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Full Name of Author — Nom complet de l'auteur

QUENTIN HARALD GOODBODY

Date of Birth — Date de naissance

23 APRIL 1956

Country of Birth — Lieu de naissance

REPUBLIC OF IRELAND

Permanent Address — Résidence fixe

CLONMULLEN
BALLYBOUGHLIN
CLARA
Co. OFFALY REPUBLIC OF IRELAND

Title of Thesis — Titre de la thèse

SILURIAN RADIOLARIA FROM THE CAPE PHILLIPS FORMATION OF THE CANADIAN ARCTIC ARCHIPELAGO

University — Université

UNIVERSITY OF ALBERTA

Degree for which thesis was presented — Grade pour lequel cette thèse fut présentée

MSc

Year this degree conferred — Année d'obtention de ce grade

1981

Name of Supervisor — Nom du directeur de thèse

DR. B.D.E. CHATTERTON

Date

14·3·81

Signature

Quentin H Goodbody

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Silurian Radiolaria from the Cape Phillips Formation of the Canadian Arctic Archipelago

by

© Quentin H. Goodbody

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

IN

SCIENCE

GEOLOGY

EDMONTON, ALBERTA

SPRING 1981

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR Quentin H. Goodbody

TITLE OF THESIS Silurian Radiolaria from the Cape Phillips Formation of the Canadian Arctic Archipelago

DEGREE FOR WHICH THESIS WAS PRESENTED MASTER OF SCIENCE

YEAR THIS DEGREE GRANTED SPRING 1981

(SIGNED) Quent. H. Goodbody

PERMANENT ADDRESS:

Clonmollen, Ballyboughlin

Clara Co. Offaly

Republic of Ireland

DATED 11th February 1981

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Silurian Radiolaria from the Cape Phillips Formation of the Canadian Arctic Archipelago submitted by Quentin H. Goodbody in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in SCIENCE.

....

Supervisor

....

....

....

Date. February 11th 1981

ABSTRACT

An upper Llandovery to lower Ludlow radiolarian fauna from sections of the Cape Phillips Formation of the Canadian Arctic Islands is described and illustrated. Three families and two informal groups (as defined by Holdsworth, 1978) were found to be present, these being the Entactiniacea, Palaeoscenidiidae, Ceratoikiscidae, rotasphaerids and palaeoactinommids. Of the twenty six genera present, six are new. All sixty seven species described are new. Range charts comparing the distribution of the radiolarian species to the better known graptolite zonation scheme are provided and from these it can be seen that Silurian Radiolaria have a potential stratigraphic value in the Canadian Arctic.

The palaeoactinommids, rotasphaerids and palaeoscenids range throughout the time span sampled (upper Llandovery to lower Ludlow) and are the most common fossils by a large margin. Ceratoikiscids are common from the Middle Wenlock on, appearing suddenly in the samples. In direct contradiction to the other Lower Paleozoic radiolarian faunas sampled to date, the Entactiniidae are very sparsely represented.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the aid, supervision and encouragement given to him by Dr. Brian Chatterton during the preparation of this thesis, both in the field and in the university.

Very special thanks are due to Dr. Brian Jones for his helpful advice and introduction to the computer, something which must have taxed his boundless patience and enthusiasm.

Dr. A. Lenz of the University of Western Ontario kindly supplied processed material from the 1976 Cape Phillips section and proved a good host during a week spent at that university in the spring of 1979.

George Braybrook of the Entomology Department gave much help and instruction in the use of the scanning electron microscope.

Field support in the form of air transport, tents and radios was supplied from Resolute by the Polar Continental Shelf Project.

Other financial assistance was gained from the University of Alberta by means of a teaching assistantship and intersession bursaries.

TABLE OF CONTENTS

LIST OF TEXT FIGURES

LIST OF TABLES

APPENDIX

Appendix maps

Appendix Tables

1. INTRODUCTION

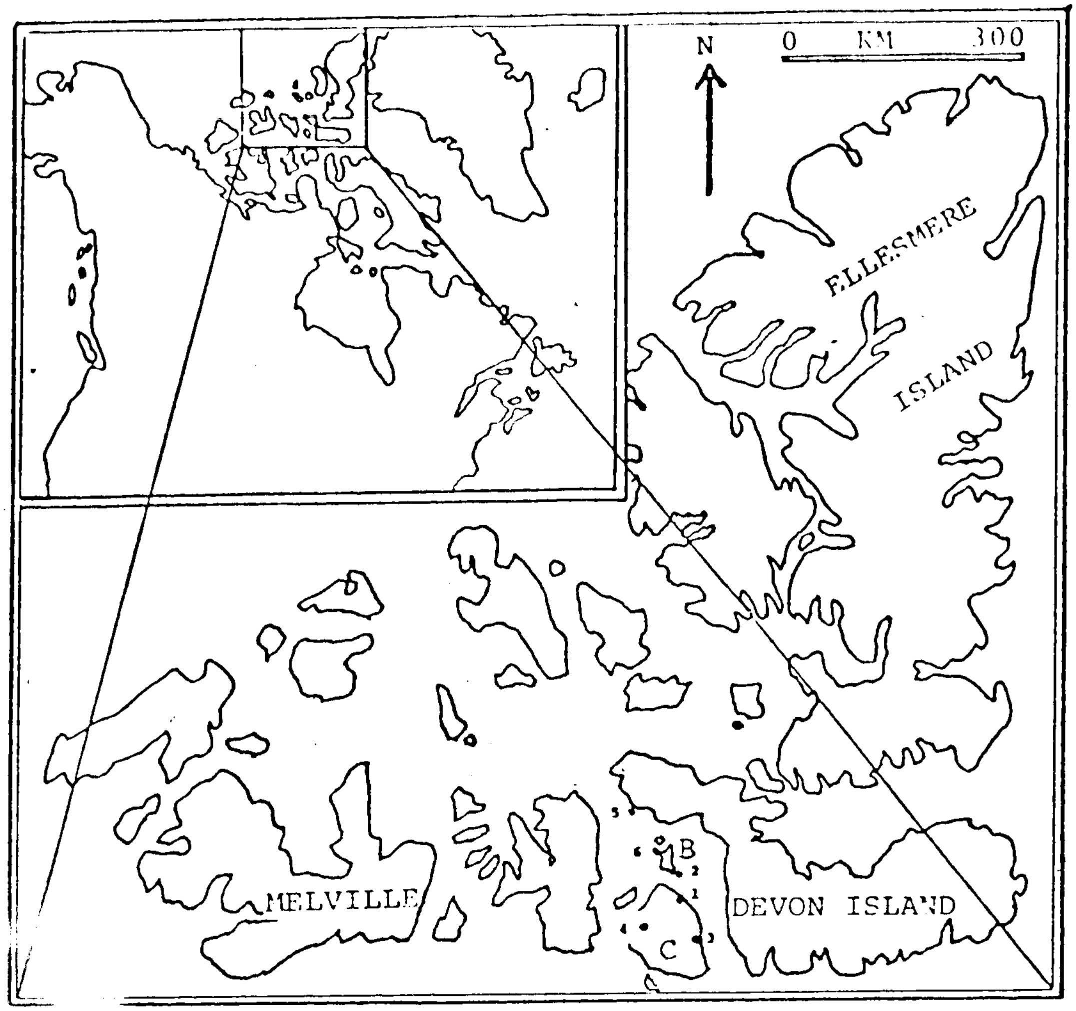
In 1958 Dr. R. Thorsteinsson of the Geological Survey of Canada reported the presence of well preserved radiolarian material along with three dimensional graptolites and some fish from calcareous nodules and thin limestone beds in a Silurian sequence at Cape Phillips, Cornwallis Island, N.W.T. Thorsteinsson measured the section and proposed the name Cape Phillips Formation for the sequence of calcareous shales and thin lime beds approximately 5000 feet (1643 m.) thick at the type location. He also proposed a graptolite zonation for these sedimentary rocks. These beds are interpreted as a continental slope sequence, and can be seen, on Baillie Hamilton Island particularly, to contain allochthonous beds of calcareous material slumped from a nearby carbonate shelf. On the east side of Cornwallis Island, near Laura Lakes (93 degrees 40 minutes west : 75 degrees 11 minutes north) the Cape Phillips Formation intertongues with carbonate shelf dolomites of the Allen Bay and Read Bay formations.

Dr. Thorsteinsson forwarded some carbonate nodules containing Radiolaria to several workers - Foreman, Riedel and Holsdworth. The latter author has illustrated some of the material and commented briefly on the assemblage (Holdsworth,1978), whereas the others mentioned the fauna (Riedel and Foreman,1961) with a promise of further research which does not seem to have been published.

During the field seasons of 1976, 1977 and 1978 Drs. Chatterton (U. of Alberta), Lenz (U. of Western Ontario) and the late Dr. Perry (U. of British Columbia) collected samples of the Cape Phillips carbonate nodules from localities at Cape Phillips, Laura Lakes and Abbott River (all on Cornwallis Island); southern Baillie-Hamilton Island and from Cape Becher, Devon Island. This collecting was primarily undertaken to obtain shelly, conodont and graptolite faunas. The writer was permitted to study any radiolarians which these samples contained and ascertained that while all the localities mentioned above were productive, the Cape Phillips and southern Baillie-Hamilton Island sections had by far the richest faunas.

During the field season of 1979, Dr. Chatterton and the writer collected a more complete set of samples specifically for the Radiolaria from the lower 700 feet of Thorsteinsson's type section of the Cape Phillips Formation and from two sections on the southern coast of Baillie-Hamilton Island (see Appendix map 2). In addition a section of the Cape Phillips Formation at Fitzjames Point on the extreme north-west of Baillie-Hamilton Island was also collected from.

The Fitzjames Point section contains more terrestrial material - quartz silt - than the other sections and only one ceratoikiscid was found in these samples (See Appendix map 3). This specimen was fragmentary and unidentifiable below the family level.



C = CORNWALLIS ISLAND
B = BAILLIE-HAMILTON ISLAND
1 = CAPE PHILLIPS SECTIONS
2 = BAILLIE- HAMILTON SECTIONS
? = LAURA LAKES SAMPLING AREA
= ABBOTT RIVER SAMPLING AREA
= CAPE BECHER SECTION
= POINT FITZJAMES SECTION

TEXT FIGURE I

M... ...O... THE ...ATION OF THE SECTIONS
FR... ...ADIOLARIA WERE OBTAINED FOR
...HIS STUDY.

More detailed locality information is
supplied in the Appendix.

In this study particular attention was paid to the sections at Cape Phillips and southern Baillie-Hamilton Island to obtain as continuous a picture as possible of the Radiolaria present and their ranges. These two sections, when taken together (they are in sight of one another), provide a continuous sequence of sedimentary rocks ranging from the Upper Llandovery to the lower Ludlow.

Many of the samples, particularily those from the Cape Phillips section, produced an unmanageably large number of specimens. The rarity of the taxa described in this study is tabulated in the appendix. Four indications of the number of specimens observed in the samples are used, these being; rare, sparse, common and abundant. Where numbers of specimens are mentioned in the text under the heading Material and Horizon they refer to the number of specimens viewed under the scanning electron microscope and not to the actual number of specimens observed. Considerable lengths of time were spent looking for additional specimens of the species described for which only one specimen is noted.

132 samples were processed and picked for radiolarians. Of these, 72 were productive and 60 barren. A complete tabulation of all the samples processed from the sections is provided in the appendix. Not all the samples collected were processed: This is due to three principle factors; the extremely high productivity of the Cape Phillips samples, the richness of the fauna and the time available for the study. To obtain maximum coverage only those samples

collected in 1979 which did not directly correspond to the interval collected by Lenz et al. in 1976 were processed; hence many of the samples from above the 400 foot level of the section remain unprocessed. A complication arises in that the 1976 samples were processed specifically for graptolites while the 1979 samples were processed for radiolarians. It is possible that some species of Radiolaria may have been present in the 1976 samples and were lost. The time available did not permit this to be thoroughly checked. This factor may account for the ranges of some Radiolaria terminating at the 400 foot level of the 1979 section. The presence of an unproductive portion of the section, from the 175 to 300 foot level, may explain why many species are shown to appear at approximately the 300 foot level of the 1976 Cape Phillips section.

SAMPLE COLLECTION AND PREPARATION

In the 1979 field season one to two kilograms of limestone (bedded or in nodular form) were collected as frequently as such horizons occurred in the sections. The average sample interval for the Cape Phillips section is slightly less than 3 meters: the interval was slightly larger for the less calcareous Baillie-Hamilton Island sections.

In the laboratory 0.5 to 1 kilogram of each sample was subjected to dissolution by acetic acid. The resulting residue consisted of siliceous material (sand, sponge spicules, radiolarians and silicified ostracods),clay minerals and organic materials. The residues included rare conodonts, scolecodonts, fish scales and locally abundant three dimensional graptolitic material. At least two unidentified groups of microfossils, possibly fish teeth and dinoflagellate cysts, were also present in some of the samples. Oil staining was present in every sample, and when excessive, was cleaned off the residue by immersion in a weak hydrogen peroxide solution.

Radiolarians were picked from the productive samples using a dampened fine paintbrush under a binocular microscope. For most of this work, twenty times eyepieces were needed because of the small size of many of the specimens. A ten times eyepiece graticule was used for the measurement of the diameters of the shells of the larger palaeoactinommids. In other cases, measurements were taken from the electron micrographs. In cases where naturally broken specimens were not available, these were broken to determine the internal structure by pressing a dissecting needle against the specimen (for this operation it was found necessary to immerse the specimen to be broken in a drop of water to stop from recoiling out of the field of view - or sometimes out of the slide altogether - from the touch of the needle tip).

It was not found possible to observe clearly or describe the specimens meaningfully using the light microscope. At the commencement of the study as many specimens as was practical were observed using the scanning electron microscope and were photographed to ascertain the variety of the fauna and what variation should be looked for between similar forms. As the author became more familiar with the fauna it was possible to distinguish between most species using the light microscope. A general policy of photographing specimens from several levels for each species was adhered to in the hopes of discerning any evolutionary changes within species that might have occurred. This has not proved possible to document as yet simply due to the large variety of the fauna to be described, b material and illustrations have been kept to enable such a study to be carried out.

Several specimens of the same species from each sample were, when available, photographed and observed under the scanning electron microscope to enable the author to obtain an idea of any ontogenetic, phenotypic and possible genotypically based variation that might have been present. Evidence of this variation, when present, has been illustrated in the plates and commented on later in the text.

For observation under the scanning electron microscope damp specimens were placed on an aluminium stub whose head had been ground with 600 weight carborundum powder and then coated with a thin layer of gum tragacanth. Particular care had to be taken to ensure that the radiolarian came off the brush cleanly onto the stub, rather than adhering to the brush, and, in attempts to dislodge it, becoming smothered in a layer of glue. This proved extremely difficult with some of the more fragile specimens, but with practice a high success rate was achieved.

The stub with the specimens was then coated with gold using an Edwards high vacuum sputter coater with a 1.5kv. sputter voltage and a current of 25ma. Coating time was approximately 1.5 minutes and this furnished the specimens with a 150 angstrom thick layer of gold. The scanning electron microscope used was a Cambridge Stereoscan S 150.

Photography of the specimens was done on an attachment to the scanning electron microscope using Kodak 120 Plus X Pan film.

RADIOLARIAN CLASSIFICATION

The Radiolaria constitute a Subclass of the Class Rhizopoda of the Phylum Protista. Slight variation among authors may be seen at this level of classification. Radiolaria may be classified as an Order of the Class Rhizopoda, or Subclass of the Subphylum Sarcodina and by some zoologists are grouped together with the acantharians and the heliozoans into the Class Actinopoda. Radiolarians are planktonic marine protozoans and are allied to the amoeboids, dinoflagellates and foraminifers.

The subdivision of the subclass Radiolaria is currently in a state of considerable flux after the rejection, in the late 1960's, of Haeckel's system of classification which had lasted essentially unchanged since 1883.

Previous to the work done by Haeckel, other workers such as Ehrenberg and Muller had been describing fossil and Recent Radiolaria, but had not drawn up a comprehensive classification scheme for the whole subclass. Haeckel's classification can be viewed as the first attempt at such, but it had an immediate flaw in that the specimens that Haeckel used were largely Recent in age. His scheme was based solely on the recognition of different morphologic types and the assignment of known forms into these 'pigeon holes'. Within the last quarter century many data about the phylogeny of various Radiolaria have come to light and this information has shown that Haeckel's classification scheme separates by a large margin different morphotypes which are very closely related.

Current changes in the classification of the Radiolaria are attempts to compensate for the inadequacies of the previously accepted Haeckelian system.

Due to the fact that all the papers concerned with fossil Radiolaria prior to 1967 used Haeckel's system of classification, it is deemed necessary to trace the changes in radiolarian classification which have taken place. The following brief resume, it is hoped, will enable the reader to 'translate' from Haeckel's system of classification to that proposed by Riedel, 1967 and elaborated upon by Holdsworth, 1978.

Haeckel spent ten years (1877-1887) studying and describing the Radiolaria obtained from the plankton nets of the H.M.S. Challenger Expedition (1873-1876). On the basis largely of the Recent Radiolaria he described, he proposed the division of the Radiolaria into four Legions - based on the physical and chemical nature of the skeleton (See Table I).

1	2	3	4
SPUMELLARIA	ACANTHARIA	NASSELLARIA	PHAEODARIA
Skeleton siliceous or wanting	Skeleton acanthinic	Skeleton a single piece of silica.	Skeleton a silica carbon mixture.

TABLE I

Synopsis of the four Legions of Radiolaria of Haeckel.

Haeckel divided the Radiolaria into the Legion Spumellaria which contains all Radiolaria which possess a skeleton of silica bars (or in the special case of the Colloidea no skeletal bars at all); the Legion Acantharia which has a skeleton made up of the substance acanthin (an organic compound of strontium and sulphate); the Legion Phaeodaria whose members possess a skeleton of a silica and carbon mixture; and the Legion Nassellaria with a single-piece siliceous skeleton. The Legions Acantharia and Phaeodaria are rarely, if ever, seen in the fossil record, so will not be dealt with here in the same depth as will those which occur as paleontological specimens. Conversely, the Legions Spumellaria and Nassellaria with their silica skeletons can be recognised in the fossil record and are thus of importance to this study.

Haeckel's division of these Legions into orders was based on the physical parameters of the skeleton, i.e. whether it was of a latticed or non-latticed nature. The Legion Spumellaria, one of the paleontologically important legions, was divided into two orders and six suborders. The Order Collodaria constituted all spumellarians which either did not possess a skeleton or had an imperfect non-latticed one. The Suborder Colloidea represents those that totally lack a skeleton while in the Beloidea the skeleton was represented by numerous scattered spicules.

The other order of the Spumellaria, the Order Sphaerellaria, is made up of those radiolarians in which the skeleton was either a perfect shell of lattice-work, or spongy and resembling wicker-work. This order was divided into four suborders dependant on the shape of the skeleton (see Table II).

ORDER	SUBORDER DIAGNOSIS	SUBORDER
COLLODARIA	Skeleton entirely wanting	Colloidea
Skeleton wanting		
or quite imperfect,	Skeleton represented by	
not latticed.	numerous scattered spicules	Beloidea
SPHAERELLARIA	Shell spherical	Sphaeroidea
Skeleton a perfect	Shell ellipsoidal	Prunoidea
shell of latticework,	Shell discoidal	Discoidea
or spongy resembling	Shell with different extent	
wickerwork.	of growth in three axes.	Larcoidea

TABLE II

Synopsis of the Orders and Suborders of the Legion SPUMELLARIA

The other Legion of Radiolaria which is important palaeontologically is the Nassellaria. This was divided into two orders, Plectellaria for those Nassellaria without a complete lattice shell and Cyrtellaria for those Nassellaria with a complete lattice shell. Each of these orders contained three suborders based on the presence or absence of a skeleton and on the morphology of this skeleton (See table III).

ORDER	SUBORDER DIAGNOSIS	SUBORDER
PLECTELLARIA	No skeleton	NASSOIDEA
Nassellaria without complete latticed shell.	Skeleton with a basal tripod, without ring.	PLECTOIDEA
	Skeleton with a sagittal ring.	STEPHOIDEA
CYRTELLARIA	Cephalis bilocular, with a sagittal constriction.	SPYROIDEA
Nassellaria with a complete lattice shell.	Cephalis multilocular, with two or more constrictions.	BOTRYOIDEA
	Cephalis simple, without constriction and lobes.	CYRTOIDEA

TABLE III

Synopsis of the orders and suborders of the Legion NASSELLARIA

In Haeckel's classification, the lower orders were based on the idea that the Radiolaria could be fitted into a system that was similar to the crystallographic method used for describing crystal systems. Haeckel felt that a geometrical system was a logical, simple plan capable of expressing the genetic history and relations of the multitudinous forms belonging to the Radiolaria. It was believed that the simplest skeletal plans belonged to the most primitive types and that evolution acted on these to produce more complex skeletons. It now appears that this was not necessarily the case.

Campbell, 1954 in the Treatise of Invertebrate Paleontology essentially used Haeckel's system. The only major differences lie in the changing of the rank of some of Haeckel's subdivisions (See tables IV and V). In spite of growing awareness of the defects in Haeckel's system of classification, it remained in use, with minor modifications, until 1967 when Riedel proposed a new classification of the siliceous Radiolaria, this time with fossil specimens providing greater phylogenetic information.

As early as 1887 Haeckel himself commented on some of the inadequacies of his system. Deflandre (1953, p.410) states that 'Haeckel's genera are superfluous and needlessly complicate the systematics, rendering taxonomic determination more difficult, and above all masking the true affinities of the specimens'.

Riedel, 1967 stated that the apparent reason why the

Haeckelian system had remained in use till then with only slight modifications was that no one researcher had been able to familiarise himself with all the exceedingly numerous species described, and to recast them into a fundamentally different classification. Riedel's classification (Table VI) was not intended to be complete, but rather to be a pilot scheme for a greater revision in the future once more data had been gathered. He began to revise the classification in several ways, these being:

1. Detailed investigations of intraspecific variation. This has revealed that the type species of some genus-group taxa are conspecific or are very closely related. As a result some generic and subgeneric names can be placed in synonymy and the taxonomic system simplified to that extent. (A possible case for doing this with several genera described in the present study is in the group of genera Echinomma, Cromyomma, Cromyechinus and Caryomma. These are obviously very closely related and with further study the number of separate genera used in the Haeckelian system might be reduced).

2. The examination of evolutionary lineages using the fossil record to work out phylogenetic relationships is, and will in the future, bring to light more of the inadequacies of the Haeckelian system (see Table VI for Riedel's classification of the siliceous Radiolaria).

In 1978, Holdsworth, having more data on fossil radiolarians, published a modification of Riedel's scheme

(Table VII). This modified scheme is the classification used in this study. Holdsworth was dealing primarily with Paleozoic Radiolaria and his scheme differs from Riedel's in the rank of some of the groupings and in the creation of newly recognised groupings. This new scheme is an attempt to indicate taxonomically several recognised breaks amongst the Radiolaria which are not indicated by previous classifications. This explains Holdsworth's erection of the group palaeoactinommids for Paleozoic Spumellaria with a single, or several, concentric shells. (This group is included in Riedels' Actinommidae, a family of the Suborder Spumellaria). Holdsworth states 'though palaeoactinommids show clear morphologic similarities to post Paleozoic Actinommidae, known Paleozoic faunas seem to show a marked decline in palaeoactinommids by the late Paleozoic, and it is not completely clear that they are, in fact, present in late Paleozoic rocks. Stratigraphic distribution suggests that the palaeoactinommids and the Actinommidae could, therefore, be phylogenetically separate'.

If this is the case, then the simplest solution to marrying the existing generic names defined by Haeckel et al. and given to Paleozoic forms which resemble Recent forms would be to add the prefix 'palaeo' to them. This would make it clear to which grouping the species belonged and would indicate a lack of genetic continuity between Paleozoic and Recent forms which are phenotypically similar. However, as yet, the presence or absence of genetic continuity throughout the greater part of the Phanerozoic is not known. Intuitively it seems unlikely, though blue-green algae can be shown to have apparently changed little in many millions of years.

The position of the Nassellaria is uncertain at the moment due to the suggestion by fossil evidence that this group may have been derived from the Entactiniacea.

In addition to the erection of the new informal group "palaeoactinommids", Holdsworth created another group called the "rotasphaerids". This consists of Paleozoic Spumellaria with a single, spherical, latticed shell with angular meshes, lacking the internal spicular system of the Entactiniacea and displaying a point or points on the shell from which radiate five or more strong straight lattice bars.

The Superfamily Entactiniaceae (Family Entactiniidae Riedel, 1967) is made up of Radiolaria with a spicule of four or more rays, point or bar centred, constituting the main part of the skeleton or incorporated within a latticed or spongy shell which is essentially spherical. These changes in radiolarian classification are an attempt to allow for the greater amount of information which has been gleaned from recent studies of fossil radiolarian assemblages.

LEGION	SUBLEGION	ORDER
SPUMELLARIA	COLLODARIA	BELOIDEA
		COLLOIDE
	SPHAERELLARIA	SPHAEROIDEA
		DISCOIDEA
		PRUNOIDEA
		LARCOIDEA
NASSELLARIA	PLECTELLARIA	NASSOIDEA
		PLECTOIDEA
		STEPHOIDEA
	CYRTELLARIA	SPYROIDEA
		BOTRYOIDEA
		CYRTOIDEA

TABLE IV

HAECKEL'S 1887 CLASSIFICATION OF THE SILICEOUS RADIOLARIA

SUBORDER	DIVISION	SUPERFAMILY
		THALASSICOLICAE
	COLLODARI	THALASSOSPHERICAE
		OROSPHAERICAE
SPUMELLINA		
		LIOSPHERICAE
	SPHAERELLARI	ELLIPSIDIICAE
		CENODISCIDAE
		LARACARIICAE
	PLECTELLARI	PLAGONIICAE
		STEPHANIICAE
NASSELLINA		
		TRIOPYRIDICAE
	CYRTELLARI	ARCHIPILIICAE
		CAMIOBOTRYDICAE

TABLE V

CAMPBELL'S 1954 VERSION OF THE CLASSIFICATION

OF THE SILICEOUS RADIOLARIA

ORDER POLYCISTINA

SUBORDER SPUMELLARIA		SUBORDER NASSELLARIA	
FAMILY	ENTACTINIIDAE	FAMILY	PLAGONIIDAE
"	OROSPHAERIDAE	"	ACANTHODESMIIDAE
"	COLLOSPHAERIDAE	"	THEOPERIDAE
"	ACTINOMMIDAE	"	CARPOCANIIDAE
"	PHACODISCIDAE	"	PTEROCORYIDAE
"	COCCODISCIDAE	"	AMPHIPYNDAXIDAE
"	SPONGODISCIDAE	"	ARTOSTROBIIDAE
"	PSEUDAULOPHACIDAE	"	CANNOBOTRYIDAE
"	PYLONIIDAE		

(+ Incertae Sedis)

TABLE VI

RIEDEL'S 1967 CLASSIFICATION OF THE SILICEOUS RADIOLARIA

	INFORMAL GROUPING "PALAEOACTINOMMIDS"	
	INFORMAL GROUPING "ROTASPHAERIDS"	
SUBORDER SPUMELLARIA	SUPERFAMILY ENTACTINIACEA	
	SUPERFAMILY ENTACTINIACEA	F. ENTACTINIIDAE
		F. PYLENTONEMIDAE
		? F. PALAEOSCENIDIIDAE
		? F. POPOFSKYELLIDAE
SUBORDER ALBAILLARIA		F. CERATIOKISCIDAE
		F. ALBAILLELLIDAE
RADIOLARIA INCERTAE SEDIS		RADIOLARIA FAMILIA NOVA
		GENUS CORYTHOECIA
		SPICULAR FORMS

TABLE VII

HOLDSWORTH'S 1978 CLASSIFICATION OF THE PALAEOZOIC POLYCYSTINE RADIOLARIA

RADIOLARIAN SKELETONS;
THEIR FORMATION AND ONTOGENY

Very little is known about how Radiolaria secrete their skeletons. The most voluminous work on the subject is that by D'Arcy Thompson, 1952 in which he treats skeletal formation from a theoretical crystallographic point of view, according to which the physical forces of crystallisation are proposed to govern the skeletal form rather than an overriding genetic control. Earlier workers, notably Muller, 1858 and Lehmann were also struck by the symmetry of the skeletons and proposed a number of laws to explain their observations. Thompson discusses these laws, but admits that this explanation cannot be entirely true. Although he does not state as much, it can be gathered from his conclusions that he admits a certain amount of genetic control, coupled with the physical laws of crystallisation, is responsible for the symmetries and forms of the Radiolaria (and other Protozoa).

Equally little is known about the reactions inside the cell by which the skeleton is deposited. In the words of Hollande and Enjumet, 1960 "All that is certain is that a definite cytoplasmic architecture exists, a submicroscopic network, whose physico emical properties are such that SiO_3^{--} ions precipitate ...". What is known is that the actual deposition of the skeleton is a rapid process and is not preceded by a stage of semi-silicification.

Scattered reports concerning skeletal ontogeny in the Radiolaria exist in the literature. Normally one would assume that in a skeleton composed of several concentric shells the innermost shell would be the oldest while the outermost shell would be the most recent addition. This is in some instances, however, known not to be the case. Sturmer,1966 illustrates three growth stages of a palaeoactinommid from the Silurian Kieselschiefern of Germany. His plates and explanations show quite clearly that in the case of this species the innermost shell is laid down after the shell which surrounds it. After this innermost shell has been completed growth proceeds with the addition of a shell external to the original shell. This example serves to remind the taxonomist that he must be aware of potential ontogenetic variation before assigning a particular specimen to an Haeckelian genus. Several workers have drawn attention to this problem.

Haeckelian genera are strictly defined as to the number of shells found in the skeleton and in the number of spines radiating from these. This sort of definition works only if one can recognise a fully developed stage (ontogenetically) from a less developed stage of the same species. In the course of the present study it was felt that this was possible as intermediate stages were nearly always present and in general the lattice type of different shells of the same species varied little (This was not always the case, but even these can be recognised with experience).

Ontogenetic variation in the Cape Phillips fauna is easily recognised in those forms consisting of several concentric shells. Examples of these can be seen in:

PLATE	FIGURES	SPECIES
IV	1-5	Echinomma new species A
VI	1-8	Caryomma new species A
VII	5-8	
VIII	1-4	Hexalonche new species A

In these forms growth can be seen to occur in the extension of secondary spines from the already existing shell. These spines branch at a fixed distance from the shell and the branches from adjacent spines coalesce to form the lattice of the new shell.

Other instances of possible ontogenetic variation are found in the following:

PLATE	FIGURES	SPECIES
III	6,7	Cenosphaera aff. C. affinis Hinde
XIV	1-8	Haliomma new species A
XV	1-4	Haliomma new species B
XV	5-8	Haliomma aff. H. new species B
XVI	1-8	Haliomma new species C
XVIII	1-4	Haliomma new species D

In Cenosphaera aff. C. affinis Hinde,1899 growth seems to occur by the accretion of silica to the pore bars thickening them, and by the development of spines radiating from the shell. In the haliommids silica is added to the spines radiating from an established shell, thickening them and increasing their length. This is especially noticeable in the interpreted ontogenetic sequence seen in Haliomma new species C. Spine number does not seem to increase in any of these types.

Growth cannot be documented for the Entactiniidae due to the paucity of specimens.

Among the rotasphaerids an increase in secondary spine length and robustness is attributed to ontogeny. (See plate XX; an interpreted sequence runs from figure 2-1-4).

Ontogeny in the Ceratoikiscidae is believed to be manifested by the development of the caveal ribs. Growth of the triangular part of the A frame in this family would require the concurrent dissolution of silica from the inside of the bars with silica precipitation on their outer margins. A simpler explanation in the author's view is that the triangular part of the A frame remains constant in size while silica is added to the skeleton at the distal tips of the skeletal bars and to the caveal rib and petagial tissue areas. It must be emphasised that this is only a suggestion and no concrete evidence has been assembled proving or disproving it.

Palaeoscenidium species (see plates XXX and XXXI) are thought to develop and grow by the addition of silica to the distal ends of the rays, in the increasing area and complexity of the apical net, and in the development of fine spinules in some species. New Genus C (plate XXXII) is considered to be similar in these respects.

Inspection of other members of the Palaeoscenidiidae described in this paper indicates that growth takes place by an increase in ray length, an increase in the number of branches constituting the rays and an increase in the length of the spicules on the rays. These features can be seen especially well in New Genus E new species A (plate XXXIV figures 1-6) and in New Genus F new species K (plate XXXVIII).

A note of caution must be added in that without an exhaustive population study, it is not possible to distinguish definitely between phenotypic and ontogenetic variation. It is felt that in this study the instances cited where increasing skeletal development is evident are best explained as being due to ontogeny.

CAMBRIAN TO DEVONIAN RADIOLARIAN ASSEMBLAGES

Knowledge of Paleozoic Radiolaria is at present gaining momentum with the discovery of new important sites which date as far back as the Lower Ordovician. The known localities are shown on Table VIII. Unfortunately it is not possible to compare the constituents of these faunas very meaningfully due to the large time gap separating the discovery of some of these faunas. As can be seen from the part of this thesis concerned with radiolarian classification, considerable change has taken place in the classification of Radiolaria in recent years with the recognition of several new groups. These groups naturally will not appear in those faunas described before their recognition. As well as the classification problems, technological improvements in instruments such as light microscopes and the development of the scanning electron microscope have meant that the faunas can be better studied and, with well preserved material, one would expect more accurate descriptions of species and any variation that can be seen to occur.

On account of these factors, many of the earliest known faunas need to be looked at again, especially with a view to revising their taxonomy.

Paleozoic radiolarian faunas also seem to have suffered from the problem of palaeontologists being satisfied to draw attention to their existence without providing any systematic descriptions of them. The recently reported Spitzbergen and Newfoundland faunas are good examples of this. The only real descriptive work on Lower Paleozoic Radiolaria at present is being done by the Russians on material from Kazakhstan where their faunas, coupled with graptolite faunas, have stratigraphic significance.

Despite these difficulties, it has proven possible to obtain, from a review of the literature, a broad idea of the suprageneric taxa constituting these faunas.

The oldest well preserved fauna is that reported from Spitzbergen by Fortey and Holdsworth,1971 from the Lower Ordovician Valhallfonna Formation. This fauna is described as being made up of primitive shelled forms of the Entactiniidae and tentatively recognised palaeoactinommids. The authors state that palaeoscenids are absent from this fauna, however in the text of this thesis (page 209) it is argued that the palaeoscenids may have given rise to the entactiniids and in the view of the author the spicular entactiniids of Fortey and Holdsworth are best described as belonging to the Palaeoscenidiidae.

Bergstrom,1974 noted the presence of a similar fauna from the Lower Ordovician Humber Arm group of Newfoundland. This fauna apparently has not yet been described.

Middle Ordovician assemblages composed of mainly Entactiniidae with isolated specimens of the Ceratcikiscidae and Palaeoscenidiidae are described by the Russians from the Bestamak suite of eastern Kazakhstan.

Reudemann and Wilson, 1936 described an Ordovician fauna from the Normanskill Chert of New York. All of their specimens were assigned to Haeckelian genera which would now be grouped among the pal[illegible]actinom[illegible] The quality of preservation, (if the illus[illegible] [illegible] [illegible]per show the best specimens) seems to negate ac[illegible] [illegible]ent[illegible]ication. The Normanskill fauna needs to be re exam[illegible]ned if it is to be compared to other Ordovician faunas.

The next oldest fauna is that described by Hinde, 1890 from the Llandeilo-Caradoc interval of southern Scotland. This assemblage appears to be made up predominantly of palaeoactinommids. Many of the 'Detached spicules of Radiolaria' illustrated seem suspiciously like sponge spicules.

Isolated samples of a fauna of late Ordovician age from the Hanson Creek Formation, Eureka County, Nevada, were described by Dunham and Murphy, 1976. The authors only classified their specimens to the Suborder Spumellaria. Examination of their plates suggests that this fauna might consist of mainly palaeoactinommids and possibly members of the Pylentonemidae, though for any sure identifications one would need to inspect the internal structure of their specimens.

The radiolarian fauna described in this thesis seems to be the only one known for the Lower to Upper Silurian interval. [illegible] it, five of the main radiolarian groupings or superfamilies have been recognised; the fauna is dominated by palaeoactinommids and the Palaeoscenidiidae. The Entactiniidae, in contrast to the majority of Paleozoic faunas, is only represented by isolated specimens. (The Upper Devonian fauna from the Ford Lake Shale, Alaska is also dominated by palaeoactinommids, but it has a significant number of pylentonemids).

The only other well desc ibed Silurian radiolarian fauna is that from the Tamwor... eries of New South Wales, Australia (Hinde,1890). The ... possible Middle Silurian age to the Lower Dev..ian ... ugh this fauna was described before the Entactiniidae were recognised, the excellent illustrations permit one to see that the fauna contains both palaeoactinommids and Entactiniidae.

Several papers mention the presence of radiolarian faunas in the Silurian(?) to Lower Devonian Kieselschiefern of Western Germany. However despite being known for a considerable period of time (Rothpletz,1880 was one of the earliest to draw attention to these faunas) they still remain to be adequately described. The fact that the samples are in cherts, from which it is difficult to separate the Radiolaria, may be the main reason for this lack of description.

Well preserved Upper Devonian faunas are found in North America in the Ohio Shale (Foreman,1963) and from the Ford Lake Shale in Alaska (Holdsworth et al.,1978). The remarkably well preserved Ohio shale fauna is dominated by the Entactiniidae and contains lesser numbers of the

Palaeoscenidiidae, Ceratoikiscidae and the Nassellaria. As has been noted earlier, the Ford Lake Shale, in contradiction to this, is made up mainly of palaeoactinommids and pylentonemids.

The Cape Phillips Formation of the Canadian Arctic extends from the Upper Ordovician in the Bathurst and Cornwallis Island areas and grades up through an ill-defined boundary into the Eids Shale of Lower to Middle Devonian age on southern Ellesmere Island. It is the writers opinion that considerably more than the Llandovery to Ludlow interval of this shale is likely to be productive. The likliehood is high that other discoveries from this formation will greatly aid in piecing together the jigsaw of information that we now have of Lower Paleozoic radiolarian evolution.

AGE	LOCALITY: BRITAIN	GERMANY	AUSTRALIA	N. AMERICA	U.S.S.R.	SPITZBERGEN
DEVONIAN		IN KIESELSCHIEFERN		OHIO ALASKA	S.URALS	
SILURIAN			TAMWORTH SERIES N.S.W.	CANADIAN ARCTIC		
ORDOVICIAN	S.UPLANDS			NEW YORK NEWFOUNDLAND	KAZAKHSTAN	VALHALLFONNA FMN.
CAMBRIAN						

DISTRIBUTION AND AGES OF CAMBRIAN TO DEVONIAN RADIOLARIAN ASSEMBLAGES

TABLE VIII

SUBCLASS RADIOLARIA Muller, 1858

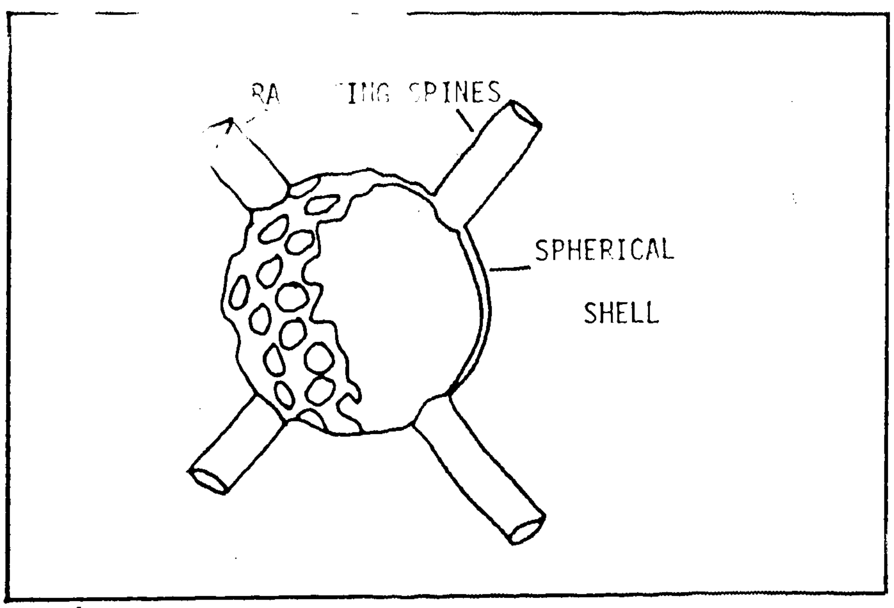
ORDER POLYCISTINA Ehrenberg, 1854 emended Riedel, 1967

SUBORDER SPUMELLARIA Ehrenberg, 1854

FAMILY ACTINOMMIDAE Riedel, 1967

PALAEOACTINOMMIDS Holdsworth, 1978

An informal grouping. Paleozoic Spumellaria with a single latticed shell, or two or more shells, sometimes pylomate, lacking the internal spicule system of the Entactiniidae and the characteristic lattice structure of the rotasphaerids.



CHARACTERISTIC STRUCTURE OF THE PALAEOACTINOMMIDS

TEXT FIGURE 2

Genus *Acanthosphaera* Ehrenberg, 1858

Diagnosis

Spumellaria with numerous (8 or more) similar radial spines on the surface of a single spherical shell.

Type Species: *Acanthosphaera haliphormis* Ehrenberg, 1861

Acanthospheara new species A

Plate I Figures 1-6

Diagnosis

Eight distally tapering spines radiate from a single hollow latticed sphere with a diameter of up to 120µm. These spines are up to 80µm in length and have a basal width of approximately 10µm. The shell lattice is composed of fine lattice bars of uniform thickness enclosing slightly variable subrounded pores in a simple honeycomb-like pattern.

Description

Eight evenly spaced conical spines radiate from the single hollow latticed sphere of diameter 100-120µm. The spines are similar in length (80µm) and basal thickness (10µm). The extreme bases of the spines branch into the lattice of the single shell. The lattice is composed of uniform lattice bars (thickness approximately 3µm) which enclose subpolygonal pores of slightly varying size. These pores average 10µm across and are arranged in a simple honeycomb-like pattern.

Numerous fine minor spines approximately 5µm in length may arise from the lattice bars.

Comments

Variation can be seen in the specimens figured in plate I. Figures 1, 3 and 4 display prominent minor spines while figures 2, 5 and 6 do not. This variation seems unlikely to be ontogenetic considering the larger specimens lack spines. It may be a factor of preservation or may represent genetic differences between the specimens.

Material and Horizon

Thirteen specimens. Nine of these specimens were extracted from the 6-132 foot interval of the Cape Phillips 1979 section, two specimens from the Baillie-Hamilton Island 1976 section 1 at the 33-36 foot interval and two specimens from the 165 foot horizon of the Cape Phillips 1976 section. Rare specimens were observed in the Laura Lakes 1976 sample 9. These stratigraphic horizons show this species to range from the upper Llandovery to the lower Wenlock.

Genus Arachnosphaera Haeckel, 1862 emended

Diagnosis

Spumellaria with numerous spines radiating from a central spherical porous ball-like structure of five or more concentric lattice shells. These spines are of two types; the larger, 8-12 in number, are ridged on three sides. More than 60 minor spines radiate from the outer margin of the porous central structure. The minor spines are considerably shorter and less robust than the major spines.

Emendation

Haeckel's use of the Family Astrosphaerida in his original definition of this genus is replaced by the broader term Spumellaria in an attempt to modernise the radiolarian taxonomy. In the light of the new taxonomy Haeckel's families and subfamilies are redundant.

Type Species: Arachnosphaera oligacantha Haeckel, 1862

Arachnosphaera new species A

Plate I, Figures 7-8; Plate II, Figures 1-8

Diagnosis

8-10 major spines up to 270μm in length radiate from a central spherical lattice. The outer part of this porous central structure is weakly differentiated into two to three spherical shells that are joined to one another and to the less structured central region. The radiating major spines rapidly subdivide into lattice bars after entering the central spherical structure. The lattice bars of the concentric shells arise by the lateral branching of numerous radiating minor spines. The lattice pores bounded by the bars are slightly variable in size, ranging from 5-10μm across. The major spines are deeply grooved on three sides.

Description

8-10 major spines up to 270μm in length radiate from the central spherical body of the skeleton. These spines are deeply grooved on three sides and taper distally to a point from a basal width of 25-30μm.

The central body of the skeleton is made up of four to five closely spaced shells. The innermost shell has a diameter of approximately one quarter of that of the outer shell. These shells have diameters of 50 and 200μm respectively. The shells are a series of poorly differentiated closely interconnected concentric layers composed of interconnecting bars (the minor spines) which branch periodically to produce the shells. The bases of the major spines branch into the lattice of the innermost shell. The shells are evenly spaced, approximately 20μm apart. In the shells the lattice bars enclose pores 10-15μm across.

The minor spines extend 60um beyond the outer shell and are less than 5μm thick.

Comments

There is considerable variation in the size of the central sphere of the skeleton and in the development of the minor spines radiating from the central spherical body in the specimens figured. This may reflect true genetic diversity, a more thorough study being needed to ascertain this.

Material and Horizon

Numerous specimens from the upper Llandovery of the 6 foot to 353 foot interval of the Cape Phillips 1979 section and from the Llandovery of the Baillie-Hamilton 1976 section 1 at the 33-36 foot interval. Specimens were observed from the 1976 Laure Lakes sample 9 (middle Wenlock).

Genus Astrosphaera Haeckel, 1887 emended

Diagnosis

Spumellaria with two concentric shells connected by long prismatic radial spines; numerous spines of two orders of size radiate from the outer shell.

Emendation

Haeckel's use of the family Astrosphaerida in his original definition of this genus is redundant in the light of recent changes in radiolarian classification.

Type Species: Astrosphaera hexagonalis Haeckel, 1887

Astrosphaera new species A

Plate XII, Figures 7,8

Diagnosis

The fully developed skeleton is made up of two concentric shells of diameter 100 and 200µm approximately. Both these shells consist of bars 5µm thick enclosing angular to subrounded pores 5-30µm across. 6-12 main spines join the shells and extend up to 50um beyond the outer shell. The basal thickness of these major spines ia approximately 10µm. Numerous minor spines up to 30µm in length, with a basal thickness of 5µm, are borne by both shells.

Description

The skeleton consists of two shells, the inner of which has a diameter of 100μm and the outer a diameter of approximately 200μm. Both shells have lattices composed of variably sized pores, the pore size increasing slightly with the diameter of the shell. In the outer shell pore size varies from 5-30μm across. The separating lattice bars are approximately 5μm thick.

Two types of spines are present radiating from both the outer and inner shells. The larger spine type (12-16 in number) extends 80μm beyond the outer shell. These spines have a slightly buttressed base where they meet the outer shell. The minor spines, which are numerous, arise from the pore bar intersections of both the shells and extend up to 30μm from the shell. Only the larger spines connect the two shells. Broken specimens show that the spines do not continue inside the inner shell.

Comments

The open nature of the lattice in this form is similar to that of the palaeoactinommid New Genus A new species C. Both types occur in the same horizon. Differences between them lie in the presence of two types of spines in the Astrosphaera new species A specimen, the presence of a two dimensional lattice, the smaller diameter of the outer shell and in the number of shells making up the skeleton.

The arrangement of the spines on the Astrosphaera new species A skeleton is similar to that seen in Echinomma new species B.

Material and Horizon

Eight specimens ranging from the 6 foot horizon to the 353 foot horizon of the Cape Phillips 1979 section and one specimen from the 1976 Laura Lakes sample 9 (upper Llandovery to middle Wenlock).

Genus Caryomma Haeckel, 1887 emended

Diagnosis

Spumellaria with five to six or more concentric spherical lattice shells composed of ordinary lattice-work from which radiate numerous spines.

Emendation

Haeckel's use of the term Arachnosphaerida in his original definition of this genus is redundant in the light of recent changes in radiolarian classification.

Type species: Caryomma regulare Haeckel, 1887

Caryomma new species A

Plate VI, Figures 1-8

Diagnosis

The skeleton, in its fully developed state, consists of five concentric shells of respective diameters 40μm, 120μm, 260μm, 450μm and 600μm. The three inner shell lattices are compact, while those of the outer two shells are delicate and composed of lateral branches from numerous minor spines which have their base on the third shell.

Ten major spines extending up to 900μm from the outer shell of the complete adult stage radiate from the spherical shells.

Description

The skeleton consists of five concentric shells. The innermost of these shells has a diameter of 40μm. The structure of this shell is not known. The second shell has a diameter of 120μm and a lattice made up of rounded lattice bars separating subrounded pores measuring 5-15μm across.

The third shell, with a diameter of 250-300μm is composed of an homogeneous lattice with approximately equidimensional rounded pores 10μm across. The lattice bars are approximately 5μm thick. Slightly larger more angular pores are present adjacent to the bases of the main spines with this shell where they branch into the lattice.

Numerous minor spines of thickness 5-10μm arise from the lattice bar intersections on the third shell. These spines extend 100μm from the shell where they produce lateral branches. Further lateral branches are produced by these spines 80μm distally from this.

The joining of the lateral branches from the adjacent minor spines forms the framework for the lattices of the poorly differentiated fourth and fifth shells of the skeleton. These shells are of a much more delicate character than the inner three shells. Pores in these lattices vary greatly in size from 5-40μm across, separated by lattice bars 5μm thick.

Approximately 10 major spines radiate from the innermost shell, penetrating all the outer shells of the skeleton. These spines are at their most delicate between the first and third shells, but thicken considerably at the third shell from where they taper distally. Spine length from the third shell to the distal tip is 900μm in the fully developed specimens.

Comments

This species is similar morphologically to Echinomma new species A and Cromyechinus new species A. Differences lie in the number of the shells, the character of the outer shells, the length of the major and minor spines and in the overall sizes of the skeletons. It would appear that these forms are closely related and should ideally be put into a single genus. The classification scheme used at the generic level here is that of Haeckel which relies on the number of shells and the type of spines radiating from the skeleton for their division into different genera. It is obvious, using this system, that one has to make sure one is dealing with the fully developed stage of a species. In the writer's opinion it is unsatisfactory for such similar forms to be split up into several genera.

Material and Horizon

Twenty specimens from the 325-400 foot interval of the Cape Phillips 1976 section, four specimens from the 470-600 foot interval of the Baillie Hamilton Island 1976 section 1, four specimens from the Cape Becher 1976 section 1 90-114 meter interval and two specimens from the Laura Lakes 1976 sample number 7. The age range for this species is from the Middle to upper Wenlock.

Genus Cenosphaera Ehrenberg, 1854 emended

Diagnosis

Spumellaria with a single lattice sphere, with simple pores (not prolonged into free tubuli). Shell cavity simple (without internal radial beams).

Emendation

Ehrenberg's use of the Family Liosphaerida in his original definition of this genus is redundant in the light of recent changes in radiolarian classification. If this original classification was adhered to, on account of the possession of radial spines, Cenosphaera aff. C. affinis would have to be assigned to a different family than the specimen under consideration here. In view of the similarities between the specimens, the actuality of such a taxonomic separation is considered unlikely.

Type Species: Cenosphaera plutonis Ehrenberg, 1854

Cenosphaera new species A

Plate III, Figures 1-5

Diagnosis

A single simple spherical shell approximately 200μm in diameter. Lattice bars less than 5μm thick enclose hexagonal pores, the sides of which are up to 35μm in length.

Description

The skeleton consists of a single spherical shell with no radial spines. This shell is 200μm in diameter. The lattice of the shell consists of hexagonal pores the sides of which are 35μm in length and are bounded by lattice bars approximately 5μm thick.

Comments

The lattice bars of this species are less robust than those of Cenosphaera aff. C. affinis Hinde. Also the skeletons of the two forms differ in that Cenosphaera aff. C. affinis possesses spines radiating from the shell. These are not seen on Cenosphaera new species A.

Similarities are apparent between this form and Cenosphaera hexagonalis Aberdeen, 1940, but the quality of the illustrations in Aberdeen's paper negate worthwhile comparisons.

Material and Horizon

One specimen from the Baillie-Hamilton Island 1976 section 1 at the 480 foot horizon and four specimens from the 600 foot horizon of same section. These samples are of Middle to upper Wenlock age. Rare specimens were also seen in the 1976 Cape Phillips section at the 325-350 foot interval.

Cenosphaera aff. C. affinis Hinde, 1899

Plate III, Figures 6,7

Description

The skeleton consists of a single spherical shell from which radiate 10-15 short spines which arise from the lattice bars. These spines are 20-40µm in length and taper distally from a basal width of 5µm. The shell lattice consists of rounded lattice bars 5-10µm thick which enclose subrounded pores 30-40µm across. The spherical shell has a diameter of approximately 150µm.

Comments

The lattice bars of this species are more robust than those of Cenosphaera new species A. The skeletons also differ noticeably in the possession by Cenosphaera aff. C. affinis of 10-15 spines which radiate from the lattice. This skeleton bears considerable resemblance to that assigned to Cenosphaera affinis by Hinde, 1899 from the Devonian Tamworth Series of New South Wales. Differences appear to lie in the larger pores and more slender pore bars of the Cape Phillips specimens.

Material and Horizon

Two specimens from the lower Wenlock of the Cape

Phillips 1979 section at the 180 foot horizon and three specimens from Laura Lakes sample 9.

Genus _Cromyechinus_ Haeckel, 1881 emended

Diagnosis

Spumellaria with a skeleton consisting of four concentric lattice shells and numerous simple radial spines of two different kinds; larger major spines and smaller minor spines.

Emendation

Haeckel's use of the Family Astrosphaerida in his original definition of this genus is redundant in the light of recent changes in radiolarian classification.

Type Species: _Cromyechinus isocanthus_ Haeckel, 1887

Cromyechinus new species A

Plate V, Figures 4-7

Diagnosis

About 10 major spines extend up to 420μm beyond the outer shell of the spherical part of the skeleton. The fully developed skeleton consists of four concentric shells, the inner three of these are composed of a closely knit lattice while that of the outer shell is noticeably more delicate. The outer shell is supported by numerous spines arising from the third shell. These minor spines are approximately 60 in number and extend beyond the outer shell for a distance of up to 70μm.

Some of the major spines are joined to the lattice of the fourth shell while others extend through it via a distinct pore.

Description

The skeleton consists of four concentric shells. The innermost shell has a diameter of 40μm and appears to be hollow. The lattice of this shell is produced by the branching of the proximal ends of the main spines which radiate through all of the outer shells. The second shell has a diameter of 100μm and is composed of a network of lattice bars surrounding pores less than 5μm across. This shell is connected to the third shell by the 10 (approximately) major spines radiating throughout the structure.

The third shell has a diameter of approximately 380μm and is composed of a slightly three dimensional lattice with a loose network of fine silica threads on the inside which at points is incorporated into the outer parts of the shell. The lattice visible from the outside is composed of lattice bars surrounding angular to subrounded pores 15μm across.

The third shell lattice also bears about 60 minor spines. These spines, 5-10μm thick at the base extend to a length of 150μm from the shell, where they produce lateral branches to form the fourth shell. Many of the minor spines pierce this shell and extend beyond it an average of 120μm.

The 10 or so main spines which radiate through the skeleton from the innermost shell increase in thickness at each of the three inner shell junctions (going outwards). The spines can be seen to branch into the lattice of these three inner shells, but only some of them branch into the fourth shell lattice. Others of them pass through this shell by means of conspicuous pores in the lattice.

At the third shell the spine bases measure 30µm across and the spines taper distally from here to end in a point 700µm from the third shell and 450µm from the fourth shell in fully developed specimens

Comments

These specimens closely resemble those assigned to Echinomma new species A, differing from them in the length and number of the minor spines, the generally less robust nature of the major spines and in the relatively increased length of these spines. Also there are four shells present in the fully developed members of Cromyechinus new species A while only three exist in a fully developed member of Echinomma new species A. A discussion of the possible affinities of this genus with Echinomma and Caryomma is presented on page 45.

Material and Horizon

Numerous specimens ranging from the 6 foot interval of the 1979 Cape Phillips section and eleven specimens from the 340-425 foot interval of the Cape Phillips 1976 section .

These specimens range from the upper Llandovery to the upper Wenlock.

Genus Cromyomma Haeckel, 1881 emended

Diagnosis

Spumellaria with four concentric lattice spheres and numerous simple radial spines of one kind.

Emendation

Haeckel's use of the Family Astrosphaerida in his original definition of this genus is redundant in the light of recent changes in radiolarian classification.

Type species: Cromyomma villosum Haeckel, 1887 (Recent).

Cromyomma new species A

Plate V, Figures 1-3

Diagnosis

The fully developed skeleton consists of four concentric shells with similar lattices, the largest of which has a diameter of approximately 650μm. The shells are joined by numerous non-continuous fine spines which arise from the junctions of the pore bars on each shell. The spacing between the consecutive shells varies between 150 and 200μm.

Description

The fully developed skeleton consists of four concentric shells with respective diameters of approximately

100, 300, 450 and 650μm.

The lattice of the shells is made up of bars 5-10μm thick which enclose angular to subrounded pores 10-50μm across. Pore size increases slightly in the fully developed skeleton from the inner to the outer shell.

The four shells are joined to their nearest neighbours by similar spines, 5-10μm thick, which arise at the lattice bar intersections. These spines do not appear to be continuous between all the shells. Spine number increases with the diameter of the shell, reaching well over 100 in number between the third and fourth shells. Very delicate spines extend 10-20μm from the outer shell.

Comments

This species, which appears to range throughout the processed 1979 samples from Cape Phillips samples can be seen to be similar to the Echinomma, Cromyechinus and Caryomma group of genera, but differs from them in lacking stout main spines radiating from the skeleton. These four genera are interpreted as having been very closely related.

Material and Horizon

Seven specimens from the upper Llandovery to the middle Wenlock of the 6 foot to 329 foot interval of the 1979 Cape Phillips section.

Genus Cubaxonium Haeckel, 1887 emended

Diagnosis

The skeleton consists of a spherical or octahedral spongy central body from which radiate six simple spines of equal size. The spines are arranged opposite in pairs in the three dimensive axes, perpendicular to one another.

Emendation

Haeckel's use of the Family Cubosphaerida in his original definition of this genus is redundant in the light of recent changes in radiolarian classification.

Type species: Hexadoras spongiosum Haeckel, 1887

Cubaxonium new species A

Plate VII, Figures 1-4

Diagnosis

Six distally tapering unsculptured spines arranged regularly in three mutually perpendicular axes radiate from a central spongy spherical lattice approximately 100µm in diameter. The spines extend up to 80µm beyond the spherical lattice before tapering to a point.

Description

The skeleton consists of a spherical three dimensional lattice approximately 100µm in diameter. The lattice of the shell is made up of bars less than 5um thick separating variably sized pores 5-20μm across. Six spines, arranged in three mutually perpendicular axes radiate from this skeleton, extending up to 80μm beyond the lattice. These spines are smooth sided, tapering distally. The proximal ends of the spines branch forming the innermost part of the spongy lattice.

Comments

The arrangement of six spines into three mutually perpendicular axes is considered distinctive. It is on the basis of this that the specimens assigned to this species are separated from those specimens assigned to New Genus A new species B. The lack of concentricity in the central spherical spongy lattice separates these specimens from Cubosphaera.

Material and Horizon

Nine specimens from the middle Wenlock of the 325-355 foot interval of the Cape Phillips 1976 section .

Genus Cubosphaera Haeckel, 1887

Diagnosis

The skeleton consists of a central body of five or more concentric spherical shells from which radiate six simple spines of equal size arranged opposite in pairs in the three dimensive axes.

Emendation

Haeckel's use of the Family Cubosphaerida in his original definition of this genus is redundant in the light of recent changes in radiolarian classification.

Type Species: Cubosphaera cubaxonia Haeckel, 1887

Cubosphaera new species A

Plate IX, Figures 1-8

Diagnosis

Six deeply sculptured spines radiate from a spherical lattice of about 100-150μm diameter. The spines are up to 180μm in length external to the spherical lattice. Numerous smaller spines are also present. The pores in the lattice are highly irregular in size and are subrounded in shape.

Description

The skeleton consists of a three dimensional latticed sphere 100-150μm in diameter from which radiate six sculptured spines. These spines are trigonal in cross section, and extend outward up to 180μm from the central sphere. At their outer contact with the sphere the spine bases are up to 20μm thick, and they can be seen to contribute to the lattice by lateral branching.

Numerous minor spines less than 5μm thick extend out from the lattice to a length of 10μm. The lattice on close inspection can be seen to have a basic structure of radiating minor spines connected by lateral cross bars to form poorly differentiated shells. (This can be seen in Figure 5 plate IX where a rough concentricity in the skeleton is apparent). Lattice bars are approximately 5μm thick and enclose rounded pores ranging in size from 5-15μm across.

The central structure of the skeleton is not known.

Comments

This skeleton is similar to that of Cubaxonium new species A in the number of major spines radiating from the central sphere. However the detailed structure of the central sphere differs in that a concentricity is apparent which is not seen in Cubaxonium new species A, and in the fact that minor spines radiate from the sphere. These attributes indicate a definite similarity between this species and Arachnosphaera new species A.

The possession of six major spines in both Cubaxonium new species A and Cubosphaera new species A may have resulted from convergent evolution rather than from actual close genetic relationships between these two species. *Cubaxonium* new species A may be closer related to *Arachnosphaera* new species A.

Material and Horizon

Eleven specimens from the Middle to upper Wenlock of the 325-400 foot interval of the Cape Phillips 1976 section and scattered occurrences throughout the 6 foot to 312 foot horizons of the 1979 Cape Phillips section (upper Llandovery to lower Wenlock).

Cubosphaera aff. C. new species A

Plate V, Figure 8

Description

A pattern of six major sculptured spines, organised in three axes, is discernible in this skeleton. Two other orders of spines are also present. The intermediate (in size) order of spines is similar to the major spines in also being grooved and trigonal in cross section. The minor spines are very thin and apparently rounded.

All these spines radiate from a central apparently three dimensional spherical skeleton 120µm in diameter which consists of subrounded pores 10-15µm across separated by bars less than 5um thick. The major spines extend 90µm outside the central sphere. The intermediate spines (approximately six in number) are 50µm in length and 10µm in width while the minor spines (approximately 12 in number) extend up to 30µm be d the sphere and have a basal width of 5-10µm.

The internal structure of the skeleton is not known.

Comments

This skeleton can be seen to have similarities to both Arachnosphaera new species A and to Cubosphaera new species A. Its stratigraphic position is between the two. If a continuum of forms between these two species existed, this form could be argued to represent the modification of the spine organisation from that of *Arachnosphaera*, with 10-15 major spines, to the six major spines of *Cubosphaera*.

Material and Horizon

One specimen from the lower Wenlock of the Cape Phillips 1976 section at the 135 foot horizon.

Genus Echinomma Haeckel, 1881 emended

Diagnosis

Spumellaria with skeletons consisting of three concentric lattice spheres and numerous radial spines of two different kinds; larger main spines and smaller minor spines.

Emendation

Haeckel's use of the Family Astrosphaerida in his original definition of this genus is redundant in the light of recent changes in the classification of the Radiolaria.

Type species: Echinomma echinidium Haeckel, 1887

Echinomma new species A

Plate IV, Figures 1-5

Diagnosis

In the adult stage 8 distally tapering spines extend up to 360μm from the second spherical shell of the skeleton. The outermost shell consists of lateral branches of minute spines which arise from the lattice of the second shell 40μm interior to this shell. The eight major spines pass through the external shell lattice and have true bases only on the first and second shells. This outermost shell has a diameter of approximately 400μm. The second, or intermediate shell has a considerably more robust lattice than the outer shell (which is not present in many specimens).

Description

The skeleton consists of three concentric shells of diameter 120, 300 and approximately 400µm. The innermost shell is hollow and is joined by apparently 8 spines to the second shell where these spines increase in robustness. The lattice of the innermost shell is composed of bars less than 5µm thick which enclose pores 5-10µm across.

The lattice of the second shell is very slightly spongy in character with a loose network of fine silica strands on the inside which at points is incorporated into the outer part of the shell. The lattice visible from the outside of the shell consists of variably sized angular to subrounded pores ranging from 5-15µm across. The largest pores occur where the spine bases branch into the lattice; here the pores may reach 20µm across. The average lattice bar thickness is 5µm.

Many of the intersections of the lattice bars in the second shell give rise to slender minor spines of similar thickness to the lattice bars. These spines, numbering more than 100, extend 40µm beyond the second shell where they produce lateral branches. These branches commonly join those from adjacent minor spines and constitute the third or outer shell of the skeleton.

The eight main spines which connect the inner shell to the second shell greatly increase in thickness at the second shell. External to this shell the spines have a thi s of 40µm compared to their 5µm width immediately interna o this shell. These spines taper to a point distally 400µm from the second shell.

Comments

Plate IV Figures 1, 2 and 5 illustrate the ontogenetic development of members of this species. The youngest specimen is that seen in figure 1 and displays sparse development of the minor spines on the second shell. Figures 2 and 5 show the increasing development of these spines and their lateral branching to form the lattice of the third or external shell.

This species differs from Echinomma aff. E. new species A in the lesser development of the minor spines beyond the third shell.

Material and Horizon

Numerous specimens from the lower Wenlock of the 135 foot horizon of the Cape Phillips 1976 section, the 33-36 foot interval of the Baillie-Hamilton Island 1976 section 1, from sample 9 of the 1976 Laura Lakes samples and from the 118-353 foot interval of the 1979 Cape Phillips section.

Echinomma aff. E. new species A

Plate III, Figure 8

Description

The external shell, of diameter 600µm, is composed of lattice bars 5-10µm thick which enclose fine angular pores 5-15µm across. This shell is penetrated by two types of spines which radiate from the skeleton.

Approximately 10 major spines, 4[illegible] thick at their junction with the outer shell, exten[illegible] beyond this shell before tapering to a point. The taper on the spines is gradual until the distal 50µm of the spine wh[illegible] it is greatly increased.

Numerous minor spines, 10µm thick at the junction with the outer shell, also extend up to 400µm from the shell.

The inner structure of the skeleton is not known.

Comments

Although the inner structure of the skeleton is not known, the external appearance with approximately 10 major spines and numerous minor spines extending beyond the outer shell to a length of 400µm is similar to the pattern seen in Echinomma new species A.

Material and Horizon

One specimen from the upper Wenlock of the 425 foot horizon of the Cape Phillips 1976 section.

Genus Haliomma Ehrenberg, 1838 emended

Diagnosis

Spumellaria whose skeleton consists of two concentric spherical shells united by radial beams. 8 or more (commonly between 20 and 30) radial spines are on the surface of the outer shell.

Emendation

The use of the Family Astrosphaerida in the definition of this genus is redundant in the light of recent changes in the classification of the Radiolaria.

Type Species: Haliomma aequorum Ehrenberg, 1844

Comments

Numerous specimens belonging to Haliomma were extracted from samples of upper Wenlock to lower Ludlow age. Nine different types have been described, showing variation in the size of the spherical shells, the number of spines radiating from the outer shell and in the amount of basal flaring of these spines. The members of this genus, as described here, seem to be very closely related types. A statistical study of the haliommids is deemed necessary, in the authors opinion, for certain assignment into separate species of the spectrum of types found within these horizons.

Haliomma new species A

Plate XIV, Figures 1-8

Diagnosis

5-10 spines radiate from the inner shell while 20-30 radiate from the outer shell. Those spines radiating from the outer shell are similar in size and have slightly expanded bases (maximum width [illegible]0μm) two to three times thicker than the spine width 100μm from the shell. Shell diameter variable: the inner shell with values between 50-90μm and the outer shell varying from 150-280μm.

Description

The mature skeleton consists of two spherical concentric shells. The inner shell, of diameter 50-90μm, consists of a weakly developed lattice with polygonal pores up to [illegible]5μm across separated by lattice bars less than 5um thick. This sphere is hollow. The lattice of this shell is produced by the dividing and branching of the proximal ends of the 15 (approximately) spines which radiate from it. These spines are 5μm thick and extend to the outer shell where they coincide with the bases of the largest of the spines radiating from the surface of this shell. The outer shell lattice, of diameter 150-280μm, consists of subrounded pores 5-10μm across separated by bars less than 5um thick.

20-30 spines occur on the outer shell, these varying in length and robustness. Those spines which have continuations to th inner shell have expanded bases 30μm across and may re 200μm in length outside the outer shell. The spines wh do not have these internal continuations tend to be shorter and have less robust bases.

Variation is seen between the specimens assigned to this species in the robustness and length of the spines radiating from the shell.

Comments

The broad range in spine sizes radiating from the outer shell of the specimens assigned to this species is interpreted as due to ontogeny. Figures 5 and 7 plate XIV are considered to represent adult stages while those with thinner spines are juvenile. (Figure 4 plate XIV)

Due to the poor quality of illustrations, it is not meaningful to draw comparisons between these specimens and those assigned to Haliomma by Reudemann and Wilson, 1936 from the Ordovician cherts of New York.

Material and Horizon

Seventeen specimens from the Middle to upper Wenlock of the Baillie-Hamilton Island 1976 section 1 at the 765 foot horizon and six specimens from the Baillie-Hamilton Island 1976 section 2 at the 290 foot interval.

Haliomma aff. H. new species A

Plate XIII, Figures 5,6

Description

The skeleton consists of two concentric shells. The inner shell has a diameter of approximately 80μm and its lattice is weakly developed, being composed of a loose network of fine lattice bars originating from the division of the proximal ends of the spines radiating from this shell. No spines penetrate this lattice and the sphere is hollow.

The outer shell has a diameter of approximately 200μm. There are two forms of lattice on this shell; The A type lattice, which occupies the major portion of the shell surface, is composed of lattice bars less than 5um thick separating pores 5-10μm across. The remainder of the shell area is occupied with the B type lattice - enlarged pores up to 20μm across adjacent to the spine bases. 20-30 spines radiate from the surface of the shell. These spines are similar in robustness, but differ in length (50-130μm). All are characterised by slightly enlarged buttressed bases. In mature individuals the spine bases radiate outwards on the lattice of the outer shell to join one another, providing a distinctive pattern of ridges.

Comments

These specimens may not belong to Haliomma new species

A, but do belong to a group of similar looking haliommids. The extent of phenotypically versus genotypically based variation of this group has not yet been elucidated.

