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PALYNOLOGY AND PALEOBOTANY OF THE JAVA AND LOWERMOST CANADAWAY FORMATIONS, UPPER DEVONIAN (SENECAN/CHAUTAUQUAN) NEW YORK STATE

By

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ABSTRACT

PALYNOLOGY AND PALEOBOTANY OF THE JAVA AND LOWERMOST CANADAWAY FORMATIONS, UPPER DEVONIAN (SENECAN/CHAUTAUQUAN BOUNDARY), NEW YORK STATE

By

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Forty-two palynomorph genera are described and figured from the Senecan age Java Formation (Pipe Creek Shale, Hanover Shale Members) and the lowermost Chautauquan age Canadaway Formation (Dunkirk Shale, Gowanda Shale Members), Upper Devonian, from 16 localities in southwestern New York State. Twenty-three genera are spores: *Anapiculatisporites*, *Ancyrospora*, *Apiculiretusispora*, *Auroraspora*, ?*Baculatisporites*, ?*Biharisporites*, *Calamospora*, *Convolutispora*, *Emphanisporites*, *Endosporites*, *Geminospora*, *Grandispora*, *Hymenozonotriletes*, *Hystricosporites*, *Leiotriletes*, *Lophozonotriletes*, *Nikitinisporites*, *Punctatisporites*, *Retusotriletes*, *Spelaeotriletes*, *Spinozonotriletes*, *Stenozonotriletes*, *Verrucosisporites*; seventeen are acritarch genera: *Baltisphaeridium*, *Diexallophasis*, *Gorgonisphaeridium*, *Micrhystridium*, *Multiplicisphaeridium*, *Ozotobrachion*, *Cymatiosphaera*, *Muraticavea*, *Navifusa*, *Estiastra*, *Evittia*, *Veryhachium*, *Polyedryxium*, *Maranhites*, *Leiosphaeridia*, *Lophosphaeridium*, *Tasmanites*; and two are chitinozoan genera: *Angochitina* and *Sphaerochitina*.

This assemblage generally may be characterized as having poor preservation and apparently infrequent representation of certain taxa.

Plant macrofossils, occurring as coalified compressions and calcium carbonate-iron pyrite petrifactions, are discussed and figured. Two petrifactions from the Hanover Shale were positively identified as Callixylon. This is the first reported occurrence of identifiable plant macrofossils from the Hanover Shale. Four coalified compressions were tentatively identified as Callixylon from the Dunkirk and Gowanda Shales. Secondary wood cells of Callixylon are illustrated by scanning electron micrographs.

Insufficient representation of certain taxa, the recovery of numerous new forms, and the presence of long ranging taxa with little stratigraphic merit preclude the construction of a sound biostratigraphic zonation at this time. Comparison with spore and acritarch suites of similar age indicates relationships at the generic level; however, few conspecific taxa exist between these described assemblages.

Qualitative palynological data were used for paleoenvironmental interpretations. Abundance of microspores, anchor-tipped spores, acritarchs with processes and/or membranes, and Scutellomorphitae/Sphaeromorphitae/Tasmanititae was computed from samples of three essentially complete geologic sections and displayed as histograms. The final palynological assemblage is extensively controlled by sedimentological and depositional factors related to sea-land oscillations in a deltaic environment. The nearshore marine-deltaic deposits (calcareous siltstones

and gray shales) are dominated by microspores, and subordinate numbers of acritarchs with processes and/or membranes, and anchor-tipped spores. Samples characterized by anchor-tipped spores often contain plant detritus with structure preserved also indicative of a nearshore environment. Anoxic shelf-basin and destructive deltaic environments (represented by black shales) are dominated by the acritarch subgroups Scutellomorphitae/Sphaeromorphitae/Tasmanititae (*Leiosphaeridia* sp., *Lophosphaeridium micrograifer*, *Tasmanites huronensis*, *Maranhites brasiliensis*). This microplankton assemblage is believed to typify a recurrent species grouping. Amorphous organic debris recovered from these black shales by maceration represent the bacterial degradation of fungal, algal, and terrestrial plant materials in an anaerobic, stagnant, bottom environment.

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INTRODUCTION

One of the thickest and most complete sections of Devonian rocks in North America lies between east-central Pennsylvania and southwestern New York state. In New York, these Devonian sediments range from approximately 10,000 feet in the Catskill Mountain area to 2,500 feet at the Lake Erie shoreline (southwestern New York). This essentially complete sequence is presently accepted as the reference standard for the Devonian System of North America.

The Devonian of this area has long been a focal point for coupling geological field observations with theoretical analysis. This was initiated by James Hall's paleontological and stratigraphical observations on Devonian strata, which ultimately led to the concept of the geosyncline. Hall's research was subsequently elaborated upon in the 1920's and 1930's in the classical "facies" papers of Chadwick, Caster, and Cooper on the Middle to Upper Devonian sediments of the Catskill Delta complex.

Although this area is well studied geologically and paleontologically, Upper Frasnian (Upper Senecan)/Lower Famennian (lowermost Chautauquan) paleobotanical and palynological studies are lacking. The objectives of this study were: (1) Identification, description, and illustration of spores, acritarchs, chitinozoans, scolecodonts, and plant macrofossils from the Java and lowermost Canadaway Formations, upper Senecan/lowermost Chautauquan, southwestern New York State; (2) Discernment, if possible, of the Frasnian/Famennian boundary using palynomorphs;

(3) Study of the relationships between spores and acritarchs from southwestern New York state and palynomorph assemblages of comparable age from other regions; and (4) Paleoenvironmental analysis of the study area using abundances of palynological subgroups with corroborative evidence from related fields.

NORTH AMERICAN PALEOBOTANICAL STUDIES

The Devonian sediments of New York are noted for a diversity of Devonian plant megafossils. However, the majority of these are from mid-Frasnian or older strata. Larger plant fossils of Upper Frasnian through Famennian age are only sparingly reported. Upper Frasnian fossil plants have been figured by Arnold (1930, 1935, 1939), Grierson and Banks (1963), Krausel and Weyland (1949), and Fry and Banks (1955). Callixylon erianum (Arnold, 1930), from the Gowanda Shale, is the only plant macrofossil described from the units under investigation.

Heterosporous plants and a cupulate seed have been described from the Oswayo Formation (Famennian) of Pennsylvania (Pettit, 1965; Pettit and Beck, 1968). The Hampshire Formation (Famennian) locality of Valley Head, West Virginia, has been the focal point of several studies (Krausel and Weyland, 1941; Andrews and Phillips, 1968; Phillips, et al., 1972; Cornet, et al., 1976).

Several major contributions concerning Upper Devonian floras based on permineralized wood and other vascular tissue have been published. These include papers by Arnold (1931, 1934), Cross and Hoskins (1951 a, b), Hoskins and Cross (1951, 1952), Phillips, et al. (1972), Niklas (1976), Niklas and Phillips (1971), Read (1936, 1937), Read and Campbell (1939), and Schopf and Schwietering (1970).

Upper Devonian-Lower Carboniferous floral assemblages were reviewed by Cross and Hoskins (1951, a, b) and Hoskins and Cross (1951, 1952).

They determined that the genera Lepidodendron, Lepidostrobus, Cladoxylon, and Clepsydropsis spanned the Devonian-Carboniferous boundary, whereas Protolepidodendron, Reimannia, Protosalvinia (Foerstia), and "Sporangites" were characteristically Devonian forms.

REVIEW OF UPPER DEVONIAN PALYNOLOGICAL STUDIES

There are numerous publications concerning Upper Devonian palynomorphs. Many of these studies deal with Devonian-Carboniferous transition assemblages. This review of palynological literature is not intended as an exhaustive overview. The more important Upper Devonian references are presented here by geographic region.

UNITED STATES

Norton (1970) and Norton and Allen (1970) published preliminary studies on the Frasnian rocks from the New York Finger Lakes region. Their study noted that the palynomorphs exhibit poor preservation and high levels of carbonization. Von Almen (1970 a, b), Curry (1973, 1975), and Wicander and Loeblich (1977) have described Frasnian spore and/or Famennian acritarch assemblages from Oklahoma, Virginia, and West Virginia, and Indiana, respectively.

Famennian acritarchs have been illustrated by Boneham (1967, 1970) from Michigan, Indiana, and Ohio, and from various midwestern localities by Wilson and Urban (1971). Upper Devonian-Lower Mississippian assemblages have been reported by Winslow (1962), Eames (1974), and Wicander (1974), from northern Ohio. Warg and Traverse (1973) studied assemblages of similar age from Pennsylvania, Bharadwaj, et al. (1973) from Kentucky, and Sanburg, et al. (1972) from Montana and Illinois.

Canada

Numerous detailed contributions have been published on Upper Devonian palynology by Canadian workers. Frasnian spore assemblages have been described from Alberta (McGregor, 1964) and eastern Quebec (Brideaux and Radforth, 1970). Boneham (1967) reported the occurrence of *Tasmanites* from the Famennian of southwestern Ontario.

Several studies spanning th Frasnian-Famennian have focused on the Canadian Arctic Islands and the District of Mackenzie (Northwest Territories). Spore assemblages have been reported from Melville Island (Chi and Hills, 1976, a, b; Hills, et al., 1975; McGregor, 1960; and McGregor and Uyeno, 1972); from Prince Patrick Island (Chi and Hills, 1976, a, b; Hills, et al., 1975; Owens, 1971); from Bathurst Island (Chi and Hills, 1976, a, b; Hills, et al., 1975; Kerr, et al., 1965; and McGregor and Uyeno, 1972); from Banks Island (Chi and Hills, 1976, a, b; Hills, et al., 1971; and Hills, et al., 1975); from Ellesmere Island (Chaloner, 1959; Chi and Hills, 1976, a, b; Hills, et al.,1975); and from Helena Island (Kerr, et al., 1965). Assemblages from the District of Mackenzie have been described by Chi and Hills (1974, 1976 a, b), Hills, et al. (1975), and McGregor and Owens (1966).

United Kingdom and European Mainland

In the British Isles, Frasnian assemblages have been described by Clayton and Graham (1974) from Ireland, and Mortimer and Chaloner (1967) from England. Devonian-Carboniferous assemblages have been illustrated from Ireland (Clayton, et al., 1974; Dolby, 1970; Higgs, 1975); and from England (Clayton, et al., 1977; Dolby, 1970; Dolby and Neves, 1970; Neves and Dolby, 1967; Utting and Neves, 1970).

Famennian acritarchs have been reported from German deposits (Jux, 1975). Gorka (1974 a, b) has described and illustrated Famennian acritarchs from Poland. Upper Devonian-Carboniferous acritarchs and spores have also been reported by Turnau (1975) from northern Poland.

Bouckaert, et al. (1972) and Stockmans and Williere (1962 a) have described spores and acritarchs from strata near the Frasnian-Famennian boundary. Several studies have concentrated on Famennian (Bouckaert, et al., 1968; Bouckaert, et al., 1960; Caro-Moniez, 1962; Stockmans and Williere, 1962 b, 1969), and on Devonian-Carboniferous boundary assemblages (Alberti, et al., 1974; Becker, et al., 1974; Paproth and Streel, 1970; Streel, 1966, 1967, 1969, 1970, 1974).

Australia

Balme (1960) and de Jersey (1966) have described Frasnian and/or Famennian spore assemblages. Studies concerned with Upper Devonian-Carboniferous palynofloras of the Canning Basin have also been published (Balme and Hassell, 1962; Playford, 1976).

South America

The Algomycetes and Tasmanaceae from the Devonian sediments of the Parana Basin, Brazil, have been summarized by Sommer and van Boekel (1967). Daemon, et al. (1967) also described a palynoflora from the Upper Devonian of the Parana Basin. Brito (1967) has reported acritarchs of probable Upper Devonian age from the Maranhao Basin, Brazil, and Stover (1967) figured a Devonian-Carboniferous acritarch assemblage from eastern Venezuela.

Africa

Frasnian and/or Famennian palynomorphs have been illustrated from Ghana (Bar and Riegel, 1974; Anan-Yorke, 1974), and Libya (Massa and Moreau-Benoit, 1976). Lanzoni and Magloire (1969) described Upper Devonian palynomorphs from Algeria.

Russia

The Upper Devonian palynomorph assemblages of Russia have been the subject of numerous publications. Unfortunately, the majority of these are short papers, usually consisting of species lists and illustration of only characteristic spore types.

Accounts of Frasnian spore assemblages have been published by Mikhailova (1966), Ozolinya (1963), and of Famennian assemblages by Nadler (1966), Rashatova (1966, 1973), and Naumova (1960). Devonian-Carboniferous palynofloras have been reported by Kedo (1962) and Umnova (1971).

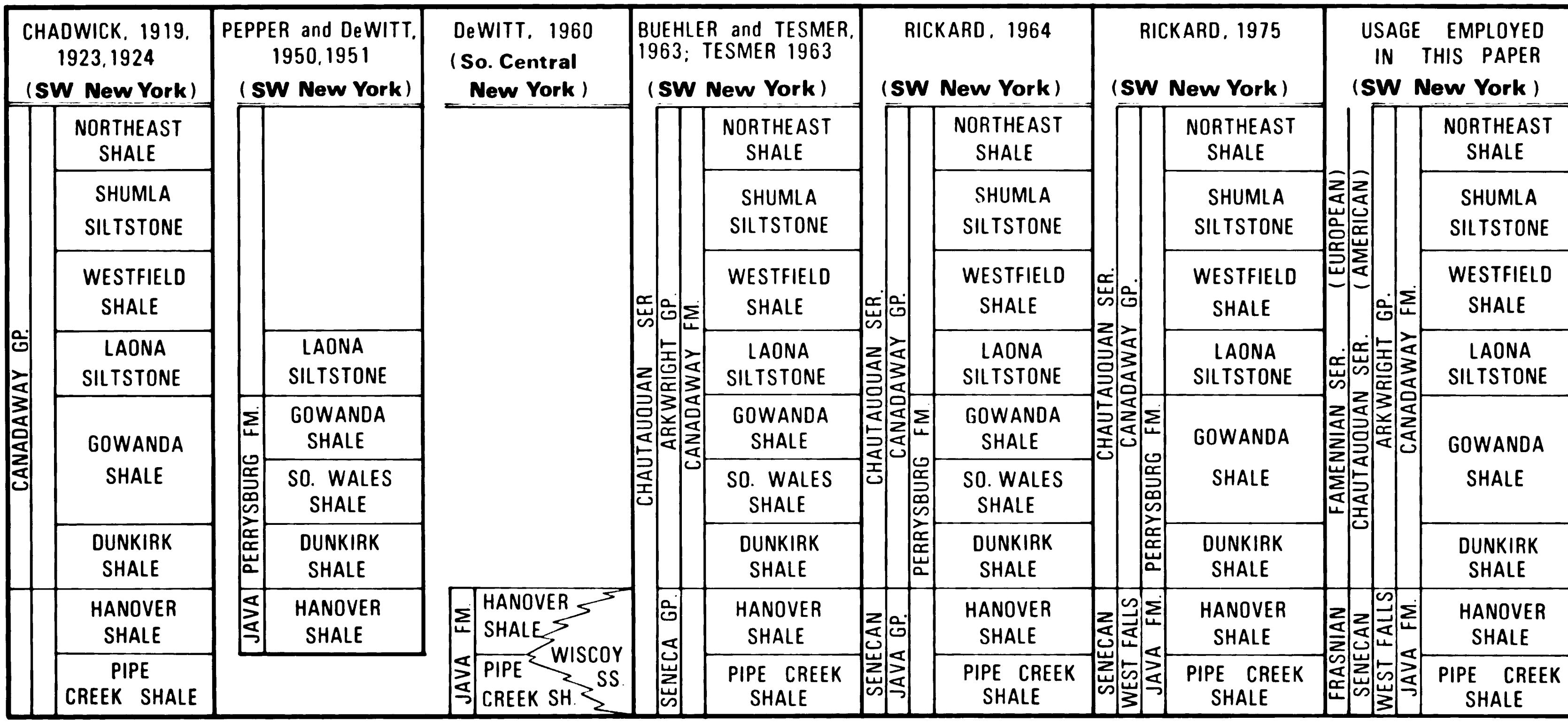
GEOLOGICAL OVERVIEW

STRATIGRAPHY

The Upper Devonian marine sediments of New York are restricted essentially to the southwestern portion of the state, and are divided into two series; an older Senecan (= European Frasnian) and a younger Chautauquan (= European Famennian). In southwestern New York, the uppermost Senecan is represented by the Java Formation (Pipe Creek Shale, Hanover Shale) of the West Falls Group, Cohocton Stage. The lowermost Chautauquan is represented by the Canadaway Formation (Dunkirk Shale, Gowanda Shale, Laona Siltstone, Westfield Shale, Shumla Siltstone, and Northeast Shale Members) of the Arkwright Group, Cassadaga Stage. This study is limited to the strata of the Pipe Creek and Hanover Shale Members of the Java Formation, and the Dunkirk and Gowanda Shale Members of the Canadaway Formation. Previous age assignments and stratigraphic nomenclature for the rocks of southwestern New York State are summarized in Text-Figure 1.

Java Formation

The Java Formation was proposed by de Witt (1960) to include three members: the Pipe Creek Shale, Wiscoy Sandstone, and Hanover Shale. The type locality is the exposure along Beaver Meadow Creek, above Angel Falls, Java Township, Wyoming County, west-central New York. However, in the study area of study, only the Pipe Creek Shale and Hanover Shale Members are present. The Wiscoy sandstone, absent in southwestern New



Text-Figure 1. Chart of previous age assignments and stratigraphic nomenclature for rocks of southwestern New York State.

York, is the dominant stratigraphic unit of this formation in central New York State (Tesmer, 1967; de Witt, 1960).

Pipe Creek Shale

The Pipe Creek Shale was named by Chadwick (1923) for an exposure in Pipe Creek Glen, Colden Township, Erie County, New York, approximately 15 miles west of Java Village. This black shale unit ranges from less than 1 foot to as much as 28 feet in the study area (Pepper and de Witt, 1950; Pepper, et al., 1956; de Witt, 1960; Tesmer, 1963; Buehler and Tesmer, 1963).

Fossils previously reported from the Pipe Creek include fish (Carter, 1945) conodonts (Hass, 1958), brachiopods, and fragments of carbonized wood (Tesmer, 1963; Buehler and Tesmer, 1963).

Hanover Shale

The Hanover Shale was initially designated the Silver Creek Shale by Hartnagel (1912) for gray shales below the overlying black Dunkirk Shale in exposures near Hanover, Chautauqua County, New York. Chadwick (1933) renamed this unit the Hanover Shale, and it was subsequently measured and mapped extensively in western New York by Pepper and de Witt (1950). The Hanover was redefined by de Witt (1960) to include interbedded gray and black shales and calcareous siltstones exposed along Silver Creek, in the town of Silver Creek, Hanover Township, Chautauqua County, New York (see Plate 1, figures 1 and 2). In the area of investigation, the Hanover ranges up to approximately 90 feet in thickness. Regionally, the Hanover thickens from central to western New York.

Fossils reported from this member include cephalopods (de Witt and Colton, 1953), conodonts (Hass, 1958), and gastropods (Tesmer, 1963). Trace fossils including pascichnia (grazing traces), fodinichnia (feeding traces), and domichnia (dwelling traces) were commonly found in the gray shales (Plate 1, figs. 5-6).

Canadaway Formation

The term Canadaway was initially applied as a group name by Chadwick (1933) for the strata from the base of the Dunkirk Shale to the base of the Cuba Sandstone as exposed in Canadaway Creek, Chautauqua County, New York. Pepper and de Witt (1951) subsequently recognized the "Perrysburg" Formation (= lowermost Canadaway Group) in which they included, in ascending order, the Dunkirk Shale, South Wales Shale, and Gowanda Shale Members. Tesmer (1955) suppressed the name "Perrysburg" Formation and transferred the Canadaway to formational rank. In southwestern New York, the Canadaway Formation is comprised of six members: the Dunkirk Shale, Gowanda Shale , Laona Siltstone, Westfield Shale, Shumla Siltstone, and Northeast Shale (Rickard, 1975).

Dunkirk Shale

The Dunkirk Shale (Plate 1, figs. 2-3) was named by Clarke (1903) for dark-gray to black shales exposed between the strata presently considered the Hanover and Gowanda Shale, in a declevity at Point Gratiot, in Dunkirk, Chautauqua County, New York. In southwestern New York, the

Dunkirk ranges from approximately 47 to 70 feet in thickness. Regionally, this member generally thickens from central to western New York.

Fossils previously noted from this unit include conodonts (Hass, 1951) and carbonized plant remains (Pepper and de Witt, 1951).

Gowanda Shale

The Gowanda (Plate 1, figs. 2-3), as originally described by Chadwick (1919), consisted of interbedded gray to black shales and calcareous siltstones situated between the Dunkirk Shale and Laona Siltstone. The type locality was designated by Chadwick (1924) for a section on Cattaraugus Creek, in Gowanda, New York. Pepper and de Witt (1951) subsequently divided this unit into an older South Wales Shale Member and a younger Gowanda Shale Member. They designated an exposure in a small tributary of the east branch of Cazenovia Creek, three miles south of South Wales, Erie County, New York, as the type section of the South Wales Member. Tesmer (1963), noting that the upper and lower contacts of the Gowanda could not be ascertained on Cattaraugus Creek, proposed that an essentially complete section exposed on Walnut Creek, near the town of Silver Creek, Chautauqua County, be assigned as the redefined type section of the Gowanda (sensu Pepper and de Witt, 1951). Recently, however, Rickard (1975) suppressed the name South Wales and included these strata within the Gowanda. The Gowanda (sensu Rickard, 1975) varies from approximately 210-300 feet in thickness in southwestern New York. Regionally, this unit thickens from central to western New York.

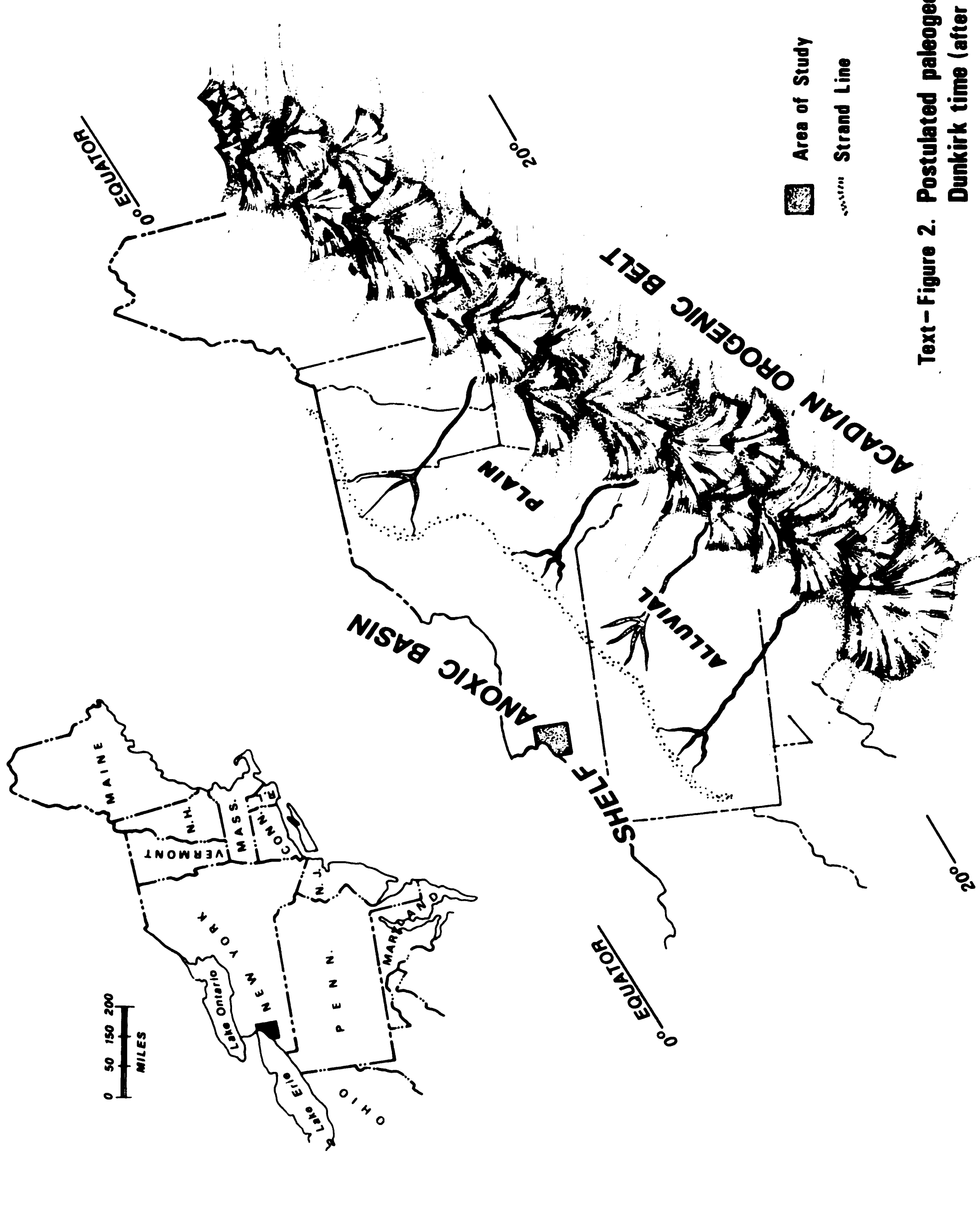
Plant macrofossils, *Callixylon erianum* Arnold (1930), conodonts

(Hass, 1951), gastropods, and pelecypods (Tesmer, 1963) have been described from the Gowanda.

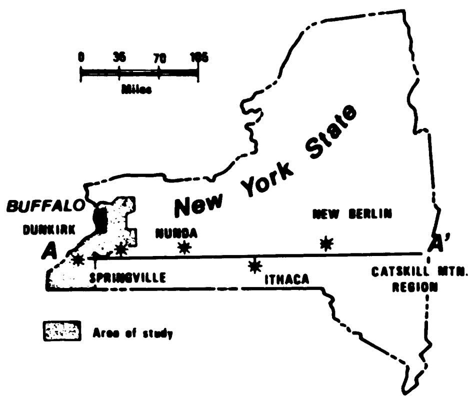
Local Geological Setting

During Middle Devonian time, carbonate deposition prevailed over most of the western New York area. Deltaic sedimentation prevailed during the Late-Middle Devonian when rivers prograded west-northwest from the Acadian orogenic belt which lay east of the present day Catskill Mountain area of southeastern New York (Text-Figure 2).

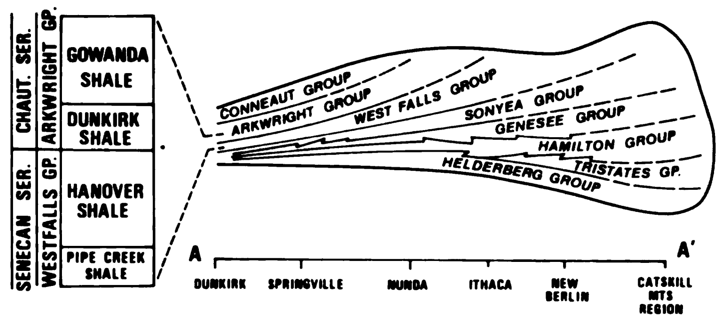
This deltaic sequence exhibits a complex lateral and vertical gradation of sedimentary facies consistant with patterns of similar environments in modern deltas (Friedman and Johnson, 1966; Roe, 1976). Text-Figure 3 shows the lateral facies relationships during the uppermost Senecan-lowermost Chautauquan of New York State. The easternmost facies of this complex is an association of red, green, and gray shales, and blue-gray sandstones that have been interpreted as subaerial and fluvial floodplain deposits (Thayer, 1974; Sutton, et al., 1970; Woodrow, et al., 1973). Woodrow, et al. (1973) concluded that the Catskill coastal plain nearest the sea was marked by meandering streams, indistinct shoreline, and low relief of 0.3-1.0 m per km (1-3 ft. per mile). Successive depositional facies in the direction of progradation are composed predominantly of fine sands, coarse to fine silts and clays generally associated with delta platform, prodelta-shelf, and shelf-basin deposits (Sutton, et al., 1970; Thayer, 1974; Roe, 1976).



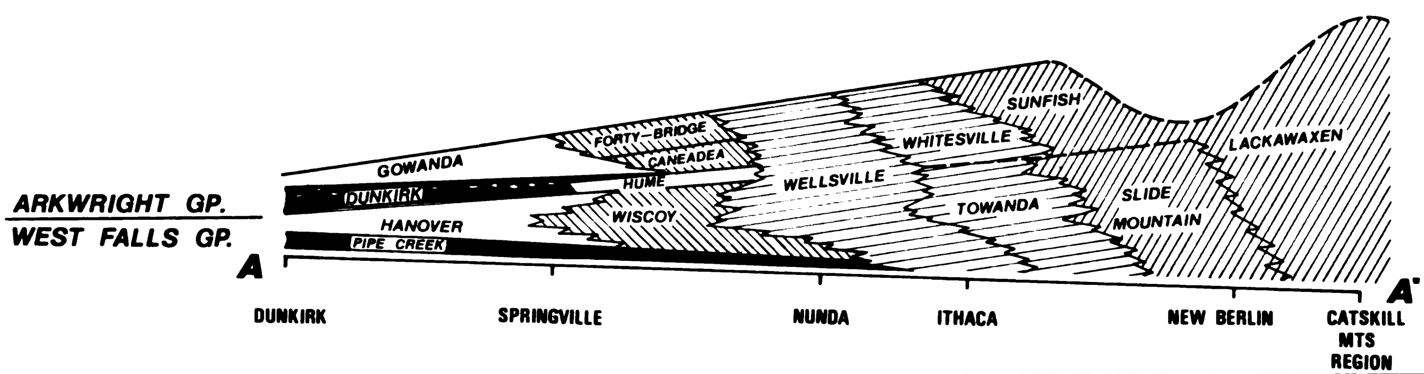
Text-Figure 2. Postulated paleogeographic map of Hanover–Dunkirk time (after Dott and Batten, 1971 and Woodrow et al., 1973)



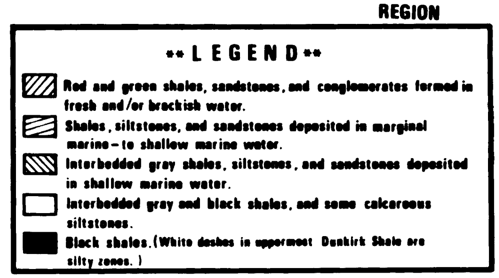
A. Map showing location of cross-section line (A-A') detailed in diagrams B and C.



B. Generalized stratigraphic cross-section of Devonian rocks along line A-A'. Stratigraphic column to the left is detailed in diagram C.



C. Detailed cross-section (along line A-A') showing facies relationships and laterally equivalent stratigraphic units of the upper most West Falls and lower most Arkwright Group.



Text-Figure 3. Highly generalized stratigraphic cross sections showing facies relationships of the uppermost West Falls Group and lowermost Arkwright Group of New York State, (after Dott and Batten, 1971; House, 1975; Woodrow, et al; 1973).

The Frasnian-Famennian setting in southwestern New York is predominantly marine. Sediments consist mainly of gray and black shales interbedded with thin calcareous siltstone beds approximately 6 to 36 cm thick. Although numerous theories have been advanced concerning the deposition of the Upper Devonian black shales of west-central New York (e.g., Cooper, 1957; Hard, 1931); Heckel, 1972; Raymond, 1942; Rich, 1951; Ruedemann, 1935), recent research has coupled their deposition to the dynamics of a fluviodeltaic, anoxic basin-shelf system (Bowen, et al., 1974; Byers, 1973; Roe, 1975, 1976; Sutton, et al., 1970; Thayer, 1974).

Roe (1975, 1976), in his reconstruction of the depositional environments of the Pipe Creek Shale, Hanover Shale, and Dunkirk Shale, attributed their development to a constructive-destructive deltaic, anoxic shelf-basin system. The black shales represent anoxic shelf-basin conditions initiated by marine transgression and/or deltaic abandonment and reflects extremely low sedimentation rates. The nearshore-shelf, deltaic dominated facies is characterized by gray shales. Present in the Hanover and Gowanda Shales (but absent in the Pipe Creek and Dunkirk Shales) are thin calcareous siltstone units. The interbedding of these lithologic units may represent periods of deltaic progradation and distributary migration (Roe, 1976) and/or epeiric oscillation (Dennison and Head, 1975). Dennison and Head (1975) state that sea level fluctuated 10-100 m in the Appalachian Basin during the Cohocton Stage (Uppermost Senecan). However, many calcareous siltstone units are flat-bottomed, laminated (silt-size, graded-upwards from coarse to fine), and exhibit ripple bedding on upper surfaces (see Plate 1, figs. 3-4). Morphologically, these beds are similar to storm-spread deposits, where storm tides, currents, and surges disseminate sediments seaward from beaches, bars, etc., associated with deltaic supply (Hayes, 1967; Masters, 1967; Reineck and Singh, 1972, 1975; Swift, et al., 1971, 1972). Such storm sheets may transport sediments more than 45 km from their original source (Hayes, 1967). Reineck and Singh (1972, p. 127) suggest that the laminated silt was deposited from a suspension cloud during the heavy storm leading to a temporary increase in water level. The ripple-bedded upper surface was generated when water level fell and storm waves, currents, or surges produced ripples on the ocean bottom. The absence of these deposits in the black shales of the Dunkirk and Pipe Creek suggests that these units, in the area of study, were too far offshore to be affected by storm waves and currents.

No trace fossils (i.e., escape burrows) were observed in any calcareous siltstone; however, gray shales capping these beds are often burrowed and bioturbated indicating the repopulation of the substrata by benthonic organisms. Black shales immediately above these units lack evidence of benthonic inhabitants; however, the overlying waters may have had a full complement of pelagic marine life (Haeckel, 1972). The black color of these shales is the result of a high content of either unoxidized organic matter or finely divided iron sulphide reflecting an anaerobic, fetid, stagnant bottom, or a combination of these.

