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DEPARTMENT OF ENERGY, MINES AND RESOURCES

BULLETIN 221

CHITINOZOA AND ACRITARCHA OF THE HAMILTON FORMATION (MIDDLE DEVONIAN), SOUTHWESTERN ONTARIO

J. A. Legault

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By
J. A. Legault

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PREFACE

Research in systematic paleontology is one of the means by which the Geological Survey provides data for the calibration of the geological time scale so necessary for the precise dating and correlation of the rocks that make up the geological framework of Canada.

Palynomorphs are rapidly becoming a foremost paleontological tool in the elucidation of biostratigraphical problems. Of these, fossil microplankton of Paleozoic age promise to be of decisive importance in correlation. In this report the author describes such microplankton from subsurface study of the petroliferous Hamilton Formation of southwestern Ontario, indicates their usefulness as stratigraphic indices, and presents a detailed study of their occurrence and variation.

Y. O. FORTIER,
Director, Geological Survey of Canada

OTTAWA, August 15, 1972

CONTENTS

Illustrations

CHITINOZOA AND ACRITARCHA OF THE HAMILTON FORMATION (MIDDLE DEVONIAN), SOUTHWESTERN ONTARIO

Abstract

The Middle Devonian (Givetian) Hamilton Formation of southwestern Ontario is rich in Chitinozoa and Acritarcha. Three cores from southwestern Ontario were sampled and numerous and varied palynomorphs were recovered. The Chitinozoa are represented by sixteen genera, two new, and forty-seven species, eight new; Acritarcha are represented by nine genera, one new, and twelve species, two new. The Chitinozoa–Acritarcha assemblages are relatively consistent with only two groups of Chitinozoa being stratigraphically differentiated: that of the species of *Angochitina*, and the genera *Desmochitina*, *Eisenackitina*, and *Poteriochitina* n. gen. Variation in relative percentages of Chitinozoa and Acritarcha is unrelated to lithological changes in the Hamilton Formation, but percentage trends do change at stratigraphic boundaries. The use of Chitinozoa and Acritarcha as biostratigraphical tools is strengthened because they appear to be unaffected by local ecological factors.

Résumé

La formation Hamilton (Givétien) du Devonien moyen du sud-ouest de l'Ontario contient une abondance de Chitinozoaires et d'Acritarches. Trois carottes furent considérées et un grand nombre de palynomorphes d'une grande variété furent étudiés. Les Chitinozoaires sont représentés par seize genres, dont deux nouveaux, et quarante-sept espèces, dont huit nouvelles; les Acritarches sont représentés par neuf genres, dont un nouveau, et douze espèces, dont deux nouvelles. La représentation des taxons de Chitinozoaires et d'Acritarches est relativement constante. Seulement deux groupes de Chitinozoaires sont différenciés stratigraphiquement: les espèces d'*Angochitina*, et celles de *Desmochitina*, *Eisenackitina* et *Poteriochitina* n. gen. Les variations dans les pourcentages relatifs de Chitinozoaires et d'Acritarches n'ont aucune relation avec les changements lithologiques dans la formation Hamilton, mais il y a changement dans le cours des pourcentages aux limites stratigraphiques. L'emploi de Chitinozoaires et d'Acritarches comme outils biostratigraphiques est renforci car on constate qu'ils ne sont pas affectés par certains facteurs d'écologie locale.

INTRODUCTION

Numerous megafossils and ostracodes of the Hamilton Formation have been studied in detail, but palynomorphs (spores and Chitinozoa) have been only generally reported (Fritz, 1939; Boneham, 1967), and Acritarcha have not previously been considered.

The Hamilton Formation outcrops in Canada in southwestern Ontario (Fig. 1), and in the United States in New York, Pennsylvania, Michigan, and Wisconsin. In southwestern Ontario the formation has been divided into members, in ascending order, Bell, Rockport Quarry, Arkona, Hungry Hollow, Widder, and Ipperwash. The lithologies of the various members are relatively similar and their division has been supported by paleontological criteria (Stumm and Wright, 1958).

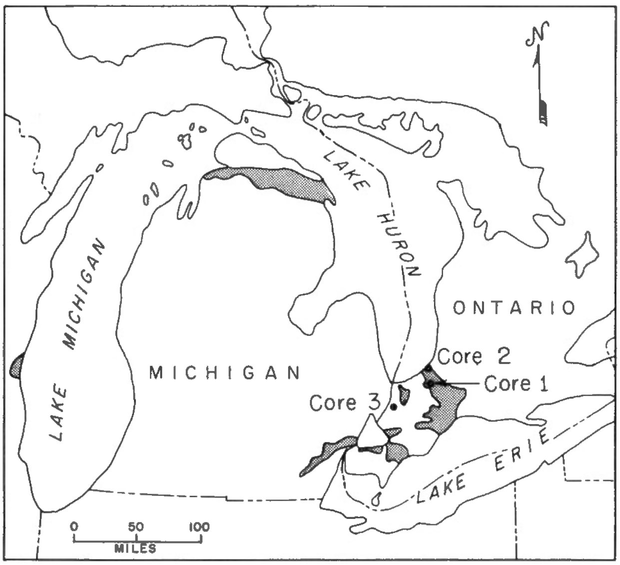

FIGURE 1
Map of outcrop area of Hamilton Formation in Michigan Basin and location of cores studied. (Core 1: GSC Arkona No. 1; Core 2: GSC Ipperwash No. 1; Core 3: Argor 65–1)

Chitinozoa and Acritarcha from cores through the Hamilton Formation have proved to be numerous and varied. The objectives of this investigation are to establish which Chitinozoa and Acritarcha are present, consider their pattern of distribution, and determine what relationships exist among them.

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This project was undertaken as partial fulfillment of the requirements for a Doctorate degree at the University of Oklahoma under the direction of L. R. Wilson, who also critically reviewed the present manuscript. Thanks are extended to members of the committee and the staff at that institution. The Geological Survey of Canada provided two of the cores studied, and Imperial Oil Company of Canada Limited made the third core available through the Geological Survey of Canada. Special gratitude is extended to M. J. Copeland for suggestions and assistance.

STRATIGRAPHY

The structure of the Michigan Basin originated early in the Paleozoic. It is bounded by the Canadian Shield to the north, the Wisconsin and Cincinnati Arches to the southwest, and the Findlay and Algonquin Arches to the southeast and east. It was connected with the Appalachian Basin by the Chatham Sag between the Findlay and Algonquin Arches. Devonian sediments attain their greatest thickness (about 3,700 feet) in central Michigan, thin toward southwestern Ontario to about 1,000 feet in the area of the Chatham Sag, and thicken again into the Appalachian Basin. Middle Devonian strata are well represented in Michigan and southwestern Ontario; the Hamilton Formation (Figs. 1, 2) is an important component of these rocks.

<table>
<tr><th rowspan="2">EPOCH</th><th colspan="2">STAGE</th><th rowspan="2" colspan="2">STRATIGRAPHIC UNITS</th></tr>
<tr><th>N.A.</th><th>EUROPE</th></tr>
<tr><td rowspan="8">MIDDLE DEVONIAN</td><td rowspan="8">ERIAN</td><td rowspan="8">GIVETIAN</td><td colspan="2">KETTLE POINT</td></tr>
<tr><td rowspan="6">HAMILTON</td><td>IPPERWASH</td></tr>
<tr><td>WIDDER</td></tr>
<tr><td>HUNGRY HOLLOW</td></tr>
<tr><td>ARKONA</td></tr>
<tr><td>ROCKPORT QUARRY</td></tr>
<tr><td>BELL</td></tr>
<tr><td colspan="2">DUNDEE</td></tr>
</table>

FIGURE 2
Generalized stratigraphic section of the Hamilton Formation in Ontario.

The name Hamilton was first used by Vanuxem (1840) for rocks at West Hamilton, Madison County, New York, which underlie the Moscow Shales and overlie the Skaneateles Shales. His definition applies to what was later called the Ludlowville Shales. Cooper (1930) studied these rocks across New York and redefined the Hamilton Group to include the Marcellus Shales and Skaneateles, Ludlowville, and Moscow Formations, in ascending order.

In Ontario, the occurrence of Hamilton rocks was reported by Logan (1863). Caley (1943) and Winder (1967) referred these strata to the Hamilton Formation, but Stumm *et al.* (1956)

and Sanford (1967) considered the sequence as the Hamilton Group. Liberty (1969) and Liberty and Bolton (1971) refer to the sequence as a formation, and this usage is adopted in this report.

The Hamilton rocks from Ontario were subdivided by Stumm *et al.* (1956) into four formations—Arkona, Hungry Hollow, Widder, and Ipperwash, in ascending order—with the Arkona being considered equivalent to the Bell Shale, Rockport Quarry Limestone, and Ferron Point Shale of Michigan. Sanford (1967) indicated that the Bell and Rockport Quarry are present in the subsurface of Ontario. Consequently he added them to the sequence independent of and below the Arkona.

The Bell Formation was named by Grabau (1902). He did not specify a type locality, but was probably referring to the former settlement of Bell in Presque Ile County, Michigan (Warthin and Cooper, 1943). The Bell Member in Ontario comprises 30 feet of soft blue and grey calcareous shale, with, occasionally, local thin limestone lenses (Sanford, 1967), resting disconformably on the Dundee Formation. It is probably equivalent to the middle Skaneateles Formation of New York (Warthin and Cooper, 1943).

The name Rockport Quarry Formation was proposed by Cooper and Warthin (1941) to replace the preoccupied term Rockport Limestone. The type section is at Rockport, northeast Alpena County, Michigan. Southeastward across Ontario the limestone of the Rockport Quarry grades into shale and the member is not recognized south of the north shore of Lake Erie. It transgressively overlaps the Bell Member.

The Arkona Member was originally named by Grabau (1917) who correlated it with the Olentangy. Its type locality is on the banks of the Ausable River, 1½ miles northeast of Arkona, Ontario. The Arkona rocks consist mainly of soft bluish grey, highly calcareous and fissile shale (or mudstone) with thin, occasional interbeds of highly calcareous limestone. For convenience the term Arkona is used to refer to the combined Bell and Arkona Members under Lake Erie. The Arkona Member correlates with the Plum Brook Shale and Silica Formation of Ohio (Driscoll *et al.*, 1965), and the combined Ferron Point Shale, Genshaw, Newton Creek, and Alpena Formations of Michigan (Sanford, 1967).

The Hungry Hollow Member of Cooper and Warthin (1941) has its type locality at Hungry Hollow (Marsh's Mill), 2½ miles east of Arkona, where it is approximately 5½ feet thick. This member comprises 2½ feet of light brown limestone overlain by 3 feet of calcareous shale. The limestone is crinoidal and the shale contains many corals. The lower contact of the member, with the Arkona Member, is at an apparent disconformity (Mitchell, 1967, p. 178) marked by pebbles, phosphate nodules, casts of burrows, sole markings, and abraded fossils. The member has been correlated with the Centerfield Limestone Member of the Ludlowville Formation of New York, the Four Mile Dam Formation of Michigan, and the Ten Mile Creek Formation of northwestern Ohio (Sanford, 1967).

The Widder was named by Stauffer (1915) who referred to it as a member of the Hamilton Formation. Stumm *et al.* (1956) extended the definition of the Widder to include the Petrolia Shale. The type locality of this member was given as the railroad cutting at the overhead bridge, a mile east of Thedford, Ontario, and 1¼ miles north of Widder. The village of Widder does not now exist. The type section is covered and the Widder exposure at Rock Glen, which Stauffer also mentioned, is more accessible. This member consists of blue-grey argillaceous limestone with grey calcareous shale interbeds. It is extremely rich in invertebrate megafossils. Stauffer (1915) reported it to be about 50 feet thick, but the given thickness of the member will vary with the accepted definition. The lower boundary was defined by Wright and Wright (1961) to be below a 9-inch shale unit that lies below a 1½-foot-thick limestone unit. This limestone unit had previously been accepted as the base of the Widder. Consequently, the shale unit below the limestone probably has been considered the upper unit of the Hungry

Hollow Formation. The Widder correlates with part of the Ludlowville Formation of New York (Stumm *et al.*, 1956) and with part of the Norway Point Formation of Michigan (Stumm *et al.*, 1956; Sanford, 1967).

The Ipperwash Member was named by Stauffer (1915) for rocks on Stony Point, at the north end of Ipperwash Beach on Lake Huron. It is made up of about 50 feet of grey limestone with some bluish shale. Wright and Wright (1963) extended the term to cover rocks found at Kettle Point, and subdivided the unit into two parts. The upper part of the Ipperwash, exposed at Kettle Point, is approximately 2 feet thick, and consists of dark grey limestone and some shale partings. The lower part consists of the rocks that Stauffer (1915) described from Stony Point. The upper contact of the member with the black shale of the Kettle Point Formation is very sharp, at an uneven surface (Wright and Wright, 1963). Winder (1967, p. 713) described the contact at Ipperwash Beach as occurring below a bed of black chert 6 inches thick. The lower contact of the member, with the Widder Formation, is not exposed but is considered to be sharp (Winder, 1961). The Ipperwash Member correlates with the upper part of the Norway Point Formation of Michigan (Stumm *et al.*, 1956; Sanford, 1967) and with the upper part of the Ludlowville Formation of New York (Stumm *et al.*, 1956).

METHODS OF INVESTIGATION

Sampling

Material for this study of the Hamilton Formation was recovered from three cores (*see* Appendix). The Geological Survey of Canada No. 1 Arkona No. 1 core and the Geological Survey of Canada No. 2 Ipperwash No. 1 core begin at surface level. The stratigraphic determinations made by B. V. Sanford for the Arkona and Ipperwash wells are not necessarily those followed in this paper. The upper part of the Widder Member and all of the Ipperwash Member are missing in the Arkona No. 1 core; the upper part of the Ipperwash Member is missing from the Ipperwash No. 1 core. The Argor Consolidated Morrison 65–1 core is through the complete Hamilton Formation. Figure 3 illustrates the general lithology of the cores and their correlation.

Samples 5 inches long and consisting of a quarter segment of the core were taken at 5-foot intervals. Another series of samples of the same size was taken both immediately above and below the formational boundaries, if this interval has not been covered by the first sampling. The boundaries had been determined on lithological criteria. A total of 195 samples was taken and processed.

The samples were assigned a three-symbol code. The first symbol is numerical, representing the core from which the sample was removed: (1) GSC Arkona No. 1; (2) GSC Ipperwash No. 1; and (3) Argor 65–1. The second symbol is a letter indicating the sampling series: (A) 5-foot intervals; (B) boundary samples. The third symbol is numerical indicating the sequential sample number.

Processing

Each sample was washed, broken where necessary into one-quarter-inch fragments, and weighed. The samples ranged from 17.0 to 118.5 grams, and averaged 52.7 grams. Treatment with concentrated hydrochloric acid for twenty-four hours removed soluble carbonates. The samples were washed with distilled water, and treated with 52 per cent hydrofluoric acid for six to eight days. The samples were washed with distilled water until neutral. The residues were sieved and the fraction greater than 0.044 mm was retained. This fraction was then

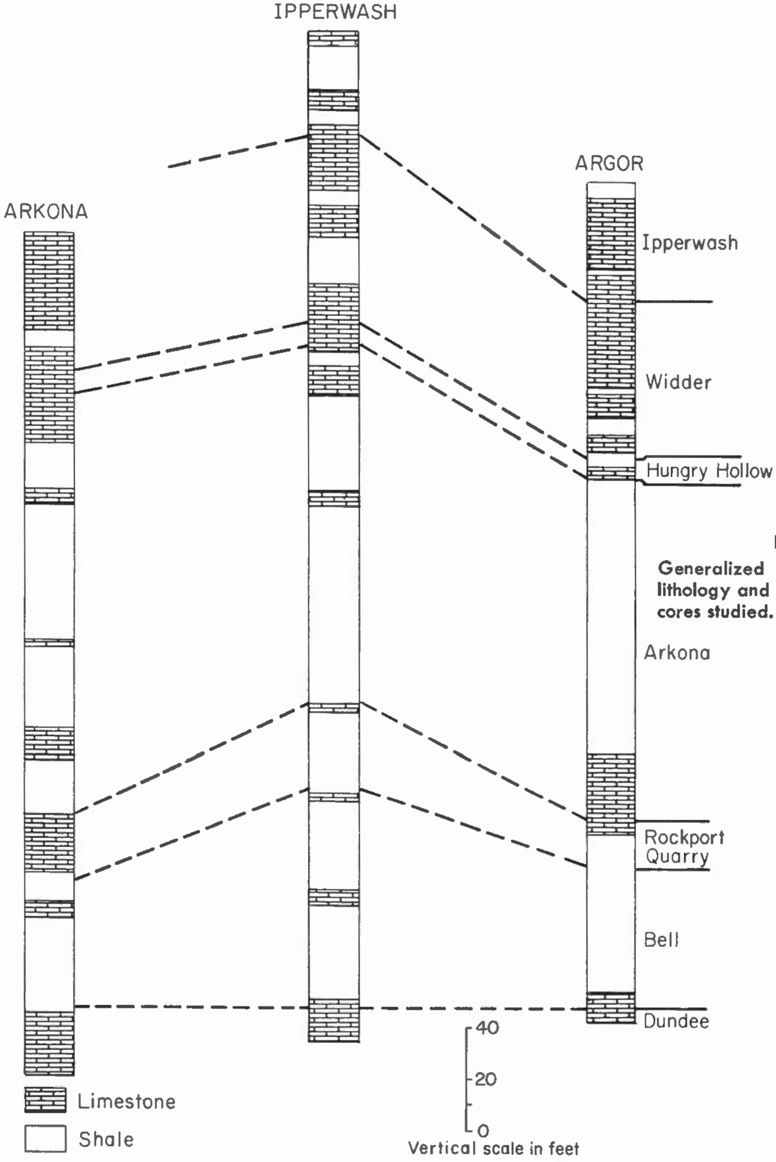

FIGURE 3
Generalized representation of the lithology and correlation of the three cores studied.

treated with concentrated hydrochloric acid and heated in a water bath for four to six hours. The samples were subsequently washed until neutral and temporarily stored.

Utmost care was exercised to prevent breakage of the Chitinozoa. Thus, the samples were not disaggregated using a mortar and pestle, a minimum of stirring was done, and very little centrifuging was effected. All the washing processes were done by allowing several hours for the sediment to settle in distilled water and subsequently decanting the supernatant liquid.

Standard procedure involves the use of a base, often ammonium hydroxide, after the hydrofluoric acid treatment. In many of the Hamilton samples this caused gelatinous clumps to form which were nearly impossible to disaggregate. Hydrogen peroxide helped in breaking the clumps but its action was too violent for the Chitinozoa and Acritarcha. It destroyed most of the Acritarcha and some of the Chitinozoa, and caused the remaining Chitinozoa to break into fragments too small to identify. Heating of the affected samples in hydrochloric acid succeeded in disaggregating some of the clumps, but not completely. Consequently, the use of a base was curtailed, to be replaced by heating in hydrochloric acid. This last step helped to clear much of the unwanted residue.

Because the samples were not treated to various oxidizing agents and bases they often did not digest completely. To concentrate the palynomorphs it was necessary to pick them from residues in water by using a binocular microscope and fine hand-drawn pipettes. Some of the samples in which the Chitinozoa were densely opaque were treated with Schulzs' solution for one to four minutes, in order to bleach them, and then washed until neutral. Although some of the Chitinozoa remained unbleached, the process was not prolonged because other Chitinozoa were bleached and further processing would have destroyed them.

Permanent slides were prepared from these concentrated residues, using a water-miscible mountant (Wilson, 1968).

Research

Slide counts were done in order to establish what Chitinozoa and Acritarcha were present in the samples. Wherever possible at least 200 Chitinozoa and Acritarcha were identified and counted from at least two slides per sample to ensure that adequate survey was made and that no taxon was ignored. More than one slide was used, when available, because assemblage counts can vary from one slide to another due to differential settling during preparation of the slides.

Criteria to determine abundances of taxa at different levels were difficult to establish. A major difficulty arose because the Chitinozoa and Acritarcha had been picked, thus introducing a bias in the sampling. Abundances are described as follows: if 5 or less specimens of a taxon were found in a picked sample it is termed rare; 6 to 10, uncommon; 11 to 20, common; 21 or more, abundant. This arbitrary scale is only a general reflection of the true numerical situation. For specimens from the Dundee Formation, only their number is recorded because only a small part of the formation was sampled and no overall picture was studied.

Specimens were photographed on KB14 Adox Film with fair to satisfactory results. If surface detail on Chitinozoa did not show up satisfactorily, use of Kodak infrared film was very advantageous and permitted surface detail and internal structure of Chitinozoa to be recorded. Some Acritarcha being transparent offered too little contrast for satisfactory photomicrographs to be taken.

Various tables portray some of the relationships found. Tables I to III (*in pocket*) indicate the Chitinozoa at particular levels in each well. These range charts are graphic representations and do not take sampling interval thicknesses into account. Figures 4 to 6 present the relative percentages of the total Acritarcha–Chitinozoa assemblages obtained.

STRATIGRAPHIC DISTRIBUTION

Chitinozoa and Acritarcha

Acritarcha are the most abundant palynomorphs in the Hamilton Formation. They are present in nearly all sampling intervals and generally make up over 50 per cent of the Chitinozoa–Acritarcha assemblages (Figs. 4–6) with little taxonomic variation.

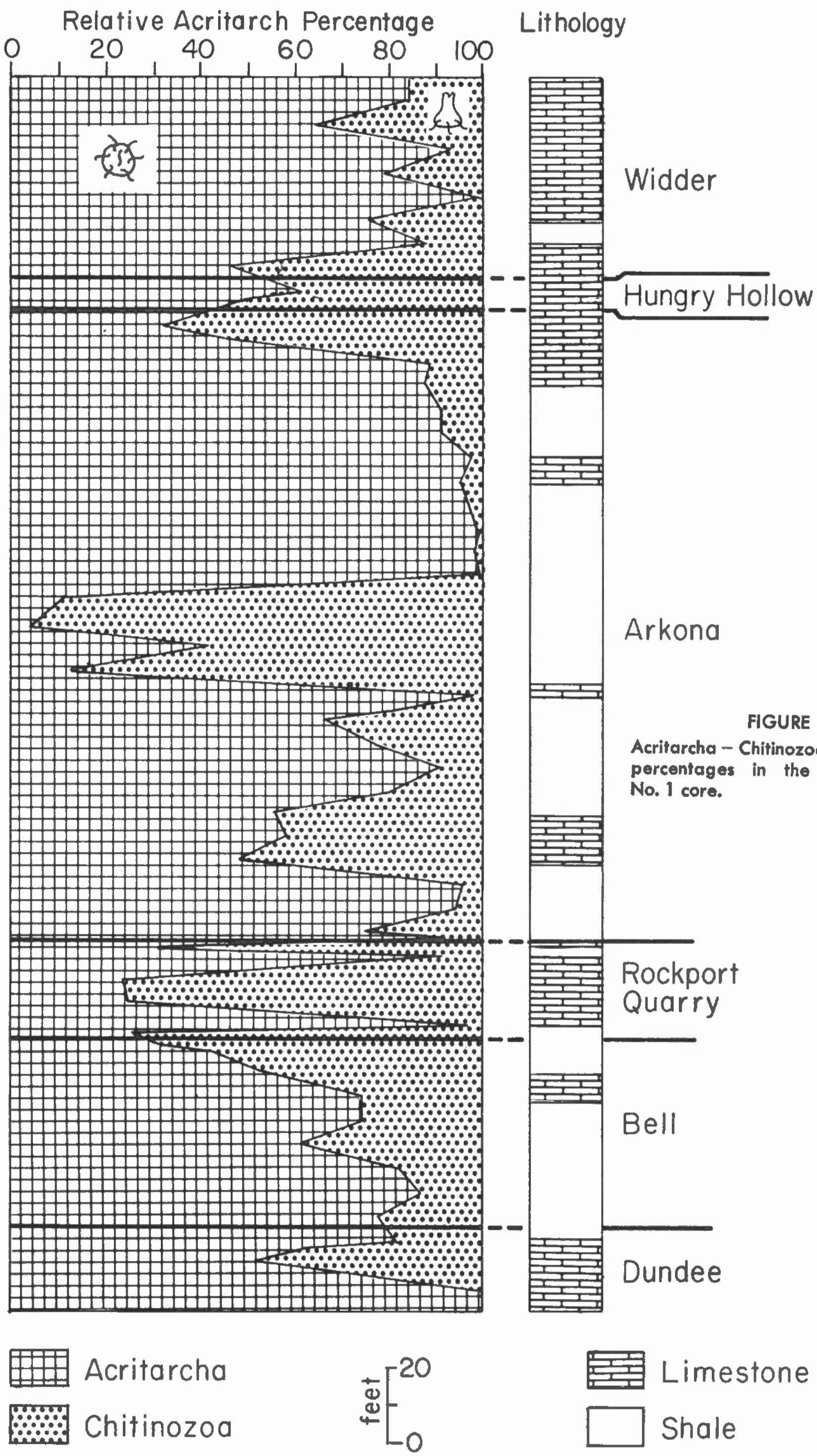

FIGURE 4
Acritarcha – Chitinozoa assemblage percentages in the GSC Arkona No. 1 core.

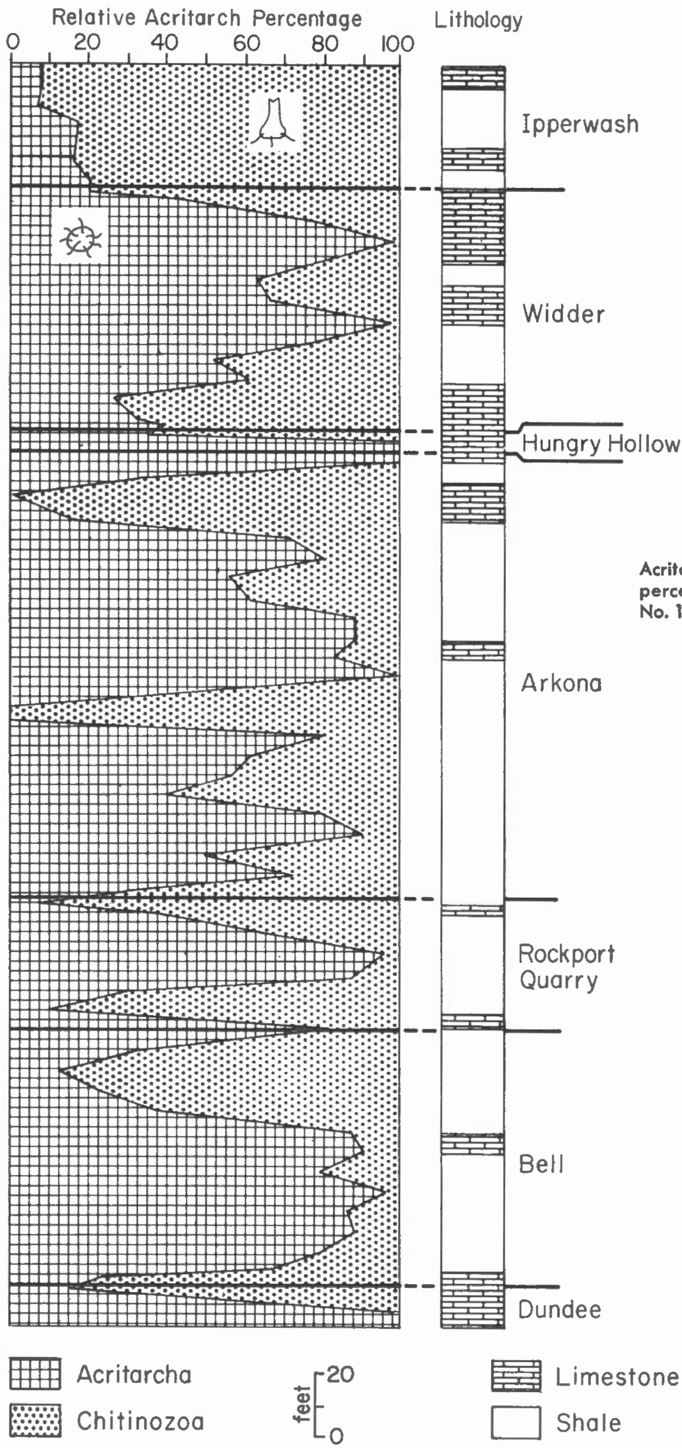

FIGURE 5
Acritarcha – Chitinozoa assemblage percentages in the GSC Ipperwash No. 1 core.

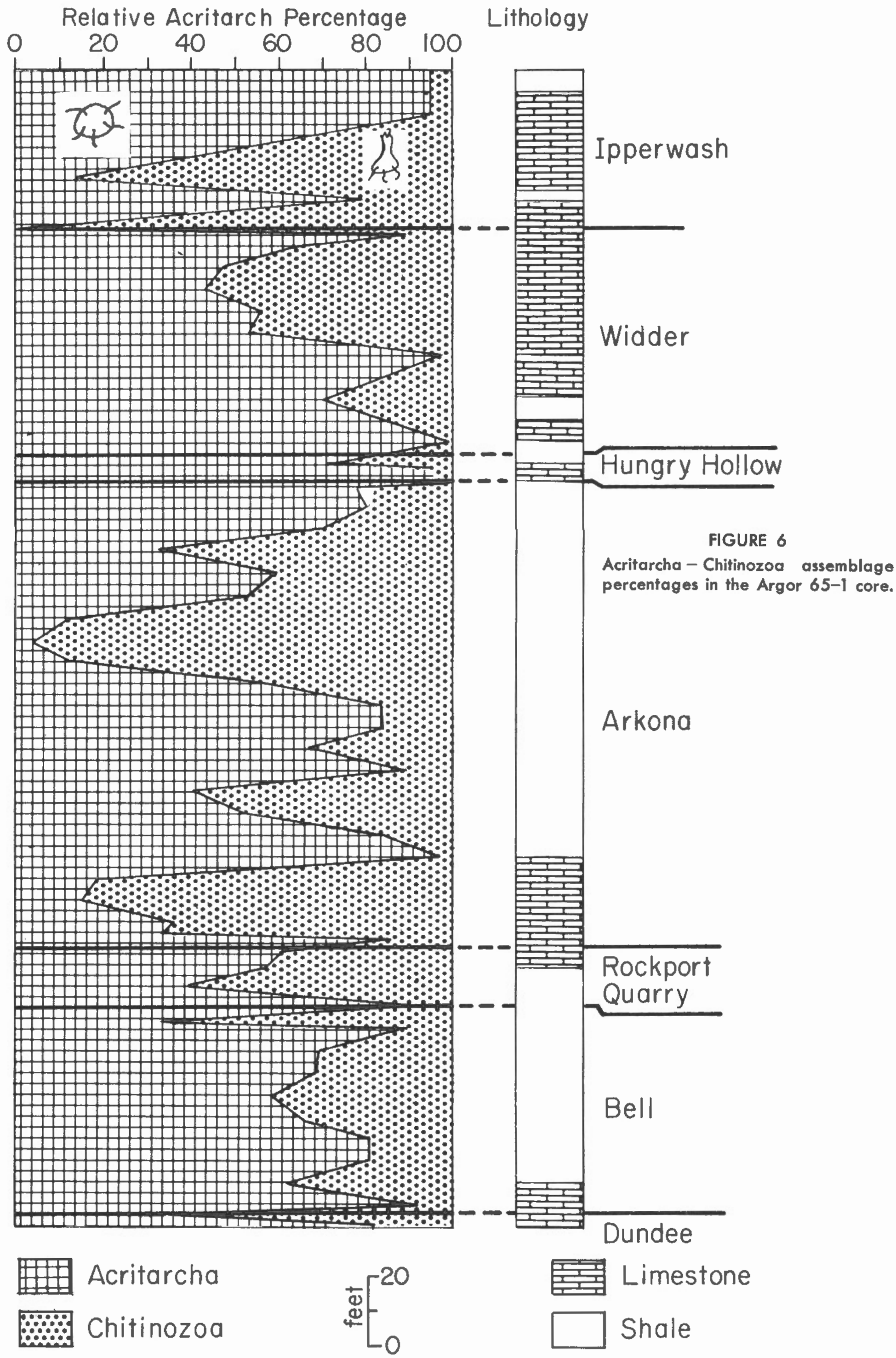

FIGURE 6
Acritarcha – Chitinozoa assemblage percentages in the Argor 65–1 core.

