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The University of Oklahoma, Ph.D., 1971
Geology

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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

CHITINOZOA AND ACRITARCHA OF THE HAMILTON GROUP (MIDDLE DEVONIAN) OF SOUTHERN ONTARIO

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

JOCELYNE ANDREE LEGAULT

Norman, Oklahoma

1971

CHITINOZOA AND ACRITARCHA OF THE HAMILTON GROUP

(MIDDLE DEVONIAN) OF SOUTHERN ONTARIO

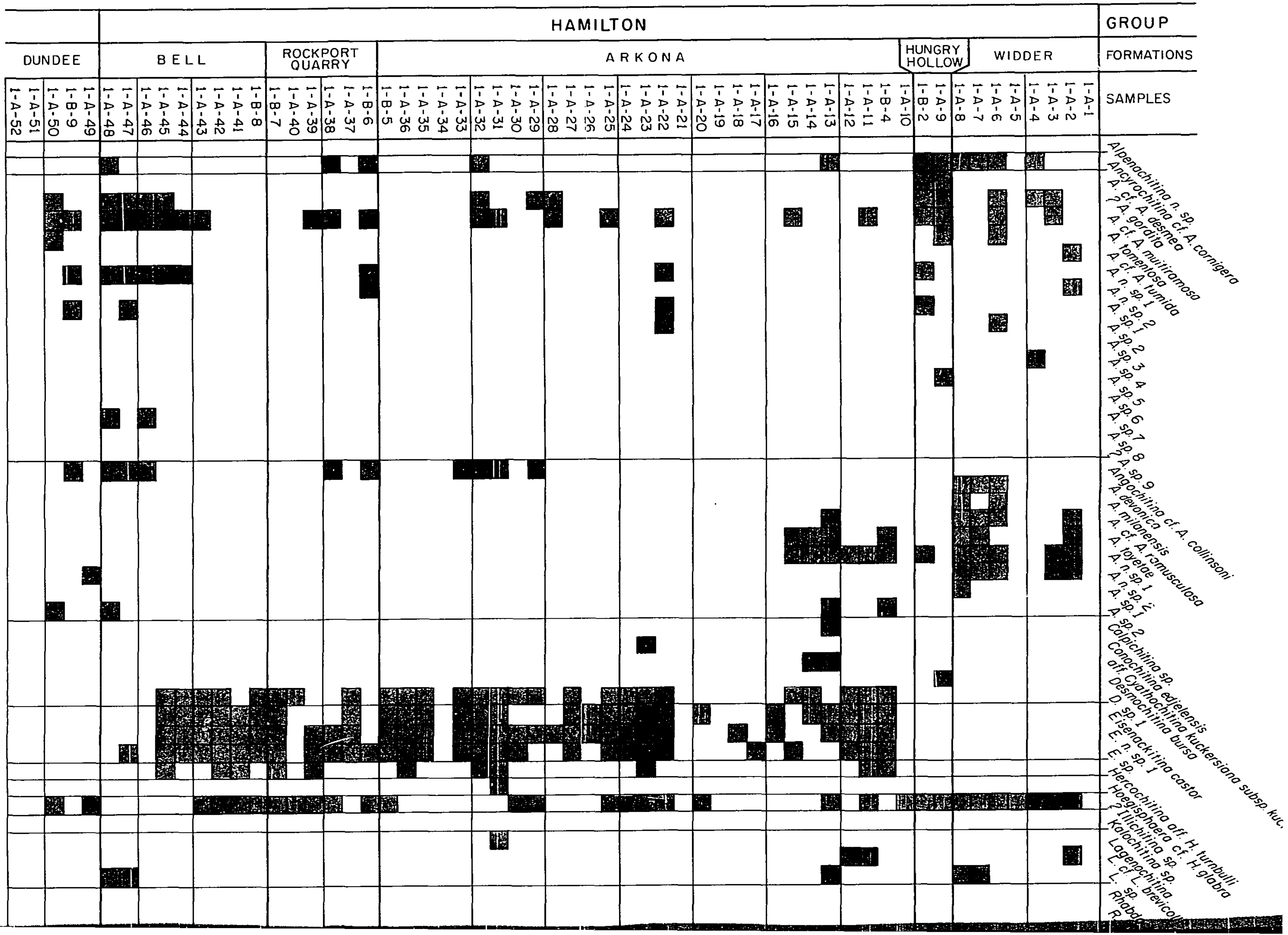
APPROVED BY

L. R. Wilson

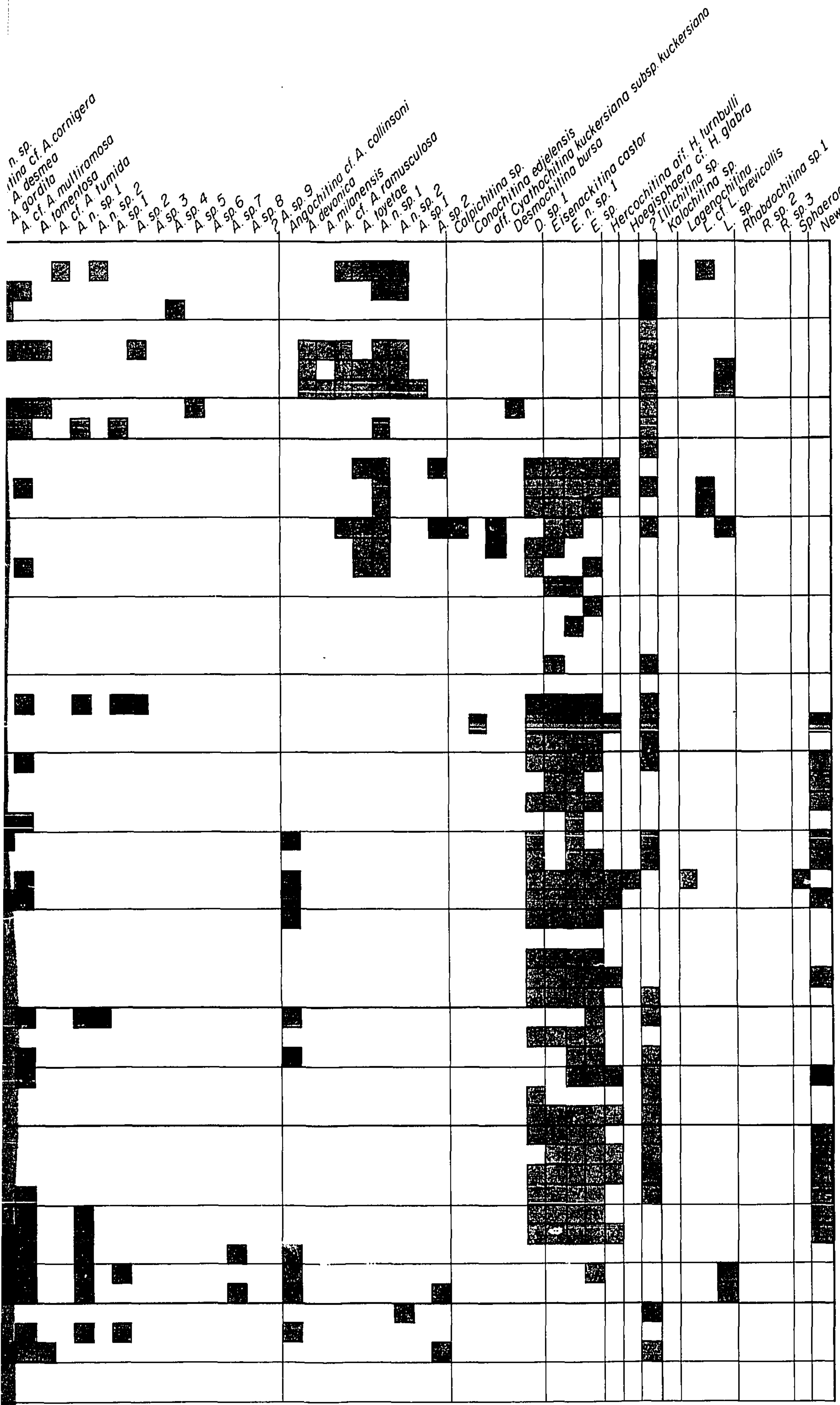
Paul W. Nygreen

George T. Stone

DISSERTATION COMMITTEE



CHITINOZOA PRESENT IN THE ARKONA CORE



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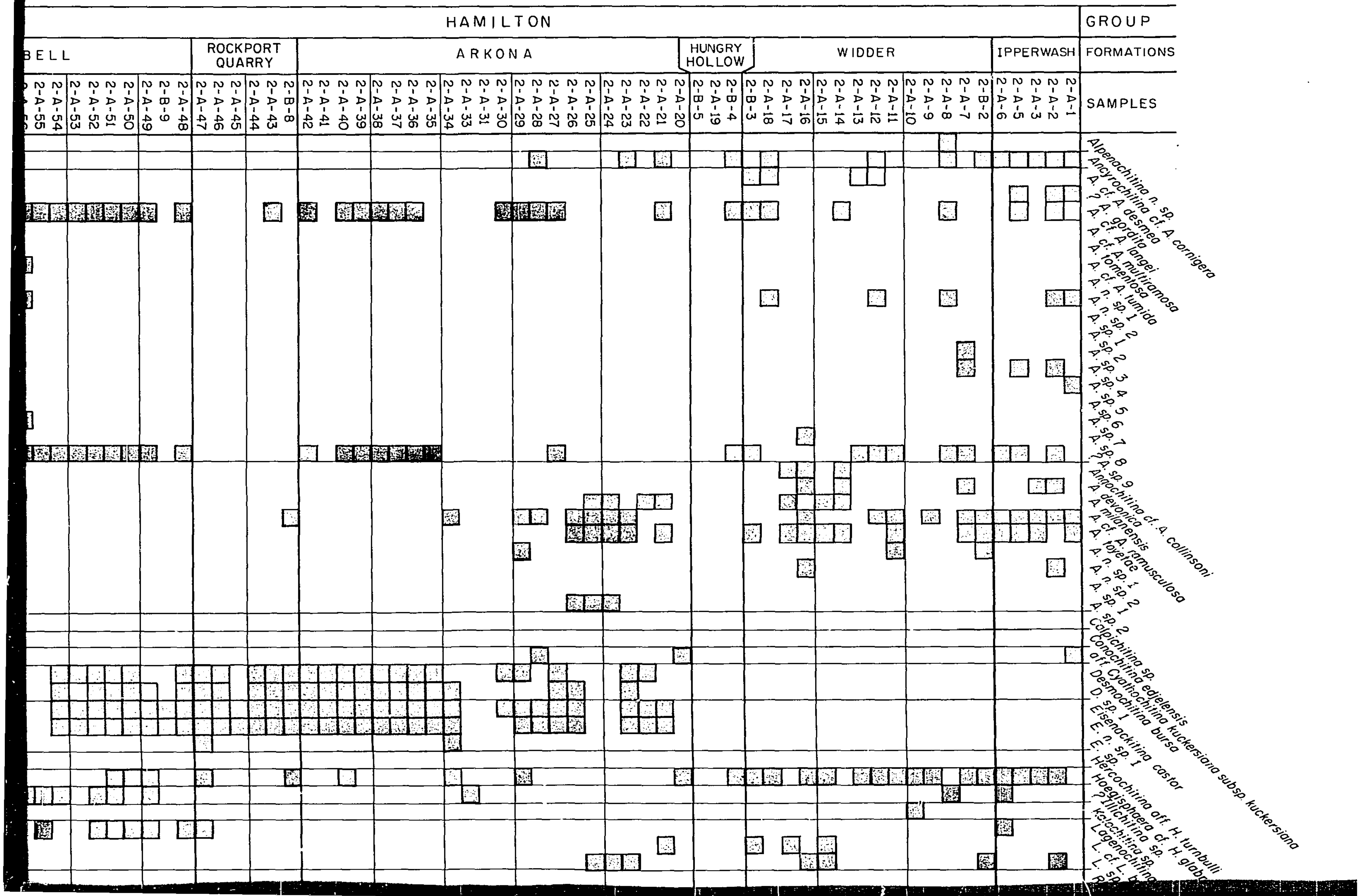

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ROCKPORT QUARRY
ARKONA
HUNGRY HOLLOW
WIDDER
IPPERWASH
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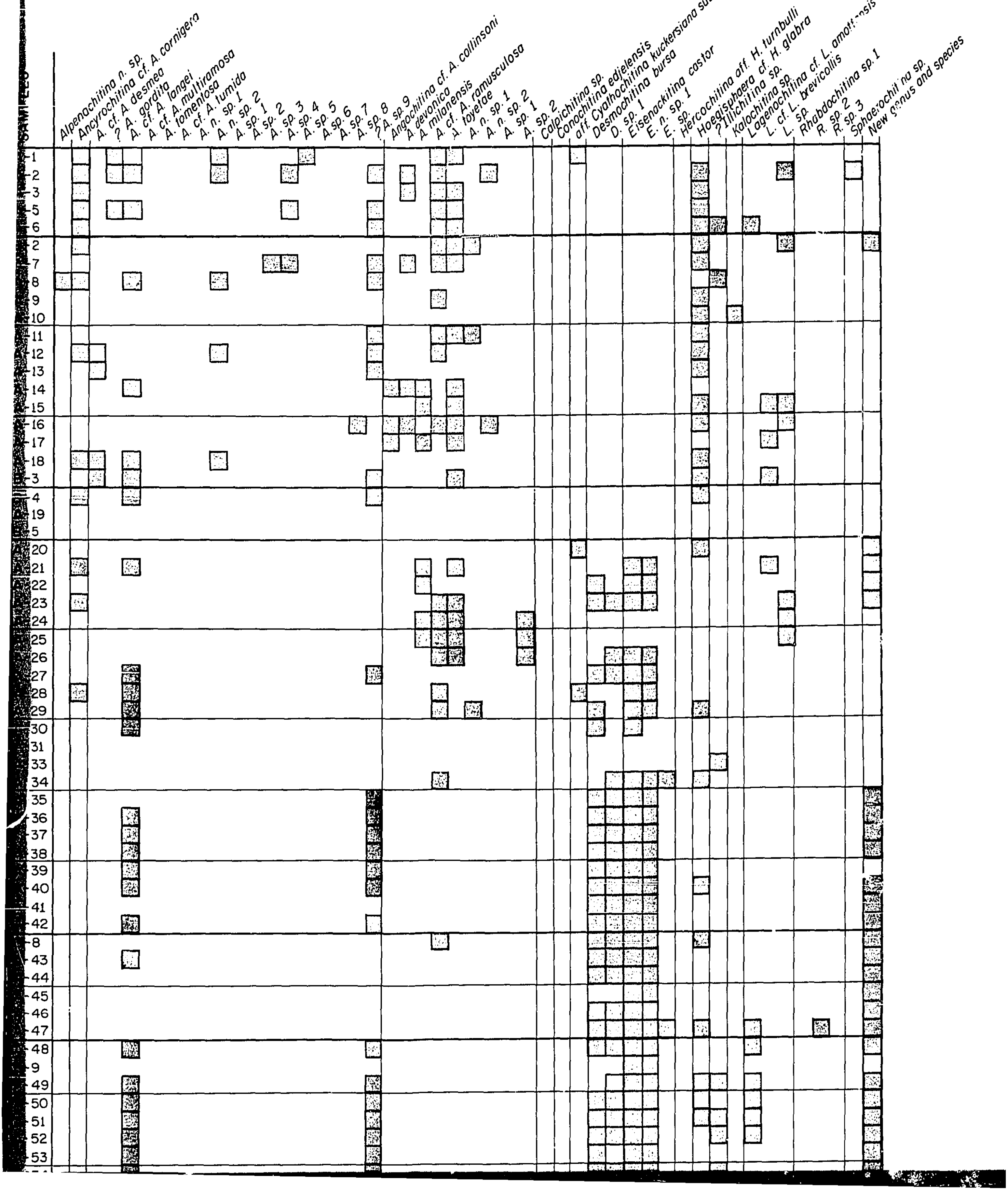
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R. sp. 3
Sphaerochitina sp.
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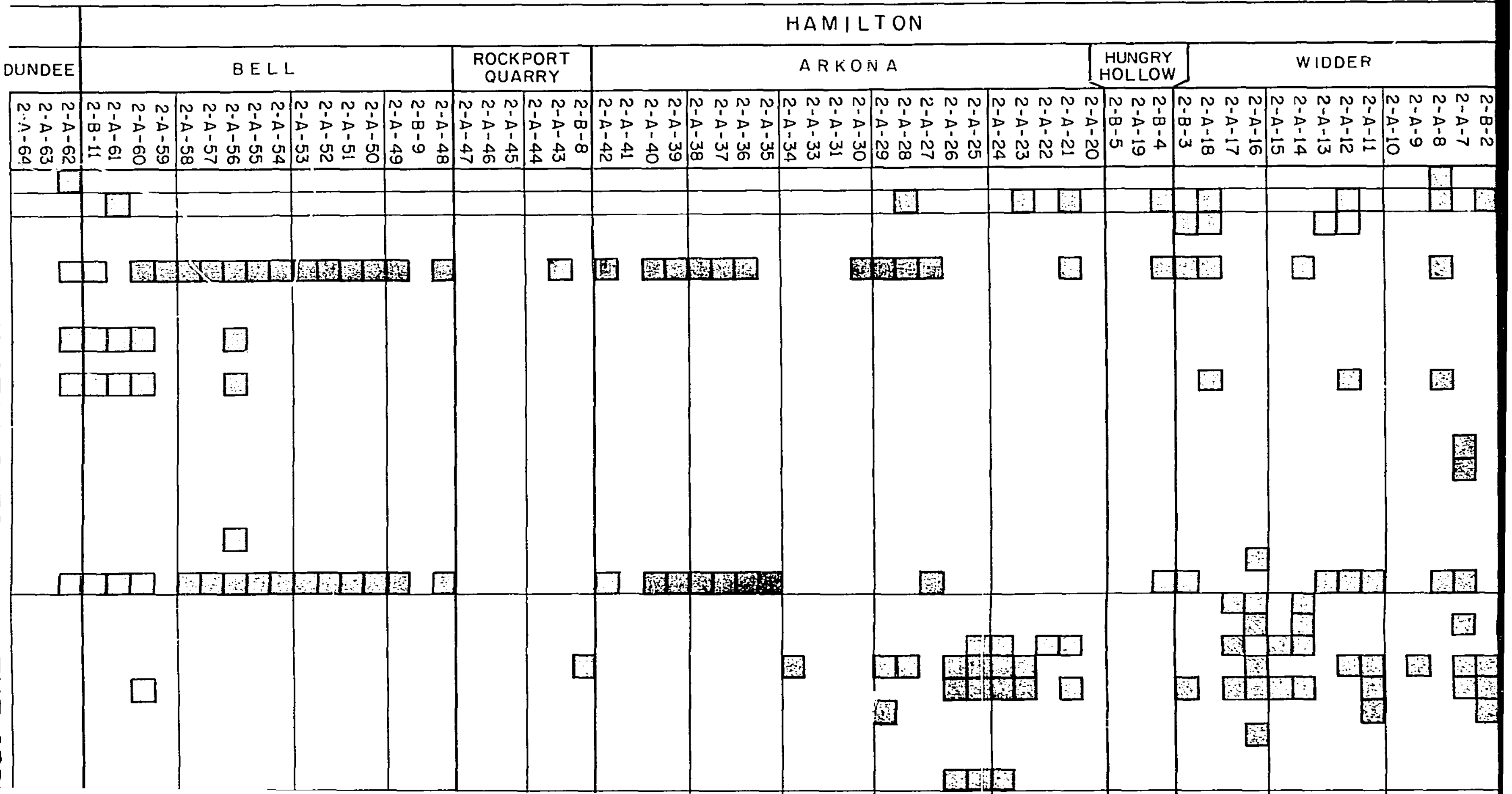
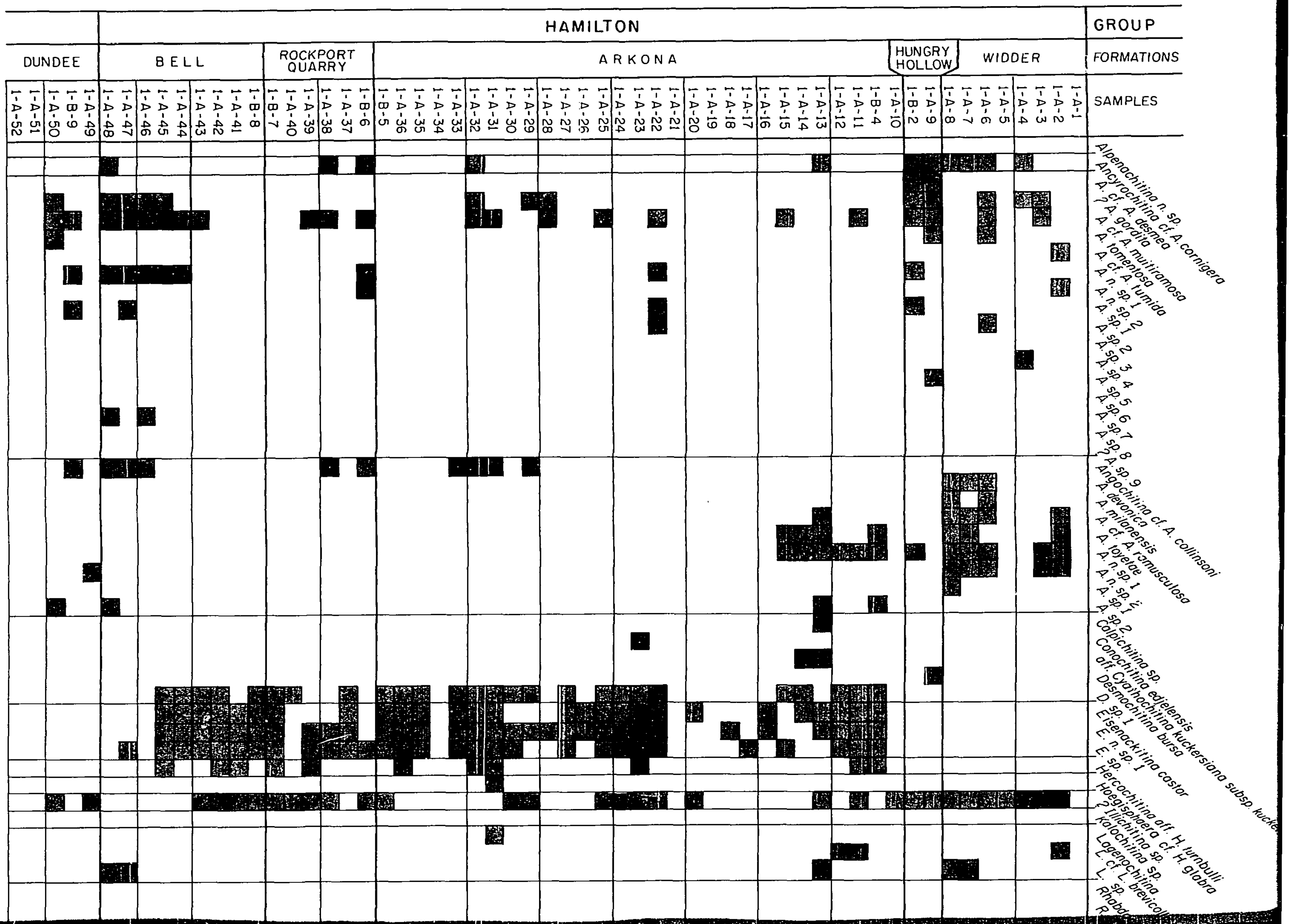
CHITINOZOA PRESENT IN THE IPP





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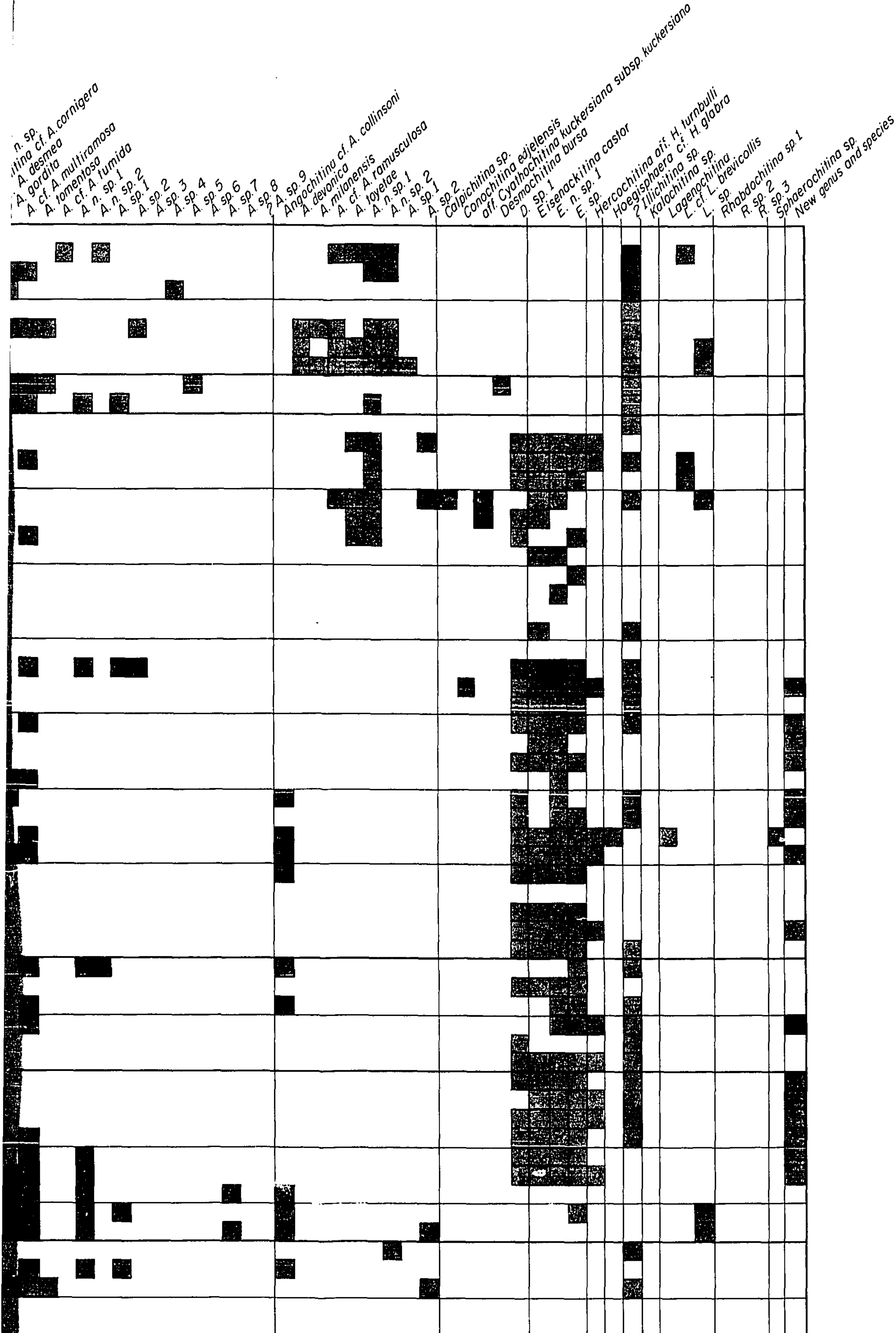

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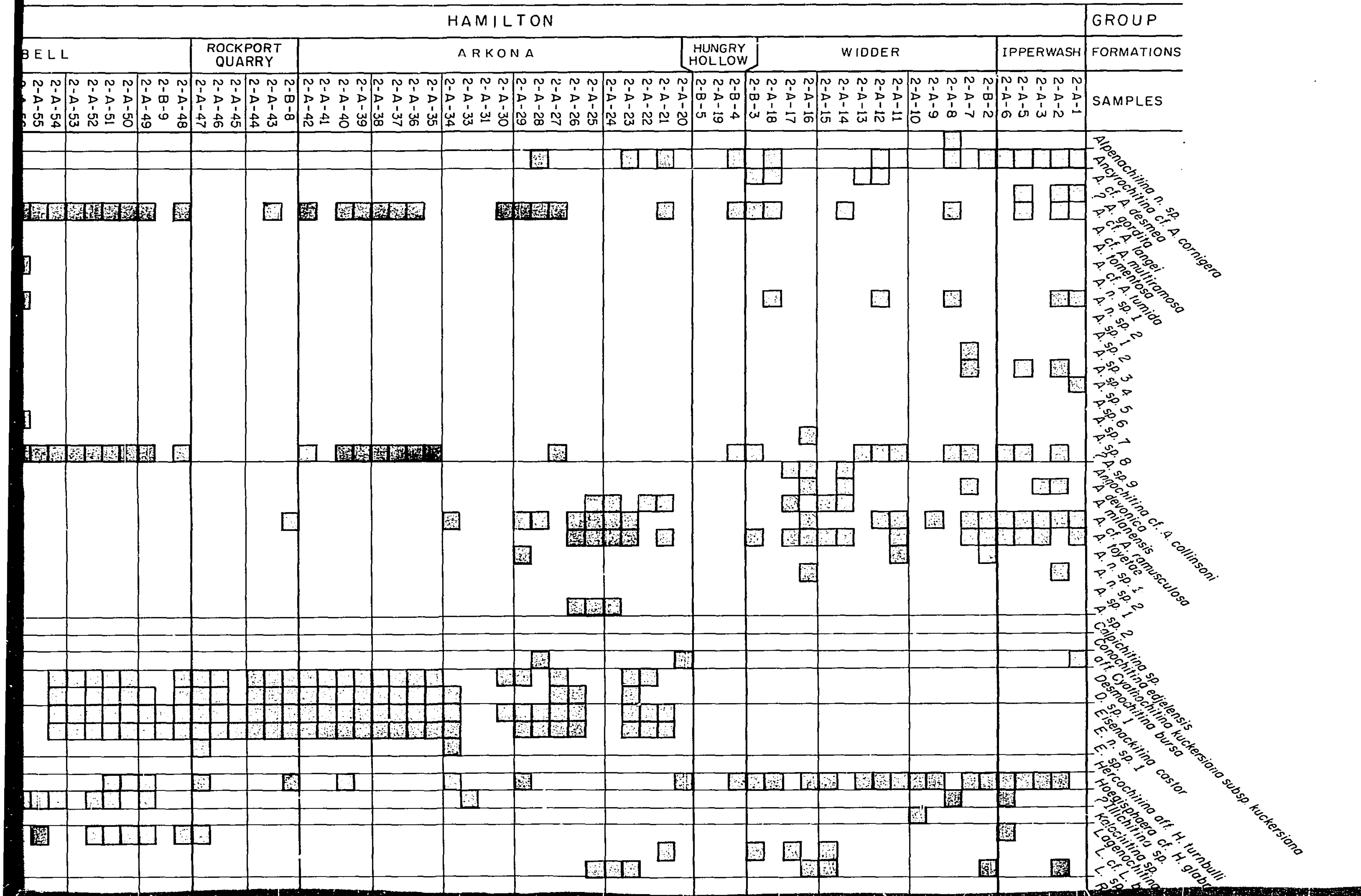

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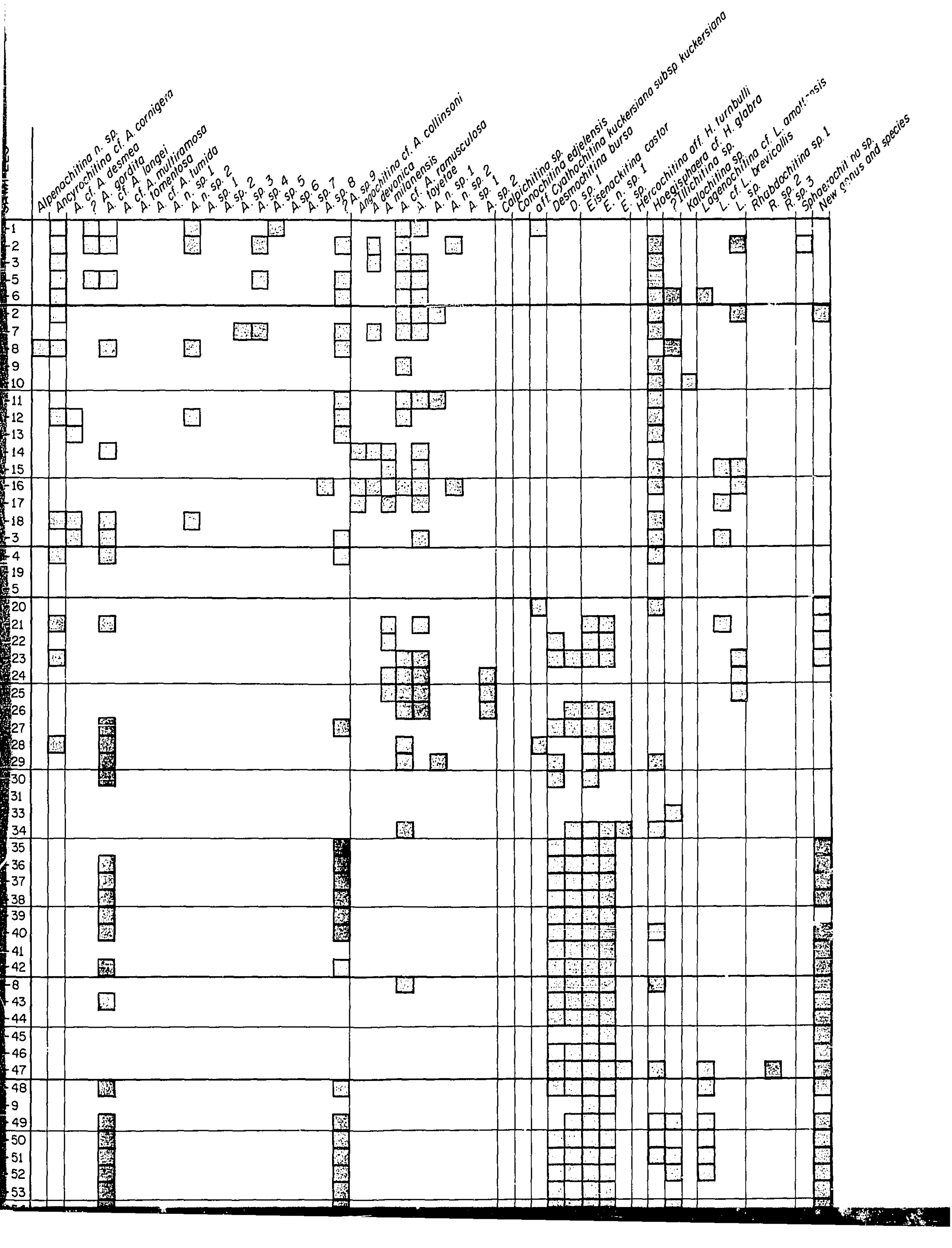
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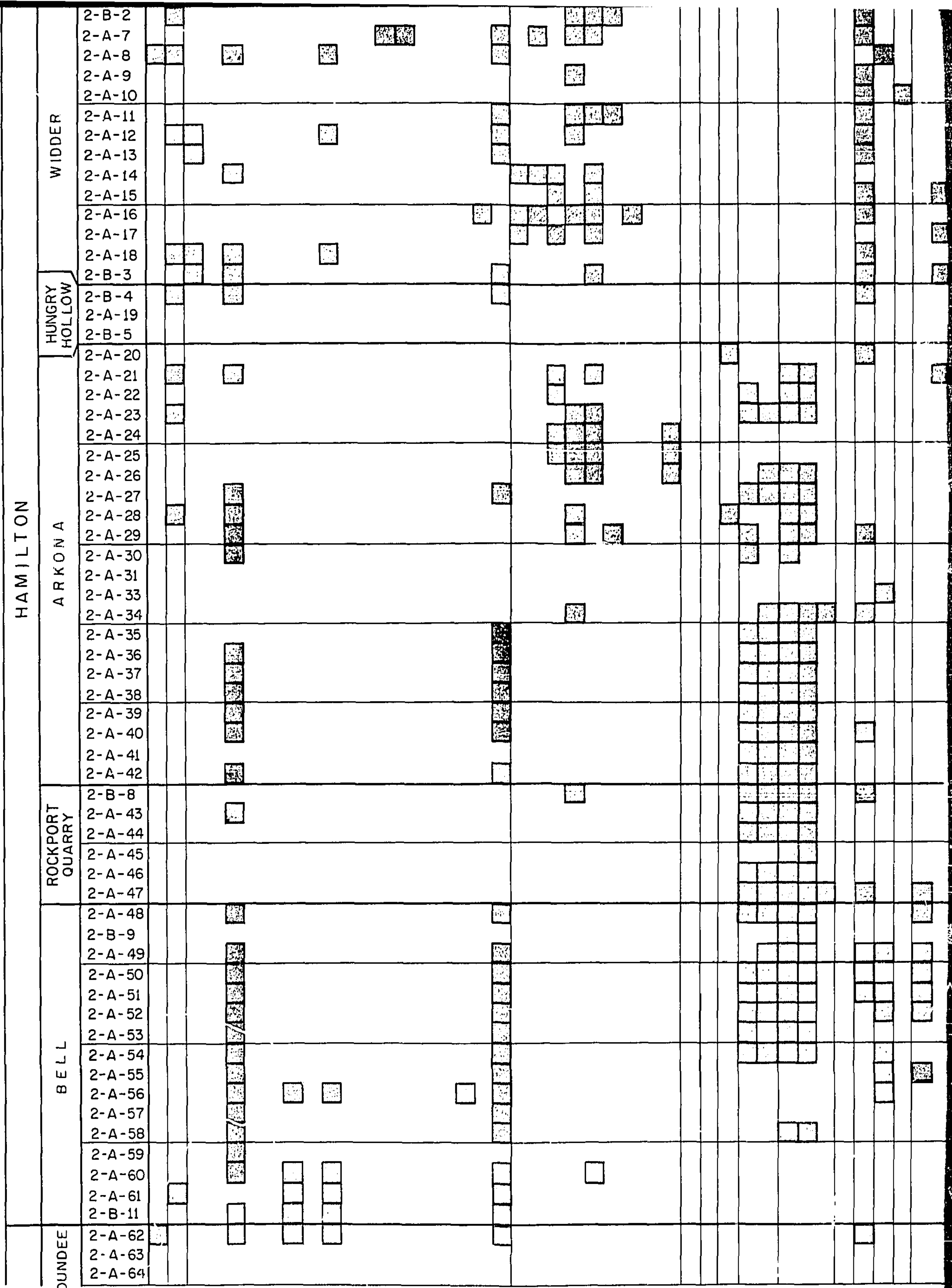
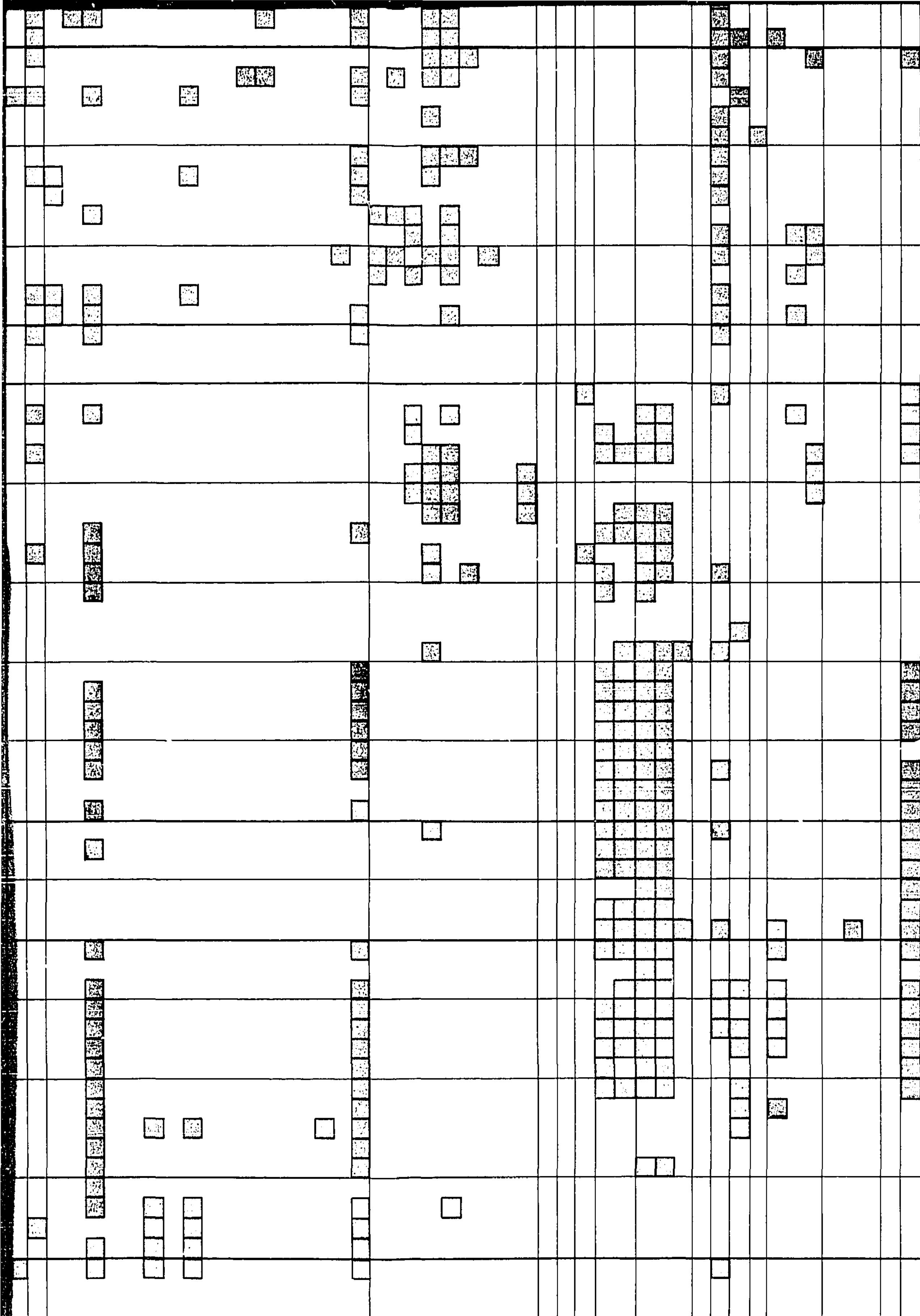