In summary, the stratigraphic interval under investigation is a part of a fluviodeltaic, anoxic basin-shelf system. The Pipe Creek and Dunkirk black shales represent comparatively long periods of stagnant, anoxic bottom conditions in shelf areas. The Hanover and Gowanda Shales have relatively small scale environmental oscillations characterized by interbedded lithologies of shallow shelf marine muds periodically inundated by storm-spread deposits. The dynamics of this system could be drastically affected by: (1) shifts in progradational direction of deltaic lobes (Roe, 1975, 1976; Thayer, 1974; Sutton, et. al., 1970); (2) differential basinal settling (Roe, 1976); (3) stochastic tectonic activity (initiating deltaic rejuvination) in the source area (Friedman and Johnson, 1966; Johnson, 1971; Roe, 1976); and (4) sea level oscillations (Dennison and Head, 1975; Johnson, 1971).

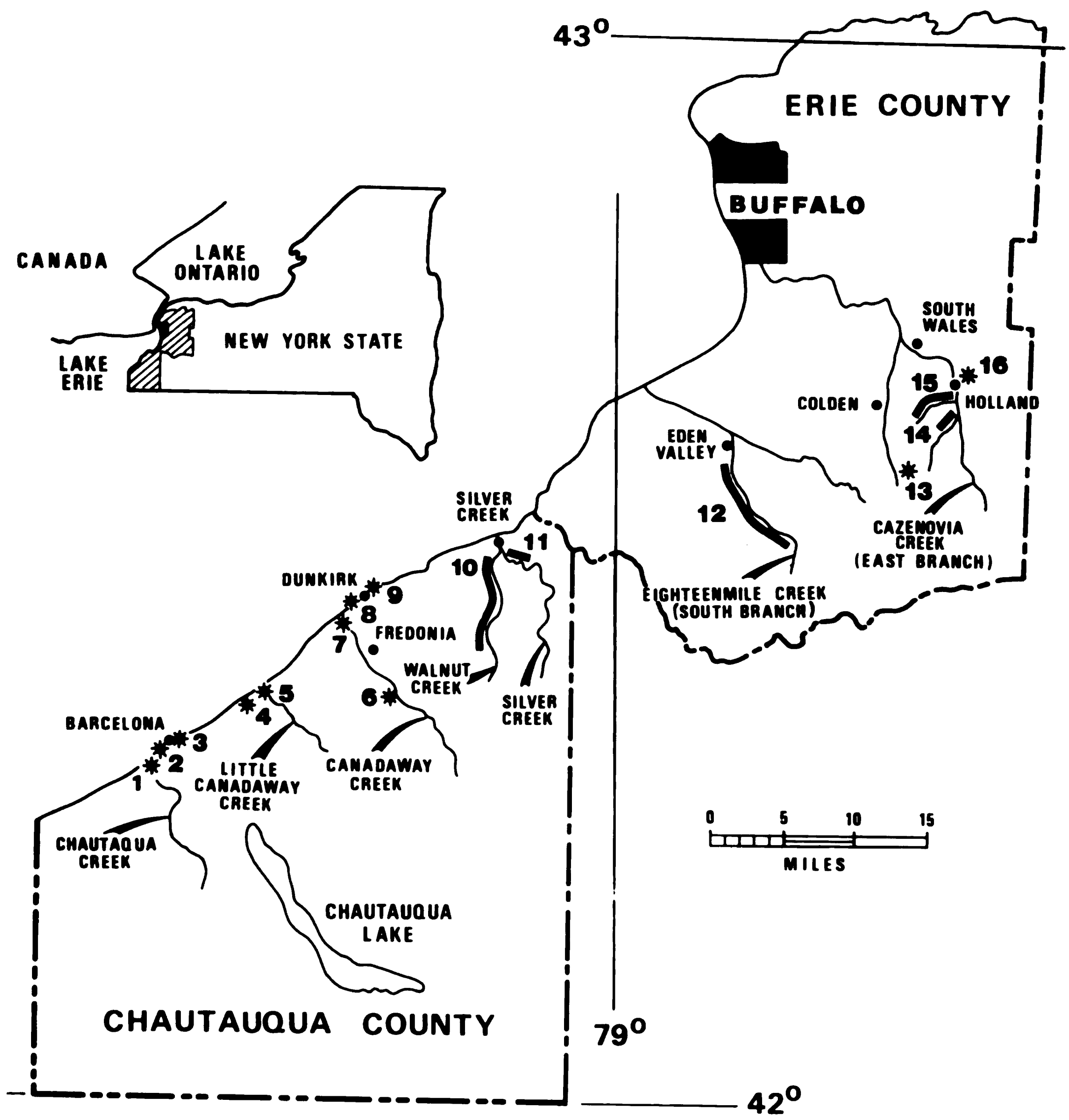
COLLECTIONS AND PREPARATIONS

Sample Collection

Two hundred and twenty-nine samples were collected from 16 outcrop sections in Chautauqua and Erie counties, western New York State (Text-Figure 4). The geographic description of each sampling locality is given below. Locality numbers refer to Text-Figure 4. Samples are listed in Appendix 1 by locality, maceration number, gross lithology, stratigraphic member, and relative stratigraphic position. The samples were collected by Dr. Aureal T. Cross (Department of Geology, Michigan State University), Dr. Leonard E. Eames (Amoco Production Company, Research Center, Tulsa, Oklahoma), Dr. John A. Clendening (Amoco Production Company, Houston, Texas), and the author.

Locality 1. Exposure under bridge on Chautauqua Creek, 0.32 mile west of New York Routes 5 and 17 intersection in Barcelona, Westfield Township, Chautauqua County, New York (42°19'51" N. Lat., 79°35'40" W. Long.). Stratigraphic unit collected: Gowanda Shale.

Locality 2. Exposure in a declevity of the Lake Erie shore cliffs, adjacent to the Daniel Read Memorial Pier, 1000 feet east of the lighthouse at Barcelona, Westfield Township, Chautauqua County, New York (42°20'21" N. Lat., 79°35'20" W. Long.). Stratigraphic unit collected: Gowanda Shale.



Text - Figure 4. Outline map of study area showing collection sites discussed in the text.

Locality 3. Ottaway Park (formerly Barcelona City Park), just north of N. Y. Route 5, 0.75 mile east of lighthouse, near Barcelona, Westfield Township, Chautauqua County, New York (42°20'26" N. Lat., 79°34'56" W. Long.). Stratigraphic unit collected: Gowanda Shale.

Locality 4. Lake Erie shore cliffs, at the Lake Erie State Park, west of Van Buren Point, Portland Township, Chautauqua County, New York (42°24'26" N. Lat., 79°22'18" W. Long.). Stratigraphic unit collected: Gowanda Shale.

Locality 5. Exposures in Little Canadaway Creek, adjacent to N.Y. Route 5, at bridge, 0.1 mile southwest of intersection of N.Y. Route 5 and Berry Road, south of Van Buren Point, Portland Township, Chautauqua County, New York (42°26'2" N. Lat., 79°22'18" W. Long.). Stratigraphic unit collected: Gowanda Shale.

Locality 6. Outcrop at bridge over Canadaway Creek, just west of main intersection of Webster Road and old N.Y. Route 60, at Laona, Pompfret Township, Chautauqua County, New York (42°25'8" N. Lat., 79°16'14" W. Long.). Stratigraphic unit collected: Gowanda Shale.

Locality 7. Section is located on Canadaway Creek, just west of Temple Road, approximately 0.3 mile south of N.Y. Route 5. Exposure on bank of Canadaway Creek, opposite service road entrance to county infirmary (noted as community/township nature preserve on Dunkirk Quadrangle map), west of Dunkirk township, Chautauqua County, New York (42°28'30" N.

Lat., 79°21'7" W. Long.). Stratigraphic units collected: Dunkirk Shale, Gowanda Shale.

Locality 8. Exposures along the Lake Erie shoreline, Point Gratiot, Dunkirk, Chautauqua County, New York (42°29'20" N. Lat., 78°21'2" W. Long.). Stratigraphic unit collected: Dunkirk Shale.

Locality 9. Section exposed in cliffs on Lake Erie shoreline at northeast end of Wright Park, northeast side of Dunkirk, Chautauqua County, New York (42°30'5" N. Lat., 79°19'2" W. Long.). Stratigraphic unit collected: Hanover Shale.

Locality 10. Section exposed along Walnut Creek, beginning at the southwest side of the town of Silver Creek, Hanover Township, Chautauqua County, New York (42°32'5" N. Lat., 79°9'27" W. Long.). Stratigraphic units collected: Pipe Creek Shale, Hanover Shale, Dunkirk Shale, Gowanda Shale.

Locality 11. Section exposed along Silver Creek, at the southeast side of the town of Silver Creek, Hanover Township, Chautauqua County, New York (42°32'15" N. Lat., 79°8'55" W. Long.). Stratigraphic units collected: Pipe Creek Shale, Hanover Shale.

Locality 12. Section exposed along the south branch of Eighteenmile Creek, Erie County, New York (42°38'19" N. Lat., 78°51'55" W. Long.).

Stratigraphic units collected: Pipe Creek Shale, Hanover Shale, Dunkirk Shale, Gowanda Shale.

Locality 13. Section in Pipe Creek Glen, Colden Township, Erie County, New York (42°38'24" N. Lat., 78°57'20" W. Long.). Stratigraphic unit collected: Pipe Creek Shale.

Locality 14. Exposure along an unnamed, east-flowing tributary to the east branch of Cazenovia Creek (this locality will be designated as Cazenovia Creek in the text), south of South Wales, Holland Township, Erie County, New York (42°39'55" N. Lat., 78°33'50" W. Long.). Stratigraphic unit collected: Gowanda Shale (type section of the South Wales Shale of Pepper and de Witt (1951)).

Locality 15. Unnamed, east flowing tributary to the east branch of Cazenovia Creek (designated as Cazenovia Creek I in text), approximately 800 feet south of Blanchard Road, on west side of N.Y. State Highway 16, south of South Wales, Holland Township, Erie County, New York (42°40'2" N. Lat., 78°33'5" W. Long.). Stratigraphic units collected: Pipe Creek Shale, Hanover Shale, Dunkirk Shale, Gowanda Shale.

Locality 16. Small abandoned quarry on the east side of the intersection of Weed Hill Road and Hunter Creek Road, southeast of South Wales, Erie County, New York (42°42'55" N. Lat., 78°31'35" W. Long.). Stratigraphic unit collected: Pipe Creek Shale.

Preparation of Samples

This study incorporated samples processed by both the Amoco Production Company (Tulsa, Oklahoma) and the author. The following discussion describes the maceration technique used by the author. Variations on this procedure, employed by Amoco, will also be reviewed.

Rock samples were washed with a brush under running water to remove extraneous sediments and then allowed to dry. Bulk samples (120 grams) were broken into pieces approximately 1 centimeter in diameter and placed on a large piece of paper. By quartering the sample (i.e., rolling the sample back and forth on this sheet and intermittently halving it twice), a representative 30 gram aliquot was procured. This 30 gram sample was then placed in a polycarbonate beaker and treated with a 10% hydrochloric acid (HCl) solution to remove soluble carbonates. When the sample ceased to effervesce in HCl, it was washed twice in warm water. Cold hydrofluoric acid (HF) was then added to dissolve soluble silicates. After 24-48 hours in HF, depending on sediment type, the sample was washed once with HCl, and then four times in distilled water. Following this treatment, the sample was subjected to heavy liquid separation using zinc chloride (1.95 specific gravity). The supernatant fraction was collected, washed once in HCl, and three times in distilled water. The sink fraction was discarded, if barren.

At this stage, wet mounts were examined to determine the degree of carbonization level of the palynomorphs and cold nitric acid (20% HNO_3) was added to clear the palynomorphs if necessary. The duration of HNO_3 treatment was determined by the condition of palynomorphs.

Subsequently, residues were sieved through a 200 and a 20 um sieve nest (Kidson and Williams, 1969) using 100% methanol. The -20 and +200 size fractions were examined for palynomorphs and discarded if barren. The +20 and -200 size fractions were transferred to a small vial and centrifuged with distilled water. Following centrifugation, each vial was completely filled with hydroxyethylcellulose (HEC)[1], a preservative.

The sample processing technique employed by Amoco differed from the above procedure in the following steps: (1) use of 39-100 grams of sample; (2) zinc bromide for heavy liquid separation; (3) Schulze solution used where carbonization was evident; and (4) residue vials were filled with a phenol-distilled water mixture.

Microslide Preparations

Three drops of residue were mounted on a cover glass in HEC and the cover glass subsequently affixed to a 1"x3" glass-slide using Harleco Synthetic Resin (HSR)[2]. Four slides were prepared from each residue and coded with a laboratory number and slide number, e.g., PB 10774-1,-2,-3,-4. The maceration number is Pb 10774 and 1-4 designates the slide numbers of that sample. Sample residues processed by Amoco were mounted

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[1]Hydroxyethylcellulose, Fisher Scientific, 34401 Industrial Road, Livonia, Michigan 48150.

[2]Harleco, Synthetic Resin, Fisher Scientific, 34401 Industrial Road, Livonia, Michigan 48150.

on coverglasses in Clearcol and then mounted to the slides with Elvacite 2044[2] resin. All slides and extra bulk sample (including those processed by Amoco Production Company) are housed in the Paleobotanical and Palynological Collections, Department of Geology, Michigan State University.

Light and Scanning Electron Microscopy

Light photomicrographs were taken on a Leitz Ortholux microscope with attached Leitz Orthomat camera, using Kodak Panatomic-X film. Coordinates for figured specimens (noted in plate explanations) are for a Leitz Ortholux stage (No. 591962). In all cases, coordinates were recorded with the slide placed in the stage holder with the label to the left of the observer.

Because two methods were employed in examining palynomorphs with the SEM, two types of preparation mounts were required. Palynomorphs were mounted on a circular cover glass using a micropicker (Kidson and Williams, 1969) or by strewing the residue on the cover glass. These cover glasses were then cemented onto an aluminum stub and coated with a mixture of gold/palladium. Tissues isolated from plant macrofossils were mounted directly on the surface of aluminum stubs and also coated with a gold/palladium mixture.

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[1]Clearcol, H. W. Clark, 33 South High St., Melrose, Mass. 02176 (no longer available)

[2]Elvacite 2044 Resin Mfg. by E. I. DuPont DeNemours & Co. Inc., Wilmington, Delaware 19898. Available at Brainard Chemical Co. Inc., Sheridan at 42nd St., Tulsa, Oklahoma 74156.

Scanning electron photomicrographs of palynomorphs were taken on a Cambridge Stereoscan Mark IIA SEM (Amoco Production Company, Research Center, Tulsa, Oklahoma) using Polaroid Polaplan Type 52 BW film. Photomicrographs of plant tissue were taken on an International Scientific Instruments Super-Mini SEM (Pesticide Research Building, Michigan State University), using Polaroid P/N film and on a Cambridge Steroscan Mark IIA SEM (see above).

SYSTEMATICS: PLANT MACROFOSSILS

Plant macrofossils occur as calcium carbonate/iron pyrite petrifactions, coalified (vitrinized) remains (or a combination of both), and as impressions and compressions. These were relatively rare and poorly preserved. Some showed evidence of boring by marine organisms (see Plate 2, Figs. 1-2). Others displayed the effects (i.e., shrinkage cracks) of extended periods in water (see Plate 6, Figure 1). Only calcium carbonate-iron pyrite-coalified remains exhibited anatomical structure (Plates 2-4, Plate 5, Figure 1). Owing to the poor preservation, thin-sections were of negligible value. The specimens were tentatively identified on the basis of reflected light to the genus *Callixylon*. This taxonomic designation was confirmed with the scanning electron microscope.

Callixylon Zalessky, 1911

Type species: *Callixylon trifilievi* Zalessky, 1911.

Callixylon sp. 1

(Plate 2, Figures 1-3; Plate 3, Figures 1-2)

Description: Tracheids 30-36 μm in width; bordered pits, 8-10 per group, usually aligned in two rows; pit groups spaced 20-27 μm apart.

Discussion: The above description was made from a single badly preserved iron pyrite-coalified specimen (collection number 10/17/76-I-7a). Only the presence of grouped pits allowed generic determination. Differs from *C. Newberryi* and *C. Zalessky* in number and arrangement of pits, and *C. bristolense* in lacking a vertical pit orifice.

Occurrence: Collected from a gray shale (15 feet from base of member) of the Hanover Shale, south Branch of Eighteen-mile Creek (Locality 12), Erie County, New York.

Callixylon sp. 2

(Plate 3, Figure 3; Plate 4, Figures 1-4; Plate 5, Figure 1)

Description: Tracheids 35-38 μm in width; bordered pits, 6-10 per group; large pit apertures and horizontal pitting of tracheid wall evident; pit groups spaced 8-16 μm apart.

Discussion: The foregoing description was based on a single specimen (collection number 10/17/76-I-1). Differs from *Callixylon* sp. 1 by the number of pits per group, the presence of large cross-pit apertures, horizontally pitted walls, and spacing distance between pit groups. Similar to *C. erianum*, however, *C.* sp. 2 displays a more uniform number of pits per group.

Occurrence: Collected from a gray shale (18 feet from base of member) of Hanover Shale, south Branch of Eighteenmile Creek (Locality 12), Erie County, New York.

Doubtful and Uncertain Forms

Plant macrofossils, tentatively identified as Callixylon using reflected light, were also recovered from the Java and lowermost Canadaway Formations. These occurred as coalified impressions and compressions (Plate 5, Figures 2, 4-5; Plate 6, Figures 1-3). Structured organic detritus (tracheids, cuticle, etc.) were often abundant in palynological residues (i.e., Plate 5, Figure 3).

SYSTEMATICS: PALYNOMORPHS

SPORES

The spores are classified alphabetically by genus and species in preference to suprageneric categories that insinuate natural relationships between genera (Potonie and Kremp, 1954). The former classification scheme is believed to be the most practical; whereas, the latter may imply phylogenetic affiliations between completely unrelated plants that produce similar spore types (see Schopf, 1964, pp. 47-51). An index of spore taxa arranged alphabetically is provided in Appendix II.

Genus *Anapiculatisporites* (Potonie and Kremp) emend. Smith and Butterworth, 1967

Type species: *Anapiculatisporites isselburgensis* Potonie and Kremp, 1954

Anapiculatisporites hystricosus Playford, 1963
(Plate 7, Figure 1)

1963 *Anapiculatisporites hystricosus* Playford, p. 16-17; Pl. 3, figs. 13-15.

Description: Specimens conform to original description given by Playford (1963, p. 16-17).

Discussion: This species has been reported from the Upper Devonian of Norway (Kaiser, 1970, 1971) and the Lower Carboniferous of Canada (Playford, 1963), and Belgium (Streel in Becker et al., 1974).

Occurrence: *Anapiculatisporites hystricosus* was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10819, 11260, 11261.

Dunkirk - Pb 10793.

Gowanda - Pb 11294.

Genus *Ancyrospora* (Richardson) emend. Richardson, 1962

Type species: *Ancyrospora grandispinosa* (Richardson) Richardson, 1962

Ancyrospora ancyrea (Eisenack) Richardson, 1962
(Plate 7, Figure 2)

1944 *Triletes ancyrea* Eisenack, p. 19; Pl. 2, fig. 2.

1962 *Ancyrospora* (*Triletes*) *ancyrea* (Eisenack) Richardson, 1962, p. 176; Text-fig. 5.

Description: Specimens conform to the description of Richardson (1962, p. 176).

Discussion: This species is exclusively Devonian in its occurrence. Comparable forms have been reported from Germany (Eisenack, 1944), England (Richardson, 1962), and Virginia (Curry, 1973).

Occurrence: *Ancyrospora ancyrea* was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species is noted below by stratigraphic unit.

Hanover - Pb's 10773, 10774, 10777, 10778, 19781, 10782, 10819, 10824, 10825, 10832, 10833, 10836, 10840, 10842, 10846, 10847, 10848, 11259, 11260, 11262, 11263, 11265, 11275, 11318, 11321, 11324, 11325, 11326, 11327, 11536, and 11537.

Dunkirk - Pb's 10791, 10850, 10860, 10862, 11248, 11249, 11252, 11253, and 11254.

Gowanda - Pb's 10806, 10808, 10809, 10810, 10812, 10867, 10877, 10879, 10881, 10883, 10888, 10889, 10891, 10894, 10895, 10896, 10902, 11275, 11278, 11280, 11283, 11285, 11298, 11306, 11307, 11308, 11310, 11313, 11314, 11334, and 11335.

Ancyrospora cf. *A. furcula* Owens, 1971

(Plate 7, Figure 3)

1971 *Ancyrospora furcula* Owens, p. 71-72; Pl. 23, figs. 1-4.

1972 *Ancyrospora* n. sp. 2 McGregor and Uyeno, p. 34; Pl. 4, fig. 13.

Description: According to Owens' (1971) diagnosis, *A. furcula* possesses only bifurcate appendage terminations and a large (up to 30 μm) apical prominence. The forms reported by Higgs (1975) and those reported here differ from those described by Owens (1971) in possessing mainly bifurcate and some trifurcate appendage terminations and having a smaller apical prominence (8-14 μm).

Discussion: *Ancyrospora furcula* has been reported from the Upper Devonian of northern Canada (Owens, 1971; McGregor and Uyeno, 1972), Ireland (Higgs, 1975), and Libya (Massa and Moreau-Benoit, 1976).

Occurrence: *Ancyrospora* cf. *A. furcula* was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10773, 10774, 10777, 10778, 10781, 10788, 10817, 11259, and 11325.

Dunkirk - Pb 10791.

Gowanda - PB's 11310 and 11336.

Ancyrospora langii (Taugourdeau-Lantz) Allen, 1965

(Plate 7, Figure 4)

1960 *Archaeotriletes langii* Taugourdeau-Lantz, p. 145; Pl. 3, figs. 33-34, 39.

1964 Ancyrospora cf. simplex Vigran, p. 26; Pl. 6, figs. 1-3.

1965 Ancyrospora langii Allen, p. 743; Pl. 106, figs. 5-7.

Description: Specimens generally conform to the description in Allen (1965, p. 743).

Discussion: This species has been reported from Middle Devonian through Upper Devonian sediments of Europe (Taugourdeau-Lantz, 1960, 1971; Paproth and Streel, 1970; Becker, et al, 1974), Vestspitsbergen (Vigran, 1964; Allen, 1965), and Libya (Massa and Moreau-Benoit, 1976).

Occurrence: Ancyrospora langii was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10782, 10787, 10788, 10825, 10833, 10840, 10842, 10844, 10848, 11259, 11262, 11267, 11268, 11270, 11318, 11319, 11320, and 11321.

Dunkirk - Pb's 10791, 10793, 10850, 10857, 10860, 10865, 11251, 11252, 11253, 11255.

Gowanda - Pb's 10808, 10810, 10812, 10867, 10868, 10872, 10876, 10877, 10879, 10881, 10883, 10889, 10891, 10893, 10897, 10899, 10900, 10903, 10905, 11276, 11285, 11286, 11306, 11307, 11309, 11314, and 11322.

Ancyrospora sp. 1

(Plate 7, Figures 5, 6)

Description: Spores, radial, trilete; amb subtriangular to subcircular; laesurae sinuous, extending entire length of inner body; exine two layered; intexine, granulate to laevigate, 54-71 μm in diameter; exoexine 70-83 μm in diameter; distal and equatorial surfaces of exoexine ornamented with 15-23 slender appendages 22-40 μm in length, 4-9 μm in width (at base), terminating in very fine bifurcate and trifurcate processes; bases of appendages generally do not fuse.

Discussion: Ancyrospora furcula generally has a greater number of appendages (up to 35) and a distinctive apical prominence. Ancyrospora langii possesses shorter (12-25 μm) appendages and usually is larger in overall size (up to 140 μm in diameter).

Occurrence: Ancyrospora sp. 1 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10822 and 11264.

Dunkirk - Pb 11254.

Gowanda - Pb's 10872, 10902, 10903, and 10906.

Ancyrospora sp. 2

(Plate 7, Figure 7)

Description: Spores, radial, trilete; amb subcircular to subtriangular; laesurae sinuous, ± distinct; exine two-layered; intexine laevigate, 87-98 μm in diameter; exoexine 92-103 μm in diameter; distal and equatorial regions of exoexine bearing 23-33 appendages, 18-23 μm in length, 6-12 μm in width (at base), with bi- tri- or multifurcate terminations; appendages taper distally and have broad bases that may fuse to form an equatorial flange.

Discussion: Ancyrospora sp. 1 has longer (22-40 μm) appendages and lacks multifurcate terminations. Ancyrospora furcula and Ancyrospora langii have narrower (12-25 and 12-48 μm, respectively) equatorial flanges.

Occurrence: Ancyrospora sp. 2 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10787, 10820, 10824, 10836, 11259, and 11260.

Dunkirk - Pb's 10792 and 10859.

Gowanda - Pb's 10808, 10813, 10876, 10879, 10886, and 11333.

Ancyrospora sp. 3

(Plate 8, Figures 1-3)

Description: Spores, radial, trilete; amb subtriangular and subcircular; laesurae straight, ± distinct, extending entire length of inner body; exine two-layered; intexine laevigate, 90-109 µm in diameter; exoexine 97-112 µm in diameter, distal and equatorial surfaces of the exoexine ornamented with 19-29 appendages, 27-43 µm in length, 7-16 µm in width (at base), usually variable in morphology often with bifurcate terminations; appendages usually taper distally or may be fused 1/2 to 2/3 distance from base.

Discussion: This form is distinguished from A. langii, A. furcula, and A. ancyrea in having variable shaft and termination morphologies. Ancyrospora sp. 2 has shorter (18-23 µm) appendages.

Occurrence: Ancyrospora sp. 3 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10782, 10787, 10788, 10820, 10824, 10833, 10836, 10842, 10844, 11259, 11319, and 11320.

Dunkirk - Pb's 10791 and 10857.

Gowanda - Pb's 10808, 10813, 11275, 11276, 11279, 11283, 11284, 11286, 11309, 11334, and 11336.

Ancyrospora sp. 4

(Plate 8, Figure 4)

Description: Spores, radial, trilete; amb subcircular to subtriangular; laesurae sinuous, distinct; extending entire length of inner body; exine two-layered, intexine laevigate, 79-91 μm in diameter; exoexine 103-121 μm in diameter; distal and equatorial areas of exoexine ornamental with 12-19 anchor-tipped appendages 23-30 μm in length, 13-20 μm in width (at base); anchor tips 13-17 μm across.

Discussion: The large anchor-shaped terminations distinguish this form from other known representatives of this genus. Although this description is based on a single complete specimen, the large, distinctive, anchor tips were often encountered as detached entities in the residues.

Occurrence: Ancyrospora sp. 4 was recovered from one sample of the Gowanda Shale (Pb 10877).

Genus Apiculiretusispora (Streel) emend. Streel, 1967

Type species: Apiculiretusispora brandtii Streel, 1964

Apiculiretusispora sp. 1

(Plate 8, Figures 5-6)

Description: Spores, radial, trilete; amb circular to subcircular, 30-42 μm in diameter; laesurae distinct, straight (less often sinuous), may be slightly elevated, extended 4/5 to entire spore radius; contact area ± distinct, slight curvaturae present; proximally infragranulate; equatorial and distal surfaces ornamented with densely distributed grana and/or minute coni, ca. 1-2 μm in height.

Discussion: This form lacks the common concentric folds of *Apiculiretusispora gaspiensis* McGregor, 1973. *Apiculiretusispora* sp. 2 is larger (43-51 μm) in size, and has a slight lip development.

Occurrence: *Apiculiretusispora* sp. 1 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10773, 10774, 10778, 10820, 10838, 10848, and 11325.

Dunkirk - Pb's 10795, 10798, and 10865.

Gowanda - Pb's 10869, 10874, 10876, 10877, 11309, and 11310.

Apiculiretusispora sp. 2

(Plate 8, Figure 7)

Description: Spores, radial, trilete; amb circular to subcircular, 43-51 μm in diameter; laesurae distinct, straight, often accompanied by lip development; extending up to 4/5 radius of spore; proximal contact area infragranulate, slight curvaturae present; distal surface ornamented with minute, dense, grana and/or coni, ca. 1-2 μm in height.

Discussion: The lip development distinguishes this form from other examples of *Apiculiretusispora*. *Geminospora* forms are excluded because they lack curvaturae.

Occurrence: *Apiculiretusispora* sp. 2 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10773, 10774, 10777, 10782, 10787, 10820, 10824, 10842, 11259, and 11263.

Dunkirk - Pb's 10789, 10791, 10795, 10796, 10798, and 11248.

Gowanda - Pb's 10809, 10881, 10894, 10895, 11277, 11280, and 11310.

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

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

The genera *Endosporites*, *Auroraspora*, and *Discernisporites* are presently in a confused taxononic state (see discussion under *Endosporites*). The following species is placed in this genus because it is identical to that described by Higgs (1975).

Auroraspora torquata Higgs, 1975
(Plate 8, Figure 8)

1975 *Auroraspora torquata* Higgs, p. 398; Pl. 4, figs. 1-3.

Description: Specimens conform to the description of Higgs (1975, p. 398).

Discussion: Higgs (1975) reported this species from the Upper Devonian of Ireland.

Occurrence: *Auroraspora torquata* was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10778, 10788, 10838, 11260, and 11264.

Dunkirk - Pb 10798.

Gowanda - Pb's 10812, 10881, 10889, 10894, 10905, 10906, 11285, 11295, 11296, 11299, 11303, 11310, 11314, 11335, 11336.

Genus Baculatisporites Pflug and Thomson, 1953

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

? Baculatisporites sp.

(Plate 9, Figures 1-2)

Description: Spores, radial, trilete; laesurae, simple, straight, distinct, extending 3/4 spore radius; amb subcircular to rounded triangular 47-59 μm in diameter; proximal area laevigate; distal and equatorial regions ornamented with baculae and/or spinae 1-3 μm in length, 1-2 μm in basal width.

Discussion: Specimens are tentatively assigned to Baculatisporites based on their morphology, although this genus is generally considered a Mesozoic form. The absence of curvaturae, apiculae, and grana preclude its assignment to either Apiculiretusispora and Granulatisporites, respectively. The recovery of only a few specimens from but a single sample does not warrant a detailed taxonomic comparison.

Occurrence: This form was recovered from one sample of the Hanover Shale (Pb 11327).

Genus Biharisporites Potonie, 1956

Type species: Biharisporites (**Triletes**) spinosus (Singh) Potonie, 1956.

? Biharisporites sp.
(Plate 9, Figure 3)

Description: Spores, radial, trilete (?); amb circular to subcircular in outline (?); 95-107 μm in diameter; proximo-equatorial surface ornamented with dense coni, baculae, and spinae, 1-3 μm in length, and 1-2 μm in basal width.

Discussion: This specimen, a single specimen, is questionably assigned to Biharisporites on the basis of overall size and distinctive ornamentation.

Occurrence: This form was recovered from one sample of the Gowanda Shale (Pb 10906).

Genus Calamospora Schopf, Wilson, and Bentall, 1944

Type species: Calamospora hartungiana Schopf in Schopf, Wilson, and Bentall, 1944.

Calamospora sp.

(Plate 9, Figure 4)

Description: Spores, radial, trilete; laesurae distinct, straight, extends up to 3/5 spore radius; amb circular to subcircular, 47-56 µm in diameter; contact area distinctively darkened, often folded; proximal and distal surfaces laevigate to infragranulate.

Discussion: Differs from *Calamospora breviradiata* Allen, 1965, in lacking elevated lips and from *Calamospora pannucea* Richardson, 1965, in larger (77-131 µm) size.

Occurrence: *Calamospora* sp. was recovered from the Hanover and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb 11259.

Gowanda - Pb's 10868 and 10874.

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

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

Convolutispora sp.

(Plate 9, Figure 5)

Description: Spores, radial, trilete; lasurae simple, straight, generally indistinct, extending 3/5 to 4/5 spore radius; amb circular to subcircular (equatorial margin undulate), 38-47 μm in diameter; proximal and distal surfaces consist of low, convolute, anastomosing ridges, 2-5 μm in height, 2-4 μm in width, creating a reticulate appearance; surface of anastomosing ridges laevigate.

Discussion: Convolutispora tequila Allen, 1965, is morphologically similar to Convolutispora sp., however, the latter lacks a punctate exine.

Occurrence: Convolutispora sp. was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Pipe Creek - Pb 11271.

Hanover - Pb's 10777, 11269, and 11536.

Dunkirk - Pb's 10791, 10804, 10853, 10862, 10865, 11249, 11251, 11255, and 11315

Gowanda - Pb's 10808, 10812, 10869, 10872, 10874, 10875, 10876, 10877, 10878, 11283, 11285, 11286, 11301, 11302, 11303, 11307, and 11308

Genus _Emphanisporites_ McGregor, 1961

Type species: _Emphanisporites rotatus_ (McGregor) McGregor, 1973.

Emphanisporites annulatus McGregor, 1961

(Plate 9, Figure 6)

1956 Unnamed, Radforth and McGregor; Pl. 1, fig. 6.

1961 _Emphanisporites annulatus_ McGregor, p. 3; Pl. 1, figs. 5-6.

1962 _Radiaspora_ sp., Balme, p. 6; Pl. 1, fig. 13.

1963 _Emphanisporites erraticus_ (Eisenack) McGregor in Chaloner, p. 103-105; fig. 1.

1967 _Emphanisporites_ cf. _erraticus_ McGregor in Daemon, et al, p. 106; Pl. 1, fig. 10.

1968 _Emphanisporites radiatus_ Schultz, p. 30 (no fig.).

1973 _Emphanisporites annulatus_ McGregor, p. 45; Pl. 6, figs. 3-4

Description: Specimens conform to the descriptions of McGregor (1961, p. 3 and 1973, p. 45).

Discussion: This species has a wide geographic occurrence (note discussion in McGregor, 1973). It has been reported from Lower Devonian (Chaloner, 1963) through Uppermost Devonian (Clayton, et. al., 1977) sediments.

Occurrence: Emphanisporites annulatus was recovered from one sample of the Gowanda Shale (Pb 11311).

Emphanisporites rotatus (McGregor) emend.
McGregor, 1973
(Plate 9, Figure 7)

A concise synonomy of this species through 1972 is presented by McGregor (1973).

Description: Specimens conform to the description as emended by McGregor (1973, p. 46-47).

Discussion: McGregor (1973, p. 47) presently considers E. robustus a junior synonym of E. rotatus. This species is a very common component of Lower Devonian through Lower Carboniferous (see Clayton, et al., 1977) palynological assemblages.

Occurrence: Emphanisporites rotatus was recovered from one sample of the Hanover Shale (Pb 10819).

Genus Endosporites Wilson and Coe, 1940

Type species: Endosporites ornatus Wilson and Coe, 1940.

