THE SUITABILITY OF THE TERM

INDEX PLANT MICROFOSSIL

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By

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SCOPE AND CONTENTS:

Plant Microfossils have been extracted from separate thin layers of a sample of rock from the York River formation of the Gaspé region. These have been illustrated and described. An index plant microfossil assemblage for that particular facies has been illustrated.

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INTRODUCTION

According to Schrock (31) an index fossil is one which identifies and dates the strata or succession of strata in which it lies. Ideally it should be restricted in stratigraphic range but have a broad geographic distribution. Unfortunately such species are not common and genera with a narrow stratigraphic range combined with a rather broad geographic distribution are now used as index fossils. In many cases it is permissible to perform correlations on the basis of the use of genera rather than species. Before the suitability of plant microfossils as index fossils is considered, a few words on their occurrence and attributes may not be amiss.

Plant fossil remains of microscopic dimensions but showing characteristic structure have been extracted by maceration from deposits of organic nature such as coal and peat and also from many classes of sedimentary rocks such as sandstones, shales, greywackes and salt deposits. The term plant microfossil includes spores (mega and micro-spores), pollen, pieces of cuticle, strands of conductive tissue and portions of sporangia. The term megaspores is used to define spore-like bodies greater than 200 μ in size. Their presence is usually restricted to deposits of a purely organic nature, their large size rendering them particularly vulnerable to damage from harder mineral particles during and following deposition. G.K. Guennel, (4) proposes the use of the term 'miospore' for fossil spores and spore like bodies under 200 μ in size. He includes homospores, true micro-

spores, small megaspores pollen grains and pro-pollen within this definition.

There are a number of other microfossils that can be used by the palaeontologist. Of animal origin are Ostrocods, Foraminifera and small fragments such as sclerites sponge spicules and conodonts. Of problematic origin but abundant in some deposits are scolecondonts and hystrichosphaerids. Of plant origin are megaspores, microspores, pollen grains, pro-pollen, homospores, portions of sporangia, cuticle, conductive tissue and fungal hyphae. Sporangial fragments are especially useful if they have spores associated with them. The outline of epidermal cells can often be seen in cuticle and if stomata are present the characteristics of the guard cells can be diagnostic. Algal remains such as those of diatoms and dinoflagellates are also found.

The proven occurrence of these varied classes of microfossils in such a wide range of sedimentary formations suggests that they might be useful as index fossils either distinct species or as assemblages, and previous workers have found this to be so.

The Objectives of the Present Study

The examination of a piece of York River sandstone to see if it contained plant microfossils. In the event of a favourable outcome to this preliminary investigation it was proposed to examine the microfossil content of successive thin layers from the rock sample, rather than that obtained by the maceration of samples of irregular size taken at random such as is usually employed. It is hoped that this will reveal finer shades of occurrence and distribution of microfossils that

may provide significant information on a number of different topics.

(a) To investigate the significant factors involved in compiling an index plant microfossils assemblage for the facies of York River sandstone under investigation.

(b) The conditions under which the rock was deposited.

(c) The ecology of the floral community which gave rise to the microfossils described and illustrated herewith.

(d) To contrast the picture presented to us by the macrofossil remains on the one hand and by the microfossil remains on the other.

Uses of Plant Microfossils

By reason of their possession of characteristic features, enabling their classification into species 'per se' and as a result of the advantages they share with other microfossils such as widespread occurrence in large numbers, and diversity of form, plant microfossils are of great use to both the palaeontologist and also to the botanist.

Plant microfossils are of considerable importance to economic palaeontologists both in the coal and oil industries (24). They are ofespecial use in the dating of segments of cores from oil exploration as they are often the only fossils to be found under such conditions. It is possible that certain assemblages of plant microfossils extracted from cores may afford a method of recognizing some of the stratigraphic traps in which oil may occur.

Plant microfossils can be used to determine the location of ancient shore lines. Erdtman has shown that spores and pollen are accumulating in near shore sediments off the coast of Sweden at a rate of 50,000 per square inch each year. The pollen and spore count per gram of sediment rises very sharply for near shore sediments compared with those off shore. (24). This is for recent sediments but we have no reason to believe that this would not occur in much earlier sediments. Pollen and spores are carried vast distances by the wind, and they have been found in abyssal sediments of the Mediterranean but their numbers fall off rapidly as we leave the shore line.

Spores and pollen are very useful for zoning continental deposits in the absence of interbedded marine strata. Foraminifera can be used to zone marine deposits, Ostrocods serve the same function for sediments laid down under brackish waters and now plant microfossils, such as spores and pollen, provide a useful tool in the case of continental deposits. The deposits produced by evaporating seas rich in mineral salts that restricted the growth of organisms in them, were, in the past, very difficult to date, but once again we find plant microfossils present in the salt deposits and these enable us to locate them in the geological series.

Plant microfossils are also an abundant source of botanical information. They shed light on ancient phylogenetic relationships and on the morphology of their parent plants. Most important of all is their use in the interpretation of palaeoecology. In all these spheres if macrofossils have been present workers have tended to put too much

importance on the picture they present. We should, however, take heed of Sporne's warning, "Organisms fossilized might not be a representative sample of the vegetation, but might show a bias towards particular plants with some peculiar ecological preference or towards plants with some metabolic peculiarity." (16). When we examine miospores however, it is probable that we are seeing a much more representative selection of plant remains. We shall see later how we are forced to visualize a different picture of Devonian plant communities when we examine microfossil evidence than that to which we have been accustomed, as a result of past workers placing too much weight on macrofossil evidence alone, as we shall see later on in the discussion.

Historical Review

The first worker to discover spores in the course of palaeobotanical work was Witham in 1833 who was working on thin sections of coal and noticed what he described as traces of organization which were later found to be spores. In 1840 Morris illustrated the first fossil megaspores. An important discovery was that of Franz Schultze who, in 1855, found that coal could be macerated chemically without destroying the microfossils by the use of the solution which bears his name. Although this greatly facilitated the isolation of microspores little systematic work was done on them until Reinsch (1884), and Bennie and Kidston (1886) appeared on the scene. In 1883 F. Trybom a Swedish Zoologist noted the resistant character of pine and spruce pollens in the course of his studies on lake sediments and suggested that these fossils should be useful to palaeontologists. The year 1896 found the

German botanist and stratigrapher C.A. Weber investigating the significance of pollen frequency ratios. Lennart van Post was the first worker to use pollen diagrams to illustrate the differences between various stratigraphic horizons. Barlett (1928) laid the foundation for systematic studies on spores and pollen. Of tremendous importance in the development of the application of miospores and in itself, a most elegant piece of applied palaeobotany was the work of Raistrick and Simpson (1933) in the correlation of a number of Northumberland coal seams.

The great majority of work on plant microfossils up until about five years ago was in connection with organic deposits such as coal (Carboniferous) and peat (Recent). Just recently, however, more and more effort is being directed towards the study of microfossils from predominantly inorganic sediments. It is rather surprising that this aspect of microfossil work should have been so long in arousing interest because as far back as 1871 Dawson noted flattened disc like bodies occurring in the Devonian black shales of Kettle Point, Ontario. He named these Sporangites.

Indian workers such as Sahni and Mehta were, for a while, more active in the extraction of spores from inorganic matrices than were their colleagues in the rest of the world. They were quick to realize the potential of plant microfossils for ageing assorted sediments in the absence of other fossils. Russian workers, for example Luber, Waltze and Naumova have done a great deal of work on microspores from inorganic sediments. Naumova has extracted, named and classified vast numbers of spores from the Devonian of the Russian platform. Her publications present an object lesson to workers of lesser repute. She has also

been successful in disintering spores from pre-Devonian strata from the Cambrian, Ordovician and Silurian. This extends the potential of plant microfossils for ageing purposes even further.

A considerable impetus to the investigation of the potential of plant microfossils for the dating of inorganic sediments especially those of Devonian age, has occurred in the last few years as a result of the exploration activities of oil companies. Ten years ago, so far as is known, only one oil company in the United States was conducting research on the use of spores and pollen as a general stratigraphic tool but today major oil companies the whole world over are using plant microfossils in their correlation and exploration work.

Materials and Methods

Material

The rock sample used in this study can be described as a piece of thinly but irregularly bedded, medium grained but very poorly sorted greenish grey impure bituminous sandstone containing abundant feldspars and mica. It could probably be defined under the heading greywacke (Dr. Best). Abundant plant remains are visible both black carbonized fragments and also brown cuticular portions. They show a size gradation from about 1 sq. cm. downwards. Stem portions with dichotomies are present but the remains are of too fragmentary a nature to permit precise identification. (Plate 1).

The sample was removed from the outcrop along the shore line between the Anse à Brillant River and Tar Point. This has been stated to belong to the York River formation which lies at the base of the Middle Devonian in this region (20). The formation has a thickness of from 1,000 to 6,000 feet.

The York River formation grades into the better known Battery Point formation both vertically and laterally. At Tar Point the Battery Point sandstone lies conformably on top of a thin zone of York River sandstone. The York River formation has been described (20) as consisting of greenish-grey, medium to fine-grained felspathic sandstones with interbedded greenish shales which become more common towards the base of the formation. No sharp boundary can be drawn between the

York River and the overlying Battery Point formation and indeed interbedding does occur between the two. The sandstones of the two formations are generally distinguished on a petrological or mineralogical basis: the York River sandstones are finer grained, less pebbly and not so sharply cross bedded but the chief point of distinction lies in the feldspar which is brownish-red to flesh-coloured orthoclase.

