preparation P270/4, 23.8×97.8, GSC No. 13087.

Figures 7–9 *Converrucosisporites parvinodosus* n. sp. (Page 15)
7, distal surface, preparation P277B/4, 35.0×94.5, GSC No. 13088; 8, holotype, proximal surface, preparation P290/192, 37.4×98.6, GSC No. 13089; 9, proximal surface, preparation P290/62, 37.2×102.0, GSC No. 13090.

Figures 10–12 *Anapiculatisporites tersus* n. sp. (Page 17)
10, holotype, proximal surface, preparation P290/188, 39.2×99.6, GSC No. 13091; 11, distal surface, preparation P290/179, 36.7×108.2, GSC No. 13092; 12, proximal surface, preparation P290/189, 34.2×102.5, GSC No. 13093.

Figures 13–15 *Anapiculatisporites hystricosus* n. sp. (Page 16)
13, distal surface, preparation P297/23, 40.8×100.0, GSC No. 13094; 14, proximal surface, preparation P298/1, 28.9×97.1, GSC No. 13095; 15, holotype, proximal surface, preparation P297/1, 29.4×107.0, GSC No. 13096.

Figures 16, 17 *Anapiculatisporites ampullaceus* (Hacquebard) n. comb. (Page 16)
16, distal surface, preparation P266C/16, 33.3×101.6, GSC No. 13097; 17, distal surface, preparation P266C/4, 54.6×104.2, GSC No. 13098.

Figures 18–20 *Pustulatisporites gibberosus* (Hacquebard), n. comb., emend. (Page 18)
18, proximal surface, preparation P266C/8, 37.3×101.3, GSC No. 13099; 19, distal surface, preparation P266C/128, 32.7×104.1, GSC No. 13100; 20, proximal surface, preparation P266C/118, 40.7×102.2, GSC No. 13101.

Figures 21, 22 *Apiculatasporites compactus* n. sp. (Page 18)
21, holotype, subpolar view, preparation P270/101, 34.2×101.7, GSC No. 13102; 22, proximal surface, preparation P270/88, 36.1×99.2, GSC No. 13103.

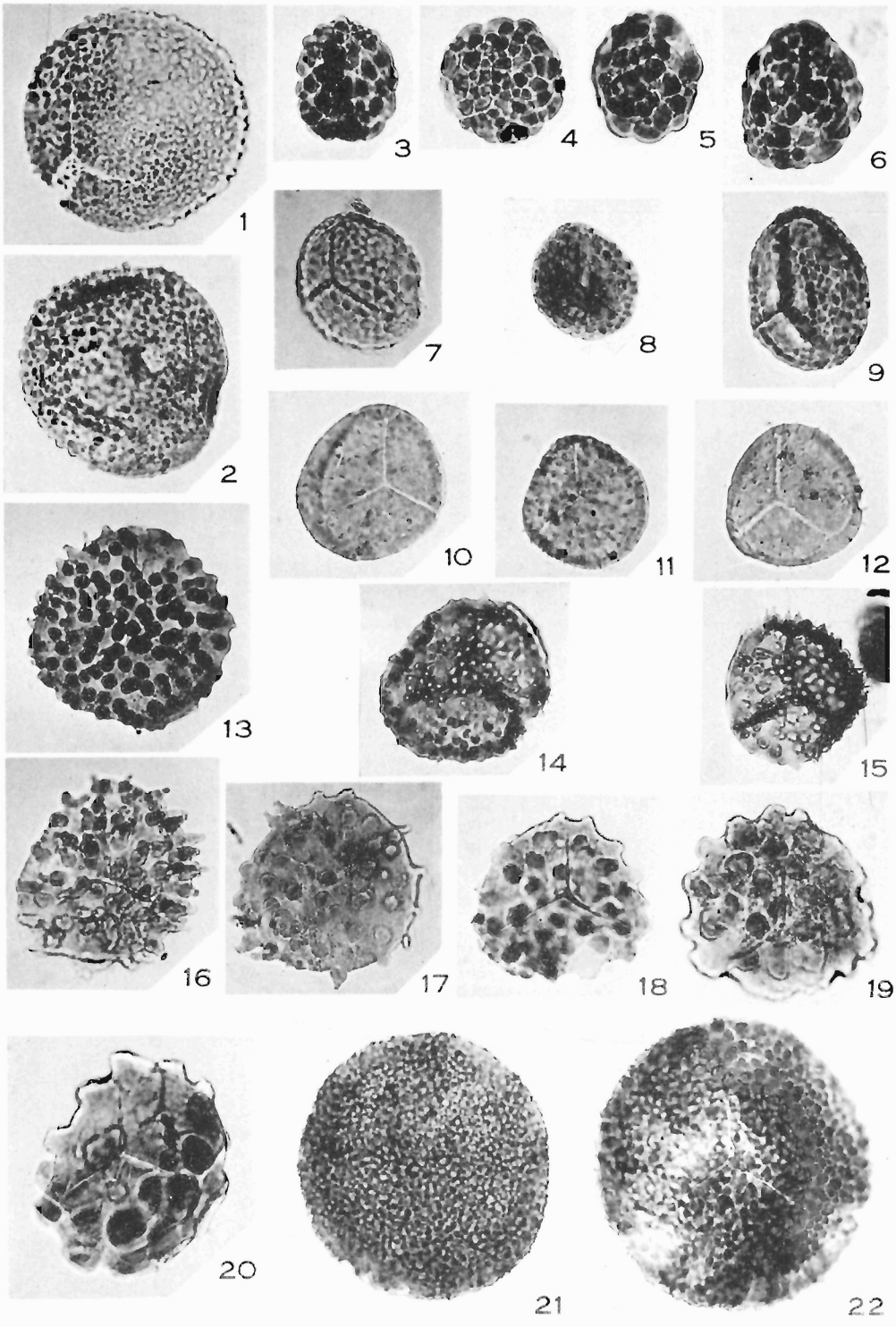
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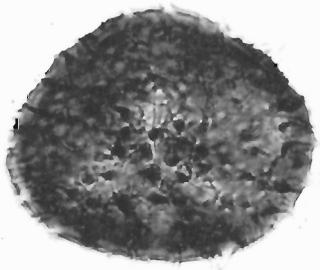
PLATE IV

(All figures $\times 500$, and from unretouched negatives)

Figures 1–4 *Acanthotriletes hacquebardii* n. sp. (Page 20)
1, proximal surface, preparation P297/14, 35.0×100.5, GSC No. 13104; 2, holotype, distal surface, preparation P297/45, 35.2×101.7, GSC No. 13105; 3, subpolar view, preparation P297/60, 36.3×100.2, GSC No. 13106; 4, distal surface, preparation P297/32, 38.6×100.6, GSC No. 13107.