Endosporites includes a plethora of species many of which are of questionable assignment to this genus are questionable (see Smith and Butterworth, 1967; p. 270). Presently, this genus stands unemended and its distinction from *Auroraspora* and *Discernisporites* is not clear. The presence or absence of an equatorial limbus, presently considered an important character by many workers (Potonie and Kremp, 1954; Bharadwaj, 1957; Chaloner, 1953, 1958; Richardson, 1960; Neves and Owens, 1966), was not included in the original diagnosis of *Endosporites* by Wilson and Coe (1940). *Auroraspora* and *Discernisporites* were subsequently separated from *Endosporites* by the latter's lack of an equatorial limbus (see Richardson, 1960, p. 49; Smith and Butterworth, 1967, p. 270-271). *Endosporites* has yet to be emended with respect to this character, and recent studies have shown that certain forms (i.e., *Endosporites micromanifestus* Hacquebard) are variably limbate (Smith and Butterworth, 1967, p. 270, note that *Endosporites* usually possesses a limbus). Although specimens recovered from southwestern New York lack an equatorial limbus, they most closely adhere to the original description of *Endosporites* of Wilson and Coe (1940). Hence, *Endosporites* will be used here because of taxonomic priority. Hopefully, a reexamination of type materials will appropriately differentiate the *Endosporites*-*Auroraspora*-*Discernisporites* complex (see also discussion under *Auroraspora*).

Endosporites sp.

(Plate 9, Figure 8-9)

Description: Spores, radial, trilete; laesurae straight, extending entire radius of inner body, usually accompanied by exoexinal folds; amb broadly rounded-triangular, total spore diameter, 59-73 μm; central body 40-51 μm in diameter; surface of central body and flange laevigate to scabrate; exoexine may occasionally have radiating wrinkles.

Discussion: The Endosporites sp. described here differs from previously described forms in having radiating wrinkles. All of the observed specimens lack a limbus.

Occurrence: Endosporites sp. was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10785, 10820, 10822, 10833, 10835, 10838, 10842, 11259, 11260, 11264, 11265, 11268, 11327, and 11328.

Dunkirk - Pb's 10791, 10796, 10850, and 11248.

Gowanda - Pb's 10867, 10868, 10872, 10874, 10875, 10876, 10877, 10879 10881, 11280, 11310, 11322, and 11333.

? *Endosporites* sp.

(Plate 9, Figures 10-11)

Description: Spores, radial, trilete; laesurae ± straight, ± distinct, extending entire radius of central body; amb broadly rounded triangular; overall diameter 84-97 μm; central body 58-70 μm in diameter; distal surface of exoexine over central body ornamented with tubercles; remaining proximal and distal areas laevigate to scabrate; equatorial area possesses small spinae, 1-2 μm in length.

Discussion: This form is questionably assigned to *Endosporites* although none of the forms assigned to this genus have proximal tubercules. *Grandispora longus* Chi and Hills, 1976, has similar distal tubercles; however, it is much larger in size and also has equatorial coni.

Occurrence: This form was recovered from the Hanover (Pb 10820), Dunkirk (Pb 10791), and Gowanda (Pb 10906) Shales.

Genus *Geminospora* (Balme) emend. Owens, 1971

Type species: *Geminospora lemurata* Balme, 1960.

Geminospora cf. G. lemurata Balme, 1960

(Plate 10, Figures 1-2)

1960 Geminospora lemurata Balme, p. 5; Pl. 1, figs. 5-10.

Description: Specimens differ from the description of Balme (1960) in that the size range of the New York forms is 29-40 μm as compared to 38-67 μm.

Discussion: This species has been reported from Famennian sediments of Australia (Balme, 1960; Playford, 1976), Norway (Kaiser, 1971), and Libya (Massa and Moreau-Benoit, 1976).

Occurrence: Geminospora cf. G. lemurata was recovered only from the Hanover Shale.

Hanover - Pb's 10777, 10781, 10785, 11266, 11270, 11320, 11325, and 11327.

Geminospora micrograna de Jersey, 1966

(Plate 10, Figures 3-5)

1966 Geminospora micrograna de Jersey, p. 17-18; Pl. 10, figs. 4-6.

Description Specimens conform to the original diagnosis of de Jersey (1966, p. 17-18).

Discussion: This species has been reported previously from the Upper Devonian of the Australia (de Jersey, 1966). The present occurrences from New York are believed to be the first from North America.

Occurrence: *Geminospora micrograna* was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10777, 10785, 10824, 11263, 11265, and 11266.

Dunkirk - Pb's 10789, 11248, and 11257.

Gowanda - Pb's 11301, 11305, and 11306.

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

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

Discussion: McGregor (1973) emended this genus to include the genera *Calyptosporites*, *Samarisporites*, and *Spinozonotriletes*. However, specimens referable to *Spinozonotriletes* were recovered in this study and they have been retained here as representatives of that genus as differentiated by Hacquebard (1957). Forms which compare with *Samarisporites* and *Calyptosporites* as set apart generically by McGregor (1973) were not found in this study.

Grandispora sp.

(Plate 10, Figures 6-7)

Description: Spores, radial, trilete; subtriangular to subcircular in outline; laesurae distinct, sutures usually paralleled and obscured by elevated folds that may extend to spore equator; exine two-layered; intexine laevigate, 47-53 µm in diameter; exoexine, 104-112 µm in diameter, distal-polar region of exoexine ornamented with spinae, baculae, or elongated tubercles; equatorial region sparsely ornamented with coni, proximal surface of exoexine laevigate.

Discussion: This spore differs from Grandispora longus Chi and Hills, 1976, in being smaller in size. Only one specimen was recovered in this study.

Occurrence: Recovered from one sample in Gowanda Shale (Pb 10895).

Genus Hymenozonotriletes (Naumova) Potonie, 1958

Type species: Hymenozonotriletes polyacanthus Naumova, 1953 (as designated by Potonie, 1958, p. 29).

Hymenozonotriletes sp.

(Plate 11, Figure 3)

Description: Spores, radial, trilete; laesurae distinct, extending entire radius of inner body; exine two-layered (zonate); intexine laevigate, triangular 37-45 μm in diameter; exoexine laevigate, subtriangular to subcircular, 63-71 μm in diameter; dense zona at juncture of intexine and exoexine.

Discussion: Taxonomic assignment of the present form was difficult in that only two specimens were recovered. Tentative assignment to Hymenozonotriletes is based on general similarity of size, shape, and the presence of a zona.

Occurrence: Hymenozonotriletes sp. was recovered from the Hanover Shale (Pb's 10838 and 10839.

Genus Hystricosporites McGregor, 1960

Type species: Hystricosporites delectabilis McGregor, 1960.

Hystricosporites porrectus (Balme and Hassell) Allen, 1965

(Plate 11, Figure 1)

1962 Archaeotriletes porrectus Balme and Hassell, p. 10; Pl. 5, figs. 1-4.

1965 Hystricosporites porrectus (Balme and Hassell) Allen, p. 698-699; Pl. 95, figs. 1-3.

Description: Specimens conform to the diagnosis in Allen (1965, p. 698-699).

Discussion: This species has been reported from the Upper Devonian of Australia (Balme and Hassell, 1962; Playford, et al, 1976), Vestspitsbergen (Allen, 1965), France (Taugourdeau-Lantz, 1971), and Germany (Riegel, 1973).

Occurrence: Hystricosporites porrectus was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - PB's 10777, 10836, 11260, and 11264.

Dunkirk - Pb's 10851, 10865, and 11255.

Gowanda - Pb's 10813, 10869, 10888, 10889, 10891, 10893, 10906, and 11306.

Hystricosporites sp.

(Plate 11, Figure 2)

Description: Spores, radial, trilete; laesurae indistinct (often hidden by sinuous folds or obscured due to carbonization); exine three-layered (layering usually obscured by carbonization); overall diameter 93-107 µm; proximo-equatorial and distal regions ornamented with 36-48 grapnel-shaped appendages, 15-24 µm in length.

Discussion: Differs from *H. porrectus* and *H. porcatus* (Winslow) Allen, 1965, in the number and length of appendages and the lack of proximo-radial muri, respectively.

Occurrence: *Hystricosporites* sp. was recovered from the Hanover (Pb's 10788 and 10836) and Gowanda (Pb's 10906 and 11307) Shales.

Genus *Leiotriletes* (Naumova) emend Potonie and Kremp, 1954

Type species: *Leiotriletes sphaerotriangulus* (Loose) Potonie and Kremp, 1954.

Leiotriletes inermis (Waltz) Ishchenko, 1952
(Plate 11, Figure 4)

1938 *Azonotriletes inermis* Waltz *in* Luber and Waltz, p. 11; Pl. 1, fig. 3; Pl. 5, fig. 58; Pl. A, fig. 2.

1952 *Leiotriletes inermis* (Waltz) Ishchenko, p. 9; Pl. 1, figs. 2-3.

1955 *Asterocalamotriletes inermis* (Waltz) Luber, p. 40; Pl. 1, figs. 20-21.

1962 *Leiotriletes inermes* (Waltz) Ischenko, p. 574; Pl. 78, figs. 3-4.

Description: Specimens generally conform to the description of Playford (1962, p. 574).

Discussion: This species has been recorded from the Upper Devonian-Lower Carboniferous sediments of Russia (Luber and Waltz, 1938; Ishchenko, 1952; Luber, 1955), Spitsbergen (Playford, 1962), Europe (Streel *in* Becker et al., 1974), and Germany (Potonie and Kremp, 1955).

Occurrence: *Leiotriletes inermis* was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Pipe Creek - Pb's 10769, 10771, 10816, and 10912.

Hanover - Pb's 10822, 10844, 10846, 0848, and 11324.

Dunkirk - Pb's 10791, 10850, 10851, 10865, 11250, and 11258.

Gowanda - Pb's 10808, 10869, 10895, 10906, 11277, 11286, 11295, 11296, 11297, and 11302.

Genus *Lophozonotriletes* (Naumova) emend. Potonie, 1958

Type species: *Lophozonotriletes lebedianensis* (Naumova) as designated by Potonie, 1958.

Lophozonotriletes sp.

(Plate 11, Figures 5-6)

Description: Spores, radial, trilete; amb subcircular to subtriangular; laesurae ± distinct extending entire radius of inner body; central body laevigate, subcircular to rounded triangular 36-40 μm in diameter; ornamentation consists of distal disposed tuberculae and verrucae, 1-3 μm high, 5-7 μm in basal width often extending onto zona; zona 3-5 μm wide, generally crenulate at equatorial margin.

Discussion: Differs from Lophozonotriletes dentatus Hughes and Playford, 1961, and Lophozonotriletes lebedianensis (Naumova) Richardson, 1964, in having smaller verrucae and possessing wider zona, respectively.

Occurrence: Lophozonotriletes sp. was recovered from the Hanover and Dunkirk Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10774, 10780, 10787, 10838, 11264, 11324, 11325, and 11326.

Dunkirk - Pb 10791.

Genus Nikitinisporites Chaloner, 1959

Type species: Nikitinisporites canadensis Chaloner, 1959.

Nikitinisporites sp.

(Plate 11, Figure 7)

Description: Megaspore; trilete; laesurae indistinct; amb circular to subcircular ca. 207 μm in diameter; ca. 10-20 appendages, 87-96 μm in length, 10-17 μm in width; appendages taper distally.

Discussion: The large size and general morphology of this single representative allows an assignment to *Nikitinisporites*. This is the first occurrence of this genus in the United States.

Occurrence: A single specimen of *Nikitinisporites* sp. was recovered from the Hanover Shale (Pb 10820).

Genus *Punctatisporites* (Ibrahim) emend.

Potonie and Kremp, 1954

Type species: *Punctatisporites punctatus* Ibrahim, 1933.

Punctatisporites sp.

(Plate 11, Figures 8-9)

Description: Spore, radial, trilete; laesurae usually extend 2/3 to 4/5 radius of spore; amb cicular to subcircular, 37-42 μm in diameter; exine 2-4 μm thick, may often be folded; exine surface laevigate to infragranulate-infrascabrate.

Discussion: Specimens differ from Punctatisporites fissus Hoffmeister, Staplin, and Malloy, 1955, an Upper Mississippian form, and Punctatisporites irrasus Hacquebard, 1957, by being smaller in size.

Occurrence: Punctatisporites sp. was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers of each occurrence of this form are noted below by stratigraphic unit.

Pipe Creek - Pb's 10816 and 10818.

Hanover - Pb's 10774, 10780, 10822, 10823, 10825, 10835, 10836, 10846, 10848, 11325, 11327, and 11328.

Dunkirk - Pb's 10798, 10850 and 11332.

Gowanda - Pb's 10898, 10899, 10900, 10901, 10902, 10903, 10905, 10906, and 11286.

Genus Retusotriletes (Naumova) emend. Streel, 1964

Type species: Retusotriletes simplex Naumova, 1953.

Retusotriletes dubiosus McGregor, 1973

(Plate 12, Figure 1)

1944 Triletes dubius Eisenack, p. 115; Pl. 2, fig. 7.

1965 Retusotriletes dubius (Eisenack) Richardson, p. 564; Pl. 88, figs. 5-6.

1973 Retusotriletes dubiosus McGregor, p. 21: Pl. 2, fig. 1.

Description: Conforms to the diagnosis of Richardson (1965, p. 564).

Discussion: This species has been previously reported from the Devonian of Germany (Eisenack, 1944), England (Richardson, 1965), and Canada (McGregor, 1973; McGregor and Camfield, 1976).

Occurrence: Retusotriletes dubiosus was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Pipe Creek - Pb's 10816 and 10818.

Hanover - Pb's 10773, 10777, 10787, 10825, 10832, 10833, 11260, 11264, 11265, 11326, 11327, 11328, and 11537.

Dunkirk - Pb's 10791, 10798, 10850, and 10865.

Gowanda - Pb's 10806, 10812, and 10877.

Retusotriletes greggsii McGregor, 1964

(Plate 12, Figure 2)

1964 Retusotriletes greggsii McGregor, p. 8-9; Pl. 1, figs. 1-12.

1974 Aneurospora greggsii (McGregor) Streel in Becker et al., p. 24; Pl. 16, figs. 6-15.

1975 Apiculiretusispora cf. Retusotriletes greggsii (McGregor) Turnau, p. 507-509; Pl. 1, figs. 7-9.

1977 Aneurospora greggsii (McGregor) Streel in Clayton et al.; Pl. 1, fig. 4.

Description: Specimens conform to the description of McGregor (1964, p. 8-9).

Discussion: Some confusion currently exists as to whether this species should be placed in the Genus Aneurospora, Streel, 1964. This form is assigned to Retusotriletes because it lacks the slightly elevated labra and banded curvaturae noted in Streel's (1964) original diagonsis of Aneurospora. This species has been reported from the Devonian of Germany (Lanninger, 1968), Norway (Kaiser, 1970), Poland (Turnau, 1975), Belgium (Becker, et al., 1974), Libya (Massa and Moreau-Benoit, 1976), and Canada (McGregor, 1964).

Occurrence: Retusotriletes greggsii was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10838, 11262, and 11325.

Dunkirk - Pb's 10851 and 11254.

Gowanda - Pb's 10808, 11303, and 11305.

Genus Spelaeotriletes Neves and Owens, 1966

Type species: Spelaeotriletes triangulus Neves and Owens, 1966.

Spelaeotriletes sp.

(Plate 12, Figure 3)

Description: Spores, radial, trilete; laesurae simple, straight, extending entire radius of central body; amb subcircular to broadly rounded triangular; central body 47-58 µm in diameter; intexine thin walled, diameter 42-51 µm overall; exoexine 2-5 µm thick; distal and equatorial surfaces ornamented with minute grana, 1-2 µm in diameter.

Discussion: This form is assigned to Spelaeotriletes on the basis of gross morphology. It differs from Endosporites, Aurora-spora, and Grandispora in the character of corpus ornamentation.

Occurrence: Spelaeotriletes sp. was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10840, 10847, 11260, 11264, 11265, 11326, 11327, and 11328.

Dunkirk - Pb's 10798, 10801, 10804, 10806, 10855, 10856, 10858, 10861, 10863, 10866, 11249, 11251, 11254, and 11255.

Gowanda - Pb's 10806, 10870, 10871, 10880, 10883, 10887, 11278, and 11279.

Genus Spinozonotriletes (Hacquebard) emend. Neves and Owens, 1966

Type species: Spinozonotriletes uncatus Hacquebard, 1957.

Playford (1971, p. 45-47) and McGregor (1973, p. 58-59) have suggested the incorporation of Spinozonotriletes into Grandispora principally on the basis that generic differentiation, particularly with respect to the attachment of wall layers, was impractical when studying compressed specimens. However, some specimens from New York are considered to be assignable to the genus Spinozonotriletes as emended by Neves and Owens (1966). These, as well as spores in other assemblages (Bertelsen, 1972; Eames, 1974), appear discernible from Grandispora on the basis of wall layer attachment. Therefore, both Spinozonotriletes and Grandispora are considered taxonomically valid in this study.

Spinozonotriletes uncatus Hacquebard, 1957

(Pate 12, Figure 4)

1957 Spinozonotriletes uncatus Hacquebard, p. 316; Pl. 3, figs. 8-10.

1962 Spinozonotriletes uncatus Hacquebard in Playford, p. 657; Pl. 94, fig. 4-6.

1966 _Spinozonotriletes_ cf. _uncatus_ Hacquebard _in_ Streel, p. 83-84; Pl. 2, fig. 27.

1966 _Grandispora_ sp. A Sullivan and Marshall, p. 282; Pl. 4, fig. 6.

1969 Sporetrilete a grandes espines no. 3268 Lanzoni and Magloire, p. 464-465; Pl. 6, figs. 3-4.

1969 _Grandispora_ _reticulatus_ Hibbert and Lacey, p. 434; Pl. 83, figs. 1-2, 4-5, 10.

1969 _Corystisporites_ sp. A Brideaux and Radforth, p. 36; Pl. 2, fig. 15.

1970 _Spinozonotriletes_ cf. _uncatus_ Hacquebard _in_ Paproth and Streel, p. 394 (no fig.).

1971 _Grandispora_ _uncata_ Playford, p. 47-49, (no fig.).

1973 _Spinozonotriletes_ cf. _uncatus_ Hacquebard _in_ Kaiser, p. 113; Pl. 18, fig. 11.

Description: Specimens conform to the description of Hacquebard (1957, p. 316).

Discussion: This species has been reported from Upper Devonian and/or Lower Carboniferous sediments of Canada (Hacquebard, 1957; Brideaux and Radforth, 1969), Spitsbergen (Playford, 1962), Europe (Streel, 1966; Paproth and Streel, 1969; Kaiser, 1973), United Kingdom (Sullivan and Marshall, 1966; Hibbert and Lacey, 1969) and Australia (Playford, 1971).

Occurrence: *Spinozonotriletes uncatus* was recovered from the Hanover (Pb's 10905 and 11327) and Dunkirk (11248) Shales.

Spinozonotriletes sp. 1
(Plate 12, Figure 5)

Description: Spores, radial, trilete; laesurae obscured by large sinuous lips extending entire radius of spore; inner body 39-42 μm in diameter, circular to subcircular in shape; overall diameter 62-67 μm; distal and equatorial ornamentation consists of small spines, 3-4 μm in length, 1-2 μm in diameter (at base).

Discussion: The above description was based upon but one specimen. The large, sinuous lips distinguish this form from *Spinozonotriletes uncatus* and *Spinozonotriletes* sp. 2.

Occurrence One specimen of *Spinozonotriletes* sp. 1 was recovered from the Gowanda Shale (Pb 10906).

Spinozonotriletes sp. 2
(Plate 12, Figure 6)

Description: Spores, radial, trilete; laesurae sinuous; extends entire radius of spore; inner body 55-63 μm in diameter, circular to subcircular in shape; overall diameter 69-75 μm; proximo-equatorial and distal regions ornamented with small spines 3-4 μm in length, 2-3 μm in width (at base).

Discussion: The above description was based on the recovery of one specimen.

Occurrence: One specimen of Spinozonotriletes sp. 2 was recovered from the Hanover Shale (Pb 11325).

Genus Stenozonotriletes (Naumova) emend. Potonie, 1958

Type species: Stenozonotriletes conformis Naumova, 1953.

Stenozonotriletes clarus Ishchenko, 1958
(Plate 12, Figure 7)

1958 Stenozonotriletes clarus Ishchenko, p. 74; Pl. 1, fig. 136.

Description: Specimens conform to description in Hughes and Playford (1961, p. 74).

Discussion: This species differs from Stenozonotriletes extensus var. major Naumova, 1953, by the latter's larger size and wider cingulum. Stenozonotriletes clarus has been reported from the Upper

Devonian and Lower Carboniferous of Russia (Ishchenko, 1958; Kalibova, 1971), Canada (Barss, 1967; Brideaux and Radforth, 1970), Germany (Lanninger, 1968) and Spitsbergen (Hughes and Playford, 1961).

Occurrence: *Stenozonotriletes clarus* was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10777, 10785, 10788, 11263, 11268, 11318, and 11321.

Dunkirk - Pb's 10791, 11253, and 11315.

Gowanda - Pb 10905.

Stenozonotriletes sp.

(Plate 12, Figure 8)

Description: Spores, radial, trilete; laesurae, straight, distinct; amb circular to subcircular; extending entire radius of inner body; inner body 32-39 μm in diameter, surrounded by a cingulum; overall diameter 35-42 μm; exine laevigate to finely punctate.

Discussion: Differs from *Stenozonotriletes furtivus* Allen, 1965, and *Stenozonotriletes insessus* Allen, 1965, in lacking lips. *Stenozonotriletes* sp. is smaller in size than *S. clarus*.

Occurrence: *Stenozonotriletes* sp. was recovered from the Hanover Shale (Pb's 11324 and 11325)

Genus *Verrucosisporites* (Ibrahim) emend.
Smith and Butterworth, 1967

Type species: *Verrucosisporites verrucosus* (Ibrahim, 1932) Ibrahim, 1933.

Verrucosisporites bullatus Taugourdeau-Lantz, 1967
(Plate 12, Figure 9)

1967 *Verrucosisporites bullatus* Taugourdeau-Lantz, p. 26-27; Pl. 1, figs. 13-14, 17.

Description: Specimens conform to the description of Taugourdeau-Lantz (1967, p. 26-27).

Discussion: This species has previously been reported from France (Taugourdeau-Lantz, 1967; 1971) and Libya (Massa and Moreau-Benoit, 1976).

Occurrence: *Verrucosisporites bullatus* was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10820, 10838, 11260, and 11270.

Dunkirk - Pb's 10795 and 10857.

Gowanda - Pb's 10810, 11294, and 11305.

Verrucosisporites sp. 1

(Plate 12, Figure 10)

Description: Spores, radial, trilete; laesure straight, indistinct, extending 2/3 to 4/5 radius of spore; amb circular to subcircular, 57-62 μm in diameter; exine 3-5 μm thick; ornamentation consists of variably spaced verrucae, 1-2 μm in height and 4-6 μm in width.

Discussion: The variably spaced verrucae and overall size distinguish *Verrucosisporites* sp. 1 from *Verrucosisporites congestus* Playford, 1971, and *Verrucosisporites perverrucosus* (Loose) Smith and Butterworth, 1967.

Occurrence: *Verrucosisporites* sp. 1 was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Pipe Creek - Pb's 10772, 10816, and 10818.

Hanover - Pb's 10788, 10791, 11262, 11325, 11326, and 11327.

Dunkirk - Pb 11258

Gowanda - Pb's 10869, 11294, 11296, 11299, 11300, 11303, 11307, 11308, and 11309.

Verrucosisporites sp. 2

(Plate 12, Figure 11; Plate 13, Figures 1-3)

Description: Spores, radial, trilete; laesurae straight, indistinct, extending 4/5 of spore radius; amb circular to subcircular in outline, 55-66 μm in diameter; exine 3-4 μm thick; discrete dense verrucae, 3-4 μm in height, 2-3 μm in width.

Discussion: Differs from Verrucosisporites bullatus and Verrucosisporites sp. 1 in wall thickness and ornamentation dimensions.

Occurrence: Verrucosisporites sp. 2 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below in stratigraphic unit.

Hanover - Pb's 10781, 10788, 10819, 11261, and 11325.

Dunkirk - Pb's 10789, 10791, and 11250.

Gowanda - Pb's 11285 and 11309.

Genus Uncertain

Spore Type A

(Plate 13, Figure 4)

<u>Description</u>: Spores, radial, trilete (?); specimens always occur as tetrads; spores 65-78 μm in diameter; amb circular to subcircular; ornamented with low "coni" and/or verrucae, 1-2 μm in height, 2-3 μm in width; exine 3-4 μm in thickness.

<u>Discussion</u>: Occurrence as tetrads only is the major characteristic of this form. Only six corroded tetrads were recovered in two samples.

<u>Occurrence</u>: Spore Type A was recovered from the Gowanda Shale (Pb's 10905 and 10906)

Spore Type B

(Plate 14, Figure 1)

<u>Description</u>: Spores, radial, trilete; laesurae straight, distinct, extending to 2/3 of spore radius; amb circular to subcircular 44-52 μm in diameter; proximo-equatorial and distal surfaces ornamented with minute grana; (?) weak "curvaturae" present.

Discussion: The presence of (?) "weak curvature" suggests that this form may have affinity to Retusotriletes; however, because only a single specimen was recovered, taxonomic determination is tenuous.

Occurrence: Spore Type B was recovered from the Hanover Shale (Pb 11325).

ACRITARCHS

The systematic classification of the acritarchs used in this study is, in part, that established by Downie, Evitt, and Sarjeant (1963). Included in the acritarch classification are the subsequent restrictions proposed by Staplin, Jansonius, and Pocock (1965) and the inclusion of the Subgroup Scutellomorphitae Brito, 1967. An index of acritarch taxa, arranged by Subgroup, is provided in Appendix III.

Group ACRITARCHA Evitt, 1963

Subgroup ACANTHOMORPHITAE Downie, Evitt, and Sargeant, 1963

Genus *Baltisphaeridium* (Eisenack) emend. Downie and Sarjeant, 1963

Type species: *Baltisphaeridum* (al. *Ovum hispidum*) *longispinosum* (Eisenack) Eisenack, 1958

Discussion: Deflandre (1937) established the genus *Hystrichosphaeridium* for specimens exhibiting a more or less spherical vesicle, greater than 20 µm in diameter (in contrast with *Micrhystridium*), lacking lacunae and sutures, and possessing processes open or closed distally. Subsequently, Eisenack (1958) later circumscribed *Hystrichosphaeridium* to embrace only forms with processes open distally and established the genus, Baltisphaeridium, for forms with processes closed distally. Staplin (1961) concluded that the type species of Baltisphaeridium (B. longispinosum) was essentially identical to the type species of Micrhystridium and recommended abandonment of Baltisphaeridium. He proposed that the upper (20 um) size limit be eliminated, and emended Micrhystridium to include only simple-spined forms, with spines closed distally, and generally uniform in morphology. Forms displaying branched processes were incorporated into the genus, Multiplicisphaeridium Staplin. Eisenack (1962) rejected Staplin's emendation on the basis that a division into branched and unbranched types was not a good character for generic differentiation. Subsequently, Downie and Sarjeant (1963) defended the 20 um size limit separating Michrystridium and Baltisphaeridium, and rejected Multiplicisphaeridium. Lister (1970, p. 83-86), however, considered Multiplicisphaeridium a valid genus with the following diagnostic characters: (1) vesicle and processes single-walled; (2) processes hollow; (3) processes communicate freely with vesicle cavity, (4) some or all processes branch distally; and (5) the nature of branching is variable within a single individual. In light of the present study, the latter feature is most helpful and consistent in discerning Baltisphaeridium, Micrhystridium, Multiplicisphaeridium. Therefore, the following scheme is employed: Baltisphaeridium, processes terminating in one order of branching (never ramifying), vesicle diameter usually more than 20 microns; Micrhystridium, processes simple, vesicle diameter usually less than 20 microns; Multiplicisphaeridium, although variable on a singe specimen, most processes terminate in ramifying branches, vesicle diameter usually more than 20 microns in diameter.

Baltisphaeridium sp. 1

(Plate 14, Figures 2-5)

Description: Vesicle shape spherical to subspherical, 37-46 μm in diameter; vesicle and processes laevigate or bearing minute grana; processes 20-29 in number, straight, hollow, shafts open to vesicle cavity; processes 17-23 μm in length, 3-5 μm in width (greatest), and branch distally into tetra- or pentafurcate terminations.

Discussion: Differs from Puteoscortum Wicander in lacking a foveoreticulate vesicle wall. Multiplicisphaeridium sprucegrovensis Staplin is very similar but possesses only tetrafurcate terminations.

Occurrence: Baltisphaeridium sp. 1 was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Pipe Creek - Pb 11287.

Hanover - Pb's 10774, 10777, 10778, 10782, 10788, 10819, 10822, 10825, 10832, 10836, 10838, 10839, 10844, 10847, 10848, 11259, 11260, 11270, 11318, 11319, 11321, 11325, 11326, 11327, 11328, and 11587.

Dunkirk - Pb's 10789, 10791, 10795, 10798, 10804, 10849, 10851, 10853, 10854, 10857, 10859, 10860, 10862, 10866, 11251, and 11252.

Gowanda - Pb's 10806, 10807, 10808, 10809, 10810, 10812, 10813, 10814, 10869, 10872, 10874, 10875, 10876, 10877, 10879, 10881, 10883, 10884, 10886, 10887, 10889, 10891, 10893, 10894, 10895, 10896, 10898, 10905, 11275, 11278, 11279, 11280, 11283, 11285, 11297, and 11303.

Baltisphaeridium sp. 2

(Plate 14, Figure 6)

Description: Vesicle shape spherical to oval, 10-12 μm in diameter; vesicle and process surfaces laevigate; 11-17 hollow processes, expanded in center, constricted proximally but open to the vesicle cavity; processes 10-13 μm in length, 4-6 μm in width (greatest), usually terminating in 4-5 equally spaced minute spines.

Discussion: A single specimen of Baltisphaeridium sp. 2 was recovered. Previously described members of Baltisphaeridium lack the centrally expanded processes.

Occurrence: *Baltisphaeridium* sp. 2 was recovered from the Hanover Shale (Pb 11325).

Baltisphaeridium sp. 3

(Plate 14, Figure 7)

Description: Vesicle shape spherical to oval; 32-45 μm in diameter; vesicle and processes laevigate; 41-56 hollow, distally-tapered processes, 9-13 μm in length, 2-4 μm in width (at base); processes open to the vesicle cavity, and branch distally into bi- and trifurcate tips.

Discussion: This form is differentiated from *Baltisphaeridium* sp. 1 by the presence of bi- and trifurcate process tips.

Occurrence: *Baltisphaeridium* sp. 3 was recovered from the Hanover Shale (Pb's 10819 and 11325).

Baltisphaeridium sp. 4

(Plate 14, Figure 8)

Description: Vesicle shape spherical to subspherical, 37-48 μm in diameter; vesicle and processes laevigate; 20-29 hollow processes, 7-10 μm in length, 2-4 μm in width (at base); process bases expanded and open to the vesicle cavity; processes terminate in large trifurcate tips; tips 3-5 μm in length, 1-3 μm in width.

Discussion: *Baltisphaeridium* sp. 4 has more (41-56) processes. *Baltisphaeridium* sp. 1 has only tetra- and pentafurcate process terminations.

Occurrence: *Baltisphaeridium* sp. 4 was recovered from the Gowanda Shale (Pb's 10906, 11296, 11303, and 11303).

Baltisphaeridium sp. 5

(Plate 15, Figure 1)

Description: Vesicle shape spherical to subspherical; 37-47 μm in diameter; vesicle and processes laevigate; 53-71 hollow processes, 10-13 μm in length, 2-4 μm in width (at base); processes open to the vesicle cavity; processes taper distally and terminate in tri- and tetrafurcate tips.

Discussion: *Baltisphaeridium* sp. 1 has less processes (20-29) which are of greater length (17-23 μm).

Occurrence: *Baltisphaeridium* sp. 5 was recovered from the Hanover Shale (Pb's 10819, 10837, and 11537).

Baltisphaeridium sp. 6

(Plate 15, Figure 2)

Description: Vesicle shape spherical to subspherical; 39-52 μm in diameter; vesicle and processes laevigate; 19-27 hollow processes, 9-14 μm in length, 3-5 μm in width (at base); processes open to the vesicle cavity, taper distally, and terminate with bifurate tips.

Discussion: Differs from *Baltisphaeridium* sp. 3 and *Baltisphaeridium* sp. 5 in process number (41-56) and lack of trifurcate process terminations, respectively.

Occurrence: *Baltisphaeridium* sp. 6 was recovered from the Hanover Shale (Pb 10819).

Genus *Diexallophasis* (Deunff) emend Playford, 1977

Type species: *Diexallophasis remota* (Deunff) Playford, 1977; originally designated as *D. denticulata* (Stockmans and Williere) by Loeblich (1970, p. 714).

Diexallophasis remota (Deunff) Playford, 1977

(Plate 15, Figure 3)

1955 *Veryhachium remotum* Deunff, p. 146; Pl. 4, fig. 8.

1959 Baltisphaeridium longispinosum (Eisenack) Downie, p. 58; Pl. 10, figs. 1-2.

1963 Baltisphaeridium denticulatum Stockmans and Williere, p. 458; Pl. 1, fig. 13.

1963 Baltisphaeridium granulatispinosum Downie, p. 640-641; Pl. 91, figs. 1, 3c, 7.

1970 Evittia granulatispinosum (Downie) Lister, p. 67-69; Pl. 4, figs. 2-3, 5-9, 12; Pl. 5, fig. 2.

1970 Evittia remota (Deunff) Lister, p. 69-70; Pl. 4, figs. 10-11, 13-15; Pl. 5, fig. 1.

1970 Diexallophasis denticulata (Stockmans and Williere) Loeblich, p. 715; figs. 8a-e, 9a-c.

1972 Baltisphaeridium rojensis Jankavskas and Vaitiekuniene, p. 121; Pl. 17, figs. 10-11.

1973 Multiplicisphaeridium denticulatum (Stockmans and Williere) Eisenack and Cramer, p. 587-603, 653.

1973 Multiplicisphaeridium remotum (Deunff) Eisenack and Cramer, p. 773.

1977 Diexallophasis remota (Deunff) Playford, p. 19-21; Pl. 6, figs. 12-14; Pl. 7, figs. 1-11.

Description: Specimens conform to description of Playford (1977, p. 146).