High relative percentages of Chitinozoa occur in two zones in the Bell Member. One zone occurs at the base of the member in two cores (GSC Ipperwash No. 1 and Argor 65–1; Figs. 5, 6); in the GSC Arkona No. 1 core (Fig. 4) this increase in Chitinozoa occurs 10 feet below the top of the Dundee Formation. Above this lower Chitinozoa zone, the Acritarcha percentages increase and remain high. The second zone of high Chitinozoa percentages occurs at or near the top of the member in all three cores (Figs. 4–6).

Two zones of high relative percentages of Acritarcha occur in the Rockport Quarry Member. These are at the bottom and above the middle of the member in the three cores. These peaks are separated by high Chitinozoa percentages. The lower Acritarcha peak is 5 feet above the base of the member in the GSC Arkona No. 1 core (Fig. 4).

The Arkona Member has two major intervals of high relative percentages of Acritarcha separated by samples with high relative percentages of Chitinozoa near the middle of the member. This zone of high relative percentage for Chitinozoa seems to indicate a contemporaneous set of events in all three cores. The lower peak in relative Acritarcha abundance is not so great or so constantly sustained as the upper peak. This relative Acritarcha abundance in the upper part of the Arkona Member is high, ranging from 80 to 100 per cent and in two cores (GSC Arkona No. 1, Argor 65–1) extends for 50 and 60 feet respectively.

In the Widder Member the Acritarcha generally comprise more than 50 per cent of the Chitinozoa–Acritarcha assemblages. There is a relative decrease in their abundance near the Widder–Hungry Hollow contact, and a relative increase in the Hungry Hollow Member. In two cores (GSC Ipperwash No. 1, Argor 65–1) this increase is such that the Acritarcha are more than 90 per cent of the Chitinozoa–Acritarcha assemblages. In the GSC Arkona No. 1 core the relative percentage increase of the Acritarcha reaches only 61 per cent.

Variations of Chitinozoa–Acritarcha relative percentages do not correspond to lithological changes within the Hamilton Formation. This indicates that the lithological changes and the variations in Chitinozoa–Acritarcha percentages were not contemporaneous or controlled by precisely the same factors.

Acritarcha in the Hamilton Formation show little vertical variation. Therefore their sensitivity to those factors which caused the lithological changes was rather low. There are some vertical differences in the distribution of Chitinozoa within the Hamilton Formation. Consequently it can be concluded that the Chitinozoa were perhaps more sensitive to some undetermined factors than were the Acritarcha.

Spores

Spores have been recovered from all members of the Hamilton Formation. Many genera and species are represented at various levels; at no level does any species assume numerical importance. There appear to be several new forms, as well as some forms whose geological ranges will have to be extended.

BIOSTRATIGRAPHIC CONCLUSIONS

Study of the Chitinozoa and Acritarcha has shown that both groups are consistent through the stratigraphic sequence. Neither group shows great sensitivity to obvious local factors; this enhances their value as stratigraphic tools. The cores studied are geographically close, being less than 50 miles apart, and so provide a detailed picture of the microplankton in a small area only. Lack of similar information concerning fossil microplankton from other localities of Middle Devonian rocks in the Michigan Basin prevents formulation of widely applicable biostratigraphic conclusions. Potential for zonation using high percentage levels has been indicated at certain stratigraphic levels, but these are obscured by local factors which cannot be eliminated without data from more widely separated areas.

Stratigraphic boundaries set at lithological boundaries are, in several places, reflected in drastic numerical reductions of one or the other group of microplankton. These reductions could have been caused by actual lack of living microplankton or could reflect removal of the vesicles by mechanical or chemical means induced during sea regression or non-deposition. Lithological changes and relative percentages of Chitinozoa–Acritarcha, however, do not appear to be closely related (Figs. 4–6).

The fossil microplankton composition is relatively stable throughout the studied samples; this suggests that little overall change occurred during the time of deposition of these rocks. The Acritarcha assemblages remain virtually unchanged throughout the formation except for the Ipperwash Member where a decrease is apparent. Of the Chitinozoa two major distribution changes are observed in the vertical distributions of: 1) species of *Angochitina*, and 2) species of *Desmochitina*, *Eisenackitina*, and *Poteriochitina*. Species of *Angochitina* are generally restricted to the sequence above the midpoint of the Arkona Member. The group composed of *Desmochitina*, *Eisenackitina*, and *Poteriochitina* is generally found below the Hungry Hollow Member. In the *Angochitina* the control may be ecological because species of *Angochitina* occur below this stratigraphic level at other localities. Ecological control may also be a valid factor for the second group of Chitinozoa, but it could also be due to extinction, its ecological niche being occupied by species of *Angochitina*.

Abundance and good preservation of the Chitinozoa in the Hamilton Formation have contributed to an elucidation of the wide range of previously unknown variations which several species exhibit. The original description of *Ancyrochitina cornigera*, for example, takes into account only a small part of the range of variation that it is now shown to have. As a result of this study, it is indicated that descriptions of *Ancyrochitina cornigera*, *A. gordita*, *A. langei*, *A. tumida*, and *Angochitina devonica* should be expanded. Formal emendation of these species, however, must await examination of the originally described material.

The recognition of the Hamilton Formation as a biostratigraphical entity has been strengthened by observation of the unity among Chitinozoa and Acritarcha found in it. This stratigraphic unit can be zoned on the basis of the larger invertebrates present.

Several lines for future research in the Hamilton Formation are suggested by this study. The chemistry of the Hamilton Formation sediments might prove a discriminating indicator for environmental conditions and show a relationship between some chemical factor and the relative Chitinozoa–Acritarcha percentages. Paleomagnetic studies already undertaken (C. W. Harper, pers. com.) may provide data to explain geographic distribution and variation of the fossil biota.

PALEONTOLOGY

Chitinozoa

Chitinozoa are a group of extinct organisms, generally considered as animals. They range from Ordovician to Devonian, but have been reported from Mississippian rocks (Wilson and Clarke, 1960). Chitinozoa occur in marine rocks of various lithologies, more commonly shale; they are widely distributed, and evolved rapidly; their various taxa have short stratigraphic ranges. These attributes, their small size (60 to 2,000 microns), and chemical resistance make them stratigraphically useful especially if only small amounts of rock are available for study.

Chitinozoa were first found in Germany (Eisenack, 1931) and have since been described from Europe, Africa, North America, and South America. They flourished in Ordovician and

Silurian times with a large variety of forms, and persisted until the end of the Devonian. In Africa and Europe there seems to have been a general reduction in size of Devonian forms as compared with those of the Ordovician and Silurian. In North America there are some exceptions to this, such as the large Chitinozoa described by Collinson and Scott (1958) from the Cedar Valley Formation.

Basically a chitinozoan is a hollow, organic-walled test radially symmetrical about a longitudinal axis (Jenkins, 1970). It is closed at one end, with or without an operculum that closes the open end in forms without necks, or a "plug" that fits into the neck. The vesicle or test is spherical or cylindrical, or comprises a spherical, conical, or cylindrical chamber and a neck that is generally cylindrical and may flare orally. The oral end, the open extremity of the vesicle, may be simple, flared into a collar, or constricted into a thickened lip. The vesicle wall may be smooth or ornamented with a wide range of features from papillae to spines of varying complexity. The aboral end, or basal extremity of the vesicle, may be simple, thickened into a basal callus, or extended into a copula. The basal callus and copula attest to the chain-type of habit of some Chitinozoa.

Although most of the Chitinozoa previously reported are represented by individual vesicles, sequences of Chitinozoa in chains are common, and it is probable that many Chitinozoa lived at least part of their life cycle in chains with the oral end of one vesicle appressed to the aboral end of the succeeding vesicle. Koslowski (1963) described Chitinozoa that occurred in colonial aggregates in which the oral ends of the vesicles were free and the tests were secured only by their aboral ends. These aggregates, in some instances, were enclosed in cases.

The term prosome has been used to describe an extensile-retractile structure that lies within the neck (Jenkins, 1970, p. 4). When fossilized in retracted state, it is supposed to look like a plug, and is usually situated at the base of the neck. This term is not so clear as the above definition implies. Several authors (Combaz and Poumot, 1962; Combaz *et al.*, 1967) used the term prosome in the above sense, but they illustrated it to seem as if the prosome were a part of the neck wall. Consequently some confusion exists, and the term should be defined whenever used. In the Hamilton Formation, two types of structures were observed which could be termed prosome. In one specimen (Pl. VI, fig. 5) a banded appearance at the base of the neck was observed, but this could be due to thickened rings on the inner surface of the wall; it need not be a prosome in the sense of a structure separate from the wall. In other specimens, a discrete dark structure has been observed distinct from the vesicle walls, and which in some specimens protrudes from the neck of the Chitinozoa. On one of these (Pl. VI, fig. 6) the structure bears discrete spines directed distally. It is visible in part beyond the oral edge of the test and appears as a solid structure, not a contracted "concertina-like" structure. Because of the ambiguity of the term prosome in the literature this term is not used in this report. Instead the term plug has been used (Jenkins, 1970, p. 4). This term implies a function which may not have been that of the structure. Therefore it is used with some reservation as indicated by the use of quotation marks: "plug." This is to indicate that although the term is adequate in some ways, not all its ramifications are accepted. "Plugs" were not observed in all forms, but may have been present at one time and subsequently lost. Species without necks have a plate-like cap, an operculum, which can be observed to cover the oral opening.

The terms used in this study as well as the symbols for the measurements effected are illustrated in Figure 7.

The problem of the systematic position of Chitinozoa has been considered by many researchers, but the solution has not been determined. Eisenack (1931) suggested that the Chitinozoa were related to protozoans of the rhizopod order Testacea, and subsequently

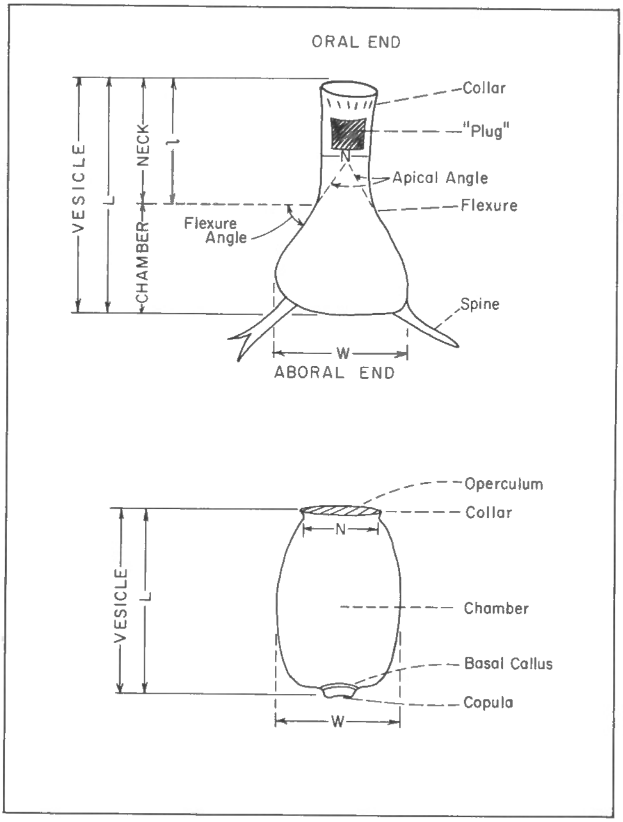

FIGURE 7
Morphological terms and measurement symbols used for the Chitinozoa.

(1932) suggested that they were similar to the flagellate protozoan *Trachelomonas.* Deflandre (1945) commented on the resemblance between some Chitinozoa and some ciliophoran protozoans. Collinson and Schwalb (1955) found some similarity between chitinozoans and the testacean genus *Gromia.* Koslowski (1963) assigned them to the metazoans, and suggested that the aggregates he found with cases are remotely analogous to eggs and egg capsules of some existing metazoans.

Jenkins (1970) mentioned that Chitinozoa and graptolites are very closely associated in the geological record. Their geological ranges are roughly similar, they often occur together, and there seems to be a relationship in their abundances. He proposed that Chitinozoa may perhaps be preprosicular stages of graptolites.

The Chitinozoa in this report have been described in an arbitrary sequence based on morphological features. Those specimens illustrated herein are measured and indicated in the specific descriptions by GSC type fossil numbers.

Acritarcha

Acritarcha are a polyphyletic group of organic-walled fossil microplanktonic organisms of undetermined biological affinities. They are classified according to their morphological structure, mainly because the biological affinities are vague and probably varied.

The term Acritarcha was proposed (Evitt, 1963) for a group of fossils previously referred to by the informal term "hystrichosphere" or "hystrix." Ehrenberg (1838) was the first to make known observations of these micro-organisms in fossil state. The term hystrichosphere was initiated by Wetzel (1933) who named the genus *Hystrichosphaera* to denote Ehrenberg's erroneously assigned forms, and noted its uncertain biological affinities. He also named a new family Hystrichosphaeridae, implying animal affinities. Deflandre (1937) corrected Ehrenberg's type assignations and erected another genus, *Hystrichosphaeridium*. Deflandre (1947) indicated that the Order Hystrichosphaeridae was polyphyletic, containing varied and often unrelated forms.

The Order Hystrichosphaeridae was expanded to include a great variety of morphological types for which no biological affinities could be proposed. Evitt (1963) stated that the morphology of *Hystrichosphaera* and *Hystrichosphaeridium* shows that they are dinoflagellates. He emended the family Hystrichosphaeraceae and excluded from it those forms which show no morphological characters of dinoflagellates. The change in family name was necessitated to follow the International Code of Botanical Nomenclature, which encompasses the dinoflagellates.

Evitt suggested the name Acritarcha for those forms excluded from the hystrichospheres. This name encompasses a group of morphologically varied microfossils whose affinities cannot be determined. Consequently, the term Acritarcha, because of its polyphyletic implication, has no formal status in taxonomic nomenclature but it is retained as a "catch-all" category. When an acritarch's affinities can be determined it should be removed to the appropriate taxonomic entity.

Acritarcha are morphologically varied. The test or vesicle can be spherical, polyhedral, cigar-shaped, or irregular. The walls can be unornamented or bear appendages, spines, ridges or papillae, and be one- or two-layered, perforate, or imperforate. Some Acritarcha may be resting cysts, the opening (pylome) of which perhaps served as an escape outlet for the organism. Further terminology relies mainly on unspecialized descriptive terms.

The geologic history of the Acritarcha extends from Precambrian (Barghoorn and Tyler, 1965) to Recent. Paleozoic Acritarcha are varied and numerous; certain groups emerged rapidly and disappeared, offering great potential as stratigraphic indicators; others persisted for longer periods of time. In the Mesozoic and Cenozoic dinoflagellates tend to displace them in numbers and in stratigraphic importance.

The Acritarcha in this report have been classified according to the system proposed by Downie *et al.* (1963), which is based on morphological criteria.

Systematic Paleontology

CHITINOZOA

Alpenachitina Dunn and Miller, 1964

Type species: *Alpenachitina eisenacki* Dunn and Miller, 1964

"Small, flask shaped vesicles, base rounded, neck distinct, body with two or three horizontal rows of coarse branching spines." (Jansonius, 1967, p. 348.)

Alpenachitina ontariensis n. sp.

Plate I, figures 1, 3

Description. Vesicle cylindro-conical; chamber conical, 0.6 of vesicle length, base flat, sides straight; flexure distinct; neck subcylindrical, flaring orally from constriction at flexure; ornamentation of two horizontal rows of spines on vesicle, one row around basal edge, consisting of seven long (approx. 20 microns), coarse, complexly branching spines with some shorter and thinner spines between them, second row with four to five long (up to 26 microns), coarse, branching spines approximately 0.7 up chamber from base; oral edge fringed with short (7 microns) spines; rest of surface laevigate.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)
1–A–50	30554	107	31	79	28	0.7	0.4	60

Discussion. This species differs from *Alpenachitina eisenacki* Dunn and Miller, 1964 by the shape of the chamber. In *A. eisenacki* the chamber is cylindrical to rounded, but never as sharply conical as in the species described here. The new species has fewer spines around the chamber (two rows of seven) than *A. eisenacki* (two rows of ten to twelve); *A. ontariensis* has only one ring of spines at the oral edge whereas *A. eisenacki* is more complexly ornamented with a ring of five or six spines, less complex spines at midlength of the neck, spines between the ring and the oral opening, and many smaller spines at the oral edge.

Occurrence. Widder Member: rare (two specimens); Dundee Formation: seven specimens.

Figured specimen. Holotype, GSC No. 30554.

Ancyrochitina Eisenack, 1955

Type species: *Ancyrochitina ancyrea* Eisenack, 1955

"Small vesicles, body conical to pyriform, cylindrical neck well developed; base shallow convex, large spines or appendages on basal edge, other spines may occur on neck and body; prosome complex elongate, possibly with an annulated tube." (Jansonius, 1967, p. 348.)

The genus *Ancyrochitina* is represented in the Hamilton Formation by eighteen species. Seven are referable to named species, two are new, and nine are unnamed.

Ancyrochitina cf. *A. cornigera* Collinson and Scott, 1958

Plate I, figures 2, 4–12

Description. Vesicle cylindro-conical; chamber conical with apical angle of 40 to 77 degrees, base flat to slightly convex, sides straight; flexure distinct to imperceptible; neck cylindrical with or without flaring; basal edge ornamented by three to seven spines, 25 to 38 microns long, ranging from coarse (10 to 13 microns wide at base) imperforate to perforate, to wide-based and hook-like to clavate or distally fused; oral edge fringed with spines, fine to coarse, simple to bifurcating, up to 12 microns long; remainder of surface laevigate; internal "plug" observed on some specimens.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–48	30557	161	64	100	41	0.6	0.4	58	60
2–B–4	30558	128	61	94	38	.7	.4	77	55
3–A–26		125	56	94	46	.8	.4	67	63
3–A–27		115	38	77	38	.7	.3	43	71
3–A–28	30556	112	—	56	28	.5	—	40	—
3–A–37		105	39	71	36	.7	.4	47	70
3–A–37		102	28	66	28	.6	.3	41	77
3–A–37	30555	115	38	77	38	.7	.3	43	71

Discussion. Collinson and Scott (1958) described *Ancyrochitina cornigera* from the Solon Member, Cedar Valley Formation of Iowa, which correlates with the Upper Hamilton Group of New York (Collinson, 1967, p. 964). The specimens on which they based this species are larger (167 to 199 microns) than those recovered in this study (102 to 161 microns). The basal edge ornamentation which they attribute to this species consists of "short, simple spines that may be straight or slightly curved" (p. 168). Collinson and Scott illustrated short, broad-based coarse spines which are simple and imperforate. The oral edge ornamentation that they mentioned and illustrated is sparse. Specimens from the Hamilton Formation of Ontario have a much wider range of variation in basal edge spines. Some spines are short, conical and stubby, like the Cedar Valley specimens, but some are perforate. These perforations range in size from 1 to 8 microns, and may penetrate one or both walls of the spines. A gradation has been observed from simply pierced to clavate processes. The oral edge of the Hamilton specimens is ornamented by a fringe of spines of uniform size on each specimen, but may vary from one specimen to another. These spines range from short stubs a few microns long, to longer ones up to 13 microns long, and can be simple to complexly bifurcating. This variable character was not reported in the original description of the species. Because of the more comprehensive range of ornamentation, it is thought that the species definition could be emended to include the above-mentioned range in ornamentation of both the basal and oral edges.

Occurrence. Ipperwash Member: rare to abundant; Widder Member: rare to abundant; Hungry Hollow Member: rare; Arkona Member: rare to abundant; Rockport Quarry Member: rare to abundant; Bell Member: uncommon.

Figured specimens. Hypotypes, GSC Nos. 30555–30558.

Ancyrochitina cf. *A. desmea* Eisenack, 1964

Plate II, figures 1–3

Description. Vesicle cylindro-spherical; chamber conical with apical angle of 60 degrees, base flat, sides straight; flexure distinct at 0.6 of distance from base; neck cylindrical; ornamentation consisting of several long (26 microns) complexly branching spines at basal edge and smaller (18 microns) branching spines below oral opening; rest of surface laevigate.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
2–A–12	30559	117	49	79	31	0.7	0.4	60	64

Discussion. Ancyrochitina desmea was originally described from Silurian rocks. Lange (1967) described a similar species, which he named *A.* cf. *A. desmea,* from Middle Devonian strata of the Parana Basin. The Hamilton specimens are comparable to both previously described forms. The specimens described by Eisenack (1964) and Lange (1967) are larger than the Hamilton specimens, being 130 to 180 microns and 180 to 210 microns respectively, and the Hamilton specimens being 117 microns. But the relative proportions of length to width remain similar. The Parana and Hamilton specimens have spines at midlength on the neck. The Hamilton specimens appear to be morphologically more closely related to the *A.* cf. *A. desmea* of the Parana Basin than to the German material.

Occurrence. Widder Member: rare to uncommon; Hungry Hollow Member: uncommon; Arkona Member: rare.

Figured specimen. Hypotype, GSC No. 30559.

?*Ancyrochitina gordita* Cramer, 1964

Plate II, figures 4–6, 8

Description. Vesicle cylindro-conical; chamber conical with apical angle ranging from 54 to 60 degrees, base flat to slightly convex, sides straight to slightly convex; flexure more or less distinct; neck short, cylindrical; ornamentation of coarse, branching spines, 28 microns long, at basal edge; oral edge fringed with short stubby (5 microns) to long (28 microns) fine, simple to bifurcating spines, or unornamented; "plug" 26 by 31 microns observed.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–9	30563	100	—	89	33	0.9	—	60	67
1–A–44	30561	102	23	92	33	0.9	0.2	55	—
3–A–27	30562	94	26	79	38	0.8	0.3	55	—
3–A–47	30560	94	—	89	33	0.9	—	54	—

Discussion. In the original description of this species, Cramer (1964) mentioned "A few short smooth processes that are simple or simply bifurcated at their tips, may be present" (p. 339). In the Hamilton specimens, a much wider range of ornamentation is observed. There are simple forms with no evident ornamentation (Pl. II, fig. 4), some with short stubby spines at the oral opening (Pl. II, fig. 6), some with long simple to complex spines at the oral opening (Pl. II, fig. 5), forms with complex spines at the base (Pl. II, fig. 8), and some with less obvious, perhaps broken, ornamentation in that area.

The specimen Cramer described is larger than the Hamilton specimens, the former being approximately 150 microns, and the latter varying from 94 to 102 microns long. Despite the size difference it is felt that the Hamilton specimens are conspecific with Cramer's specimen and that the species definition should be expanded to include the wider range of ornamentation.

Occurrence. Ipperwash Member: rare to common; Widder Member: rare; Hungry Hollow Member: rare; Arkona Member: rare to uncommon; Bell Member: rare to uncommon; Dundee Formation: three specimens.

Figured specimens. Hypotypes, GSC Nos. 30560–30563.

Ancyrochitina cf. *A. langei* Sommer and van Boekel, 1964

Plate II, figures 7, 9–12; Plate III, figures 1–6

Description. Vesicle cylindro-conical; chamber conical with apical angle 40 to 65 degrees, base flat to slightly convex, sides straight to slightly concave; flexure more or less distinct to imperceptible; neck cylindrical, slight oral flaring common; basal edge ornamented with three to eight spines, 10 to 60 microns long, with simple to distally branching, some with slightly bulbous tips; oral edge fringed with simple to branching spines, 1 to 40 microns long; "plug," when present, can have orally oriented spines.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–9	30570	110	—	87	28	0.8	—	57	—
1–A–9	30571	120	—	97	33	.8	—	—	—
1–A–9	30567	156	77	89	38	.6	0.5	53	61
1–A–38	30564	112	38	89	33	.8	.3	54	70
1–A–44		112	—	94	31	.8	—	65	—
1–A–47		120	33	79	31	.7	.3	48	70
1–A–47	30565	148	64	82	66	.6	.4	45	70
1–A–48		117	—	97	28	.8	—	—	—
2–A–51	30569	115	—	71	41	.6	—	42	—
2–A–51		120	—	69	28	.6	—	40	—
2–A–51		—	—	82	33	—	—	—	—
2–A–51	30566	126	51	97	38	.8	.4	60	67
2–A–54	30568	135	—	89	31	.7	—	40	—
2–A–59		102	—	82	31	.8	—	—	—
2–B–4		168	94	102	38	.6	.6	50	70

Discussion. Sommer and van Boekel (1964) described *Ancyrochitina langei* from Lower Devonian beds of Brazil and Bolivia. Their figured specimen is similar in vesicle shape, width to length ratio and character of ornamentation to the Hamilton specimens. Their holotype, however, is larger than most of the Hamilton specimens, being 165 microns. The specimens from the Hamilton Formation show a much wider range of variation than does the type material. The type material of *A. langei* has two to six simple basal edge spines; those of the Hamilton specimens can range up to eight and vary from simple to complex. In the original description of the species little mention is made of the oral edge spines; they are described as shorter and thinner than the basal edge spines. It was not specified whether they are simple or complex. In the Hamilton species the development of the oral edge spines varies from less to equally well developed than those of the type material.

The specimens from the Hamilton Formation assigned to *A.* cf. *A. langei* resemble *A. pilosa curta* Taugourdeau (1962) from the Frasnian of North Africa. The vesicle length and chamber width are similar, but the apical angle of *A. pilosa curta* is 70 degrees, and thus greater than that of the Hamilton specimens (40 to 65 degrees). The neck in *A. pilosa curta* is shorter than that of the Hamilton specimens; it can be so reduced in length to be termed a collar and not a neck. In the Hamilton specimens, the neck is always well developed. In *A. pilosa curta* the basal edge spines are shorter than in the Hamilton specimens, but in both they branch distally. The oral edge spines vary from hair-like spines to sparse conical tubercles.

The vesicle shape and type of ornamentation of the Hamilton specimens are more closely related to those of *A. langei.* The size of the Hamilton specimens is closer to that of *A. langei,* but the factors controlling size in Chitinozoa are not known and wide size discrepancies occur within one species collected from different localities. Thus the criterion of size need not be diagnostic of a species.

Ancyrochitina langei has been reported from Lower Devonian strata of Brazil and Bolivia, whereas *A. pilosa curta* has been reported from lower Upper Devonian strata of North America. It can be postulated that although slightly more similar to *A. langei*, this Hamilton species is an intermediate form between *A. langei* and *A. pilosa curta*, and could possibly indicate a sequence in which *A. langei* eventually evolves into *A. pilosa curta*. This is suggested by the morphological characteristics and the intermediate stratigraphic position of the Hamilton specimens. Additional material must be found and studied before this can be substantiated.

Occurrence. Ipperwash Member: rare to abundant; Widder Member: rare to abundant; Hungry Hollow Member: abundant; Arkona Member: rare to abundant; Rockport Quarry Member: rare to abundant; Bell Member: rare to abundant; Dundee Formation: 104 specimens.

Ancyrochitina cf. *A. langei* is the most abundant and widely distributed species of this genus in the Hamilton Formation. In the Bell Member, there is a level at which this species is abundant in all three cores. At that level, this species comprises 45 per cent or more of the Chitinozoa assemblage. This level is approximately at the mid-point of the member in two cores (GSC Arkona No. 1, Argor 65–1) and 2/3 up in the third core (GSC Ipperwash No. 1) and might be contemporaneous at all three localities.

Figured specimens. Hypotypes, GSC Nos. 30564–30571.

Ancyrochitina cf. *A. multiramosa* Taugourdeau and de Jekhowsky, 1960

Plate III, figure 10

Description. Vesicle cylindro-conical; chamber conical with apical angle 50 degrees, base flat, sides straight; flexure distinct; neck cylindrical; basal edge ornamented by many spines, 31 microns long, slender, branching distally; oral edge fringed with spines, 10 microns long, coarse.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–9	30572	115	49	69	33	0.6	0.4	50	70

Discussion. The species from the Hamilton Formation is similar to the type specimen of *Ancyrochitina multiramosa* which Taugourdeau and de Jekhowsky (1960) described from Silurian rocks of North Africa. In the description of that species it is indicated that the basal edge spines are more numerous than in any other species of the genus. The Hamilton specimens in this study have a large number of slender, distally branching spines. This is the character that relates the two occurrences. The forms differ in size, the holotype being larger by 40 microns, and in width to length ratio, that of the holotype being 0.5 and that of the Hamilton specimen being 0.6. Further study may indicate that two discrete species exist although ornamentation in both is similar.

The Hamilton specimen shows very unusual, large (8 microns) perforations aligned in one row around the neck at the flexure area and on the chamber. That this might indicate that a row of spines had been present is not borne out in other specimens attributed to this species from the Hamilton Formation. This character probably indicates areas which were weaker (thinner?) and therefore more susceptible to solution during diagenesis or sample processing.

Occurrence. Widder Member: rare (one specimen); Hungry Hollow: rare; Arkona: rare; Dundee Formation: seven specimens. All the specimens were recovered from GSC Arkona No. 1 core.

Figured specimen. Hypotype, GSC No. 30572.

Ancyrochitina tomentosa Taugourdeau and de Jekhowsky, 1960

Plate III, figure 11

Description. Vesicle cylindro-conical; chamber conical, base flat, sides slightly convex; flexure masked by distortion on specimen; neck cylindrical; ornamentation of coarse spines, up to 28 microns long, complexly branching, distributed over all the vesicle, pitted.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L
1–A–2	30573	107	33	79	41	0.7	0.3

Discussion. Taugourdeau and de Jekhowsky (1960) described this species from a Silurian–Upper Devonian sequence in North Africa. Those specimens are much larger (holotype: 160 microns) than the Hamilton specimen (107 microns). The overall shapes and ornamentation of both forms are nearly identical, and consequently they are considered conspecific. This species has a wide stratigraphic range in Africa, but its rarity in the Hamilton Formation precludes comment on stratigraphic range in southern Ontario.

Occurrence. Widder Formation: rare (two specimens). Both specimens were recovered from the same level (1–A–2) of GSC Arkona No. 1 core.

Figured specimen. Hypotype, GSC No. 30573.

Ancyrochitina cf. *A. tumida* Taugourdeau and de Jekhowsky, 1960

Plate III, figures 7–9, 12; Plate IV, figure 1

Description. Vesicle cylindro-conical; chamber conical with apical angle 55 to 69 degrees, base slightly convex, sides straight; flexure distinct, from 59 to 69 degrees; neck cylindrical with slight oral tapering in some specimens; ornamentation of two to eight spines at basal edge, up to 43 microns long, slender to coarse and pitted, simple to complexly branching; oral opening fringed with spines, 10 to 28 microns long, simple to complexly branching.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–22		125	51	87	38	0.7	0.4	61	63
1–A–45	30575	120	36	94	33	.8	.3	63	59
1–A–45	30577	117	28	89	43	.8	.2	59	60
1–A–47	30576	130	51	100	36	.8	.4	55	69
1–A–48	30574	130	46	77	33	.6	.4	69	62
2–A–61		117	38	87	43	.7	.3	60	68

Discussion. Ancyrochitina cf. *A. tumida* from the Hamilton Formation differs from the type specimens from Silurian and Middle Devonian strata of North Africa, only in the presence of oral edge ornamentation. This is probably not important enough a criterion to separate them as two different species.

Occurrence. Hungry Hollow Member: uncommon; Arkona Member: rare to uncommon; Rockport Quarry Member: rare to common; Bell Member: rare; Dundee Formation: 27 specimens.

Figured specimens. Hypotypes, GSC Nos. 30574–30577.

Ancyrochitina hamiltonensis n. sp.

Plate IV, figures 2, 3

Description. Vesicle cylindro-conical; chamber conical with apical angle 72 degrees, base slightly convex, sides straight; flexure distinct; neck cylindrical with slight oral flaring; ornamentation of a few spines at basal edge, 38 microns long; thick fringe of many coarse complexly branching spines, 20 microns long, 3 microns wide, at oral edge; "plug" observed in lower half of neck.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
3–A–27	30578	125	54	97	33	0.8	0.4	72	45

Discussion. The general shape of the vesicle and proportions are somewhat similar to those of *Ancyrochitina langei* Sommer and van Boekel (1964), but the apical angle is larger (72 degrees) than in *A.* cf. *A. langei* (40 to 65 degrees) from the Hamilton Formation. The oral edge ornamentation is the distinguishing character of this species. It is a ring of closely spaced spines which are relatively long (20 microns), coarse (3 microns wide), taper only at their tips, vary from simple to complex, and are densely set at the oral edge. No other such oral edge ornamentation has yet been described. Because of the unique character of the ornamentation the specimens are recognized as a new species.