Figures 5–7 *Pustulatisporites pretiosus* n. sp. (Page 19)
5, proximal surface, preparation P270/47, 36.0×1009, GSC No. 13108; 6, holotype, proximal surface, preparation P270/103, 33.7×99.2, GSC No. 13109; 7, proximal surface of specimen possessing mesosporoid, preparation P297/27, 40.4×105.4, GSC No. 13110.



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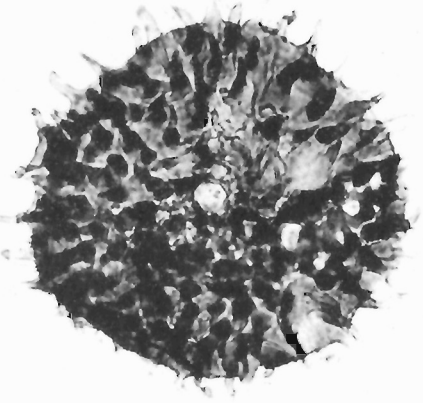

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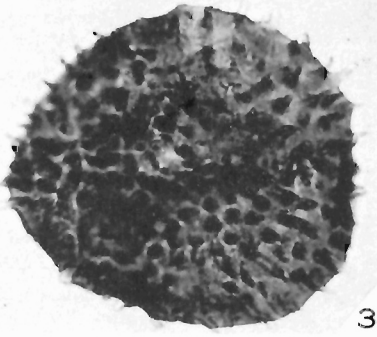

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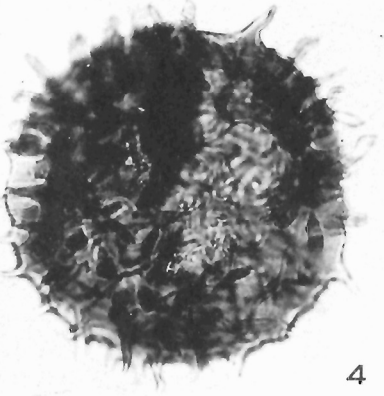

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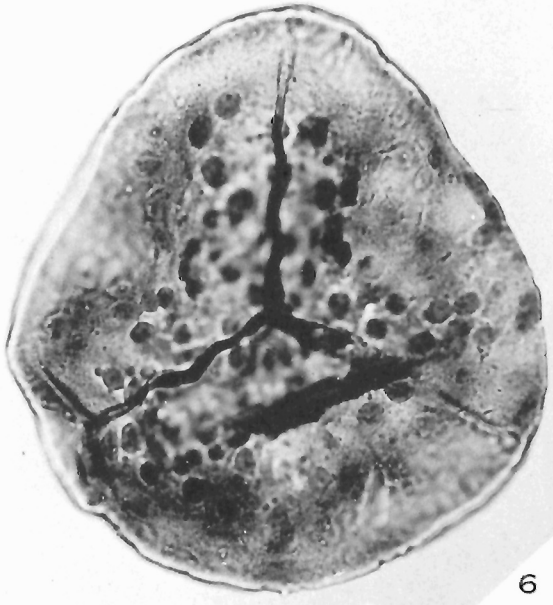

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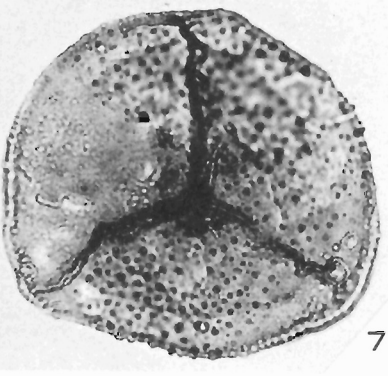

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Plate V

(All figures $\times 500$, and from unretouched negatives)

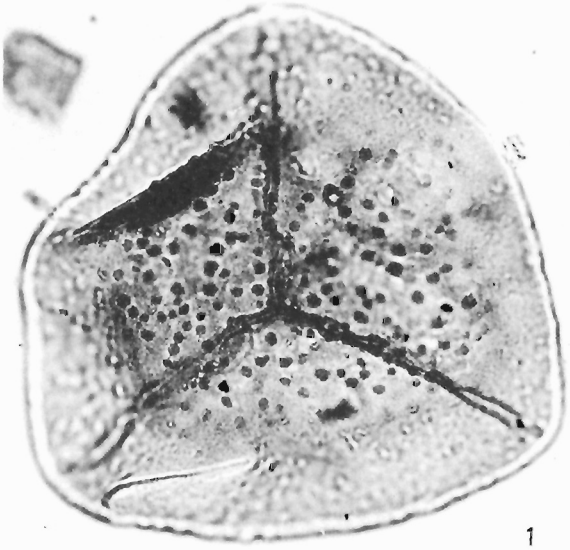
Figure 1 — *Pustulatisporites pretiosus* n. sp. (Page 19)
Proximal surface, preparation P270/4, 38.4×110.6, GSC No. 13111.

Figure 2 — *Grandispora echinata* Hacquebard, 1957. (Page 22)
Proximal surface, preparation P266C/226, 40.0×105.1, GSC No. 13112.

Figures 3, 4 — *Spinozonotriletes conspicuus* n. sp. (Page 22)
3, distal surface, preparation P266C/127, 39.3×98.4, GSC No. 13113; 4, holotype, distal surface, preparation P266C/53, 36.5×103.1, GSC No. 13114.