Many beds of the York River formation have been found to be abundantly fossiliferous and McGerrigle presents an impressive list including the following phyla:

Porifera	1 species
Coelenterata	1
Annelida	2
Echinodermata	2
Bryozoa	4
Brachiopods	29
Pelecypods	30
Gastropods	11
Scaphopods	1
Pteropods	1
Cephalopods	2
Trilobites	2
Archaeostraca	1
Vertebrates	1
Plants	2

The latter figure should be borne in mind and considered in comparison with the evidence to be deduced from examination of the plant microfossils. These are Psilophyton princeps and Lepidodendron Sp. Logan (1863) lists the following:

Leptophloum rhombicum
Didymiphyllum rhoforme
Prototaxites simplex
P. minus
Lycopodites

In consideration of the materials it is necessary to contemplate the geological history of the area.

It is generally accepted that the Gaspé sandstones were deposited in shallow waters but whether under a shallow sea or under fresh water conditions on a continent, is still a matter on which geologists differ. The presence of intraformational conglomerates, cut and fill structures, ripple marks, impressions of rain drops, cross bedding, basal conglomerates and numerous plant macrofossils indicate shallow water deposition. The poor sorting of the mineral fraction indicates rapid erosion and deposition with the parent source fairly close to the depositional basin. The occurrence of fairly well preserved plant macrofossils in relatively course grained sediments (compared with shales) suggests rapid deposition and burial. This could have occurred under continental conditions or in shallow seas bordering the continental regions. McGerrigle favours the latter view.

Considerable oil seepage has occurred in the general vicinity hence the name 'Tar Point'. A large number of wells have been drilled into the York River and the associated Battery Point formations. 'Petroleum' of good quality is obviously present as indicated by the 'shows' of oil in seepages and in wells.

Laboratory Techniques

The original rock sample was of the order of size 15x10x1.5 cm. To avoid all possibility of contamination from adjacent layers and external sources the exposed portions of the sample were removed, leaving a piece of sandstone approximately 7.5x5x1 cm. in size. With the aid of a scalpel successive thin sections of the rock were eased off the parent block and transferred to sample bottles. The sample of sandstone used showed a fairly marked tendency to separate into layers of fairly constant thickness thus facilitating this technique. The successive layers were approximately 1.5 mms. in thickness. These were numbered 1-6 from the top downwards. To avoid discrepancies due to transfer of loose microfossils between adjacent layers only alternate odd numbered sections were examined with the exception of the basal layer 6.

Preliminary maceration experiments were performed along the lines of approach used by Radforth, Rouse and McGregor to see if, in fact, microfossils were present and if so, whether they existed in sufficient numbers and in a suitable state of preservation to permit more intensive investigation.

The most suitable time of reaction with various reagents was found to be as follows:

HF	Schultze's solution	KOH
140 hrs.	30 hrs.	1 hr.

The rock sample was broken into pieces about 1 cm. square, placed in a clean polyethylene beaker and covered with about 75 mls.

of hydrofluoric acid. The mixture was agitated gently at 12 hourly intervals and left covered in a fume cupboard. After the time of treatment had elapsed the hydrofluoric acid was decanted and the residue washed several times by decantation with distilled water. Finally it was transferred into two 50 ml. centrifuge tubes, the larger pieces of organic material being left in the beaker and the distilled water carefully removed. This was followed by the addition of about 25 mls. of Schultze's solution to the contents of each tube, the whole being mixed gently. The Schultze's solution was prepared by dissolving 1 ml. of potassium chlorate in 50 mls. of concentrated nitric acid. In the preliminary trial run samples were removed from the Schultze's solution at intervals and examined under the microscope to ascertain whether or not the microfossils had been cleared sufficiently. When their appearance was judged to be satisfactory the Schultze's solution was poured off, and the sediment washed by decantation several times with distilled water. The microfossils are very delicate at this stage and great care must be taken to avoid undue damage. The final stage in the process consists of heating the organic residue with 10% potassium hydroxide solution on a water bath for a period of one hour. The supernatent liquid is decanted once more and the microfossils washed with distilled water. The rate of sedimentation of the microfossils in the KOH solution is very slow but can be accelerated by the addition of a drop of "Photo-Flo".

The HF dissolved the mineral matrix and silica fraction of the rock but had little or no effect on the organic material. Hence, the time of immersion was not critical provided it was long enough to

dissolve the mineral crystals. In rock samples which contain an appreciable percentage of carbonates it is necessary to remove these using hydrochloric acid prior to treatment with HF. In this case such treatment was found to be unnecessary. Schultze's solution is a strong oxidizing agent and has the effect of removing excess carbon from the microfossils rendering them semi-transparent. (This process is known as clearing). The time of reaction with the Schultze's solution is quite critical. If it is too short the microfossils will appear opaque: if it is too long the fine structure and ornamentation of the wall may be destroyed. Excessive immersion in Schultze's solution may destroy the microfossils completely. Treatment with 10% KOH has the effect of dissolving humic material: this causes the separation of clumps of organic particles and the removal of small adhering debris from the microfossils.

In an investigation of this nature it is important to arrive at a standardized technique for the extraction of microfossils and to use this method in each maceration performed. Variations in the time of reaction with Schultze's solution render the microfossils more or less opaque and affect the appearance and relief of the ornamentation of the wall so rendering identification more difficult and hazardous.

Preparation of Slides

Slides were made using corn syrup as a mounting medium as described by Radforth and subsequently used by Rouse and McGregor. A few crystals of phenol were first added to corn syrup to prevent

subsequent attack of fungi. The corn syrup was then diluted with distilled water in the ratio of about three parts of syrup to one of water and a drop placed on a slide with a glass rod. It is important that the slide should be perfectly clean and free from grease. The organic residue in the bottom of the centrifuge tube is shaken with a small amount of water and a drop removed with a pipette to be mixed with the corn syrup drop on the slide. This is done with a fine glass rod and the mixture spread thinly and evenly over the slide which is then left to set overnight in a cool place. If preferred the microfossils may be stained with safranin prior to mounting. This is useful if the sample contains a large proportion of thin transparent microfossils. One should avoid making the corn syrup solution too dilute or the preparation will form 'waves' on drying. This can also occur if the slides set in a too hot and dry atmosphere. The refractive index of corn syrup is very favourable for good resolution but one should work with as thin a layer as possible.

Photography

A binocular microscope was used for scanning, the slide being transferred to a monocular for detailed examination and for the photographic recording of the microfossils. This was done using the Exakta camera in conjunction with a 10x eyepiece and a 47.5x objective, the resulting negatives requiring a magnification of about 4 times to give the standard 500x scale of reproduction of the original microfossils. In recording microfossils photographically one is faced with the

problem of combining optimum resolution, maximum depth of field with fairly high contrast and fine grain on the final print. Critical illumination must be maintained and a blue filter was found to enhance the resolution obtainable. To preserve a clear background and ensure high resolution a fairly wide opening of the substage condenser was used. Adox KB14 film developed in Afga 15 was found to give the best balance between fine grain, high resolution, high contrast and reasonable gradation. Exposure time was determined in the first instance by measurement of the brightness of the microfossil on the reflex screen using the SEI photometer.

RESULTS

In the piece of sandstone used in this investigation numerous miospores, some hystrichosphaerids, pieces of well preserved cuticle, fragments of sporangia, conducting elements and problematical fragments of animal nature were found and isolated from small pieces of rock which although showing promise of organic remains to the naked eye possessed no identifiable macrofossils.

Most attention has been paid to the microfossils which have been photographed, and, as far as possible, identified. In most cases it has been possible to assign miospores to a previously described Palaeozoic genus but only in a few cases has it been possible to identify them with described species. Detailed description of the miospores has not been attempted. The generic description has been given and notes amplifying this for each species have been added.

For each thin layer of rock 100 spores have been counted. The occurrence and numbers of the various genera are shown on plates 2, 3 and 4. In the four layers 23 genera could be recognized and 72 species of these genera. These are described in the following pages and illustrated on plates 5-

DESCRIPTION OF MIOSPORES

The scheme of classification followed here is that devised by Potonié and Kremp (1954). These authors recommend that hyphenated spellings of certain generic names be abandoned and that has been done in this treatise, (e.g. Punctati-sporites becomes Punctatisporites).

SPORITES H. Potonié 1893

Division TRILETES Reinsch 1881

Subdivision Azonotriletes Luber 1935

Suite Laevigate (Bennie and Kidston 1885)

Genus Leiotriletes (Naumova 1937)

Trilete, subtriangular miospores with a smooth outline, surface Laevigate to infrapunctate or infragranulate.

Leiotriletes Species A

Pl. 2, Fig. 1.

Represented by two not very well preserved specimens of diameter approximately 20 µ. The wall surface is Laevigate and the trilete marking not well marked.

Leiotriletes Species B

Pl. 2, Figs.2 and 3.

The diameter of this group of spores varies from 25 - 34 µ. There is a distinct trilete aperture. The wall surface varies from smooth to infragranulate.

This spore resembles Leiotriletes simplex (Naumova).

Leiotriletes Species C

Pl. 2, Fig. 4.

Diameter 48 - 68 µ. Spores subtriangular. Well marked trilete marking. Surface infrapunctate. Wall thin and folded. This spore strongly resembles Naumova's Leiotriletes nigratus even to the darkened area round the trilete mark, but she figures her specimens as being more circular than subtriangular. She gives the size range of L. nigratus as being from 60 - 70 µ.

Leiotriletes Species D

Pl. 2, Fig. 5.

Diameter 50 - 53 µ. The wall surface is Laevigate and has no apparent thickness except on one folded specimen. These spores are thrown into folds and subtriangular shape is not apparent making them resemble a species of Calamospora but the trilete aperture is well marked.

Leiotriletes Species E

Pl. 2, Fig. 6.

Diameter 42 - 60 µ. Spores subtriangular. The wall is thin with infragranulate ornamentation. The Lacsurae of the trilete aperture extend to the equator of the spore: as a result of this specimens of this species are often found to be torn.

Leiotriletes Species F

Pl. 2, Fig. 7.

Diameter 36 - 44 µ. This group of spores resembles the

previous species but the wall is Laevigate and the size range smaller.