CHITINOZOA PRESENT IN THE IPPERWASH CORE



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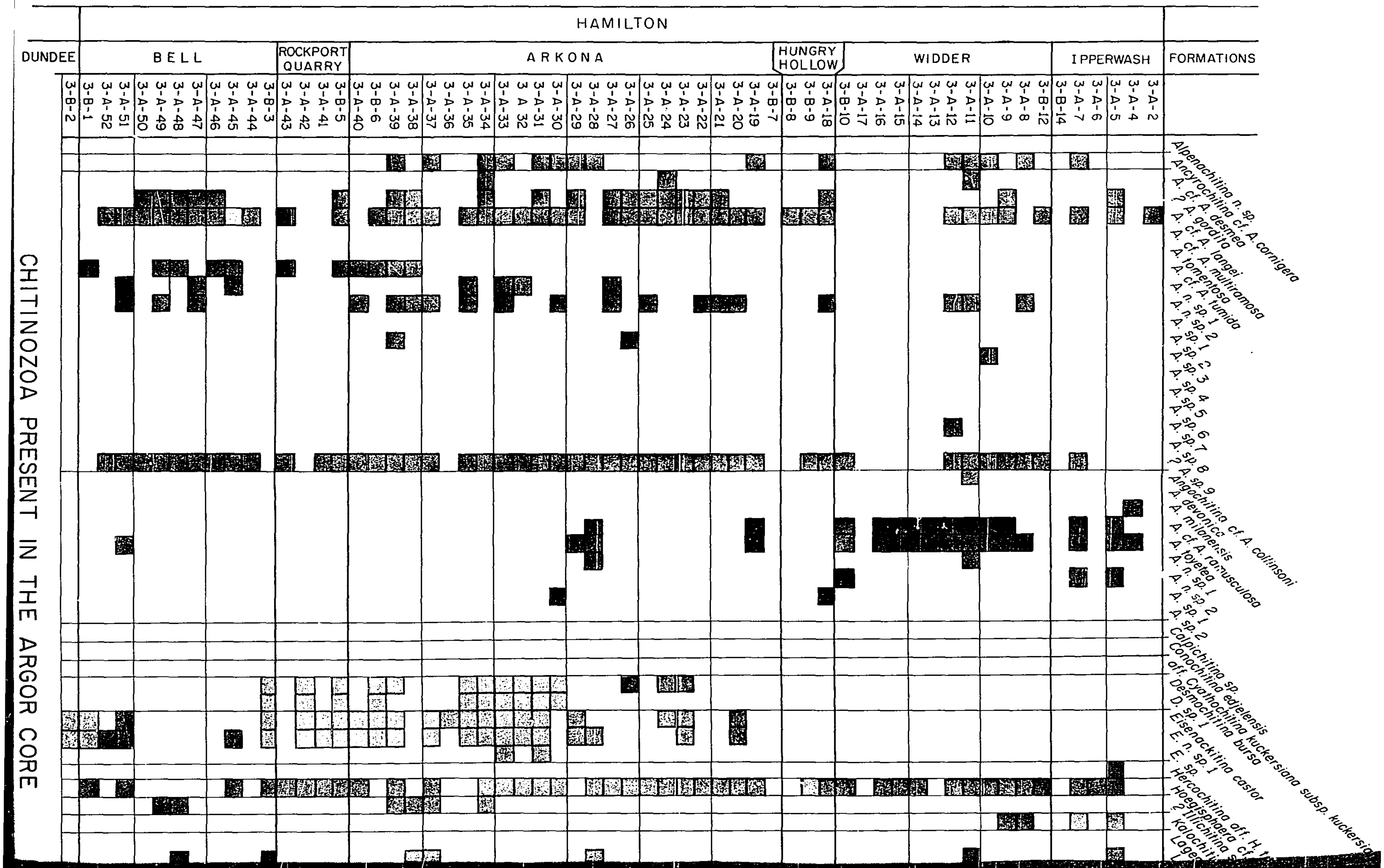

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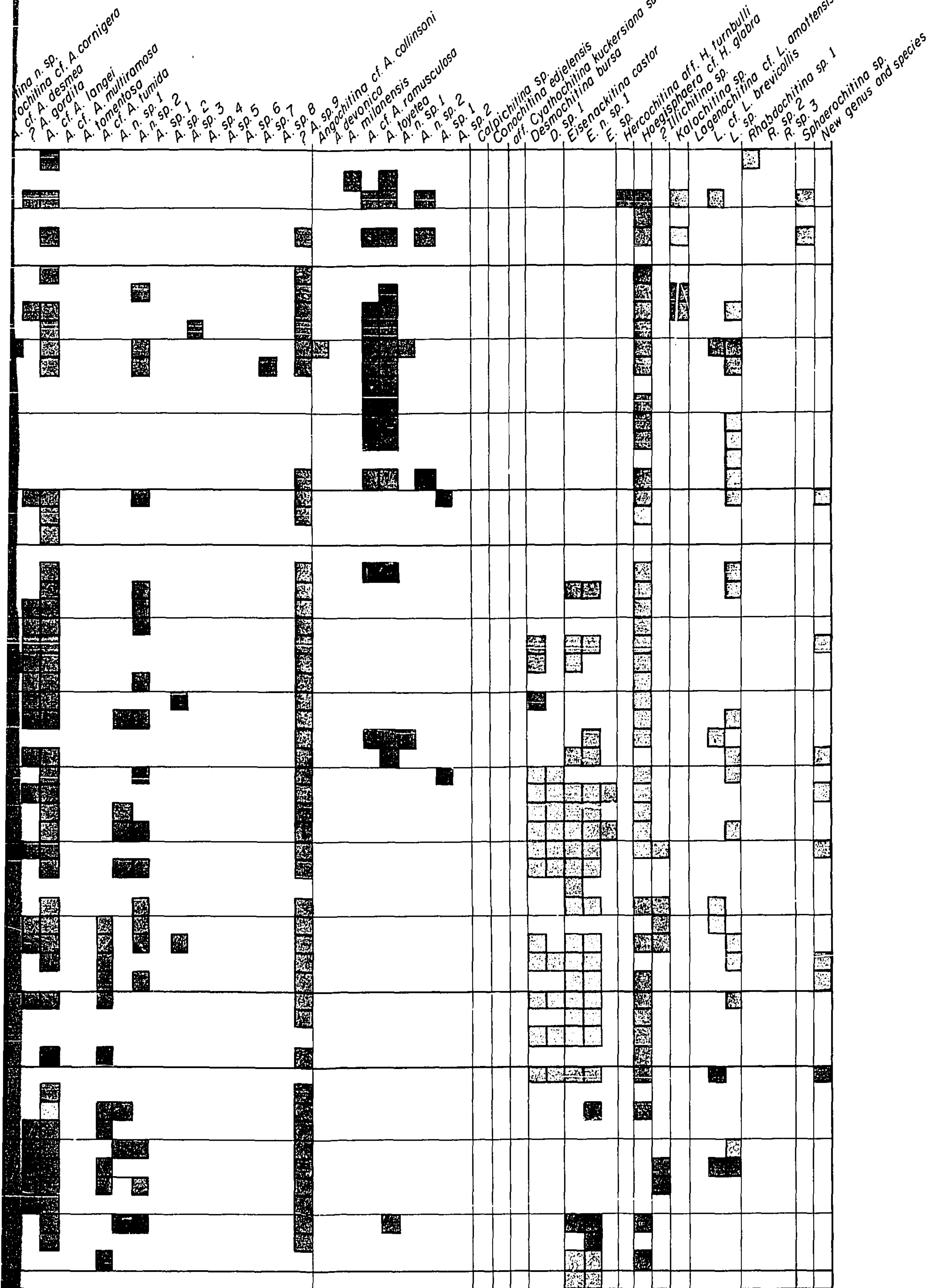

CHITINOZOA PRESENT IN THE ARGOR CORE

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ABSTRACT

The Middle Devonian (Givetian) Hamilton Group of southern Ontario is rich in Chitinozoa and Acritarcha. The formations present are the Bell, Rockport Quarry, Arkona, Hungry Hollow, Widder, and Ipperwash Formations. Three cores from southern Ontario were sampled for these palynomorphs: one from Arkona, one from Ipperwash Beach, and one from the Sarnia area. The palynomorphs recovered occur in large numbers and great variety. The Chitinozoa are represented by sixteen genera, two of which are new, and forty-nine species, eight of which are new; the Acritarcha are represented by nine genera, of which one is new, and twelve species, of which two are new. The Chitinozoa-Acritarcha assemblages are relatively constant in taxon representation with only two groups of Chitinozoa being stratigraphically differentiated: the species of *Angochitina*, and those of *Desmochitina*, *Eisenackitina* and *new genus B*. Variation in relative percentages of Chitinozoa and Acritarcha is unrelated to lithological changes in the Hamilton Group, but percentage trends do change at formational boundaries. The use of Chitinozoa and Acritarcha as biostratigraphical tools is strengthened because it is shown that they are unaffected by local ecological factors.

CHITINOZOA AND ACRITARCHA OF THE HAMILTON GROUP (MIDDLE DEVONIAN) OF SOUTHERN ONTARIO

CHAPTER I

INTRODUCTION

Nature of investigation

Devonian Chitinozoa and Acritarcha are numerous and varied, but comparatively little work has been done on them from North American rocks. The Chitinozoa and Acritarcha from the Middle Devonian Hamilton Group of southern Ontario present an opportunity for study which would clarify and extend knowledge concerning their occurrence, types, and ranges of variation. Megafossils and ostracodes of the Hamilton Group have been studied in some detail, but the spores and microplankton remain to be considered.

The Hamilton Group in Canada crops out in southern Ontario (Fig. 1, p. 2). In the United States, it is found in New York, Pennsylvania, Michigan and Wisconsin. Equivalent strata occur further south. The Hamilton Group has been divided into several formations. In southern Ontario these formations are, in ascending order, the Bell, Rockport Quarry, Arkona, Hungry Hollow, Widder, and Ipperwash. The

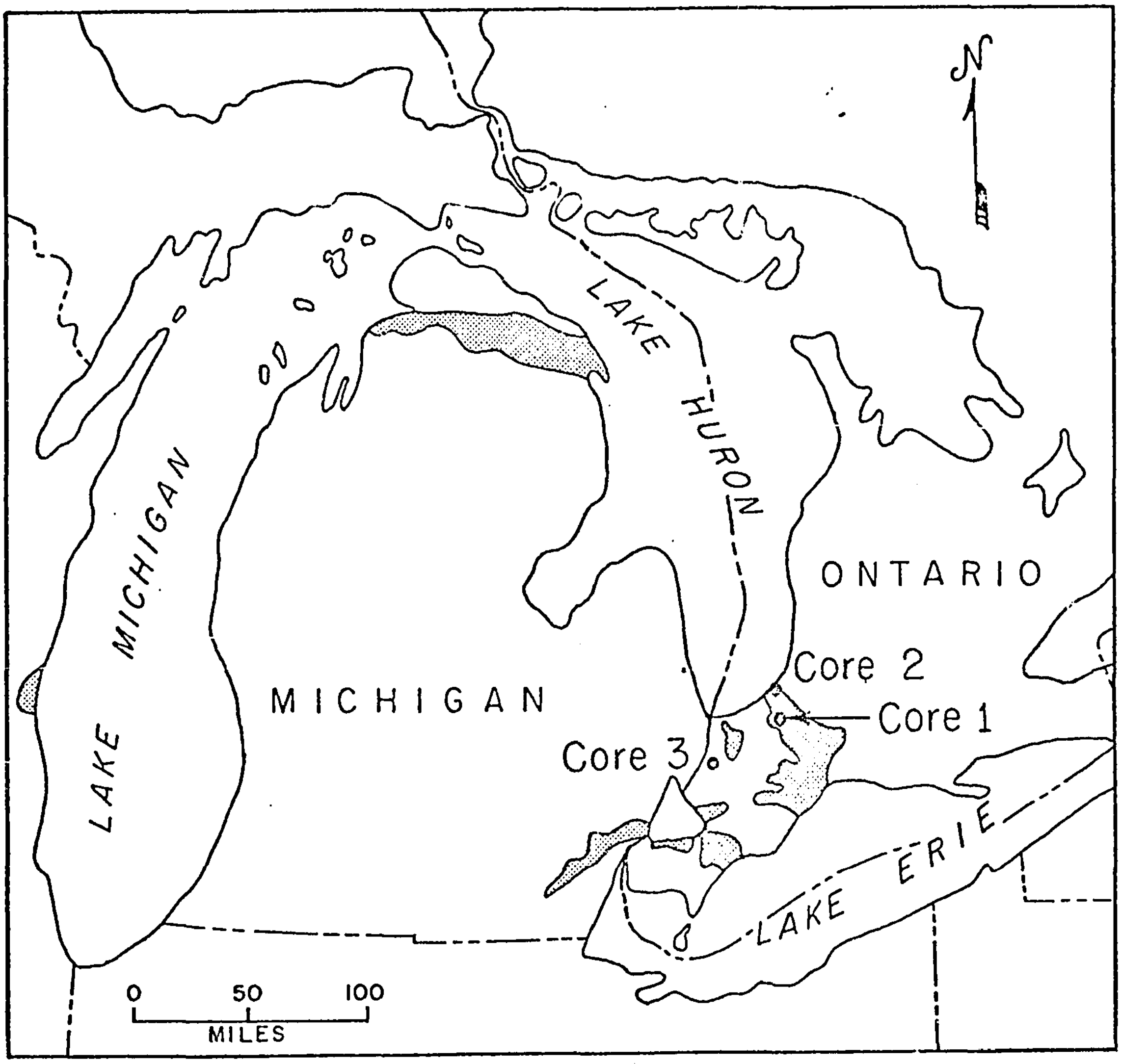

Figure 1. Map of outcrop area of Hamilton Group (Stipled area) and locations of cores studied (Core 1 : Arkona core; Core 2 : Ipperwash core; Core 3 : Argor core)

lithologies of the various formations are relatively similar and the divisions have been supported by paleontological criteria (Stumm and Wright, 1958). There is a possibility that the paleontological criteria used were more environmentally than temporally controlled and therefore would not provide true time-stratigraphic control.

Palynomorphs consisting of spores and Chitinozoa have been reported from the Hamilton Group (Fritz, 1939; Boneham, 1967) but not in any great detail. This project involves a detailed study of the Chitinozoa and Acritarcha.

The objectives of this investigation are to establish which Chitinozoa and Acritarcha are present, to consider their pattern of distribution, and to determine what if any are the relationships among them.

Acknowledgments

The author is grateful for the help and inspiration provided by Dr. L. R. Wilson who directed this project. Thanks are extended to the members of the Committee, Drs. G. T. Stone, C. W. Harper, G. J. Goodman, and P. W. Nygreen who have read the manuscript and provided valuable criticism. Special gratitude is due to Dr. C. J. Mankin who found the necessary financial assistance.

Special thanks are extended to the Geological Survey of Canada who provided two of the cores studied and to Imperial Oil of Canada who made the third core available.

Special consideration goes to Dr. M. J. Copeland who suggested this study and whose comments, suggestions, and enthusiasm were great inspiration and encouragement.

Members of the teaching staff of the School of Geology and Geophysics, each in his own way deserve thanks for courses, suggestions, and attitudes.

CHAPTER II

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 by 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 (approximately 3700 feet) in central Michigan. They thin toward southern Ontario to approximately 1000 feet in the area of the Chatham Sag, and thicken again into the Appalachian Basin. The Middle Devonian is well represented in Michigan and southern Ontario. The Hamilton Group (Fig. 2, p. 6) is an important component of the Middle Devonian section in southern Ontario.

Hamilton Group

The name Hamilton Group was used by Vanuxem (1840) to designate the rocks at West Hamilton, Madison County, New York, which underlie the Moscow Shales and overlie the

<table>
<tr><th rowspan="2">EPOCH</th><th colspan="2">STAGE</th><th rowspan="2">GROUP</th><th rowspan="2">FORMATION</th></tr>
<tr><th>N. A.</th><th>EUR-OPE</th></tr>
<tr><td rowspan="8">MIDDLE DEVONIAN</td><td rowspan="8">ERIAN</td><td rowspan="7">GIVETIAN</td><td></td><td>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>
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</table>

Figure 2. Schematic representation of the Hamilton Group sequence

Skaneateles Shales. His definition applies to what was later called the Ludlowville Shales. For many years the term Hamilton was used according to varying definitions. Cooper (1930) undertook a detailed study of these rocks across New York and redefined the Hamilton Group to include the Marcellus Shale, the Skaneateles Formation, the Ludlowville Formation, and the Moscow Formation, in ascending order.

In Ontario, the occurrence of Hamilton rocks was reported by Logan (1863). Stauffer (1915) recognized that the "bottom limestone" of the Hamilton contained some fossil forms distinct from those present in the Onondaga Limestone and in the other Hamilton beds. He identified this limestone as the Delaware because of its great lithological and faunal similarity with the Delaware Limestone of Ohio. Caley (1943), Sanford and Brady (1955), and Winder (1967) referred to the Hamilton rocks as a formation but Stumm, Kellum, and Wright (1956) and Sanford (1967) considered the sequence as the Hamilton Group.

The Hamilton Group in Ontario was subdivided by Stumm, Kellum, and Wright (1956) into four members, in ascending order: Arkona, Hungry Hollow, Widder, and Ipperwash, 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 Formations are present in the subsurface of Ontario. Consequently he added them to the sequence independent of and below the Arkona. He considered all these units as formations.

Bell Formation

The Bell Formation was named by Grabau (1902). He did not specify a type locality, but he was probably referring to the former settlement of Bell in Presque Ile County, Michigan (Warthin and Cooper, 1943). This formation is the lowermost formation of the Traverse Group in Michigan.

The Bell Formation is composed of soft blue and grey calcareous shale with, occasionally, local thin limestone lenses (Sanford, 1967). Its thickness at Rockport Quarry in Michigan is approximately eighty feet, and in Ontario, thirty feet. This formation is probably equivalent to the middle Skaneateles Formation of New York (Warthin and Cooper, 1943). It rests disconformably on the Dundee Formation.

Rockport Quarry Formation

The name Rockport Quarry Formation was proposed by Cooper and Warthin (1941) to replace the term Rockport Limestone which was three times preoccupied. The type section is at Rockport in northeast Alpena County, Michigan. At this locality, the rock consists of grey and brown limestone with some shale (Cooper and Warthin, 1941). In Michigan it is approximately forty-one feet thick. Southeastward across Ontario the limestone grades into shale and the formation is not recognized south of the north shore of Lake Erie. It transgressively overlaps the Bell Shale.

Arkona Formation

The Arkona Formation was originally named by Grabau (1917) who designated it a member of the Hamilton formation, and correlated it with the Olentangy. Its type locality is on the banks of the Ausable River, one and one-half miles northeast of Arkona, Ontario.

Caley (1943) indicated that some of the rock exposures described by Stauffer (1915) were probably Petrolia. He used the term Olentangy to refer to these rocks. Stumm et al. (1956) and Sanford (1967) retained the term Arkona. Stumm et al. correlated the Arkona Formation of southwest Ontario with the Bell Shale, Rockport Quarry Limestone, and Ferron Point Shale of Michigan. Sanford (1967) however showed that the Arkona in southwest Ontario is underlain by the Rockport Quarry Formation and the Bell Shale, and therefore is distinct from them.

The Arkona Formation consists 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 marine sequence consisting of the Bell and Arkona Formations under Lake Erie.

The Arkona Formation correlates with the Plum Brook Shale and the Silica Formation of Ohio (Driscoll et al., 1965), the combined Ferron Point Shale, Genshaw, Newton Creek, and Alpena Formations of Michigan (Sanford, 1967).

Hungry Hollow Formation

The Hungry Hollow Formation was named by Cooper and Warthin (1941). Its type locality is at Hungry Hollow (Marsh's Mill), two and one-half miles east of Arkona, Ontario. At its type locality it is approximately five and one-half feet thick.

This formation consists of two and one-half feet of light brown limestone overlain by three feet of calcareous shale. The limestone is rich in crinoid remains while the shale contains many corals as well as other fossils.

The lower contact of the formation, with the Arkona Formation, is at an apparent disconformity (Mitchell, 1967, p. 178) marked by pebbles, phosphate nodules, casts of burrows, sole markings and abraded fossils.

The formation 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).

Widder Formation

The Widder Formation was named by Stauffer (1915) who referred to it as a member of the Hamilton Formation.

He defined it to include all the argillaceous limestones above the Olentangy Shale and below the Petrolia Shale. Cooper and Warthin (1941) called the lower six feet of this formation the Hungry Hollow. Stumm et al. (1956) extended the definition of the Widder to include the Petrolia Shale.

The type locality of the Widder Formation was given as the railroad cutting at the overhead bridge, one mile east of Thedford, and one and a quarter mile north of Widder. This village now does not exist. The type section is presently covered and Widder exposure at Rock Glen, which Stauffer also mentioned, is more accessible.

The Widder Formation consists of blue-grey argillaceous limestone with grey clacareous shale interbeds. It is extremely rich in invertebrate megafossils. Stauffer (1915) reported it to be approximately fifty feet thick, but the given thickness of the formation will vary with the accepted definition.

The lower boundary was defined by Wright and Wright (1961) to be below a nine-inch shale unit which lies below a one and a half 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 previously considered the upper unit of the Hungry Hollow Formation.

The Widder Formation 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).

Ipperwash Formation

The Ipperwash Formation was named by Stauffer (1915) to denote rocks on Stony Point, at the north end of Ipperwash Beach on Lake Huron, in Ontario. He called it the uppermost member of the Hamilton Formation. It is made up of approximately fifty 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 formation into two parts. The upper part of the Ipperwash is exposed at Kettle Point, approximately two feet thick, and consists of dark grey limestone and some shale partings. The lower part consists of the rocks which Stauffer (1915) described from Stony Point.

The upper contact of the formation 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 six inches thick. The lower contact of the formation, with the Widder Formation, is not exposed but is considered to be sharp (Winder, 1961).

The Ipperwash Formation is correlative 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).

CHAPTER III

METHODS OF INVESTIGATION

Sampling techniques

Material for this study was taken from three cores. Two of the cores were recovered by the Geological Survey of Canada, and the third was made available by Imperial Oil of Canada through the Geological Survey of Canada. The cores are described in Appendix 1.

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

The samples were assigned a three symbol code. The first symbol is numerical, representing from which core the sample was removed (1 for the Arkona core, 2 for the Ipperwash core, and 3 for the Argor core); the second symbol is a letter indicating the sampling series (A for five-foot intervals; B for boundary samples); the third symbol is numerical indicating the sequence of sampling.

Processing technique

Each sample was carefully washed to remove contamination from other levels. They were broken, where necessary, into pea-sized fragments and weighed. The weights of the samples ranged from 17.0 to 118.5 grams, and averaged 52.7 grams. Treatment with concentrated hydrochloric acid for 24 hours removed soluble carbonates. The samples were washed with distilled water, placed in polyethylene containers and treated with 52% hydrofluoric acid for 6 to 8 days. The samples were washed until neutral with distilled water. The residues were sieved to remove the clay, and the fraction greater than 44 mm. was retained. This fraction was then treated with concentrated hydrochloric acid and heated in a water bath during 4 to 6 hours. They were subsequently washed until neutral and temporarily stored.

Utmost care was exercised to prevent breakage of the Chitinozoa. Thus, the samples were not disaggregated in 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. This was repetitious and time-consuming, but an essential precaution to prevent the destruction of any of the fine ornament structures on the Chitinozoa.

Standard procedure involves the use of a base, often ammonium hydroxide, after the hydrofluoric acid step. In a high percentage of the Hamilton samples this caused gelatinous clumps to form which were nearly impossible to disaggregate. Hydrogen peroxide did help 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, as well as 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. As a result, the samples were not lost, but they were difficult to prepare. Consequently, the use of a base was curtailed, to be replaced by heating in hydrochloric acid. This last step helped in clearing a good portion of the unwanted residue.

Because the samples were not treated to various oxidizing agents and some bases they often did not digest completely. To concentrate the paolynomorphs it became necessary to pick them from residues in water by using a binocular microscope and fine hand-drawn pipettes. This concentration step eliminated a substantial amount of inorganic residues. Some of the samples in which the Chitinozoa were densely opaque were treated with Schulz's solution during one to four minutes, then washed until neutral. This bleached some of the Chitinozoa. Although some of the Chitinozoa remained unbleached, the process was not carried for a longer period of time because other Chitinozoa were bleached and further processing would have been destructive to them.

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

Research techniques

In order to establish what Chitinozoa and Acritarcha are present in a sample, and to determine their relative abundances, slide counts were done. Wherever possible at least 200 Chitinozoa and Acritarcha were identified and counted from at least two slides per level. Two hundred specimens were counted to insure that adequate survey was made and thus that no taxon was ignored. More than one slide, when available, was used 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. The major difficulty arose from the fact that the Chitinozoa and Acritarcha had been picked. This introduced a bias into the sampling: the larger, darker, or otherwise more conspicuous forms would automatically be picked more commonly than the lighter colored, smaller, or less showy forms, in spite of the awareness and self-control this would trigger in the researcher. It was decided that if 5 or less specimens of a taxon were found in a picked sample it would be termed rare; 6 to 10, uncommon; 11 to 20, common; 21 or over, abundant. This is an arbitrary scale and notice is taken that this is only a general reflection of what the true numerical situation was. 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 using a Carl Zeiss photomicroscope equipped with a Neofluar 25/0.60, Neofluar 40.0.75, and Neofluar 100/1.30 Oel objectives, 1.25, 1.6, and 2 optivar, and 3.2 and 6.3 projection. KB14 Adox film gave fair to satisfactory results. In some cases surface detail on Chitinozoa did not show up. Some Acritarcha being transparent offered too little contrast for satisfactory photomicrographs to be taken. Use of Kodak infrared film was very advantageous. It permitted surface detail and internal structure of Chitinozoa to be recorded photographically. It added little to the Acritarcha study.

Various charts were prepared to portray some of the relationships found among the taxa. One set of charts (Charts 1, 2, 3) indicates whether a taxon was recorded at a particular level or not. These charts are graphic representations and do not take level thickness into account. They give the range of various taxa with the Hamilton Group.

Another set of charts (Fig. 5, p. 34, Fig. 6, p. 35; Fig. 7, p. 36) presents the percentage of the whole Acritarcha-Chitinozoa complex which makes up the studied assemblages.

CHAPTER IV

PALEONTOLOGY

Chitinozoa

Chitinozoa are a group of extinct organisms, generally thought to be animals, with organic-walled, radially symmetrical, hollow tests or vesicles, closed at one end (Jenkins, 1970). They range in age from Cambrian to Devonian, but have been reported from Mississippian (Wilson and Clarke, 1960) and Permian rocks. In both cases, they were probably recycled. Chitinozoan fossils have been recovered only from marine rocks of various lithologies, more commonly in shales. Chitinozoa are widely distributed, and they evolved rapidly. The various taxa within the group have short stratigraphic ranges. These attributes along with the small size of the Chitinozoa (60 microns to 2,000 microns) and their chemical resistance make them useful to stratigraphers, especially where only small amounts of rock are available for study.

Chitinozoa were named by Eisenack (1931) who studied these fossils from Ordovician and Silurian rocks of the Baltic region extensively. The Silurian rocks that he studied however were glacial boulders, and precise stratigraphic determinations could not be effected. Until the fifties, Eisenack's publications constituted the only literature of significance on Chitinozoa except for short notes that added little to Eisenack's information. Eisenack established a terminology and a system of classification which are still generally used.

Chitinozoa literature in the western hemisphere appeared in the fifties with papers by Lange (1949, 1952) who described some Devonian specimens from Brazil. Collinson and Schwalb (1955), Collinson and Scott (1958), and Dunn (1959) described material from Illinois and Iowa in the United States. Most of this work dealt with Devonian forms.

Research on Chitinozoa in France and North Africa gained impetus in the early sixties with significant papers being published by de Jekhowsky and Taugourdeau (1961), Taugourdeau (1961), Doubinger (1963 a,b), Taugourdeau and de Jekhowsky (1960), Benoit and Taugourdeau (1961), Combaz and Poumot (1962), and Bouche (1965) to mention only a few. These researchers still remain significant contributors in the field of Chitinozoa research.

Little work has been published on Chitinozoa from Canada. Staplin (1961) mentioned them from Devonian reefs in Alberta, Jansonius (1964, 1967) described Chitinozoa from various localities and Boneham (1967) published on Chitinozoa from the Middle Devonian of southern Ontario.

Some of the important observations to be derived from the above-mentioned research are the widespread geographic distribution of the Chitinozoa, especially in the Devonian of North America (Collinson and Scott, 1958) and in correlation of strata between American and Baltic areas, and potential for stratigraphic zonation over wide areas, as indicated in Africa (Taugourdeau and de Jekhowsky, 1960).

Chitinozoa were recorded as first appearing in the Tremadocian, which is the uppermost Cambrian or basal Ordovician (Poumot, unpublished typescript 1964, 1968), Combaz (1967, 1968). Chitinozoa from uppermost Lower Cambrian strata of British Columbia have been observed by the author, but this observation has not been published yet. Chitinozoa flourished in Ordovician and Silurian times with a large variety of forms and persisted until the end of the Devonian. In African and European areas there seems to have been a general reduction in size of Devonian forms as compared with Ordovician and Silurian forms. In North America, there are some exceptions to this fact such as the Chitinozoa described by Collinson and Scott (1958) from the Cedar Valley Formation which are very large compared to other Devonian forms. Some Chitinozoa are reported from Lower Mississippian (Kinderhookian) strata (Jenkins, 1970), and younger forms have been reported from Upper Mississippian (Wilson and Clarke, 1960) and Permian beds respectively. These forms are probably recycled because they are rare in their occurrences. More evidence is needed before it can be established that the Chitinozoa lived beyond the Devonian.

Morphology

The group of organisms encompassed by the term Chitinozoa includes a wide variety of forms and ornamentations. Basically, a chitinozoan consists of a hollow, organic-walled test which is radially symmetrical about a longitudinal axis. It is closed at one end, with or without an operculum which closes the open end in forms without necks, or a "plug" which fits into the neck. The vesicle or test is a spheroidal or cylindrical unit, or it is made up of a spheroidal, conical, or cylindrical chamber, and a neck which is generally cylindrical but which may flare away from the chamber. 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 it may be ornamented with a wide range of features from papillae to spines of varying complexity. The āboral end, or basal extremity, of the vesicle may be simple, or thickened into a basal callus or extended into a copula. The basal callus and the copula attest to the chain-type of habit of some Chitinozoa.

Although most of the Chitinozoa reported until now are represented by individual vesicles, sequences of

Chitinozoa in chains are common, and it is probable that a great number of Chitinozoa lived at least part of their life cycle in chains in which the oral end of one vesicle was appressed to the aboral end of the other. Koslowski (1963) described Chitinozoa which 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 which 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 as clear as the above definition implies. Several authors (Combaz and Poumot, 1962; Combaz et al., 1967) use the term prosome in the above sense, but they illustrate it to seem as if the prosome were a part of the neck wall. Consequently confusion exists because of the difference in usage. Therefore, it becomes necessary to define the term whenever one wishes to use it.

In the Hamilton Group specimens, two types of structures were observed which could be termed prosome. In one specimen (Pl. VII, fig. 6) a banded appearance at the base of the neck was observed, but this could be due to thickened rings on the inside surface of the wall; it need not be a prosome in the sense of a discrete structure separate from the wall. In other specimens, a discrete dark structure has been observed which is distinct from the vesicle walls, and which in some cases protrudes from the neck of the chitinozoan. On one of these (Pl. III, fig. 8,9) the structure bears discrete spines directed aborally. It is visible in part beyond the oral edge of the test, and it appears to be a solid structure, not a contracted "concertina-like" structure.

Because of the ambiguity of the term prosome in the literature, and also because no unextended prosome was observed in Hamilton specimens and those structures which were observed did not correspond fully to the description of a prosome, the term prosome will not be used in this report. 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 this term will be 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 they may have been present at one time and subsequently lost. Species without necks have a plate-like cap, operculum, which can be observed to cover the oral opening.

