

# MICROPLANKTON FROM THREE PALAEOZOIC FORMATIONS IN THE PROVINCE OF LEÓN, NW-SPAIN

BY

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## CONTENTS

|   |     |
|---|-----|
| ABSTRACT . . . . .  | 255 |
| I. INTRODUCTION . . . . .   | 256 |
| II. TREATMENT OF SAMPLES . . . . .  | 258 |
| <i>Laboratory techniques</i> . . . . .                                      | 258 |
| <i>Counting techniques</i> . . . . .  | 261 |
| <i>Microphotography</i> . . . . .   | 261 |
| III. GENERAL OUTLINE OF THE FORMATIONS INVESTIGATED . . . . .               | 262 |
| 1. <i>The Formigoso Formation</i> . . . . .                                 | 262 |
| 2. <i>The San Pedro Formation</i> . . . . .                                 | 262 |
| 3. <i>The La Vid Formation</i> . . . . .                                    | 264 |
| a. <i>The La Vid Carbonate Member</i> . . . . .                             | 264 |
| b. <i>The La Vid Shale Member</i> . . . . .                                 | 265 |
| 4. <i>Geological distribution of the formations</i> . . . . .               | 266 |
| IV. OUTLINE OF THE VERTICAL DISTRIBUTION OF MICROPLANKTON IN LEÓN . . . . . | 267 |
| <i>Procedure</i> . . . . .  | 267 |
| <i>Acritarchs</i> . . . . .   | 267 |
| <i>Chitinozoans</i> . . . . .   | 276 |
| <i>Stratigraphical value</i> . . . . .                                      | 279 |
| V. DESCRIPTION OF THE MOST COMMON FORMS OF MICROPLANKTON IN LEÓN . . . . .  | 280 |
| 1. <i>Acritarchs</i> . . . . .  | 280 |
| <i>General</i> . . . . .  | 280 |
| <i>List of acritarchs</i> . . . . .   | 280 |
| <i>Descriptions</i> . . . . .   | 284 |
| 2. <i>Chitinozoans</i> . . . . .  | 336 |
| <i>General</i> . . . . .  | 336 |
| <i>List of chitinozoans</i> . . . . .                                       | 337 |
| <i>Descriptions</i> . . . . .   | 338 |
| VI. SUMARIO EN ESPAÑOL . . . . .  | 354 |
| INDEX OF SYMBOLS AND ABBREVIATIONS USED . . . . .                           | 356 |
| REFERENCES . . . . .  | 359 |

## ABSTRACT

In the Lower Palaeozoic where true palynological microfossils become rare, much use can be made of other acid-resistant microfossils such as acritarchs and chitinozoans.

This study gives some of the results of an investigation on the presence of acritarchs and chitinozoans in three essentially Lower Palaeozoic formations of the Province of León in north-west Spain, viz. the Formigoso, the San Pedro, and the La Vid Formations. They range from Upper Llandoveryan to the middle part of the Emsian. The techniques used to prepare the samples are discussed.

The vertical distribution of the most common acritarchs and chitinozoans in the region investigated are given, as well as the changes of frequency in the associations of some selected groups of acritarchs from a number of sections of the San Pedro and the La Vid Formations. Most formgroups show characteristic changes of frequency providing the possibility of detailed correlation within the formations. The most common forms of acritarchs and chitinozoans used for correlation purposes are described. A list of species may be found on pages 280 and 337. Most of these forms had not yet been recorded.

## I. INTRODUCTION

The systematic geological mapping of the Palaeozoic rocks of the southern slope of the Cantabrian Mountains in North Spain by students of the University of Leiden, The Netherlands, has given an impulse to many detailed stratigraphical investigations. The object of the present investigation has been to discover whether acid-resistant microfossils occur in pre-Carboniferous sediments of the Cantabrian Mountains in the Provinces of León and Palencia and, if so, whether these fossils can be used for stratigraphical purposes. In the first instance samples were collected of all kinds of Lower Palaeozoic sedimentary rocks from the area between the river Pisuerga in the east and the river Luna in the west. Laboratory treatment revealed the presence of microfossil assemblages in many horizons throughout the Lower Palaeozoic. The preservation of the microfossils, such as sporomorphs, chitinozoans, scolecodonts, and acritarchs, is rather changeable in the region studied and is usually different for the distinct groups of microfossils. Since the richest and best preserved associations have been found in the shales and sandy shales of the Silurian and Lower Devonian of the northwestern part of the province of León, this region was chosen for a closer investigation. The acid-resistant microplankton of the Formigoso, San Pedro, and La Vid Formations, ranging from approximately Upper Llandoveryan to the middle part of the Emsian, is the subject of this paper.

The lithostratigraphy of the Palaeozoic in the province of León has been outlined a. o. by P. Comte (1959) and his subdivisions have mainly been used here. For adjacent regions there are other stratigraphical divisions in use but, since they are largely based on easily recognisable lithostratigraphic units, they can be compared without difficulty (Lotze and Szduy, 1961; Radig, 1961; Poll, 1963). The geological map of the southern slope of the Cantabrian Mountains and its explanation (de Sitter, 1962) show the most important features of this part of the mountain chain.

Up to the present no papers have been published on acid-resistant microplankton from the Palaeozoic of this region. The present paper does not pretend to be a refined systematic study of the microplankton. For nomenclatural questions the reader is referred to Downie and Sarjeant (1963), Downie, Evitt and Sarjeant (1963), Evitt (1963), Sarjeant (1964), a.o. A complete inventory of the microplankton from the northwestern part of the Cantabrian Mountains lies beyond the scope of this paper. It deals with some of the most common forms of microplankton that were met with in an investigation on the usefulness of microplankton for stratigraphic purposes. As far as thought relevant to the results of this study, cases of synonymy have been indicated, but for forms of minor importance this has been omitted.

The section dealing with the preparations has been based on data of various authors of whom the most important is de Jekhowsky (1959). It is his standard technique that yielded the first good preparations. It has been adapted to the sediments from northwest Spain in points of secondary importance.

*Acknowledgements*

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The slides containing the holotypes of the species described in this paper will be subjected to further investigations, after which the slides will be stored according to Recommendation 7A of the International Code of Botanical Nomenclature, in the Department of Stratigraphy and Palaeontology, where also information as to the coordinates of the holotypes can be obtained.

## II. TREATMENT OF SAMPLES

Lower Palaeozoic sediments in the region studied are indurated but non-metamorphic. Good outcrops, where it is easy to collect fresh unweathered samples, are not infrequent. They are generally situated at recent road and railway cuttings and near rapidly eroding brooks and rivers. Shales and sandstones have yielded relatively rich associations, whereas from highly or moderately calcareous sediments only poor assemblages could be obtained.

At each locality some fifty grams per sample of unweathered sediment were collected for laboratory treatment.

*Laboratory techniques.* The object of the laboratory treatment is to free the organic components — i.e. the microfossils — from the surrounding sediment. An efficient way to do this is to mechanically reduce the sample to small pieces and subsequently dissolve its sediment, a part of its mineral components or both, with a suitable mineral acid. Since there is a great enough difference in specific gravity between the microfossils and the mineral components of the sediment, gravitative separation with the aid of a suitable liquid can easily be carried out. For the gravitative separation a mixture of bromoform and ethanol with a specific gravity of 2.0 was used. Because of the very low viscosity of the mixture the separation by flotation in a centrifuge is not as time-consuming a process as that using the other cheap liquid of high specific gravity, i.e. Herzberg's solution (a saturated solution of  $ZnCl_2$  in water, s.g. = 2.0).

In general it was not necessary to bleach the acritarchs. However, for a few samples the application of Schulze's solution, for three to fifteen minutes, was found advantageous. It had more success than other decarbonising reagents. Heating the microfossils or treating them with a five to ten percent solution of  $KClO_3$  in water had no effect at all.

Method followed for bleaching acritarchs and sporomorphs.

1. Wash the residue containing microfossils with distilled water, centrifugating it for two minutes at 4000 r/'. Retain the sedimented matter.

Use 15 ml glass tubes for centrifugating.

2. Add to the sediment in the centrifuge tube about two ml of reagent. Mix the components with a glass rod. When the desired degree of maceration has been reached, add as much distilled water as possible and centrifugate two minutes at 4000/'. Wash the residue once with 1 % ammonia solution. Wash again with distilled water.

In order to avoid a too rapid reaction it is advisable to work at room temperature.

The reagent is obtained by adding to nine parts of concentrated nitric acid one part of a saturated solution of  $KClO_3$  in water. Dissolving the maceration products with stronger ammonia solution or with other bases proved to be a destructive process.

The sporomorphs of the Leonese Palaeozoic sediments were much more resistant to treatment with Schulze's solution than the other groups of microfossils. In fact, at the moment that all the acritarchs had disappeared from the preparation, the sporomorphs became transparent. Chitinozoans resisted none of the mentioned bleaching processes.

The sporomorphs and acritarchs treated with Schulze's solution were very susceptible to dyeing in a one percent solution of safranin in ethanol, a phenomenon which unmacerated microfossils did not display.

The microfossils were concentrated from the samples more or less according to the standard technique of de Jekhowsky (1959). Since his method was modified at several points, the final procedure of preparation is described here in full.

The acritarchs and related microplankton discussed in this paper were prepared according to the following sequence of operations.

1. Crush the sample and clean it from particles of other than 1—3 mm diameter.

Be careful not to contaminate the sample.

2. Add to ten grams of the crushed sample 100 ml of technical nitric acid diluted with water to 25 vol %. If a reaction occurs, allow it to finish, eventually adding more acid. After half an hour remove the acid. Retain the residue.

Use for this process a polyethene beaker of two liters. If the sample consists of limestone or another carbonate, take a larger sample and correspondingly more acid.

In case the sample reacts with the acid, wash the residue at least twice with water to remove as much of the Ca-ions from the liquid as possible. Use 100 ml glass tubes for centrifuging. Centrifugate two minutes at 4000 r/.

If no reaction occurs, decant the acid. Washing the residue is not necessary.

Put the residue back into the plastic beaker.

3. Add to the residue 150 ml of 40 % technical hydrofluoric acid and then, carefully, add 30 ml of concentrated hydrogensuperoxide. Keep the reagents at about 50° C for two hours. Then concentrate the residue by centrifugating two minutes at 4000 r/.

Wash the residue three times with 10 % technical hydrochloric acid at 50° C (two minutes at 4000 r/).

Let the reactions take place in a two liters polyethylene beaker placed on a waterbath at about 50° C. Use 100 ml glass tubes for centrifugating. The hydrofluoric acid attacks the tubes only superficially in the short time that it reacts with the glass. By washing the residue with warm diluted hydrochloric acid much of the silicofluorides and hydroxides will be removed. Neutralising the acids with strong bases such as potassium or sodium hydroxide, or ammonia, seems to have the effect of dissolving the microfossils.

4. Wash the residue at least three times with 2 % hydrochloric acid, centrifugating it for two minutes at 4000 r/.

This operation serves to remove as much hydrofluoric acid as possible from the residue. The flocculation of hydroxides etc. is prevented by keeping the residue in an acid environment.

5. Wash the residue at least three times with 96 % technical alcohol (two minutes at 4000 r/) and let the centrifuge tubes drip upside down on filter paper for at least ten minutes.

This operation serves to remove the water from the residue.

6. Mix the residue thoroughly with about 30 ml of a bromoform-ethanol mixture of a specific gravity of 2.0. Separate the light fraction by centrifugating ten minutes at maximum 1500 r/. Retain the light fraction.

The residue and the bromoform-ethanol can be well mixed by stirring with a glass rod. An ultrasonic equipment used for short periods mixes the residue even better.

The samples are put in glass beakers of 100 ml during the ultrasonic treatment.

If the complete sample does not become well-mixed, pass it through a sieve of 1 mm meshes to eliminate the lumps.

Use 100 ml glass tubes for centrifugating. Be careful not to accelerate the centrifuge too rapidly in order to avoid the microfossils from being forced to the bottom of the tube due to the umbrella effect of the rapidly sinking heavy mineral matter. In order to avoid whirling up the sedimented heavy fraction, do not use the brake of the centrifuge when stopping.

If the sample does not mix well with the bromoform-ethanol and forms a lumpy jelly-like mass, all the water has not been removed. In this case operation 5 should be repeated.

7. Mix the light fraction with as much 96 % alcohol as possible and centrifugate five minutes at 4000 r/'. Retain the sediment.

Use 100 ml glass tubes for centrifugating. Do not use the brake of the centrifuge.

8. Wash twice with 96 % alcohol and twice with distilled water (five minutes at 4000 r'). Let the centrifuge tubes drip on filter paper for at least ten minutes.

Use 15 ml glass tubes for centrifugating. The residue is washed with alcohol to remove the bromoform. After this operation slides can be made with safranin glycerine jelly in the usual manner.

The following procedure was followed to prepare microfossils of more than 50  $\mu$  diameter, such as chitinozoans and sporomorphs.

1. Crush about 50 grams of the sample. Clean the crushed sample from pieces of other than 2—3 mm diameter.

Be careful to avoid contamination of the sample.

2. Add to 25 grams of the crushed sample 250 ml of technical nitric acid diluted with water to 25 vol %. If a reaction occurs allow it to finish, eventually adding more acid. Then dilute with water to two liters. Decant after two hours. Retain the residue.

Use for this process a polyethene beaker of two liters. If the sample consists of limestone or is very calcareous, take a larger sample and correspondingly more acid.

3. Add to the residue 250 ml of 40 % technical hydrofluoric acid and then add, carefully, 50 ml of concentrated hydrogenperoxide. After twelve hours dilute the reagents in the beaker with water to two liters. Stir well and pass the muddy liquid through a sieve of 1.5 mm mesh. Retain the filtrate.

A sieve of red copper wire can be used, as the diluted acid will not attack it very quickly. Clean the sieve with much water immediately after use.

4. Pass the filtrate through a sieve of 50  $\mu$  meshes. Retain the residue.

5. Wash the residue once with 2 % hydrochloric acid, centrifugating it for two minutes at 4000 r/'. Retain the residue.

Use 100 ml tubes for centrifugating. This procedure serves to concentrate the residue at the bottom of the centrifuge tube. The residue should be kept as long as possible in an acid environment to prevent hydroxides and silicofluorides from flocculating.

6. Wash the residue at least three times with 96 % technical alcohol (two minutes at 4000 r') and let the centrifuge tubes drip upside down on filter paper for at least ten minutes.

Washing with concentrated alcohol is done to remove the water from the residue so that it can be mixed with the bromoform-ethanol. If the residue has a volume of more than about two ml, wash again with 96 % alcohol.

7. Mix the residue with about 50 ml of a bromoform-ethanol mixture of a specific gravity of 2.0. Add the mixture to a separatory funnel and allow the heavy components to settle for at least twelve hours. Then separate and keep the light fraction.

If the residue does not mix well, forming a lumpy jelly-like mass, all the water has not been removed. In this case operation 6 should be repeated.

Cover the funnel with a glass disc to prevent the liquid from evaporating.

If greater speed is required, omit the procedure with the separatory funnel and go on directly with operation 8. Usually, however, the preparation will not have the highest efficiency, this is an important point when the sample is poor.

8. Centrifugate the light fraction for at least ten minutes at maximum of 1500 r/'. Retain the light fraction.

Use 100 ml glass tubes for centrifugating. Be careful not to accelerate the centrifuge too rapidly in order to avoid the microfossils from being forced to the bottom of the tube due to the umbrella effect of the rapidly sinking mineral matter. When stopping the centrifuge do not use the brake. This is to prevent the sedimented mineral matter from whirling up and making the preparation dirty.

9. Mix the light fraction with as much 96 % alcohol as possible and centrifugate five minutes at 4000 r/'. Retain the sediment.

Use 100 ml glass tubes for centrifugating. Do not use the brake of the centrifuge.

10. Wash twice with 96 % alcohol and twice with distilled water (five minutes at 4000 r'). Let the centrifuge tubes drip upside down on filter paper for at least ten minutes.

Use 15 ml glass tubes for centrifugating. The residue is washed with alcohol to remove the bromoform. After this operation slides can be made in the usual manner with safranin glycerine jelly.

*Counting techniques.* The slides have been quickly scanned under a 200x magnification after mounting, in order to classify them as good, bad, or moderate for analysis, taking into account such factors as quantity of clay matter present, amount of broken and unrecognisable microfossils, too poor or too rich to be analysed without difficulty, and so forth. This classification has been made in order to get an idea of the time to be spent in analysing the samples of a section, and to judge whether it is advantageous to analyse a relatively bad preparation or to prepare the sample again.

Unless otherwise stated the assemblages of acritarchs and chitinozoans have been counted to more than 250 and more than 100 specimens respectively. After counting the desired number of specimens, one or two other slides of the same sample were scanned to detect the presence of any inhomogeneously mixed rare constituents of the assemblage.

*Microphotography.* During the analysis of the slides interesting specimens were photographed and, when necessary, drawn. The pictures were taken with a LEICA on a Leitz Ortholux microscope on which an electronic flash-light had been mounted. ADOX KB 14 film was used and exposed and processed as 14° DIN with AGFA Rodinal. It was printed on AGFA Brovira normal paper.