These spores show a close resemblance to McGregor's Leiotriletes dissimilis but he quotes a size range of 43 - 55 µ which is larger than that found for my specimens.

Leiotriletes Species G

Pl. 2, Figs.8 and 9.

Diameter 36 - 40 µ. Spores subtriangular with a thin wall showing infragranulate ornamentation. The Laesurae extend almost to the equator of the spore.

Leiotriletes Species H

Pl. 2, Fig. 10.

Diameter 22 - 25 µ. The wall ornamentation is infragranulate. The Laesurae of the trilete marking extend almost to the equator of the spore.

Genus Trachytriletes (Naumova 1937).

Trachytriletes Species A

Pl. 2, Fig. 11.

Size 15 - 21 µ. A dark brown triangular spore with a broad dark trilete ray the arms of which extend to the angles of the spore. It resembles Ischenko's Trachytriletes graneus but is too small (T graneus 40 - 45 µ), and has one angle more acute than the other two.

Genus Punctatisporites (Ibrahim 1933)

Trilete, circular, exine punctate to infrareticulate or infragranulate (outline smooth), trilete ray usually exceeds half the radius, contact areas absent.

Punctatisporites Species A

Pl. 2, Figs.12 and 13.

Diameter 58 - 67 µ. Wall up to 3 µ in thickness. The ornamentation is finely granulate. The trilete ray is dark and extends almost to the equator of the spore.

Punctatisporites Species B

Pl. 2, Fig. 14.

Diameter 24 µ. There is no obvious trilete ray and the spore appears to be covered with fine spines judging by the appearance of the margins. This suggests that it does belong to the genus Punctatisporites and the general appearance and size agrees with that of Ibrahim's Punctatosporites-minutus.

Punctatisporites Species C

Pl. 2, Fig. 15.

Diameter 48 - 55 µ. The wall is up to 2.5 µ in thickness and has infragranulate ornamentation. One arm of the trilete ray is 2/3 rds. the length of the radius of the spore and the other two about 1/3 rd.

Genus Calamospora (Schopf, Wilson and Bentall 1944)

Trilete, circular, thin walled, contact areas often present, exine without structure (rarely a slight internal punctuation), trilete raysshort, secondary taper point folding often present.

Calamospora Species A

Pl. 2, Figs.16, 17, 18 and 19.

Diameter 40 - 50 µ. Spores generally pale brown in colour. They are often folded: sometimes just the wall is thrown into folds, sometimes the spore assumes an elongate taper point shape. The trilete ray is about 2/3 rds. the length of the radius of the spore.

Calamospora Species B

Pl. 2, Figs. 20, 21, 22 and 23.

Diameter 41 - 65 µ. This species closely resembles species A but is larger in size and shows a more marked tendency to folding especially to an elongate shape.

Calamospora Species C

Pl. 3, Figs. 1, 2, 2a and 3.

Diameter 60 - 70 µ. Again this species closely resembles the two described above.

Calamospora Species D

Pl. 3, Figs. 4, 5, 6 and 7.

Diameter 70 - 80 µ. The exine shows a very fine infragranulate ornamentation. The trilete ray is short, the arms varying from 1/4 to 1/3 the length of the radius. Taper point folding does occur but not so much as in the previous species. The wall is often irregularly distorted.

Calamospora Species E

Pl. 3, Figs.8, 9 and 10.

Size 92x52 µ — 110x72 µ. All the specimens were distorted to

an elongate shape. The wall exhibits fine infragranulate ornamentation. A short trilete ray could be seen on one example.

Calamospora Species F

Pl. 3, Figs.11,12, 13 and 14.

Diameter 24 - 34 µ. Several examples show a wall 2 - 3 µ in thickness but this could be an artifact induced under compression. The arms of the trilete ray vary from 1/3-2/3 rds. the length of the radius.

Calamospora Species G.

Pl. 3, Fig. 15.

Diameter 52 - 68 µ. The exine has infragranulate ornamentation. The wall shows irregular folding but no specimens with taper point folding were seen. The arms of the trilete ray are about 1/3 rd. the length of the radius.

Genus Granulatisporites (Ibrahim 1933)

Trilete, subtriangular, exine densely granulose, granules rather spherical and of approximately equal size overall.

Granulatisporites Species A

Pl. 4, Fig. 1.

Diameter 27 - 29 µ. Wall 1 - 2 µ in thickness. The arms of the trilete ray are about 2/3 rds. the length of the radius.

Granulatisporites Species B

Pl. 4, Fig. 5.

Diameter 40 - 45 μ. One arm of the trilete ray about half the length of the other two which are almost equal to that of the radius.

Granulatisporites Species C

Pl. 4, Fig. 2.

Diameter 22 μ. Wall 2 μ in thickness. The arms of the trilete ray are about half the length of the radius.

This spore closely resembles Naumova's Lophotriletes minutissimus which McGregor renames Granulatisporites minutissimus. Naumova quotes a size range of 20 - 25 μ.

Granulatisporites Species D

Pl. 4, Fig. 6.

Diameter 19 μ. There is no apparent trilete mark on this specimen. The wall is very thick, about 2.5 μ. I am not sure whether this might not in fact be a fringe. If it is, it suggests that this spore may be a species of Lycospora.

Granulatisporites Species E

Pl. 4, Figs.3 and 4.

Diameter 70 - 80 μ. Wall thin. There appears to be a trilete aperture with short Laesurae (1/3 rd. the length of the radius).

Genus Cyclogranisporites (Potonie and Kremp)

Trilete, circular spores with exine similar to Granulatisporites.

Cyclogranisporites Leopoldi (Potonié and Kremp 1955)

Pl. 4, Fig. 7.

Diameter 27 - 31 µ which agrees well with the dimensions given by Potonié and Kremp (25 - 35 µ). The trilete ray is indistinct.

Cyclogranisporites Species C

Pl. 4, Fig. 9.

Diameter 41 µ. The wall is of singular appearance consisting of two layers, an internal mesosporium and an external exine. The arms of the well marked trilete ray are about 2/3 rds. the length of the radius. It could possibly belong to the genus Planisporites.

Cyclogranisporites Species D

Pl. 4, Fig. 8.

Diameter 47 - 50 µ. The wall of this spore is thin and tends to become folded. The arms of the trilete ray are about half the length of the radius.

Suite Apiculati Bennie and Kidston (Potonié and Kremp 1954).

Genus Perimetrisporites (McGregor 1957)

Trilete miospores of subtriangular outline which bear small more or less elongate projections equatorially, in depressions in the interradial margins. Wall thin.

Perimetrisporites parvus (McGregor 1957)

Pl. 4, Fig. 10.

Diameter 32 μ which agree well with that quoted by McGregor for the holotype, viz 33 μ. Small papillae (approximately 2.5 μ in length), occur all round the equator of the spore.

Genus Planisporites (Knox 1950)

Triloto, circular; very small cones densely arranged overall, approximately equal in size and development, their height approximates to the diameter of the base.

Planisporites Species A

Pl. 4, Fig.11.

Diameter 45 - 48 μ. Thin walled. The specimens in question occur in a group of six adhering together and it is probable that they are somewhat immature. No trilete ray is visible though it looks as if one would be present.

Genus Apiculatisporites (Ibrahim 1933)

Trilete, circular; thickly covered with tapered cones whose basal diameter can equal their height, more or less variable in size, so closely crowded that their bases may touch.

Apiculatisporites Species A

Pl. 4, Fig. 12.

Diameter 48 - 56 μ. Cones short (2 μ), blunt and not closely packed. Arms of the trilete ray approximately half the length of the radius of the spore.

Genus Lophotriletes (Naumova 1937)

Trilete, subtriangular, otherwise similar to Apiculatisporites.

Lophotriletes Species A

Pl. 4, Fig. 13.

Diameter 40 - 45 µ. Cones very small and closely packed. The arms of the trilete ray are about half the length of the radius of the spore. The wall is thin and tends to become folded.

This species closely resembles Naumova's Lophotriletes rugosus but is smaller; she quotes a size range of 50 - 55 µ for L. rugosus.

Lophotriletes Species B

Pl. 4, Fig. 14.

Diameter 45 µ. Cones very small and closely packed. Wall thin and shows a tendency to become irregularly folded. The trilete ray has broad dark arms extending to the equator of the spore.

Lophotriletes Species C

Pl. 4, Fig. 15.

Diameter 47 µ. Cones very small and closely packed. The wall is thin and undergoes a considerable amount of folding. The arms of the trilete are dark and extend into the angles of the spore reaching the equator. In the centre of the spore they do not appear to all meet at the same point.

Genus Anapiculatisporites (Potonié and Kremp 1954)

Trilete, circular to convexly subtriangular; proximal surface smooth, distal covered with cones or spines similar to those of Apiculatisporites and Acanthotriletes.

Anapiculatisporites Species A

Pl. 4, Fig. 16.

Diameter 19 μ. Wall about 1.5 μ in thickness. The arms of the trilete ray are about 2/3 rds. the length of the radius.

Genus Acanthotriletes (Naumova 1937)

Trilete, ciliate; spines closely crowded, attenuate, longer than twice their diameter; the greater length of spines their attenuation and often sharper tips distinguish them from the processes of Lophotriletes and Apiculatisporites.

Acanthotriletes Species A

Pl. 4, Figs.17 and 19.

Diameter 29 - 31 μ. Length of the spines about twice that of their diameter. Wall thin; the spores tend to be distorted in shape. The trilete ray is not typically visible but is present as a gaping commissure in one specimen.

Acanthotriletes Species B

Pl. 4, Figs.20 and 21.

Diameter 55 - 60 μ. Spines 2 - 3 times as long as their basal diameter. The spores show a tendency to undergo taper point folding. The arms of the trilete ray are equal to about half the radius.

Acanthotriletes Species C

Pl. 4, Fig. 18.

Diameter 19 µ. Spines about twice as long as their basal diameter. No trilete ray is visible.