The name Chitinozoa was used by Eisenack (1931) because he thought that these organisms were chitinous in

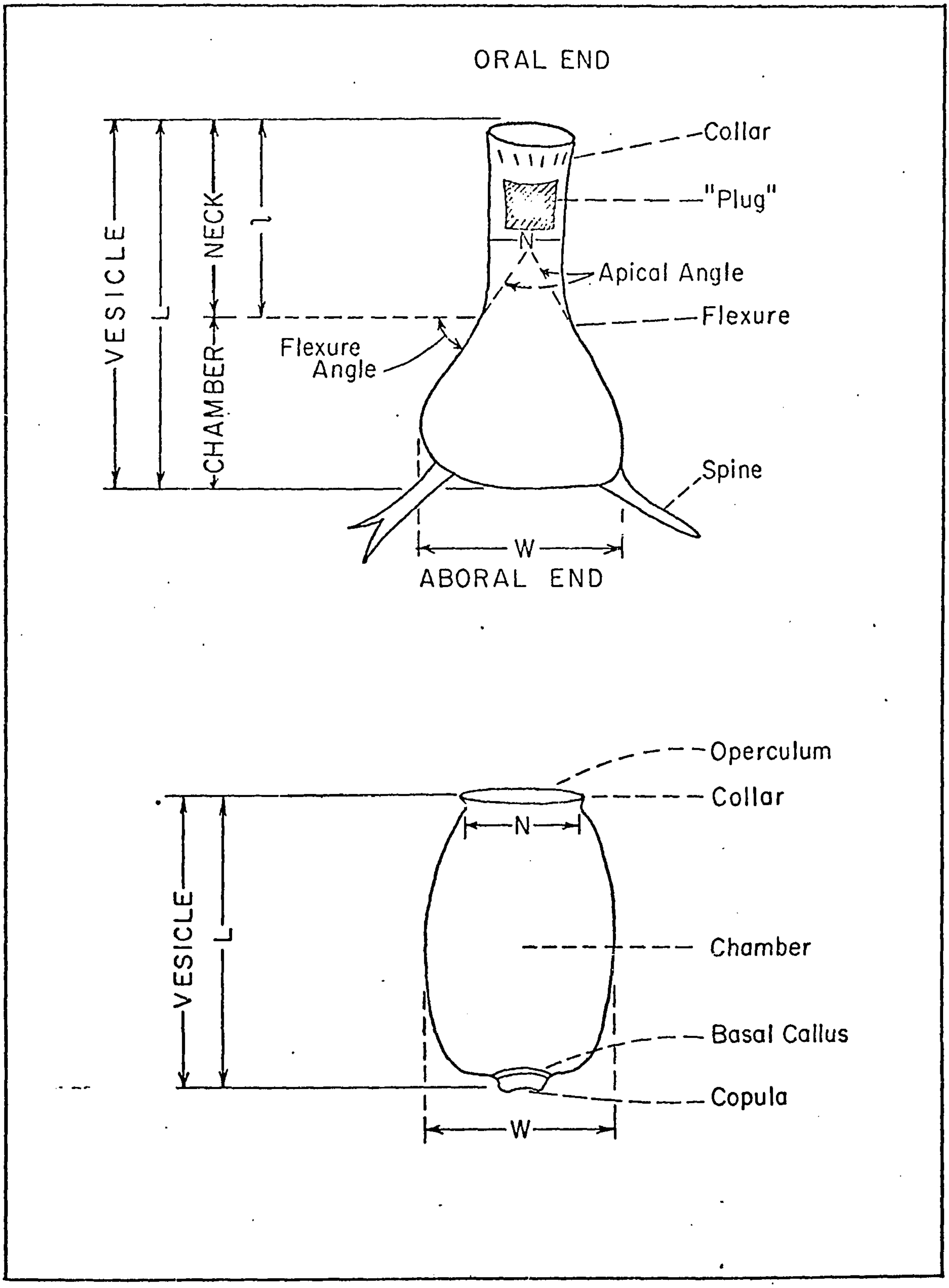

Figure 3. Terms used to describe Chitinozoa and symbols for measurements

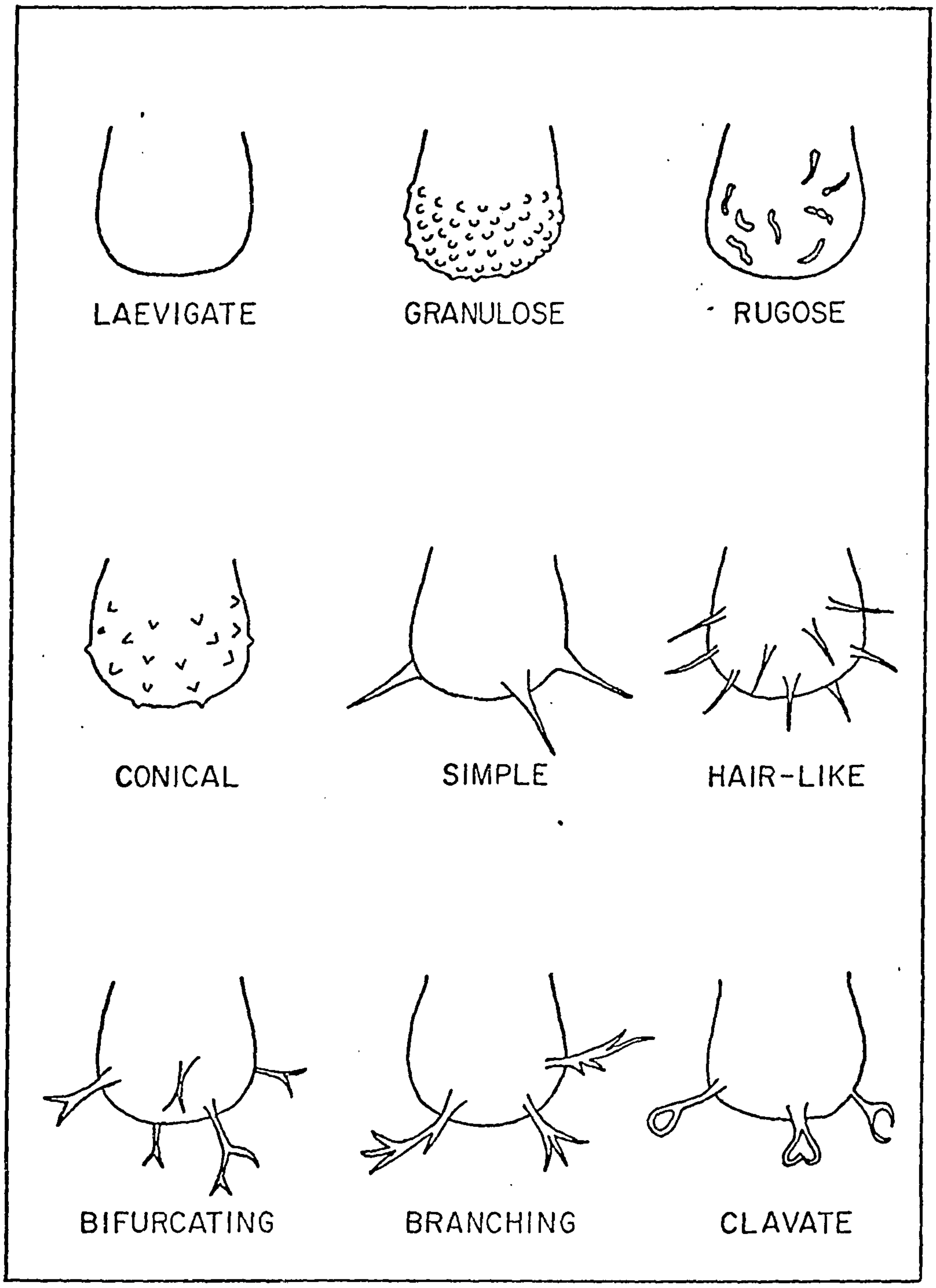

Figure 4. Types of ornamentation and spines on Chitinozoa

found some similarity between chitinozoans and the testacean genus Gromia. They considered various analyses and contended that the composition of Chitinozoa is close to that of Gromia and not close to chitin. They proposed that the composition might be closer to that of pseudochitin. They pointed out that Chitinozoa have characters in common with both the flagellate and rhizopod orders of protozoans, but do not fit closely in any of these. They conclude:

> Therefore it seems best to consider the Chitinozoa as an extinct order of marine protozoans which, because of their thick pseudochitinous tests and marine habitat we are referring to the class Rhizopoda (Sarcodina).

Koslowski (1963) suggested that Chitinozoa are protozoan or metazoan cysts; then he rejected their attribution to the Protozoa and therefore assigned them to the metazoans. The aggregates he found with cases made him consider Chitinozoa as being morphologically complex eggs of metazoans. He indicated that they are remotely analogous to eggs and egg capsules of some existing metazoans.

Jenkins (1970) mentioned the fact that Chitinozoa and graptolites are very closely associated in the geological record. Their geological ranges are roughly similar, they generally occur together, and there seems to be a relationship in their abundance. He does admit that preparation methods might tend to bias this observation to the detriment of forms which dissolve in acids. Further, Chitinozoa and graptolites seem to be chemically similar.

He proposed that Chitinozoa may perhaps be preprosicular stages of graptolites.

Acritarcha

Acritarchs make up a polyphyletic group of organic-walled fossil microplanktonic organisms of undetermined biological affinities. They occur in a large variety of shapes and ornamentation. Acritarchs are classified according to their morphological structure, mainly because the biological affinities are vague and probably varied.

The term Acritarcha was proposed (Evitt, 1963) to apply to 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 microorganisms in fossil state. He described dinoflagellates and another group which he erroneously called _Xanthidium_. Subsequent studies showed that what Ehrenberg had called _Xanthidium_ was in fact unrelated to the modern fresh water genus _Xanthidium_. The term hystrichosphere was initiated by O. 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) studied many Cretaceous hystrichospheres and corrected Ehrenberg's type assignations, and further split off another genus

Hystrichosphaeridium in which the spinose ornamentation is not patterned as it is in *Hystrichosphaera*; eventually this new genus came to apply to forms with tubular processes.

Following Deflandre's work, it became apparent that these fossils could be removed from rock by acid treatment, and research in this field expanded. Deflandre (1947) summarized previous work and knowledge in the field of hystrichosphere study, and concluded that these fossils were found only in marine rocks. He also indicated that the Order Hystrichosphaeridae was polyphyletic, containing varied and often unrelated forms.

The Order Hystrichosphaeridae was expanded to contain a great variety of morphological types for which no biological affinities could be proposed. Evitt (1963) stated that the morphology of *Hystrichosphaera* and of *Hystrichosphaeridium* shows that they are dinoflagellates. He amended the family Hystrichosphaeraceae to exclude from it those forms which show no morphological characters of dinoflagellates. The change in the family name was necessary because the dinoflagellates are considered to be plants, and as such their nomenclature follows the International Code of Botanical Nomenclature. He suggested that the use of the name Hystrichosphaeridae in reference to non-dinoflagellates be discontinued, because the forms on which this name is based are, in fact, dinoflagellates. Thus, the informal terms "hystrichosphere" and "hystrix" also should be modified and restricted to apply to those forms with dinoflagellate affinities.

He proposed the name Acritarcha for those forms which were excluded from the hystrichospheres. This name is used to encompass a group of morphologically varied microfossils whose affinities cannot be determined at present. It is possible that some acritarchs are dinoflagellates that do not show enough characters to be recognized. Some forms may be eggs or cysts of various plants or animals. Consequently, the term acritarch, which has essentially the same significance as fossilis incertae sedis, because of its polyphyletic implications, was not given a formal status in taxonomic nomenclature such as Class or Order, but it is retained as a "catch-all" category. When an acritarch's affinities can be determined, it should be removed from that category and transferred to whatever taxonomic entity to which it has been found to belong.

Acritarchs are morphologically varied and it becomes difficult to make any general statement about their morphology. The test or vesicle can be spherical, polyhedral, cigar-shaped, or irregular. The walls can be unornamented or variously ornamented by appendages, spines, ridges, or papillae, and can be one- or two-layered, perforate or imperforate. Some forms of acritarchs may be resting structures which have an opening (pylome) that perhaps serves as an outlet for the organism to escape from the cyst. Further terminology relies mainly on unspecialized descriptive terms.

The geologic history of the acritarchs extends from the Precambrian (Barghoorn and Tyler, 1965) to Recent. Paleozoic acritarchs are varied and numerous; certain groups emerged rapidly and disappeared, while others persisted for longer periods of time. During Pennsylvanian and Permian time they became fewer in number. In many instances they offer great potential as stratigraphic indicators. They occur in the Mesozoic, but dinoflagellates tend to displace them in numbers and in stratigraphic importance. This trend continues into the Cenozoic.

CHAPTER V

DISCUSSION

Chitinozoa and Acritarcha

Acritarchs have the greatest numerical predominance of the palynomomorphs in the Hamilton Group. Representatives of the acritarchs are present at nearly all levels and generally make up over 50 per cent of the Chitinozoa-Acritarcha assemblages (Fig. 5, p. 33 Fig. 6, p. 34; Fig. 7, p. 35) and little taxonomic variation occurs in the acritarchs of the Hamilton Group. Most taxa of the Hamilton acritarchs are present in varying numbers throughout all of the formations.

Chitinozoa occur in two zones of high relative percentages in the Bell Formation. At the base, there is a zone of high relative percentages of Chitinozoa in two of the cores, the Ipperwash and Argor cores; in the Arkona core, this increase in Chitinozoa occurs in the upper 5 to 10 feet of the Dundee Formation. Above this high Chitinozoa zone, the acritarch percentages increase and remain high through the formation. The top of the formation is marked by a sharp, but in two of the cores, thin (5 to 10 feet thick) zone with high Chitinozoa percentages

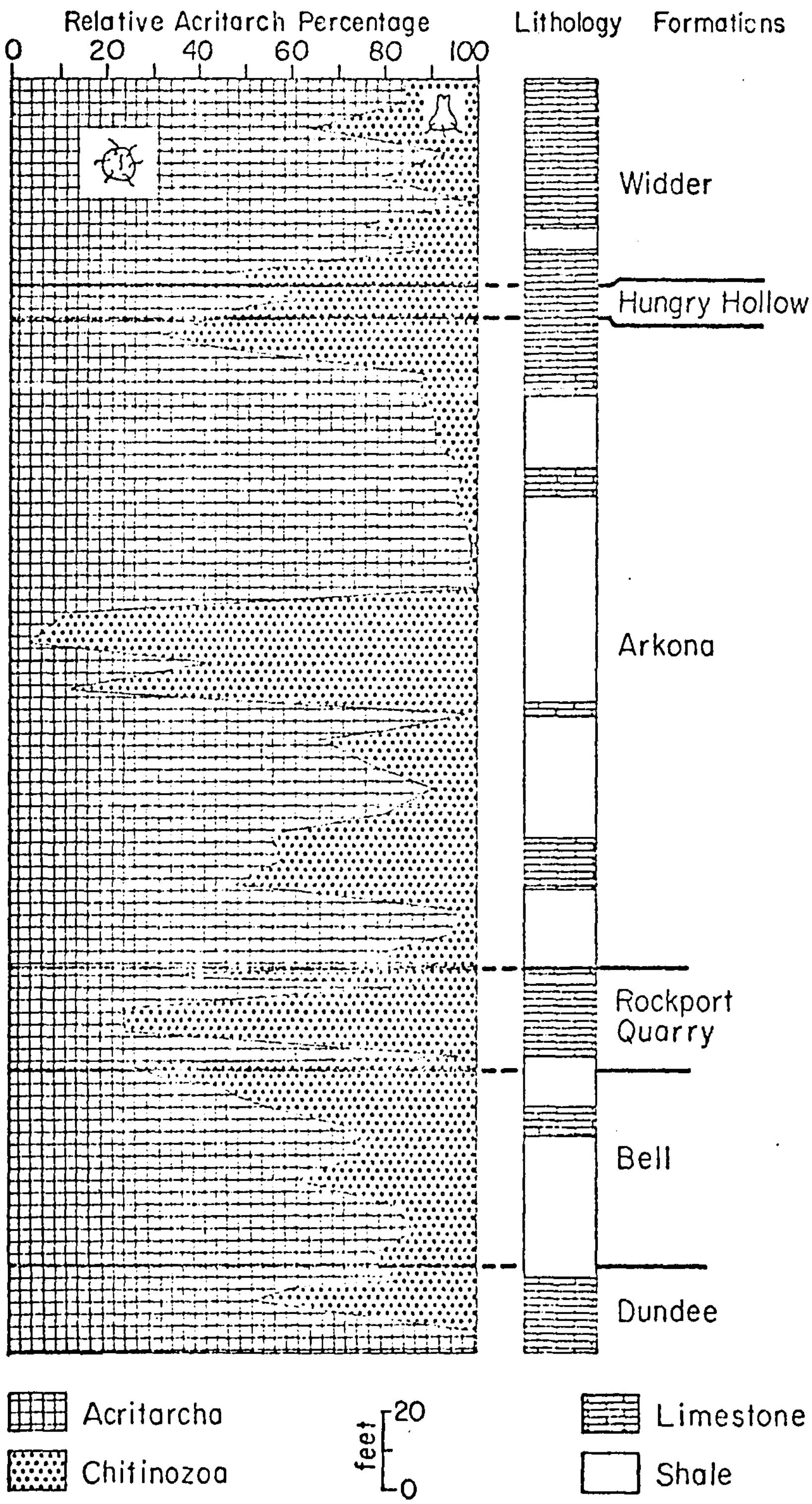

Figure 5. Acritarcha-Chitinozoa percentages in the Arkona core

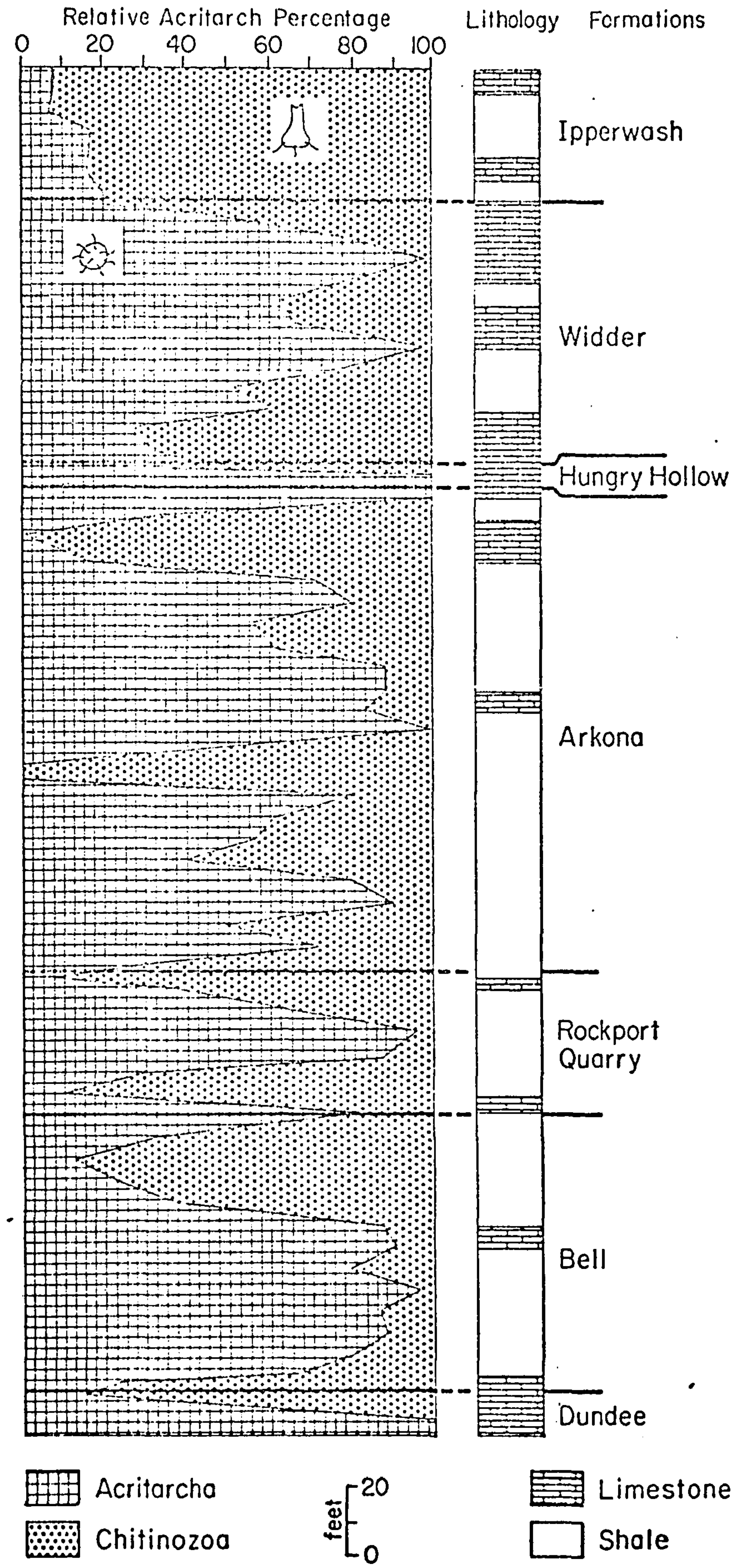

Figure 6. Acritarcha-Chitinozoa percentages in the Ipperwash core

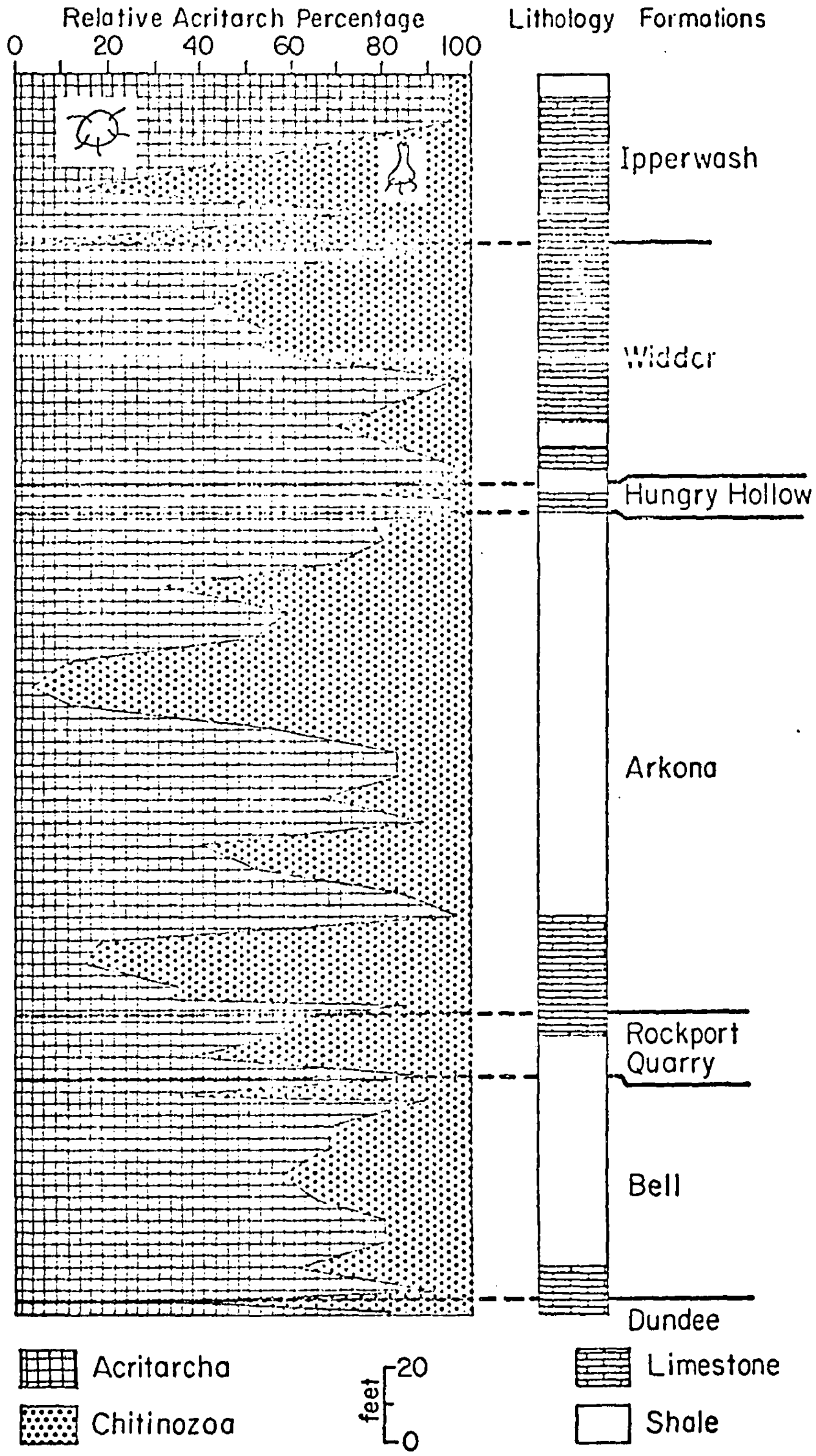

Figure 7. Acritarcha-Chitinozoa percentages in the Argor core

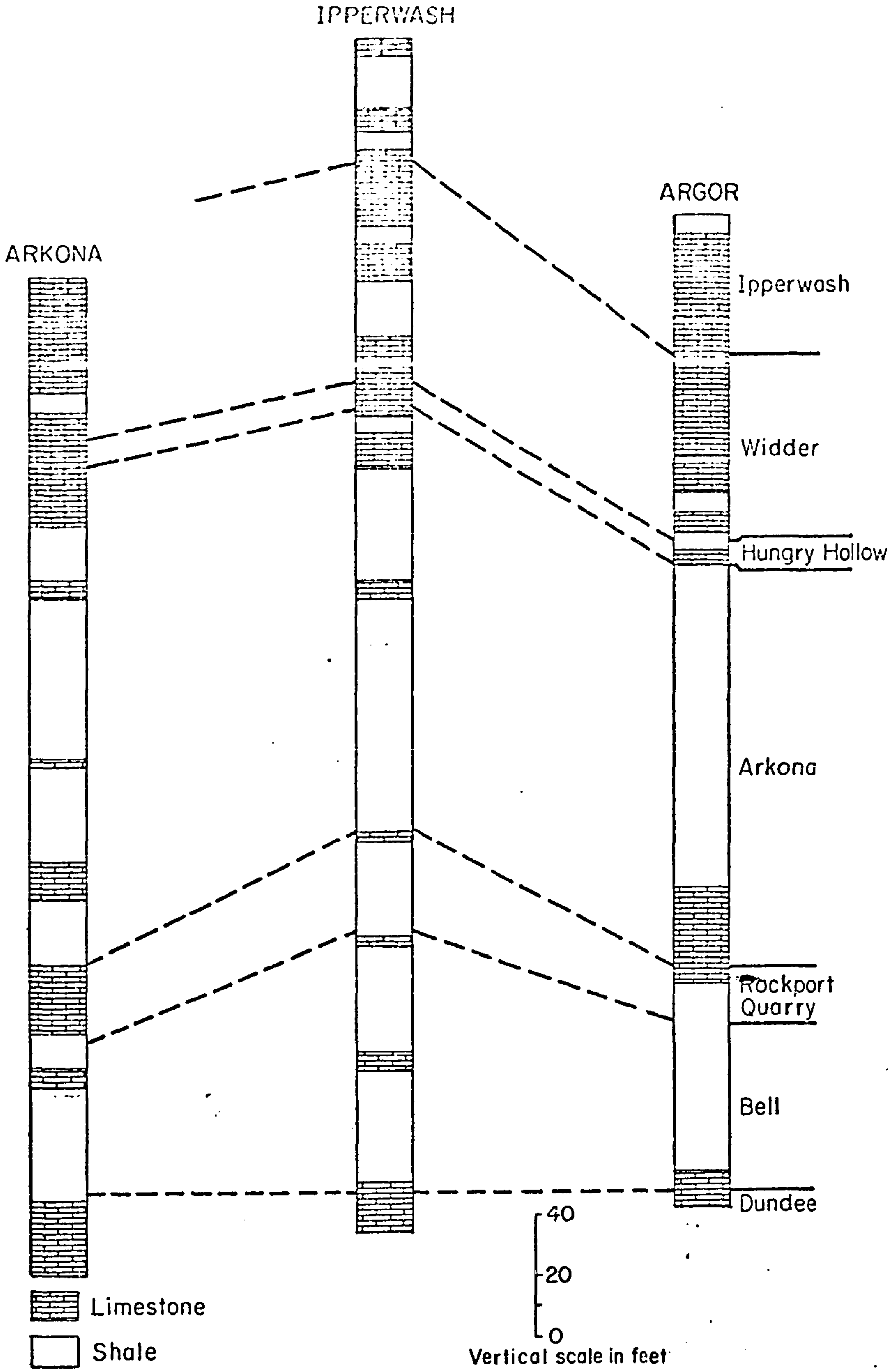

Figure 8. Schematic representation of lithology and correlation of the cores studied

across the three cores.

Two zones of high relative percentages for the Acritarcha occur in the Rockport Quarry Formation. These are at the bottom and top of the formation in the three cores. These peaks are separated by high Chitinozoa percentages and this high Chitinozoa percentage zone occurs in all three cores. The lower Acritarcha peak is five feet above the boundary in the Arkona core.

The Arkona Formation has two major acritarch peaks of relative percentage and these are separated by samples with high relative percentages of Chitinozoa, approximately at the center of the formation. The relative acritarch abundance in the upper part of the Arkona Formation is high, ranging from 80 per cent to 100 per cent and in two cores (Arkona and Argor cores) this abundance extends for 50 and 60 feet respectively. Near the center of the formation there is a thin interval approximately 5 to 20 feet thick in which the Chitinozoa assume a high relative percentage. Below this, there is again a relative percentage increase in acritarchs which extends nearly all the way to the bottom of the formation. This peak in relative acritarch abundance is not as great nor as constantly sustained as the first peak in the formation. Near the base of the Arkona Formation there is a relative increase in Chitinozoa percentage. This increase occurs at the base in the Arkona and Argor cores, but approximately 15 feet above the base in the Ipperwash core. This zone of high relative percentage for Chitinozoa seems to indicate a contemporaneous set of events, and because of its higher position in the Ipperwash core suggests that the formational boundaries may not indicate time.

In the Widder Formation the acritarchs generally make up over 50 per cent of the Chitinozoa-Acritarcha assemblages. There is a relative decrease in abundance near the Widder and Hungry Hollow formational contact and then a relative increase in the Hungry Hollow Formation. In two cores, the Argor and Ipperwash cores, this increase is such that the Acritarcha are over 90 per cent of the Chitinozoa-Acritarcha assemblages. In the Arkona core, the relative percentage increase of the Acritarcha reaches only 61 per cent.

The significance of the variation between relative numbers of Acritarcha and Chitinozoa might have some bearing on water depth and shoreline position. Staplin (1961) studying Devonian microplankton from Alberta, and basing some of his conclusions on Wilson's work on Lower Paleozoic Chitinozoa of New York (1955, personal communication to Staplin) stated that the presence of Chitinozoa might indicate proximity to shallower platform areas. He found that types of acritarchs changed away from reef areas toward deeper water and their numbers also increase. Thus, in the

Hamilton Group, the widespread zones of relatively high Chitinozoa abundance would indicate shallowing of the water and possibly closer proximity to the shoreline.

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

Acritarcha in the Hamilton Group 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 Group. Consequently it can be concluded that the Chitinozoa were probably more sensitive to some undetermined factors than were the Acritarcha.

Chitinozoa

Generic discussion

General trends can be seen in the generic distribution of some of the Hamilton Group Chitinozoa, and they are illustrated in charts 1, 2, and 3. The genus *Ancyrochitina* occurs in all the Hamilton Group, with no stratigraphic restriction on various species. There is some stratigraphic restriction on the genus *Angochitina*. Barring six samples, all species of *Angochitina* occur in the sequence consisting of the upper half of the Arkona Formation, the Hungry Hollow, Widder, and Ipperwash Formations, with very little representation in the Hungry Hollow Formation.

The genera Desmochitina, Eisenackitina, and new genus B are closely related morphologically and stratigraphically. Barring one occurrence in the Hungry Hollow Formation which may be accidental, no species of these genera occur above the Arkona Formation. They appear in substantial numbers in the Bell Formation and maintain their numerical and relative Chitinozoa percentage dominance throughout their range of occurrence. Hoegisphaera, another genus from the same tribe as the above three genera, is ubiquitous throughout the Hamilton Group. Desmochitina, Eisenackitina, and the new genus B are more similar morphologically to each other, than any one of them is to Hoegisphaera. As later discussed there is also a difference in life habit; the first three genera affect a chain habit, and last genus affects a colonial aggregate habit. Thus, the difference in stratigraphic distribution and the morphologic variance might indicate a wider taxonomic gap than has been postulated.

Representatives of other genera are rarer and consequently no trends in stratigraphic distribution have been detected.

Specific discussion

The genus Alpenachitina (Dunn and Miller, 1964) has been a monotypic genus. In this study a new form assigned to it was found which exhibits considerable variance from the type species *A. eisenacki*. The differences lie in the more conical chamber shape, the smaller number of basal edge spines, and the lesser number of spines on the neck in the Hamilton species. The specimens represent a new species and are here assigned to Alpenachitina. It is rare in the Hamilton Group, only two specimens having been found, both at the same level in the Widder Formation. Seven other specimens have been found in the Dundee Formation and all from the first level below the Dundee-Bell contact.

The genus Ancyrochitina is represented in the Hamilton Group by 18 different species. Seven are referrable to named species, three are new species, and nine are unnamed forms. The genus Ancyrochitina has the largest number of species in the Hamilton Group.

Ancyrochitina cf. *A. cornigera* occurs in all the formations of the Hamilton Group. In the Bell Formation it was recovered from only one level (1-A-6) in the Arkona core. Specimens were also recovered from the Rockport Quarry Formation in the same core at two levels (1-A-48, 1-B-6). The species is abundant in 1-A-48. It is generally rare to uncommon in the Arkona Formation and abundant only at three levels. In the Hungry Hollow Formation it is rare. In the Widder Formation it is rare to uncommon at several levels, but abundant at one level in two of the cores (3-A-12, 2-A-12). It is abundant in the Ipperwash Formation.

Ancyrochitina cf. *A. cornigera* in the Hamilton Formation exhibits a wide range of basal edge ornamentation. Some forms have conical spines with broad bases as attributed to the material on which the species was founded from the Cedar Valley Formation (Collinson and Scott, 1958). Other forms have similar spines, but with perforations either through only one wall or through both. This type of perforation varies in size and ranges into the clavate type of spine. The oral edge of Hamilton specimens is ornamented by a fringe of spines that are uniform in size on each specimen, but may vary from one specimen to another. This variable character was not reported in the original description of the species. Because of the more comprehensive range of ornamentation, it is felt that perhaps the species definition should be emended to include the above-mentioned range in morphologic variation in ornamentation of both the basal and oral edges.

This is a size difference between the specimens from the Hamilton and Cedar Valley Formation. Specimens from the Cedar Valley Formation are the larger. In spite of the difference in size, the forms are considered as probably conspecific.

Ancyrochitina cf. *A. desmea* occurs in only three of the Hamilton Group formations. In the Arkona Formation it was recovered from only the Argor core and at three levels where it is rare. In the Hungry Hollow Formation it is uncommon having been recovered from only the Arkona core. In the Widder Formation it occurs in two of the cores: at three levels in the Ipperwash core, one in the Argor. It is rare in all except but one level, 1-A-12, where it is uncommon.

The Hamilton specimens attributed to this species are smaller than the type material for the species (Eisenack, 1964), but similar to material from the Parana Basin (Lange, 1967). The relative proportions of width to length are similar in all three. The Parana and Hamilton specimens have neck spines above midlength of the neck, while the type material has the neck 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.

Specimens similar to ?*Ancyrochitina gordita* were recovered in small numbers. They are rare to uncommon in the Bell, Arkona, and Ipperwash Formations, and rare in the Rockport Quarry, Hungry Hollow and Widder Formations. The Hungry Hollow specimens were recovered from only the

Arkona core, and the Rockport Quarry specimens only from the Argor core.

The Hamilton specimens are conspecific with, but show a wider range of ornamentation variation than does the ?*Ancyrochitina gordita* which was originally described by Cramer (1964). The Hamilton forms range from forms which are unornamented to forms ornamented with spines only at the oral edge, spines at both the oral and basal edges, and spines only at the basal edge. The original material of Cramer (1964) has a few spines at the basal edge which may or may not be present. The Hamilton specimens are smaller by approximately 50 microns. In spite of the size difference it is felt that the Hamilton specimens are conspecific with Cramer's specimens and that the species definition should be expanded to include the wider range of ornamentation.

Ancyrochitina cf. *A. langei* is the most abundant and widely distributed species of this genus in the Hamilton Group. One hundred and four specimens were counted from the uppermost levels of the Dundee Formation. In the Bell Formation, there is one level where this species is abundant in all three cores. At that level, this species comprises 45% or more of the Chitinozoa assemblage. This level is approximately at the center of the formation in two cores (Arkona and Argor cores) and 2/3 up in the third core (Ipperwash core). This zone might represent a time level across the three cores. In the Rockport Quarry Formation, Ancyrochitina cf. A. langei is abundant in the Arkona core but rare in the Ipperwash and Argor cores. In the Arkona Formation it was recovered in varying amounts at many levels. It is abundant in the Hungry Hollow Formation where it makes up a high percentage of the Chitinozoa assemblage. In the Widder and Ipperwash Formations it occurs in some levels and varies from rare to abundant but not as abundant as in the Hungry Hollow Formation.

The Hamilton specimens of A. cf. A. langei are similar in shape, width to length ratios, and character of ornamentation to the specimens on which Sommer and van Boekel (1964) based their definition of the species A. langei. Their holotype is 165 microns long, which is larger than the majority of the Hamilton specimens. As in the previously discussed species, variation of the Hamilton specimens covers a wider range than does that of the type material for the species. In the type material for A. langei the number of basal edge spines varies from 2 to 6 and the spines are simple; in the Hamilton specimens the number of basal edge spines can range up to 8, and the spines vary from simple to complex. In the original description of the species (Sommer and van Boekel, 1964) little mention is made concerning the oral edge spines; they are described as shorter and thinner than the basal edge spines. In the Hamilton species the development of the oral edge spines varies from less to equally well developed than those of the type material.

Ancyrochitina cf. A. langei from the Hamilton Group also resembles A. pilosa curta (Taugourdeau, 1962) from the Frasnian of North Africa. Their length and width measurements are similar, but their apical angle measurements differ, being 70° in A. pilosa curta, and 40° to 65° in A. cf. A. langei. In A. pilosa curta the neck is shorter and in some instances so reduced as to approximate a collar instead of a neck. The neck is always well developed in the Hamilton specimens. The length of the basal edge spines in A. pilosa curta is shorter, but there is some similarity in the complexity of the spine structure. It has been observed that A. cf. A. langei from the Hamilton Group has some characters in common with A. langei, and some others in common with A. pilosa curta, without being identical with either. Its characters seem to be an intermediate between the other two species: it has the vesicle shape, width to length ratio, and general character of basal edge ornamentation of A. langei, and the dimensions and character of oral edge ornamentation of A. pilosa curta. Stratigraphically, the Hamilton species occurs between both other species: A. langei from the Lower Devonian of Brasil and Bolivia and A. pilosa curta from the lower Upper Devonian of north Africa.

It can be postulated that although slightly more similar to Ancyrochitina 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 characters and the intermediate stratigraphic position of the Hamilton specimens. Additional material must be found and studied before this suggestion can be substantiated.

One specimen of the species Ancyrochitina cf. A. multiramosa was recovered in the Hamilton Group, and this from the Widder Formation. Seven specimens were recovered from the Dundee Formation. All specimens were recovered from the Arkona core. The species from the Hamilton Group is similar to the type specimen for this species for Ancyrochitina multiramosa which Taugourdeau and de Jekhowsky (1960) described from the Silurian rocks of north Africa. In the description of that species it is indicated that the basal edge spines are in much greater number than in any other species of the genus. The Hamilton specimens in this study have a large number of slender terminally branching spines. This is the character which 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 0.7. Further study may indicate that two discrete species exist although ornamentation in both is similar.

The two Hamilton specimens of Ancyrochitina tomentosa were recovered from the same level in the Widder Formation. They resemble the type specimens of the species (Taugourdeau and de Jekhowsky, 1960) from the Silurian to Upper Devonian rocks of north Africa, except in size. The African specimen is approximately 50 microns greater than the Hamilton specimens. This species has a wide stratigraphic range in Africa, but its rarity in the Hamilton Group precludes comment of stratigraphic range in southern Ontario. Rarity in southern Ontario may or may not be due to stratigraphic restriction.