Drawing of the specimens was facilitated by using a WILD M 5 microscope provided with a drawing tubus according to Treffenberg. The drawings of the acritarchs were originally made with a 1500x magnification and then reduced to the present scale of this paper.

### III. GENERAL OUTLINE OF THE FORMATIONS INVESTIGATED

#### A. THE FORMIGOSO FORMATION (COMTE, 1959)

*Lithology.* The Formigoso Formation consists of very fine black ampelitic shales with some mica. The thickness of the layers varies from finely laminated to thin bedded. The formation is very sandy at the base as well as at the top, coinciding with a greater thickness of the layers. The transition from the underlying Barrios Quartzite Formation is gradual. The transition to the overlying San Pedro Formation is also gradual, although it takes place within a few meters. In the upper part, and occasionally in the lower part, many casts of worm-tracks can be found on the bedding planes of the sandy layers. The gross amount of sandy material varies laterally and, as a rule, the formation is more sandy towards the western part of the region investigated. The black shales contain graptolites and, occasionally, brachiopods, especially at the base of the formation. During the microscopical analysis of the preparations, remains of graptolites have been found, although in very small numbers, throughout the whole formation.

*Thickness.* The average thickness of the formation can be estimated at 100 meters.

*Age.* The not very abundant graptolites permit a dating of the basal layers of this formation as Upper Llandoveryan (Comte, 1959). Poll (1963) places the beginning of the analogous Corral Formation, province of Asturias, in the Middle Llandoveryan. The section near El Tueiro, Villasimpliz, that has yielded the best preserved and most complete series of microplankton of the Formigoso Formation, shows an abnormal contact with the Barrios Quartzite Formation. Comparison with undisturbed sequences at short distances suggests that the very basal layers are missing here. The oldest chitinozoans described in this paper come from the lowermost layers of the section near El Tueiro. According to Comte, their age is Upper Llandoveryan.

#### B. THE SAN PEDRO FORMATION (COMTE, 1959)

*Lithology.* The San Pedro Formation consists of occasionally very ferruginous sandstones and quartzites of bluish red to reddish gray color, in layers ranging from laminated to very thick bedded. They alternate with very fissile bright green to dark gray shales with some mica. The shales occasionally contain some very light colored to white, silty to sandy, layers which are very finely laminated to thickly bedded. The shales occur in layers of less than 0.3 mm to more than 1 m thickness. Locally, the San Pedro Formation contains volcanic ash beds.

The gross quantity of shales within the formation is variable. At some outcrops the sequence consists of predominantly greenish shales, while in other sections, at a little distance, the shales form but a minor constituent. The variation in shale content is independent of the differences in iron content in the formation. No systematic change in the iron content has been observed.

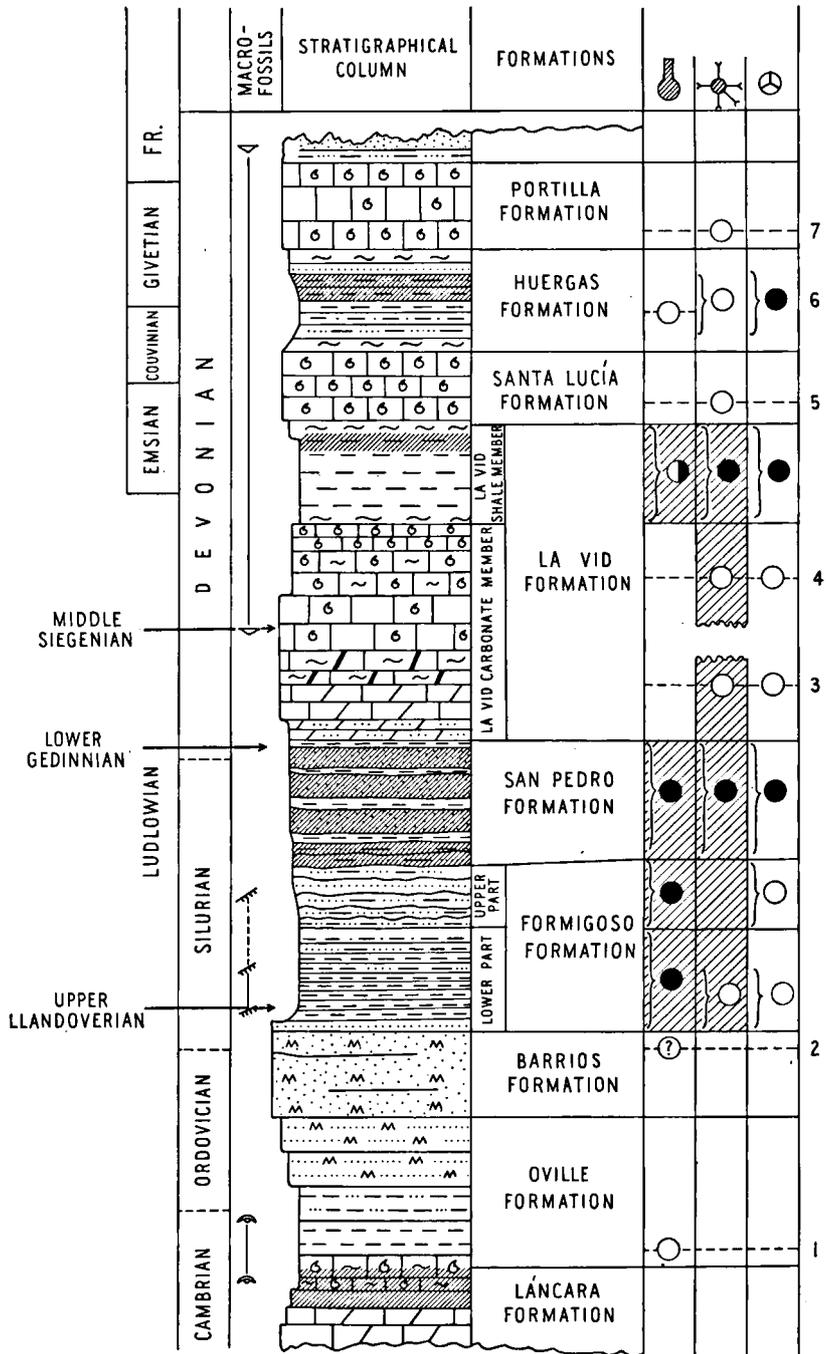


Fig. 1. Generalized section of the Palaeozoic strata in the northwest of the Province of León, Spain.

The numbers indicate horizons where microfossil assemblages occur: 1 = Láncara de Luna; Aralla de Luna. 2 = Shale layer in the Barrios Formation near El Tueiro, Villasimpliz. 3 = North of Mirantes at the reservoir of the Luna. 4 = Same as 3. 5 = Near Santa Lucía de Gordón. 6. = Same as 5. 7 = South of Vega de Gordón.

*Age.* Although remains of brachiopods are not rare, the few well preserved fossils do not permit a precise dating of the formation. Poll (1963) places the basal layers of the Furada Formation in Asturias (analogous to the lower part of the San Pedro Formation in León) at the Upper Wenlockian. The rest of the upper part of the sequence, the essentially ferruginous part of the Furada Formation, is Ludlovian to Gedinnian. The dolomitic sandstones or sandy dolomites and marls (Lower Nieva Formation that overlies the Furada Formation) have been attributed by Poll to the Upper Gedinnian.

The San Pedro Formation thus covers at least the Ludlovian and a part of the Lower Gedinnian, and possibly a part of the Wenlockian as well. There is no great difference between the composition of the microflora of the top layers of the ferruginous part and that of the dolomitic part of the sequence.

*Thickness.* The thickness of the formation varies in undisturbed sequences from 100 m in sections rich in shales to 140 m in sandy sections. The constitution of the terrain does not allow tracing of individual layers over some distance from one outcrop to another.

### C. THE LA VID FORMATION (COMTE, 1959)

The La Vid Formation is divided here into two members, the La Vid Carbonate Member and the La Vid Shale Member.

#### 1. *The La Vid Carbonate Member*

*Lithology.* Via a sandy gray dolomite with ocre-yellow weathering the San Pedro Formation changes within a few meters into the limestones and dolomites of the La Vid Formation. The sequence consists of gray to dark gray dolomites that weather yellowish. They are followed by gray (yellowish weathering) limestones, marls, and dolomitic limestones devoid of macrofossils. The thickness of the individual layers varies from five centimeters, or even less, to very thick bedded. The thick bedded layers predominate. The upper part of the La Vid Carbonate Member consists of generally fossiliferous limestones with shale partings or thin marly layers. The color of this part of the formation is gray to almost black (weathered gray to yellowish gray). Towards the top of the member the sequence becomes more shaly and the amount of fossiliferous limestones diminishes. There is a gradual transition into the shales of the La Vid Shale Member. The fossiliferous (fetid) limestones and marls occur in very thick beds at the lower levels but towards the top of the member they become thin bedded. The transitional layers of the members are colored a greenish yellow. The very fossiliferous limestones and marly bands are bluish to brownish.

*Age.* The lower part of the La Vid Carbonate Member has not yielded determinable macrofossils here, but at the top of the member many groups of fossils occur in tremendous quantities. The spirifers of the lowest fossil horizons have a Middle Siegenian age (Mr. Th. F. Krans, University of Leiden — thesis in preparation). The microfossil content of the very lowest part of the member, the sandy dolomites, marls, and dolomitic sandstones, is not fundamentally different from that of the topmost layers of the ferruginous San Pedro sequence. Poll (1963) indicates a Lower Gedinnian age for the equivalent of the lower part of the Carbonate Member. The upper part of the Carbonate Member gives only very poorly preserved microfossil assemblages.



## 2. *The La Vid Shale Member*

*Lithology.* There is a very gradual transition from the fossiliferous limestones and marls of the Carbonate Member to the shales of the Shale Member. This transition occurs within some five to ten meters. The color of the shales and marly shales is olive green at the base of the member but at higher levels it grades into yellowish gray. Throughout the member thin, very fossiliferous limestone bands in locally different amounts are intercalated. Their color is bluish and they weather yellow. At the top of the member one or more reddish beds (5 to 10 m thick) of shales or marly shales may be found.

*Age.* Fossils of many different groups occur in enormous numbers throughout the whole member, which has been dated as Siegenian by Comte (1959). The spirifers, which are being studied by Mr. Th. F. Krans, University of Leiden, permit an exact dating of the shales. The lower part of the La Vid Shales is of Siegenian age, the upper part of the member is of Lower and Middle Emsian age. The boundary between the Emsian and Couvinian is found approximately in the middle of the overlying Santa Lucía Formation (Comte, 1959; Krans, 1964, personal communication).

*Thickness.* Since the La Vid Shale Member is generally more or less tectonised, it shows secondary changes in thickness. A thickness of some 80 m may be taken as a rough average. The Carbonate Member is about 100 m thick.

## D. DISTRIBUTION OF THE FORMATIONS

The Formigoso, San Pedro, and La Vid Formations are widespread in the region investigated. The provisional map of de Sitter and collaborators (1962) indicates them in a belt of 80 km long and 25 km broad, where they crop out in long ribbon-like structures approximately parallel to the tectonic structures in this part of the mountain chain.

## IV. OUTLINE OF THE VERTICAL DISTRIBUTION OF MICROPLANKTON IN LEÓN

### PROCEDURE

In the individual sections frequency diagrams have been composed for the different components of the associations. Two major groups of microfossils have been used for this purpose, viz. acritarchs and chitinozoans. Besides, sporomorphs have been met with in varying but usually large quantities in most sections. The results of the analysis of the associations of sporomorphs are not yet available.

Between the most pronounced changes in frequency of the different species or formgroups in the individual sections, ghost horizons were drawn. It is interesting to see that, at least in the pre-Devonian part of the column, the major changes in frequency within the two groups of organisms are comparable.

In the younger part of the column the chitinozoans are too infrequent to permit the composition of reliable frequency diagrams. In the very lowest part of the Formigoso Formation acritarchs occur in small quantities. In two sections, about 6 km apart, acritarchs have been isolated in quantities great enough to permit the composition of frequency diagrams of some 200, sometimes 300, specimens per sample. Here too the variations coincide for the two groups of organisms studied. The procedure of drawing ghost horizons within a formation permits a detailed correlation between different sections. The text-figures 3 and 13a have been composed on the basis of these detailed subdivisions within the formations. These text-figures thus give the average vertical extension of the different forms or formgroups occurring in this part of the Cantabric Mountains. The different kinds of shading indicate areas of approximately the same microplankton assemblage for each of the different formations. The detailed vertical distribution has been represented in text-figures 3 and 13a.

The new species mentioned in the text have been met with in sufficient great number to exclude the possibility of establishing new species on aberrant variations. If the new species has been found in one sample only, at least twenty specimens have been examined. A new species occurring in more than one sample, either in one section or more, should have a frequency of over 2 % of the total assemblage in at least one sample.

Although a few species of fairly consistent characteristics have been met with, most species show a large variation in dimensions, number of processes, etc.

The photographs and drawings have been made of average representative specimens.

### ACRITARCHS

*Variations in composition of the assemblages of acritarchs and their implications.* The lateral and vertical variations in frequency of some selected groups of acritarchs in León are best illustrated by their original diagrams (text-figures 4 to 7 and 9 to 11).

*San Pedro Formation.* The following sections have been sampled and analysed: *Torrestío*, *Láncara de Luna*, *Oblanca de Luna*, *Los Barrios de Luna*, *Aralla de Luna*, *Geras de Gordón*, *Villasimpliz*, *La Vid de Gordón*, a section at the river Torio between *Valverdín* and *Getino*, and *Corniero*. The textfigures show the frequency curves in the *italicized* sections. The sections that have not been represented here have curves that are roughly intermediate between the nearest represented sections.