Figure 5 — *Spinozonotriletes uncatus* Hacquebard, 1957. (Page 23)
Distal surface, preparation P290/138, 37.4×102.0, GSC No. 13115.

Figures 6, 7 — *Spinozonotriletes tenuispinus* Hacquebard, 1957. (Page 23)
6, partial tetrad comprising three specimens, preparation P290/271, 36.8×105.9, GSC No. 13116; 7, distal surface, preparation P290/272, 31.0×99.5, GSC No. 13117.



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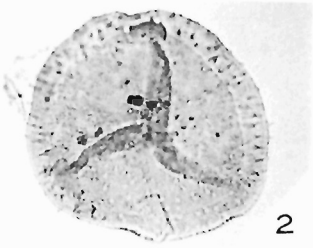

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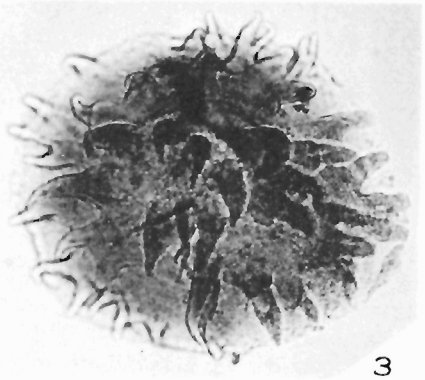

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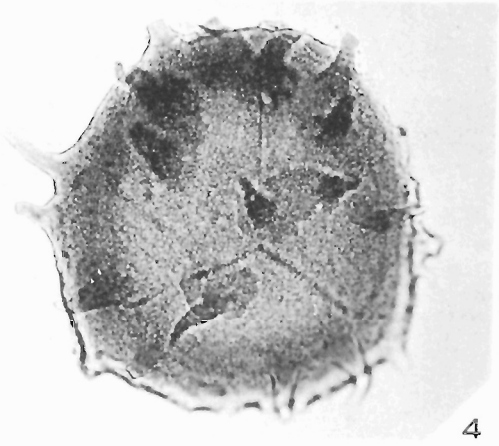

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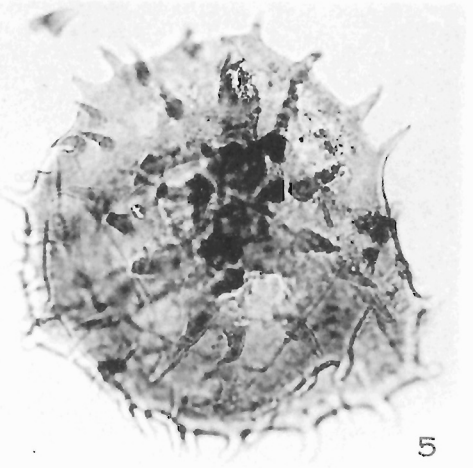

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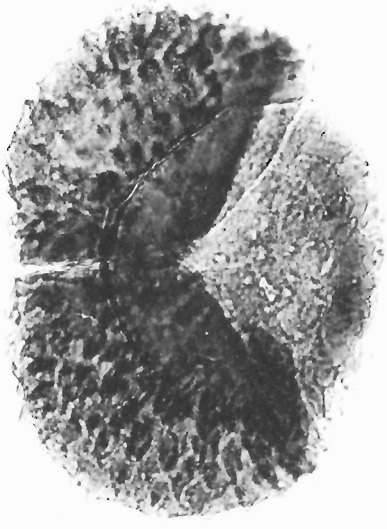

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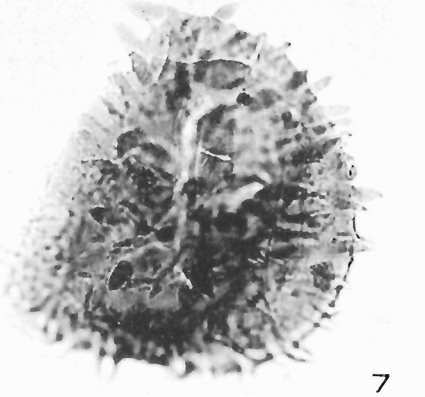

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PLATE VI

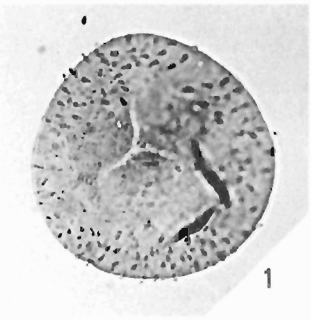
(All figures $\times 500$, and from unretouched negatives)

Figures 1–3 *Raistrickia abstrusa* n. sp. (Page 24)
1, holotype, proximal surface, preparation P290/100, 36.9×103.1, GSC No. 13118; 2, distal surface, preparation P290/20, 42.0×104.8, GSC No. 13119; 3, distal surface, preparation P290/149, 43.8×104.4, GSC No. 13120.

Figure 4 *Raistrickia baculosa* Hacquebard, 1957. (Page 24)
Proximal surface, preparation P266C/109, 34.9×105.0, GSC No. 13121.

Figures 5–10 *Raistrickia clavata* Hacquebard, 1957, emend. (Page 24)
5, distal surface, preparation P290/228, 37.3×101.7, GSC No. 13122; 6, distal surface, preparation P266C/2, 22.3×107.7, GSC No. 13123; 7, proximal surface, preparation P290/250, 41.7×100.4, GSC No. 13124; 8, distal surface, preparation P290/58, 36.0×104.6, GSC No. 13125; 9, distal surface preparation P266C/229, 39.4×102.0, GSC No. 13126; 10, proximal surface, preparation P290/259, 32.1×104.4, GSC No. 13127.