Ancyrochitina cf. A. tumida is absent from the Widder and Ipperwash Formations. Both the Arkona and Argor cores contain specimens from the Bell Formation but the species is rare in all six levels from which it was recovered. Only one specimen was recovered from the Rockport Quarry Formation, and that from the Argor core. In the Arkona Formation this species was recovered from four levels in the Argor core, the species being common in only one, and rare in the others. Eight specimens were recovered from one level in the Hungry Hollow Formation in the Arkona core. No specimens of this species were found in the Ipperwash core.

Ancyrochitina cf. A. tumida from the Hamilton Group differs only in the presence of oral edge ornamentation from the type specimen (Taugourdeau and de Jekhowsky, 1960) from Silurian and Middle Devonian rocks of north Africa. This is probably not important enough a criterion in this case to separate these two forms into two different species.

Ancyrochitina n. sp. 1 was recovered from eight levels in the Hamilton Group. It is rare in the Rockport Quarry and Widder Formations, and present in these formations only in the Arkona core. It is rare to uncommon in the Arkona Formation, having been recovered from three levels, one in the Ipperwash core, and two in the Argor core. It was recovered from the Bell Formation in the Argor core where it is rare and present in three levels.

This new species is somewhat similar to A. langei in vesicle shape and proportions. Its apical angle is greater, being 72° and that of A. cf. A. langei in the Hamilton being 40° to 65°. The oral edge of the new species is fringed by distinctive ornamentation. Spines are relatively long (20 microns), coarse (3 microns wide), taper only at their tips, and vary from simple to complex. They are densely set at the oral edge and confer a unique appearance to this chitinozoan. No other such oral edge ornamentation has been yet described. Because of the unique character of the ornamentation the specimens are recognized as belonging to a new species.

Ancyrochitina n. sp. 2 was recovered from all three cores in this study. Seventeen specimens were found in the Dundee Formation. In the Bell Formation it is rare in four levels and common in one (1-A-61). It is rare in the Arkona Formation, in the Arkona core, occurring at only one level (1-A-22); in the same formation in the Argor core it occurs in twelve levels, abundant in three. In the Hungry Hollow Formation it has been found in the Arkona and Argor cores; it is rare in the first and uncommon in the second. In the Widder Formation from the Ipperwash and Argor cores it is rare to uncommon. It was found to be rare in two levels of the Ipperwash Formation in the Ipperwash core.

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 and thus breakable, consequently they 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. This species is similar to a species Cousminer (1964, unpublished Ph.D. dissertation) named *Ancyrochitina depilosa*. Because the work has not been published the name is not valid and consequently will not be used in this study.

Ancyrochitina sp. 1 is rare in the Hamilton Group. Specimens were recovered from the Arkona and Argor cores at four levels (1-A-6, 1-A-22, 3-A-26, 3-A-27). All levels yielded only one specimen each except 1-A-22 which yielded two. All the recovered specimens were broken at the oral edge therefore the presence or absence of oral edge ornamentation cannot be verified.

Ancyrochitina sp. 2 is another rare form of which only three specimens were recovered, one each from three levels of the Arkona Formation (1-A-32, 3-A-27, 3-A-39). The three specimens are slightly similar to A. multiramosa, but differ in their relatively shorter necks, more convex chamber, and less distinct basal edge ornamentation. The character of the basal edge ornamentation is incompletely known because the specimens appear to be broken.

Ancyrochitina sp. 3 was recovered from the Widder Formation at one level from two different cores (1-A-4, 2-A-7). These levels do not represent a biostratigraphic zone, 1-A-4 being well within the formation and 2-A-7 in the top five feet of the formation. The small number of specimens may represent a numerical rarity rather than stratigraphic restriction. The distinctive characters of this form are its numerous hair-like spines and their distribution on the lower 0.2 and oral 0.2 portions of the vesicle. This combination of spine type and distribution over the vesicle has not previously been described.

Because of the small number of specimens available, it is difficult to determine if this character is of specific importance.

<u>Ancyrochitina</u> sp. 4 is a rare form recovered from 3 levels: 2-A-5 in the Ipperwash Formation where three specimens were found, 2-A-7 in the Widder Formation where nine specimens were found, and 1-A-9 in the Hungry Hollow Formation where one specimen was recovered. The neck of this form is long (86.7 microns) and ornamented with short hair-like spines. Spines probably were present on the chamber because there appear to be broken spine bases on it. The complete ornamentation structure of the form is not known.

Only one specimen of <u>Ancyrochitina</u> sp. 5 was found. It occurred in the lower ten feet of the Arkona Formation (3-A-39). Its ornamentation consists of coarse spines at the basal and oral edges. With only one specimen it cannot be ascertained if this coarseness is an extreme variation which can be related to an already described form.

<u>Ancyrochitina</u> sp. 6 is represented by one specimen recovered from the Bell Formation (1-A-46). Its basal edge is ornamented by a ring of nine coarse tuft-like complexly branching spines that are 18 microns long. Similar but shorter spines, 8 microns long, surround the oral opening. This type of tuft-like spine has not been described on any species of this genus. Because of the

rarity of specimens, the specific value of this character cannot be established.

Coarsely granulose Chitinozoa are not common. Ancyrochitina sp. 7 is a very coarsely granulose form which is rare in the Hamilton Group. One specimen was recovered from the Widder Formation (1-A-1) and one from the Bell Formation (1-A-56). The granules on this form are 12 to 13 microns wide at their base, and 3 to 4 microns high. Minute granules occur on the larger. This coarseness of granulation has been reported previously by Taugourdeau and de Jekhowsky (1960) on Urochitina verrucosa from the Lower and Middle Devonian rocks of the Sahara. This rare type of ornamentation has also been observed by the author on Lower Cambrian specimens, but the occurrence has not been officially reported yet.

Ancyrochitina sp. 8 is represented by a distorted and cracked specimen and thus its characteristics are not fully determinable. This one specimen was found in the Arkona Formation (1-A-31). It 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 reported from any other Chitinozoa.

?Ancyrochitina sp. 9 is well represented in all the formations of the Hamilton Group, as well as in the Dundee Formation. It is rare to common in the Bell, Rockport

Quarry, Widder and Ipperwash Formations; rare to abundant in the Arkona and common in the Hungry Hollow Formation. This species follows closely the trends of Ancyrochitina cf. A. langei for they commonly occur together and in a few cases make up a high percentage of the Chitinozoa assemblage. A generic assignment for this form offers some difficulty. In the original description of the genus, Eisenack (1955) 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, unpublished Ph.D. dissertation) described a new species, A. depilosa, in which some forms lacked basal edge ornamentation. His species also included forms with basal edge ornamentation, and thus he implied that basal edge ornamentation is not a necessarily essential character for this genus. Considering this interpretation the Hamilton forms would belong to Ancyrochitina. Further study might warrant enlarging the generic definition by emendation to include such basally unornamented forms.

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

Angochitina cf. *A.* ?*collinsoni* is restricted to the Widder Formation where it is rare to common. It was recovered from four levels (1-A-6, 1-A-7, 1-A-8, 2-B-2). The type specimen for this species (Taugourdeau, 1961), from the Lower Devonian of north Africa, is broken at the neck. Thus its generic position is questionable because some of the specimen is missing. In the Hamilton specimens, some forms are broken, but one (Pl. VI, fig. 1) has a distinct neck, 10.4 microns long. The Hamilton form is smaller than the type specimen and has a greater number of spines. Spines on the inside wall of the neck have been observed.

The species *Angochitina devonica* was recovered only from the Ipperwash and Widder Formations in two cores (Arkona and Ipperwash cores). In the Ipperwash Formation *A. devonica* was found at two levels (2-A-2, 2-A-3) where it is rare in the former and uncommon in the latter. It was recovered at three levels in the Widder Formation in the Ipperwash core, two levels in the lower 25 feet of the formation, and at two levels in the Arkona core both in the lower 15 feet of the formation. In the Arkona core, some of the upper part of the formation is absent. Thus it is possible that another level containing *A. devonica* would have been found had the formation been complete. In all five levels of the Widder Formation this species makes 5 to 25 per cent of the Chitinozoa assemblage. 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 core introduces some question as to how valid or widespread such a zone would be.

The specimens of Angochitina devonica from the Hamilton Group agree closely in size, shape, proportions and ornamentation with the originally described material of this species which Eisenack (1955) reported from Middle Devonian strata of Eifel. Collinson and Scott (1958) described specimens of A. devonica from the Cedar Valley Formation which are larger by 8 to 90 microns than the largest Hamilton specimens. All three occurrences are considered conspecific in spite of the size discrepancy of the Cedar Valley Formation specimens. Hamilton specimens exhibit large variation in type of spines, ranging from slender simple to bifurcating, to coarse and complexly branching.

Angochitina milanensis was recovered from three formations in the Hamilton Group. It is rare to uncommon in the Arkona Formation, rare to abundant in the Widder Formation, and rare in the Ipperwash Formation where it occurs in only one sample (3-A-4). In the Widder Formation its distribution is closely related to that of A. devonica consisting of 6 to 30 per cent of the Chitinozoa assemblage in the lower 20 feet of the formation in the Arkona and

Ipperwash cores. This corresponds to the "zone" of Angochitina devonica. A. milanensis is rare in the Argor 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 reduces the chances of technical omission and leads one to consider reasons for the lack in the Argor core. There is no evidence for a physical barrier between the Argor core and the other two cores, and their geographical proximity makes it difficult to consider factors other than those which 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 to them than other Chitinozoa. Because no evidence is yet available on these factors, no conclusion is drawn. Study of more Widder Formation material from widespread localities might clarify the distribution pattern of these two species.

Specimens of Angochitina cf. A. ramusculosa are rare to abundant in the Arkona, Widder and Ipperwash Formations, common in the Hungry Hollow Formation and absent in the other formations of the Hamilton Group. In the Ipperwash core, the species makes up a high percentage (25 to 85 per cent) of the Chitinozoa assemblage in a sequence over 20 feet thick. In the Argor core this species comprises a high percentage of the Chitinozoa assemblage over approximately 50 feet of the Widder Formation. Also in the Argor core, this species makes up 95 to 100 per cent of the Chitinozoa assemblage in the Hungry Hollow Formation. In the Arkona Formation there are two levels, one in the Arkona and one in the Ipperwash cores, 20 feet down from the Hungry Hollow-Arkona contact, where this species represents approximately 60 per cent of the Chitinozoa assemblage. None of the high percentage levels are reliably traceable from one core to another.

The Hamilton Angochitina cf. A. ramusculosa differs somewhat from the material on which this species is based. The type material (Cramer, 1964) from the Upper Ludlovian of northwest Spain, is less spinose, has shorter vesicles and longer necks than the Hamilton specimens. Consequently they may not be conspecific.

Angochitina toyetae is rare to abundant in the Widder and Ipperwash Formations, rare in the Hungry Hollow Formation, rare to uncommon in the Arkona Formation, and uncommon in the Bell Formation. In the Widder Formation 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 formation, the second approximately 10 feet above the first, and third in the top 5 to 10 feet of the formation. The lowest zone is 10 to 15 feet thick, and the other two are 5 to 10 feet thick.

The specimens on which this species is based (Cramer, 1964) of Emsian age from northwest Spain are slightly but not significantly larger than the Hamilton specimens. The spines on the Hamilton specimens are often broken; therefore, the character, length, and complexity of the spines on these specimens have not been determined. Internal spines, visible at the oral edge, have been observed on some specimens.

Angochitina n. sp. 1 was recovered from the Widder Formation where it occurs in seven samples, but it is rare in all, and in the Arkona Formation where it occurs in only three samples, and is common in only one of them (1-A-11). One specimen recovered from the Dundee Formation probably belongs to this species. This new 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 for this morphologic type. The oral edge shows internal spines.

Angochitina n. sp. 2 has been found only in the Arkona Formation. It has been recovered at three levels in the Arkona core and one in the Argor core; it is rare in two, uncommon in one, and abundant (40 specimens) in one. 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 spines are widely spaced over the chamber and not in great numbers. 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 with that of Angochitina milanensis, but the difference in ornamentation easily separates them.

Angochitina sp. 1 was recovered only from the Ipperwash and Widder Formations. In the Ipperwash Formation it was recovered from three samples. It is common in 3-A-5 and rare in 2-A-2 and 3-A-7. In the Widder Formation, it was recovered from four samples, being rare in 3-A-8 and 3-B-10, and uncommon in 1-A-8, and 2-A-16. Three of the Widder samples occur in the lower 15 feet of the formation, perhaps indicating some zonal potential. The high ratio of chamber to neck length (4:1) and ornamentation type sets this species apart from others of this genus. Spines range to 13 microns long, are simple to bifurcating, and some have wide flaring bases ranging up to 8 microns wide. The spines on the neck are slightly shorter. Too few well preserved specimens were found to establish this as a new species or as a variation of one already described.

Angochitina sp. 2 is rare in all the formations from which it was recovered. These are the Rockport Quarry, Arkona and Hungry Hollow Formations. One specimen was found in the Dundee Formation. In all a total of nine specimens were found and none are from the Ipperwash core. This species has a long neck, 61.2 microns in length, and a chamber nearly circular in vertical section. Annulate thickenings are present at the base of the neck and just above the flexure. The 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 was recovered to determine specific affinities and the range of variation of this form.

The genus Sphaerochitina is represented in the Hamilton Group by only one species. This is a new species and was found at only four levels, three in the Ipperwash Formation (2-A-2, 3-A-5, 3-A-7) and one in the Arkona Formation (1-A-31). It ranges in number from five to eleven per level. This species has ornamentation somewhat similar to that of S. spinigera Eisenack (1964), but the spines are finer, the neck is shorter, and the chamber more conical. Thus the differences seem significant enough to warrant setting up a new species.

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

Wilson and Dolly (1964) on reviewing the literature, raised some doubt as to the validity of the genus. They suppressed Calpichitina and included it in the genus Hoegisphaera Staplin (1961), which they emended. They transferred Calpichitina scabiosa, the type species of the genus, to Hoegisphaera scabiosa. In a letter from Jansonius, part of which was published in Wilson and Dolly (1964), he 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 keeping 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 have been yet reported.

The specimen found in the Hamilton Group has a distinct and wide collar. A collar or trace of one has not been observed on any of the many *Hoegisphaera* specimens which have been studied from the Hamilton Group. Although this specimen of *Calpichitina* has a larger diameter and a smoother wall than the material originally described as *Calpichitina*, the resemblance cannot be denied. Perhaps this genus should not have been suppressed and it is possible that further study might reinstate it. The one specimen found in the Hamilton Group is not enough evidence to do so, but it does indicate a possibility for eventual restudy of the situation. Although the genus *Calpichitina* has been suppressed by Wilson and Dolly (1964), and not yet been officially reinstated, the name has been used in this study. It is felt that placing the Hamilton specimen in either *Hoegisphaera* or *Desmochitina* would be erroneous.

Urban (1971, in press) has studied and emended the genus *Hoegisphaera*. He suggests that *Calpichitina scabiosa* does not belong in the genus *Hoegisphaera*, and thus that *Calpichitina* should be retained as a valid distinct genus.

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

Desmochitina bursa is absent from the Hungry Hollow and Ipperwash Formations. In the Bell Formation it is abundant in sample 1-A-51, and uncommon in the other eleven levels. In the Rockport Quarry Formation it is rare to uncommon. In the Arkona Formation it is abundant in one sample (1-A-31) and rare to uncommon in 39 other levels. It is rare in the Widder Formation only one specimen having been recovered (3-A-11). There is some similarity in occurrences and percentages of Chitinozoa assemblages between the Arkona and Ipperwash cores; but none with the Argor core.

Desmochitina bursa from the Hamilton Group is slightly larger than the type material on which the species is based (Taugourdeau and de Jekhowsky, 1960), from the Lower and Middle Devonian of north Africa. The type specimen for the species is 75 microns long and 100 microns wide, and the Hamilton species ranges from 89.3 to 99.5 microns long and 104.6 to 125.0 microns wide. The main distinguishing character of the species is its somewhat rectangular outline in lateral view and its finely tubercular 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 the Hamilton Group.

Desmochitina sp. is absent from the Hungry Hollow, Widder, and Ipperwash Formations. In the Bell Formation it is rare to common at twelve levels and abundant at two levels (2-A-48, 2-A-50). In the Rockport Quarry Formation it is rare to uncommon. In the Arkona Formation it is rare to common in 36 levels and abundant in one (1-A-25). In the Arkona core there are three levels (1-A-16, 1-A-20, 1-A-27) where the species makes up 50 to 56 per cent of the Chitinozoa. These high relative abundance levels have not been traced to the other cores.

Desmochitina sp. can be separated from D. bursa which was previously mentioned by its smaller width to length ratio which is 0.9 to 1.0 instead of 1.1 to 1.4, and its finer ornamentation. No chain formation was observed.

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

Eisenackitina castor is abundant at most levels where it occurs in the Bell, Rockport Quarry, and Arkona Formations. It shows five different sets of levels in the Arkona Formation, two in the Rockport Quarry, and one in the Bell Formation where it makes up a high percentage of the Chitinozoa assemblages. The above levels are traceable across the Arkona and Ipperwash cores, and with somewhat lesser accuracy in the Argor core.

Eisenackitina castor from the Hamilton Group 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. This is the case for all the Hamilton specimens except for a few which measure only 102.0 microns. In Eisenackitina the vesicles have simple morphology and thus specific assignment can be difficult. E. castor is characterized by a simple oral edge, 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 high 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 new species of Eisenackitina is restricted to the Bell, Rockport Quarry, and Arkona Formations where it is rare to abundant. It is closely related to E. castor in its occurrence and high percentages of the Chitinozoa assemblages occurring at approximately the same levels.

Eisenackitina n. sp. differs from E. castor in having a well developed though not prominent lip or collar at the oral edge. This feature is reduced and usually absent in Eisenackitina castor. The new species also has a well developed basal callus, and at times a copula, features not seen in E. castor. The ornamentation is the same in both forms. Thinning of the wall is not apparent in the new species.

Eisenackitina sp. is rare in Rockport Quarry and Arkona Formations. Only six specimens have been recovered. This species agrees in morphology with the generic description (Jansonius, 1964). When Jansonius described the genus he stated that the greatest width was near the base, and that 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 in E. castor can be and generally is rounded.

The genus Hoegisphaera is represented by one species in the Hamilton Group: H. cf. H. glabra. This genus whose type species is H. glabra was defined by Staplin (1961). It has been emended by Urban (1971, in press). This emendation was effected to alter the definition to include a distal carina which can vary from reduced to extended. Inclusion of this character does not alter the interpretation of this genus other than to exclude Hoegisphaera scabiosa which should have stayed in Calpichitina, and H. bransoni. This character could perhaps be of importance at the specific level, but not at the generic level. This emendation is not necessary or warranted.

In the Hamilton Group Hoegisphaera cf. H. glabra occurs in all the formations and in the Dundee Formation. It is rare to abundant in the Hamilton Group formations. In some levels this form dominates the Chitinozoa assemblage (up to 100 per cent) but these levels are not traceable from core to core. In the Ipperwash core, this species is less abundant than in the other cores.

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 the species of Eisenackitina. Differences between Hoegisphaera specimens are in the ornamentation; the size and shape of the vesicle are the same. Consequently the Hamilton Group specimens are considered as only one species. H. 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. Great care was exercised in processing the samples. Some apparently delicate membrane structure surrounding and attached to laevigate specimens of *Hoegisphaera* was recovered. 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 condition and not induced.

Taugourdeau (1965) has stated that the only reliable criterion for distinguishing species of *Hoegisphaera* is size. Using that criterion the Hamilton species falls immediately below the range attributed to *H. glabra*: the range of *H. glabra* is 110 to 130 microns, and that of the Hamilton specimens is 102.0 to 110.9 microns. On size. *H. glabra* and the Hamilton specimens are very closely related although *H. glabra* is defined as being laevigate. Because ornamented forms from the Hamilton Group are included in the same species with laevigate forms, assignment to *H. glabra* could be questioned. It might be desirable to expand the definition of *H. glabra* to include ornamented species.

Bouche (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. Bouche 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. The Hamilton specimens are not predominantly lenticular.

Some Hoegisphaera specimens have been recovered from the Hamilton Group which add a new dimension to the knowledge of Chitinozoa life habit. The occurrence of Chitinozoa in chains is a well-documented fact; the genus Desmochitina in particular has many representatives of this phenomenon. The chain consists of the oral edge of one individual being appressed to the aboral edge of the next individual above it. Some structures have developed, such as the copula, the basal callus, and the siphon, which give clear indication that the life habit of Chitinozoa, at least for some part of their cycle, was in a chain.

Another type of life habit was described by Kozlowski (1963). He found material in which the Chitinozoa occurred in aggregates, somewhat analogous to bunches of grapes, in which the aboral ends are fixed but the apertures are free and directed outward. He found single chains, double chains, and large masses in which the Chitinozoa were slightly superposed on each other. He also found aggregates like those previously described which were included in a cocoon-like wrapping. This type of cluster is relatively rare but it does indicate diversification in life habit.

A third type of life habit has been observed in the Hamilton material. Specimens belonging to the genus Hoegisphaera have never been reported to occur in either chains or bunches. It now can be shown that Hoegisphaera lived in a colonial aggregate of discrete vesicles separated from each other and held together by organic material. In a few of the Hamilton specimens a membrane, lighter in color than the vesicle, and apparently more porous in structure, was observed clinging to some Hoegisphaera. Aggregates of two and three vesicles (Pl. IX, figs. 6, 8) were also observed. In these instances the vesicles are not in immediate contact with each other. They are held together by a membranous material which surrounds each vesicle and extends to and around the other. The vesicles are in lateral succession rather than in oral to aboral succession. This occurrence is rare, but it does indicate that Hoegisphaera developed neither in chains nor in clusters, but rather in lateral associations and joined by an external membrane. This habit may suggest a colonial structure in which the individuals are contemporary and independent of each other. In chains, there is obviously some dependence when the aperture of one vesicle is closed by another vesicle. In the clusters, there would be no interaction between vesicles if the Chitinozoa were eggs or cyst-like structures.

A new genus and species (Pl. X, figs. 4-11) was found in the Hamilton Group which fits well in to the Tribe Desmochitina. This genus is rare in the Rockport Quarry, Hungry Hollow, and Widder Formations, rare to uncommon in the Arkona Formation and rare to common in the Bell Formation. In no sampled level does it make up a large percentage of the Chitinozoa assemblage.

Specimens of the new genus consist of forms with a short cylindrical vesicle, a flat to indented base, and parallel sides. The width is often greater than the length. There is no evidence of opercular structures. The ornament consists of short stubby conical spines distributed over all the vesicle. Chain formation was observed (Pl. X, figs. 10, 11) in one instance. This genus differs from Desmochitina in that there is no differentiation at the oral edge and it has a distinct quadrangular aspect in profile. Some species of Desmochitina, i. e. D. bursa, have little if any oral differentiation, but the lateral profile aspect is never as quadrangular as in the new genus. This new genus differs from Hoegisphaera in not being spherical, and from Eisenackitina which generally has a longer vesicle and thus different width to length ratios. The vesicle sides in the new genus are more nearly parallel while in Eisenackitina there is some tapering.

The basal surface instead of being thickened or having joining structures is thin and often so weak that it is broken. Even in the two vesicles which were found in a chain, the basal weakness is apparent.

Conochitina edjelensis is rare in the Hamilton Group, only one specimen has been observed and that in the Arkona Formation (1-A-13). The species was described (Taugourdeau, 1963) from the Middle and Upper Llandovery of north Africa. It differs from C. simplex in not ever having a basal callus. The Hamilton specimen is within the size range of the type specimens for the species.

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

Only one specimen of Rhabdochitina sp. 1 was found and it occurs in the Ipperwash Formation (3-A-2). The vesicle is long (351.9 microns), cylindrical, with a slight enlargement at the basal end. The large size and cylindrical shape distinguish it from the other two forms of this genus in the Hamilton Group.

One specimen of Rhabdochitina sp. 2 was found in the Rockport Quarry Formation (2-A-47). This form is subconical and is somewhat like Lagenochitina, but it lacks a differentiated neck.

The one specimen of Rhabdochitina sp. 3 was observed in the Rockport Quarry Formation (2-A-43). It is long (306.0 microns) and cylindrical. It does not have the basal enlargement present in R. sp. 1. It is ornamented by short stubby conical spines, and thus differs from both Rhabdochitina sp. 1 and R. sp. 2 which are laevigate. In the one observed specimen there is a constriction one-third of the distance up from the base. This feature could be due to mechanical distortion, in which case, it would be of no taxonomic value. It is possible that this specimen could be an abnormal development of a Rhabdochitina species or a form of Eisenackitina, since their ornamentation is somewhat similar.

Hercochitina aff. H. turnbulli is rare in the two levels in which it occurs (1-A-31, 3-A-5). In size, shape, and longitudinal alignment of spines it is somewhat similar to H. turnbulli. But in the latter species, the spines are numerous and fused terminally. There are fewer spines in the Hamilton specimens, and they are free at their tips. The longitudinal alignment of the spines is sometimes difficult to discern.

Kalochitina ? sp. occurs in three of the Hamilton Group formations. It is rare in the Arkona, rare to abundant in the Widder, and common in the Ipperwash. This species has randomly distributed spines and a longer neck than H. aff. H. turnbulli. The neck development is not as great as in Hercochitina and Belonechitina. Therefore the species is tentatively assigned to Kalochitina.

The genus Cyathochitina is represented by a form which is rare to uncommon in the Arkona Formation, rare in the Hungry Hollow Formation, and uncommon in the Widder Formation. Cyathochitina is defined as having a carina at the basal edge (Eisenack, 1955). The Hamilton specimens possess a sharp basal edge which is interpreted as perhaps indicating a reduced carina. On this morphologic basis, C. kuckersiana subsp. kuckersiana is the form it most closely resembles. But it has not yet been reported from the Devonian.

The genus Lagenochitina is represented in the Hamilton Group by three species, two referrable to named species, and one unnamed.

Lagenochitina cf. L. amottensis is rare to uncommon in the Bell Formation, and rare in the Rockport Quarry and Ipperwash Formations. It is similar to L. amottensis described from the Middle and Upper Devonian of Morocco (Grignani and Mantovani, 1964). Because the Hamilton specimens are distorted and broken, and their original shape must be postulated, there is some difficulty in comparing them.

Lagenochitina cf. L. brevicollis is rare in the Bell, Arkona, and Ipperwash Formations, and rare to uncommon in the Widder Formation. The type material for this species (Taugourdeau and de Jekhowsky, 1960) from the Ordovician of north Africa, is larger by 90 to 100 microns than the Hamilton specimens, but both groups of specimens are similar in shape.

Lagenochitina sp. is rare in the Bell, Rockport Quarry, Hungry Hollow, and Ipperwash Formations, rare to common in the Arkona Formation, and rare to uncommon in the Widder Formation. This species shows some similarity with L. crassa from the Middle and Upper Devonian of Morocco (Grignani and Mantovaní, 1964). It has a less differentiated neck and less rounded chamber than L. crassa. It also resembles a form which Cramer (1964) described from the Ludlovian of northwest Spain and called Sphaerochitina llorona. The genus Sphaerochitina has generally been interpreted to include forms with tiny tubercles or spinules on an otherwise smooth wall (Collinson and Scott, 1958). In the original description of Sphaerochitina, Eisenack (1955) stated that the walls are smooth or have tubercles. This is the true description of the genus and this smooth form should be eligible for inclusion in this genus. This is the interpretation that Cramer followed and therefore his generic assignment is not incorrect. It can be seen however that this might bring forth confusion because of the overlap with Lagenochitina. It is recommended that Sphaerochitina be restudied keeping in mind the albeit erroneous but nevertheless practical misinterpretation of the genus. Emendation may be justified in the interest of practicality.

Acritarcha

Baltisphaeridium sp. occurs in the Bell Formation where only one specimen was found. The specimen is a hollow spherical vesicle with solid simple spines, 13 microns long, sparsely distributed over the vesicle.

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

Cymatiosphaera "*canadensis*" was found in all the formations of the Hamilton Group. It is rare to abundant in the Bell, Rockport Quarry, Arkona and Hungry Hollow Formations, and rare to uncommon in the Widder and Ipperwash Formations. In the Bell and Arkona Formations, it makes up a high percentage of the Acritarch assemblage (50 to 60 per cent) at various levels. These peaks are not traceable from core to core, and thus do not constitute biostratigraphic zones.

The species *C.* "*canadensis*" is not valid. Deunff (1954) who named it, failed to give a description and a collection locality for the species. All he provided was a drawn illustration, the name in the figure legend, and the fact that he had recovered the specimen from a *Favosites* polyp from the Onondaga of Ontario. This is not enough to set up a valid species. The name is used 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 as it now stands. 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 sp. was found in all the formations of the Hamilton Group, but it is rare in all of its occurrences. It is a delicate form with thin crests. It shows less variation in number of polygonal areas than does C. "canadensis".

Dictyotidium dictyotum was recovered from all but one of the Hamilton Group formations. It is rare to abundant in the Bell and Arkona Formations, rare to common in the Rockport Quarry Formation, and rare in the Hungry Hollow and Widder Formations. It is absent from the Ipperwash Formation. These Hamilton specimens show less size variation than do the Silurian specimens on which the species is based (Eisenack, 1955). There is variation however in the degree of coarseness of the reticulation on the vesicle wall. There are fine forms in which the lacunar areas are small and numerous, and coarser forms in which the lacunar areas are larger and less numerous. These latter forms are only slightly more reticulate than fine forms of C. "canadensis".

New genus C was recovered from all the Hamilton Group formations except for the Ipperwash Formation. It is rare to uncommon in the Bell, rare in the Rockport Quarry and Widder Formations, rare to abundant in the Arkona Formation, and uncommon in the Hungry Hollow Formation. It consists of a hollow polyhedral vesicle with an equatorial edge indented by large pits, 5 microns wide, which give it a scalloped appearance. Each hemisphere is made up of two to four segments only, separated by ridges diverging away from the polar areas. This new genus has less faces than Polyedrixium 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 indentations caused by corrosion of Cymatiosphaera are not regularly disposed.

Quisquilites n. sp. was recovered from all the Hamilton Group formations. It is rare to abundant in all except the Ipperwash Formation where it is rare. There are two zones in the Bell Formation, one in the Rockport Quarry Formation, and three in the Arkona Formation where the species constitutes high percentages of the Acritarcha assemblages. These high percentage zones are traceable across the three cores. This species of Quisquilites differs from Quisquilites buckhornensis in being longer and less varied in width. Q. buckhornensis has been found in curved attitude, but this was never the case with the Hamilton specimens which are invariably straight. Q. buckhornensis varies from cylindrical to bean-shaped, but the Hamilton specimens are exclusively cylindrical.

The genus Veryhachium is represented by three species: V. cf. V. lairdi, V. sp. 1 and V. sp. 2. This genus consists of polygonal to subpolygonal tests with three to eight closed hollow spines. Simple morphology of this type can only provide a limited number of variations. The exceedingly great number of species attributed to this genus is unrealistic and renders the genus and its species less than useful. Species have been separated on the criteria of straightness of the walls (V. lairdi and V. valiente); such criteria are influenced by diagenesis and processing and therefore do not necessarily separate species. The genus Evittia was erected to include Veryhachium-like forms in which the spines were branched, but not all the Veryhachium species with branched spines were transferred to Evittia. Therefore the value of the distinction remains untested. A detailed study of all species of Veryhachium should be undertaken in order to determine how fine a division can be effected and still retain a realistic and useful species. It is quite probable that many so-called species should be lumped together.

Veryhachium cf. V. lairdi is rare to abundant in all the Hamilton Group Formations, except the Rockport Quarry where it is uncommon to abundant. In the Arkona Formation there are three zones where this species constitutes moderately high percentages of the Acritarcha assemblages. These zones are roughly traceable across the three cores. Veryhachium cf. V. lairdi includes triangular and square forms with one or two spines projecting from the vesicle faces, and the apices prolonged into spines. All the included forms can be reasonably assumed to belong to the same species, although some workers might split them into several species. This is not warranted in this case.

Veryhachium sp. 1 is rare to abundant in the Bell Formation, rare in the Rockport Quarry Formation, rare to common in the Arkona and Hungry Hollow Formations, rare to uncommon in the Widder Formation. It is absent from the Ipperwash Formation. This is a rather coarse form with granulose walls in which the apices are not tapered into long spines, but only slightly extended into coarse processes.

Veryhachium sp. 2 is rare in all the Hamilton Group formations except in the Rockport Quarry where it is rare to common. This is a distinctive form made up of two superposed triangular units offset by 60° in the same plane.

The genus Polyedrixium is represented by two species in the Hamilton Group. This genus is invalid. It lacks a described type species and a type locality. When he described the genus in a footnote, Deunff (1955) named a type species, P. deflandrei, as well as four other species. His generic diagnosis would have covered the type species had the genus been monotypic, but this was not the case. Jansonius (1962) emended the genus and named P. deflandrei as lectotype provisionally until Deunff redescribed it. This has not yet been done, therefore the genus remains invalid. The name will be used in this study for practical purposes, but its invalidity will be indicated by quotation marks.

"Polyedrixium cuboides" is rare to uncommon in the Bell, Rockport Quarry and Hungry Hollow Formations, rare to abundant in the Arkona Formation, and rare in the Widder and Ipperwash Formations. At no time does it assume any relative numerical importance in the Hamilton Group. This specific name is invalid for the same reasons as Cymatiosphaera "canadensis" was invalid: it lacks a description and type locality. This is a sturdy coarse form with a cubic vesicle in which the faces are often centrally depressed.

"Polyedrixium pharaonis" is rare to common in the Bell, Hungry Hollow and Ipperwash Formations, and rare to abundant in the Rockport Quarry, Arkona and Widder Formations. This species also is invalid because it lacks description and type locality. This is a delicate, nearly always transparent form in which the apices of the cube are prolonged in long tapering spines, longer than the cube edge.

Tornacia sp. was only recovered from the Dundee Formation. It consists of a spherical vesicle with equatorially disposed spines, 15 microns long. This specimen is considerably larger than the type species, *Tornacia sarjeanti*, by approximately 40 microns.

Triangulina cf. *T. alargada* is rare to common in the Arkona Formation, and rare in the Bell and Rockport Quarry Formations. It is similar in shape and structure to the type specimen which Cramer (1964) described from the Emsian of northwest Spain. It is larger than the type specimen, and the inner body is not darker than the outer body as in Cramer's specimen. This genus differs from *Onondagella* (Cramer, 1966) in that the processes are shorter and the asymmetry less pronounced.

The genus *Leiosphaeridia* is represented by two species in the Hamilton Group. It is rare to abundant in all the formation. *Leiosphaeridia* sp. 1 is an imperforate thin-walled laevigate species in which no pylome has been observed. It was observed in a wide range of sizes, but this range is divisible into two discrete units: 20 to 110 microns, and 130 to 270 microns. This size break might indicate a natural separation of two species. *L.* sp. 2 has a thicker imperforate wall and a slit-like pylome.

Tunisphaeridium concentricum is rare in all the Hamilton Group formations except the Arkona Formation where it is rare to common. It is a species consisting of a spherical vesicle, 36 to 46 microns in diameter with more than 15 spines of equal length (20 to 28 microns) whose outer tips are flared and interconnected by a very delicate thin membrane.

Tasmanites sp. is rare to abundant in all the Hamilton Group formations. It consists of a thick-walled opaque spherical vesicle with pores perforating it. It is described and included with the acritarchs although its affinities have been determined with the Chlorophyceae.

Spores

Spores have been recovered from all of the Hamilton Group Formations. There are many genera and species represented at various levels. At no time does any species assume any numerical importance. There appear to be several new forms, as well as some forms whose geological ranges will have to be extended as a result of their being found in the Hamilton Group. Their numbers and complexity warrant a separate study being made of them.

CHAPTER VI

SYSTEMATIC PALEONTOLOGY

Introduction

The Chitinozoa described in this section have been classified according to the system proposed by Jansonius (1967) in which he divided them into five tribes. This division is based on morphological features and is arbitrary.

The Acritarcha have been classified according to the system proposed by Downie, Evitt and Sarjeant (1963) which is also based on morphological criteria.

Chitinozoa

Tribe ANCYROCHITINA

Genus ALPENACHITINA

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. (after Jansonius, 1967)

Alpenachitina n. sp.

(Pl. I, figs 1,2)

Description

Vesicle cylindro-conoidal; chamber conical making up 0.6 of total 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 around basal edge of seven long (approximately 20 microns), coarse, complexly branching spines with some shorter and thinner spines between them, second row of four to five long (up to 26 microns), coarse, branching spines at approximately 0.7 the distance up chamber from base, oral edge fringed with short (7 microns) spines, remainder of surface laevigate.

Dimensions (in microns)

Specimen	1-A-50
Vesicle length L	107.0
Neck length l	30.6
Chamber width W	79.1
Neck width N	28.1
W/L	0.7
l/L	0.4
Apical angle	60°

Occurrence

Widder Formation : rare (2 specimens)

Dundee Formation : 7 specimens

Discussion

This new 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 a smaller number of spines (7) around the chamber than A. eisenacki has (10 to 12); it has only one ring on the collar while A. eisenacki has a ring of 5 or 6 spines, less complex spines at midlength of the neck, and spines between the ring and the oral opening; and it has many smaller spines at the oral edge.

This species is rare in the Hamilton Group, occurring only in the Widder Formation, but it has also been observed in the Dundee Formation.

Genus ANCYROCHITINA

Ancyrochitina Eisenack, 1955

Type species : Ancyrochitina ancyrea Eisenack, 1955

Small vesicle, 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. (after Jansonius, 1967)

Ancyrochitina cf. A. cornigera Collinson and Scott, 1958
(Pl. I, figs 3-9, Pl. II, figs 1-3)

Description

Vesicle cylindro-conoidal; chamber conical with apical angel ranging from 40° to 70°, base flat to slightly convex, sides straight; flexure distinct to imperceptible; neck cylindrical with or without flaring; ornamentation of spines, three to seven at basal edge, 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

(see next page)

Occurrence

Ipperwash Formation : rare to abundant

Widder Formation : rare to abundant

Hungry Hollow Formation : rare

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to abundant

Bell Formation : uncommon.