Acanthotriletes Species D

Pl. 4, Figs.22 and 24.

Diameter 38 - 45 µ. Typically subtriangular in shape with rounded corners but tends to become distorted. Spines about twice as long as their basal diameter. No trilete ray is visible.

Acanthotriletes Species E

Pl. 4, Fig. 23.

Diameter 56 µ. Subtriangular in shape. A gaping trilete commissure is visible. The spines are 3 - 4 times as long as their basal diameter.

Suite Muronati Potonié and Kremp 1954.

Genus Microreticulatisporites Knox 1950

Trilete, subtriangular to circular, exine extrareticulate with small lumina which do not exceed 6 µ in diameter, muri imperfect and branched, variable in height.

Microreticulatisporites Species A

Pl. 4, Figs.25, 26 and 27.

Diameter 60 - 65 µ. Spores generally subtriangular. The trilete ray is only rarely visible but when it can be seen the arms are from 1/2 - 3/4 the length of the radius. The

wall is thin and tends to become folded and distorted. The ornamentation is very finely reticulate.

The spores closely resemble those described above but the wall ornamentation appears to be slightly finer and they possess a well marked trilete ray with dark arms that almost reach the equator of the spore.

Microreticulatisporites Species B

Pl. 5, Fig. 1.

Diameter 50 - 58 µ. Spores subtriangular. Wall thick 3 - 5 µ. Ornamentation irregularly reticulate. Well marked trilete ridge the rays of which are 1/2 - 2/3 rds. the length of the radius.

Microreticulatisporites Species C

Pl. 5, Fig. 2.

Diameter 48 - 56 µ. Ornamentation is markedly reticulate. The lumina are pentagonal in outline and from 3 - 5 µ across with muri about 2 - 2.5 µ in height. The wall is thick and the spores are dark brown in colour. The arms of the trilete ridge extend almost to the equator.

Genus Radiospora (McGregor 1957)

Trilete miospores with radially disposed rib-like thickenings on the proximal portion. Outline of transversely compressed specimen's subtriangular to circular.

Radiospora Species A

Pl. 5, Fig. 3.

Diameter 41 - 44 μ. Circular in outline. Thin walled. Well marked dark trilete rays the arms of which extend almost to the equator of the spore. In the area between two of these arms are about five radial ribs.

Radiospora Species B

Pl. 5, Fig. 4.

Diameter 35 μ. Subtriangular in outline. Crenulate margin. Trilete ray not very distinct. The radial ribs are more numerous than in species A but not so well marked.

Radiospora rotata (McGregor)

Pl. 5, Fig. 5.

Diameter 45 μ. McGregor quotes 42 μ for his holotype.

Radiospora Species D

Pl. 5, Fig. 6.

Diameter 45 - 50 μ. All specimens of this species are folded but otherwise they show a close resemblance to Radiospora rotata but McGregor states that the latter is only rarely folded.

Series Arcuati (McGregor 1957)

Aconate miospores and megaspore genera of varied ornamentation which possess an apea, i.e. the interradial areas of the proximal face of the spore delimited by more or less thickened arcuate lines.

Genus Retusotriletes (Naumova 1953) Emend McGregor 1957

Miospores with obvious arcuate lines, more or less thickened, delimiting the interradial areas of the proximal portion of the spore. They thus possess an apea in the sense of Naumova 1953. Spores Laevigate or variously ornamented. The apea possesses similar ornamentation to the rest of the spore, or at most differs from the rest of the spore only to a minor degree.

Retusotriletes Species A

Pl. 5, Figs.7 and 8.

Diameter 40 - 52 µ. Spore radial, trilete rays about 2/3 rds. length of radius, ovate to subtriangular. Thick walled (2-3 µ). The tips of the rays branch into a broad "V" to delineate the apea. The portion external to the apea is infragranulate, the apea granulate. The wall is often folded.

Retusotriletes Species B

Pl. 5, Fig. 9.

Diameter 50 - 65 µ. Spore circular, trilete, the arms of the trilete ray extending about half way to the equator. Both the apea and the portion of the spore external to it show an equal degree of granular ornamentation. The wall shows a tendency to become folded.

Retusotriletes Species C

Pl. 5, Fig. 12.

Diameter 32 µ. Spore subtriangular with well rounded corners. Trilete commissure extending 2/3 rds. the length of the radius. The commissure branches in a manner reminiscent of that of the two outer elements of a 'Fleurs-de-Lys'. Ornamentation infragranulate throughout.

Retusotriletes Species D

Pl. 5, Fig. 10.

Diameter 50 - 63 µ. Spore oval. Trilete commissure the arms of which are about half the length of the radius. The apea has infragranulate ornamentation, the part of the spore external to this is Laevigate. It is debatable whether the inner portion does comprise an apea. The outer portion could be an equatorial cingulum in which case this species does not belong to the genus Retusotriletes.

Retusotriletes Species E

Pl. 5, Fig. 11.

Diameter 24 µ. Spore subtriangular. The arms of the trilete ray extend 2/3 rds. the length of the radius, and branch into a broad "V" to encircle the apea. Both the apea and the region external to it are Laevigate.

DIVISION ZONALES (Bennie and Kidston 1886)

Suite Auriculati (Schopf 1938)

Subdivision Zonotriletes (Waltz 1935)

Suite Cingulati Potonié and Klaus 1954

Genus Lycospora (Schopf, Wilson and Bental 1944)

Trilete, with cingulum (equatorial girdle) appearing as a cuneiform ring in cross section, central body Laevigate, infragranulate or granulate, trilete rays clear, extended almost to the equator.

Lycospora Species A

Pl. 5, Fig. 13.

Diameter 42 µ. Subtriangular in outline. Trilete ray in the form of a gaping commissure — not very well marked. Cingulum 4-5 µ across, well marked on two sides of the spore, not so well marked on the other.

Genus Anulatisporites (Loose 1934)

Trilete, equatorial cingulum broad, relatively high, massive, sculptureless, often brown in colour, at least as broad as high at the radial corners as interradially; interradial sides convex; peripheral edge of cingulum rather strongly rounded, not always tapered; sometimes with a few places of fracture; central body, smooth to infrapunctate, trilete rays indistinct to perceptible.

Anulatisporites anulatus (Loose 1932)

Pl. 5, Fig. 14.

Dimensions 31x48 μ. A diameter of 37.5 μ is quoted for the holotype but most specimens are more oval than rounded.

Division Ducomurales (McGregor 1957)

Miospores and megaspores with triradiate tetrad mark, and no other germinal apparatus, and without auriculae, cingulum, zoni or sacci. Distinguished by possession of a perisporium-like wall, Laevigate or variously ornamented, which completely surrounds, and is more or less closely oppressed to an internal body.

Subdivision Membranites (McGregor 1957)

Trilete miospores and megaspores, with a perisporium-like outer wall which is thin walled and semi-transparent. Outer wall variously ornamented or occasionally Laevigate. Inner body also thin-walled, usually unornamented.

Genus Archaeozonotriletes (Naumova emend McGregor)

Trilete miospores with an outer envelope (here designated as a perisporium), which is more or less oppressed to the body of the spore. Perisporium Laevigate or with low ornamentation.

Archaeozonotriletes Species A

Pl. 5, Fig. 17.

Diameter 120 μ. Both perisporium and body possess granulate ornamentation. The perisporium appears to be fairly robust

but shows some folding which makes the spore assume an oval shape. One of the Laesurae extends to edge of the body the other two are about 2/3 rds. the length of the radius.

Genus Hymenozonotriletes (Naumova 1937)

Hymenozonotriletes Species A

Pl. 5, Fig. 16.

Diameter 50 µ. Both perisporium and body exhibit infragranulate ornamentation. There is a well marked trilete ray the arms of which extend to the margins of the perisporium. In the specimen found one of the perisporial segments bound by two arms of the trilete ray is missing.

Division MONOLETES Ibrahim 1933

Subdivision Azonomotriletes Luber 1935

Genus Laevigatosporites Ibrahim 1933

Monolete, Laevigate to infrareticulate, equatorial outline broadly oval to approximately circular, distal surface in section a weak circular arch, never angled distally as in Latosporites. Exine always without sculpture, monolete suture straight.

Laevigatosporites Species A

Pl. 5, Fig. 15.

Dimensions 68x75 µ. Spore broadly oval in shape. Dark monolete marking. Infragranulate ornamentation. Thin walled.

Laevigatosporites Species B

Pl. 5, Fig. 18.

Dimensions 39x48 µ. Spores broadly oval in shape. Fine monolete marking. Ornamentation infragranulate. Thin walled.

Laevigatosporites Species C

Pl. 6, Fig. 1.

Dimensions 71x95 µ. Spore oval in shape, pale brown in colour. No monolete mark is visible. Ornamentation Laevigate. Thin walled.

Laevigatosporites Species D

Pl. 6, Fig. 2.

Dimensions 40x48 µ. Spores oval in shape. Monolete mark varying in length from 1/2 to almost 3/4 that of the spore. Ornamentation infragranulate. Thin walled.

Laevigatosporites Species E

Pl. 6, Fig. 3.

Dimensions approximately 44x50 µ. Spores oval to circular in shape. A monolete mark is present but on two examples it runs across the width of the spore and appears to be a fold in the wall. Thin walled. Ornamentation infragranulate.

Laevigatosporites Species F

Pl. 6, Fig. 4.

Dimensions 75x54 µ. Spore oval to subtriangular in outline. The spore is dark brown in colour and no monolete marking is visible. Ornamentation Laevigate. Thin walled.

Laevigatosporites Species H

Pl. 6, Fig. 5.

Dimensions 17x28 μ -- 22x36 μ. Spores subrectangular to oval in shape. Wall 1.5-2 μ in thickness showing punctate ornamentation. Well marked monolete mark running almost the whole length of the spore.

Laevigatosporites Species I

Pl. 6, Fig. 6.