| FORMIGOSO Fm. (PART)                  | SAN PEDRO FORMATION | LA VID CARB. MBR. (La Vid Part) | LA VID CARB. MBR. (Vid Part) | LA VID SHALE MEMBER |
|---------------------------------------|---------------------|---------------------------------|------------------------------|---------------------|
| B DILATISPINOSUM DOWNIE               |                     |                                 |                              |                     |
| B CARINIOSUM N.SP.                    |                     |                                 |                              |                     |
| B PILAR N.SP.                         |                     |                                 |                              |                     |
| B TRAUMATICUM N.SP.                   |                     |                                 |                              |                     |
| B ECHINOGERMIUM N.SP.                 |                     |                                 |                              |                     |
| B SOPHONISC N.SP.                     |                     |                                 |                              |                     |
| B OLIGOFURCATUM EIS.                  |                     |                                 |                              |                     |
| B BORRACHEROSUM N.SP.                 |                     |                                 |                              |                     |
| B BRACHYDENDRUM N.SP.                 |                     |                                 |                              |                     |
| B DROSOMUERTOSUM N.SP.                |                     |                                 |                              |                     |
| B LONGISPINOSUM (EIS)                 |                     |                                 |                              |                     |
| B CANTABRICUM N.SP.                   |                     |                                 |                              |                     |
| B PARAGUATERUM N.SP.                  |                     |                                 |                              |                     |
| B JULIAE N.SP.                        |                     |                                 |                              |                     |
| B ESCOBAIDES N.SP.                    |                     |                                 |                              |                     |
| B LOBELIUM N.SP.                      |                     |                                 |                              |                     |
| B MICRODICTYUM (EPL)                  |                     |                                 |                              |                     |
| B RASPA N.SP.                         |                     |                                 |                              |                     |
| B MALUM N.SP.                         |                     |                                 |                              |                     |
| B ARBUSCULIFERUM DOWNIE               |                     |                                 |                              |                     |
| B POLYFORMALE (EIS)                   |                     |                                 |                              |                     |
| B ROBERTIUM N.SP.                     |                     |                                 |                              |                     |
| B RAMUSCULOSUM (DEFL)                 |                     |                                 |                              |                     |
| B TOYETAE N.SP.                       |                     |                                 |                              |                     |
| B CT ASTARTES SANM.                   |                     |                                 |                              |                     |
| B TRIFURCATUM (EIS) V. PROCERUM SANM. |                     |                                 |                              |                     |
| B GUAFUM N.SP.                        |                     |                                 |                              |                     |
| B DENTICULATUM ST & W FORMA I         |                     |                                 |                              |                     |
| B DENTICULATUM ST & W FORMA II        |                     |                                 |                              |                     |
| B DENTICULATUM ST & W FORMA III       |                     |                                 |                              |                     |
| B MOLINUM N.SP. FORMA I               |                     |                                 |                              |                     |
| B MOLINUM N.SP. FORMA II              |                     |                                 |                              |                     |
| B RANOSUM N.SP.                       |                     |                                 |                              |                     |
| B RACZI N.SP.                         |                     |                                 |                              |                     |
| 7B CARMINAE N.SP.                     |                     |                                 |                              |                     |
| 7B VALENTINUM N.SP.                   |                     |                                 |                              |                     |
| 7B DUPLIX N.SP.                       |                     |                                 |                              |                     |
| M MALPENHADUM N.SP.                   |                     |                                 |                              |                     |
| M PICORRICUM N.SP.                    |                     |                                 |                              |                     |
| FORMGROUP M. STELLATUM                |                     |                                 |                              |                     |
| FORMGROUP V. EROPAEUM                 |                     |                                 |                              |                     |
| FORMGROUP V. TRISPINOSUM              |                     |                                 |                              |                     |
| V ROSENAE N.SP.                       |                     |                                 |                              |                     |
| V HELICAE N.SP.                       |                     |                                 |                              |                     |
| V LEONENSE N.SP.                      |                     |                                 |                              |                     |
| V CERATIODES ST & W                   |                     |                                 |                              |                     |
| V BERNADEINAE N.SP.                   |                     |                                 |                              |                     |
| V TRISPINULATUM N.SP.                 |                     |                                 |                              |                     |
| V INFUSISSIMUM N.SP.                  |                     |                                 |                              |                     |
| V SERPENTINATUM N.SP.                 |                     |                                 |                              |                     |
| V CALORUM N.SP.                       |                     |                                 |                              |                     |
| V COCHINUM N.SP.                      |                     |                                 |                              |                     |
| V VALLENTE N.SP.                      |                     |                                 |                              |                     |
| V TOLUNTULUM N.SP.                    |                     |                                 |                              |                     |
| V STELLIBERUM DIFF V ASPERUM          |                     |                                 |                              |                     |
| V ASTURIANUM N.SP.                    |                     |                                 |                              |                     |
| V CARMINAE N.SP.                      |                     |                                 |                              |                     |
| V SCABRATUM N.SP.                     |                     |                                 |                              |                     |
| V TORRESTONENSE N.SP.                 |                     |                                 |                              |                     |
| V THYRAE N.SP.                        |                     |                                 |                              |                     |
| V JOSSEAE N.SP.                       |                     |                                 |                              |                     |
| V LAIADI (DEFL) DIFF.                 |                     |                                 |                              |                     |
| V STELLIBERUM DIFF.                   |                     |                                 |                              |                     |
| V ESTRELLITA N.SP.                    |                     |                                 |                              |                     |
| P RABIANI N.SP.                       |                     |                                 |                              |                     |
| P TETRAHEDROIDE                       |                     |                                 |                              |                     |
| P BECORUM DIFF.                       |                     |                                 |                              |                     |
| P HELICINAE N.SP.                     |                     |                                 |                              |                     |
| P EMPURUM N.SP.                       |                     |                                 |                              |                     |
| P ASPERUM N.SP.                       |                     |                                 |                              |                     |
| P PHARADIS DIFF.                      |                     |                                 |                              |                     |
| P PSEUDOPHARADIS ST & W.              |                     |                                 |                              |                     |
| P EVOLUTUM N.SP.                      |                     |                                 |                              |                     |
| A INSOLITUS DIFF.                     |                     |                                 |                              |                     |
| L CF TUMIDA DOWNIE FORMA D            |                     |                                 |                              |                     |
| L PASTORINA N.SP.                     |                     |                                 |                              |                     |
| L BONAERITICA CMB.                    |                     |                                 |                              |                     |
| L FUSIFORMIS EIS.                     |                     |                                 |                              |                     |
| L BERNESEA CMB.                       |                     |                                 |                              |                     |
| L CANTABRICA CMB.                     |                     |                                 |                              |                     |
| L FILIFERA DOWNIE                     |                     |                                 |                              |                     |
| L STRATIATYRA CMB.                    |                     |                                 |                              |                     |
| L ESTRECHA CMB.                       |                     |                                 |                              |                     |
| D CF MONOSPINOSA                      |                     |                                 |                              |                     |
| L CF TUMIDA DOWNIE FORMA M            |                     |                                 |                              |                     |
| L LELIAE N.SP.                        |                     |                                 |                              |                     |
| D MONACANTHA (DIFF)                   |                     |                                 |                              |                     |
| L PEPINO N.SP.                        |                     |                                 |                              |                     |
| FORMGROUP CYMATIOSPHAERA              |                     |                                 |                              |                     |
| C FRANJADA N.SP.                      |                     |                                 |                              |                     |
| C CARMENITICAE N.SP.                  |                     |                                 |                              |                     |
| C PELIGROSA N.SP.                     |                     |                                 |                              |                     |
| PH HERMOSITA N.SP.                    |                     |                                 |                              |                     |
| PH BERARDINAE N.SP.                   |                     |                                 |                              |                     |
| PH RABIDA N.SP.                       |                     |                                 |                              |                     |
| PH CARMINAE N.SP.                     |                     |                                 |                              |                     |
| PH CHIQUITINA N.SP.                   |                     |                                 |                              |                     |
| PH GUARITA N.SP.                      |                     |                                 |                              |                     |
| PH OMOHAGANENSIS DIFF.                |                     |                                 |                              |                     |
| H ARKANOSIS N.SP.                     |                     |                                 |                              |                     |
| S RADIANS N.SP.                       |                     |                                 |                              |                     |
| S RADIOFURCATUS N.SP.                 |                     |                                 |                              |                     |
| 7M <sub>2</sub> HUESCOPINOSUM N.SP.   |                     |                                 |                              |                     |
| 7L ALARGADA N.SP.                     |                     |                                 |                              |                     |
| L CARMINAE N.SP.                      |                     |                                 |                              |                     |
| P <sup>7</sup> HOBLOGA (STAPIN)       |                     |                                 |                              |                     |
| C <sup>4</sup> PUERCOSPINOIDE N.SP.   |                     |                                 |                              |                     |
| Q FANTASTICUM N.SP.                   |                     |                                 |                              |                     |
| Q INOSUM N.SP.                        |                     |                                 |                              |                     |
| ACR CF TV. HASICUM ETC.               |                     |                                 |                              |                     |
| ACR FORMA I                           |                     |                                 |                              |                     |
| ACR FORMA B                           |                     |                                 |                              |                     |
| ACR FORMA M                           |                     |                                 |                              |                     |
| SCOLECIBONTS                          |                     |                                 |                              |                     |
| SPOROZOOIDS                           |                     |                                 |                              |                     |
| CYTHOZOIDS                            |                     |                                 |                              |                     |
| REMAINS OF GRAPTOLITES                |                     |                                 |                              |                     |
| FORMIGOSO Fm. (PART)                  | SAN PEDRO FORMATION | LA VID CARB. MBR. (La Vid Part) | LA VID CARB. MBR. (Vid Part) | LA VID SHALE MEMBER |

VERTICAL REPARTITION OF THE MOST COMMON ASTRICIDS IN THE SAN PEDRO AND LA VID FORMATIONS, PROVINCE OF LEÓN, NW SPAIN.

Fig. 3.

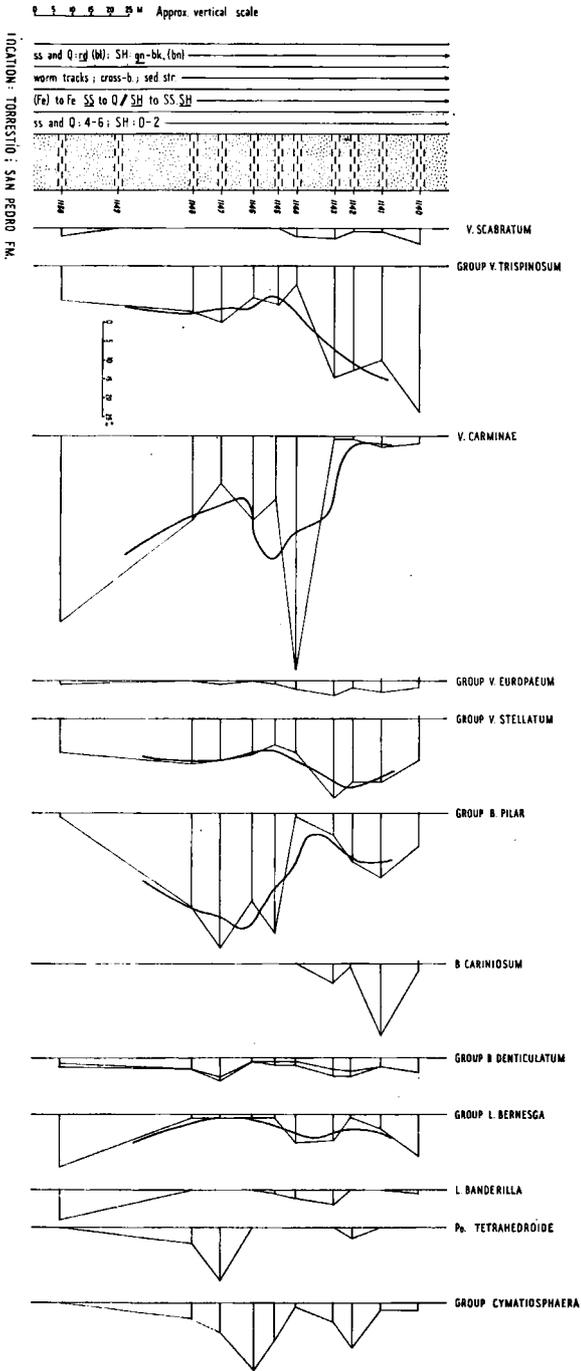


Fig. 4.

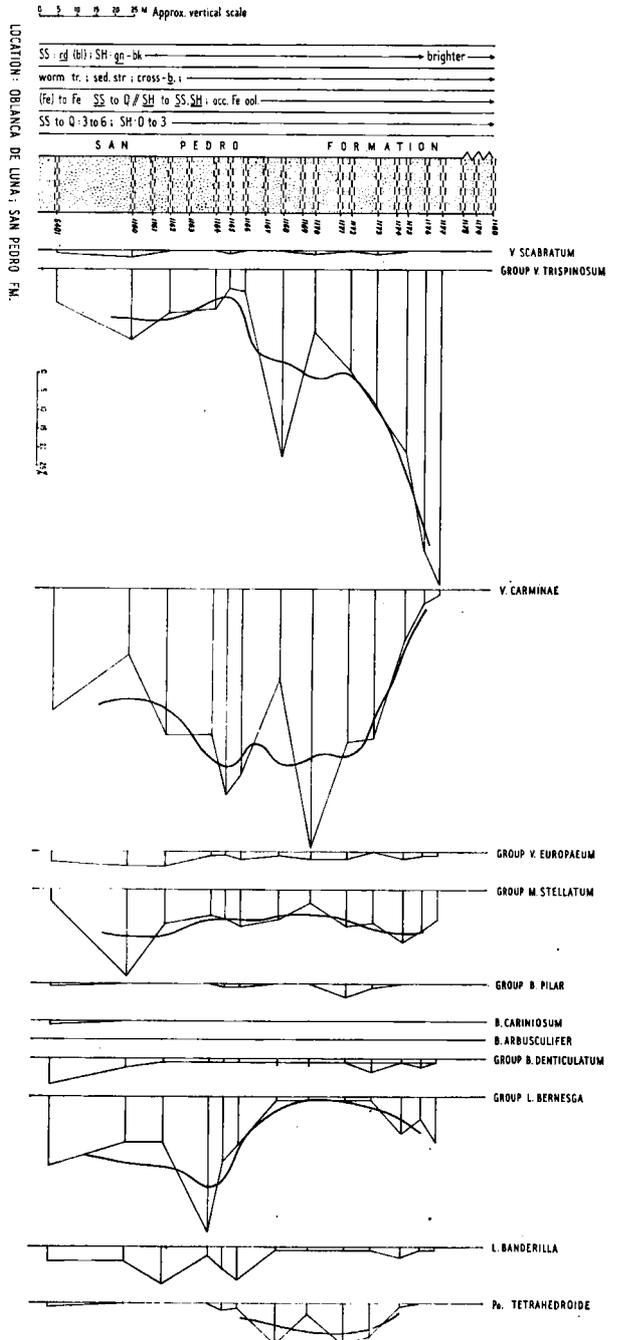


Fig. 5.

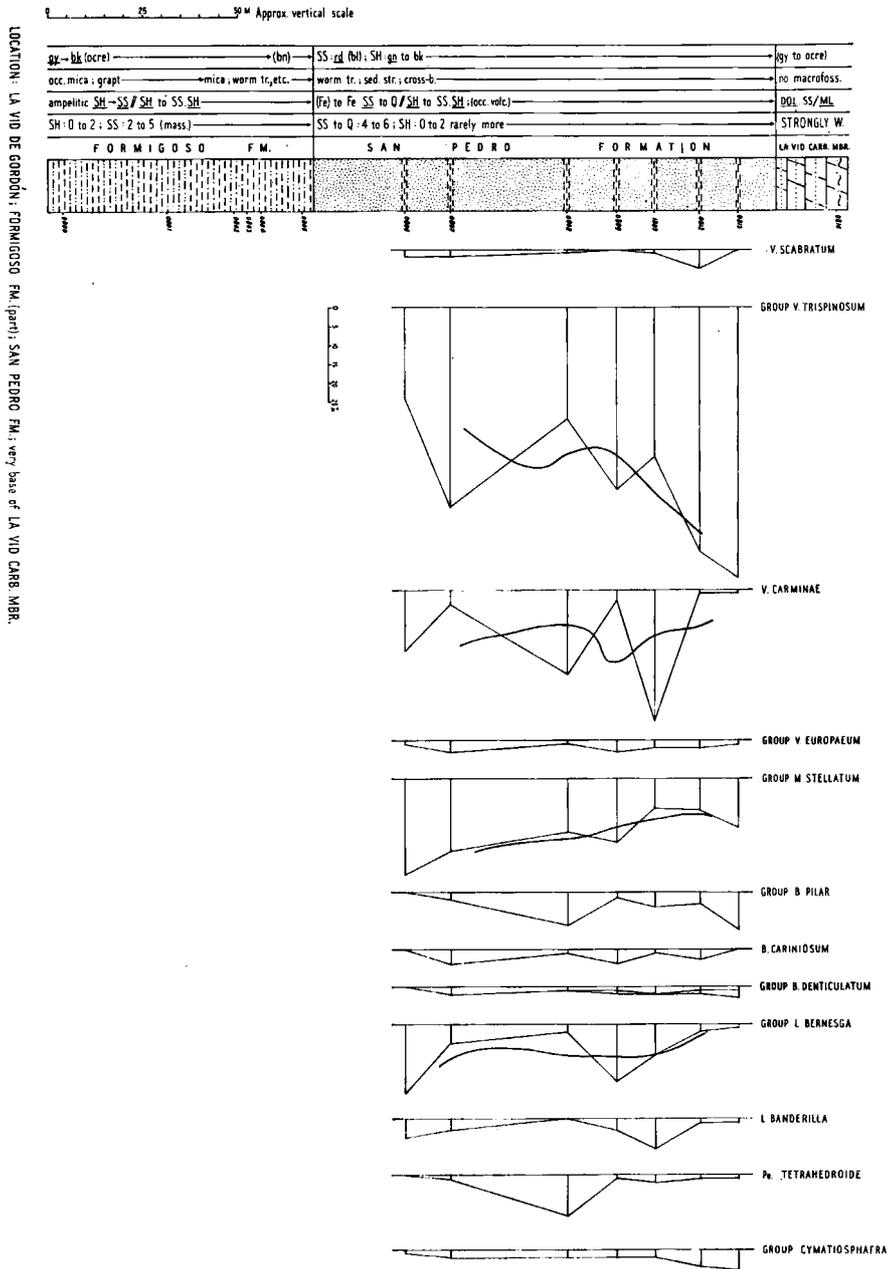


Fig. 6.

Vertical distribution of microplankton

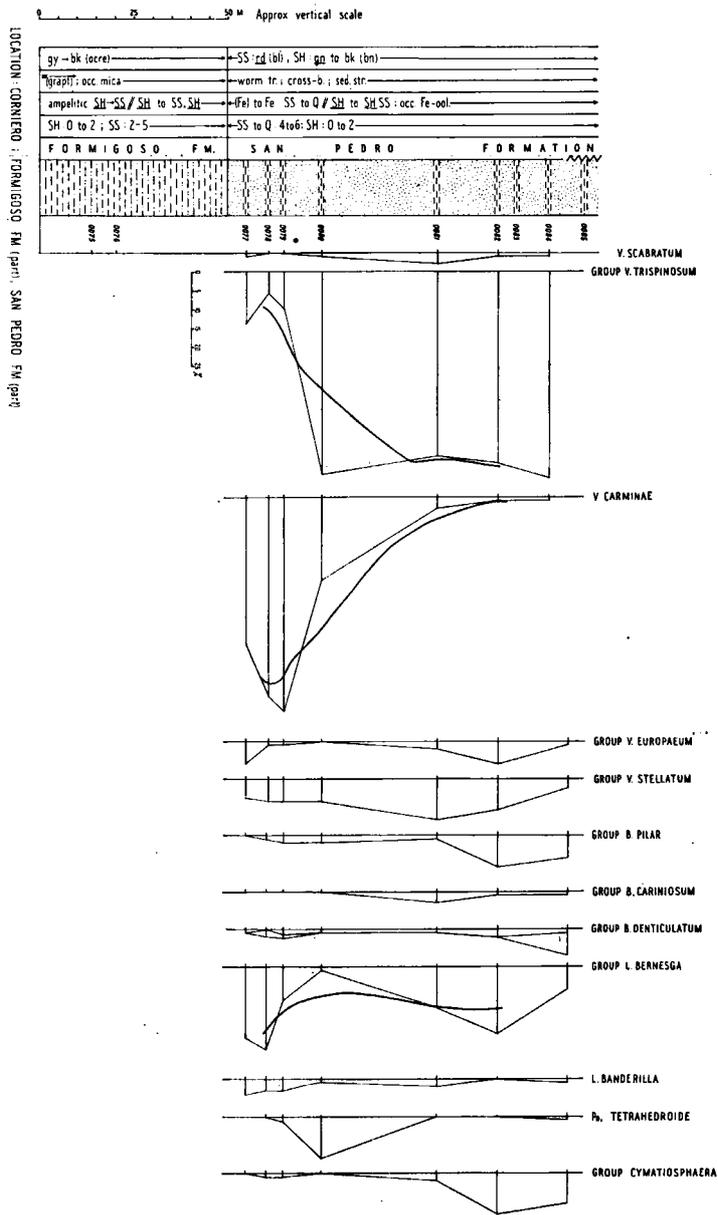


Fig. 7.