Discussion: This species is a common component of Lower Silurian through Middle Devonian palynological assemblages of the northern hemisphere. The occurrences in western New York extend the range of this species to include the Upper Devonian.

Occurrence: *Diexallophasis remota* was recovered from the Hanover and Dunkirk Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10782, 10788, 11265, and 11325.

Dunkirk - Pb 10791.

Genus *Gorgonisphaeridium* Staplin,
Jansonius, and Pocock, 1965

Type species: *Gorgonisphaeridium winslowii* Staplin, Jansonius, and Pocock, 1965.

Gorgonisphaeridium absitum Wicander, 1974
(Plate 15, Figure 4)

1974 *Gorgonisphaeridium absitum* Wicander, p. 25; Pl. 11, figs. 10-12.

Description: Specimens conform to the original description of Wicander (1974, p. 25).

Discussion: This species is distinguished from *Gorgonisphaeridium* sp. 1 in having shorter processes, and from *G.* sp. 2 and *G.* sp. 3 in lacking anchor and bi-tetrafurcate process tips, respectively. *G. absitum* has been reported from Upper Devonian sediments of the United States (Wicander, 1974) and Australia (Playford, 1976).

Occurrence: Gorgonisphaeridium absitum was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Pipe Creek - Pb 11287.

Hanover - Pb's 10820, 10825, 10837, 10842, 10844, 10846, and 11325.

Dunkirk - Pb's 10790, 10795, 10804, 10852, 10853, and 10865.

Gowanda - Pb's 10808, 10812, 10871, 10872, 10881, 10898, 10902, 10906, 11302, and 11303.

Gorgonisphaeridium sp. 1

(Plate 15, Figures 5-6)

Description: Vesicle shape spherical, 26-34 μm in diameter; vesicle and processes surface laevigate; 40-57 solid processes, 8-18 μm in length, 1-2 μm in width, tapering distally to a point.

Discussion: The greater length and larger number of processes in this form distinguishes it from previously described representatives of this genus.

Occurrence: Gorgonisphaeridium sp. 1 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10825, 10837, 10842, 10844, 10846, 11259, 11260, 11261, 11263, 11265, 11267, 11268, 11318, 11319, 11321, and 11325.

Dunkirk - Pb's 10790, 10795, 10803, 10853, 10865, 11249, 11251, 11254, 11255, and 11257.

Gowanda - Pb's 10871, 10878, 10879, 10880, 10887, 11286, 11310, 11314, and 11334.

Gorgonisphaeridium sp. 2

(Plate 15, Figure 7)

Description: Vesicle shape spherical; 47-56 μm in diameter; vesicle and processes laevigate; 28-41 solid (?) processes, 4-7 μm in length, 2-4 μm in width; processes terminate in anchor tips.

Discussion: The anchor-tipped processes are unique for this genus; however, this description is based on the characteristics of a single specimen.

Occurrence: *Gorgonisphaeridium* sp. 2 was recovered from the Hanover Shale (Pb 11260).

Gorgonisphaeridium sp. 3

(Plate 15, Figure 8; Plate 16, Figure 1)

Description: Vesicle shape spherical; 29-37 μm in diameter; vesicle and process surfaces laevigate; 25-39 solid process, 3-6 μm in length, 2-3 μm in width; process tips simple to tetrafurcate.

Discussion: This form is distinguished from *Gorgonisphaeridium absitum*, and *G*. sp. 1 in having bi-tetrafurcate process tips.

Occurrence: *Gorgonisphaeridium* sp. 3 was recovered from the Hanover and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10778, 10779, 10782, 10846, 11259, 11318, and 11319.

Gowanda - Pb's 10868, 10871, 10877, and 10878.

Genus *Micrhystridium* (Deflandre) emend. Lister, 1970

Type species: *Micrhystridium inconspicuum* (Deflandre) Deflandre, 1937.

Micrhystridium complurispinosum Wicander, 1974

(Plate 16, Figure 2)

1974 *Micrhystridium complurispinosum* Wicander, p. 28; Pl. 14, fig. 1.

Description: Specimens conform to original description of Wicander (1974, p. 28).

Discussion: This species differs from *Micrhystridium stellatum* in having longer processes. This species has been reported from Upper Devonian-Lower Carboniferous sediments of Ohio (Wicander, 1974).

Occurrence: *Micrhystridium complurispinosum* was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10777, 10782, 10819, 10820, 10824, 10833, 11325, 11326, 11536, and 11537.

Dunkirk - Pb 11253.

Gowanda - Pb 11311.

Micrhystridium coronatum Stockmans and Williere, 1963

(Plate 16, Figure 3)

1963 *Micrhystridium coronatum* Stockmans and Williere, p. 467, Pl. 2, fig. 9.

Description: Specimens conform to original description of Stockmans and Williere (1963, p. 467).

Discussion: This species ranges from the Silurian through the Lower Carboniferous (see Wicander and Loeblich, 1977). *M. coronatum* has been reported from Belgium (Stockmans and Williere, 1963, 1966, 1967, 1974; Bain and Doubinger, 1965), France (Martin, 1969), and the United States (Wicander and Loeblich, 1977).

Occurrence: *Micrhystridium coronatum* was recovered from the Hanover Shale. Sample maceration numbers for each occurrence of this species are noted below.

Hanover - Pb's 10782, 10788, 10825, 11260, 11269, 11318, 11319, 11328, and 11537.

Micrhystridium inusitatum Wicander, 1974

(Plate 16, Figure 4)

1974 *Micrhystridium inusitatum* Wicander, p. 28; Pl. 14, figs. 4, 5.

Description: Specimens conform to the original description of Wicander (1974, p. 28).

Discussion: *M. inusitatum* differs from *Baltisphaeridium triangulare* Stockmans and Williere, 1962, in having shorter processes. This species has been reported from the Upper Devonian of Ohio (Wicander, 1974).

Occurrence: *Micrhystridium inusitatum* was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10836, 11321, and 11326.

Dunkirk - Pb's 10856, 10862, 11252, and 11253.

Gowanda - Pb's 10809 and 10876.

Micrhystridium stellatum Deflandre, 1945

(Plate 16, Figures 5-6)

1945 *Micrhystridium stellatum*, p. 45; Pl. 3, figs. 16-19.

Description: Specimens conform to the original description of Deflandre (1945, p. 45).

Discussion: This is a stratigraphically wide ranging (Silurian to Lower Mesozoic) and geographically ubiquitious acritarch species (see Lister, 1970, and Playford, 1977).

Occurrence: *Micrhystridium stellatum* was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Pipe Creek - Pb's 10768, 10770, 10771, 10816, 10818, 11271, and 11534.

Hanover - Pb's 10774, 10778, 10781, 10783, 10788, 10819, 10832, 10833, 10836, 10838, 10840, 10847, 10848, 11259, 11263, 11267, 11270, and 11324.

Dunkirk - Pb's 10789, 10792, 10795, 10797, 10798, 10801, 10803, 10850, 10854, 10859, 10860, 10865, and and 10866.

Gowanda - Pb's 10806, 10808, 10809, 10810, 10867, 10868, 10872, 10877, 10882, 10883, 10884, 10885, 10886, 10888, 10894, 10895, 11277, 11278, 11279, 11280, 11283, and 11310.

Genus *Multiplicisphaeridium* (Staplin) emend. Lister, 1970

Type species: *Multiplicisphaeridium ramispinosum* Staplin, 1961.

Multiplicisphaeridium leptaleoderos Loeblich and Wicander, 1976
(Plate 17, Figure 1)

1976 *Multiplicisphaeridium leptaleoderos* Loeblich and Wicander, p. 18; Pl. 5, fig. 5.

Description: Specimens conform to description of Loeblich and Wicander (1976, p. 18).

Discussion: Multiplicisphaeridium mergaeferum Loeblich, 1970, has a smaller vesicle diameter. M. leptaleoderos has been reported from the Lower Devonian of Oklahoma (Loeblich and Wicander, 1976).

Occurrence: Multiplicisphaeridium leptaleoderos was recovered from the Hanover and Dunkirk Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 11325, 11326, and 11327.

Dunkirk - Pb 10865.

Multiplicisphaeridium cf. M. ramispinosum Staplin, 1961

(Plate 17, Figures 2-4)

Description: Specimens conform to the original description of Staplin (1961, p. 411) except that the forms recovered in this study possess a greater number of processes.

Discussion: This species is a very common element in this flora and has been reported from the Upper Devonian of Alberta, Canada (Staplin, 1961) and Oklahoma (von Almen, 1970a). The processes of Multiplicisphaeridium ramusculosum Lister, 1970, branch up to the 5th order as do M. ramispinosum; however, the processes of the latter are longer.

Occurrence: Multiplicisphaeridium cf. M. ramispinosum was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Pipe Creek - Pb's 10769, 10770, 10816, 10818, 10912, 11534, and 11535.

Hanover - Pb's 10774, 10780, 10788, 10822, 10824, 10832, 10833, 10836, 10838, 10839, 10842, 10844, 10846, 11259, 11260, 11265, 11269, 11324, and 11325.

Dunkirk - Pb's 10795, 10802, 10803, 10804, 10862, 10865, 11251, 11252, and 11253.

Gowanda - Pb's 10809, 10810, 10811, 10814, 10869, 10872, 10876, 10877, 10893, 10895, 10896, 11275, 11278, 11279, 11283, 11285, 11286, 11293, 11294, 11295, 11296, 11297, 11304, 11305, 11307, 11308, 11309, 11310, and 11311.

Multiplicisphaeridium sp. 1

(Plate 17, Figure 5)

Description: Vesicle shape subspherical to polygonal in outline; 22-30 μm in diameter; vesicle and processes laevigate; 8-12 hollow processes, 12-16 μm in length, 3-6 μm in width; processes display one major bifurcation distally; each bifurcation is terminated by ramifying tips.

Discussion: This form was a rather rare element of the microplankton assemblage. It differs from *Multiplicisphaeridium anastomosis* Wicander, 1976, in having a larger vesicle diameter.

Occurrence: *Multiplicisphaeridium* sp. 1 was recovered from the Hanover Shale. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 11262 and 11325.

Multiplicisphaeridium sp. 2

(Plate 17, Figure 6; Plate 18, Figures 1-2)

Description: Vesicle shape subspherical to subpolygonal, 17-21 μm in diameter; vesicle and processes laevigate; 9-13 hollow processes, 7-12 μm in length, 1-2 μm in width, variably branched (i.e., may or may not have a major bifurcation or ramifying terminations).

Discussion: Vesicle diameter and process length of this form are shorter than *Multiplicisphaeridium leptaleoderos*, *M. ramispinosum*, and *M.* sp. 1.

Occurrence: *Multiplicisphaeridium* sp. 2 was recovered from the Hanover and Dunkirk Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb 10842.

Dunkirk - Pb 11251.

Genus Ozotobrachion Loeblich and Drugg, 1968

Type species: Ozotobrachion palidodigitatus (Cramer) Playford, 1977; originally designated as Ozotobrachion dactylos Loeblich and Drugg (1968, p. 130).

Ozotobrachion palidodigitatus (Cramer) Playford, 1977 (Plate 18, Figure 3)

1967 Baltisphaeridium palidodigitatum Cramer, p. 25; Pl. 1, fig. 8.

1968 Ozotobrachion dactylos Loeblich and Drugg, p. 130, 132; Pl. 1 figs. 1-6.

1971 Baltisphaeridium palidodigitatum Cramer emend. Cramer, p. 168-170; Pl. 13, fig. 192.

1973 Multiplicisphaeridium palidodigitatum (Cramer) Eisenack and Cramer, p. 709-711.

1974 Ozotobrachion dactylos Loeblich and Drugg in Jardine, et al, p. 322 (no fig.)

1977 Ozotobrachion palidodigatatus Playford, p. 31-32; Pl. 14, figs. 11-12.

Description: Specimens conform to description of Playford (1977, p. 31-32).

Discussion: This species is more commonly an element of Lower to Middle Devonian strata (see discussion in Playford, 1977). Only one specimen was recovered; hence, the possibility exists that it may be reworked.

Occurrence: *Ozotobrachion palidodigitatus* was recovered from one sample of the Hanover Shale (Pb 11325).

Subgroup HERKOMORPHITAE Downie, Evitt, and Sarjeant, 1963

Genus *Cymatiosphaera* (Wetzel) emend. Deflandre, 1954

Type species: *Cymatiosphaera radiata* O. Wetzel, 1933; by subsequent designation of Deflandre (1954, p. 257).

Cymatiosphaera turbinata Wicander and Loeblich, 1977

(Plate 18, Figure 4)

1977 *Cymatiosphaera turbinata* Wicander and Loeblich, p. 141; Pl. 3, Fig. 5-7.

Description Conforms to the original description of Wicander and Loeblich (1977, p. 141).

Discussion: This species has previously been reported from the Upper Devonian Antrim Shale of Indiana (Wicander and Loeblich, 1977). *Cymatiosphaera labyrinthica* Wicander 1974, and *C. acinosa* Wicander 1974, have reticulocristate and fossulate ornamented lacunae, respectively. *Cymatiosphaera* sp. 1 and *C.* sp. 2 have more lacunae per field view.

Occurrence: *Cymatiosphaera turbinata* was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Pipe Creek - Pb's 10771 and 11287.

Hanover - Pb's 10773, 10774, 10778, 10782, 10788, 10819, 10820, 10832, 10833, 10835, 10836, 10838, 10840, 10844, 10848, 11260, 11263, 11264, 11267, 11268, 11324, and 11327.

Dunkirk - Pb's 10789, 10793, 10795, 11248, 11249, 11251, and 11252.

Gowanda - Pb's 10806, 10808, 10809, 10810, 10812, 10813, 10893, 10895, 10898, 10900, 10904, 10906, 11278, 11283, 11286, 11300, 11303, 11305, and 11308.

Cymatiosphaera sp. 1

(Plate 18, Figure 5)

Description: Vesicle shape spherical to subspherical, 45-54 μm in diameter; vesicle surface divided into polygonal lacunae 9-12 per field of view, 12-17 μm across; muri 4-7 μm high, laevigate to finely granulate.

Discussion: Differs from *Cymatiosphaera canadensis* Deunff in not displaying a uniform 10-12 lacunae per field.

Occurrence: *Cymatiosphaera* sp. 1 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10778, 10782, 10788, 10823, and 11260.

Dunkirk - Pb's 10789, 10790, 10798, and 10858.

Gowanda - Pb's 10808, 10897, 11286, and 11307.

Cymatiosphaera sp. 2

(Plate 18, Figures 6-7)

Description: Vesicle shape spherical to subspherical, 29-37 μm in diameter; vesicle surface divided into polygonal lacunae 13-18 per field of view, 7-10 μm across; muri 3-4 μm high, laevigate, and membranous.

Discussion: The large number of lacunae in this form distinguishes it from *Cymatiosphaera turbinata* and *C*. sp. 1. *Cymatiosphaera brevicrista* Wicander, 1974, has reticulocristate lacunae ornamentation.

Occurrence: *Cymatiosphaera* sp. 2 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10778, 10782, 10787, 10824, and 11260.

Dunkirk - Pb's 10790 and 11249.

Gowanda - Pb's 10806 and 10881.

Genus Muraticavea Wicander, 1974

Type species: Muraticavea entechia Wicander, 1974.

Discussion: Differs from Cymatiosphaera in usually having six or less lacunae per field of view (Wicander, 1974).

Muraticavea sp. 1

(Plate 19, Figures 1-2)

Description: Vesicle surface laevigate, spherical in outline, 15-21 µm in diameter; vesicle divided into 3-5 lacunae per field of view, 4-5 µm across, by membraneous, laevigate ridges, 3-4 µm in height.

Discussion: The small size of the vesicle diameter distinguishes this form from others in this genus.

Occurrence: Muraticavea sp. 1 was recovered from the Hanover and Dunkirk Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10785, 10788, 10820, 10824, and 11260.

Dunkirk - Pb's 10789, 10850, 11249, and 11257.

Muraticavea sp. 2

(Plate 19, Figures 3-5)

Description: Vesicle surface laevigate, spherical in outline, 42-47 μm in diameter; vesicle divided into 6 polygonal lacunae per field of view (usually five-sided); laevigate-foveate muri. 5-7 μm across, by 4-6 μm high.

Discussion: This is the first representative of *Muraticavea* having foveate sculpture. Lacunae number and morphology is consistent with Wicander's (1974) original diagnosis of this genus; hence, the assignment of this form *Muraticavea*.

Occurrence: *Muraticavea* sp. 2 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10778, 10785, 10788, 10820, 10837, 11259 11260, 11325, 11326, and 11328.

Dunkirk - Pb 10790.

Gowanda - Pb 10808.

Muraticavea sp. 3

(Plate 19, Figure 6)

Description: Vesicle scabrate-granulate, spherical to oblong in outline, 27-38 μm in diameter; vesicle surface divided into

4-5 lacunae per field of view, 9-12 μm across, by 9-12 μm high, transparent, laevigate, muri.

Discussion: *Muraticavea* sp. 1 is smaller (15-21 μm) in diameter. *Muraticavea* sp. 2 has more (6) lacunae per field and narrower (4-6 μm) ridges. Both *M.* sp. 1 and *M.* sp. 2 lack scabrate-granulate ornamentation.

Occurrence: *Muraticavea* sp. 3 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10786, 10819, 10836, 10837, and 11260.

Dunkirk - Pb's 10792, 10851, 11252, and 11255.

Gowanda - Pb 11306.

Subgroup NETROMORPHITAE Downie, Evitt and Sarjeant, 1963

Genus *Navifusa* Combaz, Lange, Pansart, 1967

Type species: *Navifusa navis* (Eisenack) Combaz, Lange, Pansart, 1967.

Navifusa bacillum (Deunff) Playford, 1977

(Plate 20, Figures 1-2)

1955 *Leiofusa bacillum* Deunff, p. 148; Pl. 4, fig. 2.

1965 *Leiofusa brasiliensis* Brito and Santos, p. 7; Pl. 1, fig. 2; Pl. 2, fig. 3.

1965 Leiofusa brasiliensis lingula Brito and Santos, p. 8; Pl. 1, fig. 1; Pl. 2, fig. 2.

1965 Leiofusa cylindricum Brito and Santos, p. 16; Pl. 1, fig. 4.

1965 Leiofusa eisenacki Brito and Santos, p. 17; Pl. 1, fig. 3.

1973 Quisquilites widderensis Legault, p. 60-61; Pl. 11, fig. 17-21.

1974 Navifusa brasiliensis (Brito and Santos) Combaz, Lange, and Pansart in Anan-Yorke, p. 129; Pl. 27, figs. 1-3.

1974 Navifusa drosera Wicander, p. 30; Pl. 15, figs. 7-9.

1977 Navifusa bacillum (Deunff) Playford, p. 29-30; Pl. 12, figs. 1-9.

Description: Specimens conform to description of Playford (1977, p. 29-30).

Discussion: Playford (1977) considers the long-thin form (Plate 20, Fig. 1) and short-wide form (Plate 20, Fig. 2) of this species as end members and not as two different species. The author's view conforms to that of Playford with respect to the specimens from western New York because both forms usually occur together. This species has been recovered in Middle to Upper Devonian sediments from North Africa, North America, Canada, and South America (see summary in Playford, 1977, p. 30).

Occurrence: Navifusa bacillum was recovered from Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Pipe Creek - Pb's 10768 and 10770.

Hanover - Pb's 10788, 10822, 10823, 11260, 11262, 11320,
11321, 11325, 11326, 11328, 11536, and 11537.

Dunkirk - Pb 10795.

Gowanda - Pb 10881.

Subgroup POLYGONOMORPHITAE Downie, Evitt, and Sarjeant, 1963

Genus *Estiastra* Eisenack, 1959

Type species: *Estiastra magna* Eisenack, 1959.

Estiastra rugosa Wicander, 1974
(Plate 21, Figure 1)

1974 *Estiastra rugosa* Wicander, p. 23-24; Pl. 11, figs. 1-4.

Description: Conforms to original description of Wicander (1974, p. 23-24).

Discussion: This species has been reported from the Upper Devonian of Ohio (Wicander, 1974). *E. rugosa* differs from *E granulata* Downie, 1963, in having only six processes, and from *E. barbata* Downie, 1963, in not having an echinate surface of the wall.

Occurrence: *Estiastra rugosa* was recovered from one sample each of the Dunkirk (Pb 10850) and Gowanda (Pb 11310) Shales.

Genus *Evittia* Brito, 1967

Type species: *Evittia sommeri* Brito, 1967.

Evittia sp. 1

(Plate 20, Figure 3)

Description: Vesicle surface laevigate; shape polygonal, 35-44 μm in diameter; differentiation of vesicle and process bases often difficult; 7-11 hollow processes, 37-46 μm in length, and wide 7-15 μm bases; processes usually possess one major bifurcation; however, most processes terminate in short finger-like digitations; process surface usually ornamented by minute spinae or grana.

Discussion: Morphology of the processes distinguish this *Evittia* sp. 1, from *E*. sp. 2, and *E*. sp. 3.

Occurrence: *Evittia* sp. 1 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10819, 10824, 10840, 10844, 11260, 11264, 11325, 11326, 11536, and 11537.

Dunkirk - Pb's 10791, 10855, 10862, 10865, and 11251.

Gowanda - Pb's 10810, 10813, 10872, 10874, 10875, 10877, 10878, 10881, 10886, 10896, 10898, 10906, and 11285.

Evittia sp. 2

(Plate 20, Figure 4)

Description: Vesicle, surface laevigate; shape polygonal, 30-42 μm in diameter; vesicle and process bases often difficult to differentiate; 5-7 hollow, laevigate processes, 18-22 μm in length, 10-21 μm in width; processes variable in branching pattern, often possessing a major bi- or trifurcate split, and terminate in irregular forkings up to the third order; process bases expanded.

Discussion: Morphology of processes distinguishe this form from *Evittia* sp. 1 and *E*. sp. 3 in having multi-branched process terminations.

Occurrence: *Evittia* sp. 2 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 11325 and 11537.

Dunkirk - Pb's 10798.

Gowanda - Pb's 10813, 10877, 10889, 10893, 10894, 10898, 10900, 10904, 10905, 11275, and 11310.

Evittia sp. 3

(Plate 20, Figure 5)

Description: Vesicle surface laevigate; shape spherical to polygonal; 28-36 μm in diameter; 6-8 laevigate processes, 34-40 μm in length, 5-8 μm in width; processes terminate in digitate tips.

Discussion: Morphology of processes, particularly their lack of greatly expanded bases, distinguish this species from Evittia sp. 1, and E. sp. 2.

Occurrence: Evittia sp. 3 was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10774, 10778, 10781, 10788, 10819, 11260, and 11265.

Dunkirk - Pb's 10796, 10854, 10864, 10865, and 11251.

Gowanda - Pb's 10806, 10808, 10809, 10810, 10877, 10905, 10906, 11310, 11324, and 11325.

Genus Veryhachium Deunff ex Downie, 1959

Type species: Veryhachium trisulcum (Deunff) Deunff, 1959.

Veryhachium downiei Stockmans and Williere, 1962

(Plate 21, Figures 2-3)

1962 Veryhachium downiei Stockmans and Williere, p. 47-48; Pl. 2, figs. 20-22.

Description: Specimens conform to the descriptions of Stockmans and Williere (1962, p. 47-48) and Playford (1977, p. 38-39).

Discussion: Veryhachium downiei is known widely from Silurian through Lower Carboniferous sediments (see discussion in Playford, 1977, pp. 38-39).

Occurrence: Veryhachium downiei was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10773, 10783, 10787, 11261, and 11263.

Dunkirk - Pb's 10793, 10798, 10854, 11254, 11256, and 11258.

Gowanda - Pb's 10808, 11286, and 11310.

Veryhachium lairdii Deflandre ex Deunff, 1959

(Plate 21, Figure 4)

1946 Hystrichosphaeridium lairdi Deflandre, p. 257; fig. 112.

1959 Veryhachium lairdi (Deflandre) Deunff, p. 28; Pl. 8, figs. 75-79.

1970 *Veryhachium lairdii* (Deflandre) *ex* Deunff; Loeblich, p. 741-742.

Description: Specimens conform to the description by Playford (1977, p. 39).

Discussion: A very common element in Silurian-Devonian deposits of Europe (Deflandre, 1946; Deunff, 1959; Cramer, 1964; Beju, 1967), Africa (Anan-Yorke, 1974, Moreau-Benoit, 1974), United States (Loeblich, 1970), and Australia (Playford, 1977). This species differs from *V. downiei*, *V. trispinosum* and *V, polyaster* in having four processes.

Occurrence: *Veryhachium lairdii* was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 11265 and 11325.

Dunkirk - Pb's 10792, 10797, and 11249.

Gowanda - Pb's 10877 and 11283.

Veryhachium polyaster Staplin, 1961

(Plate 21, Figures 5-6)

1961 *Veryhachium polyaster* Staplin, p. 413; Pl. 49, figs. 19-20.

Description: Specimens conform to the descriptions of Staplin (1961, p. 413).

Discussion: Previously reported from the Middle Devonian (Playford, 1977) and Upper Devonian (Staplin, 1961) of Canada. Veryhachium lairdii differs from V. polyaster in having four processes.

Occurrence: Veryhachium polyaster was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Hanover - Pb's 10782, 10789, 10819, 10820, 10844, 11262, 11265, 11325, and 11536.

Dunkirk - Pb's 10797, 10850, 11253, 11255, and 11257.

Gowanda - Pb 11285.

Veryhachium trispinosum (Eisenack) Duenff, 1954

(Plate 21, Figure 7)

1938 Hystrichosphaeridium trispinosum in Eisenack, p. 14, 16; figs. 2-3.

1954 Veryhachium (Hystrichosphaeridium) trispinosum Duenff, p. 306.

1958 Veryhachium trisulcum var. reductum Deunff, p. 27, figs. 8, 10, 11, 12, 17.

1974 Veryhachium roscidum Wicander, p. 35-36; Pl. 19, figs. 4, 5, 6, 7.

Description: Specimens conform to description given by Eisenack (1938, p. 14).

Discussion: Several authors (e.g., Wicander, 1974; Playford, 1977, p. 38) have noted that *Veryhachium downiei* intergrades with *V. trispinosum*. In this study, *V. downiei* is differentiated from *V. trispinosum* by the latter's shorter processes.

Occurrence: *Veryhachium trispinosum* was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Pipe Creek - Pb's 10768, 10769, 10770, 10771, 10816, 10818, 10912, 11271, 11273, and 11535.

Hanover - Pb's 10773, 10774, 10777, 10778, 10781, 10782, 10787, 10822, 10823, 10832, 10833, 10836, 10842, 10846, 10848, 11259, 11260, 11263, 11267, 11268, 11270, 11326, 11328, 11536, and 11537.

Dunkirk - Pb's 10789, 10791, 10792, 10797, 10798, 10853, 10855, 10856, 10857, 10858, 10860, 10862, 10865, 10866, 11249, and 11250.

Gowanda - Pb's 10806, 10808, 10809, 10810, 10812, 10813, 10867, 10872, 10874, 10876, 10880, 10881, 10883, 10887, 10888, 10889, 10891, 10892, 10894, 10896, 11275, 11276, 11286, 11310, and 11336.

Veryhachium sp.

(Plate 21, Figure 8)

Description: Vesicle 20-25 μm in diameter; vesicle outline formed by two square to rectangular "bodies" that are connected to each other at their centers; each body is offset (i.e., squares and rectangles not superimposed) and bears a process in each corner, 28-34 μm in length, 3-5 μm in width; vesicle is laevigate and processes bear minute spinae.

Discussion: Vesicle construction distinguishes this form from other described members of Veryhachium.

Occurrence: Veryhachium sp. was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below in stratigraphic unit.

Pipe Creek - Pb 10771.

Hanover - Pb's 10774, 11260, and 11265.

Dunkirk - Pb 10803.

Gowanda - Pb's 10810, 10872, 10877, 10895, and 10896.

Acritarch Type A

(Plate 22, Figure 1)

Description: Vesicle surface laevigate, pentagonal in outline, 10-14 μm in diameter; each corner of pentagon bears a solid process, 12-15 μm in length, ca. 1 μm in width.

Discussion: Pentagonal shape bearing processes in each corner differentiates this form from any described species. Placement in the Polygonomorphitae was made on the basis of the presence of polygonal vesicle and lack of an inner body.

Occurrence: One specimen was recovered from the Hanover Shale (Pb 10819).

Acritarch Type B

(Plate 22, Figure 2)

Description: Vesicle surface laevigate, pentagonal in outline, 14-20 μm in diameter; each corner of pentagon bears a hollow process, 7-12 μm in length, 3-5 μm in width; processes possess one bifurcation near tip, and each bifurcation may branch up to three orders.

Discussion: Although similar in vesicle outline, this form differs from Acritarch Type A in having hollow, terminally branched processes. Placement in the Polygonomorphitae was made on the basis of the presence of a polygonal vesicle and lack of an inner body.

<u>Occurrence</u>: One specimen was recovered from the Gowanda Shale (Pb 11314).

Subgroup PRISMATOMORPHITAE Downie, Evitt, and Sarjeant, 1963

Genus *Polyedryxium* Deunff *ex* Deunff, 1961

<u>Type species</u>: *Polyedryxium deflandrei* Deunff, 1961.

Polyedryxium pharaonis Deunff, 1961

(Plate 20, Figures 6-7)

1954 *Polyedryxium pharaonis* Deunff, p. 1065; fig. 13 (nom. nud.).

1955 *Polyedryxium pharaonis* Deunff, p. 143; fig. 13 (nom. nud.).

1961 *Polyedryxium pharaonis* Deunff, p. 217

1968 *Veryhachium pharaonis* Jardine, et al., p. 390-391; Pl. 2, figs. 6-8, 10.

1972 *Crameria pharaonis* (Deunff) Jardine, et al., p. 301-302; Pl. 2, figs. 6-10.

1974 *Crameria pharaonis* Anan-Yorke, p. 112; Pl. 25, fig. 7.

<u>Description</u>: Specimens conform to the description given by Playford, (1977, p. 35).

<u>Discussion</u>: This species has been reported from many Devonian localities from the northern hemisphere (see summary Playford, 1977, p. 35).

Occurrence: *Polyedryxium pharaonis* was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Pipe Creek - Pb 10771.

Hanover - Pb's 10782, 10819, 10842, 10844, 10848, 11320, and 11321.

Dunkirk - Pb's 10801, 10854, 10858, 10861, 10863, 10866, and 11315.

Gowanda - Pb's 10808, 10810, 10813, 10814, 10867, 10869, 10874, 10876, 10877, 10878, 10881, 10882, 10883, 10884, 10885, 10886, 10888, 10889, 10892, 10894, 10896, 11275, 11279, 11283, 11310, 11311, 11333, and 11334.

Subgroup SCUTELLOMORPHITAE Brito, 1967

Genus *Maranhites* (Brito) emend. Daemon, Quadros and de Silva, 1967

Type species: *Maranhites brasiliensis* (Brito) Daemon, Quadros, and de Silva, 1967.

Maranhites brasiliensis (Brito) Daemon,
Quadros and de Silva, 1967
(Plate 23, Figure 1)

1956 Tasmanites mosesi Sommer, p. 458; figs 5-8.

1963 Tapajonites mosesii Sommer and van Boekel, p. 62; Pl. 2, figs. 1-3.

1965 Maranhites brasiliensis Brito, p. 2; Pl. 1, fig. 1.

1967 Maranhites brasiliensis Form A, Daemon, et al, p. 120; Pl. 4, Form A

1968 Maranhites gallicas Taugourdeau-Lantz, p. 162; Pl. 13, fig. 4; Pl. 14, figs. 1-3.

Description: Specimens conform to the description of Daemon, et al. (1967, p. 120).

Discussion: The genus Tapajonites (T. mosesii) was erected by Sommer and van Boekel (1963) for circular "grains" displaying marginal ("equatorial") pads or shields. Maranhites (M. brasiliensis) was erected by Brito (1965) for circular "grains" with a crenulate or "scalloped" margin ("equator"). Daemon, et. al. (1967) noted that representatives of the Tapajonites mosesii-Maranhites brasiliensis complex displayed an intergradation of margin ornamentation. It is difficult to pinpoint meaningful criteria for separating them. They concluded that ornamentation differences were infra-specific and emended Maranhites to include T. mosesii forms under Maranhites brasiliensis. This taxonomic practice is followed here. _M_. _brasiliensis_ has been reported from the Devonian of South America (Brito, 1965), Europe (Taugourdeau-Lantz, 1968), Africa (Jardine, et al., 1974; Bar and Riegel, 1974; Anan-Yorke, 1974), and the United States (von Almen, 1970a).

Occurrence: _Maranhites brasiliensis_ was recovered from the Pipe Creek, Hanover, and Dunkirk Shales. Sample maceration numbers for each occurrence in this species are noted below by stratigraphic unit.

Pipe Creek - Pb's 10771 and 10772.

Hanover - Pb's 10820, 10836, and 10838.

Dunkirk - Pb 11255.

Subgroup SPHAEROMORPHITAE Downie, Evitt and Sarjeant, 1963

Genus _Leiosphaeridia_ (Eisenack) emend.
Downie and Sarjeant, 1963

Type species: _Leiosphaeridia baltica_ Eisenack, 1958.

Leiosphaeridia sp.
(Plate 22, Figures 3-4)

Description: Vesicle surface laevigate; shape spherical to ellipsoidal, 20-24 μm in diameter; wall thin, 1-3 μm in thickness, often folded or collapsed.

Discussion: Although Devonian leiospheres have often been divided into two groups on a size basis (see von Almen, 1970a; Legault, 1973), the author believes that because the morphology of the genus is so simple, and that all sizes occur together, this criterion is not distinctive enough to be indicative of two separate forms. This form occurs in most samples. It is the major palynomorph constituent of the black shales.

Occurrence: Leiosphaeridia sp. was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Pipe Creek - Pb's 10768, 10769, 10770, 10771, 10816, 10818, 10912, 11271, 11273, 11287, 11288, 11289, 11290, 11291, 11292, 11316, and 11317.

Hanover - Pb's 10773, 10774, 10777, 10778, 10780, 10781, 10782, 10785, 10786, 10788, 10819, 10820, 10822, 10823, 10825, 10832, 10833, 10835, 10837, 10838, 10839, 10840, 10842, 10848, 11259, 11260, 11261, 11262, 11263, 11266, 11269, 11270, 11318, 11319, 11320, 11321, 11324, 11325, 11326, 11327, and 11328.