Figures 11, 12 *Raistrickia ponderosa* n. sp. (Page 25)
11, distal surface, preparation P298/2, 55.0×107.1, GSC No. 13128; 12, holotype, subpolar view, preparation P297/2, 46.8×110.0, GSC No. 13129.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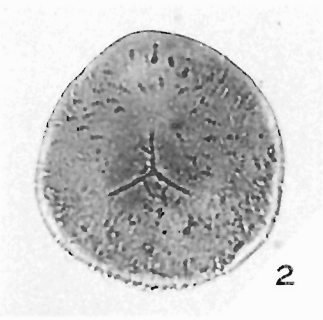
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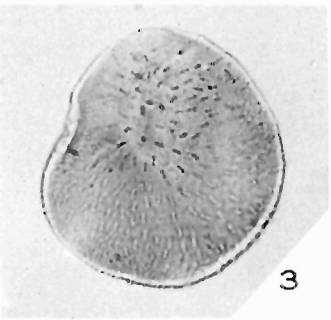
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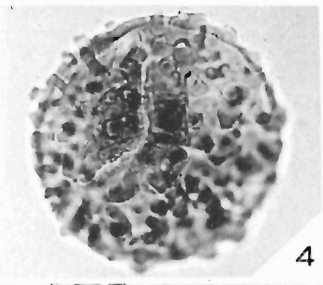
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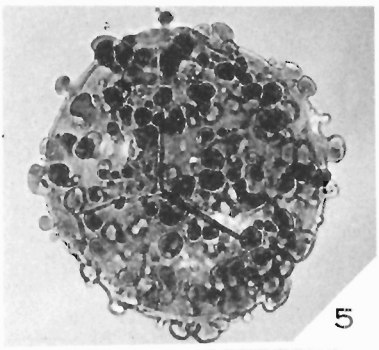
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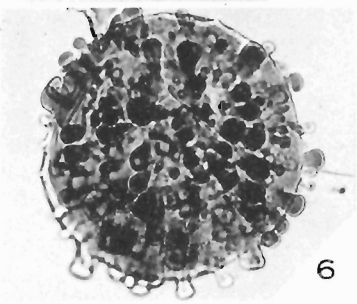
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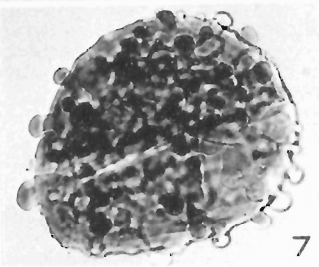
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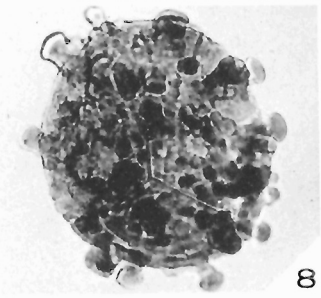
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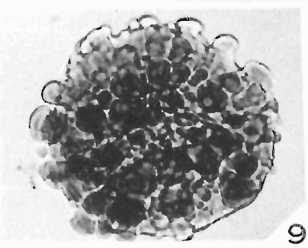
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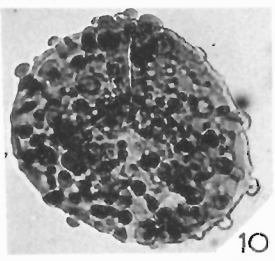
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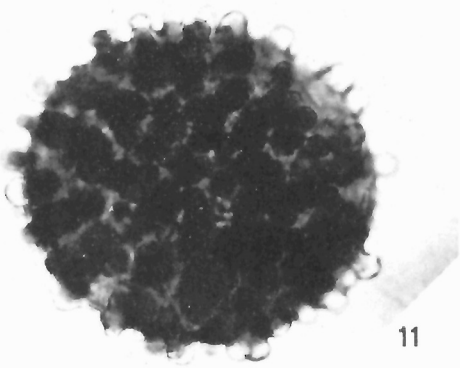
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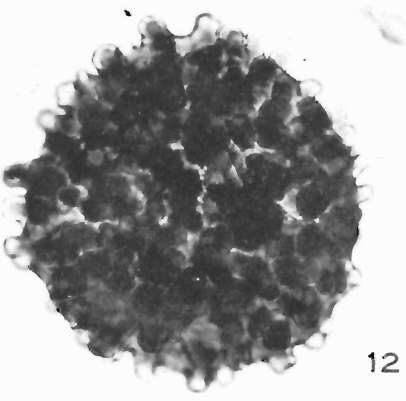
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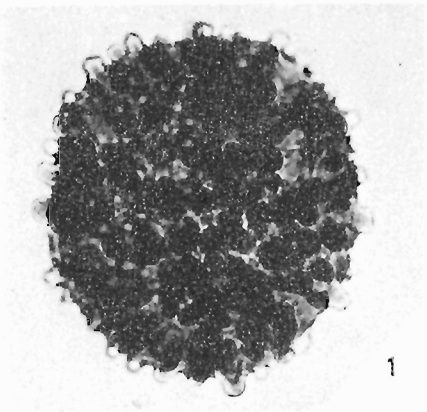
PLATE VII

(All figures $\times 500$, and from unretouched negatives)

Figure 1 — *Raistrickia ponderosa* n. sp. (Page 25)
Proximal surface, preparation P297/6, 48.0×109.2, GSC No. 13130.

Figures 2–7 — *Schopfites augustus* n. sp. (Page 26)
2, lateral view, preparation P266C/10, 33.4×100.0, GSC No. 13137; 3, 4, holotype, proximal and distal surfaces respectively, preparation P290/169, 31.9×102.0, GSC No. 13138; 5, proximal surface, preparation P266C/27, 33.0×102.6, GSC No. 13139; 6, distal surface, preparation P266C/125, 31.2×103.0, GSC No. 13140; 7, lateral view, preparation P296/3, 55.7×106.4, GSC No. 13141.