Most of the samples have been taken from the thicker shale layers in the sections. Therefore the number of samples is roughly relative to the gross shale content of the formation in the location of the section.

The sections near Oblanca de Luna and Torrestío are the most shaly and have the longest frequency curves. Towards the southeast of the region investigated the curves are shorter while the sections are sandier. While sand was being sedimented at the border, clay, with abundant microfloras, was laid down in the deeper parts of the basin. For this reason the lower parts of the curves may be absent in the direction of the shallower parts of the basin.

The whole character of the sequence indicates a very unquiet environment, with possibly many places of nondeposition situated usually in the shallow parts of the basin. This and the wide spacing of the samples exclude a precise coinciding of the sets of frequency curves. The normal procedure of drawing ghost horizons between points of maximal coincidence in the sets of frequency curves of the different sections has been employed (a.o. de Jekhowsky, 1958, 1959). The suggested implication of the comparison of the frequency curves is represented in text-figures 8 and 12. Results of the analysis of the chitinozoan assemblages of the same sections are not contradictory.

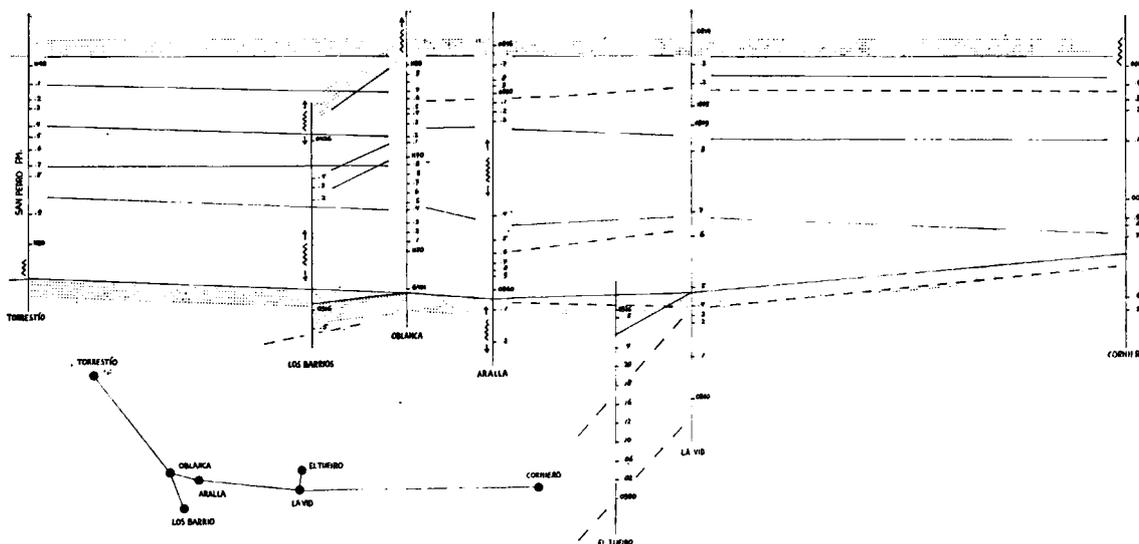


Fig. 8. Section of the San Pedro Formation in the region investigated.

*La Vid Formation.* Samples have been taken in many sections. Possibly as a result of the deep-reaching weathering in the very soft, rather tectonised shales and marly shales, sections that yield series of samples with well preserved microplankton are rare. Because of this difficulty in obtaining good long sections, only three sections situated at relatively short distances from each other could be represented here.

From samples taken in sections near the river Luna only poorly preserved large acritarchs could be prepared. To the east of the region investigated the preservation of the acritarchs becomes poorer. Section Argovejo has yielded good chitinozoan assemblages, whilst the acritarchs were generally undeterminable.

The suggested implication of the comparison between sets of frequency curves of the sections of text-figures 9, 10 and 11, is represented in text-figure 12.

Vertical distribution of microplankton

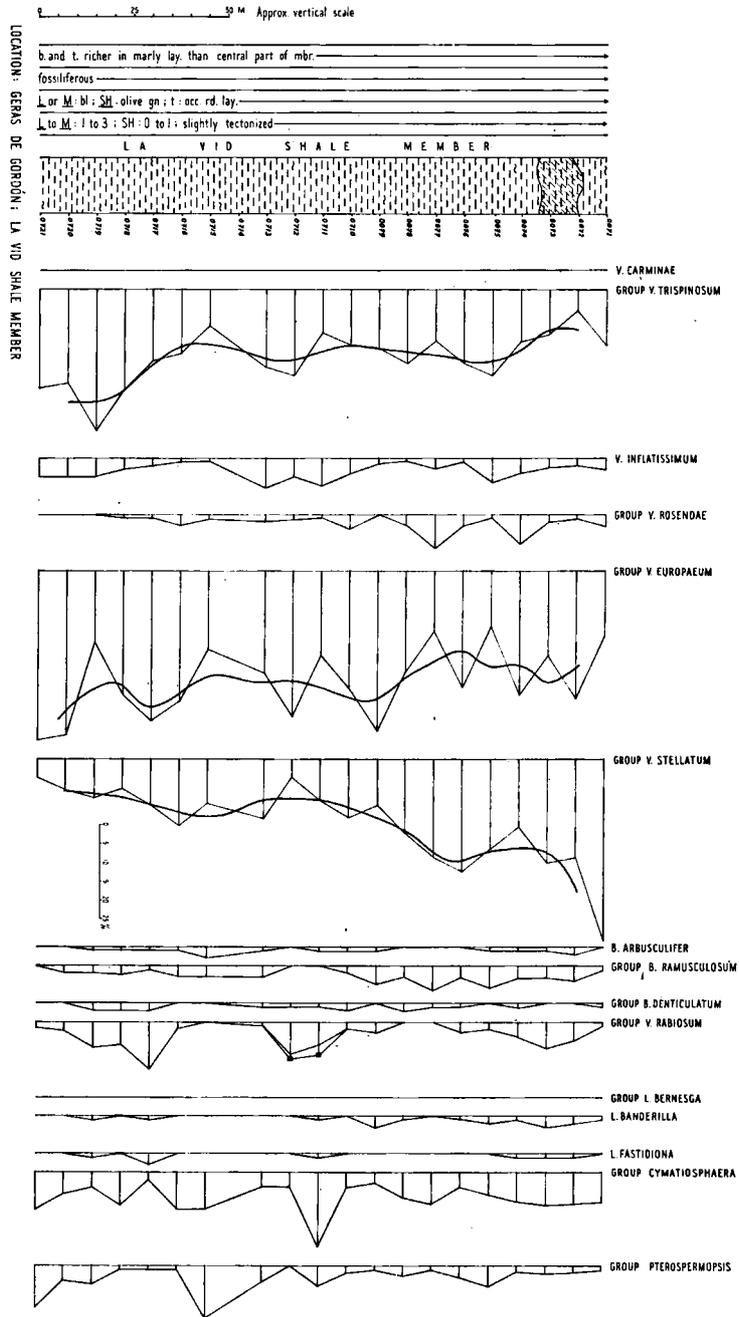


Fig. 9.

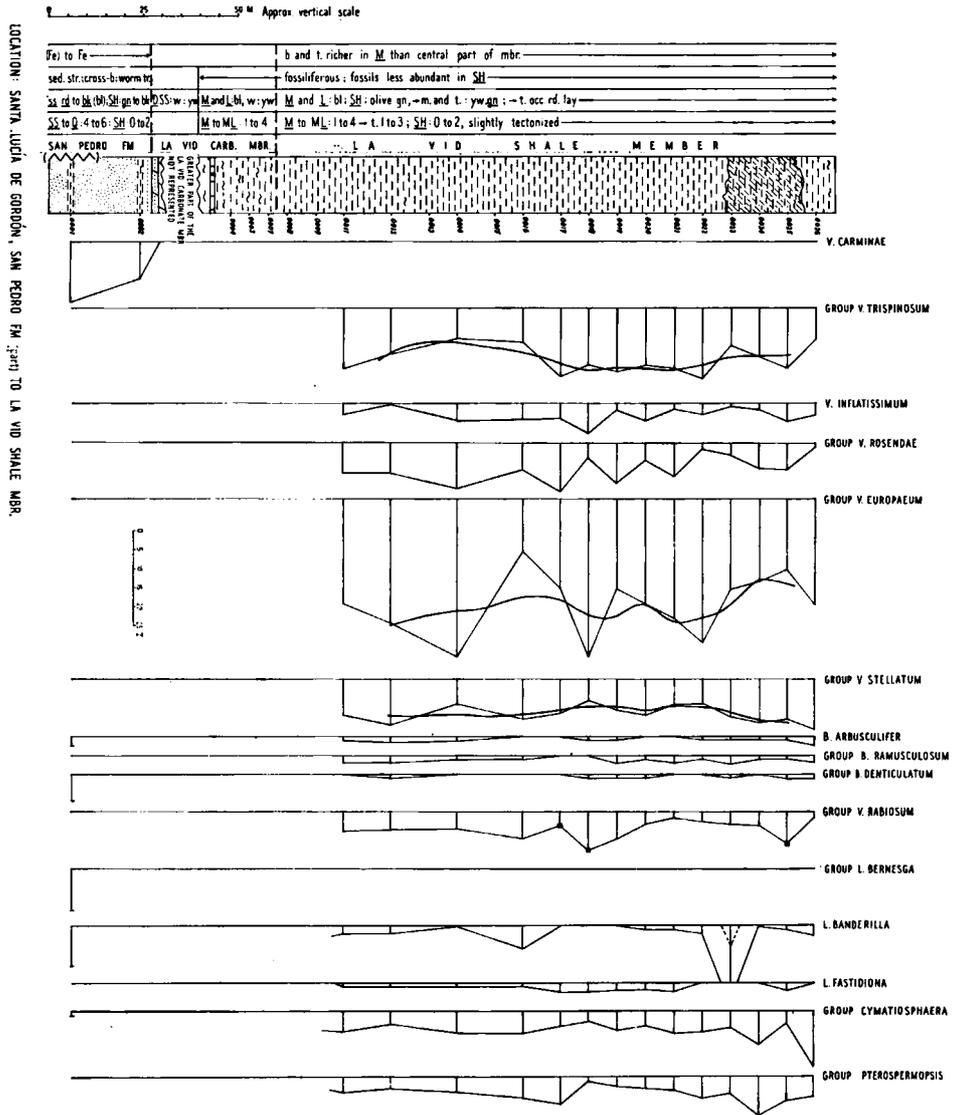


Fig. 10.

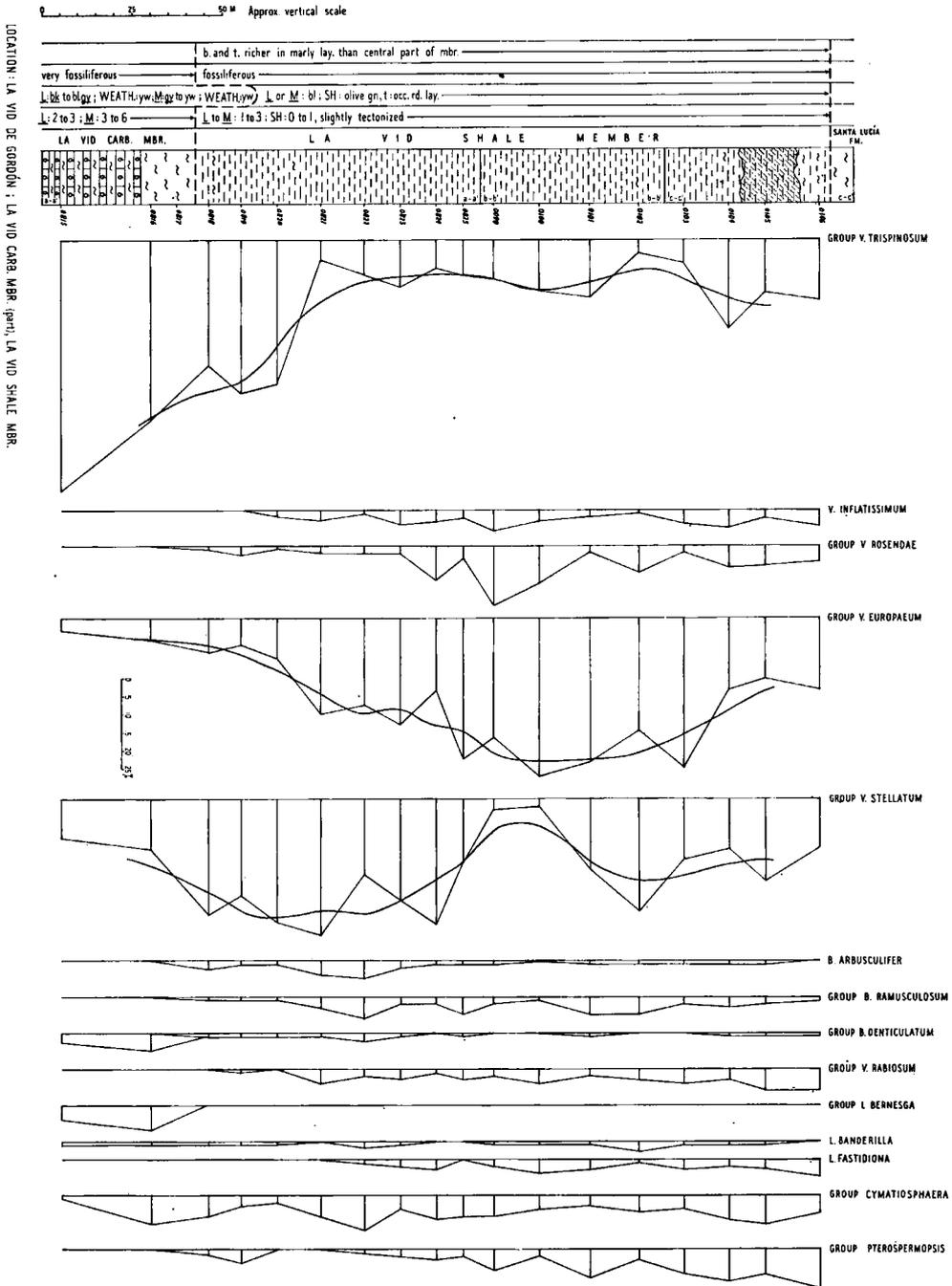


Fig. 11.