Dunkirk - Pb's 10789, 10790, 10792, 10793, 10795, 10796, 10797, 10798, 10801, 10802, 10803, 10804, 10849, 10850, 10851, 10852, 10853, 10854, 10855, 10856, 10857, 10858, 10859, 10861, 10862, 10863, 10864, 10865, 10866, 11248, 11249, 11250, 11251, 11252, 11255, 11256, 11257, 11258, 11315, 11329, 11330, 11331, and 11332.

Gowanda - Pb's 10806, 10807, 10809, 10810, 10811, 10812, 10813, 10814, 10868, 10869, 10870, 10871, 10872, 10874, 10875, 10876, 10877, 10878, 10880, 10881, 10882, 10883, 10884, 10885, 10886, 10887, 10889, 10892, 10843, 10895, 10897, 10898, 10900, 10902, 10904, 10905, 10906, 11275, 11276, 11277, 11278, 11279, 11280, 11284, 11285, 11296, 11298, 11299, 11300, 11301, 11302, 11303, 11304, 11305, 11306, 11307, 11308, 11309, 11310, 11312, 11313, 11314, 11322, 11334, 11335, and 11336.

Genus *Lophosphaeridium* Timofeyev *ex* Downie, 1963

Type species: *Lophosphaeridium citrinum* Downie, 1963.

Lophosphaeridium microgranifer (Staplin) Jux, 1975

(Plate 22, Figure 5)

1961 *Protoleiosphaeridium microgranifer* Staplin, p. 405; Pl. 48, fig. 4.

1975 *Lophosphaeridium microgranifer* (Staplin) Jux, p. 16; Pl. 3, fig. 3.

Description: Specimens conform to the descriptions of Staplin (1961, p. 405) and Jux (1975, p. 16).

Discussion: This species has been previously reported from the Upper Devonian of Canada (Staplin, 1961) and Germany (Jux, (1975).

Occurrence: Lophosphaeridium microgranifer was recovered from the Pipe Creek, Hanover, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are listed below by stratigraphic unit.

Pipe Creek - Pb 10818.

Hanover - Pb's 10820, 10823, 10839, 10840, 11325, and 11327.

Gowanda - Pb 11333.

Subgroup TASMANITITAE Staplin, Jansonius, and Pocock, 1965

Genus Tasmanites (Newton, 1875) emend.
Schopf, Wilson, and Bentall, 1944

Type species: Tasmanites (al. Protosalvinia) punctatus Newton, 1875.

Tasmanites huronensis (Dawson) Winslow, 1962

(Plate 22, Figures 6-7)

1886 *Protosalvinia huronensis* Dawson, p. 115; figs. 4, 4a, 4b, 5, 6, 6a, 7b, 11, and 12.

1962 *Tasmanites huronensis* (Dawson) Winslow, p. 81-83; Pl. 21, figs. 1, 1a.

Description: Specimens generally conform to description of Winslow (1962, p. 81-83).

Discussion: *Tasmanites huronensis* has been reported from the Devonian sediments of Canada (Dawson, 1886; Boneham, 1967), the mid-continent United States (Winslow, 1962; Boneham, 1967) and Germany (Jux, 1968, 1975).

Occurrence: *Tasmanites huronensis* was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this species are noted below by stratigraphic unit.

Pipe Creek - Pb's 10768, 10769, 10770, 11271, and 11272.

Hanover - Pb's 10788, 10820, 10842, 11266, and 11270.

Dunkirk - Pb's 10863, 11329, 11331, 11332.

Gowanda - Pb's 10876, 10877, 10878, 10881, 10886, and 10887.

CHITINOZOA

Chitinozoa were formally named, described, and illustrated by Eisenack (1931). They are an enigmatic group of hollow bottle-shaped, organic walled microfossils of unknown affinity. Classification is based on gross morphology and external and internal elaborations (i.e., appendices, mucra, copula, opistosome, prosome, etc.) of the test. The classification scheme used here is that of Eisenack (1931, 1932, and 1955).

CHITINOZOA Eisenack, 1931

Genus *Angochitina* Eisenack, 1931

Type species: *Angochitina echinata* Eisenack, 1931

Angochitina sp.

(Plate 23, Figure 2)

Description: Vesicle cylindro-spheroidal, 118-138 μm in total length; chamber spheroidal, 87-98 μm in diameter; flexure distinct, neck cylindrical, 32-41 μm in length, 21-33 μm in width, with slight oval flaring; ornamentation consists of short spines 0.5-1 μm in height, 1-2 μm in basal width; ornamentation unevenly distributed over neck and chamber.

Discussion: Similar to Angochitina toyetae Cramer in gross morphology; however, A. sp. lacks complexly branched spines. Sphaerochitina schwalbi Collinson and Scott has longer and thinner spines.

Occurrence: Angochitina sp. was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10777, 10820, 11261, 11262, and 11270.

Dunkirk - Pb's 10803, 11248, and 11254.

Gowanda - Pb's 10809, 10810, 10875, 10876, 10895, 10898, 10905, 10906, 11285, 11286.

Genus Sphaerochitina Eisenack, 1955

Type species: Sphaerochitina sphaerocephala (Eisenack) Eisenack, 1955.

Sphaerochitina sp.

(Plate 23, Figure 3)

Description: Vesicle cylindro-conoidal, 105-120 µm in diameter; flexure ± distinct; neck cylindrical, 76-84 µm in length, 38-51 µm in width; ornamentation consists of spines, 1-4 µm in length, 0.5-1 µm in width, unevenly distributed over neck and chamber.

Discussion: Differs from Sphaerochitina pilosa and Sphaerochitina schwalbi in having a shorter neck.

Occurrence: *Sphaerochitina* sp. was recovered from the Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence of this form are noted below by stratigraphic unit.

Hanover - Pb's 10777, 11259, and 11262.

Dunkirk - Pb's 10792, 11249, and 11253.

Gowanda - Pb's 10810, 10871, 10872, 10874, 10877, 10895, 10896, 10905, 10906, 11279, 11280, 11284, 11310, and 11335.

Chitinozoan sp.

(Plate 23, Figure 4)

Description: Vesicle cylindro-conoidal, 97-113 μm in length; chamber 72-83 μm in diameter; flexure ± distinct; neck cylindrical 25-33 μm in length, 37-52 μm in width; with slight oral flaring; surface laevigate.

Discussion: Similar to *Lagenochitina brevicollis* Taugourdeau and de Jekhowsky and *Lagenochitina crassa* Grignani and Mantovani in shape, but is smaller.

Occurrence: *Chitinozoan* sp. was recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration numbers for each occurrence for this form are noted below by stratigraphic unit.

Pipe Creek - Pb 11271.

Hanover - Pb's 10837, 11264, 11266, 11267, and 11327.

Dunkirk - Pb 10803.

Gowanda - Pb's 10869, 10870, 10893, 11278, 11310, and 11335.

SCOLECODONTS

(Plate 23, Figures 5-10)

Scolecodonts are the (fossil) chitinous jaws of marine polychaetous annelids. Samples were not processed specifically for scolecodonts and no attempt was made to treat them taxonomically. They were considered as a single group (with respect to their occurrence), although several genera are probably represented.

Scolecodonts were recovered from the Pipe Creek, Hanover, Dunkirk, and Gowanda Shales. Sample maceration number for each occurrence of this form is noted below by stratigraphic unit.

Pipe Creek - Pb 11271.

Hanover - Pb's 10777, 10820, 10837, 11259, 11261, 11262, 11264, 11266, 11267, 11270, and 11327.

Dunkirk - Pb's 10792, 10803, 11248, 11249, 11253, and 11254.

Gowanda - Pb's 10809, 10810, 10869, 10870, 10871, 10872, 10874, 10875, 10876, 10877, 10893, 10895, 10896, 10898, 10905, 10906, 11285, 11286, 11310, and 11335.

COMPOSITION OF ASSEMBLAGES

General Statement

Forty-two palynomorph genera were recovered from the Upper Devonian Java and lowermost Canadaway Formations (uppermost Senecan-lowermost Chautauquan), of southwestern New York State. These include twenty-three spore genera (Anapiculatisporites, Ancyrospora, Apiculiretusispora, Auroraspora, ?Baculatisporites, ?Biharisporites, Calamospora, Convolutispora, Emphanisporites, Endosporites, Geminospora, Grandispora, Hymenozonotriletes, Hystricosporites, Leiotriletes, Lophozonotriletes, Nikitinisporites, Punctatisporites, Retusotriletes, Spelaeotriletes, Spinozonotriletes, Stenozonotriletes, Verrucosisporites); seventeen acritarch genera (Baltisphaeridium, Diexallophasis, Gorgonisphaeridium, Micrhystridium, Multiplicisphaeridium, Ozotobrachion, Cymatiosphaera, Muraticavea, Navifusa, Estiastra, Evittia, Polyedryxium, Veryhachium, Leiosphaeridia, Lophosphaeridium, Tasmanites, Maranhites); and two chitinozoan genera, Angochitina and Sphaerochitina. Two spores, two acritarchs, and one chitinozoan are unnamed.

Although a large assemblage is illustrated from these units, many samples were barren, and many contained poorly preserved specimens and/or very few taxa. The poor preservation make some morphologic interpretations difficult. For example, ten taxa were identified on the basis of a single specimen (Ancyrospora sp. 4, ?Biharisporites sp., Grandispora sp., Nikitinisporites sp., Spinozonotriletes sp. 1, Spinozonotriletes sp. 2, Spore Type B, Baltisphaeridium sp. 2, Ozotobrachion palidodigatus, Acritarch Type A, Acritarch Type B); four additional species occurred as two specimens (?Baculatisporites sp., Hymenozonotriletes sp., Spore Type A, Multiplicisphaeridium sp. 1, Estiastra rugosa; and five taxa were represented by four or five specimens (Anapiculatisporites hystricosus, ?Endosporites, Baltisphaeridium sp. 4, Diexallophasis remota, Gorgonisphaeridium sp. 2). With respect to the total assemblage, 26 spores (Ancyrospora sp. 1, Ancyrospora sp. 2, Ancyrospora sp. 3, Ancyrospora sp. 4, Apiculiretusispora sp. 1, Apiculiretusispora sp. 2, ?Baculatisporites sp., ?Biharisporites, Calamospora sp., Convolutispora sp., Endosporites sp., ?Endosporites sp., Grandispora sp., Hymenozonotriletes sp., Hystricosporites sp., Lophozonotriletes sp., Nikitinisporites sp., Punctatisporites sp., Spelaeotriletes sp., Spinozonotriletes sp. 1, Spinozonotriletes sp. 2, Stenozonotriletes sp., Verrucosisporites sp. 1, Verrucosisporites sp. 2, Spore Type A, and Spore Type B) and 23 acritarchs (Baltisphaeridium sp. 1, Baltisphaeridium sp. 2, Baltisphaeridium sp. 3, Baltisphaeridium sp. 4, Baltisphaeridium sp. 5, Baltisphaeridium sp. 6, Gorgonisphaeridium sp. 1, Gorgonisphaeridium sp. 2, Gorgonisphaeridium sp. 3, Multiplicisphaeridium sp. 1, Multiplicisphaeridium sp. 2, Cymatiosphaera sp. 1, Cymatiosphaera sp. 2, Cymatiosphaera sp. 3, Muraticavea sp. 1, Muraticavea sp. 2, Muraticavea sp. 3, Evittia sp. 1, Evittia sp. 2, Evittia sp. 3, Veryhachium sp., Acritarch Type A, and Acritarch Type B) are either new forms or taxa that cannot be identified to species designation because of poor preservation and/or inadequate representation.

Comparison of Palynomorphs from the Walnut Creek, Eighteenmile Creek, and Cazenovia Creek Sections

The stratigraphic positions of selected palynomorphs from the Walnut Creet (locality 10), south branch of Eighteenmile Creek (locality 12), and Cazenovia Creek I (locality 15) sections, are plotted on Tables 1, 2, and 3. The inferred stratigraphic ranges of these palynomorphs are also indicated. These tables may be used to: (1) compare the ranges of taxa in these major sections, (2) show the occurrences of these taxa, and (3) display the basis for the biostratigraphic composite presented in Tables 4 and 5. Both occurrences and ranges of palynomorph taxa are probably closely related to palynomorph preservation and/or lithology (see chapter on Paleoenvironmental Interpretations).

An examination of these sections reveals a marked variation in the ranges of certain taxa, some of which are detailed below. *Anapiculatisporites hystricosus* was recovered from the lowermost Hanover sample on Walnut Creek, the uppermost Hanover (2 samples) on Eighteenmile Creek, and from 1 sample of the Dunkirk from Cazenovia Creek I. *Ancyrospora* sp. 1, which occurs infrequently but is long ranging in the Walnut Creek section, is fairly rare and displays shorter range or single occurrences in the Eighteenmile Creek and Cazenovia Creek I localities. *Leiotriletes inermis*, which occurs sporadically through the entire section on Walnut Creek, was recovered in a proportionate number of samples (but in slightly restricted range terminally) on Eighteenmile Creek and Cazenovia Creek I sections, and does not appear as early in the Eighteenmile Creek section as it does in the Walnut Creek and Cazenovia Creek I sections.

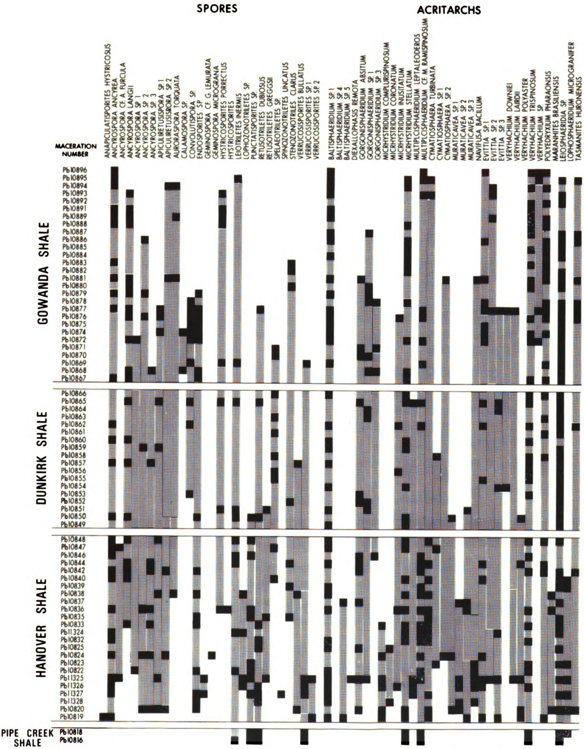

Table 1. Presence and inferred stratigraphic range of selected spore and acritarch taxa from the Walnut Creek section (locality 10), Chautauqua County, New York.

■ Present

▒ inferred stratigraphic occurrence.

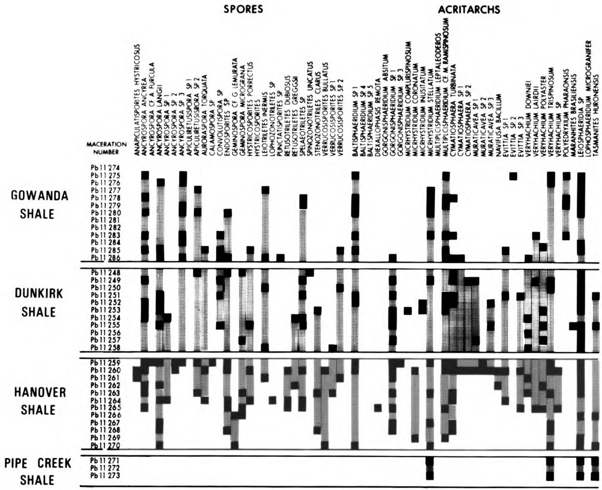

Table 2. Presence and inferred stratigraphic range of selected spore and acritarch taxa from the south branch of Eighteenmile Creek section (locality 12) , Erie County , New York.

■ Present

▒ inferred stratigraphic occurrence

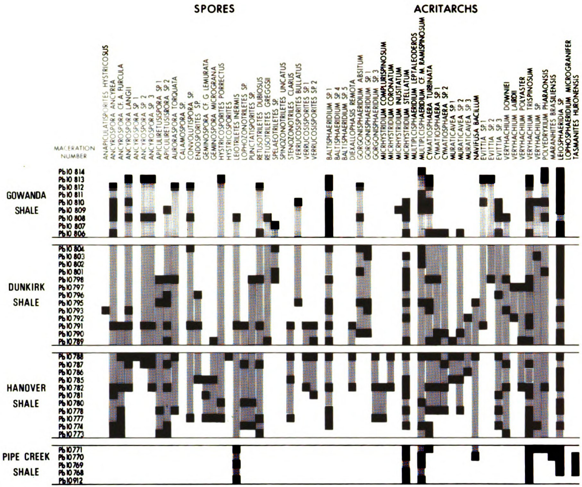

Table 3. Presence and inferred stratigraphic range of selected spore and acritarch taxa from the Cazenovia Creek I section (locality 15) Erie County, New York.

■ Present

▒ inferred stratigraphic occurrence

Ancyrospora sp. 2 ranges from the lowermost Hanover through the upper Gowanda (7 samples) at Walnut Creek, and from upper Hanover through lower Gowanda (5 samples) at the Cazenovia Creek locality, but appears to be restricted to upper Hanover (2 samples) at Eighteenmile Creek. Calamospora sp. was recovered from the upper Hanover (1 sample) and lower Gowanda (2 samples) at Walnut Creek, the upper Hanover (1 sample) from Eighteenmile Creek, and the upper Hanover of Cazenovia Creek sections. The three species of Verrucosisporites show principal ranges in the Hanover and Dunkirk but with somewhat different distribution in the three sections.

The acritarchs of these three sections display stratigraphic and geographic distributions similar to those exhibited by the spores. This is particularly exemplified by the genus Muraticavea, which appears to be best developed in the Hanover and Dunkirk at all three localities, with the exception of Muraticavea sp. 2 which is found in the lowermost sample of the Gowanda at the Cazenovia Creek I section. Multiplicisphaeridium leptaleoderos ranges from the lower Hanover through upper Dunkirk (4 samples) of the Walnut Creek section, but is absent from the Eighteenmile Creek and Cazenovia Creek I localities. Evittia sp. 1 is absent from the Hanover Shale of Cazenovia Creek I but present in this unit from the Walnut Creek and Eighteenmile Creek localities. Gorgonisphaeridium absitum ranges from the lower Hanover through lower Gowanda (13 samples) from Walnut Creek, the lower Dunkirk through lower Gowanda (6 samples) of the Cazenovia Creek I locality, but absent from the Eighteenmile Creek section. The most anomalous occurrence is that exhibited by Baltisphaeridium sp. 4, which is absent in the above sections but present in the Gowanda from localities 2, 5, and 14. Some of the anomalies of stratigraphic occurrences may actually be controlled by the geographic position of the sections sampled and thus indicate the complex facies patterns inherent in a deltaic system. This will be discussed later more fully in the section Paleoenvironmental Interpretations.

Biostratigraphy

Tables 4 and 5 display ranges of selected palynomorph taxa grouped according to (base) and latest (top) occurrence, respectively, identified in samples from all 16 localities. At present, however, the biostratigraphic merit of these ranges may be inconclusive for the folowing reasons: (1) poor preservation or insufficient representation of certain taxa making identification to the species level difficult; (2) the recovery of many new "species"; and (3) presence of species that are stratigraphically long ranging. Examples of taxa which appeared earlier or extended later than the time included in the sections sampled include Leiotriletes inermis, Micrhystridium stellatum, Veryhachium trispinosum, Polyedryxium pharaonsis, and Retusotriletes dubiosus. The majority of these palynomorphs first appear (Table 4) in the Hanover Shale (22 of 28 spores and 23 of 33 acritarchs), which is predominately a gray shale. This may represent a lithological-preservational bias. The poorest recovery experienced from any stratigraphic unit was in the black shale of the Pipe Creek Member (as well as most other black shales). For these

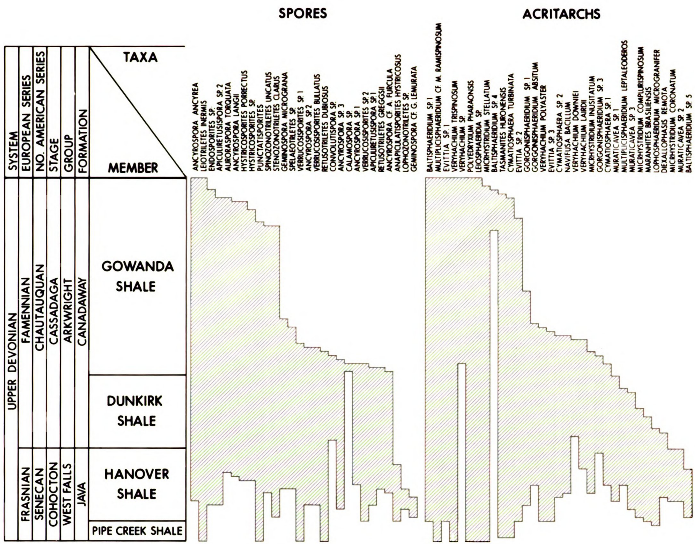

Table 4. Range of selected spores and acritarchs plotted by latest occurrence including records from all localities.

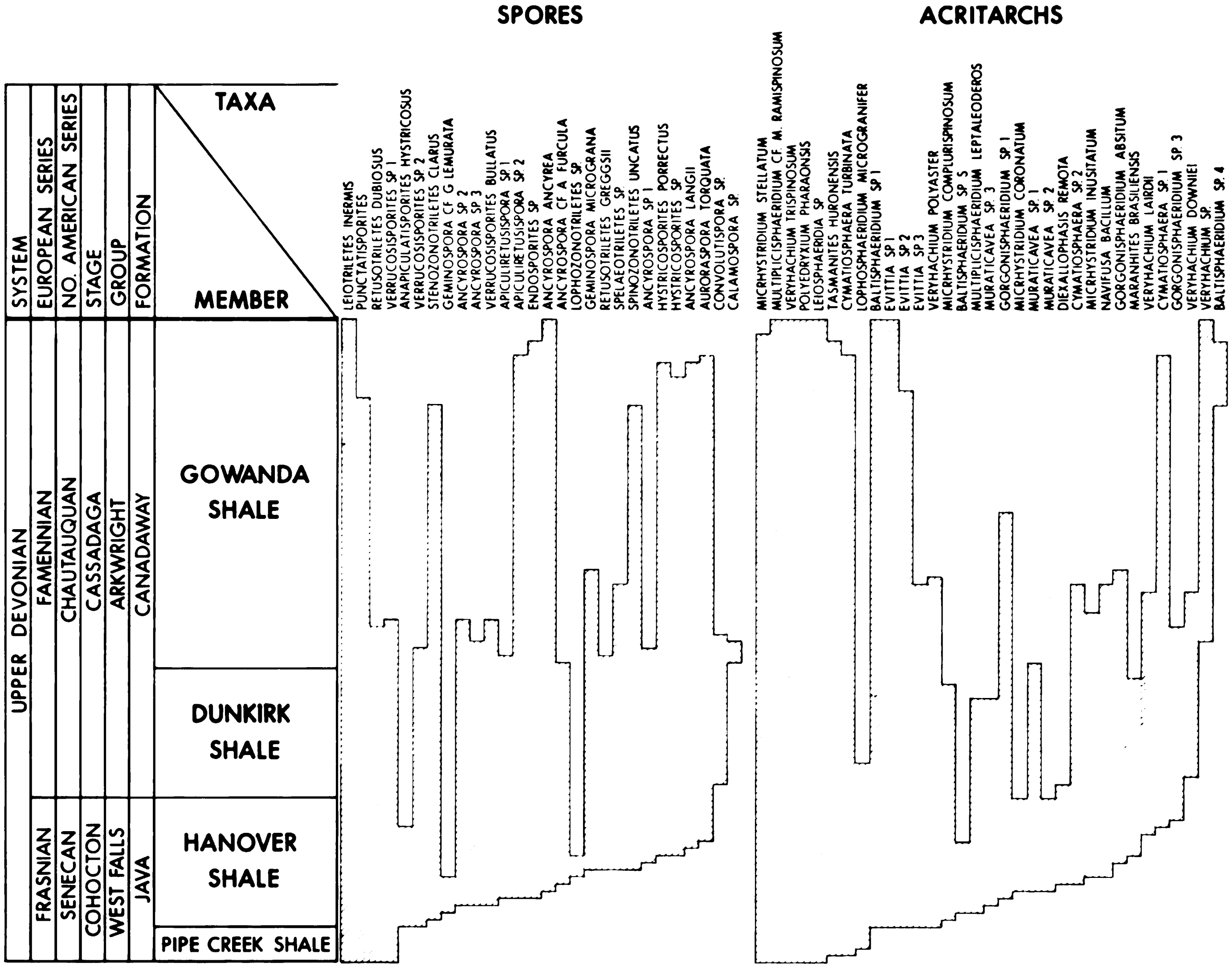

Table 5. Range of selected spores and acritarchs plotted by earliest occurrence including records from all localities.

reasons, correlation of this assemblage with others of similar age is difficult, or tenuous, at best, and the establishment of definitive palynomorph zones for biostratigraphic purposes is not possible at this time. The significance of the stratigraphic distribution of new species must be verified or determined by future studies.

The composite table showing the latest occurrences (Table 6) displays a significant break in early Gowanda, and another break in the late Gowanda. These also require further consideration of the three points mentioned above.

The lower Gowanda break is marked by spores (*Spelaeotriletes* sp., *Verrucosisporites* sp. 1, *Ancyrospora* sp. 2, *Convolutispora* sp., *Ancyrospora* sp. 3, *Calamospora* sp., *Ancyrospora* sp. 1, *Verrucosisporites* sp. 2, *Apiculiretusispora* sp. 1) and acritarchs (*Evittia* sp. 3, *Cymatiosphaera* sp. 2, *Gorgonisphaeridium* sp. 3, *Cymatiosphaera* sp. 1) that are new or could not be determined to the species level. The spores (*Geminospora micrograna*, *Verrucosisporites bullatus*, *Retusotriletes dubiosus*, *Retusotriletes greggsii*, and *Ancyrospora* cf. *A. furcula*, and the acritarchs *Veryhachium polyaster* and *Micrhystridium inusitatum*, with few exceptions (*Gorgonisphaeridium absitum*, *Navifusa bacillum*, *Veryhachium downiei*, *Veryhachium lairdii*) have comparable stratigraphic ranges recorded in other studies.

The upper Gowanda break in ranges of palynomorphs is not conclusive. The spores which show range terminations here are either new forms or those not assignable to species rank (*Endosporites* sp., *Apiculiretusispora* sp. 2, *Hystricosporites* sp., *Punctatisporites* sp.) or forms known to range into younger sediments elsewhere (Auroraspora torquata, Ancyrospora langii, Hystricosporites porrectus, Spinozonotriletes uncatus). The acritarchs terminating at this interval are either new forms (Baltisphaeridium sp. 4, Evittia sp. 2) or are known to occur in younger sediments (Micrhystridium stellatum, Tasmanites huronensis). Cymatiosphaera turbinata has been previously reported only from Senecan sediments (Wicander and Loeblich, 1977). This occurrence in the lower Chautauquan sediments marks an extention of its previously reported stratigraphic range.

The relatively rapid appearance in spore types during Hanover Shale deposition (Table 4) may indicate an increase in the species diversity in "source" plant communities possibly initiated by gradual environmental amelioration (e.g., in climate, edaphic characters, etc.) and/or decreasing distance between deltaic debouchment sites and the study area due to active progradation. The increase in acritarch species probably represents improvement of ecological and environmental conditions (i.e., increase in nutrient input, salinity, etc.) in the Hanover sea. The gradual attrition in the diversity of both spores and acritarchs (Table 5), particularly in the lower Gowanda Shale, may be indicative of a progressive deterioration of various environmental conditions (i.e., climate, local and regional land-sea ratios, etc.) which adversely affected both terrestrial and marine communities.

COMPARISON WITH OTHER ASSEMBLAGES

Spores

The generic similarities between selected Upper Devonian spores and acritarchs from New York and those reported in Upper Devonian spore and acritarch suites is summarized in Table 6. However, this is a generalized comparison owing, in part, to the comparatively poor preservation of the New York assemblage and the lack of well-illustrated Upper Frasnian/Lower Famennian spore assemblages from North America.

The Frasnian assemblages studied by Curry (1973, 1975) from the eastern United States and by Taugourdeau-Lantz (1971) from France, list 13 genera which are found to be in common with those identified in the present study. The Canadian assemblages reported by Owens (1971) and Brideaux and Radforth (1970) have 12 and 5 genera in common, respectively. Von Almen's study of samples from Oklahoma (1970 a,b) has 9 genera found here. The Australian assemblage described by Balme and Hassell (1962) also has 9 common genera. The Givetian/Frasnian spores of Spitsbergen (Vigran, 1964) has 8 genera which occur in both areas.

The Frasnian/Famennian assemblages from Canada (McGregor and Owens, 1966) and Libya (Massa and Moreau-Benoit, 1976) have 13 and 12 mutually occurring genera, respectively, and spores from Ghana reported by Bar and Reigel (1974) has 10 in common.

Eames' study of Upper Devonian/Carboniferous spores from Ohio (1974) shows an assemblage which is quite comparable to the western New York Upper Devonian assemblage. Twenty genera occur mutually. Floras

GENERA FROM THIS STUDY	UNITED STATES				CANADA			EUROPE				AFRICA		AUSTRALIA
	CURRY 1973, 1975 (MARYLAND, VA., WEST VIRGINIA)	EAMES, 1974 (OHIO)	WINSLOW, 1962 (OHIO)	VON ALMEN, 1970a,b (OKLAHOMA)	BRIDEAUX AND RADFORTH, 1970	McGREGOR AND UYENO, 1966 (CANADIAN ARCTIC)	OWENS, 1971 (CANADIAN ARCTIC)	VIGRAN, 1964 (SPITSBERGEN)	HIGGS, 1975 (IRELAND)	TAUGOURDEAU-LANTZ, 1971 (FRANCE)	STREEL IN BECKER, ET AL., 1971 (BELGIUM)	MASSA AND MOREAU-BENOIT 1976 (ALGERIA)	BAR AND RIEGEL, 1974 (GHANA)	BALME AND HASSELL, 1962 (WESTERN AUSTRALIA)
ANAPICULATISPORITES	●	●	●	●	●			●		●	●			
ANCYROSPORA	●	●	●	●	●	●	●	●	●	●	●	●	●	
APICULIRETUSISPORA				●			●		●		●		●	
AURORASPORA		●					●		●		●	●	●	
BACULATISPORITES		●							●					
? BIHARISPORITES	●				●			●						
CALAMOSPORA	●	●	●		●	●			●	●	●	●		●
CONVOLUTISPORA	●	●	●			●	●	●	●			●		●
EMPHANISPORITES	●	●		●				●		●			●	
ENDOSPORITES		●	●							●				●
GEMINOSPORA	●	●	●	●		●	●		●	●	●		●	
GRANDISPORA		●				●	●		●	●		●	●	
HYSTRICOSPORITES	●	●	●		●	●	●	●	●	●	●	●		
HYMENOZONOTRILETES		●				●			●				●	●
LEIOTRILETES		●		●				●		●	●	●		●
LOPHOZONOTRILETES		●		●		●			●	●	●	●	●	
NIKITINISPORITES								●						
PUNCTATISPORITES	●	●	●	●		●	●	●	●	●	●			●
RETUSOTRILETES	●	●		●		●	●		●		●	●	●	●
SPELAEOTRILETES	●	●							●		●	●		
SPINOZONOTRILETES	●	●				●	●						●	
STENOZONOTRILETES		●				●	●			●		●		●
VERRUCOSISPORITES	●	●	●			●	●	●	●	●	●	●		●

Table 6. Comparisons between spore genera recorded in the present study and Upper Devonian assemblages from other geographic areas.

GENERA FROM THIS STUDY	UNITED STATES				CANADA			EUROPE					AFRICA		AUSTRALIA
	CURRY 1973, 1975 (MARYLAND, VA., WEST VIRGINIA)	EAMES, 1974 (OHIO)	WINSLOW, 1962 (OHIO)	VON ALMEN, 1970a,b (OKLAHOMA)	BRIDEAUX AND RADFORTH, 1970	McGREGOR AND UYENO, 1966 (CANADIAN) ARCTIC	OWENS, 1971 (CANADIAN) ARCTIC	VIGRAN, 1964 (SPITSBERGEN)	HIGGS, 1975 (IRELAND)	TAUGOURDEAU-LANTZ, 1971 (FRANCE)	STREEL IN BECKER, ET AL., 1971 (BELGIUM)	MASSA AND MOREAU-BENOIT 1976 (ALGERIA)	BAR AND RIEGEL, 1974 (GHANA)	BALME AND HASSELL, 1962 (WESTERN AUSTRALIA)
ANAPICULATISPORITES	●	●	●	●	●			●		●	●			
ANCYROSPORA	●	●	●	●	●	●	●	●	●	●	●	●	●	
APICULIRETUSISPORA				●			●		●		●		●	
AURORASPORA		●					●		●		●	●	●	
BACULATISPORITES		●							●					
? BIHARISPORITES	●				●			●						
CALAMOSPORA	●	●	●		●	●			●	●	●	●		●
CONVOLUTISPORA	●	●	●			●	●	●	●			●		●
EMPHANISPORITES	●	●		●				●		●			●	
ENDOSPORITES		●	●							●				●
GEMINOSPORA	●	●	●	●		●	●		●	●	●		●	
GRANDISPORA		●				●	●		●	●		●	●	
HYSTRICOSPORITES	●	●	●		●	●	●	●	●	●	●	●		
HYMENOZONOTRILETES		●				●			●				●	●
LEIOTRILETES		●		●				●		●	●	●		●
LOPHOZONOTRILETES		●		●		●			●	●	●	●	●	
NIKITINISPORITES								●						
PUNCTATISPORITES	●	●	●	●		●	●	●	●	●	●			●
RETUSOTRILETES	●	●		●		●	●		●		●	●	●	●
SPELAEOTRILETES	●	●							●		●	●		
SPINOZONOTRILETES	●	●				●	●						●	
STENOZONOTRILETES		●				●	●			●		●		●
VERRUCOSISPORITES	●	●	●			●	●	●	●	●	●	●		●

Table 6. Comparisons between spore genera recorded in the present study and Upper Devonian assemblages from other geographic areas.