Figures 8, 9 — *Convolutispora vermiformis* Hughes and Playford, 1961. (Page 27)
8, proximal surface, preparation P297/2, 57.8×96.5, GSC No. 13142; 9, subpolar view, preparation P297/3, 20.4×111.2, GSC No. 13143.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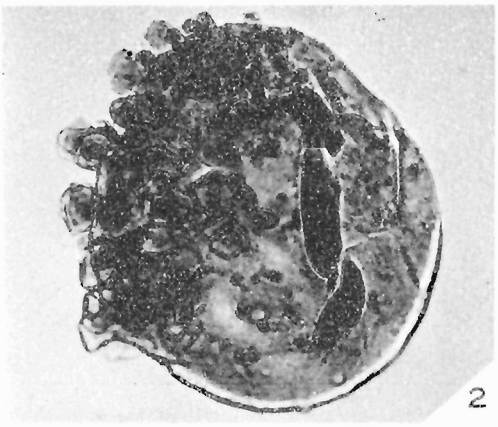
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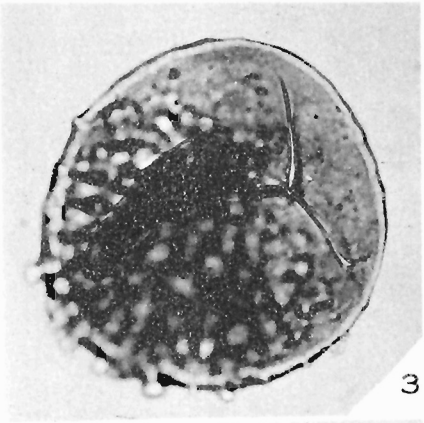
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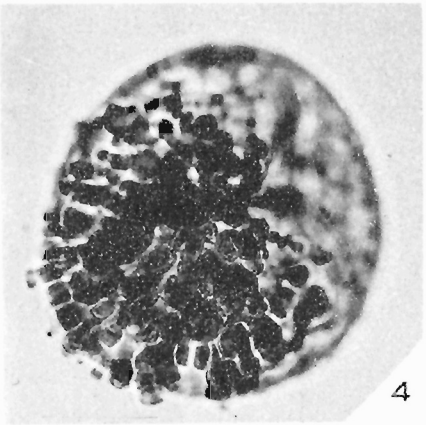
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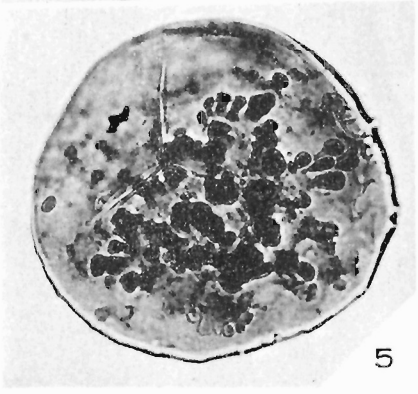
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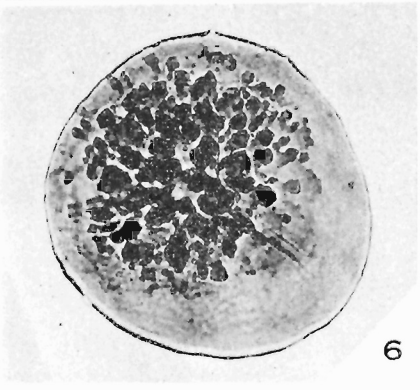
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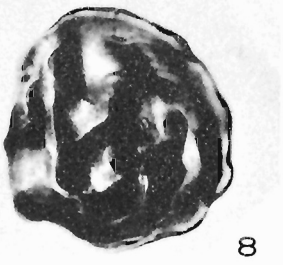
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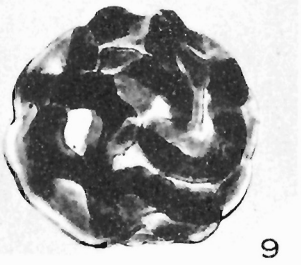
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PLATE VIII

(All figures $\times 500$, and from unretouched negatives)

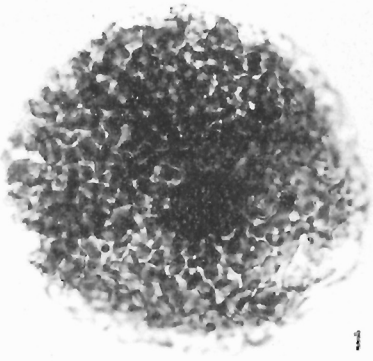
Figures 1, 2 *Convolutispora* cf. *finis* Love, 1960. (Page 27)
1, distal surface, preparation P270/29, 36.8×100.4, GSC No. 13144; 2, proximal surface, preparation P270/87, 32.2×99.0, GSC No. 13145.

Figures 3, 4 *Microreticulatisporites hortonensis* n. sp. (Page 28)
3, holotype, proximal surface, preparation P290/180, 36.8×100.9, GSC No. 13146; 4, proximal surface, preparation P266C/230, 48.3×98.7, GSC No. 13147.

Figures 5–8 *Dictyotriletes admirabilis* n. sp. (Page 29)
5, holotype, subpolar view, preparation P266C/78, 29.3×100.8, GSC No. 13148; 6, group of specimens, preparation P290/183, 39.2×99.1, GSC Nos. (clockwise from and including specimen on bottom right-hand corner) 13149–13153; 7, proximal surface, preparation P266C/1, 27.6×109.0, GSC No. 13154; 8, subpolar view, preparation P266C/113, 31.2×103.4, GSC No. 13155.

Figures 9–13 *Dictyotriletes submarginatus* n. sp. (Page 29)
9, holotype, proximal surface, preparation P270/3, 51.9×107.7, GSC No. 13156; 10, distal surface, preparation P297/7, 38.5×98.5, GSC No. 13157; 11, distal surface, preparation P297/3, 29.4×105.5, GSC No. 13158; 12, distal surface, preparation P270/2, 45.7×97.0, GSC No. 13159; 13, distal surface, preparation P270/104, 34.9×102.5, GSC No. 13160.