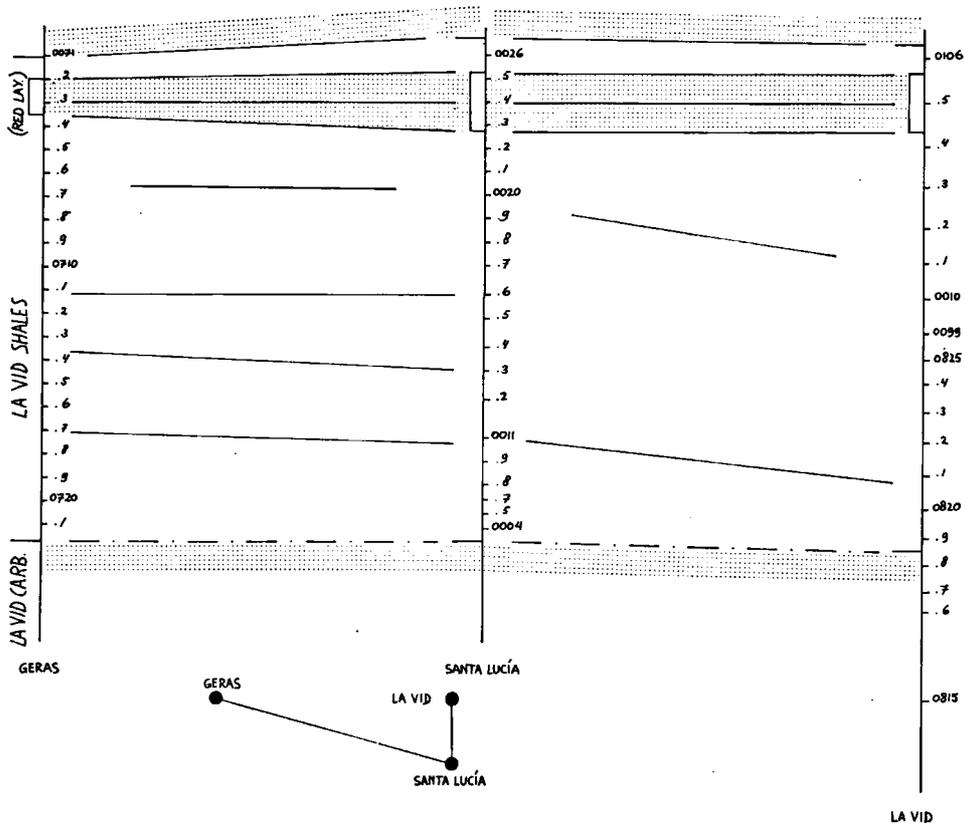


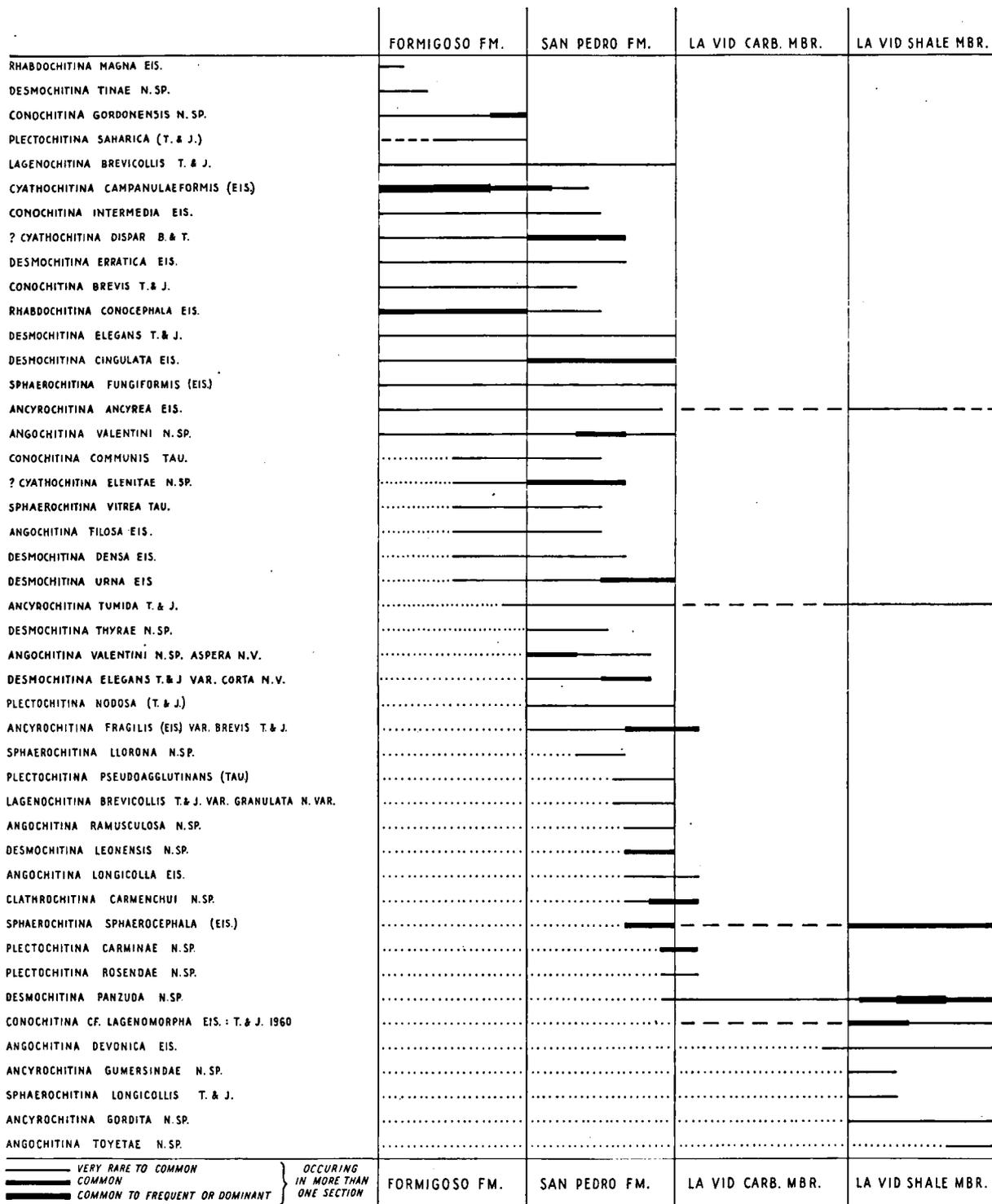
Fig. 12. Section of the La Vid Formation in the western part of the region investigated.

### CHITINOZOANS

Major qualitative changes in the composition of the assemblages do not usually coincide with changes in lithology. This is not surprising since a great number of the previously described species have been recorded from purely clastic sediments as well as from limestones and marls.

Quantitative analyses show that the associations are composed of a high and a low percentage group. The high percentage group consists of only a few species which together form 60 to more than 90 percent of the total assemblage. The low percentage group consists of a large number of species occurring with less than 2%. The lateral variation in frequency in the latter group is of course considerably greater so that this part of the associations is hardly usable for correlation.

Although showing lateral variation as well, the vertical changes in frequency of the high percentage group have the same succession in the whole region. The lateral variation in the high percentage group increases towards the upper part of the La Vid Formation where two simultaneous associations can be distinguished. In the La Vid Shale Member the assemblages are very poor and composed of only a few species.



The range of the species indicated here is not necessarily the total range.

Fig. 13a. Vertical repartition of the most common chitinozoans in the Formigoso, San Pedro and La Vid Formations, Province of León, NW-Spain.

The following average major classes of associations succeed each other in the León region:

1. Dominant to common: *Cy. campanulaeformis* Eis. 1955; *R. conocephala* Eis. 1934; *Co. gordonensis* n. sp.; of secondary importance: *Co. intermedia* Eis. 1955; *S. fungiformis* (Eis. 1931); *Co. brevis* T. & J. 1960; plus in the upper part: *S. vitrea* Tau. 1962; ?*Cy. dispar* B. & T. 1961.

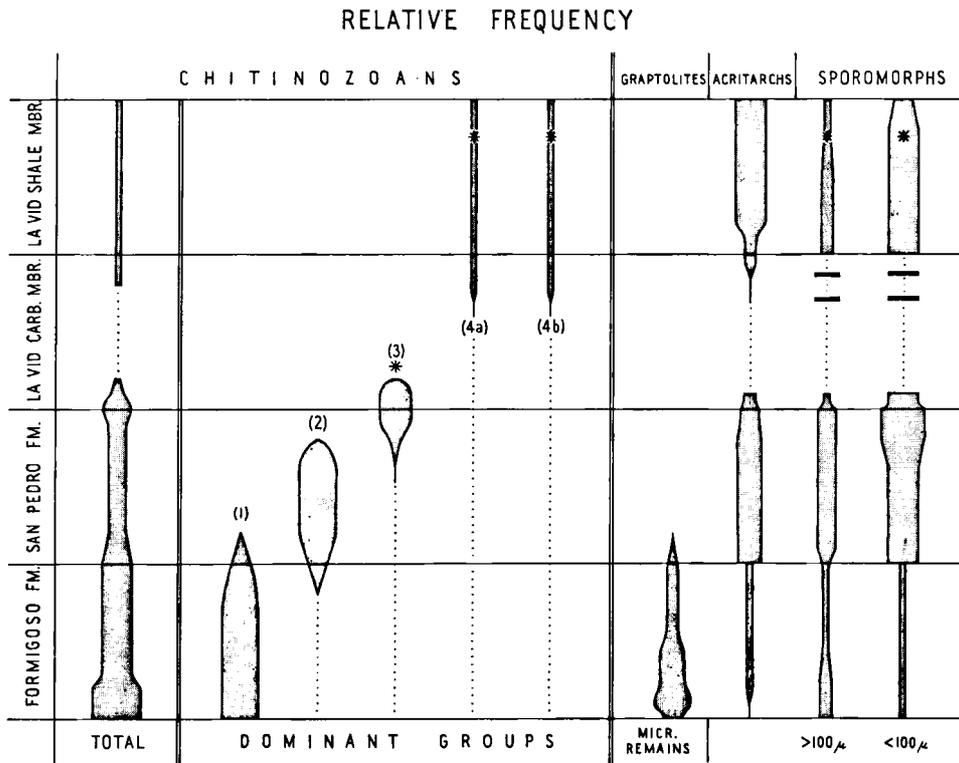
2. Common to dominant: ?*Cy. dispar* B. & T. 1961; *D. cingulata* Eis. 1937; *Ang. valentini* n. sp.; *Ang. valentini* var. *aspera* n.var; of secondary importance: *S. fungiformis* (Eis. 1931); *D. elegans* T. & J. 1960; especially in the lower part: *S. vitrea* Tau. 1962.

3. Dominant to common (lateral variation increasing): *D. cingulata* Eis. 1937; *D. densa* Eis. 1962; *Anc. fragilis* var. *brevis* T. & J. 1960; *D. leonense* n. sp.; *Cl. carmenchui* n. sp.; *P. carminae* n. sp.; *S. sphaerocephala* (Eis. 1932).

4a. Dominant to common *S. sphaerocephala* (Eis. 1932) plus *D. panzuda* n. sp.; of secondary importance spp. of *Angochitina* with spinose to echinate wall and *Anc. ancyrea* Eis. 1931 with very complex appendages and a spinose upper part of the neck.

4b. Dominant to common: *D. panzuda* n. sp. plus *S. sphaerocephala* (Eis. 1932); of secondary importance: same as for 4a.

In the Formigoso Formation the assemblages consist of predominantly large species. These are succeeded by smaller forms in the San Pedro Formation. Colonial forms



achieve importance in the middle and upper parts of the San Pedro Formation. At the top of the San Pedro Formation the large forms such as *Rhabdochitina* spp., *Conochitina* spp., and *Cyathochitina* spp., have disappeared even from the low percentage groups. Their place has been taken by *Plectochitina* spp., *Clathrochitina* spp., and by colonial forms of *Desmochitina* with a pronounced keel. The latter species plus a great number of *Angochitina* spp. and *Ancyrochitina* spp. mark the La Vid Formation.

#### STRATIGRAPHICAL VALUE OF THE MICROPLANKTON.

The forms represented in the text-figures 3 and 13a may be divided into two groups:

*a. Long-ranging forms and formgroups.* Their value as index fossils is of course very small. When plotted in frequency diagrams these forms may have good stratigraphic value as shown by the consistent changes in assemblages at similar stratigraphic horizons. The implications of variations in form and dimensions, as well as in the composition of microfloras, are not yet clear. They may be due, however, to the relatively low number of specimens counted per formgroup and per sample in the test sections. It has not been appropriate to raise the number of specimens to be counted within the formgroup, since the time spent on counting is not proportional to the results. In the León region the possible detailed subdivision of the formations is indicated by the changes in frequency of the total formgroup. It may however be that these variations within a formgroup are of stratigraphical value in other regions.

*b. Short-ranging forms and formgroups.* It is clear that forms with a short range in this region have not necessarily a comparatively short range in more or less distant areas. A good example is *Anc. fragilis* var. *brevis* T. & J. 1960, which has a range from the Middle Llandoveryan until the Siegenian in the Sahara, but is limited in the León region from the ?Lower Wenlockian (pars) to the Lower Gedinnian (pars). Their value as index fossils is also very restricted and it will become even more so when further work on this group of fossils is done. This is apparent in the great number of occurrences cited in literature for some long established species. Many of these species, acritarchs as well as chitinozoans show a long time-range.

The acritarchs and chitinozoans, however, are an excellent tool in stratigraphy if the proper procedure is followed.

## V. DESCRIPTION OF THE MOST COMMON FORMS OF MICROPLANKTON IN LEÓN

### 1. ACRITARCHS

#### *General*

As a rule the acritarchs recovered from the sediments in Northern León were well preserved. However, their preservation varies, even within one species, from sample to sample. Acritarchs showing casts of cubic crystals are quite common. No mutual relations between the abundance of acritarchs, chitinozoans, and sporomorphs within the same sample or series of samples have been observed. Except for the Formigoso Formation, where forms covered with black organic matter were often found, all other formations have yielded mainly determinable fossils. The preservation of the fossils in limestone, dolomite and marly parts of the column is poorer than in the shale and sandstone parts. The good preservation of one group of fossils does not imply an equally good preservation of the other groups. The rather changeable iron content in the rocks of the San Pedro Formation is found to have no influence on the preservation of the microfossils. Neither does it affect the composition of the microfossil assemblages as compared with the immediately over- and underlying associations from the shale layers.

In the vicinity of faults the preservation of microplankton is poor.

The text-figures 4 to 7 and 9 to 11 give an impression of the lateral and vertical variations in frequency of some selected species and formgroups in the San Pedro Formation and the La Vid Shale Member.

The text-figures in the descriptions are schematic drawings. Specimens have not been retouched in any of the photographs, although some dark shadows in the background have been covered when found necessary. The dimensions given in the descriptions as well as, in many cases, the sizes of the enlargements mentioned in the text, are approximate. The figure numbers marked with an asterisk indicate pictures of holotypes. The length of the lines on the photos of Plates I to XIX is 10  $\mu$  unless otherwise indicated.

All samples have been prepared according to the standard techniques, page 259.

#### *List of acritarchs*

Incertae Sedis.

Group *Acritarcha* Evitt 1963.

Subgroup *Acanthomorphae* D., E. & S. 1963.

1. Genus *Baltisphaeridium* Eis. 1958, emend. D. & S. 1963.

a. *Forms with dark central bodies and pale colored, hollow processes.*

*B. carinosum* n. sp.

*B. dilatispinosum* Downie 1963.

*B. cf. echinodermum* St. & W. 1963.

*B. gordonense* n. sp.

*B. pilar* n. sp.

*B. traumaticum* n. sp.

b. *Forms with dark central bodies enveloped by a transparent shell; the processes contain central nerves.*

- ?*B. carminae* n. sp.  
 ?*B. duplex* n. sp.  
 ?*B. valentinum* n. sp.

c. *Other forms.*

- B. arbusculiferum* Downie 1963.  
*B. cf. astartes* Sann. 1955.  
*B. borracherosum* n. sp.  
*B. brazosdesnudum* n. sp.  
*B. cantabricum* n. sp.  
*B. dedosmuertos* n. sp.  
 Formgroup *B. denticulatum* St. & W. 1963.  
*B. erraticum* Eis. 1954.  
*B. escobaides* n. sp.  
*B. guapum* n. sp.  
*B. guillermi* n. sp.  
*B. juliae* n. sp.  
*B. lobeznum* n. sp.  
*B. longispinosum* (Eis. 1938).  
*B. microfurcatum* (Dff. 1957).  
*B. malum* n. sp.  
 Formgroup *B. molinum* n. sp. (*B. molinum* n. sp.; *B. raczi* n. sp.; *Veryhachium rabiosum* n. sp.)  
*B. oligofurcatum* (Eis. 1954).  
*B. paraguaferum* n. sp.  
*B. polygonale* (Eis. 1931).  
*B. ramusculosum* (Defl. 1942).  
*B. raspa* n. sp.  
*B. robertinum* n. sp.  
*B. toyetae* n. sp.  
*B. trifurcatum* (Eis. 1931) var. *procerum* Sann. 1955.

2. Genus *Micrhystridium* Defl. 1937, emend. D. & S. 1963.

- M. malpeinadam* n. sp.  
*M. picorricum* n. sp.  
 Formgroup *M. stellatum* (Defl. 1942).

Subgroup *Polygonomorphitae* D., E. & S. 1963.

Genus *Veryhachium* Dff (1954) 1958, emend. D. & S. 1963.

- Formgroup *V. europaeum* St. & W. 1960.  
 Formgroup *V. trispinosum* (Eis. 1931).

a. *Forms with the processes not situated in one plane; surface smooth; processes simple.*

- V. inflatissimum* n. sp.  
*V. trispininflatum* n. sp.

b. *Forms with the processes situated in one plane. Processes simple.*

- V. carminae* n. sp.  
*V. lairdi* (Defl. 1946) Dff. 1958.  
*V. serpentinatam* n. sp.  
*V. stelligerum* Dff. 1958.  
*V. stelligerum* Dff. 1958 var. *asperum* n. var.  
*V. valiente* n. sp.

c. *Forms with the processes not situated in one plane; surface not smooth.*

Formgroup *V. rosendae* n. sp. (*V. bernardinae* n. sp.; *V. ceratiooides* St. & W. 1960; *V. helenae* n. sp.; *V. leonense* n. sp.; *V. rosendae* n. sp.)

*V. asturiae* n. sp.

*V. cazurrum* n. sp.

*V. cochinum* n. sp.

*V. estrellitae* n. sp.

*V. josefae* n. sp.

*V. scabratum* n. sp.