These specimens are separated from Haliomma new species A due to the more consistent size and robustness of the spines radiating from the outer shell. Also the pattern of ridges on the shell formed by the interconnection of adjacent spine roots is not seen in Haliomma new species A.

Material and Horizon

Three specimens from the 1976 Laura Lakes sample 10 (lower Ludlow).

<u>Haliomma</u> new species B

Plate XV, Figures 1-4

Diagnosis

The 20-40 spines radiating from the outer shell (diameter 180-200µm) of this species have greatly expanded bases where they join the lattice of the shell. The expansion of the spine bases (up to 70µm across) is so great that these bases form a major part of the shell lattice.

Description

The internal structure of the skeleton is incompletely known due to poor preservation.

The external shell has a diameter of 180-220µm and is composed of a lattice of variably sized pores. Two types of lattice are present:

A type lattice: Bars 5-10 µm thick separating rounded pores 5-20 µm across.

B type lattice: Elongate pores 10-30µm in length adjacent to the spine bases. The buttresses forming part of the spine bases are 10-20µm thick close to the spines and thin distally.

20-40 spines radiate from the shell. These are evenly spaced and are characterised by heavily sculptured flaring bases forming part of the shell. The sculpturing of the spine bases continues up to 90µm above the junction of the spine with the shell. The width of the spine bases is

50-70μm close to the latticed sphere. Above the sculptured base, the spines are smooth and taper distally, terminating 60-150μm from the shell. Spine length is very variable.

Broken specimens show the continuation of some of the spines inward through the outside shell, converging toward the centre of the skeleton. However in all cases these spine extensions were broken before their natural proximal termination.

Comments

As it has proved impossible to delimit any special trait in this range of specimens, they have here been assigned to the same species. Variable features in these specimens are the number of spines radiating from the shell, the thickness of these spines and, as a result of this, a variation in the ratio of A type to B type lattice in the shell. A general trend in time seems to be the thickening of the spine bases on the outer shell and hence an increase in the B type lattice.

This species differs from Haliomma new species A in the greater width of the spines radiating from the outer shell and in the developed stages the joining of the adjacent spine roots forming ridges on the shell lattice. This is not seen on Haliomma new species A.

Haliomma aff. H. new species A appears to be an intermediate form between the above species, it not showing the same degree of basal spine robustness or the same amount of ridging of the shell lattice that is seen in Haliomma new species B.

Haliomma aff. new species B differs from Haliomma new species B in the greater number of spines radiating from the outer shell.

Material and Horizon

Five specimens from the 150-290 foot interval of the Baillie-Hamilton Island 1976 section 2 and one specimen from the 1976 Laura Lakes 1976 sample 10 (upper Wenlock and lower Ludlow respectively).

Genus Haliomma aff. H. new species B

Plate XV, Figures 5-8

Description

The single visible spherical shell has a diameter of 200-250μm. Approximately 60 similar spines radiate from this shell. These spines have greatly elongated bases which branch into the shell lattice, which is largely made up of B type lattice. The basal width of the spines ranges up to 80μm. Pores in the shell lattice are subrounded, measuring 5-10μm across, separated by lattice bars less than 5μm thick. The spines may extend up to 250μm beyond the shell before tapering to a point.

Comments

These specimens show similarity to Haliomma new species B but differ in the number of spines that radiate from the shell. The two forms appear to be closely related and occur in the same horizon. Haliomma new species B is separated by its more numerous finer spines and a lesser degree of basal expansion of these.

The specimens assigned to Haliomma aff. H. new species B show variation in the size of the skeleton. The specimen in Figure 7 Plate XV has a greater number of more delicate spines radiating from its outer shell. This has been interpreted as due to phenotypic variation.

Material and Horizon

One specimen from the 1976 Baillie-Hamilton Island section 2 from each of the 215 foot and 265 foot horizons and four specimens from the 290 foot horizon of this section. These specimens are of lower Ludlow age.

Halionma new species C

Plate XVI, Figures 1-8

Plate XLII, Figures 7,8

Diagnosis

More than 60 similar spines radiate from the outer shell in the adult stage. The bases of the spines show limited expansion and buttressing, being up to 10µm thick at the junction with the outer shell. 20-40 spines radiate from the inner shell and connect this shell with the one which encloses it.

Description

The skeleton consists of two concentric spherical shells. The outer shell has a diameter of 170-300µm and is almost completely composed of B type lattice - a type of three dimensional lattice resulting from the perforation of the basal spine buttresses by pores. Lattice pores are subrounded, measuring 5-10µm across. 40-60 spines join the inner shell (diameter 50µm) to the outer shell. The lattice of this inner shell is made up by the branching of the proximal ends of the spines which connect it with the outer shell.

More than 60 similar spines radiate from the outer shell. The number of these spines varies between specimens. Spine length may attain 100µm but is commonly shorter than this. During ontogeny the spines radiating from the external shell increase in length and robustness till they attain a length of 400μm beyond the outer shell.

Comments

There is considerable variation in the number of spine bases present on the outer shell of the specimens assigned to this species. This species is seperated from Haliomma new species D due to its possession of more numerous and more delicate spine bases.

Material and Horizon

Seven specimens from the Baillie-Hamilton Island 1976 section 1 at the 765 foot horizon and thirteen specimens from the 215-290 foot interval of the Baillie-Hamilton Island 1976 section 2. These samples range from the upper Wenlock to the lower Ludlow.

<u>Haliomma</u> aff. <u>H.</u> new species C

Plate XIII, Figures 7,8

<u>Description</u>

The skeleton consists of two concentric shells. The inner shell has a diameter of 60-120μm while the outer shell has a diameter of 200-220μm.

The inner shell is hollow, consisting of an open lattice with bars less than 5μm thick separating pores 15μm across. This lattice is made up of the proximal ends of the 15-20 spines which radiate inwards from the outer shell dividing and coalescing with the branches from adjacent spines.

The outer shell is extremely spinose with more than 60 spines radiating from it. The lattice of this shell has pores 5-10μm across. The spine bases are slightly buttressed and branch discretely into the lattice.

The 15-20 spines which radiate from the inner shell through the outer shell tend to be the most robust of the spines. They extend beyond the outer shell up to a length of 100μm and at their bases are 20μm across. Those spines which have their origin in the outer shell are shorter and less robust.

<u>Comments</u>

These specimens bear a distinct resemblance to those assigned to <u>Haliomma</u> new species C. Differences are apparent between them though in the form of less robust spine bases in Haliomma aff. H. new species C. Also these specimens tend to have a smaller diameter to the outer shell and a more obvious differentiation in the size of the spines which continue through the outer shell from the inner sphere.

Material and Horizon

Five specimens from the Baillie-Hamilton Island 1976 section 1 in the 600 to 765 foot interval and one specimen from the 1976 Laura Lakes sample 4. These samples are of upper Wenlock age.

Haliomma new species D

Plate XVII, Figures 1-

Diagnosis

The outer shell of the skeleton is s ...ly spongy. having an elevated lattice type produced by the perforation of the sloping spine bases. This lattice overlies and joins into a lower normal shell lattice not affected by the spine bases. 50-60 similar spines radiate from the outer shell. Lattice pores are subrounded in shape and are largest adjacent to the spine bases.

Description

Two concentric shells are present. The inner shell has a diameter of 40µm while the outer has a diameter of 120-180µm. The inner shell is composed of an apparently uniform fine lattice (finer than that of the outer shell) from which radiate 10-20 spines. These spines do not appear to penetrate this inner shell.

The outer shell is composed of two lattice types; an A type lattice in the areas of the shell unaffected by the branching of the spine bases into the lattice. In this type the height of the lattice bars is uniform. Pores are rounded and vary in size from 5-10µm across and are separated by bars approximately 10µm thick.

The other type of lattice, the B type lattice, is composed of sloping bars which enclose pores 10-15µm across and join to solid spine material. This sloping lattice represents the perforated expanded base of the spines. The B type lattice frequently overlies the A type lattice in those areas of the shell adjacent to the spines.

40-60 spines radiate from the lattice of the external shell. These spines are of similar robustness but vary in length from 35-250μm (though not in the same specimen).

Comments

In the four specimens from the same horizon that are figured here there appears to be a growth series. The youngest specimen is interpreted as that in Figure 1 Plate XVII with age increasing through figures 2 to 4 of this plate. Concurrent with the greater development of the spines is the development of the B type lattice on the outer shell.

This species is separated from Haliomma new species C on account of the greater perforation of the fewer spine bases and the resultant formation of a more open B type lattice. In Haliomma new species C the spine bases are less perforated and are closer together. The specimens figured in plate XLII bear superficial resemblance to the others assigned to Haliomma new species D. Their internal structure is not known however, and assignment to this species is tentative.

Material and Horizon

Four specimens from the upper Llandovery to the lower

Wenlock of the 1976 Baillie-Hamilton Island section 1 at the 765 foot horizon and two specimens from the 245 foot horizon of the Baillie-Hamilton Island 1976 section 2 (upper Wenlock)

<u>Haliomma</u> new species E

Plate XVII, Figures 5,6

Diagnosis

10-20 spines of length 160-180µm radiate from the outer shell of the skeleton. These spines have a restricted buttressing at their bases against the outer shells, their bases being up to 10µm thick and tapering within 10µm of the length of the spine to 5µm thick. The spines taper distally gradually from this point.

Description

The skeleton consists of two concentric shells, the inner having a diameter of 40-80µm and the outer shell a diameter of 140-180µm. 20-30 spines radiate from the outer shell. These spines may be up to 180µm in length, tapering distally from a basal thickness of 20µm.

The lattice of the outer shell is composed of bars less than 5µm thick separating variably sized pores measuring 5-10µm across. The bases of the spines branch into the lattice. These spines appear to continue through the outer shell into the inner shell.

The central structure of the skeleton is unclear, but no definite evidence has been seen to indicate the presence of an internal spicule.

Comments

This species is based on limited material from two different sections. The specimens appear to be very similar except in the aspect of size, that from the Cape Phillips section being approximately twice the size of that from Baillie-Hamilton Island. Correlation of the sections would indicate that the specimen from the Cape Phillips section is considerably older than that from the Baillie Hamilton Island section. The time difference in the age of the samples may explain the size difference between the two specimens.

This species of Haliomma is much simpler in form than the other species of this genus described from this assemblage and is easily recognisable due to the lesser number of spines radiating from the outer shell.

Material and Horizon

One specimen from the 1976 Cape Phillips section at the 390-400 foot interval (upper Wenlock) and one specimen from the 1976 Baillie-Hamilton Island section 2 at the 265 foot horizon (Lower Ludlow).

Genus Haliomma ? new species F

Plate XVII, Figures 7,8

Diagnosis

› two shells that comprise the spherical central body of the skeleton are composed of spongy lattices. The inner shell is hollow. No increase in the number of spines radiating from the outer shell compared to that from the inner shell is seen.

Description

The skeleton consists of two concentric spherical shells of diameters 120 and 160-200µm. The lattice of the outer shell is spongy. Pores var in size, being up to 10um in diameter. This outer shell is noticeably supported by the numerous spines which pass through it from the inner shell. The spines do not show any significant thickening on contact with the outer shell, rather they appear to be thickest at the inner shell and taper distally from it. They branch laterally at the outer shell contributing to the shell lattice.

The inner shell, whose structure is not clear, is made up of a finer spongy lattice than the outer shell. The spines do not penetrate into this shell, but appear to branch into the lattice. The number of spines does not increase between the inner and outer shells. The spines are of similar length and robustness, some being slightly curved along their length, but most are straight.

No evidence is seen for a structure internal to the inner shell.

Comments

This species is unlike any of the other Haliommid species in the possession of a spongy inner shell lattice. As a result it is difficult to discuss its possible relationships with the others of this broad group. It may be related to Spongoplegma representing a form in which the straight lattice bars have been thickened and emphasised to form true spines. The lack of increase in the number of spines radiating from the outer shell compared to the number radiating from the inner shell separates this form from the other haliommids previously described.

Material and Horizon

Four specimens from the 215-265 foot interval of the Baillie-Hamilton Island 1976 section 2. These samples are lower Ludlow in age.

Genus Hexalonche Haeckel, 188 , emended

Diagnosis

Spumellaria with six similar spines radiating from a spherical central body consisting of two concentric shells.

Emendation

Haeckel's use of the Family Cubosphaerida in the original definition of this genus is redundant in the light of recent changes in the classification of the Radiolaria.

Type Species: Hexalonche phaenaxonia Haeckel, 1881

Hexalonche new species A

Plate VII, Figures 5-8

Plate VIII, Figures 1-4

Diagnosis

The inner shell is made up by the branching of the proximal ends of the six spines. The lattice of this shell is of a more open nature, with thicker lattice bars and larger pores, than the lattice which constitutes the second (outer) shell. The outer shell results from spines radiating from the inner shell and branching laterally approximately 15um from the inner shell. Very minor spines may radiate from the second shell, these extending less than 5µm beyond the shell.

Description

The skeleton consists of six smooth rays arranged in three mutually perpendicular axes which radiate from a central spherical body of two concentric shells. These rays extend up to 120μm from the inner shell. The inner shell, of diameter 50-80μm, is made up by the lateral branching of the main spines into roots which act as the lattice bars. These lattice bars, approximately 5μm thick, enclose angular to subrounded pores 10-20μm across.

Numerous spines less than 5μm thick arise from the lattice bars of the shell and branch laterally 15μm from the shell to form the lattice of the outer shell. The outer shell lattice may be very slightly spongy, the bars being more delicate than those of the inner shell

Very minor spines may extend up to 5μm from the lattice of the outer shell.

Comments

This species is similar to New Genus A new species A, but differs from it in the possession of two well defined concentric shells. The differences in the lattice make-up of the inner and outer shells seperates this form from Hexalonche? new species B.

Material and Horizon

Sixteen specimens from the 6 to 385 foot interval of the Cape Phillips 1979 section. These samples are of upper

Llandovery to lower Wenlock age.

Genus Hexalonche ? new species B

Plate VIII, Figures 5-8

Diagnosis

Six similar distally tapering spines arranged in three mutually perpendicular axes radiate from a central body of two well defined concentric shells. The major spines extend up to 200μm beyond the outer shell. The two shells are connected by numerous radiating spines. The inner shell has a diameter of approximately 50μm while the outer shell has a diameter of 120μm. The lattices of the inner and outer shells are similar in nature.

Description

Six distally tapering spines extend 200μm beyond the outer shell. These spines, 15-20μm in width, are arranged with two in each of three mutually perpendicular axes.

The central body consists of two concentric shells, of diameter 50μm and 120μm. The lattices of both are similar, with bars approximately 5μm thick enclosing subrounded pores 5-10μm across. The inner shell is hollow.

Numerous minor spines connect the inner shell to the outer shell . The number of these minor spines apparently doubles at the outer shell where over 100 spines 5μm thick extend 25μm from the shell. In some specimens there is an indication of the development of a third shell lattice 20um external to the second shell by the lateral branching of these minor spines.

Comments

The indicated development of a third shell in the skeleton of this species questions its assignment to the genus Hexalonche. However as this evidence has only been seen in one specimen and the development of this shell is scanty, the obvious similarity of this species to the other species assigned to this genus would seem to justify this assignment. The similarity of the lattices constituting the inner and outer shells distinguishes this form from Hexalonche new species A.

Material and Horizon

15 specimens from the Upper Llandovery to lower Wenlock of the 6 foot to 385 foot interval of the Cape Phillips 1979 section.

Genus Plegmosphaera Haeckel, 1881 emended

Diagnosis

Spumellaria consisting of a single hollow spongy latticed sphere from which no spines radiate.

Emendation

Haeckel's use of the Family Liosphaerida in his original definition of this genus is redundant in the light of recent changes in radiolarian classification.

Type Species: Plegmosphaera maxima Haeckel, 1887

Plegmosphaera new species A

Plate XI, Figures 6-8

Diagnosis

The ske[illegible]to[illegible]nsists of a hollow three [illegible]nsional latticed sphere [illegible]iameter 160-170µm. Pseudospines, or lattice bars, can be seen to radiate interiorly towards the centre of the hollow sphere from the inner margin of the shell lattice. These, however, do not reach the centre of the skeleton.

Description

The skeleton is composed of a hollow latticed sphere of diameter 160-170µm. The lattice of the sphere is 20um thick and is made up of bars less than 5µm thick surrounding rounded lattice pores 5-20μm across. No spines or pseudospines radiate externally from the lattice. Such structures can be seen to radiate towards the interior from the internal surface of the spherical lattice. These pseudospines do not reach the centre of the skeleton, but stop 10μm from the centre. These structures are, away fro their bases, approximately 1μm thick.

There is an indication of an enlargement of the lattice pores externally from the inner surface of the shell, the outer pores having diameters 1.5 times those of the inermost pores.

Comments

This species resembles the specimens assigned to Plegmosphaera aff. P. new species A in the basic structure of the skeleton, but differs from it in the diameter of the sphere and in the coarseness of the lattice bars. The apparent homogeneity of the lattice in the P. aff. P. new species A could also be used as a distinguishing feature.

Material and Horizon

Three specimens from the upper Wenlock of the Baillie-Hamilton Island 1976 section 1 at the 765 foot horizon and the 1976 Laura Lakes sample 9. Three specimens from the lower Ludlow of the 245-265 foot interval of the Baillie-Hamilton Island 1976 section 2.

Plegmosphaera ? aff. P. new species A

Plate XII, Figures 1-2

Description

The skeleton consists of an homogeneous spongy lattice 120µm in diameter and 20µm in thickness. The lattice of the shell is made up of subrounded pores 5-10µm across separated by lattice bars less than 5µm thick.

Comments

This skeleton is similar to that of the specimens assigned to Plegmosphaera new species A, but differs from it in the diameter of the shell and the apparent homogeneity of the lattice.

Material and Horizon

Two specimens from the upper Wenlock of the Cape Phillips 1976 section at the 390-400 foot interval.

Plegmosphaera new species B

Plate XII, Figure 3

Diagnosis

The skeleton consists of a hollow three dimensional spherical shell, diameter 100μm. The outside of this shell is distinguished by the presence of thin radial lattice bars or 'pseudospines' which extend up to 5μm out from the main lattice.

Description

The skeleton consists of a hollow three dimensional spherical shell of diameter approximately 100μm and thickness 10-20μm. The lattice of the shell is composed of subrounded pores 5μm across separated by lattice bars approximately 2μm thick.

The outside of the lattice is marked by 'pseudospines' or radial lattice bars extending 5μm from the main lattice of the shell.

Comments

The skeleton of this specimen differs from that of the specimens assigned to Plegmosphaera new species A in the diameter of the single shell and in the more delicate nature of the lattice. The presence of 'pseudospines' is also a distinguishing characteristic. This separates this species from the specimens assigned to Plegmosphaera aff. new species A.

<u>Material and Horizon</u>

One specimen from the middle Wenlock of the Cape Phillips 1976 section at the 340-350 foot interval.

<u>Plegmosphaera</u> new species C

Plate XII, Figure 4

<u>Diagnosis</u>

The skeleton is composed of a hollow three dimensional shell of diameter 220-250μm. Fine spines up to 50μm in length radiate from this shell.

<u>Description</u>

The skeleton is composed of a three dimensional spherical lattice 60μm thick with a diameter of 220-250μm. The interior of this shell is hollow. The lattice is made up of bars less than 5μm thick surrounding pores 5-10μm across. The lattice appears to be homogeneous. Fine spines, derived from straight lattice bars, radiate from the shell. The original number of these spines is not known. These spines are less than 5μm thick and extend up to 10μm beyond the main lattice.

<u>Comments</u>

The diameter of the shell is considerably larger in this specimen than that of the specimen assigned to <u>Plegmosphaera</u> new species B. The fine spines of <u>Plegmosphaera</u> new species C may represent the elongation of the straight lattice bars seen on the skeletons of <u>Plegmosphaera</u> new species B. The apparently small number of these spines would indicate the presence of preferential sites for this activity.

Material and Horizon

Two specimens from the Wenlock of the Laura Lakes 1976 sample 7.

<u>Plegmosphaera</u> new species D

Plate XII, Figures 5,6

<u>Diagnosis</u>

A single homoge ious spongy shell of diameter 120µm from which radiate approximately 10 spines 40µm in length. These spines have a basal thickness of up to 10µm and taper distally.

<u>Description</u>

The skeleton appears to consist of an homogeneous spongy latticed shell of diameter 120µm. The lattice of this shell is made up of lattice bars less than 5µm thick separating sub-rounded pores 5-10µm across. The hollow internal part of the skeleton has diameter of 80µm. Approximately 10 spines 30µm in length radiate from the spongy shell. These spines do not appear to be regularly arranged.

<u>Comments</u>

This skeleton is similar to that of the specimen assigned to <u>Plegmosphaera</u> new species A, but differs from it in the diameter of the shell and in the possession of spines radiating from the spongy shell. The smaller diameter of the shell separates <u>P.</u>new species D from <u>P.</u> new species A.

Material and Horizon

Several specimens from the 29 foot interval of the Cape Phillips 1979 section (upper Llandovery). Rare specimens tentatively assigned to this species (viewed under the binocular microscope) occur in the 118, 127, 132 and 155 foot intervals of the same section.

Genus *Rhizoplegma* Haeckel, 1881 emended

Diagnosis

Spumellaria with numerous spines radiating from the surface of the outer spherical shell. This outer shell is spongy and is connected to a two dimensional inner shell by radial spines.

Emendation

Haeckel's use of the Family Astrosphaerida in his original definition of this genus is redundant in the light of recent changes in the classification of the Radiolaria.

Type Species: *Rhizoplegma polyacanthum* Haeckel, 1887

Rhizoplegma new species A

Plate XVIII, Figures 1-3

Diagnosis

The skeleton consists of two concentric shells, the outer one spongy (diameter approximately 300μm) and the inner one a two dimensional lattice of diameter 100μm. A gap of approximately 40μm separates the shells which are connected by radiating spines from the inner shell. Two types of lattice are visible on the outer shell, from which 50-60 similar spines radiate.

<u>Description</u>

Two concentric shells comprise the skeleton. The inner shell has a diameter of 100µm while the outer shell has a diameter of approximately 300µm. A gap of 40um is present between the two shells.

The inner shell is composed of a uniform lattice of bars 5µm thick separating rounded pores 5-10µm across. The outer shell consists of a three dimensional lattice 60um thick. Looking at this shell from the outside two types of lattice can be seen to be present;

A type lattice: Lattice unaffected by spine roots. Pores are rounded , 5-15µm across and separated by lattice bars 5-10µm thick.

B type lattice: Very large lattice pores, up to 40µm across of varying shapes bounded by spine roots branching off the base of the spines into the A type lattice. The configuration of this B type lattice varies widely between spine bases.

The ratio of the two types of lattice present on the surface of the outer shell is approximately 1:3 (A to B).

50-60 spines radiate from the outer shell. These spines are all of similar robustness, tapering distally to a point approximately 180µm from the shell surface. All the spines seem to pierce the outer shell and converge on the lattice of the inner shell where their proximal ends appear to branch into the lattice. The inner shell is hollow.

Comments

The presence of a three dimensional outer shell separates this species from the otherwise similar Haliomma new species D. As the specimens of this species occur within the range of the haliommid species it is possible that it may have shared a common ancestor with them. However it is also possible, in the face of negative evidence (no similar forms have been found in the lower sections) that this species is derived from the haliommid lineage. These specimens differ from that assigned to Incertae Sedis G in the larger size of the skeleton. In both types the largest pores are adjacent to the spine bases and occur in B type lattice.

Material and Horizon

One specimen from the 35 foot and two specimens from the 150 foot horizons of the Baillie-Hamilton Island 1976 section 2 (upper Wenlock and lower Ludlow).

Genus *Spongoplegma* Haeckel, 1881 emended

Diagnosis

Spumellaria without radial spines on the surface of the spherical skeleton. The skeleton consists of two concentric shells, the outer of which is comprised of a spongy lattice.

Emendation

Haeckel's use of the Family Liosphaerida in his original definition of this genus is redundant in the light of recent changes in radiolarian classification.

Type Species: *Spongoplegma urschanense* Rust, 1885

Spongoplegma new species A

Plate XI, Figures 3-5

Diagnosis

The skeleton consists of two concentric spongy latticed shells with diameters of 40μm and 180μm which are connected by a layer of less dense three dimensional lattice. The interior of the skeleton is hollow.

Description

Externally the skeleton is seen as an homogeneous latticed sphere with subrounded pores 5-25μm across separated by lattice bars less than 5μm thick.

The external shell is approximately 30um thick and encompasses an area of less dense lattice 20-30μm thick. Proximal to this area of sparse lattice bars is a more densely latticed sphere 40μm in diameter. This central shell appears to be hollow. The lattice of this inner shell is similar to that of the outer shell.

Comments

This skeleton is similar somewhat similar to Spongoplegma longispinosa Aberdeen, 1940, however a detailed comparison cannot be made due to the quality of the illustrations in that paper. The sizes of the skeleton are different. The preservation of the samples examined in this study is poor, making interpretation of the structure difficult.

Material and Horizon

Three specimens from the upper Wenlock of the Baillie-Hamilton Island 1976 section 1 at the 710 foot horizon and one specimen from the upper Wenlock/lower Ludlow of the 130 foot interval of the Baillie-Hamilton Island 1976 section 2.

Genus Spongostylus Haeckel, 1881 emended

Plate XI, Figures 1-2

Diagnosis

Two spines protrude from a central spherical to ovoid body which consists of two spongy shells.

Emendation

Haeckel's use of the Family Stylosphaerida is redundant in the light of recent changes in the classification of the Radiolaria. The weight applied by Haeckel to the nature of the inner shell (whether spongy or latticed) is not applied in the emended definition.

Type species: Spongostylus hastatus Haeckel, 1887

Spongostylus new species A

Diagnosis

The skeleton consists of two poorly discernible spongy latticed shells. The lattice of the external shell is round to ovoid, composed of bars less than 5μm thick enclosing rounded pores. The two spines, not always in the same axis, but arranged so as to be generally opposing one another, extend from the inner shell through the outer shell lattice and taper to a point 15-30μm from the outer shell.

Description

The complete internal structure of the skeleton is not known. There is evidence of a shell internal to that seen from the outside of the skeleton. The lattice of the external shell is three dimensional, being 20-40µm thick and composed of rounded pores 10-25µm across, separated by lattice bars of varying attitude (3-10µm thick).

The shape of the skeleton is slightly ovoid. A single spine arises from the lattice at each of the sharp ends of the ovoid. These spines are approximately 10µm thick at their junction with the shell but taper distally to a point 20-30µm from the shell.

The skeleton measures approximately 170µm in length (long axis) and 160µm in breadth (short axis).

Comments

The sparse spinulation of the central body and the possession of at least one, possibly two, spongy shells would seem to indicate that this form has close affinities with Spongoplegma. The lack of naturally broken specimens necessitated the breakage of specimens of this form with a dissecting needle to observe the internal structure. This method, in this case, due to the small size and fragility of the specimens, has largely proved unsatisfactory.

Material and Horizon

Four specimens from the lower Ludlow of the 245-265 foot interval of the Baillie-Hamilton Island 1976 section 2.

Genus Styptosphaera Haeckel,1881 emended

Diagnosis

Spumellaria without radial spines, the skeleton being composed of a spongy latticed sphere without a central cavity.

Emendation

Haeckel's use of the Family Liosphaerida in the original definition of this genus is redundant in the light of recent changes in the classification of the Radiolaria.

Type Species: Styptosphaera spumacea Haeckel,1887

Styptosphaera new species A

Plate XIII, Figures 1-4

Diagnosis

The skeleton consists of a solid three dimensional spherical lattice of up to 230μm in diameter. The pores in the lattice mesh are subrounded and vary in size from 5-20μm across. The lattice bars are 3-10μm thick.

Indications of a relict inner and outer shell seperated by an area of more open lattice are present in the now continuous lattice material.

Description

A three dimensional network of lattice bars constitutes a spherical skeleton. This sphere measures 150-230µm in diameter. The lattice pores are subrounded and vary in size from 5µm to 20µm across, being separated by bars 3-10µm thick. No straight lattice bars, pseudospines or true spines are seen in this skeleton. The lattice appears inhomogeneous with smaller pores 5-10µm across in the central 50µm and external 20µm of the skeleton. The intrvening 50µm consists of larger pores between the lattice bars (pores up to 20um across). The lattice bars are of uniform thickness throughout the skeleton (up to 5µm) See Figure 2 Plate XIII.

Comments

This genus is impossible to distinguish from Plegmosphaera and Spongoplegma externally, but the lack of a central cavity is distinctive. It appears that species of this genus are larger than those assigned to these other genera.

Material and Horizon

Fifteen specimens from the upper Wenlock of the 765 foot horizon of the Baillie-Hamilton Island 1976 section 1.

New Genus A

Diagnosis

More than 15 spines radiate from a central three dimensional lattice. These spines are of variable length, the largest (and the most robust) being of similar length to the diameter of the central spherical lattice. The spherical lattice encloses a central cavity.

Discussion

Variation in this genus is seen in the spongy nature of the shell lattice, the size of the pores in the shell lattice, the presence of discernible shells, the number and the size of the spines radiating from the central latticework. Of the three forms attributed to this genus, New Genus A new species A and New Genus A new species B appear to be the most similar, differing from each other most noticeably in the distinctiveness of the central shell cavity and in the number of spines radiating from the central lattice. Neither of these forms have discernible shells in their spongy spherical lattices. New Genus A new species C, despite the general spongy nature of the central spherical body of the skeleton, does possess in this lattice three distinct shells. It would appear to be a 'more advanced' form than New Genus A new species A and New Genus A new species B. It is grouped with these other two species here due to the spongy nature of the central lattice and to the common possession by these forms of spines which radiate from the inner part of the lattice and give rise to the lattice by lateral branching.

New Genus A new species A

Plate IV, Figures 6-8

Diagnosis

A three dimensional spherical lattice of diameter approximately 150um composed of variably sized pores (5-30μm across) makes up the centre of the skeleton. From this spherical lattice numerous spines (20-40) of variable length and robustness (5-10μm thick at the base) radiate. These spines may extend up to 200μm from the central sphere.

Description

A three dimensional lattice made up of lattice bars 5-10um thick around variably sized pores 5-30μm across comprises the centre of the skeleton. This spherical structure has a diameter of 150μm. The centre of the lattice sphere is hollow and the cavity has a diameter of 50μm.

20-40 spines of variable length (up to 200μm) and robustness radiate from the lattice. These spines thicken slightly at the spine/lattice contact and can be seen to contribute significantly to the lattice by branching proximally into it.

Comments

This species differs from New Genus A new species B by possessing a more closed lattice in the central sphere. The central cavity is distinctive in this form while in New Genus A new species B it is less apparent due to the open nature of the lattice and the smaller size of the central void (the spines in New Genus A new species B converge almost to the centre of the skeleton before completely branching to the lattice).

Material and Horizon

Nine specimens from the Middle to upper Wenlock of the 325-400 foot interval of the Cape Phillips 1976 section.

New Genus A new species B

Plate X, Figures 1-4

Diagnosis

The skeleton is made up of a three dimensional spherical lattice. The lattice consists of bar approximately 5μm thick separating pores up to ross. These is no distinct central cavity to this latt the mature stage at least 15 spines of slightly varying robustness and length radiate from the lattice.

Description

A single three dimensional open lattice up to 130μm in diameter with angular pores up to 20μm across separated by pore bars approximately 5μm thick surrounds the centre of the skeleton. At least 15 spines radiate from this lattice. These spines vary in length and robustness, extending to a length of 120μm beyond the lattice sphere before tapering to a point. The spines do not join at the centre of the structure, but terminate proximally by branching into the lattice.

Comments

This species has close simila ties to those specimens assigned to New Genus A new species A. The differences are in the smaller less obvious central cavity to the lattice in New Genus A new species B and in the more delicate open nature of the lattice when compared to New Genus A new species A. New genus A new species B also has external similarities to <u>Cubosphaera</u> new species A with the skeletons of both forms possessing three dimensional lattices from which radiate spines. <u>Cubosphaera</u> new species A differs in the number and positioning of the spines which radiate from the central sphere.

<u>Material and Horizon</u>

Four specimens from the middle Wenlock of the 470 foot horizon of the Bai lie-Hamilton Island 1976 section 1 and seven specimens from the 83.5m. horizon of the 1976 Cape Becher section.

New Genus A new species C

Plate X, Figures 5-8

Diagnosis

The skeleton consists of numerous spines radiating through a very open three dimensional lattice which is composed of three lattice shells. The innermost shell, of diameter approximately 60μm, results from the branching of the proximal ends of the spines. The pores in this innermost shell are smaller than those of the outer shells. Pore size increases outwards through the shells. Irregular bars that join the radiating spines in the outermost shell are distinctly stronger and longer than the bars that form this shell. The pores in this shell are up to 70μm across.

Description

The skeleton consists of an open lattice, three dimensional in nature, in which three separate shells are visible. These shells have diameters of 60, 220 and 360μm respectively. All the shells are composed of an open lattice with large pores separated by thin pore bars. The size of the pores and the thickness of the pore bars increases with the diameter of the shell.

In the innermost shell the pores are of almost uniform size, about 10um across. ~ is shell is separated from the second shell by a gap of 70μm in which no horizontal lattice bars occur.

The second shell is composed of variably sized pores between 10 and 40µm across. The pores have subangular outlines. This shell is not distinctly separate from the outer shell, but is connected with it by the presence of sparse lattice bars which span the 50µm gap between the shells.

The outer shell is made up of a very open lattice of widely varying pore sizes (20-70µm across). Areas of small pores fill the interstices between these large and more angular pores.

Numerous spines with slightly expanded bases at the shells penetrate the skeleton. These spines contribute by lateral branching to the lattice and terminate proximally by branching and forming part of the innermost shell. These spines are of uniform robustness and extend up to 70µm beyond the outer shell.

Comments

These specimens can be seen to possess, in common with the other species assigned to this genus, a three dimensional skeleton through which radiate spines. New Genus A new species C appears to have a more organised shell structure (with more distinct lattice shells) and may be the most structurally advanced of the three types of skeleton. Advancement in the skeleton is seen in the arrangement of the three shells which are two dimensional in nature from a three dimensional lattice. The openness of the skeletal lattice is similar to that seen in Astrosphaera new species A, but the lattice in this species consists of more distinct shells. The spines in New Genus A new species C do not show the same degtee of increase in robustness compared to the lattice bars that is seen in the two other species assigned to this genus.

Material and Horizon

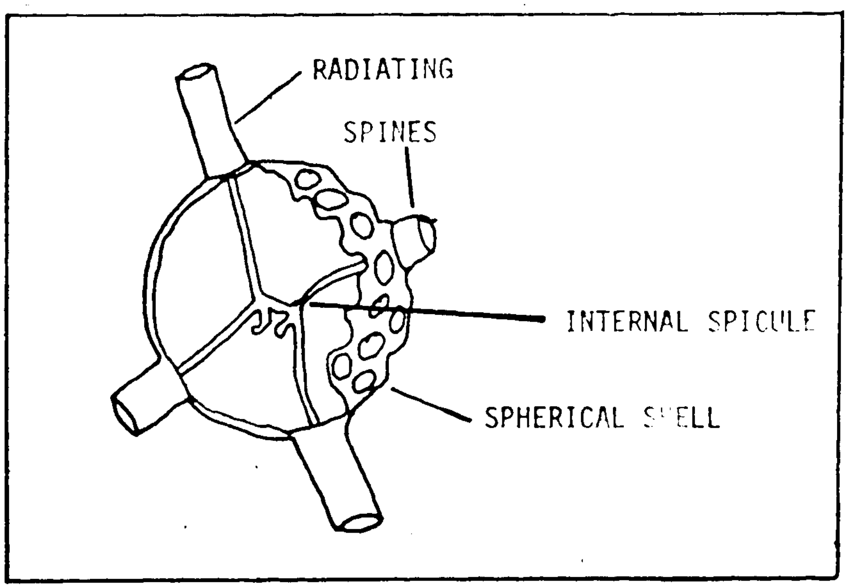
Eleven specimens from the 1976 Laura Lakes sample 9 (Middle to upper Wenlock) and one specimen from the Cape Phillips 1976 section at the 390-400 foot interval.

Superfamily Entactiniacea Riedel 1967

Family Entactiniidae

Diagnosis

Entactiniacea with unlatticed skeletons, the spicule rays not differentiated to define apical and basal hemispheres. More commonly skeletons latticed, essentially spherical, lacking pylome.



CHARACTERISTIC STRUCTURE OF THE ENTACTINIIDAE

TEXT FIGURE 3

Type Genus: Entactinia Foreman, 1963

Diagnosis

A single well developed latticed or spongy shell (sometimes with external spongy material) and an internal six rayed double spicule more delicate than the main spines.

Type Species: Entactinia herculea Foreman, 1963

Entactinia new species A

Plate XVIII, Figures 4-7

Diagnosis

Six major spines emerge from the single latticed shell of diameter approximately 200μm. Inside the shell the spines continue to a bar centred junction which does not lie at the centre of the shell. Numerous minor spines arise from the lattice bars of the shell.

Description

The skeleton consists of a six rayed spicular structure which lies within a single spherical shell. The rays of the spicular structure pierce the shell and radiate out from it as major spines. The bar centre of the spicular structure is not central to the spherical shell. The shell, of diameter approximately 200μm, is composed of rounded lattice bars 5um thick which enclose angular pores up to 50μm in length. The lattice bars bear minor spines less than 5μm thick on their external surface. These minor spines may be up to 15μm in length. The six major spines radiating from the shell are similar and are 120μm in length.

Comments

These specimens can be assigned to the Entactiniidae rather than the Palaeoscenidiidae on account of their possession of a latticed shell surrounding the six rayed spicule. The specimens occur in the same samples that specimens of New Genus F new species K are found. The similarity between the two skeletal forms is evident, the main difference apart from the size of the skeletons is the degree of the development of the shell. New Genus F new species K does not possess a latticed shell, but rather a lacework of spines which make up a shell-like structure around the six rayed spicule. Entactinia new species A does possess a latticed shell. It would appear that the two forms are closely related. The smaller size and the more open nature of the lattice of the specimen shown in Figure 8 Plate XVIII warrants its assignment to a seperate species.

Material and Horizon

One specimen from the 6 foot horizon and two specimens from the 27 foot horizon of the upper Llandovery of the 1979 Cape Phillips section.

Entactinia new species B

Plate XVIII, Figure 8

Diagnosis

Six major spines up to 70μm in length radiate from a single spherical shell of diameter 100μm. 30-40 minor spines less than 30um in length and 5μm thick at their base also radiate from the shell. The major and minor spines may be straight or may bend slightly along their length. The single spherical shell, of diameter 100μm, is made up of lattice bars which enclose angular pores up to 30μm across. Within the shell the six major spines continue and join in a bar centred spicular structure. The junction of the rays is not central to the single shell.

Description

The skeleton consists of a six rayed spicular structure which is internal to a single spherical shell of diameter 100μm. The spicular structure is bar centred and the rays extend out through the shell as the major spines. External to the shell these spines may attain a length of approximately 70μm, tapering to a point from a basal thickness of approximately 10μm. The bar centre of the spicular structure is not central to the shell, but is conspicuously nearer the pole from which emerge four more closely spaced of the six major spines. Within the shell the rays of the spicule are 5-10μm thick.

The shell is composed of rounded lattice bars approximately 5 μm thick which enclose angular pores up to 30μm across. Minor spines arise from the junctions of the pore bars, these spines being less than 5μm thick and up to 30μm in length. Some of these spines branch near their distal ends before tapering to a point. At the base of the major spines, conspicuous spine 'roots' branch into the shell lattice.

Comments

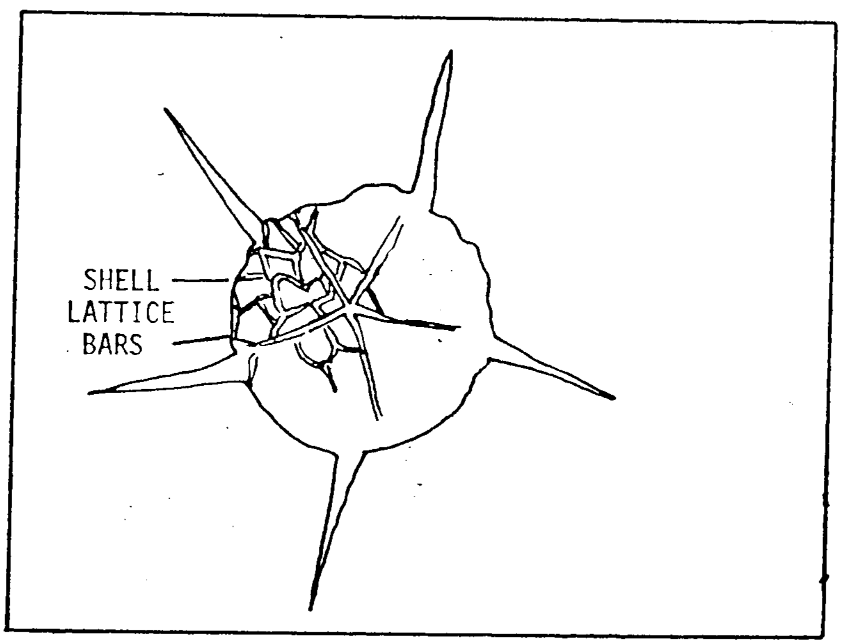
This species is distinct morphologically from Entactinia new species A due to its smaller size, the more openness of the shell lattice and the more delicate nature of the major and minor spines. It occurs in significantly younger strata than does E. new species A.

Material and Horizon

One specimen from the middle Wenlock of the Cape Phillips 1976 section at the 325-330 foot interval.

Informal Grouping ROTASPHAERIDS Holdsworth, 1978

An informal grouping of Paleozoic Spumellaria with a single spherical latticed shell with angular meshes lacking the internal spicular system of the Entactiniacea and displaying a point or points upon the shell from which radiate five or more straight lattice bars.



CHARACTERISTIC STRUCTURE OF THE POTASPHAERIDS SHOWING THE RADIATING LATTICE BARS OF THE SHELL.

TEXT FIGURE 4

New Genus B

Diagnosis

Rotasphaerids bear [illegible] all of which have their bases at a point in the [illegible] adiate five or more lattice bars.

New Genus B new species A

Plate XIX, Figures 1-8

Plate XX, Figures 1-4

Diagnosis

At least twelve distally tapering spines radiate from the spherical lattice and attain lengths up to 165μm. The bases of these spines are 5-10μm thick. Varying numbers of lesser spines radiate from the skeleton. These minor spines have a maximum length of 50μm.

Description

The skeleton consists of a single spherical lattice shell with variably sized polygonal lattice pores up to 20μm across. The lattice bars are straight and robust, approximately 5μm thick. Four to six straight lattice bars radiate from the base of the main spines, these bars tending to be slightly more robust than those bars which form the connections between them.

Two sizes of spines are present in fully developed skeletons. All the spines are straight, unbranching, and taper distally. The spine bases do not penetrate the single lattice shell. No fluting is present on the sides of the spines. The major spines may reach a length of 150µm and are approximately 20µm thick at their junction with the shell lattice. The minor spines range up to 100µm in length and are delicate structures less than 5µm thick at their bases. The main spines number at least twelve while the number and development of the minor spines [illegible] greatly between specimens.

Shell diameter is between 100 and 130µm.

Comments

There appears to be a correlation between the length of the main spines and the development of the minor spines. Increasing length of the main spines accompanies an increase in the number and the length of the secondary spines. This trend would indicate that the differences between the specimens can be attributed to growth.

This species differs from the other rotasphaerid species described here by its larger size and longer finer major and minor spines.

Material and Horizon

Numerous specimens from samples ranging from upper Llandovery to lower Wenlock age. Specimens were obtained from the 6-353 foot interval of the Cape Phillips 1979 section, the Cape Phillips 1976 section at the 135 foot horizon, the Baillie-Hamilton Island 1976 section 1 at the 33-36 foot interval and from the 1976 Laura Lakes sample 9.

New Genus B new species B

Plate XX, Figure 5

Diagnosis

Approximately twelve similar spines radiate from the spherical shell. The bases of these spines join the lattice of the shell at a point from which radiate six lattice bars. These radiating bars are more robust than other bars in the lattice. The spines are delicate, being 50μm in length and having a basal thickness of approximately 5μm. No minor spines radiate from the shell.

Description

The skeleton consists of a single spherical lattice shell with no internal structure. Lattice bars in the shell are straight and of varying thickness: the more robust lattice bars are those which radiate in a set of six from the base of the spines. The interconnecting bars tend to be thinner. Lattice pores are polygonal and of [illegible] sizes. Those pores closest to the bases of the spines [illegible] the largest.

One set of unbranching, distally tape[illegible] spines radiates from the spherical shell. These spines are approximately twelve in number, and are of similar length (50μm) and robustness (basal width approximately 5μm).

The diameter of the shell in the specimen available is 100μm.

<u>Comments</u>

The possibility that this form represents a juvenile stage in the development of a form with more than one order of spines in the adult stage cannot be ruled out. The size of the skeleton is considerably smaller than that of New Genus B new species A and the lattice bars are comparatively more delicate than those of the other rotasphaerids seen in this study.

<u>Material and Horizon</u>

Three specimens from the 325-350 foot interval (middle Wenlock) and one specimen from the 600 foot interval (middle to Upper Wenlock [illegible] Baillie-Hamilton 1976 section 1.

New Genus B new species C

Plate XXI, Figures 1-5

Diagnosis

Approximately ten spines 60um in length and at their bases up to 10 µm thick radiate from the spherical skeleton. Numerous minor spines 10 µm in length arise from the lattice bars of the skeleton. The lattice bars of the shell vary in thickness, the most robust ones radiating in sixes from the bases of the largest spines. The interstitial bars are shorter and thinner, usually extending half the distance between the radiating bars where they join other interstitial bars of varying attitude in the shell lattice.

Description

The skeleton is apparently a single latticed sphere of diameter 100µm. Six straight lattice bars are visible radiating from the base of each of the major spines, about ten in number, which extend from the sphere. Thinner, less robust lattice bars make up the rest of the lattice. The basic lattice pattern is that of minor lattice bars coming off the thick radiating bars at an even spacing of 8um and at angles of 90-120 degrees. These minor lattice bars extend half the distance between the main radiating bars where they join other interstitial bars which zigzag in a line subparallel to the main bars.

Two orders of spines radiate from the sphere.

Approximately ten major spines up to 60µm in length, tapering distally to a point from a basal thickness of 5-10µm arise from the lattice at the convergent points of six major lattice bars. The spines are cone shaped and do not exhibit fluting or sculpturing in their sides. Numerous minor spines up to 10µm in length and less than 3µm thick arise from the external surfaces of the lattice bars.

Pores in the lattice are angular in outline and measure up to 10µm across.

Comments

An apparent ontogenetic development sequence is shown on plate XXI figures 1 to 4. Figure 1 is interpreted as the least developed stage of the species in which no minor spines are developed. Figures 2 to 4 show the increasing development of these spines. New Genus B new species D resembles this form but differs in its possession of straight minor lattice bars instead of the zigzag pattern seen here.

Material and Horizon

Fifteen specimens from the Middle to upper Wenlock of the 325-400 foot interval of the 1976 Cape Phillips section.

New Genus B aff. B new species C

Plate XX, Figures 6-8

Description

The skeleton consists of a single spherical lattice 80-120µm in diameter. Approximately ten major spines, similar to each other in length, 50µm, and robustness, basal width 10-15µm radiate from this sphere. The lattice of the sphere is coarse, with lattice bars 5-10µm thick enclosing pores 10µm across. Minor spines arise from this lattice, these spines having an average length of 10µm and a thickness of 3-5µm.

Comments

The three specimens assigned to this type are interpreted as different ontogenetic stages of the same species. The sequence from youngest to oldest is from the specimen shown in plate XX figure 8 through figure 7 to the specimen in figure 6. Ontogeny is reflected by the development of the minor spines on the shell lattice in length and number till the configuration seen in figure 6. is attained. The fully developed specimen in figure 6 differs from New Genus A new species C in the robustness of the minor spines, and in the development of a wall between adjacent pores by the connection of the bases of the spines. In the less developed stages the lattice bars of the shell in this form are more robust than those in New Genus B new species C. Otherwise the skeletons of the two forms are similar.

Material and Horizon

Three specimens from the middle Wenlock of the 325-355 foot interval of the Cape Phillips 1976 section and three from the 1976 Laura Lakes sample number 9.

New Genus B new species D

Plate XXI, Figures 6-8

Diagnosis

Approximately six major spines up to 60µm in length and with a basal width of 20-25µm radiate from a spherical shell, the lattice of which is hidden by numerous minor spines less than 5µm thick and 15-20µm in length.

Description

The skeleton consists of a spherical shell of diameter 100µm. Six major spines, arranged nearly in three mutually perpendicular axes, radiate from the single shell. These spines are up to 60µm in length and have a basal width of 20-25µm. The spines are smooth and taper strongly distally to a point.

Numerous minor spines also radiate from the shell. These are 15-20 µm in length and are less than 5µm thick.

Comments

These specimens resemble New Genus B new species C but differ in the thicker nature of the major spines. The two species are interpreted as having close phylogenetic connections.

Material and Horizon

Twenty specimens from the upper Llandovery to lower

Wenlock of the Cape Phillips 1979 section in the 6-308 foot interval.

Suborder Albaillellaria Deflandre,1953

(emended Holdsworth,1969)

Family Ceratoikiscidae Holdsworth,1969.

Diagnosis Albaillellaria in which the skeletal frame is closed and typically consists of three rods, A rod, B rod and Intersector; the A rod commonly bearing paired spines (caveal ribs) developed in a plane normal to that of the frame. Ideal frame with both ends of all principle rods produced as extra-triangular extensions, but some extensions may be suppressed.

Type Genus:Ceratoikiscum Deflandre,1953.

Type Species:Ceratoikiscum avimexpectans Deflandre,1953

Skeletal nomenclature

The skeletal frame consists of three triangularly arranged rods. Foreman,1963 termed these rods 'A rod', 'B rod' and 'Intersector'. Ideally, the A rod and B rod are more curved and the Intersector is perfectly straight. The A rod is easily recognised in the majority of species by the presence of attached paired rods, varying in number and arrangement from species to species,termed 'caveal ribs'. When numerous, the caveal ribs constitute a cage or 'cavea'. All three rods ideally have extra-triangular extensions. Both the triangular and extratriangular portions of the rods are often linked by an irregular lamella of spongy disc, for which the term 'petagium' is used.

Holdsworth,1969 elaborated on this nomenclature by defining the A rod as dorsal and the junction of the B rod and Intersector as being ventral. The junction between the A rod and the B rod is taken as defining the anterior of the skeleton. Reading clockwise from the A-B junction of the ideal skeleton we have:

AA A rod (extratriangular) anterior portion.

BT B rod triangle forming portion.

IV Intersector (extratriangular) ventral portion.

BV B rod (extratriangular) ventral portion.

IT Intersector, triangle forming portion.

AP A rod (extratriangular) posterior portion.

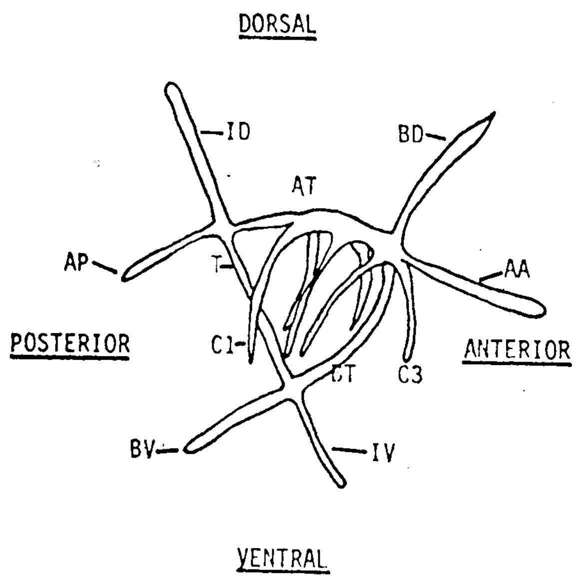
ID Intersector (extratriangular) dorsal portion.

AT A rod, triangle forming portion.

BD B rod (extratriangular), dorsal portion.

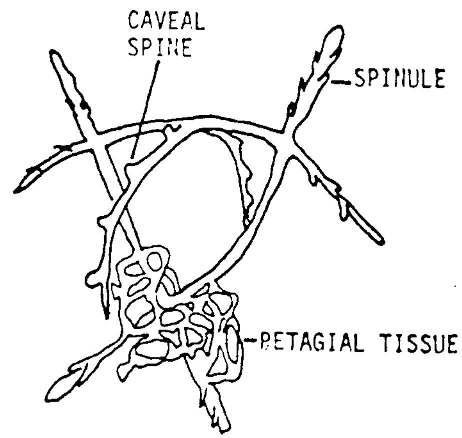
The pairs of caveal ribs are numbered in any one species from the posterior ie C1, C2, C3, etc. In the case of the Ceratoikiscidae, where the ribs occur anterior to the triangle, the tip of AA is taken as the most anterior part so the ribs are counted down BT and along AA.

The term 'petagial tissue', used by Holdsworth,1969 to denote spongy layers of fibres developed between extratriangular rods and often enveloping rod junctions is adopted here. 'Caveal spines' denote the presence of ordered spines on the dorsal surface of the caveal ribs in some species. These are interpreted as a rudimentary stage in the development of the caveal vanes seen in Devonian and Carboniferous forms.



ANATOMICAL NOMENCLATURE OF THE CERATOIKISCID FRAME

(a)



NOMENCLATURE OF CERATOIKISCID STRUCTURAL DETAILS

(b)

(after HOLDSWORTH 1969)

TEXT FIGURE 5

Genus Ceratoikiscum Deflandre, 1953

Diagnosis

Ceratoikiscidae with A rod, B rod and Intersector so arranged that the triangle is approximately equilateral. Cavea composed of pairs of ribs not joined laterally to form a lamellar wall; sometimes represented by only one or a few pairs of ribs.

Comments

This genus as described by Deflandre, 1953 should possibly be elevated to sub family rank to allow for the recognition of species groups within the present genus at the generic rank. At the moment, there is a wide variety of forms gathered under a single genus. (Compare some of the Devonian and Carboniferous forms with the Silurian forms in the present study and the Ordovician forms described by Nazarov, 1975).

The Lower Paleozoic forms are much simpler in construction than some of the later species, lacking petagial vanes in the true sense (though petagial material is present arising from the BI junction of some specimens) and in invariably possessing all six extratriangular extensions.

It is felt that Ceratoikiscum as it is currently diagnosed is too unwieldy, and contains too much variation for a grouping of such low taxonomic rank.

In the present study of upper Wenlockian to lower Ludlovian ceratoikiscids two groups of species are discernible. The first group, consisting of one species (Ceratoikiscum new species A) is characterised by the presence of caveal ribs and elongate spinules posterior and anterior to the AT/BT junction. The second group, composed of three species, Ceratoikiscum new species B, C and D is characterised by the absence of ribs or elongate spinules anterior to the triangular portion of the skeleton. The division of this group into three species is based on characters such as the possession in Ceratoikiscum new species B of a giant rib at the anterior of the triangle, in Ceratoikiscum new species C of a steady increase in the rib size along AT and in Ceratoikiscum new species of long, often curved extratriangular extensions.

The division of this latter group into three species may, in the light of detailed examination of many specimens, be seen to be unnecessary, the differences being phenotypic rather than genotypic.

The species described here bear close resemblance to the Caradocian form Ceratoikiscum acatangulatum Nazarov, 1975 and the Frasnian Ceratoikiscum rectum Nazarov, 1973 in their lack of a well developed petagium.

Ceratoikiscids do not occur throughout the sections studied, being conspicuously absent from the samples of upper Llandovery to middle Wenlock age. They appear suddenly with fair abundance in the Middle to upper Wenlock samples.

Ceratoikiscum new species A

Plate XXII, Figures 1-8

Plate XXIII, Figures 1-4

Diagnosis

Caveal ribs occur on the anterior extratriangular portions of the A and B rods. The caveal ribs and extratriangular extensions are unusually spiny.

Description

All six extratriangular extensions are developed. The anterior portions of the A and B rods are larger than their posterior portions and the Intersector extratriangular portions, which tend to be equal in length.

AA, AP, BD and BV are straight. AT and BT are of equal curvature near the apex of the triangle (AB junction). IV, ID and IT are all slightly curved , the Intersector rod having a pronounced apical bow. All extratriangular portions are longer than the triangular portions. Spinules are present on all parts of the skeleton, but are best developed on the AA portion. Anterior to the last rib, AA may bear paired vestigial caveal ribs.(see figure 6 plate XXIII)

Two to five pairs of caveal ribs (bases not always positioned oppositely on the rods) occur. These ribs arise on the interior-lateral faces of the AA and BD rods and on the AB junction at angles of 20 to 70 degrees to the plane of the triangle, curving backwards to provide an 'umbrella' for the intra-triangular area.

In some specimens the dorsal surface of the ribs is ornamented with caveal spines.

Evidence for petagial tissue at the AI, BI junctions may be present in the form of clustered spinules on the IT rod and the portion of the ID or IV rod nearest these junctions.

Dimensions

AT	70µm	AA	180µm	BV	140µm
BT	70µm	BD	165µm	ID	120µm
IT	60µm	AP	140µm	IV	130µm

Comments

In the specimens with three caveal ribs present, the A rod is defined as that rod which usually possesses elongated spinules anterior to the main caveal rib on the extratriangular extension. The AA portion anterior to this also possesses a greater number of spinules than does any other extratriangular extension.

Material and Horizons

6 specimens from samples of Wenlockian age at the 325-375 foot interval of the 1976 Cape Phillips section.

Ceratoikiscum new species B

Plate XXIV, Figures 1-8

Plate XXV, Figs 1-4

Diagnosis

This species is distinguished from the other climbing rib species by the presence of a giant rib in a near apical anterior triangular position on AT.

Description

All six extratriangular extensions are developed, the anterior portions (AA and BD) tending to be longer than the lateral projections (ID and IV) which may be the same length or slightly longer than the posterior extensions (AP and BV). All extratriangular extensions are straight. AT and BT are slightly bowed while the Intersector bar is straight.

Five to eight pairs of caveal ribs are borne on the T portions of the A and B rods. Of these ribs two to six occur on AT, one pair on the anterior apex of the triangle and two to to three pairs on the anterior end of BT. Ribs arise as far as one quarter way anterior along the AT rod from the AI junction. These ribs are evenly spaced. In an apical (or near apical) position a giant rib occurs, longer and more robust than the others.

Petagial tissue in the form of a loose ball network of tissue may be present on the AT and BT junctions with the Intersector bar. Often its presence is hinted at in the samples by the occurrence of increased spinulation in these areas (see figs 3,5,6 plate XXIV).

The caveal ribs arise at angles of 60-80 degrees to the plane of the triangle and curve posteroventrally to provide a cover umbr[illegible] the whole of the intratriangular area. The smaller [illegible] ribs excluding the giant rib) curve to an angle of [illegible] degrees to the plane of the triangle. The giant rib [illegible]tains a greater angle and tends to be straight, not curved (see figure 1 plate XXIV).

Dimensions

AA	130μm	IV	110μm	IT	60μm
BD	120μm	ID	110μm	AT	60μm
BV	100μm	AP	100μm	BT	60μm

Comments

Sparse spinules may be present on the extratriangular portions of the rods; and the caveal ribs may bear caveal spines on their external surfaces (see figure 3 plate XXIV). There appears to be no great size differences among these specimens.

The specimen shown in figures 7,8 plate XXIV seems to be allied to this species as it possesses an extremely long near-apical rib, but this rib does not show the distinctly greater diameter of the giant rib seen in the other specimens.

Material and Horizon

10 specimens from the Baillie-Hamilton Island 1976 section 1 at 765 feet, the Cape Phillips 1976 section at 325-330 feet , Laura Lakes 1976 sample 10 and the Baillie-Hamilton Island section 2 at 215 feet (upper Wenlock to lower Ludlow).

<u>Ceratoikiscum</u> new species C

Plate XXVI, Figures 1-8

Plate XXVII, Figures 1-4

Diagnosis

The caveal ribs increase in size evenly anteriorly along AT and decrease abruptly in size posteriorly along BT. The anterior extratriangular extensions are smooth.

Description

All six extratriangular extensions are developed and are of approximately equal length. The Intersector rod has a slight bow over its entire length while the A and B rods have flexures only in their triangular portions. The triangle formed by the three rods is equilateral. Five to eight pairs of caveal ribs occur. AT bears most of these ribs along the greater part of its length, the ribs on this rod increasing in length and robustness towards the anterior. The largest pair of ribs is borne on the BT side of the AB junction and smaller ribs occur posterior to this on this bar. These BT ribs often have a common fused base and slant (in posterior horizontal view of the skeleton) towards the ventral side of the frame; the AT ribs slant towards the dorsal side. Looking from the posterior into the cup formed by the ribs, the rib cage can be seen to be assymmetrical on an axis running from the AB junction to the centre of the IT bar (see figure 4 plate XXV). The number of ribs on AT is on certain specimens (see figure 7 Plate XXVI) difficult to count due to the most posterior ribs being vestigial. Posterior to C1 on certain specimens there may be spinules which on an ontogenetically older specimen would have developed into recognisable ribs.

Petagial tissue in the form of loose networks of fine silica strands is present on the AT/Intersector junction (or may be represented by an increase in the number of spinules in this area). The ribs bear caveal spines which in figure 2 plate XXVII can be seen to have developed a loose network analagous to the petagial vane of Holdsworth.

Ribs arise at angles of 80 degrees to the plane of the triangle but curve within 10 um to an angle of 20-30 degrees to this plane. They extend as far posteriorwards as the Intersector bar, the longest ribs (C4-C6) extending behind this, providing complete coverage of the intratriangular area.

Dimensions

AA	110µm	ID	90µm	IT	75µm
BD	110µm	IV	90µm	AT	65µm
AP	80µm	BV	90µm	BT	70µm

Comments

This species is distinguished from Ceratoikiscum new species B by the absence of a giant rib in the region of the anterior apex of the triangle. These were by far the most common type of ceratoikiscid encountered in this study. There is a possibility that the specimens figured in plate XXVI figures 7,8, may be segregated from the other specimens assigned to this species on account of the obvious herringbone arrangement of the caveal ribs along AT, but as only two of this type were found and the basic pattern agrees with the species description given above, they have not been partitioned off. Further examination of the species with well preserved specimens may permit subdivision. The number of caveal ribs present may be an important factor in such a subdivision, but ontogenetic changes in the skeleton would have to be fully understood before speciation is based on a factor such as this.

Materials and Horizon

20 specimens from the upper Wenlock of the 315-330 foot interval of the 1976 Cape Phillips section.

Ceratoikiscum new species D

Plate XXVIII, Figures 1 5

Plate XXIX, Figures 1-4

Diagnosis

The extratriangular extensions are equal or greater than (up to a factor of two) the triangular rods of the skeleton. These extensions are often noticeably flexed.

Description

Frame with all six extratriangular extensions well developed. The ral triangle is equilateral. The extratriangular extensions are longer than the triangular portions by a factor of up to two. These extensions are often curved.

Six to seven caveal ribs are present; of these C1-4,5 occur on AT and two pairs on BT. The ribs increase in size anteriorly along AT, the largest ribs being in the vicinity of the AB junction. On BT the ribs decrease in size away from the AB junction.

Petagial tissue may be present as extensions of the caveal spines and of spinules along the Intersector bar. (see figures 7,8 plate XXVIII).

Dimensions

AA	110µm	D	100µm	AT	50µm
BD	110µm	IV	70µm	BT	50µm
AP	100µm	IT	50µm	BV	µm

Material and Horizons

8 specimens from the lower Ludlow of the 215-265 foot interval of the 1976 Baillie-Hamilton Island section 2.

Superfamily Entactiniacea Holdsworth, 1978

Family Palaeoscenidiidae Riedel, 1967 emended Holdsworth, 1978

Diagnosis

Paleozoic spicular, siliceous skeletons comprising six to eight divergent rays, arising most commonly from the ends of a very short median bar. Three to four rays stronger and/or more elaborately ornamented define a basal hemisphere; Two to four weaker, usually unornamented rays define an apical hemisphere.

Type genus: Palaeoscenidium Deflandre, 1953.

Comments

In this study, a variety of spicular forms with less than six and more than eight diverging rays were found. Hence it is recommended that the above family diagnosis be emended to read thus:

Paleozoic spicular, siliceous skeletons comprising five to ten divergent rays, arising most commonly from the ends of a short median bar. Commonly three to eight rays stronger and/or more elaborately ornamented define a basal hemisphere; one to four weaker, usually unornamented rays define an apical hemisphere.

The type genus was poorly described in the original publication. Deflandre (1953, page 408) described

Palaeoscenidium "en forme de quatre arêtes prolongées par de solides cornes épineuses." This generic description has proven inadequate in the light of the present study.

Five new genera of palaeoscenidiid radiolarians are described in this work. The most important characteristics used to separate these being the number of diverging rays in the structure and the pattern of branching of these rays. Skeletons with five, six, eight and ten rays were seen, those with six rays showing the greatest variety.

Features such as ray attitude, branching patterns, overall robustness and size were used in species separation. These were measured largely qualitatively due to the extreme difficulty of specially orienting the specimens on the scanning electron microscope stubs so as to obtain a quantitative measurement.

Palaeoscenidium Deflandre, 1953 emended

Diagnosis

Bar centred to point centred skeleton; two unequal pairs of rays coming off each end of the central bar/point. The basal rays are up to ten times the length of the apical rays.

Emendation

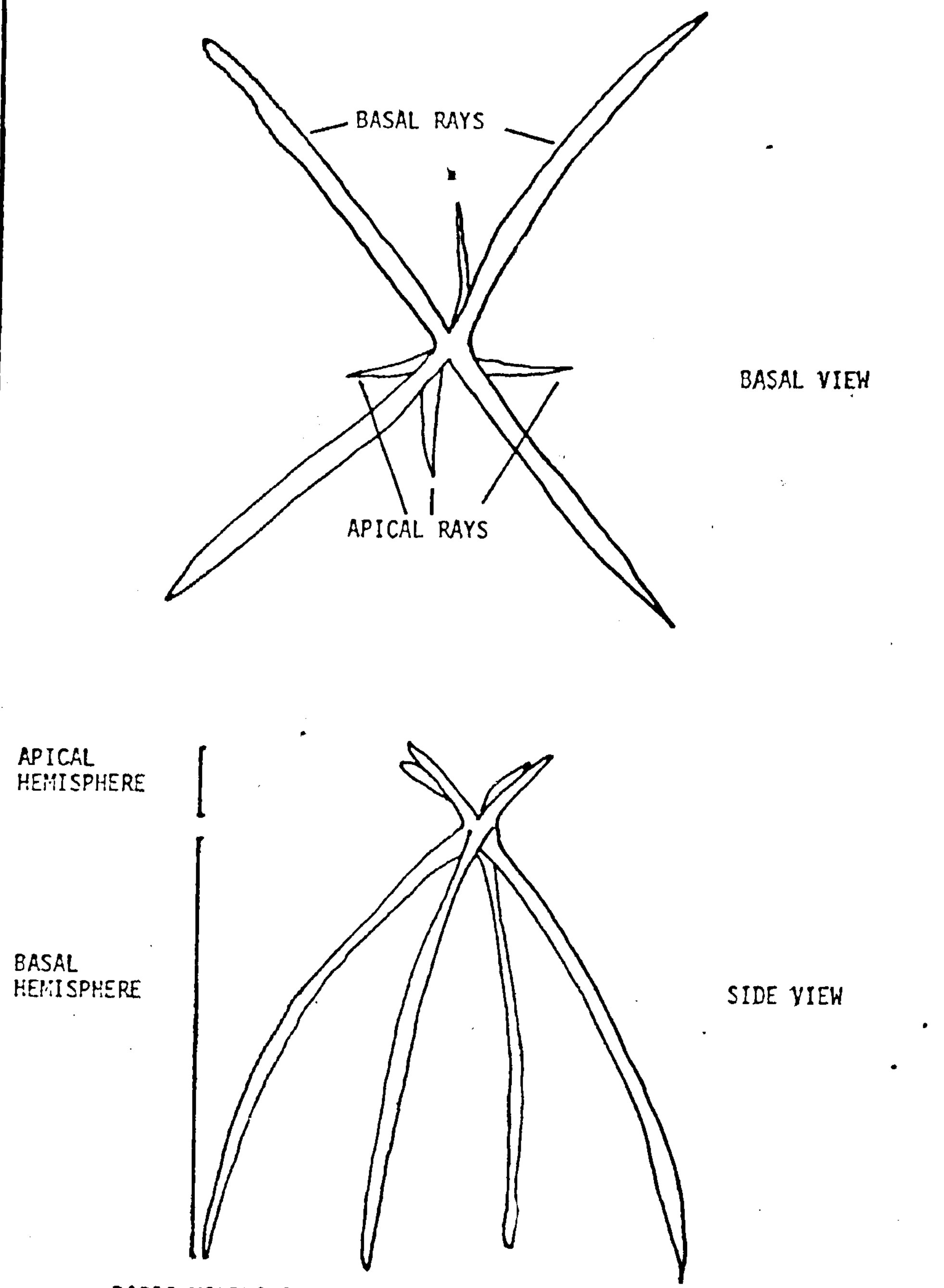
See discussion on page 148

Type Species: *Palaeoscenidium cladophorum* Deflandre, 1953.

Comments

The generic diagnosis of Deflandre, 1953 appears to be unsatisfactory in the light of some of the specimens seen in the present study. In this work distinction is made between those skeletons which possess four apical rays as well as four basal rays from those which possess only two apical rays and four basal rays. Deflandre's diagnosis cites the number of basal rays (quatre arêtes), but does not cite the number of apical rays (prolongées par de solides cornes épineuses). Hence it was that the form *Palaeoscenidium bicorne* (Deflandre, 1960), described by Holdsworth, 1973 was assignable to this genus.

Under the classification scheme adopted in this thesis, *Palaeoscenidium bicorne* would be assigned to a separate genus (new genus F) from *Palaeoscenidium cladophorum* due to its possession of two apical rays in the place of the four seen in Palaeoscenidium cladophorum.