Figure 14 *Stenozonotriletes extensus* var. *major* Naumova, 1953. (Page 33)
Proximal surface, preparation P266C/159, 35.8×104.1, GSC No. 13161.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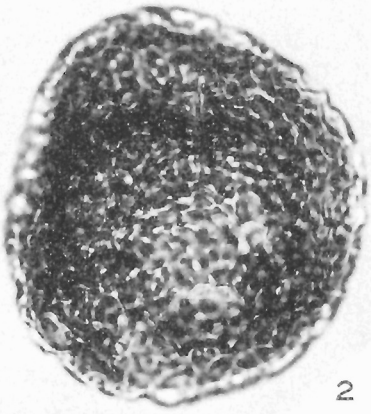
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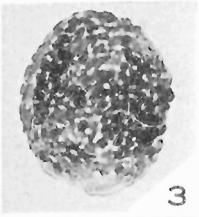
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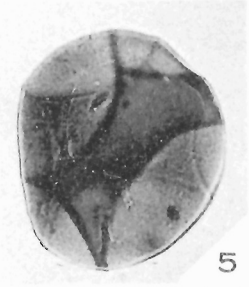
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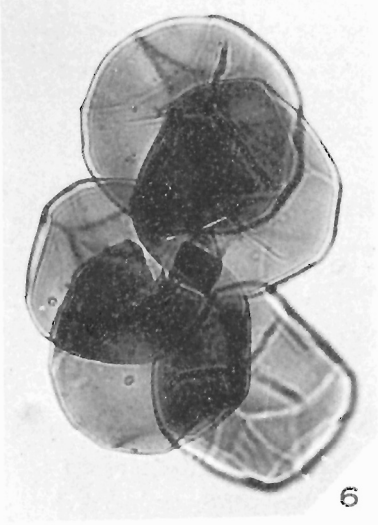
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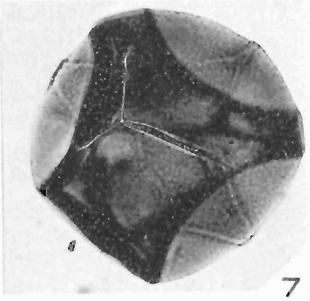
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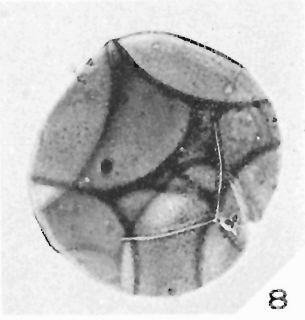
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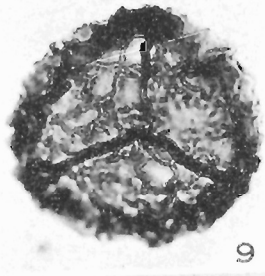
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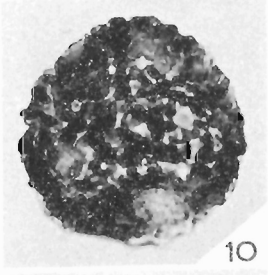
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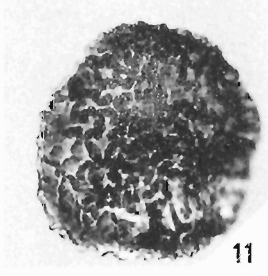
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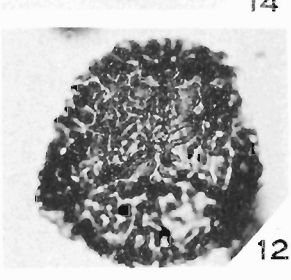
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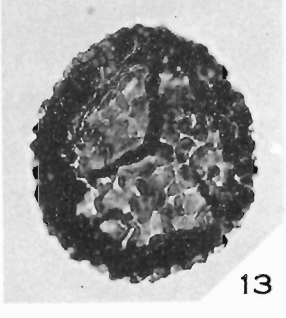
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PLATE IX

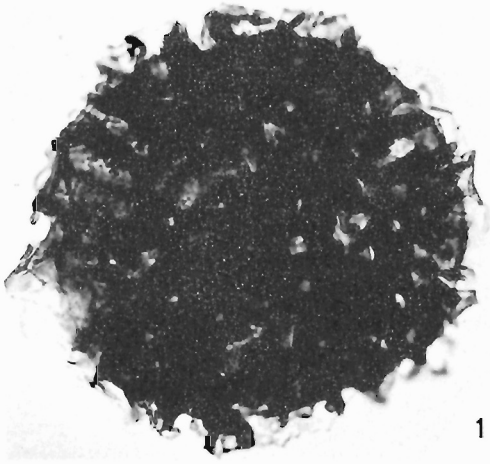
(All figures $\times 500$, and from unretouched negatives)

Figures 1–3 *Reticulatisporites cheveriensis* n. sp. (Page 30)
1, holotype, distal surface, preparation P297/59, 35.4×105.1, GSC No. 13162; 2, distal surface, preparation P297/41, 37.3×99.2, GSC No. 13163; 3, subpolar view, preparation P297/2, 38.7×106.9, GSC No. 13164.

Figure 4 *Camptotriletes* sp. (Page 32)
Distal surface, preparation P266C/175, 37.3×104.7, GSC No. 13165.

Figure 5 *Perotriletes magnus* Hughes and Playford, 1961. (Page 32)
Proximal surface, preparation P290/242, 38.2×95.4, GSC No. 13166.