*V. thyrae* n. sp.

*V. tolontolum* n. sp.

*V. torrestionense* n. sp.

Subgroup *Prismatomorphitae* D., E. & S. 1963.

Genus *Polyedryxium* Dff. 1954.

?*P. asperum* n. sp.

*P. decorum* Dff. 1955.

*P. embudum* n. sp.

*P. evolutum* Dff. 1955.

*P. helenaster* n. sp.

*P. pharaonis* Dff. 1955.

*P. pseudopharaonis* St. & W. 1962.

*P. rabians* n. sp.

*P. tetrahedroide* n. sp.

Subgroup *Netromorphitae* D., E. & S. 1963.

1. Genus *Anthractus* Dff. 1954.

*A. insolitus* Dff. 1954.

2. Genus *Deunfia* Downie 1960.

*D. monacantha* (Dff. 1959).

*D. cf. monospinosa* Downie 1960.

3. Genus *Leiofusa* Eis. 1938.

*L. banderilla* Cmr. 1964.

*L. bernesga* Cmr. 1964.

*L. blanca* n. sp.

*L. cantabrica* Cmr. 1964.

*L. elenae* n. sp.

*L. estrecha* Cmr. 1964.

*L. fastidiona* n. sp.

*L. filifera* Downie 1959.

*L. striatifera* Cmr. 1964.

*L. cf. tumida* Downie 1959.

Subgroup *Herkomorphitae* D., E. & S. 1963.

Genus *Cymatiosphaera* O. Wetzel 1933, emend. Defl. 1954.

*C. nebulosa* (Dff. 1954).

*C. pavimentum* (Defl. 1944).

*C. cf. mirabilis* Dff. 1959.

*C. wenlockia* Downie 1959.

*C. flosdevonica* St. & W. 1960.

*C. carminae* n. sp.

*C. franjada* n. sp.

*C. peligrosa* n. sp.

Subgroup *Pteromorphitae* D., E. & S. 1963.

1. Genus *Pterospermopsis* W. Wetzel 1952.

*P. bernardinae* n. sp.

*P. carminae* n. sp.

*P. chiquitina* n. sp.

*P. guapita* n. sp.

*P. cf. helios* Sarjeant

*P. hermosita* n. sp.

*P. onondagaensis* Dff. 1955.

*P. rajada* n. sp.

2. Genus *Helios* n. g.

*H. aranaides* n. sp.

3. Genus *Sol* n. g.

*S. radians* n. sp.

*S. radiofurcatus* n. sp.

Subgroup *Diacromorphitae* D., E. & S. 1963.

Genus *Lophodiacrodium* Timofiev 1958, emend. G. & M. Defl. 1962.

*L. pepino* n. sp.

Microfossils referable to *Dinophyceae*.

Genus *Hystriosphæridium* Defl. 1937, restr. Eis. 1958.

?*H. huecospinosum* n. sp.

Subgroup *Uncertain*.

1. Genus *Cepillum* n. g.

*C. puercoespinoide* n. sp.

2. Genus *Leoniella* n. g.

*L. carminae* n. sp.

3. Genus *Polyplanifer* n. g.

*P. exoticum* n. sp.

4. Genus *Quadraditum* n. g.

*Q. fantasticum* n. sp.

*Q. incisum* n. sp.

5. Genus *Triangulina* n. g.

*T. alargada* n. sp.

*Tetraporina horologia* (?) (Staplin 1960): Playford 1962, pag. 659; Plate 95: 14.

*Acritarch cf. Verrucium vandenbergheni* (?) St. & W. 1960 and *V. nasicum* (?) St. & W. 1960.

*Acritarch* sp. I.

*Acritarch* sp. II.

*Acritarch* sp. III.

*Acritarch* sp. IV.

### Descriptions

1. Genus *Baltisphaeridium* Eis. 1958, emend. D. & S. 1963.

a. Forms with dark central bodies and pale colored, hollow processes.

*Baltisphaeridium carinosum* n. sp.

Plate I: 13\*; text-figure 14: 7, 8.

*Dimensions.*  $\varnothing_i$  = about 30  $\mu$ ;  $\varnothing_t$  = about 45  $\mu$ .

Central body and processes hollow, with not uniform walls. The central body is roughly spherical, its wall has an irregularly echinate to scabrate sculpture. The central body is usually less transparent than the processes. The processes have the form of short pilars, irregularly branched at the tips. The wall of the processes is psilate at 1200  $\times$  magnification. Number of processes about 10 in optical section.

*Frequency and provenance.* Frequent in the San Pedro Formation. Holotype from 1142, Torrestío, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian, NW-Spain.

*Baltisphaeridium dilatispinosum* Downie 1963.

Plate II: 8; text-figure 14: 6.

*Dimensions.*  $\varnothing_i$  = about 25  $\mu$ ;  $\varnothing_t$  = about 40  $\mu$ .

*Frequency and provenance.* Very rare to rare in the lower part of the San Pedro Formation near Torrestío.

*Known stratigraphical range.* Wenlock Shale, England — Downie 1963; Lower part of San Pedro Formation, Ludlovian (part), NW-Spain.

*Baltisphaeridium cf. echinodermum* St. & W. 1963.

Plate I: 16.

*Dimensions.* Rather variable,  $\varnothing_t$  = 20—60  $\mu$ .

The processes are slightly different from the forms described by Stockmans and Willièrè. The processes may have simple endings or they may have knobs. The wall of the body and the processes is psilate at 1200  $\times$  magnification.

*Frequency and provenance.* Very rare to common in the upper part of the San Pedro Formation; absent in the very top.

*Known stratigraphical range.* Tarranonian, Belgium — Stockmans and Willièrè (1963) (holotype); San Pedro Formation, Ludlovian (part), NW-Spain.

*Baltisphaeridium gordonense* n. sp.

Plate I: 9\*; text-figure 14: 4.

*Dimensions.*  $\varnothing_i$  = 10—15  $\mu$ ;  $\varnothing_t$  = 20—40  $\mu$ .

Central body and processes hollow, with not uniform walls. The central body is roughly spherical, moderately thin walled and transparent. The wall of the central body is rugulate, sometimes granulate. The wall of the processes is moderately thin and transparent; it is psilate at 1200 × magnification. The processes are conical, end in a sharp tip and do not bifurcate. Number of processes 1 to 6 (3).

*Frequency and provenance.* Rare to very rare in the La Vid Shales. Holotype from 0823, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shales, Middle Siegenian to Emsian (part), NW-Spain.

*Similar forms.* *B. gordonense* n. sp. differs from *B. traumaticum* n. sp. by its psilate not bifurcated processes; it differs from *B. robustispinosum* Downie, by the distinct form of the processes.

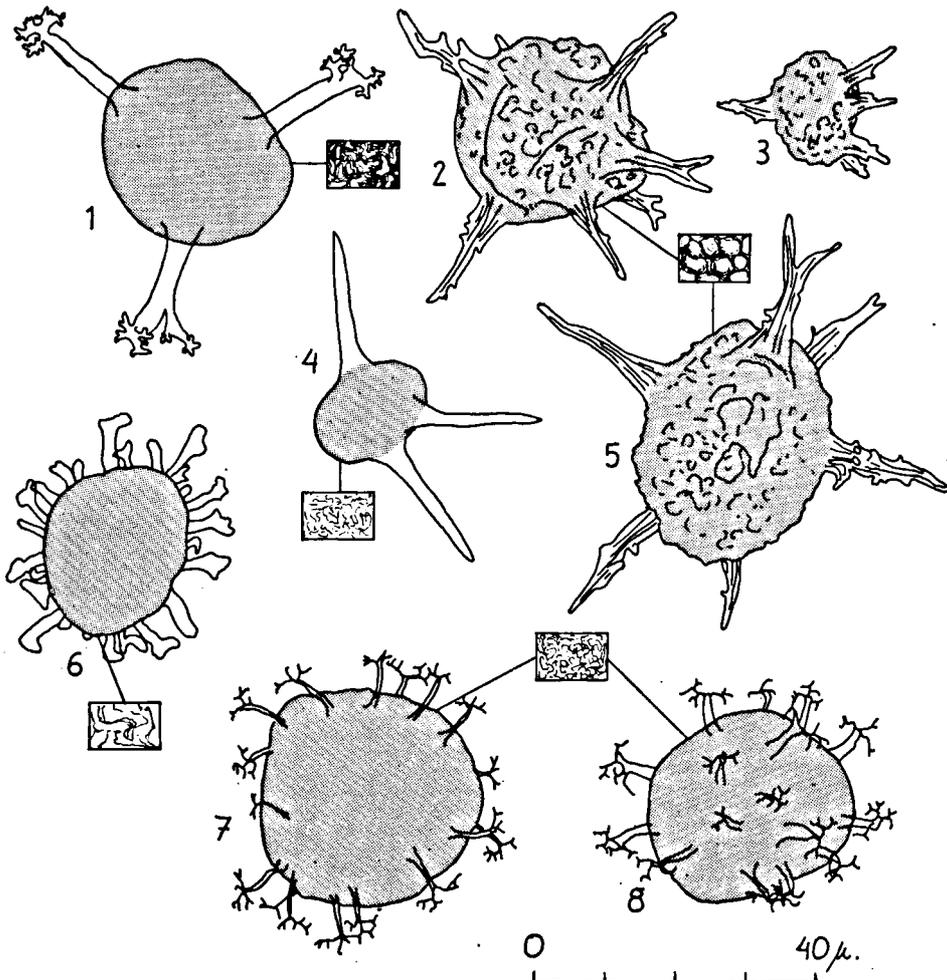


Fig. 14. 1. *B. pilar* n. sp.; 2 and 3. *B. traumaticum* n. sp.; 4. *B. gordonense* n. sp.; 5. *B. traumaticum* n. sp.; 6. *B. dilatispinosum* Downie; 7 and 8. *B. carinosum* n. sp.

*Baltisphaeridium pilar* n. sp.

Plate I: 1\*, 2; text-figure 14: 1.

*Dimensions.*  $\text{Ø}_i = 20\text{--}30 \mu$ ;  $\text{Ø}_t = 50\text{--}65 \mu$ .

Central body and processes hollow, with not uniform walls. The central body is roughly spherical. It has a moderately thin wall, that is moderately transparent to not transparent. The wall of the central body is scabrate to irregularly rugulate. The central body is usually less transparent than the processes. The processes have the form of slender pilars and branch at the tips. They are psilate at  $1200 \times$  magnification. Number of processes 3 to 10 (5 to 6).

*Frequency and provenance.* San Pedro Formation, frequent to very rare or absent. Holotype from 1165, Oblanca de Luna, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian, NW-Spain.

*Similar forms.* *B. ravum* Downie 1963 is very proximate to *B. pilar* n. sp., but its processes show a distinct type of branching. The number of processes of *B. pilar* is generally smaller. The central body of *B. ravum* has a different sculpture.

*Baltisphaeridium traumaticum* n. sp.

Plate I: 3\*; 5; text-figure 14: 2, 3, 5.

*Dimensions.*  $\text{Ø}_i = \text{about } 30 \mu$ ;  $\text{Ø}_t = \text{about } 65 \mu$ .

Central body hollow, moderately thin walled and moderately transparent. The central body is roughly spherical, its wall has a coarsely granular to rugulate sculpture. Processes hollow, conical, sometimes simply branched. The wall of the processes is thinner and hence more transparent than the wall of the central body. The processes show a faint longitudinal striation. Often the forms are quite small and do not have branched processes. The larger, branched forms occur especially at the base of the San Pedro Formation, section La Vid de Gordón. About 4—9 (6—7) processes present.

*Frequency and provenance.* Very rare in the San Pedro Formation (small forms). Holotype from 0806, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian, NW-Spain.

*Similar forms.* *B. traumaticum* n. sp. differs from *B. gordonense* n. sp. by its striate and branched processes; it differs from *B. robustispinosum* Downie 1959 by the distinct sculpture of the body and processes.

*b. Forms with dark central bodies enveloped by a transparent shell; the processes contain central nerves.*

*?Baltisphaeridium carminae* n. sp.

Plate IV: 7, 12\* and 13\*; text-figure 15: 2.

*Dimensions.*  $\emptyset_i$  = up to 50  $\mu$ , usually smaller; processes about 150 % or more of  $\emptyset_i$ .

The central body consists of an inner, subspherical, not transparent body, enveloped by an outer, transparent, shell that produces into the processes. The processes are hollow and contain a thin, not transparent nerve. Wall of the outer body and the processes smooth. There are low, perpendicular crests between the processes. The crests are transparent and have smooth boundaries. The structure of the surface of the inner central body could not be observed. 6 to 10 (6 to 8) processes, the processes are more or less regularly distributed.

*Frequency and provenance.* Very rare in the upper part of the La Vid Shale Member. Holotype from 0712, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of the La Vid Shale Member, Emsian (part), NW-Spain.

*Similar forms.* See *?B. duplex* n. sp.

*?Baltisphaeridium duplex* n. sp.

Plate V: 1\*, 2, 4, 5; text-figure 15: 1, 4.

*Dimensions.*  $\emptyset_i$  = up to 100  $\mu$ ; processes 100 % to 150 % of  $\emptyset_i$ .

The central body consists of an inner, not transparent to moderately transparent body, enveloped by a very thin and transparent outer shell that produces to form the outer wall of the numerous processes. Both inner and outer shell are psilate at 1200  $\times$  magnification. The outer wall of the processes and the central body have the same structure. The tips of the processes are connected with the central body by a few rather thin, moderately transparent to not transparent nerves. These nerves have a broad base and end in a sharp tip. The outer wall of the processes ends in a rounded tip. No crests between the processes. Number of processes: 6 to 10 (8); the processes are more or less irregularly distributed over the central body.

*Frequency and provenance.* Rare in the upper part of the La Vid Shales. Holotype from 0172, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of the La Vid Shales, Emsian (part), NW-Spain.

*Similar forms.* *B. crucistellatum* (Deunff 1955) has processes with a differently formed nerve. *B. carminae* n. sp. possesses crests between the outer wall of the processes.

*?Baltisphaeridium valentinum* n. sp.

Plate XV: 9\*; text-figure 15: 3, 5.

*Dimensions.*  $\emptyset$  inner shell = about 30  $\mu$ ;  $\emptyset$  outer shell = about 35  $\mu$ ;  $\emptyset_t$  = 55—70  $\mu$ .

Central body subspherical, made up by an inner and an outer shell. Inner shell hollow, moderately transparent to not transparent. Walls of inner shell smooth. Outer shell very transparent to transparent, thin walled. The wall of the outer body is simple; it is psilate at 1200  $\times$  magnification. The processes are very transparent

and are productions of the outer shell. They have a simple wall that is psilate at  $1200\times$  magnification. The processes possess a thin not transparent nerve that is connected with the inner shell. This nerve has a roughly central position within the processes. Three processes present. The central body and the processes are situated in one plane.

*Frequency and provenance.* La Vid Shale Member: very rare. Holotype from 0103, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

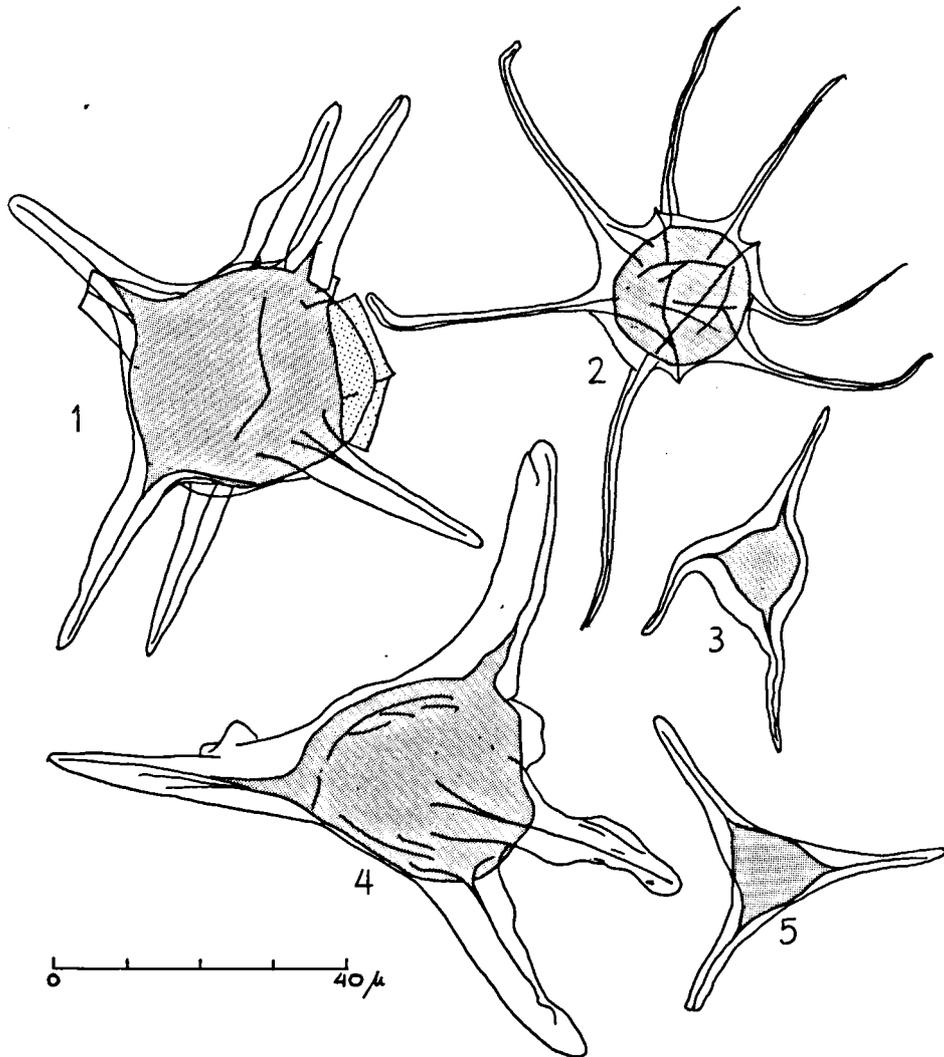


Fig. 15. 1. *?B. duplex* n. sp.; 2. *?B. carminae* n. sp.; *?B. valentinum* n. sp.; 4. *?B. duplex* n. sp.; 5. *?B. valentinum* n. sp.