BASIC MORPHOLOGY OF THE GENUS PALAEOSCENIDIUM

TEXT FIGURE 6

Palaeoscenidium new species A

Plate XXX, Figures 1-4

Diagnosis

A skeletal net occurs at the apex of the basal hemisphere composed of parallel "flame-like" branches coming off the basal rays. This net extends approximately 50um from the apex of the basal hemisphere. The basal rays are approximately four times the length of the apical rays and curve inward one third to one half of the distance along their length from the apex, thus restricting the flare of the basal hemisphere.

Description

The skeleton is bar centred, with the bar extremely short. Four apical rays extend upward and outward; four basal rays rays are pendant. Both sets of rays are curved. The basal rays arise at an angle of approximately 70 degrees and curve distinctly one third of the way down their length. The apical rays are uniformily arcuate and taper towards their distal ends.

Immediataly basal to the bar centred apex, each basal ray gives rise to two parallel pseudomonopodially branching blades, one blade in each adjoining inter-ray space. These blades, up to one quarter of the length of the basal rays, create a walled off area at the apex of the basal hemisphere of the skeleton. There is no fusion of the blade branches in this skeleton net.

Dimensions

Length of apical rays 50μm

Length of basal rays 200μm

Maximum width of basal hemisphere 160μm.

Comments

Variation can be seen amongst the specimens figured in the development of the branches coming off the apical part of the basal rays. These variations are interpreted as being ontogenetic.

The "flame-like" appearance of these branches distinguishes this species from other Palaeoscenidium species described in this work. The apical rays are relatively larger, when compared with the basal rays, in this species than in *P.* new species B.

Material and Horizon

Numerous specimens from the middle Wenlock of the Cape Phillips 1976 section at the 315-375 foot interval and three specimens from the 480 and 600 foot horizon of the 1976 Baillie-Hamilton Island section 1.

Palaeoscenidium new species B

Plate XXX, Figures 5-8

Diagnosis

The basal rays in this species are straight, producing a widely flaring basal hemisphere. Besides bearing branches in their proximal one-third to one-half, the basal rays are also ornamented with microspinules along their entire length. The apical rays are sub-equal in length. The branches coming off the basal rays form a tent-like structure at the apex of the basal hemisphere which extends up to 80μm posteriorwards.

Description

The basal rays are up to five times the length of the apical rays. The apical rays are straight while the basal rays are gently arcuate. The basal rays arise from the apex at an angle of approximately 45 degrees from the horizontal and only deviate slightly from this along their length, thus creating a very wide base to the basal hemisphere. A skeletal net is present between the basal rays near the apex, the structure of which is unclear, but which appears to be extensions of spinules which occur on the rays. This skeletal tissue extends half-way down the length of the rays. Microspinules ornament the basal rays, but are not apparent on the apical rays.

Dimensions

Length of apical rays	.....	35µm
Length of basal rays	..	200µm
Maximum width of basal hemisphere		250µm

Comments

This species differs from species A and D of this genus in the angle of flaring of the basal rays from the bar centre. The apical rays of this species are all of the same magnitude whereas in species C one of the apical rays is longer than than the three others. The length ratio between the apical and basal rays is much less in this species than in species A. Of the tented types, species B is the only species to bear microspinules on the basal rays.

Material and Horizon

10 specimens from the Middle to upper Wenlock of the Cape Phillips 1976 section at the 315-375 foot interval.

Palaeoscenidium new species C

Plate XXXI, Figures 1-3

Diagnosis

The basal rays of this species are ornamented with simple basally directed spines. These spines do not occur in the proximal portions of the rays, the first 30-40μm of them being smooth. The next 60-100μm are spine bearing. The spines from each ray do not interfere with those from adjacent rays so no tent-like structure is present. One of the four apical rays is distinctly longer (by a factor of three) than the others.

Description

The apical rays are unequal, one ray being three times the length of the other three. The longest apical ray is broader than the others and is curved while the shorter rays are straight.

The basal rays are approximately twice the length of the longest apical ray. The skeleton is bar centred, the angles between the opposite pairs of basal rays obtuse while those between rays of the same pair are acute. The basal rays are gently arcuate arising from the bar centre at approximately 60 degrees to the horizontal.

One half to one third of the basal rays is occupied by spines concentrated on the lateral edges of the rays forming a loose skeletal framework semi-enclosing the apical end of the basal hemisphere.

Comments

This skeleton cannot be viewed as an ontogenetic stage of the the tented form described (P. new species B) as there is a different placing of the spines on the basal rays and distinct variation in the size of the apical rays). The smooth proximal portion of the basal rays is distinctive.

Dimensions

Length of large apical ray	.....	100µm
Length of short apical rays	.....	30µm
Length of basal rays	.....	220µm
Maximum width of basal hemisphere	....	250µm

Material and Horizon

Two specimens from the middle Wenlock of the Baillie-Hamilton Island 1976 section 1 and the Cape Phillips 1976 section at the 600 foot and 315-325 foot intervals respectively. Sparse specimens were observed in the middle Wenlock 1976 Laura Lakes sample 9.

<u>Palaeoscenidium</u> new species D

Plate XXXI, Figures 5-8

<u>Diagnosis</u>

The apical and basal rays of the skeleton bear ornamentation in the form of microspinules. Apart from this, no other ornamentation occurs on the rays. The four apical rays are of similar size and are approximately one seventh of the length of the basal rays.

<u>Description</u>

Four apical rays reclined; four basal rays pendant. The apical rays are approximately one-seventh of the length of the basal rays. All the rays are slightly curved. The apical rays are strongly flexed one half way ng their length so that their distal tips are basally directed. The basal rays appear slightly flexed so that their distal tips point externally from the basal inter-ray space. Microspinule ornamentation occurs throughout the skeleton.

<u>Dimensions</u>

Length of apical rays	.....	60µm
Length of basal rays	.....	400µm

<u>Comments</u>

The microspinule ornamentation seen on the rays of this species is also seen on the rays of Palaeoscenidium new species B, however the skeleton of that species also bears a tent-like structure in the proximal portion of the basal hemisphere. This feature which does not occur in the species under review is considered evidence for differentiating them into two separate species. Other differences include the style of the apical rays which in new species B are short, whereas in new species D they are longer and more slender. The microspinulation also sets this typ from aff P. new species C which lacks ray ornamentat

Material and Horizons

Four specimens from the middle Wenlock of the Cape Phillips 1976 section at the 315-375 foot interval and fifteen from the 480-765 foot interval of the Baillie-Hamilton Island 1976 section 1.

Palaeoscenidium aff. *P.* new species D

Plate XXXI, Figure 4

Description

Four apical rays sub-horizontal; four basal rays pendant. One of the apical rays appears to be slightly longer than the other three. The basal rays are two to three times the length of the short apical rays. All rays are smooth. The apical rays are slightly curved while the basal rays are straight.

Comments

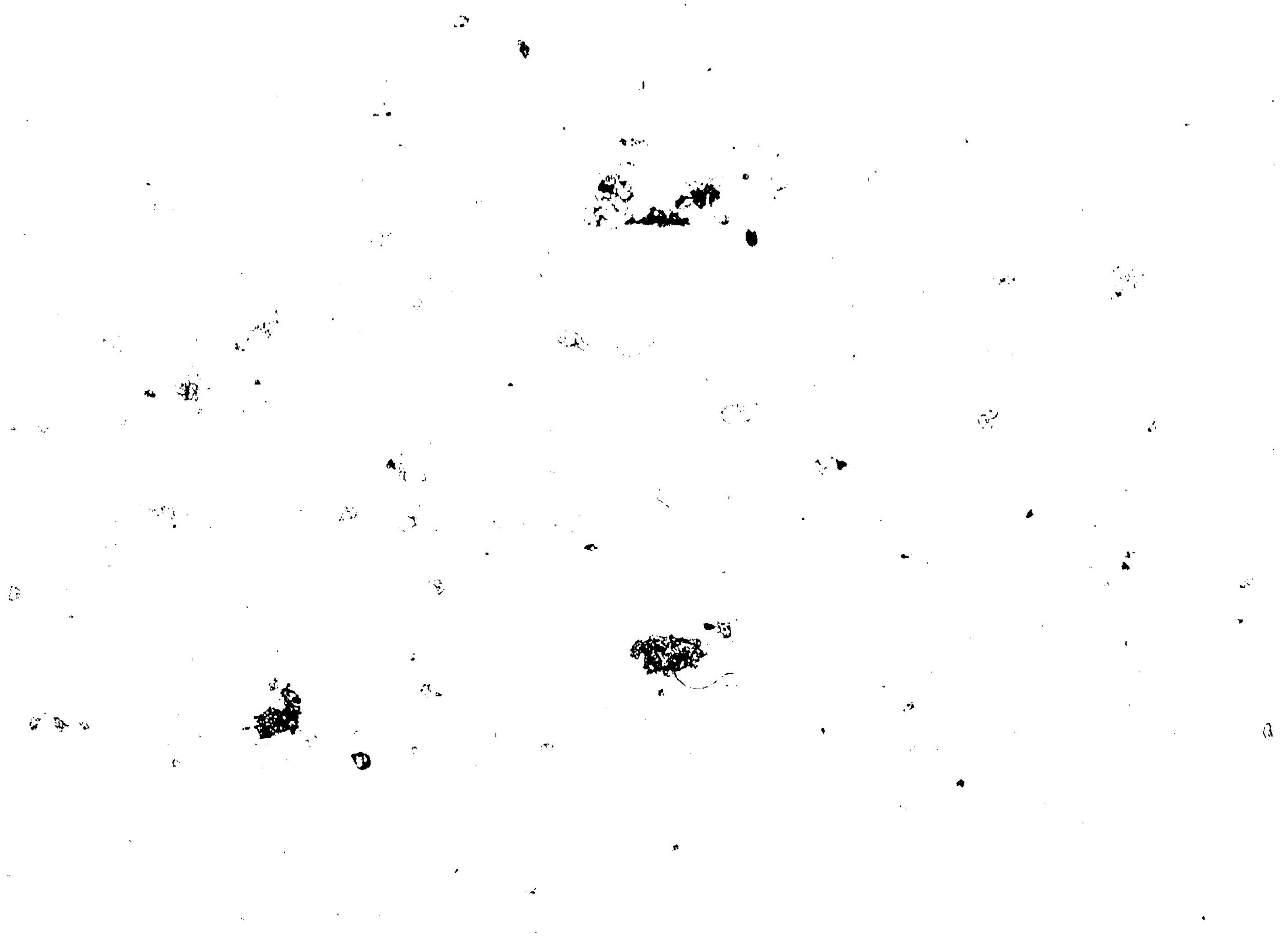
The lack of ornamentation on the rays distinguishes this form from the otherwise similar species D of this genus. It is possible that this form is a younger ontogenetic stage of species D. Otherwise the apparent presence of one apical ray longer than the three others suggests affinity with *P.* new species C.

Dimensions

Length of long apical ray	......	90µm
Length of short apical rays	......	[illegible]0µm
Length of basal rays	......	170µm

Material and Horizon

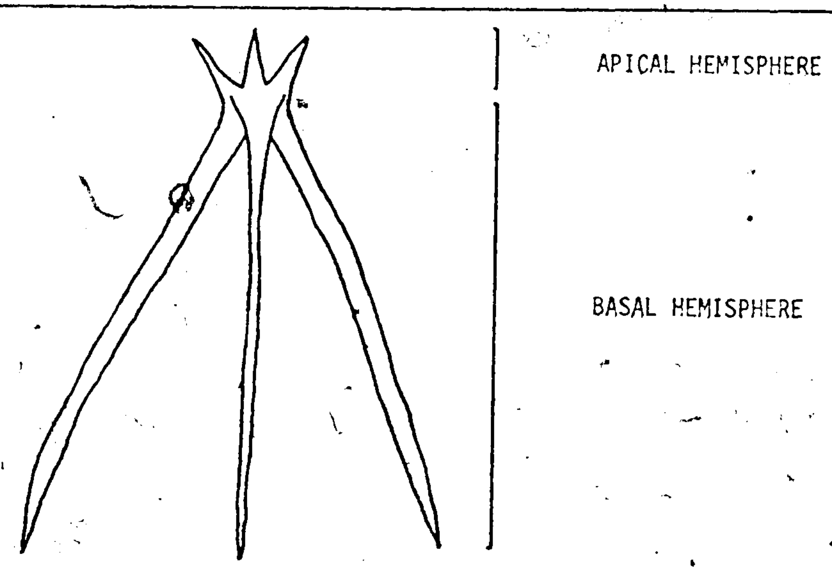
One specimen from the middle Wenlock of the Cape Phillips section at the 315-325 foot interval.



NEW GENUS C

Diagnosis

Six rods arising from a point or bar centre. The three apical rays are shorter than the three basal rays. Ray sets arranged regularily, each set bounding an almost equilateral tetrahedral-like space. The rays may show some curvature. (See text figure 7)



BASIC MORPHOLOGY OF NEW GENUS C

TEXT FIGURE 7

New Genus C Subgenus C

Diagnosis

The six rays constituting the framework of the skeleton show no signs of branching.

New Genus C New Subgenus C new species A

Plate XXXII, Figures 1-4

Diagnosis

The skeleton consists of six rays that do not branch. A latticed skeletal net occurs on the apical portion of the three large basal rays and extends one third of the way down the length of hese rays. The apical rays are extremely reduced.

Description

Six rays arise from a point centre. Three reclined apical rays are very short; the three basal rays well developed, being up to twenty times the length of the apical rays. All the rays taper towards their distal ends.

The basal rays give rise to a number of spines whose branches fuse to form a fenestrated net between the apical one-third of the basal rays. The basal rays curve in a slightly convex outward manner.

Dimensions

Length of apical rays	.....	10µm
Length of basal rays	.....	220µm
Maximum width of basal hemisphere		210µm

Comments

The skeletal net seen in these skeletons is obviously analagous to the similar structure seen in Palaeoscenidium new species A and Palaeoscenidium new species B. The basic pattern of three apical r shorter than three basal rays is similar to new species B of this subgenus. The skeletons of the two forms differ in the lack of the skeletal net in New Genus C subgenus C new species B and in the relative lengths of the apical to basal rays. This difference in the relative length of the rays indicates tha he skeleton attributed to new species B of this subgenus is not an early ontogenetic stage of this form.

Material and Horizon

Seven specimens from the Middle to upper Wenlock of the Baillie-Hamilton Island 1976 section 1 at 480-600 foot interval and numerous specimens from the Cape Phillips 1976 section at the 315-400 foot interval.

New Ge[illegible] [illegible]ogenus C new species B

Plate XXXII, Figure 5

Diagnosis

The skeleton consists of three similar curved apical rays one-third to one-half the length of the basal rays. All the rays bear microspinules, as their sole ornamentation, along their entire lengths.

Description

Six rays arise from a short bar centre. Three apical rays curve outwards towards the horizontal distally so their tips are basally oriented. They are ornamented with microspinules. The apical rays are shorter than the basal rays by a factor of two to three. The three basal rays are slightly curved towards the horizontal distally and bear minute spinules. All the rays taper towards their distal ends. The rays are regularily arranged, those belonging to each hemisphere being identical to the other rays in the same hemisphere.

Dimensions

Length of apical rays	.....	100µm
Length of basal rays	.....	220µm
Maximum width of basal hemisphere		300µm

Comments

The skeleton is similar to that of New Genus C Subgenus C new species C in the possession of an ornament of microspinules on all the rays. However the skeletons can be separated on account of the greater length of the apical rays when compared to the basal rays in new species B than in new species C of this subgenus. New species C is also separated on account of the long basally directed spine which occurs on each of its basal rays.

The skeletal net seen at the apex of the basal hemisphere in new species A of this subgenus is not present in this species. New species A does not bear any microspinule ornament on its rays and the relative length of the apical and basal rays differs from that of new species B of this subgenus.

Material and Horizon

One specimen from the middle Wenlock of the Baillie-Hamilton Island 1976 section 1 at the 480 foot horizon and one specimen from the 315-325 foot interval of the Cape Phillips 1976 section (middle Wenlock).

New Genus C Subgenus C new species C

Plate XXXII, Figure 6

Diagnosis

The members of this species have basal rays that bear a single basally directed spine about one-third of the distance from the skeletal centre to the distal tips of the rays. The ratio of the lengths of the apical to the basal rays is approximately one to six. The skeleton appears to have a very short bar centre.

Description

The skeleton is six rayed. Three apical rays are reclined; three basal rays are pendant. The apical rays are one-sixth of the length of the basal rays. Both sets of rays taper towards their distal tips and are not significantly curved.

The three basal rays are similar and are regularly arranged, bearing minute spinules along their entire length. One-third of the way along their length from their origin a basally directed spine one third of their length is borne. This spine may branch one to two times.

Dimensions

Length of apical rays	.....	30µm
Length of basal rays	.....	180µm
Maximum width of basal hemisphere		200µm

Comments

This skeleton is similar to that of new species B of this subgenus in that they both bear microspinules along the rays. Differences occur in the length ratio of the apical and basal rays (the apical rays are relatively shorter in new species C) and in the presence of the spines on the basal rays in new species C. The spines on the basal rays are not interpreted as branchings of the basal rays due to the inequality in length and robustness between them and the basal rays.

Material and Horizon

One specimen from the middle Wenlock of the Cape Phillips 1976 section at the 315-325 foot interval.

New Genus C New Subgenus Y

Diagnosis

The three apical rays may or may not bifurcate once before tapering to a point. The three pendant basal rays bifurcate up to six times, the primary and secondary branches being subequal while the more distal branches are unequal.

New Genus C Subgenus Y new species D

Plate XXXIII, Figures 1-4

Diagnosis

The three basal rays divide producing up to seventh order branches. At the majority of the divisions one of the branches produced is noticeably shorter or less robust than the other. This pattern of branching creates a basal curtain of skeletal material enclosing the basal hemisphere.

Description

Six rayed structures with a short bar centre. Three apical rays reclined; three basal rays pendant. The three apical rays are approximately equivalent in length to the proximal arm of the basal rays. They are symmetrically arranged, their bases bisecting the angle between the basal rays. The apical rays taper strongly and may bifurcate three-quarters of the way along their length to produce fine equal branches before ending in a point.

The three basal rays emerge, symmetrically arranged, from the ventral side of the bar centre. Approximately 50um along their length they bifurcate. The two branches resulting from this are similar in robustness, but subsequent bifurcations usually produce unequal branches. Of these sub-branches one may or may not give rise to one or more bifurcations before tapering to a point. The other sub-branch bifurcates pseudomonopodially three to four times and usually is noticeably curved.The minor branches of these bifurcations may divide close to their distal end. This pattern of branching creates a basal "curtain" of skeleton enclosing the basal hemisphere.

Dimensions

Length of apical rays	Primary branches ...	40μm
	Secondary branches .	20μm
Length of basal rays	primary branches ...	50μm
	secondary branches variable	
Maximum width of basal hemisphere	...	180μm
Overall height of the skeleton	...	200μm

Comments.

These specimens differ from those assigned to New Genus C aff. C new species D of this subgenus in the manner of the branching of the apical rays. In the specimens assigned New

Genus C Subgenus Y aff. new species D to the pattern of division tends to produce subequal branches whereas in new species D of this subgenus more unequal pairs of branches result.

Material and Horizon

Four specimens from the upper Wenlock of the Baillie-Hamilton Island 1976 section 1 at the 600 and 765 foot horizon and from the lower Ludlow of the Baillie-Hamilton Island 1976 section 2 at 215 feet. Rare specimens were also found in the 1976 Laura Lakes sample 9.

New Genus C Subgenus Y aff.

New Genus C Subgenus Y new species D

Plate XXXII, Figure 7

Description

Six rayed point centred skeleton. Three reclined apical rays ; three pendant basal rays. The three apical rays appear to be short (they are broken in the only specimen).

The three basal rays emerge, symmetrically arranged, from the underside of the point centre. The secondary branches produced in this bifurcation are similar. These secondary branches are 20 to 30um in length and give rise to tertiary branches which may differ in either not bifurcating, but tapering to a point, or bifurcating to produce dissimilar branches. One of these quaternary branches is abortive while the other is robust and bifurcates after an interval of 60um to produce similar fifth order branches which in turn bifurcate. The rays then taper to a point.

Dimensions

Length of apical rays	.....	30μm
Length of basal rays	primary branch	70μm
	secondary branch	25μm
	tertiary branch	25μm
	fourth order branch	60μm
	fifth order branch	70μm

n order branch 60 μm

Comments

This skeletal type bears obvious similarities to those specimens assigned to new species D of this subgenus, but differs from them in the greater equality of the branches produced at each division of the basal rays. Also the number of divisions in this type appears to be less than that occurring in new species D of this subgenus. Stratigraphically both types occur at the same horizon.

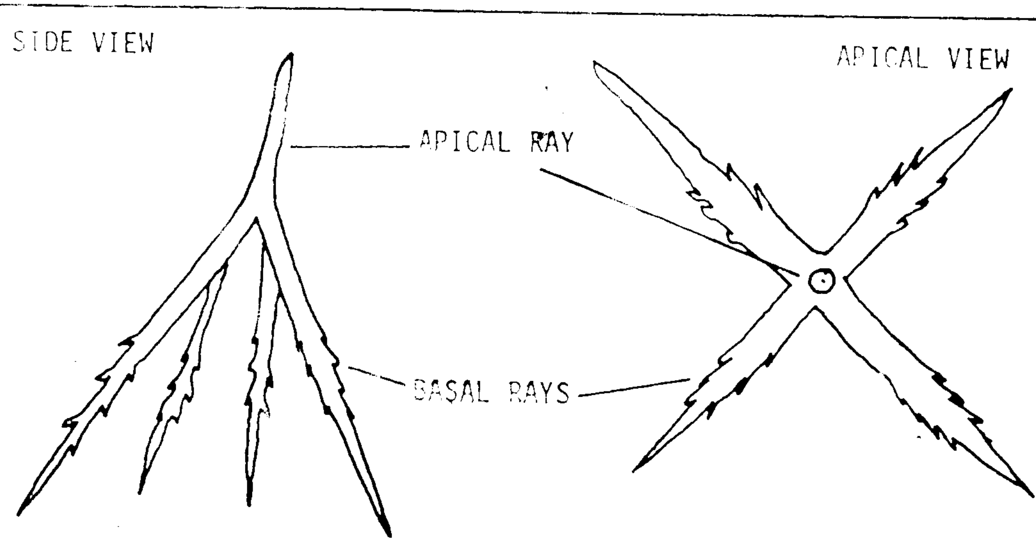
Material and Horizon

One specimen from the upper Wenlock of the Cape Phillips 1976 section at the 340-350 foot interval.

NEW GENUS D

Diagnosis

Point centred to bar centred is consisting of five divergent rays. One ray is oriented at an obtuse angle to the four others. This ray is interpreted as being erect and apical. The other four rays are arranged regularily so that their distal tips constitute the corners of a square. The rays may bear radially arranged spinules for the proximal half to two-thirds of their length, these spines not aris[illegible] immediately at the apex of the structure, but 1[illegible] to 2[illegible] [illegible] ray from the junction.



BASIC MORPHOLOGY OF NEW GENUS D

TEXT FIGURE 8

New Genus D new species A

Plate XXXIII, Figures 5-8

Diagnosis

The skeleton consists of one apical ray and four basal rays. The rays may bear microspinules along at least two-thirds of their length, these microspinules varying considerably in length and development. The apical ray is of similar robustness to, but only half the length of, the four similar basal rays. All the rays are straight.

Description

The apical ray is shorter than the four basal rays which are all of the same length. Microspinules are present on the basal rays for at least two-thirds of their length, commencing 10-20 µm from the apex of the skeleton. These microspinules are radially arranged and vary considerably in length. The apical ray may bear microspinules similar to those on the basal rays, but in some specimens no microspinules are borne. In their stead small 'pustules' are present which may represent the future site of a microspinule. The angle between adjacent basal rays is approximately 90 degrees, while that between the basal rays and the apical ray is 135 degrees.

Dimensions

Length of apical ray	.....	90µm
Length of basal rays	.....	200µm
Maximum width of basal hemisphere		200µm

Comments

This skeleton is the only one in the assemblage studied from the Cape Phillips Formation of the Canadian Arctic which possesses five rays; consequently its affinities are unclear. The varying degrees of spinulation of the specimens is interpreted as being due to different ontogenetic stages of development and also to phenotypic variation.

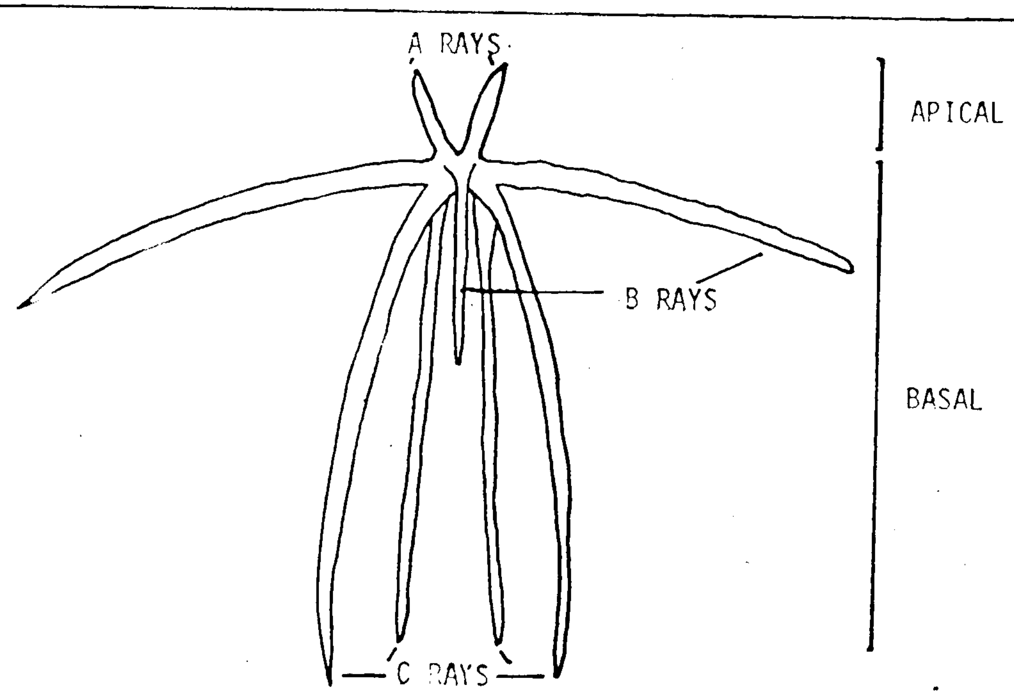
Material and Horizon

Five specimens ranging in age from the uppermost Llandovery to the middle Wenlock. These specimens occurred in the Cape Phillips 1979 section at the 180 and 278 foot horizons and in the Cape Phillips 1976 section at the 135 foot and the 390-400 foot intervals.

NEW GENUS E

Diagnosis

The skeleton of this genus consists of ten rays, two of which are interpreted as belonging to the apical hemisphere with the remaining eight rays being in the basal hemisphere.



BASIC MORPHOLOGY OF NEW GENUS E

TEXT FIGURE 9

New Genus E new species A

Plate XXXIV, Figures 1-6

Diagnosis

A threefold groundplan of ray attitude is clearly evident in this species. The two erect rays are interpreted as belonging to the apical hemisphere. The remaining eight basal rays can be divided up into two sets of four, or two pairs of pairs. Four of the basal rays are pendant in attitude in all the specimens while four rays are subhorizontal to pendant in attitude. The basal rays are longer than the apical rays by up to a factor of four. In some specimens the four pendant rays are equal in length and longer than the subhorizontal to pendant rays.

Description

Ten rayed spicular radiolarians. Two erect rays are interpreted as apical whereas the subhorizontal and pendant rays are interpreted as belonging to the basal hemisphere. Of these basal rays four are pendant and four are horizontal to pendant. The latter four rays are shorter than the pendant rays. The four pendant rays (labelled C rays in text figure 9) always bear some spinulation whereas the B rays may or may not be spinulated. The apical rays (A rays in text figure 9) are smooth and are shorter than the basal rays by a factor of at least three.

Comments

This species contains a considerable amount of variation in the length of the rays, the amount of spinulation present and in the configuration of the basal hemisphere. The B rays are variable in their length and attitude. This variation may be explained by phenotypic and ontogenetic variation.

Dimensions

Length of apical rays (A rays)	...	70μm
Length of basal B rays	...	90-150μm
Length of basal C rays	...	250μm
Maximum width of basal hemisphere	...	300μm

Material and Horizon

Numerous specimens ranging in age from the upper Llandovery of the 1979 Cape Phillips section at 91 feet to the lower Wenlock 353 foot sample of this section. Several specimens also occurred in the 1976 Cape Phillips 135 foot horizon, in the 1976 Laura Lakes sample 7, in the 33-36 foot interval of the 1976 Baillie-Hamilton Island section 1 and in sample 5 of the Abbot River section.

NEW GENUS F

Diagnosis

Six rayed bar centred Radiolaria. Two reclined apical rays and two pairs of pendant basal rays comprise the skeleton.

New Genus F new species A

Plate XXXIV, Figures 7,8

Diagnosis

The rays are robust (5-10μm thick). The basal rays branch evenly up to four times with only short distances between the points of branching. The apical rays may branch evenly up to three times. Overall length of the apical rays is less than that of the basal rays by a factor of one-third.

Description

Robust six-rayed Radiolaria. Bar centred, with two reclined apical rays and four pendant basal rays.

All the rays bifurcate approximately 40μm from the central bar. Tha apical rays bifurcate up to three times before the resultant branches taper to points. The basal rays bifurcate two to four times so that a lacework of branches is created in the distal portion of the basal hemisphere. The distance between the bifurcations appears to decrease after the second bifurcation, when the branches also begin to significantly taper distally.

Dimensions

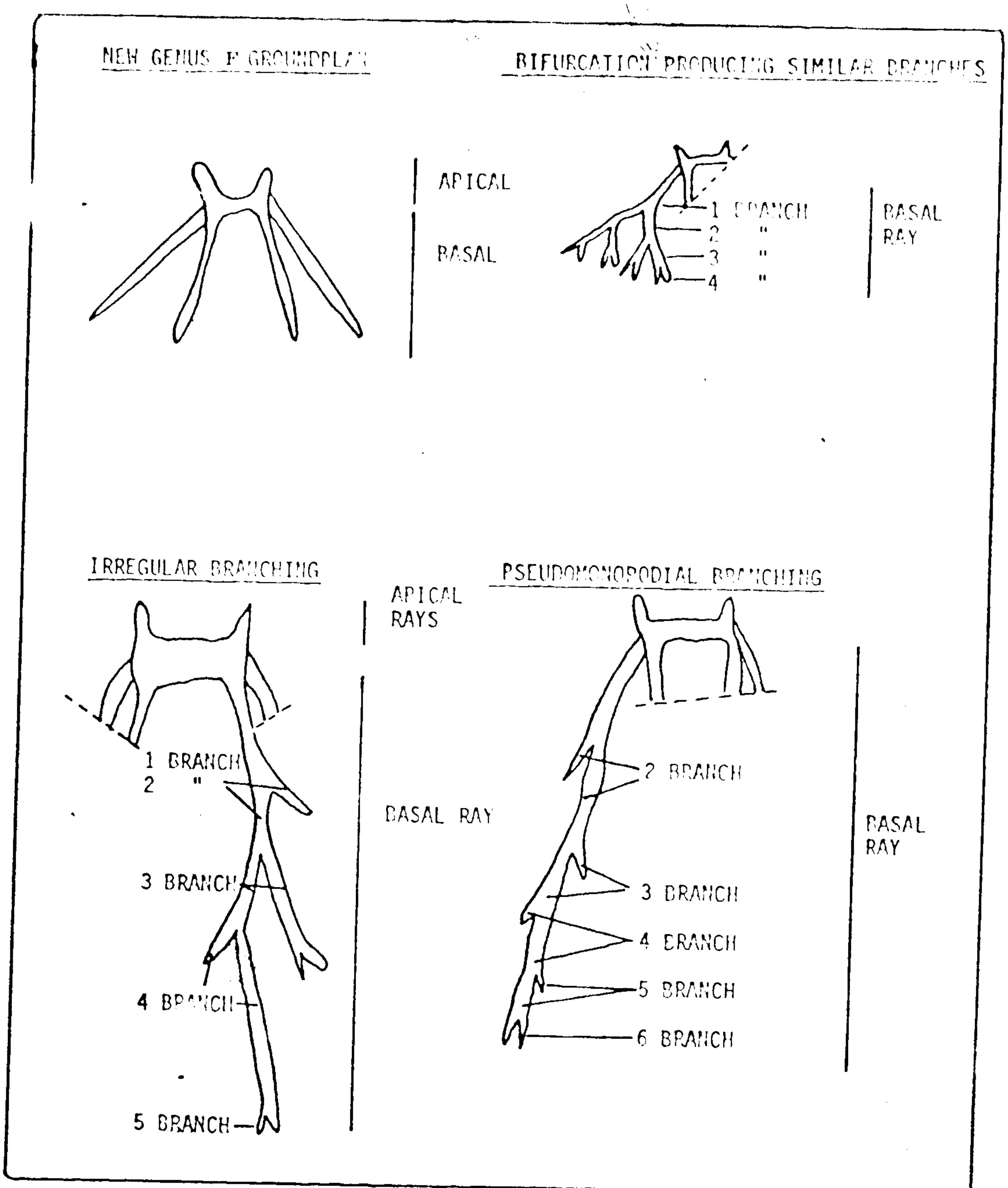
Length of apical rays	....	60µm
Length of basal rays	....	80-100µm
Maximum width of basal hemisphere		150µm

Comments

The members of this species bear a distinct resemblance to those of New Genus F new species D. Differences lie in the greater robustness and the greater number of bifurcations in new species A of this genus. Because of the difference in age of these species it is possible that New Genus F new species D (which occurs at the 315 foot horizon of the Cape Phillips 1976 section) is an evolutionary precursor to New Genus F new species A (which occurs at the 365-375 foot interval of the same section). The pattern of branching of the rays sets these two species apart from the others in New Genus F.

Material and Horizon

One specimen from the Cape Phillips 1976 section at the 365-375 foot interval (upper Llandovery).



TEXT FIGURE 10

New Genus F new species B

Plate XXXV, Figures 1,2

Diagnosis

The skeleton consists of two unbranching apical rays approximately 20μm in length and four basal rays approximately 120μm in length. The basal rays may bifurcate evenly twice. All the rays are ornamented with microspinules.

Description

Six rayed bar centred radiolarian. Two apical rays, reclined; two pairs of pendant basal rays. The apical rays are much shorter than the basal rays and do not branch, whereas the basal rays bifurcate one to two times before tapering to a point. The primary branches of the apical rays are approximately equal in length to the secondary branches of these rays. The tertiary branches are one quarter of the length of the other branches. All the basal rays are similar. All the rays bear an ornamentation of randomly arranged microspinules.

Dimensions

Length of apical rays	.....	20μm
Length of basal rays	Primary branch	50μm
	Secondary branches	40μm
	Tertiary branches	5-10μm

Comments

This species is distinguished from the similar New Genus F new species C by the greater robustness of the rays, the smaller size of the skeleton, the presence of microspinule ornamentation over the whole skeleton and the lack of branching in the apical rays. Phylogenetic relationships between these species would appear to be extremely close, with both occurring in the same horizon.

Material and Horizon

Two specimens from the Lower to middle Wenlock of the Cape Phillips 1976 section at the 315-325 foot interval.

New Genus F new species C

Plate XXXV, Figures 3,4

Diagnosis

The two apical rays and the four basal rays bifurcate once producing equal branches before tapering distally. No microspinule ornamentation is present on any of the rays. The apical rays are approximately one fifth of the length of the basal rays and bifurcate five sixths of thwe way along their length whereas the basal ray bifurccation occurs approximately one third way down the length of the ray.

Description

Six rayed bar-centred Radiolaria. Two apical rays, reclined; four basal rays pendant. The apical rays are much shorter than the basal rays and bifurcate once four-fifths of the way along their length to produce strongly tapering secondary arms.

The basal rays bifurcate approximately 60 μm from the bar centre to produce non-bifurcating secondary basal branches. These may bear rare spinules along their outer edges. The secondary branches are commonly longer than the primary branches. The apical rays and the primary branches of the basal rays do not bear spinules.

Dimensions

Length of apical rays Primary branches 30μm

	Secondary branches	5µm
Length of basal rays	Primary branches	60µm
	Secondary branches	130µm

Comments

The greater size and relative fragility of the skeleton, the branching of the apical rays and the lack of ornamentation of the rays distinguishes this species from New Genus F new species B. New Genus F new species C also does not possess the second bifurcation of the basal rays that is seen in New Genus F new species B. Both species occur in the same sample and are suspected of having close phylogenetic connections.

Material a[illegible] zons

One s[illegible] from the Cape Phillips section at the 315-325 foo[illegible]rval (upper Llandovery).

New Genus F new species D

Plate XXXV, Figures 5,6

Diagnosis

The two apical rays of the skeleton bifurcate once producing similar branches before tapering to a point distally. The four basal rays divide up to four times, producing similar branches at each division. The apical rays are equivalent in length to the combined length of the primary and secondary branches of the basal rays.

Description

Six rayed bar-centred radiolarians. Two apical rays, reclined; four basal rays, pendant. The primary and secondary branches of the apical rays appear to be of the same order of length as the basal primary and secondary branches, but the secondary apical branches taper to a point whereas the secondary basal branches bifurcate.

Bifurcation may occur up to four times in the basal rays. The branches get thinner and more delicate after each bifurcation, the distance between the bifurcations varying little. The angle between the new branches at a bifurcation point is constant at approximately 130 degrees.

The third and fourth order branches of adjacent basal rays appear to overlap producing an enclosed basal hemisphere.

Dimensions

Length of apical rays	Primary branches	40μm
	Secondary branches	15μm
Length of basal rays	Primary branches	50μm
	Secondary branches	40μm
	Tertiary branches	35μm
	Quaternary branches	30μm
	Fifth order branches	8μm

Comments

Distinct similarities are obvious in the gross form of this species and that of new species A of the same genus. However new species D differs from new species A in the less robust nature of the skeleton and in the lesser number of bifurcations occurring on the rays. It is possible that new species D or similar forms gave rise to new species A.

Material and Horizon

One specimen from the lower Wenlock of the Cape Phillips 1976 section 1 at the 315-325 foot interval.

New Genus F new species E

Plate XXXII, Figure 8

Diagnosis

The apical rays of the skeleton are similar in size to the basal rays. Bifurcation may occur up to three times in all the rays and unequal branches may result. The primary branches of the rays are the thickest part of the skeleton and are noticeably ornamented with microspinules. The robustness of the branches decreases distally from the skeletal bar centre.

Description

Six rayed bar-centred radiolarians. Two reclined apical rays and four pendant basal rays make up the skeleton. The primary apical branches are slightly more robust than the primary basal branches and appear to be of similar or slightly greater length. The apical rays bifurcate unequally at the first division point producing branches much less robust than the primary parts of the ray. These secondary branches bifurcate producing unequal arms after a short interval. The third order branches are delicate and taper to a point distally.

The basal rays bifurcate up to three times, the interval between the divisions being somewhat variable. The fourth order branches may be the longest branches of the ray and are much thinner than the more proximal branches.

The primary and secondary branches of the apical and basal rays bear seemingly randomly oriented microspinules. These are seen on some third order apical branches, but are not seen on branches of this category in the basal rays.

Dimensions

Length of apical rays	Primary branches	70μm
	Secondary branches	20μm
	Tertiary branches	50μm
	Quaternary branches	40μm
Length of basal rays	Primary branches	40μm
	Secondary branches	40μm
	Tertiary branches	30μm
	Quaternary branches	110μm

Comments

The pattern of branching of the apical and basal rays can be seen to provide a loose 'frame-work' surrounding the central six rayed spicule. This could be thought of as being analogous to the 'shell' of New Genus F new species K and to the true shell of the Entactiniidae.

Material and Horizon

One specimen from the middle Wenlock of the Baillie-Hamilton Island 1976 section 1 at the 480 foot horizon. Several specimens, tentatively assigned to this species, were observed from the 600 foot level of this section.

New Genus F new species F

Plate XXXV, Figures 7,8

Diagnosis

The skeleton is made up of six rays which are similar in robustness, length and branching pattern. Bifurcation may occur on each ray up to four times, equal branches resulting from each division. The first bifurcation occurs one fifth of the length down the ray from the bar centre of the skeleton. The tertiary branches comprise the longest portion of the rays, being up to three times the length of the primary rays.

Description

Six rayed bar centred Radiolaria. Two reclined apical [illegible]s: four pendant basals rays. All six rays are of the same [illegible] of magnitude, bifurcating approximately 70µm from the [illegible] The resulting branches may taper to a point un[illegible] the ray may bifurcate up to three more times be[illegible]nches taper to a point. On some specimens the dis[illegible] may be [illegible]gated, reaching up to 200µm in leng[illegible] [illegible]d in [illegible]int.

Dimensions

Length [illegible] rays similar		
	[illegible] branches	70µm
	Secondar[illegible] bran[illegible]es	10-20µm

Tertiary branches	up to 200μm
Quaternary branches	up to 60μm
Fifth order branches	15μm

Comments

Similarities can be seen between this species and New Genus F new species E, but the pattern of branching of the rays differs between the two species. Both species occur at approximately the same stratigraphic level.

Material and Horizon

Five specimens from the middle Wenlock of the Cape Phillips 1976 section in the 315-355 foot interval.

New Genus F new species G

Plate XXXVI, Figures 1-6

Diagnosis

The skeleton consists of two apical rays which may or may not bifurcate before tapering to a point. The four similar basal rays, two to three times the length of the apical rays, bifurcate once approximately one fifth of the way along the length of the ray. The secondary branches of the basal rays may bear basally directed spines along their proximal half which can be equivalent in length to the branches which bear them.

Description

The two apical rays are shorter than the basal rays and may or may not bifurcate half way along their length to produce similar tapering branches. The basal rays are all similar, bifurcating about one fifth way along their length to produce two similar tapering branches. These secondary branches may bear prominent spinules on their lateral edges. These spinules may be up to 20µm in length and horizontal to pendant in attitude.

Dimensions

Length of apical rays	Primary branches	up to 150µm
	Secondary branches	30µm
Length of basal rays	Primary branches	50µm

Secondary branches up to 400μm

Maximum width of basal hemisphere up to 800μm

Comments

There is considerable variation in the size of the skeleton in this species. This variation does not seem dependant on the horizon of origin of the specimen. Similarities can be seen in the type of skeleton between this species and New Genus F new species I. The latter species differs in the differentiation of the basal rays into two slightly different pairs, and in the lack of bifurcation of the apical rays.

Material and Horizon

Rare specimens from scattered horizons in the Cape Phillips 1979 section (6 foot horizon to the 180 foot horizon) and numerous specimens from the 1976 Cape Phillips section. In the Baillie-Hamilton Island sections specimens were seen to occur sparsely in the 480-600 foot interval of section 1 and in the 215 foot horizon of section 2. Specimens were also present in the 1976 Laura Lakes samples 9 and 10. The overall range for this species is from the upper Llandovery to the lower Ludlow.

New Genus F new species H

Plate XXXVI, Figure 7

Diagnosis

The very robust skeleton consists of two apical rays of similar robustness to the four basals, but which appear to be of greater length. The basal rays divide into numerous short branches at a single division point. The apical rays bifurcate half way along their length. The secondary branches may divide into numerous third order branches at a single point on attaining a length equivalent to the primary branches.

Description

Six rayed bar-centred radiolarian. Two reclined apical rays; four pendant basal rays. The two apical rays appear larger than the basal rays. The apical rays bifurcate half way along their length to produce two branches which bifurcate again. These tertiary branches divide irregularily near the end of the ray, producing a "tassel" of arms. The basal rays do not undergo bifurcation, but divide into numerous branches at a single point producing distal tassles.

Dimensions

Length of Apical rays	primary branches	50μm
	secondary branches	40μm

	tertiary branches	35µm
	fourth order branches	15µm
Length of Basal rays	primary branches	30µm
	secondary branches	15µm

Comments

The style of branching seen in this skeleton is unique. This species bears resemblance to New Genus F new species E, which occurs in the same sample, as regards the robustness of the primary branches of the rays and the bifurcation of these. These two species are suspected of having close phylogenetic relationships.

Material and Horizon

One specimen from the middle Wenlock of the Baillie-Hamilton Island 1976 section 1 at the 480 foot interval.

New Genus F new species I

Plate XXXVII, Figures 1-4

Diagnosis

The skeleton consists of two unequal unbranching apical rays arising at opposite ends, and directed towards opposite sides, of the bar centre. These rays are shorter than the four basal rays which bifurcate once one-third to one-half way along their length to produce slightly variable secondary branches. These secondary branches may bear spines on their proximal portions.

Description

Six rayed bar centred skeleton. Two erect apical rays which are unequal in length make up the apical hemisphere. These rays are unbranched. The four pendant basal rays are similar and bifurcate approximately 70μm from the apex of the skeleton to produce slightly variable secondary branches. The secondary branches may bear spines up to 15um in length on their proximal portions.

Dimensions

Length of Apical rays	short ray	50-60μm
	long ray	60-150μm
Length of Basal rays	primary branches	50-70μm
	secondary branches	50-160μm

Comments

Noticeable differences occur between the two specimens assigned to this species. The specimen in figure 4 of plate XXXVII has one apical ray which is twice the length of the other, whereas in the specimen figured in figure 1 of the same plate the apical rays are of approximately equal length. There is a difference in the size of the specimens also. Despite these differences it is felt that the skeletons are sufficiently alike, in the face of a lack of further data, to assign them to the same species. The specimen in plate XXXVII figure 1 was extracted from a sample of Middle to upper Wenlockian age while the specimen in plate XXXVII figure 4 was found in lower Ludlow samples.

Material and Horizon

Two specimens. One specimen from the Middle to upper Wenlock of the Cape Phillips 1976 section at the 390-400 foot interval; the other specimen was extracted from the lower Ludlow of the Baillie-Hamilton Island 1976 section 2 at the 215 foot horizon.

New Genus F new species J

Plate XXXVII, Figures 5-8

Diagnosis

The apical hemisphere consists of two apical rays which bifurcate once before tapering distally. Four similar basal rays, two to three times the length of the apical rays , divide up to five times. Each division (after the first division in some cases) produces two unequal branches. One of these branches is usually short (25μm) and tapers to a point without further division. The other branch is longer and divides again to continue the ray. Bifurcation of the main basal rays into two sub-equal branches may occur at the first or second division point.

Description

The skeleton is six rayed and bar-centred. The two apical rays are similar, being approximately equivalent in length to the primary branch of the basal rays. The apical rays bifurcate at a point one-half to three-quarters of the way up their length to produce strongly tapering branches which end in a point. The rays arise from opposite ends of the bar-centre and are directed to different sides of the bar-centre line.

The basal rays arise from the underside of the ends of the bar-centre, a pair from each end. They are symmetrically arranged. 50-60μm along their length they bifurcate to produce similar secondary branches. These secondary branches bifurcate producing dissimilar tertiary branches after an interval of approximately 30μm. Further bifurcations produce dissimilar branches at irregular intervals. The rays may extend to fifth order branches before tapering to a point.

Dimensions

Length of Apical rays	primary branches	40μm
	secondary branches	25μm
Length of Basal rays	primary branches	60μm
	secondary branches	30μm
	third to fifth order branches	30-60μm

Comments

Variation occurs among the specimens in the spacing of the bifurcations of the basal rays. Those specimens from the 215 foot horizon of the Baillie-Hamilton Island section 2 do not exhibit a tendency for the main ray to split into two main branches, as is seen in some of the specimens from the older horizons. There are no really distinctive differences between the specimens from the various horizons (though they represent a considerable stratigraphic spread) so they have all been assigned to the same species.

Material and Horizon

Fifteen specimens. Two specimens from the

Baillie-Hamilton Island 1976 section at the 480 foot horizon and rare specimens from the 600 foot horizon of this section;five specimens form the Cape Phillips 1976 section at the 330-375 foot interval and eight specimens from the Baillie-Hamilton Island 1976 se[illegible]n 2 at 215 feet. Rare specimens were also observed in the 1976 Laura Lakes sample. These samples are middle Wenlock to lower Ludlow in age.

New Genus F new species K

Plate XXXVIII, Figures 1-5

Diagnosis

The ratio of the length of the apical rays to the basal rays ranges from 1:2 to 1:1 in the specimens. All the rays bear stout spines (which in turn bear spines) up to one quarter the length of the ray along the proximal one-third to one-half of their length. Those spines from adjacent rays tend to interact to form a cocoon-like structure around the six rayed spicule.

Description

Two reclined apical rays; four pendant basal rays. The length of the apical rays varies between specimens from one half of to equal in length to the basal rays. All the rays are of similar robustness. The rays bear stout spines on their proximal half to one-third. These spines, which vary in length and may bear subsidiary spinules, in the fully developed stage of the skeleton interact with those from adjacent rays to form a cocoon-like structure around the six rayed spicule. The bar centre of the spicule lies towards the apical pole of the cocoon.

Dimensions

Length of apical rays	.....	90-200µm
Length of basal rays	.....	200-400µm

Maximum width of basal hemisphere 200-700μm

Comments

This species, as described here, contains considerable variation in the size and robustness of the skeleton. The four specimens obtained from the Middle to upper Wenlock appear to be significantly less robust than the specimens from older horizons. Whether this represents an actual trend is not clear with the paucity of specimens from samples of the younger ages.

The ontogeny of the species is evident from the specimens figured in plate XXXVIII, figures 3-5. The earliest ontogenetic stage recognised is where the six rays bear sparse spines along part of their length. The length of these spines increases and subsidiary spines may develop on them. After a certain length of spine is attained they interact with the spines from adjacent rays to form a loose network or cocoon around the central junction of the six rayed spicule. (See plate XXXVIII, figure 5).

This stage bears considerable resemblance to the specimens assigned to the Entactiniidae where a latticed shell surrounds a central six rayed spicule. The main difference between the two types is in the organisation of a latticed shell. The cocoon of New Genus F new species K is not as organised as a distinct shell, but may be viewed as a possible precursor to the development of such.

Another similarity between the Entactiniidae and new species K is the off-central positioning of the internal spicule. In New Genus F new species K it results because the spines from the apical rays that take part in the production of the cocoon are more proximal to the centre of the spicule than are those from the basal rays. If the Entactiniidae did develop from such Palaeoscenidiidae it is likely that the off-central nature of the central spicule arose in this way.

New Genus F new species K can be described as a possible link between the Palaeoscenidiidae and the Entactiniidae. If this is correct, then the Entactiniidae can be seen to have a polyphyletic origin, since they are present in Ordovician strata (Nazarov,1975) and show signs of originating from the Palaeoscenidiidae in the Lower to Middle Silurian.

Material and Horizon

Numerous specimens from the upper Llandovery to lower Wenlock of the Cape Phillips 1979 section from the 6 foot to the 300 foot horizon. Fewer samples were obtained higher up in the section, but specimens were obtained from the 400 foot horizon of the Cape Phillips 1976 section. Several specimens were extracted from the 480 foot horizon of the 1976 Baillie-Hamilton Island section. One specimen was obtained as high as the lower Ludlow age 215 foot interval of the Baillie-Hamilton Island 1976 section 2.

New Genus F aff. F new species K

Plate XXXVIII, Figures 6-8

Description

These specimens closely resemble new species K in form and size, but differ from it in the division of some of the rays outside the cocoon-like structure.

Comments

It is unlikely that these specimens represent a different species, but rather a phenotypic variation of new species K. The specimen in plate XXXVIII figure 6 would seem to indicate a continuous spectrum of forms .

Material and Horizon

Seven specimens from the Cape Phillips 1979 section in the 6 -155 foot interval (middle Llandovery).

New Genus F new species I

Plate XXXIX, Figures 1-4

Diagnosis

The basal hemisphere of the skeleton has a ground plan of four rays which bifurcate approximately 60um along their length to produce similar tapering branches. This symmetry is broken by irregularity in the length of the basal rays and in the possible bifurcation of one of the secondary branches on each ray before they taper distally to a point. The apical hemisphere consists of two rays which may or may not branch. Tha apical rays are equivalent in length to the primary branches of the basal rays. The complete skeleton is ornamented with microspinules.

Description

The two apical rays may bifurcate once producing short subequal branches before tapering to a point.

The proximal or primary branches of the basal rays are regularily arranged. The basal rays differ in the position of subsequent bifurcation points and in the lengths of the resultant branches. The secondary or tertiary branches on some of the rays are greatly elongated.

Microspinules are present over the entire skeleton.

Dimensions

Length of apical rays 30-60µm

Length of basal rays 250-450μm

Comments

Considerable variation is seen in the total length of the basal rays in a single specimen and am he specimens. This species is similar in its groundplan o rimary bifurcation of the basal rays to New Genus F cies B and New Genus F new species C, but differs from n the greater size of the skeleton. It is likely that the species are closely related. New Genus F new species New Genus F new species C occur slightly lower in the stratigraphic section than New Genus F new species L and one of them may have given rise to new species L. The most likely candidate is New Genus F new species B on account of its possession of microspinules on the rays of its skeleton.

Material and Horizon

Nineteen specimens of Middle to upper Wenlock age. One specimen from the 480 foot interval of the Baillie-Hamilton Island 1976 section 1, five specimens from the 600 foot interval of the same section and twelve specimens from the 325-400 foot interval of the Cape Phillips 1976 section. One possible specimen from the lower Ludlow of the Baillie-Hamilton Island 1976 section 2 at the 215 foot horizon.

New Genus F new species M

Plate XXXVI, Figure 8

Diagnosis

The apical rays divide once producing similar branches equal in length to the primary branches of the apical and basal rays. The first bifurcation of the basal rays produces two short branches, both of which bifurcate to produce longer tertiary branches. One of these sets of branches does not branch again while the other set may bifurcate twice more.

Description

The two apical rays bifurcate approximately half way along their length to produce similar branches which taper to points.

The four basal rays are regularily arranged and bifurcate to produce two short branches 60-70μm down their length. One of these branches bifurcates, with short similar branches resulting which taper distally. The other secondary branch bifurcates to produce tertiary branches equal in length to the primary branches. Two bifurcations take place producing similar branches beyond the tertiary branches before the rays taper distally to terminate in points.

Dimensions

Length of apical ray	primary branch	50μm

	secondary branch	80µm
Length of basal ray	primary branch	70µm
	secondary branch	20µm
	tertiary branch	20-50µm
	quaternary branch	70µm
	fifth order branch	30µm

Comments

This specimen bears resemblance to New Genus F new species N, the manner of the bifurcation of the basal rays producing similar trailing branches in a succession of bifurcations. The specimen differs from new species N in that the branches of adjacent rays do not interact to produce a basal net. Also the specimens of New Genus F new species N do not show evidence of the production of a short secondary branch in the basal rays which divides to produce undividing tapering branches of equal length to the secondary branch.

Material and Horizon

One specimen from the middle Wenlock of the 340-350 foot interval of the Cape Phillips 1976 section.

New Genus F new species N

Plate XXXIX, Figures 5-8

Diagnosis

The basal rays divide 100μm from the long bar centre of the skeleton to produce equal secondary branches. The distal tips of these secondary branches join with a similar branch from the adjacent basal ray. From this junction a shared branch results, approximately equal in length to the secondary branches. This branch in turn bifurcates producing similar rays and the process is repeated. Up to four series of bifurcations occur in the basal hemisphere and the result is a trailing basal net. The two apical rays bifurcate once producing secondary branches three to five times the length of the primary branches.

Description

Six rayed bar-centred skeleton, the length of the central bar being variable. Two apical rays of similar length and robustness bifurcate one fifth to one half of the way along their length to produce similar branches which taper to points distally.

The four regularily arranged basal rays bifurcate approximately 100μm from the central bar. Similar branches equal in length to the primary branch are produced. The secondary branches of adjacent rays join and from this junction is produced a single tertiary ray of length 100μm.

This branch bifurcates at its distal end to produce similar branches which in turn join at their distal tips with similar branches from adjacent rays. In this way a trailing basal net is created.

In some specimens the joining of similar branches between adjacent rays is postphoned for one bifurcation cycle.

A total sequence of up to six bifurcations may occur in this basal hemisphere net.

<u>Dimensions</u>

Length of apical rays	primary branches	20-50µm
	secondary branches	20-100µm
Length of basal rays	All branches of similar length of approximately 100µm	

<u>Comments</u>

This species is somewhat similar to New Genus F new species M in the bifurcation of the basal rays to produce similar branches . Differences lie in the constancy of the length of the branches in New Genus F new species N and in the junction of similar order branches from adjacent rays to produce a basal net. The similarity of the branching pattern of the rays would appear to indicate some degree of genetic relationship between the two species.

Material and Horizon

Ten specimens from samples of middle Wenlock age in the 330-350 foot interval of the Cape Phillips 1976 section.

New Genus F new species O

Plate XL, Figures 1-6

Diagnosis

All rays are unbranched. The apical rays are shorter than the shortest basal ray and may or may not bear spinules. Three of the basal rays are similar in length, curvature and in the possession of spinules along part of their length. The other basal ray is shorter and lacks spinules.

Description

Two similar apical rays arise from opposite ends of a point to bar-centred six rayed spicule. These rays are shorter than any of the four pendant basal rays and may or may not bear sparse spinules along part of their length.

Two basal rays arise at each end of the point to bar-centre. Three of these rays are similar in length, curvature and in the possession of spinules along part of their length. The type of spinulation varies from being ordered into annulations to spinules arising from only the lateral parts of the rays. The remaining basal ray is shorter than the others by a factor of one third and bears no spinules. Microspinules appear to be present over the entire skeleton.

Dimensions

Length of apical rays	....	30-60µm
Length of short basal ray	....	40-120µm
Length of long basal rays	....	100-300µm

Comments

The consistent dissimilarity of one of the basal rays to the other three is unique to this species and could be taken to represent a possible morphological pathway between the skeletal pattern of New Genus F with two apical and four basal rays, and New Genus A with three apical rays and three basals. All that would be needed to occur is that the short unornamented basal ray of New Genus G new species O become shortened to equal the apical rays in length. This reasoning is strengthened by the fact that the specimens of New Genus F new species O occur in strata of Upper Llandovery to middle Wenlock age while all the New Genus A specimens occur in samples of Middle to upper Wenlock age.

Material and Horizon

Numerous specimens from the upper Llandovery to lower Wenlock samples of the 6 foot to 353 foot interval of the Cape Phillips 1979 section. Fewer specimens were collected from samples in the 1976 Cape Phillips section in the 135-400 foot interval and from the 1976 Laura Lakes sample 9. This species can be seen to range throughout the Cape

Phillips sections.

New Genus F new species P

Plate XLI, Figures 1-4

Diagnosis

All six rays are similar and regularily arranged, dividing into three secondary branches two thirds to three quarters of the way down their length from the short bar centre of the skeleton. Microspinule ornamentation is absent.

Description

The skeleton consists of six similar rays approximately 300μm in length. Three rays arise from each end of the bar-centre. Apical rays are indistinguishable from basal rays. The rays are approximately 5μm thick and are constant in thickness till they divide two thirds to three-quarters way down their length to produce similar secondary branches. Three branches are most commonly produced at the division point, in rare cases more. These secondary branches are 50-100μm in length and taper distally to end in points.

Dimensions

Length of primary branch 150μm

Length of secondary branch 75μm

Comments

The skeleton of this species, with the distal trifurcation of the similar rays does not resemble any other species in New Genus F. Consequently its affinities are unknown.

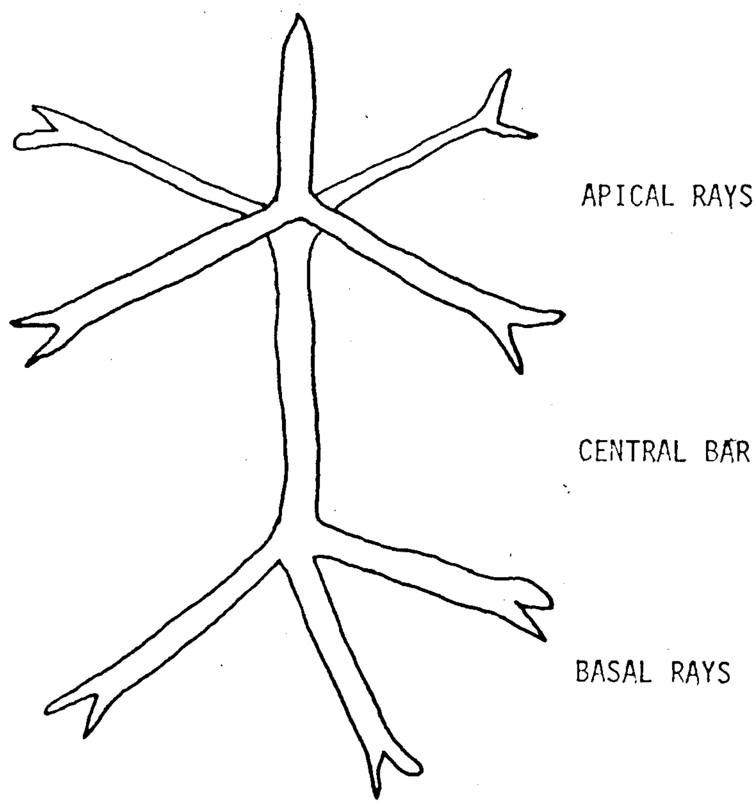
Material and Horizon

Specimens were found ranging from the 6 foot interval of the 1979 Cape Phillips section (upper Llandovery) to the 400 foot level of the Cape Phillips 1976 section (upper Wenlock). Rare specimens were also extracted from the 600 foot level of the Baillie-Hamilton Island section 1.

New Genus G

Diagnosis

Skeletons compr[illegible] cen[illegible]ral bar, the basal and apical ends of w[illegible]h g[illegible]se [illegible] three and five rays respectively. The rays com[illegible]y divide distally producing similar branches. (See text figure 11)



MORPHOLOGY OF NEW GENUS G

TEXT FIGURE 11

Comments

The number of rays and the layout of the skeleton bears no resemblance to the patterns observed in the other genera described in this or other studies of the Palaeoscenidiidae. Hence the affinities of this genus remain obscure.

New G[illegible] new species A

Pla[illegible] 7 8

Diagnosis

The skeleton is composed of a conspicuous central bar, the ends of which give rise to three and five rays respectively. The apical end of the structure is interpreted as that end of the bar which gives rise to five rays. One of these rays emerges from the central bar oriented parallel to the direction of the bar.This ray divides two thirds to four fifths of the way along its length giving rise to similar branches. These may bifurcate in turn. The four other apical rays are symmetrically arranged around the tip of the bar and are oriented subhorizontally. These rays divide approximately half way along their length giving rise to similar branches. Division may occur up to three times on these rays.

Three similar basal rays arise, symmetrically arranged, from the basal end of the central bar. These rays trifurcate one half to two thirds of the way along their length and the resulting branches bifurcate before tapering to a point.

Description

The erect apical ray trifurcates four-fifths of the way along its length to produce similar branches which taper to distal points.

The sub-horizontal apical rays bifurcate or trifurcate two thirds to one half of the way along their length to produce similar branches. The erect apical ray is equivalent in length to the primary branches of the sub-horizontal apical rays.

Three symmetrically arranged basal rays radiate from the basal end of the central bar inclined about 20 degrees below the horizontal. These rays trifurcate to produce similar branches which trifurcate in turn before tapering to a point.

Dimensions

Length of apical rays	Erect ray	primary branch	25μm
		secondary branch	8μm
	Horizontal rays	primary branch	35μm
		secondary branch	30μm
Length of basal rays		primary branch	50μm
		secondary branch	20μm
		tertiary branch	20μm

<u>Comments</u>

The three specimens that were obtained from the Baillie-Hamilton section were more delicate than were those from the Cape Phillips section. This is interpreted as phenotypic variation, but may also be due in part to some change in the genetic make-up of this species during the time interval between the samples. Because the skeletal make up of this genus is unique the relationships of this form remains obscure.

<u>Material and Horizon</u>

Three specimens from the 480 foot interval [illegible]e Baillie-Hamilton Island 1976 section (middle Wenlock in age) and three specimens from the upper Wenlock of the 390-400 foot interval of the Cape Phillips 1976 section.

Incertae Sedis A

Plate XLI, Figures 5,6

Description

Spicular skeletons consisting of eight rays. The only apical ray is erect and is rectilinear with a single basal ray. The skeleton is point centred. Six basal rays radiate from the point centre, lying slightly below the horizontal and curving basally and distally . The basal hemisphere has a hexagonal symmetry.

Microspi[illegible]les ma[illegible] be present on the lateral rays. If present th[illegible] [illegible]ally arranged on the erect apical ray and ar[illegible] situa[illegible] [illegible]xternal edges of the rays. The central [illegible]sa[illegible] [illegible] sm[illegible]th.

Comments

The large scale of this spicular structure, the coarseness of its constituent rays and the peculiarity of the skeletal form throw doubt on its assignment to the Radiolaria. It is the opinion of the author that this form most likely belongs with the Porifera.

Material and Horizon

Five specimens from the Midd[illegible] to upper Wenlock of the 315-330 foot interval of the Cape [illegible]llips 1976 section and the 480-600 foot interval of the Baillie-Hamilton 1976 section 1.

aff. Incertae Sedis A

Plate XLI, Figures 7,8

Comments

These skeletons resemble in groundplan those assigned to Incertae Sedis A, but differ from them in the possession of elongate spines on the outer edges of the lateral rays.

Material and Horizon

Two specimens from the Cornwallis Abbott River 1976 sample 5c. (Age of this sample unknown).

Incertae Sedis B

Plate XLII, Figures 1,2

Description

Ten rayed structure. Two rays arranged vertically, eight subhorizontal. Of the vertical rays one is in the apical hemisphere while the other is in the basal hemisphere. Eight similar subhorizontal rays radiate from the point centre, tapering to a point. These rays possess spines on their apical surface, those spines having the greatest length being closest to the centre of the structure.

Dimensions

Length of apical ray	70μm
Length of vertical basal ray	at least 30μm
Length of lateral basal rays	100μm
Maximum width of basal hemisphere	220μm

Comments

This specimen resembles Incertae Sedis A in its groundplan, and it is likely that it belongs to the same animal group as Incertae Sedis A, which would appear to be the Porifera rather than the Radiolaria.

Material and Horizon

One specimen from the upper Wenlock of the 390-400 foot interval of the Cape Phillips 1976 section.

Incertae Sedis C

Plate XLII, Figures 3,4

Description

Ten to fifteen equal rays radiate out from a point centre. No distinction can be made between the apical and basal hemispheres. The rays are unornamented and do not branch before tapering to a point distally 240μm from the point centre.

Comments

These specimens do not resemble the other ten rayed skeletons of New Genus E in that they show no distinction of the rays into apical and basal hemispheres. It is not known whether these skeletons belong to the Radiolaria, but their size and fragility would suggest such affinity rather than to the Porifera which usually exhibit more robust spicules.

Material and Horizon

Three specimens. Two specimens from the 600 foot horizon of the Baillie-Hamilton Island 1976 section and one specimen from the 330-340 foot interval of the Cape Phillips 1976 section. These horizons are of Middle to upper Wenlock age.

Incertae Sedis D

Plate XLII, Figures 5,6

Description

The skeleton consists of several concentric shells connected by numerous similar radiating spines. The diameter of the largest shell is 250µm and the spines which radiate from it average 120µm in length with a basal thickness of 5-10µm. Lattice bars approximately 5um thick enclose subrounded pores 5-15µm across in the shell lattice.

One conspicuous pore 100µm in diameter with an elevated latticed border occurs in the outer shell(at least) of the skeleton.

Comments

The general make up of the skeleton with several closely spaced semi-spongy shells and numerous spines radiating from these is similar to the skeleton of New Genus A new species C. The large pore is the only distinguishing characteristic.

It is considered unlikely that a six rayed spicule occurs internal to the shells, hence this skeleton has not been assigned to the Pylentonemidae. This specimen may represent an example of convergent evolution between phylogenetically separate forms, if the pore serves the same purpose in the two types.

Material and Horizon

One specimen from the upper Llandovery of the Cape Phillips 1979 section at the 6 foot horizon.

Incertae Sedis E

Plate XLIII, Figures 1,2

Description

The structure internal to the visible external shell is not known due to poor preservation. The visible shell, of diameter 200-350um is composed of two types of lattice, an A type and a B type. The A type lattice occupies one half of the shell surface and consists of bars 5-10μm thick separating rounded pores of variable size, up to 30μm across. The second lattice type, the B type lattice , occupies one quarter of the shell surface and is that part of the lattice affected by the branching of the spine bases into the shell. In this area the pores are greatly enlarged, measure 40-50μm across and are bounded by spine bases on one side and by the elevated (compared to the A type lattice) roots of the spines.

30-40 spines radiate from the shell. All the spines are characterised by having extremely expanded bases which are heavily sculptured. Spine bases are up to 100μm wide, though there is considerable variation in this character. Spine length is also variable, ranging from 100-200μm.

Comments

The two specimens described here are considered to represent different stages in the ontogeny of this type. In the light of the paucity of specimens the size difference between the two is interpreted as phenotypic as well as ontogenetic, rather than being an expression of genetic differences. The specimen in plate XLIII, figure 1 is interpreted as being the younger of the two. Growth occurs through the addition of silica to the spines, thus thickening them.

Due to the uncertainty of the internal structure of these skeletons they cannot be assigned to any particular genus. However they do resemble those members of Haliomma described earlier.

Material and Horizon

Two specimens from the 265 foot horizon of the 1976 Baillie-Hamilton Island section 2. This horizon is of lower Ludlow age.

Incertae Sedis F

Plate XLIII, Figure 7

Description

Approximately 30 spines radiate from the external shell of the skeleton. The spherical latticed shell has a diameter of 170µm. The spines are of two types, which are equal in number. The larger spines extend at least 150µm from the shell. For the proximal 50µm the spines are sculptured due to the branching off of buttresses or roots into the shell lattice. Above this the spines are smooth and conical. The smaller spine type is a miniature replica of the major spine extending only 70µm from the shell.

The lattice of the shell consists of two types, analogous to the types A and B of Incertae Sedis F. The A type lattice is characterised by lattice bars less than 5um thick separating rounded to subrounded pores 5-10µm across. The B type lattice is restricted to the area immediately adjacent to the spine bases. The ratio of the area covered by the lattice types in the shell is 2:1 (A type to B type). Lattice only occupies about one half of the shell surface, the remainder being occupied by solid spine material.