Discussion

Collinson and Scott (1958) described Ancyrochitina cornigera from the Cedar Valley Formation

Dimensions (in microns)

Specimens	1-A-48	2-B-4	3-A-26	3-A-27	3-A-28	3-A-37	3-A-37
Vesicle length L	160.7	127.5	125.0	114.8	112.2	104.6	102.0
Neck length l	63.8	61.2	56.1	38.3	--	38.6	28.1
Chamber width W	99.5	94.4	94.4	76.5	56.1	71.4	66.3
Neck width N	40.8	38.3	45.9	38.3	28.1	35.7	28.1
W/L	0.6	0.6	0.8	0.7	0.5	0.7	0.7
l/L	0.4	0.5	0.5	0.3	--	0.4	0.3
Apical angle	58°	77°	67°	43°	40°	47°	41°
Flexure angle	60°	55°	63°	71°	--	70°	77°

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 from the Hamilton Group (102.0 to 160.7 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 which they mentioned and illustrated is sparse.

Specimens from the Hamilton Group have a much wider range of variation in basal edge spines. Some spines are short and stubby, like the Cedar Valley specimens, but some are perforate. These perforations range in size from 1 to 8 microns, and may penetrate only one or both walls of the spines. A gradation has been observed from simply pierced to clavate processes.

The oral edge of Hamilton Group specimens is ornamented with a fringe of spines. These spines range in size from short stubs a few microns long, to longer spines, up to 13 microns long, and they can be simple to complexly bifurcating.

The Hamilton and Cedar Valley Formation forms appear closely related, if not conspecific, in spite of the size discrepancy.

Ancyrochitina cf. A. desmea Eisenack, 1964

(Pl. II, figs 4-6)

Description

Vesicle cylindro-spheroidal; chamber conical with apical angle of 64°, 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	2-A-12
Vesicle length L	117.3
Neck length l	48.5
Chamber width W	79.1
Neck width N	30.6
W/L	0.7
l/L	0.4
Apical angle	60°
Flexure angle	64°

Occurrence

Widder Formation : rare to uncommon

Hungry Hollow Formation : uncommon

Arkona Formation : rare

Discussion

The species Ancyrochitina desmea was described by Eisenack (1964) 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.

In his original description, Eisenack (1964) mentioned appendages approximately midlength of the neck. In both the Brazilian and Hamilton specimens, the spines are situated slightly nearer to the oral opening.

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 specimen being 117.3 microns. But the relative proportions of length to width remain similar.

? Ancyrochitina gordita Cramer, 1964

(Pl. II, figs 7-10)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle ranging from 54° to 60°, 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" 25.5 by 30.6 microns observed.

Dimensions (in microns)

Specimens	1-A-9	1-A-44	3-A-27	3-A-47
Vesicle length L	99.5	102.0	94.4	94.4
Neck length l	--	23.0	25.5	--
Chamber width W	89.3	91.8	79.1	89.3
Neck width N	33.2	33.2	38.3	33.2
W/L	0.9	0.9	0.8	0.9
l/L	--	0.2	0.3	--
Apical angle	60°	55°	55°	54°
Flexure angle	67°	-	--	

<u>Occurrence</u>

Ipperwash Formation : rare to common

Widder Formatiin : rare

Hungry Hollow Formation : rare

Arkona Formation : rare to uncommon

Bell Formation : rare to uncommon

Dundee Formation : 3 specimens

<u>Discussion</u>

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". In the Hamilton specimens, a much wider range of ornamentation is observed. There are simple forms with no evident ornamentation (Pl. II, fig. 7), some with short stubby spines at the oral opening (Pl. II, fig. 9), some with long simple to complex spines at the oral opening (Pl. II, fig. 8); there are also forms with complex spines at the base and some with less obvious, perhaps, broken, ornamentation in that area.

The specimen Cramer described is larger than the Hamilton specimens; Cramer's is approximately 150 microns in length, and the Hamilton specimens vary from 94.4 to 102.0 microns. In spite of the size discrepancy and wider range in type of ornamentation, the Hamilton species is considered conspecific with the originally described species.

<u>Ancyrochitina</u> cf. <u>A.</u> <u>langei</u> Sommer and van Boekel, 1964

(Pl. II, figs 11,12; Pl. III, figs 1-9)

<u>Description</u>

Vesicle cylindro-conoidal; chamber conical with apical angle ranging from 40° to 65°, 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 3 to 8 spines, 10 to 60 microns long, simple to terminally branching, some with slightly bulbous tips; oral edge fringed with simple to branching spines, 1 to 40 microns long; "plug", when present, with aborally oriented spines.

Dimensions

(see next page)

Dimensions (in microns)

Specimens	1-A-9	1-A-9	1-A-9	1-A-38	1-A-44	1-A-47	1-A-47
Vesicle length L	109.7	119.9	155.6	112.4	112.2	119.9	147.9
Neck length l	--	--	76.5	38.3	--	33.2	63.8
Chamber width W	86.7	96.9	89.3	89.3	94.4	79.1	81.6
Neck width N	28.1	33.2	38.3	33.2	30.6	30.6	66.3
W/L	0.7	0.8	0.6	0.8	0.8	0.7	0.6
l/L	--	--	0.5	0.3	--	0.3	0.4
Apical angle	57°	-	53°	54°	65°	48°	45°
Flexure angle	-	--	61°	70°	--	70°	70°

Dimensions (in microns)

Specimens	1-A-48	2-A-51	2-A-51	2-A-51	2-A-51	2-A-54	2-A-59	2-B-4
Vesicle length L	117.3	114.8	119.9	--	125.5	135.2	102.0	168.3
Neck length l	--	--	--	--	51.0	--	--	94.4
Chamber width W	96.9	71.4	68.9	81.6	96.9	89.3	81.6	102.0
Neck width N	28.1	40.8	28.1	33.2	38.3	30.6	30.6	38.3
W/L	0.8	0.6	0.6	--	0.8	0.7	0.8	0.6
l/L	--	--	--	--	0.4	--	--	0.2
Apical angle	--	42°	40°	--	60°	40°	--	50°
Flexure angle	--	--	--	--	67°	--	--	70°

Occurrence

Ipperwash Formation : rare to abundant

Widder Formation : rare to abundant

Hungry Hollow Formation : abundant

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to abundant

Bell Formation : rare to abundant

Dundee Formation : 104 specimens

Discussion

Sommer and van Boekel (1964) described *Ancyrochitina langei* from Lower Devonian beds of Brasil 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 the majority of the Hamilton specimens, being 165 microns.

The specimens from the Hamilton Group show a much wider range of variation than does the type material. The range in number of basal edge spines varies from 2 to 8 instead of from 2 to 6; the basal spines are simple to complex instead of simple; the oral edge spines vary from less well developed than the type specimens to equally well developed, and from simple to complex. Sommer and van Boekel (1964) mentioned only that the oral edge spines of this species are shorter and thinner than the basal edge spines, and did not comment on their being simple or complex.

The Hamilton specimens assigned to Ancyrochitina of A. langei resemble A. pilosa curta Taugourdeau (1962), from the Frasnian of North Africa. The vesicle length and chamber width dimensions are similar. The apical angle in A. pilosa curta is 70°, and thus greater than in the Hamilton specimens where the angle ranges from 40° to 65°. The neck in A. pilosa curta is shorter than in 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 groups they branch terminally. The oral edge spines vary from hair-like spines to sparse conical tubercles.

The vesicle shape of the Hamilton specimens is more closely related to that of A. langei. The type of ornamentation of the Hamilton specimens is also more closely similar to that of A. langei than it is to A. pilosa curta. 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 do occur within one species collected from different localities. Thus the criterion of size is not always diagnostic of a species.

Ancyrochitina langei has been reported from Lower Devonian strata of Brazil and Bolivia, while A. pilosa curta has been reported from lower Upper Devonian strata of North Africa. The Hamilton specimens provide an intermediate in stratigraphic position and in morphological characters between these species. Further study of more material from other Devonian deposits might possibly show that A. langei, A. cf. A. langei, and A. pilosa curta are further related.

Ancyrochitina cf. A. multiramosa
Taugourdeau and de Jekhowsky, 1960
(Pl. IV, fig. 1)

Description

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

Dimensions (in microns)

Specimen	1-A-9
Vesicle length L	114.8
Neck length l	48.5
Chamber width W	68.9
Neck width N	33.2
W/L	0.7
l/L	0.4
Apical angle	50°
Flexure angle	70°

Occurrence

Widder Formation : rare (1 specimen)

Dundee Formation : 7 specimens

Discussion

Taugourdeau and de Jekhowsky (1960) described this species from the Silurian of North Africa. Their holotype is larger than the Hamilton specimen by approximately 40 microns. Their specimen has a smaller width to length ratio (0.5) than the Hamilton species has (0.7). They stated that the number of basal spines is much larger than in any other species of the genus Ancyrochitina. On this basis there is some similarity between these forms.

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. This could perhaps indicate that there may have been a row of spines in that area. This is not borne out, however, in other specimens attributed to this species from the Hamilton Group. Those specimens have neither spines nor pits at the flexure. This characteristic probably indicates areas which were weaker (thinner?) and therefore more susceptible to solution during diagenesis or sample processing.

Ancyrochitina tomentosa

Taugourdeau and de Jekhowsky, 1960

(Pl. IV; fig. 2)

Description

Vesicle cylindro-conoidal; 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	1-A-2
Vesicle length L	107.1
Neck length l	33.2
Chamber width W	79.1
Neck width N	40.8
W/L	0.7
l/L	0.3

Occurrence

Widder Formation : rare (2 specimens)

Discussion

Taugourdeau and de Jekhowsky (1960) described this species from a Silurian to Upper Devonian sequence in North Africa. The African specimens are much larger (holotype : 160 microns) than the Hamilton specimen (107.0 microns). The overall shapes and ornamentation of both forms are nearly identical, and consequently the Hamilton specimens are considered conspecific with the African.

Ancyrochitina cf. *A. tumida*

Taugourdeau and de Jekhowsky, 1960

(Pl. IV; figs 3-7)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle ranging from 55° to 69°, base slightly convex, sides straight; flexure distinct, angle ranging from 59° to 69°; neck cylindrical with slight oral tapering in some instances; ornamentation of 2 to 8 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

(see next page)

Occurrence

Hungry Hollow Formation : uncommon

Arkona Formation : rare to uncommon

Rockport Quarry Formation : rare to common

Bell Formation : rare

Discussion

The material which Taugourdeau and de Jekhowsky (1960) described from Silurian to Middle Devonian strata in

Dimensions (in microns)

Specimens	1-A-22	1-A-45	1-A-45	1-A-47	1-A-48	2-A-61
Vesicle length L	125.0	119.9	117.3	130.1	130.1	117.3
Neck length l	51.0	35.7	28.1	51.0	45.9	38.1
Chamber width W	86.7	94.4	89.3	99.5	76.5	86.7
Neck width N	38.3	33.2	43.4	35.7	33.2	43.4
W/L	0.7	0.8	0.8	0.8	0.6	0.7
l/L	0.5	0.3	0.2	0.4	0.4	0.3
Apical angle	61°	63°	59°	55°	69°	60°
Flexure angle	83°	59°	60°	69°	62°	68°

North Africa does not show spinose ornamentation at the oral opening. The Hamilton specimens are similar to the African, but oral ornamentation is present. For this reason, the Hamilton specimens might be separated from Ancyrochitina tumida.

Ancyrochitina n. sp. 1

(Pl. IV; figs 8-9)

Description

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

Dimensions (in microns)

Specimen	3-A-27
Vesicle length L	125.0
Neck length l	53.6
Chamber width W	96.9
Neck width N	33.2
W/L	0.8
l/L	0.4
Apical angle	72°
Flexure angle	45°

Occurrence

Widder Formation : rare (1 specimen)

Arkona Formation : rare to uncommon

Rockport Quarry Formation : rare

Bell Formation : rare to common

Discussion

The general shape of the vesicle and proportions are somewhat similar to those of *Ancyrochitina langei* Sommer and van Boekel (1964). The apical angle in this species (72°) is larger than that in *A.* cf. *A. langei* (40° to 65°) from the Hamilton Group.

The oral edge ornamentation is the distinguishing character of this species. The oral edge is fringed by a thick ring of closely spaced coarse spines, 3 microns wide, which taper only at their tips. *A. langei* has oral edge ornamentation, but it is not as dense nor as large as that of this new species.

Ancyrochitina n. sp. 2

(Pl. IV, figs 10-12; Pl. V, figs 1-2)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle ranging from 45° to 66°, base flat to convex, sides straight; flexure distinct to imperceptible; neck cylindrical with or without slight oral flaring; ornamentation 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 14 microns long).

Dimensions

(See next page)

Occurrence

Ipperwash Formation : rare

Widder Formation : rare to uncommon

Hungry Hollow Formation : rare to uncommon

Arkona Formation : rare to abundant

Bell Formation : rare to common

Dundee Formation : 13 specimens

Discussion

The distinctive characteristic of this species is the ornamentation at the oral edge, and, if present, only slight basal edge ornamentation.

Cousminer (1964, unpublished Ph.D. dissertation) described *Ancyrochitina depilosa*, a new species from the Devonian of South America. The Hamilton specimens agree with his description of *A. depilosa* and are therefore considered conspecific with that species. Cousminer indicated a geological range of Middle Devonian to basal Upper Devonian (Frasnian) for *A. depilosa* (p. 173).

Dimensions (in microns)

Specimens	1-A-22	1-A-32	1-A-46	2-A-61	2-A-61	3-A-8	3-A-36	3-A-27
Vesicle length L	136.2	130.1	137.7	122.4	137.7	204.0	153.0	117.3
Neck length l	--	45.9	61.2	51.0	53.6	135.2	63.8	40.8
Chamber width W	96.9	99.5	96.9	89.3	84.2	91.8	94.4	79.1
Neck width N	28.1	40.8	35.7	33.2	33.2	48.5	38.3	35.7
W/L	0.8	0.8	0.7	0.7	0.6	0.5	0.6	0.7
l/L	--	0.4	0.4	0.4	0.4	0.7	0.4	0.4
Apical angle	52°	55°	59°	66°	56°	45°	55°	50°
Flexure angle	--	65°	48°	57°	73°	67°	68°	--

The name Ancyrochitina depilosa has not been published and consequently the name is not valid according to the International Code of Zoological Nomenclature. Hence, the Hamilton species has not been given the name A. depilosa.

One of the illustrated specimens from the Hamilton Group (Pl. IV, fig. 11) has a very long neck. Because only one specimen has that characteristic, it is considered aberrant and remains in this species.

Ancyrochitina sp. 1

(Pl. V, fig. 3)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle ranging from 59° to 71°, base slightly convex, sides straight to slightly concave; flexure distinct; neck cylindrical; ornamentation of 2 to 4 spines at basal edge, 15 microns long, coarse, simple to terminally branching, remainder of surface laevigate.

Dimensions (in microns)

Specimens	3-A-26	3-A-27
Vesicle length L	109.7	104.6
Neck length l	38.3	33.2
Chamber width W	89.3	81.6
Neck width N	35.7	35.7
W/L	0.8	0.8
l/L	0.4	0.3

Apical angle	59°	71°
Flexure angle	64°	55°

Occurrence

Widder Formation : rare (1 specimen)

Arkona Formation : rare (4 specimens)

Discussion

All the specimens of this species which were recovered are broken at the oral edge; therefore, it is not known whether the oral edge is ornamented or not. Only 5 specimens have been observed; consequently not enough is known to determine their taxonomic status.

Ancyrochitina sp. 2

(Pl. V, fig. 4)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle ranging from 49° to 55°, base slightly convex, 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)

Specimens	1-A-32	3-A-27
Vesicle length L	114.8	112.4
Neck length l	48.5	43.4
Chamber width W	74.0	81.6
Neck width N	33.2	35.7

W/L	0.6	0.7
l/L	0.4	0.4
Apical angle	49°	55°
Flexure angle	66°	74°

Occurrence

Arkona Formation : rare (3 specimens)

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 two conspecific. It is possible that the short spines visible on this species are longer spines which have broken off. Thus, not enough is known to effect definite taxonomic assignment.

Ancyrochitina sp. 3

(Pl. V, fig. 6)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle of 62°, base flat, sides straight; flexure distinct; neck cylindrical; ornament 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	1-A-4
Vesicle length L	119.9
Neck length l	48.5
Chamber width W	91.8
Neck width N	40.8
W/L	0.8
l/L	0.3
Apical angle	62°
Flexure angle	65°

Occurrence

Widder Formation : rare (3 specimens)

Discussion

The very delicate character and distribution of the ornamentation separated these specimens from any previously described species of the genus *Ancyrochitina*.

Ancyrochitina sp. 4

(Pl. V, fig. 5)

Description

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

Dimensions (in microns)

Specimen	1-A-9
Vesicle length L	178.5
Neck length l	86.7
Chamber width W	99.5
Neck width N	43.4
W/L	0.6
l/L	0.5
Apical angle	54°
Flexure angle	62°

Occurrence

Ipperwash Formation : rare (3 specimens)

Widder Formation : uncommon

Hungry Hollow Formation : rare (1 specimen)

Discussion

This form is characterized by its long neck and short hair-line spines on the neck. 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. This form does not resemble any previously described species of this genus.

Ancyrochitina sp. 5

(Pl. V, fig. 7)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle of 53°, 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, and coarse complexly branching spines, 18 microns long at oral edge, remainder of surface laevigate.

Dimensions (in microns)

Specimen	3-A-39
Vesicle length L	104.6
Neck length l	25.5
Chamber width W	74.0
Neck width N	33.2
W/L	0.7
l/L	0.2
Apical angle	53°
Flexure angle	66°

Occurrence

Arkona Formation : rare (1 specimen)

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 an extreme variation of the ornamentation of an already established species.

Ancyrochitina sp. 6

(Pl. V, fig. 8)

Description

Vesicle conical, slightly wider than long, base flat, sides straight; flexure indistinct; ornamentation a ring of tuft-like coarse, complexly branching spines, 18 microns long, at basal edge, and ring of 9 similar but shorter spines, 8 microns long, around oral opening, remainder of surface laevigate.

Dimensions (in microns)

Specimen	1-A-46
Vesicle length L	81.6
Chamber width W	86.7
Oral opening N	35.7
W/L	1.1

Occurrence

Bell Formation : rare (1 specimen)

Discussion

This Hamilton form has a very distinct type of ornamentation, tuft-like spines. This type of ornamentation has not yet been reported in any other published study. Because only one specimen was recovered, and studied, specific assignment cannot be effected.

Ancyrochitina sp. 7

(Pl. V, fig. 11)

Description

Vesicle cylindro-conoidal; chamber conical, making up approximately 0.5 of total vesicle length, apical angle of 50° to 52°, base flat to slightly convex, sides straight; flexure more or less distinct; neck conical flaring out from flexure; ornamentation on chamber very coarsely granulose, granules approximately 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)

Specimens	1-A-1	2-A-56
Vesicle length L	142.8	145.4
Neck length l	56.1	48.6
Chamber width W	76.5	74.0
Neck width N	25.5	25.5
Collar width	33.2	40.8
W/L	0.5	0.5
l/L	0.4	0.3
Apical angle	50°	52°

Occurrence

Widder Formation : rare (1 specimen)

Bell Formation : rare (1 specimen)

Discussion

The type of very coarse granulation which this species exhibits is very rare in Chitinozoa. It has been reported (Taugoudeau and de Jekhowsky, 1960) on *Urochitina verrucosa* from the Lower to Middle Devonian of the Sahara. It has also been observed on Lower Cambrian Chitinozoa.

Ancyrochitina sp. 8

(Pl. V, fig. 9)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle of 37°, 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	1-A-31
Vesicle length L	76.5
Chamber width W	74.0
Neck width N	25.5
W/L	1.0
Apical angle	37°

Occurrence

Arkona Formation : rare (1 specimen)

Discussion

This specimen is mechanically distorted, therefore the occurrence of a shoulder may not be inherent. This very spinose form does not correspond to any previously described species of this genus.

The tiny spines which seem to project from the inner surface are not a common feature on Chitinozoa.

? Ancyrochitina sp. 9

(Pl. V, fig. 10)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle of 36°, base convex, sides straight; flexure imperceptible; neck cylindrical, short; surface laevigate; "plug" observed in oral opening, 17.9 by 17.9 microns.

Dimensions (in microns)

Specimen	1-A-29
Vesicle length L	117.3
Neck length l	--
Chamber width W	76.5
Neck width N	25.5
W/L	0.7
l/L	--
Apical angle	36°

Occurrence

Ipperwash Formation : rare to common

Widder Formation : rare to common

Hungry Hollow Formation : common

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to common

Bell Formation : rare to common

Dundee Formation : 20 specimens

Discussion

This species, which is very common in the Hamilton Group, has the general shape of *Ancyrochitina*. It lacks any type of ornamentation however. In his original description of this genus Eisenack (1955) stated that it has spines at the basal edge. Further study of this genus revealed various species which had oral edge ornamentation as well as basal edge spines. Cousminer (1964, unpublished Ph.D. dissertation) described a species, *A. depilosa*, in which some specimens did not have basal edge ornamentation. The Hamilton specimens under consideration here lack ornamentation completely.

The genus *Cyathochitina* includes forms with conical chambers, cylindrical necks, and laevigate surfaces; but it is also characterized by the presence of a carina at the basal edge. Because the Hamilton specimens assigned to this species do not have a carina, it is not possible to include them in the genus *Cyathochitina*.

Although this group of Chitinozoa lacks ornamentation, its general shape seems to indicate that it belongs to the genus *Ancyrochitina*.

This species is closely related in shape and occurrence to Ancyrochitina cf. A. langei in the Hamilton Group. 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. n. sp. 2 from which the oral edge ornament has been weathered.

Genus ANGOCHITINA

Angochitina Eisenack 1931

Type species : Angochitina echinata Eisenack, 1931

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

Angochitina cf. A. ? collinsoni

Taugourdeau and de Jekhowsky, in Taugourdeau, 1961

(Pl. VI, figs 1, 2)

Description

Vesicle spheroidal; neck cylindrical, short, 20.4 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)

Specimens	1-A-8	2-A-14
Vesicle length L	86.7	114.8
Neck length l	--	20.4
Chamber width W	71.4	74.0
Neck width N	33.2	35.7
W/L	0.8	0.6
l/L	--	0.2

Occurrence

Widder Formation : rare to common

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 this specimen makes the generic assignment tenuous. The Hamilton form is smaller and has more spines than the type specimen for the species A.? collinsoni. One of the Hamilton specimens (Pl. VI, fig. 2) is also broken, but one is complete (Pl. VI, fig. 1).

Internal spines are visible inside the oral opening. Such spines are rare in Chitinozoa.

Angochitina devonica Eisenack, 1955

(Pl. VI, figs 3-5)

Description

Vesicle cylindro-spheroidal; chamber spheroidal to subspheroidal, making up approximately 0.6 of the total vesicle length, chamber width 0.5 vesicle length; flexure at approximately 0.6 of 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" 23.0 by 33.2 microns present in some cases.

Dimensions (in microns)

Specimens	1-A-6	1-A-8	2-A-14	2-A-14
Vesicle length L	142.8	150.5	155.6	137.7
Neck length l	58.7	58.7	66.3	58.7
Chamber width W	71.4	71.4	74.0	71.4
Neck width	25.0	40.8	40.8	38.3
W/L	0.5	0.5	0.5	0.5
l/L	0.4	0.4	0.4	0.4

<u>Occurrence</u>

Ipperwash Formation : rare to uncommon

Widder Formation : rare to common

<u>Discussion</u>

The holotype for this species (Eisenack, 1955) is 146 microns long whereas in the Hamilton specimens vesicle lengths vary from 137.7 to 155.6 microns. There is, therefore close agreement between the holotype, which is from Middle Devonian beds of Eifel, and the Hamilton specimens. Collinson and Scott (1958) described specimens from the Solon Member of the Cedar Valley Formation which belongs to this species that are considerably greater in size

(163 to 254 microns long) 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. VI, figs 3, 5) to coarse and complexly branching on others (Pl. VI, fig. 4).

<u>Angochitina</u> <u>milanensis</u> Collinson and Scott, 1958

(Pl. VI, figs 6-8)

<u>Description</u>

Vesicle cylindro-spheroidal; chamber spheroidal to subcylindrical with convexly rounded base, approximately 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)

Specimens	1-A-8	1-A-13	1-A-13
Vesicle length L	145.4	158.1	142.8
Neck length l	48.5	48.5	--
Chamber width W	71.4	66.3	71.4
Neck width N	35.7	40.8	38.3
W/L	0.5	0.4	0.5
l/L	0.4	0.3	--

Occurrence

Ipperwash Formation : rare

Widder Formation : rare to abundant

Arkona Formation : rare to uncommon

Discussion

In their original 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 portion 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 *A. cornigera*, there has been a substantial size differential, with the much larger specimens occurring in the Cedar Valley Formation.

Angochitina cf. *A. ramusculosa* Cramer, 1964

(Pl. VI, figs 9-11)

Description

Vesicle cylindro-spheroidal; chamber subspheroidal, making up approximately 0.7 to 0.8 of the total 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 terminally, distributed over all the vesicle, shorter spines on neck, oral opening fringed with spines, up to 5 microns long.

Dimensions (in microns)

Specimens	1-A-8	1-A-14	1-A-14
Vesicle length L	137.7	150.5	176.0
Neck length l	25.0	38.3	48.5
Chamber width W	66.3	66.3	66.3
Neck width N	38.3	35.7	43.4
W/L	0.5	0.4	0.4
l/L	0.2	0.3	0.3

<u>Occurrence</u>

Ipperwash Formation : rare to abundant

Widder Formation : rare to abundant

Hungry Hollow Formation : common

Arkona Formation : rare to abundant

<u>Discussion</u>

The figured specimens on which Cramer (1964) based the species <u>Angochitina</u> <u>ramusculosa</u>, from the Upper Ludlovian of northwest Spain, are less spinose than the Hamilton specimens. Cramer's specimens also have shorter vesicles and longer necks than do the Hamilton specimens. Of the figured specimens of the Hamilton Group, one (Pl. VI, fig. 10) 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, and does not occur in many specimens.

<u>Angochitina</u> <u>toyetae</u> Cramer, 1964

(Pl. VI, fig. 12; Pl. VII, figs 1, 2)

<u>Description</u>

Vesicle cylindro-spheroidal; chamber spheroidal, 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, on some specimens, more concentrated on neck on others, internal neck spines on one specimen; in some specimens neck wall slightly thinner than chamber wall.

Dimensions (in microns)

Specimens	1-A-6	1-A-6	1-A-7	1-A-15	1-B-2	2-B-2
Vesicle length L	127.5	130.1	104.6	132.6	155.6	130.1
Neck length l	48.5	40.8	40.8	25.5	48.5	45.9
Chamber width W	79.1	68.9	66.3	84.2	96.9	86.7
Neck width N	43.4	38.3	40.8	35.7	43.4	38.3
W/L	0.6	0.5	0.6	0.6	0.6	0.6
l/L	0.4	0.3	0.4	0.2	0.3	0.4

<u>Occurrence</u>

Ipperwash Formation : rare to abundant

Widder Formation : rare to abundant

Hungry Hollow Formation : rare

Arkona Formation : rare to uncommon

Bell Formation : uncommon.

Discussion

The ornamentation in this species shows some variation. In some specimens (Pl. VI, fig. 1) the spines are sparsely distributed over all the vesicle; in others (Pl. VI, fig. 2) those on the neck are slightly denser in distribution. In one figured specimen (Pl. VII, fig. 2) there are short internal spines at the oral opening. 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 which are present are either simple or simply bifurcating.

This species is based on specimens from northwest Spain which are Emsian (part) in age. Those specimens are slightly larger than the Hamilton specimens, and the character of the spines is clearer.

Angochitina n. sp. 1

(Pl. VII, fig. 4)

Description

Vesicle cylindro-spheroidal; chamber spheroidal, making up 0.8 of total vesicle length; flexure distinct; neck cylindrical with oral flaring; ornamentation of spines, up to 31 microns long, complexly branching terminally, 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	2-A-11
Vesicle length L	107.0
Neck length l	23.0
Chamber width W	68.9
Neck width N	33.2
W/L	0.6
l/L	0.2

<u>Occurrence</u>

Widder Formation : rare

Arkona Formation : rare to common

Dundee Formation : 1 specimen

<u>Discussion</u>

The nature and distribution of the ornamentation of this species is distinctive. The very long chamber spines, branching only at their terminal extremities, and their scattered distribution over the chamber, the shorter neck spines and their denser distribution, separate this species from any other described species of this genus.

At the neck, some of the spines project from the inner surface.

Angochitina n. sp. 2

(Pl. XII, figs 5, 6)

Description

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

Dimensions (in microns)

Specimen	2-A-26
Vesicle length L	137.7
Neck length l	40.8
Chamber width W	81.6
Neck width N	40.8
W/L	0.6
l/L	0.3
Flexure angle	60°

Occurrence

Arkona Formation : rare

Discussion

The type of ornamentation on this species is the character which separates this species from all others in the genus *Angochitina*. The general vesicle shape is similar to that of *A. milanensis*, but its ornamentation is much coarser, and less complex. These species are not easily confused.

Spines in this form are generally slightly curved and tapering, with their tips being blunt to slightly bulbous.

Angochitina sp. 1

(Pl. VII, fig. 3)

Description

Vesicle cylindro-spheroidal; chamber spheroidal making up nearly 0.8 of total 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	2-A-16
Vesicle length L	163.2
Neck length l	38.3
Chamber width W	86.7
Neck width N	30.6
W/L	0.5
l/L	0.2

Occurrence

Ipperwash Formation : rare to common

Widder Formation : rare to uncommon.

Discussion

The chamber making up a relatively large amount of vesicle length, the short neck, and ornamentation type separate this species from any already described. Too few specimens are available to determine whether this is a new species or an extreme variation of a previously described form.

Angochitina sp. 2
(Pl. VII, figs. 6, 7)

Description

Vesicle cylindro-spheroidal; chamber spheroidal with strongly convex base; flexure distinct; neck cylindrical, approximately 0.4 of total vesicle length, oral edge frayed; two or three annulate thickenings at and just above flexure; ornamentation of a row of spine bases (spine remnants) just below widest part of chamber, surface of vesicle rugose; "plug" 25.5 by 35.7 microns with short spines at its oral edge.

Dimensions (in microns)

Specimen	1-A-48
Vesicle length L	168.3
Neck length l	61.2
Chamber width W	81.6
Neck width N	66.3
W/L	0.5
l/L	0.4

Occurrence

Hungry Hollow Formation : rare (1 specimen)

Arkona Formation : rare

Rockport Quarry Formation : rare (1 specimen)

Dundee Formation : 1 specimen

Discussion

This long-necked form does not occur frequently in the Hamilton Group. Therefore its range of variation and taxonomic affinities cannot be determined.

Genus SPHAEROCHITINA

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. (after Jansonius, 1967)

Sphaerochitina n. sp.

(Pl. VII, figs 5, 8)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle of 67°, 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" 23.0 by 25.5 microns, observed inside vesicle.

Dimensions (in microns)

Specimen	1-A-31
Vesicle length L	89.3
Neck length l	30.6
Chamber width W	76.1
Neck width N	35.7
W/L	0.9
l/L	0.3
Apical angle	67°
Flexure angle	64°

Occurrence

Ipperwash Formation : rare to uncommon

Arkona Formation : common

Discussion

The Hamilton specimen has ornamentation somewhat similar to that of *Sphaerochitina spinigera* Eisenack 1964. The ornamentation of the latter is coarser than that of the Hamilton species. The Hamilton species has a shorter neck and a more conical chamber than *S. spinigera* has.

New genus A, new species 1

(Pl. VII, fig. 9)

Description

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

Dimensions (in microns)

Specimen	1-A-45
Vesicle length L	165.8
Neck length l	38.3
Chamber width W	79.1
Neck width N	35.7
W/L	0.5
l/L	0.2
Apical angle	65°
Flexure angle	52°

Occurrence

Bell Formation : rare (1 specimen)

Discussion

No other Chitinozoa yet described has a vesicle shape similar to that of the specimen here described. The chamber assuming the shape of a bowling pin 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 new genus B, from the Hamilton Group, 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 unwise to describe a new genus on the basis of one specimen. This specimen however has a characteristic shape that is impossible to fit into the limits of any known genus or species. It differs from Ancyrochitina in the lower part of its chamber which tapers aborally; this feature is not present in Ancyrochitina. Other genera, in which the chamber is conical do not have this type of aboral tapering. That this tapering was not due to stretching is indicated by the apparently undisturbed spines on the chamber, and by the rather brittle nature of Chitinozoa walls.

Tribe DESMOCHITINA

Genus CALPICHITINA

Calpichitina Wilson and Hedlund, 1964

Type species : Calpichitina scabiosa Wilson and Hedlund, 1964

Vesicles 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. (after Jansonius, 1967)

Calpichitina ? sp.

(Pl. VIII, fig. 1)

Description

Vesicle spheroidal to subspheroidal; no flexure; no neck; surface laevigate; thin area in center of basal surface; large flange approximately 15 to 20 microns wide, flaring out from oral opening.

Dimensions (in microns)

Specimen	2-B-8
Vesicle width W	117.3
Flange width	15.0 - 20.0

Occurrence

Rockport Quarry : rare (1 specimen)

Discussion

This genus was described by Wilson and Hedlund (1964) from the Sylvan Shale (Upper Ordovician) of Oklahoma. Wilson and Dolly (1964) raised some doubt as to the validity of the genus and suppressed it, although in a letter, Jansonius stated that in his opinion it should not be suppressed. Wilson and Dolly (1964) transferred Calpichitina to the genus Hoegisphaera.

This specimen from the Hamilton has a very distinct and wide collar. No such collar nor any trace of any was found on any of the many specimens of Hoegisphaera considered in this study. It is felt that placing this specimen in the genus Hoegisphaera would be erroneous. Consequently it is suggested that the genus should perhaps not have been suppressed and that it should be maintained in order to include specimens such as this one. Urban (1971, in press) also suggests that the genus should not have been suppressed.

Genus DESMOCHITINA

Desmochitina Eisenack, 1931

Type species : Desmochitina nodosa Eisenack, 1931

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

Desmochitina bursa Taugourdeau and de Jekhowsky, 1960

(Pl. VIII, figs 2, 3)

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 base, ring of spines inside oral opening; operculum present in some cases; chain formation observed.

Dimensions (in microns)

Specimens	1-A-23	1-A-30	1-A-31		2-A-48
Vesicle length L	99.5	86.7	89.3	94.4	99.5
Vesicle width W	125.0	104.6	112.2	109.7	104.6

Oral opening N	84.2	--	--	--	68.9
W/L	1.3	1.2	1.3	1.2	1.1

Occurrence

Widder Formation : rare

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to uncommon

Bell Formation : rare to abundant

Discussion

The holotype of *Desmochitina bursa* is from the Lower and Middle Devonian of north Africa and it is slightly smaller than the Hamilton specimens. Its measurements are 75 microns long and 100 microns wide. This species is characterized by a somewhat rectangular outline and finely tubercular surface.

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

Two vesicles in chain formation (Pl. VIII, fig. 2) have been observed.

Desmochitina sp.

(Pl. VIII, figs 4, 5)

Description

Vesicle subspherical, base convex, sides nearly straight, more or less quadrangular in lateral view; no flexure; no neck; oral aperture constricted and bordered with 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)

Specimens	1-A-36	2-A-38	2-A-50
Vesicle length L	117.3	107.1	122.4
Vesicle width W	112.2	99.6	109.7
Oral opening N	74.0	68.9	53.6
Collar width	79.1	76.5	58.7
W/L	1.0	0.9	0.9

Occurrence

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to uncommon

Bell Formation : rare to abundant

Discussion

This species differs from Desmochitina bursa Taugourdeau and de Jekhowsky (1960) in its smaller width to length ratio (0.9 to 1.0) and in its finer ornamentation.

Genus EISENACKITINA

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 chains. (after Jansonius, 1964)

<u>Eisenackitina</u> <u>castor</u> Jansonius, 1964

(Pl. VIII, figs 6 - 10)

<u>Description</u>

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 cases wall thins near oral opening; operculum, when attached, appressed to oral opening.

Dimensions

(see next page)

<u>Occurrence</u>

Widder Formation : rare

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to abundant

Bell Formation : abundant

<u>Discussion</u>

The specimens of this species which Jansonius (1964) measured from the Givetian of western Canada, range in size from 120 to 200 microns in length. The Hamilton specimens fit into this range, except for a few forms which measure only 102.0 microns.

Dimensions (in microns)

Specimens	1-A-31	1-A-41	1-A-45	2-A-34	2-A-34	2-A-36	2-A-42	2-B-9
Vesicle length L	137.7	122.4	140.3	127.5	122.4	102.0	122.4	122.4
Vesicle width W	94.4	102.0	119.9	112.2	96.9	96.9	102.0	96.9
Oral opening N	71.4	66.3	79.1	71.4	53.6	71.4	66.3	74.0
W/L	0.7	0.8	0.9	0.9	0.8	1.0	0.8	0.7

Jansonius (1964) in his description of Eisenackitina, stated that it differs from Desmochitina in having straighter sides and in lacking a flexure and collar; it also differs from Conochitina in having an operculum and ornamented surface.

The simplicity in shape of this genus makes specific assignment difficult. The species Eisenackitina castor is characterized by its simple oral edge, its lack of flexure and of collar and its type of ornamentation; wall roughened to minutely verrucose.

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

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

Eisenackitina n. sp. 1

(Pl. VIII, figs 11, 12; Pl. X, fig. 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

(see next page)

Occurrence

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to abundant

Bell Formation : rare to abundant

Discussion

Jansonius (1964) in his description of this genus mentioned the ". . . neck or lip very much reduced, usually absent. . . ." In this species the lip (collar) 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 *E. castor*.

The lip development in this species approaches a collar in aspect. The sides are straighter than in most *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 the Hamilton forms, and their collar development is more extensive than in the Hamilton forms. Consequently the Hamilton specimens are not included in the genus *Desmochitina*. The shorter specimens are similar to *Desmochitina* sp., previously described, and further research may indicate a

Dimensions (in microns)

Specimens	1-A-22	1-A-42	1-B-4	2-A-40	2-A-51	2-B-8
Vesicle length L	165.8	122.1	153.0	102.2	142.8	104.6
Vesicle width W	94.4	91.8	89.3	86.7	76.5	56.1
Oral opening N	56.1	68.9	63.8	61.2	66.3	38.3
W/L	0.6	0.8	0.6	0.9	0.5	0.5

close relationship between Eisenackitina and Desmochitina, and support their assignment to the same tribe (Jansonius, 1967).