GENERA FROM THIS STUDY	UNITED STATES				CANADA			EUROPE				AFRICA		AUSTRALIA
	CURRY 1973, 1975 (MARYLAND, VA., WEST VIRGINIA)	EAMES, 1974 (OHIO)	WINSLOW, 1962 (OHIO)	VON ALMEN, 1970a,b (OKLAHOMA)	BRIDEAUX AND RADFORTH, 1970	McGREGOR AND UYENO, 1966 (CANADIAN ARCTIC)	OWENS, 1971 (CANADIAN ARCTIC)	VIGRAN, 1964 (SPITSBERGEN)	HIGGS, 1975 (IRELAND)	TAUGOURDEAU-LANTZ, 1971 (FRANCE)	STREEL IN BECKER, ET AL., 1971 (BELGIUM)	MASSA AND MOREAU-BENOIT 1976 (ALGERIA)	BAR AND RIEGEL, 1974 (GHANA)	BALME AND HASSELL, 1962 (WESTERN AUSTRALIA)
ANAPICULATISPORITES	●	●	●	●	●			●		●	●			
ANCYROSPORA	●	●	●	●	●	●	●	●	●	●	●	●	●	
APICULIRETUSISPORA				●			●		●		●		●	
AURORASPORA		●					●		●		●	●	●	
BACULATISPORITES		●							●					
? BIHARISPORITES	●				●			●						
CALAMOSPORA	●	●	●		●	●			●	●	●	●		●
CONVOLUTISPORA	●	●	●			●	●	●	●			●		●
EMPHANISPORITES	●	●		●				●		●			●	
ENDOSPORITES		●	●							●				●
GEMINOSPORA	●	●	●	●		●	●		●	●	●		●	
GRANDISPORA		●				●	●		●	●		●	●	
HYSTRICOSPORITES	●	●	●		●	●	●	●	●	●	●	●		
HYMENOZONOTRILETES		●				●			●				●	●
LEIOTRILETES		●		●				●		●	●	●		●
LOPHOZONOTRILETES		●		●		●			●	●	●	●	●	
NIKITINISPORITES								●						
PUNCTATISPORITES	●	●	●	●		●	●	●	●	●	●			●
RETUSOTRILETES	●	●		●		●	●		●		●	●	●	●
SPELAEOTRILETES	●	●							●		●	●		
SPINOZONOTRILETES	●	●				●	●						●	
STENOZONOTRILETES		●				●	●			●		●		●
VERRUCOSISPORITES	●	●	●			●	●	●	●	●	●	●		●

Table 6. Comparisons between spore genera recorded in the present study and Upper Devonian assemblages from other geographic areas.

of similar age from Ohio (Winslow, 1962), Ireland (Higgs, 1976), and Belgium (Becker, et. al., 1974), have 9, 15, an 14 genera in common, respectively.

Although many genera are identified in common with those in other Upper Devonian studies (see review in Streel, 1974), these assemblages actually bear little resemblance to the western New York sections at the species level. The conspecific taxa recognized are usually long-ranging forms with little stratigraphic value.

The Frasnian assemblages from the eastern United States (Curry, 1973, 1975) have three species in common. These are *Ancyrospora ancyrea*, *Emphanisporites annulatus*, and *E. rotatus*. The Frasnian assemblage from Oklahoma (von Almen, 1970 a, b) have six in common (*Ancyrospora ancyrea*, *Emphanisporites annulatus*, *E. rotatus*, *Geminospora lemurata*, *Retusotriletes dubiosus* (= *R. dubius*), *R. greggsii*). Taugourdeau-Lantz (1971) reported three (*Ancyrospora langii*, *Hystricosporites porrectus*, *Verrucosisporites bullatus*) mutual occurrences from France. The Upper Devonian assemblage from eastern Quebec described by Brideaux and Radforth (1970), contains only two comparable forms, *Ancyrospora ancyrea* and *Spinozonotriletes uncatus*. The Canadian assemblage illustrated by Owens (1971) has two mutually occurring species: *Ancyrospora furcula* and *Retusotriletes dubiosus*.

The Frasnian/Famennian assemblages of Canada and Libya have few species in common with the present study. McGregor and Owens (1966) illustrate three similar species (*Emphanisporites rotatus*, *Retusotriletes greggsii*, *Geminospora lemurata*) from the Northwest Territories, Canada.

Ancyrospora furcula, A. langii, Geminospora lemurata, and Verrucosisporites bullatus have been reported from the Frasnian/Famennian of Libya (Massa and Moreau-Benoit, 1976). Emphanisporites annulatus is the only entity here identified as conspecific with palynomorphs of comparable age from Ghana (Bar and Riegel, 1974).

Although Eames' (1974) flora is very similar at the generic level, only 5 spores are conspecific. These are Leiotriletes inermis, Retusotriletes greggsii, Spinozonotriletes uncatus, Emphanisporites annulatus, and E. rotatus.

Only two European studies have reported similar species. Higgs (1976) lists only one species in common, Auroraspora torquata. At this time, A. torquata has been reported only from Ireland. Streel (in Becker, et. al., 1974) has reported five conspecific taxa from the Upper Devonian of Belgium; Leiotriletes inermis, Retusotriletes greggsii (= Aneurospora greggsii), Anapiculatisporites hystricosus, Ancyrospora ancyrea, and A. langii).

Acritarchs

The generic comparisons of the New York acritarchs and those reported in selected Upper Devonian acritarch studies are detailed in Table 7.

At the generic level, acritarchs are closely associated to other assemblages described from the United States. Eleven genera are also found in the Upper Devonian/Carboniferous sediments of Ohio (Wicander, 1974). Frasnian studies of Oklahoma (von Almen, 1970 a,b) and Indiana

		UNITED STATES			EUROPE	AFRICA
		WINCANDER, 1974 (OHIO)	WINCANDER AND LOEBLICH, 1977 (INDIANA)	VON ALMEN 1970a (OKLAHOMA)	STOCKMANS AND WILLIERE 1962a,b; 1969; 1974 (BELGIUM)	JARDINE, EL. AL., 1972 (ALGERIA)
SUBGROUP	ACANTHOMORPHITAE					
	BALTISPHAERIDIUM				●	
	DIEXALLOPHASIS	●				
	GORGONISPHAERIDIUM	●	●			●
	MICRHYSTRIDIUM	●	●		●	
	MULTIPLICISPHAERIDIUM	●	●	●		
	OZOTOBRACHION					
SUBGROUP	HERKOMORPHITAE					
	CYMATIOSPHAERA	●	●	●	●	
	MURATICAVEA	●				
SUBGROUP	NETROMORPHITAE					
	NAVIFUSA	●		●		●
SUBGROUP	POLYGONOMORPHITAE					
	ESTIASTRA	●				
	EVITTIA					
	VERYHACHIUM	●	●	●	●	●
SUBGROUP	PRISMATOMORPHITAE					
	POLYEDRYXIUM		●	●	●	●
SUBGROUP	SCUTELLOMORPHITAE					
	MARANHITES			●		●
SUBGROUP	SPHAEROMORPHITAE					
	LEIOSPHAERIDA	●		●		
	LOPHOSPHAERIDIUM		●			
SUBGROUP	TASMANITITAE					
	TASMANITES	●		●	●	

Table 7. Comparisons between acritarch genera recorded in the present study and Upper Devonian assemblages from geographic areas.

(Wicander and Loeblich, 1977) have 8 and 7 mutually occurring genera. The New York assemblage has little generic similarity with the acritarchs from the Sahara (Jardine, et al., 1974) or from Belgium (Stockmans and Williere, 1962 a,b; 1967).

At the species level, the Belgium acritarch palynoflora (Stockmans and Williere, 1962 a,b; 1967) exhibits the greatest similarity with six mutually occurring species (*Micrhystridium stellatum*, *M. coronatum*, *Polyedryxium pharaonsis* (= *Eisenackidium martensianum*), *Veryhachium downiei*, *V. lairdii*). Studies in Ohio (Wicander, 1974) and Indiana (Wicander and Loeblich, 1976) have five (*Estiastra rugosa*, *Gorgonisphaeridium absitum*, *Micrhystridium complurispinosum*, *M. insitatum*, *Navifusa bacillum* (= *Navifusa drosera*), and three (*Cymatiosphaera turbinata*, *Gorgonisphaeridium absitum*, *Micrhystridium coronatum*) comparable species, respectively. The assemblage described by von Almen (1970 a,b) has four conspecific taxa (*Multiplicisphaeridium ramispinosum*, *Veryhachium trispinosum*, *Maranhites brasiliensis*, *Tasmanites huronensis*), and the report by Jardine, et. al. (1974) has three (*Navifusa bacillum*, *Polyedryxium pharaonsis*, *Maranhites brasiliensis*).

Discussion

The lack of comparable spore species between southwestern New York and other regions may be the result of the geographic distance between these localities. Spore assemblages of similar age in Europe, Australia, Africa, and Canada could represent different floral complexes, whereas studies from the United States may depict regional differences in plant communities.

The dissimilarities exhibited between acritarch species from Europe, Africa, and the United States may be related to the distribution of seaways existing during the Upper Devonian. The interconnection of seaways would serve as inroads for the mixing of individual phytoplankton components on both a local or regional scale.

The type of lithofacies would also be a factor. The diversity and abundance of palynomorphs is closely associated to grain size and distance from shoreline (see Christopher, 1977); hence, comparing a shale to a fine-grained sandstone would quite possibly result in markedly different assemblages. Comparisons of two gray shales, one of which is slightly silty, may also yield dissimilar palynological suites (note discussion in section on Paleoenvironmental Interpretations).

Lastly, some taxonomic differences between these studies may result from introduction of new forms. This necessitates the emendation or redescription of taxa described in older published studies. Perhaps, a restudy of type materials, and reassignment of some taxa to their proper systematic position in the present classification system would effect the degree of comparability.

PALEOENVIRONMENTAL INTERPRETATIONS

Introduction

Palynological abundance percentages of samples from the Walnut Creek (locality 10), south branch of Eighteenmile Creek (locality 12), and Cazenovia Creek I (locality 15) sections are displayed as histograms in Tables 8, 9, and 10, respectively. These localities were used in abundance counts because they represent the most complete sections from the localities investigated. Palynomorphs were divided into four morphological groups: microspores, anchor-tipped spores (*Ancyrospora*, *Hystricosporites*, *Nikitinisporites*), acritarchs with processes and/or membranes (Acanthomorphitae, Herkomorphitae, Netromorphitae, Polygonomorphitae, Prismatomorphitae), and Scutellomorphitae/Sphaeromorphitae/Tasmanititae. Structured plant detritus (i.e., cuticle and wood, see Pl. 5, fig. 3) was also recorded in qualitative terms (e.g., very abundant, abundant, common, rare, and none). In all cases, the palynomorphs from one complete slide were counted. Unidentifiable fragments were not included in the count.

Locality 10, Walnut Creek (Table 8). The Pipe Creek Shale contains high percentages of Scutellomorphitae/Sphaeromorphitae/Tasmanititae, and subordinate amounts of microspores and ornamented and/or membranous acritarchs. Palynomorphs isolated from this member were poorly preserved, and two of four samples were barren. The black shale of the Pipe Creek Shale member, as with all other black shales in this study, contains abundant amorphous organic debris.

WALNUT CREEK (LOCALITY 10)

Unit	FOOTAGES	MACERATION NUMBER	LITHOLOGY*	STRUCTURED PLANT DETRITUS**
GOWANDA SHALE	255'10" - 256' 8"	Pb10896	GS	A
	234' - 235'	Pb10895	GS	C
	215' - 216'	Pb10894	GS	C
	192' - 193'	Pb10893	GS	A
	184' - 185'	Pb10892	BS	C
	160' - 161'	Pb10891	CS	R
	142' - 143'	Pb10890	GS / BS	
	113' - 113' 7"	Pb10889	GS	VA
	112' 9" - 113' 1"	Pb10888	CS	C
	100' 4" - 101'	Pb10887	BS	R
	79' 8" - 80' 6"	Pb10886	GS / BS	R
	77' 11" - 78' 7"	Pb10885	BS	R
	76' - 76' 8"	Pb10884	BS	C
	74' - 75'	Pb10883	GS	A
	73' - 73' 8"	Pb10882	BS	R
	60' - 61'	Pb10881	GS	VA
	51' - 52'	Pb10880	BS	R
	41' - 42'	Pb10879	CS	VA
	35' - 35' 6"	Pb10878	BS	R
	34' - 35'	Pb10877	GS	VA
	31' - 32' 4"	Pb10876	CS	VA
	29' - 29' 8"	Pb10875	GS	R
	19' - 19' 6"	Pb10874	GS / BS	A
	18' - 18' 6"	Pb10873	CS	
	16' 6" - 17'	Pb10872	GS / BS	C
	15' - 15' 6"	Pb10871	GS BS	C
	12' - 13'	Pb10870	BS	C
	11' - 12'	Pb10869	BS/GS	C
	2' - 3'	Pb10868	GS	C
	0 - 5"	Pb10867	CS	C
DUNKIRK SHALE	68' - 68' 7"	Pb10866	BS	A
	65' - 66'	Pb10865	GS	A
	62' - 63'	Pb10864	BS	R
	57' - 58'	Pb10863	BS	R
	55' 6" - 57'	Pb10862	GS	C
	54' - 55'	Pb10861	BS	R
	52' 6" - 53' 3"	Pb10860	GS	A
	51' - 52'	Pb10859	GS / BS	C
	48' - 49'	Pb10858	GS / BS	C
	40' - 41'	Pb10857	GS / BS	A
	34' - 34' 6"	Pb10856	BS	C
	25' - 25' 6"	Pb10855	BS	R
	10' - 11'	Pb10854	GS / BS	C
	6' - 6' 6"	Pb10853	BS	R
	4' - 4' 6"	Pb10852	BS	R
	2' - 2' 8"	Pb10851	BS	C
	1' - 1' 6"	Pb10850	GS / BS	A
	0 - 6"	Pb10849	BS	R
HANOVER SHALE	72' 4" - 72' 10"	Pb10848	GS	VA
	70' 10" - 71' 7"	Pb10847	GS	A
	69' - 69' 6"	Pb10846	CS	C
	67' 5" - 68'	Pb10845	LS CO	
	65' 1" - 65' 8"	Pb10844	GS	A
	64' 4" - 65' 1"	Pb10843	CS	
	63' 7" - 64' 4"	Pb10842	GS	A
	55' 11" - 56' 4"	Pb10841	CS	
	55' 2" - 55' 11"	Pb10840	GS	C
	47' 1" - 47' 8"	Pb10839	BS	R
	46' - 46' 6"	Pb10838	GS	A
	44' 6" - 45' 2"	Pb10837	BS	R
	43' 4" - 44' 6"	Pb10836	GS	C
	32' - 33' 6"	Pb10835	BS	R
	26' 6" - 27'	Pb10834	GS	
	25' 4" - 25' 11"	Pb10833	GS / BS	VA
	21' - 21' 6"	Pb11324	GS	C
	19' 6" - 20'	Pb10832	GS	C
	12' 6" - 13'	Pb10825	BS	R
	11' - 11' 6"	Pb10824	CS	A
	9' - 9' 6"	Pb10823	BS	R
	8' - 8' 10"	Pb10822	GS	C
	7' 6" - 8'	Pb11325	GS	VA
	6' 7" - 7' 4"	Pb11326	GS	C
	6' 2" - 6' 7"	Pb10821	LS CO	
	5' - 5' 6"	Pb11327	BS	R
	3' - 3' 6"	Pb11328	GS	VA
	2' - 2' 6"	Pb10820	GS	A
	0 - 1' 6"	Pb10819	GS	A
PIPE CREEK SHALE	4' 8" - 5' 5"	Pb10818	BS	
	3' 2" - 3' 8"	Pb10817	BS	
	1' 6" - 2'	Pb10816	BS	
	0 - 6"	Pb10815	BS	

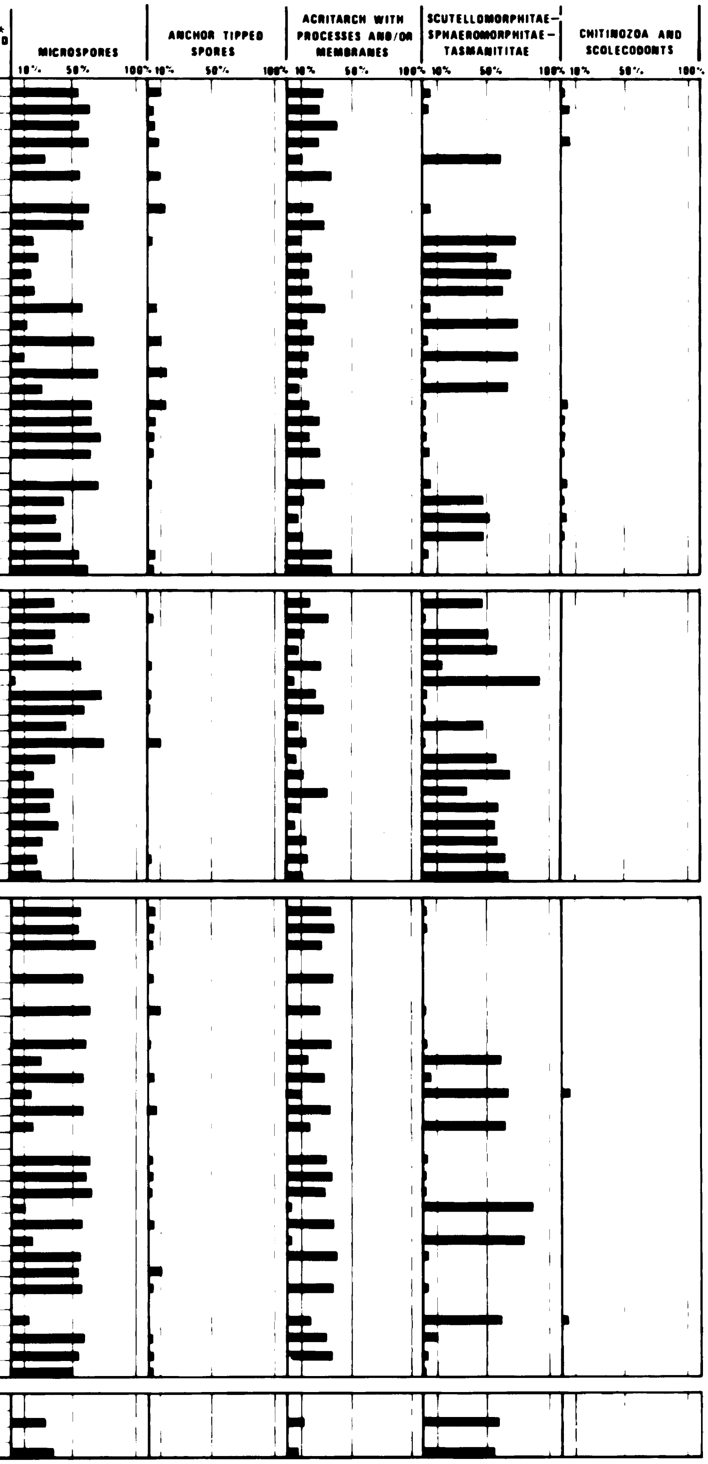

Table 8. Histograms showing relative frequency from the Walnut Creek section (locality 10), Chautauqua County, New York (samples lacking histograms were barren).

*LITHOLOGY

GS = gray shale
BS = black shale
GS/BS = gray/black shale
CS = calcareous siltstone
LS. CO. = limestone concretion

**STRUCTURED PLANT DETRITUS

R = rare
C = common
A = abundant
VA = very abundant

The gray shales and calcareous siltstones of the Hanover are dominated by microspores, anchor-tipped spores, and acritarchs possessing processes and/or membranes. Anchor-tipped spores were accompanied by common to very abundant structured plant detritus and were absent in black shales. Scutellomorphitae/Sphaeromorphitae/Tasmanititae dominated the black shales, but never exceeded 12% of the total assemblage in gray shales or calcarous siltstones. Five samples of the Hanover from this locality were barren.

The Dunkirk, essentially a black shale, contains abundant Scutellomorphitae/Sphaeromorphitae/Tasmanititae. All black shale samples were dominated by this assemblage, and all samples contained components of this group. The predominate constituents of gray shales and two black shales (Pb 10859, Pb 10857) were microspores, and lesser amounts of anchor-tipped spores, and ornate-membraneous acritarchs. Four of the six samples containing anchor-tipped spores (Pb's 10865, 10860, 10857, 10850) possess abundant structured plant detritus. Two gray-black shales (Pb's 10858, 10850) had a higher percentage of Scutellomorphitae/Sphaeromorphitae/Tasmanititae than microspores.

The Gowanda Shale contains essentially the same litho-palynological relation typified by the Hanover and Dunkirk shales. The gray shales and calcareous siltstones of the Gowanda are dominated by microspores, anchor-tipped spores, and acritarchs possessing processes and/or membranes. Scutellomorphitae/Sphaeromorphitae/Tasmanititae never exceed 8% of the total assemblage in these lithologies. In contrast, the black shales are dominated by Scutellomorphitae/Sphaeromorphitae/Tasmanititae, with amounts ranging from 48% (Pb 10869) to 89% (Pb 10882). This group also comprised the major constituents of two gray-black shales (Pb 10871, Pb 10886). Anchor-tipped spores were present in gray shales, calcareous siltstones, and two gray-black shales. Nine of the samples bearing anchor-tipped spores contained abundant to very abundant structured plant detritus.

Locality 12, South Branch of Eighteenmile Creek (Table 12). The productive Pipe Creek Shale samples contained Scutellomorphitae/Sphaeromorphitae/Tasmanititae in abundance. The remainder of these assemblages were composed of microspores and acritarchs with processes and/or membranes.

The three black shale samples from the Hanover Shale (Pb's 11261, 11266, 11269) are dominated by Scutellomorphitae/Sphaeromorphitae/Tasmanititae assemblages. Microspores, acritarchs with processes and/or membranes, and anchor-tipped spores were the major plant constituents in the gray shales. Nine samples contained anchor-tipped spores (Pb's 11259, 11260, 11262, 11263, 11264, 11265, 11267, 11268, 11270) and all incorporated abundant to very abundant plant detritus with structure preserved. The gray shales of this section also contained the calcium carbonate-iron pyrite petrifactions identified as Callixylon sp. 1 (Plate 2, fig. 1) and Callixylon sp. 2 (Plate 3, fig. 3). Numerous coalified plant impressions (Plate 5, figs. 4-5) of unknown taxonomic affinity were found in the black shales.

All samples of the Dunkirk Shale, except one (Pb 11253) contained Scutellomorphitae/Sphaeromorphitae/Tasmanititae. This group also dominated all black shale lithologies. The two gray shales (Pb's 11253,

SOUTH BRANCH OF EIGHTEENMILE CREEK (LOCALITY 12)

	FOOTAGES	MACERATION NUMBER	LITHOLOGY *	STRUCTURED PLANT DETRITUS **
GOWANDA SHALE	86' - 86' 4"	Pb 11274	CS	
	85' - 86'	Pb 11275	GS	A
	71' - 72'	Pb 11276	GS	A
	61' - 61' 10"	Pb 11277	BS	R
	50' 9" - 51'	Pb 11278	GS	A
	40' - 40' 6"	Pb 11279	GS	A
	29' 6" - 29' 10"	Pb 11280	GS	C
	29' 3" - 29' 6"	Pb 11281	CS	
	23' 6" - 24' 6"	Pb 11282	CS	
	21' - 21' 6"	Pb 11283	GS	C
	4' 9" - 5' 6"	Pb 11284	GS	A
	4' 6" - 4' 9"	Pb 11285	GS	VA
	0 - 10"	Pb 11286	CS	C
DUNKIRK SHALE	81' 5" - 82'	Pb 11248	GS	C
	72' - 72' 8"	Pb 11249	BS	A
	39' 4" - 39' 10"	Pb 11250	BS / GS	C
	35' 6" - 36"	Pb 11251	BS / GS	C
	32' 9" - 33' 3"	Pb 11252	BS	C
	32' - 32' 9"	Pb 11253	GS	A
	31' 8" - 32'	Pb 11254	BS	C
	19' 8" - 20' 4"	Pb 11255	GS / BS	VA
	11' 6" - 12"	Pb 11256	BS	R
	10' 6" - 11'	Pb 11257	BS	R
	0 - 8"	Pb 11258	BS	C
HANOVER SHALE	70' - 70' 8"	Pb 11259	GS	VA
	65' 6" - 66"	Pb 11260	GS	A
	62' - 63'	Pb 11261	BS / GS	C
	59' 6" - 60'	Pb 11262	GS	VA
	49' 6" - 50'	Pb 11263	GS	A
	40' - 40' 6"	Pb 11264	GS	VA
	30' 9" - 31'	Pb 11265	GS	VA
	23' 8" - 24' 3"	Pb 11266	BS	R
	22' 6" - 22' 9"	Pb 11267	GS	A
	20' - 20' 6"	Pb 11268	GS	A
	10' - 10' 6"	Pb 11269	BS	A
	0 - 6"	Pb 11270	GS	A
PIPE CREEK SHALE	6' - 6' 6"	Pb 11271	BS	R
	3' - 3' 6"	Pb 11272	BS	
	0 - 4"	Pb 11273	BS	R

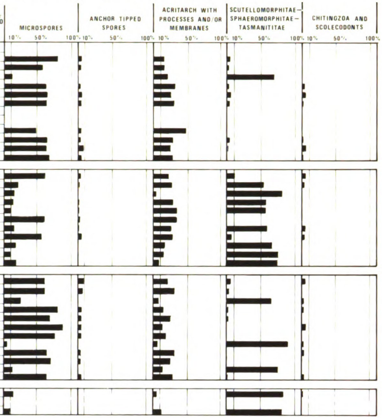

Table 9. Histograms showing relative palynomorph frequency from the south branch of Eighteenmile Creek section (locality 12) Erie County, New York (samples lacking histograms were barren).

*LITHOLOGY

GS = gray shale
BS = black shale
GS/BS = gray/black shale
CS = calcareous siltstone

**STRUCTURED PLANT DETRITUS

R = rare
C = common
A = abundant
VA = very abundant

11248) and the gray-black shale (Pb 11255) had the highest percentages of microspores, anchor-tipped spores. These three samples also had abundant to very abundant structured plant detritus. Four black shale samples (Pb's 11249, 11251, 11252, 11254) contained minor percentages of anchor-tipped spores.

Only one sample from the Gowanda Shale, a black shale (Pb 11277), was dominated by Scutellomorphitae/Sphaeromorphitae/Tasmanititae. The gray shales and calcareous siltstones are composed predominantly of microspores and acritarchs with processes and/or membranes. Minor amounts of anchor-tipped spores occurred in the productive samples except one (Pb 11277, a black shale). Six of the anchor-tipped spore-bearing samples (Pb's 11275, 11276, 11278, 11279, 11284, 11285) had abundant to very abundant structured plant detritus.

Locality 15, Cazenovia Creek I (Table 10). The five productive black shale samples of the Pipe Creek Shale contained high percentages of Scutellomorphitae/Sphaeromorphitae/Tasmanititae. As in all other black shales from this study, all residues contained large amounts of structureless amorphous organic detritus. Microspores and acritarchs with processes and/or membranes are minor constituents in these samples and no anchor-tipped spores were found.

The gray-black shale (Pb 10780) and a black shale (Pb 10796) from the Hanover were the only samples composed primarily of Scutellomorphitae/Sphaeromorphitae/Tasmanititae. Microspores and spinose and/or membranous acritarchs were the major constituents of all remaining samples. Seven samples (Pb's 10773, 10777, 10778, 10781, 10782, 10787, 10788) contained

CAZENOVIA CREEK I (LOCALITY 15)

	FOOTAGES	MACERATION NUMBER	LITHOLOGY *	STRUCTURED PLANT DETRITUS **
GOWANDA SHALE	39' – 39' 6"	Pb 10814	GS/ BS	R
	36' 6" – 37'	Pb 10813	GS/ BS	C
	31' – 31' 6"	Pb 10812	CS	C
	28' – 28' 6"	Pb 10811	BS	C
	19' 6" – 20'	Pb 10810	GS	A
	12' – 12' 6"	Pb 10809	CS	C
	10' – 10' 6"	Pb 10808	GS	A
	9' 6" – 10'	Pb 10807	BS	R
	1' – 1' 6"	Pb 10806	GS	R
	0 – 8"	Pb 10805	CS	
DUNKIRK SHALE	53' 8" – 54' 2"	Pb 10804	BS	R
	51' – 51' 6"	Pb 10803	BS	R
	49' – 49' 6"	Pb 10802	BS	R
	48' – 48' 6"	Pb 10801	BS	R
	28' 6" – 29'	Pb 10800	LS CO	
	28' – 28' 6"	Pb 10799	GS	
	27' – 27' 6"	Pb 10798	LS. CO.	C
	18' 6" – 19'	Pb 10797	BS	R
	15' – 15' 6"	Pb 10796	BS	R
	13' 4" – 13' 11"	Pb 10795	GS	A
	11' – 11' 8"	Pb 10794	CS	
	10' 6" – 11'	Pb 10793	GS	A
	9' – 9' 6"	Pb 10792	BS	R
	6' – 6' 6"	Pb 10791	GS	C
	3' – 3' 6"	Pb 10790	BS	R
	0 – 1' 2"	Pb 10789	GS / BS	C
HANOVER SHALE	56' – 56' 7"	Pb 10788	CS	A
	55' 6" – 56'	Pb 10787	GS	A
	54' 6" – 55'	Pb 10786	BS	R
	53' – 53' 7"	Pb 10785	CS	C
	52' – 53'	Pb 10784	GS	
	50' 8" – 51' 2"	Pb 10783	CS	
	49' 11" – 50' 7"	Pb 10782	GS	A
	48' – 48' 6"	Pb 10781	GS	A
	37' – 37' 8"	Pb 10780	GS / BS	C
	29' 5" – 30'	Pb 10779	GS	
	18' 6" – 19'	Pb 10778	GS	A
	16' 6" – 17'	Pb 10777	GS	C
	14' 4" – 15'	Pb 10776	LS. CO.	
	6' 6" – 7'	Pb 10775	GS	
	5' 6" – 6'	Pb 10774	GS	A
	0 – 8"	Pb 10773	GS	A
PIPE CREEK SHALE	23' 8" – 24' 4"	Pb 10772	BS	
	19' 6" – 20'	Pb 10771	BS	C
	15' – 15' 6"	Pb 10770	BS	C
	10' – 10' 6"	Pb 10769	BS	R
	4' – 4' 8"	Pb 10768	BS	C
	2' – 2' 6"	Pb 10913	BS	
	0 – 6"	Pb 10912	BS	C

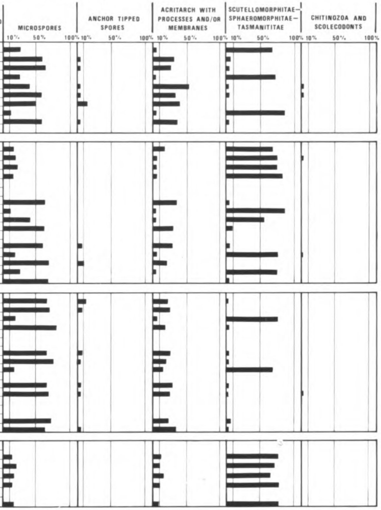

Table 10. Histograms showing relative palynomorph frequency from the Cazenovia Creek I section (locality 15), Erie , County , New York (samples lacking histograms were barren) .

* LITHOLOGY

GS = gray shale

BS = black shale

GS/BS = gray/black shale

CS = calcareous siltstone

** STRUCTURED PLANT DETRITUS

R = rare

C = common

A = abundant

anchor-tipped spores (10% in Pb 10788) and six of these had abundant structured plant detritus.

All productive samples, except Pb 10791, from the Dunkirk Shale contained Scutellomorphitae/Sphaeromorphitae/Tasmanititae, and all black shales were dominated by this group. Anchor-tipped spores were recovered from two gray shales (Pb 10791, 10793).

In the Gowanda Shale, only Pb 10814 (a gray-black shale) and Pb's 10807 and 10811 (black shales) contained large numbers of Scutellomorphitae/Sphaeromorphitae/Tasmanititae. The gray-black shale (Pb 10813) and all productive gray shales (except Pb 10810) and calcareous siltstones were dominated by microspores. Sample Pb 10810 was the only sample in this study whose assemblage was dominated by acritarch with processes and/or membranes.

Results

The following results can be abstracted with respect to the above analyses: (1) Gray shales and calcareous siltstones are dominated by microspores, (2) the major constituent palynomorphs of the black shales are Scutellomorphitae/Sphaeromorphitae/Tasmanititae, (3) structured plant debris is usually found in gray shales and calcareous siltstones, whereas black shale residues were often characterized by amorphous organic matter, (4) common to very abundant structured plant detritus was associated with anchor-tipped spores (except for sample Pb 10891), (5) anchor-tipped spores are generally absent from all black shale samples except Pb's 10887, 11249, 11251, 11252, and 11254 where this group is of minor importance (less than 3%), (6) acritarchs with processes and/or membranes comprise less than 17% of the assemblages which contain more than 60% Scutellomorphitae/Sphaeromorphitae/Tasmanititae, and (7) all gray shales contain acritarchs with processes and/or membranes in percentages of 22% or greater.