Comments

This specimen bears resemblances to those of Incertae Sedis E , differing from them in the possession of two types of spines radiating from the shell. Both these types would appear to belong to the haliommid group.

Material and Horizon

One specimen from the 265 foot horizon of the 1976 Baillie-Hamilton Island section 2. This horizon is lower Ludlow in age.

Incertae Sedis G

Plate XLIII, Figure 5

Description

The outer s[illegible] of this specimen has a diameter of 200µm. Two types of lattice occur on the surface of the shell. Large rounded pores encircle the bases of the spines. These pores measure 10-15µm across.

The lattice unaffected by the spine bases is characterised by bars 5µm thick separating pores less than 10um across.

Approximately 40 spines radiate from the shell. These spines are all similar, tapering to a p[illegible] 100µm from the shell. There is no noticeable expansion of these spines bases. Instead the spines are perforated by large pores, making a B type lattice adjacent to the spines.

Comments

The lattice of this skeleton bears a close resemblance to that of Rhizoplegma new species A. This specimen is not assigned to that genus because its internal structure is not kn[illegible]n. Di[illegible]erences can be seen between the forms in the smaller diameter of the Incertae Sedis G specimen and in the lesser number of spines which radiate from its outer shell.

Material and Horizon

One specimen from the 765 foot horizon of the

Baillie-Hamilton Island 1976 section 1. This horizon is upper Wenlock in age.

Incertae Sedis H

Plate XLIII, Figure 6

Description

The internal structure of this skeleton is not known. The outside shell has a diameter of 180µm. The lattice of this shell consists of two types: Type A and type B lattices. The most striking feature of the shell is the joining of the solid spine roots between adjacent spines.

The A type lattice exists in skeletal depressions between the elevated spine roots, and is composed of bars less than 5µm thick separating subrounded pores 3-10µm across. The B type lattice occurs adjacent to the spine bases and has larger pores than the A type lattice. An apron of B type lattice may drape down from part way up the spine and join the A type lattice, or extend to the adjacent spine providing an extra lattice covering over part of the shell. Large 'pseudopores' may be created between the edges of the B type lattice drapes and the underlying A type lattice. 40-60 spines radiate from the shell, these spines having expanded bases which branch prominently into the shell and may extend to adjacent spines adding to the three dimensional character of the essentially two dimensional shell lattice. All the spines are of similar robustness and may extend up to 120µm from the shell.

Comments

The twin nature of the lattice of the outer shell in this skeleton bears a resemblance to that seen in the specimens assigned to some of the new species of *Haliomma* described previously.

Material and Horizon

One specimen from the 1976 Baillie-Hamilton Island section 2 at the 265 foot horizon. This specimen is of lower Ludlow age.

Incertae Sedis I

Plate XLIII, Figure 8

Description

Th[illegible]n appears to consist of a loose network of thin lat[illegible]rs. 3-5μm thick which enclose angular to subr[illegible]ores 10-50μm across. This seems to make up a single hollow three dimensional shell 50μm thick and 200μm in diameter. Straight to slightly curved spines arise from the open framework of the shell. These spines, which taper distally from a basal thickness of 5-10μm, may extend 100μm from the shell. Several lattice bars from the shell form a root-like or buttressing structure at the bases of these spines.

Comments

The open nature of the shell lattice and the near equality of the thickness of the spines to the lattice bars is similar to the pattern observed in the palaeoactinommid New Genus A new species . While this specimen can be confidently assigned to the palaeoactinommids, the uncertainty of its internal structure precludes any further classification.

Material and Horizon

One specimen from the middle Wenlock of the 390-400 foot interval of the 1976 Cape Phillips section.

Incertae Sedis J

Plate XLIII, Figures 3,4

Description

The internal structure is unclear, but the skeleton seems to consist of a single spherical shell 180μm in diameter which surrounds an internal spicular structure. The individual rays of this structure extend out through the shell as major spines. The number of these spines is not known, but seems to be less than ten.

The single shell is slightly three dimensional in nature and is made up of bars 2-5μm thick. These bars branch laterally as well as outwards from the innermost part of the shell. The bars thin towards the outside of the shell. True pores exist only in the inner part of the shell and are subrounded in shape, varying from 5μm to 10μm across. The outermost bar branches of the shell appear as small bifurcating spines which extend 5-10μm from the surface of the shell.

Comments

The apparent internal spicular structure of this skeleton would indicate that it belongs to the Entactiniidae. The pattern observed here whereby the inner spicules extend out through the shell as major spines is similar to that observed in the specimens assigned to the Entactiniidae.

Material and Horizon

One specimen from the middle Llandovery 276 foot horizon of the 1979 Cape Phillips section.

RADIOLARIA AS CORRELATION TOOLS IN THE CANADIAN ARCTIC

Text-figures 12 and 13 show the ranges of Radiolaria which are common to the three main sections investigated in this study. The Laura Lakes and Abbott River samples are not included in this correlation due to uncertainty as to the relative position of the samples to each other in the stratigraphic record.

The writer proposes to discuss the ranges of each of the common species seperately and then to synthesise the overall findings in a discussion of the proposed radiolarian correlation between the three section areas (Cape Phillips, southern Baillie-Hamilton Island and Cape Becher) as is shown in Text-figure 14.

One would expect the two areas of Cape Phillips and southern Baillie-Hamilton Island to show the greatest degree of similarity between the sections as they are within sight of one another (assuming no major fault movement has taken place in the Maury Channel which seperates them by about twelve miles).

Acanthosphaera new species A appears in the first part of both these sections (it is absent from Cape Becher) but whereas it has a stratigraphic range of 300 feet in the Cape Phillips section, it was found to occur in only one sample from Baillie-Hamilton. Three possible explanations are deducible from this: The first is that the ranges as shown in the text-figure are the true ranges and differing conditions in the Baillie-Hamilton area killed off the population of this species while it survived in Cape Phillips; the second is that the ranges shown are accurate and that greater sedimentation occurred on the Cape Phillips section at this time, with the species having similar ranges in both areas. The third interpretation is that due to the barreness of the samples in the 36 foot to 470 foot interval of the Baillie-Hamilton section 1 the true range of the species here is not shown. In writers opinion the latter explanation is the most acceptable.

<u>Cenosphaera</u> new species A is stratigraphically the next taxon common to these two areas. It occurs at approximately the 200 foot level of the combined 1976 and 1979 Cape Phillips sections and in the 470-600 foot interval of the Baillie-Hamilton Island section 1. Hence, providing the ranges depicted are correct and the range boundaries can be taken as time lines, a greater rate of sedimentation occurred in the Baillie-Hamilton area at this time.

Although the slope of the range boundary lines for <u>Caryomma</u> new species A differs considerably from those of <u>Cenosphaera</u> new species A the fanning of the boundary lines is in the same direction also indicating a greater rate of sedimentation in the Baillie-Hamilton area compared to the Cape Phillips area. In the field, evidence can be seen to support this in the greater amounts of allochthonous slumped beds in the Baillie-Hamilton area. These beds can be easily picked out by their sedimentary features and in their obviously allochthonous shelly faunas of brachiopods, corals and trilobites.

Caryomma new species A also occurs in the 300-350 foot interval of the Cape Becher section indicating a lesser rate of sedimentation here compared to the Baillie-Hamilton area. This is also shown by the range of the palaeoactinommid New Genus A new species A which is common to these two areas. Both sets of range lines also show the same slope which indicates that the 450-600 foot interval of the Baillie-Hamilton Island area is equivalent to the 200-350 foot interval on Cape Becher.

Haliomma new species A occurs in one sample of the Cape Phillips and Baillie-Hamilton Island section 1 at the 700 foot and [illegible] foot horizons respectively. If this can be taken as a time line a slightly greater degree of sedimentation can be seen to have occurred between this and the incoming of Acanthosphaera new species A in the Baillie-Hamilton Island area compared to Cape Phillips.

The other group of radiolarians which may be used to provide a tentative correlation between the sections is the Palaeoscenidiidae. (See Text-figure 13). New Genus E new species A has a range remarkably similar to that of Acanthosphaera new species A and again, in the writers opinion appears as it does due to the poor productivity of the lower part of the Baillie-Hamilton sections. 'Single sample' taxa occurring between these two section areas (Palaeoscenidium aff. P. new species C, Palaeoscenidiidae New Genus C Subgenus C new species A and Palaeoscenidium new species C) ind ate correlation between the 600 foot level of the Cape Ph section and the 470-600 foot interval of the Baillie-Hamilton Island section. The first two of these taxa are not shown on text-figure 13 for reasons of clarity. No Palaeoscenidiidae common to the Baillie-Hamilton Island and Cape Phillips sections were found in the Cape Becher section, hence is group cannot be used for correlation between these areas.

Ceratoikiscum new species B occurs as a 'single sample' taxon in the Cape Phillips and Baillie-Hamilton Island sections at the 625 and 760 foot horizons respectively.

Text-figure 14 is a attempt to use Radiolaria as a correlation tool between these sections.

Using the assumption that the incoming of taxa can be used as time lines it is possible to correlate the bases of the Cape Phillips and Baillie-Hamilton Island sections. Considering the evidence of the palaeoactinommids, it appears that the 600 foot level of the composite Cape Phillips section is approximately equivalent to the 460 foot level of the Baillie-Hamilton Island section 1. This would also appear to be equivalent to the 270 foot horizon of the Cape Becher section.

Haliomma new species A is the only guide-line to the correlation of the upper part of the Cape Phillips and Baillie-Hamilton sections. Its occurrence here is used tentatively as a time line.

Using this extremely fragmenta evidence, several things can be said about these sections as regards their relative ages and sedimentation rates.

1. The Cape Phillips and Baillie-Hamilton 1 sections are practically time equivalent at their bases and have an overall similar sedimentation rate.

2. Sedimentation rates appear to be greater in the lower part of the Cape Phillips sections than in the Baillie-Hamilton Island section 1 as the first 600 feet of the Cape Phillips area is time equivalent to the first 460 feet of the Baillie-Hamilton section 1. However this state of affairs reverses and above this sedimentation takes place more rapidly in the Baillie-Hamilton Island area.

No comments of this nature can be made about the Cape Becher section as there is not enough information available to compare horizons.

CORRELATION BETWEEN CAPE PHILLIPS, BAILLIE-HAMILTON AND CAPE BECHER USING GRAPTOLITES.

Thorstiensson (1958) of the Geological Survey of Canada proposed a graptolite zonation for the Cape Phillips type section. This is shown in Text-figure 15. The zonation shown for the Baillie-Hamilton Island and Cape Becher sections was drawn up from field notes made by Drs. Chatterton, Perry and Lenz in the field seasons of 1976-78 and by Dr. Chatterton and the writer in 1979. Thr zonal boundaries shown for the two non type sections (Baillie-Hamilton and Cape Becher) should not be taken as definitive, but rather as approximations.

Text-figure 15, apart from showing the graptolite zonation, also shows correlation between the sections using the zone boundaries as time lines.

According to this correlation the 300 foot level of the Cape Phillips section is equivalent to the 200 foot level of the Baillie-Hamilton section 1 and the 50 foot level of the Cape Becher section. Sedimentation between the 300 foot and 400 foot levels of the Cape Phillips section and the 200-300 foot levels of the Baillie-Hamilton section is constant and time equivalent whereas above this the sedimentation rate in the Baillie-Hamilton area is greater than that for the Cape Phillips area. The top of the Cape Phillips section can be seen to be equivalent to the top of the Cape Becher section. In the Baillie-Hamilton Island area the base of the Monograptus testis Zone is not seen in section 1 but occurs at or just below the base of section 2, this graptolite being found in the lowermost part of this section.

COMPARISON BETWEEN THE RADIOLARIAN AND GRAPTOLITE CORRELATIONS.

Great similarities can be seen in the conclusions obtained from using Radiolaria and Graptolites as correlation tools between these sections. The agreement of these two methods, even considering the paucity of presently available radiolarian material, indicates that Lower Paleozoic Radiolaria have a potential use as s atigraphic tools in the Canadian Arctic.

BIBLIOGRAPHY

Aberdeen, E., 1940. The radiolarian fauna of the Caballos Formation Marathon Basin, Texas. J. Paleont. 14 No.2:127-139

Anderson, O.R., 1976. A cytoplasmic fine structure study of two spumellarian Radiolaria and their symbionts. Marine Micropaleontology, 1 No.1 p.81

Berendsen, P. and Nodine-Zeller, D., 1978. Radiolaria and sponge bearing phosphate nodules from Pennsylvanian black shales, south east Kansas. Geol. Soc. Am. Abstr. Progr. 10 No.1 pp.1-2

Berger, W.H., 1968. Radiolarian skeletons: Solution at depth. Science 159 pp.1237-8.

Bergstrom, S.M., 1974. The oldest known well preserved radiolarians from N.America. Geol. Soc. Am. Abstr. Prog. 6 p.491.

Bergt, W., 1905. Radiolarinfuhrende Kieselschiefer in "Kambrium" von Tharandt in Sachen. Zentralblatt fuer mineralogie, geologie und palaontologie 13 p.411

Cachon, J. and Cachon, M., 1974. A comparative study of the cytology and skeletal architecture of the Radiolaria: A new basis for a systematics. in Marine Plankton and Sediments and the Third Planktonic Conference. Int. Counc. Sci. Unions. U.N.E.S.C.O.

1974. Les systèmes axopodiaux. Année Biol. (Paris). 13 No.11-12 pp.523-560.

1976. The axopods and Radiolaria in their free and ectoplasmic parts: Structure and function. Arch. ProKstanKd. 118 No.4 pp.310-320

Campbell,A.S., 1951. New genera and subgenera of Radiolaria. J. Paleont. 25 No.4 pp.527-30.

1954. Radiolaria. In Treatise on Invertebrate Paleontology D Protista 3 pp.11-163. ed Moore,R.C. Geol. Soc. Am. and U. of Kansas Press.

Casey,R.E., 1971. Radiolarians as indicators of past and present water masses. In The Micropaleontology of the Oceans, Ed. Funnell, B.M. and Riedel,W.R. pp.331-341. Cambridge Univ. Press.

1977. Ecology and distribution of Recent Radiolaria. Oceanic Micropaleontology 2 pp.809-896. ed. Ramsey,A.T.S. Academic Press.

Deflandre,G., 1953. Radiolaires fossiles in Traité de Zoologie, Anatomie, Systématique, Biologie. 1 Fasc.II pp.390-436.

1960. Á propos du dévellopment des recherches sur les Radiolaires fossiles. Rev. Micropal. 2 pp.212-213.

1972. Further remarks on the morphology and nomenclature of some Paleozoic radiolarian genera. Acad. Sci. C.R. Ser.D. 275 No.1 pp.13-16.

1973. Observations et remarques sur les

radiolaires sphaerellaires du Palaeozoique à propos d une nouvelle espèce, visèenne, du genre Foremaniella Deflandre, parfait intermédaire entre les Periaxoplastidies et les Pylentonemides. Acad. Sci. C.R. 276 No.7 pp.1147-1151.

Dunham,J.B. and Murphy,M.A., 1975. An occurrence of well preserved radiolarians from the Upper Ordovician of central Nevada. Geol. Soc. Am. Abst. Prog. 7 No.3 p.313.

Enriques,P. 1931. Formazione e suiloppo dello scheletio siliceo nei Radiolari. Boll. di Soc. Ital di Biologia sperimentali pp.350-356.

Foreman,H. 1963. Upper Devonian Radiolaria from the Hur Member of the Ohio Shale. Micropaleo. 9 No.3 pp.267-304

Fortey,R.A. Holdsworth,B.K. 1971. The oldest known well preserved Radiolaria. Boll.della Soc. Paleont. Italiana 10 pp.35-41.

Gadea,E. 1975. Heliozoans at the crossroads of rhizopod phylogeny. Soc. Espan. Hist. Nat. Bol. Secc. Biol. 72 pp.67-73.

Grunau,H. 1965. Radiolarian cherts and associated rocks in space and time. Eclogae Geol. Helv. 58 No.1.

Gutschick,R.C. and Sandberg,C.A. 1977. Mississippian Radiolaria and agglutinated forams. from deep water sediments in Utah. Geol. Soc. Am. Abstr. Prog. 9 No.5 pp.601.

Haeckel,E. 1887. Report on the Radiolaria collected by H.M.S. Challenger during the years 1873-1876. Challenger reports, Zoology, 18 (2 parts).

Henbest,L.B. 1936. Radiolaria in the Arkansas novaculite, Caballos novaculite and the Bigfork chert. J.Paleont. 10 pp.76-78.

Hinde,J.G. 1890. Notes on Radiolaria from the Lower Paleozoic rocks (Llandeilo-Caradoc) of the south of Scotland. Ann.and Mag. Natur. History. Series 6 Vol 6 No.31.

1899. On the Radiolaria in the Devonian rocks of New South Wales. Quart. J. Geol. Soc. Lond. 55. p.38.

Holdsworth,B.K. 1966. A preliminary study of the paleontology and paleoenvironment of some Namurian limestone "bullions". The Mercian Geologist 1 pp.315-[illegible]

1969. The relationship between the genus Albaillella (Deflandre) and Ceratoikiscid Radiolaria. Micropaleo. 15 No.2 pp.230-236.

1969. Namurian Radiolaria of the genus Ceratoikiscum from Staffordshire and Derbyshire. Micropaleo. 15 No.2 pp.221-229.

1971. The ceratoikiscid nature of the Radiolaria Lapidpiscum piveteaui (Deflandre). Micropaleo.17 No.2 pp.244-248.

1973. The Radiolaria of the Baltalimani

Formation., Lower Carboniferous, Istanbul. in The Paleozoic of Istanbul. ed., Kaya,O. Ege. Univ. Fen. Fak. Kitaplar. Serisi, Jeol., 40 pp.117-134.

1977. Paleozoic Radiolaria: Stratigraphic distribution in Atlantic Borderlands. In The Stratigraphic micropaleontology of Atlantic Basin and Borderlands. Ed.Swain,F.M. pp.167-184. Developments in Paleontology and Stratigraphy 6. Elsevier.

Jones,D., Allison,C. 1978. Upper Devonian radiolarians separated from chert of the Ford Lake Shale, Alaska. U.S. Geol. Surv. J. Res. 6 No.6 pp.775-788.

Hollande,A. and Enjumet,M. 1960. Cytologie, évolution et systèmatique des Sphaeroides (Radiolaires). Arch. Mus. Nat. Hist. Natur. Ser.7 Vol.7 pp.7-134.

Jasna,L.F. 1976. Lower Paleozoic Radiolaria bearing limestones from the Baffin Island shelf. Can. Geol. Surv. Paper 76-1B pp.99-105.

Kling,S.A. 1978. Siliceous Microfossils: Radiolaria: in Introduction to Marine Micropaleontology. Eds., Haq,B.U. et al. pp.203-244. Elsevier.

Kozlova,G.E. 1971. Experience in coding systematic features of Radiolaria. Vses. Neft Nauch-Issled. Geol. Inst. Trudy No 291 pp.107.

Lipman,R.A. 1973. Invertebrates, Protozoans, Radiolarians.

(Translation). Stratigrafiya S.S.S.R. Devonskaya sistema. Kniga 2; fauna (Ed. Nalivkin et al.) p.228.

Loeblich,A.R. and Tappan,H. 1961. Remarks on the systematics of the Sarcodina (Protozoa); renamed homonyms and new and validated ge[illegible] Proc. Biol. Soc. Wash. 74 [illegible] .213-[illegible]

MacKenzie,W.S. 1977. Radiolaria f[illegible] the [illegible] Formation N.W.T. Can.Geol.Surv.Paper 74-[illegible] p.319.

McMillen,K.J. 1977. Ecology, d[illegible]ibution and preservation of polycistine Radiolaria in the Gulf of Mexico and the Caribbean. Diss. Abstr. Int. 38 No.3 pp.1100.

1977. Modern radiolarian habitats and the reliability of interpretations based on the fossil record. Geol. Soc. Am. Abstr. Prog. 9 No.7 p.1091.

Molina-Cruz,A. 1977. Radiolarian assemblages and their relationships to the oceanography of the sub-tropical southeast Pacific. Marine Micropaleontology 2 No.4 p.315.

Moore,T. 1969. Radiolaria: change in skeletal weight and resistance to solution. Geol.Soc.Am. Bull.80 No.10 pp.2103-2107.

Mordukhai-Boltuvskoi,D.D. 1936. Geometriya radiolyarii. Uchen.zap. Rostovskogo na Donu Gos.Universiteta. Vol 7 pp.1-91.

Nazarov B.B. 1973. The first discovery of the Radiolaria

Entactiniidae and Ceratoikiscida in the Upper Devonian of the S.Urals. Akad. Nauk. S.S.S.R. Dokl. 210. No.3 pp.696-699.

1975. Systematics of the Paleozoic sphaeroids. Vses.Nauchno-Issled.Geol.Inst.Trudy 226 pp.35-40.

1975. Lower to Middle Paleozoic radiolarians of Kazakhstan. Akad.Nauk.S.S.S.R.Geol.Inst. Trudy 275 pp.1-203

1977. A new radiolarian family from the Ordovician of Kazakhstan. Paleont. J. 11 No.2 p. 165.(Translated from the Russian version)

Nazarov,B.B., Popov.L. and Apollovov,M.K. 1977. Lower Paleozoic radiolarians of Kazakhstan. Int.Geol.Rev. 19 No.8 pp.913-920.

Ormiston,A.R. and Lane,H.R. 1975. Exceptional Radiolaria and associated conodonts from the Sycamore Lst. Arbuckle Mts. Oklahoma. Geol.Soc.Am.Abstr.Prog. 7 No.6 p.832.

Petrushevskaya,M.G. 1970. The adaptive significance of body shape in radiolarians. Akad.Nauk.S.S.S.R. Dokl. Vol 194 No.2

1971. On the natural system of Polycistine Radiolaria. Procceedings of the second Planktonic Conference of Rome(1970). pp.981-992.

1974. On the evolution of radiolarian species. Teoreticheskiye voprosy sistematiki i filogenii zhivotuykh. Akad.Nauk.S.S.S. ol. Inst.Trudy 53.pp.83-92.

Popofsky,A. 1911. Die Sph ellarien der warmwassergebietes. Deutsche Sudpolar-Expedition (1901-1903). Vol 13 (Zool. Vol 5) pp.73- 9.

Reudemann,R. and Wilson,T.Y. 1936. Eastern New York Ordovician cherts. Geol.Soc.Am.Bull. 47 pp.1535-86.

Riedel,W.R. 1967. Some new families of Radiolaria. Proc.Geol.Soc.Lond. No.1640 pp.148-9.

et al. 1967. Subclass Radiolaria. In The Fossil Record, ed.Harland. Geol.Soc.Lond. pp.291-8.

Riedel,W.R. and Foreman,H. 1961. Type specimens of North American Radiolaria. J. Paleont. 35 pp.628-32.

Rodic,J. 1931. Radiolarien in Kieselshciefern Mittel-Bohemens. Lotus No.79.

Rothpletz,A. 1880. Radiolarien, Diatomacean und Sphaeromatiten in Silurischen Kieselschiefer von Langenstriegis in Sachsen. Z.D sch.Geol.Ges. 32.

Rust,R.D. 1891-1892. Beitrage zur Kenntniss der fossilen Radiolarien ams Gesteinen der Trias und der Palaeozoischen Schichten. Palaeontographica 38.

Sadrislamov,B.M. 1972. Significance of radiolarians in clarifying the stratigraphy of Paleozoic deposits in the southern Urals. in Problems of geology and magmatism of the southern Urals. Proc. first Uralian Conference of Young Geologists and Geophysicists. April 1972. Izd.-vo Ural'sk.

Fil. AN S.S S.R. Sverdlovsk.

Schwarz,A. 1931. Uber den Korperbau der Radiolarien. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 43 pp.1-17.

Smirnova,N.A. 1971. The possibility of correlating the Lower Paleozoic deposits of Kazakhstan on the basis of the Radiolaria. Strat.Conf. on the pre Paleozoic and Paleozoic Kazakhstan. (Abstract of papers).

Smirnova,N.A. and Pupyshev,N.A. 1975 ie correlation of Lower Paleozoic deposits of central Kazakhstan based on the Radiolarians. Vses Nauchno-Issled. Geol Inst. Trudy. 226 pp.63-66.

Smith,W.D. 1916. Notes on a radiolarian chert in Oregon. Am.Jour.Sci. 4th Series Vol 42 pp.299-300.

Sturmer,W. 1966. Das Wachstum siluri er Sphaerellar an und ihre spateren chemischen Umnandlungen. Palaon.. 40 pp.257-261.

Thompson,D'Arcy. 1952. On growth and Form. (2 Vols). Second Edition. Cambridge University Press.

Thorsteinsson,R. 1958. Cornwallis and Little Cornwallis Islands, District of Franklin, Northwest Territories. Geol. Surv. Can. Mem. 294

Thorsteinsson,R. and Kerr,W. 1968. Cornwallis Island and adjacent smaller islands, Canadian Arctic Archipelago. Geol.Surv.Can. Pape 67-64.

APPENDIX

SECTION LOCATIONS AND INVENTORY OF SAMPLES PROCESSED

CAPE PHILLIPS SECTIONS

1976 Cape Phillips (See Appendix map 1)

Total thickness: 550 feet.

Starting Point: At small creek junction wi h coastline.

Ending Point: At covered interval just before the deep gullied creek running at right angles o the shoreline.

This section is equivalent to the 4720-4330ft. interval of Thorsteinsson's section (G.S.C. Memoir 294).

Collected and measured by: A.C.Lenz and D.G.Perry.

1979 Cape Phillips (See Appendix map 1)

Total thickness: 714 feet.

Starting Point: Where tectonic disturbance ends east of the major cliff forming ?Disappointment Bay Fmn, permitting section measurement.

Ending Point: At covered interval just before the deep gullied creek running at right angles to the shoreline. (As for 1976 CP).

This section meets the 1976 section base 320 ft. and Thorsteinsson's fish beds (4640-30ft.) at 439ft (N.B. Thorstein measured down the stratigraphic section while the 1976 and 1979 sections were measured in the younging direction).

Collected and measured by: B.D.E.Chatterton and Q.H.Goodbody.

HORIZON	PRODUCTIVITY
135ft (44m)	PRODUCTIVE
165ft (54m)	PRODUCTIVE
175ft (57m)	PRODUCTIVE
295-300ft (97-98m)	PRODUCTIVE
315-325ft (103-107m)	PRODUCTIVE
325-330ft (107-108m)	PRODUCTIVE
325-350ft (108-115m)	PRODUCTIVE
330-340ft (108-112m)	PRODUCTIVE
340-350ft (115-116m)	PRODUCTIVE
340-355ft (112-116m)	PRODUCTIVE
365-375ft (120-123m)	PRODUCTIVE
390-400ft (128-131m)	PRODUCTIVE
425ft (139m)	PRODUCTIVE
445ft (146m)	PRODUCTIVE
465ft (152m)	PRODUCTIVE

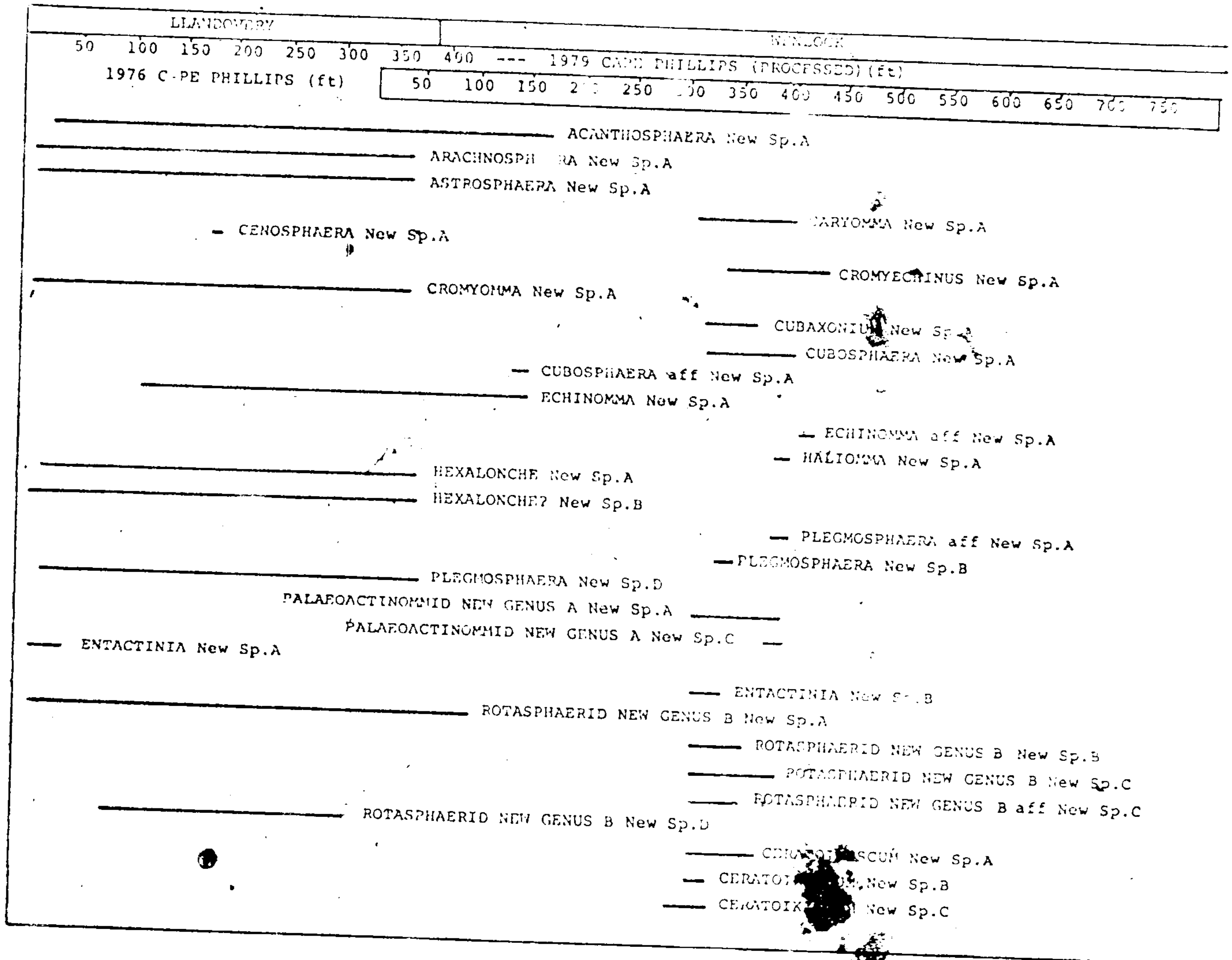
SAMPLES PROCESSED AND PROCESSING RESULTS FROM THE 1976 CAPE PHILLIPS SECTION

APPENDIX TABLE I

HORIZON	PRODUCTIVITY	HORIZON	PRODUCTIVITY
6ft (2m)	PRODUCTIVE	165ft (51.5m)	PRODUCTIVE
15ft (5m)	PRODUCTIVE	180ft (54m)	PRODUCTIVE
25ft (8m)	PRODUCTIVE	215ft (59m)	PRODUCTIVE
27ft (8.5m)	PRODUCTIVE	238ft (70.5m)	PRODUCTIVE
29ft (9.5m)	PRODUCTIVE	254ft (78m)	PRODUCTIVE
58ft (19m)	PRODUCTIVE	263ft (83.5m)	PRODUCTIVE
67ft (22m)	PRODUCTIVE	267ft (86.5m)	PRODUCTIVE
70ft (23m)	BARREN	271ft (87.5m)	PRODUCTIVE
91ft (30m)	PRODUCTIVE	276ft (89m)	PRODUCTIVE
108ft (33m)	PRODUCTIVE	279ft (90.5m)	PRODUCTIVE
118ft (39m)	PRODUCTIVE	308ft (101m)	PRODUCTIVE
127ft (41.5m)	PRODUCTIVE	312ft (102m)	PRODUCTIVE
129ft (42m)	PRODUCTIVE	329ft (108m)	PRODUCTIVE
132ft (43m)	PRODUCTIVE	330ft (108.5m)	PRODUCTIVE
150ft (49m)	PRODUCTIVE	349ft (114.5m)	PRODUCTIVE
155ft (51m)	PRODUCTIVE	353ft (116m)	PRODUCTIVE

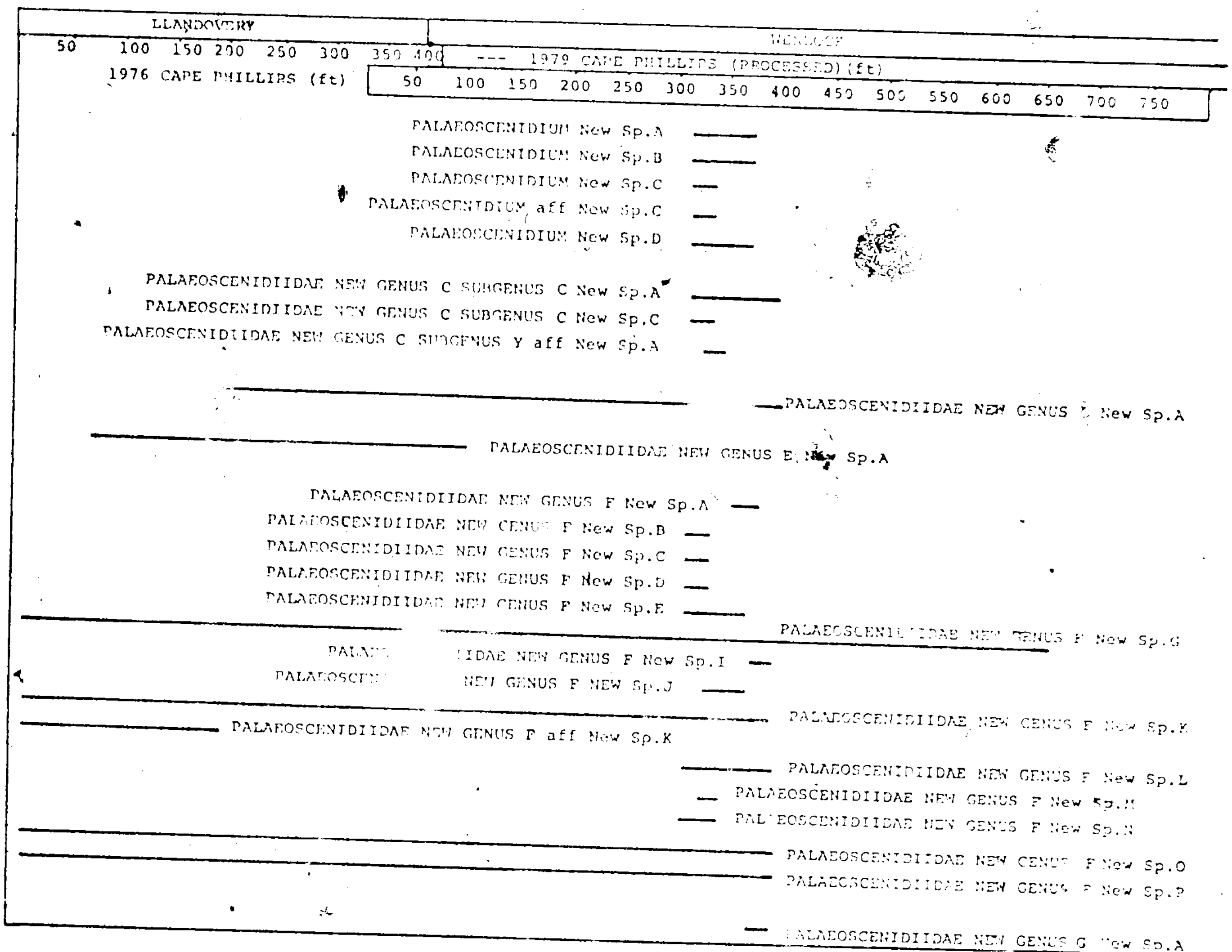
SAMPLES PROCESSED AND PROCESSING RESULTS FROM THE 1979 CAPE PHILLIPS SECTION

APPENDIX TABLE II



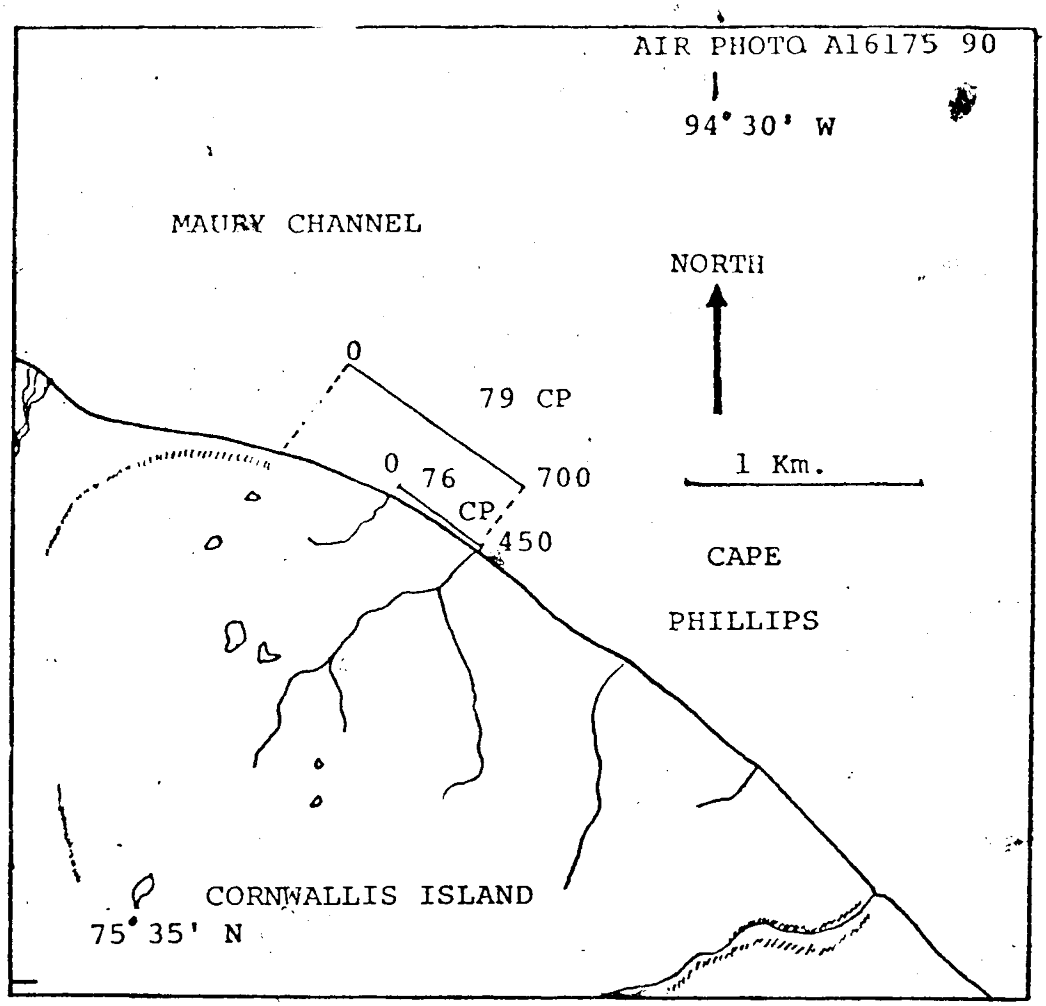
RANGES OF RADIOLARIA FOUND IN THE CAPE PHILLIPS SECTIONS: ENTACTINIIDAE, CERATOIKISCIDAE, PALAEOACTINOMMIDS AND ROTASPHAERIDS.

APPENDIX TABLE IIIa.



RANGES OF RADIOLARIA FOUND IN THE CAPE PHILLIPS SECTIONS: PALAEOSCENIDIIDAE

APPENDIX TABLE IIIb



LOCATION OF THE 1976 AND 1979 CAPE PHILLIPS SECTIONS.

APPENDIX MAP 1.

BAILLIE-HAMILTON SECTIONS

1976 Baillie-Hamilton Island Section 1

Location: 75 degrees 94 mins. North 94 degrees 25 mins. West.

Total thickness: 925ft.

Starting Point: Start of section within the Cape Phillips Fmn. approximately 200ft. east of Thorsteinsson's Camp Creek in the centre of a small sharp anticline along the shoreline.

Ending point: At the limit of outcrop approximately 300ft. above sea level south-east of a small lake which is half a mile inland.

Collected and measured by: B.D.E.Chatterton, A.C.Lenz and D.G.Perry.

1976 Baillie-Hamilton Island section 2

Location: 75 degrees 46 mins. North 94 degrees 23 mins. West. (See Appendix map 2)

Total thickness: 400ft.

Starting Point: Approximately 600 feet east of a small creek flowing into the sea. Section taken from the first outcrop along the shoreline.

Collected and measured by: B.D.E.Chatterton, A.C.Lenz and D.G.Perry.

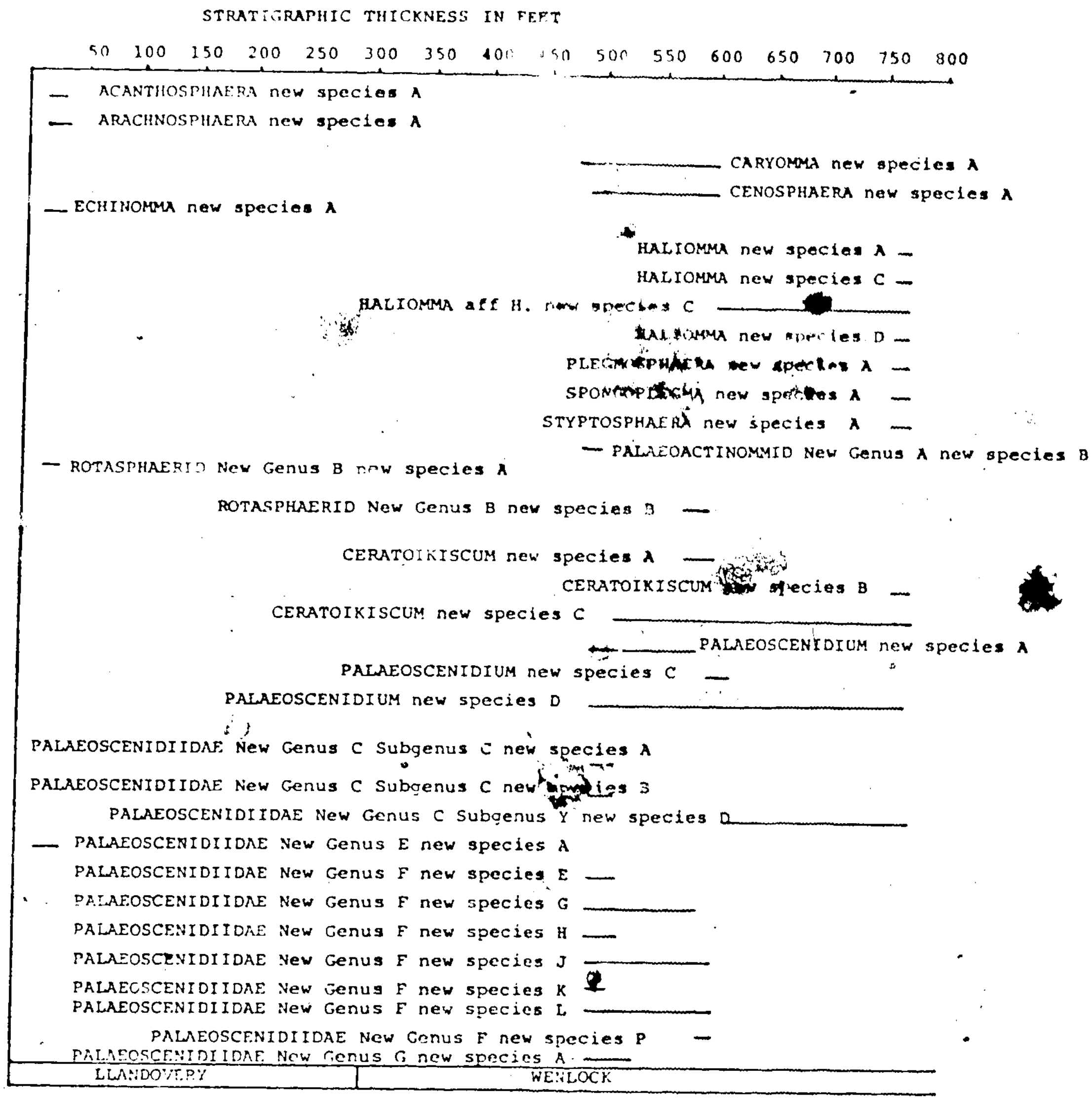
HORIZON	PRODUCTIVITY
33-36ft (11-12m)	PRODUCTIVE
91ft (30m)	BARREN
200ft (98.5m)	BARREN
358ft (117m)	BARREN
362ft (119m)	BARREN
369ft (121m)	BARREN
409ft (134.5m)	BARREN
470ft (154.5m)	PRODUCTIVE
480ft (157.5m)	PRODUCTIVE
487ft (160m)	BARREN
520ft (171m)	PRODUCTIVE
540ft (177.5m)	BARREN
600ft (197m)	PRODUCTIVE
670ft (220m)	BARREN
675ft (222m)	BARREN
685ft (225m)	BARREN
710ft (233m)	PRODUCTIVE
765ft (251m)	PRODUCTIVE

SAMPLES PROCESSED AND PROCESSING RESULTS FROM THE 1976 BAILLIE-HAMILTON ISLAND SECTION 1

APPENDIX TABLE IV

HORIZON	PRODUCTIVITY
5ft (1.5m)	BARREN
25ft (8m)	BARREN
35ft (11.5m)	PRODUCTIVE
45ft (15m)	BARREN
60ft (20m)	BARREN
130ft (42.5m)	PRODUCTIVE
150ft (49m)	PRODUCTIVE
185ft (60.5m)	PRODUCTIVE
215ft (70.5m)	PRODUCTIVE
235ft (77m)	PRODUCTIVE
245ft (80.5m)	PRODUCTIVE
265ft (87m)	PRODUCTIVE
290ft (95m)	PRODUCTIVE
368ft (121m)	BARREN

SAMPLES PROCESSED AND PROCESSING RESULTS FROM THE 1976
BAILLIE-HAMILTON ISLAND SECTION 2
APPENDIX TABLE V

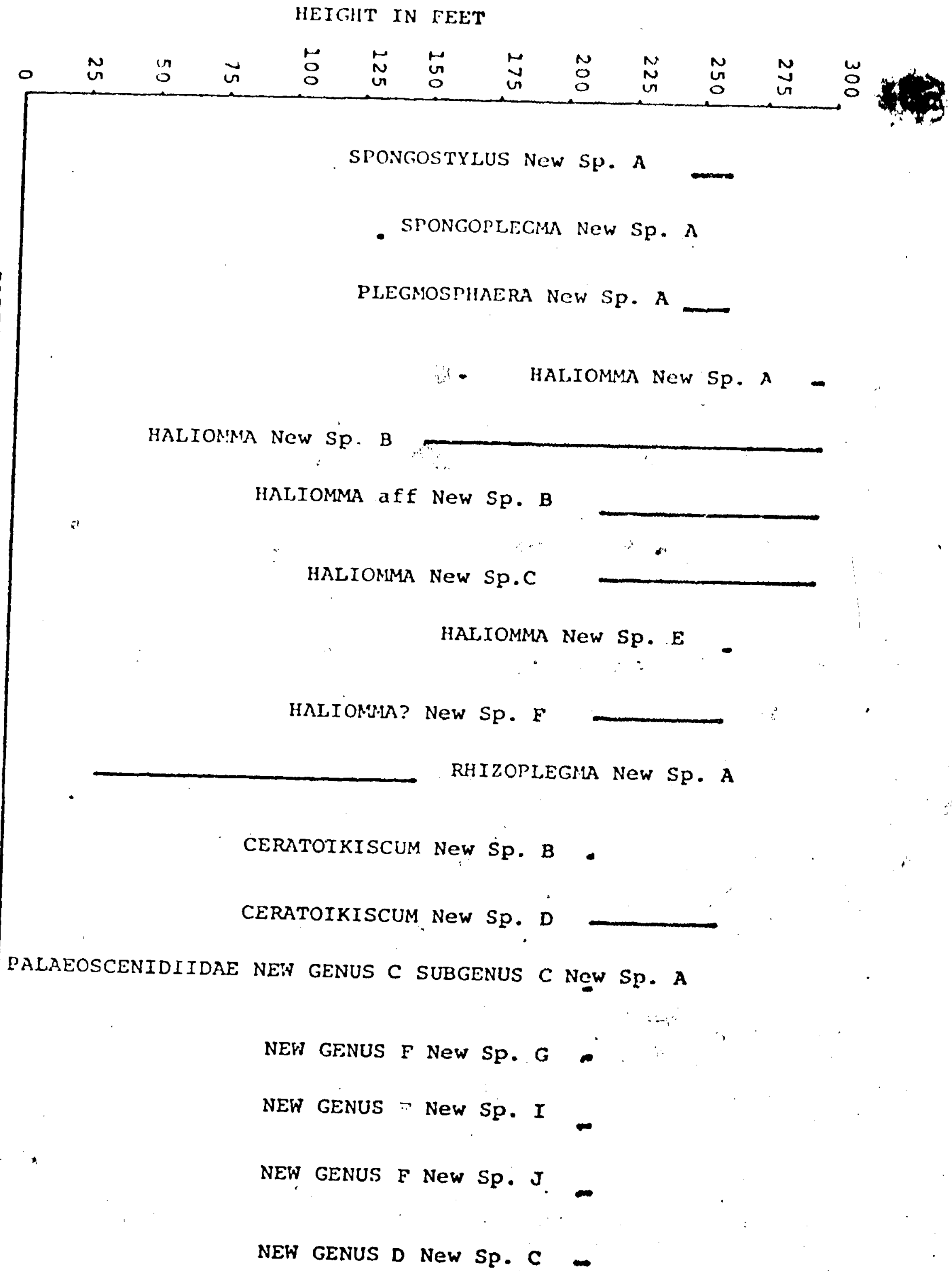


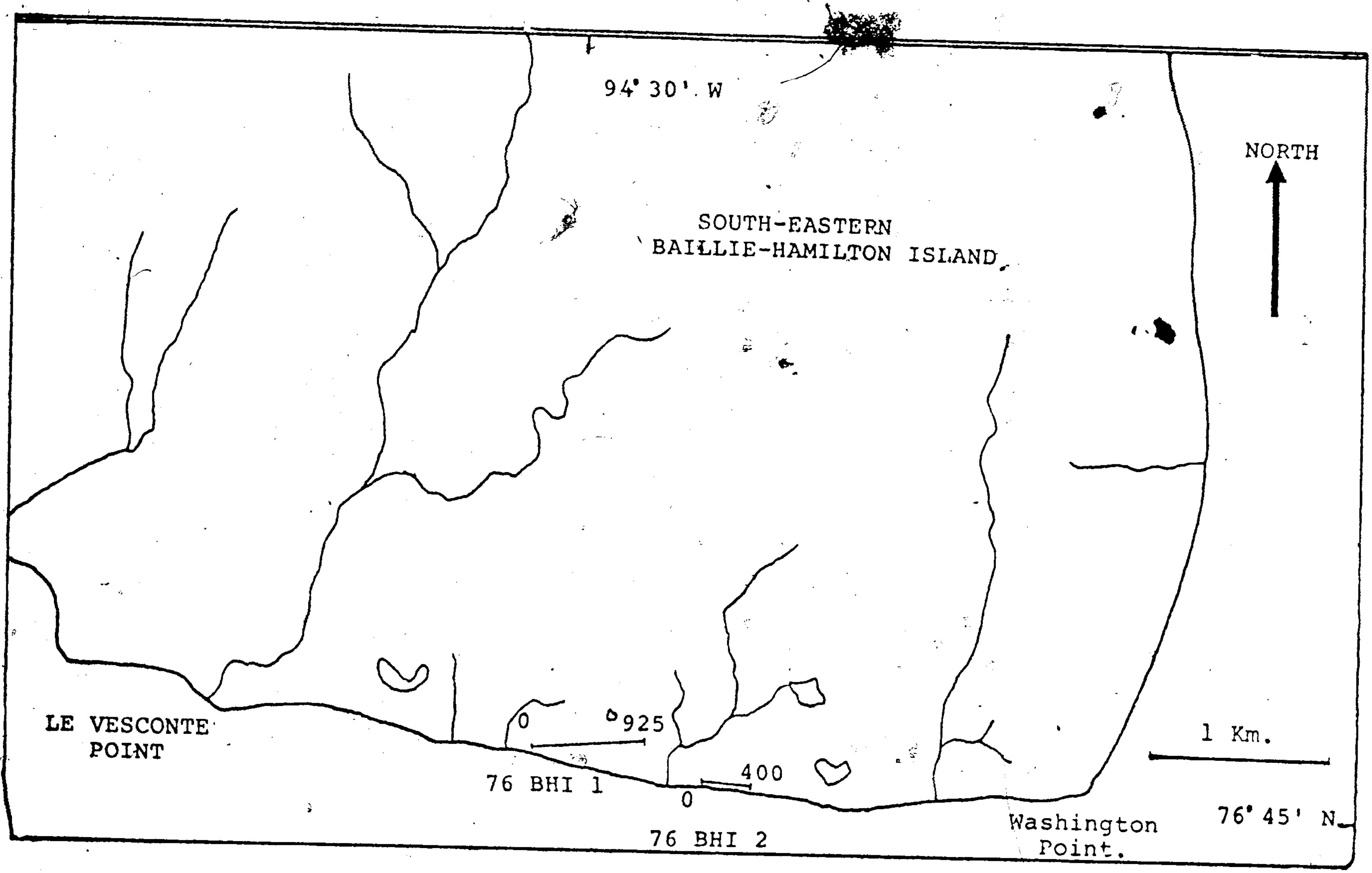
RANGES OF RADIOLARIA FOUND IN BAILLIE HAMILTON ISLAND
SECTION I

APPENDIX TABLE VI

APPENDIX TABLE VII

RADIOLARIA OCCURRING, AND THEIR POSITION, IN THE 1976 BAILLIE-HAMILTON ISLAND SECTION 2





APPENDIX MAP 2

AIR PHOTO A 16175-93

SKETCH MAP OF LOCATION OF BAILLIE-HAMILTON ISLAND SF [illegible]ONS

1979 Point Fitzjames Section, Baillie-Hamilton Island

Location: 75 degrees 57 mins. North 94 degrees 51 mins. West

Total thickness: 498ft. (section measured in meters-thickness 152m)

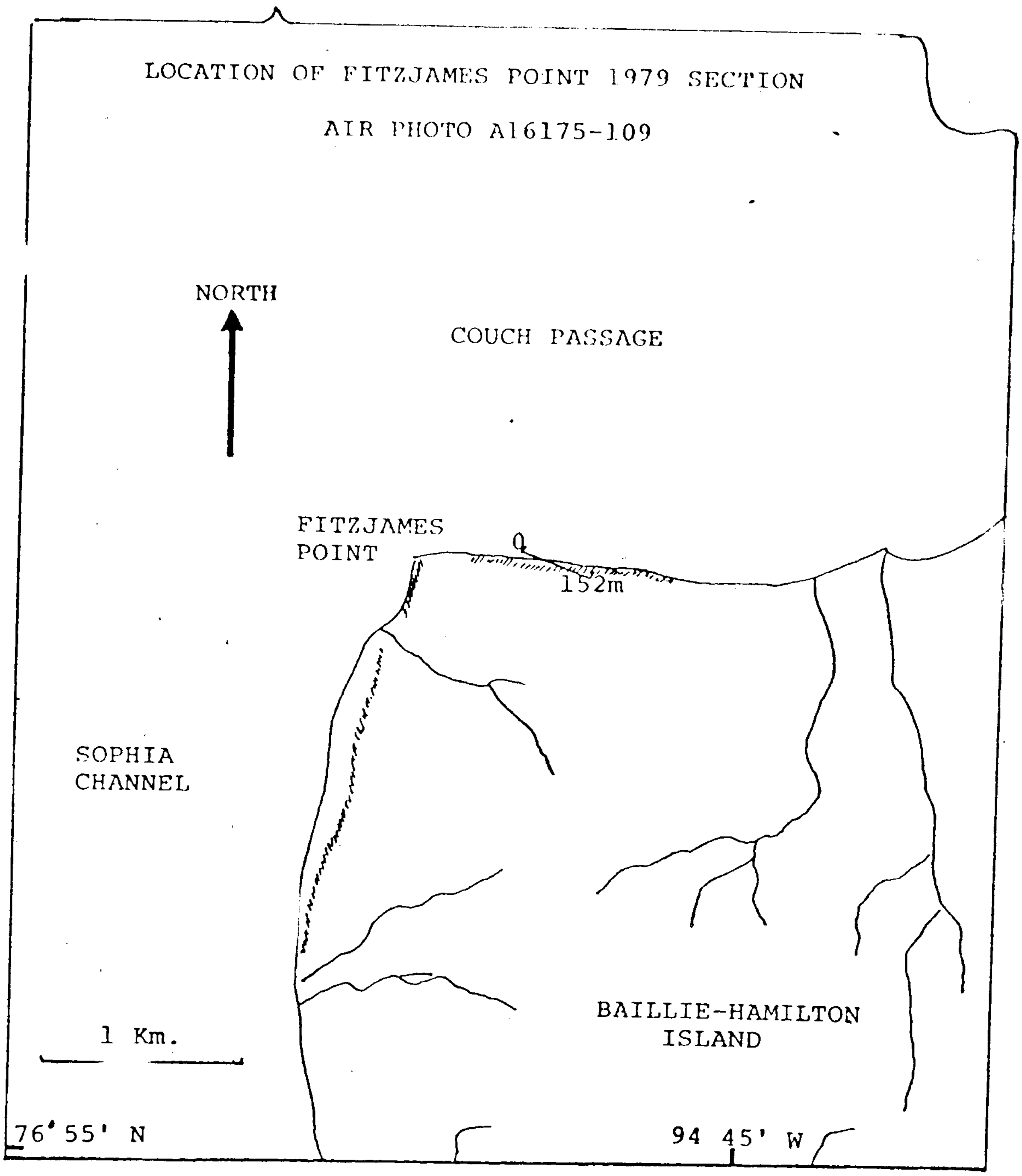
Starting Point: On the East side of a small box-fold/conjugate fault pair approximately 1200 ft. from the point.

Collected and measured by: B.D.E.Chatterton and Q.H.Goodbody.

HORIZON	PRODUCTIVITY
0	BARREN
8.5m (28ft)	BARREN
11.5m (38ft)	BARREN
12m (39ft)	PRODUCTIVE
19m (62ft)	BARREN
24m (79ft)	BARREN
25m (82)	BARREN
27.5m (90ft)	BARREN
35m (115ft)	BARREN
56m (184ft)	BARREN

SAMPLES PROCESSED AND PROCESSING RESULTS FROM THE 1979 FITZJAMES POINT SECTION, BAILLIE-HAMILTON ISLAND

APPENDIX TABLE VIII



APPENDIX MAP III

1976 Abbott River, Cornwallis Island

Location: 75 degrees 14 mins. North 95 mins. West (See Appendix map 4)

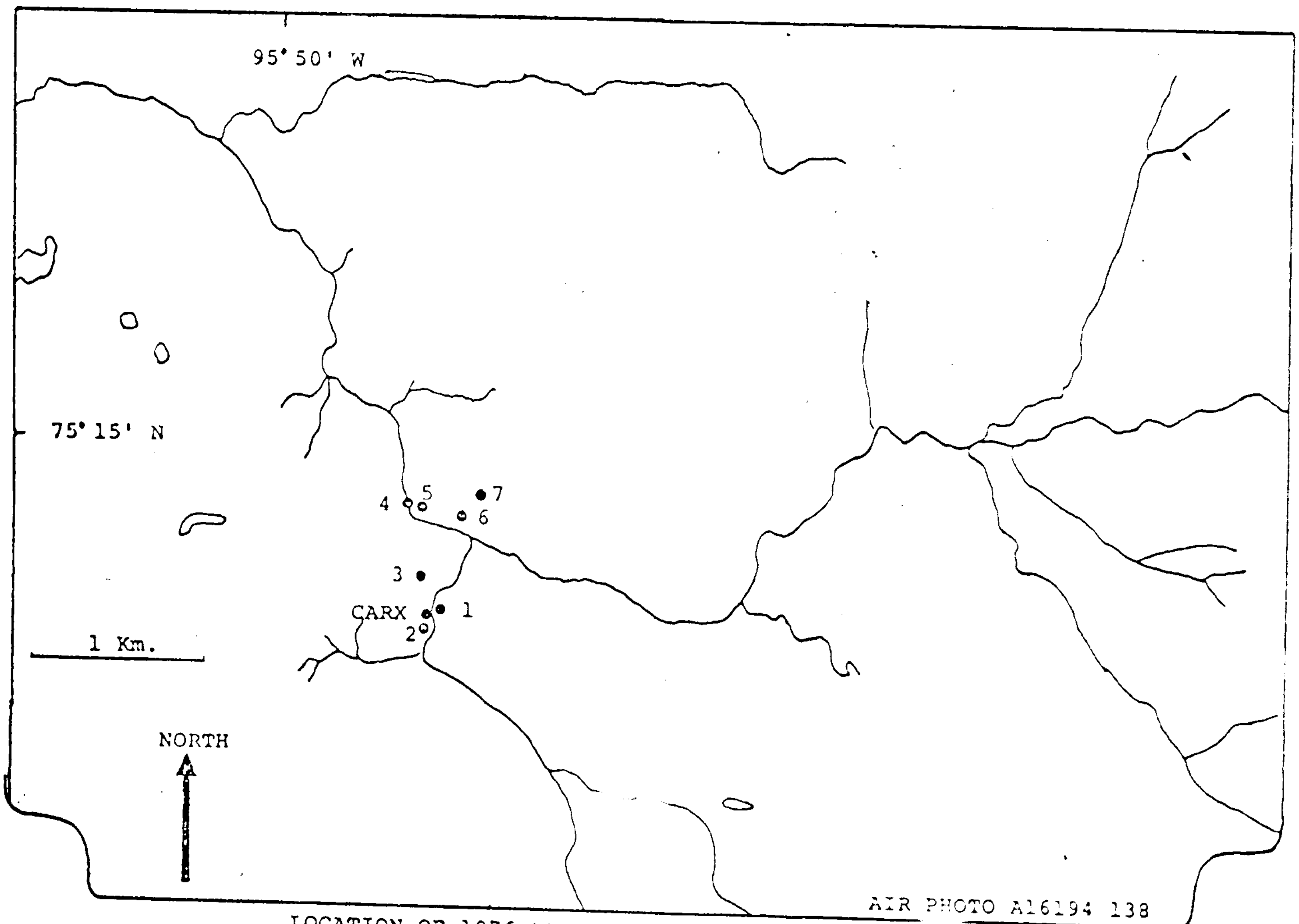
Samples from outcrops in the vicinity of the river. CAR 1 and CARX are both short sections, CARX being across the river and slightly to the south of CAR 1 in younger rocks. CAR 2 is uphill from CAR X.

Collected and measured by: B.D.E.Chatterton, A.C.Lenz and D.G.Perry

HORIZON	PRODUCTIVITY
CAR 1	BARREN
CAR 3	BARREN
CAR 4	BARREN
CAR 5	PRODUCTIVE
CAR 6	BARREN
CAR 7	BARREN
CARX 40	BARREN
CARX 45	PRODUCTIVE
CARX 78	BARREN
CARX 105	BARREN

SAMPLES PROCESSED AND PROCESSING RESULTS FROM THE UPPER WENLOCK OF THE ABBOTT RIVER AREA CORNWALLIS ISLAND

APPENDIX TABLE IX



LOCATION OF 1976 ABBOTT RIVER SAMPLES: CORNWA IS ISLAND.

APPENDIX MAP IV

Sample locations from the Laura Lakes area, eastern Cornwallis Island.

Location: 75 degrees 11 mins. North 94 degrees 55 mins. West (See Appendix map 5)

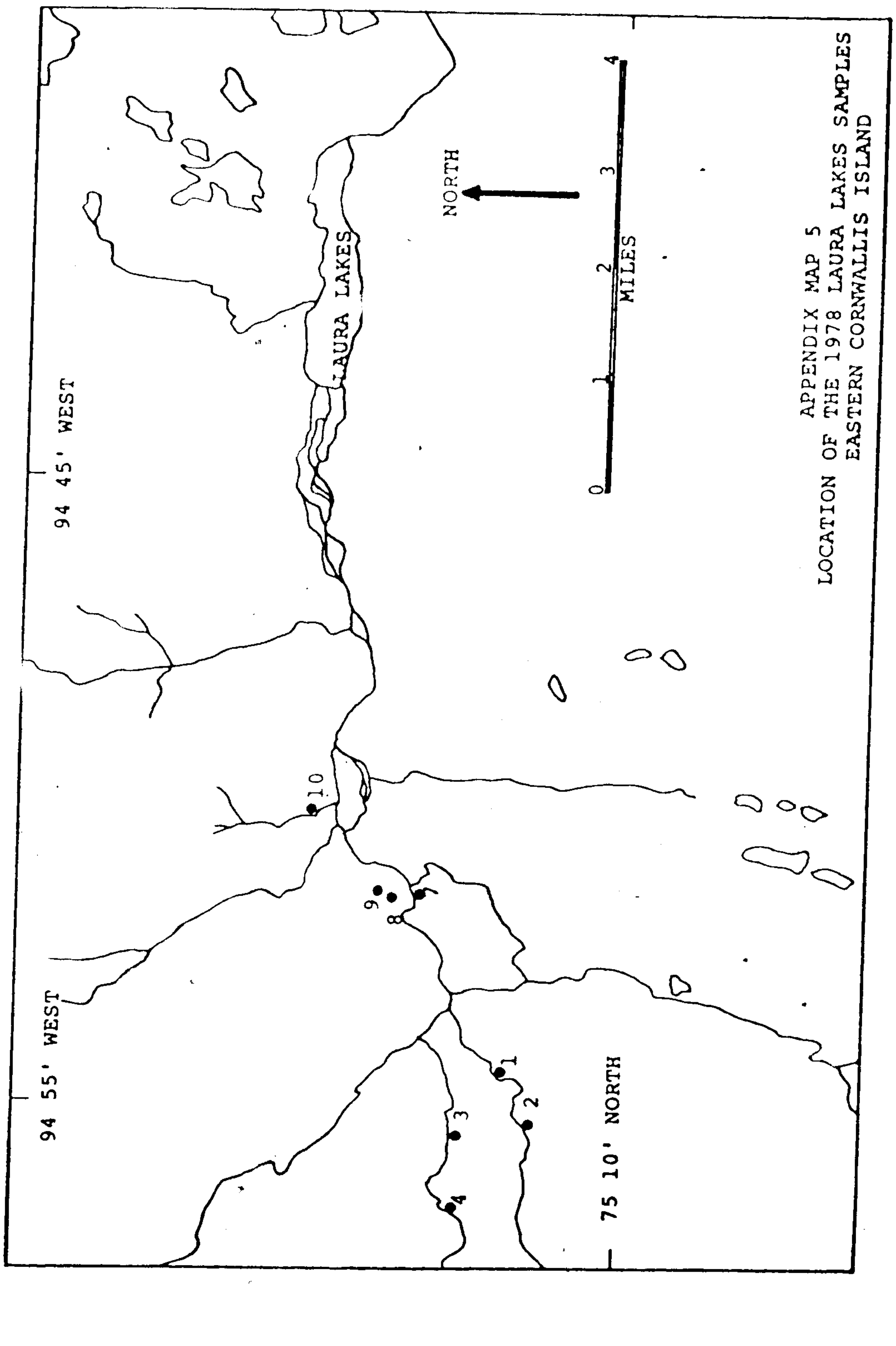
Samples from outcrops along the deeply incised stream valleys. The oldest samples taken are in the west, the samples ranging from the Lower Llandovery (LL 4) to the lower Ludlow (LL 10).

Collected and measured by: A.C.Lenz and D.G.Perry.