Occurrence. Widder Member: rare (one specimen); Arkona Member: rare to uncommon; Rockport Quarry Member: rare; Bell Member: rare to common.

Figured specimen. Holotype, GSC No. 30578.

Ancyrochitina arkonensis n. sp.

Plate IV, figures 4, 5, 7–9

Description. Vesicle cylindro-conical; chamber conical with apical angle 45 to 66 degrees, base flat to convex, sides straight; flexure distinct to imperceptible; neck cylindrical with or without slight oral flaring; ornamentation, generally present, of fine basal edge spines, up to 23 microns long on some specimens; oral edge ornamented with short knobs, 1 to 2 microns long, or spines 2 to 15 microns long, simple to bifurcating; remainder of surface laevigate; "plug" observed in some specimens, can be spinose at upper surface, spines up to 14 microns long.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–22		135	—	97	28	0.7	—	52	—
1–A–32		130	46	100	41	.8	0.4	55	65
1–A–46	30580	138	61	97	36	.7	.4	59	48
2–A–61		122	51	89	33	.7	.4	66	57
2–A–61		138	54	84	33	.6	.4	56	73
3–A–8	30581	204	135	92	49	.5	.7	45	67
3–A–26	30579	153	64	94	38	.6	.4	55	68
3–A–27	30582	117	41	79	36	.7	.4	50	—

Discussion. This new species is characterized by the presence of oral edge ornamentation and the absence or near absence of basal edge ornamentation. The oral edge ornamentation ranges from short knobs, 1 to 2 microns long, to spines, 2 to 15 microns long, which are simple to complex. The basal edge, when ornamented, has fine spines up to 23 microns long. They are delicate, consequently can be broken off the vesicle at their bases. There are many specimens that show no evidence of basal edge spines ever having been present.

Cousminer (1964) described as a new species specimens from the Devonian of South America. The Hamilton specimens agree with that description and are therefore considered conspecific. Cousminer indicated a geological range of Middle Devonian to basal Upper Devonian (Frasnian) for his specimens (p. 173). Because his work has not been published, a new name, *A. arkonensis*, is here proposed.

One of the specimens from the Hamilton Formation (Pl. IV, fig. 7) has a very long neck. Because only one specimen has that characteristic it is considered aberrant and remains in the species.

Occurrence. Ipperwash Member: rare; Widder Member: rare to uncommon; Hungry Hollow Member: rare to uncommon; Arkona Member: rare to abundant; Bell Member: rare to common; Dundee Formation: thirteen specimens.

Figured specimens. Holotype, GSC No. 30579; paratypes, GSC Nos. 30580–30582.

Ancyrochitina sp. 1

Plate IV, figure 6

Description. Vesicle cylindro-conical; chamber conical with apical angle 59 to 71 degrees, base slightly convex, sides straight to slightly concave; flexure distinct; neck cylindrical; ornamentation of two to four spines at basal edge, 15 microns long, coarse, simple to distally branching; remainder of surface laevigate.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
3–A–26		110	38	89	36	0.8	0.4	59	64
3–A–27	30583	105	33	82	36	0.8	0.3	71	55

Discussion. All observed specimens of this species are broken at the oral edge; it is not known if the oral edge is ornamented. Only five specimens have been observed; consequently insufficient is known to determine their taxonomic status.

Occurrence. Widder Member: rare (one specimen); Arkona Member: rare (four specimens).
Ancyrochitina sp. 1 is rare in the Hamilton Formation. Specimens were recovered from GSC Arkona No. 1 and Argor 65–1 cores at four levels (1–A–6, 1–A–22, 3–A–26, 3–A–27).

Figured specimen. GSC No. 30583.

Ancyrochitina sp. 2

Plate IV, figure 11

Description. Vesicle cylindro-conical; chamber conical with apical angle 49 to 55 degrees, base and sides slightly convex; flexure distinct; neck cylindrical; ornamentation of numerous short spines around basal edge; oral edge fringed with short (10 microns) spines.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–32		115	49	74	33	0.6	0.4	49	66
3–A–27	30584	122	43	82	36	0.7	0.4	55	74

Discussion. The three specimens observed are similar to *Ancyrochitina multiramosa* Taugourdeau and de Jekhowsky (1960), except for the relatively shorter neck and more convex chamber of the Hamilton specimens. The less distinct aspect of the basal edge spines also precludes making these conspecific. It is possible that the short spines visible on this species are remnants of longer spines which have broken. Thus, not enough is known to effect definite taxonomic assignment.

Occurrence. Arkona Member: rare (three specimens).

Figured specimen. GSC No. 30584.

Ancyrochitina sp. 3

Plate IV, figure 12

Description. Vesicle cylindro-conical; chamber conical with apical angle 62 degrees, base flat, sides straight; flexure distinct; neck cylindrical; ornamentation of numerous short, up to 18 microns long, delicate hair-like spines on the basal 0.2 of chamber and on top 0.2 of neck; remainder of surface laevigate.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–4	30585	120	49	92	41	0.8	0.4	62	65

Discussion. The distinctive characters of this form are its numerous hair-like spines and their distribution on the lower and oral 0.2 parts of the vesicle. This combination of spine type and distribution over the vesicle has not previously been described. Because of the few specimens available, it is difficult to determine if this character is of specific importance.

Occurrence. Widder Member: rare (three specimens).

Figured specimen. GSC No. 30585.

Ancyrochitina sp. 4

Plate IV, figure 10

Description. Vesicle cylindro-conical; chamber conical with apical angle 54 degrees, base convex, sides straight; flexure distinct; neck cylindrical; ornamentation of a few papillae on surface which may be bases of spines that have broken off, delicate, sparsely distributed over neck area; remainder of surface laevigate.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–9	30586	179	87	100	43	0.6	0.5	54	62

Discussion. This form is characterized by its long neck which bears short hair-like spines. The complete ornamentation is not known with certainty because some of the features appear to be broken spine bases. Therefore the form may be spinose, but the character of these spines is unknown.

Occurrence: Ipperwash Member: rare (three specimens); Widder Member: uncommon; Hungry Hollow Member: rare (one specimen).

Figured specimen. GSC No. 30586.

Ancyrochitina sp. 5

Plate V, figure 1

Description. Vesicle cylindro-conical; chamber conical with apical angle 53 degrees, base flat, sides slightly concave; flexure vague; neck cylindrical with slight oral flaring; ornamentation of coarse complexly branching spines, 20 microns long, at basal edge; coarse complexly branching spines, 18 microns long, at oral edge; remainder of surface laevigate.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
3–A–39	30587	105	26	74	33	0.7	0.3	53	66

Discussion. The coarseness of the complex spines sets this specimen apart from any previously described species of this genus. With only one specimen it is not possible to determine whether this characteristic is of specific importance, or whether it is extreme variation of the ornamentation of an already established species.

Occurrence. Arkona Member: rare (one specimen).

Figured specimen. GSC No. 30587.

Ancyrochitina sp. 6

Plate V, figure 4

Description. Vesicle conical, slightly wider than long, base flat, sides straight; flexure indistinct; ornamentation of a ring of nine tuft-like coarse complexly branching spines, 18 microns long, at basal edge; ring of nine similar but shorter spines, 8 microns long, around oral opening; remainder of surface laevigate.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	W/L
1-A-46	30588	82	87	36	1.1

Discussion. This Hamilton form has a very distinct type of ornamentation of tuft-like spines that has not yet been reported in any other published study of this genus. Because only one specimen was recovered, specific assignment is not possible.

Occurrence. Bell Member: rare (one specimen).

Figured specimen. GSC No. 30588.

Ancyrochitina sp. 7

Plate IV, figure 13

Description. Vesicle cylindro-conical; chamber conical, making up approximately 0.5 of vesicle length, apical angle 50 to 52 degrees, base flat to slightly convex, sides straight; flexure more or less distinct; neck conical flaring out from flexure; chamber ornamentation very coarsely granulose, granules approx. 12 to 13 microns wide and 3 to 4 microns high, small granules on larger granules; neck laevigate to slightly granulose; spines at basal edge coarse, 54 microns long; ring of smaller spines, up to 18 microns long at oral opening.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)
1-A-1		143	56	77	26	0.5	0.4	50
2-A-56	30589	145	49	74	26	0.5	0.3	52

Discussion. The type of very coarse granulation that this species exhibits is very rare on Chitinozoa. It has been reported (Taugourdeau and de Jekhowsky, 1960) on *Urochitina verrucosa* from the Lower to Middle Devonian of the Sahara region.

Occurrence. Widder Member: rare (one specimen); Arkona Member: uncommon; Bell Member: rare (one specimen).

Figured specimen. GSC No. 30589.

Ancyrochitina sp. 8

Plate V, figure 2

Description. Vesicle cylindro-conical; chamber conical with apical angle 37 degrees, base slightly convex, sides straight; flexure more or less distinct; shoulder apparent; neck cylindrical; ornamentation of slender spines, simple to complex, up to 43 microns long, distributed over the vesicle; simple internal spines apparent in neck area.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	W/L	Apical angle (degrees)
1-A-31	30590	77	74	26	1.0	37

Discussion. This specimen is mechanically distorted, therefore the occurrence of a shoulder may not be inherent. The vesicle is densely spinose and unlike any form yet described.

Internal spines have been observed at the neck edge. This character has been observed in some other Hamilton forms, but it has not been widely reported from many other Chitinozoa.

Occurrence. Widder Member: rare; Arkona Member: rare (one specimen).

Figured specimen. GSC No. 30590.

?*Ancyrochitina* sp. 9

Plate V, figure 3

Description. Vesicle cylindro-conical; chamber conical with apical angle 36 degrees, base convex, sides straight; flexure imperceptible; neck cylindrical, short; no ornamentation; surface laevigate; "plug" observed in oral opening, 18 by 18 microns.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	W/L	Apical angle (degrees)
1–A–29	30591	117	77	26	0.7	36

Discussion. This species is very common in the Hamilton Formation and has the general shape of *Ancyrochitina.* It lacks any type of ornamentation, and generic assignment is difficult. In the original description of the genus, Eisenack (1955a) stated that *Ancyrochitina* has basal edge ornamentation. On that basis, this Hamilton form would not belong to the genus. Subsequent studies have broadened the concept of the genus. Cousminer (1964) described as belonging to a new species, specimens bearing or lacking basal edge ornamentation. Thus he implied that basal edge ornamentation is not necessarily an essential characteristic for this genus. At present, however, it is considered questionable if such unornamented forms should be contained in *Ancyrochitina* but further study might warrant their inclusion.

The genus *Cyathochitina* includes forms with conical chambers, cylindrical necks and laevigate surfaces, but is also characterized by a carina at the basal edge. The Hamilton specimens assigned to this species do not possess a carina.

This species follows closely the trends of *A.* cf. *A. langei* in the Hamilton Formation: they commonly occur together and in a few samples make up a high percentage of the Chitinozoa assemblages. There are enough individuals to ascertain that this species does not consist of weathered specimens of *A.* cf. *A. langei* from which all the spines have been broken, nor of *A. arkonensis* n. sp. from which the oral and basal edge ornament have been weathered.

Occurrence. Ipperwash Member: rare to common; Widder Member: rare to common; Hungry Hollow Member: common; Arkona Member: rare to abundant; Rockport Quarry Member: rare to common; Bell Member: rare to common; Dundee Formation: 20 specimens.

Figured specimen. GSC No. 30591.

Angochitina Eisenack, 1931

Type species: *Angochitina echinata* Eisenack, 1931

"Small to medium vesicles, body subspherical to pyriform with greatest width near middle of long axis; neck cylindrical, well developed; fine spinose sculpture evenly distributed over body and lower neck." (Jansonius, 1967, p. 348.)

The genus *Angochitina* is represented in the Hamilton Formation by nine different forms: five named species, two new species, and two unnamed forms. The species are to be found mainly in the upper part of the Hamilton Formation: the Ipperwash, Hungry Hollow, and Widder Members.

Angochitina cf. *A.*? *collinsoni* Taugourdeau and de Jekhowsky, *in* Taugourdeau, 1961

Plate V, figures 5, 10

Description. Vesicle spherical; neck cylindrical, short, 20 microns long; ornamentation of slender spines, 15 microns long, simple to bifurcating to complexly branching, distributed over all the vesicle; shorter spines, 3 microns long, on basal surface; some internal spines visible at oral edge.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L
1–A–8	30593	87	—	71	33	0.8	—
2–A–14	30592	115	20	74	36	0.6	0.2

Discussion. The specimen which Taugourdeau and de Jekhowsky (1961) used as a holotype for this species, from the Lower Devonian of North Africa, is broken. The absence of the neck on that specimen makes the generic assignment tenuous. The Hamilton form is smaller and has more spines than the holotype. One of the Hamilton specimens (Pl. V, fig. 10) is also broken, but one (Pl. V, fig. 5) is complete. Internal spines are visible inside the oral opening.

Occurrence. Widder Member: rare to common.

Figured specimens. Hypotypes, GSC Nos. 30592, 30593.

Angochitina devonica Eisenack, 1955

Plate V, figures 9, 11, 13

Description. Vesicle cylindro-spherical; chamber spherical to subspherical, 0.6 of vesicle length, chamber width 0.5 vesicle length; flexure at approximately 0.6 length from base, distinct; neck cylindrical; ornamentation of spines up to 33 microns long, simple to bifurcating to complexly branching, distributed over all the vesicle, shorter on neck in some specimens; "plug" 23 by 33 microns present in some specimens.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L
1–A–6	30596	143	59	71	25	0.5	0.4
1–A–8		151	59	71	41	.5	.4
2–A–14	30595	156	66	74	41	.5	.4
2–A–14	30594	138	59	71	38	.5	.4

Discussion. The holotype of this species is 146 microns long; in the Hamilton specimens vesicle lengths vary from 138 to 156 microns. There is, therefore, close agreement between the holotype, which is from the Middle Devonian of Eifel, and the Hamilton specimens. Collinson and Scott (1958) described specimens from the Solon Member, Cedar Valley

Formation, which belong to this species that are considerably longer (163 to 254 microns) than either the Eifel or Hamilton specimens.

There is some variation in the character of the ornamentation, ranging from slender simple and bifurcating spines on some specimens (Pl. V, figs. 11, 13) to coarse branching on others (Pl. V, fig. 9).

Occurrence. Ipperwash Member: rare to uncommon; Widder Member: rare to common.

This species was recovered at three levels in the Widder Member in GSC Ipperwash No. 1 core, two of which are in the lower 25 feet, and at two levels in the GSC Arkona No. 1 core, both in the lower 15 feet. In GSC Arkona No. 1 core, some of the upper part of the member is absent. In all five levels of the Widder Member this species composes 5 to 25 per cent of the Chitinozoa assemblages. These high percentage levels in the five levels appear to indicate a biostratigraphic peak zone, but the absence of any representatives of this species in the Argor 65–1 core introduces some question as to how valid or widespread such a zone would be.

Figured specimens. Hypotypes, GSC Nos. 30594–30596.

Angochitina milanensis Collinson and Scott, 1958

Plate V, figures 6, 7, 12

Description. Vesicle cylindro-spherical; chamber spherical to subcylindrical with convexly rounded base, approximately $\frac{2}{3}$ the length of the vesicle; flexure more or less distinct; neck cylindrical with little or no oral flaring; ornamentation of fine to coarse spines, simple to complexly branching, up to 23 microns long, slightly shorter on neck, distributed over all the vesicle.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L
1–A–8	30598	145	49	71	36	0.5	0.3
1–A–13	30597	158	49	66	41	.4	.3
1–A–13		143	—	71	38	.5	—

Discussion. In their description of *Angochitina milanensis,* Collinson and Scott (1958) presented the following ranges of measurements for their specimens: vesicle length, 140 to 213 microns; neck length, 45 to 77 microns; chamber width, 86 to 118 microns; neck width, 36 to 50 microns; neck length/vesicle length, 0.3 to 0.4. The Hamilton specimens fall within the lower part of these ranges except for the chamber width measurements which are smaller. The close agreement in size between the Hamilton and Cedar Valley specimens is somewhat unexpected because in other species which have been compared from these two localities, such as *A. devonica* and *Ancyrochitina cornigera,* there has been a substantial size differential, with the much larger specimens occurring in the Cedar Valley Formation.

Occurrence. Ipperwash Member: rare; Widder Member; rare to abundant; Arkona Member: rare to uncommon.

In the Widder Member the distribution of this species is closely related to that of *Angochitina devonica,* comprising 6 to 30 per cent of the Chitinozoa assemblage in the lower 20 feet of the member in GSC Arkona No. 1 and GSC Ipperwash No. 1 cores. This corresponds to the previously mentioned "zone" of *A. devonica. A. milanensis* is rare in Argor

65-1 core, only two specimens having been found. The absence of one species could be due to collection or preparation techniques, but the absence of one and the near-absence of another closely related species reduce the chances of technical omission and lead to consideration of reasons for the lack in Argor 65-1 core. There is no evidence for a physical barrier between Argor 65-1 core and the other two cores, and their geographical proximity makes it difficult to consider factors other than those that vary drastically in short spaces. Factors such as change in salinity, or current direction could have been effective over short distances, assuming that *A. devonica* and *A. milanensis* were more susceptible than other Chitinozoa. Because no evidence is yet available on these factors, no conclusion is drawn. Study of more Widder Member material from widespread localities might clarify the distribution pattern of these two species.

Figured specimens. Hypotypes, GSC Nos. 30597, 30598.

Angochitina cf. *A. ramusculosa* Cramer, 1964

Plate V, figure 8; Plate VI, figures 7, 9

Description. Vesicle cylindro-spherical; chamber subspherical, approximately 0.7 to 0.8 of vesicle length; flexure indistinct; neck cylindrical with little or no oral flaring; ornamentation of long spines, up to 56 microns long, coarse, complexly branching, generally distally, distributed over all the vesicle; shorter spines on neck; oral edge fringed with spines, up to 5 microns long.

Dimensions (in microns):

Specimen	GSC No.	L	l	W	N	W/L	l/L
1–A–8	30600	138	25	66	38	0.5	0.2
1–A–14	30601	151	38	66	36	.4	.3
1–A–14	30599	176	49	66	43	.4	.3

Discussion. The figured specimens on which Cramer (1964) based the species *Angochitina ramusculosa*, from the Upper Ludlovian of northwest Spain, are less spinose, have shorter vesicles and longer necks than do the Hamilton specimens. Of the figured specimens from the Hamilton Formation, one (Pl. VI, fig. 7) is smaller than the others and has longer and coarser spines. This increased coarseness of the spines is an extreme for the range of variation of the Hamilton specimens.

Occurrence. Ipperwash Member: rare to abundant; Widder Member: rare to abundant; Hungry Hollow Member: common; Arkona Member: rare to abundant; Rockport Quarry Member: rare.

In GSC Ipperwash No. 1 core, this species makes up a high percentage (25 to 85) of the Chitinozoa assemblage in a sequence over 20 feet thick. In Argor 65-1 core, this species comprises a high percentage of the Chitinozoa assemblage over approx. 50 feet of the Widder Member. Also in Argor 65-1 core, this species makes up 95 to 100 per cent of the Chitinozoa assemblage in the Hungry Hollow Member. In the Arkona Member there are two levels, one in GSC Arkona No. 1 core and one in GSC Ipperwash No. 1 core, 20 feet below the Hungry Hollow–Arkona contact, where this species represents approximately 60 per cent of the Chitinozoa assemblage. None of the high percentage levels is reliably traceable from one core to another.

Figured specimens. Hypotypes, GSC Nos. 30599–30601.

Angochitina toyetae Cramer, 1964

Plate VI, figure 10; Plate VII, figures 1, 2

Description. Vesicle cylindro-spherical; chamber spherical, approximately 0.6 of total vesicle length; flexure distinct; neck cylindrical with little or no oral flaring; ornamentation of slender spines, simple to complexly branching, sparsely distributed over the vesicle, more concentrated on neck of some specimens than others; internal neck spines on one specimen; in some specimens neck wall slightly thinner than chamber wall.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L
1–A–6	30603	128	49	79	43	0.6	0.4
1–A–6	30602	130	41	69	38	.5	.3
1–A–7	30604	105	41	66	41	.6	.4
1–A–15		133	26	84	36	.6	.2
1–B–2		156	49	97	43	.6	.3
2–B–2		130	46	87	38	.7	.4

Discussion. The ornamentation in this species shows some variation. In some specimens (Pl. VI, fig. 10) the spines are sparsely distributed over all the vesicle; in others (Pl. VII, fig. 1) those on the neck are slightly denser in distribution. In most instances, the spines are broken and only spine bases remain; thus, the complexity of the spines and their dimensions are difficult to determine. Those that are present are either simple or simply bifurcating. This species is based on specimens from northwest Spain and Emsian (part) age (Cramer, 1964). Those specimens are slightly larger than the Hamilton specimens, and the character of the spines is clearer.

Occurrence. Ipperwash Member: rare to abundant; Widder Member: rare to abundant; Hungry Hollow Member: rare; Arkona Member: rare to uncommon; Bell Member: uncommon.

In the Widder Member there are three zones in which this species comprises a substantial percentage of the Chitinozoa assemblage. These zones occur in the lower 5 to 15 feet of the member, the second approximately 10 feet above the first, and the third in the top 5 to 10 feet. The lowest zone is 10 to 15 feet thick, and the other two are 5 to 10 feet thick each.

Figured specimens. Hypotypes, GSC Nos. 30602–30604.

Angochitina huronensis n. sp.

Plate VI, figure 4

Description. Vesicle cylindro-spherical; chamber spherical, 0.8 of vesicle length; flexure distinct; neck cylindrical with oral flaring; ornamentation of spines, up to 31 microns long, complexly branching distally, distributed over all the chamber, neck free of spines from flexure to 14 microns from oral opening, there shorter spines, up to 20 microns long, similar to chamber spines, becoming shorter (3 to 5 microns) orally; internal spines at oral edge.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L
2–A–11	30605	107	23	69	33	0.6	0.2

Discussion. This species is characterized by spinose ornamentation. The spines are long, up to 31 microns, and branch complexly only at their tips. They are randomly distributed over all the chamber. The neck is free of spines to the last aboral 14 microns. There, spines 3 to 5 microns long of the same type as the chamber spines occur. This type and distribution of spines is quite distinctive and as yet not reported for this genus. Consequently a new species is proposed.

Occurrence. Widder Member: rare; Arkona Member: rare to common; Dundee Formation: one specimen.

Figured specimen. Holotype, GSC No. 30605.

Angochitina calcarata n. sp.

Plate X, figures 8, 9

Description. Vesicle cylindro-spherical; chamber spherical to subcylindrical, base flattened, sides slightly rounded; flexure distinct; neck cylindrical; ornamentation of a few spines, scattered over chamber, 31 microns long, coarse, simple, tapering, blunt-ended to bulbous, curved; oral edge smooth.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Flexure angle (degrees)
2–A–25	30607	160	62	86	42	0.5	0.4	—
2–A–26	30606	138	41	82	41	0.6	0.3	60

Discussion. This species is characterized by its distinctive spinose ornamentation. The spines are coarse, long (up to 31 microns), simple, curved and somewhat tapered. They are either blunt or slightly bulbous at their tips. The few spines are widely spaced over the chamber. No oral edge ornamentation has been observed. This large coarse ornamentation makes the species distinct from any other in the genus. There is a resemblance of vesicle shape to that of *A. milanensis*, but the difference in ornamentation easily separates them.

Occurrence. Ipperwash Member: rare; Widder Member: rare; Arkona Member: rare.

Figured specimens. Holotype, GSC No. 30606; paratype, GSC No. 30607.

Angochitina sp. 1

Plate VI, figure 3

Description. Vesicle cylindro-spherical; chamber spherical making up nearly 0.8 of vesicle length; flexure vague; neck cylindrical; ornamentation of spines, up to 13 microns long, simple to bifurcating, some with widely flaring bases, up to 8 microns wide; neck spines slightly shorter than those on chamber.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L
2–A–16	30608	163	38	87	31	0.5	0.2

Discussion. The high ratio of chamber to neck length (4:1) and ornamentation set this species apart from other species of this genus. Too few well preserved specimens were found to establish this as a new species or as a variation of one already described.

Occurrence. Widder Member: rare to uncommon.

Three of the samples recovered from the Widder Member occur in the lower 15 feet of the unit, perhaps indicating some zonal potential.

Figured specimen. GSC No. 30608.

Angochitina sp. 2

Plate VI, figures 5, 6

Description. Vesicle cylindro-spherical; chamber spherical with strongly convex base; flexure distinct; neck cylindrical, approximately 0.4 of vesicle length, oral edge frayed; two or three annulate thickenings at and just above flexure; ornamentation of a row of spine bases just below widest part of chamber; surface of vesicle rugose; "plug" 26 by 36 microns with short spines at its oral edge.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L
1–A–48	30609	168	61	82	66	0.5	0.4

Discussion. This long-necked form does not occur frequently in the Hamilton Formation. Annulate thickenings (internal?) are present at the base of the neck and just above the flexure. The external surface is rugose and probably had chamber spines at its widest part because bumps can be observed which are probably bases of broken spines. An insufficient number of specimens were recovered to determine specific affinities and the range of variation of this form.

Occurrence. Hungry Hollow Member: rare (one specimen); Arkona Member: rare; Bell Member: rare (one specimen); Dundee Formation: one specimen.

Figured specimen. GSC No. 30609.

Sphaerochitina Eisenack, 1955

Type species: *Sphaerochitina sphaerocephala* (Eisenack, 1932) Eisenack, 1955

"Small vesicles, body sub-spherical to pyriform; neck distinct, long, cylindrical. Wall may show minute sculpture, but is smooth in type species." (Jansonius, 1967, p. 350.)

Sphaerochitina rockglenensis n. sp.

Plate VI, figures 1, 2

Description. Vesicle cylindro-conical; chamber conical with apical angle 67 degrees, base flat, sides straight; flexure distinct; neck cylindrical; ornamentation of spines, up to 18 microns long, uniform in length, simple to complexly bifurcating, distributed over all the vesicle; "plug" 23 by 26 microns observed inside vesicle.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–31	30610	89	31	76	36	0.9	0.4	67	64

Discussion. This species has ornamentation somewhat similar to that of *Sphaerochitina spinigera* Eisenack (1964), but the spines are finer, the neck is shorter and the chamber more conical.

Occurrence. Ipperwash Member: rare to uncommon; Arkona Member: common.

Figured specimen. Holotype, GSC No. 30610.

Chitinozoa n. gen.

Diagnosis. Vasiform vesicle with greatest width near or above midlength of chamber; sides straight to convex; neck cylindrical; ornamentation spinose, possibly variable.

Chitinozoa n. gen., n. sp.

Plate VI, figure 8

Description. Vesicle vasiform; greatest width of chamber at 0.6 the distance from the flat base, sides straight to slightly convex; flexure distinct; neck cylindrical; ornamentation of spines, 20 microns long, sparsely distributed over the chamber, mainly at and below widest part of chamber, coarse, simple to bifurcating; oral edge with spines, 13 microns long, simple; wall thinner on neck toward aboral end; "plug" observed at flexure and into chamber.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–45	30611	166	38	79	36	0.5	0.2	65	52

Discussion. No other Chitinozoa yet described has a vesicle shape like that of this specimen. The shape of the vasiform chamber is unique. The base of the chamber is torn on this specimen, but apparently it was flat. The tear may be similar to that in *Poteriochitina* n. gen., from the Hamilton Formation, that is, indicative of an inherent wall weakness, probably due to the tendency of this form to occur in chains, or at least to be joined to other units at its base.

It is not considered advisable to describe as new a genus based on one specimen. This specimen, however, has a characteristic shape that is impossible to ascribe to any known genus or species. It differs from *Ancyrochitina* and other genera, in which the chamber is conical, in that the lower part of its chamber tapers aborally. That this tapering is not due to stretching is indicated by the apparently undisturbed spines on the chamber, and by the specimen's unbroken walls.

Occurrence. Bell Member: rare (one specimen).

Figured specimen. GSC No. 30611.

Calpichitina Wilson and Hedlund, 1964

Type species: *Calpichitina scabiosa* Wilson and Hedlund, 1964

"Vesicle small, sub-spherical; height usually less than width, neck reduced to a collar, operculum external; outer wall layer distinctly granular to spongy; usually not occurring in chains." (Jansonius, 1967, p. 348.)

Calpichitina sp.

Plate VII, figure 5

Description. Vesicle spherical to subspherical; no flexure; no neck; surface laevigate; thin area in centre of basal surface; large flange approximately 15 to 20 microns wide flaring out from oral opening.

Dimensions (in microns).

Specimen	GSC No.	W	Collar width
2–B–8	30612	117	15–20

Discussion. Only one specimen of *Calpichitina* sp. was found and it occurs in the Rockport Quarry Member. This genus was described by Wilson and Hedlund (1964) from the Sylvan Shale (Upper Ordovician) of Oklahoma. Its distinguishing characteristics were given as follows: "The occurrence of an operculum, the lack of cupola [copula], and the subspherical test with a flaring, membranous collar are morphological characters that warrant the assignment of the specimens to a new genus." (p. 164)

Wilson and Dolly (1964) suppressed *Calpichitina* and included it in the genus *Hoegisphaera* Staplin (1961), which they emended. In a letter, part of which was published in Wilson and Dolly (1964), Jansonius stated that perhaps the two genera should be maintained, while stating the possibility that they may be synonymous. Jansonius felt that the cuticle layering and the presence of a definite collar may be valid criteria for retaining *Calpichitina.* Wilson and Dolly disagreed, claiming that the collar could be destroyed by severe processing, and that more careful processing might preserve collars where none has been yet reported.

The specimen from the Hamilton Formation has a distinct and wide collar. A collar or trace of one has not been observed on any of the many specimens of *Hoegisphaera* cf. *H. glabra* Staplin which have been studied from this formation. Although this specimen of *Calpichitina* is of larger diameter and has a smoother wall than *Calpichitina scabiosa*, the inclusion of this specimen in the genus cannot be denied.

Occurrence. Rockport Quarry Member: rare (one specimen).

Figured specimen. GSC No. 30612.

Desmochitina Eisenack, 1931

Type species: *Desmochitina nodosa* Eisenack, 1931

"Small vesicles with sub-spherical body, neck reduced to a collar; operculum simple, external; chains may occur, but no hollow copula observed." (Jansonius, 1967, p. 349.)

The genus *Desmochitina* is represented in the Hamilton Formation by two species: *D. bursa* and one unnamed species.

Desmochitina bursa Taugourdeau and de Jekhowsky, 1960

Plate VII, figures 4, 7

Description. Vesicle subspherical, base rounded to nearly flat, sides subparallel, rounded to nearly rectangular in lateral view; width exceeds length; no flexure; no neck; ornamentation of short spines, 1 to 3 microns long, conical, distributed over all the vesicle, some spines bifurcate near their bases; ring of spines inside oral opening; operculum present in some specimens; chain formation observed.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	W/L
1-A-23		100	125	84	1.3
1-A-30	30614	87	105	—	1.2
1-A-31	30613	89	112	—	1.3
1-A-31	30613	94	110	—	1.2
2-A-48		100	105	69	1.1

Discussion. Specimens of *Desmochitina bursa* from the Hamilton Formation are slightly larger than those from the Lower and Middle Devonian of North Africa. The holotype is 75 microns long and 100 microns wide, and the Hamilton species ranges from 89 to 100 microns long and 105 to 125 microns wide. The main distinguishing character of the species is its somewhat rectangular outline in lateral view and its finely tuberculate surface. Using surface texture as a specific criterion may perhaps be tenuous because such features can be obliterated by processing (Jenkins, 1969), but when such textures are present and distinct they provide a factor which can be compared from form to form. Thus, although the absence of surface texture may not be of specific value, its presence nevertheless should be noted and used. Chain formation has been observed in specimens from the Hamilton Formation (Pl. VII, fig. 4).

This Hamilton species differs from *Desmochitina* sp., also from the Hamilton Formation, in its greater width to length ratio (1.1 to 1.3) and slightly coarser ornamentation.

There is some similarity in occurrences and percentages of *D. bursa* assemblages between GSC Arkona No. 1 and GSC Ipperwash No. 1 cores; but none with the Argor 65–1 core.

Occurrence. Arkona Member: rare to abundant; Rockport Quarry Member: rare to uncommon; Bell Member: rare to abundant.

Figured specimens. Hypotypes, GSC Nos. 30613, 30614.

Desmochitina sp.