One of the illustrated specimens (Pl. X, fig. 1) is constricted due to mechanical distortion in its lower half.

Eisenackitina sp.

(Pl. X, figs 2, 3)

Description

Vesicle subcylindrical, base flat, sides convex, inflated 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 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)

Specimens	1-B-7	2-A-47
Vesicle length L	114.8	162.5
Vesicle width W	91.8	127.5
Oral opening N	48.5	80.0
Base	40.8	67.5
W/L	0.8	0.8

Occurrence

Arkona Formation : rare (4 specimens)

Rockport Quarry Formation : rare (2 specimens)

Discussion

The outward bulging of the walls in the lower part of the vesicle separates this species from Eisenackitina castor Jansonius (1964). In his description of the genus, Jansonius stated: ". . . greatest width near the basal edge, lower part of the body chamber bulging; . . ." In his description of E. castor, which is the only species of this genus he named, he did not mention nor figure this bulge. It is considered, at least in the Hamilton specimens, that there is a difference between the two forms: the forms with and those without the bulging. Those with the bulging are rare, but when they occur, they are distinctive, and their base is definitely flat. Eisenackitina castor, however, does not have the bulge, nor is the base as definitely flat.

Genus HOEGISPHAERA

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. (after Jansonius, 1967)

Hoegisphaera cf. H. glabra Staplin, 1961

(Pl. IX, Figs. 1-8)

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)

Specimens	1-A-23	1-A-14	1-A-41	2-B-3	2-B-8
Height L	--	--	--	--	91.8
Diameter W	104.6	110.9	102.0	91.8	104.6
Oral opening	40.8	44.6	40.8	38.3	35.7
Operculum diameter	40.8	--	40.8	38.4	--
W/L	--	--	--	--	1.1

Occurrence

Ipperwash Formation : rare to abundant

Widder Formation : rare to abundant

Hungry Hollow Formation : rare to abundant

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to abundant

Bell Formation : rare to abundant

Dundee Formation : 9 specimens

Discussion

Although Wilson and Dolly (1964) stated that ornamentation on Chitinozoa has specific value, they also stated that ". . . severe processing can destroy these characters." Most of the Hamilton specimens appear to be laevigate, but some are ornamented. This may be a true character for differentiating between different taxa, but it may also be due to processing. 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 *Hoegisphaera glabra* Staplin (1961): 102.0 to 110.9 microns as compared to 110 to 130 microns in *H. glabra*. *H. glabra*, however, is defined as being laevigate. Most of the Hamilton specimens are laevigate, but some are ornamented with short stubby conical spines. Perhaps the definition of *H. glabra* should be expanded to include ornamented forms, in which case the Hamilton species could definitely be included in the species.

The diameter measurements of *Hoegisphaera lenticularis* Bouché (1965) have a wide range (75 to 150 microns). A characteristic of this species is its lenticular form as opposed to the spherical form of other species. Bouche stated that the flattening which caused the lenticular shape was probably secondarily imposed. Therefore the main taxonomic character of this species is not a feature inherent to the species. Although the Hamilton specimens fall within the size for *H. lenticularis*, they are not always flattened vertically to a lenticular shape, and this flattening is not a reliable or inherent character.

New genus B, new species 1

(Pl. X, figs 4-11)

Description

Vesicle cylindrical, short (68.8 to 102.2 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 networks 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

(see next page)

Occurrence

Widder Formation : rare (1 specimen)

Hungry Hollow Formation : rare (1 specimen)

Arkona Formation : rare to uncommon

Rockport Quarry Formation : rare

Bell Formation : rare to common

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, D. bursa for one, but the overall aspect of these species

Dimensions (in microns)

Specimens	1-A-27	1-A-31	1-A-34	1-A-41	1-A-44	1-B-8	2-A-52
Vesicle length L	91.8	74.0	68.9	84.2	99.5	102.0	109.7
Vesicle width W	117.3	91.8	86.7	96.9	112.4	107.1	140.2
W/L	1.3	1.2	1.3	1.2	1.1	1.1	1.3

is never as quadrangular as representatives of this new genus.

This genus differs from Hoegisphaera in its 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.

In several specimens the aboral edge seems to be pierced or torn (Pl. X, fig. 9). 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 in chains, this weak area remains observable (Pl. X, figs. 10, 11), indicating that these forms could stay in chains without the copula or similar linking structure.

Tribe EREMOCHITINA

Genus CONOCHITINA

Conochitina Eisenack, 1931

Type species : Conochitina claviformis Eisenack, 1931

Taugourdeau (1966) has restricted the genus to a group of medium to large, conical vesicles with cylindrical necks and a short cylindrical or rudimentary copula at the aboral pole. This concept differs drastically from the emendation by Eisenack (1955); redescription of the type species would be desirable to establish the new concept. (after Jansonius, 1967)

Conochitina edjelensis Taugourdeau, 1963

(Pl. XI, fig. 1)

Description

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

Dimensions (in microns)

Specimen	1-A-13
Vesicle length L	117.3
Vesicle width W	74.0
Oral opening N	51.0
W/L	0.6

Occurrence

Arkona Formation : rare (1 specimen)

Discussion

This specimen is considered conspecific with Conochitina edjelensis which Taugourdeau (1963) described from the Middle and Upper Llandovery 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 (1931) indicated the presence of a basal callus in certain cases. Taugourdeau gave the size range of this species as being 76 to 275 microns long, 50 to 85 microns wide. The Hamilton forms fall within this range.

The slight constriction which can be observed on the figured specimen is probably due to distortion after deposition.

Genus RHABDOCHITINA

Rhabdochitina Eisenack 1931

Type species : Rhabdochitina magna Eisenack 1931

Large, elongated, cylindrical vesicles. (after Jansonius, 1967)

Rhabdochitina sp. 1

(Pl. XI, fig. 2)

Description

Vesicle cylindrical, base convex with slight enlargement up to 66.3 microns, in lower 20 microns of vesicle, sides parallel; no flexure; surface laevigate; wall appears to thin orally; "plug" 35.7 by 40.3 microns observed at approximately 80 microns down from oral opening.

Dimensions (in microns)

Specimen	3-A-2
Vesicle length L	351.9
Vesicle width W	58.7
Basal width	66.3
W/L	0.2

Occurrence

Ipperwash Formation : rare (1 specimen)

Discussion

This species differs from Rhabdochitina sp. 2 which is described next, in its much greater length, 351.9 microns as opposed to 130.1 microns; it is cylindrical while R. sp. 2 is subconical.

Rhabdochitina sp. 2

(Pl. XI, fig. 3)

Description

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

Dimensions (in microns)

Specimen	2-A-47
Vesicle length L	130.1
Vesicle width W	45.9
Oral opening N	23.0
W/L	0.4

Occurrence

Rockport Quarry Formation : rare (1 specimen)

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.

Rhabdochitina sp. 3

(Pl. XI, fig. 4)

Description

Vesicle cylindrical, constricted at 1/3 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	2-A-43
Vesicle length L	306.0
Vesicle width W	91.8
W/L	0.3

Occurrence

Rockport Quarry Formation : rare (1 specimen)

Discussion

The constriction observed one-third the distance from the base is probably due to mechanical distortion. Therefore it is not considered as necessarily characteristic of a species.

Tribe EUCONOCHITINA

Genus HERCOCHITINA

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 rods, ribs or fins, that may project beyond the basal edge as spines. (after Jansonius, 1967)

<u>Hercochitina</u> aff. <u>H.</u> <u>turnbulli</u> Jenkins, 1969

(Pl. XI, figs 5, 6)

<u>Description</u>

Vesicle cylindro-conoidal; chamber conical with small apical angle ranging from 20° to 36°, 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)

Specimens	1-A-31	1-A-31	3-A-5
Vesicle length L	114.8	122.4	119.9
Neck length l	40.8	--	51.0
Chamber width W	68.9	63.8	76.5
Neck width	35.7	33.2	38.3
W/L	0.7	0.5	0.6
l/L	0.4	--	0.4
Apical angle	32°	20°	36°
Flexure angle	75°	--	71°

<u>Occurrence</u>

Ipperwash Formation : rare (3 specimens)

Arkona Formation : rare (1 specimen)

<u>Discussion</u>

This species is vaguely similar to <u>Hercochitina turnbulli</u> in size, shape, and in the alignment of spines in longitudinal rows. But in the Hamilton specimens, the spines are discrete at their tips while in *Hercochitina turnbulli* they are joined at their tips.

Genus *ILLICHITINA*

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. (after Collinson and Schwalb, 1955)

? *Illichitina* sp.

(Pl. XI, fig. 7)

Description

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

Dimensions (in microns)

Specimen	2-A-49
Vesicle length L	102.0
Chamber width W	89.3
Neck width N	23.0

W/L 0.9

Apical angle 50°

Occurrence

Ipperwash Formation : rare (4 specimens)

Arkona Formation : rare to uncommon

Bell Formation : rare.

Discussion

Grignani and Mantovani (1964) illustrated a specimen which they called ? *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 were cautious in their generic assignment.

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

Genus *KALOCHITINA*

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. (after Jansonius, 1967)

Kalochitina ? sp.

(Pl. XI, figs 8, 9)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle ranging from 45° to 51°, 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" 17.9 by 28.1 microns observed.

Dimensions (in microns)

Specimens	1-A-31	1-A-31
Vesicle length L	114.8	117.3
Neck length l	45.9	38.3
Chamber width W	89.3	81.6
Neck width N	43.4	40.8
W/L	0.8	0.7
l/L	0.4	0.3
Apical angle	51°	45°
Flexure angle	61°	76°

Occurrence

Ipperwash Formation : common

Widder Formation : rare to abundant

Arkona Formation : rare (2 specimens)

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 those in *Belonechitina* and *Hercochitina*. The spine distribution is random.

Tribe LAGENOCHITINA

Genus CYATHOCHITINA

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. (after Jansonius, 1967)

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

(Pl. XI, fig. 10)

Description

Vesicle cylindro-conoidal; chamber conical with apical angle of 53°, 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	2-A-1
Vesicle length L	114.8

Neck length l	25.5
Chamber width W	99.5
Neck width N	30.6
W/L	0.9
l/L	0.2
Apical angle	53°

Occurrence

Widder Formation : uncommon

Hungry Hollow Formation : rare (4 specimens)

Arkona Formation : rare to uncommon

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. In that case, the Hamilton specimens of this group would belong to the genus *Cyathochitina*, and would most closely resemble the species *C. kuckersiana* subsp. *kuckersiana*. This latter species has not yet been reported from any Devonian strata. Consequently the slight resemblance does not justify drawing a closer tie between the two species.

Genus LAGENOCHITINA

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. (after Jansonius, 1967)

<u>Lagenochitina</u> cf. <u>L</u>. <u>amottensis</u>

Grignani and Mantovani, 1964

(Pl. XII, fig. 1)

<u>Description</u>

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)

Specimens	2-A-48	2-A-50
Vesicle length L	178.5	132.6
Chamber width W	81.6	79.1
Neck width N	38.3	33.2
W/L	0.5	0.6

<u>Occurrence</u>

Ipperwash Formation : rare (2 specimens)

Rockport Quarry Formation : rare (1 specimen)

Bell Formation : rare to uncommon

<u>Discussion</u>

This species is not abundant in the Hamilton Group. One of the measured specimens (2-A-50) is broken at the oral edge, and thus the neck measurement and W/L ratio are inconclusive.

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.

Lagenochitina cf. *L. brevicollis*

Taugourdeau and de Jekowsky, 1960

(Pl. XI, figs 12, 13)

Description

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

Dimensions (in microns)

Specimens	1-A-7	1-A-8
Vesicle length L	104.6	119.9
Chamber width W	66.3	68.9
Neck width N	40.8	30.6
W/L	0.6	0.6

Occurrence

Ipperwash Formation : rare (1 specimen)

Widder Formation : rare to uncommon

Arkona Formation : rare

Bell Formation : rare (2 specimens)

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 it is considerably larger (220 microns long, 130 microns wide).

One of the Hamilton specimens figured (Pl. XI, fig. 13) 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, that is, the operculum belonged to another form and its presence in this specimen is fortuitous. This particular specimen has a very short neck with ragged edges which could be due to breakage during diagenesis or processing.

Lagenochitina sp.

(Pl. XI, fig. 11)

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 cases, in one instance 2 hair-like spines on neck.

Dimensions (in microns)

Specimens	1-A-8	1-A-13
Vesicle length L	147.9	170.9
Neck length l	51.0	35.7
Chamber width W	74.0	89.3
Neck width N	38.3	40.8

W/L	0.5	0.5
l/L	0.3	0.2

Occurrence

Ipperwash Formation : rare (1 specimen)

Widder Formation : rare to uncommon

Hungry Hollow Formation : rare (1 specimen)

Arkona Formation : rare to common

Rockport Quarry Formation : rare (1 specimen)

Bell Formation : rare

Discussion

Lagenochitina sp. has a long and gently tapering chamber and a short neck. It is similar to *L. crassa* Grignani and Mantovani (1964) from the Middle and Upper Devonian of Morocco. This latter form has a more clearly differentiated neck and a rounder chamber than have the Hamilton specimens.

Cramer (1964) illustrated a form in the Ludlovian of northwest Spain, which is very similar to *L.* sp., but he included his specimen in the genus *Sphaerochitina*. His species is *S. 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 original description of *Sphaerochitina*, Eisenack (1955) stated that the walls are smooth or with tubercles.

If this original interpretation is to be considered, and it should until the genus is redefined, unornamented forms can be included in the genus. This could lead to some confusion with species of Lagenochitina. Cramer (1964) apparently adhering to Eisenack's interpretation named the species S. llorona. His specimens are larger than the Hamilton specimens, their length being 180 to 230 microns, and 147.9 to 170.9 microns respectively.

Tribe Unknown

Chitinozoa 1

(Pl. XII, fig. 3)

Description

Vesicle cylindrical, with five bead-like swellings, largest swelling terminal, 102.0 microns wide, base expanded, convexly rounded, pierced, sides irregular; no flexure; no neck; surface laevigate except on basal swelling where it is rugose.

Dimensions (in microns)

Specimen	1-A-4
Vesicle length L	186.2
Average width of swellings	33.2

Occurrence

Widder Formation : rare (1 specimen)

Discussion

This specimen is included in the Chitinozoa because its morphology is similar to that of Chitinozoa tests. Its hollow cylindrical shape, with one end narrowed is similar to the general shape of *Rhabdochitina*. Its peculiar bead-like shape and its open ends make this assignment tentative.

Chitinozoa 2

(Pl. XII, fig. 4)

Description

Vesicle cylindrical, base broken (?), one end of tube swollen to a diameter of 91.8 microns for 98.0 microns of the length, sides, other than on swelling, parallel; no flexure; no neck; surface faintly rugose.

Dimensions (in microns)

Specimen	3-A-38
Vesicle length L	242.3
End width	40.8
	52.4
Maximum width	91.8

Occurrence

Arkona Formation : rare (1 specimen)

Discussion

The apparent nature and color of the hollow test wall are similar to that of the Chitinozoa. The open-ended aspect of the tube as well as its swelling make this assignment tentative.

Acritarcha

Subgroup ACANTHOMORPHITAE Downie, Evitt and Sarjeant, 1963

Genus BALTISPHAERIDIUM

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

Type species : Baltisphaeridium longispinosum Eisenack 1958

Vesicles spherical; few to numerous spines; vesicle 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 vesticle; 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 thickned, 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. (after Staplin, Jansonius, and Pocock, 1965)

Baltisphaeridium sp.

(Pl. XII, figs 7, 8)

Description

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

Dimensions (in microns)

Specimen	2-A-56
Diameter	63.8
Spines	13.0

Occurrence

Bell Formation : rare (1 specimen)

Discussion

Only one representative of this species has been recovered from the Hamilton Group. Fragments which possibly belong to this species were observed, but they were unidentifiable.

Subgroup HERKOMORPHITAE Downie, Evitt and Sarjeant, 1963

Genus CYMATIOSPHAERA

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 junction of membrane (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. (Translation in Norris and Sarjeant, 1965)

<u>Cymatiosphaera</u> "<u>canadensis</u>" Deunff, 1954

(Pl. XII, figs 9-14)

<u>Description</u>

Vesicle spheroidal; 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)

Specimens	1-A-18	1-A-22	2-A-34	2-A-37	2-A-39	2-A-54
Diameter	71.4	58.7	63.8	56.2	63.8	63.8

<u>Occurrence</u>

Ipperwash Formation : rare to uncommon

Widder Formation : rare to uncommon

Hungry Hollow Formation : rare to abundant

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to abundant

Bell Formation : rare to abundant

Dundee Formation : 27 specimens

<u>Discussion</u>

This species was described by Deunff (1954) but the name is not valid. Deunff illustrated a specimen from Ontario and named it in the figure legend. He did not include a description nor did he give the collection locality except to state 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, and did so as if the name were valid.

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

The Hamilton specimens are conspecific with Deunff's specimen, as far as can be presumed from the inadequate description and illustration available in the literature. Some of the Hamilton specimens are finely polygonal, like Deunff's specimen, others are much more coarsely polygonal, the walls are thicker, higher and less numerous. These are considered variations within the species.

Cymatiosphaera sp.

(Pl. XIII, figs 1, 2)

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	1-A-50
Diameter	56.1
Ridge height	8.0

Occurrence

Ipperwash Formation : rare (2 specimens)

Widder Formation : rare

Hungry Hollow Formation : rare (2 specimens)

Arkona Formation : rare

Rockport Quarry : rare

Bell Formation : rare

Dundee Formation : 2 specimens

Discussion

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

Genus DICTYOTIDIUM

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. (from Staplin, 1961)

<u>Dictyotidium</u> <u>dictyotum</u> (Eisenack) Eisenack, 1955

(Pl. XIII, figs. 3-6)

<u>Description</u>

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

Dimensions (in microns)

Specimens	1-A-29	1-A-37	2-A-37	2-A-38	2-A-49
Diameter	76.5	79.1	76.5	86.7	79.1

<u>Occurrence</u>

Widder Formation : rare (3 specimens)

Hungry Hollow Formation : rare (2 specimens)

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to common

Bell Formation : rare to abundant

<u>Discussion</u>

The Hamilton specimens agree very accurately with the description of <u>D</u>. <u>dictyotum</u> which Eisenack (1955) described from the Silurian <u>Beyrichia</u>-Kalk. He gave a size range of 60 to 100 microns. The Hamilton specimens show less size variation, ranging from 76.5 to 86.7 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 are somewhat 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.

New genus C, n. sp. 1

(Pl. XIII, figs 7, 8)

Description

Hollow polyhedral vesicle; equatorial outline polygonal, indented by large pits, 5 microns wide, causing scalloped appearance; the upper and lower halves divided into 2 to 4 segments by centrally diverging ridges; ridges made up of two elevated strips, one from each neighboring segment; surface slightly pitted.

Dimensions (in microns)

Specimen	3-A-27
Sides	30.6
	63.3
	43.4
	28.1
	43.4
	35.7

Occurrence

Widder Formation : rare (3 specimens)

Hungry Hollow Formation : uncommon

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare (3 specimens)

Bell Formation : rare to uncommon

Dundee Formation : 2 specimens

Discussion

This Hamilton form is somewhat similar to some forms in the genus *Polyedrixium*, but it generally has less sides than *Polyedrixium* is not known to have. This form could also be related to *Cymatiosphaera*, especially forms of that genus with few faces and corroded edges. However the scalloped edges appear too systematically placed and too often to be due to corrosion which is a random process.

Subgroup NETROMORPHITAE Downie, Evitt, and Sarjeant, 1963

Genus *QUISQUILITES*

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 smooth or ornamented, approximately one-third as thick as inner, both layers penetrated vertically by mega- and microcanals, the former one-half to one micron in diameter and scattered, and latter approximately .01 micron in diameter and uniformly dense throughout; known dimensions of palynomorphs 80 to 145 microns long, 30 to 80 microns in diameter. (after Wilson and Urban, 1971, in press)

Quisquilites n. sp. 1

(Pl. XIII, figs 9-13)

Description

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

Dimensions (in microns)

Specimens	1-A-4	1-A-7	1-A-7	1-A-13	2-A-39
Length L	140.3	142.8	186.2	173.4	145.4
Width W	33.2	40.8	30.6	30.6	30.6
W/L	0.3	0.3	0.2	0.2	0.2

Occurrence

Ipperwash Formation : rare

Widder Formation : rare to abundant

Hungry Hollow Formation : rare to abundant

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to abundant

Bell Formation : rare to abundant

Dundee Formation : 16 specimens

Discussion

Quisquilites buckhornensis Wilson and Urban (1963) is similar to this Hamilton species in general aspect. These two forms differ in two respects. *Q. 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 Quisquilites buckhornensis is 85 to 145 microns long, 30 to 80 microns wide. In the Hamilton species, the length is generally greater, ranging from 142.8 to 186.2 microns; the width has a narrower range: 30.6 to 40.8 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 mega-canals of Wilson and Skvarla (1967).

Subgroup POLYGONOMORPHITAE

Downie, Evitt, and Sarjeant, 1963

Genus VERYHACHIUM

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

Type species : Veryhachium trisulcum Deunff, 1954

A genus of hystrichospheres having polygonal or sub-polygonal 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. (after Downie and Sarjeant, 1963)

Veryhachium cf. V. lairdi

(Deflandre) Deunff, 1958

(Pl. XIV, figs 1-5)

Description

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

Dimensions (in microns)

Specimens	1-A-4	2-A-48	2-A-52
Side length	35.7	38.3	25.6
Spine length	26	51	32
	41	44	39
	51	41	39
			39
			41

Occurrence

Ipperwash Formation : rare to abundant

Widder Formation : rare to abundant

Hungry Hollow Formation : rare to common

Arkona Formation : rare to abundant

Rockport Quarry Formation : uncommon to abundant

Bell Formation : rare to abundant

Dundee Formation : 166 specimens

Discussion

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

Veryhachium sp. 1

(Pl. XIV, figs 6, 9-11)

Description

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

Dimensions (in microns)

Specimens	2-A-54
Altitude	17.3
Spines	40.0
	41.0
	32.4

Occurrence

Widder Formation : rare to uncommon

Hungry Hollow Formation : rare to common

Arkona Formation : rare to common

Rockport Quarry Formation : rare

Bell Formation : rare to abundant

Dundee Formation : 10 specimens

Discussion

This species is quite distinct from Veryhachium cf. V. lairdi previously described in its coarse vesicle, wide processes which do not branch, and its slightly granulose surface.

Veryhachium sp. 2

(Pl. XIV, figs 7, 8)

Description

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

Dimensions (in microns)

Specimens	2-A-38	2-A-52
Altitudes	38.3	28.1
	35.7	
	38.3	
Spine length	23.0	35.6
	23.0	48.6
	23.0	33.5

Occurrence

Ipperwash Formation : rare (5 specimens)

Widder Formation : rare

Hungry Hollow Formation : rare (3 specimens)

Arkona Formation : rare

Rockport Quarry Formation : rare to common

Bell Formation : rare

Dundee Formation : 2 specimens

Discussion

Specimens of this species generally have hollow spines. Some specimens however have been recovered (Pl. XIV, figs 7, 8) in which the spines are solid. Although this criterion has been used to distinguish various species, it is felt that in this case it is a fortuitous occurrence, perhaps due to preservation, and no differentiation is effected.

Subgroup PRISMATOMORPHITAE

Downie, Evitt and Sarjeant, 1963

Genus *POLYEDRIXIUM*

Polyedrixium Deunff, 1954, ex. and emend. Jansonius, 1962

Type species : *Polyedrixium deflandrei* Deunff, 1954, ex. Jansonius, 1962 nomen nudum

Planktonic microfossils; vesicle tetrahedral to polyhedral, parallelopipedal or prismatic, sides often arched inward with a small recessed flat central area.

The ridges where two sides meet carry membranes with more or less pronounced ornaments, which may also be present on the corners; there ornaments are funnel or chimney-shaped processes with more or less flaring and indented rims. Size range: approximately 20 to 60 microns; color yellow or brown, rarely black. (after Jansonius, 1962)

This genus has never been properly validated. Deunff (1954) described it in a footnote and he stated that the type species is Polyedrixium deflandrei, but he failed to describe P. deflandrei. Had the genus been monotypic, the generic description would have been sufficient to encompass the type species. This was not the case as he also named four other species belonging to this genus in the same paper.

Jansonius (1962) emended the genus and designated P. deflandrei as lectotype, provisionally, until Deunff described the species. Deunff has not yet done so. Therefore this genus remains without a true type species and thus it is lacking one of the essential requisites for being a valid genus.

The generic name Polyedrixium will be used in this paper, because its use is common and its definition adequate, but it will be qualified by the addition of quotation marks because it is not valid.

"*Polyedrixium cuboides*" Deunff, 1955

(Pl. XV, figs 4, 7, 9, 10)

Description

Vesicle cubic, edges equal to each other, scalloped in some cases, 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)

Specimens	1-A-8	1-A-18	2-A-54
Edge length	25.5	40.8	25.5

Occurrence

Ipperwash Formation : rare (3 specimens)

Widder Formation : rare

Hungry Hollow Formation : rare to uncommon

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to uncommon

Bell Formation : rare to uncommon

Dundee Formation : 2 specimens

Discussion

Even if the generic name were valid, this specific name would be invalid. Deunff (1955) gave an illustration of the specimen and named it in the figure legend; he gave no description nor any collection locality. The specimen was associated with a *Favosites* polyp from the Onondaga Stage of Ontario.

Cramer (1964) named a species Polyedrixium embudum which has the cubic shape and depressed walls similar to the Hamilton specimens. In the case of his specimens however, the cubic vesicle is small and there are high crests on the edges. These high crests result in presenting the same appearance as that of a cubic vesicle with centrally depressed faces. His interpretation of a small vesicle and high crests was substantiated only by a text figure. He offered no photographs, and this makes it difficult to compare his specimen with any from the Hamilton Group.

"Polyedrixium pharaonis" Deunff, 1955

(Pl. XV, figs 1-3, 5, 6, 8)

Description

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

Dimensions (in microns)

Specimens	1-A-3	1-A-7	2-A-49	2-A-52
Side length	33.2	25.5	25.5	25.5
Spine length	41	41	31	36
	26		28	31
	36		28	38
	33			31
	36			41
	36			

Occurrence

Ipperwash Formation : rare to common

Widder Formation : rare to abundant

Hungry Hollow Formation : rare to common

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to abundant

Bell Formation : rare to common

Dundee Formation : 22 specimens

Discussion

This species which was named by Deunff (1955) is invalid. He introduced the name in the legend to an illustration with no further explanation. He gave no description, assigned no type, and indicated no type locality. All he mentioned was that the material he studied was found in a *Favosites* polyp from the Onondaga Stage of Ontario. This does not meet the requirements of the International Rules of Botanical Nomenclature.

Cramer (1964) found forms which he considered conspecific with Deunff's material, and he assigned it the same specific name, attributing it to Deunff as if it were valid.

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. The measurements effected were taken along the sides, and they were found to be effectively equal to each other. In all the measured specimens the spines are longer than the cube side, and more or less equal to each other.

Subgroup RETRASTOMORPHITAE Brito, 1969

Genus TORNACIA

Tornacia Stockmans and Williere, 1965

Type species : Tornacia sarjeanti Stockmans and Williere, 1965

Spherical organisms, diameter range 15 to 21 microns, with 9 to 12 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 up rather distinctly against a generally clearer vesicle. (translated from Stockmans and Williere, 1955)

This genus had been placed in the subgroup Acanthomorphitae Downie, Evitt, and Sarjeant by Stockmans and Williere (1965). It was transferred, along with Triangulina, to the subgroup Retrastmorphitae by Brito (1969) when he defined this subgroup.

Tornacia sp.

(Pl. XV, fig. 11)

Description

Vesicle spherical; ring of equatorially placed spines, 15.3 microns long, simple tapering, straight; spine bases 8 microns wide, 3 microns into vesicle, dark; surface laevigate.

Dimensions (in microns)

Specimen	1-B-9
Diameter	63.8
Spine length	15.3
Spine base width	8

Occurrence

Dundee Formation : rare (1 specimen)

Discussion

This specimen from the Dundee Formation is considerably larger than the type species *Tornacia sarjeanti*, which was described from the Tournaisian (Lower Mississippian) of Belgium. The diameter of the type species ranges from 15 to 21 microns, that of the Dundee specimen is 63.8 microns; the spines of the type species number 9 to 12 and are 4.5 microns long and 2.2 microns wide; in the Dundee specimen they number 7, and are 15.3 microns long and 8 microns wide.

This major size discrepancy does not obviate the fact that the specimens are similar, that the description for the genus applies accurately to the Dundee specimen. This is probably a new species.

Genus TRIANGULINA

Triangulina Cramer, 1964

Type species : Triangulina alargada Cramer, 1964

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

Triangulina cf. T. alargada Cramer, 1964

(Pl. XV, fig. 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
Altitude	63.3
	53.6
	58.7
Process length	38.3
	23.0
	28.1

Occurrence

Arkona Formation : rare to common

Rockport Quarry Formation : rare

Bell Formation : rare

Dundee Formation : 2 specimens

Discussion

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

This genus is somewhat similar to *Onondagella* Cramer (1966) but the processes are shorter and the asymmetry less pronounced.

Subgroup SPHAEROMORPHITAE

Downie, Evitt, and Sarjeant, 1963

Genus *LEIOSPHAERIDIA*

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. (after Downie and Sarjeant, 1963)

Leiosphaeridia sp. 1

(Pl. XVI, fig. 1)

Description

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

Dimensions (in microns)

Specimens	1-A-10	1-A-49
Diameter	165.8	181.1

Occurrence

Ipperwash Formation : rare to abundant

Widder Formation : rare to abundant

Hungry Hollow Formation : rare to abundant

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to abundant

Bell Formation : rare to abundant

Dundee Formation : 259 specimens

Discussion

This genus is very widely represented in the Hamilton Group. This species, typical by its thin-walled appearance is nearly ubiquitous. Small and large forms occur, the small forms ranging from 30 to 110 microns and the larger forms from 130 to 270 microns, with a 20 micron break between them. This probably indicates a natural break between two species. The morphology of this genus is so simple that size becomes a major criterion in separating species.

Leiosphaeridia sp. 2

(Pl. XVI, figs 10, 12)

Description

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

Dimensions (in microns)

Specimens	2-A-45	1-A-6	1-A-24
Diameter	63.8	68.8	84.2

Occurrence

See previous species

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, although not in specimens of the Hamilton Group. 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.

Subgroup uncertain

Genus TUNISPHAERIDIUM

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 spheroidal 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. (from Deunff and Evitt, 1968)

Tunisphaeridium concentricum Deunff and Evitt, 1968

(Pl. XVI, figs 2-7)

Description

Vesicle spherical, diameter ranging from 35.7 to 45.9 microns; numerous (more than 15) solid rodlike spines, uniform in length, 20 to 28 microns long, expanded at their tips and connected terminally by a thin membrane concentric with the vesicle; no pylome observed.

Dimensions (in microns)

Specimens	1-A-16	1-A-16	1-A-18
Vesicle diameter	45.9	38.3	35.7
Spine length	20.4	28.0	20.5
Number of spines	20+	15+	18+

Occurrence

Ipperwash Formation : rare (3 specimens)

Widder Formation : rare

Hungry Hollow Formation : rare (1 specimen)

Arkona Formation : rare to common

Rockport Quarry Formation : rare

Bell Formation : rare

Dundee Formation : 1 specimen

Discussion

This species which was described by Deunff and Evitt (1968) from the Middle Silurian of New York 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. This 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.

Others

Class Chlorophyceae

Family Tasmanaceae

Genus TASMANITES

Tasmanites Newton 1875

Type species : Tasmanites punctatus Newton, 1875

<u>Tasmanites</u> sp.

(Pl. XVI, figs 8, 9, 11)

Description

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

Dimensions (in microns)

Specimen	1-A-16	1-A-37	2-A-21
Diameter	63.8	247.4	252.5

Occurrence

Ipperwash Formation : rare to abundant

Widder Formation : rare to abundant

Hungry Hollow Formation : rare to abundant

Arkona Formation : rare to abundant

Rockport Quarry Formation : rare to abundant

Bell Formation : rare to abundant

Dundee Formation : 193 specimens

Discussion

This species is present, generally abundant, in all the formations of the Hamilton.

CHAPTER VI

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. They did not provide a means to zone the Michigan Basin Hamilton Group biostratigraphically. The cores studied are close to each other, being less than 50 miles apart, and provide a detailed picture of the microplankton in a small area. Lack of similar information concerning fossil microplankton from other localities of the Middle Devonian in the Michigan Basin prevents formulation of widely applicable conclusions about the biostratigraphy. Potential for zonation using high percentage levels was indicated in some instances, but these are obscured by local factors which cannot be eliminated without data from geographically separated areas.

Formational boundaries that were set at lithological breaks in several cases are reflected in drastic numerical reductions 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.

The fossil microplankton composition is relatively stable over all the Hamilton Group and thus suggests that little overall change occurred during the time of deposition of the rocks of the Hamilton Group. The Acritarcha assemblages are virtually unchanged through all the formations of the Hamilton Group except for the Ipperwash Formation where a decrease in abundance is apparent. In the Chitinozoa two major distribution changes are observed: in the vertical distribution of species of *Angochitina*, and in species of *Desmochitina*, *Eisenackitina*, and the new genus B is generally found below the Hungry Hollow Formation. In the case of *Angochitina* the control is probably ecological because species of *Angochitina* occur below this stratigraphic level at other localities. The control may also be ecological for the second group of Chitinozoa, but it could also conceivably be due to extinction. Neither *Desmochitina bursa* nor *Eisenackitina* are known to occur above the Givetian. Thus at their extinction the ecological niche they had occupied could have been taken over by the species of *Angochitina*. Richness and good preservation of the Chitinozoa in the Hamilton Group have contributed to an elucidation of the wide range of variations which several species exhibit and which has not been shown before. The description of

Ancyrochitina cornigera, for example, takes into account only a small part of the range of variation which it has been found to have. Thus, if intermediate forms between the originally described specimens for this species and those with clavate processes which were found in the Hamilton Group had not been recovered, two separate species would have been set up. The specific descriptions of *Ancyrochitina cornigera*, *A. gordita*, *A. langei*, *A. tumida*, *Angochitina devonica* should be expanded.

Lithological changes and relative percentages of Chitinozoa-Acritarcha do not appear to be related (Figs. 5, 6, 7). This presents some question about Staplin's (1961) statement that Chitinozoa and Acritarcha distributions are reflections of distance from reefs or shore areas. Distance from shore and/or shallowing would be reflected in the lithology. This is not borne out by data from the Hamilton Group. His observations should be restricted to reef complexes and they may reflect an oversimplification of a complex situation in which nutrients, light, and temperature are the controlling factors.

The use of the Hamilton Group as a biostratigraphical entity has been strengthened by the observation of the unity among Chitinozoa and Acritarcha found in it. This group can be subdivided into smaller units by using the larger invertebrates.

Several lines for future research are suggested by this study of the Chitinozoa and Acritarcha of the Hamilton Group. The chemistry of the Hamilton Group sediments might prove to be a more discriminating indicator for environmental conditions than lithology. As a result of this type of study, one might find correlation between some chemical factor and the relative Chitinozoa-Acritarcha percentages. Paleomagnetic studies which have already been undertaken (C.W. Harper, personal communication) might provide data to explain geographic distribution and variation of the fossil biotas.

The genus *Veryhachium* is in serious need of restudy. Subdivisions into so-called species have fragmented the genus beyond usefulness. Many so-called species are probably subspecific categories. The genus *Leiosphaeridia* also should be considered. Perhaps forms with circular pylomes, with slit-like pylomes, and without pylomes should be segregated into three different genera.

Ostracodes from the Arkona and Ipperwash cores have been recovered and a study paralleling the Chitinozoa-Acritarcha with the ostracodes might provide further information concerning the conditions in the Hamilton Basin in the Middle Devonian.

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APPENDIX

Descriptions of cores

D.D.#1 Arkona

Location: Rock Glen Park - Ausable River Conservation Authority - Arkona

Surficial Deposits	Thickness (in feet)
No core recovered	0-4.0
Limestone, dark greyish-brown, finely crystalline to sub-aphanitic, 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
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 here and there.	49.4-50.2
Limestone, medium greyish-brown crinoidal calcarenite, medium grained (Encrinal limestone)	50.2-51.8

<u>Arkona Formation</u>

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 here and there.	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 here and there.	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; grades to shaly limestone here and there.	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, non-calcareous 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

<u>Dundee Formation</u>

Limestone, greyish brown, argillaceous, varies from finely crystalline to micro-granular 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

D.D.#2 Ipperwash

Location: Stoney Point, Ipperwash Provincial Park, on bedrock surface.

Hamilton Group	Thickness (in 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, sub-aphanitic, 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, sub-aphanitic, 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, sub-aphanitic, argillaceous.	87.2-94.5

Hungry Hollow Formation

Shale, calcareous and limestone; fine crystalline; contains interbeds of lighter colored 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	97.5-99.5

limestone. This is the crinoidal limestone zone of the Hungry Hollow Formation.