Diameter 44 μ. This spore is almost circular in outline which is not typical for the genus. A well marked monolete mark is present. Ornamentation granulate.

A spore 18 μ in diameter bearing three distinct colpae was found. This is a feature associated with certain groups of Angiosperm pollen. It closely resembles McGregor's G17 from sample 6403, Devonian mudstone from a core from the Wabamun Lake, Alberta. He quotes the diameter of his specimen as being 18 μ also. (Pl. 6, Fig. 7).

A four celled spore of apparently fungal origin (similar to that by the present day genus Helminthosporium). Its dimensions are 43x14 μ. (Pl. 6, Fig. 8).

One Hystrichosphaerid apparently belonging to the genus Leiofusa was found. It is, however, much smaller (58x20 μ) than those described by McGregor (134x54). (Pl. 6, Fig. 12).

Among the microspores which defied recognition are some worthy of attention.

L. 14. Appears to belong to the division Zonales. It has an open trilete commissure. In addition to this there are two monolete markings which do not appear to be folds. The exine appears to be echinate at the equator. The wall appears to be in three distinct layers. The inner part of the spore bears granulate ornamentation, the portion external to this is Laevigate. (Pl. 6, Fig. 11).

TP 1/128. A triangular spore with a trilete marking in the form of a dark line. The wall is thin with infragranulate ornamentation (Pl. 6, Fig. 9).

TP 3/88. A thin subtriangular spore with a broad triangular marking. This could be a fold in the fall but it closely follows the outline of the spore. (Pl. 6, Fig. 14).

TP 3/107. A thin walled spore with Laevigate ornamentation. It possesses a broad dark trilete ray two arms of which extend to the equator. The third is only half the length of the other two but is crossed by another similar marking that runs across the breadth of the spore.

Radforth and McGregor (17) have drawn attention to the varying distribution of certain distinct form features within spore assemblages of different ages.

In connection with the miospore assemblage as a whole some indication of the occurrence and frequency of recognizable 'form features' is desirable. A table indicating their occurrence is appended:-

Abundant	Present	Absent
Thin wall	Small size	Attenuate appendages
circular	Area contagionis	Reticulum
Trilete	Large size	Equatorial thickening
	Radial striations	Stout spines
	Perispore	Ridges
	Thick wall	Bladders
	Granules	Furrow Fold
	Apiculations	Pores
	Punctate	
	Equatorial flange	
	Subtriangular	
	Monolete	
	Apea	
	Triangular shape	

DISCUSSION

A considerable body of literature now exists in which microfossil remains from the Devonian are described and illustrated. In particular there is McGregor's work on the Battery Point Formation which overlies the York River Formation. There were grounds to believe that plant microfossils and, of most importance, miospores would be found in the York River sandstone and that was found to be the case.

Spores inevitably suffer a certain amount of distortion due to the pressure of the overlying strata and damage again tends to occur during extraction. The chemicals used in maceration, especially Schultze's solution, can destroy fine details of ornamentation and in subsequent centrifugation the spores tend to become broken and distorted. Their ability to resist damage depends on their size, wall thickness and the nature of its ornamentation. Spores are best preserved in a purely organic matrix such as is found in coal and peat. Mineral particles are on a much greater scale of hardness than spores, and their presence causes damage, due to abrasion during deposition, and by distortion on contact and subsequent compaction. The finer grained the sediment, the better are the spores preserved. As media for spore preservation we may place inorganic sediments in the following order of diminishing usefulness:- mudstones and shales, sandstone, greywackes; in accordance with the progressive increase of grain size exhibited by these rocks. In 1946 Wilson (15) stated that

sandstones and sedimentary deposits with a similar order of grain size could not be used for the extraction of satisfactory microfossils, but since then they have been used by workers such as Sahni, McGregor and others.

Microfossils possess a number of very real advantages over macrofossils in many stratigraphic and ecological studies. If a rock bed can be placed in its correct position within a series using one or two present distinctive and abundant index macrofossils, one will obviously use them. In many cases the accessible outcrop is limited and we cannot be certain that we have covered sufficient material to find the index macrofossils. Even within one bed of a series the distribution of a macrofossils may be localized and uneven. Many sedimentary rocks are completely lacking in macrofossils but are found to contain numerous microfossils. Macrofossils are of no use when we examine cores as even if they are present the chance of our getting one in our sample is infinitesimal. As soon as we turn to microfossils however, the picture brightens. When we examine our sample under the microscope at a magnification of 500x we are magnifying our sample, our outcrop, by the same degree. It is as if we were examining an exposure miles in length. From one small sample weighing a few grams we can extract many thousands of durable microfossils and select that particular group with which we are best acquainted, to interpret. We can investigate stratigraphic and ecological changes on a much more precise basis and over shorter time intervals. For example Erdtmann has investigated the floristic changes occurring

during interglacial periods by the study of pollen grains extracted from varves, the fine annual layers of sediment deposited on Lake bottoms. Studies on such a fine scale as this can only be done using microfossils. It is possible that annual changes such as this could be traced in much older sediments as it is not inconceivable that 'fossilized varves' might exist within sediments.

Where large numbers of diverse microfossils can be extracted and identified it is possible to prepare block histograms which can be used as a basis for stratigraphic correlation. A classic piece of work in this sphere is that of Raistrick and Simpson who used miospores for correlating a number of Northumberland coal seams. It is necessary to survey the microfossil conspectus as a whole and then to select a number of dominant species for counting. The number of individuals that have to be counted depends on the number of dominant species.

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* Let us apply the χ^2 test to the hypotheses that none of the observed frequencies of occurrence of Calamospora Leiotriletes differ significantly from the value we would expect on consideration of the mean. A value of χ^2 greater than 7.815 for the 3 degrees of freedom would indicate that the hypothesis should be rejected. (Snedecor Statistical Methods (43) p. 190).
The values of χ^2 5.15 and 2.48 are less than 7.815 so our hypotheses need not be rejected. The probability of a larger but still acceptable value of chi-square occurring is between 10 and 20% in the case of Calamospora and 50% in that of Leiotriletes.

L. R. Wilson (15) states that satisfactory correlation results have been attained with counts of 200 where there are 6-8 dominant species and 500 where there are 12 or more species involved. The dominant species should occur in a frequency of 5% or more in the total count. A variation on this method of defining a microfossil assemblage is that described by Radforth and McGregor (17). Instead of considering a conspectus of species they draw attention to the characteristic distribution of different features of spore morphology through the geological time scale. We should note, however, that certain morphological features and also some species of microspore persist throughout a number of major geological time zones (26).

Perusal of the results (Table 1) indicates that Calamospora is the dominant genus being present in percentages ranging from 39-63.*

Let us apply the X^2 test to the frequencies of Calamospora and Leiotriletes in the four layers.

Calamospora

Observed	Expected	$\frac{(o - e - .5)^2}{e}$	
39	52.5	$\frac{13^2}{52.5}$	= 3.22
63	52.5	$\frac{10^2}{52.5}$	= 1.90
53	52.5	—	—
55	52.5	$\frac{2^2}{52.5}$	= .034

$$X^2 = \frac{(O - e)^2}{e} = 5.15$$

For 3 degrees of freedom this indicates a probability >10 <20%.

Leiotriletes

Observed	Expected	$\frac{(o - e - .5)^2}{e}$
12	7.75	$\frac{(3.75)^2}{7.75}$ = 1.81
5	7.75	$\frac{(2.25)^2}{7.75}$ = 0.653
8	7.75	$\frac{(0.25)^2}{7.75}$ = 0.008
6	7.75	$\frac{(0.25)^2}{7.75}$ = 0.008

$$X^2 = \frac{(o - e)^2}{e} = 2.48$$

For 3 degrees of freedom this indicates a probability of 50%.

The genus Calamospora is represented by seven different species no one of which can be said to be dominant (Table 2). Species A, B and C all vie for this position having 50, 46 and 43 individuals (out of 400). In this case it is not advisable to talk of an index microfossil: it is necessary to turn our attention towards the compilation of an index microfossil assemblage. The aim was to do this for each of the thin layers and for the sum of these layers. On examining table (2) a marked similarity between layers 3 and 5 becomes apparent. A lesser degree of similarity is present between layers 1 and 6. These resemblances are supported when the other miospore genera are considered. Unfortunately there is no well marked accessory genus or species.

If an attempt is made to correlate two rock samples on the basis one index fossil the statistical chance of the two being the same, even if the index fossil is found in each, is rather low. Take two index fossils and the chance is greatly increased. Even more so for three or more. In the case of microfossils the presence of the microfossil and also its percentage of the whole are considered. The more species or genera considered however, the greater the number of individuals that have to be counted.

The nearest approaches to accessory genera are Leiotriletes, Retusotriletes and Microreticulatisporites. Retusotriletes is however, absent from layer 6. Layer 1 has the lowest Calamospora count but the numbers of other genera, such as Leiotriletes, Punctatisporites, Microreticulatisporites and Radiospora, are correspondingly higher. Layers 3 and 5, as has been mentioned above, show a considerable similarity. The presence of five spores tentatively assigned to the genus Planisporites is due to the discovery of a group of spores. Layer 6 differed from the other three in possessing less miospores than the other three layers. This was the first layer to be examined and it was thought that this might be due to deficiencies in technique, but it was re-examined and again found to be sparsely endowed with spores.

Macroscopic cuticular remains were abundant in all the layers. These varied in size from a few cells to pieces approximately 1x5 cms. in size. Unfortunately they defied identification. Their most notable feature, in most cases, was a 'warty' structure, each 'wart' being about 20 cells across. Also present were many fragments of a

woody nature; conducting elements of various kinds.

A miospore assemblage can be considered from the viewpoint of the morphological features that it exhibits rather than from a taxonomic standpoint. The most abundant 'form features' (17) are thin wall, circular shape and trilete aperture. Also present are small sized spores; conspicuous by their absence are spores with bladders and the forms bearing stout spines and attenuate appendages. No spores with an exine showing a reticulate pattern were present, the nearest approach being an infrareticulate ornamentation.