Plate VII, figures 3, 6

Description. Vesicle subspherical, base convex, sides nearly straight, more or less quadrangular in lateral view; no flexure; no neck; oral aperture constricted and bordered by small collar; ornamentation of short stubby conical spines, approximately 1 to 2 microns long, densely distributed over all the vesicle except on collar where they are absent, coarser and denser on lower half of vesicle; operculum unornamented.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	Collar width	W/L
1-A-36	30616	117	112	74	79	1.0
2-A-38	30615	107	100	69	77	0.9
2-A-50		122	110	54	59	0.9

Discussion. Desmochitina sp. can be separated from *D. bursa* by its smaller width to length ratio which is 0.9 to 1.0, and its finer ornamentation. No chain formation was observed.

Occurrence. Arkona Member: rare to abundant; Rockport Quarry Member: rare to uncommon; Bell Member: rare to abundant.

Figured specimens. GSC Nos. 30615, 30616.

Eisenackitina Jansonius, 1964

Type species: *Eisenackitina castor* Jansonius, 1964

"Vesicles small, short, sub-cylindrical; base rounded, neck reduced to a narrow collar, operculum external; rarely observed in short chains." (Jansonius, 1967, p. 349.)

The genus *Eisenackitina* is represented in the Hamilton Formation by three forms: *E. castor*, *E. canadensis* n. sp., and *E.* sp. The genus is restricted to levels below the Hungry Hollow–Arkona contact except for one occurrence at 2–A–16 in the Widder Member.

Eisenackitina castor Jansonius, 1964

Plate VII, figures 9, 10, 12; Plate VIII, figure 2

Description. Vesicle subcylindrical, base flat to slightly convex, sides straight to slightly convex, subparallel; no flexure; oral opening slightly constricted with no collar development; surface smooth to ornamented by very short stubby conical spines, 1 to 2 microns long; when present denser on lower third of vesicle, and absent at oral edge; in some specimens wall thins near oral opening; operculum when attached, appressed to oral opening.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	W/L
1–A–31		138	94	71	0.7
1–A–41	30617	122	102	66	.8
1–A–45		140	120	79	.9
2–A–34	30618	128	112	71	.9
2–A–34	30619	122	97	54	.8
2–A–36		102	97	71	1.0
2–A–42	30620	122	102	66	0.8
2–B–9		122	97	74	.8

Discussion. Eisenackitina castor from the Hamilton Formation generally fits into the lower size range (120 to 200 microns) which Jansonius (1964) determined for this species and which he described from the Givetian of western Canada; a few of the Hamilton specimens, however, measure only 102 microns. *Eisenackitina* has vesicles of simple morphology and thus specific assignment can be difficult. *E. castor* is characterized by a simple oral edge, and lack of flexure and collar. The ornamentation is verrucose. In the Hamilton specimens, the ornamentation is roughly described as verrucose but because of good preservation it can be described with more detail. It consists of short, stubby conical spines, 1 to 2 microns long which are often so closely spaced that their bases coalesce and give a verrucose appearance. The spines are densely distributed on the lower third of the vesicle and less densely near the oral edge where the wall is thinner. In part, the thinning of the vesicle wall at the oral edge may be due to the decrease in ornamentation.

The operculum in some specimens is in its original position, closely appressed to the oral opening; in others it has been released and is loose.

Jansonius (1964) indicated that this species ranges from Upper Silurian to Middle Devonian (Givetian).

Occurrence. Widder Member: rare; Arkona Member: rare to abundant; Rockport Quarry Member: rare to abundant; Bell Member: abundant.

Eisenackitina castor is abundant at most levels where it occurs in the Bell, Rockport Quarry, and Arkona Members. It shows five different sets of levels in the Arkona Member, two in the Rockport Quarry, and one in the Bell where it makes up a high percentage of the Chitinozoa assemblages. Those levels are traceable in GSC Arkona No. 1 and GSC Ipperwash No. 1 cores, and with somewhat less accuracy in Argor 65–1 core.

Figured specimens. Hypotypes, GSC Nos. 30617–30620.

Eisenackitina canadensis n. sp.

Plate VII, figures 8, 11; Plate VIII, figure 1

Description. Vesicle subcylindrical, base flat to convex, sides subparallel to slightly convex; no flexure; no neck; oral opening slightly constricted and then flared orally; collar small but distinct and always present; surface rugose to ornamented by short stubby conical spines, 1 to 2 microns long, distributed over all the vesicle, on some specimens distributed more densely on lower third of vesicle; basal callus or copula well developed on most forms; operculum observed.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	W/L
1–A–22		166	94	56	0.6
1–A–42		122	92	69	.8
1–B–4	30622	153	89	64	.6
2–A–40		102	87	61	.9
2–A–51	30623	143	77	66	.5
2–B–8	30621	105	56	38	.5

Discussion. Jansonius (1964) in his description of this genus mentioned the "... neck or lip very much reduced, usually absent ..." (p. 912). In this species the lip is clearly, although not greatly, developed. The vesicle shape and ornamentation correspond with that of *Eisenackitina castor*. The well-developed lip and well-defined basal callus separate this species from *Eisenackitina castor*.

The lip development in this species approaches a collar in aspect. The sides are straighter than in most species of *Desmochitina*. This latter genus is generally understood to include forms in which the length does not greatly exceed the width. Although Eisenack (1931) did include some relatively long specimens in this genus, these forms are not as long as those from the Hamilton Formation and their collar development is more extensive than in the Hamilton forms. Consequently the Hamilton specimens are not included in *Desmochitina*. The shorter specimens of this species are similar to *Desmochitina* sp., and further study may indicate a close relationship between *Eisenackitina* and *Desmochitina*.

One of the illustrated specimens (Pl. VIII, fig. 1) is constricted due to mechanical distortion in its lower half. Thinning of the wall is not apparent in this new species.

Occurrence. Arkona Member: rare to abundant; Rockport Quarry Member: rare to abundant; Bell Member: rare to abundant.

This new species is closely related to *E. castor* in its occurrence and high percentages of Chitinozoa occurring at approximately the same levels.

Figured specimens. Holotype, GSC No. 30621; paratypes, GSC Nos. 30622, 30623.

Eisenackitina sp.

Plate VIII, figures 3, 9

Description. Vesicle subcylindrical, base flat, sides convex, inflated $\frac{1}{3}$ the distance up from the base, then slightly convergent to oral opening; no flexure; neck difficult to distinguish if at all developed; ornamentation of a network of short conical spines, 1 to 2 microns long, distributed over all the surface of the vesicle except around the oral edge; operculum, when present, closely appressed on oral opening, concentrically banded.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	Base	W/L
1–B–7	30625	115	92	49	41	0.8
2–A–47	30624	163	128	80	68	.8

Discussion. This species agrees in morphology with the generic description (Jansonius, 1964). When he described the genus, Jansonius stated that the greatest width was near the base, and the chamber sometimes bulged. In his description of the type species Jansonius did not refer to this bulge, nor did he figure any specimens which had obvious bulging. Thus the character is not considered inherent to *E. castor*. *Eisenackitina* sp. is distinct from *E. castor* inasmuch as there is a well-defined bulge in the lower part of the vesicle, and the basal edge is flat. The basal edge of *E. castor* can be, and generally is, rounded.

Occurrence. Arkona Member: rare; Rockport Quarry Member: rare; Bell Member: rare to uncommon.

Figured specimens. GSC Nos. 30624, 30625.

Hoegisphaera Staplin, 1961

Type species: *Hoegisphaera glabra* Staplin, 1961

"Vesicles small, lenticular; neck reduced to a narrow collar or rim, operculum external; normally not observed in chains." (Jansonius, 1967, p. 350.)

The genus *Hoegisphaera* is represented by one species in the Hamilton Formation: *H.* cf. *H. glabra.*

Hoegisphaera cf. *H. glabra* Staplin, 1961

Plate VIII, figures 4–6, 8, 10

Description. Vesicle subspherical, wider than high; oral area bordered by low annulus; surface laevigate to ornamented by short stubby conical spines, 1 to 2 microns long, coarser on lower half of vesicle; operculum simple, unornamented; colonial habit exhibited.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	Operculum	W/L
1-A-14		—	111	45	—	—
1-A-23		—	105	41	41	—
1-A-41	30627	—	102	41	41	—
1-B-7	30626	—	105	—	—	—
1-B-7	30628	—	89-102	—	—	—
1-B-7	30629	—	94	—	—	—
1-B-7	30629	—	94	—	—	—
1-B-7	30629	—	94	—	—	—
1-B-7	30630	—	92	—	—	—
1-B-7	30630	—	92	—	—	—
2-B-3		—	92	38	38	
2-B-8		92	105	36	—	1.1

Discussion. The Hamilton specimens attributed to *H.* cf. *H. glabra* are for the most part laevigate, but some forms have short stubby conical spines similar to those described for species of *Eisenackitina*. Differences between specimens of *Hoegisphaera* are in the ornamentation; the vesicle size and shape are the same. Consequently the Hamilton Formation specimens are considered as only one species. *Hoegisphaera glabra* was defined (Staplin, 1961) as laevigate. Wilson and Dolly (1964) stated that Chitinozoa ornamentation has specific value, but they also pointed out that ornamentation can be destroyed by severe processing. It might be argued that absence of ornamentation on the Hamilton specimens might be due to severe processing, but great care was exercised in processing the samples. Some apparently delicate membrane structure surrounding and attached to laevigate specimens of *Hoegisphaera* was ecovered. This indicates that severe processing did not cause the forms to lose their ornamentation. Consequently it seems apparent that absence of ornamentation on the Hamilton specimens is a normal, not induced, condition. Consequently, considering the otherwise very close agreement in size and morphology, ornamented and unornamented forms are here included in one species.

Taugourdeau (1965) stated that the only way to distinguish these simple forms is on the basis of size. On that basis, the Hamilton specimens are less than but closest to the diameter range of *H. glabra* Staplin (1961): 102 to 111 microns as compared to 110 to 130 microns in *H. glabra*. *H. glabra*, however, is defined as being laevigate. Considering the Hamilton Formation specimens it might be desirable to expand the definition of *H. glabra* to include ornamented specimens.

Bouché (1965) described the species *H. lenticularis* which he defined as being vertically compressed to a lenticular shape. The size range of this species is large (75 to 150 microns) and it includes the Hamilton specimens. Bouché stated that the flattening which caused the lenticular shape was probably secondarily imposed. Consequently the lenticular shape is not an inherent specific character and the status of such a species is doubtful.

Specimens of *H.* cf. *H. glabra* have been recovered with a light membranous material partly or completely covering the vesicle. In three instances individual vesicles are held together in lateral succession in sets of two and three vesicles (Legault, in preparation). This indicates a type of life habit which had not previously been reported for Chitinozoa. On the basis of the unusual life habit, it is suggested that the genus *Hoegisphaera* be classified separately from genera such as *Desmochitina* and *Eisenackitina* which have a chain-type of life habit.

Occurrence. All members: rare to abundant.

In some levels this form dominates the Chitinozoa assemblage (up to 100 per cent) but these levels are not traceable from core to core. This species is least abundant in GSC Ipperwash No. 1 core.

Figured specimens. Hypotypes, GSC Nos. 30626–30630.

Poteriochitina n. gen.

Type species: *Poteriochitina briarca* n. sp.

Diagnosis. Vesicle short, cylindrical; base flat to indented, sides parallel; width greater than length; oral edge simple, ornamentation verrucose; walls thin; chain formation observed.

Poteriochitina briarca n. sp.

Plate IX, figures 1–8

Description. Vesicle cylindrical, short (69 to 115 microns), base flat to slightly indented, sides straight, parallel, width generally greater than length; no flexure; no neck; oral end generally simple, but occasionally folded inward; no evidence of opercular structure; ornament consisting of network of very short (1 to 2 microns) stubby conical spines distributed over all the vesicle, some very similar spines on inside of oral edge; walls thin; chain formation observed.

Dimensions (in microns).

Specimen	GSC No.	L	W	W/L
1–A–27		92	117	1.3
1–A–31		74	92	1.2
1–A–34		69	87	1.3
1–A–41		84	97	1.2
1–A–44	30634	100	112	1.1
1–B–8	30633	102	107	1.1
2–A–38	30631	115	107	0.9
2–A–38	30631	115	112	1.0
2–A–52	30632	110	140	1.3

Discussion. This genus differs from *Desmochitina* in its lack of oral edge differentiation, its ornamentation, and its generally thinner walls. The genus *Desmochitina* has some species in which the oral edge is poorly differentiated, such as *D. bursa,* but the overall aspect of those species is never as quadrangular as specimens of *P. briarca.*

This genus differs from *Hoegisphaera* in not being spherical. It differs from *Eisenackitina* in that the width generally exceeds the length, and the sides are parallel or more nearly so than in *Eisenackitina.*

There is no evidence of opercular structures. The ornament consists of short stubby conical spines distributed over all the vesicle. Chain formation was observed in one instance (Pl. IX, figs. 1, 2). No structure similar to a copula or a basal callus was observed, but there is a weak area on the basal surface where those structures would be expected. Even when it chains, this weak area remains observable, indicating that these forms could stay in chains without the copula or similar linking structure.

Occurrence. Widder Member: rare (one specimen); Hungry Hollow Member: rare (one specimen); Arkona Member: rare to uncommon; Rockport Quarry Member: rare; Bell Member: rare to common.

Figured specimens. Holotype, GSC No. 30633; paratypes, GSC Nos. 30631, 30632, 30634.

Conochitina Eisenack, 1931

Type species. *Conochitina claviformis* Eisenack, 1931

"Vesicles medium to large, conical, with cylindrical neck; basal edge rounded; base flat to convex, with a short mucro or copula at aboral pole, often additional concentric callus; operculum probably simple." (Jansonius, 1970, p. 795.)

Conochitina edjelensis Taugourdeau, 1963

Plate VIII, figure 7

Description. Vesicle cylindrical, base convex, sides subparallel; no flexure; slight oral constriction; surface laevigate.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	W/L
1–A–13	30635	117	74	51	0.6

Discussion. Taugourdeau (1963) described *Conochitina edjelensis* from Middle and Upper Llandovery strata of North Africa. This form is distinct from others because of its rectilinear profile, and slight conical tendency at the oral edge. Taugourdeau (1963) separated it from *C. simplex* Eisenack because Eisenack indicated the presence of a basal callus on certain specimens. Taugourdeau gave the size range of the species as 76 to 275 microns long, and 50 to 85 microns wide. The Hamilton form falls within this range. The slight constriction which can be observed on the hypotype is probably due to distortion after deposition.

Occurrence. Arkona Member: rare.

Figured specimen. Hypotype, GSC No. 30635.

Rhabdochitina Eisenack, 1931

Type species: *Rhabdochitina magna* Eisenack, 1931

"Large, elongated, cylindrical vesicles." (Jansonius, 1967, p. 350.)

The genus *Rhabdochitina* is represented in the Hamilton Formation by three different forms; none of them is identified with known species.

Rhabdochitina sp. 1

Plate IX, figure 10

Description. Vesicle cylindrical, base convex with slight enlargement up to 66 microns, in lower 20 microns of vesicle, sides parallel; no flexure; surface laevigate; wall appears to thin orally; "plug" 36 by 40 microns observed at approximately 80 microns down from oral opening.

Dimensions (in microns).

Specimen	GSC No.	L	W	Base	W/L
3–A–2	30636	352	59	66	0.2

Discussion. The large size and cylindrical shape distinguish it from the other two forms of this genus in the Hamilton Formation.

Occurrence. Ipperwash Member: rare (one specimen).

Figured specimen. GSC No. 30636.

Rhabdochitina sp. 2

Plate IX, figure 11

Description. Vesicle subconical, base convex, sides subparallel; no flexure; slight oral tapering; surface laevigate; walls thin.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	W/L
2–A–47	30637	130	46	23	0.4

Discussion. The shape of this specimen is subconical and slightly reminiscent of that of *Lagenochitina*, but it has no differentiated neck. It differs from *Rhabdochitina* sp. 1 in its subconical shape and smaller size.

Occurrence. Rockport Quarry Member: rare (one specimen).

Figured specimen. GSC No. 30637.

Rhabdochitina sp. 3

Plate IX, figure 12

Description. Vesicle cylindrical, constriction at one third the length up from the base, base convex, sides parallel; no flexure; no distinct neck; ornamentation of very short, conical spines, approximately 1 to 2 microns long, denser and coarser on middle third of vesicle, finer on lower third, and absent on upper third; copula present; wall thinner on upper third of vesicle.

Dimensions (in microns).

Specimen	GSC No.	L	W	W/L
2–A–43	30638	306	92	0.3

Discussion. In the observed specimen there is a constriction $\frac{1}{3}$ of the distance up from the base. This feature could be due to mechanical distortion; if so, it would be of no taxonomic value. It is possible that this specimen is an abnormal development of a *Rhabdochitina* species or a form of *Eisenackitina*, as their ornamentation is somewhat similar. It does not have the basal enlargement present in *R.* sp. 1. Neither *R.* sp. 1 nor *R.* sp. 2 is ornamented.

Occurrence. Rockport Quarry Member: rare (one specimen).

Figured specimen. GSC No. 30638.

Hercochitina Jansonius, 1964

Type species: *Hercochitina crickmayi* Jansonius, 1964

"Medium size vesicles with conical body and short cylindrical neck; basal edge rounded; body ornamented with vertical cords, ribs, or fins, that may project beyond the basal edge as spines." (Jansonius, 1967, p. 350.)

Hercochitina aff. *H. turnbulli* Jenkins, 1969

Plate IX, figures 13, 14

Description. Vesicle cylindro-conical; chamber conical with small apical angle 20 to 36 degrees, base flat to slightly convex, sides straight to slightly convex; flexure more or less distinct; neck cylindrical; ornamentation of long spines, up to 15 microns long, slender, simple to bifurcating, distributed over all the vesicle in longitudinal rows, spine tips discrete.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1–A–31	30640	115	41	69	36	0.6	0.4	32	75
1–A–31	30639	122	—	64	33	0.5	—	20	—
.3–A–5		120	51	77	38	0.6	0.4	36	71

Discussion. This species is somewhat similar to *Hercochitina turnbulli* in size and shape, and in the alignment of spines in longitudinal rows. But in the Hamilton specimens, the spines are discrete at their tips whereas in *H. turnbulli* they are joined at their tips. The longitudinal alignment of the spines is sometimes difficult to discern.

Occurrence. Ipperwash Member: rare (three specimens); Arkona Member: rare (two specimens).

Figured specimens. Hypotypes, GSC Nos. 30639, 30640.

Illichitina Collinson and Schwalb, 1955

Type species: *Illichitina crotalum* Collinson and Schwalb, 1955

"Chamber subconical with maximum diameter at base, tapers rapidly toward the oral end, very slightly flared at aboral end; terminated orally by short thin translucent collar at end of short cylindrical neck; terminated aborally by flat base; chamber wall rather thin, brown, and translucent; external surface very finely tuberculate." (Collinson and Schwalb, 1955, p. 29.)

?Illichitina sp.

Plate IX, figure 9

Description. Vesicle cylindro-conical; chamber conical with apical angle 50 degrees, bell-shaped, base convex, sides straight; neck short, cylindrical; surface laevigate.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	W/L	Apical angle (degrees)
2-A-49	30641	102	89	23	0.9	50

Discussion. Grignani and Mantovani (1964) illustrated a specimen, *?Illichitina* sp., from the Middle and Upper Devonian of Morocco, that corresponds closely to the generic description of *Illichitina.* But because their specimens were nearly always broken, they questioned its generic assignment.

In the Hamilton Formation, specimens occur which agree very closely with the illustration by Grignani and Mantovani. But because their original description is rather sketchy, it is difficult to proceed in the generic and specific assignment without restudy of the original material.

Occurrence. Ipperwash Member: rare (four specimens); Widder Member: rare; Arkona Member: rare to common; Bell Member: rare.

Figured specimen. GSC No. 30641.

Kalochitina Jansonius, 1964

Type species: *Kalochitina multispinata* Jansonius, 1964

"Small pyriform vesicles, neck very short, with a simple operculum near the aperture; whole vesicle ornamented with abundant (often multiple) spines." (Jansonius, 1967, p. 350.)

Kalochitina? sp.

Plate X, figures 1, 10

Description. Vesicle cylindro-conical; chamber conical with apical angle 45 to 51 degrees, base flat to slightly convex, sides flat; flexure distinct; neck cylindrical; ornamentation of spines, up to 18 microns long, fine to coarse, simple to bifurcating, sparsely distributed over all the vesicle; ring of coarser spines at oral edge; "plug" 17 by 28 microns observed.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)	Flexure angle (degrees)
1-A-31	30643	115	46	89	43	0.8	0.4	51	61
1-A-31	30642	117	38	82	41	0.7	0.3	45	76

Discussion. Kalochitina, according to Jansonius (1964), differs from *Belonechitina* and *Hercochitina* in its more strongly developed neck. The Hamilton specimens have more definite neck development than he illustrated, but not as definitely developed as in *Belonechitina* and *Hercochitina.* The spine distribution is random.

Occurrence. Ipperwash Member: common; Widder Member: rare to abundant; Arkona Member: rare (two specimens).

Figured specimens. GSC Nos. 30642, 30643.

Cyathochitina Eisenack, 1955

Type species: *Cyathochitina campanulaeformis* (Eisenack) Eisenack, 1955

"Mostly large vesicles with conical body, cylindrical neck, and a sharp basal edge carrying a flange. Prosome simple?; outer wall layer pronounced, usually scabrate." (Jansonius, 1967, p. 349.)

aff. *Cyathochitina kuckersiana kuckersiana* (Eisenack), 1934

Plate X, figure 2

Description. Vesicle cylindro-conical; chamber conical with apical angle 53 degrees, base slightly convex, sides slightly concave; flexure imperceptible; neck cylindrical with slight oral flaring; surface laevigate; basal edge sharp but not extended in a carina.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L	Apical angle (degrees)
2–A–1	30644	115	26	100	31	0.9	0.2	53

Discussion. Chitinozoa belonging to the genus *Cyathochitina* have a clearly defined carina at the basal edge. The Hamilton specimens have a sharp basal edge which might indicate a reduced carina. If so, the Hamilton specimens of this group would belong to the genus *Cyathochitina*, and most closely resemble *C. kuckersiana* subsp. *kuckersiana*. This species has not previously been reported from strata of Devonian age.

Occurrence. Ipperwash Member: uncommon; Hungry Hollow Member: rare (four specimens); Arkona Member: rare to uncommon.

Figured specimen. Hypotype, GSC No. 30644.

Lagenochitina Eisenack, 1931

Type species: *Lagenochitina baltica* Eisenack, 1931

"Large flask shaped vesicles; base strongly rounded; outer wall layer thick, chagrinate; greatest width near middle of vesicle." (Jansonius, 1967, p. 350.)

Lagenochitina cf. *L. amottensis* Grignani and Mantovani, 1964

Plate X, figure 3

Description. Vesicle bottle-shaped, base convex, sides rounded; flexure imperceptible; neck cylindrical with slight oral flaring, nearly 0.5 vesicle length; surface laevigate.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	W/L
2-A-48	30645	179	82	38	0.5
2-A-50		133	79	33	.6

Discussion. Lagenochitina amottensis, which Grignani and Mantovani (1964) described from the Middle and Upper Devonian of Morocco, has a gently subspherical chamber and a long neck with slight oral flaring. The Hamilton specimens are distorted or broken, and therefore do not show perfectly the outline of *L. amottensis* as it has been described.

Occurrence. Ipperwash Member: rare (two specimens); Rockport Quarry Member: rare (one specimen); Bell Member: rare to uncommon.

Figured specimen. Hypotype, GSC No. 30645.

Lagenochitina cf. *L. brevicollis* Taugourdeau and de Jekhowsky, 1960

Plate X, figures 6, 7

Description. Vesicle spherical; flexure imperceptible; neck short with slight oral flaring; surface laevigate.

Dimensions (in microns).

Specimen	GSC No.	L	W	N	W/L
1-A-7	30646	105	66	41	0.6
1-A-8	30647	120	69	31	.6

Discussion. Lagenochitina brevicollis was described from Ordovician strata of North Africa (Taugourdeau and de Jekhowsky, 1960). It is similar in general shape to the Hamilton specimens, but is considerably larger (220 microns long, 130 microns wide). One of the Hamilton specimens (Pl. X, fig. 6) has an operculum inside the test. Possibly it is its own operculum that fell in, but it is more probable that the association is accidental. This particular specimen has a very short neck with ragged edges which could be due to breakage during diagenesis or processing.

Occurrence. Ipperwash Member: rare; Widder Member: rare to uncommon; Arkona Member: rare; Bell Member: rare (two specimens).

Figured specimens. Hypotypes, GSC Nos. 30646, 30647.

Lagenochitina sp.

Plate X, figures 4, 5

Description. Vesicle subspherical gradually passing to a short cylindrical neck, base convex; flexure more or less perceptible; neck cylindrical, 0.2 to 0.3 of vesicle length; surface laevigate in most specimens, one with two hair-like spines on neck.

Dimensions (in microns).

Specimen	GSC No.	L	l	W	N	W/L	l/L
1–A–8	30649	148	51	74	38	0.5	0.3
1–A–13	30648	171	36	89	41	0.5	.2

Discussion. Lagenochitina sp. has a long and gently tapering chamber and a short neck. This species shows some similarity with *L. crassa* from the Middle and Upper Devonian of Morocco (Grignani and Mantovani, 1964). It has a less differentiated neck and less rounded chamber than *L. crassa*. It also resembles a form that Cramer (1964) described from the Ludlovian of northwest Spain and called *Sphaerochitina llorona*. The genus *Sphaerochitina* has generally been understood to include forms with "... essentially smooth walls that bear tiny tubercles, or small thick, erect spinules." (Collinson and Scott, 1958, p. 20.) This interpretation is not wholly correct. In his description of *Sphaerochitina*, Eisenack (1955a) stated that the walls are smooth or with tubercles. This is the true description of the genus and this smooth form should be eligible for inclusion in it. This is the interpretation that Cramer followed and therefore his generic assignment is not incorrect. It can be seen that this might bring forth confusion because of the overlap with *Lagenochitina*. It is recommended that *Sphaerochitina* be restudied keeping the albeit erroneous but nevertheless practical misinterpretation of the genus.

Occurrence. Ipperwash Member: rare (one specimen); Widder Member: rare to uncommon; Hungry Hollow Member: rare (one specimen); Arkona Member: rare to common; Rockport Quarry Member: rare (one specimen); Bell Member: rare.

Figured specimens. GSC Nos. 30648, 30649.

ACRITARCHA

Subgroup ACANTHOMORPHITAE Downie, Evitt and Sarjeant, 1963

Baltisphaeridium Eisenack, emend. Staplin, Jansonius and Pocock, 1965

Type species: *Baltisphaeridium longispinosum* Eisenack, 1958

"Vesicle spherical; few to numerous spines; vesicle wall minutely granulose or scabrate, sometimes finely porate or with canals; spine wall usually hyaline, in structure differentiated from vesicle wall; spines radial, distinctly angular to vesicle; spines initially hollow, gradually becoming solid in mature stages, but the spine cavity may be partially or completely left open. At the junction of the spine and vesicle the spine wall is normally thickened, often to the extent of blocking the lumen of the spine cavity; spines simple or branching, closed at the tips; spines on one vesicle may vary but are not systematically differentiated into distinct types." (Staplin, Jansonius and Pocock, 1965, p. 188.)

Baltisphaeridium sp.

Plate XI, figures 1, 2

Description. Spherical hollow vesicle; ornamented with solid simple spines, 13 microns long, sparsely distributed over all the vesicle; translucent.

Dimensions (in microns).

Specimen	GSC No.	Diameter	Spines
2–A–56	30650	64	13

Discussion. Only one specimen has been recovered from the Hamilton Formation. Fragments that possibly belong to this species were observed, but they were unidentifiable.

Occurrence. Bell Member: rare (one specimen).

Figured specimen. GSC No. 30650.

Subgroup HERKOMORPHITAE Downie, Evitt and Sarjeant, 1963

Cymatiosphaera O. Wetzel, 1933, emend. Deflandre, 1954

Type species: *Cymatiosphaera radiata* O. Wetzel, 1933

"Shell of organic material, often brown, globular (spherical or elliptical) whose external surface is divided into polygonal fields by membranes perpendicular to the surface. Points of junctions of membranes (angles of polygons) usually thickened, and giving in lateral view the impression of small sticks or columns. No system of equatorial differentiation of the fields. No points or spines. Margin of the membrane often distinct and parallel to the shell surface, sometimes a little concave to torn or corroded. Shell surface smooth or punctate or supplied with granules. Size from a few to several dozen microns. Sometimes 100 microns, crests included." (Norris and Sarjeant, 1965, p. 22.)

Two species of *Cymatiosphaera* were recovered from the Hamilton Formation: *C.* "*canadensis*" and *C.* sp.

Cymatiosphaera "canadensis" Deunff, 1954

Plate XI, figures 3–6, 15, 16

Description. Vesicle spherical; divided into polygonal areas by vertical walls extending outward perpendicular to the vesicle; vertical walls or crests have straight parallel walls with flat to rounded tops.

Dimensions (in microns).

Specimen	1–A–18	1–A–22	2–A–34	2–A–37	2–A–39	2–A–54
GSC No.	30651	30653	30652			
Diameter	71	59	64	56	64	64

Discussion. This species named by Deunff (1954) is invalid. He illustrated a specimen, named it in the figure legend, presented no description, and only stated that the material was recovered from a *Favosites* polyp from the Onondaga Stage of Ontario. The same illustration was used several times (Deunff, 1956; 1961) but he added no further information. Górka (1969) found one specimen from the Ordovician of Poland which she attributed to this species.

The name is used in this study because there is little doubt that the Hamilton specimens are conspecific with Deunff's, but quotation marks are used to indicate the questionable status of the species. This species shows a wide range of variation from coarse forms with thick vertical walls and few polygonal areas, to finer forms with thinner vertical walls and more numerous polygonal areas.

Cymatiosphaera "canadensis" is somewhat similar to *C. pavimenta* Deflandre (1945). The latter species is much smaller, apparently never exceeding 15 microns in diameter.

Occurrence. Ipperwash Member: rare to uncommon; Widder Member: rare to uncommon; Hungry Hollow Member: rare to abundant; Arkona Member: rare to abundant; Rockport Quarry Member: rare to abundant; Bell Member: rare to abundant; Dundee Formation: 27 specimens.

Figured specimens. Hypotypes, GSC Nos. 30651–30653.

Cymatiosphaera sp.

Plate XI, figures 13, 14

Description. Hollow vesicle with delicate, nearly transparent ridges dividing vesicle into polygonal areas; at junction of ridges, rod-like supports may form.

Dimensions (in microns).

Specimen	GSC No.	Diameter	Ridge height
1–A–50	30654	56	8

Discussion. This delicate species of *Cymatiosphaera* never assumes any numerical importance in the Hamilton Formation. It is similar to *C. "canadensis"* in size, but is much thinner walled. The number of polygonal areas does not seem to be as variable as in the previously discussed species.

Occurrence. Rare in all members of Hamilton Formation; two specimens from Dundee Formation.

Figured specimen. GSC No. 30654.

Dictyotidium Eisenack 1955, emend. Staplin, 1961

Type species: *Dictyotidium dictyotum* (Eisenack) Eisenack, 1955

"Vesicle spherical; surface reticulate, ridges low, distinct, lacunar areas polygonal; some species with two distinctly smaller lacunae, one at each pole; small apiculae or spines may arise from the ridges; papillae may be present in the floors of the lacunae." (Staplin, 1961, p. 417.)

Dictyotidium dictyotum (Eisenack) Eisenack, 1955

Plate XI, figures 7–10

Description. Spherical vesicle; ornamented with vertical ridges which define polygonal lacunar areas, no differentiation among lacunar areas, floor of lacunar area laevigate, no processes on vertical walls; translucent.

Dimensions (in microns).

Specimen	1–A–29	1–A–37	2–A–37	2–A–38	2–A–49
GSC No.	30657	30656		30658	30655
Diameter	77	79	77	87	79

Discussion. The Hamilton specimens correspond with the description of *Dictyotidium dictyotum* which Eisenack (1955a) described from the Silurian *Beyrichia*-Kalk. He gave a size range of 60 to 100 microns. The measured Hamilton specimens show less size variation, ranging from 77 to 87 microns. The reticulation formed by the vertical walls varies in degree of coarseness and consequently the number of lacunar areas varies. There are some coarse forms with relatively few lacunar areas, these forms being similar to *Cymatiosphaera* "*canadensis*," differing only in their being more finely reticulate. There are also finer forms in which the lacunar areas are small and numerous.