Discussion and Conclusions

The dissimination of spores and pollen into marine environments is initiated by the wind; however, water undoubtly flushes large numbers of terrestrial palynomorphs from land areas to streams and subsequently to standing bodies of water (Christopher, 1977; Cross, et al., 1967; Darrell and Hart, 1970; Koreneva, 1964 a,b; Muller, 1959; Rossignol, 1961; Traverse and Ginsburg, 1966, 1967). As "organic particles" in an aqueous medium, pollen and spores obey the same physical laws of sedimentation as the allochthonous inorganic constituents. Christopher (1977) and Cross, et al. (1967) have shown that changes in diversity and abundance of terrestrial palynomorphs are negligible within the clay and silt-size range, but as grain size increases into the sand-size range diversity and abundance decreases appreciably. Megaspores occur in nearshore habitats (Chi and Hills, 1974, 1976 a,b; Hills, et al., 1971, 1975), and may be associated with abundant plant detritus (Batten, 1969, 1972, 1975). Palynomorphs indigenous to the depositional basin (i.e., acritarchs) also behave as detrital particles. Terrestrial/microplankton ratios have been used to interpret distance from the shore line (Sarmiento, 1957; Upshaw, 1964; Smith and Saunders, 1970), and transgressive/regressive cycles (Upshaw, 1964; von Almen, 1970a). Staplin (1961) recognized three environmental patterns with respect to reef trends. Based on morphology and abundance, he found that (1) spherical, smooth, and papillate forms (Sphaeromorphitae, Tasmanititae) occurred in all facies but increase in abundance and number of species away from reef areas; (2) thin spined forms (Acanthomorphitae) were generally found to occur at least one mile from the reefs; and (3) thick-spined and polyhedral species (Acanthomorphitae, Polygonomorphitae, and Herkomorphitae) were not found within four or more miles from the reef trend. Von Almen (1970) also found that Sphaeromorphitae/ Tasmanititae are most abundant in offshore areas, whereas acritarchs with processes and/or membranes are more abundant in nearshore regions. Acritarchs, however, present a problem in that they are of unknown affinity, and may represent the cysts of microplankton. For example, the major factor of dinoflagellate cyst distribution in modern sediments has been interpreted as mainly a function of the distribution of the parental dinoflagellates whose habitats were indirectly determined by a complex suite of ecological factors (Hulburt, 1966; Hulburt and Corwin, 1969; Hulburt and Rodman, 1963; Wall, et al, 1977; Williams, 1971; Williams and Sarjeant, 1967). The land derived palynomorphs may also reflect, to varying degrees, the initial amount of spores and pollen released by the parent plant. The dispersal of these palynomorphs can be influenced by such factors as proximity to river mouth, water currents, and water turbulence, and the final assemblage may also be modified, to some extent, by biological interception and/or decay and taphonomic considerations (see Cross, 1964; Tables 5, 6, and 7 for an extensive summary).

In deltaic environments, a major characteristic is the vertical and lateral fluctuation of environmentally controlled facies. A shift in a point source of sediment supply would result in the deltaic abandonment of a given site and the initiation of sediment to a new point source (Coleman and Gagliano, 1964; Frazier, 1967; Morgan, 1970). The sediment deprived area undergoes coastal retreat and inundation if subsidence continues. The interplay of distributary avulsion, and other extrinsic factors (e.g., climate, nutrient input, seasonal floods, etc.) would also influence the temporal and spatial distribution of nearshore plant communities (Drury and Nisbet, 1973) and plant detritus to the depositional basin. Changes would be reflected in both lithology and the terrestrially derived components of the palynological assemblage at a particular site. Rather rapid fluctuations would result in vertical interbedding of lithologies on the shelf as exhibited by the Hanover and Gowanda members. Extended periods of deltaic stagnation or marine transgression would result in the development of anoxic bottom conditions. This would produce black shale sequences on a regional area, such as exhibited in the Pipe Creek and Hanover Shales.

When palynological group abundance results from southwestern New York are coupled with the above geological and sedimentological framework, an interesting pattern emerges. The marine shelf environments nearest the point of deltaic debouchment (represented by calcareous siltstones and gray shales) are dominated by terrestrial taxa and acritarchs with processed and/or membranes, and those areas not in the course of deltaic sedimentation or further offshore (represented by black shales) are dominated by Scutellomorphitae/Sphaeromorphitae/

Tasmanititae. Anchor-tipped spores and structured plant detritus are most abundant in gray shales and calcareous siltstones. Anchor-tipped spores constituted very minor portions (less than 3%) of five black shales; however, these samples were of a silty nature indicating rather brief periods of course sediment influx from a distributary of the delta. In all cases, there is a qualitative decrease in microspores, anchor-tipped spores, and acritarchs with processes and/or membranes with a decreased deltaic influence or increased distance from shore. Conversely, there is a qualitative increase in Scutellomorphitae/ Sphaeromorphitae/Tasmanititae, indicating large bays or open sea.

The dynamics of a deltaic regime may also suppress or accentuate the influence of nearshore land plant components particularly in respect to individual ecological tolerances or stresses. This factor may be responsible for the differences in the occurrences and stratigraphic ranges of terrestrial palynomorphs between the Walnut Creek, south branch of Eighteeenmile Creek, and Cazenovia Creek I sections (note Tables 1, 2, and 3). The geographical distances between these localities and the taxonomic differences in source communities would result in differences in palynomorph occurrences and continuity of stratigraphic ranges. The major factors controlling the distribution of acritarchs are the depth, turbulence, current direction, salinity and nutrient levels of the water, all of which are intimately associated with the deltaic complex. Further dissimilarities would result in the destruction of palynomorphs by biological, chemical, or physical means.

Plant macrofossils are most abundant in gray shales. Leaves, fine stems, and other delicate tissues were not observed at any locality.

Black shales often contain coalified plant compressions.

Palynological residues of the calcareous siltstones and gray shales of the strata studied often contained large amounts of plant detritus with recognizable tissue structure and cell morphology (i.e., cuticle and tracheid material). Palynological residues of the black shales studied here also usually contain massive quantities of unorganized amorphous organic detritus. Burgess (1974) and Staplin (1977) attribute this type of amorphous debris to the bacterial degradation of organic remains (non-calcareous algae, fungi, terrestrial plant detritus) in a stagnant, anaerobic bottom environment. Bacteria attack cellulosic and cuticular structures ultimately converting them to an amorphous mass of unstructured material. The sulfurous reduction of these remains by anaerobic bacteria is probably indirectly responsible for the large amounts of sulfur (in the form of iron pyrite) present in these black shales (Haeckel, 1972; Burgess, 1974). Mass mortalities following phytoplankton blooms may also contribute to the substrate of decaying organic material. The anoxic bottom environment precludes a rich, if any, benthonic invertebrate community. This is further evidenced by the lack of trace fossils in the black shales. However, overlying waters may have had a full complement of pelagic life, although remains of animals from this habitat were absent.

The recurrence of Scutellomorphitae/Sphaeromorphitae/Tasmanititae in the transgressive black shale lithology typifies bonded species groupings (Valentine and Moore, 1965; Brideaux, 1971; Wall, et al., 1977). The components of this group (*Leiosphaeridia* sp., *Lophosphaeridium microgranifer*, *Tasmanites huronensis*, *Maranhites brasiliensis*) qualitatively dominate all black shales sampled. This recurrent association is believed to reflect a once extant marine phytoplankton community rather than a product of sedimentological dynamics (i.e., current sorting, water turbulence). These microplankton were apparently restricted to this environment. Their presence in nearshore lithologies suggests they were rare or only occasionally present in such environments. Similarly, the occurrence of acritarchs with processes and/or membranes in Scutellomorphitae/Sphaeromorphitae/Tasmanititae may be a function of hydrographic mixing allowing the interchange of respective ecological components. Wall, et al. (1977) note that the overall composition of many recurrent dinoflagellate cyst assemblages involves a combination of a few species with restricted environmental occurrences together with one or more cosmopolitan elements.

The following conclusions can be drawn concerning the paleoenvironmental analysis of the Java and lowermost Canadaway formations:

1. The final palynological assemblage is extensively controlled by the sedimentological and depositional factors related to facies oscillations in a deltaic environment.

2. The nearshore, deltaic dominated environments (represented by calcareous siltstones and gray shales) are dominated by microspores with spinose/membraneous acritarchs and with anchor-tipped spores as minor components.

3. Anchor-tipped spores and abundant vascular plant detritus are common in calcareous deposits and gray shales.

4. Microspores, anchor-tipped spores, and acritarchs with processes and/or membranes decrease in abundance with a concommittant increase in

distance from shore (as evidenced by lithology).

5. Fluctuations in the distribution of nearshore plant communities and facies oscillations are probably responsible for the differences in the occurrences and continuity of stratigraphic ranges of spores between the Walnut Creek, south branch of Eighteenmile Creek, and Cazenovia Creek I localities.

6. Scutellomorphitae/Sphaeromorphitae/Tasmanititae (*Leiosphaeridia* sp., *Lophosphaeridium microgranifer*, *Tasmanites huronensis*, *Maranhites brasiliensis*) which dominate the offshore, black shale lithologies and represent a recurrent species grouping. This is considered to reflect a phytoplankton biocoenose.

7. The unstructured amorphous debris present in black shales was formed by the bacterial degradation of fungal, algal, and terrestrial vascular plant remains.

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APPENDICES

APPENDIX 1: SAMPLING DATA

Locality	Maceration Number	Gross Lithology	Member and Position Above Base*
1	Pb 11308	Black Shale	Gowanda (1'-1'6")+
1	Pb 11307	Gray Shale	" (0-1')
2	Pb 10897	Black Shale	Gowanda (13'2"-14'4")+
2	Pb 10898	Gray Shale	" (11'9"-12'6")
2	Pb 10899	Calc. Siltstone	" (10'3"-11')
2	Pb 10900	Black Shale	" (9'9"-10'3")
2	Pb 10901	Calc. Siltstone	" (9'4"-9'9")
2	Pb 10902	Black Shale	" (8'7"-9'4")
2	Pb 10903	Calc. Siltstone	" (4'7"-4'11")
2	Pb 10904	Black Shale	" (2'6"-3'2")
2	Pb 10905	Gray/Black Shale	" (1'-1'6")
2	Pb 10906	Gray/Black Shale	" (0-1')
3	Pb 11335	Gray Shale	Gowanda (0-1')+
3	Pb 11336	Black Shale	" (7'-8')
4	Pb 11333	Gray Shale	Gowanda (3'-4')+
4	Pb 11334	Black Shale	" (7'-8')
5	Pb 11312	Gray Shale	Gowanda (0-1'6")+
5	Pb 11311	Calc. Siltstone	" (1'6"-2')
5	Pb 11310	Gray Shale	" (2'-5')
5	Pb 11309	Gray Shale	" (5'-7')

*Please note the following key with respect to section footages:

+Basal contact of Gowanda absent. Measurements refer to position of sample from exposure base. Localities 1, 2, and 5, however, do have upper contacts.

++Basal contact of Dunkirk not present.

+++Basal contacts present. Footages noted are from the base of each of the successive individual stratigraphic members.

Locality	Maceration Number	Gross Lithology	Member and Position Above Base*
6	Pb 11322	Black Shale	Gowanda (9'-10')+
7	Pb 11315	Black Shale	Dunkirk (0-2')++
7	Pb 11314	Gray Shale	Gowanda (0-1')
7	Pb 11313	Gray Shale	" (3'6"-4'8")
8	Pb 11332	Black Shale	Dunkirk (0-1')+
8	Pb 11331	Black Shale	" (2'-4')
8	Pb 11330	Black Shale	" (12'6"-13'6")
8	Pb 11329	Black Shale	" (22'6"-23'6")
9	Pb 11321	Gray Shale	Hanover (0-2')+
9	Pb 11320	Gray Shale	" (9'-10')
9	Pb 11319	Gray Shale	" (10'-11')
9	Bp 11318	Gray Shale	" (16'-17')
10	Pb 10815	Black Shale	Pipe Creek (0-6")+++
10	Pb 10816	Black Shale	" (1'6"-2')
10	Pb 10817	Black Shale	" (3'2"-3'8")
10	Pb 10818	Black Shale	" (4'8"-5'5")
10	Pb 10819	Gray Shale	Hanover (0-1'6")
10	Pb 10820	Gray Shale	" (2'-2'6")
10	Pb 11328	Gray Shale	" (3'-3'6")
10	Pb 11327	Black Shale	" (5'-5'6")
10	Pb 10821	Ls. Concretion	" (6'2"-6'7")
10	Pb 11326	Gray Shale	" (6'7"-7'4")
10	Pb 11325	Gray Shale	" (7'6"-8')

Locality	Maceration Number	Gross Lithology	Member and Position Above Base*
10	Pb 10822	Gray Shale	Hanover (8'-8'10")
10	Pb 10823	Black Shale	" (9'-9'6")
10	Pb 10824	Calc. Siltstone	" (11'-11'6")
10	Pb 10825	Black Shale	" (12'6"-13')
10	Pb 10832	Gray Shale	" (19'6"-20')
10	Pb 11324	Gray Shale	" (21'-21'6")
10	Pb 10833	Gray/Black Shale	" (25'4"-25'11")
10	Pb 10834	Gray Shale	" (26'6"-27')
10	Pb 10835	Black Shale	" (32'-33'6")
10	Pb 10836	Gray Shale	" (43'4"-44'6")
10	Pb 10837	Black Shale	" (44'6"-45'2")
10	Pb 10838	Gray Shale	" (46'-46'6")
10	Pb 10839	Black Shale	" (47'1"-47'8")
10	Pb 10840	Gray Shale	" (55'2"-55'11")
10	Pb 10841	Calc. Siltstone	" (55'11"-56'4")
10	Pb 10842	Gray Shale	" (63'7"-64'4")
10	Pb 10843	Calc. Siltstone	" (64'4"-65'1")
10	Pb 10844	Gray Shale	" (65'1"-65'8")
10	Pb 10845	Ls. Concretion	" (67'5"-68')
10	Pb 10846	Calc. Siltstone	" (69'-69'6")
10	Pb 10847	Gray Shale	" (70'10"-71'7")
10	Pb 10848	Gray Shale	" (72'4"-72'10")
10	Pb 10849	Black Shale	Dunkirk (0-6")
10	Pb 10850	Gray/Black Shale	" (1'-1'6")

Locality	Maceration Number	Gross Lithology	Member and Position Above Base*
10	Pb 10851	Black Shale	Dunkirk (2'-2'8")
10	Pb 10852	Black Shale	" (4'-4'6")
10	Pb 10853	Black Shale	" (6'-6'6")
10	Pb 10854	Gray/Black Shale	" (10'-11')
10	Pb 10855	Black Shale	" (25'-25'6")
10	Pb 10856	Black Shale	" (34'-34'6")
10	Pb 10857	Gray/Black Shale	" (40'-41')
10	Pb 10858	Gray/Black Shale	" (48'-49')
10	Pb 10859	Gray/Black Shale	" (51'-52')
10	Pb 10860	Gray Shale	" (52'6"-53'3")
10	Pb 10861	Black Shale	" (54'-55')
10	Pb 10862	Gray Shale	" (55'6"-56')
10	Pb 10863	Black Shale	" (57'-58')
10	Pb 10864	Black Shale	" (62'-63')
10	Pb 10865	Gray Shale	" (65'-66')
10	Pb 10866	Black Shale	" (68'-68'7")
10	Pb 10867	Calc. Siltstone	Gowanda (0-5")
10	Pb 10868	Gray Shale	" (2'-3')
10	Pb 10869	Gray/Black Shale	" (11'-12')
10	Pb 10870	Black Shale	" (12'-13')
10	Pb 10871	Gray/Black Shale	" (15'-15'6")
10	Pb 10872	Gray/Black Shale	" (16'6"-17')
10	Pb 10873	Calc. Siltstone	" (18'-18'6")
10	Pb 10874	Gray/Black Shale	" (19'-19'6")
10	Pb 10875	Gray Shale	" (29'-29'8")

Locality	Maceration Number	Gross Lithology	Member and Position Above Base*
10	Pb 10876	Calc. Siltstone	Gowanda (31'-32'4")
10	Pb 10877	Gray Shale	" (34'-35')
10	Pb 10878	Black Shale	" (35'-35'6")
10	Pb 10879	Calc. Siltstone	" (41'-42')
10	Pb 10880	Black Shale	" (51'-52')
10	Pb 10881	Gray Shale	" (60'-61')
10	Pb 10882	Black Shale	" (73'-73'8")
10	Pb 10883	Gray Shale	" (74'-75')
10	Pb 10884	Black Shale	" (76'-76'8")
10	Pb 10885	Black Shale	" (77'11"-78'7")
10	Pb 10886	Gray/Black Shale	" (79'8"-80'6")
10	Pb 10887	Black Shale	" (100'4"-101')
10	Pb 10888	Calc. Siltstone	" (112'9"-113'1")
10	Pb 10889	Gray Shale	" (113'1"-113'7")
10	Pb 10890	Gray/Black Shale	" (142'-143')
10	Pb 10891	Calc. Siltstone	" (160'-161')
10	Pb 10892	Black Shale	" (184'-185')
10	Pb 10893	Gray Shale	" (192'-193')
10	Pb 10894	Gray Shale	" (215'-215')
10	Pb 10895	Gray Shale	" (234'-235')
10	Pb 10896	Gray Shale	" (255'10"-256'8")
11	Pb 11534	Black Shale	Pipe Creek (0-1')+++
11	Pb 11535	Black Shale	" (5'-5'6")
11	Pb 11536	Gray Shale	Hanover (0-8")
11	Pb 11537	Gray Shale	" (2'6"-3'6")

Locality	Maceration Number	Gross Lithology	Member and Position Above Base*
12	Pb 11273	Black Shale	Pipe Creek (0-4")+++
12	Pb 11272	Black Shale	" (3'-3'6")
12	Pb 11271	Black Shale	" (6'-6'6")
12	Pb 11270	Gray Shale	Hanover (0-6")
12	Pb 11269	Black Shale	" (10'-10'6")
12	Pb 11268	Gray Shale	" (20'-20'6")
12	Pb 11267	Gray Shale	" (22'6"-22'9")
12	Pb 11266	Black Shale	" (23'8"-24')
12	Pb 11265	Gray Shale	" (30'9"-31')
12	Pb 11264	Gray Shale	" (40'-40'6")
12	Pb 11263	Gray Shale	" (49'6"-50')
12	Pb 11262	Gray Shale	" (59'6"-60')
12	Pb 11261	Black Shale	" (62'-62')
12	Pb 11260	Gray/Black Shale	" (65'6"-66')
12	Pb 11259	Gray Shale	" (70'-70'8")
12	Pb 11258	Black Shale	Dunkirk (0-6")
12	Pb 11257	Black Shale	" (10'6"-11')
12	Pb 11256	Black Shale	" (11'6"-12')
12	Pb 11255	Gray/Black Shale	" (19'8"-20'4")
12	Pb 11254	Black Shale	" (31'8"-32')
12	Pb 11253	Gray Shale	" (32'-32'9")
12	Pb 11252	Black Shale	" (32'9"-33'3")
12	Pb 11251	Gray/Black Shale	" (35'6"-36')
12	Pb 11250	Gray/Black Shale	" (39'4"-39'10")
12	Pb 11249	Black Shale	" (72'-72'8")

Locality	Maceration Number	Gross Lithology	Member and Position Above Base*
12	Pb 11248	Gray Shale	Dunkirk (81'6"-82')
12	Pb 11286	Calc. Siltstone	Gowanda (0-10")
12	Pb 11285	Gray Shale	" (4'6"-4'9")
12	Pb 11284	Gray Shale	" (4'9"-5'6")
12	Pb 11283	Gray Shale	" (21'-21'6")
12	Pb 11282	Calc. Siltstone	" (23'6"-24'6")
12	Pb 11281	Calc. Siltstone	" (29'3"-29'6"; 29'10"-30')
12	Pb 11280	Gray Shale	" (29'6"-29'10")
12	Pb 11279	Gray Shale	" (40'-40'6")
12	Pb 11278	Gray Shale	" (50'9"-51')
12	Pb 11277	Gray Shale	" (61'-61'10")
12	Pb 11276	Gray Shale	" (71'-72)
12	Pb 11275	Gray Shale	" (85'-86')
12	Pb 11274	Calc. Siltstone	" (86'-86'4")
13	Pb 11292	Black Shale	Pipe Creek (0-6")+++
13	Pb 11291	Black Shale	" (4'-4'6")
13	Pb 11290	Black Shale	" (6'-6'6")
13	Pb 11289	Black Shale	" (9'-9'6")
13	Pb 11288	Black Shale	" (13'-13'6")
13	Pb 11287	Black Shale	" (16'2"-16'6")
14	Pb 11306	Calc. Siltstone	Gowanda (0-8")+++
14	Pb 11305	Black Shale	" (5'-5'6")
14	Pb 11304	Gray Shale	" (7'-7'6")
14	Pb 11303	Gray/Black Shale	" (10'-10'6")

Locality	Maceration Number	Gross Lithology	Member and Position Above Base*
14	Pb 11302	Gray Shale	Gowanda (12'-12'6")
14	Pb 11301	Gray/Black Shale	" (15'-15'6")
14	Pb 11300	Gray Shale	" (17'-17'6")
14	Pb 11299	Calc. Siltstone	" (22'1"-22'6")
14	Pb 11298	Black Shale	" (30'-30'6")
14	Pb 11297	Gray Shale	" (32'-32'6")
14	Pb 11296	Black Shale	" (39'-39'6")
14	Pb 11295	Calc. Siltstone	" (41'-41'8")
14	Pb 11294	Gray Shale	" (45'3"-45'11")
14	Pb 11293	Calc. Siltstone	" (49'2"-49'11")
15	Pb 10912	Black Shale	Pipe Creek (0'-6")+++
15	Pb 10913	Black Shale	" (2'-2'6")
15	Pb 10768	Black Shale	" (4'-4'6")
15	Pb 10769	Black Shale	" (10'-10'6"
15	Pb 10770	Black Shale	" (15'-15'6")
15	Pb 10771	Black Shale	" (19'6"-20')
15	Pb 10772	Black Shale	" (23'8"-24'4")
15	Pb 10773	Gray Shale	Hanover (0-6")
15	Pb 10774	Gray Shale	" (5'6"-6')
15	Pb 10775	Gray Shale	" (6'6"-7')
15	Pb 10776	Ls. Concretion	" (14'6"-14'11")
15	Pb 10777	Gray Shale	" (16'6"-17')
15	Pb 10778	Gray Shale	" (18'6"-19')
15	Pb 10779	Gray Shale	" (29'6"-30')

Locality	Maceration Number	Gross Lithology	Member and Position Above Base
15	Pb 10780	Gray/Black Shale	Hanover (37'-37'6")
15	Pb 10781	Gray Shale	" (48-48'6")
15	Pb 10782	Gray Shale	" (50'-50'6")
15	Pb 10783	Calc. Siltstone	" (50'6"-51'2")
15	Pb 10784	Gray Shale	" (53'3"-54')
15	Pb 10785	Calc. Siltstone	" (54'-54'6")
15	Pb 10786	Black Shale	" (54'6"-55'3")
15	Pb 10787	Gray Shale	" (55'6"-56')
15	Pb 10788	Calc. Siltstone	" (56'-56'7")
15	Pb 10789	Gray/Black Shale	Dunkirk (0-1')
15	Pb 10790	Black Shale	" (3'-3'6")
15	Pb 10791	Gray Shale	" (6'-6'6")
15	Pb 10792	Black Shale	" (9'-9'6")
15	Pb 10793	Gray Shale	" (10'6"-11')
15	Pb 10794	Calc. Siltstone	" (11'-11'8")
15	Pb 10795	Gray Shale	" (13'4"-14')
15	Pb 10796	Black Shale	" (15'-15'6")
15	Pb 10797	Black Shale	" (18'6"-19')
15	Pb 10798	Ls. Concretion	" (27'-28')
15	Pb 10799	Gray Shale	" (28'-28'6")
15	Pb 10800	Ls. Concretion	" (28'6"-29')
15	Pb 10801	Black Shale	" (48'-49')
15	Pb 10802	Black Shale	" (49'-50')
15	Pb 10803	Black Shale	" (51'-51'6")

Locality	Maceration Number	Gross Lithology	Member and Position Above Base
15	Pb 10804	Black Shale	Dunkirk (53'9"-54'2")
15	Pb 10805	Calc. Siltstone	Gowanda (0-7")
15	Pb 10806	Gray Shale	" (1'-1'6")
15	Pb 10807	Black Shale	" (9'6"-10')
15	Pb 10808	Gray Shale	" (10'-12')
15	Pb 10809	Calc. Siltstone	" (12'-12'6")
15	Pb 10810	Gray Shale	" (19'-20')
15	Pb 10811	Black Shale	" (28'-29')
15	Pb 10812	Calc. Siltstone	" (31'-31'6")
15	Pb 10813	Gray/Black Shale	" (36'6"-37')
15	Pb 10814	Gray/Black Shale	" (39'-40'2")
16	Pb 11317	Black Shale	Pipe Creek (0-1')+++
16	Pb 11316	Black Shale	" (8'-9')

APPENDIX 2: SPORES

Anapiculatisporites hystricosus; p. 33-34, Pl. 7, fig. 1.

Ancyrospora ancyrea; p. 34-35, Pl. 7, fig. 2.

Ancyrospora cf. A. furcula; p. 35-36, Pl. 7, fig. 3.

Ancyrospora langii; p. 36-37, Pl. 7, fig. 4.

Ancyrospora sp. 1; p. 38, Pl. 7, figs. 5-6.

Ancyrospora sp. 2; p. 39, Pl. 7, fig. 7.

Ancyrospora sp. 3; p. 40, Pl. 8, figs. 1-3.

Ancyrospora sp. 4; p. 41, Pl. 8, fig. 4.

Apiculiretusispora sp. 1; p. 42, Pl. 8, figs. 5-6.

Apiculiretusispora sp. 2; p. 43, Pl. 8, fig. 7.

Auroraspora torquata; p. 44-45 (also see discussion of this genus under Endosporites, p. 50-51), Pl. 8, fig. 8.

? Baculatisporites; p. 45-46, Pl. 9, figs. 1-2.

? Biharisporites; p. 46, Pl. 9, fig. 3.

Calamospora sp.; p. 47, Pl. 9, fig. 4.

Convolutispora sp.; p. 48, Pl. 9, fig. 5.

Emphanisporites annulatus; p. 49-50, Pl. 9, fig. 6.

Emphanisporites rotatus; p. 50, Pl. 9, fig. 7.

Endosporites sp.; p. 52 (also see discussion of this genus under Auroraspora, p. 44-45), Pl. 9, figs. 8-9.

? Endosporites sp.; p. 53, Pl. 9, figs. 10-11.

Geminospora cf. G. lemurata; p. 54, Pl. 10, figs. 1-2.

Geminospora micrograna; p. 54-55, Pl. 10, figs. 3-5.

Grandispora sp.; p. 56 (also see discussion of this genus under Spinozonotriletes, p. 67), Pl. 10, figs. 3-5.

Hymenozonotriletes sp.; p. 57, Pl. 11, fig. 3

Hystricosporites porrectus; p. 57-58, Pl. 11, fig. 1.

Hystricosporites sp.; p. 58-59, Pl. 11, fig. 2.

Leiotriletes inermis; p. 59-60, Pl. 11, fig. 4.

Lophozonotriletes sp.; p. 61, Pl. 11, figs. 5-6.

Nikitinisporites sp.; p. 62, Pl. 11, fig. 7.

Punctatisporites sp.; p. 62-63, Pl. 11, figs. 8-9.

Retusotriletes dubiosus; p. 63-64, Pl. 12, fig. 1.

Retusotriletes greggsii; p. 64-65, Pl. 12, fig. 2.

Spelaeotriletes sp.; p. 66-67, Pl. 12, fig. 3.

Spinozonotriletes uncatus; p. 67-69, Pl. 12, fig. 4 (also see discussion of this genus under Grandispora, p. 56).

Spinozonotriletes sp. 1; p. 69, Pl. 12, fig. 5.

Spinozonotriletes sp. 2; p. 69-70, Pl. 12, fig. 6.

Stenozonotriletes clarus; p. 70-71, Pl. 12, fig. 7.

Stenozonotriletes sp.; p. 71-72, Pl. 12, fig. 8.

Verrucosisporites bullatus; p. 72-73, Pl. 12, fig. 9.

Verrucosisporites sp. 1; p. 73-74, Pl. 12, fig. 10.

Verrucosisporites sp. 2; p. 74, Pl. 12, fig. 11; Pl. 13, figs. 1-3.

Spore Type A; p. 75, Pl. 13, fig. 14.

Spore Type B; p. 75-76, Pl. 14, fig. 1.

APPENDIX 3: ACRITARCHA

Subgroup Acanthomorphitae

Baltisphaeridium sp. 1; p. 79-80, Pl. 14, figs. 2-5.

Baltisphaeridium sp. 2; p. 80-81, Pl. 14, fig. 6.

Baltisphaeridium sp. 3; p. 81, Pl. 14, fig. 7.

Baltisphaeridium sp. 4; p. 81-82, Pl. 14, fig. 8.

Baltisphaeridium sp. 5; p. 82, Pl. 15, fig. 1.

Baltisphaeridium sp. 6; p. 83, Pl. 15, fig. 2.

Diexallophasis remota; p. 83-85, Pl. 15, fig. 3.

Gorgonisphaeridium absitum; p. 85-86, Pl. 15, fig. 4.

Gorgonisphaeridium sp. 1; p. 86-87, Pl. 15, figs 5-6.

Gorgonisphaeridium sp. 2; p. 87, Pl. 15, fig. 7.

Gorgonisphaeridium sp. 3; p. 88, Pl. 15, fig. 8; Pl. 16, fig. 1.

Micrhystridium complurispinosum; p. 88-89 (also see discussion of this genus under Baltisphaeridium, p. 77-79), Pl. 16, fig. 2.

Micrhystridium coronatum; p. 89-90, Pl. 16, fig. 3.

Micrhystridium inusitatum; p. 90-91, Pl. 16, fig. 4.

Micrhystridium stellatum; p. 91-92, Pl. 16, figs. 5-6.

Multiplicisphaeridium leptaleoderos; p. 92-93 (also see discussion of this genus under Baltisphaeridium, p. 77-79), Pl. 17, fig. 1.

Multiplicisphaeridium cf. M. ramispinosum; p. 93-94, Pl. 17, figs. 2-4.

Multiplicisphaeridium sp. 1; p. 94-95, Pl. 17, fig. 5.

Multiplicisphaeridium sp. 2; p. 95, Pl. 17, fig. 6; Pl. 18, figs. 1-2.

Ozotobrachion palidodigitatus; p. 96-97, Pl. 18, fig. 3.

Subgroup Herkomorphitae

Cymatiosphaera turbinata; p. 97-98 (also see discussion of this genus under Muraticavea, p. 100), Pl. 18, fig. 4.

Cymatiosphaera sp. 1; p. 98-99, Pl. 18, fig. 5.

Cymatiosphaera sp. 2; p. 99, Pl. 18, figs. 6-7.

Muraticavea sp. 1; p. 100, Pl. 19, figs. 1-2.

Muraticavea sp. 2; p. 101, Pl. 19, figs. 3-5.

Muraticavea sp. 3; p. 101-102, Pl. 19, fig. 6.

Subgroup Netromorphitae

Navifusa *bacillum*; p. 102-104, Pl. 20, figs. 1-2.

Subgroup Polygonomorphitae

Estiastra rugosa; p. 104-105, Pl. 21, fig. 1.

Evittia sp. 1; p. 105-106, Pl. 20, fig. 3.

Evittia sp. 2; p. 106, Pl. 20, fig. 4.

Evittia sp. 3; p. 107, Pl. 20, fig. 5.

Veryhachium *downiei*; p. 108, Pl. 21, figs. 2-3.

Veryhachium *lairdii*; p. 108-109, Pl. 21, fig. 4.

Veryhachium *polyaster*; p. 109-110, Pl. 21, figs. 5-6.

Veryhachium *trispinosum*; p. 110-111, Pl. 21, fig. 8.

Veryhachium sp.; p. 112, Pl. 21, fig. 8.

Acritarch Type A; p. 113, Pl. 22, fig. 1.

Acritarch Type B; p. 113-114, Pl. 22, fig. 2.

Subgroup Prismatomorphitae

Polyedryxium *pharaonsis*; p. 114-115, Pl. 20, figs. 6-7.

Subgroup Scutellomorphitae

Maranhites *brasiliensis*; p. 115-117, Pl. 23, fig. 1.

Subgroup Sphaeromorphitae

Leiosphaeridia sp.; p. 117-119, Pl. 22, figs. 3-4.

Lophosphaeridium *microgranifer*; p. 119-120, Pl. 22, fig. 5.

Subgroup Tasmanititae

Tasmanites huronensis; p. 121, Pl. 22, figs. 6-7.

PLATES

PLATE 1

Figure	
1	Exposure of the Hanover Shale, Walnut Creek, Chautauqua County (Locality 10). Bar equals 20 feet.
2	Exposure of the Hanover Shale-Dunkirk Shale contact, Walnut Creek, Chautauqua County (Locality 10). Bar equals 5 feet.
3	Exposure of Dunkirk Shale-Gowanda Shale contact, south branch of Eighteenmile Creek, Erie County (Locality 12). Note rippled upper surface of the lowermost siltstone of the Gowanda (hammer for scale).
4	Surface view of rippled siltstone shown in figure 3 (white arrow points to hammer for scale).
5	Trace fossils from the Hanover Shale, south branch of Eighteenmile Creek, Erie County (Locality 12). Surface view of pascichnia (grazing traces) and fodinichnia (feeding traces). Note width of handle shank at head of hammer is 1 inch (2.54 cm).
6	Trace fossils from the Hanover Shale, south branch of Eighteenmile Creek, Erie County (Locality 12). Side view of fodinichnia (feeding traces) and domichnia (dwelling structures). Note width of handle shank at head of hammer is 1 inch (2.54 cm).

PLATE 1


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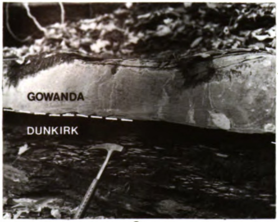

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PLATE 2

<u>Figure</u>

1	*Callixylon* sp. 1 (All figures from same specimen). Collection number 10/17/76-I-7a. Terminal portion of a 2'9" waterworn specimen, X 1/2. Arrows indicate extensively bored areas.
2	Transverse section of same specimen, X 1. Arrows point to bored areas.
3	Scanning electron micrograph of tracheid mass, X 350. Arrows denote pit groups exposed on tracheids in near radial section.

PLATE 2

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2

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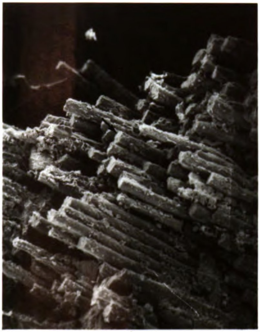
PLATE 3

Figure

1	Callixylon sp. 1 (Same specimen as Plate 2, Figure 3). Scanning electron micrograph of tracheids, X 350 (arrow for reference in Figure 2).
2	Detail of tracheids, X 790.
3	Callixylon sp. 2, X 1/3. Collection number 10/17/76-I-1.