Figures 6, 7 *Camptotriletes verrucosus* Butterworth and Williams, 1958. (Page 31)
6, subpolar view, preparation P266C/1, 24.5×92.7, GSC No. 13167; 7, proximal surface, preparation P290/261, 37.1×97.9, GSC No. 13168.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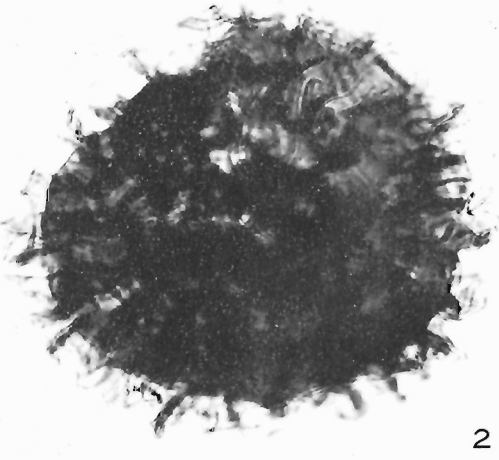
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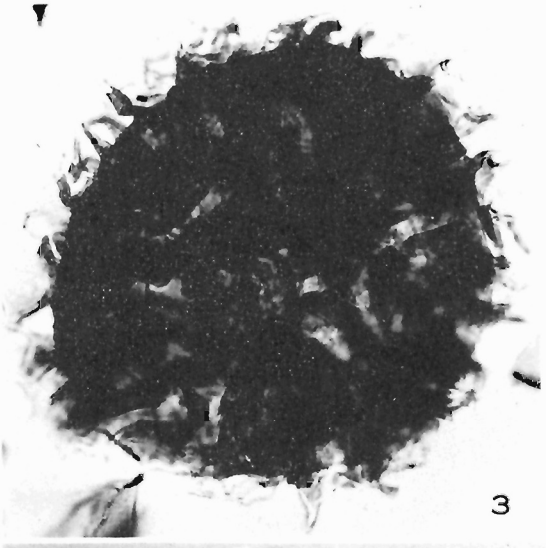
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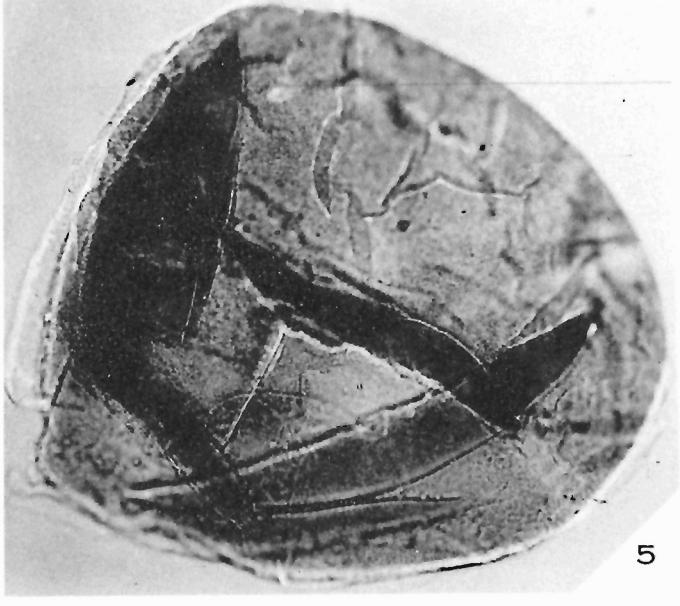
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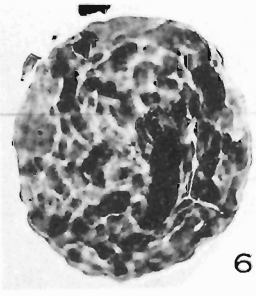
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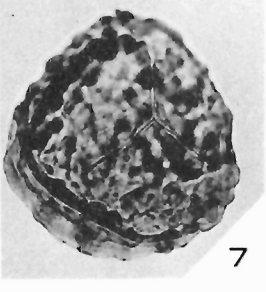
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PLATE X

(All figures ×500, and from unretouched negatives)

Figures 1–4 *Lycospora magnifica* McGregor, 1960. (Page 34)
1, proximal surface, preparation P290/215, 38.4×106.6, GSC No. 13169; 2, lateral view, preparation P290/115, 36.7×102.5, GSC No. 13170; 3, proximal surface, preparation P290/12, 36.0×105.5, GSC No. 13171; 4, proximal surface, preparation P266C/135, 47.3×105.7, GSC No. 13172.

Figure 5 *Perotrilites perinatus* Hughes and Playford, 1961. (Page 33)
Proximal surface, preparation P290/259, 45.8×96.1, GSC No. 13173.

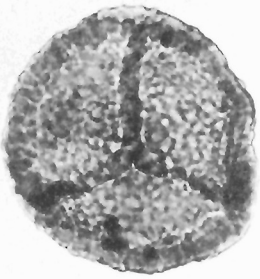
Figure 6 *Lycospora torulosa* Hacquebard, 1957. (Page 35)
Distal surface, preparation P290/28, 35.7×104.2, GSC No. 13174.

Figure 7 *Vallatisporites vallatus* Hacquebard, 1957. (Page 35)
Distal surface, preparation P266C/92, 32.6×102.4, GSC No. 13175.

Figure 8 *Vallatisporites verrucosus* Hacquebard, 1957. (Page 35)
Proximal surface, preparation P266C/3, 25.3×111.4, GSC No. 13176.

Figure 9 *Stenozonotriletes* sp. (Page 33)
Proximal surface, preparation P297/46, 28.0×104.2, GSC No. 13177.

Figure 10 *Cristatisporites echinatus* Playford, 1963. (Page 36)
Proximal surface, preparation P290/247, 35.4×101.3, GSC No. 13178.



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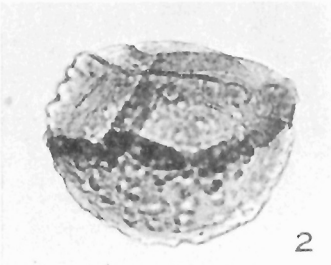

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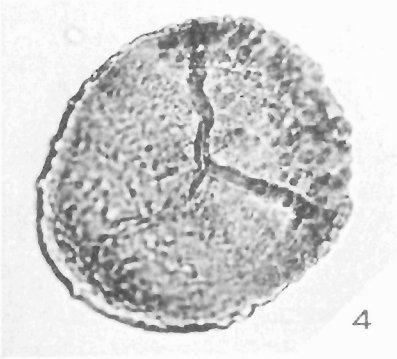

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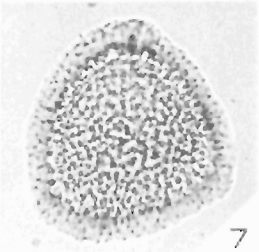

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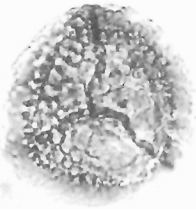