Occurrence. Widder Member: rare (three specimens); Hungry Hollow Member: rare (two specimens); Arkona Member: rare to abundant; Rockport Quarry Member: rare to common; Bell Member: rare to abundant.

Figured specimens. Hypotypes, GSC Nos. 30655–30658.

Arkonites n. gen.

Type species: *Arkonites bilixus* n. sp.

Diagnosis. Hollow polyhedral vesicle; equator scalloped by pits; hemispheres divided by two to four ridges.

Arkonites bilixus n. sp.

Plate XI, figures 22, 23

Description. Hollow polyhedral vesicle; equatorial outline polygonal, indented by large pits, 5 microns wide, causing scalloped appearance; the upper and lower halves divided into two to four segments by centrally diverging ridges; ridges made up of two elevated strips, one from each neighbouring segment; surface slightly pitted.

Dimensions (in microns).
Specimen 3–A–27; GSC No. 30659; sides, 31, 38 63,43 43,65; diameter, 82.

Discussion. This new species has less faces than *Polyedryxium* as well as having a differentiated scalloped equator. It resembles slightly some corroded forms of *Cymatiosphaera* "*canadensis*," but the scalloped indentations are quite regular, and those caused by corrosion are not regularly disposed.

This genus and species somewhat resembles *Maranhites* (Brito) Daemon *et al.* (1967), but lacks thickened borders at the equatorial periphery. The outline is definitely polygonal, and no bladders nor vestiges thereof have been observed.

Occurrence. Widder Member: rare (three specimens); Hungry Hollow Member: uncommon; Arkona Member: rare to abundant; Rockport Quarry Member: rare (three specimens); Bell Member: rare to uncommon; Dundee Formation: two specimens.

Figured specimen. Holotype, GSC No. 30659.

Subgroup POLYGONOMORPHITAE Downie, Evitt and Sarjeant, 1963

Veryhachium Deunff, 1954, emend. Downie and Sarjeant, 1963

Type species: *Veryhachium trisulcum* Deunff, 1954

"A genus of hystrichospheres having polygonal or subpolygonal tests bearing a small number (in general 3–8) of hollow pointed spines with closed tips. Size of test 10 microns to 40 microns, rarely smaller or greater." (Downie and Sarjeant, 1963, p. 93.)

Simple morphology of this type can only provide limited variations. The great number of species attributed to this genus seems unrealistic and might render the genus and its species of little use. Criteria which are influenced by diagenesis and sample preparation should not be used to separate species. When the genus *Evittia* was erected, most, but not all, *Veryhachium*-like forms with branched spines were transferred to it. Consequently, the value of the distinction is not rigid. A detailed study of species of *Veryhachium* could be undertaken in order to determine how fine a division can be effected and still retain a realistic and useful species. It is probable that many so-called species of this genus could be lumped together.

The genus *Veryhachium* is represented by three species in the Hamilton Formation: *V.* cf. *V. lairdi*, *V.* sp. 1 and *V.* sp. 2.

Veryhachium cf. *V. lairdi* (Deflandre) Deunff, 1958

Plate XII, figures 3, 6, 7, 11

Description. Hollow equilaterally triangular or square single-walled vesicle; apices prolonged into long slender tapering closed spines with simple or branched tips, fourth and fifth spines often present projecting from centre of vesicle face; surface slightly granulose; no pylome observed.

Dimensions (in microns).

Specimen	1–A–4	2–A–52	2–A–52
GSC No.	30666	30665	30667
Side length	51, 44, 41	26	—
Spine length	39, 39, 39	32, 39, 39, 39, 41	36, 49, 29, 34
Altitude	33	—	28

Discussion. Veryhachium lairdi differs from *V. valiente* Cramer (1964) only on whether the vesicle walls are straight (*V. valiente*) or concave (*V. lairdi*). Such a character could be induced by the various factors of diagenesis and processing and does not seem stringent enough to be of specific value. Thus the first specific designation will be used in this determination, because it has priority and the Hamilton specimens are perhaps more closely similar to it.

Occurrence. Ipperwash Member: rare to abundant; Widder Member: rare to abundant; Hungry Hollow Member: rare to common; Arkona Member: rare to abundant; Rockport Quarry Member: uncommon to abundant; Bell Member: rare to abundant; Dundee Formation: 166 specimens.

In the Arkona Member there are three zones in which this species constitutes moderately high percentages of the Acritarcha assemblages. These zones are roughly traceable across the three cores.

Figured specimens. Hypotypes, GSC Nos. 30665–30667.

Veryhachium sp. 1

Plate XII, figures 1, 2, 15, 18

Description. Vesicle hollow, triangular or tetrahedral, single walled; apices prolonged into wide hollow spines continuous with interior of vesicle; spines closed, tips simple; surface granulose; no true pylome observed.

Dimensions (in microns).

Specimen	1–A–16	2–A–54
GSC No.	30668	30669
Altitude	—	17
Spine length	—	40, 41, 32
Base length	77	17

Discussion. This species is distinct from *Veryhachium* cf. *V. lairdi*, in its coarse vesicle, wide, unbranched processes, and granulose surface.

Occurrence. Widder Member: rare to uncommon; Hungry Hollow Member: rare to common; Arkona Member: rare to common; Rockport Quarry Member: rare; Bell Member: rare to abundant; Dundee Formation: ten specimens.

Figured specimens. GSC Nos. 30668, 30669.

Veryhachium sp. 2

Plate XII, figures 4, 5

Description. Hollow vesicle consisting of two planar equilaterally triangular components offset in the same plane by 60 degrees, set over one another; apices of triangles prolonged into slender distally tapering digitate spines; surface smooth to slightly granulose (under oil immersion); no pylome observed.

Dimensions (in microns).

Specimen	2–A–38	2–A–52
GSC No.	30670	
Altitude	38, 36, 38	28
Spine length	23, 23, 23	36, 49, 34

Discussion. Specimens of this species generally have hollow spines; some however have been recovered in which the spines are solid. Although this criterion has been used to distinguish various species, it is felt that in the present collections it is a fortuitous occurrence, perhaps due to preservation, and no differentiation is effected.

Occurrence. Ipperwash Member: rare (five specimens); Widder Member: rare; Hungry Hollow Member: rare (three specimens); Arkona Member: rare; Rockport Quarry Member: rare to common; Bell Member: rare; Dundee Formation: two specimens.

Figured specimen. GSC No. 30670.

Subgroup PRISMATOMORPHITAE Downie, Evitt and Sarjeant, 1963

Polyedryxium Deunff, 1954, emend. Jansonius, 1962, emend. Deunff, 1971

Type species: *Polyedryxium deflandrei* Deunff, 1954, Jansonius, 1962, nomen nudum, Deunff, 1971.

Diagnosis. Microplankton preserved as more or less transparent, flexible and colourable organic matter whose colour varies with the degree of fossilization. The test is polyhedral and its faces generally made up of organic layers of unequal thickness, often curved inward toward the center, delimiting an internal chamber of variable volume. The edges of the faces may or may not have border membranes, and in most cases are ornamented by more or less developed crenellations; these are often hollow and open at their distal extremities. The angles of the test are prolonged into digitations or angular fleurons which communicate with the internal test cavity, as do the crenellated expansions. The total size ranges from 10 to 150 microns (translated from Deunff, 1971, p. 17.)

Deunff (1954) described this genus in a footnote and stated that the type species is *Polyedryxium deflandrei*, but he failed to describe this species. If monotypic, the generic description could have been sufficient to encompass the type species, but four other species belonging to this genus were designated in the same paper. Jansonius (1962) emended the genus and designated *P. deflandrei* as "lectotype," provisionally. Deunff (1971) emended the genus and described the type species.

The genus *Polyedryxium* is represented by two species in the Hamilton Formation: "*P.*" *cuboides* and "*P.*" *pharaonis*. The genus is placed in quotation marks, because these species are at variance with those of Deunff (1971).

"*Polyedryxium*" *cuboides* Deunff, 1955

Plate XII, figures 8, 9, 16, 19

Description. Vesicle cubic, edges equal to each other, scalloped in some specimens, faces centrally depressed; central depression of faces causes centripetal ridges to form from apices; apices pointed, may be slightly extended; walls thick; surface laevigate.

Dimensions (in microns).

Specimen	1–A–8	1–A–18	2–A–54
GSC No.	30672	30671	
Edge length	26	41	26

Discussion. Deunff (1955) illustrated a specimen and named it in the figure legend; he gave no description or collecting locality. The specimen was associated with a *Favosites* polyp from the Onondaga Stage of Ontario.

Cramer (1964) named a species *Polyedryxium embudum* which has the cubic shape and depressed walls similar to the Hamilton specimens. In his specimens, however, the cubic vesicle is small and there are high crests on the edges.

Deunff (1971) transferred this species to the genus *Staplinium*, on the grounds that it has neither angular fleurons nor crenellations and that the test membrane is simple. Some Hamilton specimens showed features very similar to, if not identical with, the crenellations of *Polyedryxium*. Therefore it is considered unnecessary to exclude this species from the genus *Polyedryxium*.

Occurrence. Ipperwash Member: rare (three specimens); Widder Member: rare; Hungry Hollow Member: rare to uncommon; Arkona Member: rare to abundant; Rockport Quarry Member: rare to uncommon; Bell Member: rare to uncommon; Dundee Formation: two specimens.

Figured specimens. Hypotypes, GSC Nos. 30671, 30672.

"*Polyedryxium*" *pharaonis* Deunff, 1955

Plate XII, figures 10, 12–14, 17, 20

Description. Vesicle cubic, faces flat to depressed, slightly irregular crests along edges; each apex prolonged into long, slender, tapering spines; in some instances, thin membrane encloses apices and spines; surface laevigate.

Dimensions (in microns).

Specimen	1-A-3	1–A–7	2–A–49	2–A–52
GSC No.		30674	30673	30675
Side length	33	26	26	26
Spine length	41, 26, 36, 33, 36, 36	41	31, 28, 28	36, 31, 38, 31, 41

Discussion. Deunff (1955) introduced the name of this species in the legend to an illustration with no further explanation. He gave no description, assigned no type, and indicated no type locality. The material was found in a *Favosites* polyp from the Onondaga Stage of Ontario.

Cramer (1964) identified forms from northwest Spain that he considered conspecific with Deunff's material.

The Hamilton specimens are constant in their morphology, showing little variation. Some forms are intact, while others are collapsed. The collapsed forms have central depressions on the cube faces, and thus have a hopper-like appearance. Deunff (1971) transferred this species to the genus *Veryhachium* because it seems aberrant to him: the wall transparency and thinness being the criteria on which he based this conclusion. The length of the spines also seems somewhat aberrant. However, to include this definitely cubic form in the genus *Veryhachium* seems to extend the scope of *Veryhachium* beyond its original and accepted definitions. For the time being, it is considered more practical to include this species in the genus to which it was originally attributed.

Occurrence. Ipperwash Member: rare to common; Widder Member: rare to abundant; Hungry Hollow Member: rare to common; Arkona Member: rare to abundant; Rockport Quarry Member: rare to abundant; Bell Member: rare to common; Dundee Formation: 22 specimens.

Figured specimens. Hypotypes, GSC Nos. 30673–30675.

Subgroup RETRASTOMORPHITAE Brito, 1969

Tornacia Stockmans and Willière, 1965

Type species: *Tornacia sarjeanti* Stockmans and Willière, 1965

Spherical organisms, diameter range 15 to 21 microns, with nine to twelve appendages rapidly shortened to small knobs or digitate appendages with similarly shaped bases, but larger, with obtuse extremities 4.5 microns long and 2.2 microns wide, transparent for their whole length, but with dark brown base which shows rather distinctly against a generally clearer vesicle (translated from Stockmans and Willière, 1965).

Tornacia sp.

Plate XIII, figure 14

Description. Vesicle spherical; ring of equatorially placed spines, 15 microns long, simple tapering, straight; spine bases 8 microns wide, 3 microns into vesicle, dark; surface laevigate.

Dimensions (in microns).

Specimen, 1–B–9; GSC No. 30676. Diameter, 64; spine length, 15; spine base width, 8.

Discussion. This specimen from the Dundee Formation is considerably larger than the type species *Tornacia sarjeanti*, which was described from the Tournaisian (Lower Carboniferous) of Belgium. The diameter of the type species ranges from 15 to 21 microns, that of the Dundee specimen is 64 microns; the spines of the type species number nine to twelve and are 4.5 microns long and 2.2 microns wide; in the Dundee specimen they number seven, and are 15 microns long and 8 microns wide.

This major size discrepancy does not obviate the similarity between the specimens. This is probably a new species.

Occurrence. Dundee Formation: one specimen.

Figured specimen. GSC No. 30676.

Triangulina Cramer, 1964

Type species: *Triangulina alargada* Cramer, 1964

"Acritarchs with a triangular somewhat inflated inner body, surrounded by an outer body of approximately the same shape, but with hollow processes at the corners." (Cramer, 1964, p. 334.)

Triangulina cf. *T. alargada* Cramer, 1964

Plate XI, figures 11, 12

Description. Hollow triangular inner body with apices rounded bluntly; outer body similar to inner body but extending beyond apices with hollow processes; surface laevigate.

Dimensions (in microns).

Specimen, 2–A–40; GSC No. 30677; altitude, 63,54,59; process length, 38,23,28.

Discussion. In his description of this species from the Emsian of northwest Spain, Cramer (1964) described a vesicle with an inner body darker than the close-fitting outer vesicle. In the Hamilton specimens, the inner body does not seem to be thicker nor darker than the outer body. The size of the Hamilton specimens is much greater than that of the type specimen which has an altitude of 30 microns and process lengths of 23 to 27 microns. The size differential may in time be shown to be a variation within one species if intermediate-sized forms are found.

Occurrence. Arkona Member: rare to common; Rockport Quarry Member: rare; Bell Member: rare; Dundee Formation: two specimens.

Figured specimen. GSC No. 30677.

Subgroup SPHAEROMORPHITAE Downie, Evitt and Sarjeant, 1963

Leiosphaeridia Eisenack, 1958, emend. Downie and Sarjeant, 1963

Type species: *Leiosphaeridia baltica* Eisenack, 1958

"Spherical to ellipsoidal bodies without processes, often collapsed or folded, with or without pylomes. Walls granular, punctate or unornamented; thin. Without division into fields and without transverse or longitudinal furrows or girdles." (Downie and Sarjeant, 1963, pp. 94, 95.)

The genus *Leiosphaeridia* is represented by two species in the Hamilton Formation.

Leiosphaeridia sp. 1

Plate XIII, figures 6, 13

Description. Hollow, thin-walled spherical vesicle; unornamented; no pylome observed.

Dimensions (in microns):

Specimen	1–A–10	1–A–49
GSC No.	30679	30678
Diameter	166	181

Discussion. This species, typified by thin walls, is nearly ubiquitous in the Hamilton Formation. Small and large forms occur, the small forms ranging from 30 to 110 microns and the larger from 130 to 270 microns. This probably indicates a natural break between two species. The morphology of this genus is so simple that size becomes an important criterion in separating species.

Occurrence. All members: rare to abundant; Dundee Formation: 259 specimens.

Figured specimens. GSC Nos. 30678, 30679.

Leiosphaeridia sp. 2

Plate XIII, figures 9, 11, 12, 15

Description. Hollow spherical vesicle; thick walled, unornamented; lip or slit present, probably indicating a pylome.

Dimensions (in microns).

Specimen	1–A–6	1–A–24	2–A–45
GSC No.		30681	30680
Diameter	69	84	64

Discussion. This species is slightly thicker walled than recognized members of this genus. Its wall thickness might suggest affinities with *Tasmanites* were it not for the imperforate nature of the wall, even as observed under high magnification and oil immersion. Consequently it is classified as *Leiosphaeridia.* In *Leiosphaeridia* a circular pylome has been observed in some specimens, but not in specimens from the Hamilton Formation. In this Hamilton species a slit which is at times covered by a lip is generally present. Thus, perhaps further study will warrant separating this species from this genus.

Occurrence. Included in previous species.

Figured specimens. GSC Nos. 30680, 30681.

Subgroup uncertain

Tunisphaeridium Deunff and Evitt, 1968

Type species: *Tunisphaeridium concentricum* Deunff and Evitt, 1968

"Acritarchs with an overall spherical to ellipsoidal to pyriform outline composed of a central sphaeroidal vesicle bearing numerous rodlike, apparently solid, processes whose extremities are interconnected by a diaphanous membrane alone, by a membrane reinforced with a network of faint to conspicuous filaments that radiate from the process tips, or by such filaments with only traces of a membrane. No pylome observed." (Deunff and Evitt, 1968, p. 2.)

Tunisphaeridium concentricum Deunff and Evitt, 1968

Plate XIII, figures 1–5, 7

Description. Vesicle spherical, diameter ranging from 36 to 46 microns; numerous (more than fifteen) solid rodlike spines, uniform in length, 20 to 28 microns long, expanded at their tips and connected distally by a thin membrane concentric with the vesicle; no pylome observed.

Dimensions (in microns).

Specimen	1–A–16	1–A–16	1–A–18
GSC No.	30682	30684	30683
Vesicle diameter	46	38	36
Spine length	20	28	21
Number of spines	20+	15+	18+

Discussion. This species, described by Deunff and Evitt (1968) from the Middle Silurian of New York State, is highly variable. They gave a vesicle diameter range of 23 to 45 microns, a process length range of 6 to 24 microns, and a process number range of 15 to 45. The Hamilton specimens fit into the upper half of the vesicle diameter and process length ranges. The state of preservation of these specimens is not very good and thus the number of spines is difficult to establish beyond a minimum count. Also, because of the rather poor preservation, the outer membrane is not always complete.

Occurrence. Ipperwash Member: rare (three specimens); Widder Member: rare; Hungry Hollow Member: rare (one specimen); Arkona Member: rare to common; Rockport Quarry Member: rare; Bell Member: rare; Dundee Formation: one specimen.

Figured specimens. Hypotypes, GSC Nos. 30682–30684.

ALGA

Class *Chlorophyceae*

Family Tasmanaceae

Quisquilites Wilson and Urban, 1963 emend. Wilson and Urban, 1971

Type species: *Quisquilites buckhornensis* Wilson and Urban, 1963

"Bilaterally symmetrical; oval, semi-oval to terete in longitudinal view, oval to round in cross section; germinal structure not apparent; wall translucent to transparent, two-layered; outer layer smooth or ornamented, approximately one-third as thick as inner layer; both layers penetrated vertically by megacanals and microcanals, the former one-half to one micron in diameter and scattered, the latter approximately 0.01 micron in diameter and uniformly dense throughout; known ranges of dimensions of palynomorph 80 to 145 microns long, 30 to 80 microns in diameter." (Wilson and Urban, 1971, p. 240.)

Quisquilites widderensis n. sp.

Plate XI, figures 17–21

Description. Vesicle straight, cylindrical with ends rounded and closed; walls transparent to translucent, two-layered, porate; pores generally visible only at high magnification or with oil immersion.

Dimensions (in microns).

Specimen	1–A–4	1–A–7	1–A–7	1–A–13	2–A–39
GSC No.	30661	30662	30660	30664	30663
Length (L)	140	143	186	173	145
Width (W)	33	41	31	31	31
W/L	0.2	0.3	0.2	0.2	0.2

Discussion. Quisquilites buckhornensis Wilson and Urban (1963) is similar to this Hamilton species in general aspect. These two forms differ in two respects. *Quisquilites buckhornensis* has been observed in ovoid to cylindrical outline, and straight to curved attitude. The Hamilton species has been observed only in cylindrical form, and it is always straight unless it has been broken. The size range for *Q. buckhornensis* is 80 to 145 microns long, 30 to 80 microns wide; in the Hamilton species the length is generally greater, 140 to 186 microns, and the width has a narrower range, 31 to 41 microns. The walls in the Hamilton species are thinner than in *Q. buckhornensis*. The pores which can be observed at high magnification and under oil immersion are the megacanals of Wilson and Skvarla (1967).

Occurrence. Ipperwash Member: rare; Widder Member: rare to abundant; Hungry Hollow Member: rare to abundant; Arkona Member: rare to abundant; Rockport Quarry Member: rare to abundant; Bell Member: rare to abundant; Dundee Formation: sixteen specimens.

There are two zones in the Bell Member, one in the Rockport Quarry Member and three in the Arkona Member where *Q. widderensis* constitutes high percentages of the Acritarcha assemblages. The high percentage zones are traceable across the three cores.

Figured specimens. Holotype, GSC No. 30662; paratypes, GSC Nos. 30660, 30661, 30663, 30664.

Tasmanites Newton, 1875

Type species: *Tasmanites punctatus* Newton, 1875

Tasmanites sp.

Plate XIII, figures 8, 10

Description. Vesicle spherical, walls thick, rugose, punctate; pylome not observed.

Dimensions (in microns).

Specimen	1–A–16	1–A–37	1–A–40	2–A–21
GSC No.		30686	30685	
Diameter	64	247	146	253

Occurrence. All members: rare to abundant; Dundee Formation: 193 specimens.

Figured specimens. GSC Nos. 30685, 30686.

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APPENDIX

Descriptions of Cores

Geological Survey of Canada No. 1 Arkona No. 1 core

Location: Rock Glen Park—Ausable River Conservation Authority—Arkona
Lambton Co., Bosanquet tp., lot 4, conc. SB
100 feet north of south lot line, 1.500 feet east of west lot line

Geology by B.V. Sanford

Surficial Deposits

	Depth (feet)
No core recovered	0–4.0
Limestone, dark greyish brown, finely crystalline to subaphanitic, slightly argillaceous (resembles Dundee Formation—probably surficial)	4.0–5.1
Gabbro boulder	5.1–5.6

Hamilton Group

Widder Formation

Limestone, medium dark brown, finely crystalline to aphanitic, slightly argillaceous	5.6–10.9
Shale, calcareous, dark grey, fissile, fossiliferous	10.9–11.5
Limestone, dark brownish grey, finely crystalline to aphanitic, argillaceous	11.5–11.8
Shale, medium to dark grey, calcareous, fossiliferous	11.8–12.8
Limestone, grey, argillaceous, finely crystalline; grades to coarse calcarenite at base	12.8–13.0
Shale, medium grey, calcareous, fossiliferous	13.0–14.7
Limestone, medium brownish grey, argillaceous, crinoidal	14.7–14.9
Shale, medium grey, extremely fossiliferous	14.9–15.7
Limestone as above	15.7–15.8
Shale, medium grey, fossiliferous, fissile, calcareous	15.8–17.0
Limestone, medium greyish brown, finely crystalline, argillaceous; few thin interbeds of grey calcareous shale here and there. Abundant *Spirifer mucronatus*	17.0–20.0
Shale, medium grey, soft, fissile, calcareous	20.0–21.8
Limestone, medium grey with slight brown cast, aphanitic, argillaceous	21.8–23.9
Shale, medium grey, calcareous, soft. Abundant *Spirifer* spp. From 28.0 feet downward shales become very soft and friable	23.9–30.2
Shale, medium grey, firm, calcareous	30.2–32.0
Limestone, medium grey, finely crystalline, very argillaceous	32.0–32.4
Shale, medium grey, firm at top, becoming thinly laminated and friable towards base	32.4–38.3
Limestone, finely crystalline, argillaceous	38.3–38.5
Shale, medium to dark grey, calcareous	38.5–42.6
Limestone, medium brownish grey, finely crystalline, argillaceous	42.6–44.1
Shale, medium grey, fissile, calcareous	44.1–44.2
Limestone, medium brownish grey, finely crystalline, argillaceous	44.2–44.6

	Depth (feet)
Shale, medium grey, calcareous	44.6–46.0
Limestone, medium grey, argillaceous, finely crystalline	46.0–46.7
Hungry Hollow Formation	
Shale, grey, calcareous, firm	46.7–47.4
Shale, very calcareous, and shaly limestone interbedded	47.4–48.4
Shale, calcareous, grey, firm (coral beds)	48.4–49.4
Shale, medium grey, very calcareous; grades to shaly limestone in places	49.4–50.2
Limestone, medium greyish brown crinoidal calcarenite, medium grained (Encrinal limestone)	50.2–51.8
Arkona Formation	
Shale, black, bituminous	51.8–52.2
Limestone, dark brownish grey, finely crystalline, argillaceous	52.2–52.8
Shale, medium grey, calcareous, fissile	52.8–53.0
Shale, calcareous, medium grey, soft, fissile, friable. This zone contains thin bands of very shaly limestone	53.0–77.2
Shale, calcareous, medium grey, thinly laminated, fissile	77.2–81.6
Shale, calcareous, dark grey to nearly black, very fissile and friable	81.6–85.6
Shale, calcareous, medium grey, soft, fissile	85.6–95.5
Shale, medium to dark grey, firm; few interbeds of dark grey shaly limestone	95.5–117.5
Shale, calcareous, medium grey, fissile	117.5–128.0
Shale, calcareous, medium grey, firm	128.0–130.0
Shale, medium grey, firm, very calcareous; in places grades to shaly limestone	130.0–140.1
Shale, calcareous, dark grey, firm	140.1–159–7
Limestone, medium brownish grey, calcarenite, contains an abundance of coarse skeletal material	159.7–161.0
Limestone, medium brown, aphanitic, very fossiliferous	161.0–161.3
Shale, calcareous, dark grey, firm	161.3–184.2
Rockport Quarry Formation	
Limestone, medium brownish grey, finely crystalline to aphanitic, argillaceous, fossiliferous	184.2–185.8
Limestone, medium greyish brown, aphanitic, argillaceous	185.8–188.8
Limestone, medium brown, finely crystalline to aphanitic; contains interbeds of greyish brown, argillaceous, aphanitic limestone	188.8–205.2
Bell Formation	
Shale, slightly calcareous, medium to dark grey, firm	205.2–210.0
Shale, medium to dark grey, firm, noncalcareous at top, but becomes fairly calcareous towards base, fossiliferous, pyritic (particularly organic remains)	210.0-232.2
Shale, calcareous, dark grey, firm	232.2–244.5
Shale, calcareous, dark grey; contains dark grey limestone interbeds, very fossiliferous, pyritized	244.5–246.8
Shale, medium to dark grey, unconsolidated, friable	246.8–249.4
Shale, calcareous, medium dark grey, firm, contains abundant pyritized fossil remains	249.4–251.1
Dundee Formation	
Limestone, greyish brown, argillaceous, varies from finely crystalline to microgranular texture, fossiliferous, pyritic	251.1–255.6
Limestone, light brown, finely crystalline to fine granular texture, oil stained	255.6–257.0
Limestone, light tan, finely crystalline	257.0–259.5
Limestone, light brown, finely crystalline to granular, oil stained	259.5–261.1

Geological Survey of Canada No. 2 Ipperwash No. 1 core

Location: Stoney Point, Ipperwash Provincial Park, on bedrock surface
Lambton Co., Bosanquet tp., lot 9, conc. A
1,500 feet east of west lot line on lake front

Geology by B. V. Sanford

Hamilton Group

	Depth (feet)
Ipperwash Formation	
No recovery	0–1.5
Limestone, brownish grey, fine to medium crystalline	1.5–2.7
Shale, light grey, calcareous, fissile, friable	2.7–3.0
Limestone, light brownish grey, fine to medium crystalline; contains abundant skeletal fragments	3.0–5.0
Shale, medium grey, very friable and fissile, calcareous	5.0–8.5
Limestone, light brown, medium crystalline, fossiliferous	8.5–9.5
Shale, medium grey, fissile as above, calcareous	9.5–15.0
Limestone, medium grey, very argillaceous and crinoidal; contains thin intercalations of grey calcareous shale	15.0–16.5
Shale, medium grey, calcareous	16.5–19.5
Limestone, grey, argillaceous; consists mainly of intraformational conglomerate, limestone fragments with interlaminations of shale	19.5–19.9
Limestone, light brownish grey, finely crystalline	19.9–20.8
Shale, medium grey, calcareous, fossiliferous	20.8–24.7
Limestone, medium grey, medium crystalline, argillaceous	24.7–25.0
Shale, medium grey, very calcareous, contains some intraformational limestone conglomerate	25.0–27.7
Shale, medium grey, firm, calcareous	27.7–33.0
Widder Formation	
Limestone, brownish grey, finely crystalline, argillaceous, contains interlaminations of highly calcareous grey shale	33.0–39.0
Limestone, light brown, finely crystalline, argillaceous, contains abundant crinoid stem segments	39.0–43.5
Limestone, light brown, finely crystalline, aphanitic	43.5–46.0
Limestone, dark brown, subaphanitic, very argillaceous	46.0–54.4
Limestone, dark greyish brown similar to above, but becoming increasingly argillaceous towards base. *Spirifer mucronatus* abundant in these beds	54.4–70.0
Limestone as above, grades to dark brownish grey, firm, calcareous, abundant *Spirifer* spp.	70.0–74.5
Limestone, dark brownish grey, subaphanitic, argillaceous; grades to calcareous shale here and there	74.5–77.4
Shale, dark grey, firm, very calcareous, abundant *Spirifer* spp.	77.4–87.2
Limestone, dark brown, subaphanitic, argillaceous	87.2–94.5
Hungry Hollow Formation	
Shale, calcareous and limestone; fine crystalline; contains interbeds of lighter coloured medium crystalline limestone increasing in quantity towards base. (coral beds)	94.5–97.5
Limestone, light brown, medium crystalline, crinoidal; contains two or three thin interbeds of dark brownish grey argillaceous limestone. This is the crinoidal limestone zone of the Hungry Hollow Formation	97.5–99.5
Limestone; 2″ of black bituminous limestone at top. (*Leiorhynchus* zone?) grading to brown and grey, finely crystalline to crystalline limestone; few crinoid stem segments	99.5–101.0

	Depth (feet)
Arkona Formation	
Shale, dark grey, firm, only slightly calcareous	101.0–122.0
Shale, medium dark grey, becoming very dark grey here and there, firm calcareous. In places somewhat harder bands contain increased amounts of limestone	122.0–144.5
Shale, dark grey, very calcareous; limestone constitutes high proportion of core.	144.5–151.1
Shale, dark grey, firm, high limestone content, but appears to be predominantly shale	151.1–167.2
Shale, medium dark grey, firm	167.2–176.5
Limestone, dark brownish grey, subaphanitic, very argillaceous	176.5–178.5
Shale, dark grey as above, very calcareous. In places contains hard bands where limestone and shale ratio is approximately 1:1	178.5–189.5
Shale, dark grey, firm, very calcareous, hard bands contain high percentage of limestone	189.5–211.7
Rockport Quarry Formation	
Limestone, dark brown, subaphanitic, argillaceous	211.7–213.7
Limestone, dark brown, subaphanitic, argillaceous; lowermost 6 inches consists of light brown, finely crystalline limestone	213.7–215.7
Shale, dark grey, firm, slightly calcareous in places	215.7–238.0
Shale, dark grey, firm	238.0–238.8
Limestone, dark brown, slightly argillaceous, finely crystalline	238.8–239.8
Bell Formation	
Shale, dark grey, firm, slightly calcareous in places	239.8–262.2
Shale, dark grey, firm, in places contains hard calcareous bands	262.2–265.5
Limestone, dark brownish grey, very argillaceous, subaphanitic	265.5–269.2
Shale, dark grey, calcareous	269.2–270.0
Limestone, dark brown, argillaceous, subaphanitic	270.0–272.7
Shale, dark grey, calcareous, firm	272.7–275.0
Limestone, dark brown, subaphanitic, very argillaceous, fossiliferous	275.0–278.5
Shale, dark grey, calcareous, firm	278.5–280.5
Limestone, dark brown, subaphanitic, very argillaceous, fossiliferous	280.5–285.8
Shale, dark grey	285.8–286.0
Shale, dark grey, slightly calcareous, firm	286.0–289.0
Limestone, dark brown, argillaceous, subaphanitic	289.0–290.6
Shale, dark grey, firm, calcareous	290.6–306.5
Shale and limestone interbedded; shale, dark grey, calcareous, with thin aphanitic argillaceous limestone interbedded	306.5–309.0
Dundee Formation	
Limestone, medium greyish brown, very finely crystalline, pyritic, argillaceous	309.0–310.0
Limestone, medium brown, very finely crystalline, argillaceous, pyritic	310.0–316.5
Limestone, light greyish brown, very finely crystalline, sporadic oil staining; stylolitic seams common	316.5–334.4