*c. Other forms.*

*Baltisphaeridium arbusculiferum* Downie 1963.

Plate II: 17, 18; III: 1 and 2, 10, 11; text-figure 16: 1 to 6.

*Dimensions.*  $\varnothing_t$  = about 50  $\mu$ , rather variable.

The species is rather variable in complexity of the ramifications, number of processes and dimensions. These variations do not seem to have stratigraphic usefulness in the region studied.

*Frequency and provenance.* Fossiliferous part of the La Vid Carbonate Member: very rare; La Vid Shale Member: rare.

*Known stratigraphic range.* Wenlock Shales, Wenlockian, England — Downie (1963); La Vid Formation (part), Middle Siegenian to Emsian (part), NW-Spain.

*Baltisphaeridium cf. astartes* Sannemann 1955.

Plate IV: 8, 9.

*Dimensions*  $\varnothing_t$  = about 30  $\mu$  or less.

The forms here recorded are much smaller than the original species described by Sannemann (1955).

*Frequency and provenance.* Rare in the La Vid Shales, Upper Siegenian to Emsian (part), NW-Spain.

*Baltisphaeridium borracherosum* n. sp.

Plate I: 11\*; text-figure 16: 6.

*Dimensions.*  $\varnothing_i$  = about 30  $\mu$ ;  $\varnothing_t$  = about 40  $\mu$ .

Central body roughly spherical; central body and processes hollow with a uniform wall that is psilate at 1200  $\times$  magnification and that is moderately transparent. The numerous short processes are irregularly branched. About 10 to 20 processes in optical section.

*Frequency and provenance.* Rare in the San Pedro Formation. Holotype from 0001, section Santa Lucía de Gordón, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian, NW-Spain.

*Baltisphaeridium brazodesnudum* n. sp.

Plate II: 7\*; text-figure 16: 8.

*Dimensions.*  $\varnothing_i$  = 30—40  $\mu$ ;  $\varnothing_t$  = 80—100  $\mu$ .

Central body and processes hollow with uniform walls that are psilate at 1200  $\times$  magnification and that are 1—2  $\mu$  thick. The central body is roughly spherical. The processes are hollow, subcylindrical, simple or simply branched at the tips. The very tips are solid with a thin hollow nerve, the rest of the processes is hollow.

*Frequency and provenance.* Very rare throughout the San Pedro Formation. Holotype from 0084, section Corniero, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian, NW-Spain.

*Baltisphaeridium cantabricum* n. sp.

Plate IV: 15\*, 16.

*Dimensions.*  $\varnothing_t$  = about 150  $\mu$ , rarely more.

Central body hollow, subspherical, walls uniform, psilate at 1200  $\times$  magnification. The walls are thin and transparent. 6—10 (8) processes present. The processes are situated near the poles of the central body.

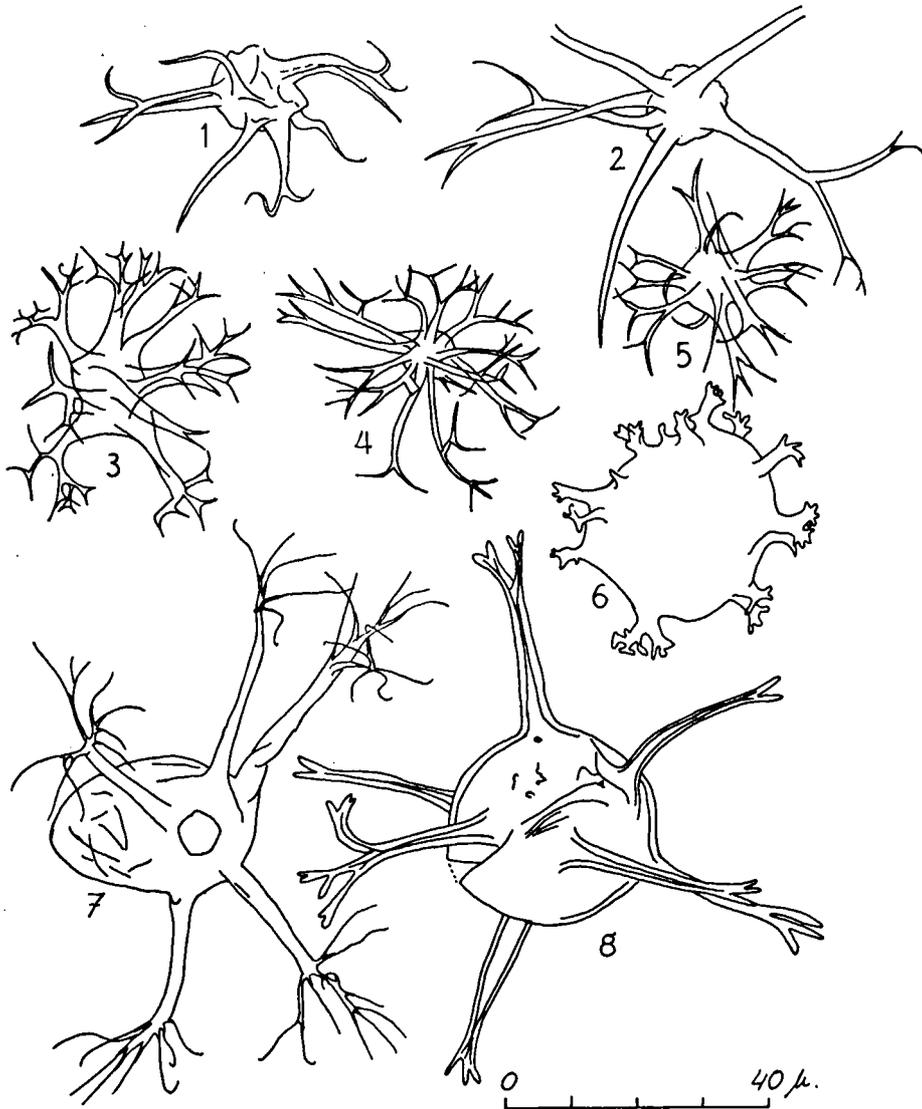


Fig. 16. 1 to 5. *B. arbusculiferum* Downie; 6. *B. borracherosum* n. sp.; 7. *B. dedosmuertos* n. sp.  
8. *B. brazosdesnudum* n. sp.

*Frequency and provenance.* Very rare to rare in the upper part of the San Pedro Formation; very rare in the lower part of the La Vid Shale Member. Holotype from 0820 La Vid de Gordón.

*Known stratigraphical range.* Ludlovian (part) to Siegenian, NW-Spain.

*Similar forms.* *B. polygonale* (Eis.) has shorter processes that are regularly distributed over the central body.

*Baltisphaeridium dedosmuertos* n. sp.

Plate II: 1\* and 2 (detail); text-figure 16: 7.

*Dimensions.*  $\text{Ø}_i = 25\text{--}40 \mu$  ( $30 \mu$ );  $\text{Ø}_t =$  about  $100 \mu$  or more.

Central body and processes, except for the secondary appendages, hollow with uniform walls. The central body is roughly spherical thin walled and moderately transparent. The walls are psilate at  $1200 \times$  magnification. The processes have the form of a slender pillar, irregularly branched at the tips. The secondary appendages are very thin and end in a sharp tip. Number of processes 5 to 10 (7); the processes are irregularly distributed over the central body.

*Frequency and provenance.* Rare in the San Pedro Formation. Holotype from 1140, Torrestío, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian, NW-Spain.

*Similar forms.* *B. eoplanktonicum* (Eis.) has processes, bifurcated up to the fourth order, while the branches of *B. dedosmuertos* n. sp. are predominantly of the second order and have a different habitus.

Formgroup *Baltisphaeridium denticulatum* St. & W. 1963.

*B. longispinosum* (Eis.): Downie 1953, (part), pl. 10: 1.

*B. granulatispinosum* Downie: Downie 1963, pl. 91: 1, 7.

There is a marked difference in form of specimens that occur at different levels in the investigated part of the geological column.

The forms that occur most commonly in the La Vid Shales, possess less branched, but longer processes than most of the older forms. Echinete forms with numerous very short processes have been recorded from the San Pedro Formation exclusively, while the stout forms with long processes range from the Formigoso Formation to the San Pedro Formation, and probably to the La Vid Carbonate Member as well. (Here only broken specimens of this group were met with). At several levels in the column intermediate forms occur.

*Baltisphaeridium denticulatum* St. & W. 1963.

*Dimensions.*  $\text{Ø}_i = 18\text{--}40 \mu$ ;  $\text{Ø}_t =$  up to more than  $125 \mu$ .

*Frequency and provenance.* See text-figure 17: (2).

*Known stratigraphical range.* Tarranonian, Belgium — Stockmans and Willière (1963). The holotype is a damaged specimen, lacking the tips of the processes. The La Vid forms, that are most similar to those described by Stockmans and Willière, possess

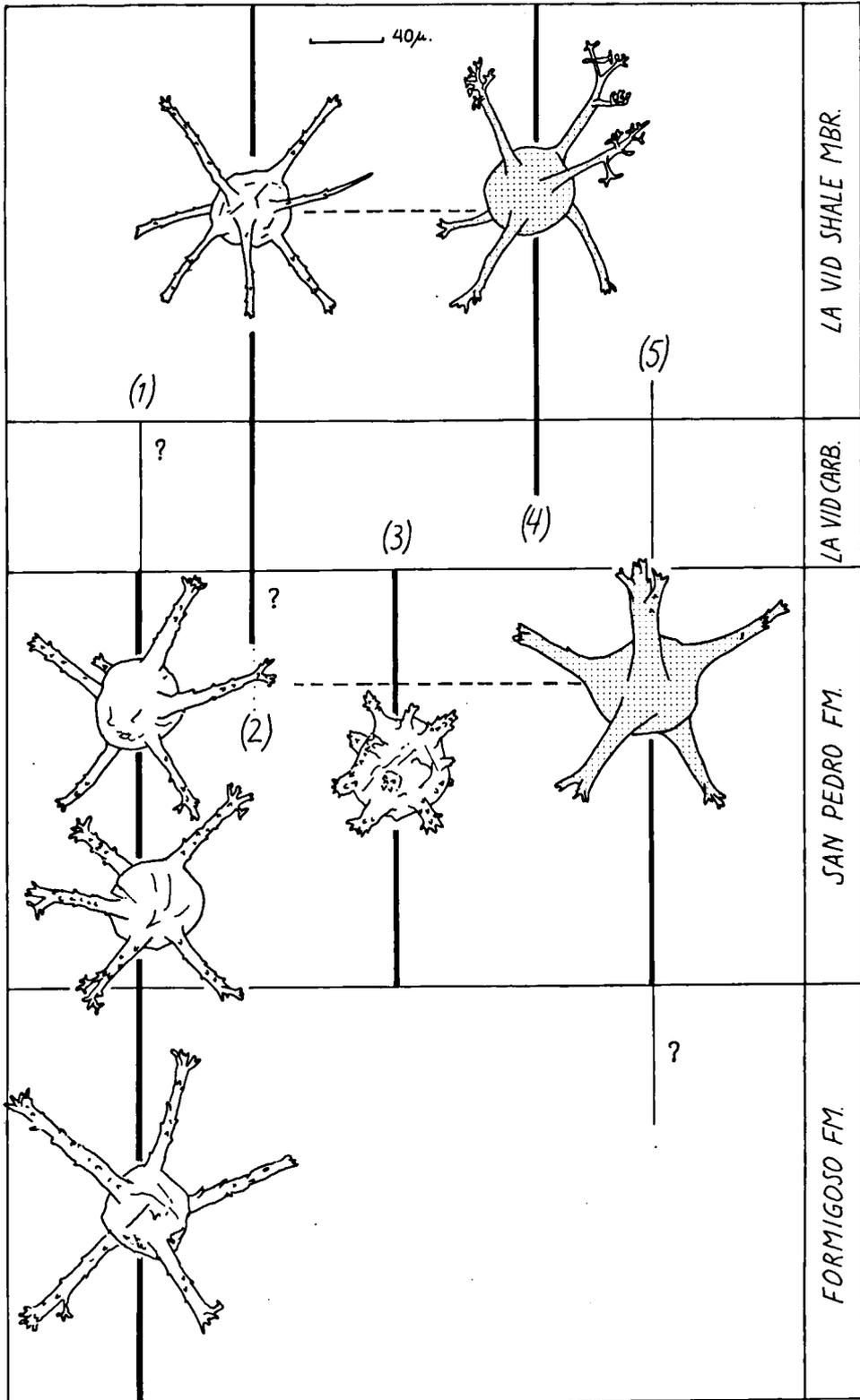


Fig. 17. Formgroup *B. denticulatum* St. & W.: the ranges of the different components. (1) *B. denticulatum*, forma I. (2) *B. denticulatum*, forma II. (3) *B. denticulatum* var. *sanpetri* n. var. forma III. (4) *B. molinum*, slender forms. (5). *B. molinum*, thick forms.

tips that have simple endings or are simply bifurcated. Upper part of San Pedro Formation (?), Ludlovian (part) to Lower Gedinnian (part); La Vid Shales, Middle Siegenian to Emsian (part), NW-Spain.

*Baltisphaeridium denticulatum* St. & W. 1963: Downie 1963.

*Dimensions.*  $\text{\O}_i = 18\text{--}45 \mu$  ( $40 \mu$ );  $\text{\O}_t = 100\text{--}150 \mu$ , rarely more.

*Frequency and provenance.* See text-figure 17: (1).

*Known stratigraphical range.* Wenlock Shales, England — Downie (1959), (1963); Formigoso Formation to La Vid Carbonate Member (?), Upper Llandoveryan to Lower Siegenian (?), NW-Spain.

*Baltisphaeridium denticulatum* St. & W. 1963 var. *sanpetri* n. var.

Plate III: 15, 16\*; text-figure 17: (3); 18.

*Dimensions.*  $\text{\O}_i = 15\text{--}50 \mu$  ( $40 \mu$ );  $\text{\O}_t = 40\text{--}70 \mu$  ( $60 \mu$ ).

*Frequency and provenance.* Rare to common in the San Pedro Formation.

*Known stratigraphical range.* San Pedro Formation, approximately Ludlovian, NW-Spain.

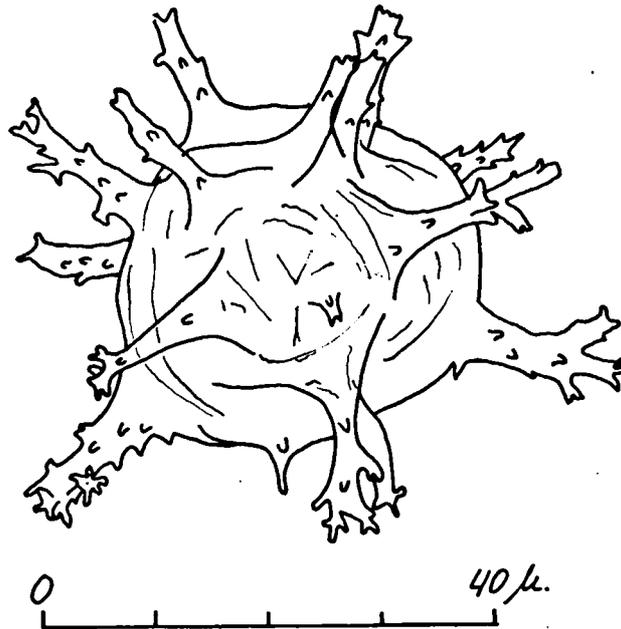


Fig. 18.

*Baltisphaeridium erraticum* Eis. 1954.

Plate I: 7; text-figure 19: 1, 1a.

*Dimensions.*  $\varnothing_i = 10\text{--}20\ \mu$ ;  $\varnothing_t = 15\text{--}40\ \mu$ .

*Frequency and provenance.* Very rare in the upper part of the La Vid Carbonate Member; Very rare to rare in the La Vid Shale Member.