The geographical and geological proximity of the York River and the Battery Point formations naturally invites comparison between the miospore assemblages of the two locations. McGregor (2) found Calamospora to be the dominant genus in his sample from the Battery Point formation in the frequency of 28%. In the sample examined from the York River sandstone Calamospora was again found to be the dominant genus but at an average percentage of 52.5%. McGregor found 18% Cyclogranisporites and 11% Archaeozonotriletes, whereas the York River sample only yielded one other genus with a frequency greater than 5%: Laiotriletes with 7.75%. The York River sandstone yielded 22 genera and 53 species compared with 18 genera and 36 species from the Battery Point formation. Nevertheless McGregor found 8 miospore genera that I did not:- Raistrickia, Converrucosisporites, Convolutispora, Cristatisporites, Reticulatisporites, Densosporites, Cirratriradiates, and Camarazonotriletes. What is probably more significant than the absence of certain genera is the absence of the 'form features' they represent.

The York River formation yielded 6 miospore genera not found in the Battery Point:- Trachytriletes, Hymenozonotriletes, Punctatisporites, Perinetrisporites, Planisporites and Lycospora. Among them they show one 'form feature' lacking in McGregor's conspectus, that is, triangular shape with pointed corners. This is demonstrated in Trachytriletes and is one unknown species (TP 1/128).

Another contrast with the assemblage derived from the Battery Point formation is the apparent absence of megaspores.

When we find spores in a sediment we should perhaps consider how they could have arrived there. They may have been liberated under calm atmospheric conditions to become buried and consolidated 'in situ'. They could have drifted on air currents to descend into sea of greater or lesser depth or into a fresh water lake. Alternatively they could have been associated with muds or similar unconsolidated sediments which were washed away and redeposited. Another possibility is that having been deposited under any of the three above conditions to form consolidated rock which was at some later time eroded and redeposited, the fossils together with the mineral fraction. In this case the fossils are said to be 're-worked'. It is obvious that re-working could be a source of considerable error in estimating the date of a sample on the microfossils but, fortunately, reworked miospores have their ornamentation eroded and show other signs of damage so they can be easily recognized as such.

In the case of the rock material under investigation it is unlikely that the fossils found have been preserved in situ. It is likely that the macrofossils were washed down and deposited under shallow water, possibly under deltaic conditions. The miospores, however, would have been transported by wind to their present resting place. In the case of coals the miospores found have most probably been deposited together with the macrofossils but in most sedimentary rocks the majority of the microfossils willhave been wind-borne whereas the macrofossils will have been transported by water.

The occurrence of plant macrofossils remains in a relatively undamaged condition suggests that the sediment was laid down fairly close to the shoreline. Combined with the fine grained nature of the consolidated rock the evidence suggests fairly rapid deposition under sluggish water not very far from the source of the vegetation. The abundance of spores and lack of marine microfossils such as hystrichosphaerids suggests a continental origin for the York River Formation.

When we attempt to draw any kind of ecological conclusions from microfossil evidence the site and mode of deposition of the sediment should be considered. This can only be done if we are certain that the microfossils have been preserved near to or within the environment that produced the parent plants. The presence of macrofossils even if fragmentary together with the microfossils, suggests this situation. To find plant remains of a delicate nature

in a reasonable state of preservation is especially encouraging. If however we find only a few miospores and no evidence of more solid fossil remains, it is highly probable that we are dealing with a sediment laid down a considerable distance off shore. The miospores will have been wind transported considerable distances before falling into the sea and will only represent those species whose spores have a morphology especially advantageous to long distance wind transport. They will probably represent forms with these properties from various different environments. To attempt to draw ecological conclusions from evidence from such sources would be folly indeed. The presence of macrofossil remains together with the microfossils, with both in a comparable state of preservation suggests that both components have a common origin. The contrast between the ecological picture presented by the macrofossil and microfossil evidence is most striking.

In reference to the macrofossil evidence to be deduced from the examination of the sandstones in the Tar Point region, Dawson (5) states that "Little else appears to have grown than a dense herbage of Psilophyton, along with plants of the genus Arthrostigma". What contrast indeed to the picture suggested by the microfossils record indicating the existence of no fewer than 22 genera with 53 species!

SUMMARY AND CONCLUSIONS

Before attempting to draw any conclusions from the evidence presented it should be emphasized that the field of investigation in this work has been very small, but it is hoped that some of the principles involved may be worthy of wider application.

The number of spores examined for each individual layer has been insufficient to give repeatable valid results except in the case of Calamospora and Leiotriletes. In the case of these two genera, however, the numbers found in each layer have been shown not to differ significantly. This is encouraging and suggests that valid index microfossil assemblages can be expected on the examination of small rock samples such as are provided from chippings from oil boring cores, for example.

On the addition of the results for the four layers sufficient meiospores have been examined to be able to present a valid index microfossil assemblage for this particular facies of the York River series.

The combination of a large number of miospores, together with abundant plant remains of a more delicate nature and the absence of marine microfossils, such as hystrichosphaerids in significant numbers, suggests a continental origin for the York River series.

The presence of a large number of often diverse genera and species of miospore suggests that a flora of considerable diversity

and phylogenetic development existed as early as lower Middle Devonian times. Potonié's (33) interpretation of the Upper Devonian as a period of floral amplification appears questionable in this light. It seems probable that the forerunners of this diverse flora become involved in Lower Devonian times or even earlier, and that the Middle Devonian represents an era of amplification.

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PLATE I

Devonian sandstone near Tar Point showing the fragmentary nature of the plant macrofossil remains.