HORIZON	PRODUCTIVITY
LL 4	PRODUCTIVE
LL 7	PRODUCTIVE
LL 9	PRODUCTIVE
LL 10	PRODUCTIVE

SAMPLES PROCESSED AND PROCESSING RESULTS FROM THE LAURA LAKES AREA OF CORNWALLIS ISLAND

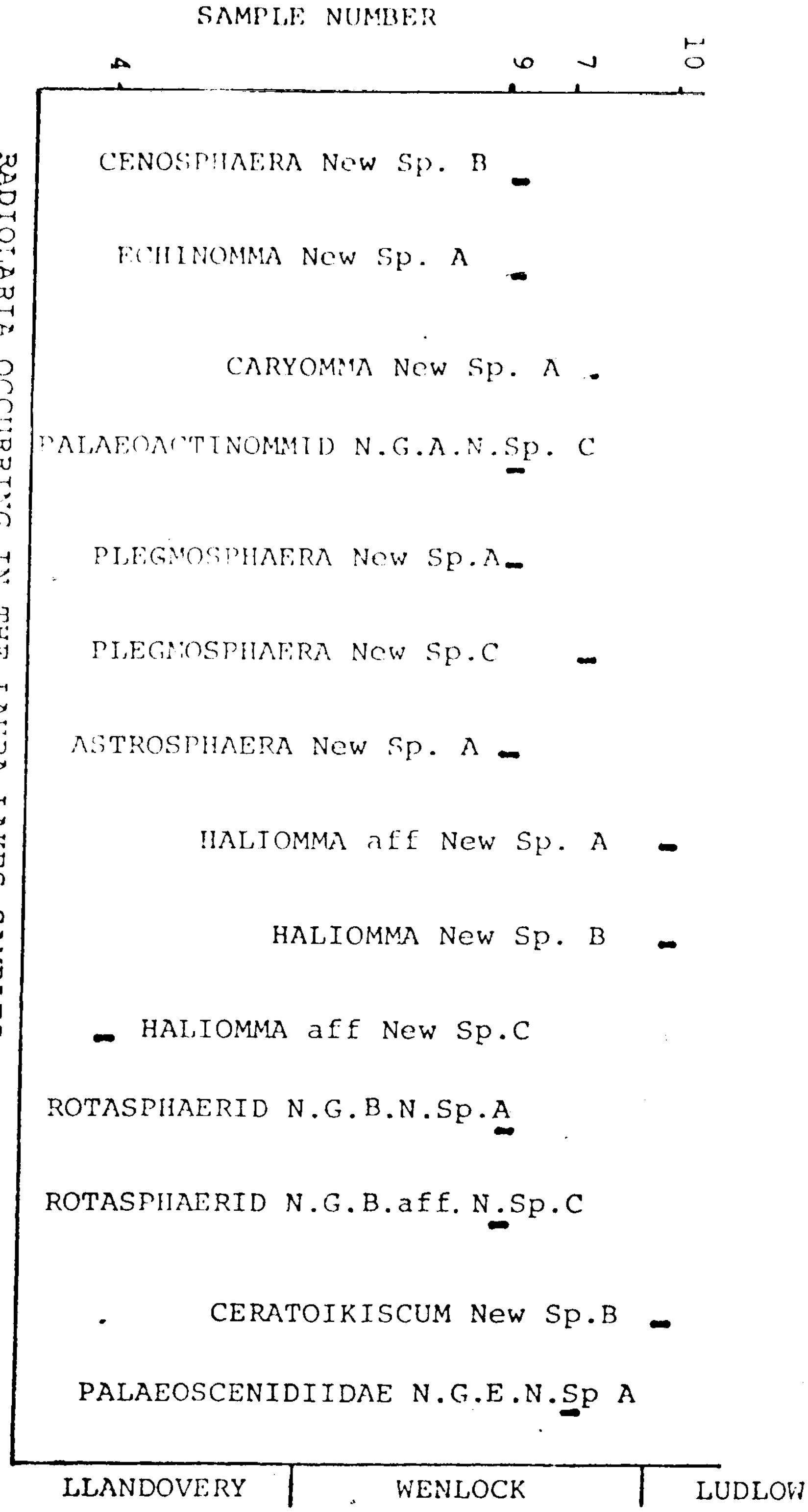
APPENDIX TABLE X



APPENDIX MAP 5
LOCATION OF THE 1978 LAURA LAKES SAMPLES
EASTERN CORNWALLIS ISLAND

APPENDIX TABLE XI

RADIOLARIA OCCURRING IN THE LAURA LAKES SAMPLES



Location of the Cape Becher (Devon Island) 1978 section

Location: 76 degrees 25 mins. North 95 degrees 15 mins. West

Section thickness: 209m(685ft)

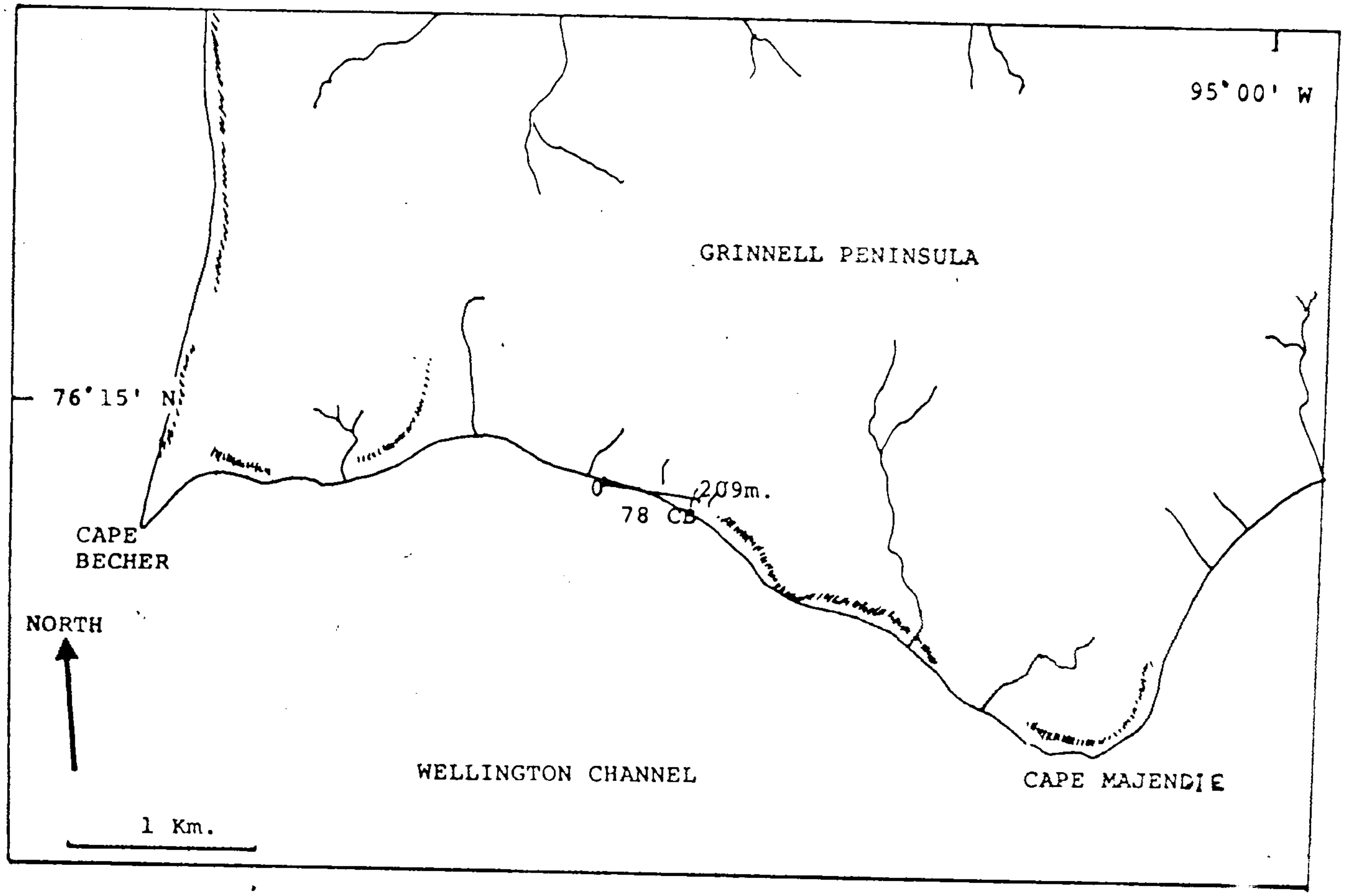
Section begins at the storm beach level in the upper Llandovery and ends in the upper Wenlock. After 209 meters of section talus limestone with minor shale occurs for another 70 meters up dip.

Collected and measured by: B.D.E.Chatterton and D.G.Perry.

HORIZON	PRODUCTIVITY
42m (137ft)	BARREN
47m (154ft)	BARREN
56.5m (185ft)	BARREN
83.5m (274ft)	PRODUCTIVE
84m (275ft)	BARREN
88m (288ft)	BARREN
90m (295ft)	PRODUCTIVE
96m (315ft)	BARREN
108m (354ft)	BARREN
113.5m (372ft)	BARREN
114m (374ft)	PRODUCTIVE
115.5m (379ft)	BARREN
143m (469ft)	BARREN
151m (495ft)	BARREN
155m (508ft)	BARREN
161m (528ft)	BARREN
176m (577ft)	BARREN
181m (594ft)	BARREN

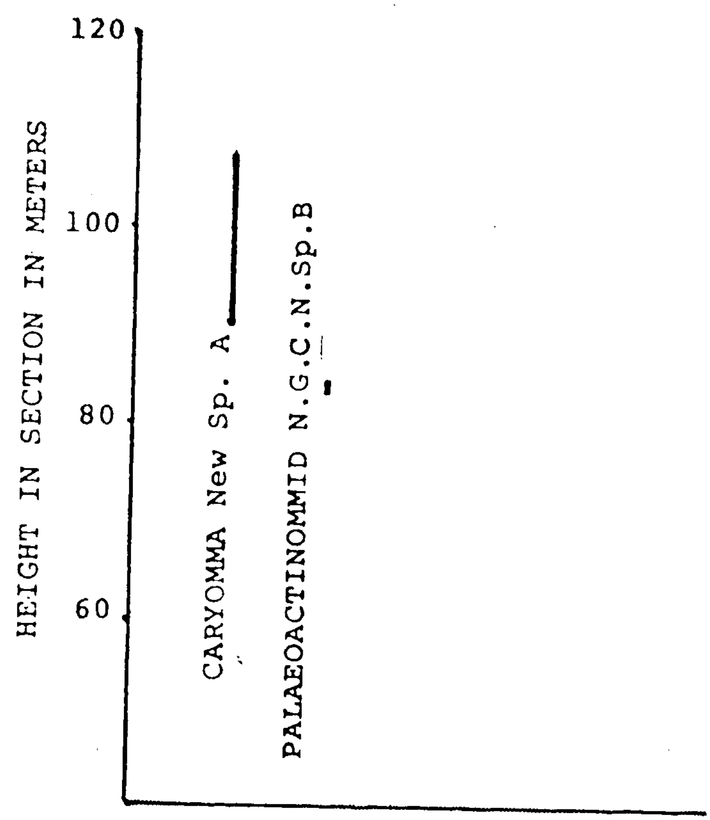
SAMPLES PROCESSED AND PROCESSING RESULTS FROM THE CAPE BECHER (DEVON ISLAND) 1978 SECTION

APPENDIX TABLE XII



APPENDIX MAP 6

LOCATION OF THE 1978 CAPE BECHER SECTION AIR PHOTO A 16749-104



RADIOLARIA OCCURRING IN THE CAPE BECHER SECTION

APPENDIX TABLE XIII

PLATE I

ACANTHOSPHAERA new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	35	79 CP	118	External
2	35	79 CP	118	External
3	35	79 CP	118	External
4	35	79 CP	118	External
5	35	79 CP	165	External
6	35	79 BHI	36	External

ARACHNOSPHAERA new species A

7	37	79 CP	180	External
8	37	[illegible]	132-135	External

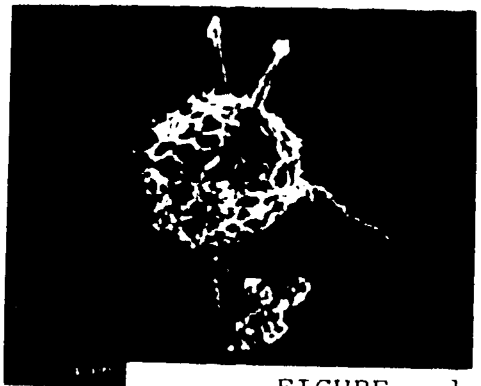


FIGURE 1

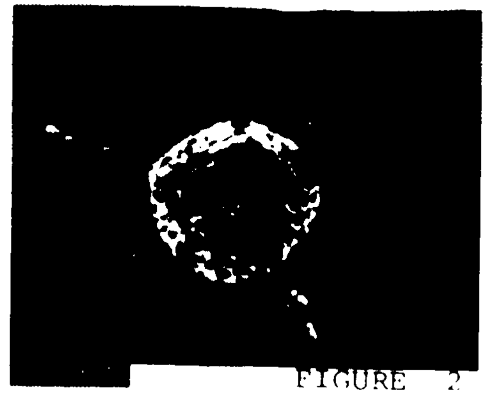


FIGURE 2

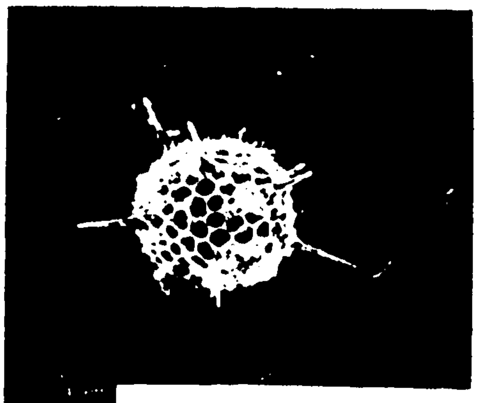


FIGURE 3

FIGURE 4

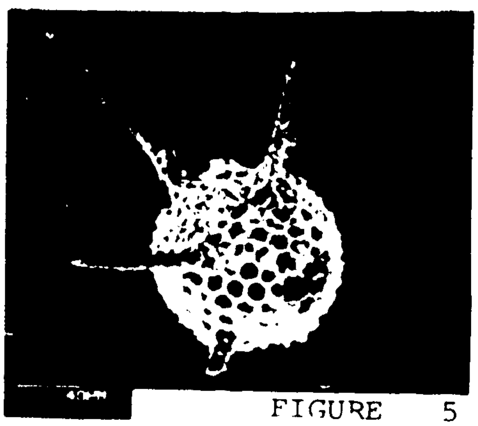


FIGURE 5

FIGURE 6

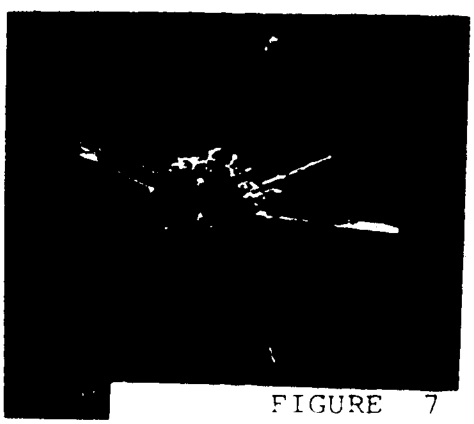


FIGURE 7

PLATE I

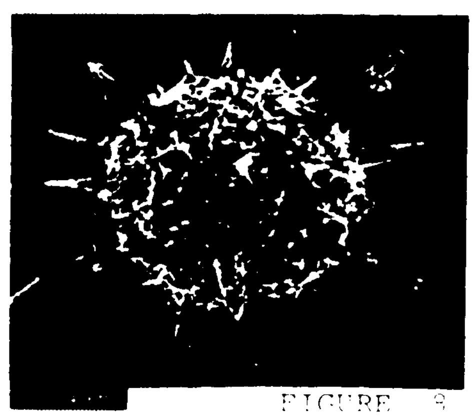


FIGURE 8

PLATE II

ARACHNOSPHAERA new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	37	79 CP	91	External
2	37	76 BH1	33-36	External
3	37	76 BH1	33-36	External
4	37	76 BH1	33-36	External
5	37	76 BH1	33-36	Broken showing internal layers
6	37	76 BH1	33-36	External
7	37	79 CP	91	External
8	37	79 CP	91	External

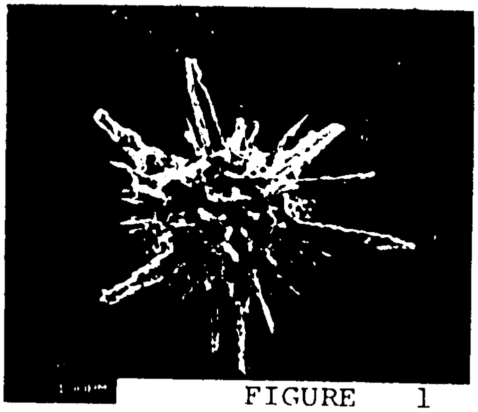


FIGURE 1

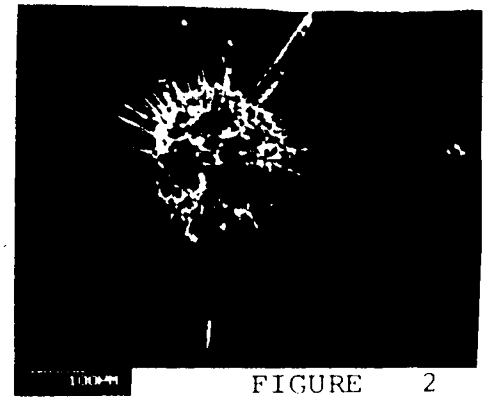


FIGURE 2

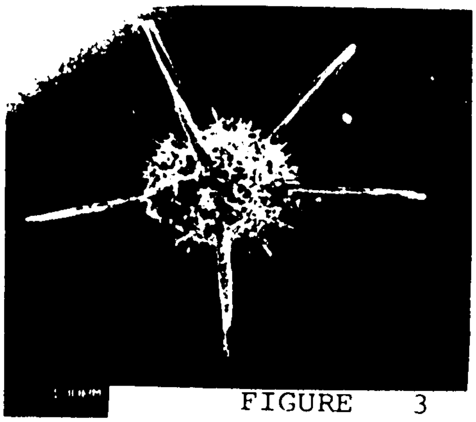
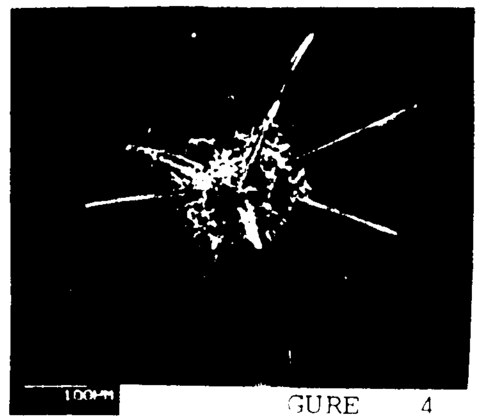


FIGURE 3



GURE 4

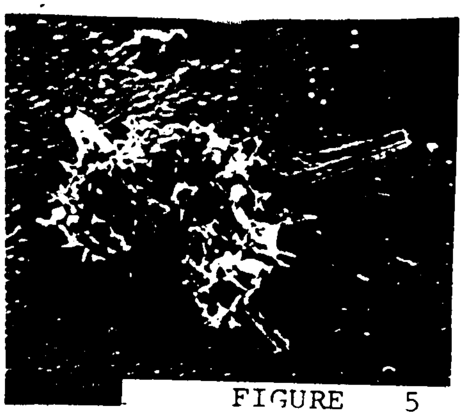


FIGURE 5

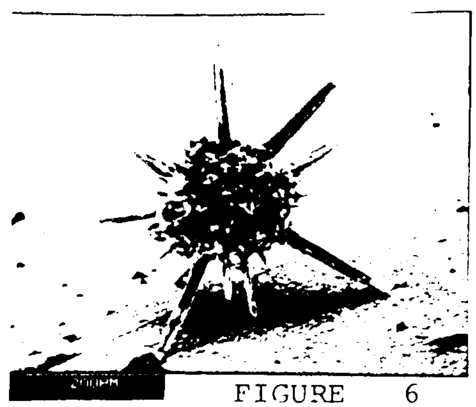
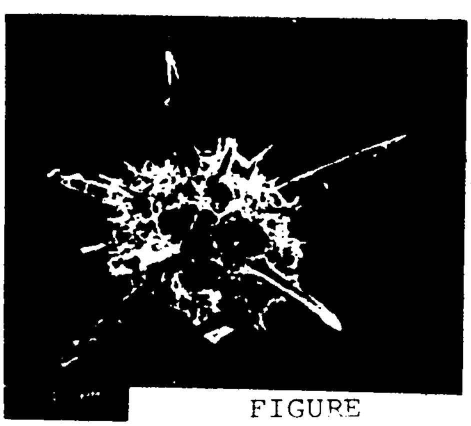


FIGURE 6



FIGURE

PLATE II

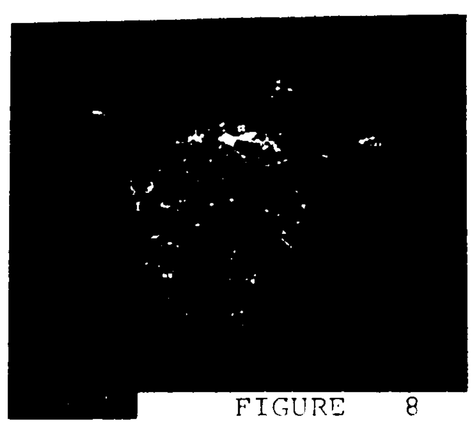


FIGURE 8

PLATE III

CENOSPHAERA new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	47	76 BH1	600	External
2	47	76 BH1	600	External
3	47	76 BH1	480	External
4	47	76 BH1	600	External
5	47	76 BH1	600	External

CENOSPHAERA aff. affinis

6	49	79 CP	180	External
7	49	79 CP	180	External

ECHINOMMA aff. E. new species A

8	67	76 CP	215	External

FIGURE 1

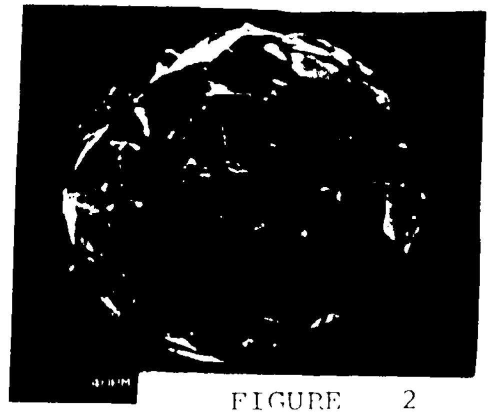


FIGURE 2

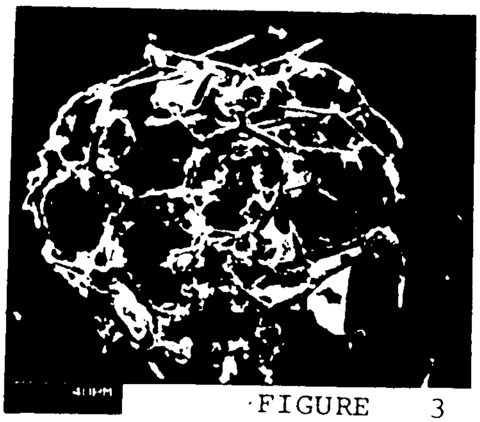


FIGURE 3

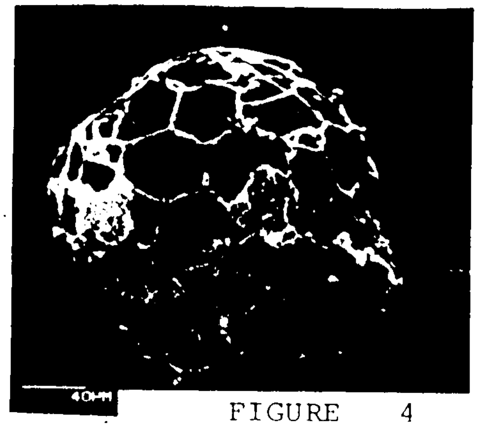


FIGURE 4

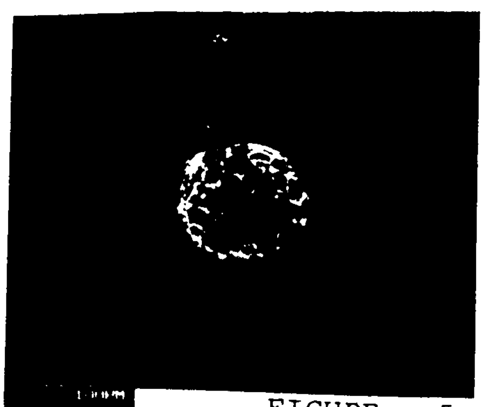


FIGURE 5

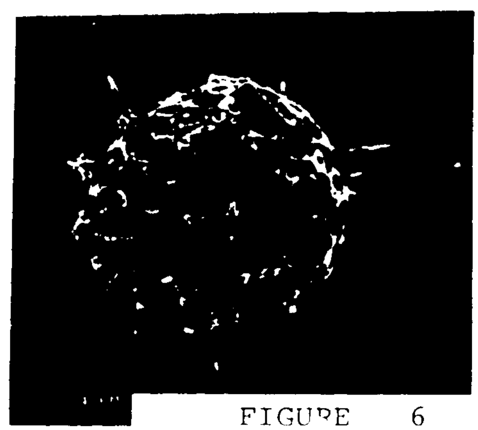


FIGURE 6

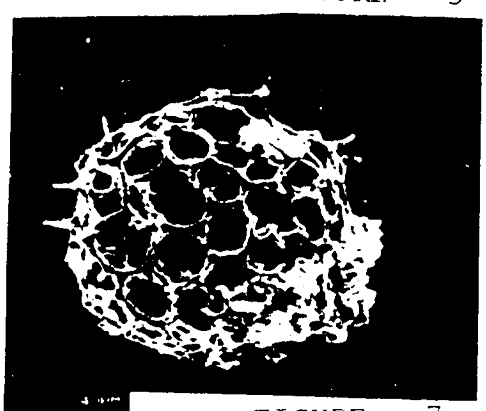


FIGURE 7

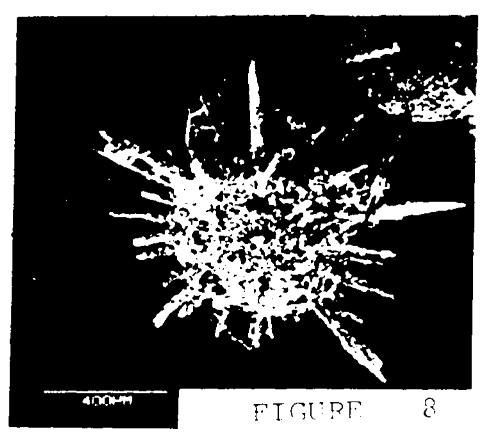


FIGURE 8

PLATE III

PLATE IV

ECHINOMMA new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	64	76 CP	135	External
2	64	LL 7		External
3	64	76 CP	135	External
4	64	76 CP	135	External
5	64	76 BH1	33-36	External
		NEW GENUS A new species A		
6	114	76 CP	325-330	External
7	114	76 CP	390-400	External
8	114	76 CP	325-330	External

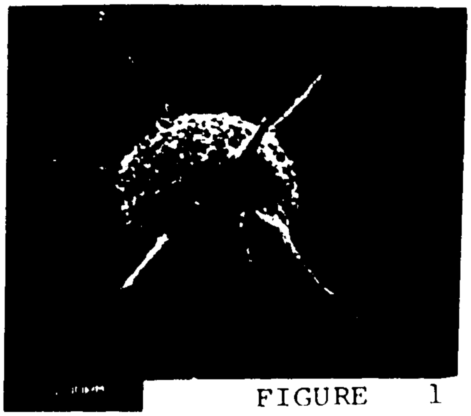


FIGURE 1

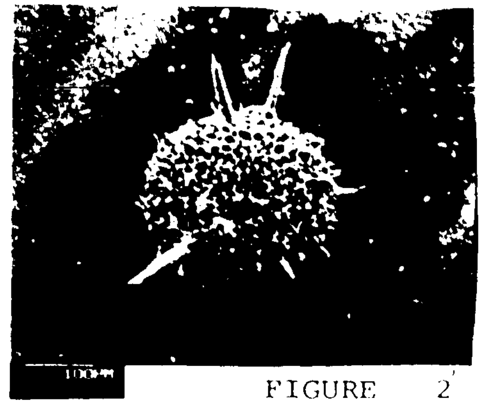


FIGURE 2

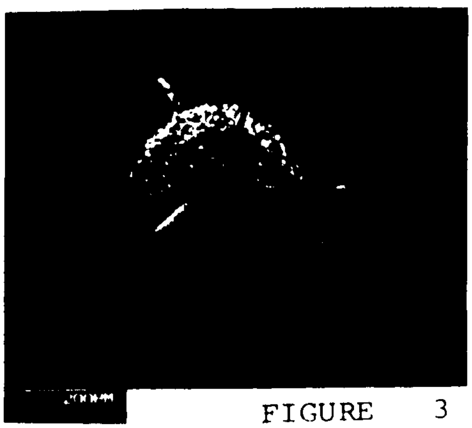


FIGURE 3

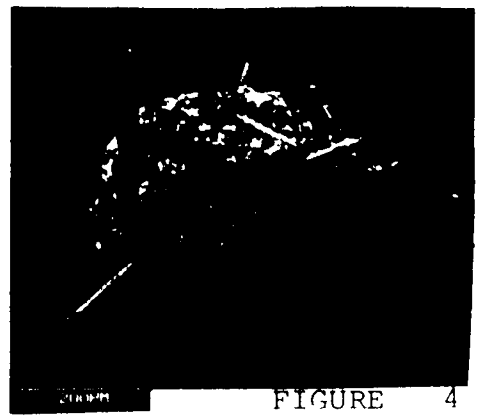


FIGURE 4

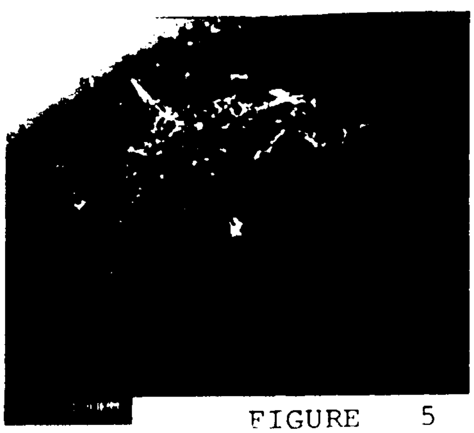


FIGURE 5

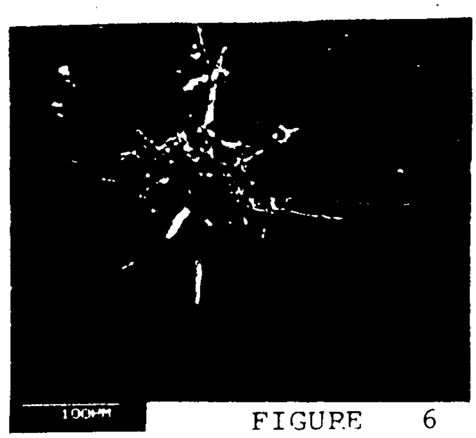


FIGURE 6

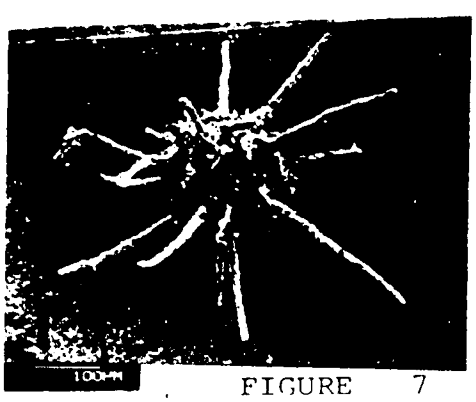


FIGURE 7

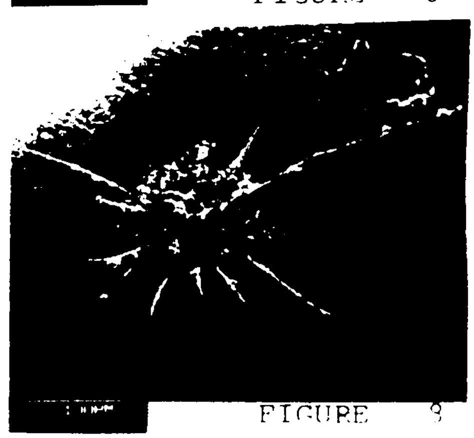


FIGURE 8

PLATE IV

PLATE V

CROMYOMMA new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	55	79 CP	6	showing internal shells
2	55	79 CP	25	Outer two shells broken
3	55	79 CP	15	External

CROMYECHINUS new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
4	51	76 CP	340-350	External shell broken
5	51	76 CP	340-350	External
6	51	76 CP	425	External
7	51	76 CP	340-350	External shell broken

CUBOSPHAERA aff. C. new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
6	62	76 CP	135	External

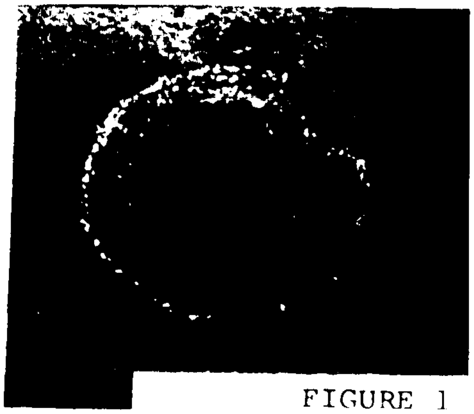


FIGURE 1

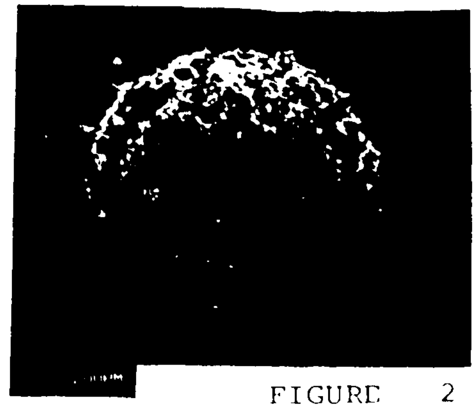


FIGURE 2

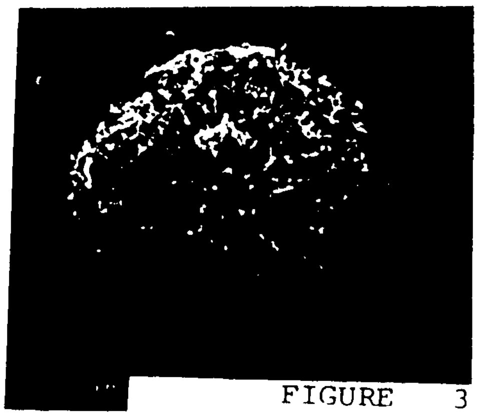


FIGURE 3

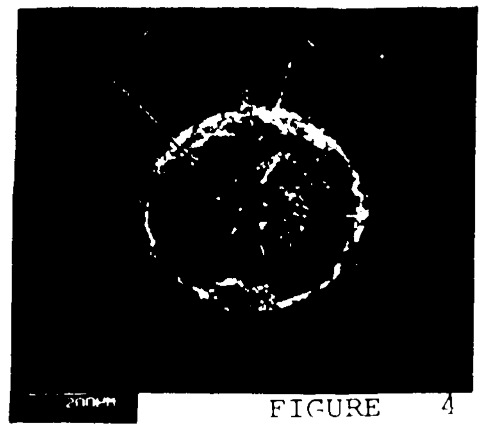


FIGURE 4

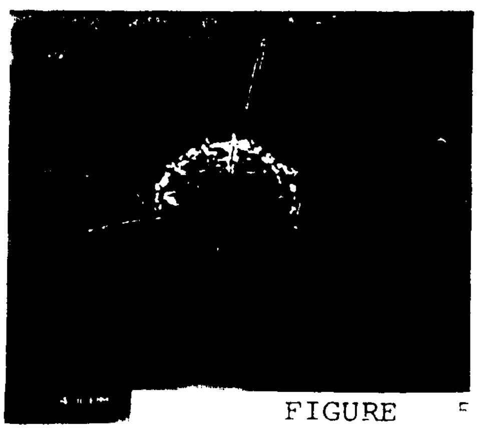


FIGURE 5

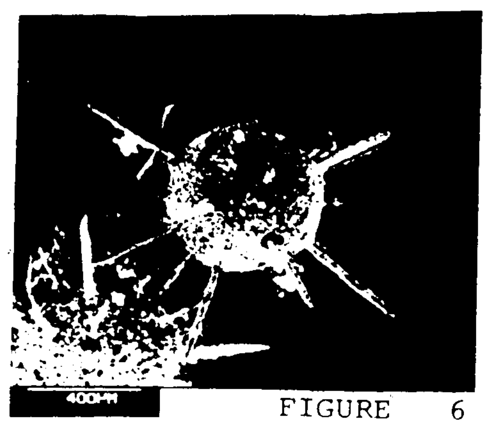


FIGURE 6

FIGURE 7

FIGURE 8

PLATE V

PLATE VI

CARYOMMA new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	43	76 CP	340-350	Third shell visible
2	43	76 CP	340-350	Vestigial fourth and fifth shells
3	43	76 CP	340-350	1st 2nd and 3rd shells visible
4	43	76 CP	340-350	Close up of Fig. 3
5	43	76 CP	340-350	External of 4th and 5th shells
6	43	76 CP	340-350	External showing 3rd shell
7	43	76 CP	365-375	External showing 3rd shell
8	43	76 BH1	480	External showing 3rd and 4th shells

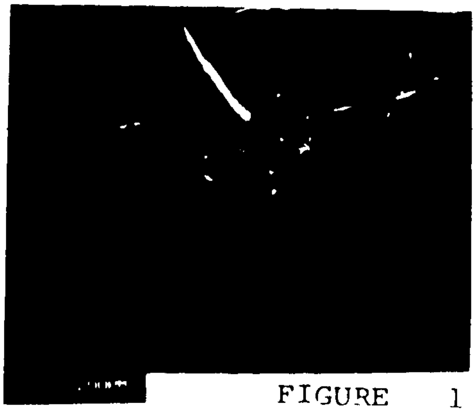
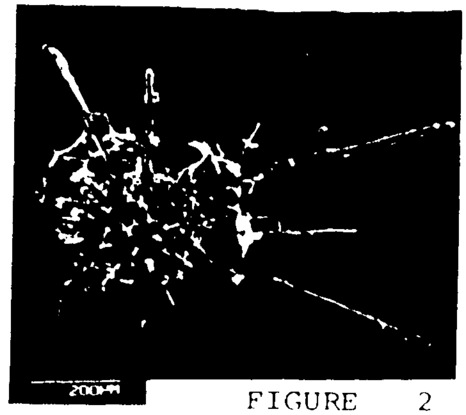


FIGURE 1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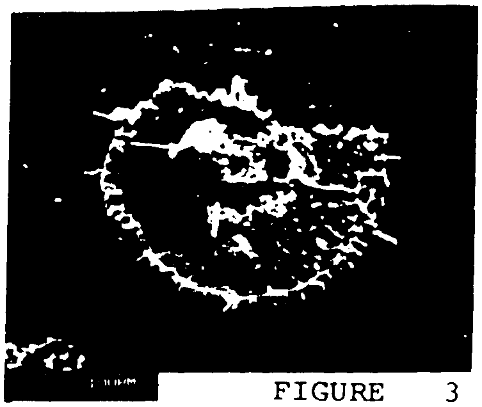
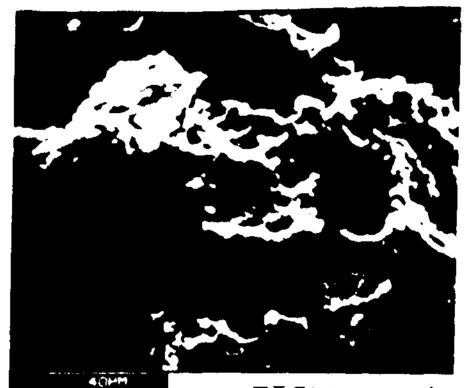


FIGURE 3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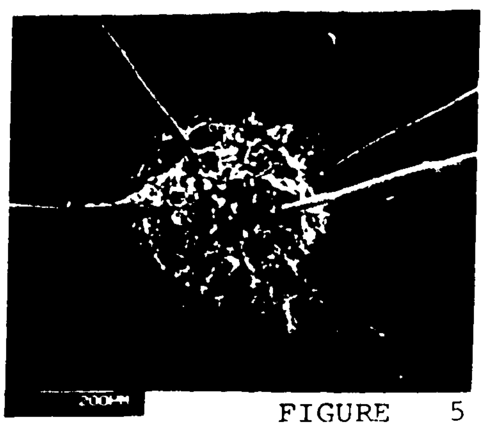


FIGURE 5

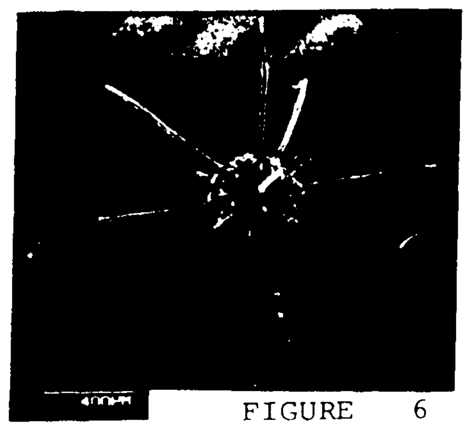


FIGURE 6

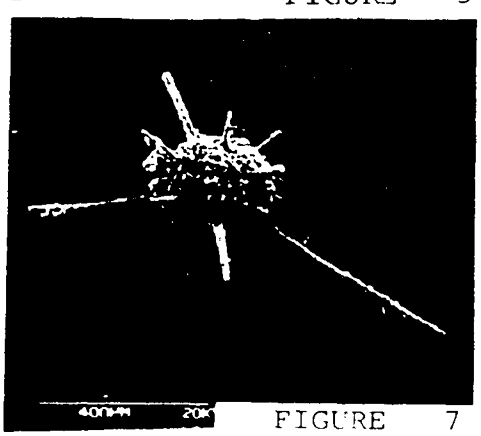


FIGURE 7

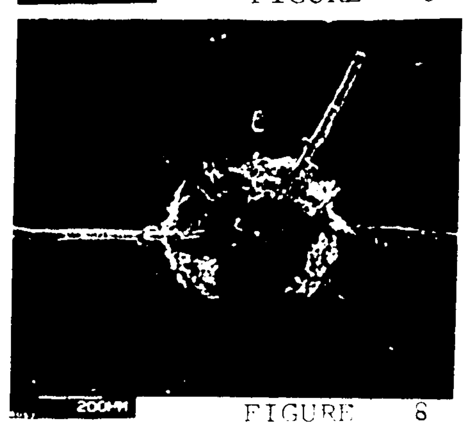


FIGURE 8

PLATE VI

PLATE VII

CUBAXONIUM new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	57	76 CP	325-330	External view
2	57	76 CP	325-330	External view
3	57	76 CP	340-355	External view
4	57	76 CP	325-330	External view

HEXALONCHE new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
5	89	79 CP	180	Vestigial 2nd shell
6	89	79 CP	180	External 2nd shell
7	89	79 CP	132-135	External 2nd shell
8	89	79 CP	132-135	Damaged outer shell

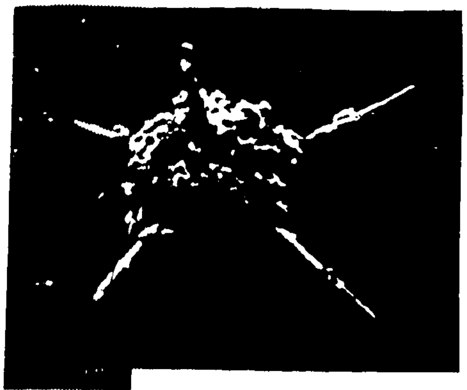


FIGURE 1

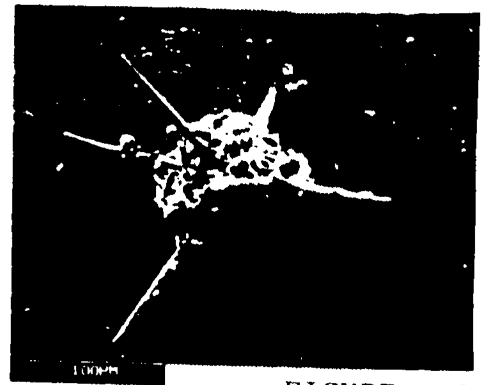


FIGURE 2

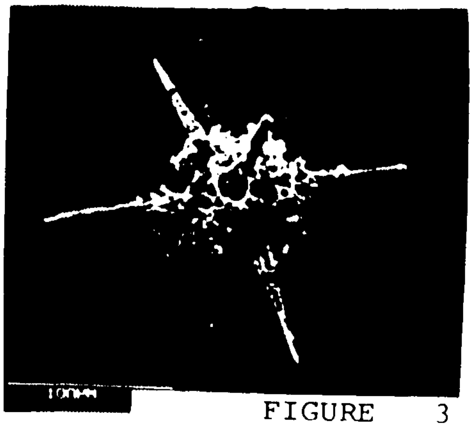


FIGURE 3

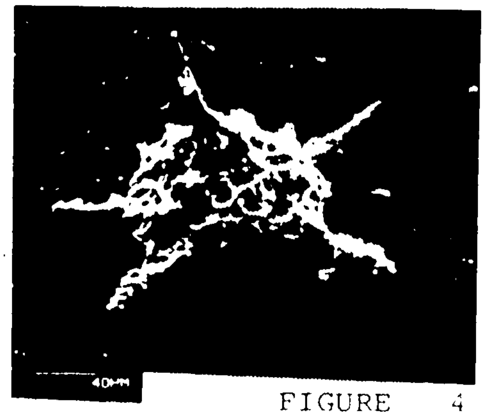


FIGURE 4

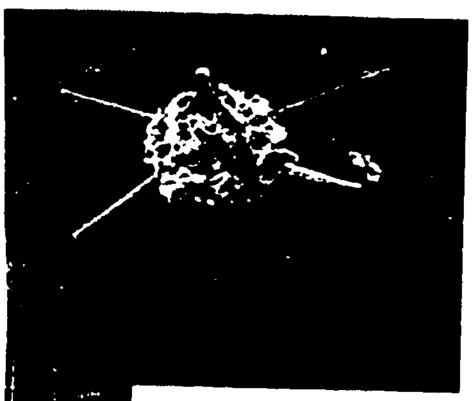


FIGURE 5

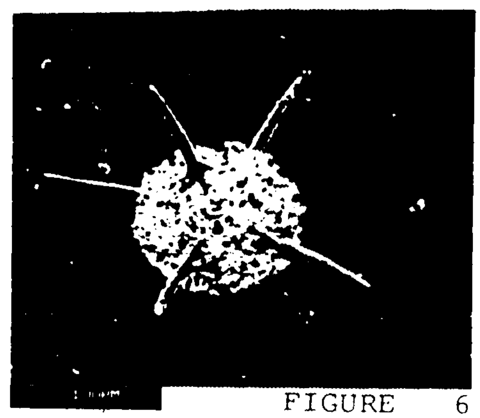


FIGURE 6

FIGURE 7

PLATE

FIGURE

PLATE VIII

HEXALONCHE new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	89	79 CP	278	Broken showing two shells
2	89	79 CP	278	External, damaged 2nd shell
3	89	79 CP	278	External, damaged 2nd shell
4	89	79 CP	132-135	External, rudimentary 2nd shell

HEXALONCHE? new species B

5	92	79 CP	278	External, rudimentary 3nd shell
6	92	79 CP	278	Broken 2nd shell showing inner shell
7	92	79 CP	9	Broken 2nd shell showing inner shell
8	92	79 CP	91	Close up of Fig. 7

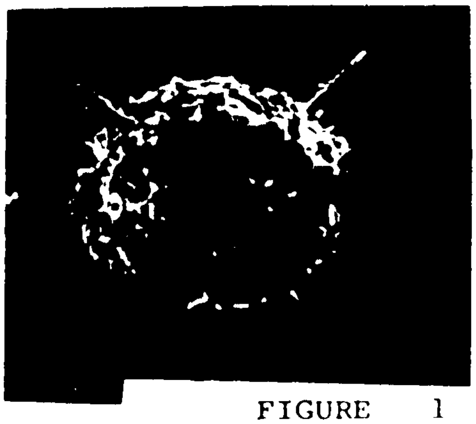


FIGURE 1

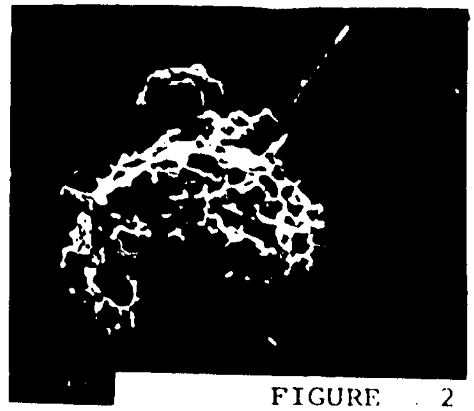


FIGURE 2

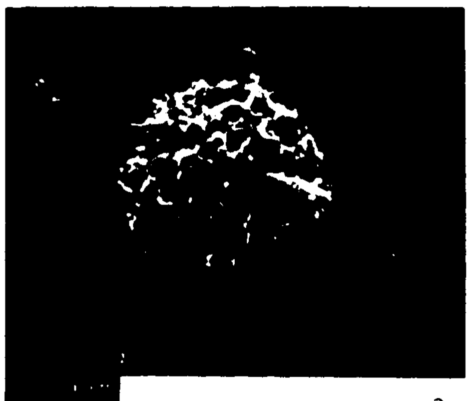


FIGURE 3

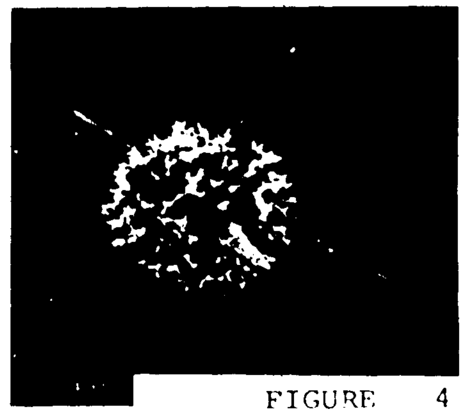


FIGURE 4

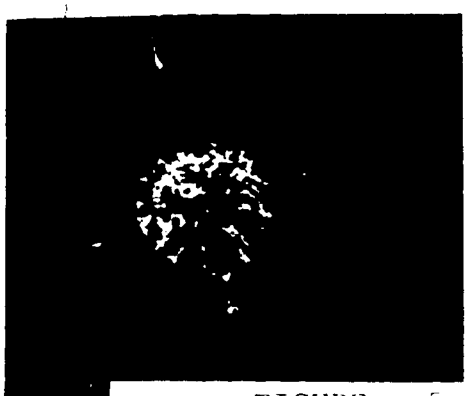


FIGURE 5

FIGURE 6

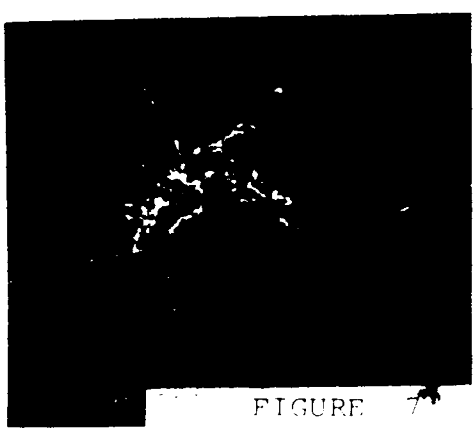


FIGURE 7

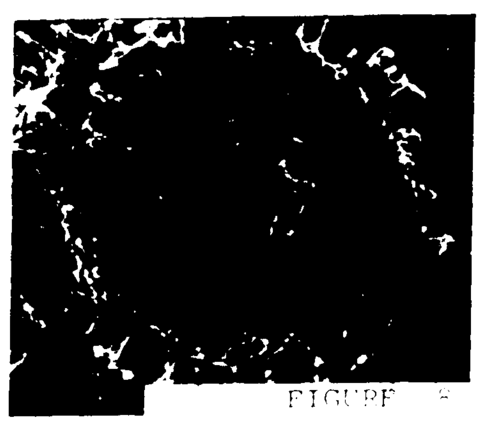


FIGURE 8

PLATE VIII

PLATE IX

CUBOSPHAERA New species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	59	79 CP	118	Damaged, external
2	59	79 CP	91	External
3	59	79 CP	278	External
4	59	79 CP	91	External
5	59	79 CP	108	Broken showing concentric shells
6	59	76 CP	390-400	External
7	59	76 CP	390-400	External
8	59	76 CP	325-330	External

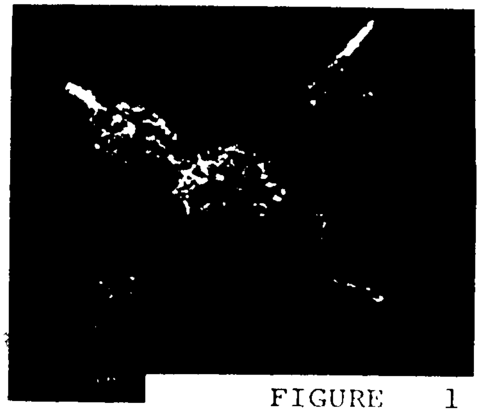
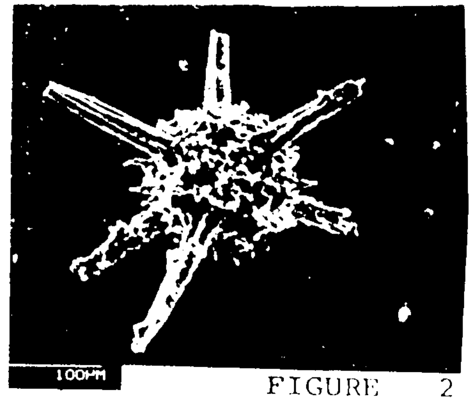


FIGURE 1



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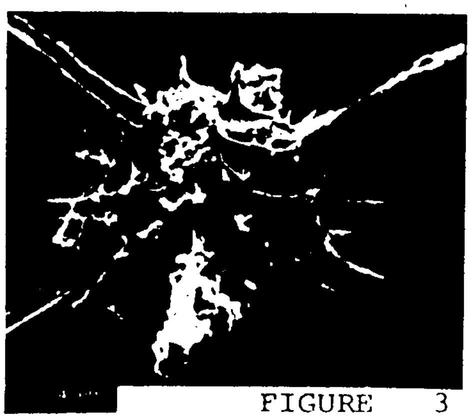

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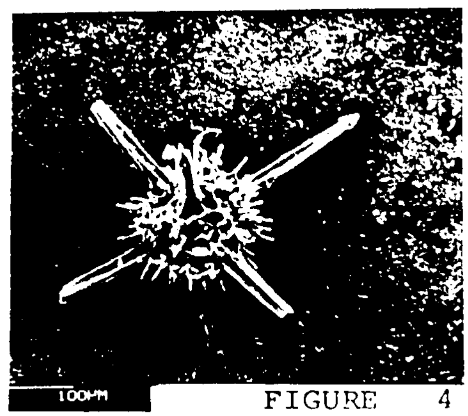


FIGURE 4

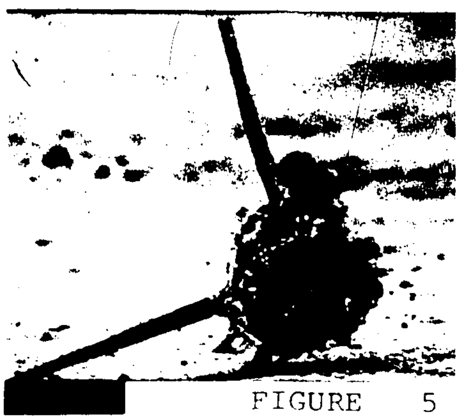


FIGURE 5

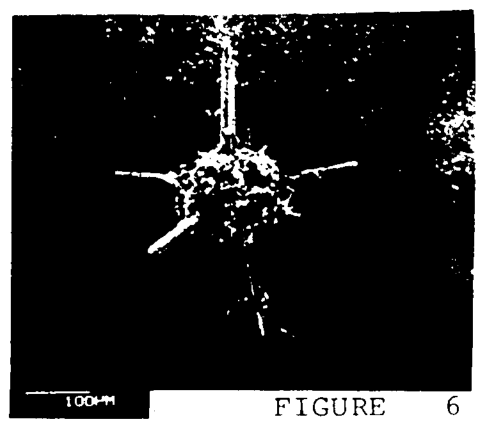


FIGURE 6

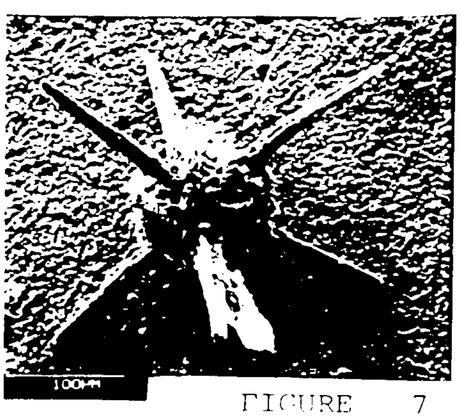


FIGURE 7

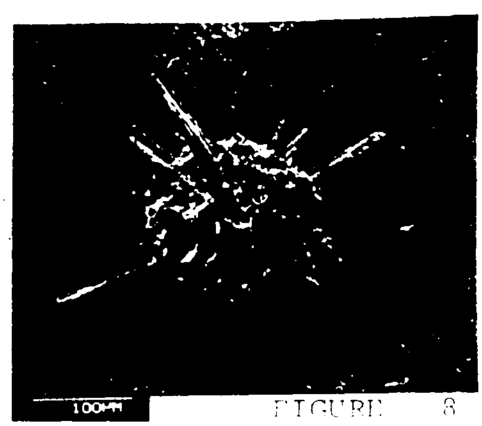


FIGURE 8

PLATE IX

PLATE X

NEW GENUS A new species B

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	116	76 BH1	470	External, damaged
2	116	76 CB	83.5m	External
3	116	76 BH1	470	External
4	116	76 CB	83.5m	External

NEW GENUS A new species C

Fig.	Text page	Section	Horizon (ft)	View of specimen
5	118	76 LL 9		External, damaged
6	118	76 LL 9		External, less developed than Fig. 5
7	118	76 LL 9		External
8	118	76 LL 9		External

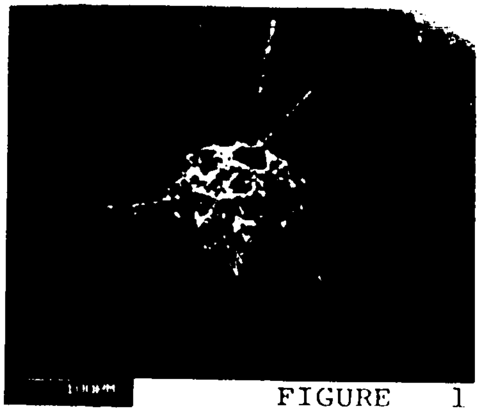


FIGURE 1

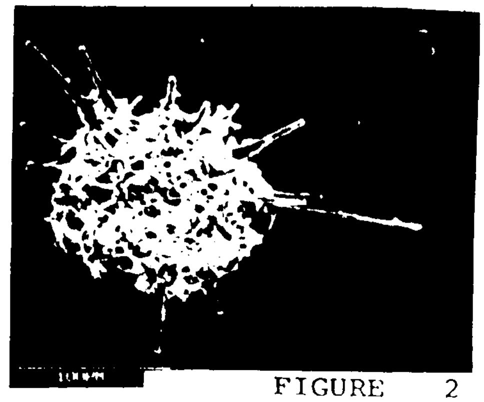


FIGURE 2

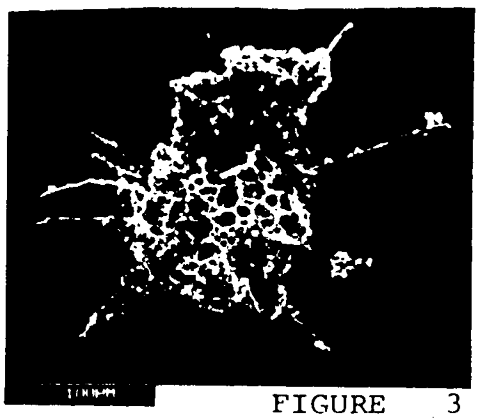


FIGURE 3

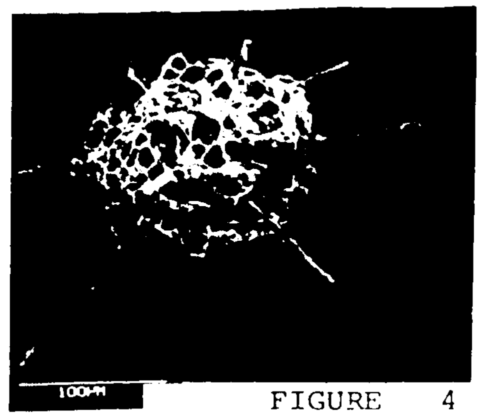
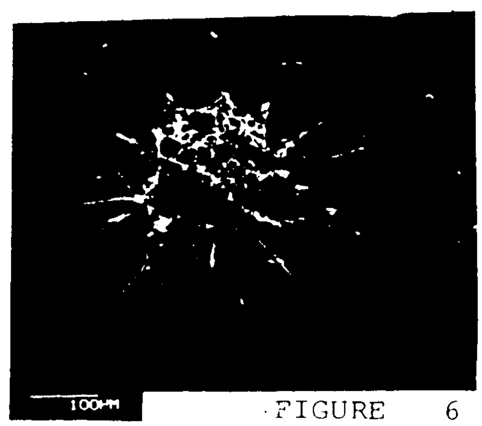


FIGURE 4

FIGURE 5



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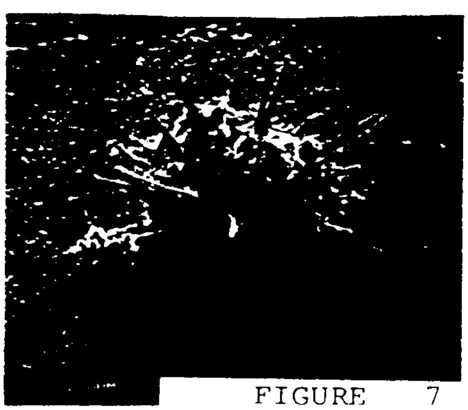


FIGURE 7

FIGURE 8

PLATE X

PLATE XI

SPONGOSTYLUS new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	108	76 BH2	265	External
2	108	76 BH2	245	External

SPONGOPLEGMA new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
3	106	76 BH2	130	External, damaged
4	106	76 BH2	710	External, damaged
5	106	76 BH2	710	External, damaged

PLEGMOSPHAERA new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
6	94	76 BH1	765	Broken showing central cavity
7	94	76 BH1	765	Broken showing central cavity
8	94	76 BH1	765	Close up of Fig.7

FIGURE 1

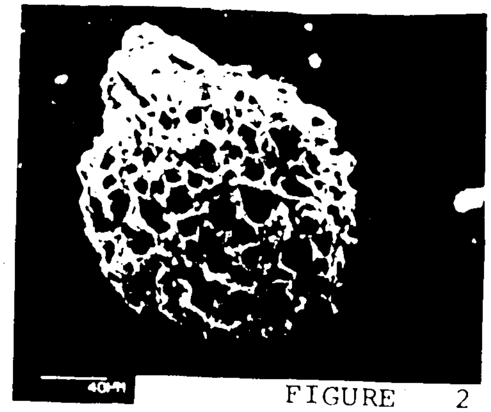


FIGURE 2

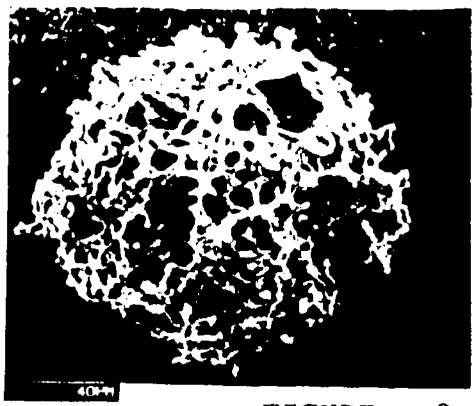


FIGURE 3

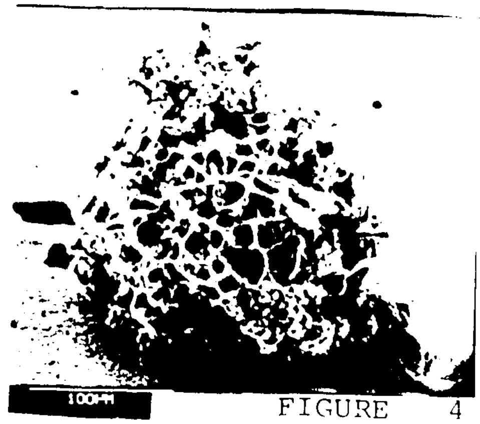


FIGURE 4

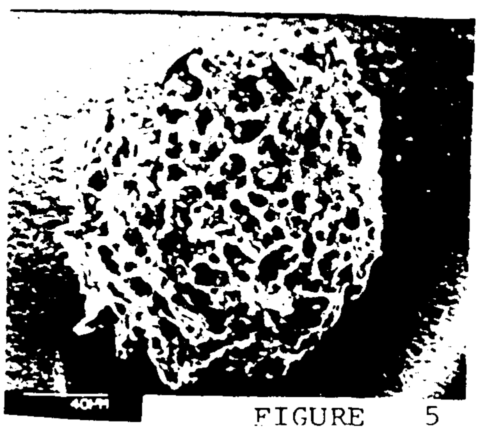


FIGURE 5

FIGURE 6

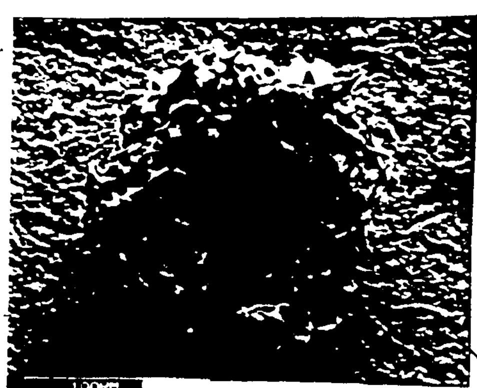


FIGURE 7

FIGURE 8

PLATE XI

PLATE XII

Fig.	Text page	Section	Horizon (ft)	View of specimen
				PLEGMOSPHAERA aff. P. new species A
1	96	76 CP	365-375	External, damaged
2	96	76 CP	390-400	External, damaged
				PLEGMOSPHAERA new species B
3	97	76 CP	340-355	Damaged showing central cavity
				PLEGMOSPHAERA new species C
4	99	76 LL9		External
				PLEGMOSPHAERA new species D
5	101	79 CP	29	External
6	101	79 CP	29	External
				ASTROSPHAERA new species A
7	40	76 CP	340-355	Poorly developed external shell
8	40	76 CP	6	Well developed external shell

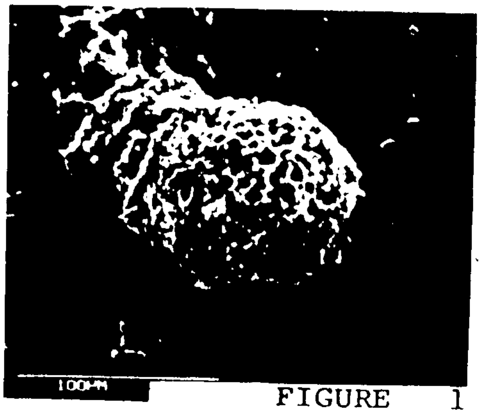


FIGURE 1

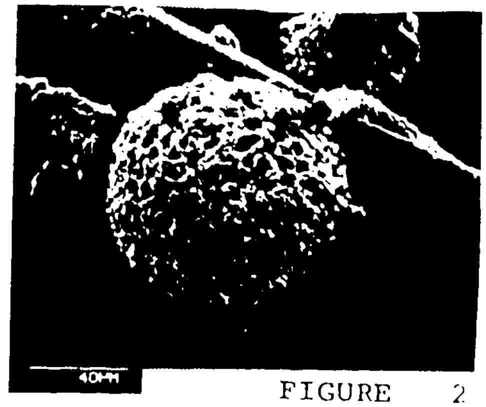


FIGURE 2

FIGURE 3

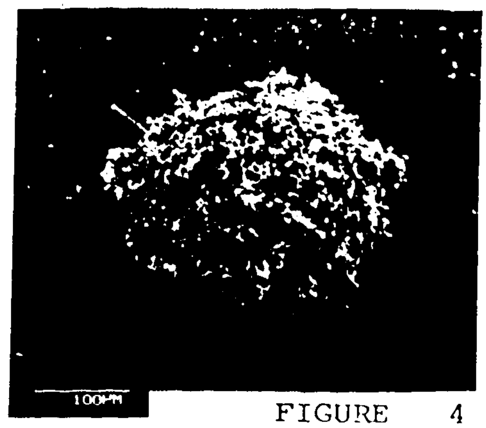


FIGURE 4

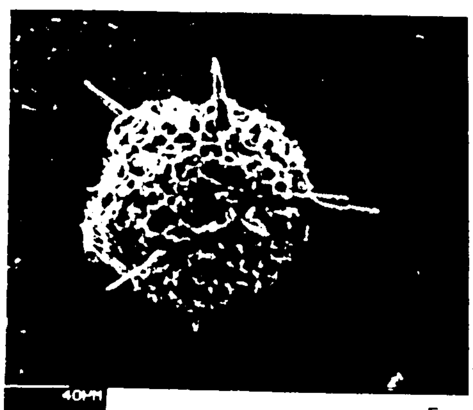


FIGURE 5

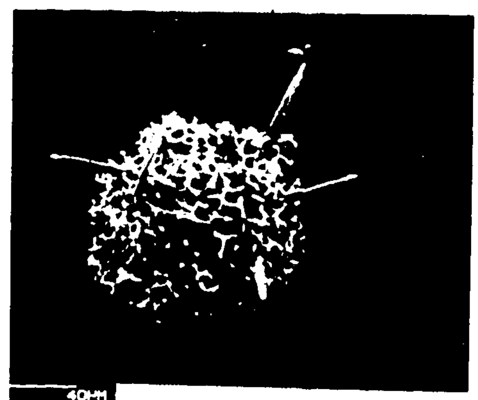


FIGURE 6

FIGURE 7

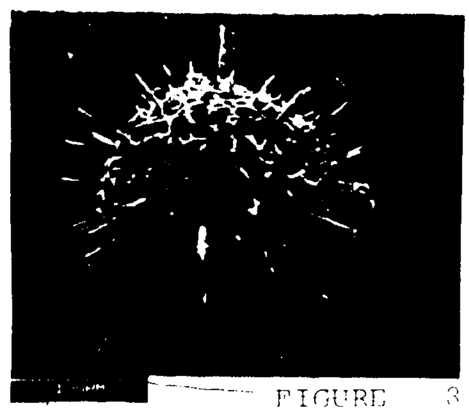


FIGURE 8

PLATE XII

PLATE XIII

STYPTOSPHAERA new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	111	76 BH1	765	External
2	111	76 BH1	765	Broken showing lack of a central cavity
3	111	BH1	765	Side view of Fig. 2
4	111	76 BH1	765	Broken showing no significant central cavity
		HALIOMMA aff. H. new species A		
5	71	76 LL10		External
6	71	76 LL10		External
		HALIOMMA aff. H. new species C		
7	80	76 BH1	600	External, damaged
8	80	76 LL 4		Damaged showing external and internal