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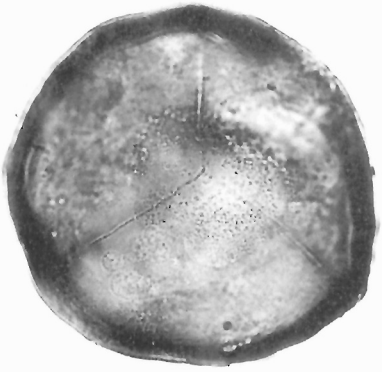

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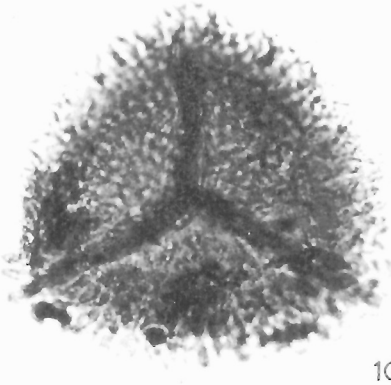

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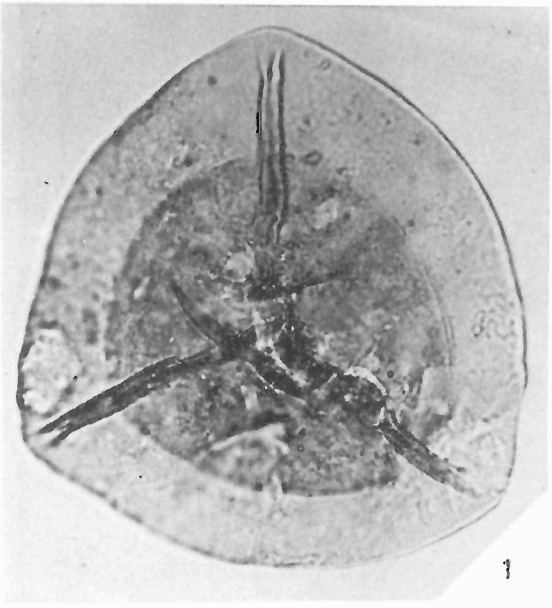
Plate XI

(All figures $\times 500$, and from unretouched negatives)

Figure 1 — *Endosporites marcomanifestus* Hacquebard, 1957. (Page 37)
Proximal surface, preparation P290/153, 28.2×101.6, GSC No. 13179.

Figure 2 — *Endosporites micromanifestus* Hacquebard, 1957. (Page 37)
Proximal surface, preparation P296/1, 22.7×95.8, GSC No. 13180.

Figures 3–5 — *Cristatisporites aculeatus* (Hacquebard) Potonié, 1960. (Page 36)
3, proximal surface, preparation P290/275, 28.8×101.8, GSC No. 13181;
4, proximal surface, preparation P266C/76, 31.6×101.7, GSC No. 13182;
5, distal surface, preparation P266C/206, 40.5×104.1, GSC No. 13183.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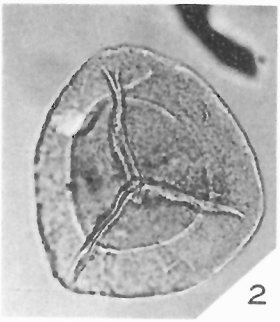
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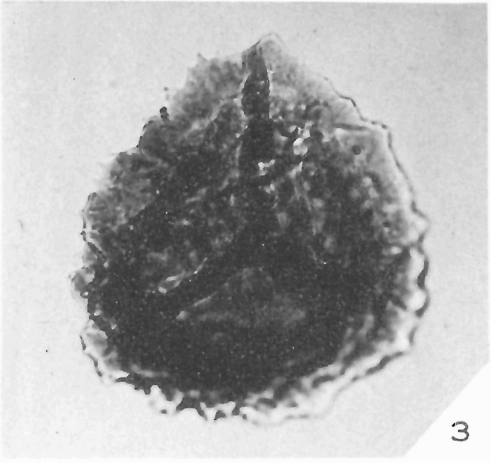
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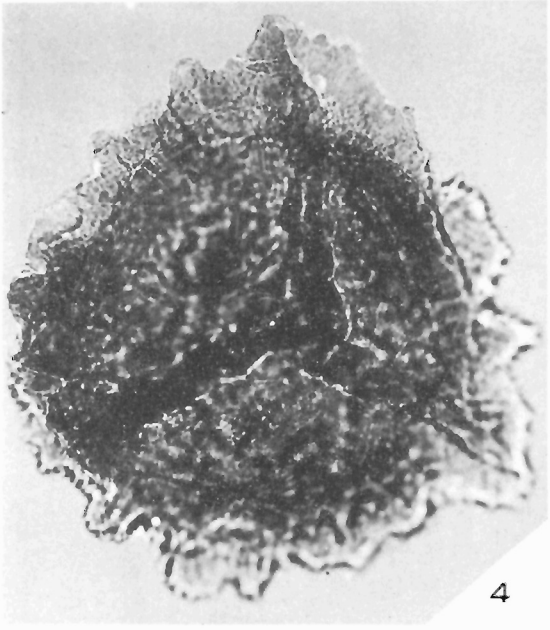
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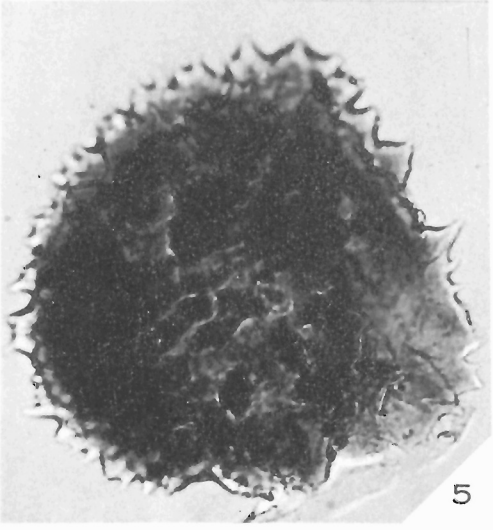
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