PLATE II

Figure 1. *Leiotriletes* species A

2 & 3. *Leiotriletes* species B

4. *Leiotriletes* species C

5. *Leiotriletes* species D

6. *Leiotriletes* species E

7. *Leiotriletes* species F

8 & 9. *Leiotriletes* species G

10. *Leiotriletes* species H

11. *Trachytriletes* species A

12 & 13. *Punctatisporites* species A

14. *Punctatisporites* species B

15. *Punctatisporites* species C

16,17,18 & 19 *Calamospora* species A

20,21,22 & 23 *Calamospora* species B

PLATE II

Figure 1. Leiotriletes species A

2 & 3. Leiotriletes species B

4. Leiotriletes species C

5. Leiotriletes species D

6. Leiotriletes species E

7. Leiotriletes species F

8 & 9. Leiotriletes species G

10. Leiotriletes species H

11. Trachytriletes species A

12 & 13. Punctatisporites species A

14. Punctatisporites species B

15. Punctatisporites species C

16,17,18 & 19 Calamospora species A

20,21,22 & 23 Calamospora species B

PLATE 2

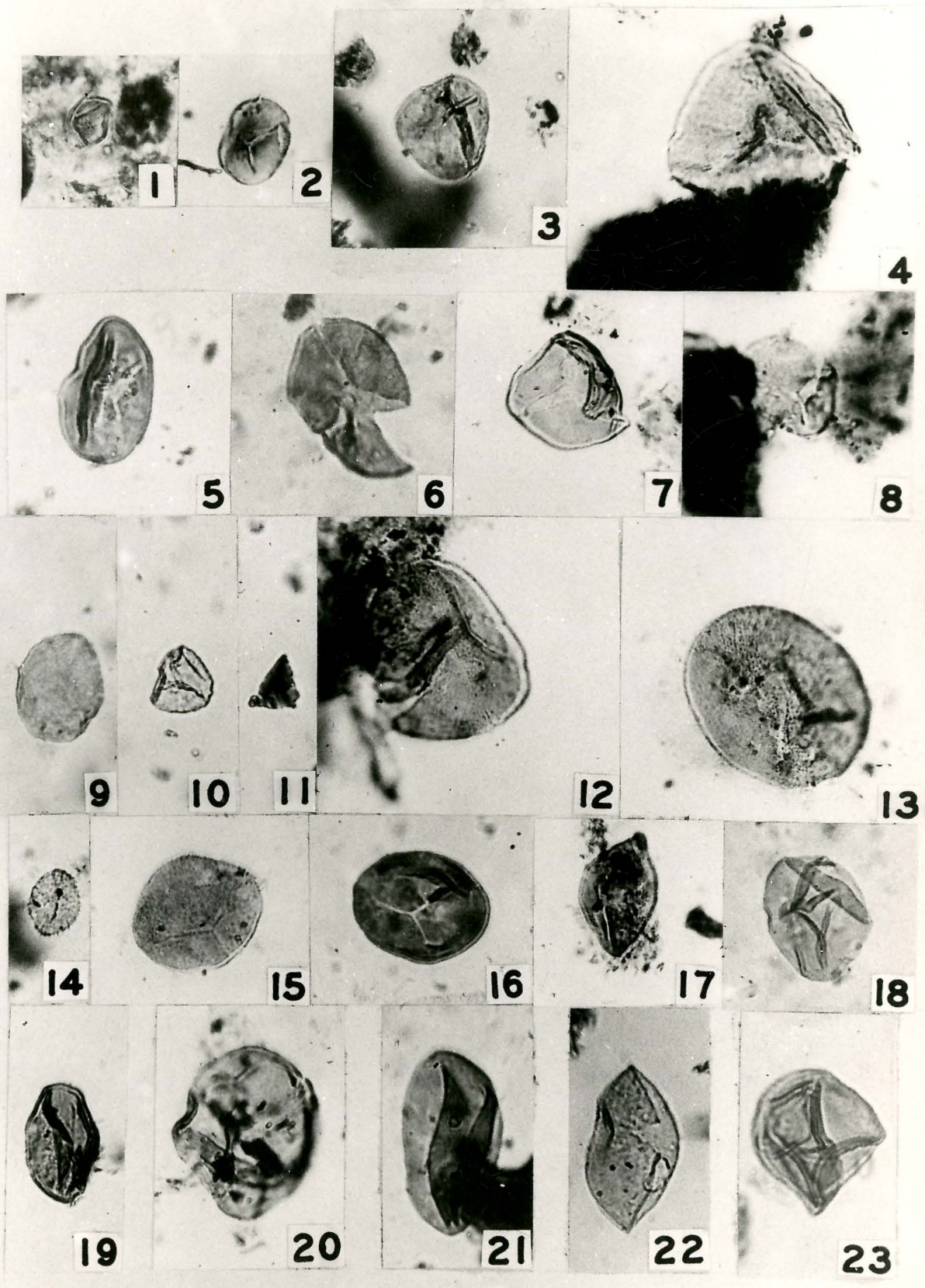

PLATE III

Figure 1,2,2a,&3. Calamospora species C

4,5,6 & 7. Calamospora species D

8,9 & 10. Calamospora species E

11,12,13 & 14. Calamspora species F

15. Calamospora Species G

PLATE 3

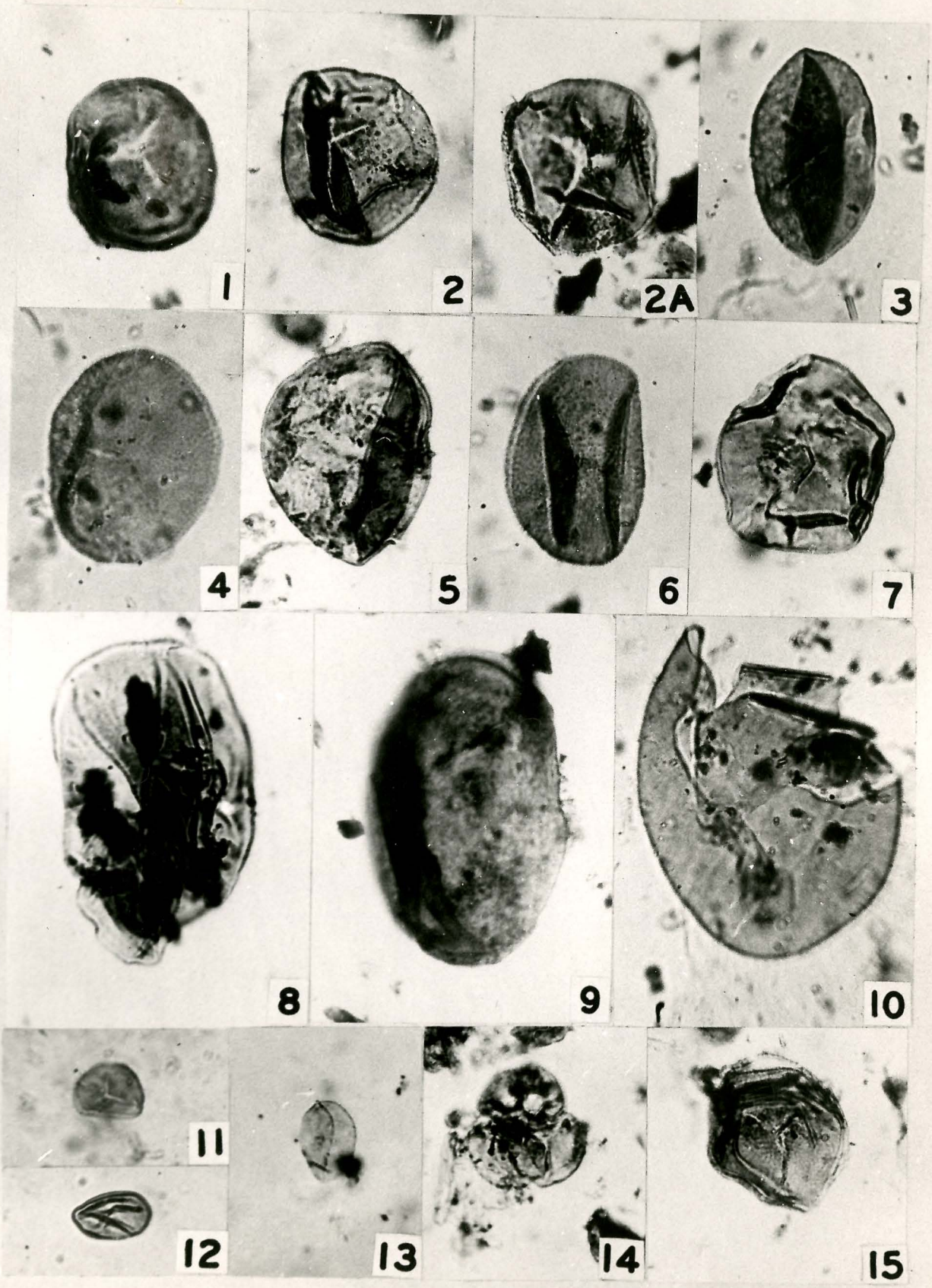

PLATE IV

Figure 1. Granulatisporites species A

2. Granulatisporites species C

3 & 4. Granulatisporites species E

5. Granulatisporites species B

6. Granulatisporites species D

7. Cyclogranisporites leopoldi

8. Cyclogranisporites species D

9. Cyclogranisporites species C

10. Perimetrisporites parvus

11. Planisporites species A

12. Apiculatisporites species A

13. Lophotriletes species A

14. Lophotriletes species B

15. Lophotriletes species C

16. Anapiculatisporites species A

17 & 19. Acanthotriletes species A

18. Acanthotriletes species C

20 & 21. Acanthotriletes species B

22.& 24. Acanthotriletes species D

23. Acanthotriletes species E

25,26&27. Microreticulatisporites species A

PLATE 4

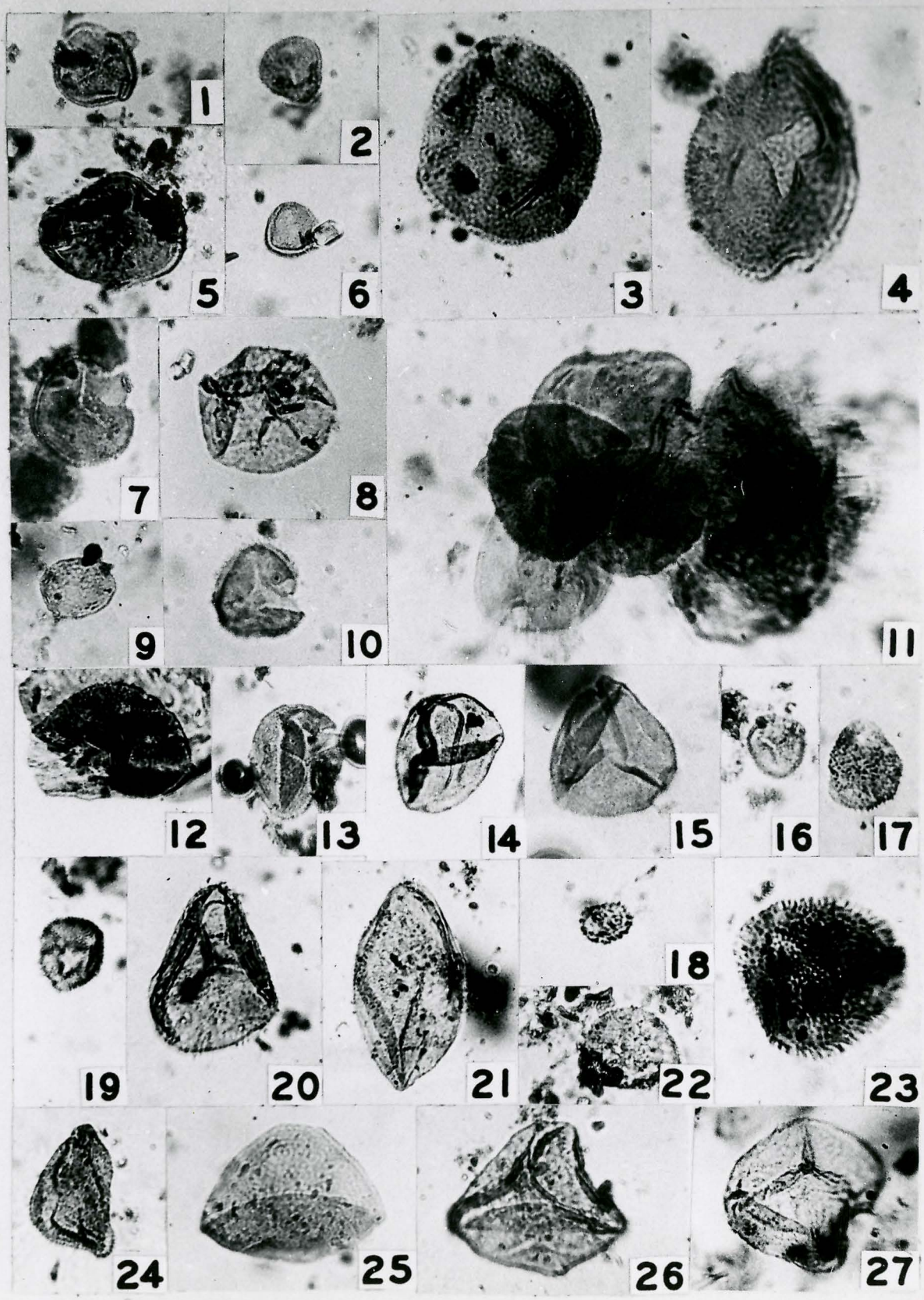