Argor Consolidated Morrison 65-1 core

Location: Lambton Co., Moore tp., lot 28, conc. II
1,500 feet south of north lot line
100 feet east of west lot line

Kettle Point Formation	
Black shale, noncalcareous, nonfissile to fissile, pyrite grains scarce	468.8–470.6
Shale, brownish grey, nonfissile, noncalcareous; pyrite grains present	470.6–471.3

	Depth (feet)
Black shale, fissile, noncalcareous, some pyrite grains present	471.3–472.3
Shale, noncalcareous, intraclastic conglomerate, pyritic	472.3–473.8

Hamilton Formation

Ipperwash Member

Limestone, light brown, fine grained, fossiliferous, some calcareous intraclasts, pyritic near bottom (at 476′)	473.8–476.0
Limestone, medium brown, medium to coarse crystalline, highly argillaceous; some vugs, crinoid stems; pyritic	476.0–477.8
Limestone, medium grey, fine to aphanitic; pyrite bands	477.8–479.0
Limestone, medium grey, with highly calcareous shale interbeds, fine to aphanitic; some pyrite bands	479.0–483.8
Shale, dark grey, very highly calcareous, highly fissile	483.8–484.8
Limestone, medium grey, fine to aphanitic	484.8–485.0
Shale, dark grey, highly calcareous, fissile	485.0–485.2
Limestone, medium grey, medium grained, fossiliferous, thin shale interbeds	485.2–485.5
Shale, dark grey, noncalcareous, fissile	485.5–485.8
Limestone, medium grey, fine to medium grained, thin shale interbeds, slightly contorted; fossil fragments	485.8–487.2
Limestone, medium grey, fine grained	487.2–487.4
Shale, dark grey, slightly calcareous, friable	487.4–487.7
Limestone, dark grey, coarse grained, large fossil fragments (up to ½″), mainly crinoid stems	487.7–488.0
Shale, dark grey, calcareous, fissile	488.0–488.4
Limestone, medium grey, coarse grained; very thin argillaceous interbeds	488.4–490.1
Shale, dark grey, highly calcareous, fissile, friable	490.1–490.5
Limestone, medium grey, medium to coarse grained; fossil fragments	490.5–490.8
Shale, dark grey, slightly calcareous fissile, friable	490.8–491.9
Limestone, light to medium grey	491.9–494.6
9.5 (thickness in inches): medium grained with large calcareous intraclasts (up to 1 inch); contorted shale interbeds.	
6.5 (thickness in inches): light grey, medium grained, crinoid stems; no intraclasts nor interbeds.	
2.5 (thickness in inches): same as 9.5-inch subunit	
13.0 (thickness in inches): same as 6.5-inch subunit	
Shale, medium to dark grey, noncalcareous, fissile	494.6–494.9
Limestone, dark grey, some medium grains in fine matrix, thin shale interbeds, crinoid stems	494.9–495.0
Shale, dark grey, noncalcareous, fissile, friable	495.0–495.2
Limestone, light grey, fine grained, very thin shale interbeds	495.2–495.4
Shale, dark grey, slightly fissile, noncalcareous; one 1½-inch limestone interbed	495.4–495.9
Limestone, dark grey, fine to aphanitic with coarse intraclasts; very argillaceous.	495.9–496.4
Dolomite, light brown, medium crystalline, massive, fossiliferous. One nodule of chert containing fossil fragments	496.4–498.1

Widder Member

Limestone, light brown, fine with coarse fossil fragments; very thin and numerous shale intercalations	498.1–522.3
Shale subunits, up to 1 inch in a few places; highly calcareous	——
Limestone, as in previous unit, medium brown, many brachiopods (*Spirifer ?*); largest brachiopods in subunits with less shale intercalations	522.3–534.8
Limestone, medium grey, fine grained, fossiliferous, highly argillaceous; rubbly friable unit	534.8–539.6
Limestone, dark grey, fine to aphanitic, fossils scarce; shale intercalations scarce; soft; argillaceous content increases downward	539.6–542.6

	Depth (feet)
Hungry Hollow Member	
Shale, dark grey, argillaceous, fissile, fossiliferous	542.6–544.0
Limestone, medium to dark grey, fine to aphanitic; fossiliferous, mainly brachiopods	544.0–545.8
Limestone, dark grey, large intraclasts (up to 1″); fossils, mainly rugose corals; very thin shale interbeds	545.8–549.3
Arkona Member	
Limestone, medium to dark grey, fine to medium grained, some shale intercalations (less than in previous unit); fossiliferous (crinoid stems and colonial tabulate coral)	549.3–551.1
Shale, dark grey, highly calcareous, not very fissile, friable in parts; 8-inch subunit in top quarter of dark grey fossiliferous argillaceous limestone	551.1–561.0
Shale, dark grey, highly calcareous, more fissile and more friable than previous unit	561.0–570.0
Same as previous unit, but more fissile and more friable	570.0–580.1
Limestone, dark grey, fine to medium grained	580.1–580.3
Shale, dark grey, highly calcareous, fissile, friable	580.3–581.5
Limestone, medium grey, fine to medium grained, fossiliferous	581.5–581.9
Shale, dark grey, highly calcareous, highly fissile, highly friable	581.9–596.0
Shale, dark grey, same as unit above, but less calcareous	596.0–602.1
Limestone, medium to dark grey, fine to medium grained, fossiliferous (small fossils); no shale intercalations	602.1–603.2
Shale, dark grey, very fissile, very friable	603.2–622.3
Limestone, dark grey, fine grained, slightly fossiliferous; argillaceous content increases downward; grades into:	622.3–622.7
Shale, dark grey, highly fissile, highly friable, calcareous; calcareous content decreases downward; grades into:	622.7–623.8
Shale, dark grey, not fissile, rubbly, friable	623.8–624.5
Shale, dark grey, calcareous (increases up to 634′), highly fissile, highly friable (friability decreases downward)	624.5–634.5
Limestone, medium to dark grey, fine grained; some crinoid columnals; more argillaceous near top	634.5–635.0
Shale, dark grey, not friable, less fissile than previous shale unit	635.0–636.6
Limestone, medium to dark grey, fine to medium grained, fossiliferous (brachiopods and crinoid columnals)	636.6–638.0
Shale, dark grey, slightly calcareous, fissile, slightly friable	638.0–641.8
Limestone, medium grey, fine grained, nonargillaceous, nonfossiliferous	641.8–642.0
Shale, dark grey to black, calcareous, highly fissile and highly friable	642.0–644.5
Limestone, fine grained, argillaceous, fossiliferous	644.5–645.2
Shale, dark grey to black, very fissile, slightly friable, fossiliferous (brachiopods).	645.2–647.0
Limestone, dark grey, with a medium grey band (about $1\frac{1}{2}$″), fine grained, fossiliferous (mainly brachiopods, some crinoid columnals)	647.0–649.3
Shale, dark grey, fissile, slightly friable, calcareous, some fossils	649.3–655.0
Shale, dark grey, same as unit above, but more fossiliferous	655.0–657.1
Rockport Quarry Member	
Limestone, medium to dark grey, fine grained, fossiliferous (brachiopods and crinoid columnals)	657.1–657.9
Shale, dark grey, nonfriable, slightly fissile, highly calcareous, fossiliferous (brachiopods)	657.9–660.2
Shale, dark grey, same as unit above, but slightly more fissile	660.2–662.3
Limestone, medium to dark grey (brownish), fine to medium grained, highly fossiliferous	662.3–663.5
Shale, dark grey, very highly calcareous, fissile, highly fossiliferous	663.5–663.7
(3.5″ missing between 663′ and 665′ markers)	
Limestone, medium brown, fine to medium grained, some very thin argillaceous intercalations, fossiliferous (brachiopods and crinoids columnals)	663.7–671.3

	Depth (feet)
Shale, dark grey, very highly calcareous, very fossiliferous, fissile, and slightly friable	671.3–672.8
Limestone, dark grey (brownish), fine grained, very fossiliferous (large *Spirifer*), argillaceous content increases downward	672.8–673.7
Bell Member	
Shale, dark grey, highly calcareous, highly fissile, very friable	673.7–680.3
Limestone, dark grey, fine grained, fossiliferous (brachiopods, and crinoid columnals), slightly argillaceous	680.3–680.9
Shale, dark grey, very fissile, friable, highly calcareous	680.9–691.2
Limestone, dark grey, fine grained, nonfossiliferous	691.2–691.5
Shale, dark grey, very fissile, friable, highly calcareous	691.5–693.0
Limestone, medium to dark grey, medium grained, fossiliferous	693.0–693.2
Shale, dark grey, very fissile, friable, highly calcareous	693.2–693.5
Limestone, dark grey, fine to aphanitic, fossiliferous (brachiopods), argillaceous content and fissility increase downward, grading into:	693.5–693.9
Shale, dark grey, slightly calcareous, highly fissile, friable	693.9–696.0
Shale, dark grey, calcareous, rubbly, fissile, friable	696.0–698.0
Shale, dark grey, highly calcareous, fissile, nonfriable	698.0–698.8
Shale, dark grey, highly calcareous, nonfissile, highly friable	698.8–699.9
Shale, dark grey, highly calcareous, fissile, nonfriable	699.9–713.4
Limestone, fine grained, argillaceous, with thin interbeds of shale, fossiliferous.	713.4–715.3
Limestone, dark grey, fine to medium grained, fossiliferous; pyritized fossils	715.3–721.2

Dundee Formation

Limestone, light brown, massive, highly fossiliferous, fine grained, stylolites	721.2–741.5

PLATES I to XIII

Plate I

Figures 1,3.	*Alpenachitina ontariensis* n. sp.	(Page 17)
	Slide 1–A–50, ring 3; GSC Arkona No. 1 core, top 5 feet of Dundee Formation; infrared photomicrograph; 1) high focal level, 3) low focal level; L=107 microns, W=79 microns; holotype, GSC No. 30554.	
Figures 2,5,8.	*Ancyrochitina* cf. *A. cornigera* Collinson and Scott, 1958	(Page 17)
	Slide 3–A–37, ring 2; Argor 65–1 core, Arkona Member, 185–190 feet below top of Ipperwash Member; 2) and 8) enlargement of clavate processes, 5) vesicle; L=115 microns, W=77 microns; hypotype, GSC No. 30555.	
Figures 4,6.	*A.* cf. *A. cornigera* Collinson and Scott, 1958	(Page 17)
	Slide 3–A–28; Argor 65–1 core, Arkona Member, 135–140 feet below top of Ipperwash Member; 4) high focal level, 6) low focal level; L=112 microns, W=56 microns; hypotype, GSC No. 30556.	
Figures 7,9.	*A.* cf. *A. cornigera* Collinson and Scott, 1958	(Page 17)
	Slide 1–A–48, ring 3; GSC Arkona No. 1 core, depth 235–240 feet, Bell Member; 7) high focal level, 9) low focal level; L=161 microns, W=100 microns; hypotype, GSC No. 30557.	
Figures 10–12.	*A.* cf. *A. cornigera* Collinson and Scott, 1958	(Page 17)
	Slide 2–B–4 (1), ring 7; GSC Ipperwash No. 1 core, depth 85–90 feet, Hungry Hollow Member; 10) enlargement of neck, 11) vesicle, 12) enlargement of basal edgę spine; L=128 microns, W=94 microns; hypotype, GSC No. 30558.	

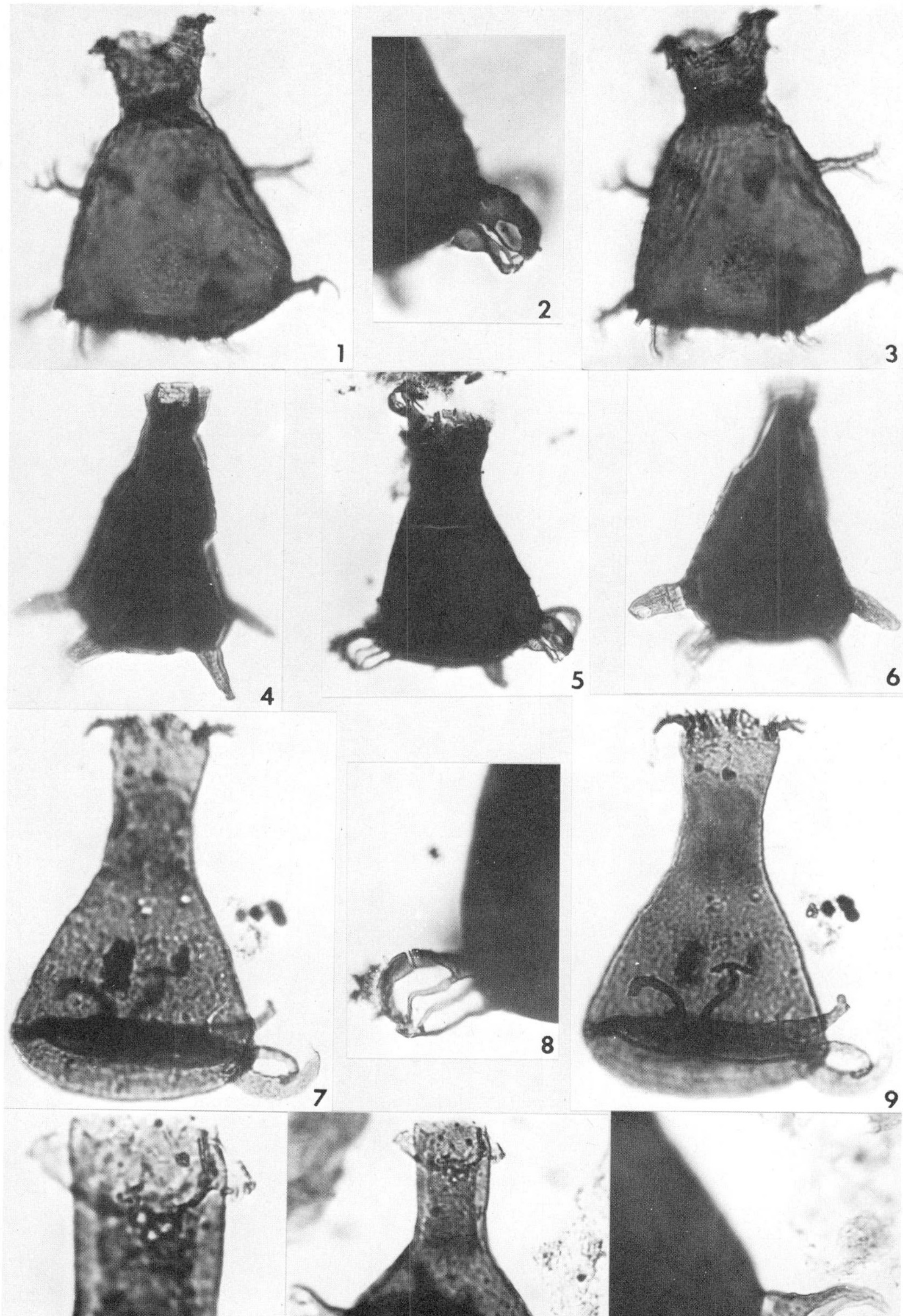
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Plate II

Figures 1–3. *Ancyrochitina* cf. *A. desmea* Eisenack, 1964 (Page 18)

Slide 2–A–12 (1) (4); GSC Ipperwash No. 1 core, depth 55–60 feet, Widder Member; 1) vesicle, 2) enlargement of neck, 3) enlargement of some basal edge spines; L=117 microns, W=79 microns; hypotype, GSC No. 30559.

Figure 4. ?*A. gordita* Cramer, 1964 (Page 19)

Slide 3–A–47; Argor 65–1 core, Bell Member, 230–235 feet below top of Ipperwash Member; L=94 microns, W=89 microns; hypotype, GSC No. 30560.

Figure 5. ?*A. gordita* Cramer, 1964 (Page 19)

Slide 1–A–44, ring 5; GSC Arkona No. 1 core, depth 215–220 feet, Bell Member; L=102 microns, W=92 microns; hypotype, GSC No. 30561.

Figure 6. ?*A. gordita* Cramer, 1964 (Page 19)

Slide 3–A–27 (1), ring 5; Argor 65–1 core, Arkona Member, 130–135 feet below top of Ipperwash Member; infrared photomicrograph; L=94 microns, W=79 microns; hypotype, GSC No. 30562.

Figure 7. *A.* cf. *A. langei* Sommer and van Boekel, 1964 (Page 20)

Slide 1–A–38, ring 2; GSC Arkona No. 1 core, depth 185–190 feet, Rockport Quarry Member; L=112 microns, W=89 microns; hypotype, GSC No. 30564.

Figure 8. ?*A. gordita* Cramer, 1964 (Page 19)

Slide 1–A–9 (2), ring 3; GSC Arkona No. 1 core, depth 40–45 feet, Hungry Hollow Member; L=100 microns, W=89 microns; hypotype, GSC No. 30563.

Figure 9. *A.* cf. *A. langei* Sommer and van Boekel, 1964 (Page 20)

Slide 1–A–47, ring 4; GSC Arkona No. 1 core, depth 230–235 feet, Bell Member; infrared photomicrograph; L=148 microns, W=82 microns; hypotype, GSC No. 30565.

Figures 10, 11. *A.* cf. *A. langei* Sommer and van Boekel, 1964 (Page 20)

Slide 2–A–51, ring 11; GSC Ipperwash No. 1 core, depth 245–250 feet, Bell Member; infrared photomicrograph; L=126 microns, W=97 microns; hypotype, GSC No. 30566.

Figure 12. *A.* cf. *A. langei* Sommer and van Boekel, 1964 (Page 20)

Slide 1–A–9 (2), ring 6; GSC Arkona No. 1 core, depth 40–45 feet, Hungry Hollow Member; infrared photomicrograph; L=156 microns, W=89 microns; hypotype, GSC No. 30567.

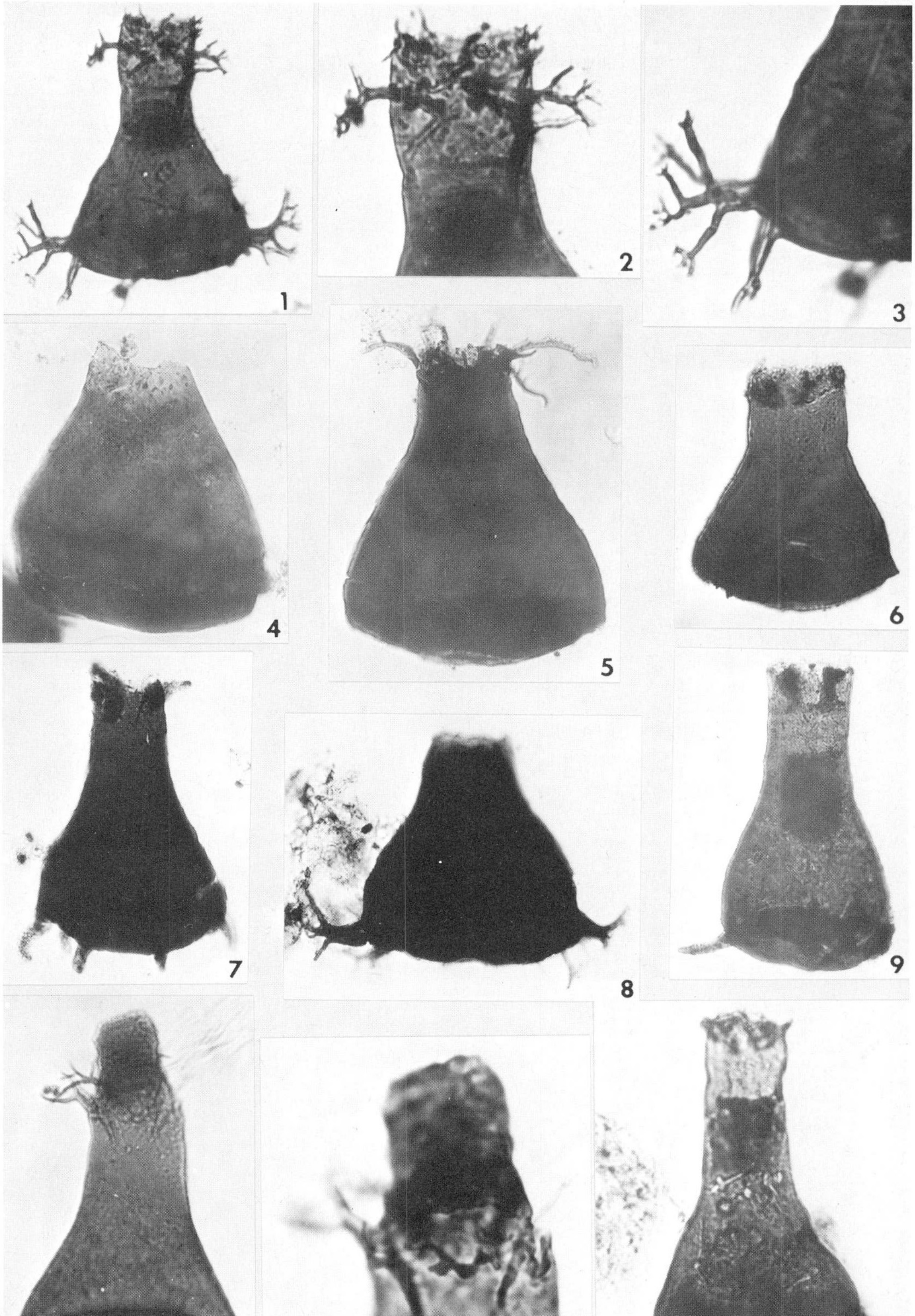
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Plate III

Figures 1, 2. *Ancyrochitina* cf. *A. langei* Sommer and van Boekel, 1964 (Page 20)

Slide 2–A–54, ring 18; GSC Ipperwash No. 1 core, depth 260–265 feet, Bell Member; infrared photomicrograph; 1) vesicle, 2) enlargement of neck; L=135 microns, W=89 microns; hypotype, GSC No. 30568.

Figure 3. *A.* cf. *A. langei* Sommer and van Boekel, 1964 (Page 20)

Slide 2–A–51, ring 6; GSC Ipperwash No. 1 core, depth 245–250 feet, Bell Member; L=115 microns, W=71 microns; hypotype, GSC No. 30569.

Figure 4. *A.* cf. *A. langei* Sommer and van Boekel, 1964 (Page 20)

Slide 1–A–9 (1), ring 6; GSC Arkona No. 1 core, depth 40–45 feet, Hungry Hollow Member; L=110 microns, W=87 microns; hypotype, GSC No. 30570.

Figures 5, 6. *A.* cf. *A. langei* Sommer and van Boekel, 1964 (Page 20)

Slide 1–A–9 (1), ring 1; GSC Arkona No. 1 core, depth 40–45 feet, Hungry Hollow Member; infrared photomicrograph; 5) enlargement of neck, 6) vesicle; L=120 microns, W=97 microns; hypotype, GSC No. 30571.

Figure 7. *A.* cf. *A. tumida* Taugourdeau and de Jekhowsky, 1960 (Page 22)

Slide 1–A–48, ring 5; GSC Arkona No. 1 core, depth 235–240 feet, Bell Member; L=130 microns, W=77 microns; hypotype, GSC No. 30574.

Figures 8, 9. *A.* cf. *A. tumida* Taugourdeau and de Jekhowsky, 1960 (Page 22)

Slide 1–A–45, ring 3; GSC Arkona No. 1 core, depth 220–225 feet, Bell Member; infrared photomicrograph; 8) vesicle, 9) enlargement of neck; L=120 microns, W=94 microns; hypotype, GSC No. 30575.

Figure 10. *A.* cf. *A. multiramosa* Taugourdeau and de Jekhowsky, 1960 (Page 21)

Slide 1–A–9 (2), ring 1; GSC Arkona No. 1 core, depth 40–45 feet, Hungry Hollow Member; L=115 microns, W=69 microns; hypotype, GSC No. 30572.

Figure 11. *A. tomentosa* Taugourdeau and de Jekhowsky, 1960 (Page 22)

Slide 1–A–2, ring 6; GSC Arkona No. 1 core, depth 5–10 feet, Widder Member; L=107 microns, W=79 microns; hypotype, GSC No. 30573.

Figure 12. *A.* cf. *A. tumida* Taugourdeau and de Jekhowsky, 1960 (Page 22)

Slide 1–A–47, ring 1; GSC Arkona No. 1 core, depth 230–235 feet, Bell Member; L=130 microns, W=100 microns; hypotype, GSC No. 30576.

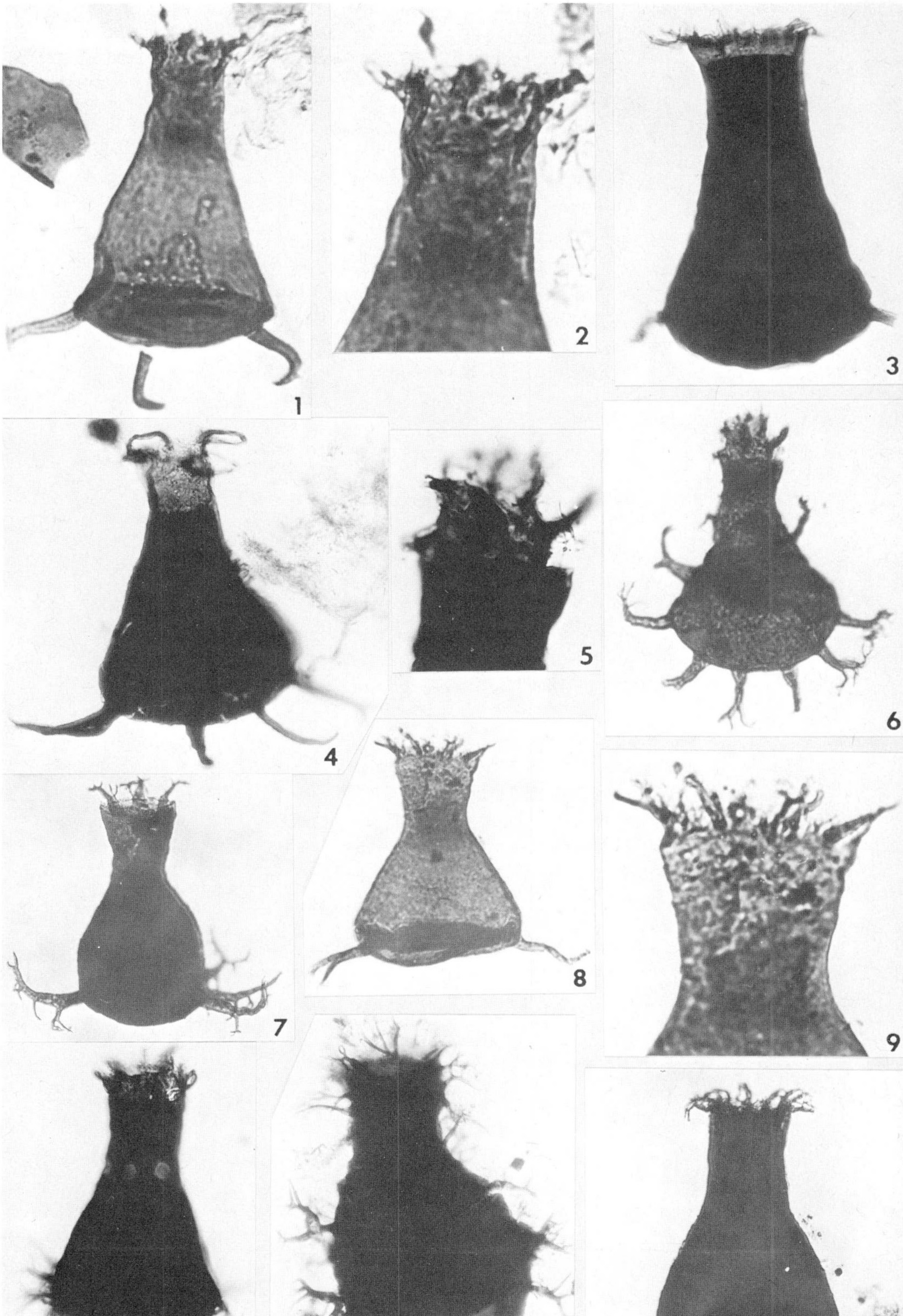
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Plate IV

Figure 1. *Ancyrochitina* cf. *A. tumida* Taugourdeau and de Jekhowsky, 1960 (Page 22)

Slide 1–A–45, ring 5; GSC Arkona No. 1 core, depth 220–225 feet, Bell Member; L=117 microns, W=89 microns; hypotype, GSC No. 30577.

Figures 2, 3. *A. hamiltonensis* n. sp. (Page 23)

Slide 3–A–27 (2); Argor 65–1 core, Arkona Member, 120–125 feet below top of Ipperwash Member; infrared photomicrograph; 2) enlargement of neck showing fringe of oral edge spines, 3) vesicle; L=125 microns, W=97 microns; holotype, GSC No. 30578.

Figure 4. *A. arkonensis* n. sp. (Page 23)

Slide 3–A–26 (2), ring 1; Argor 65–1 core, Arkona Member, 115–120 feet below top of Ipperwash Member; L=153 microns, W=94 microns; holotype, GSC No. 30579.

Figure 5. *A. arkonensis* n. sp. (Page 23)

Slide 1–A–46, ring 5; GSC Arkona No. 1 core, depth 225–230 feet, Bell Member; L=138 microns, W=97 microns; paratype, GSC No. 30580.

Figure 6. *A.* sp. 1 (Page 24)

Slide 3–A–27 (1), ring 1; Argor 65–1 core, Arkona Member, 110–115 feet below top of Ipperwash Member; L=105 microns, W=82 microns; figured specimen, GSC No. 30583.

Figure 7. *A. arkonensis* n. sp. (Page 23)

Slide 3–A–8; Argor 65–1 core, Widder Member, 25–30 feet below top of Ipperwash Member; L=204 microns, W=92 microns; paratype, GSC No. 30581.

Figures 8, 9. *A. arkonensis* n. sp. (Page 23)

Slide 3–A–27 (1), ring 2; Argor 65–1 core, Arkona Member, 120–125 feet below top of Ipperwash Member; infrared photomicrograph; 8) vesicle, 9) enlargement of neck showing fringe of oral edge spines; L=117 microns, W=79 microns; paratype, GSC No. 30582.

Figure 10. *A.* sp. 4 (Page 26)

Slide 1–A–9 (1), ring 4; GSC Arkona No. 1 core, depth 40–45 feet, Hungry Hollow Member; L=179 microns, W=100 microns; figured specimen, GSC No. 30586.

Figure 11. *A.* sp. 2 (Page 25)

Slide 3–A–27 (1), ring 4; Argor 65–1 core, Arkona Member, 120–125 feet below top of Ipperwash Member; L=122 microns, W=82 microns; figured specimen, GSC No. 30584.

Figure 12. *A.* sp. 3 (Page 25)

Slide 1–A–4 (1), ring 8; GSC Arkona No. 1 core, depth 15–20 feet, Widder Member; L=120 microns, W=92 microns; figured specimen, GSC No. 30585.

Figure 13. *A.* sp. 7 (Page 27)

Slide 2–A–56 (2), ring 1; GSC Ipperwash No. 1 core, depth 270–275 feet, Bell Member; infrared photomicrograph; L=145 microns, W=74 microns; figured specimen, GSC No. 30589.