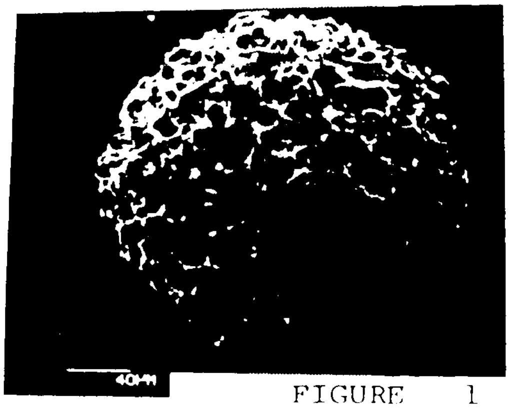
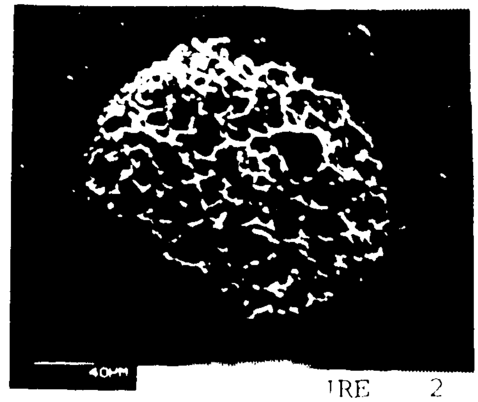


FIGURE 1



IRE 2

FIGURE 3

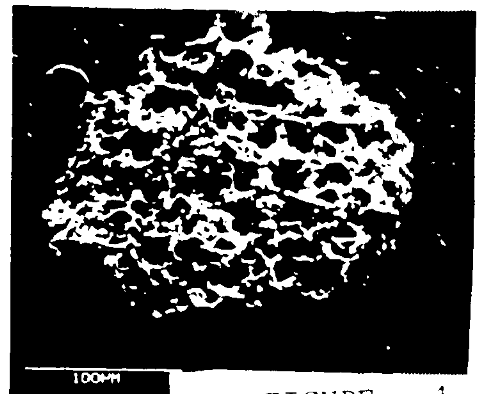


FIGURE 4

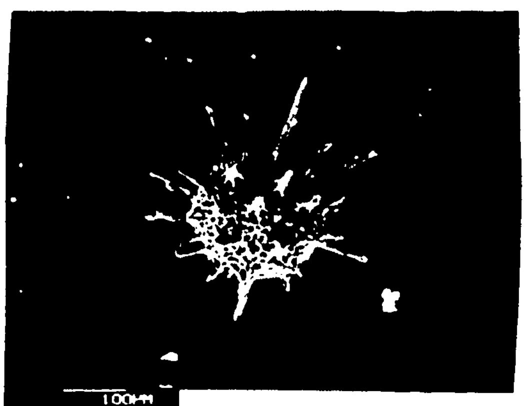


FIGURE 5

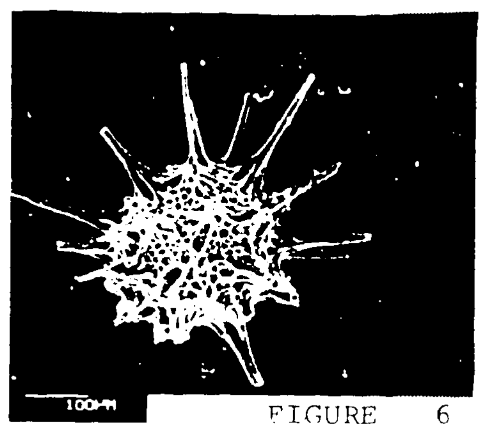


FIGURE 6

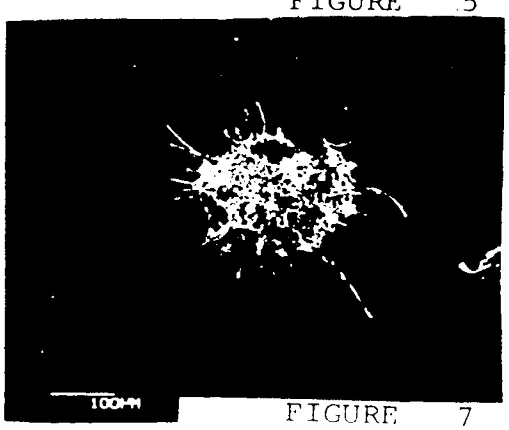


FIGURE 7

PLATE XIII

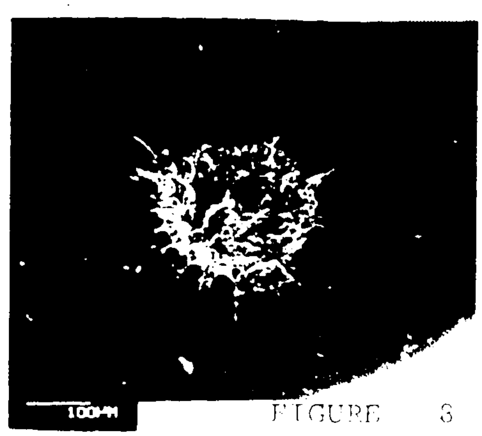


FIGURE 8

PLATE XIV

HALIOMMA new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	69	76 BH2	290	External
2	69	76 BH1	765	External
3	69	76 BH1	765	Broken showing two shells
4	69	76 BH1	765	Broken showing two shells
5	69	76 BH	765	Broken showing two shells
6	69	76 BH1	765	Close up of Fig.5
7	69	76 BH1	765	Broken showing two shells
8	69	76 BH1	765	Close up of Fig. 7

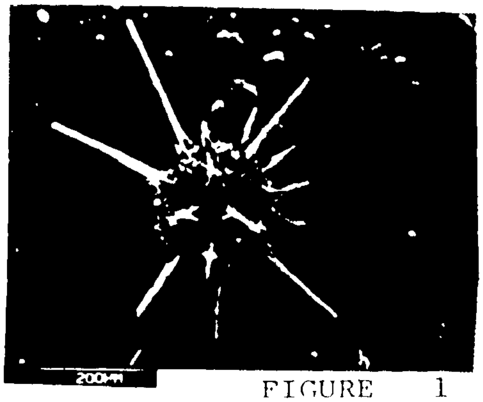


FIGURE 1

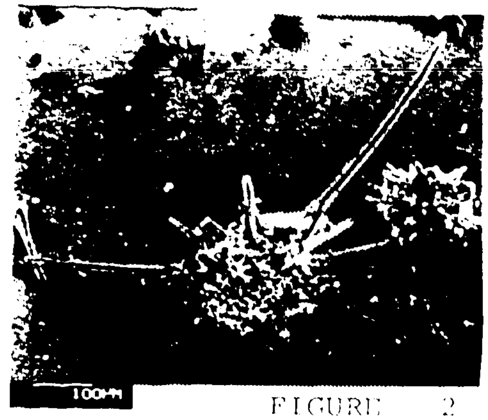


FIGURE 2

FIGURE 3

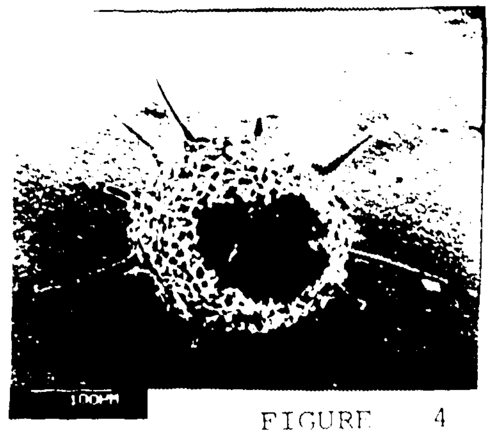


FIGURE 4

FIGURE 5

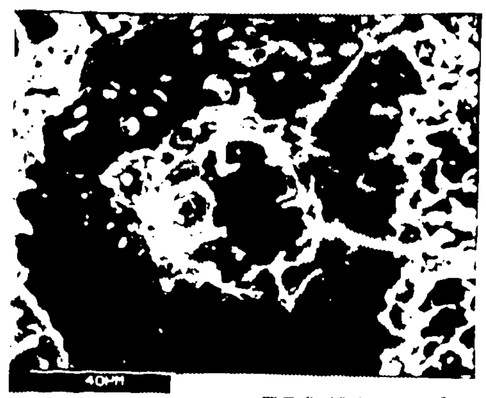


FIGURE 6

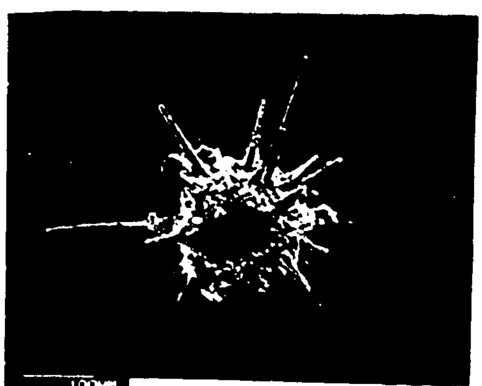


FIGURE 7

FIGURE 8

PLATE XIV

PLATE XV

HALIOMMA new species B

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	73	LL 10		External
2	73	76 BH2	150	External
3	73	76 BH2	290	External
4	73	76 BH2	290	External

HALIOMMA aff. H. new species B

Fig.	Text page	Section	Horizon (ft)	View of specimen
5	76	76 BH2	290	External
6	76	76 BH2	215	External
7	76	76 BH2	265	External
8	76	76 BH2	265	External

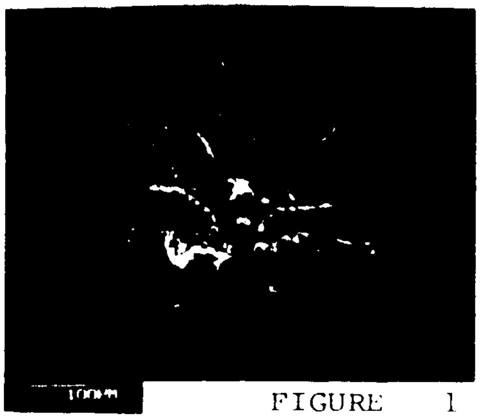


FIGURE 1

FIGURE 2

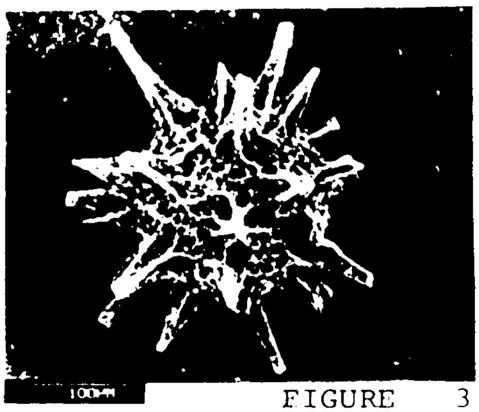


FIGURE 3

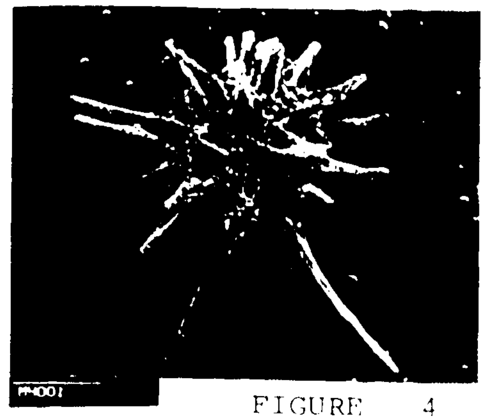


FIGURE 4

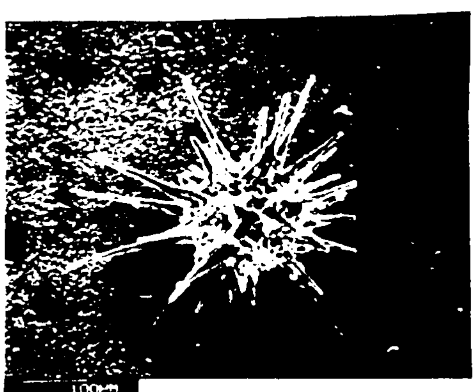


FIGURE 5

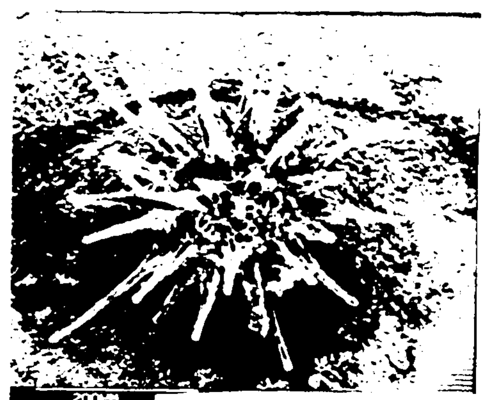


FIGURE 6

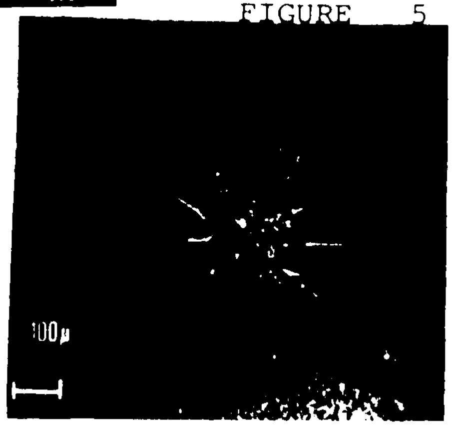


FIGURE 7

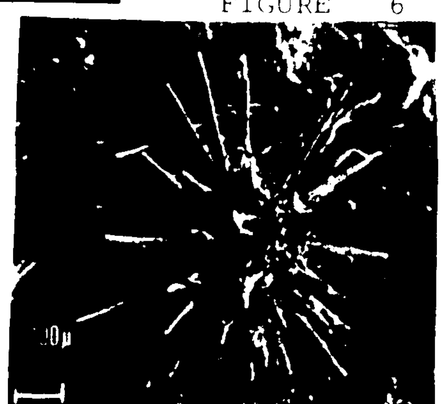


FIGURE 8

PLATE XV

PLATE XVI

HALIOMMA new species C

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	78	76 BH2	265	External, slight spine development
2	78	76 BH2	265	External, greater spine development
3	78	76 BH2	265	External, increased spine development
4	78	76 BH2	290	External, adult stage
5	78	76 BH1	765	Broken showing two shells
6	78	76 BH1	765	Broken showing two external shells
7	78	76 BH1	765	Broken showing two shells
8	78	76 BH1	765	Close up of Fig. 7

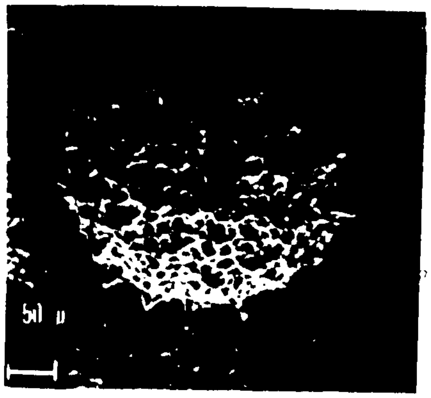


FIGURE 1

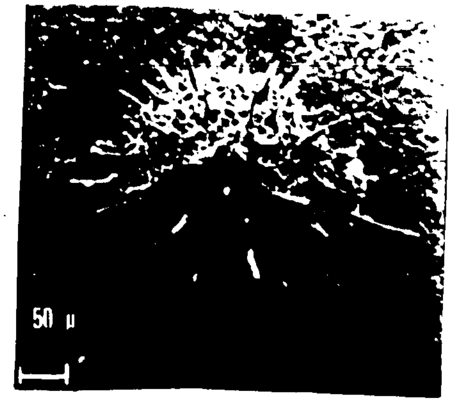


FIGURE 2

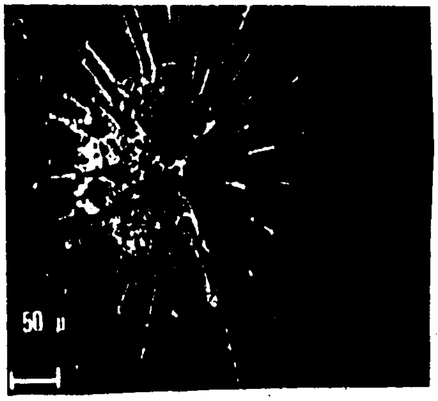


FIGURE 3

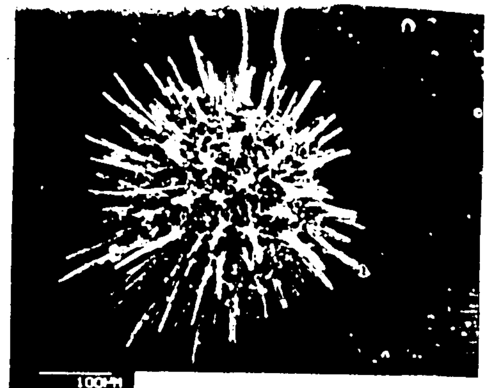


FIGURE 4

FIGURE 5

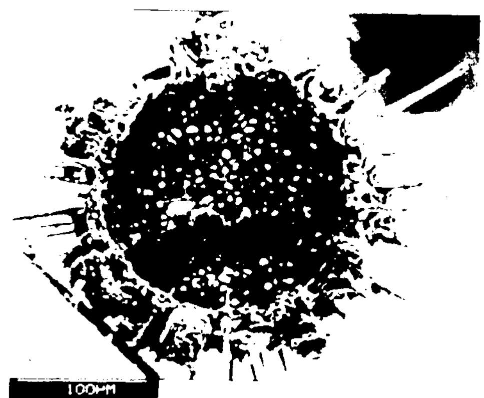


FIGURE 6

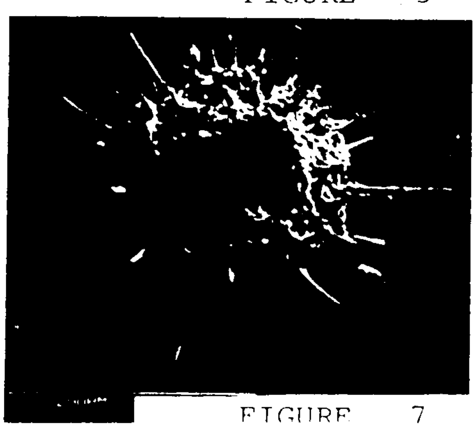


FIGURE 7

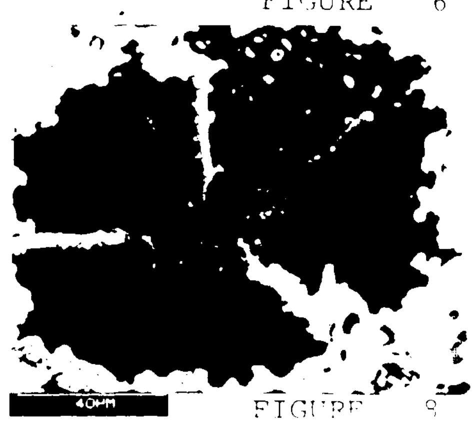


FIGURE 8

PLATE XVI

PLATE XVII

HALIOMMA new species D

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	82	76 BH1	765	External spines least developed
2	82	76 BH1	765	Spine development increasing
3	82	76 BH1	765	External
4	82	76 BH1	765	Maximum spine development

HALIOMMA new species E

5	85	76 CP	390-400	External
6	85	76 BH2	265	External

Haliomma? New species F

7	87	76 BH2	215	Damaged external and internal
8	87	76 BH2	265	External

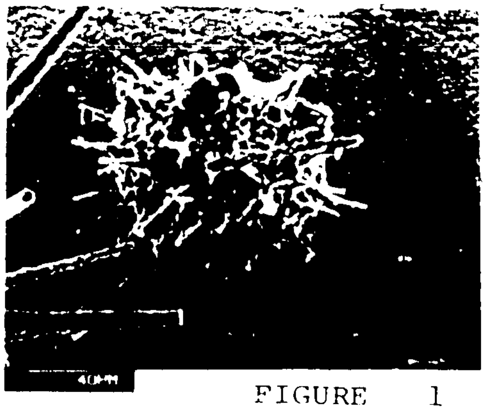


FIGURE 1

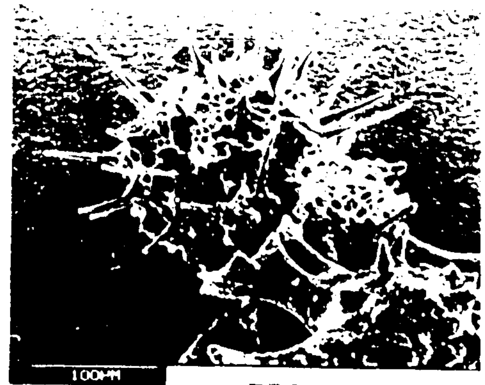


FIGURE 2

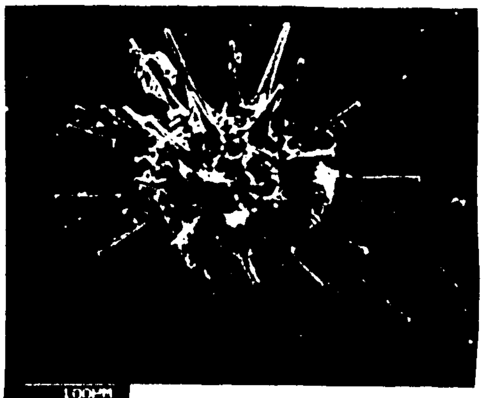


FIGURE 3

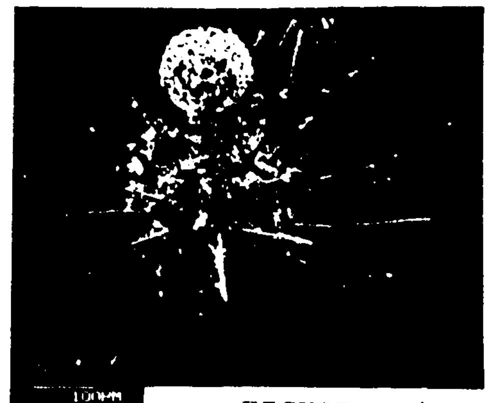


FIGURE 4

FIGURE 5

FIGURE 6

FIGURE 7

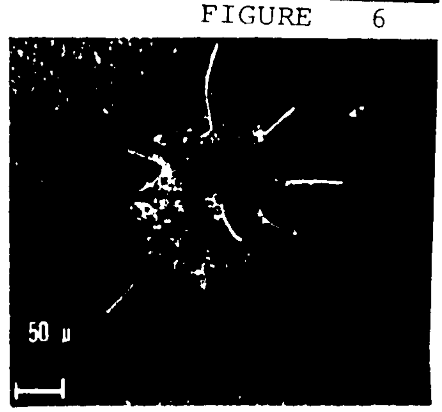


FIGURE 8

PLATE XVII

PLATE XVIII

RHIZOPLEGMA new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	103	76 BH2	150	External
2	103	76 BH2	150	External
3	103	76 BH2	150	External
				ENTACTINIA new species A
4	122	79 CP	27	External
5	122	79 CP	27	Close up of Fig. 4
6	122	79 CP	27	External
7	122	76 BH1	480	External
				ENTACTINIA new species B
8	124	76 CP	325-330	External

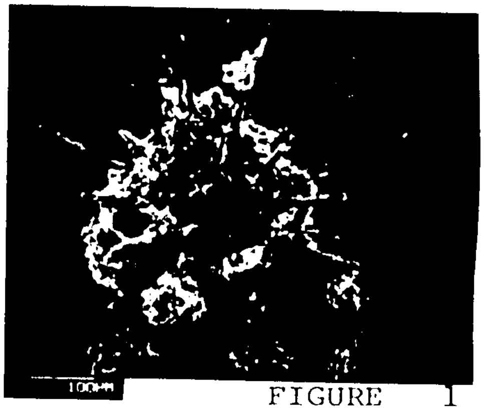


FIGURE 1

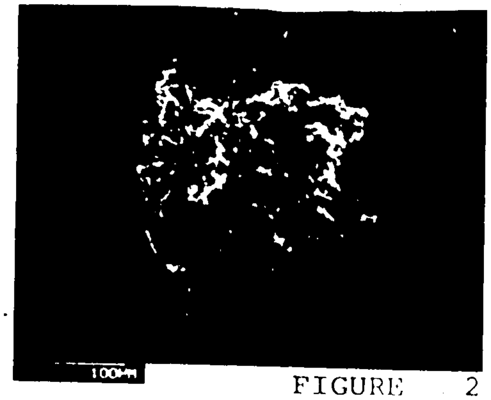


FIGURE 2

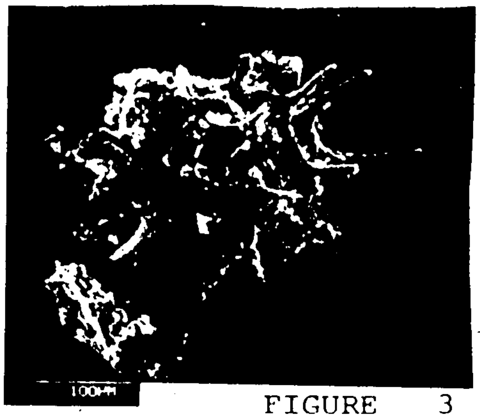


FIGURE 3

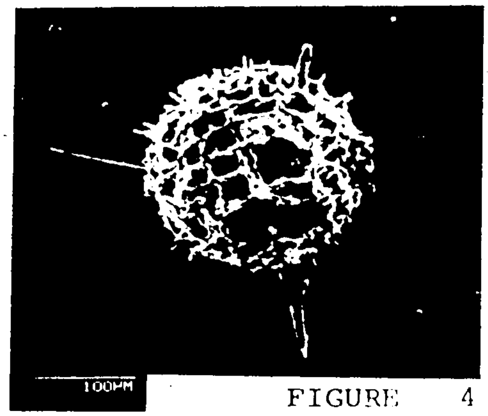


FIGURE 4

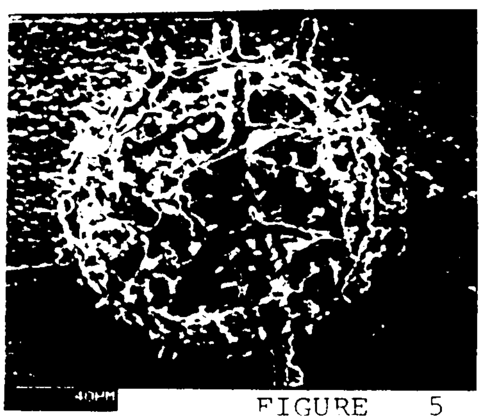


FIGURE 5

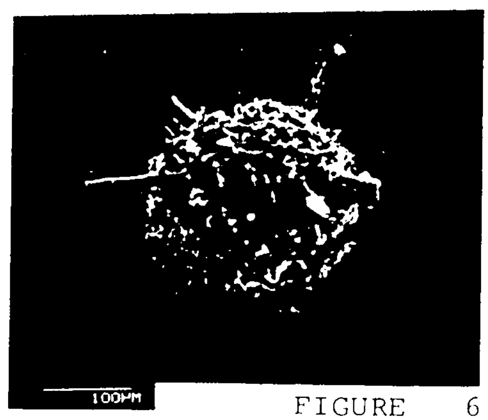


FIGURE 6

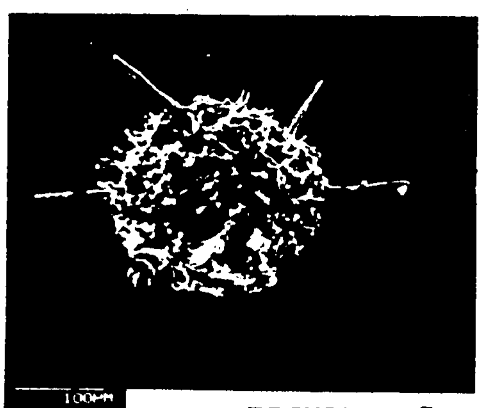


FIGURE 7

PLATE XVIII

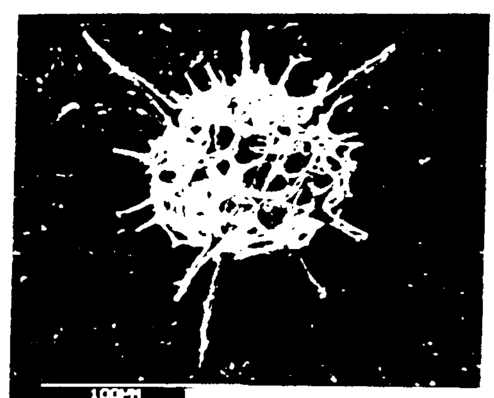


FIGURE 8

PLATE XIX

ROTASPHAERID New Genus B new species A

Fig.	Text page	Section	Hor[illegible] (ft)	[illegible] of [illegible]
1	127	76 BH1	33-36	External
2	127	76 BH1	33-36	External
3	127	76 BH1	33-36	External
4	127	76 BH1	33-36	External
5	127	76 BH1	33-36	Broken external and internal
6	127	76 BH1	33-36	External
7	127	76 BH1	33-36	Broken external and internal
8	127	76 BH1	33-36	Close up of Fig. 8

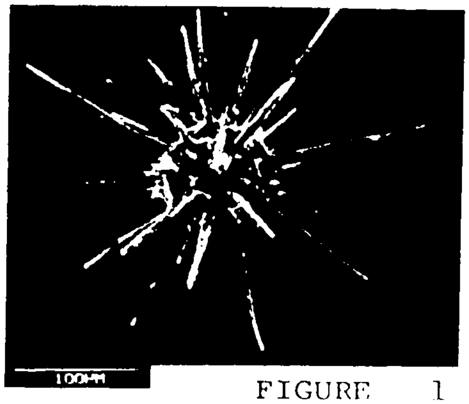


FIGURE 1

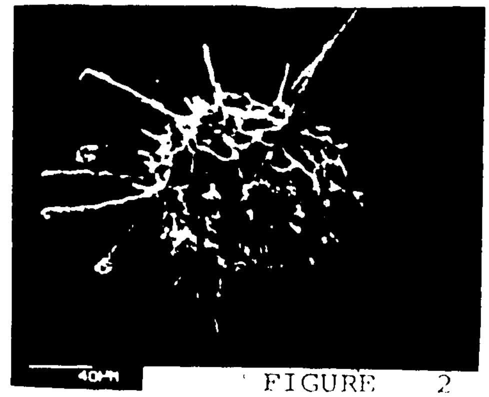


FIGURE 2

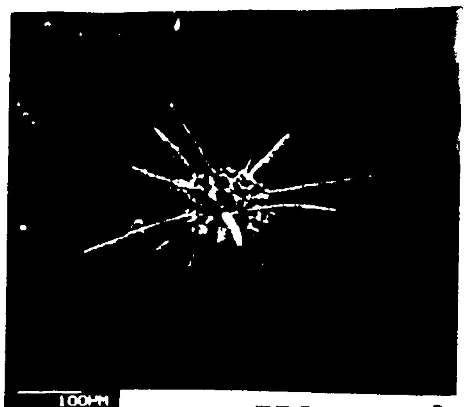


FIGURE 3

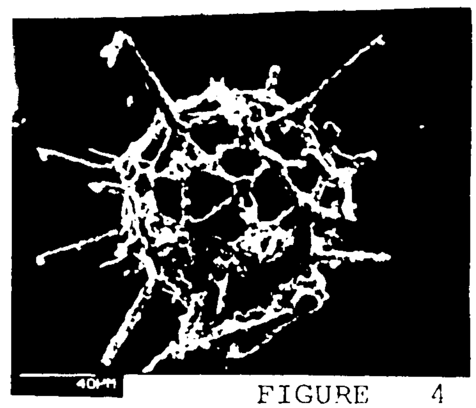


FIGURE 4

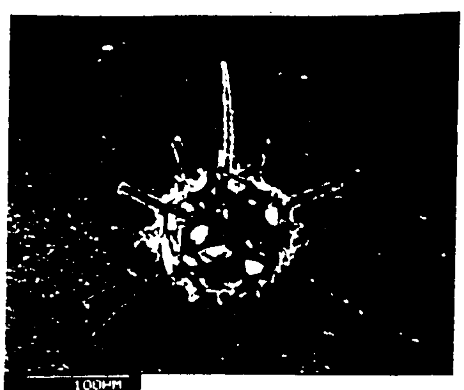


FIGURE 5

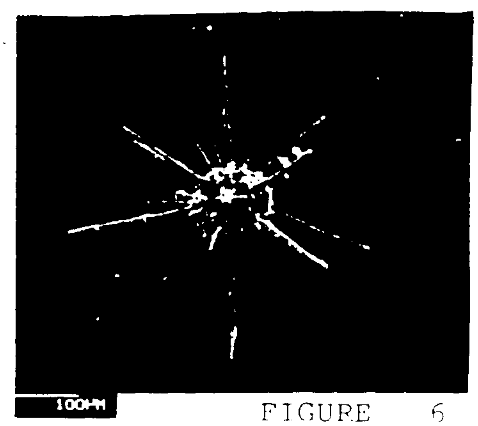


FIGURE 6

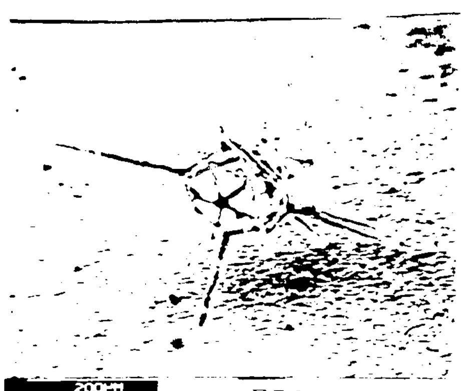


FIGURE 7

PLATE XIX

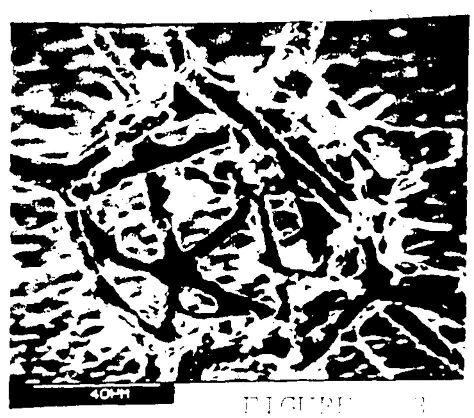


FIGURE 8

PLATE XX

ROTASPHAERID NEW GENUS B new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	127	79 CP	29	External
2	127	79 CP	27	External
3	127	79 CP	91	External. ?Youngest ontogenetic stage?
4	127	79 CP	27	External

ROTASPHAERID NEW GENUS B new species B

5	130	BH1	600	External, glue covered

ROTASPHAERID NEW GENUS B aff. B new species C

6	134	76 CP	325-330	External, maximum spine development
7	134	76 CP	325-330	External, not fully developed
8	134	76 CP	340-355	External, not fully developed

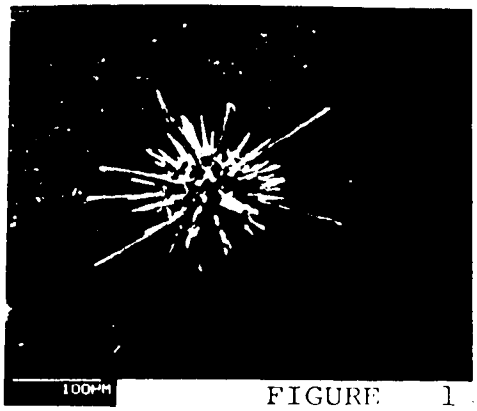


FIGURE 1

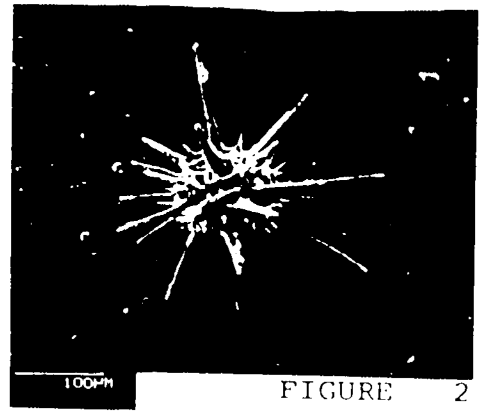


FIGURE 2

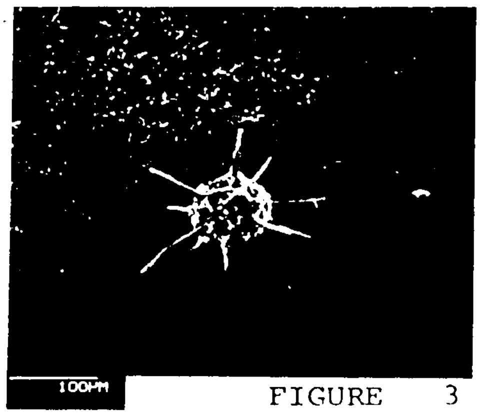


FIGURE 3

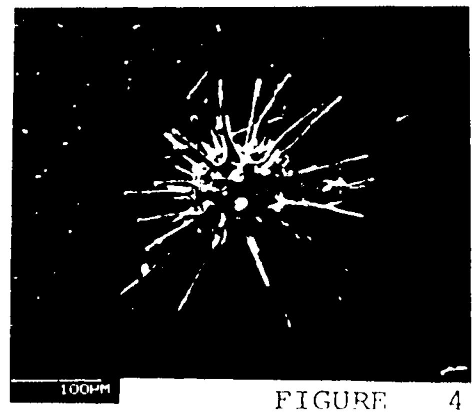


FIGURE 4

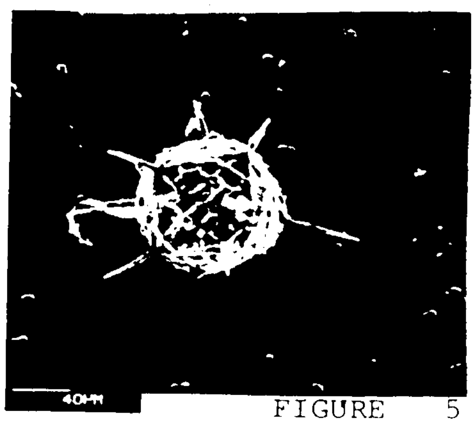


FIGURE 5

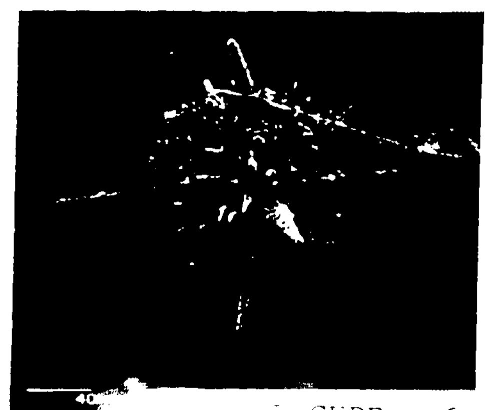


FIGURE 6

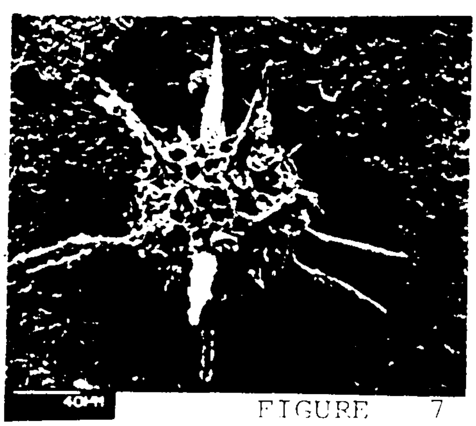


FIGURE 7

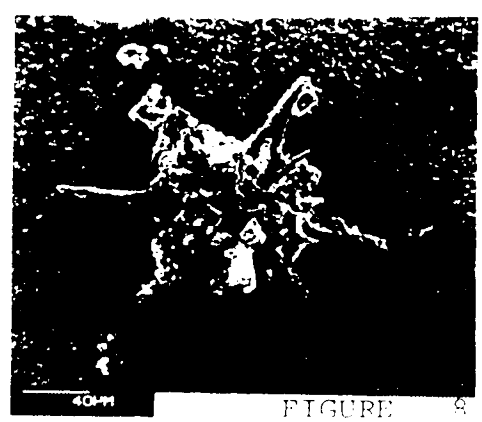


FIGURE 8

PLATE XX

PLATE XXI

ROTASPHAERID NEW GENUS B new species C

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	132	76 CP	325-330	External. No minor spine development
2	132	76 CP	390-400	External, rudimentary minor spines
3	132	76 CP	325-330	External
4	132		390-400	External
5	132		325-330	External, maximum minor spine development

ROTASPHAERID NEW GENUS B new species D

6	136	79 CP	155	External
7	136	79 CP	155	External
8	136	79 CP	155	External

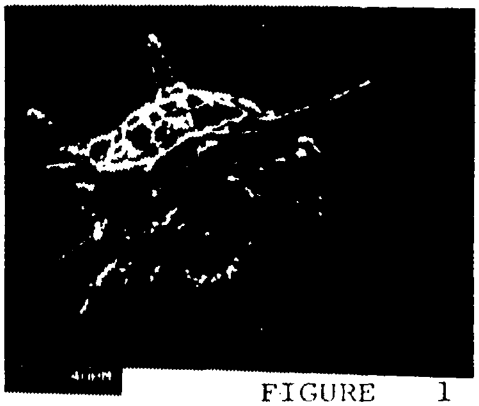


FIGURE 1

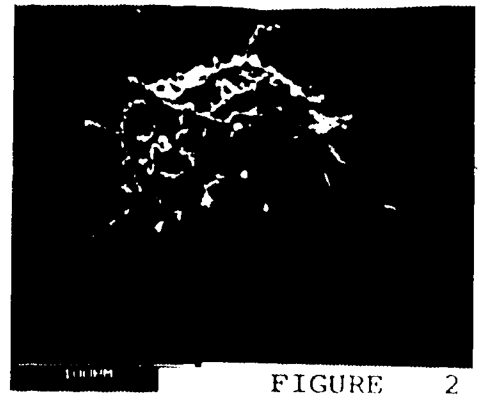


FIGURE 2

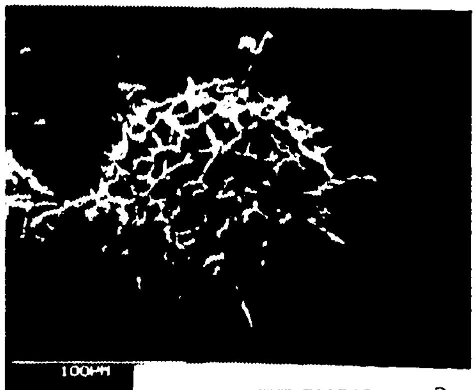


FIGURE 3

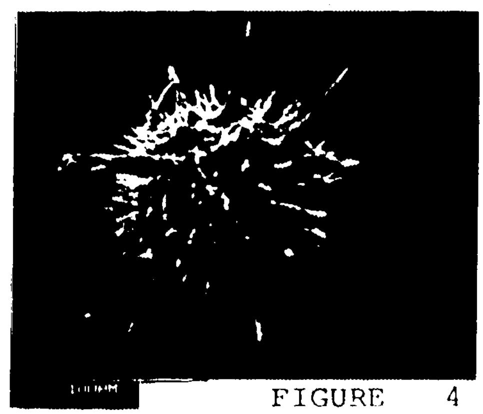


FIGURE 4

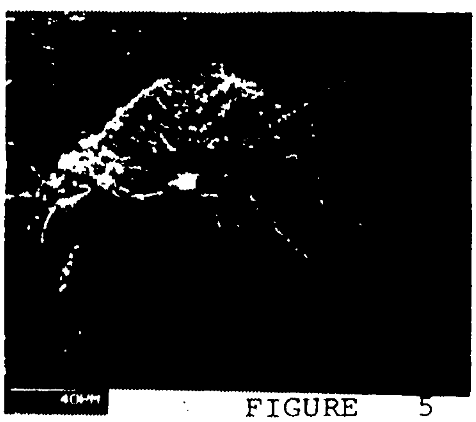


FIGURE 5

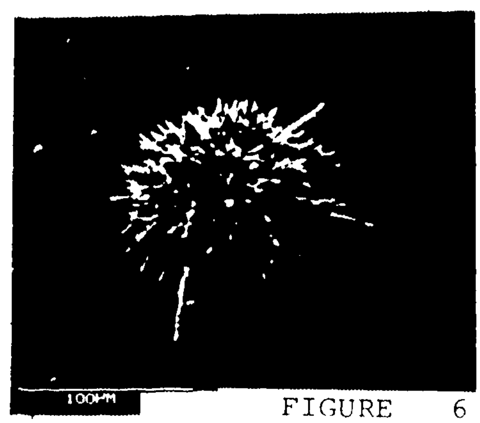


FIGURE 6

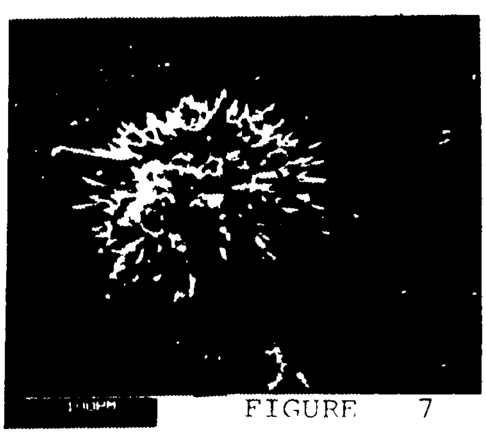


FIGURE 7

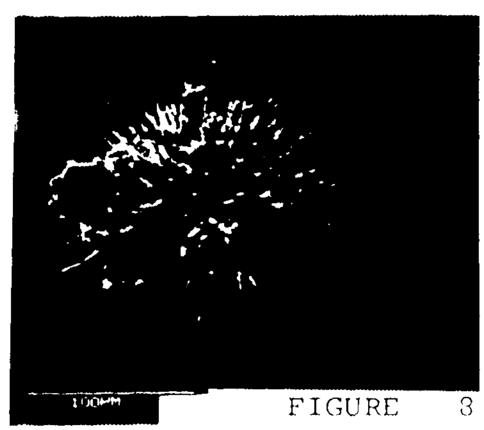


FIGURE 8

PLATE XXI

PLATES XXII AND XXIII

CERATOIKISCUM new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	143	76 CP	365-375	Side view Anterior to left.
2	143	76 CP	340-350	Side view Anterior to base of photo.
3	143	76 CP	340-350	Oblique view Anterior at bottom left
4	143	76 CP	340-350	Close up of Fig.3
5	143	76 BH1	600	Side view Anterior to top of photo.
6	143	76 BH1	600	Side view of Fig. 5 Anterior to right of photo.
7	143	76 CP	325-330	Oblique view Anterior to top left of photo
8	143	76 CP	325-330	Close up of caveal ribs of Fig.7

FIGURE 1

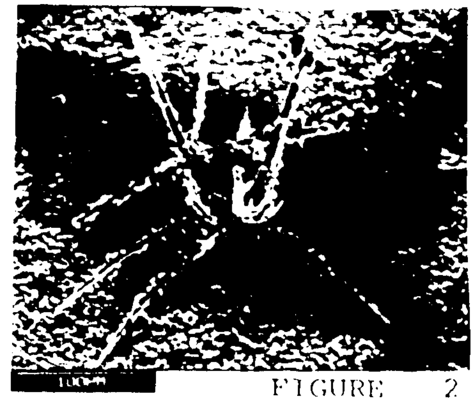


FIGURE 2

FIGURE 3

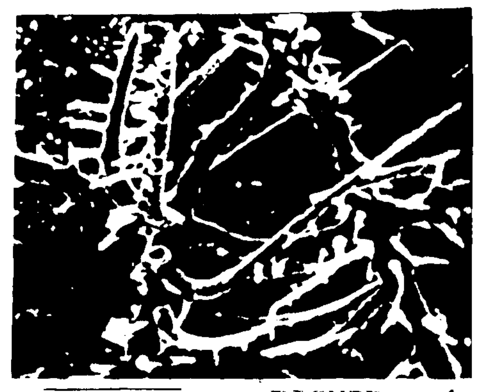


FIGURE 4

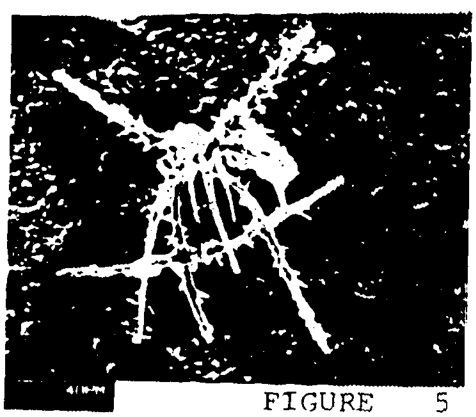


FIGURE 5

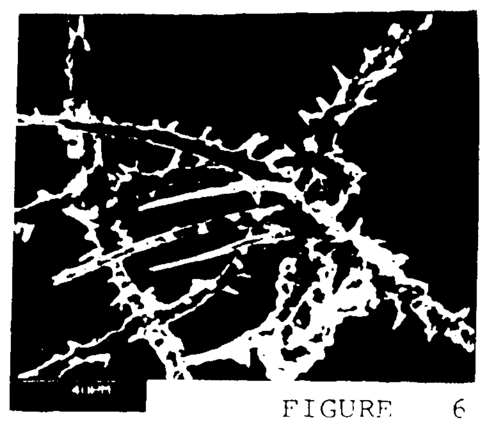


FIGURE 6

FIGURE 7

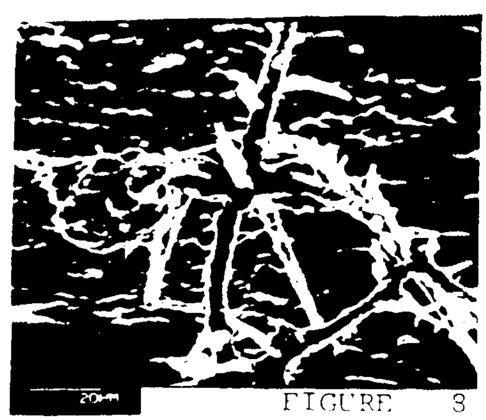


FIGURE 8

PLATE XXII

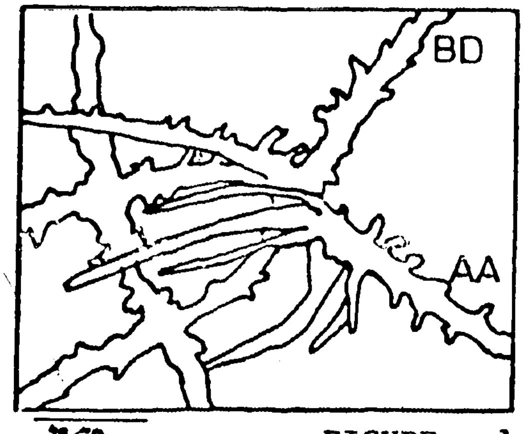


FIGURE 1

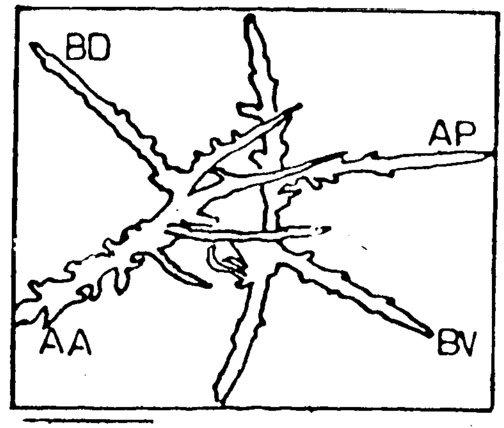


FIGURE 2

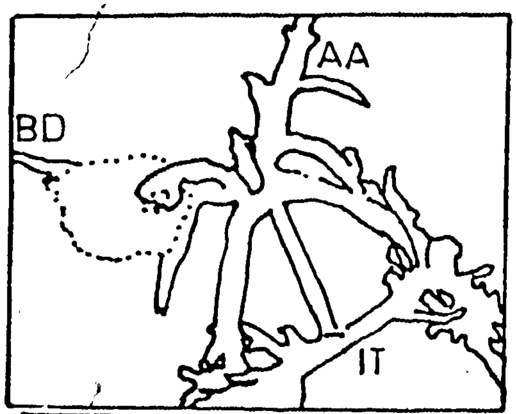


FIGURE 3

FIGURE 4

INTERPRETATION OF SKELETONS FIGURED IN PLATE XXII

PLATE XXII		PLATE XXIII
FIGURE 6	.....	FIGURE 1
FIGURE 3	.....	FIGURE 2
FIGURE 8	.....	FIGURE 3
FIGURE 4	.....	FIGURE 4

PLATE XXIII

PLATES XXIV AND XXV

CERATOIKISCUM new species B

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	145	76 BH1	765	Oblique view. Anterior to bottom left of photo.
2	145	76 BH1	765	Side view. Anterior to bottom left of photo.
3	145	76 BH1	765	Close up of caveal ribs of Fig.2
4	145	76 BH2	215	Oblique view from posterior
5	145	76 BH1	765	Side view. Anterior in top left of photo.
6	145	76 LL 10		Oblique side view. Anterior to right of photo
7	145	76 CP	325-330	Oblique side view. Anterior to bottom right
8	145	76 CP	325-330	Posterior view Fig 7

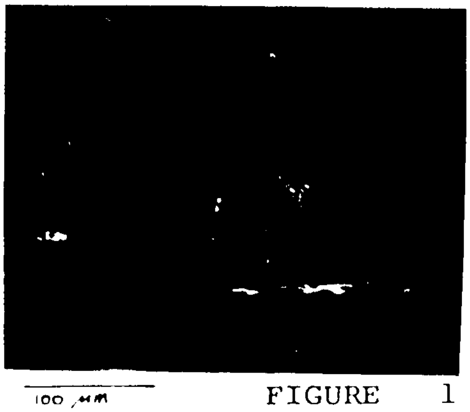


FIGURE 1

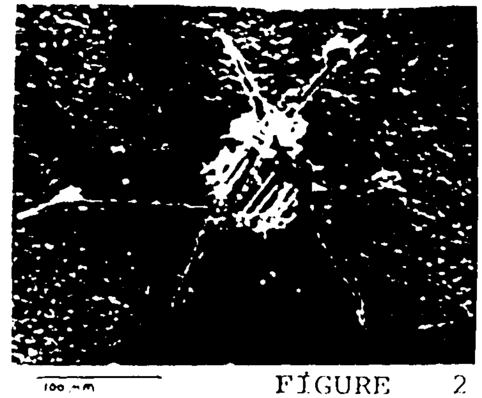


FIGURE 2

FIGURE 3

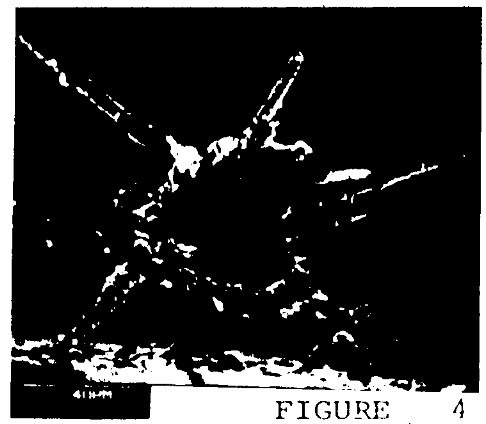


FIGURE 4

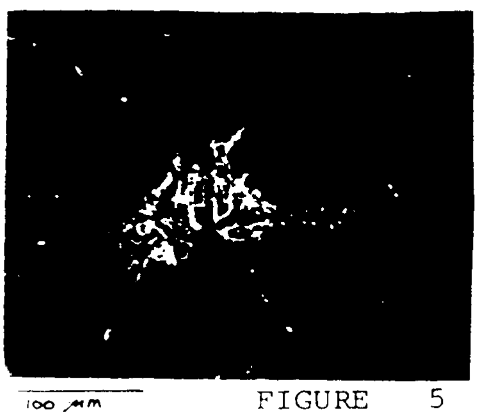


FIGURE 5

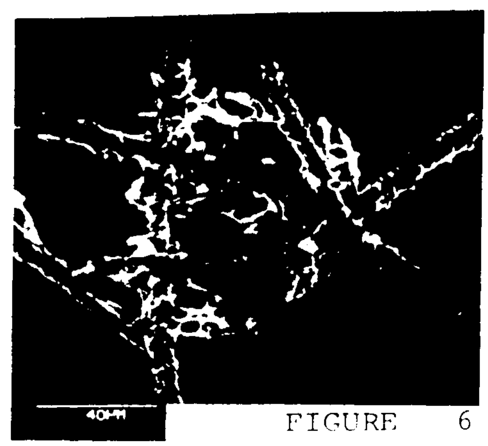


FIGURE 6

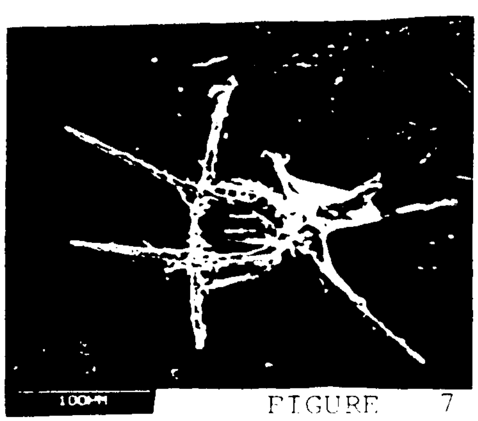


FIGURE 7

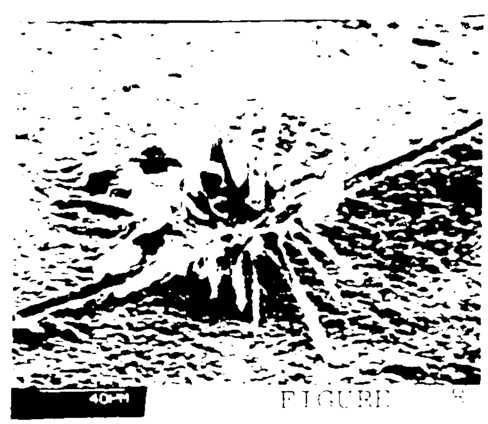


FIGURE 8

PLATE XXIV

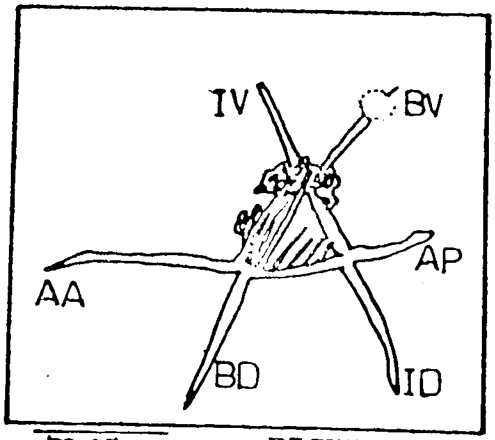


FIGURE 1

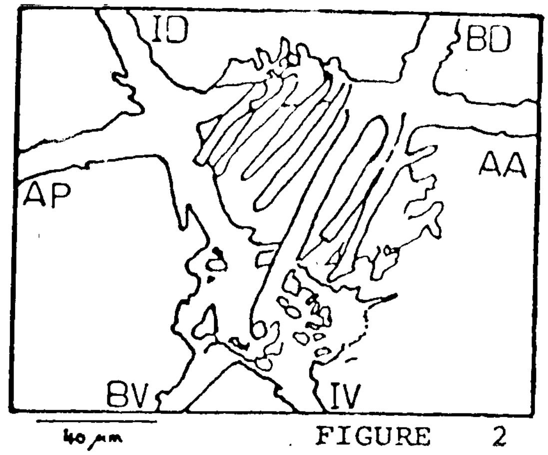


FIGURE 2

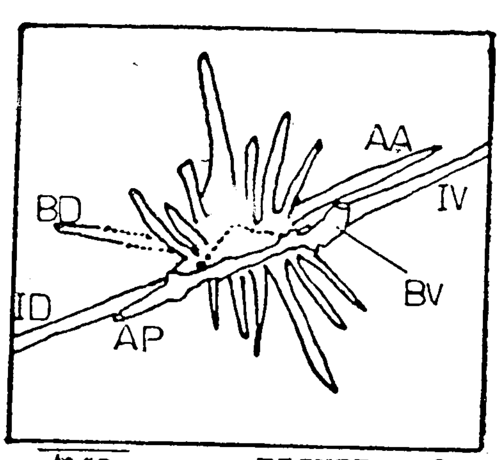


FIGURE 3

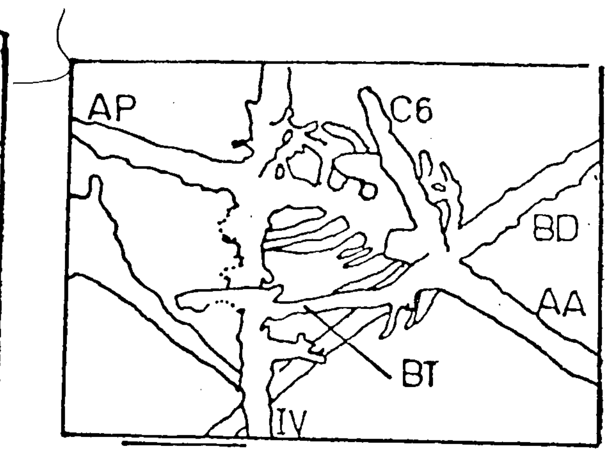


FIGURE 4

INTERPRETATIONS OF SKELETONS FIGURED IN PLATE XXIV

PLATE XXIV		PLATE XXV
FIGURE 2	.....	FIGURE 1
FIGURE 3	.....	FIGURE 2
FIGURE 8	.....	FIGURE 3
FIGURE 6	.....	FIGURE 4

PLATE XXV

PLATES XXVI AND XXVII

CERATOIKISCUM new species C

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	148	76 CP	315-325	Side view. Anterior to bottom left
2	148	76 CP	315-325	Close up of caveal ribs of Fig.1
3	148	76 CP	315-325	Posterior view
4	148	76 CP	315-325	Posterior view
5	148	76 CP	325-330	Side view. Anterior to top right of photo
6	148	76 CP	325-330	Side view of Fig 5 Anterior to top of photo
7	148	76 BH1	480	Side view. Anterior to bottom of photo
8	148	76 BH1	765	Oblique view. Anterior to left of photo

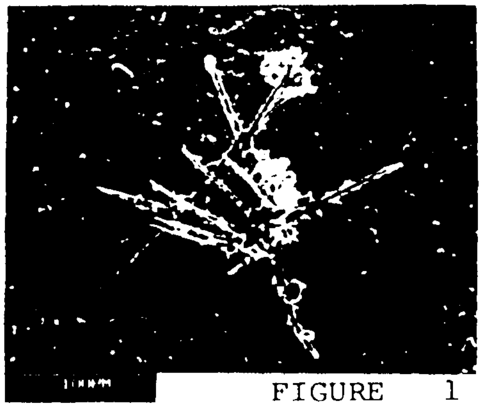


FIGURE 1

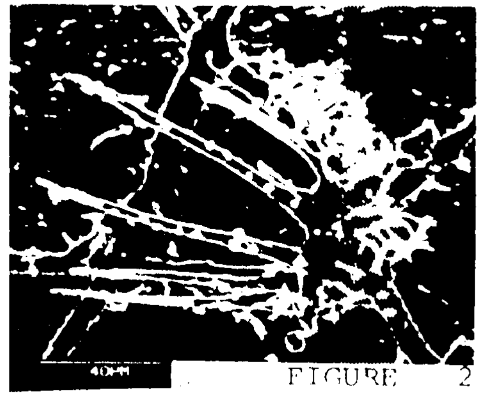


FIGURE 2

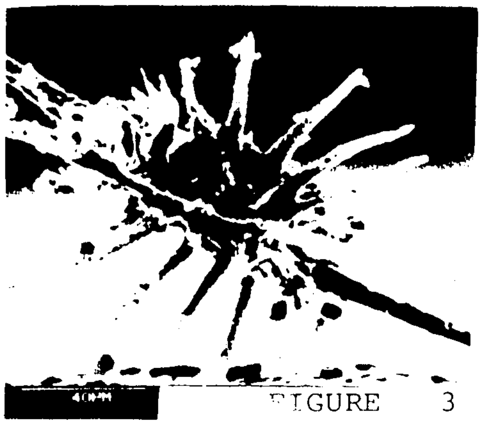


FIGURE 3

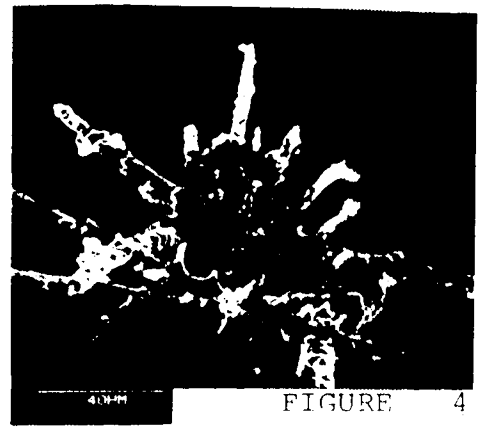


FIGURE 4

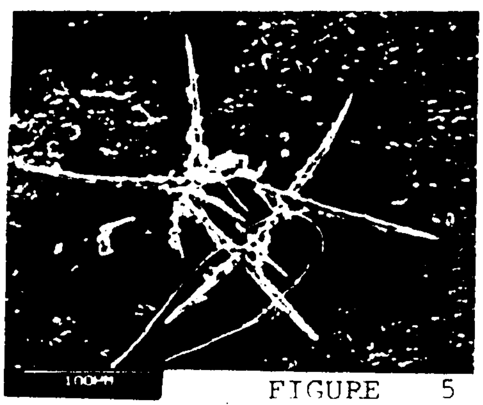


FIGURE 5

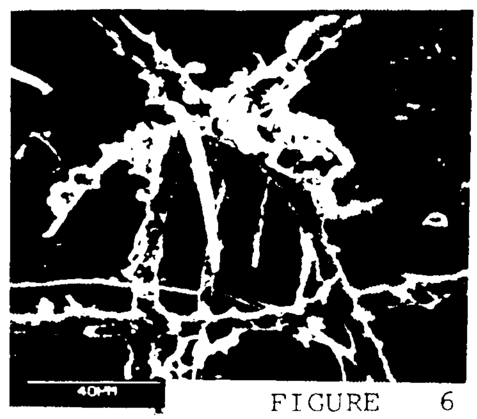


FIGURE 6

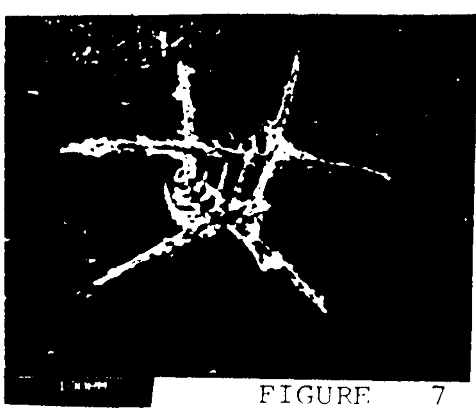


FIGURE 7

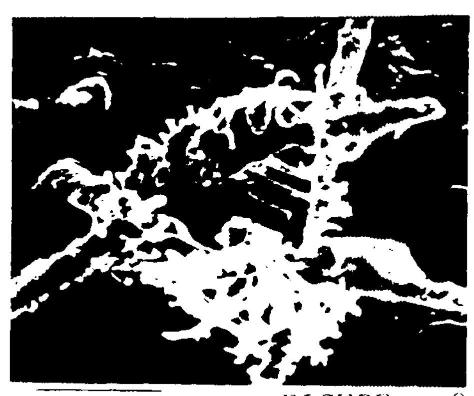


FIGURE 8

PLATE XXVI

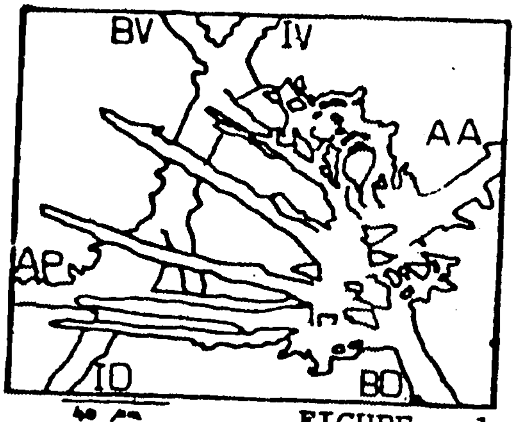


FIGURE 1

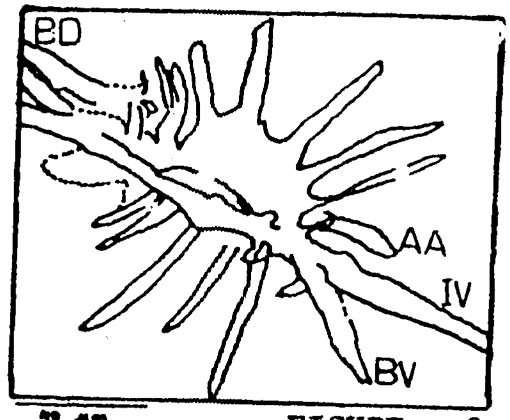


FIGURE 2

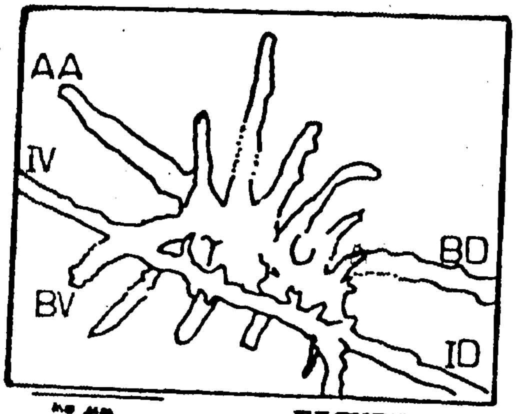


FIGURE 3

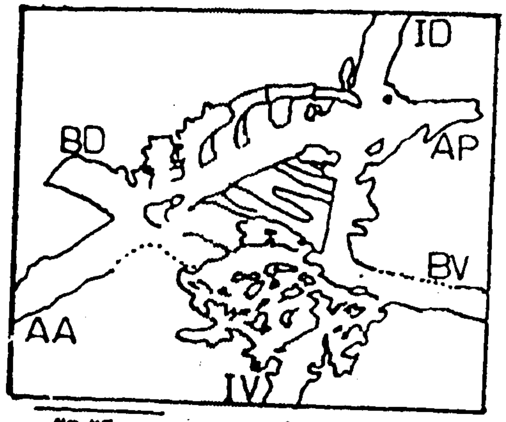


FIGURE 4

INTERPRETATION OF SKELETONS FIGURED IN PLATE XXVI

PLATE XXVI		PLATE XXVII
FIGURE 2	.....	FIGURE 1
FIGURE 3	.....	FIGURE 2
FIGURE 4	.....	FIGURE 3
FIGURE 8	.....	FIGURE 4

PLATE XXVII

PLATES XXVIII AND XXIX

CERATOIKISCUM new species D

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	151	76 BH2	265	Side view. Anterior to left of photo
2	151	76 BH1	765	Side view. Anterior to top of photo
3	151	76 BH2	265	Side view. Anterior to right of photo
4	151	76 BH2	265	Close up Fig.3
5	151	76 BH2	215	Side view. Anterior to left of photo
6	151	76 BH2	215	Side view. Anterior to right of photo
7	151	76 BH2	215	Side view. Anterior to bottom left of photo
8	151	76 BH2	215	Close up of Fig.7