PLATE 3



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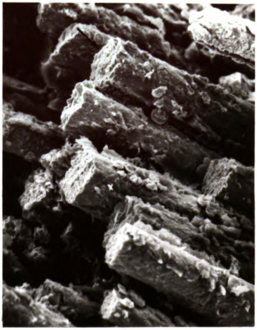

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PLATE 4

Figure

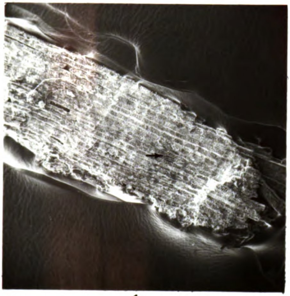
1 *Callixylon* sp. 2 (All scanning electron micrographs from same specimen as Plate 3, figure 3). Tissue mass showing tracheids in essentially radial section, X 50. Black arrow indicates area magnified in this sequence of photographs.

2 Tracheids showing radially aligned pit groups (6-8 pits per group), X 100. Note impressions of pyritized cross-pit apertures on carbonaceous (vitrain?) residium (black arrow is for reference).

3 Detail of coalified-pyritized interphase, X 500. Note pyritized casts of lumens and pit cavities immediately below coalified layer.

4 Detail of figure 3, X 1,000. White arrow denotes pit connection on tangential wall of tracheid.

PLATE 4



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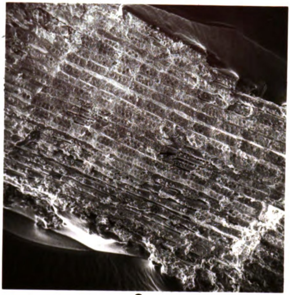

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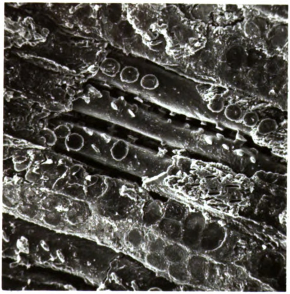

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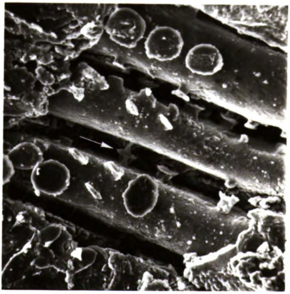

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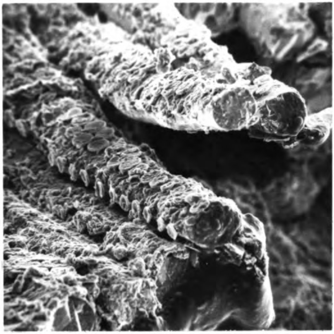
PLATE 5

Figure	
1	Callixylon sp. 2 (Same specimen as Plate 4), X 500. Note pit groups on radial walls (surfaces facing top of photo) and isolated pits in row on tangential wall (facing left).
2	Unidentified vitrainized wood from the Hanover Shale, Walnut Creek, Chautauqua County (Locality 10), X 1/4.
3	Plant detritus (structured) from the Hanover Shale, Walnut Creek, Chautauqua County (Locality 10), X 870. Pb 10845-1, 40. X 119.2.
4	Vitrainized plant impression (cf. Callixylon sp.), Dunkirk Shale, Walnut Creek, Chautauqua County (Locality 10), X 2/3. Collection number 10/15/75-II-31.
5	Vitrainized plant impression (cf. Callixylon sp.), Dunkirk Shale, Point Gratiot Park, Chautauqua County (Locality 8), X 1/2. Collection number 10/14/75-I-1.

PLATE 5



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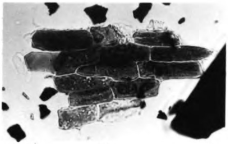

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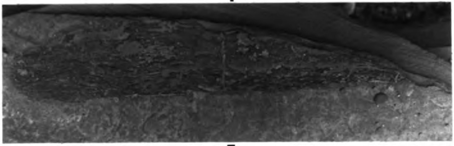

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PLATE 6

Figure

Callixylon sp., from the Gowanda Shale, Little Canadaway Creek, Chautauqua County (Locality 5). Note hammer for scale is 11-1/8 inches in length (black and white prints made from kodachrome slides).

1	Note shrinkage cracks on specimen. Collection number 10/15/76-I-2.
2	Collection number 10/15/76-I-3.
3	Collection number 10/15/76-I-4.

PLATE 6

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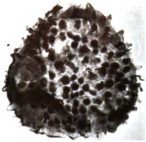
PLATE 7

All Figures X 870 except where otherwise noted.

Figure	
1	*Anapiculatisporites hystricosus* Playford 1963; Pb 11294-1, 40 X 117.3, X 975.
2	*Ancyrospora ancyrea* (Eisenack) Richardson 1962; Pb 11327-2, 43.1 X 114.8.
3	*Ancyrospora* cf. *A. furcula* Owens 1971; Pb 11310-3, 34.2 X 111.1.
4	*Ancyrospora langii* (Taugourdeau-Lantz) Allen 1965; Pb 10905-4, 25 X 128.5.
5,6	*Ancyrospora* sp. 1; 5. Pb 10906-1, 21.1 X 118.8; 6. Pb 10906-1, 23.2 X 115.
7	*Ancyrospora* sp. 2; Pb 10820-4, 30.7 X 110.4

PLATE 7



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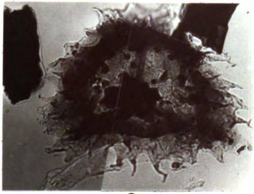

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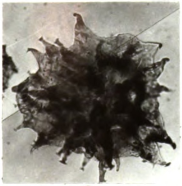

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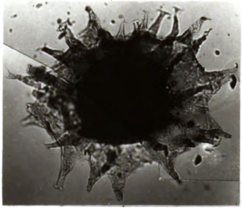

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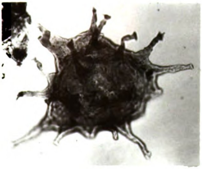

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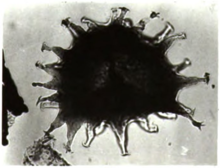

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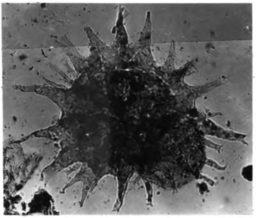
PLATE 8

All Figures X 975 except where otherwise noted.

Figure	
1,2,3	Ancyrospora sp. 3; 1. Pb 10820-4, 24.7 X 113.2; 2. Scanning electron micrograph, X 500 (arrow for reference to figure 3); Pb 10820, Stub 7; 3. Detail of spines, X 2,500.
4	Ancyrospora sp. 4; Pb 10877-3; 40.1 X 110.9.
5,6	Apiculiretusispora sp. 1; 5. Proximal focus; 6. Distal focus, X 975; Pb 11310-1, 45. X 118.3.
7	Apiculiretusispora sp. 2; Pb 10820-3, 43 X 119.7.
8	Auroraspora torquata Higgs 1975; Pb 10905-2, 25.9 x 122.5.

PLATE 8



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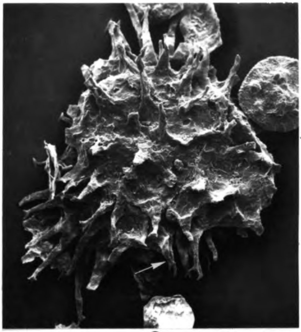

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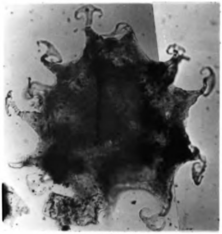

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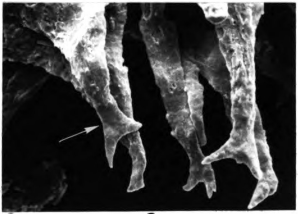

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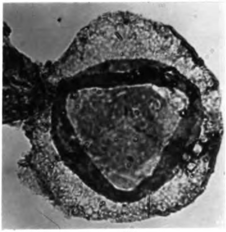

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PLATE 9

All Figures X 975 except where otherwise noted.

Figure	
1,2	? Baculatisporites sp.; 1. Distal view; 2. Proximal view; Pb 11327-3, 32.8 X 116.2.
3	? Biharisporites sp.; Pb 10906-2, 40.2 X 126.1.
4	Calamospora sp.; Pb 10824-2, 37.8 X 122.3.
5	Convolutispora sp.; Pb 10869-1, 41.6 X 125.9.
6	Emphanisporites annulatus McGregor 1961; Pb 11311-1, 39.3 X 119.8.
7	Emphanisporites rotatus (McGregor) McGregor 1973; Pb 11327-1, 42.2 X 119.1.
8,9	Endosporites sp.; 8. 11310-1, 44.6 X 110.5; 9. Pb 11310-1, 38 X 119.
10	? Endosporites sp.; Pb 10905-2, 37.5 X 118.8.

PLATE 9

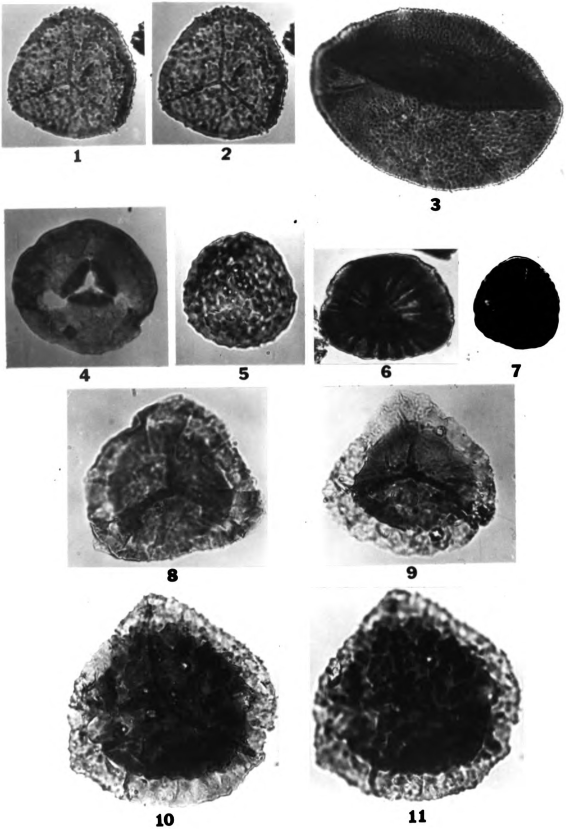

PLATE 10

All Figures X 975 except where otherwise noted.

Figure	
1,2	Geminospora cf. G. lemurata Balme 1960; 1. Polar view; Pb 11325-2, 43. X 112.8. 2. Equatorial view, Pb 11325-2, 29.5 X 113.2.
3,4,5,	Geminospora micrograna de Jersey, 1966; 3. Pb 10836, 34.1 X 124.1; 4. Scanning electron micrograph (arrow for reference to figure 5), X 1,400; 5. Detail of equatorial margin, X 2,800, Pb 10836, Stub 9.
6,7	Grandispora sp.; 6. Proximal focus; 7. Distal focus, Pb 10895-2, 30.2 X 112.

PLATE 10

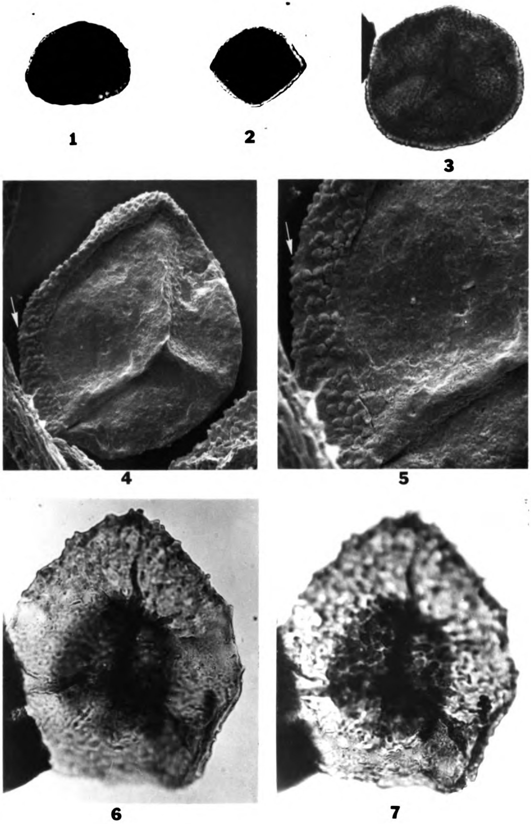

PLATE 11

All Figures X 975 except where otherwise noted.

Figure	
1	Hystricosporites porrectus (Balme and Hassel) Allen 1965, X 870; Pb 10905-2, 31.2 X 115.0.
2	Hystricosporites sp., X 870; Pb 10869-4, 30.2 X 127.1.
3	Hymenozonotriletes sp.; Pb 10838-1, 29.2 X 124.2.
4	Leiotriletes inermis (Waltz) Ischenko 1952; Pb 10906-1, 28.1 X 113.2.
5,6	Lophozonotriletes sp.; 5. Distal focus; 6. Proximal focus; Pb 11325-2, 28.2 X 110.5.
7	Nikitinisporites sp.; X 375; Pb 10820-4, 25.2 X 110.0.
8,9	Punctatisporites sp.; 8. Pb 10865-2, 14.8 X 123.9; Pb 10837-1, 21.1 X 120.2.

PLATE 11

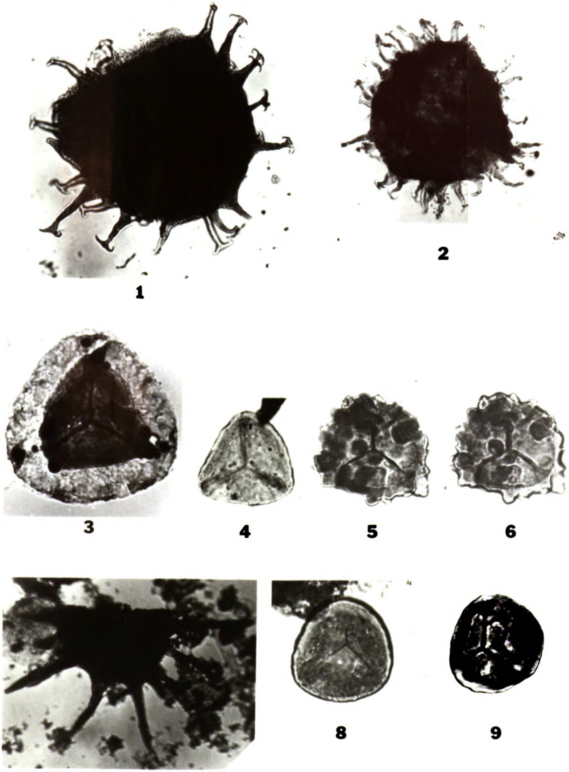

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PLATE 12

All Figures X 975 unless otherwise indicated.

Figure	
1	*Retusotriletes dubiosus* (Eisenack) McGregor 1973; Pb 10895-3, 46.1 X 117.7.
2	*Retusotriletes greggsii* McGregor 1964; Pb 10838-2, 24.5 X 115.6.
3	*Spelaeotriletes* sp.; Pb 11325-1, 36. X 119.4.
4	*Spinozonotriletes uncatus* Hacquebard 1957; Pb 11327-4, 37.1 X 117.5.
5	*Spinozonotriletes* sp. 1; Pb 10906-3, 38.1 X 129.
6	*Spinozonotriletes* sp. 2; Pb 11325-2, 37. X 114.2.
7	*Stenozonotriletes clarus* Ischenko 1958; Pb 10905-3, 33.8 X 118.4.
8	*Stenozonotriletes* sp.; Pb 11325-1, 32. X 113.
9	*Verrucosisporites* cf. *V. bullatus* Taugourdeau-Lantz 1967; Pb 10838-2, 42.5 X 120.7.
10	*Verrucosisporites* sp. 1; Pb 10869-2, 30.1 X 110.6.
11	*Verrucosisporites* sp. 2; Pb 11325-1, 33.9 X 122.2.

PLATE 12

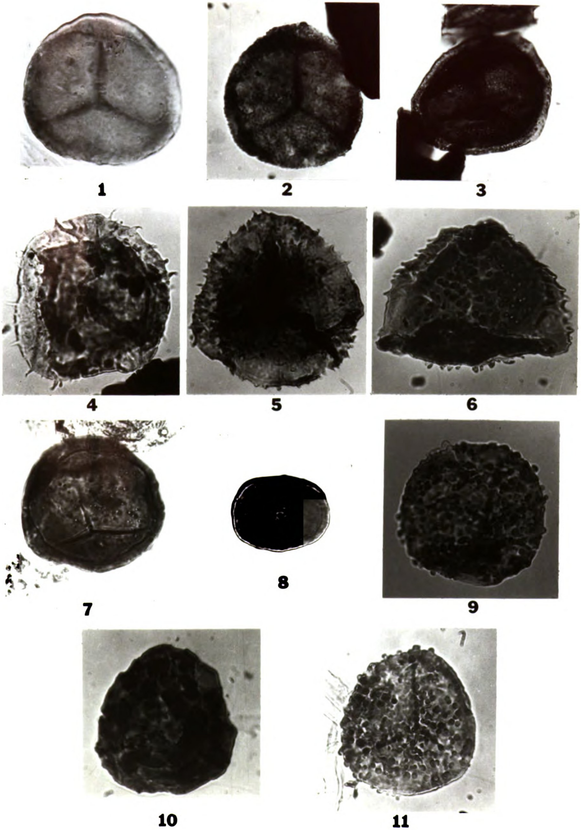


PLATE 13

All Figures X 975 unless otherwise noted.

Figure	
1,2,3	*Verrucosisporites* sp. (All Scanning electron micrographs from same specimen). 1. Proximal view of whole specimen, X 1,425 (Arrows and numbers refer to figures 2 and 3); 2,3. Detail of equatorial margin and verrucae; Figure 2, X 2,825, Figure 3, X 2,825; Pb 11325, Stub 2.
4	Spore type A; Pb 10905-4, 39.9 X 113.7.

PLATE 13

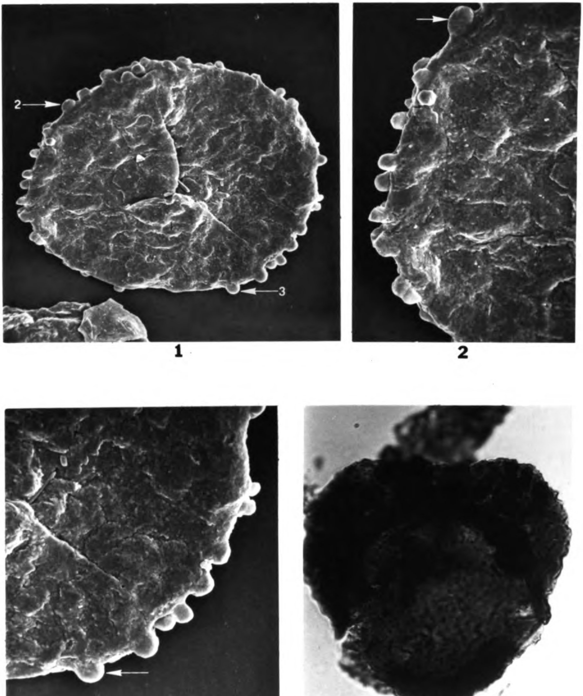


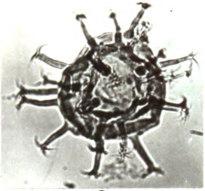
PLATE 14

All Figures X 975 unless otherwise noted.

Figure	
1	Spore type B; Pb 11325-3, 38 X 115.9.
2,3,4,5	2. *Baltisphaeridium* sp. 1; 2. Pb 11325-3, 34.3 X 126.5; 3. Pb 11325-2, 43.5 X 108.2; 4. Scanning electron micrograph, X 1,150 (arrow for reference to Figure 5); 5. Detail of processes, X 2,300; Pb 11325, Stub 2.
6	*Baltisphaeridium* sp. 2; Pb 11325-1, 30. X 123.2.
7	*Baltisphaeridium* sp. 3; Pb 10819-2, 28.2 X 117.
8	*Baltisphaeridium* sp. 4; Pb 11310-4, 32.1 X 122.5.

PLATE 14

1



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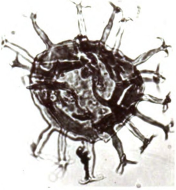

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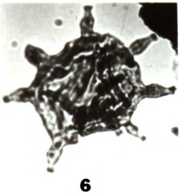

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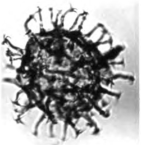
PLATE 15

All Figures X 975 unless otherwise noted.

Figure	
1	*Baltisphaeridium* sp. 5; Pb 10837-1, 18.8 X 118.9.
2	*Baltisphaeridium* sp. 6; Pb 10819-1, 34. X 112.5.
3	*Diexallophasis remota* (Deunff) Playford, 1977; Pb 10782-1, 26.3 X 111.9.
4	*Gorgonisphaeridium absitum* Wicander, 1974; Pb 11325-1, 35. X 120.6.
5,6	*Gorgonisphaeridium* sp. 1; 5. Pb 11314-3, 28.3 X 125.2; 6. Scanning electron micrograph, X 2,000; Pb 11325, Stub 2.
7	*Gorgonisphaeridium* sp. 2; Pb 11260-1, 35. X 125.5.
8	*Gorgonisphaeridium* sp. 3; Pb 11310-1, 39. X 119.

PLATE 15



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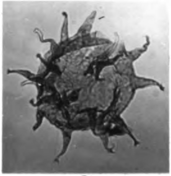

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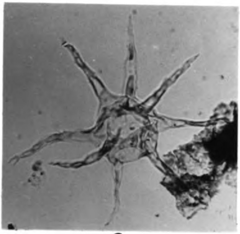

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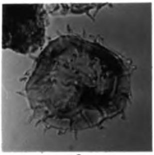

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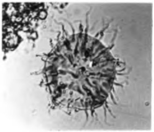

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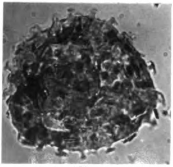

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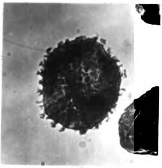

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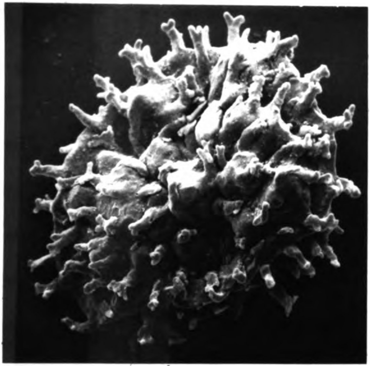
PLATE 16

All Figures X 975 unless otherwise noted.

Figure	
1	Gorgonisphaeridium sp. 3; Scanning electron micrograph, X 1,950; Pb 11310, Stub 1.
2	Micrhystridium complurispinosum Wicander 1974; Pb 11325-1, 27.5 X 118.
3	Micrhystridium coronatum Stockmans and Williere 1963; Pb 11327-4, 39. X 119.8.
4	Micrhystridium inusitatum Wicander 1974; Pb 11325-4, 30.9 X 118.6.
5,6	Micrhystridium stellatum Deflandre 1945; 5. Pb 11310-1, 40. x 116.7; 6. Scanning electron micrograph, Pb 11310, Stub 1.

PLATE 16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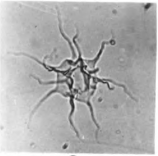
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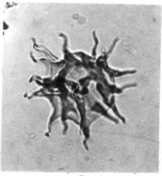
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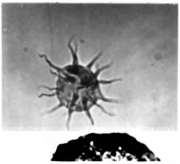
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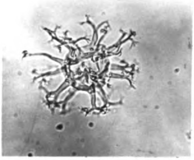
PLATE 17

All Figures X 975 unless otherwise noted.

Figure	
1	*Multiplicisphaeridium leptaleoderos* Loeblich and Wicander 1976; Pb 11327-2, 43 X 120.1.
2,3,4	*Multiplicisphaeridium* cf. *M. ramispinosum* Staplin 1961; 2. Pb 11325-2, 38.2 X 108.4; 3. Scanning electron micrograph (arrow for reference to Figure 4), X 1,125; 4. Detail of processes, X 4,450; Pb 11325, Stub 3.
5	*Multiplicisphaeridium* sp. 1; Pb 11325-2, 24.6 X 115.6.
6	*Multiplicisphaeridium* sp. 2; Pb 11260-2, 32.8 X 111.2.

PLATE 17


1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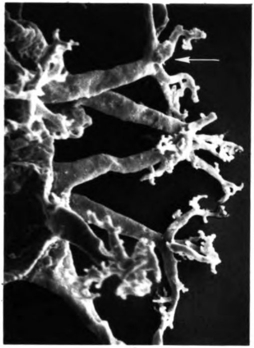
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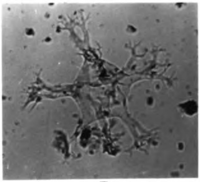
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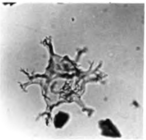
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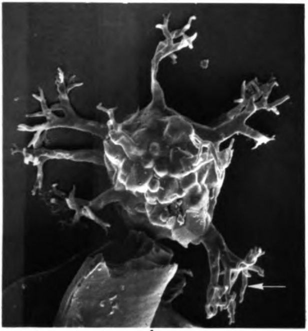
PLATE 18

All Figures X 975 unless otherwise noted.

Figure	
1,2	*Multiplicisphaeridium* sp. 2; 1. Scanning electron micrograph (arrow for reference to Figure 2), X 1,800; 2. Detail of process terminations, X 4,500; Pb 10842, Stub 5.
3	*Ozotobrachion palidodigitatus* (Loeblich and Drugg) Playford 1977; Pb 11325-4, 32.3 X 117.8.
4	*Cymatiosphaera turbinata* Wicander and Loeblich 1977; Pb 11327-3, 42.5 X 113.6.
5	*Cymatiosphaera* sp. 1; Pb 11260-1, 40.8 X 117.
6,7	*Cymatiosphaera* sp. 2; 6. Pb 11260-1, 27. X 128.5; 7. Scanning electron micrograph, X 1,900; Pb 10881, Stub 4.

PLATE 18



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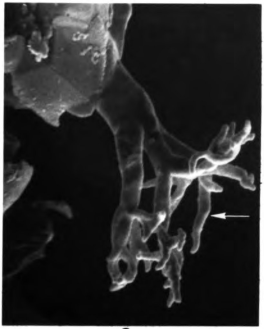

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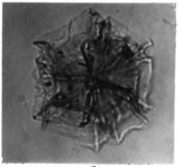

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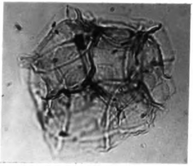

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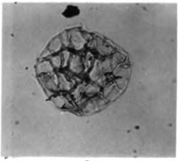

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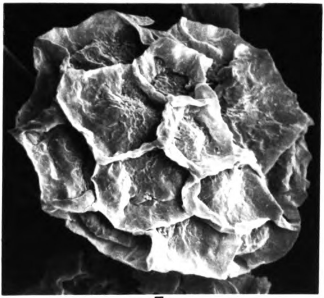

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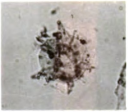
PLATE 19

All Figures X 975 unless otherwise noted.

Figure	
1,2	*Muraticavea* sp. 1; 1. Pb 11249-1, 23.1 X 110.5; 2. Scanning electron micrograph, X 3,850; Pb 10850, Stub 3.
3,4,5	*Muraticavea* sp. 2; 3. Pb 10819-1, 41 X 108.7; 4. Scanning electron micrograph (arrow for reference to Figure 5), X 1,250; 5. Detail of vesicle wall, X 2,150, Pb 11325, Stub 2.
6	*Muraticavea* sp. 3; Pb 10837-2, 35.9 X 117.8.

PLATE 19



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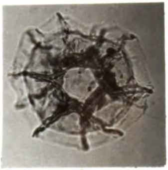

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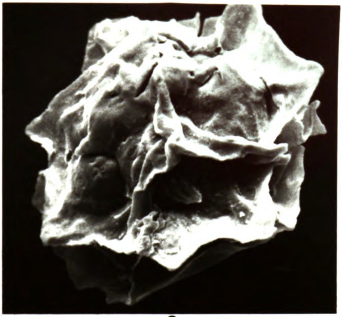

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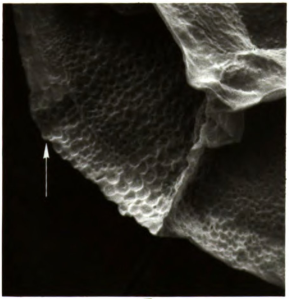

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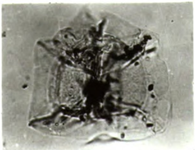

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PLATE 20

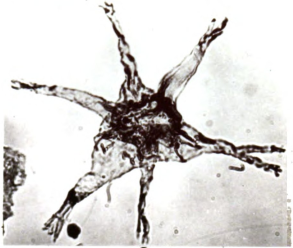
All Figures X 975 unless otherwise noted.

Figure	
1,2	Navifusa bacillum (Deunff) Playford 1977; 1. X 870; Pb 11327-2, 29 X 113.9; 2. Pb 11325-2, 30. X 124.7.
3	Evittia sp. 1; Pb 11310-1, 39.9 X 118.1.
4	Evittia sp. 2; Pb 11310-3, 44. X 111.8.
5	Evittia sp. 3; Pb 11325-3, 46.5 X 129.
6	Polyedryxium pharaonsis (Deunff) Playford 1977; 6. Pb 11310-1, 38.9 X 115.8; 7. Scanning electron micrograph, X 1,800, Pb 11310, Stub 1.

PLATE 20


1


2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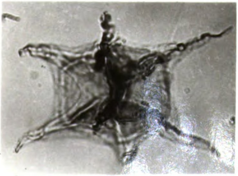
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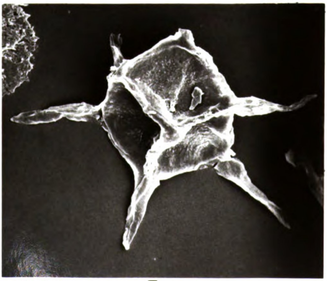
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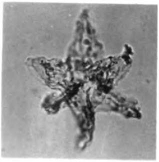
PLATE 21

All Figures X 975 unless otherwise noted

Figure	
1	Estiastra rugosa Wicander 1974; Pb 10850-4, 35. X 112.8.
2,3	Veryhachium downiei Stockmans and Williere, 1962; 2. Pb 11310-3, 46. X 123.8; 3. Scanning electron micrograph, X 2,100, b 11310, Stub 1.
4	Veryhachium lairdii (Deflandre) Deunff 1959; Pb 10877-3, 34 X 126.4.
5,6	Veryhachium polyaster Staplin 1961; 5. Pb 10844, 11.6 X 117.2; 6. Scanning electron micrograph, X 1,850, Pb 10844, Stub 8.
7	Veryhachium trispinosum (Eisenack) Deunff 1954; Pb 10865-3, 14 X 114.4.
8	Veryhachium sp. 4; Pb 11260-2, 41.5 X 117.7.

PLATE 21



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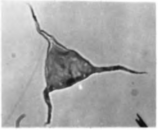

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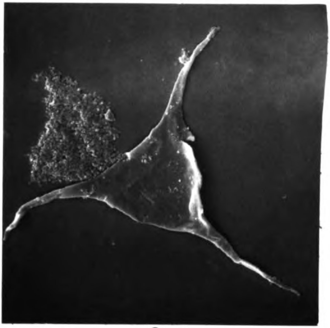

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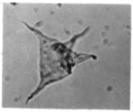

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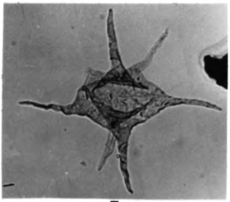

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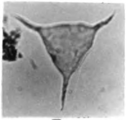

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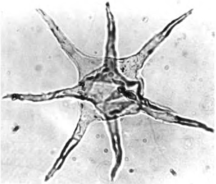

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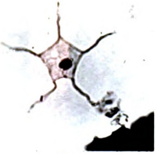
PLATE 22

All Figures X 975 unless otherwise noted.

Figure	
1	Acritarch Type A; Pb 10819-2, 19.4 X 119.
2	Acritarch Type B; Pb 11314-3, 28.5 X 125.1.
3,4	*Leiosphaeridia* sp.; 3. X 650, Pb 10865-2, 14. X 124.1; 4. Scanning electron micrograph, X 1,200; Pb 10820, Stub 7.
5	*Lophosphaeridium micrograniter* (Staplin) Jux 1975; X 1,900, Pb 11327, Stub 13.
6,7	*Tasmanites huronensis* Winslow 1962; 6. Whole specimen, X 870; 7. Detail of punctae, Pb 10820-1, 21.2 X 114.

PLATE 22



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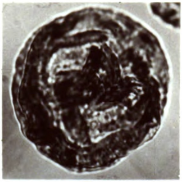

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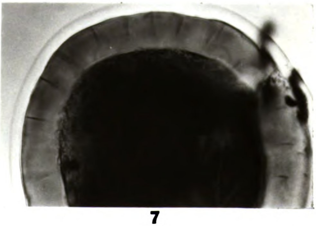

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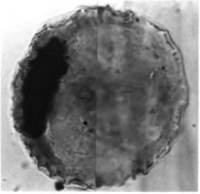
PLATE 23

All Figures X 975 unless otherwise noted.

Figure	
1	*Maranhites* *brasiliensis* Brito 1965; Pb 10820-1, 27.5 X 117.5.
2	*Angochitina* sp.; Pb 10895-1, 46. X 121.
3	*Sphaerochitina* sp.; Pb 10895-1, 46.9 X 121.
4	Chitinozoan sp.; Pb 10895-4, 47.7 X 119.2.
5	Scolecodont 1; Pb 10906-4, 42.9 X 120.1.
6	Scolecodont 2; Pb 10895-2, 30 X 117.3.
7	Scolecodont 3; Pb 10895-2, 37.2 X 122.6.
8	Scolecodont 4; Pb 10905-3, 27.2 X 113.9.
9	Scolecodont 5; Pb 10837-1, 33.5 X 114.
10	Scolecodont 6; Pb 10895-2, 23.9 X 109.2.

PLATE 23



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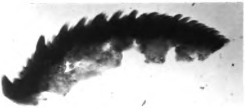

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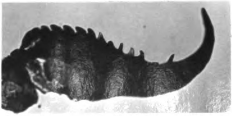

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