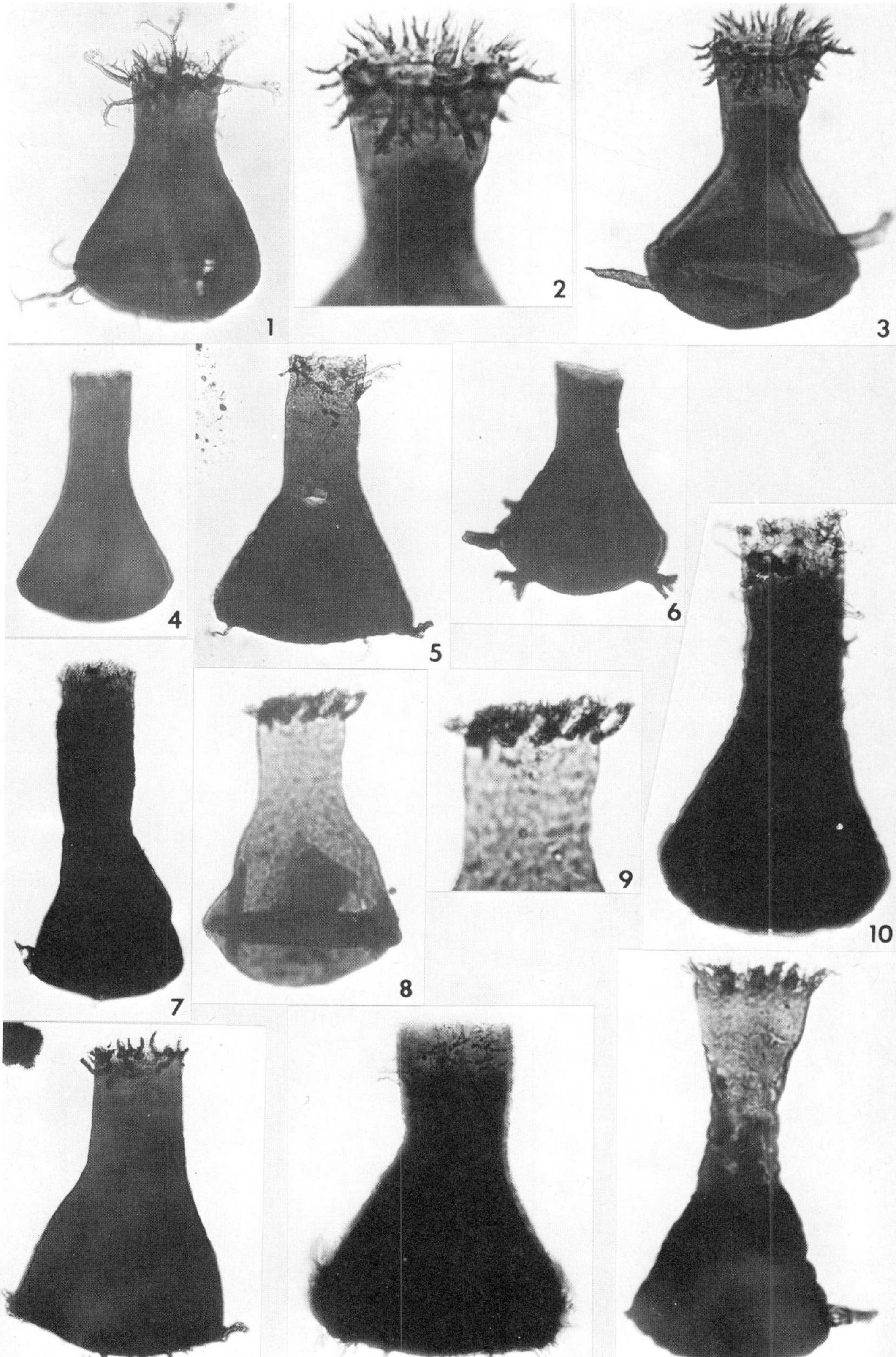
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PLATE V

Figure 1. *Ancyrochitina* sp. 5 (PAGE 26)

Slide 3–A–39; Argor 65–1 core, Arkona Member, 180–185 feet below top of Ipperwash Member; L=105 microns, W=74 microns; figured specimen, GSC No. 30587.

Figure 2. *A.* sp. 8 (PAGE 27)

Slide 1–A–31 (2), ring 3; GSC Arkona No. 1 core, depth 150–155 feet, Arkona Member; L=77 microns, W=74 microns; figured specimen, GSC No. 30590.

Figure 3. ?*A.* sp. 9 (PAGE 28)

Slide 1–A–29, ring 6; GSC Arkona No. 1 core, depth 240–245 feet, Arkona Member; L=117 microns, W=77 microns; figured specimen, GSC No. 30591.

Figure 4. *A.* sp. 6 (PAGE 26)

Slide 1–A–46, ring 4; GSC Arkona No. 1 core, depth 225–230 feet, Bell Member; L=82 microns, W=87 microns; figured specimen, GSC No. 30588.

Figure 5. *Angochitina* cf. *A.*? *collinsoni* Taugourdeau and de Jekhowsky, 1961 (PAGE 29)

Slide 2–A–14; GSC Ipperwash No. 1 core, depth 60–65 feet, Widder Member; L=115 microns, W=74 microns; hypotype, GSC No. 30592.

Figures 6, 7. *A. milanensis* Collinson and Scott, 1958 (PAGE 30)

Slide 1–A–13, ring 9; GSC Arkona No. 1 core, depth 60–65 feet, Arkona Member; 6) enlargement showing bifurcating spines, 7) vesicle; L=158 microns, W=66 microns; hypotype, GSC No. 30597.

Figure 8. *A.* cf. *A. ramusculosa* Cramer, 1964 (PAGE 31)

Slide 1–A–14, ring 8; GSC Arkona No. 1 core, depth 65–70 feet, Arkona Member; L=176 microns, W=66 microns; hypotype, GSC No. 30599.

Figure 9. *A. devonica* Eisenack, 1955 (PAGE 29)

Slide 2–A–14 (1), ring 10; GSC Ipperwash No. 1 core, depth 60–65 feet, Widder Member; L=138 microns, W=71 microns; hypotype, GSC No. 30594.

Figure 10. *A.* cf. *A.*? *collinsoni* Taugourdeau and de Jekhowsky, 1961 (PAGE 29)

Slide 1–A–8, ring 11; GSC Arkona No. 1 core, depth 35–40 feet, Widder Member; L=87 microns, W=71 microns; hypotype, GSC No. 30593.

Figure 11. *A. devonica* Eisenack, 1955 (PAGE 29)

Slide 2–A–14 (1), ring 15; GSC Ipperwash No. 1 core, depth 60–65 feet, Widder Member; infrared photomicrograph; L=156 microns, W=74 microns; hypotype, GSC No. 30595.

Figure 12. *A. milanensis* Collinson and Scott, 1958 (PAGE 30)

Slide 1–A–8, ring 5; GSC Arkona No. 1 core, depth 35–40 feet, Widder Member; L=145 microns, W=71 microns; hypotype, GSC No. 30598.

Figure 13. *A. devonica* Eisenack, 1955 (PAGE 29)

Slide 1–A–6 (1), ring 5; GSC Arkona No. 1 core, depth 25–30 feet, Widder Member; L=143 microns, W=71 microns; hypotype, GSC No. 30596.

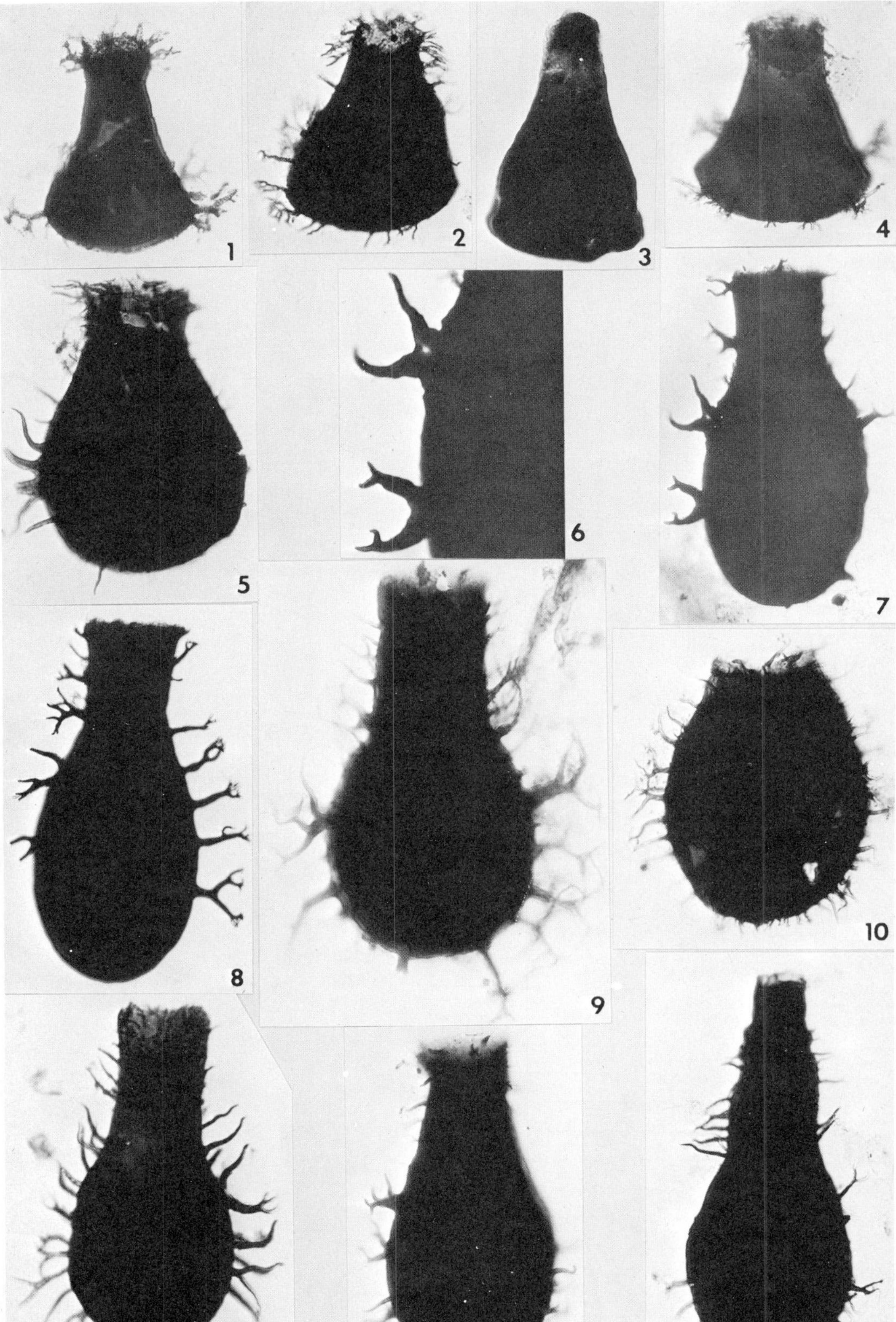
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Plate VI

Figures 1, 2. *Sphaerochitina rockglenensis* n. sp. (Page 34)

Slide 1–A–31 (2), ring 4; GSC Arkona No. 1 core, depth 150–155 feet, Arkona Member; infrared photomicrograph; 1) vesicle, 2) enlargement showing neck and "plug"; L=89 microns, W=76 microns; holotype, GSC No. 30610.

Figure 3. *Angochitina* sp. 1 (Page 33)

Slide 2–A–16 (1), ring 1; GSC Ipperwash No. 1 core, depth 70–75 feet, Widder Member; L=163 microns, W=87 microns; figured specimen, GSC No. 30608.

Figure 4. *A. huronensis* n. sp. (Page 32)

Slide 2–A–11 (1), ring 6; GSC Ipperwash No. 1 core, depth 45–50 feet, Widder Member; infrared photomicrograph; L=107 microns, W=69 microns; holotype, GSC No. 30605.

Figures 5, 6. *A.* sp. 2 (Page 34)

Slide 1–A–48, ring 4; GSC Arkona No. 1 core, depth 235–240 feet, Bell Member; infrared photomicrograph; 5) vesicle, 6) enlargement showing "plug"; L=168 microns, W=82 microns; figured specimen, GSC No. 30609.

Figure 7. *A.* cf. *A. ramusculosa* Cramer, 1964 (Page 31)

Slide 1–A–8, ring 14; GSC Arkona No. 1 core, depth 35–40 feet, Widder Member; L=138 microns, W=66 microns; hypotype, GSC No. 30600.

Figure 8. Chitinozoa n. gen., n. sp. (Page 35)

Slide 1–A–45 (2); GSC Arkona No. 1 core, depth 240–245 feet, Bell Member; infrared photomicrograph; L=166 microns, W=79 microns; figured specimen, GSC No. 30611.

Figure 9. *A.* cf. *A. ramusculosa* Cramer, 1964 (Page 31)

Slide 1–A–14, ring 5; GSC Arkona No. 1 core, depth 65–70 feet, Arkona Member; L=151 microns, W=66 microns; hypotype, GSC No. 30601.

Figure 10. *A. toyetae* Cramer, 1964 (Page 32)

Slide 1–A–6, ring 3; GSC Arkona No. 1 core, depth 25–30 feet, Widder Member; L=130 microns, W=69 microns; hypotype, GSC No. 30602.

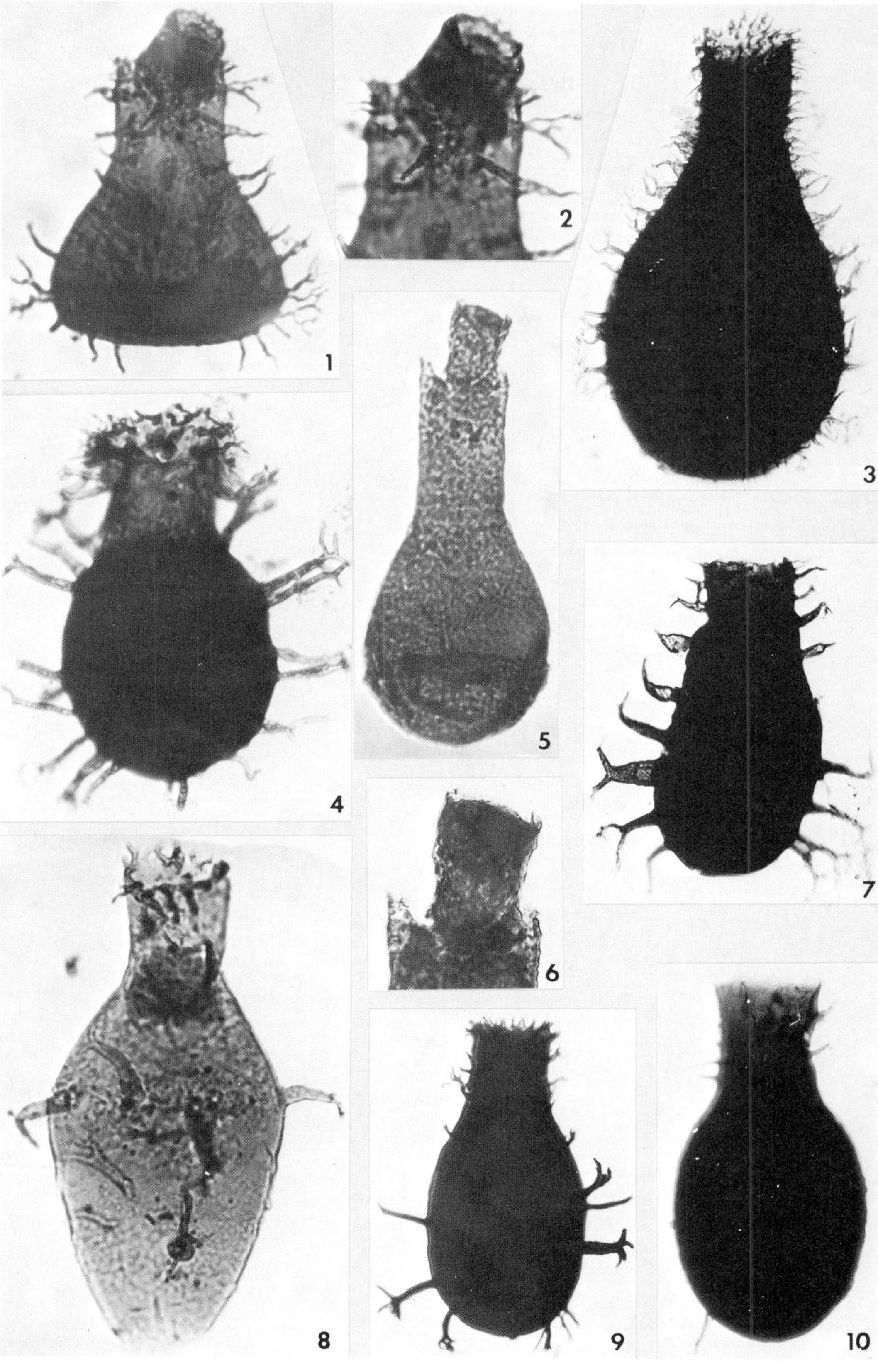
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PLATE VII

Figure 1. *Angochitina toyetae* Cramer, 1964 (PAGE 32)

Slide 1–A–6, ring 12; GSC Arkona No. 1 core, depth 55–60 feet, Widder Member; L=128 microns, W=79 microns; hypotype, GSC No. 30603.

Figure 2. *A. toyetae* Cramer, 1964 (PAGE 32)

Slide 1–A–7 (1), ring 10; GSC Arkona No. 1 core, depth 30–35 feet, Widder Member; L=105 microns, W=66 microns; hypotype, GSC No. 30604.

Figure 3. *Desmochitina* sp. (PAGE 37)

Slide 2–A–38, ring 8; GSC Ipperwash No. 1 core, depth 180–185 feet, Arkona Member; L=107 microns, W=100 microns; figured specimen, GSC No. 30615.

Figure 4. *D. bursa* Taugourdeau and de Jekhowsky, 1960 (PAGE 37)

Slide 1–A–31 (2), ring 6; GSC Arkona No. 1 core, depth 150–155 feet, Arkona Member; infrared photomicrograph; L=89, 94 microns, W=112, 110 microns; hypotype, GSC No. 30613.

Figure 5. *Calpichitina* sp. (PAGE 36)

Slide 2–B–8, ring 1; GSC Ipperwash No. 1 core, depth 210–215 feet, Rockport Quarry Member; diameter=117 microns; figured specimen, GSC No. 30612.

Figure 6. *D.* sp. (PAGE 37)

Slide 1–A–36, ring 4; GSC Arkona No. 1 core, depth 175–180 feet, Arkona Member; L=117 microns, W=112 microns; figured specimen, GSC No. 30616.

Figure 7. *D. bursa* Taugourdeau and de Jekhowsky, 1960 (PAGE 37)

Slide 1–A–30, ring 1; GSC Arkona No. 1 core, depth 145–150 feet, Arkona Member; L=87 microns, W=105 microns; hypotype, GSC No. 30614.

Figure 8. *Eisenackitina canadensis* n. sp. (PAGE 39)

Slide 2–B–8, ring 3; GSC Ipperwash No. 1 core, depth 210–215 feet, Rockport Quarry Member; L=105 microns, W=56 microns; holotype, GSC No. 30621.

Figure 9. *E. castor* Jansonius, 1964 (PAGE 38)

Slide 1–A–41 (1), ring 3; GSC Arkona No. 1 core, depth 200–205 feet, Bell Member; L=122 microns, W=102 microns; hypotype, GSC No. 30617.

Figure 10. *E. castor* Jansonius, 1964 (PAGE 38)

Slide 2–A–34 (2), ring 1; GSC Ipperwash No. 1 core, depth 160–165 feet, Arkona Member; infrared photomicrograph; L=128 microns, W=112 microns; hypotype, GSC No. 30618.

Figure 11. *E. canadensis* n. sp. (PAGE 39)

Slide 1–B–4, ring 11; GSC Arkona No. 1 core, depth 50–55 feet, Arkona Member; L=153 microns, W=89 microns; paratype, GSC No. 30622.

Figure 12. *E. castor* Jansonius, 1964 (PAGE 38)

Slide 2–A–34 (1), ring 3; GSC Ipperwash No. 1 core, depth 160–165 feet, Arkona Member; infrared photomicrograph; L=122 microns, W=97 microns; hypotype, GSC No. 30619.

PLATE VII

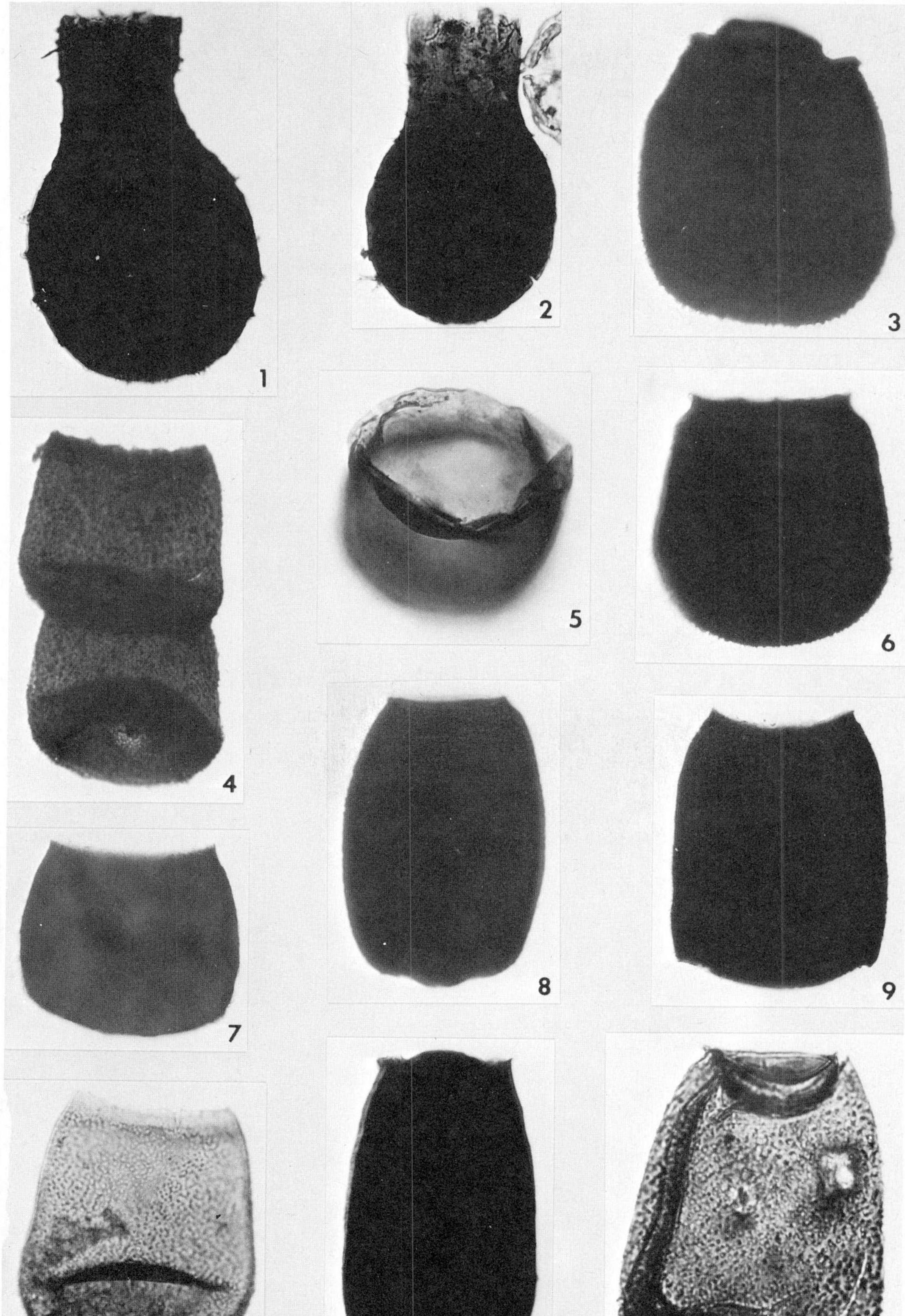

Plate VIII

Figure 1. *Eisenackitina canadensis* n. sp. (Page 39)

Slide 2–A–51, ring 10; GSC Ipperwash No. 1 core, depth 240–245, Bell Member; L=143 microns, W=77 microns; paratype, GSC No. 30623.

Figure 2. *E. castor* Jansonius, 1964 (Page 38)

Slide 2–A–42 (1), ring 6; GSC Ipperwash No. 1 core, depth 195–200 feet, Arkona Member; L=122 microns, W=102 microns; hypotype, GSC No. 30620.

Figure 3. *E.* sp. (Page 40)

Slide 2–A–47 (1), ring 8; GSC Ipperwash No. 1 core, depth 220–225 feet, Rockport Quarry Member; L=163 microns, W=128 microns; figured specimen, GSC No. 30624.

Figure 4. *Hoegisphaera* cf. *H. glabra* Staplin, 1961 (Page 40)

Slide 1–B–7 (3); GSC Arkona No. 1 core, depth 210–215 feet, Rockport Quarry Member; infrared photomicrograph; vesicle diameter=105 microns; hypotype, GSC No. 30626.

Figure 5. *H.* cf. *H. glabra* Staplin, 1961 (Page 40)

Slide 1–A–41 (2), ring 3; GSC Arkona No. 1 core, depth 200–205 feet, Bell Member; vesicle diameter=102 microns; hypotype, GSC No. 30627.

Figure 6. *H.* cf. *H. glabra* Staplin, 1961 (Page 40)

Slide 1–B–7 (2), ring 4; GSC Arkona No. 1 core, depth 210–215 feet, Rockport Quarry Member; infrared photomicrograph; vesicle diameter=89–102 microns; hypotype, GSC No. 30628.

Figure 7. *Conochitina edjelensis* Taugourdeau, 1963 (Page 43)

Slide 1–A–13, ring 8; GSC Arkona No. 1 core, depth 60–65 feet, Arkona Member; L=117 microns, W=74 microns; hypotype, GSC No. 30635.

Figure 8. *H.* cf. *H. glabra* Staplin, 1961 (Page 40)

Slide 1–B–7 (1); GSC Arkona No. 1 core, depth 210–215 feet, Rockport Quarry Member; infrared photomicrograph; vesicle diameters=94,94,94 microns; hypotype, GSC No. 30629.

Figure 9. *E.* sp. (Page 40)

Slide 1–B–7 (2), ring 2; GSC Arkona No. 1 core, depth 210–215 feet, Rockport Quarry Member; L=115 microns, W=92 microns; figured specimen, GSC No. 30625.

Figure 10. *H.* cf. *H. glabra* Staplin, 1961 (Page 40)

Slide 1–B–7 (1a); GSC Arkona No. 1 core, depth 30–35 feet, Rockport Quarry Member; infrared photomicrograph; vesicle diameters=92, 92 microns; hypotype, GSC No. 30630.

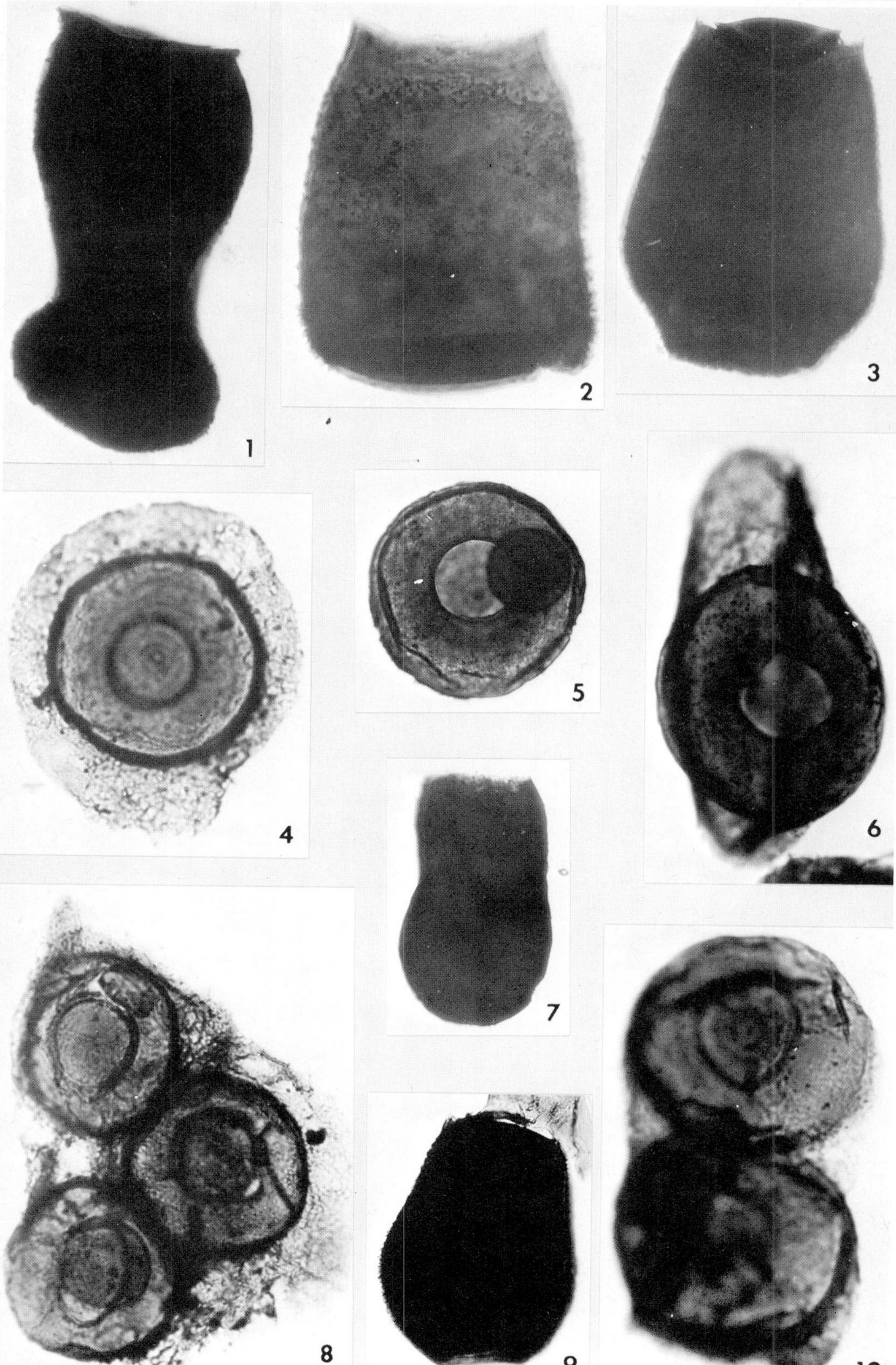
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Plate IX

Figures 1, 2. *Poteriochitina briarca* n. gen., n. sp. (Page 42)

Slide 2–A–38, ring 6; GSC Ipperwash No. 1 core, depth 180–185 feet, Arkona Member; infrared photomicrograph; 1) low focal level, 2) high focal level; L=115, 115 microns, W=107, 112 microns; paratype, GSC No. 30631.

Figures 3, 6. *P. briarca* n. gen., n. sp. (Page 42)

Slide 2–A–52, ring 5; GSC Ipperwash No. 1 core, depth 250–255 feet, Bell Member; infrared photomicrograph; 3) vesicle, 6) enlargement showing ornamentation; L=110 microns, W=140 microns; paratype, GSC No. 30632.

Figures 4, 7, 8. *P. briarca* n. gen., n. sp. (Page 42)

Slide 1–B–8 (1), ring 2; GSC Arkona No. 1 core, depth 205–210 feet, Bell Member; infrared photomicrograph: 4) vesicle, 7) enlargement showing basal edge, 8) enlargement showing ornamentation; L=102 microns, W=107 microns; holotype, GSC No. 30633.

Figure 5. *P. briarca* n. gen., n. sp. (Page 42)

Slide 1–A–44, ring 2; GSC Arkona No. 1 core, depth 215–220 feet, Bell Member; L=100 microns, W=112 microns; paratype, GSC No. 30634.

Figure 9. *Illichitina* sp. (Page 46)

Slide 2–A–49 (1), ring 5; GSC Ipperwash No. 1 core, depth 235–240 feet, Bell Member; L=102 microns, W=89 microns; figured specimen, GSC No. 30641.

Figure 10. *Rhabdochitina* sp. 1 (Page 43)

Slide 3–A–2; Argor 65–1 core, 5–10 feet below top of Ipperwash Member; L=352 microns, W=59 microns; figured specimen, GSC No. 30636.

Figure 11. *R.* sp. 2 (Page 44)

Slide 2–A–47 (1), ring 2; GSC Ipperwash No. 1 core, depth 225–230 feet, Rockport Quarry Member; L=130 microns, W=46 microns; figured specimen, GSC No. 30637.

Figure 12. *R.* sp. 3 (Page 44)

Slide 2–A–43 (1), ring 5; GSC Ipperwash No. 1 core, depth 205–210 feet, Rockport Quarry Member; L=306 microns, W=92 microns; figured specimen, GSC No. 30638.

Figure 13. *Hercochitina* aff. *H. turnbulli* Jenkins, 1969 (Page 45)

Slide 1–A–31 (2), ring 6a; GSC Arkona No. 1 core, depth 150–155 feet, Arkona Member; L=122 microns, W=64 microns; hypotype, GSC No. 30639.

Figure 14. *H.* aff. *H. turnbulli* Jenkins, 1969 (Page 45)

Slide 1–A–31 (2), ring 2; GSC Arkona No. 1 core, depth 150–155 feet, Arkona Member; L=115 microns, W=69 microns; hypotype, GSC No. 30640.