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

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. Here and there 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 sub-aphanitic, very argillaceous.	176.5-178.5

Shale, dark grey as above, very calcareous. Contains hard bands here and there 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

<u>Rockport Quarry Formation</u>

Limestone, dark brown, sub-aphanitic, argillaceous.	211.7-213.7
Limestone, dark brown, sub-aphanitic, argillaceous; lowermost 6 inches consists of light brown, finely crystalline limestone.	213.7-215.7
Shale, dark grey, firm slightly calcareous here and there.	215.7-238.0
Shale, dark grey, firm.	238.0-238.8
Limestone, dark brown, slightly argillaceous, finely crystalline.	238.8-239.8

<u>Bell Formation</u>

Shale, dark grey, firm, slightly calcareous here and there.	239.8-262.2

Shale, dark grey, firm, contains hard calcareous bands here and there.	262.2-265.5
Limestone, dark brownish-grey, very argillaceous, sub-aphanitic.	265.5-269.2
Shale, dark grey, calcareous.	269.2-270.0
Limestone, dark brown, argillaceous, sub-aphanitic.	270.0-272.7
Shale, dark grey, calcareous, firm.	272.7-275.0
Limestone, dark brown, sub-aphanitic, very argillaceous, fossiliferous.	275.0-278.5
Shale, dark grey, calcareous, firm.	278.5-280.5
Limestone, dark brown, sub-aphanitic, 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, sub-aphanitic.	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 65-1

Location: Lambton Co., Moore tp., lot 28, conc. II
1500 feet S of N lot line
100 feet E of W lot line

Kettle Point Formation	Thickness (in feet)
Black shale, non-calcareous, non-fissile to fissile, pyrite grains scarce.	468.8-470.6
Shale, brownish-grey, non-fissile, non-calcareous; pyrite grains present.	470.6-471.3
Black shale, fissile, non-calcareous, some pyrite grains present.	471.3-472.3
Shale, non-calcareous, intraclastic conglomerate, pyritic.	472.3-473.8

Hamilton Group

Ipperwash Formation

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, non-calcareous, 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 fragemnts (up to 1/2 inch), 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 9.5" : medium grained with large calcareous intraclasts (up to 1"); contorted shale interbeds. 6.5" : light grey, medium grained, crinoid stems; no intraclasts nor interbeds. 2.5" : same as 9.5" sub-unit 13.0" : same as 6.5" sub-unit	491.9-494.6
Shale, medium to dark grey, non-calcareous, 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, non-calcareous, fissile, friable.	495.0-495.2
Limestone, light grey, fine grained, very thin shale interbeds.	495.2-495.4
Shale, dark grey, slightly fissile, non-calcareous; one 1 and 1/2 inch limestone interbeds, as in previous unit.	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 'blob' of chert containing fossil fragments.	496.4-498.1

<u>Widder Formation</u>

Limestone, light brown, fine with coarse fossil fragments; very thin and numerous shale intercalations. Shale sub-units, up to 1 inch in a few cases; highly calcareous.	498.1-522.3
Limestone, as in previous unit, medium brown, many brachiopods (<u>Spirifer</u> ?); largest brachiopods in sub-units 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
<u>Hungry Hollow Formation</u>	
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
<u>Arkona Formation</u>	
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 sub-unit in top quarter of dark grey fossiliferous argillaceous limestone.	551.1-561.0

Shale, dark grey, highly calcareous, more fissile than 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, non-argillaceous, non-fossiliferous.	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 I and 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 Formation

Limestone, medium to dark grey, fine grained, fossiliferous (brachiopods and crinoid columnals).	657.1-657.9
Shale, dark grey, non-friable, 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 inches 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
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 Formation	
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, non-fossiliferous.	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, non-friable.	698.0-698.8

Shale, dark grey, highly calcareous, non-fissile, highly friable.	698.8-699.9
Shale, dark grey, highly calcareous, fissile, non-friable.	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 ...

PLATE I

Figures 1,2 — *Alpenachitina* n. sp.

Holotype : slide 1-A-50, ring 3; 107.1 by 79.1 microns

Dundee Formation

Infrared photomicrograph

1) high focal level; 2) low focal level.

Figures 3,4 — *Ancyrochitina* cf. *A. cornigera* Collinson and Scott, 1958

Slide 3-A-28; 112.2 by 56.1 microns

Arkona Formation

3) high focal level; 4) low focal level

Figures 5,6 — *A.* cf. *A. cornigera* Collinson and Scott, 1958

Slide 1-A-48, ring 3: 160.7 by 99.5 microns

Bell Formation

Infrared photomicrograph

5) high focal level; 6) low focal level

Figures 7,8,9 — *A.* cf. *A. cornigera* Collinson and Scott, 1958

Slide 3-A-37, ring 2; 114.8 by 76.5 microns

Arkona Formation

7) vesicle; 8 and 9) enlarged views of clavate processes

PLATE I

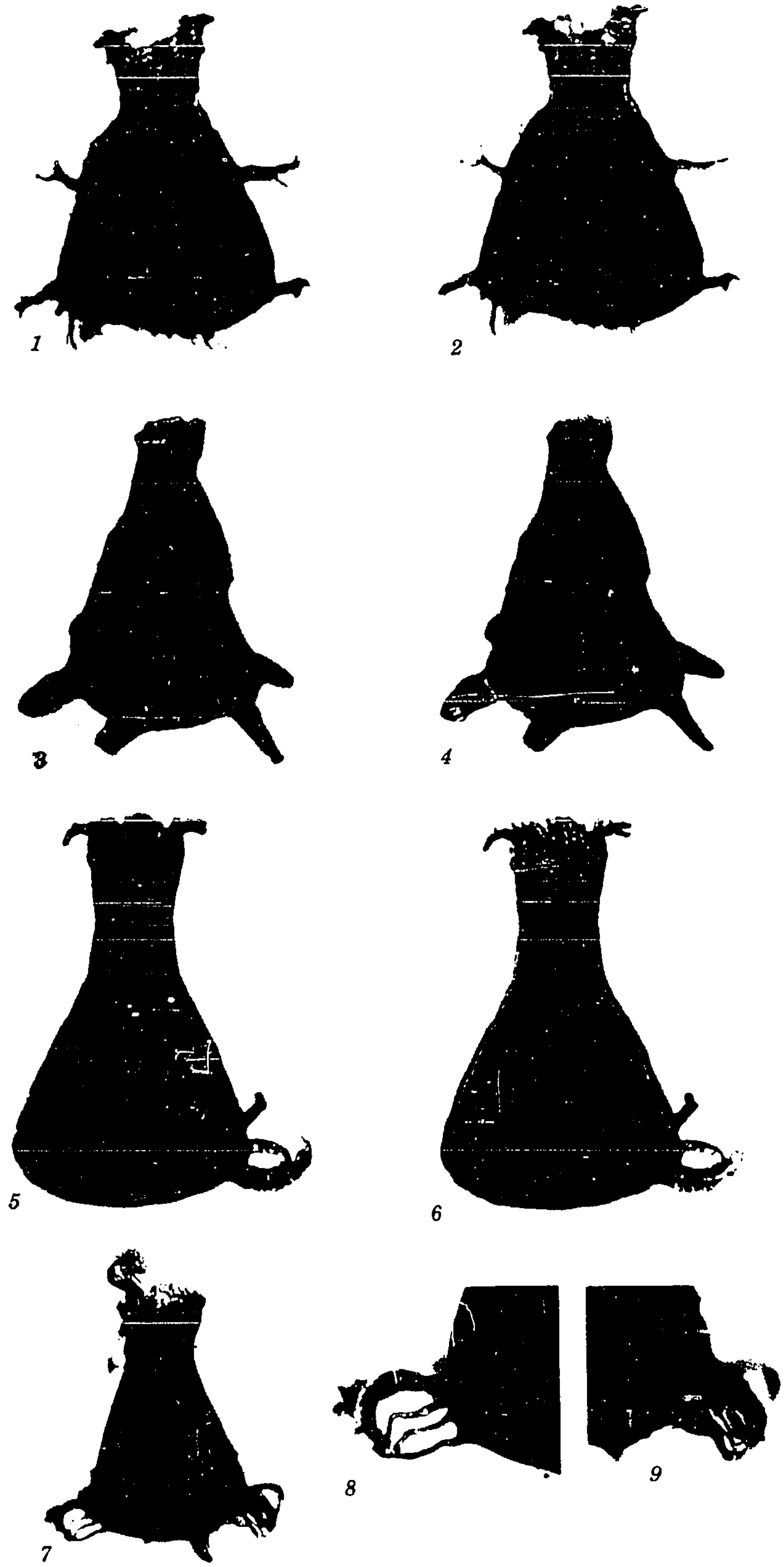

PLATE II

Figures 1,2,3 — *Ancyrochitina* cf. *A. cornigera* Collinson and Scott, 1958

Slide 2-B-4 (1), ring 7; 127.5 by 94.4 microns

Hungry Hollow Formation

Infrared photomicrograph

1) vesicle; 2) enlargement of basal edge spine; 3) enlargement of neck showing oral edge spines and "plug"

Figures 4,5,6 — *A.* cf. *A. desmea* Eisenack 1964

Slide 2-A-12,1 (4); 117.3 by 79.1 microns

Widder Formation

Infrared photomicrograph

4) vesicle; 5) enlargement of neck showing ring of spines; 6) enlargement of basal edge spines

Figure 7 — *A. gordita* Cramer 1964

Slide 3-A-47; 94.4 by 89.3 microns

Bell Formation

Figure 8 — *A. gordita* Cramer, 1964

Slide 1-A-44, ring 5; 102.0 by 91.8 microns

Rockport Quarry Formation

Figure 9 — *A. gordita* Cramer, 1964

Slide 3-A-37 (1), ring 5; 94.4 by 79.1 microns

Arkona Formation

Infrared photomicrograph

Figure 10	*Ancyrochitina gordita* Cramer, 1964 Slide 1-A-9 (2), ring 3; 99.5 by 33.2 microns Hungry Hollow Formation
Figure 11	*A.* cf. *A. langei* Sommer and van Boekel, 1964 Slide 1-A-47, ring 4; 147.9 by 81.6 microns Bell Formation Infrared photomicrograph
Figure 12	*A.* cf. *A. langei* Sommer and van Boekel, 1964 Slide 1-A-38, ring 2; 112.4 by 89.3 microns Rockport Quarry Formation

PLATE II

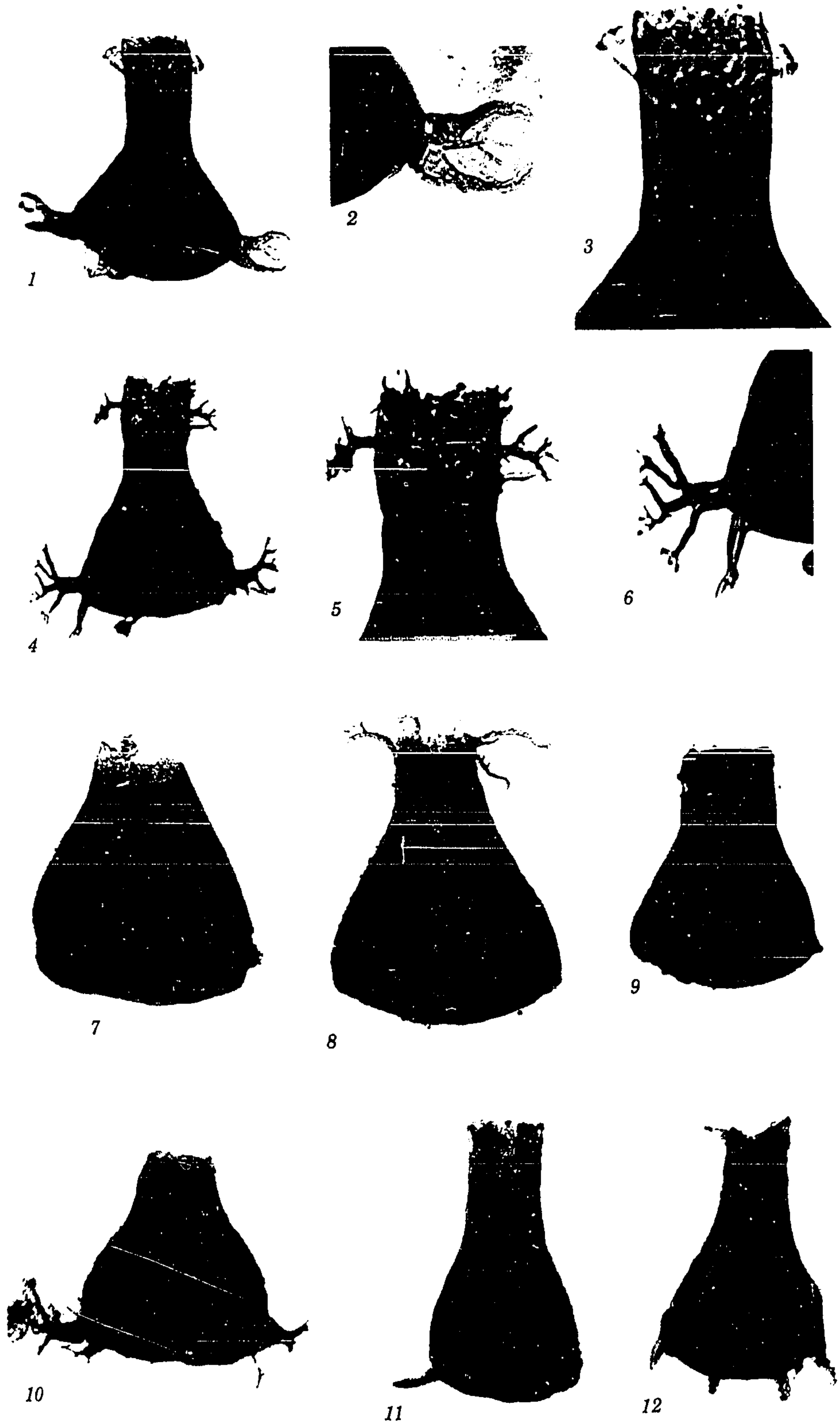

PLATE III

Figure 1 — *Ancyrochitina* cf. *A. langei* Sommer and van Boekel, 1964
Slide 1-A-9 (2), ring 6; 155.6 by 89.3 microns
Widder Formation
Infrared photomicrograph

Figures 2,3 — *A.* cf. *A. langei* Sommer and van Boekel, 1964
Slide 2-A-51, ring 11; 125.5 by 96.9 microns
Bell Formation
Infrared photomicrograph
2) vesicle; 3) enlargement showing oral edge spines and "plug"

Figures 4,5 — *A.* cf. *A. langei* Sommer and van Boekel, 1964
Slide 2-A-54, ring 18; 135.2 by 89.3 microns
Bell Formation
Infrared photomicrograph
4) vesicle; 5) enlargement of neck showing oral edge spines

Figure 6 — *A.* cf. *A. langei* Sommer and van Boekel, 1964
Slide 1-A-9 (1), ring 6; 109.7 by 86.7 microns
Hungry Hollow Formation

Figure 7 — *A.* cf. *A. langei* Sommer and van Boekel, 1964
Slide 1-A-9 (1), ring 6; 109.7 by 86.7 microns
Hungry Hollow Formation

Figures 8,9   *A.* cf. *A.* *langei* Sommer and van Boekel, 1964

Slide 1-A-9 (1), ring 1; 119.9 by 96.9 microns

Hungry Hollow Formation

Infrared photomicrograph

8) vesicle; 9) enlargement showing oral edge and "plug" with spines

PLATE III

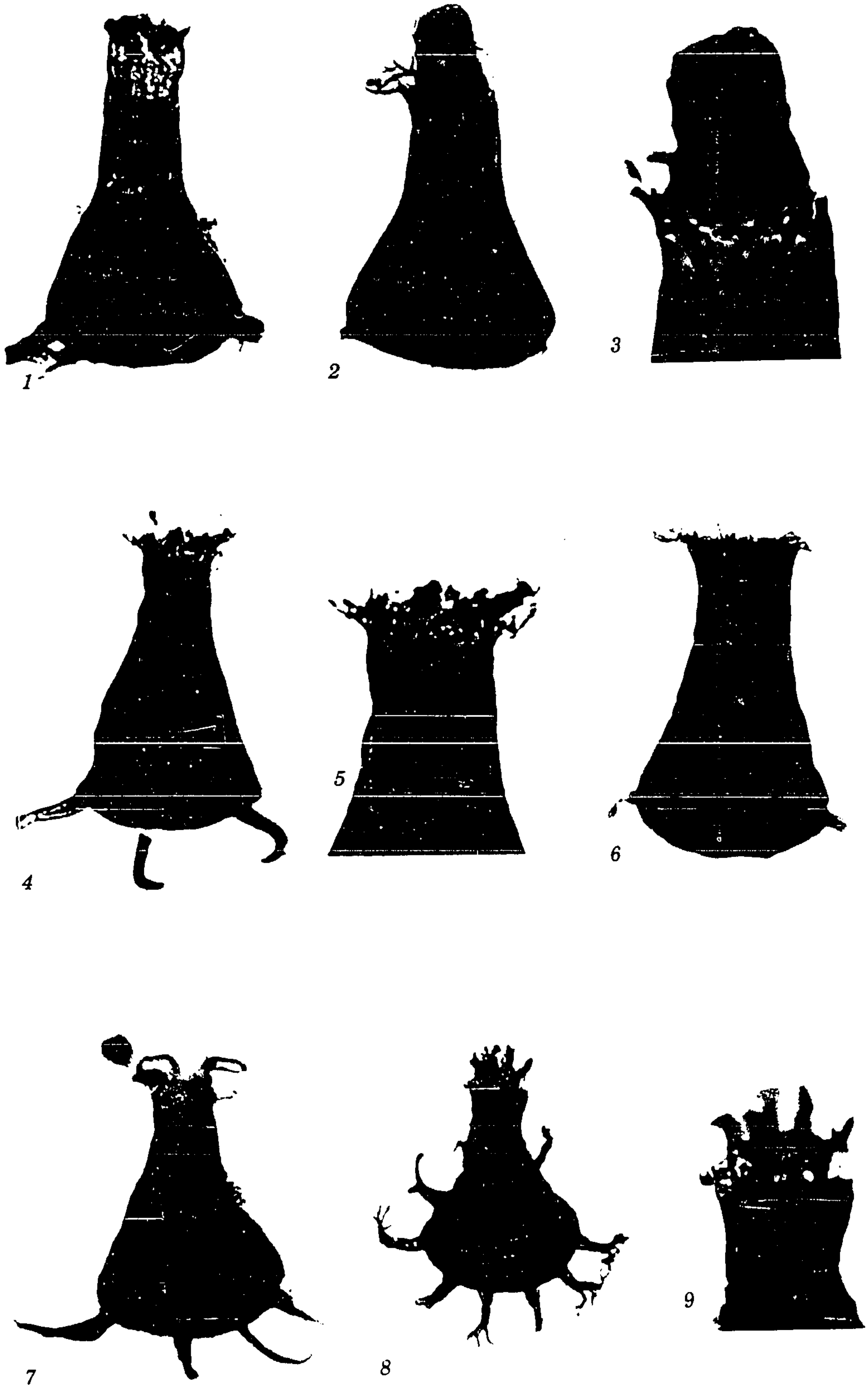

PLATE IV

Figure 1	Ancyrochitina cf. A. multiramosa Taugourdeau and de Jekhowsky 1960 Slide 1-A-9 (2), ring 1; 114.8 by 68.9 microns Hungry Hollow Formation
Figure 2	A. tomentosa Taugourdeau and de Jekhowsky, 1960 Slide 1-A-2, ring 6; 107.1 by 79.1 microns Hungry Hollow Formation
Figure 3	A. cf. A. tumida Taugourdeau and de Jekhowsky, 1960 Slide 1-A-48, ring 5; 130.1 by 76.5 microns Bell Formation
Figures 4,5	A. cf. A. tumida Taugourdeau and de Jekhowsky, 1960 Slide 1-A-45, ring 3; 110.9 by 94.4 microns Bell Formation Infrared photomicrograph 4) enlargement of neck showing "plug" and oral edge spines; 5) vesicle
Figure 6	A. cf. A. tumida Taugourdeau and de Jekhowsky, 1960 Slide 1-A-47, ring 1; 130.1 by 99.5 microns Bell Formation

Figure 7 *Ancyrochitina* cf. *A. tumida* Taugourdeau and de Jekhowsky, 1960

Slide 1-A-45, ring 5; 117.3 by 89.3 microns

Bell Formation

Figures 8,9 *A.* n. sp. 1

Holotype: slide 3-A-27 (2); 125.0 by 96.9 microns

Arkona Formation

Infrared photomicrograph

8) enlargement of neck showing fringe of oral edge spines; 9) vesicle.

Figure 10 *A.* n. sp. 2

Holotype: slide 3-A-26 (2), ring 1; 153.0 by 94.4 microns

Arkona Formation

Figure 11 *A.* n. sp. 2

Slide 3-A-8; 204.0 by 91.8 microns

Widder Formation

Figure 12 *A.* n. sp. 2

Slide 1-A-46, ring 5; 137.7 by 96.9 microns

Bell Formation

PLATE IV.

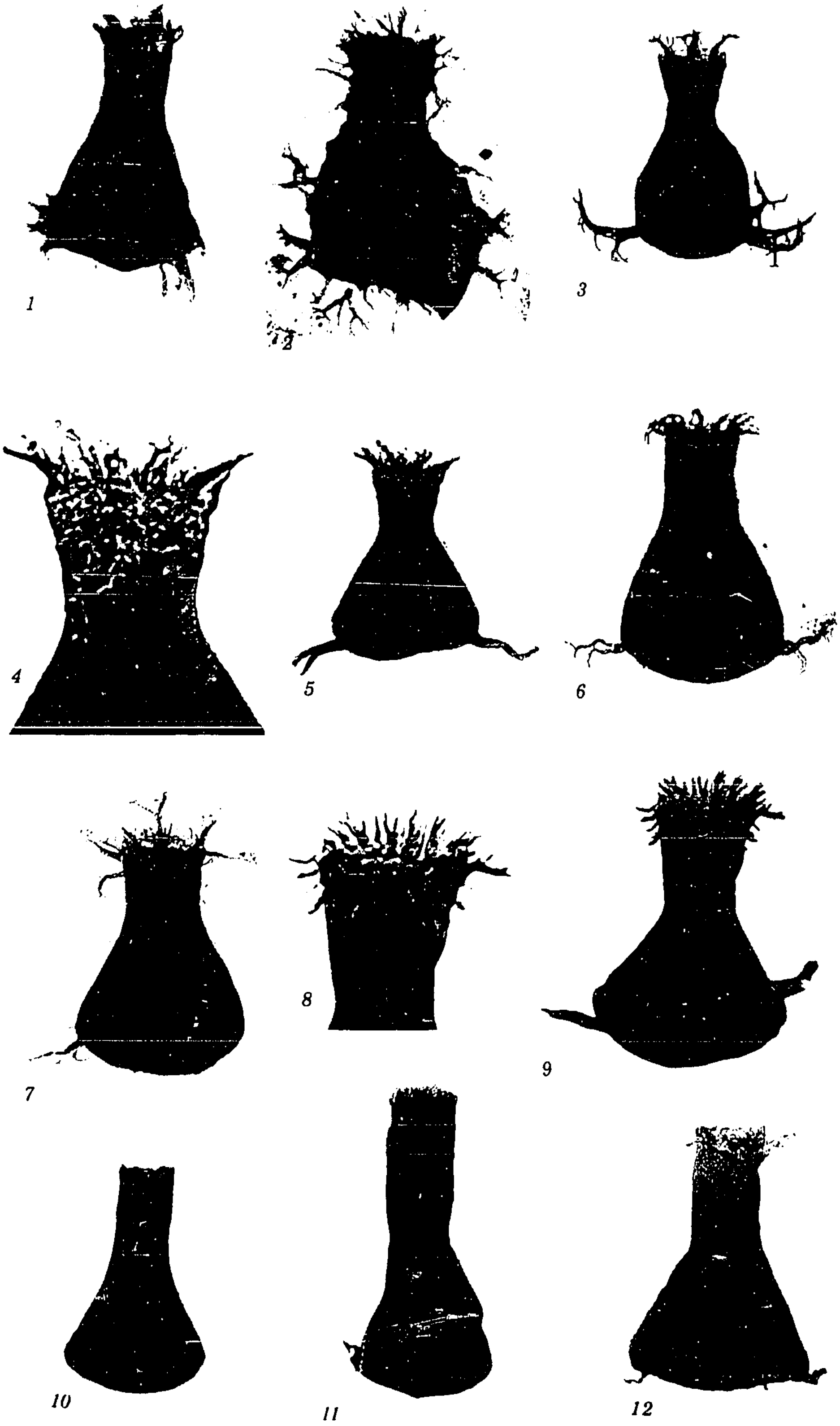

PLATE V

Figures 1,2	*Ancyrochitina* n. sp. 2 Slide 3-A-27 (1), ring 2; 117.3 by 79.1 microns Arkona Formation Infrared photomicrograph 1) vesicle; 2) enlargement of neck showing fringe of oral edge spines
Figure 3	*A.* sp. 1 Slide 3-A-27 (1), ring 1; 104.6 by 81.6 microns Arkona Formation
Figure 4	*A.* sp. 2 Slide 3-A-27 (1), ring 4; 122.4 by 81.6 microns Arkona Formation
Figure 5	*A.* sp. 4 Slide 1-A-9 (1), ring 4; 178.5 by 99.5 microns Hungry Hollow Formation
Figure 6	*A.* sp. 3 Slide 1-A-4 (1), ring 4; 119.9 by 91.8 microns Widder Formation
Figure 7	*A.* sp. 5 Slide 3-A-39; 104.6 b6 74.0 microns Arkona Formation

Figure 8	*Ancyrochitina* sp. 6
	Slide 1-A-46, ring 4; 81.6 by 35.7 microns
	Bell Formation
Figure 9	*A.* sp. 8
	Slide 1-A-31 (2), ring 3; 76.5 by 74.0 microns
	Arkona Formation
Figure 10	?*A.* sp. 9
	Slide 1-A-29, ring 6; 117.3 by 76.5 microns
	Arkona Formation
Figure 11	*A.* sp. 7
	Slide 1-A-1, ring 3; 145.4 by 74.0 microns
	Widder Formation
	Infrared photomicrograph

PLATE V

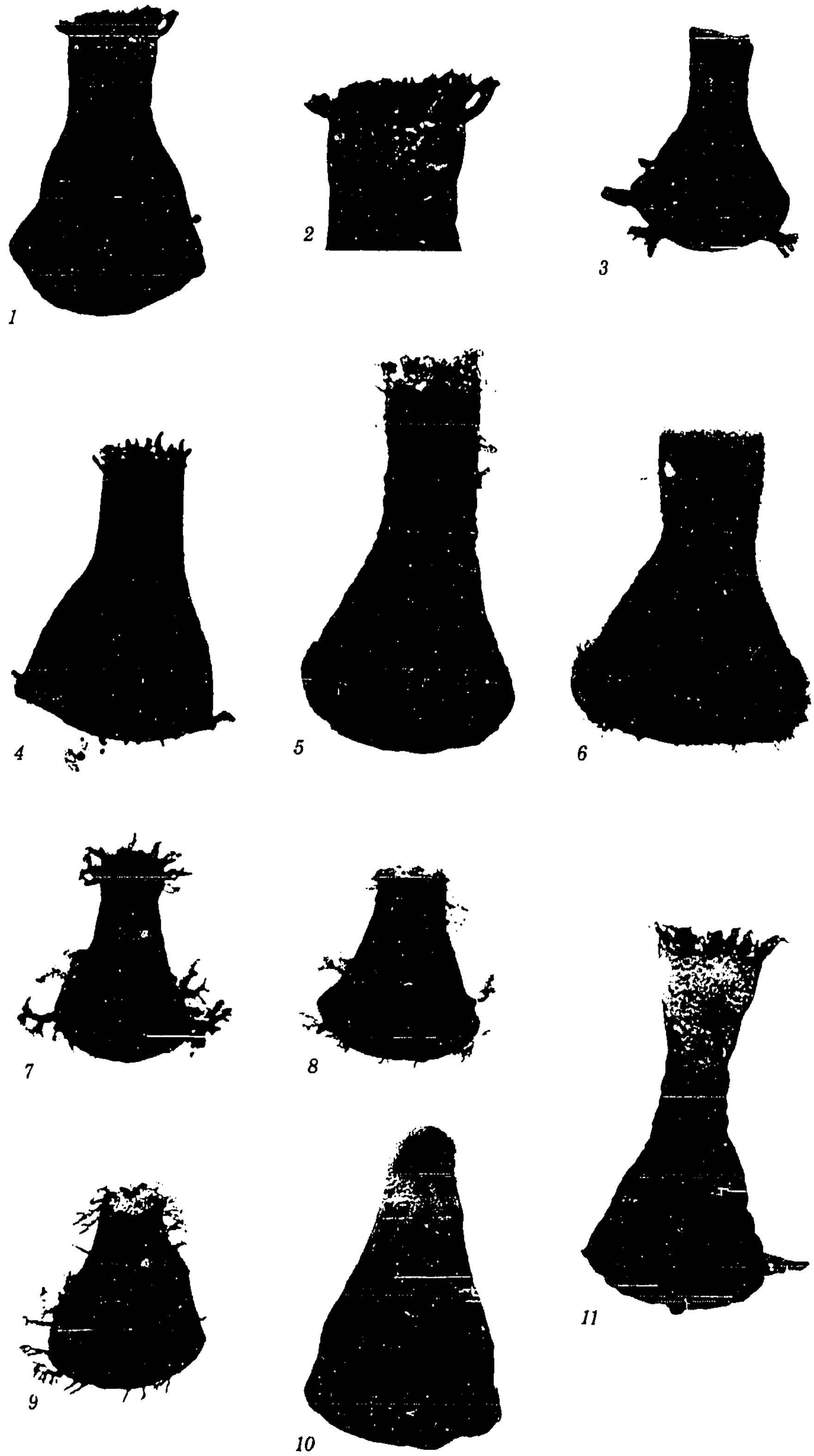

PLATE VI

Figure 1	*Angochitina* cf. *A.*? *collinsoni* Taugourdeau and de Jekhowsky, 1961 Slide 2-A-14; 114.8 by 74.0 microns Widder Formation
Figure 2	*A.* cf. *A.*? *collinsoni* Taugourdeau and de Jekhowsky, 1961 Slide 1-A-8, ring 11; 86.7 by 71.4 microns Widder Formation
Figure 3	*A.* *devonica* Eisenack, 1955 Slide 1-A-6, ring 5; 142.8 by 71.4 microns Widder Formation
Figure 4	*A.* *devonica* Eisenack, 1955 Slide 2-A-14 (1), ring 10; 137.7 by 71.4 microns Widder Formation
Figure 5	*A.* *devonica* Wisenack, 1955 Slide 2-A-14 (1), ring 15; 155.6 by 74.0 microns Widder Formation Infrared photomicrograph
Figure 6	*A.* *milanensis* Collinson and Scott, 1958 Slide 1-A-8, ring 5; 145.4 by 71.4 microns Widder Formation

Figures 7,8 — *Angochitina milanensis* Collinson and Scott, 1958

Slide 1-A-13, ring 9; 158.1 by 66.3 microns

Arkona Formation

7) vesicle; 8) enlargement showing bifurcating spines.

Figure 9 — *A.* cf. *A. ramusculosa* Cramer, 1964

Slide 1-A-14, ring 8; 176.0 by 66.3 microns

Arkona Formation

Figure 10 — *A.* cf. *A. ramusculosa* Cramer, 1964

Slide 1-A-8, ring 14; 137.7 by 66.3 microns

Widder Formation

Figure 11 — *A.* cf. *A. ramusculosa* Cramer, 1964

Slide 1-A-14, ring 8; 150.5 by 66.3 microns

ArkonaFormation

Figure 12 — *A. toyetae* Cramer, 1964

Slide 1-A-7 (1), ring 10; 104.6 by 40.8 microns

Widder Formation

PLATE VI

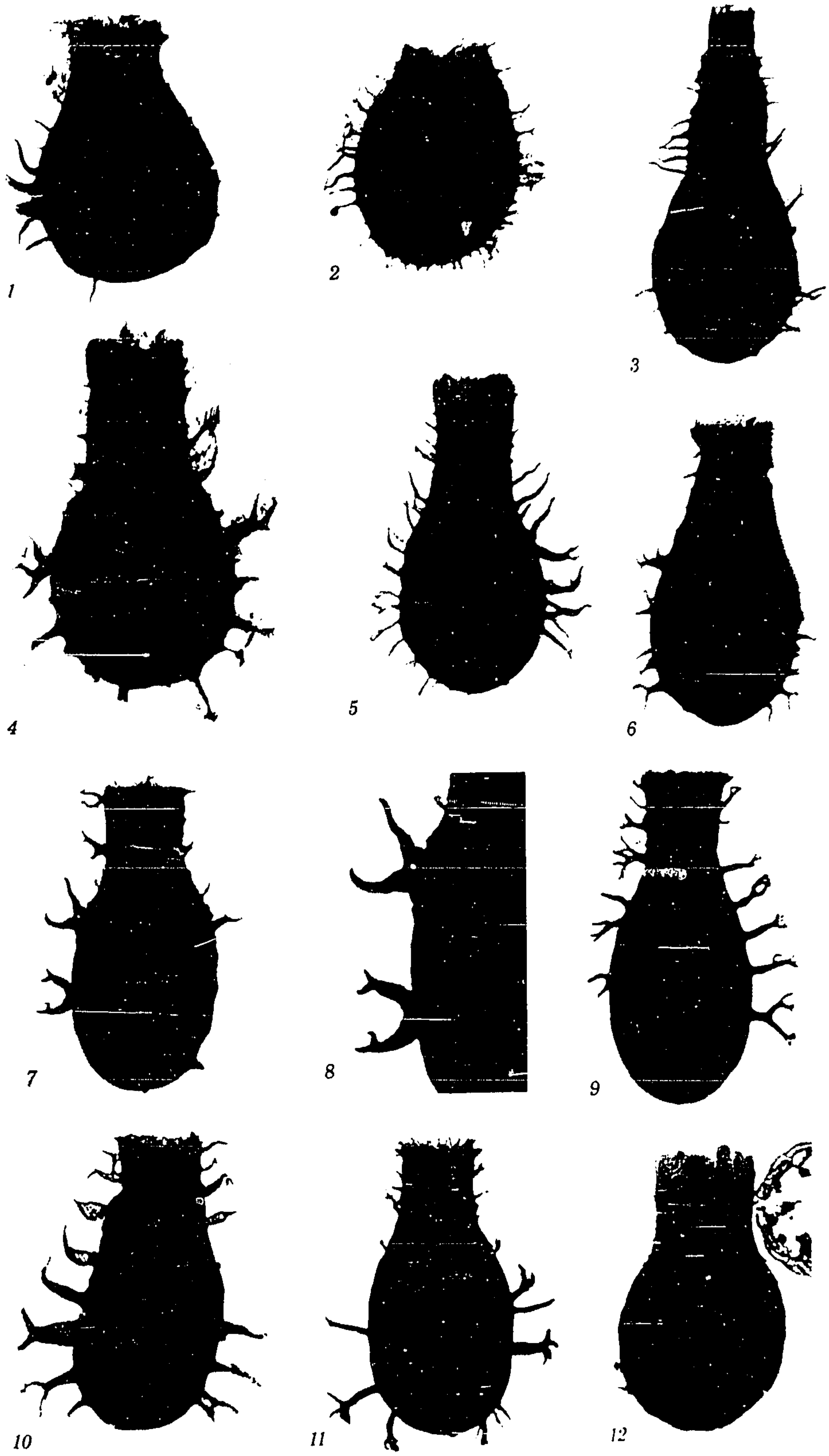

PLATE VII

Figure 1	*Angochitina toyetae* Cramer, 1964 Slide 1-A-6, ring 12; 127.5 by 79.1 microns Widder Formation
Figure 2	*A. toyetae* Cramer, 1964 Slide 1-A-6, ring 3; 130.1 by 68.8 microns Widder Formation
Figure 3	*A.* sp. 1 Slide 2-A-16 (1), ring 1; 163.2 by 86.7 microns Widder Formation
Figure 4	*A.* n. sp. 1 Holotype: slide 2-A-11 (1), ring 6; 107.1 by 68.9 microns Widder Formation Infrared photomicrograph
Figures 5,8	*Sphaerochitina* n. sp. Holotype: slide 1-A-31 (2), ring 4; 89.3 by 76.1 microns Arkona Formation Infrared photomicrographs 5) vesicle; 8) enlargement of neck showing spines and "plug"

Figures 6,7	*Angochitina* sp. 2
	Slide 1-A-48, ring 4; 168.3 by 81.6 microns
	Bell Formation
	Infrared photomicrograph
	6) vesicle; 7) enlargement of neck showing "plug"
Figure 9	New genus A, n. sp.
	Holotype: slide 1-A-45; 165.8 by 79.1 microns
	Bell Formation
	Infrared photomicrograph

PLATE VII

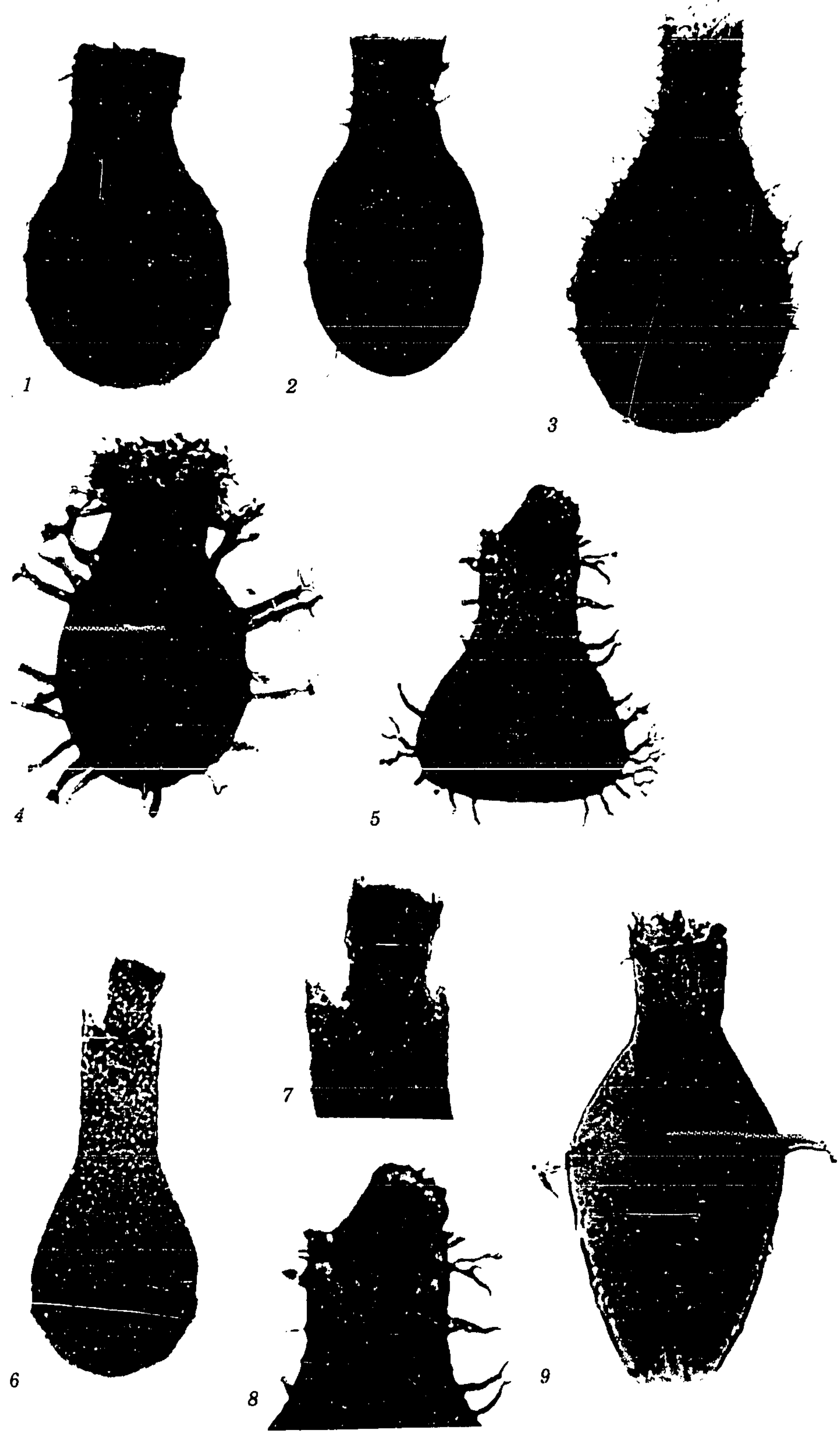

PLATE VIII

Figure 1 — *Calpichitina* ? sp.
Slide 2-B-8, ring 1; 117.3 microns diameter
Rockport Quarry Formation

Figure 2 — *Desmochitina bursa* Taugourdeau and de Jekhowsky, 1960
Slide 1-A-31 (2), ring 6; 89.3 by 112.2 microns; 94.4 by 109.7 microns
Arkona Formation
Infrared photomicrograph

Figure 3 — *D. bursa* Taugourdeau and de Jekhowsky, 1960
Slide 1-A-30, ring 1; 86.7 by 104.6 microns
Arkona Formation

Figure 4 — *D.* sp.
Slide 2-A-38, ring 8; 107.1 by 99.5 microns
Arkona Formation

Figure 5 — *D.* sp.
Slide 1-A-36, ring 4; 117.3 by 74.0 microns
Arkona Formation

Figure 6 — *Eisenackitina castor* Jansonius, 1964
Slide 1-A-41 (1), ring 3; 122.4 by 102.2 microns
Bell Formation

Figure 7 — *Eisenackitina castor* Jansonius, 1964

Slide 2-A-35 (2), ring 1; 127.5 by 112.2 microns

Arkona Formation

Infrared photomicrograph

Figures 8,9 — *E. castor* Jansonius, 1964

Slide 2-A-34 (1), ring 3; 122.4 by 96.9 microns

Arkona Formation

Infrared photomicrograph

8) enlargement of wall showing ornamentation;

9) vesicle

Figure 10 — *E. castor* Jansonius, 1964

Slide 2-A-42 (1), ring 6; 122.4 by 102.0 microns

Arkona Formation

Figure 11 — *E.* n. sp.