PLATE V

Figure 1. *Microreticulatisporites* species B

2. *Microreticulatisporites* species C

3. *Radiospora* species A

4. *Radiospora* species B

5. *Radiospora rotata*

6. *Radiospora* species D

7 & 8. *Retusotriletes* species A

9. *Retusotriletes* species B

10. *Retusotriletes* species D

11. *Retusotriletes* species E

12. *Retusotriletes* species C

13. *Lycospora* species A

14. *Anulatisporites anulatus*

15. *Laevigatosporites* species A

16. *Hymenozonotriletes* species A

17. *Archaeozonotriletes* species A

18. *Laevigatosporites* species B

PLATE 5

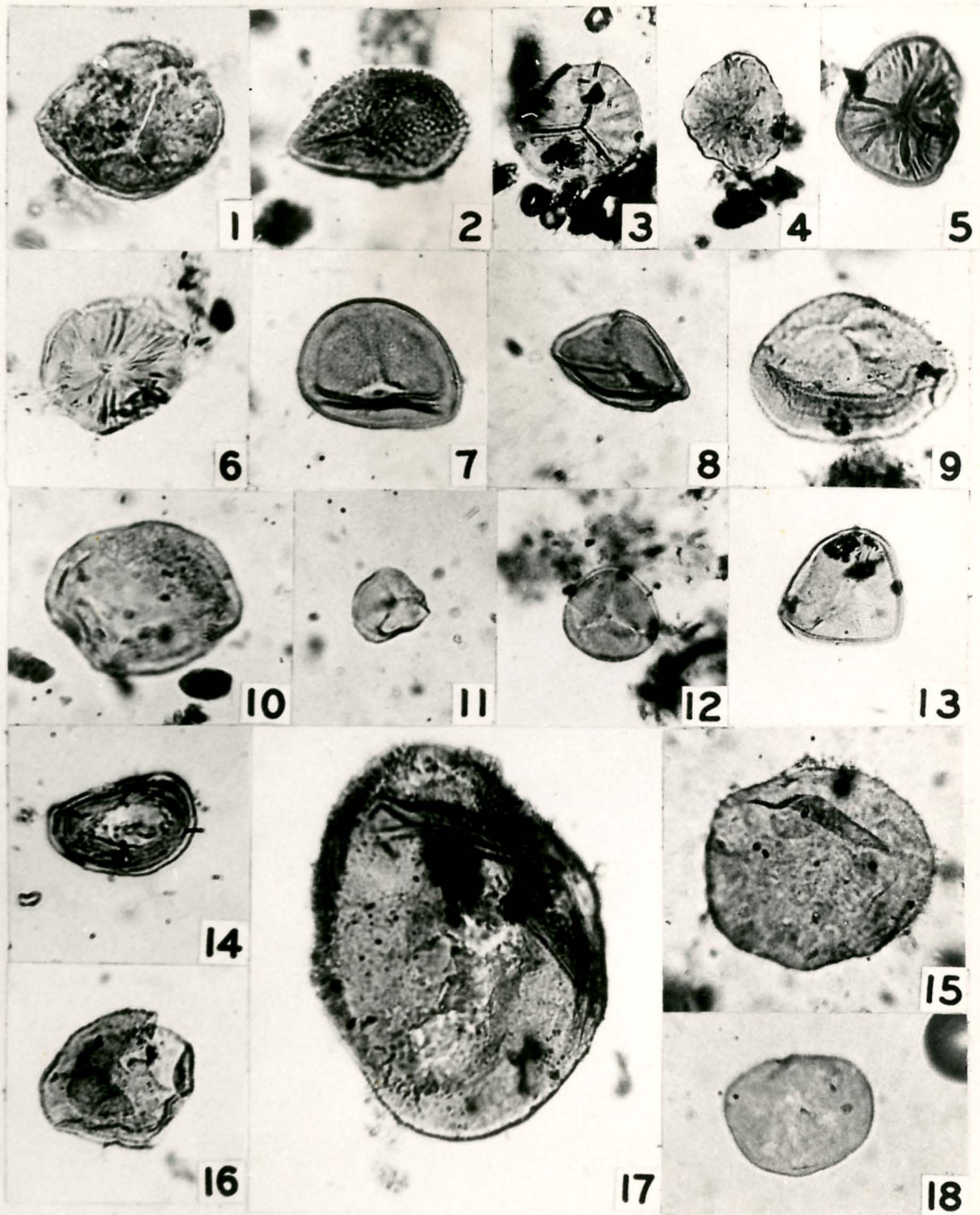

PLATE VI

Figure 1. Laevigatosporites species C

2. Laevigatosporites species D

3. Laevigatosporites species E

4. Laevigatosporites species F

5. Laevigatosporites species H

6. Laevigatosporites species I

7. TP3/98

8. TP3/66

9. TP1/128

11. L14

12. Leiofusa sp.

14. TP3/88

PLATE 6

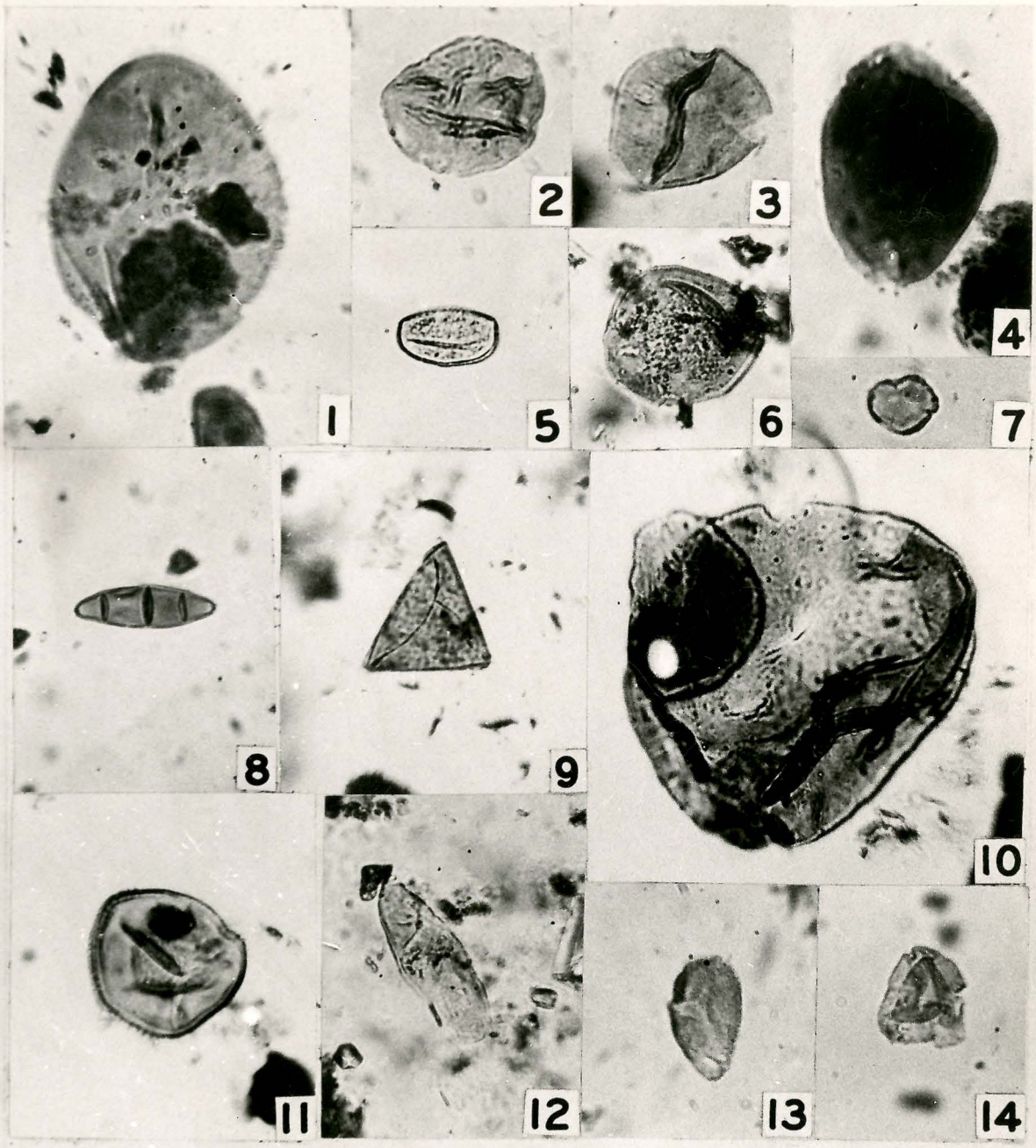

TABLE I

Occurrence in each layer and frequency of the different miospore genera.

TABLE 2

		LAYER 1	LAYER 3	LAYER 5	LAYER 6
CALAMOSPORA	SPECIES A	10	12	14	14
	SPECIES B	6	18	12	10
	SPECIES C	4	16	12	11
	SPECIES D	6	9	11	3
	SPECIES E	2	3	1	
	SPECIES F	10	3	3	13
	SPECIES G	1	2		4
	TOTAL	39	63	53	55

TABLE II

Frequency and occurrence of the different species of Calamospora

TABLE 1

GENUS	LAYER 1	LAYER 3	LAYER 5	LAYER 6
LEIOTRILETES	12	5	8	6
TRACHYTRILETES	1			
PUNCTATISPORITES	9	2	1	
CALAMOSPORA	39	63	53	55
GRANULATISPORITES	1	1	4	5
CYCLOGRANISPORITES	3	1		2
PERIMETRISPORITES		1		
PLANISPORITES ?			5	
APICULATISPORITES	2	1		1
LOPHOTRILETES	3	1	1	1
ANAPICULATISPORITES				1
ACANTHOTRILETES	3	1	4	6
MICRORETICULATISPORITES	6	3	3	4
RADIOSPORA	4	1	2	1
RETUSOTRILETES	5	3	4	
LYCOSPORA	1			
ANULATISPORITES				1
ARCHAEOZONOTRILETES	1			
LAEVIGATOSPORITES	4	4	4	4
HYMENOZONOTRILETES				1
FUNGAL SPORES		1		
ANGIOSPERM POLLEN ?		1		
HYSTRICHOSPHAERIDS				1
UNIDENTIFIED	6	11	11	11