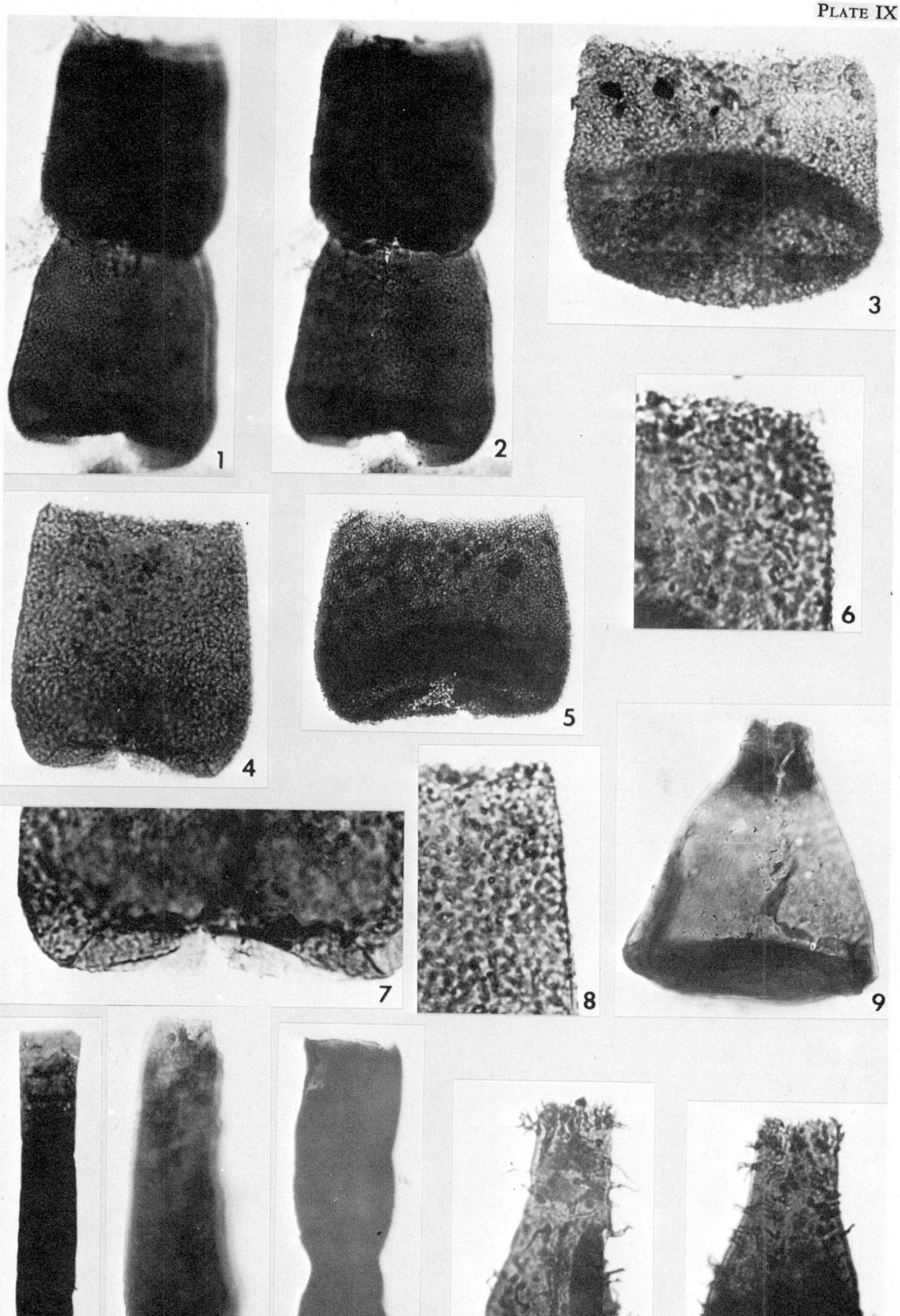
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PLATE X

Figure 1. *Kalochitina?* sp. (PAGE 46)

Slide 1–A–31 (1), ring 4; GSC Arkona No. 1 core, depth 150–155 feet, Arkona Member; infrared photomicrograph; L=117 microns, W=82 microns; figured specimen, GSC No. 30642.

Figure 2. aff. *Cyathochitina kuckersiana kuckersiana* (Eisenack), 1934 (PAGE 47)

Slide 2–A–1 (1), ring 8; GSC Ipperwash No. 1 core, depth 0–5 feet, Ipperwash Member; L=115 microns, W=100 microns; hypotype, GSC No. 30644.

Figure 3. *Lagenochitina* cf. *L. amottensis* Grignani and Mantovani, 1964 (PAGE 47)

Slide 2–A–48 (1), ring 4; GSC Ipperwash No. 1 core, depth 230–235 feet, Bell Member; L=179 microns, W=82 microns; hypotype, GSC No. 30645.

Figure 4. *L.* sp. (PAGE 48)

Slide 1–A–13, ring 6; GSC Arkona No. 1 core, depth 60–65 feet, Arkona Member; L=171 microns, W=89 microns; figured specimen, GSC No. 30648.

Figure 5. *L.* sp. (PAGE 48)

Slide 1–A–8, ring 4; GSC Arkona No. 1 core, depth 35–40 feet, Widder Member; L=148 microns, W=74 microns; figured specimen, GSC No. 30649.

Figure 6. *L.* cf. *L. brevicollis* Taugourdeau and de Jekhowsky, 1960 (PAGE 48)

Slide 1–A–7 (1), ring 12; GSC Arkona No. 1 core, depth 30–35 feet, Widder Member; L=105 microns, W=66 microns; hypotype, GSC No. 30646.

Figure 7. *L.* cf. *L. brevicollis* Taugourdeau and de Jekhowsky, 1960 (PAGE 48)

Slide 1–A–8, ring 10; GSC Arkona No. 1 core, depth 35–40 feet, Widder Member; L=120 microns, W=69 microns; hypotype, GSC No. 30647.

Figure 8. *Angochitina calcarata* n. sp. (PAGE 33)

Slide 2–A–26, ring 3; GSC Ipperwash No. 1 core, depth 115–120 feet, Arkona Member; L=138 microns, W=82 microns; holotype, GSC No. 30606.

Figure 9. *A. calcarata* n. sp. (PAGE 33)

Slide 2–A–25; GSC Ipperwash No. 1 core, depth 120–125 feet, Arkona Member; L=160 microns, W=86 microns; paratype, GSC No. 30607.

Figure 10. *K.?* sp. (PAGE 46)

Slide 1–A–31 (1), ring 10; GSC Arkona No. 1 core, depth 150–155 feet, Arkona Member; infrared photomicrograph; L=115 microns, W=89 microns; figured specimen, GSC No. 30643.

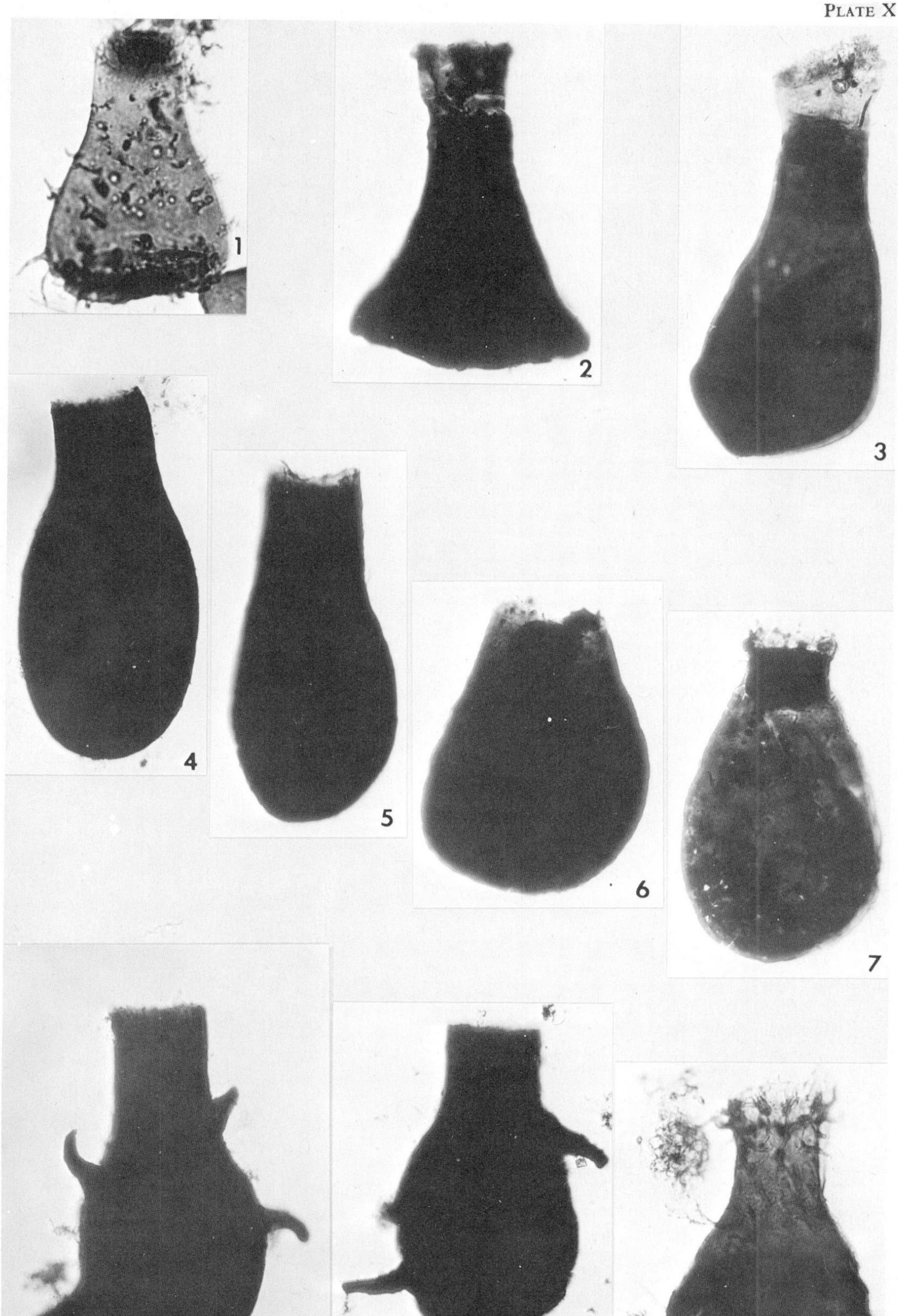

Plate XI

Figures 1, 2. *Baltisphaeridium* sp. (Page 50)
Slide 2–A–56 (2), ring 3; GSC Ipperwash No. 1 core, depth 270–275 feet, Bell Member; 1) low focal level, 2) high focal level; vesicle diameter=64 microns; figured specimen, GSC No. 30650.

Figures 3, 4. *Cymatiosphaera "canadensis"* Deunff, 1954 (Page 50)
Slide 1–A–18 (1), ring 5; GSC Arkona No. 1 core, depth 85–90 feet, Arkona Member; 3) high focal level, 4) low focal level; vesicle diameter=71 microns; hypotype, GSC No. 30651.

Figures 5, 6. *C. "canadensis"* Deunff, 1954 (Page 50)
Slide 2–A–34 (1), ring 2; GSC Ipperwash No. 1 core, depth 160–165 feet, Arkona Member; 5) low focal level, 6) high focal level; vesicle diameter=64 microns; hypotype, GSC No. 30652.

Figure 7. *Dictyotidium dictyotum* (Eisenack), 1955 (Page 52)
Slide 2–A–49 (2), ring 2; GSC Ipperwash No. 1 core, depth 235–240 feet, Bell Member; vesicle diameter=79 microns; hypotype, GSC No. 30655.

Figure 8. *D. dictyotum* (Eisenack), 1955 (Page 52)
Slide 1–A–37, ring 4; GSC Arkona No. 1 core, depth 180–185 feet, Rockport Quarry Member; vesicle diameter=79 microns; hypotype, GSC No. 30656.

Figure 9. *D. dictyotum* (Eisenack), 1955 (Page 52)
Slide 1–A–29, ring 3; GSC Arkona No. 1 core, depth 140–145 feet, Arkona Member; vesicle diameter=77 microns; hypotype, GSC No. 30657.

Figure 10. *D. dictyotum* (Eisenack), 1955 (Page 52)
Slide 2–A–38, ring 6; GSC Ipperwash No. 1 core, depth 180–185 feet, Arkona Member; vesicle diameter=87 microns; hypotype, GSC No. 30658.

Figures 11, 12. *Triangulina alargada* Cramer, 1964 (Page 58)
Slide 2–A–40 (2), ring 5; GSC Ipperwash No. 1 core, depth 190–195 feet, Arkona Member; 11) vesicle, 12) enlargement of apical process; altitude=63 microns; hypotype, GSC No. 30677.

Figures 13, 14. *C.* sp. (Page 51)
Slide 1–A–50, ring 2; GSC Arkona No. 1 core, depth 245–250 feet, Dundee Formation; 13) high focal level, 14) low focal level; vesicle diameter=56 microns; figured specimen, GSC No. 30654.

Figures 15, 16. *C. "canadensis"* Deunff, 1954 (Page 50)
Slide 1–A–22, ring 5; GSC Arkona No. 1 core, depth 105–110 feet, Arkona Member; 15) low focal level, 16) high focal level; vesicle diameter=59 microns; hypotype, GSC No. 30653.

Figure 17. *Quisquilites widderensis* n. sp. (Page 60)
Slide 1–A–7 (1), ring 2; GSC Arkona No. 1 core, depth 30–35 feet, Widder Member; length=186 microns, width=31 microns; paratype, GSC No. 30660.

Figure 18. *Q. widderensis* n. sp. (Page 60)
Slide 1–A–4 (1), ring 6; GSC Arkona No. 1 core, depth 15–20 feet, Widder Member; length=140 microns, width=33 microns; paratype, GSC No. 30661.

Figure 19. *Q. widderensis* n. sp. (Page 60)
Slide 1–A–7 (1), ring 6; GSC Arkona No. 1 core, depth 30–35 feet, Widder Member; length=143 microns, width=41 microns; holotype, GSC No. 30662.

Figure 20. *Q. widderensis* n. sp. (Page 60)
Slide 2–A–39, ring 1; GSC Ipperwash No. 1 core, depth 185–190 feet, Arkona Member; length=145 microns, width=31 microns; paratype, GSC No. 30663.

Figure 21. *Q. widderensis* n. sp. (Page 60)
Slide 1–A–13, ring 7; GSC Arkona No. 1 core, depth 60–65 feet, Arkona Member; length=173 microns, width=31 microns; paratype, GSC No. 30664.

Figures 22, 23. *Arkonites bilixus* n. gen., n. sp. (Page 52)
Slide 3–A–27 (1), ring 3; Argor 65–1 core, Arkona Member, 120–125 feet below top of Ipperwash Member; 22) high focal level, 23) low focal level; vesicle diameter=82 microns; holotype, GSC No. 30659.

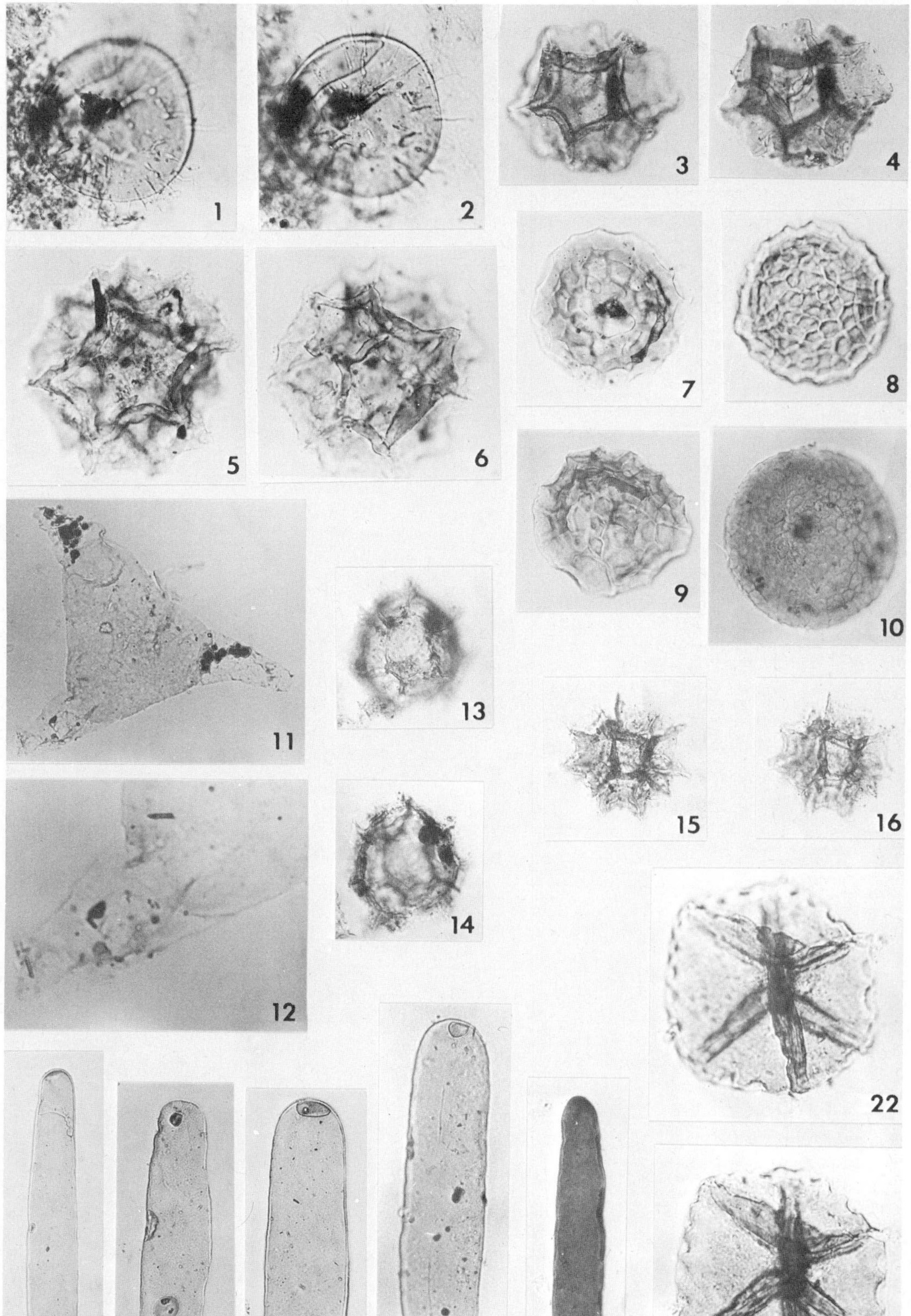
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Plate XII

Figures 1, 2.	*Veryhachium* sp. 1 Slide 1–A–16, ring 2; GSC Arkona No. 1 core, depth 85–90 feet, Arkona Member; 1) high focal level, 2) low focal level; base length=77 microns; figured specimen, GSC No. 30668.	(Page 54)
Figure 3.	*V.* cf. *V. lairdi* (Deflandre) Deunff, 1958 Slide 2–A–52, ring 8; GSC Ipperwash No. 1 core, depth 250–255 feet, Bell Member; side length=26 microns; hypotype, GSC No. 30665.	(Page 53)
Figures 4, 5.	*V.* sp. 2 Slide 2–A–38, ring 4; GSC Ipperwash No. 1 core, depth 180–185 feet, Arkona Member; altitude=38 microns; figured specimen, GSC No. 30670.	(Page 54)
Figure 6.	*V.* cf. *V. lairdi* (Deflandre) Deunff, 1958 Slide 1–A–4 (1), ring 1; GSC Arkona No. 1 core, depth 15–20 feet, Widder Member; altitude=33 microns; hypotype, GSC No. 30666.	(Page 53)
Figures 7, 11.	*V.* cf. *V. lairdi* (Deflandre) Deunff, 1958 Slide 2–A–52, ring 3; GSC Ipperwash No. 1 core, depth 250–255 feet, Bell Member; 7) low focal level, 11) high focal level; altitude=28 microns; hypotype, GSC No. 30667.	(Page 53)
Figures 8, 9.	"*Polyedryxium*" *cuboides* Deunff, 1955 Slide 1–A–18, ring 6; GSC Arkona No. 1 core, depth 85–90 feet, Arkona Member; 8) low focal level, 9) high focal level; edge length=41 microns; hypotype, GSC No. 30671.	(Page 55)
Figures 10, 14.	"*P.*" *pharaonis* Deunff, 1955 Slide 2–A–49 (1), ring 6; GSC Ipperwash No. 1 core, depth 235–240 feet, Bell Member; 10) low focal level, 14) high focal level; side length=26 microns; hypotype, GSC No. 30673.	(Page 56)
Figures 12, 13.	"*P*" *pharaonis* Deunff, 1955 Slide 1–A–7 (2), ring 4; GSC Arkona No. 1 core, depth 30–35 feet, Widder Member; 12) low focal level, 13) high focal level; side length=26 microns; hypotype, GSC No. 30674.	(Page 56)
Figures 15, 18.	*V.* sp. 1 Slide 2–A–54, ring 15; GSC Ipperwash No. 1 core, depth 210–215 feet, Bell Member; 15) high focal level, 18) low focal level; base length=17 microns; hypotype, GSC No. 30669.	(Page 54)
Figures 16, 19.	"*P.*" *cuboides* Deunff, 1955 Slide 1–A–8, ring 12; GSC Arkona No. 1 core, depth 35–40 feet, Widder Member; 16) low focal level, 19) high focal level; edge length=26 microns; hypotype, GSC No. 30672.	(Page 55)
Figures 17, 20.	"*P.*" *pharaonis* Deunff, 1955 Slide 2–A–52, ring 13; GSC Ipperwash No. 1 core, depth 250–255 feet, Bell Member; 17) low focal level, 20) high focal level; side length=26 microns; hypotype, GSC No. 30675.	(Page 56)

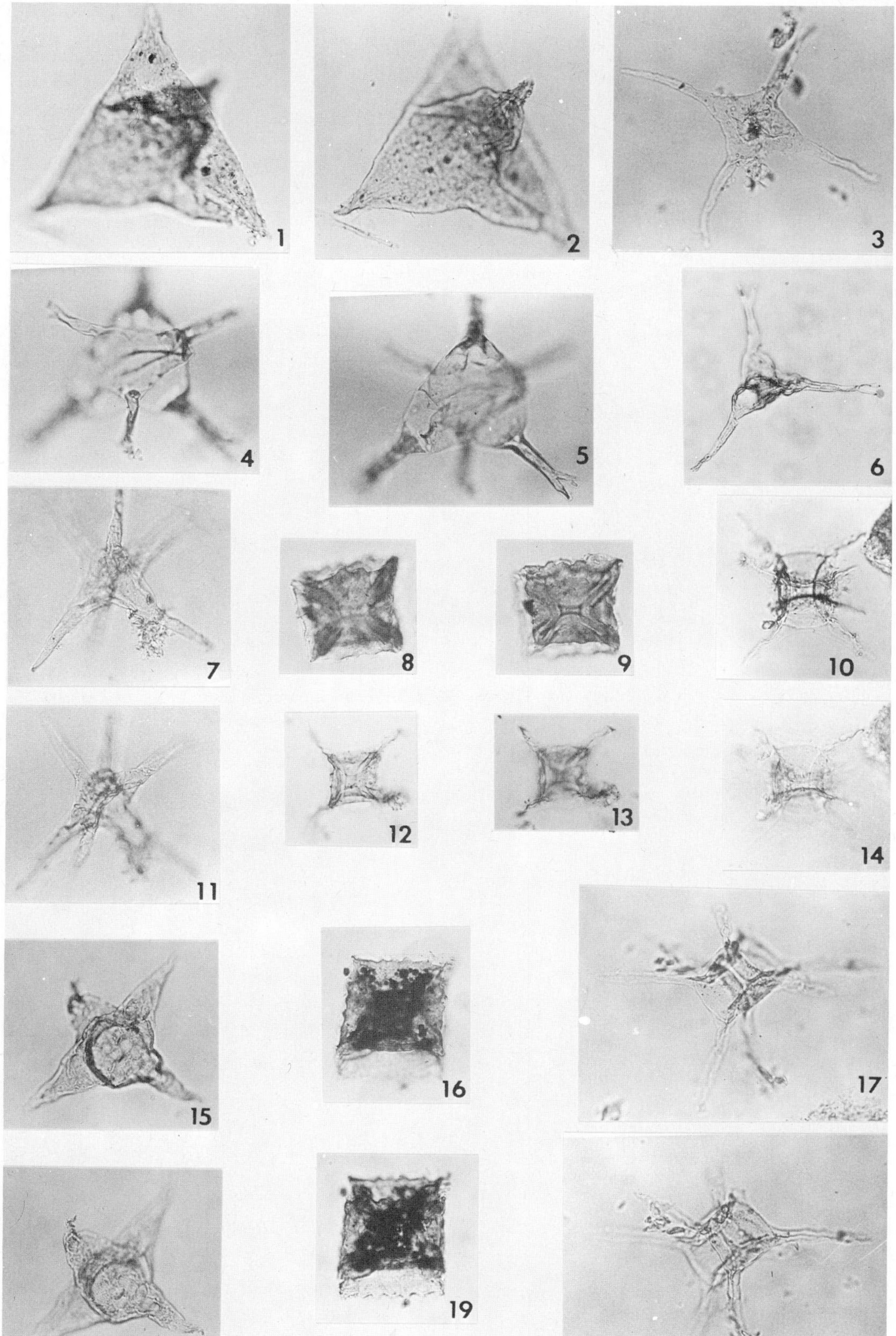
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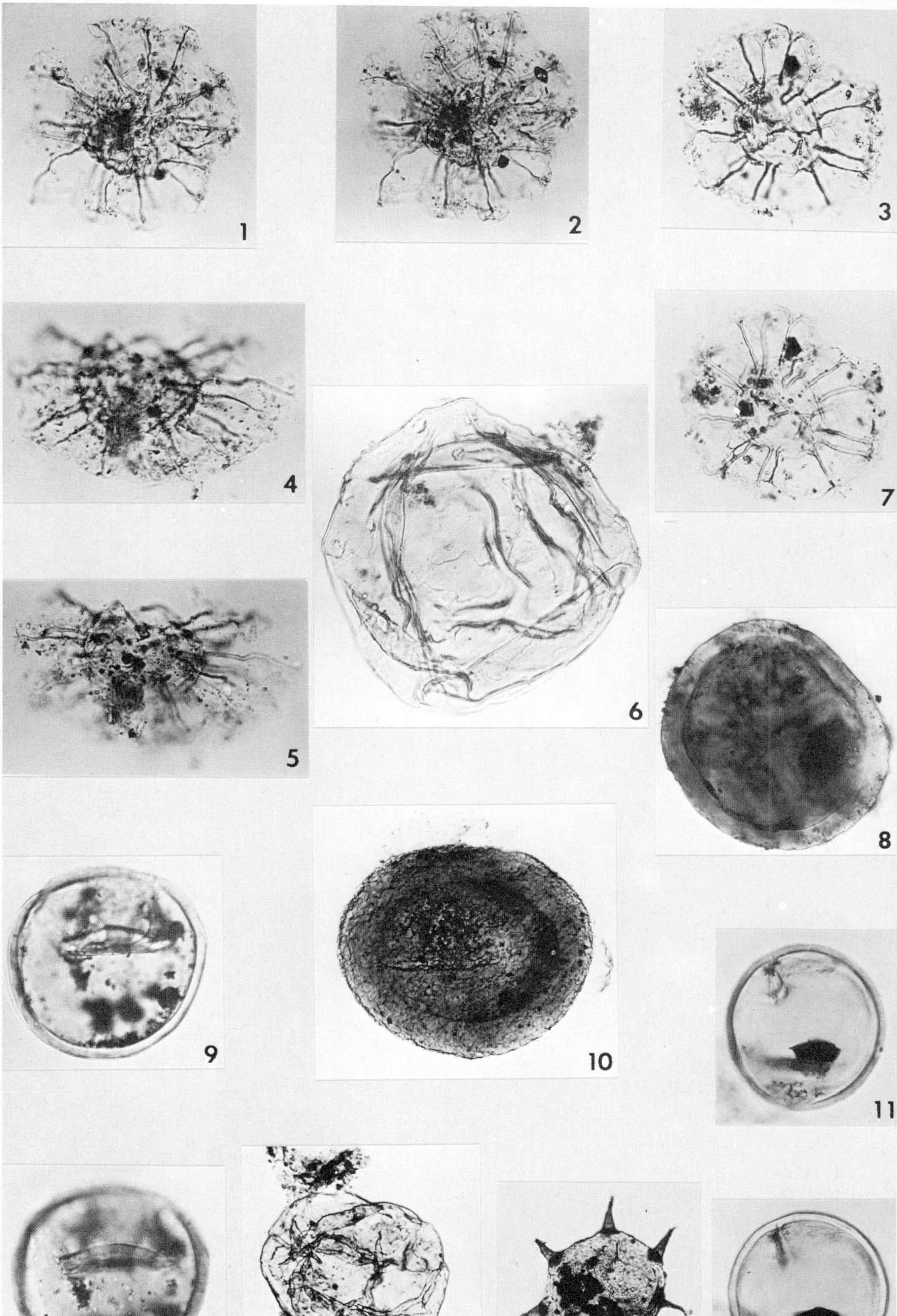
Plate XIII

Figures 1, 2.	*Tunisphaeridium concentricum* Deunff and Evitt, 1968 Slide 1–A–16 (1); GSC Arkona No. 1 core, depth 75–80 feet, Arkona Member; 1) low focal level, 2) high focal level; vesicle diameter=46 microns; hypotype, GSC No. 30682.	(Page 59)
Figures 3, 7.	*T. concentricum* Deunff and Evitt, 1968 Slide 1–A–18; GSC Arkona No. 1 core, depth 85–90 feet, Arkona Member; 3) low focal level, 7) high focal level; vesicle diameter=36 microns; hypotype, GSC No. 30683.	(Pade 59)
Figures 4, 5.	*T. concentricum* Deunff and Evitt, 1968 Slide 1–A–16 (2); GSC Arkona No. 1 core, depth 75–80 feet, Arkona Member; 4) high focal level, 5) low focal level; vesicle diameter=38 microns; hypotype, GSC No. 30684.	(Page 59)
Figure 6.	*Leiosphaeridia* sp. 1 Slide 1–A–49, ring 2; GSC Arkona No. 1 core, depth 240–245 feet, Dundee Formation; vesicle diameter=181 microns; figured specimen, GSC No. 30678.	(Page 58)
Figure 8.	*Tasmanites* sp. Slide 1–A–40; GSC Arkona No. 1 core, depth 195–200 feet, Rockport Quarry Member; vesicle diameter=146 microns; figured specimen, GSC No. 30685.	(Page 61)
Figures 9, 12.	*L.* sp. 2 Slide 2–A–45 (1), ring 7; GSC Ipperwash No. 1 core, depth 215–220 feet, Rockport Quarry Member; 9) high focal level, 12) low focal level; vesicle diameter=64 microns; figured specimen, GSC No. 30680.	(Page 59)
Figure 10.	*Tasmanites* sp. Slide 1–A–37, ring 3; GSC Arkona No. 1 core, depth 180–185 feet, Rockport Quarry Member; vesicle diameter=247 microns; figured specimen, GSC No. 30686.	(Page 61)
Figures 11,15.	*L.* sp. 2 Slide 1–A–24 (1), ring 4; GSC Arkona No. 1 core, depth 115–120 feet, Arkona Member; 11) high focal level, 15) low focal level; vesicle diameter=84 microns; figured specimen, GSC No. 30681.	(Page 59)
Figure 13.	*L.* sp. 1 Slide 1–A–10 (1), ring 1; GSC Arkona No. 1 core, depth 45–50 feet, Arkona Member; vesicle diameter=166 microns; figured specimen, GSC No. 30679.	(Page 58)
Figure 14.	*Tornacia* sp. Slide 1–B–9, ring 1; GSC Arkona No. 1 core, depth 245–250 feet, Dundee Formation; vesicle diameter=64 microns; figured specimen, GSC No. 30676.	(Page 57)


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

INDEX

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193 Petrology and structure of Poplar Creek map-area, British Columbia, *by* Peter B. Read, $4.00 (M42-193)
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