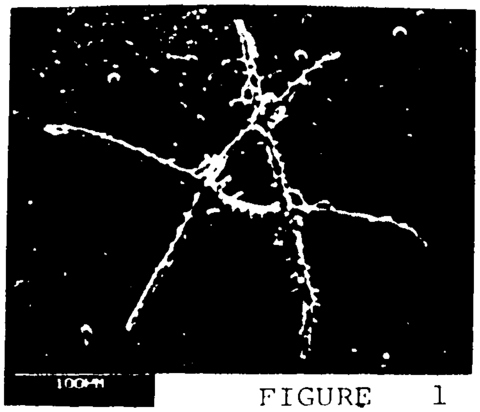


FIGURE 1

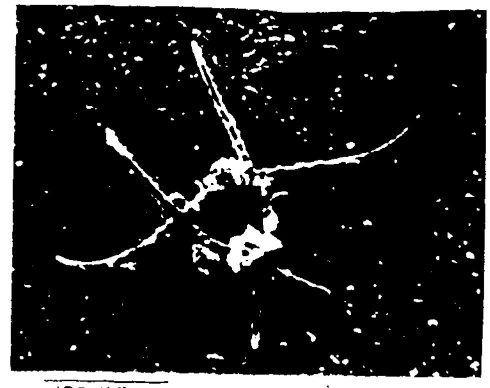


FIGURE 2

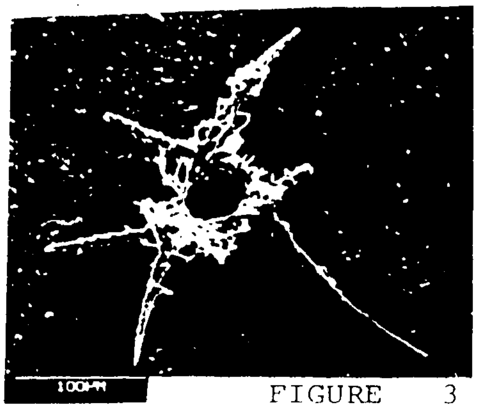


FIGURE 3

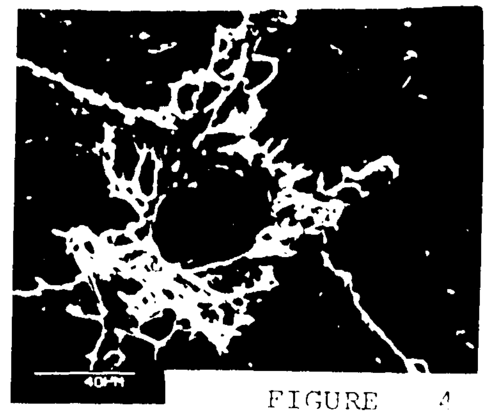


FIGURE 4

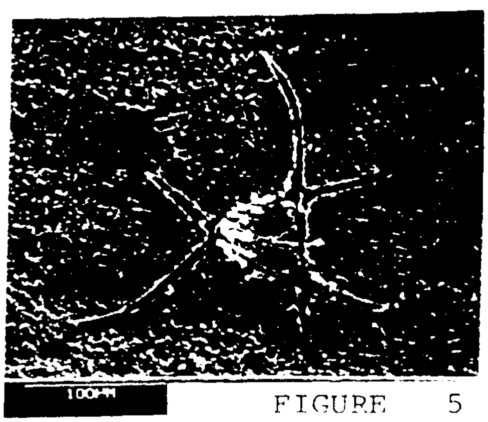


FIGURE 5

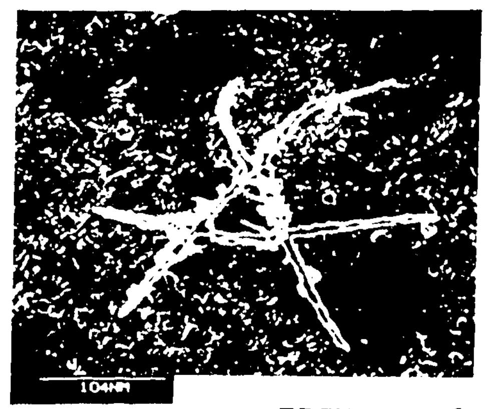


FIGURE 6

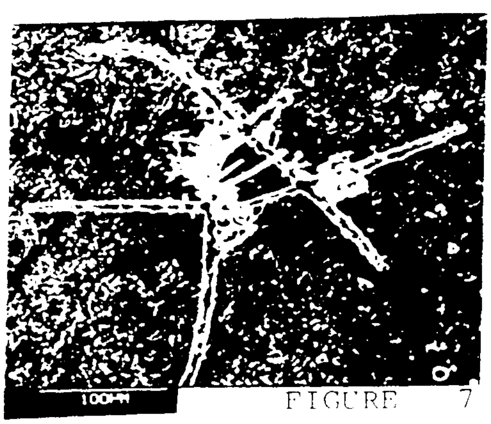


FIGURE 7

PLATE XXVIII

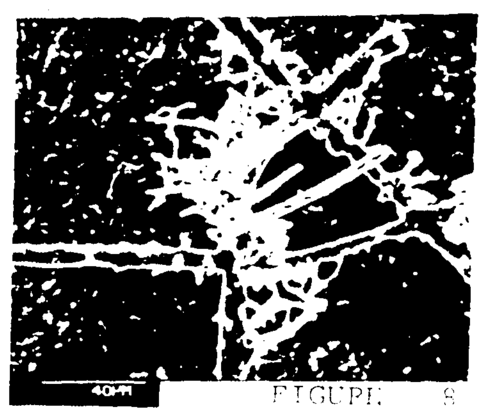


FIGURE 8

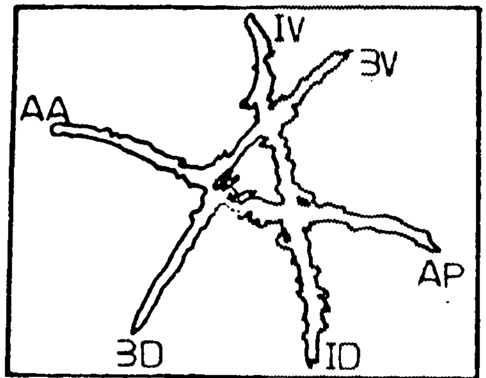


FIGURE 1

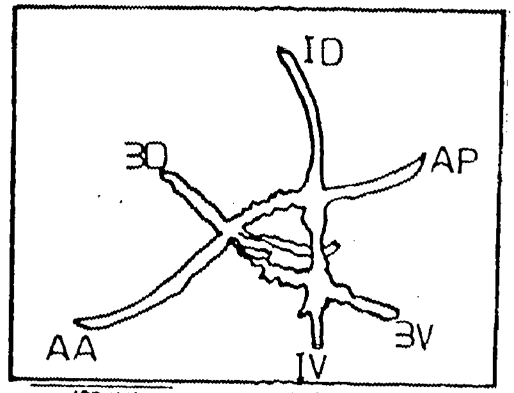


FIGURE 2

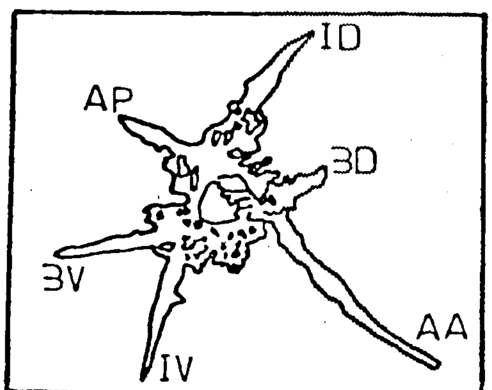


FIGURE 3

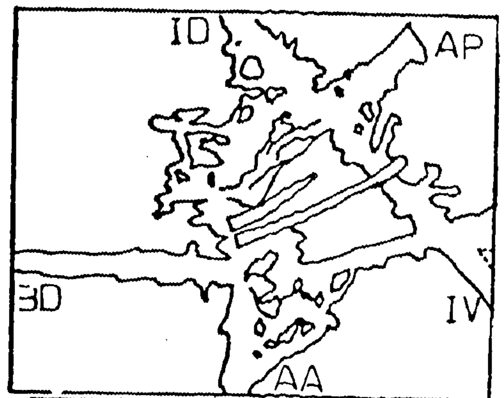


FIGURE 4

INTERPRETATION OF SKELETONS FIGURED IN PLATE XXVIII

PLATE XXVIII		PLATE XXIX
FIGURE 1	.....	FIGURE 1
FIGURE 5	.....	FIGURE 2
FIGURE 3	.....	FIGURE 3
FIGURE 8	.....	FIGURE 4

PLATE XXIX

PLATE XXX

PALAEOSCENIDIUM new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	157	76 CP	315-325	Oblique basal view
2	157	76 CP	330-355	Oblique side view
3	157	76 CP	365-375	Side view
4	157	76 CP	340-350	Side view

PALAEOSCENIDIUM new species B

5	159	76 CP	365-375	Side view
6	159	76 CP	315-325	Side view
7	159	76 CP	315-325	Basal view
8	159	76 CP	315-325	Side view

FIGURE 1

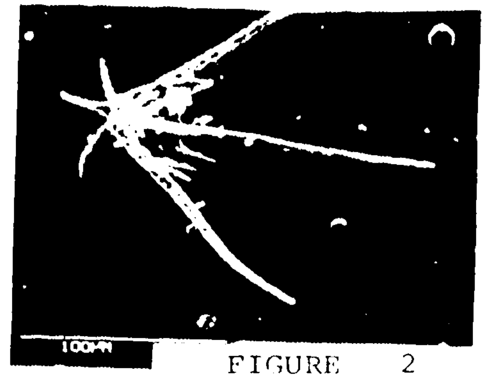


FIGURE 2

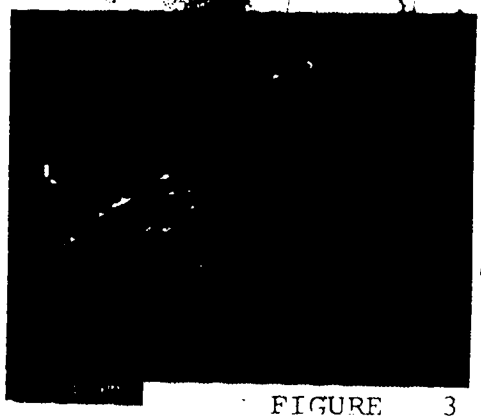


FIGURE 3

FIGURE 4

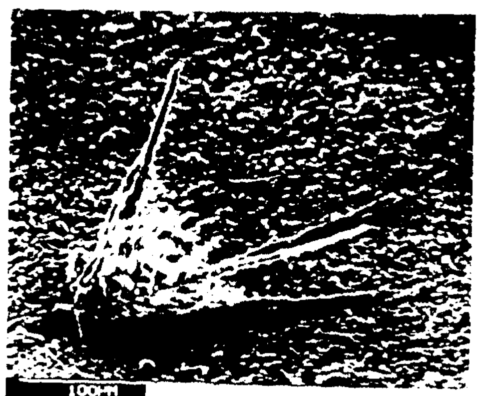
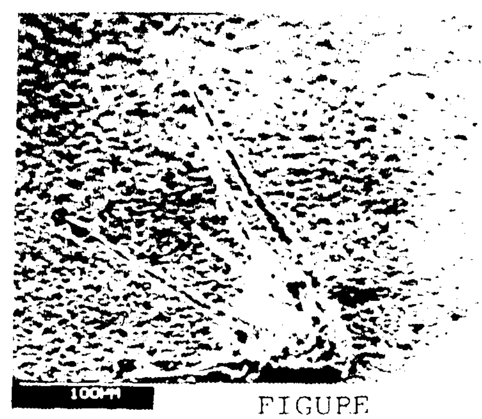


FIGURE 5



FIGURE

FIGURE 7

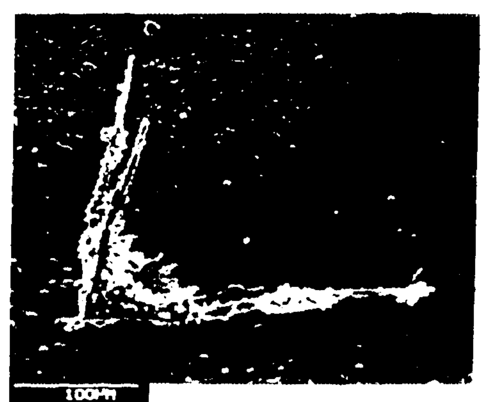


FIGURE 8

PLATE XXX

PLATE XXXI

PALAEOSCENIDIUM new species C

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	161	76 CP	315-325	Side view
2	161	76 BH1	600	Side view
3	161	76 BH1	600	Basal view of Fig.2

PALAEOSCENIDIUM aff P. new species D

4	165	76 CP	315-325	Side view

PALAEOSCENIDIUM new species D

5	163	76 CP	315-325	Oblique apical view
6	163	76 CP	365-375	Oblique apical view
7	163	76 BH1	480	Oblique basal view
8	163	76 CP	365-375	Basal view

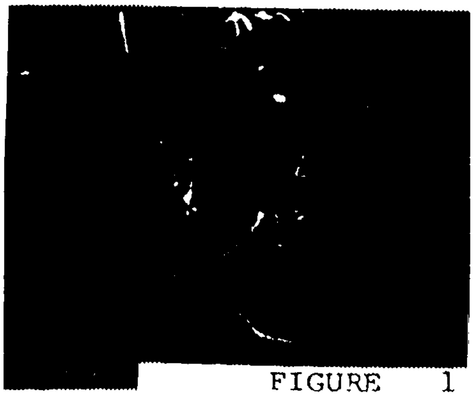


FIGURE 1

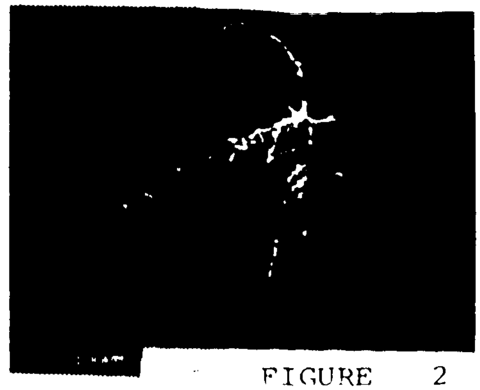
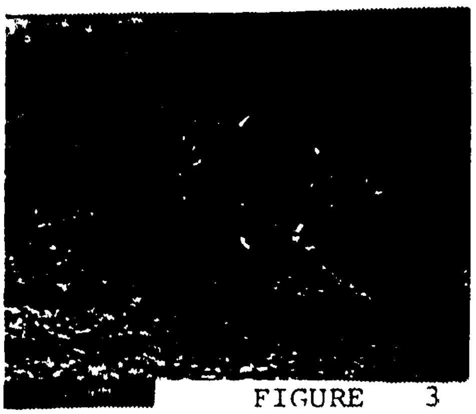


FIGURE 2



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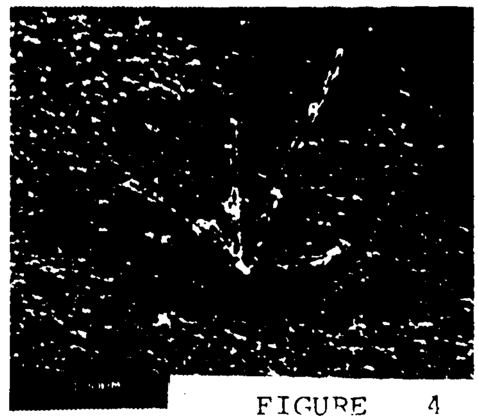


FIGURE 4

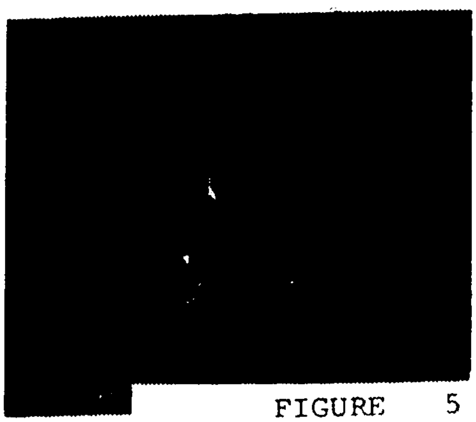


FIGURE 5

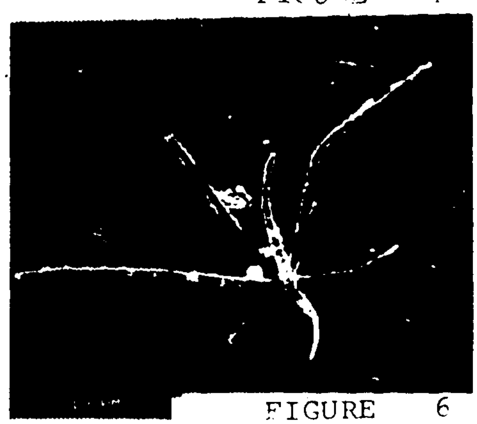


FIGURE 6

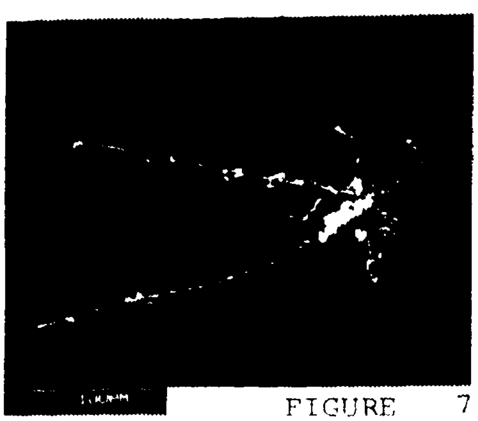


FIGURE 7

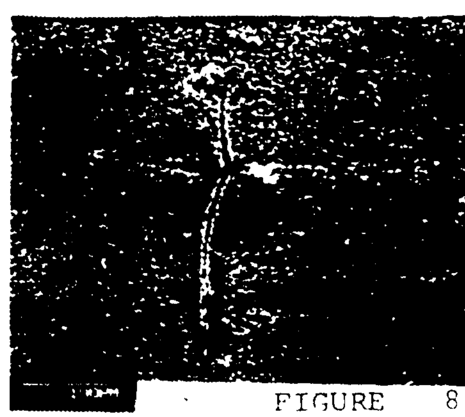


FIGURE 8

PLATE

XXXI

PLATE XXXII

PALAEOSCENIDIIDAE NEW GENUS C NEW SUBGENUS C new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	168	76 CP	340-355	Oblique.basal view
2	168	76 CP	365-375	Side view
3	168	76 BH1	480	Oblique basal view
4	168	76 BH1	480	Basal view of Fig.3

PALAEOSCENIDIIDAE NEW GENUS C SUBGENUS C new species B

5	170	76 BH1	480	Side view

PALAEOSCENIDIIDAE NEW GENUS C SUBGENUS C new species C

6	172	76 CP	315-325	Side view

PALAEOSCENIDIIDAE NEW GENUS C SUBGENUS Y aff. new species D

7	177	76 CP	340-350	Side view

PALAEOSCENIDIIDAE NEW GENUS F new species E

8	194	76 BH1	480	Side view

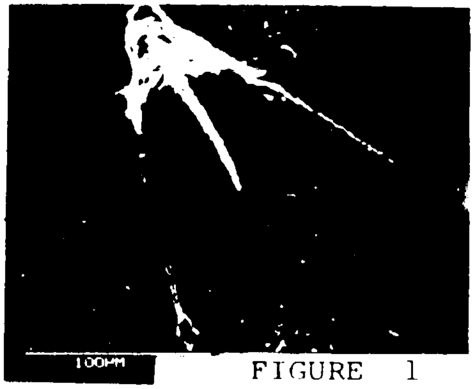


FIGURE 1

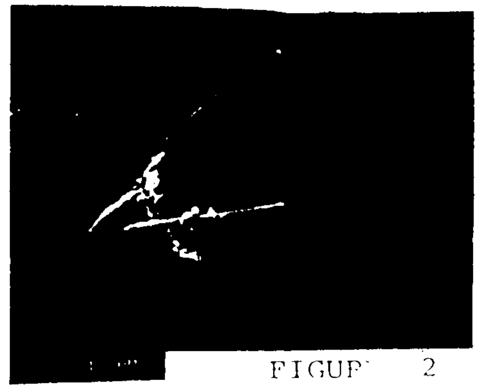


FIGURE 2

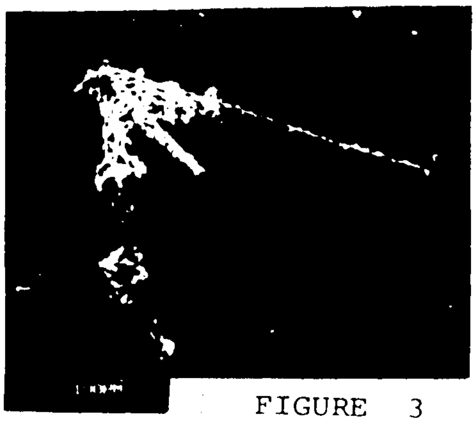


FIGURE 3

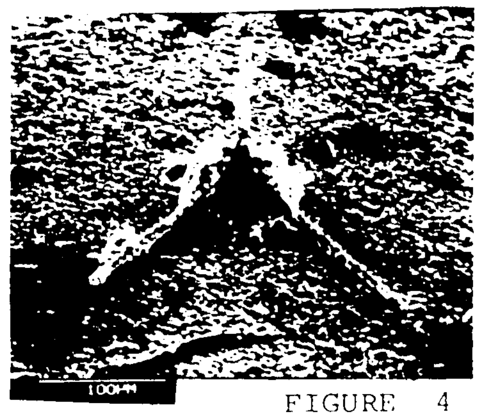


FIGURE 4

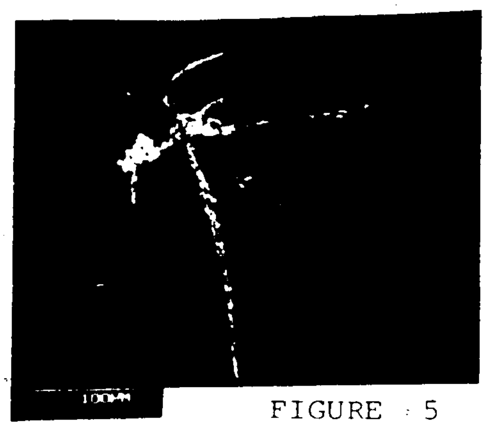


FIGURE 5

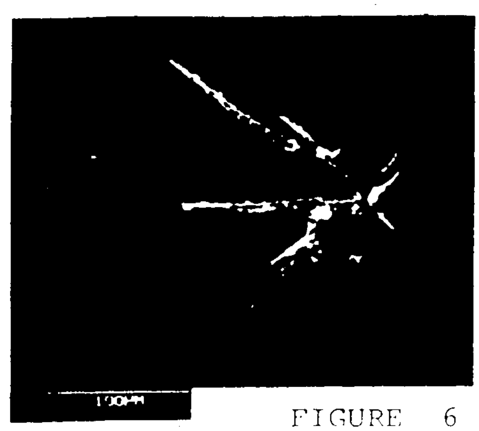


FIGURE 6

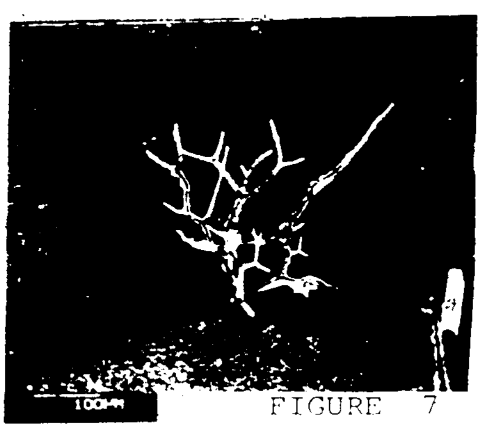


FIGURE 7

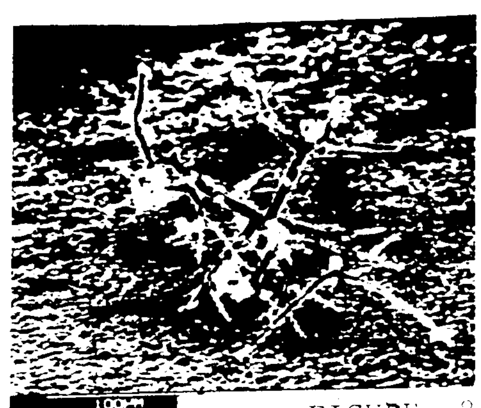


FIGURE 8

PLATE XXXII

PLATE XXXIII

PALAEOSCENIDIIDAE NEW GENUS C SUBGENUS species D

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	174	76 BH1	765	Side view
2	174	76 BH1	765	Basal view of Fig.1
3	174	76 BH1	765	Apical view
4	174	76 BH1	765	Side view of Fig.3

PALAEOSCENIDIIDAE NEW GENUS D new species A

5	180	[illegible]	135	Oblique apical view
6	180	76 CP	390-400	Basal view
7	180	79 CP	278	Oblique side view
8	180	79 CP	278	Oblique apical view Fig.7

FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

FIGURE 5

FIGURE 6

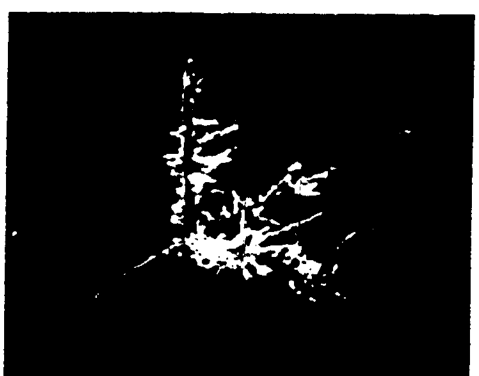


FIGURE 7

PLATE XXXIII

FIGURE 8

PLATE XXXIV

PALAEOSCENIDIIDAE NEW GENUS E new species A

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	183	79 CP	157	Basal view
2	183	79 CP	157	Oblique side view
3	183	79 CP	132	Oblique side view
4	183	79 CP	135	Basal view
5	183	79 CP	157	Oblique basal view
6	183	79 CP	157	Basal view

PALAEOSCENIDIIDAE NEW GENUS F new species A

7	185	76 CP	365-375	Oblique side view
8	185	76 CP	365-375	Basal view of Fig.7

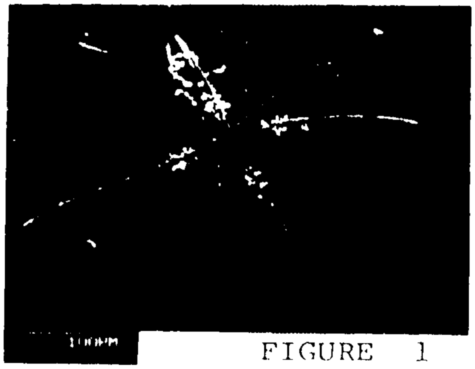
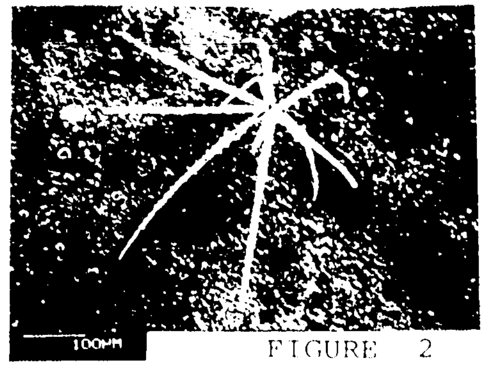


FIGURE 1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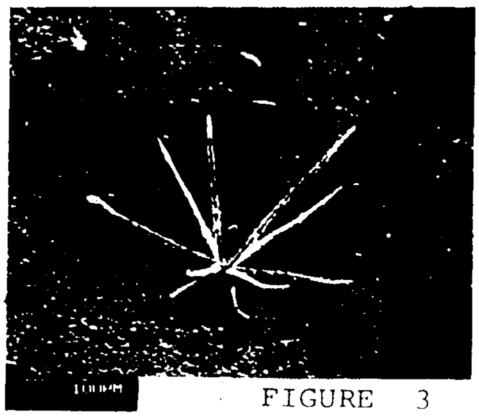
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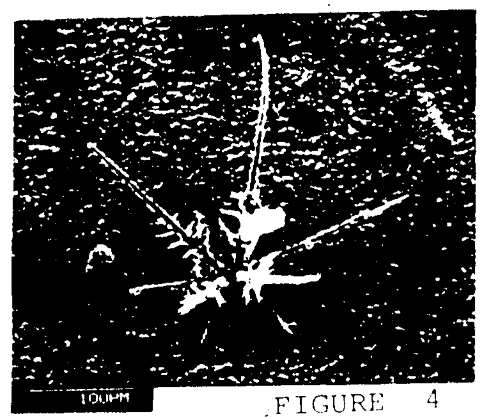
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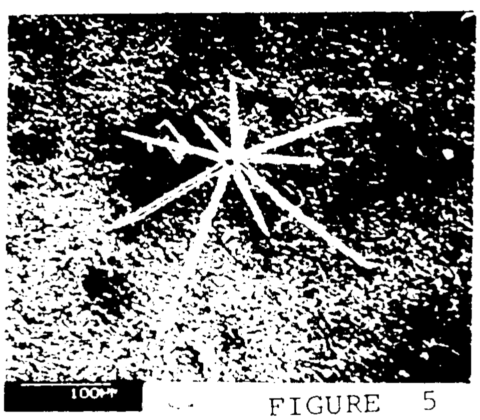
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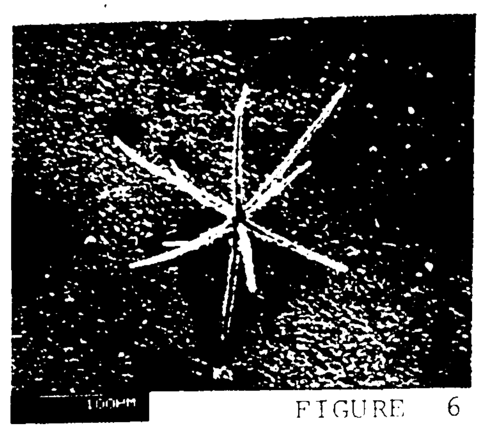


FIGURE 6


FIGURE 7

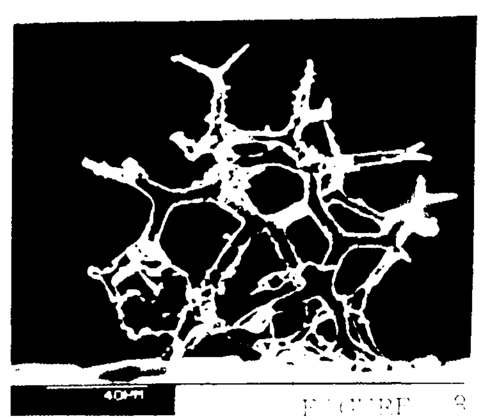


FIGURE 8

PLATE [illegible]

PLATE XXXV

PALAEOSCENIDIIDAE NEW GENUS F new species B

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	188	76 CP	315-325	Basal view
2	188	76 CP	315-325	Side view

PALAEOSCENIDIIDAE NEW GENUS F new species C

3	190	76 CP	315-325	Oblique side view
4	190	76 CP	315-325	Basal view of Fig.3

PALAEOSCENIDIIDAE NEW GENUS F new species D

5	192	76 CP	315-325	Basal view
6	192	76 CP	315-325	Oblique view of Fig.5

PALAEOSCENIDIIDAE NEW GENUS F new species F

7	197	76 CP	340-355	Side view
8	197	76 CP	330-340	Side view

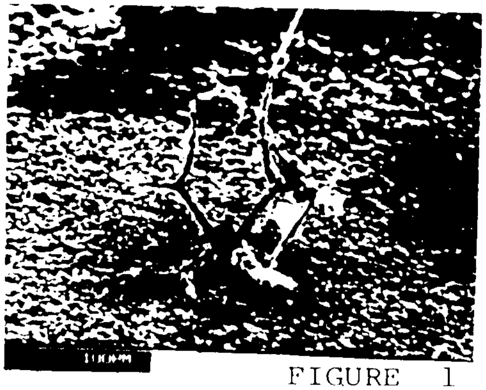
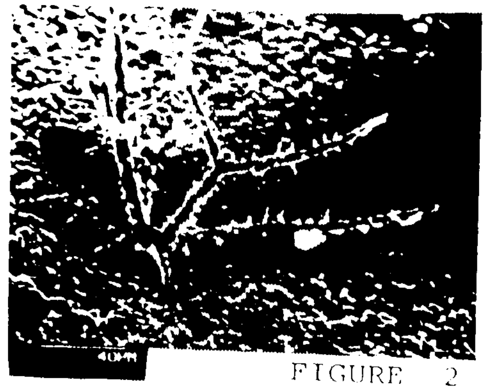


FIGURE 1



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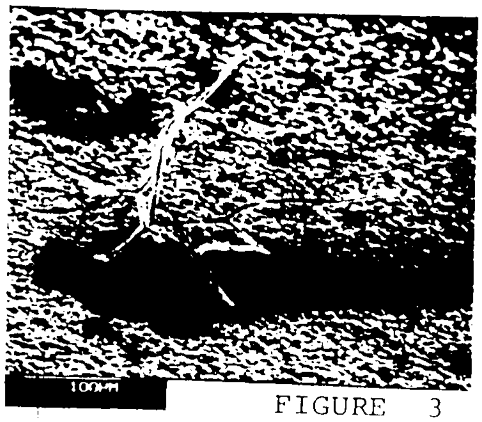
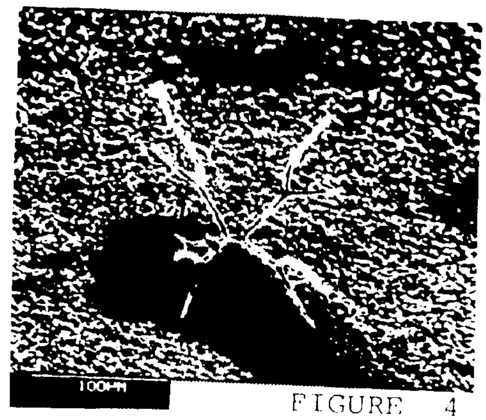


FIGURE 3



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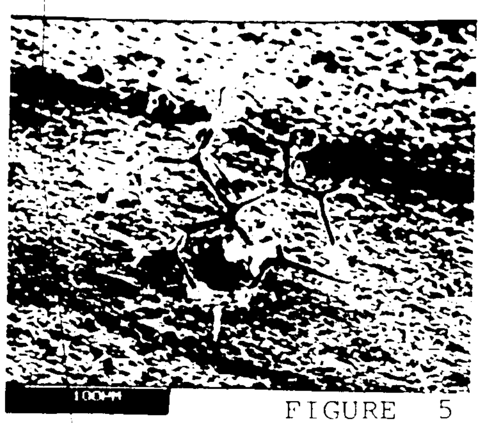
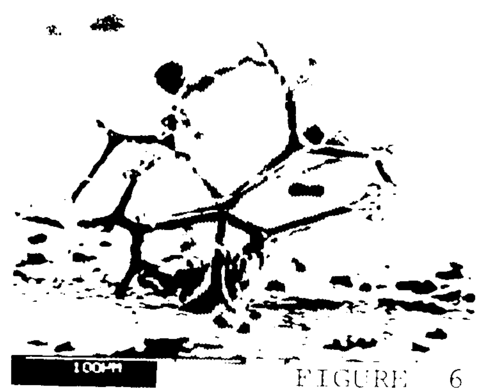


FIGURE 5



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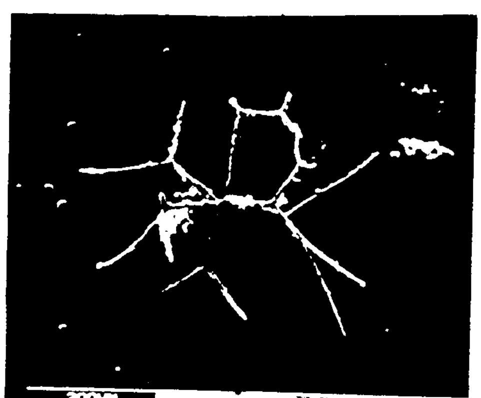


FIGURE 7

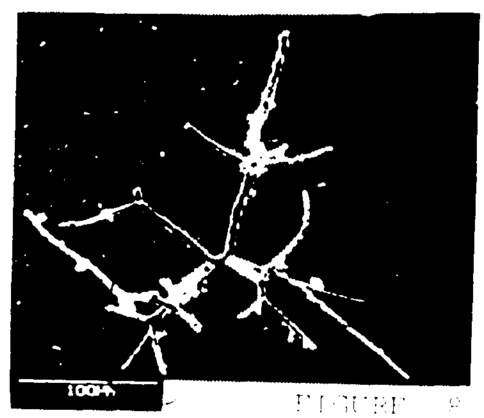


FIGURE 8

PLATE XXXV

PLATE XXXVI

PALAEOSCENIDIIDAE NEW GENUS F new species G

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	199	76 BH1	600	Basal view
2	199	76 CP	340-350	Basal view
3	199	76 CP	340-350	Oblique side view
4	199	79 CP	180	Side view
5	199	76 BH1	480	Basal view
6	199	76 BH1	480	Side view of Fig.5

PALAEOSCENIDIIDAE NEW GENUS F new species H

7	201	76 BH1	480	Side view

PALAEOSCENIDIIDAE NEW GENUS F new species M

8	214	76 CP	340-350	Side view, damaged

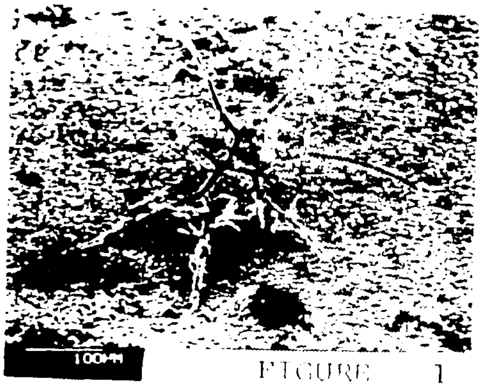
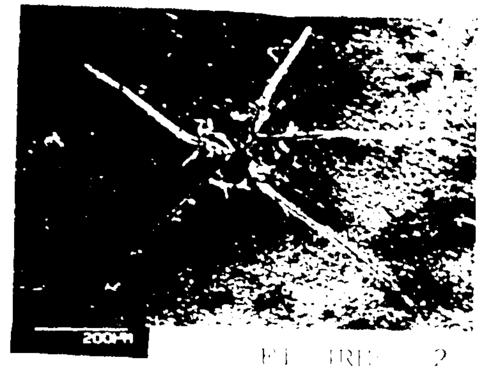


FIGURE 1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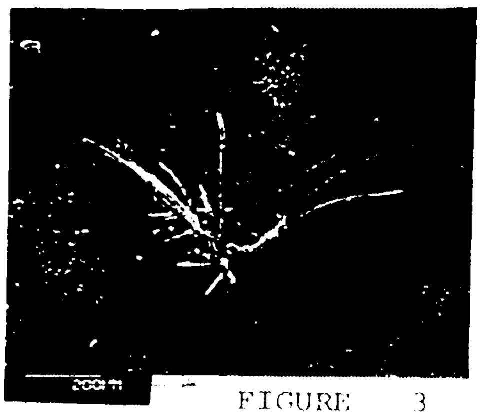
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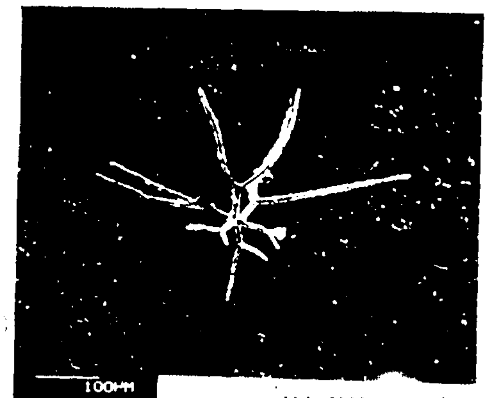


FIGURE 4


FIGURE 5

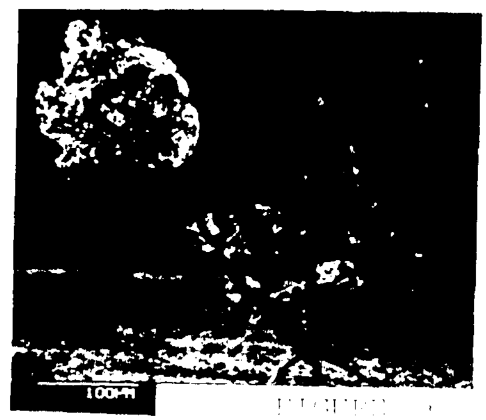


FIGURE 6

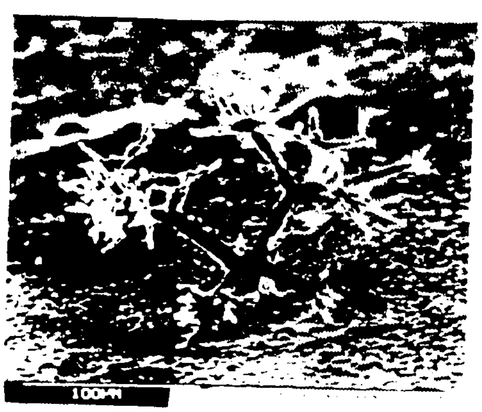


PLATE XXXVII

PALAEOSCENIDIIDAE NEW GENUS F new species I

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	203	76 CP	390-400	Side view,
2	203	76 CP	390-400	Apical view of Fig.1
3	203	76 BH2	215	Basal view,
4	203	76 BH2	215	Side view of Fig.3

PALAEOSCENIDIIDAE NEW GENUS F new species J

5	205	76 CP	340-350	Basal view, damaged
6	205	76 CP	340-350	Oblique basal view
7	205	76 CP	365-375	Side view,
8	205	76 CP	340-350	Oblique basal view

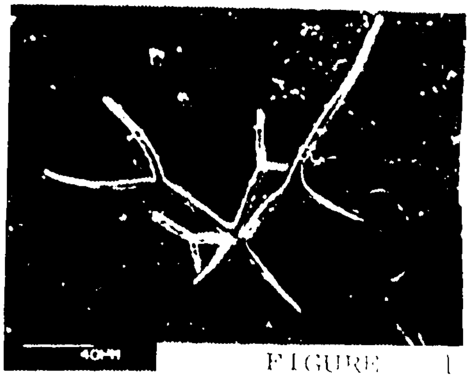


FIGURE 1

FIG

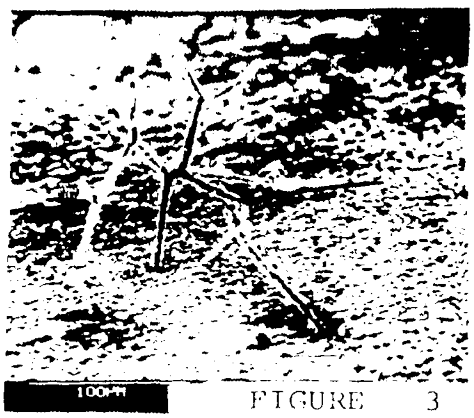


FIGURE 3

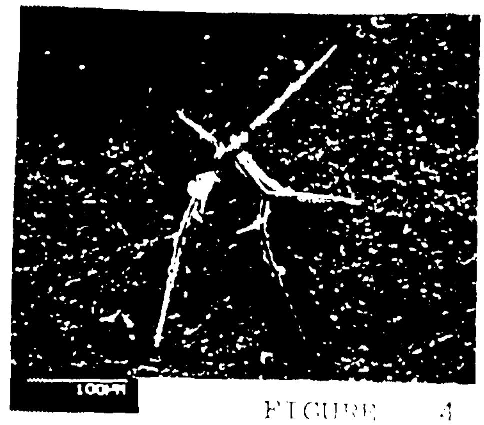
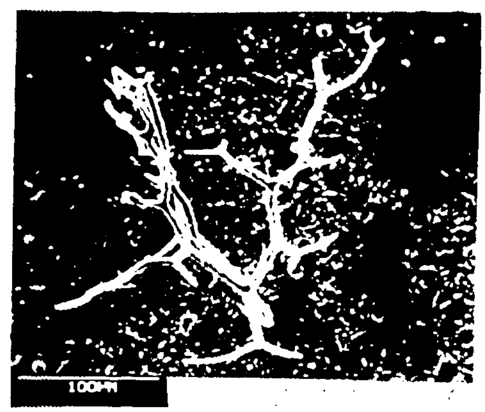


FIGURE 4

FIGURE 5



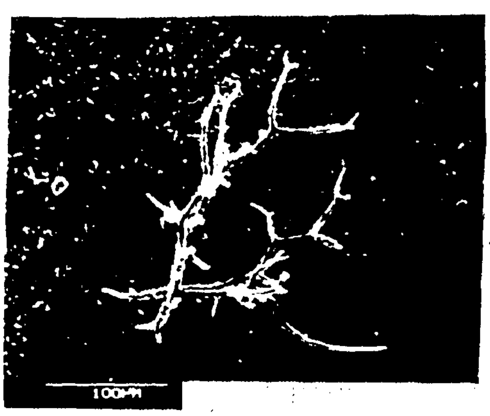


PLATE XXXVIII

PALAEOSCENIDIIDAE NEW GENUS F new species K

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	208	79 CP	15	Basal view
2	208	79 CP	6	Side view
3	208	79 CP	15	Oblique side view
4	208	79 CP	6	Apical view
5	208	79 CP	15	Oblique basal view

PALAEOSCENIDIIDAE NEW GENUS F aff. F. new species K

6	211	79 CP	6	Oblique side view
7	211	79 CP	6	Oblique basal view
8	211	79 CP	15	Basal view

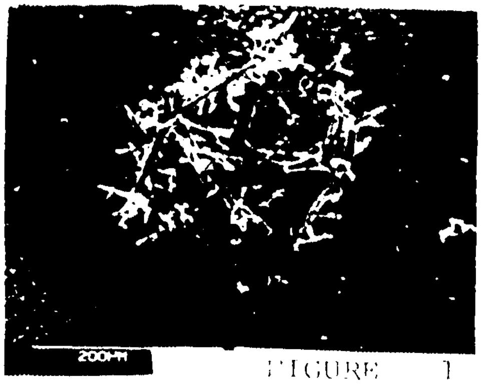


FIGURE 1

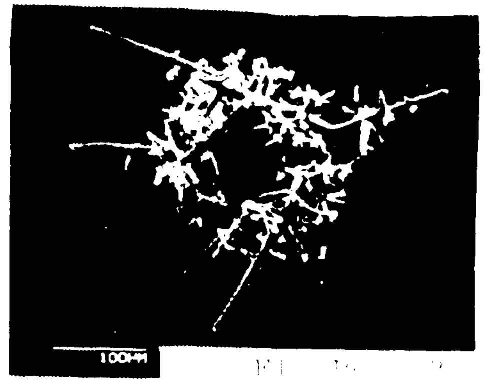


FIGURE 2

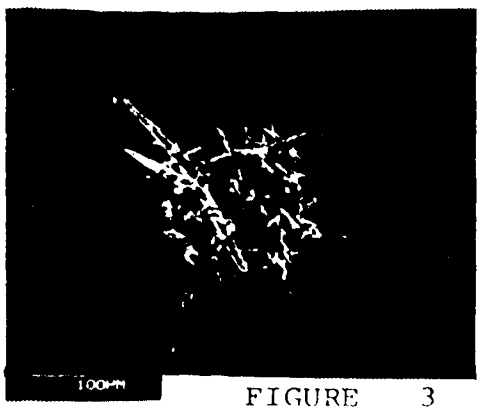


FIGURE 3

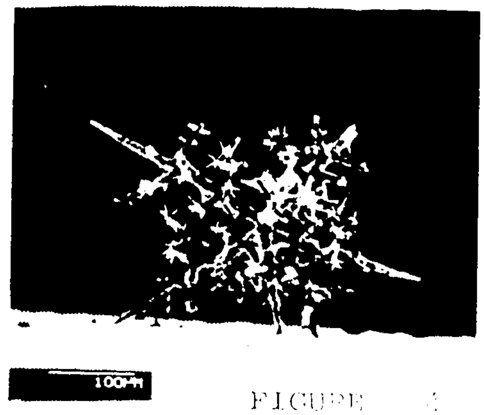


FIGURE 4

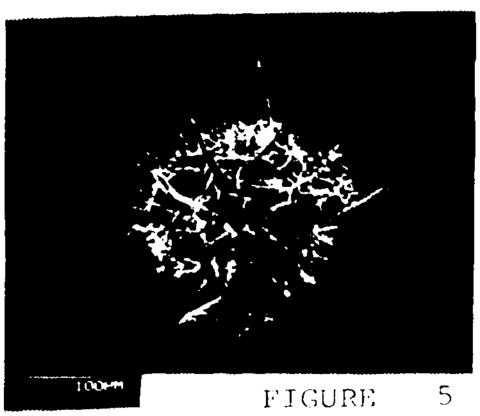


FIGURE 5

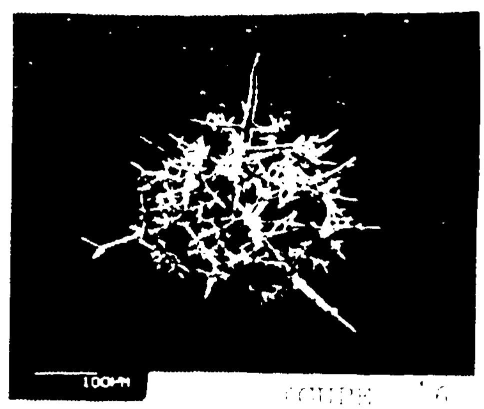


FIGURE 6

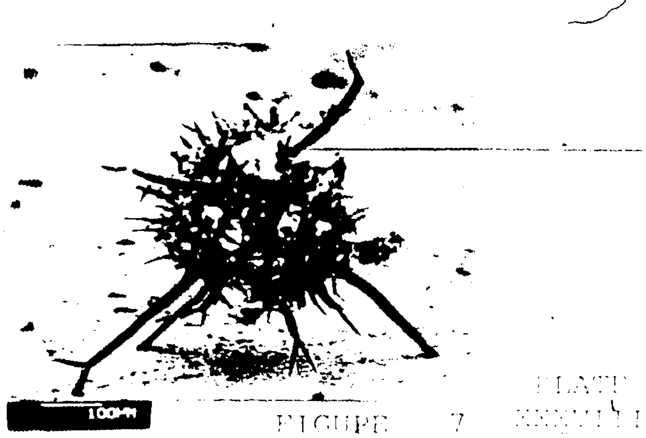


FIGURE 7

PLATE XXXVIII

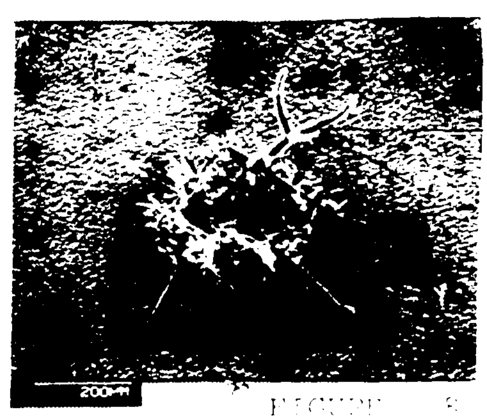


FIGURE 8

PLATE XXXIX

PALAEOSCENIDIIDAE NEW GENUS F new species L

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	212	76 CP	365-375	Basal view,
2	212	76 CP	365-375	Basal view,
3	212	76 CP	390-400	Side view,
4	212	76 CP	330-340	Side view,

PALAEOSCENIDIIDAE NEW GENUS F new species N

Fig.	Text page	Section	Horizon (ft)	View of specimen
5	216	76 CP	330-340	Side view, damaged
6	216	76 CP	330-340	O[illegible]que basal view damaged
7	216	76 CP	330-340	Side view, damaged
8	216	76 CP	340-350	Side view, damaged

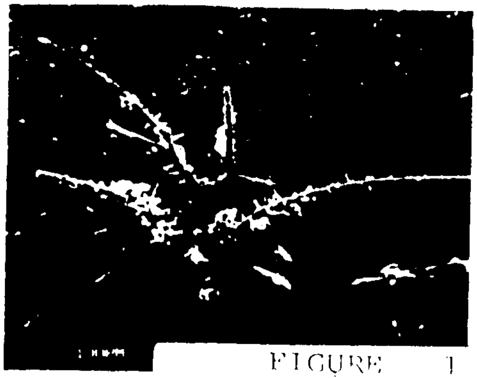


FIGURE 1

FIGURE 2

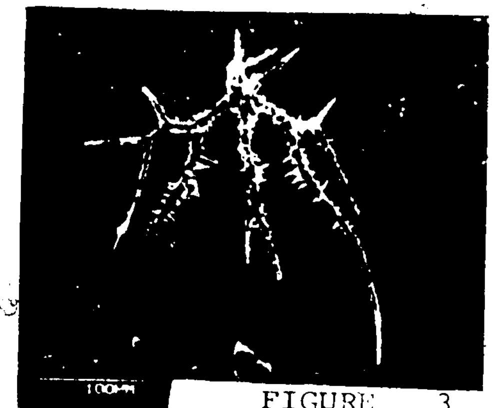


FIGURE 3

FIGURE 4

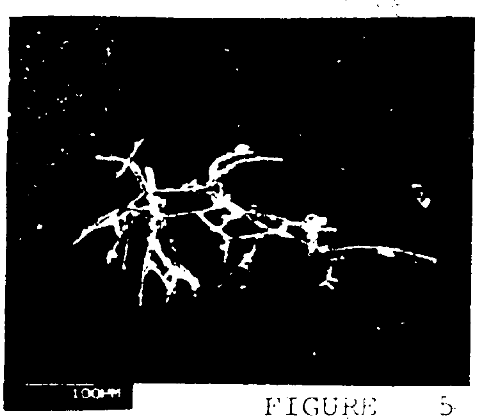


FIGURE 5

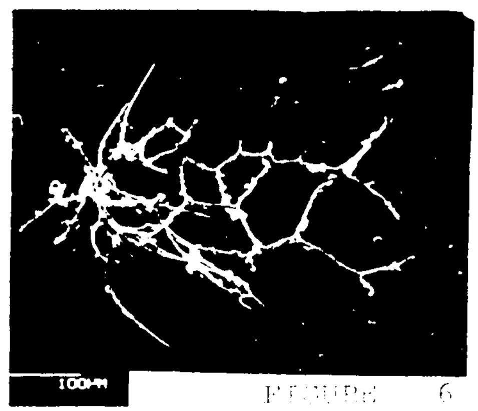


FIGURE 6

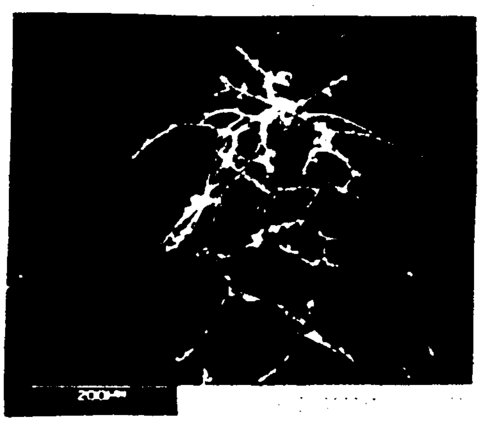


PLATE XL

PALAEOSCENIDIIDAE NEW GENUS F new species O

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	219	76 CP	135	Oblique side view
2	219	79 CP	278	Oblique side view
3	219	79 CP	29	Oblique side view
4	219	76 CP	135	Oblique apical view
5	219	79 CP	157	Basal view
6	219	79 CP	180	Oblique side view
		PALAEOSCENIDIIDAE NEW GENUS G new species A		
7	225	76 CP	390-400	Oblique apical view
8	225	76 BH1	480	Oblique side view

FIGURE 1

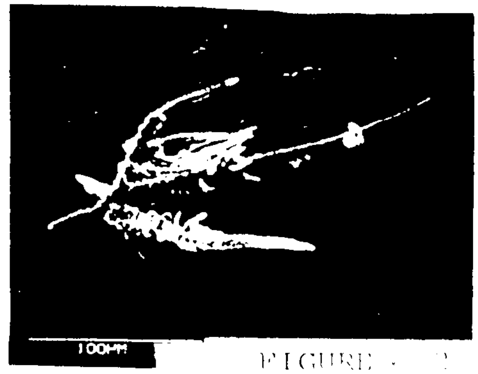


FIGURE 2

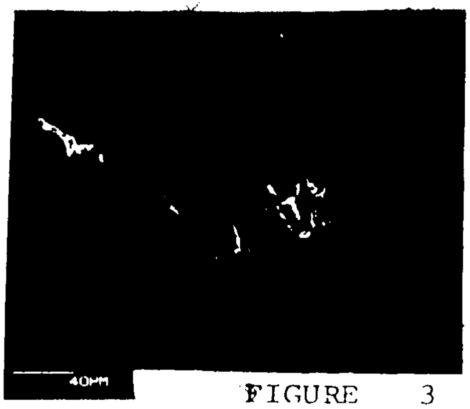


FIGURE 3

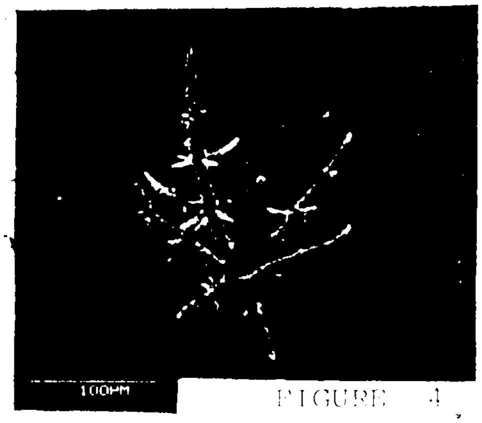


FIGURE 4

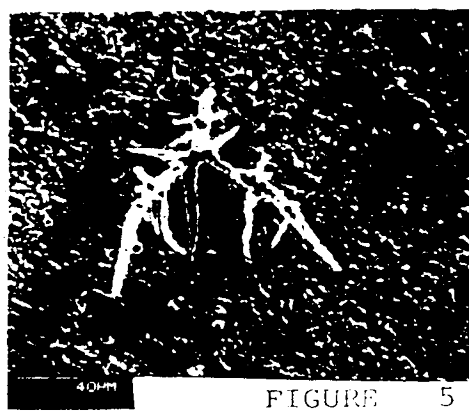


FIGURE 5

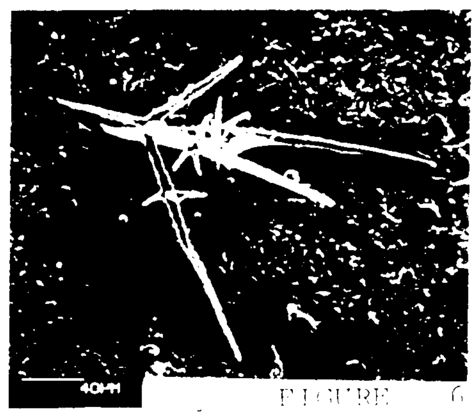


FIGURE 6

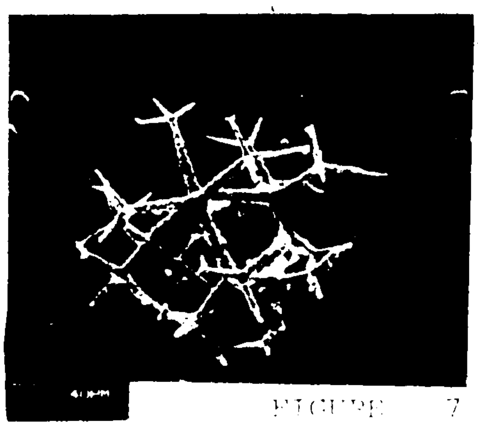


FIGURE 7

FIGURE 8

PLATE XII

PALAEOSCENIDIIDAE NEW GENUS F new species P

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	222	76 CP	390-400	Damaged
2	222	76 CP	330-340	Oblique, damaged
3	222	76 CP	390-400	Oblique
4	222	79 CP	320	Basal? damaged

INCERTAE SEDIS A

Fig.	Text page	Section	Horizon (ft)	View of specimen
5	228	76 BH1	480	Oblique basal. damaged
6	228	76 BH1	600	Side view, damaged

aff. INCERTAE SEDIS A

Fig.	Text page	Section	Horizon (ft)	View of specimen
7	229	CAR 5		Side view
8	229	CAR 5		Oblique side view

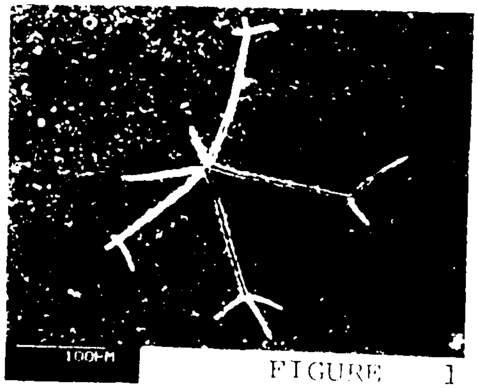
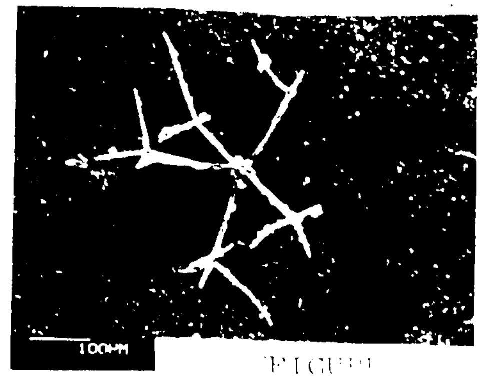


FIGURE 1



FIGURE

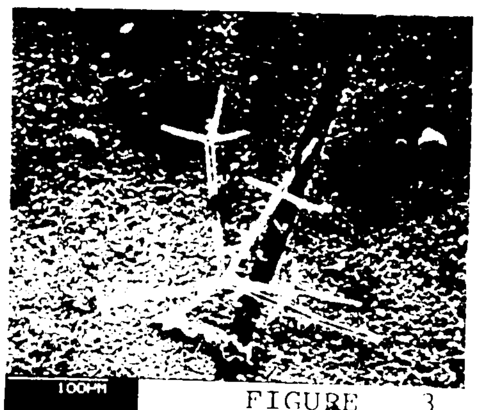


FIGURE 3

FIGURE 4

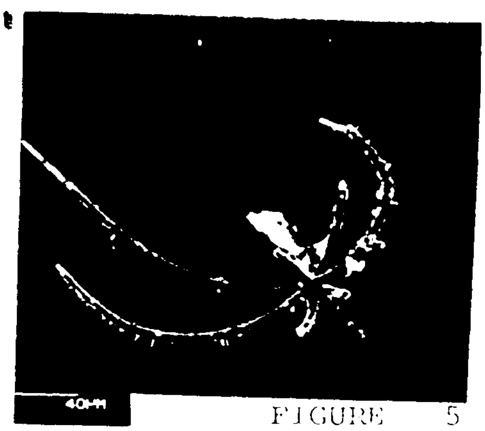


FIGURE 5

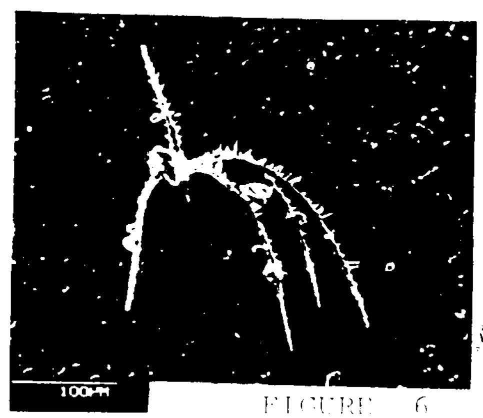


FIGURE 6

FIGURE 7

PLATE XLII

INCERTAE SEDIS B

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	230	76 CP	390-400	Oblique "basal"
2	230	76 CP	390-400	"Basal"

INCERTAE SEDIS C

3	232	76 BH1	600	Damaged
4	232	76 BH1	60[illegible]	Damaged

INCERTAE SEDIS D

5	233	79 CP	6	"Side" view
6	233	79 CP	6	View down core of Fig.5

HALIOMMA new species C

7	78	76 BH2	245	External
8	78	76 BH2	245	External

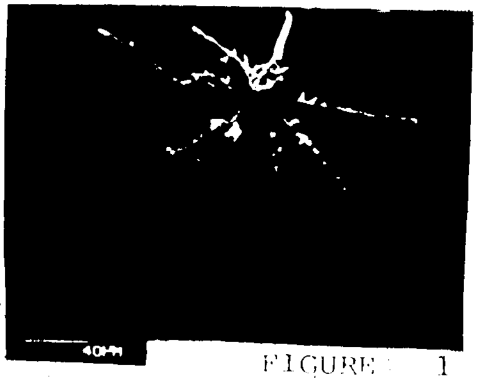


FIGURE 1

FIGURE

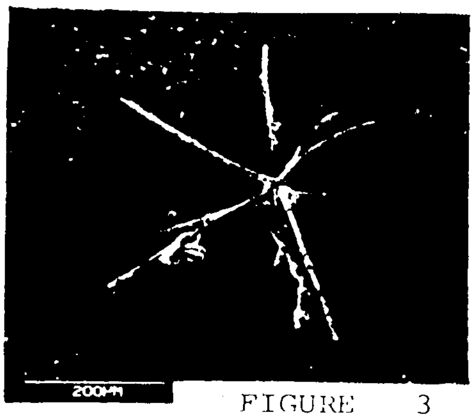


FIGURE 3

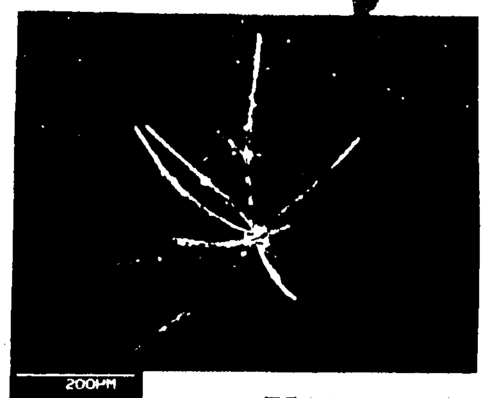


FIGURE 4

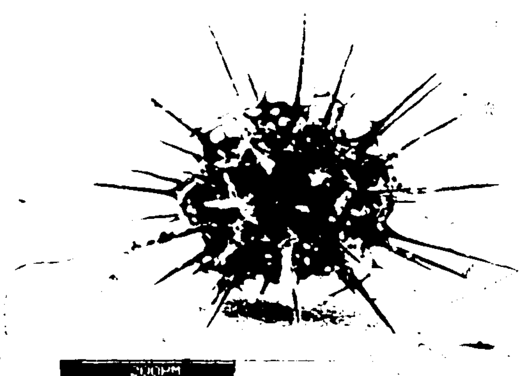


FIGURE 5

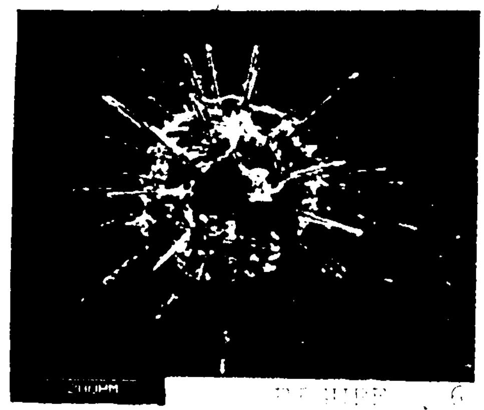


FIGURE 6

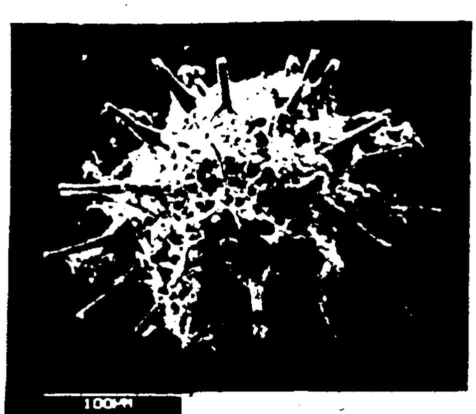
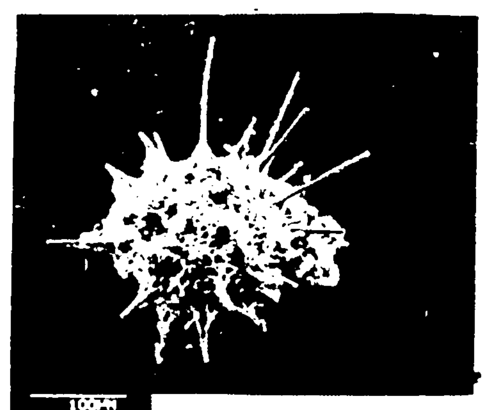