Slide 1-B-4, ring 11; 153.0 by 89.3 microns

Arkona Formation

Figure 12 — *E.* n. sp.

Holotype: slide 1-A-42, ring 1; 122.4 by 91.8 microns

Bell Formation

PLATE VIII

PLATE IX

Figure 1 — *Hoegisphaera* cf. *H. glabra* Staplin, 1961
Slide 1-A-41 (2), ring 3; 102.0 microns diameter
Bell Formation

Figure 2 — *H.* cf. *H. glabra* Staplin, 1961
Slide 1-A-23, ring 2; 104.6 microns diameter
Arkona Formation

Figure 3 — *H.* cf. *H. glabra* Staplin, 1961
Slide 1-B-7 (3); 104.6 microns diameter
Rockport Quarry Formation
Infrared photomicrograph

Figure 4 — *H.* cf. *H. glabra* Staplin, 1961
Slide 1-B-7 (2), ring 3; 104.6 microns diameter
Rockport Quarry Formation
Infrared photomicrograph

Figure 5 — *H.* cf. *H. glabra* Staplin, 1961
Slide 1-B-6, ring 1; 102.0 by 86.7 microns
Arkona Formation
Infrared photomicrograph

Figure 6 — *H.* cf. *H. glabra* Staplin, 1961
Slide 1-A-7 (1a); 91.8 microns diameter
Rockport Quarry Formation
Infrared photomicrograph

Figure 7 *Hoegisphaera* cf. *H. glabra* Staplin, 1961

Slide 1-B-7 (2), ring 4; 102.0 by 89.3 microns

Rockport Quarry Formation

Infrared photomicrograph

Figure 8 *H.* cf. *H. glabra* Staplin, 1961

Slide 1-B-7 (1); 94.4 microns, 94.4 microns, 94.4 microns diameter

Rockport Quarry Formation

Infrared photomicrograph

PLATE IX

PLATE X

Figure 1	*Eisenackitina* n. sp.
	Slide 2-A-51, ring 10; 142.8 by 76.5 microns
	Bell Formation
Figure 2	*E.* sp.
	Slide 1-B-7, ring 2; 114.8 by 91.8 microns
	Rockport Quarry Formation
Figure 3	*E.* sp.
	Slide 2-A-47 (1), ring 8; 162.5 by 127.5 microns
	Rockport Quarry Formation
Figures 4,7,8	New genus B and n. sp.
	Holotype: slide 1-B-8 (1), ring 2; 102.0 by 107.1 microns
	Bell Formation
	Infrared photomicrograph
	4) vesicle; 7) enlargement showing ornament; 8) enlargement showing basal edge
Figures 5,6	New genus B and n. sp.
	Slide 2-A-52, ring 3; 109.7 by 140.3 microns
	Bell Formation
	Infrared photomicrograph
Figure 9	New genus B and n. sp.
	Slide 1-A-44, ring 2; 99.5 by 112.4 microns
	Bell Formation

Figures 10,11 New genus B and n. sp.

Slide 1-A-38; 114.8 by 107.1 microns, 114.8 by 122.4 microns

Arkona Formation

Infrared photomicrograph

10) high focal level; 11) low focal level

PLATE X

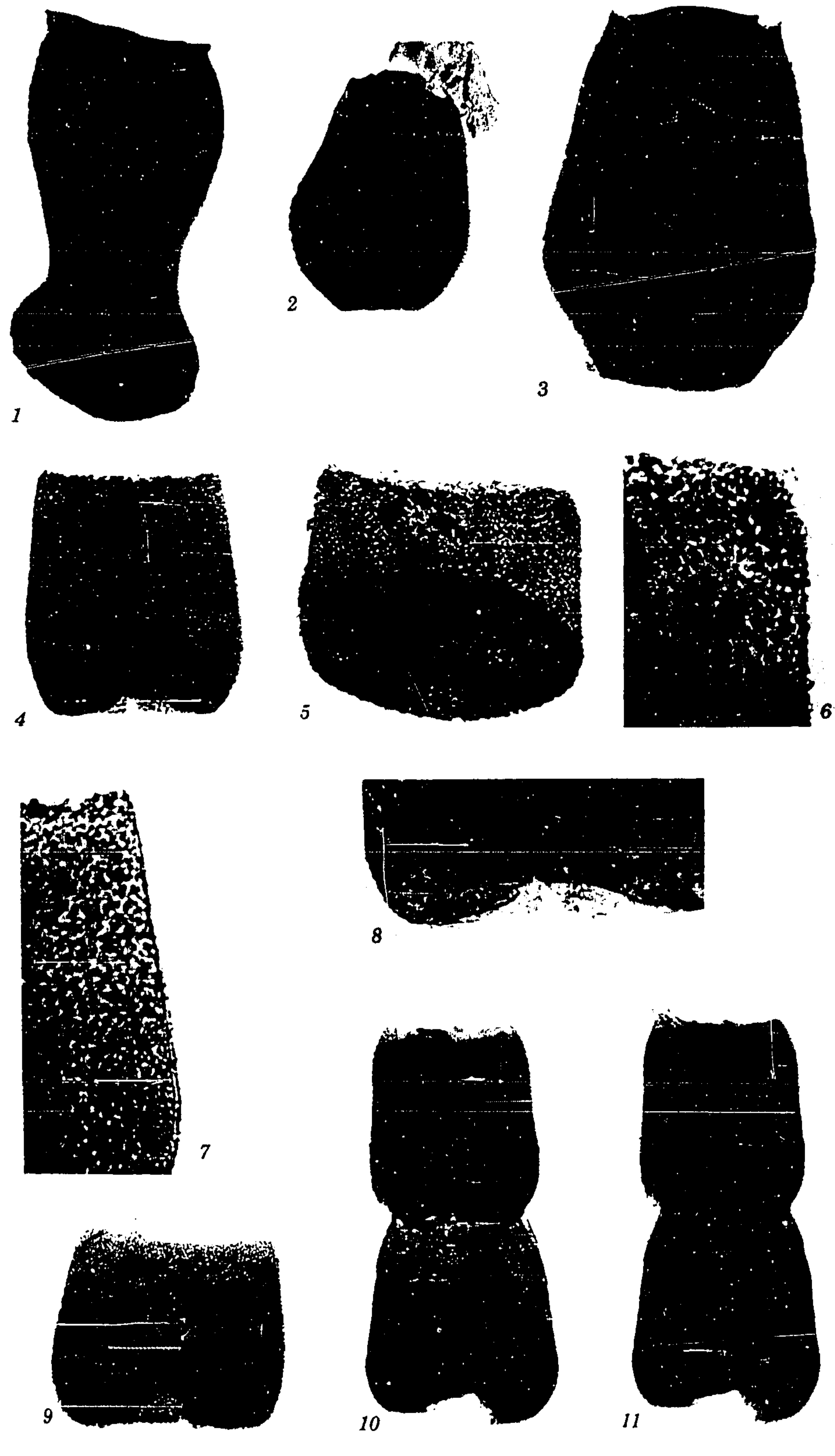

PLATE XI

Figure 1	*Conochitina edjelensis* Taugourdeau, 1963 Slide 1-A-13, ring 8; 117.3 by 74.0 microns Arkona Formation
Figure 2	*Rhabdochitina* sp. 1 Slide 3-A-2, ring 1; 351.9 by 58.7 microns Ipperwash Formation
Figure 3	*R.* sp. 2 Slide 2-A-46 (1), ring 2; 130.1 by 45.9 microns Rockport Quarry Formation
Figure 4	*R.* sp. 3 Slide 2-A-43 (1), ring 5; 306.0 by 91.8 microns Rockport Quarry Formation
Figure 5	*Hercochitina* aff. *H. turnbulli* Jenkins, 1969 Slide 1-A-31 (2), ring 6a; 122.4 by 63.8 microns Arkona Formation Infrared photomicrograph
Figure 6	*H.* aff. *H. turnbulli* Jenkins 1969 Slide 1-A-31 (1), ring 2; 114.8 by 40.8 microns Arkona Formation
Figure 7	*Illichitina* sp. Slide 2-A-49, (1), ring 5; 102.0 by 89.3 microns Bell Formation

Figure 8 *Kalochitina* ? sp.

Slide 1-A-31 (1), ring 10; 114.8 by 98.3 microns

Arkona Formation

Infrared photomicrograph

Figure 9 *K* ? sp.

Slide 1-A-31 (1), ring 4; 117.3 by 81.6 microns

Arkona Formation

Infrared photomicrograph

Figure 10 aff. *Cyathochitina kuckersiana kuckersiana* (Eisenack) 1934

Slide 2-A-1 (1), ring 8; 114.8 by 99.5 microns

Ipperwash Formation

Figure 11 *Lagenochitina* sp.

Slide 1-A-8, ring 4; 147.9 by 74.0 microns

Widder Formation

Figure 12 *L*. cf. *L*. *brevicollis* Taugourdeau and de Jekhowsky, 1960

Slide 1-A-8, ring 10; 119.9 by 68.9 microns

Widder Formation

Figure 13 *L*. cf. *L*. *brevicollis* Taugourdeau and de Jekhowsky, 1960

Slide 1-A-7 (1), ring 12; 104.6 by 66.3 microns

Widder Formation

PLATE XI

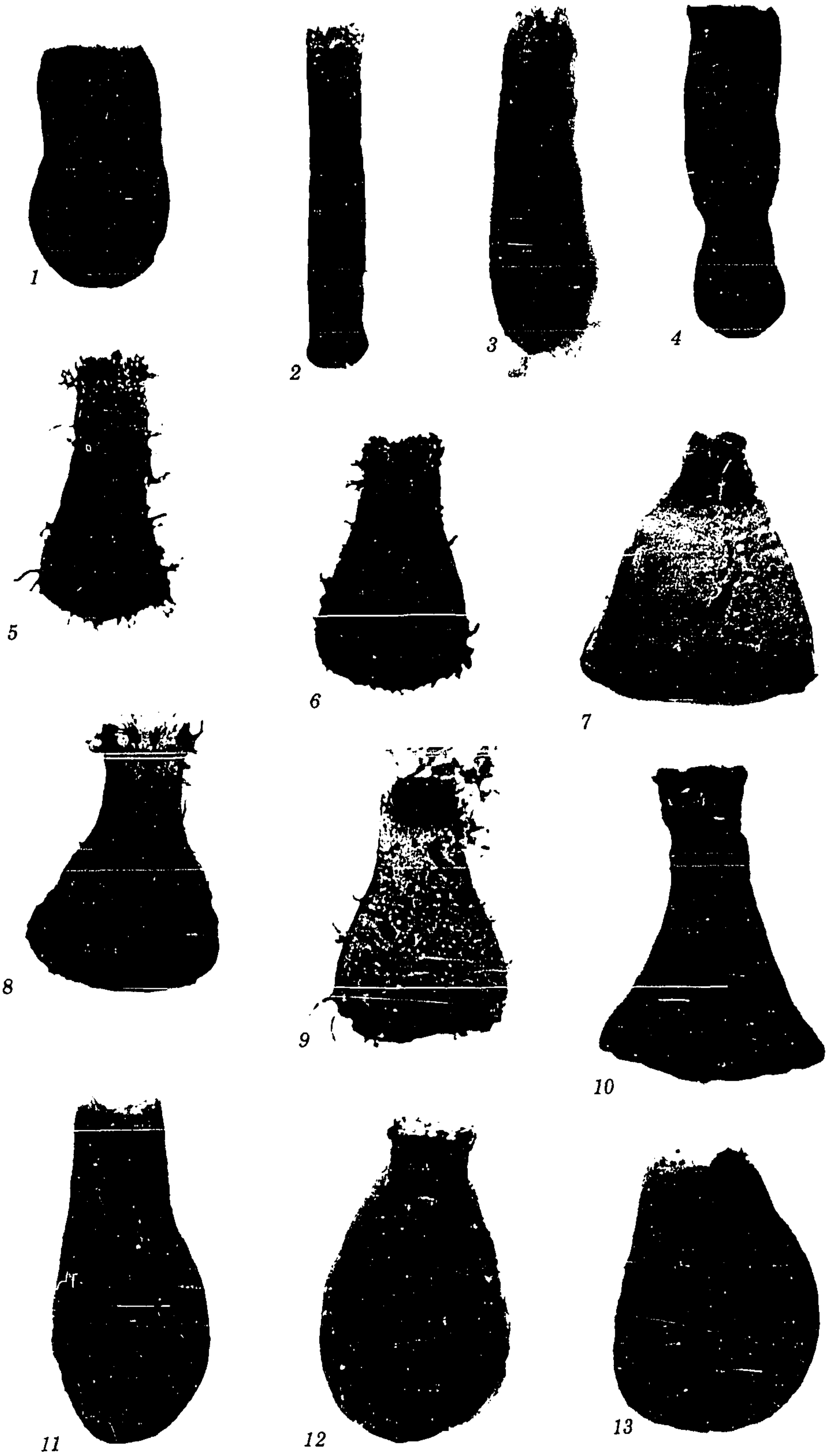

PLATE XII

Figure 1	*Lagenochitina* cf. *L. amottensis* Grignani and Mantovani, 1964 Slide 2-A-48 (1), ring 4; 178.5 by 81.6 microns Bell Formation
Figure 2	*L.* sp. 1 Slide 1-A-13, ring 6; 170.9 by 89.3 microns Arkona Formation
Figure 3	Chitinozoan 1 Slide 1-A-4 (1), ring 10; 186.2 by 33.2 microns Widder Formation
Figure 4	Chitinozoan 2 Slide 3-A-38; 242.3 by 40.8 microns Arkona Formation
Figures 5,6	*Angochitina* n. sp. 2 Holotype: slide 2-A-25; 137.7 by 81.6 microns Arkona Formation 5) enlargement of spines; 6) vesicle
Figures 7,8	*Baltisphaeridium* sp. Slide 2-A-56 (2), ring 3; diameter 63.8 microns Bell Formation 7) high focal level; 8) low focal level

Figures 9,10 *Cymatiosphaera* "*canadensis*" Deunff, 1954

Slide 2-A-34 (1), ring 2; 63.8 microns diameter

Arkona Formation

9) high focal level; 10) low focal level

Figures 11,12 *C.* "*canadensis*" Deunff, 1954

Slide 1-A-18, ring 5; 71.4 microns diameter

Arkona Formation

11) high focal level; 12) low focal level

Figures 13,14 *C.* "*canadensis*" Deunff, 1954

Slide 1-A-22, ring 5; 58.7 microns diameter

Arkona Formation

13) high focal level; 14) low focal level

PLATE XII

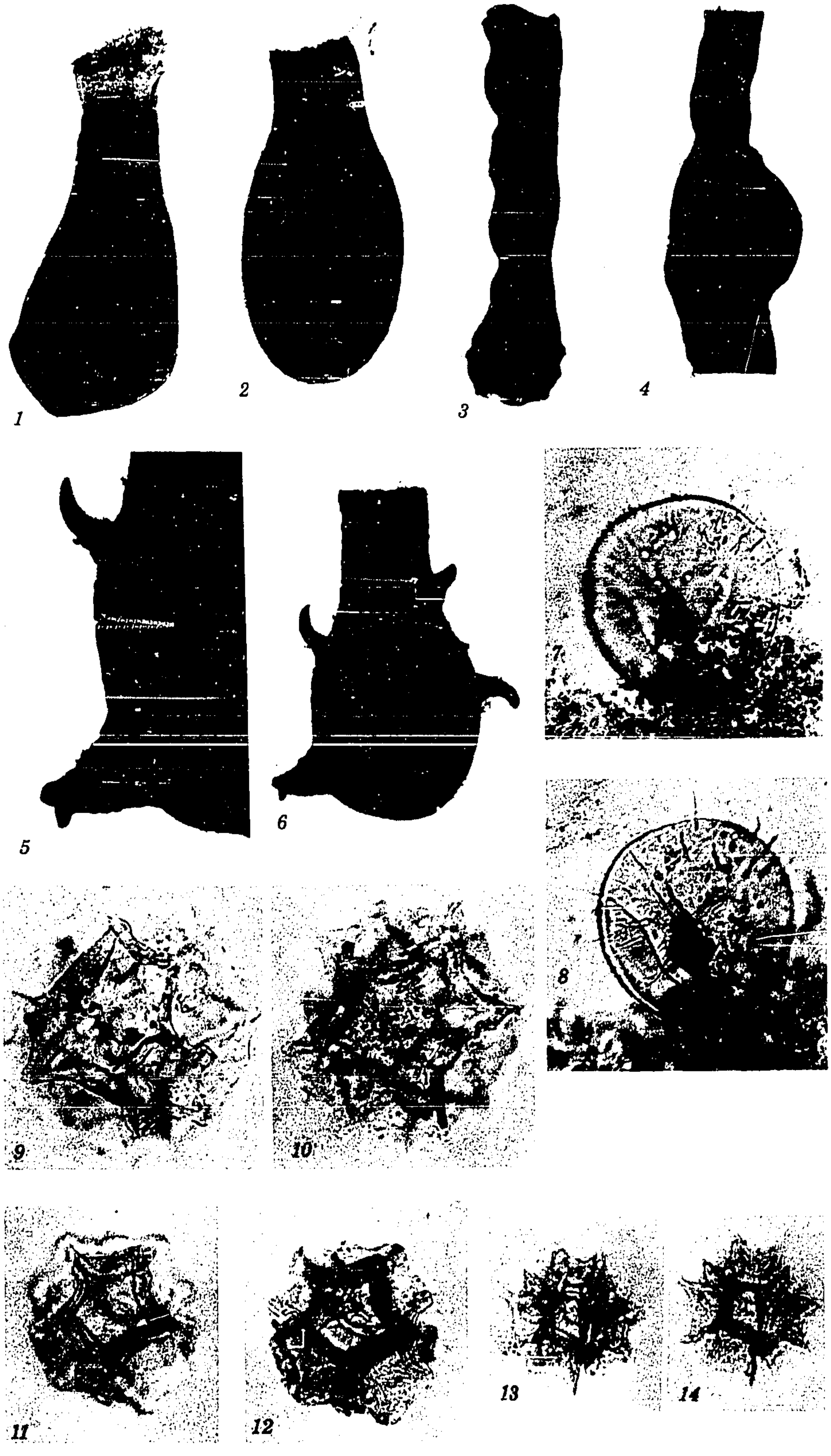

PLATE XIII

Figures 1,2	*Cymatiosphaera* sp. Slide 1-A-50, ring 2; 56.1 microns diameter Dundee Formation 1) low focal level; 2) high focal level
Figure 3	*Dictyotidium dictyotum* (Eisenack) 1938 Slide 2-A-49 (2), ring 2; 79.1 microns diameter Bell Formation
Figure 4	*D. dictyotum* (Eisenack) 1938 Slide 2-A-38, ring 6; 86.7 microns diameter Arkona Formation
Figure 5	*D. dictyotum* (Eisenack) 1938 Slide 1-A-37, ring 4; 79.1 microns diameter Rockport Quarry Formation
Figure 6	*D. dictyotum* (Eisenack) 1938 Slide 1-A-29, ring 3; 76.5 microns diameter Arkona Formation
Figures 7,8	New genus C and n. sp. Holotype: slide 3-A-36 (1), ring 3; 81.6 microns diameter Arkona Formation 7) high focal level; 8) low focal level
Figure 9	*Quisquilites* n. sp. Holotype: slide 1-A-7 (1), ring 6; 142.8 by 40.8 microns Widder Formation

Figure 10 Quisquilites n. sp.

Slide 1-A-4 (1), ring 6; 140.3 by 33.2 microns

Widder Formation

Figure 11 Quisquilites n. sp.

Slide 1-A-13, ring 7; 173.4 by 30.6 microns

Arkona Formation

Figure 12 Quisquilites, n. sp.

Slide 1-A-7 (1), ring 2; 186.2 by 30.6 microns

Widder Formation

Figure 13 Quisquilites n. sp.

Slide 2-A-39, ring 1; 145.4 by 30.6 microns

Arkona Formation

PLATE XIII

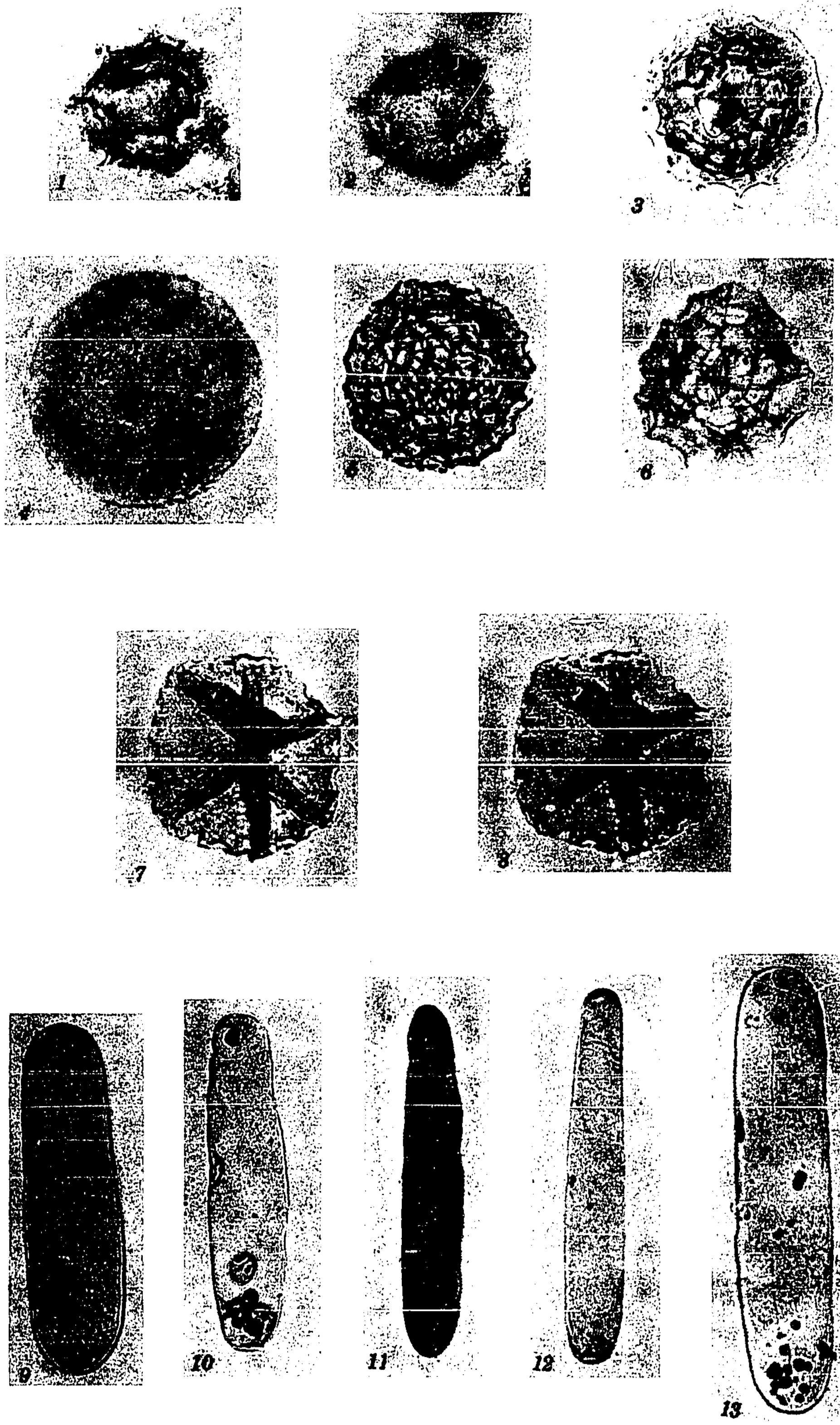

PLATE XIV

Figure 1	Veryhachium cf. V. lairdi (Deflandre) Deunff, 1958 Slide 1-A-12; 37.0 microns side Arkona Formation
Figures 2,3	V. cf. V. lairdi (Deflandre) Deunff, 1958 Slide 2-A-52, ring 3; 28.1 microns altitude Bell Formation 2) high focal level; 3) low focal level
Figure 4	V. cf. V. lairdi (Deflandre) Deunff, 1958 Slide 1-A-4 (1), ring 1; 33.2 microns altitude Widder Formation
Figure 5	V. cf. V. lairdi (Deflandre) Deunff, 1958 Slide 2-A-40 (1), ring 6; 38.3 microns altitude Bell Formation
Figures 6,9	V. sp. 1 Slide 2-A-54, ring 15; 17.3 microns base Bell Formation 6) high focal level; 9) low focal level
Figures 7,8	V. sp. 2 Slide 2-A-38, ring 4; 38.3 microns altitude Arkona Formation 7) high focal level; 8) low focal level

Figures 10,11 *V.* sp. 1

Slide 1-A-16, ring 2; 76.5 microns base

Arkona Formation

10) high focal level; 11) low focal level

PLATE XIV

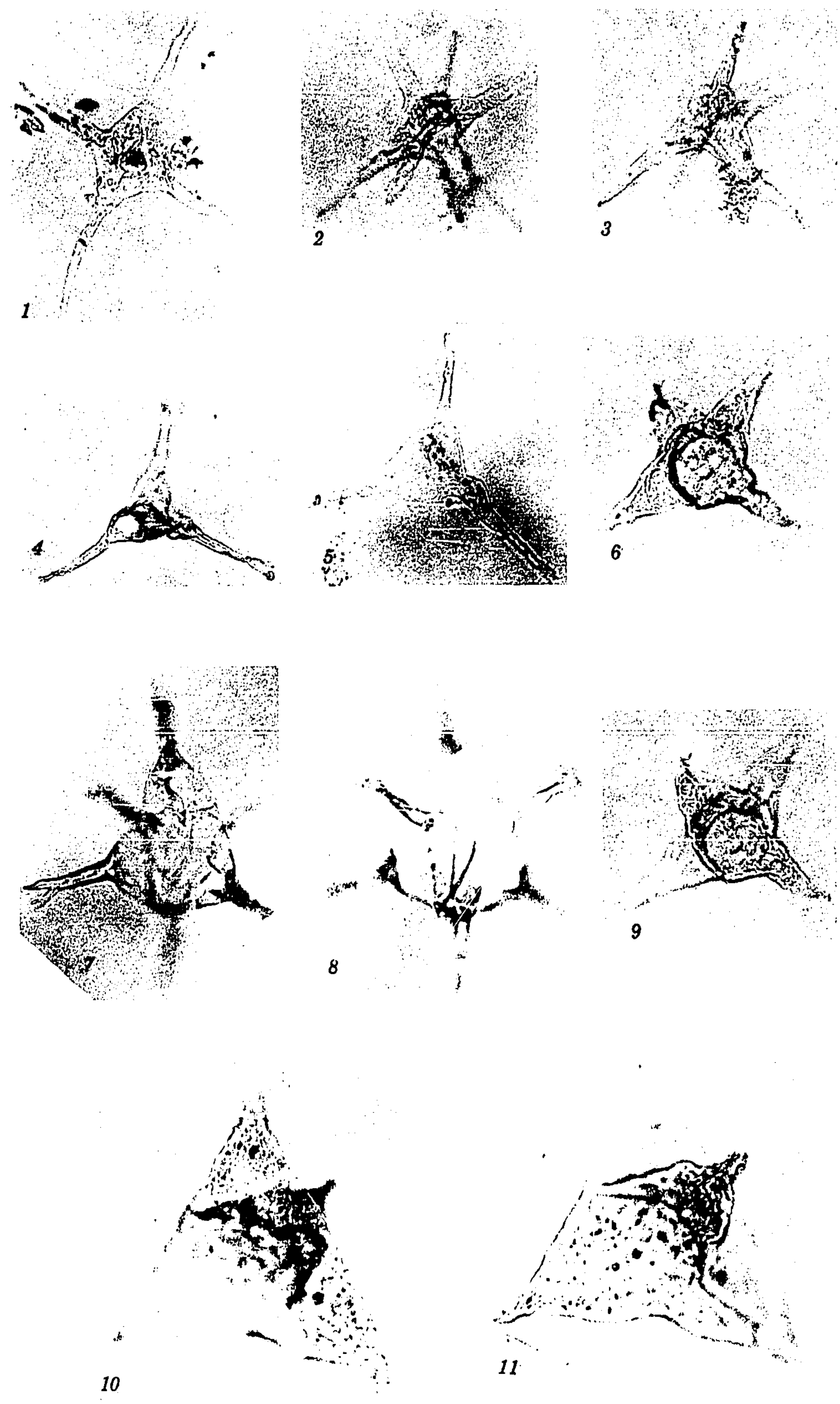

PLATE XV

Figures 1,2	"*Polyedrixium pharaonis*" Deunff, 1955 Slide 2-A-52, ring 13; 25.5 microns side Bell Formation 1) high focal level; 2) low focal level
Figures 3,6	"*P. pharaonis*" Deunff, 1955 Slide 1-A-7 (2), ring 4; 25.5 microns side Widder Formation 3) high focal level; 6) low focal level
Figures 4,7	"*P. cuboides*" Deunff, 1955 Slide 1-A-18, ring 6; 40.8 microns side Arkona Formation 4) high focal level; 7) low focal level
Figures 5,8	"*P. pharaonis*" Deunff, 1955 Slide 2-A-49 (1), ring 6; 25.5 microns side Bell Formation 5) high focal level; 8) low focal level
Figures 9,10	"*P. cuboides*" Deunff, 1955 Slide 1-A-8, ring 12; 25.5 microns side Widder Formation 9) high focal level; 10) low focal level
Figure 11	*Tornacia* sp. Slide 1-B-9, ring 1; 63.8 microns diameter Dundee Formation

Figure 12	*Triangulina* cf. *T. alargada* Cramer, 1964 Slide 2-A-40 (2), ring 5; 63.3 microns altitude Arkona Formation
Figure 13	*Leiosphaeridia* sp. 1 Slide 1-A-4, ring 2; 181.1 microns diameter Widder Formation

PLATE XV

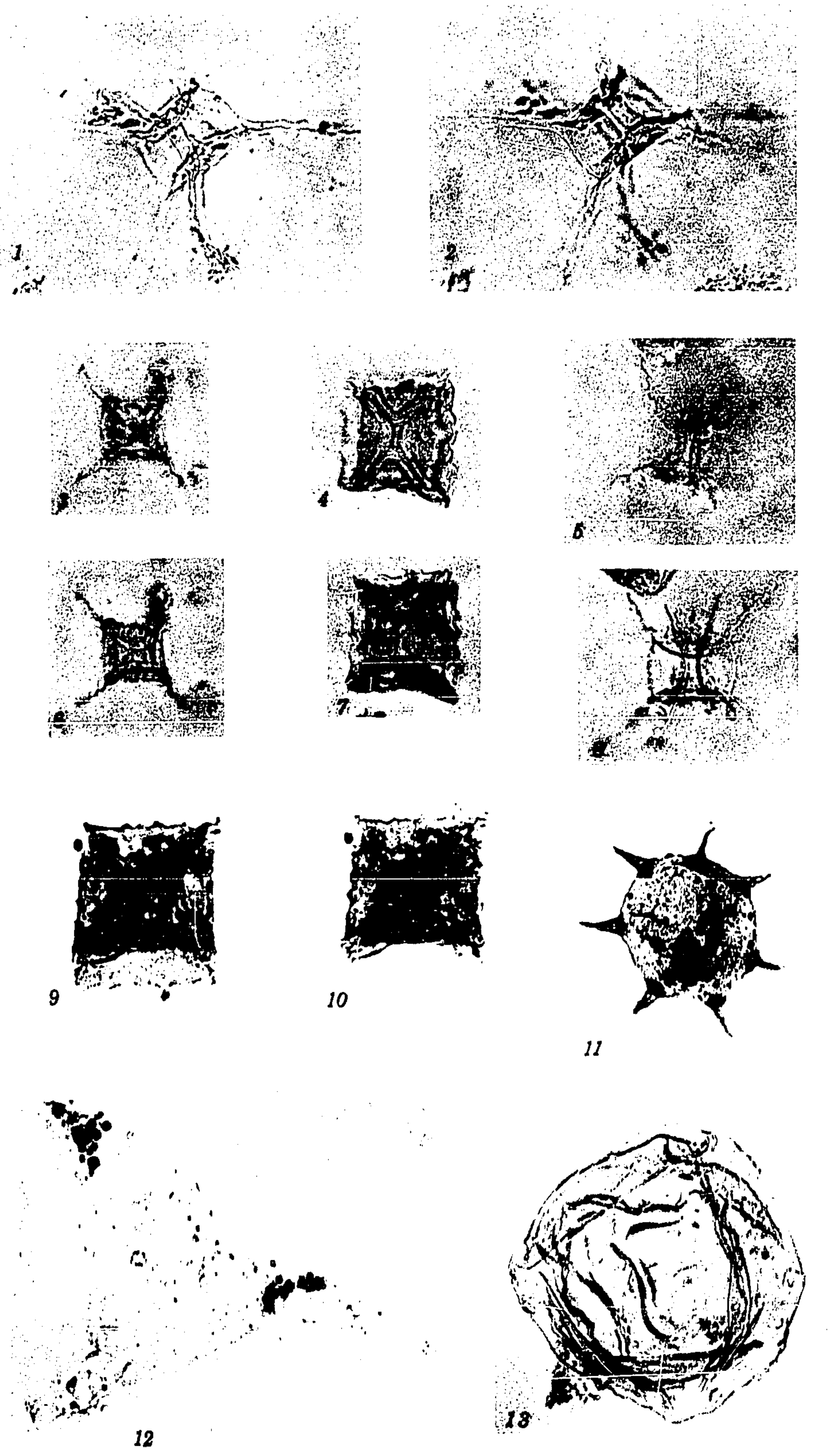

PLATE XVI

Figure 1	*Leiosphaeridia* sp. 1 Slide 1-A-10, ring 1; 165.8 microns diameter Arkona Formation,
Figures 2,4	*Tunisphaeridium concentricum* Deunff and Evitt, 1968 Slide 1-A-16 (2); 38.3 microns vesicle diameter Arkona Formation 2) high focal level; 4) low focal level
Figures 3,5	*T. concentricum* Deunff and Evitt, 1968 Slide 1-A-16 (1), 45.9 microns vesicle diameter Arkona Formation 3) high focal level; 5) low focal level
Figures 6,7	*T. concentricum* Deunff and Evitt, 1968 Slide 1-A-18; 35.7 microns vesicle diameter Arkona Formation 6) low focal level; 7) high focal level
Figure 8	*Tasmanites* sp. Slide 2-A-21 (2), ring 1; 252.5 microns diameter Arkona Formation
Figure 9	*T.* sp. Slide 1-A-37, ring 3; 247.4 microns diameter Rockport Quarry Formation

Figure 10 *L.* sp. 2

Slide 2-A-45 (1), ring 7; 63.8 microns diameter

Rockport Quarry Formation

Figure 11 *Tasmanites* sp.

Slide 1-A-16, ring 2; 63.8 microns diameter

Widder Formation

Figure 12 *Leiosphaeridia* sp. 2

Slide 1-A-24 (1), ring 4; 84.2 microns diameter

PLATE XVI