FIGURE 7



FIGURE

8	243	76 CP	390-400	External

PLATE XLIII

INCERTAE SEDIS E

Fig.	Text page	Section	Horizon (ft)	View of specimen
1	235	76 BH2	265	External
2	235	76 BH2	265	External

INCERTAE SEDIS J

Fig.	Text page	Section	Horizon (ft)	View of specimen
3	244	79 CP	276	External
4	244	79 CP	276	Close up of shell of Fig.3

INCERTAE SEDIS G

Fig.	Text page	Section	Horizon (ft)	View of specimen
5	239	76 BH1	765	External

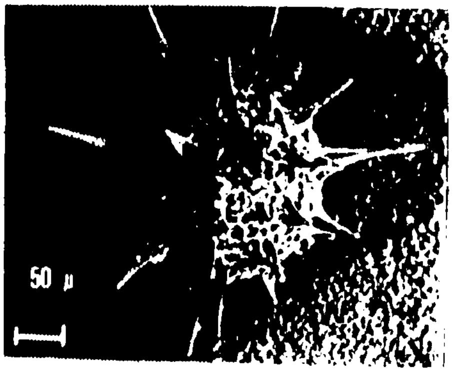
INCERTAE SEDIS H

Fig.	Text page	Section	Horizon (ft)	View of specimen
6	241	76 BH2	265	External

INCERTAE SEDIS F

Fig.	Text page	Section	Horizon (ft)	View of specimen
7	237	76 BH2	265	External

INCERTAE SEDIS I



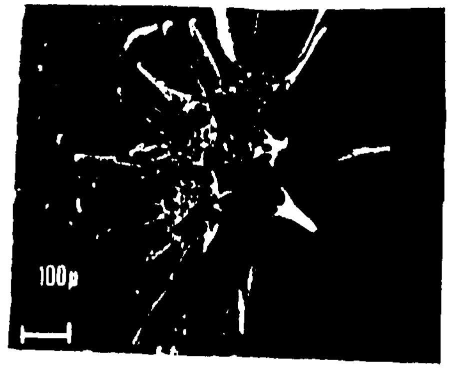


FIGURE 2

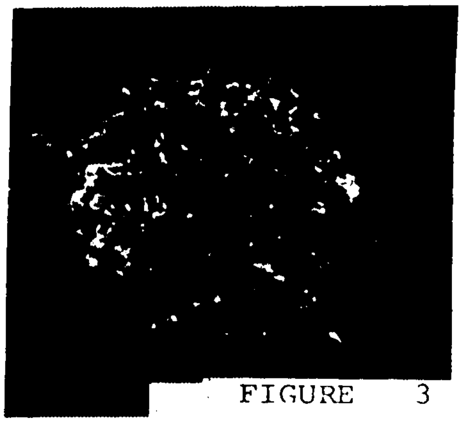


FIGURE 3

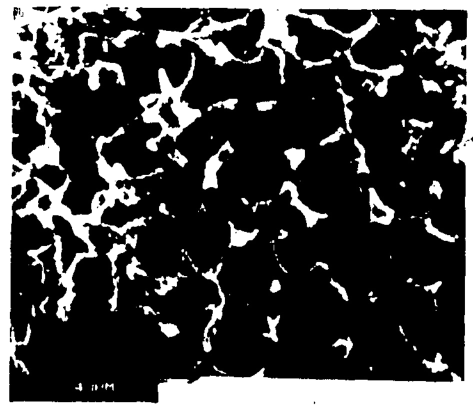


FIGURE 4

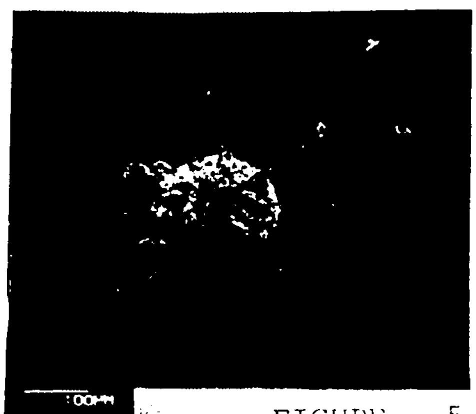


FIGURE 5

FIGURE 6

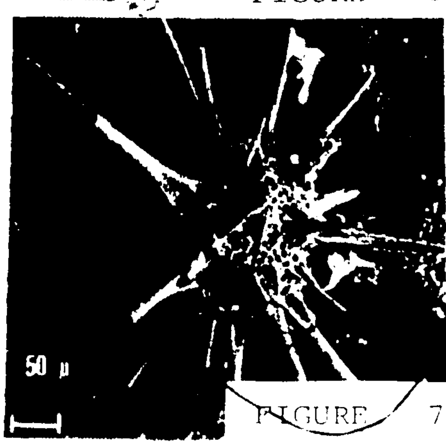
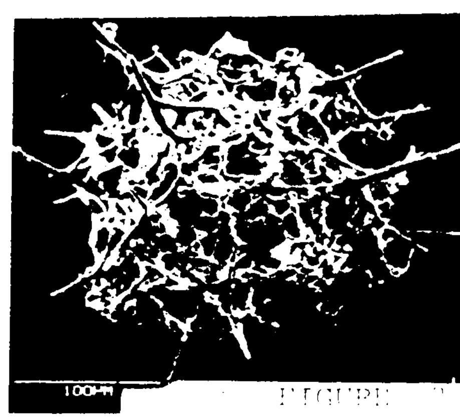


FIGURE 7



FIGURE

PLATE XLIII

A D D E N D U M

SPECIMEN CATALOGUE NUMBERS

PALEONTOLOGICAL COLLECTIONS

UNIVERSITY OF ALBERTA

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90156	9	20	1	1	79 CP	118
90156	9	20	1	2	79 CP	118
90156	9	20	1	3	79 CP	118
90156	9	20	1	4	79 CP	118
90157	2	5	1	5	76 CP	165
90158	4	5	1	6	76 BH1	36
90159	1	20	1	7	79 CP	180
90160	10	20	1	8	79 CP	132-135
90185	7	20	2	1	79 CP	91
90158	4	5	2	2	6 BH1	33-36
90158	4	5	2	3	76 BH1	33-36
90158	4	5	2	4	76 BH1	33-36
90162	4	9	2	5	76 BH1	33-36
90162	4	9	2	6	76 BH1	33-36
90163	4	20	2	7	79 CP	276
90163	4	20	2	8	79 CP	276

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90164	5	5	3	1	76 BH1	600
90165	1	4	3	2	76 BH1	600
90228	6	14	3	3	76 BH1	480
90164	5	5	3	4	76 BH1	600
90164	5	5	3	5	76 BH1	600
90159	1	20	3	6	79 CP	180
90159	1	20	3	7	79 CP	180
90166	3	5	3	8	76 CP	425
90261	2	21	4	1	76 CP	135
90167	15	8	4	2	76 LL9	
90168	1	21	4	3	76 CP	135
90168	1	21	4	4	76 CP	135
90158	4	5	4	5	76 BH1	33-36
90170	6	22	4	6	76 CP	325-330
90171	5	22	4	7	76 CP	340-400
90170	6	22	4	8	76 CP	325-330

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90172	2	20	5	1	79 CP	6
90173	2	23	5	2	79 CP	25
90174	3	23	5	3	79 CP	15
90175	4	21	5	4	76 CP	340-250
90175	4	21	5	5	76 CP	340-350
90166	3	5	5	6	76 CP	425
90175	4	21	5	7	76 CP	340-350
90168	1	21	5	8	76 CP	135
90177	1	8	6	1	76 CP	340-350
90177	1	8	6	2	76 CP	340-350
90178	2	3	6	3	76 CP	340-350
90178	2	3	6	4	76 CP	340-350
90177	1	8	6	5	76 CP	340-350
90177	1	8	6	6	76 CP	340-350
90155	1	1	6	7	76 CP	365-375
90179	6	5	6	8	76 BH1	600

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90180	2	12	7	1	76 CP	325-330
90180	2	12	7	2	76 CP	325-330
90181	3	3	7	3	76 CP	340-355
90182	1	22	7	4	76 CP	325-330
90159	1	20	7	5	79 CP	180
90159	1	20	7	6	79 CP	180
90160	10	20	7	7	79 CP	132-5
90160	10	20	7	8	79 CP	132-5
90184	3	20	8	1	79 CP	278
90184	3	20	8	2	79 CP	278
90184	3	20	8	3	79 CP	278
90160	10	20	8	4	79 CP	132-5
90184	3	20	8	5	79 CP	278
90184	3	20	8	6	79 CP	278
90185	7	20	8	7	79 CP	91
90185	7	20	8	8	79 CP	91

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90156	9	20	9		79 CP	118
90185	7	20	9	2	79 CP	91
90184	3	20	9		79 CP	278
90185	7	20	9	[illegible]	79 CP	91
90183	8	20	9	5	79 CP	108
90186	3	12	9	6	76 CP	390-400
90186	3	12	9	7	76 CP	390-400
90170	6	22	9	8	76 CP	325-330
90176	3	21	10	1	76 BH1	470
90187	4	24	10	2	76 CB	83.5
90176	3	21	10	3	76 BH1	470
90187	4	24	10	4	76 CB	83.5
90167	15	8	10	5	76 LL9	
90167	15	8	10	6	76 LL9	
90188	3	3	10	7	76 LL9	
90188	3	3	10	8	76 LL9	

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90262	6	3	11	1	76 BH2	265
90189	2	25	11	2	76 BH2	245
90190	8	26	11	3	76 BH2	130
90191	1	25	11	4	76 BH1	710
90191	1	25	11	5	76 BH1	710
90192	5	12	11	6	76 BH1	765
90192	5	12	11	7	76 BH1	765
90192	5	12	11	8	76 BH1	765
90155	1	1	12	1	76 CP	365-75
90171	5	22	12	2	76 CP	390-400
90181	3	22	12	3	76 CP	340-55
90167	15	8	12	4	76 LL9	
90161	6	20	12	5	79 CP	29
90161	6	20	12	6	79 CP	29
90193	4	23	12	7	76 CP	34[illegible]-55
90172	2	20	12	8	7[illegible] [illegible]	6

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90194	3	8	13	1	76 BH1	765
90192	5	12	13	2	76 BH1	765
90192	5	12	13	3	76 BH1	765
90192	5	12	13	4	76 BH1	765
90195	1	5	13	5	76 LL10	
90195	1	5	13	6	76 LL10	
90179	6	5	13	7	76 BH1	610
90196	10	5	13	8	76 LL	4
90197	5	26	14	1	76 BH2	2
90198	42	8	14	2	76 BH1	765
90199	5	9	14	3	76 BH1	765
90198	42	8	14	4	76 BH1	765
90200	6	9	14	5	76 BH1	765
90200	6	9	14	6	76 BH1	765
90200	6	9	14	7	76 BH1	765
90200	6	9	14	8	76 BH1	765
90195	1	5	15	1	76 LL10	

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
			15	2	76 BH2	150
90197	5	26	15	3	76 BH2	290
90197	5	26	15	4	76 BH2	290
90201	2	11	15	5	76 BH2	290
90202	3	26	15	6	76 BH2	215
90262	6	3	15	7	76 BH2	265
90262	6	3	15	8	76 BH2	265
90262	6	3	16	1	76 BH2	265
90262	6	3	16	2	76 BH2	265
90262	6	3	16	3	76 BH2	265
90197	5	26	16	4	76 BH2	290
90203	4	3	16	5	76 BH1	765
90203	4	3	16	6	76 BH1	765
90203	4	3	16	7	76 BH1	765
90203	4	3	16	8	76 BH1	765
90198	4	8	17	1	76 BH1	765

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90198	4	8	17	2	76 BH1	765
90198	4	8	17	3	76 BH1	765
90198	4	8	17	4	76 BH1	765
90171	5	32	17	5	76 CP	340-400
90262	6	3	17	6	76 BH2	265
90204	1	10	17	7	76 BH2	215
90262	6	3	17	8	76 BH2	265
	(destroyed)		18	1	76 BH2	150
	"		18	2	76 BH2	150
	"		18	3	76 BH2	150
90205	7	15	18	4	79 CP	27
90205	7	15	18	5	79 CP	27
90205	7	15	18	6	79 CP	27
90205	7	15	18	7	79 CP	27
90206	8	16	18	8	76 CP	325-330
90158	4	5	19	1	76 BH1	33-36
90158	4	5	19	2	76 BH1	33-36

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90158	4	5	19	3	76 BH1	33-36
90207	3	9	19	4	76 BH1	35-36
90207	3	9	19	5	76 BH1	36-36
90158	4	5	19	6	76 BH1	35-36
90207	3	9	19	7	76 BH1	33-36
90207	3	9	19	8	76 BH1	33-36
90208	2	16	20	1	79 CP	29
90208	2	16	20	2	79 CP	29
90209	3	16	20	3	79 CP	91
90208	2	16	20	4	79 CP	29
90179	6	5	20	5	76 BH1	600
90169	6	22	20	6	76 CP	325-330
90169	6	22	20	7	76 CP	325-330
90181	3	22	20	8	76 CP	340-55
90206	8	16	21	1	76 CP	325-330
90210	9	16	21	2	76 CP	340-400

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90206	8	16	21	3	76 CP	325-330
90210	9	16	21	4	76 CP	340-400
90169	6	22	21	5	76 CP	325-330
90211	5	16	21	6	79 CP	155
90211	5	16	21	7	79 CP	155
90211	5	16	21	8	79 CP	155
90212	11	27	22	1	76 CP	365-75
90213	2	27	22	2	76 CP	340-50
90213	2	27	22	3	76 CP	340-50
90213	2	27	22	4	76 CP	340-50
90214	8	27	22	5	76 BH1	600
90214	8	27	22	6	76 BH1	600
90215	3	27	22	7	76 CP	325-330
90215	3	27	22	8	76 CP	325-330
90216	9	27	24	1	76 BH1	765
90216	9	27	24	2	76 BH1	765

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90216	9	27	24	3	76 BH1	765
90217	5	1	24	4	76 BH2	215
90216	9	27	24	5	76 BH1	765
90218	5	27	24	6	76 LL10	
90215	3	27	24	7	76 CP	325-330
90215	3	27	24	8	76 CP	325-330
90219	4	27	26	1	76 CP	315-25
90219	4	27	26	2	76 CP	315-25
90219	4	27	26	3	76 CP	315-25
90219	4	27	26	4	76 CP	315-25
90215	3	27	26	5	76 CP	325-30
90215	3	27	26	6	76 CP	325-30
90220	7	27	26	7	76 BH1	450
90216	9	27	26	8	76 BH1	765
90221	8	1	28	1	76 BH2	265
90216	9	27	28	2	76 BH1	765

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90221	8	1	28	3	76 BH2	265
90221	8	1	28	4	76 BH2	265
90217	1	1	28	5	76 BH2	215
90217	1	1	28	6	76 BH2	215
90217	1	1	28	7	76 BH2	215
90217	1	1	28	8	76 BH2	215
90222	3	18	30	1	76 CP	315-25
90181	3	22	30	2	76 CP	340-55
90223	1	18	30	3	76 CP	365-75
90224	6	18	30	4	76 CP	340-50
90223	1	18	30	5	76 CP	365-75
90222	3	18	30	6	76 CP	315-25
90222	3	18	30	7	76 CP	315-25
90222	3	18	30	8	76 CP	315-25
90222	3	18	31	1	76 CP	315-25
90225	7	19	31	2	76 BH1	600
90225	7	19	31	3	76 BH1	600

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90226	3	19	31	4	76 CP	315-25
90222	3	18	31	5	76 CP	315-25
90227	5	14	31	6	76 CP	365-75
90228	6	14	31	7	76 BH1	480
90229	1	6	31	8	76 CP	365-75
90230	5	18	32	1	76 CP	340-55
90223	1	18	32	2	76 CP	365-75
90231	6	19	32	3	76 BH1	480
90231	6	19	32	4	76 BH1	480
90231	6	19	32	5	76 BH1	480
90232	2	19	32	6	76 CP	315-25
90177	1	8	32	7	76 CP	340-50
90231	6	19	32	8	76 BH1	480
90233	9	19	33	1	76 BH1	765
90233	9	14	33	2	76 BH1	765
90233	9	14	33	3	76 BH1	765

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90233	9	19	33	4	76 BH1	765
90234	5	19	33	5	76 CP	135
90235	3	6	33	6	76 CP	340-400
90236	1	17	33	7	79 CP	278
90236	1	17	33	8	79 CP	278
90237	6	17	34	1	79 CP	157
90237	6	17	34	2	79 CP	157
90238	4	17	34	3	79 CP	132
90239	5	4	34	4	79 CP	135
90237	6	17	34	5	79 CP	157
90237	6	17	34	6	79 CP	157
90229	1	6	34	7	76 CP	365-75
90229	1	6	34	8	76 CP	365-75
90226	3	19	35	1	76 CP	315-25
90240	4	19	35	2	76 CP	315-25
90226	3	19	35	3	76 CP	315-25

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90226	3	19	35	4	76 CP	315-25
90240	4	19	35	5	76 CP	315-25
90240	4	19	35	6	76 CP	315-25
90181	3	22	35	7	76 CP	340-55
90241	10	19	35	8	76 CP	330-340
90225	7	19	36	1	76 BH1	600
90177	1	8	36	2	76 CP	340-50
90177	1	8	36	3	76 CP	340-50
SPECIMEN LOST			36	4	79 CP	180
90231	6	19	36	5	76 BH1	480
90231	6	19	36	6	76 BH1	480
90231	6	19	36	7	76 BH1	480
90177	1	8	36	8	76 CP	340-50
90242	4	6	37	1	76 CP	340-400
90242	4	6	37	2	76 CP	340-400
90243	5	6	37	3	76 BH2	215
90243	5	6	37	4	76 BH2	215

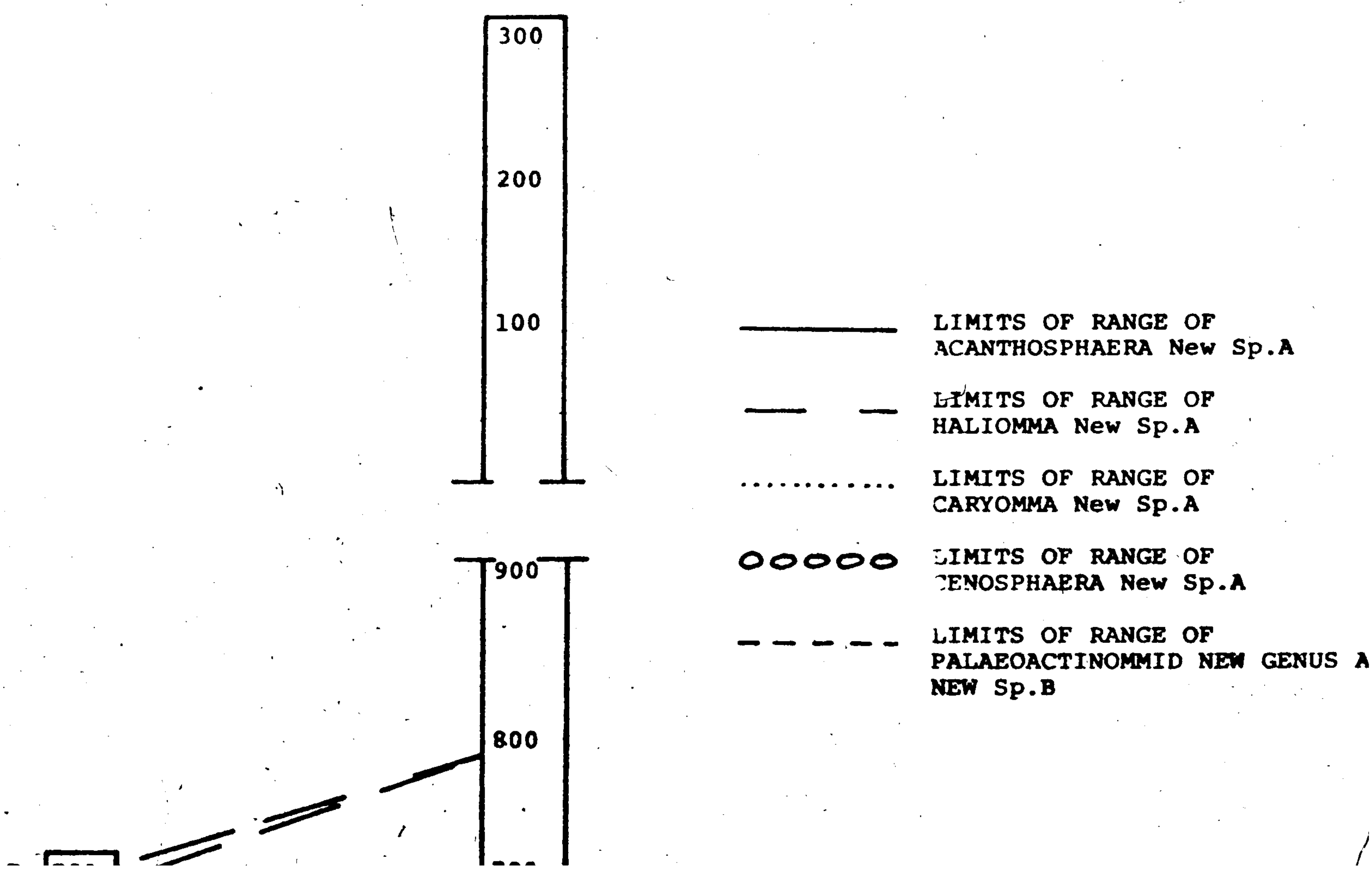
PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90244	9	6	37	5	76 CP	340-50
90244	9	6	[illegible]	6	76 CP	340-50
90229	1	6	37	7	76 CP	365-75
90245	10	6	37	8	76 CP	340-50
90246	4	2	38	1	79 CP	15
90247	3	2	38	2	79 CP	6
90246	4	2	38	3	79 CP	15
90247	3	2	38	4	79 CP	6
90248	5	2	38	5	79 CP	15
90249	1	2	38	6	79 CP	6
90247	3	2	38	7	79 CP	6
90250	6	2	[illegible]	8	79 CP	15
90229	1	6	39	1	76 CP	365-75
90229	1	6	39	2	76 CP	365-75
90235	3	6	39	3	76 CP	340-400
90241	10	19	39	4	76 CP	330-340

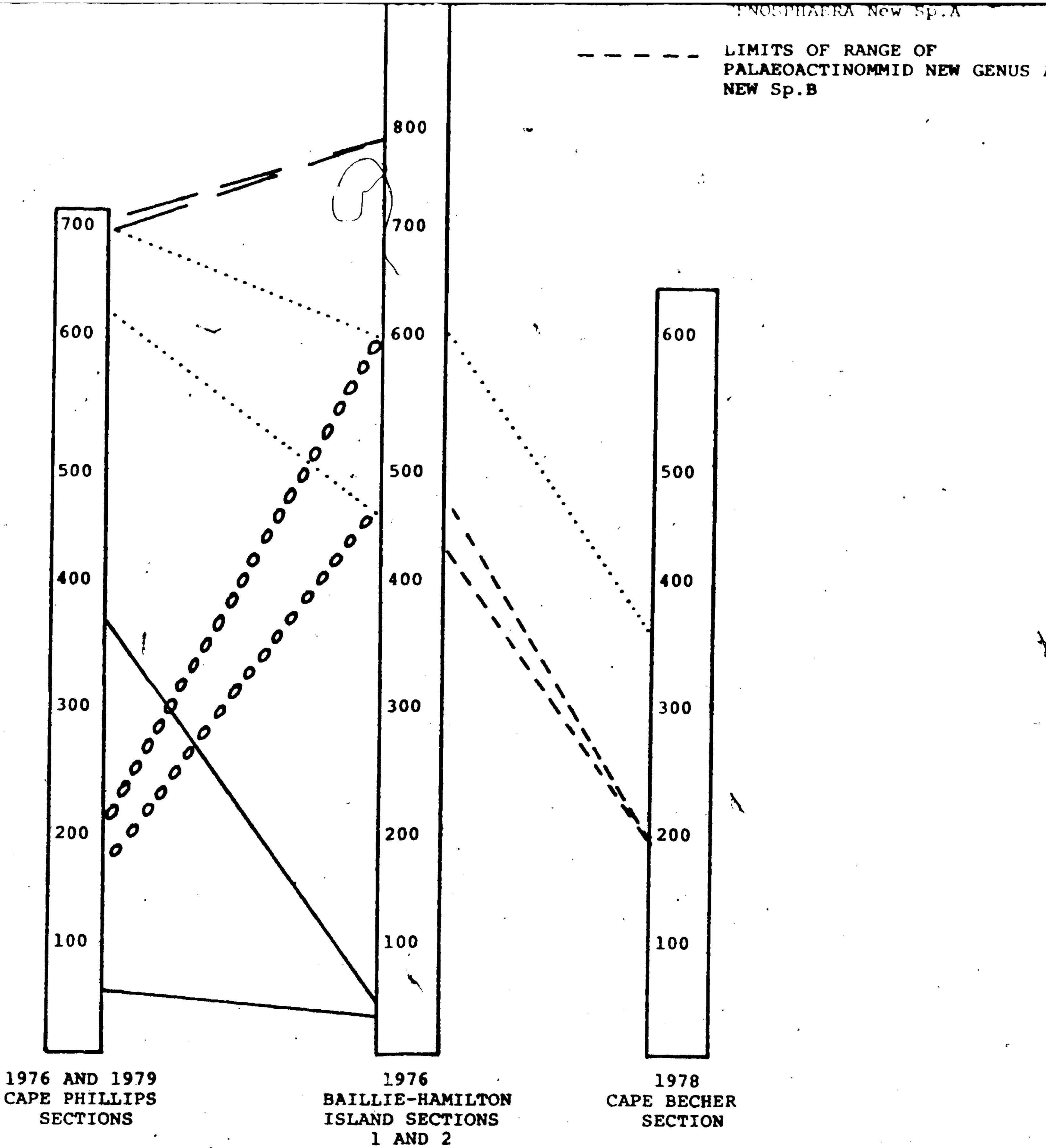
PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90241	10	19	39	5	76 CP	330-340
90241	10	19	39	6	76 CP	330-340
90241	10	19	39	7	76 CP	330-340
90244	9	6	39	8	76 CP	340-350
90234	5	19	40	1	76 CP	135
90236	1	17	40	2	79 CP	278
90252	10	2	40	3	79 CP	29
90239	5	4	40	4	76 CP	135
90237	6	17	40	5	79 CP	157
90251	7	17	40	6	79 CP	180
90253	4	4	40	7	76 CP	390-400
90228	6	14	40	8	76 BH1	480
90254	1	14	41	1	76 CP	340-400
90255	2	4	41	2	76 CP	330-40
90254	1	14	41	3	76 CP	40-400
90256	2	17	41	4	79 CP	320

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90257	7	5	41	5	76 BH1	480
90225	7	19	41	6	76 BH1	600
90258	11	8	41	7	CAR 5	
90258	11	8	41	8	CAR 5	
90242	4	6	42	1	76 CP	390-400
90242	4	6	42	2	76 CP	390-400
90225	7	19	42	3	76 BH1	600
	SPECIMEN	LOST	42	4	76 BH1	600
90172	2	20	42	5	79 CP	6
90172	2	20	42	6	79 CP	6
90259	3	25	42	7	76 BH2	245
90259	2	25	42	8	76 BH2	245
90262	6	3	43	1	76 BH2	265
90262	6	3	43	2	76 BH2	265
90163	4	20	43	3	79 CP	276
90163	4	20	43	4	79 CP	270

PCC NO.	STUB	BOX	PLATE	FIGURE	SECTION	HORIZON
90194	3	8	43	5	76 BH1	765
90262	6	3	43	6	76 BH2	265
90262	6	3	43	7	76 BH2	265
90260	1	7	43	8	76 CP	390-400

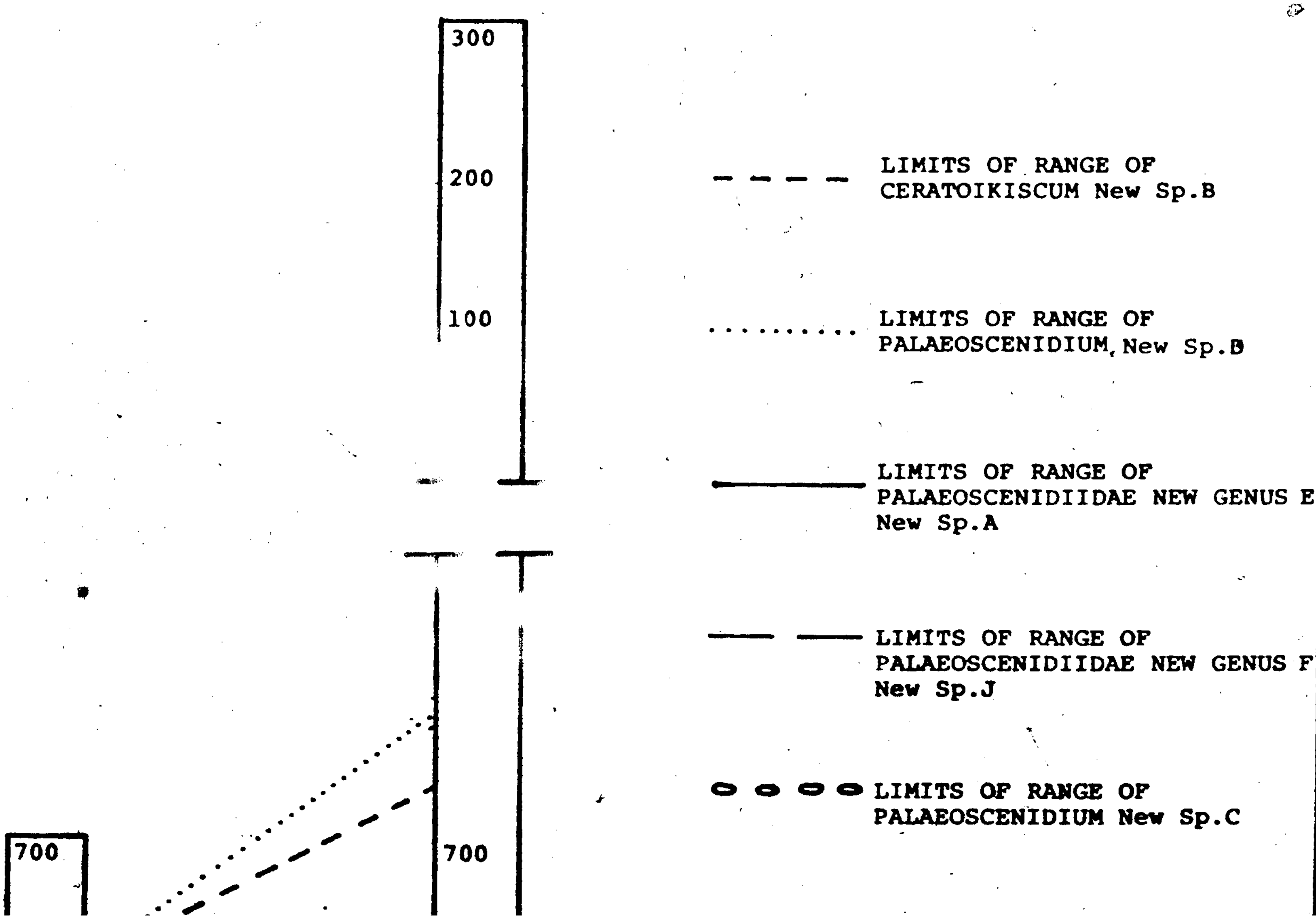
RANGE LIMITS OF PALAEOACTINOMMIDS COMMON TO THE CAPE PHILLIPS, BAILLIE-HAMILTON AND CAPE BECHER SECTIONS

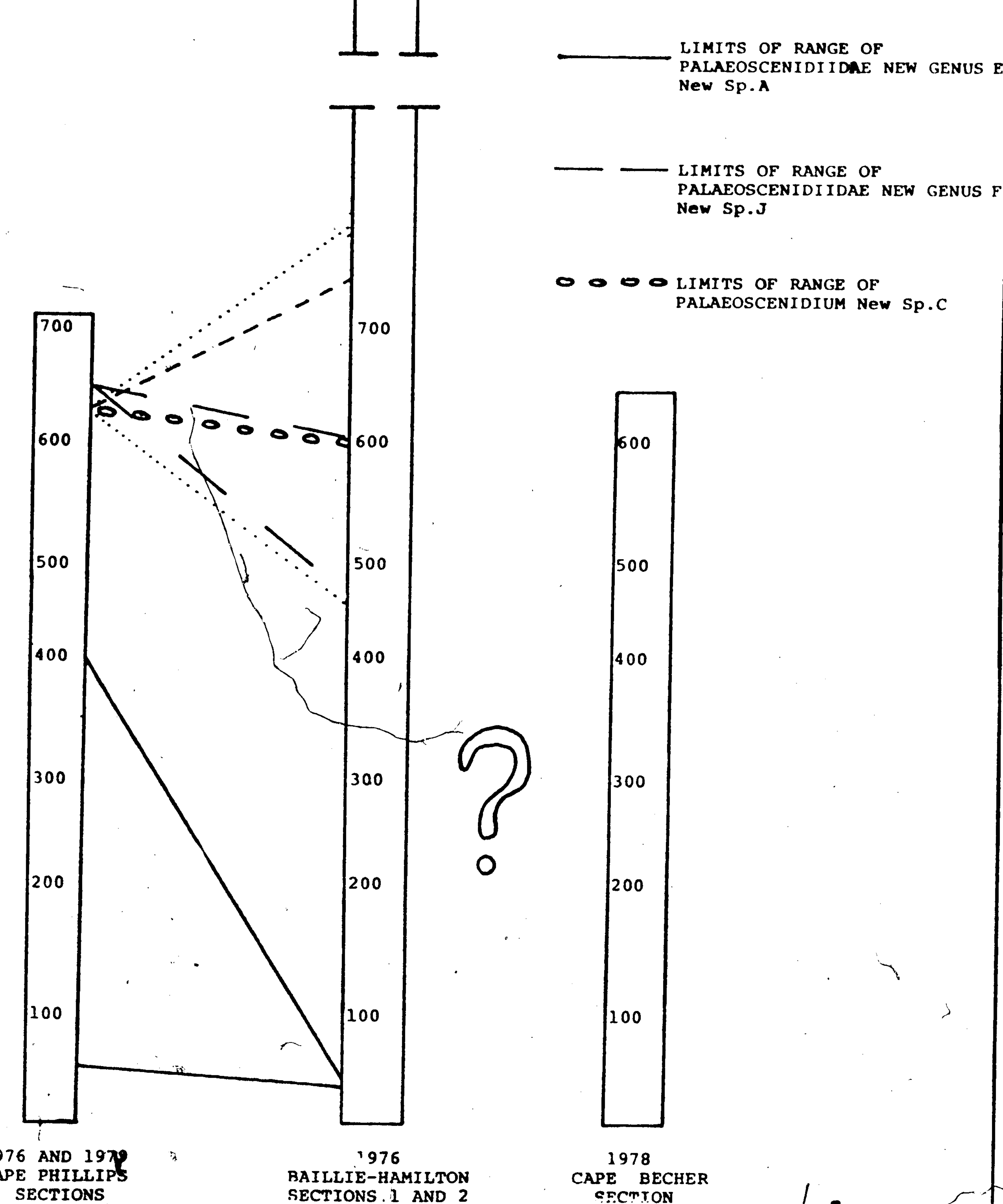




TEXT FIGURE 12.

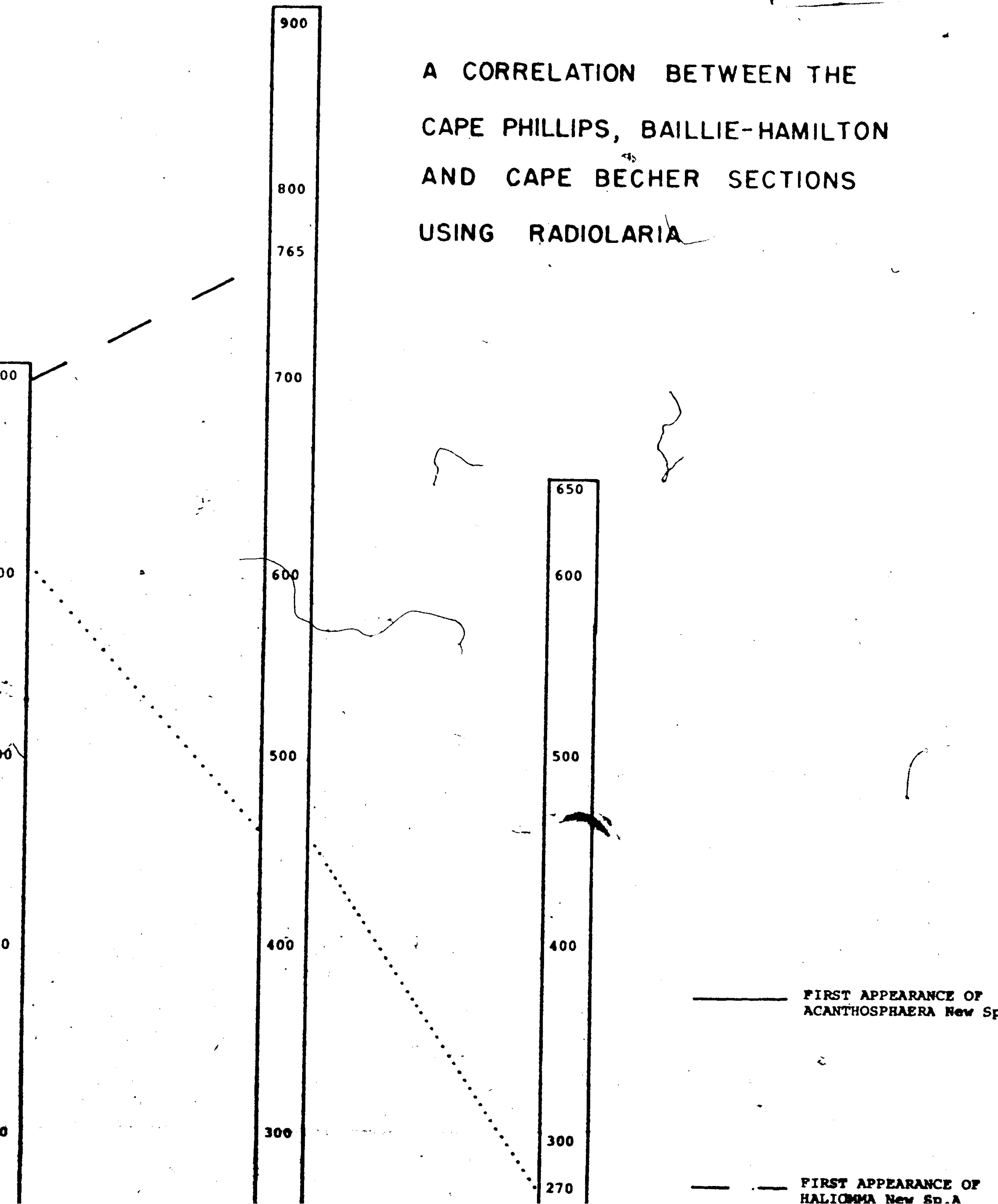
RANGE LIMITS OF CERATOIKISCIDAE AND PALAEOSCENIDIIDAE COMMON TO THE CAPE PHILLIPS, BAILLIE-HAMILTON AND CAPE BECHER SECTIONS

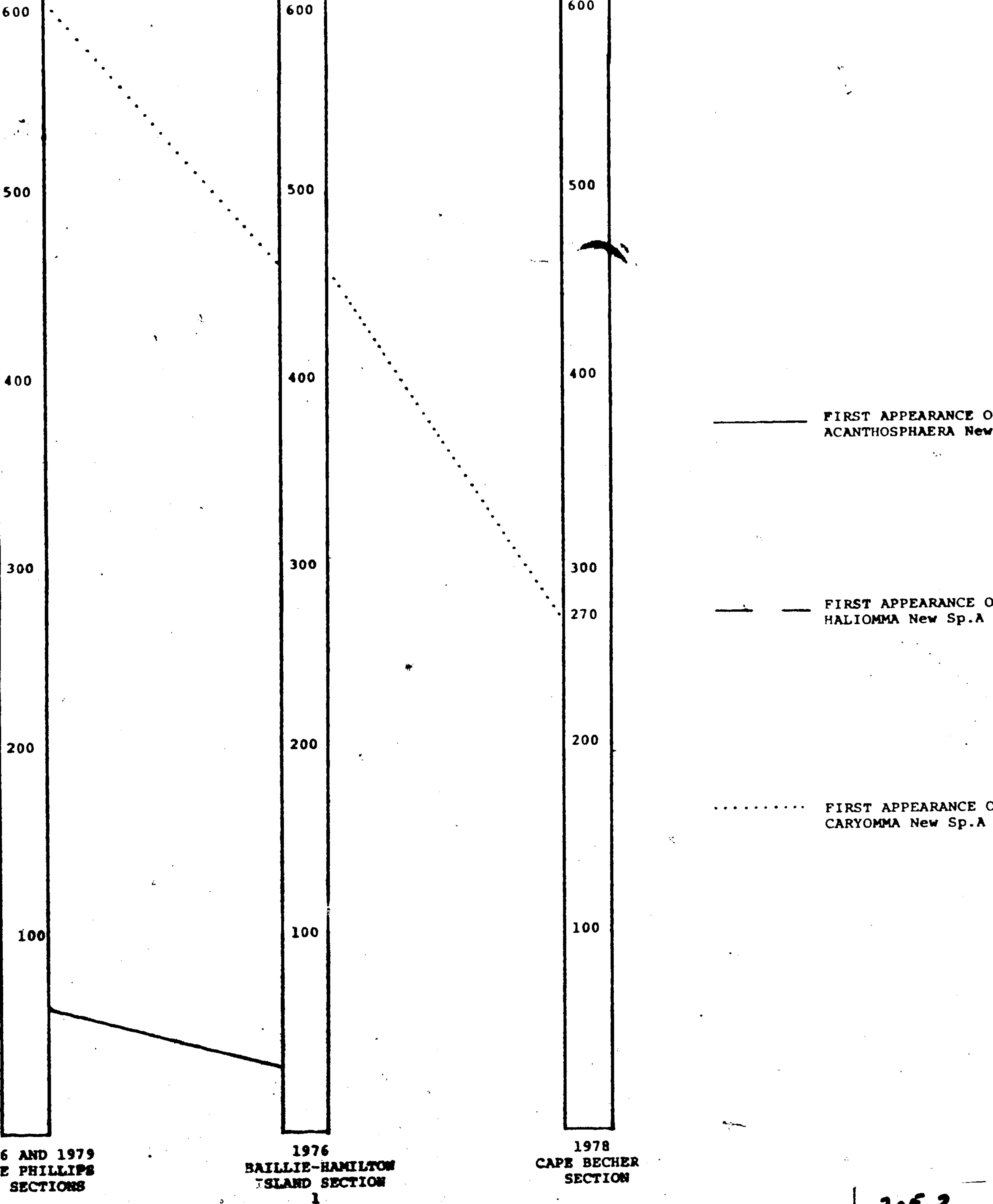




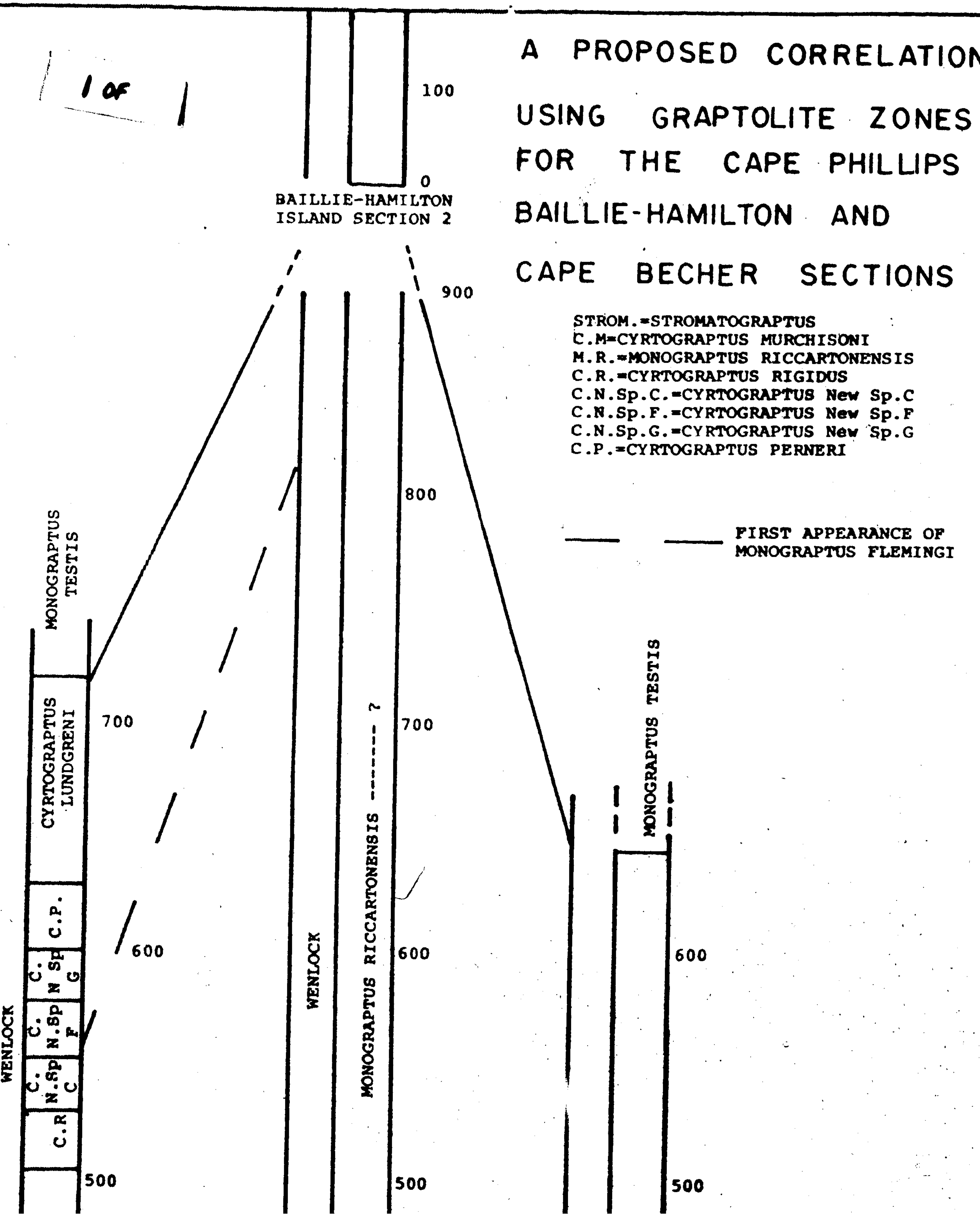
TEXT FIGURE 13

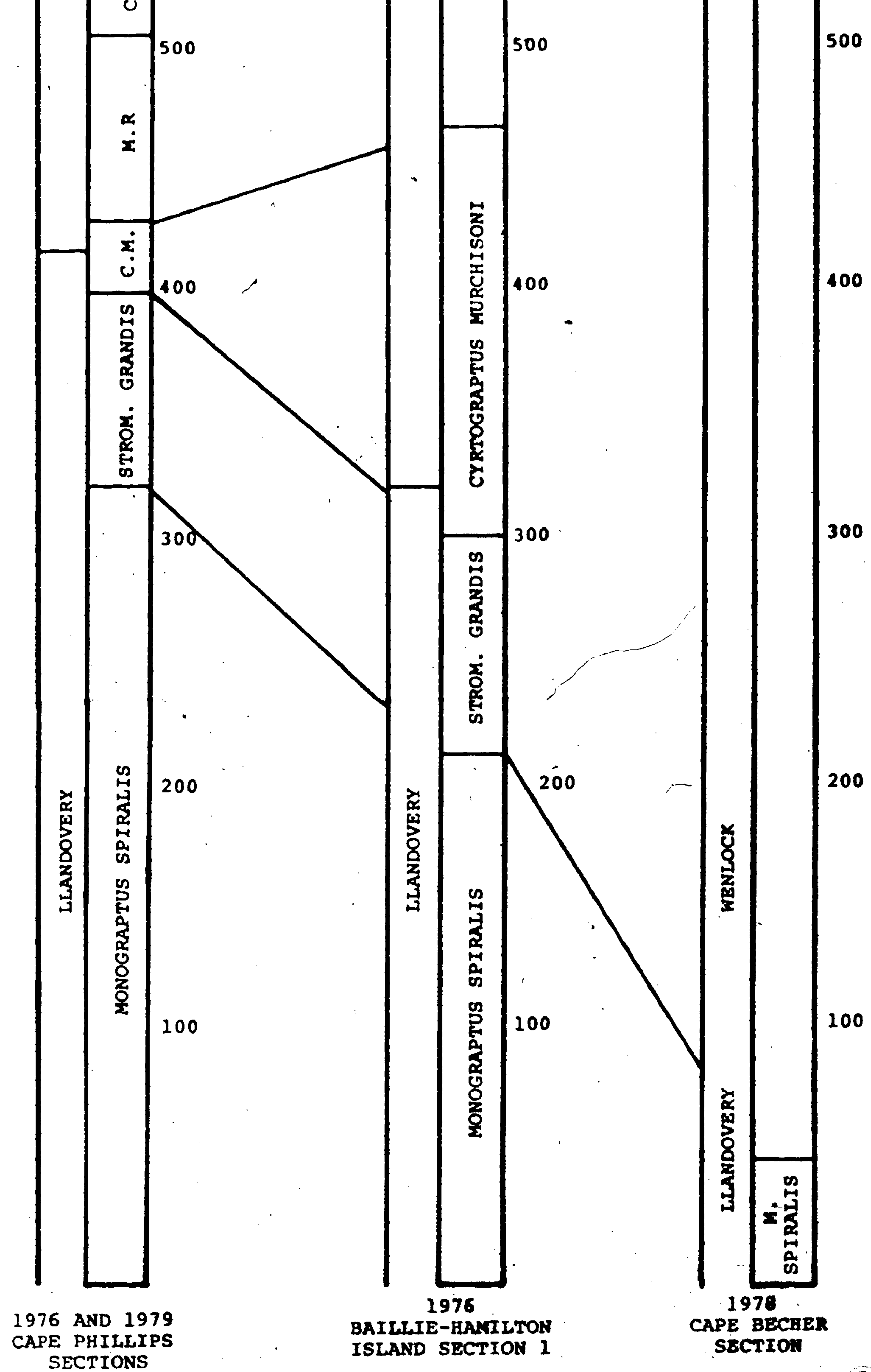
A CORRELATION BETWEEN THE CAPE PHILLIPS, BAILLIE-HAMILTON AND CAPE BECHER SECTIONS USING RADIOLARIA





TEXT FIGURE 14


A PROPOSED CORRELATION
USING GRAPTOLITE ZONES
FOR THE CAPE PHILLIPS
BAILLIE-HAMILTON AND
CAPE BECHER SECTIONS
STROM.=STROMATOGRAPTUS
C.M=CYRTOGRAPTUS MURCHISONI
M.R.=MONOGRAPTUS RICCARTONENSIS
C.R.=CYRTOGRAPTUS RIGIDUS
C.N.Sp.C.=CYRTOGRAPTUS New Sp.C
C.N.Sp.F.=CYRTOGRAPTUS New Sp.F
C.N.Sp.G.=CYRTOGRAPTUS New Sp.G
C.P.=CYRTOGRAPTUS PERNERI
FIRST APPEARANCE OF MONOGRAPTUS FLEMINGI
BAILLIE-HAMILTON ISLAND SECTION 2
100
0
900
800
700
600
500
MONOGRAPTUS TESTIS
CYRTOGRAPTUS LUNDGRENI
C.P.
C. N Sp G
C. N.Sp F
C. N.Sp C
C.R
WENLOCK
MONOGRAPTUS RICCARTONENSIS ------ ?



TEXT FIGURE 15

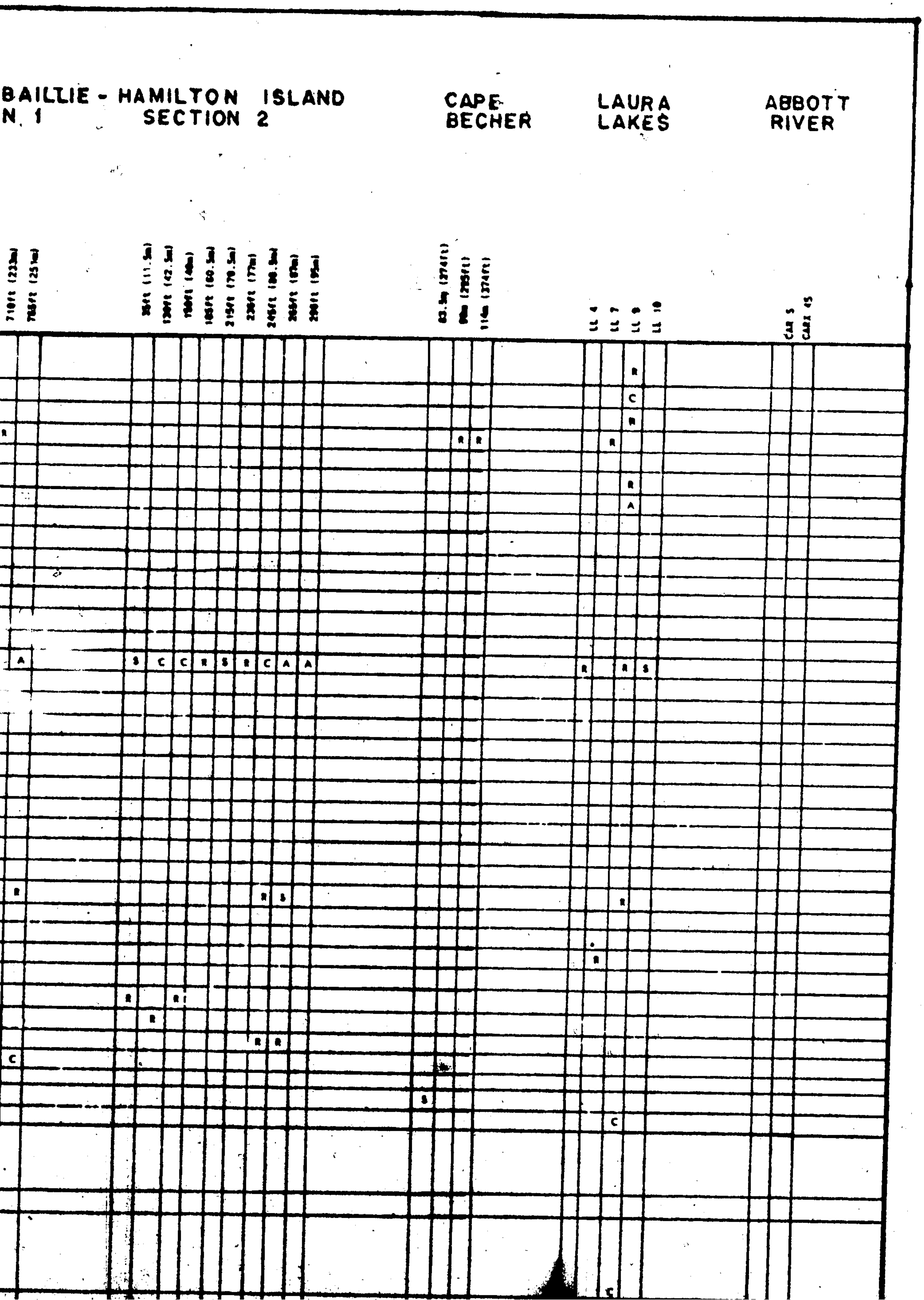
TAXA \ SECTIONS AND HORIZONS		1979 CAPE PHILLIPS																														1[...]
		6ft (2m)	15ft (5m)	25ft (8m)	27ft (8.5m)	29ft (9.5m)	56ft (17m)	67ft (22m)	91ft (30m)	100ft (33m)	118ft (38m)	127ft (41.5m)	129ft (42m)	132ft (43m)	150ft (48m)	155ft (51m)	168ft (51.5m)	180ft (54m)	215ft (58m)	230ft (70.5m)	254ft (78m)	263ft (82.5m)	267ft (85.5m)	271ft (87.5m)	276ft (88m)	300ft (101m)	312ft (102m)	329ft (108m)	330ft (108.5m)	349ft (114.5m)	353ft (116m)	135ft (44m)
INFORMAL GROUPING PALAEOACTINOMMIDS																																
Acanthosphaera new species A		R				R					S		R	R		R	R	R														
Arachnosphaera new species A		C	C	R	R	C	R		S	R	R	R	C	C		C	R	S		R		R	R	R		R	S	R			S	
Actinosphaera new species A		R														R									R	R				R	R	
Coryomma new species A																																
Cenosphaera new species A																																
Cenosphaera aff. C. affinis Hinde, 1890														R				S														
Cromyechinus new species A	COMBINED	C	R							C	R	R	S	S		A	R		S	R	R	S	C	C	S	S	C	C	S	R	R	
Cromyomma new species A	COMBINED	R	S	R											R													R				
	COMBINED																															
C[illegible]um new species A	COMBINED																															
Cubosphaera new species A	COMBINED	S	R			R			C	R	S							R									R					
Cubosphaera aff. new species A	COMBINED																															R
Echinomma new species A	COMBINED																															
Echinomma aff. new species A	COMBINED																															
Haliomma new species A	COMBINED																															
Haliomma aff. H. new species A	COMBINED																															
Haliomma new species B	COMBINED																															
Haliomma aff. new species B	COMBINED																															
Haliomma new species C	COMBINED																															
Haliomma aff. new species C	COMBINED																															
Haliomma new species D	COMBINED																															
Haliomma new species E	COMBINED																															
Haliomma? new species F	COMBINED																															
Hexalonche new species A		R				S			R		R	R	R	R		S		R								R		R				
Hexalonche? new species B		C	R			S			C	R	C	R	S	R		C		S	R	R		R			R		R				R	
Plegmosphaera new species A																																
Plegmosphaera aff. P. new species A																																
Plegmosphaera new species B																																
Plegmosphaera new species C																																
Plegmosphaera new species D						S					R	R		R		R																
Rhizoplegma new species A																																
Spongoplegma new species A																																
Spongostylus new species A																																
Stylosphaera new species A																																
New Genus A new species A																																
New Genus A new species B																																
New Genus A new species C																																
FAMILY ENTACTINIIDAE																																
Entactinia new species A		R			R																											
Entactinia new species B																																
INFORMAL GROUPING ROTASPHAERIDS																																
New Genus B new species A		A	A	R	S	A	C	R	A	C	A	R	C	C		A	A	C		R	R	C	S	C		S	R	R		R	S	R
New Genus B new species B																																
New Genus B new species C																																

1976 CAPE PHILLIPS

1976 BAILLIE - HAMILTON ISLAND SECTION 1 SECTION 2

CAPE BECH[EY]

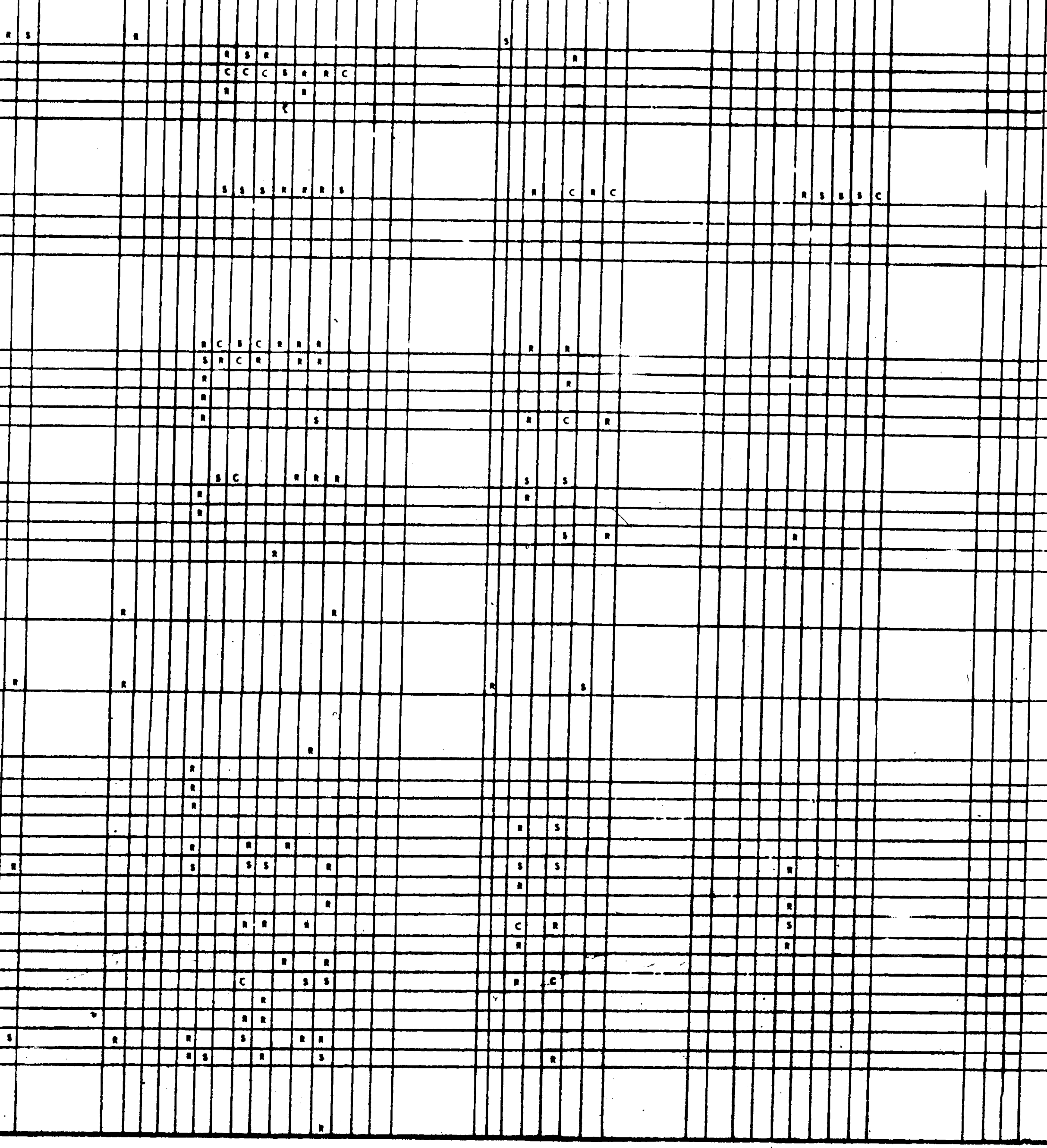
…ft (114.3m)	353ft (110m)	135ft (44m)	160ft (50m)	175ft (57m)	280-300ft (87-93m)	315-325ft (103-107m)	325-350ft (107-108m)	335-350ft (108-115m)	330-340ft (100-113m)	340-350ft (115-110m)	340-365ft (112-116m)	365-375ft (120-123m)	390-400ft (128-131m)	425ft (130m)	445ft (144m)	485ft (153m)	33-38ft (11-12m)	470ft (134.5m)	480ft (157.5m)	520ft (171m)	600ft (187m)	710ft (223m)	785ft (251m)	38ft (11.5m)	130ft (42.5m)	150ft (46m)	185ft (60.5m)	215ft (79.5m)	230ft (77m)	245ft (80.5m)	260ft (87m)	280ft (95m)	83.5m (274ft)	84m (275ft)	114m (374ft)
			R														R																		
	S																S																		
	R																																		
							R	S	S	C	R	R	C						R	S	S	R												R	R
								R											R		S														
R										C	R	C	C	R			S																		
							S	R	S		R																								
							R						R																						
		R																																	
														R																					
													R								R		A	S	C	C	R	S	R	C	A	A			
R																																			
																							R							R	S				
													R																						
										R																									
																						R		R		R									
																									R										
																														R	R				
							C	C	C				C										C												
																	R																		
												S																					S		
							R																												
		R																																	
																	S																		
							R	S	R												R														


BAILLIE - HAMILTON ISLAND
N. 1
SECTION 2
CAPE BECHER
LAURA LAKES
ABBOTT RIVER
LL 4
LL 7
LL 9
LL 10
CAR 5
CARX 45

INFORMAL GROUPING ROTASPHAERIDS																															
New Genus B new species A	A	A	R	S	A	C	R	A	C	A	R	C	C		A	A	C		R	R	C	S	C		S	R	R		R	S	R
New Genus B new species B																															
New Genus B new species C																															
New Genus B aff. B new species C																															
New Genus B new Sp D	R				S			S				R	R		S	R	S		R		R	R	R		S						
FAMILY CERATOIKISCIDAE																															
COMBINED: *Ceratoikiscum* new species A																															
Ceratoikiscum new species B																															
Ceratoikiscum new species C																															
Ceratoikiscum new species D																															
FAMILY PALAEOSCENIDIIDAE																															
Palaeoscenidium new species A																															
Palaeoscenidium new species B																															
Palaeoscenidium new species C																															
Palaeoscenidium new species D																															
Palaeoscenidium aff. P. new species D																															
New Genus C Subgenus C new species A																															
New Genus C Subgenus C new species B																															
New Genus C Subgenus C new species C																															
New Genus C Subgenus Y new species D																															
New Genus C Subgenus Y aff. C (Y) new species D																															
New Genus D new species A																	R														R
New Genus E new species A								R		C		R	S		C							R	R			R				R	R
Genus F new species A																															
Genus F new species B																															
New Genus F new species C																															
New Genus F new species D																															
New Genus F new species E																															
New Genus F new species F																															
New Genus F new species G	R				R			R					R		R		R													R	
New Genus F new species H																															
New Genus F new species I																															
New Genus F new species J																															
New Genus F new species K	C	C	R	R	R	R	R	R		S		S	S		S	R	S						R								
New Genus F aff. new species K																													R		
New Genus F new species L																															
New Genus F new species M																															
New Genus F new species N																															
New Genus F new species O	R				R					S		S	C		S	C	S					R					R			S	R
New Genus F new species P	S				R			R																							
New Genus G new species A																															

ABUNDANCES OF TAXA IN PRODU

CAPE PHILL



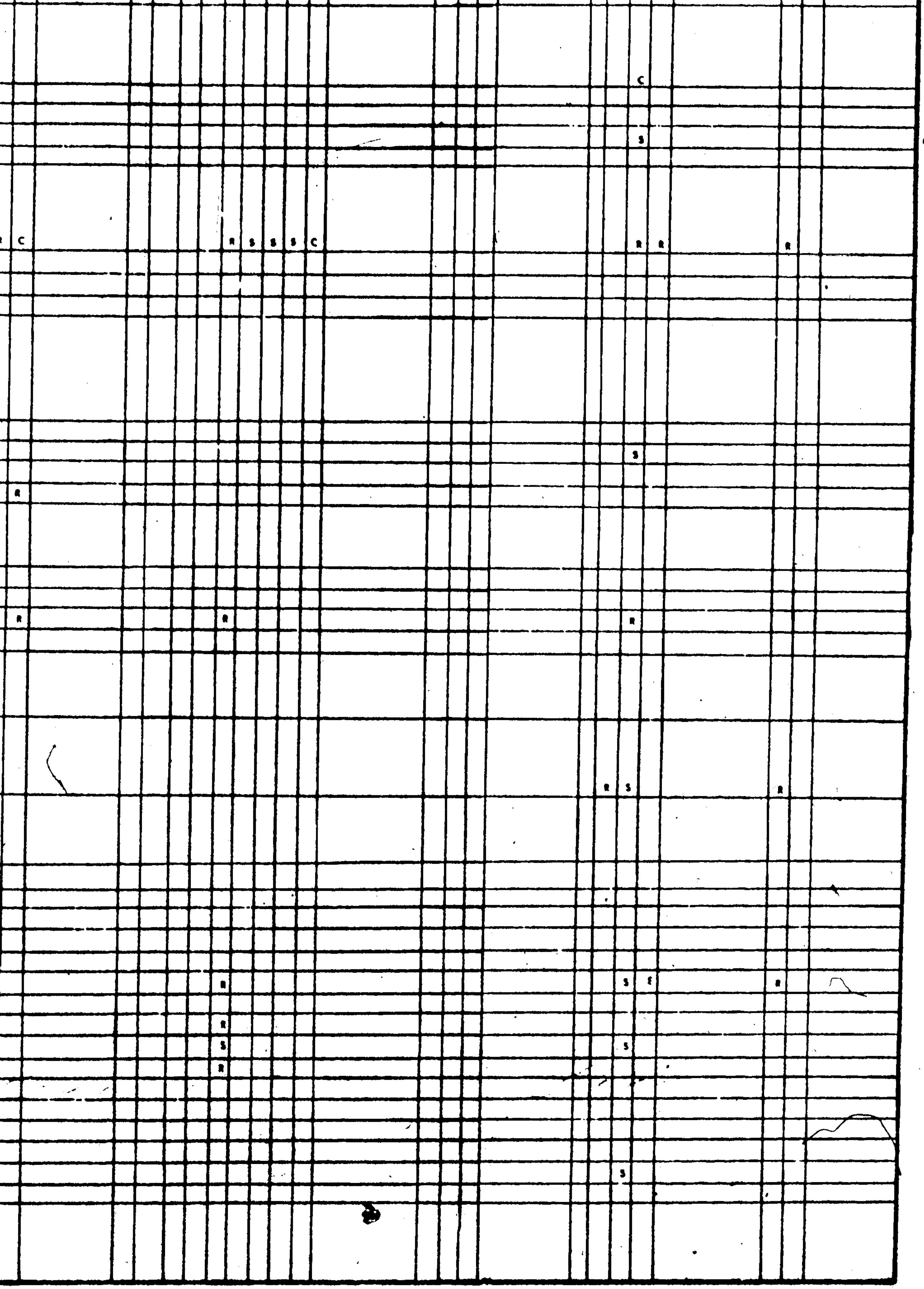
PRODUCTIVE SAMPLES FROM SEVEN SECTIONS OF T

PHILLIPS FORMATION

R= RARE
S= SPARSE

C= COMMON
A= ABUNDANT

APPENDIX TABLE XIV



SEVEN SECTIONS OF THE

R= RARE
S = SPARSE
C= COMMON
A= ABUNDANT

6 of 6