*Known stratigraphical range.* Beyrichia-Kalk, Upper Ludlovian, Gotland — Eisenack (1954) (Forms larger than those recorded here); La Vid Formation, Siegenian to Emsian (part), NW-Spain.

*Baltisphaeridium escobaides* n. sp.

Plate II: 16\*; text-figure 19: 2.

*Dimensions.*  $\varnothing_i =$  about  $20\ \mu$ ;  $\varnothing_t = 25$  to  $30\ \mu$ .

Central body and basal part of the processes hollow, moderately thin walled and transparent. The walls are psilate at  $1200\times$  magnification. The processes have very broad bases, giving the central body a roughly polygonal form. The processes may be bifurcated several times at the top; the final parts of the processes are solid. A round to ellipsoidal opening is often present. Number of processes in optical section 5 to 10 (7).

*Frequency and provenance.* Rare in the La Vid Shales. Holotype from 0073, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale Member, Middle Siegenian to Emsian (part) NW-Spain.

*Baltisphaeridium guapum* n. sp.

Plate I: 12\*; text-figure 19: 3 and 3a.

*Dimensions.*  $\varnothing_i = 15\text{--}20\ \mu$ ;  $\varnothing_t = 20\text{--}25\ \mu$ .

Central body and processes hollow with uniform walls. The central body is roughly spherical, thin walled and moderately transparent. The wall is psilate at  $1200\times$  magnification. The processes are subconical and end in a sharp tip; at about half of the length they have 4 to 6 (4) sharp tipped secondary appendages. About 20 processes in optical section.

*Frequency and provenance.* Rare in the upper part of the La Vid Shales. Holotype from 0076, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* Basal part of the La Vid Shales, approximately Upper Siegenian to Lower Emsian, NW-Spain.

*Baltisphaeridium guillermi* n. sp.

Plate IV: 10\*; text-figure 19: 4.

*Dimensions.*  $\varnothing_t =$  about  $40\ \mu$ ; processes about  $5\ \mu$  long.

Central body subspherical, hollow. The walls are uniform; they are thin and transparent. The surface is psilate at  $1200\times$  magnification. 5—10 processes visible in optical section. These processes are hollow and have a roset-like structure at their tips. Parallel to the longitudinal axis of the processes a faint lincation is present.

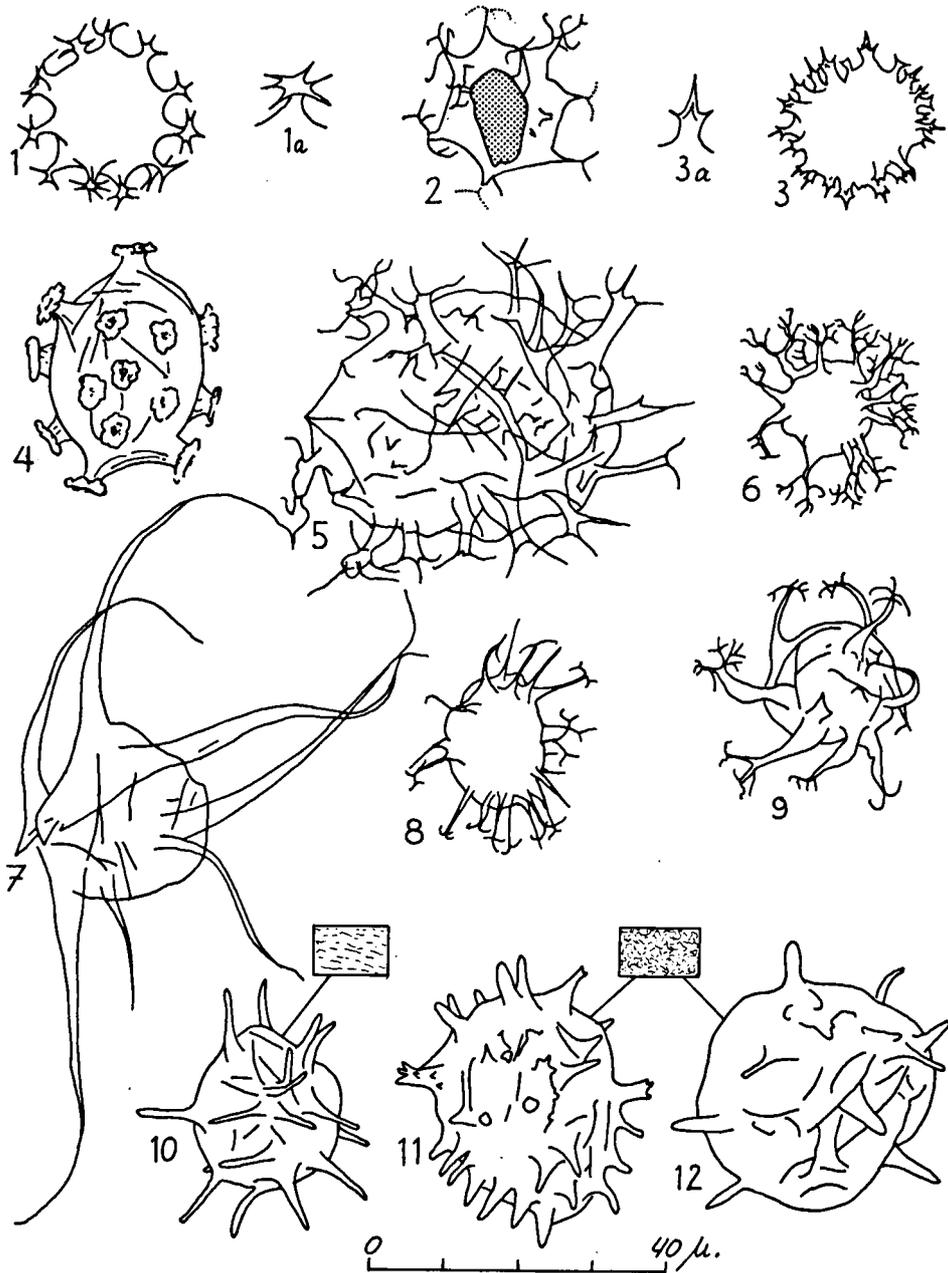


Fig. 19. 1 and 1a. *B. erraticum* Eis.; 2. *B. escobaides* n. sp.; 3 and 3a. *B. guapum* n. sp.; 4. *B. guillermi* n. sp.; 5. *B. juliae* n. sp.; *B. lobeznum* n. sp.; 7. *B. longispinosum* (Eis.); 8 and 9. *B. microfurcatum* (Dff.); 10 to 12. *B. malum* n. sp.

*Frequency and provenance.* Very rare in the La Vid Shale Member. Holotype from 0825, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

*Baltisphaeridium juliae* n. sp.

Plate I: 4\*; text-figure 19: 5; 20.

*Dimensions.*  $\text{Ø}_i = 30\text{--}40\ \mu$ ;  $\text{Ø}_t = 40\text{--}50\ \mu$ .

Central body and processes hollow with uniform walls, that are psilate at  $1200\times$  magnification and that are very thin and transparent. Central body roughly spherical. Processes hollow, ending in a rounded knob, that often bears several thin hair-like secondary appendages. The processes show a great variation in form (text-figure 20). Number of processes 10—25 (15) in optical section.

*Frequency and provenance.* Very rare in the lower part of the La Vid Shales. Holotype from 0825, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Lower part of the La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

*Similar forms.* *B. palaeoicum* St. & W. 1962 has longer and thinner appendages.

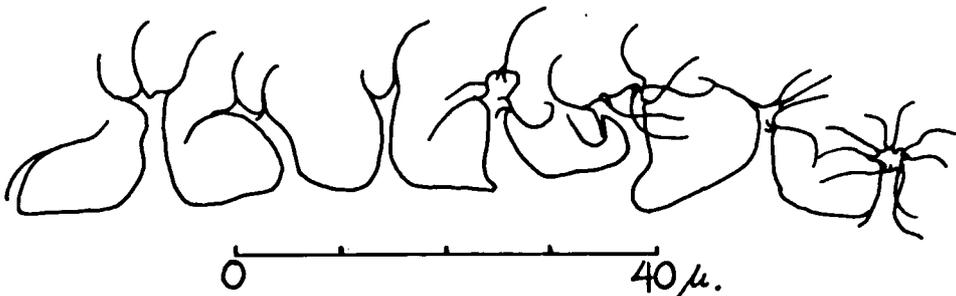


Fig. 20. Processes of *B. juliae* n. sp.

*Baltisphaeridium lobeznum* n. sp.

Plate II: 15\*; VII: 3; text-figure 19: 6.

*Dimensions.*  $\text{Ø}_i = 10\text{--}20\ \mu$  ( $15\ \mu$ );  $\text{Ø}_t = 30\text{--}45\ \mu$  ( $30\ \mu$ ).

Central body and basal parts of the processes hollow with uniform walls. The central body is roughly spherical, very thin walled and very transparent. The wall and the processes are psilate at  $1200\times$  magnification. The processes are numerous times irregularly bifurcated, giving the species a bushy appearance. Number of processes 5 to 20 (12) in optical section.

*Frequency and provenance.* Rare in the La Vid Shales. Holotype from 0075, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* Rare to very rare in the La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

*Baltisphaeridium longispinosum* (Eis. 1938).

Text-figure 19: 7.

*Dimensions.*  $\text{Ø}_i$  = about 25  $\mu$ ;  $\text{Ø}_t$  = up to 120  $\mu$ .

*Frequency and provenance.* Very rare in the San Pedro Formation.

*Baltisphaeridium microfurcatum* (Dff. 1957).

Plate II: 5 and 6, 11, 13; text-figure 19: 8 and 9.

*Dimensions.*  $\text{Ø}_t$  = 20—30  $\mu$ .

*Frequency and provenance.* Very rare in the La Vid Shale Member.

*Known stratigraphical range.* Prepared from a loose coral, *Favosites turbinata* Billings, that occurs in the Onondaga and Hamilton Formations (Index Fossils of North America, 1947: p. 107), Canada — Deunff 1957 (1955); Frasnian, Belgium — Stockmans & Willièrè (1962); La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

*Baltisphaeridium malum* n. sp.

Plate I: 6, 8\*, 10; text-figure 19: 10, 11, 12.

*Dimensions*  $\text{Ø}_i$  = about 30  $\mu$ ;  $\text{Ø}_t$  = about 45  $\mu$ .

Central body and processes hollow with uniform walls. The central body is roughly spherical, thin walled and transparent. Its wall is irregularly scabrate. The processes are conical, and have the form of a stout pillar, that ends in a rounded, simple tip. Rarely some reduced secondary appendages near the end of the processes are present. Number of processes rather variable, 10 to 26 (10) in optical section.

*Frequency and provenance.* Rare in the San Pedro Formation. Holotype from 1148, Torrestío, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian, NW-Spain.

*Similar forms.* *V. echinodermum* St. & W. has more and shorter appendages and is not scabrate.

Formgroup *Baltisphaeridium molinum* n. sp.

This formgroup comprises the following species: *B. molinum* n. sp.; *B. raczi* n. sp.; *V. rabiosum* n. sp.

*Baltisphaeridium molinum* n. sp.

Plate VI: 5\*, 7, VII: 9; text-figure 21 a.

*Dimensions.*  $\text{Ø}_t$  = up to 150  $\mu$ , rarely more.

Group of more or less related large forms characterized by a psilate not transparent to medium transparent thick wall (about 1  $\mu$  thick) and a hollow, subspherical to polygonal body that possesses thick subcylindrical to pilar-like hollow processes. The processes may show different endings at one specimen, varying from simple, simply bifurcated, to extensively bifurcated. If bifurcated, they never have bifurcations half-way the tip, as in *B. ramusculosum* (Defl.) The length of the processes may vary from 20—200 % of  $\text{Ø}_i$ . Number of processes 6—18 (8—10).

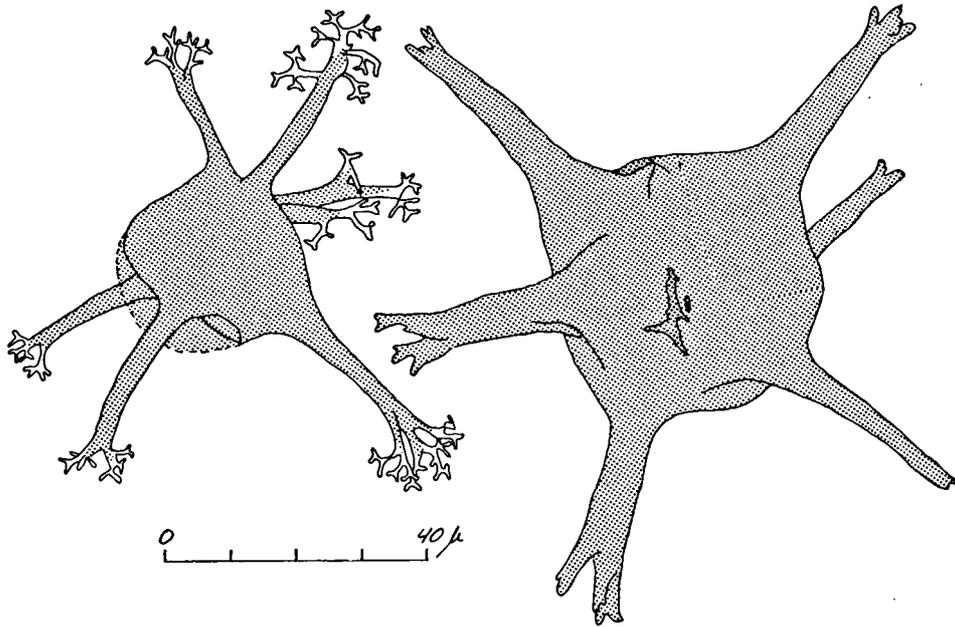


Fig. 21a.

*B. molinum* n. sp. can be placed in the group of transitional forms: *B. denticulatum* St. & W. — *B. molinum* n. sp. — *V. rabiosum* n. sp., and *V. rabiosum* n. sp. — *B. raczi* n. sp. — *B. molinum* n. sp.

Forms transitional to *V. rabiosum* n. sp. have thinner, more transparent walls, and show a rugulate sculpture, they have large final bifurcations and a polygonal central body. Forms transitional to *B. denticulatum* St. & W. are but little bifurcated. Forms transitional to *B. raczi* n. sp. are little bifurcated and have a reduced, polygonal central body, showing a faint rugulate sculpture.

*Frequency and provenance.* See text-figure 17. Holotype from 0711, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* San Pedro Formation (part), approximately Ludlovian; La Vid Shale Member, Middle Siegenian to Emsian, (part), NW-Spain.

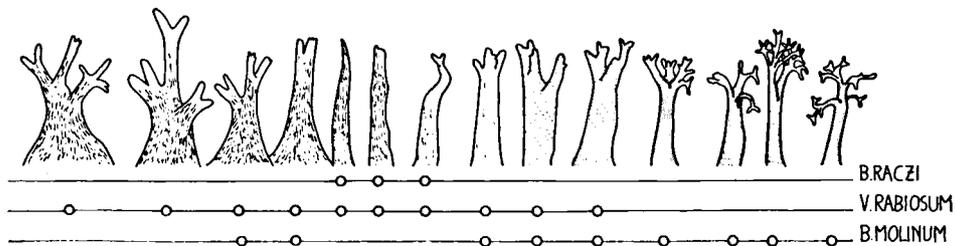


Fig. 21b.

*Baltisphaeridium raczi* n. sp.

Plate V: 8\*.

*Dimensions.*  $\text{Ø}_t$  = up to 150  $\mu$ , rarely more.

Central body polygonal, formed by fusion of the very broad bases of the processes. The processes have a slender conical outline; they end in a sharp tip. About 8 processes present in pure forms; less and thicker processes present in forms transitional to *V. rabiosum* n. sp.

The processes show a pronounced scabrate to rugulate structure in a pattern that is parallel to the direction of the processes.

*Frequency and provenance.* La Vid Shale Member: very rare. Holotype from 0715, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

*Similar forms.* *Baltisphaeridium polygonale* (Eis.) has smooth walls.

*Veryhachium rabiosum* n. sp.

Plate V: 7\*, VI: 3, 8, VII: 5, 8, 9.

*Dimensions.*  $\text{Ø}_t$  = up to 150  $\mu$ , rarely more.

The species is rather variable in outline. The central body is made up by fusion of the very broad bases of the processes. These processes may be simple, or bifurcate at the tips. They end in a rounded tip. In pure forms the central body is subsquare to octahedral, dorsoventrally compressed. Number of processes four to ten, usually four to six. The wall is simple, thick. In pure forms it shows a scabrate to rugulate structure in a pattern that is roughly parallel to the direction of the processes. The very tips of the processes are psilate. In forms that are intermediate to *B. molinum* n. sp. the wall is less transparent and thicker, it lacks the scabrate or rugulate structure; the wall is psilate in pure forms of *B. molinum* n. sp.

In forms, transitional to *B. raczi* n. sp., the processes are longer and thinner. They show a more pronounced rugulate to scabrate sculpture.

*Frequency and provenance.* La Vid Shale Member: rare to common. Holotype from 0715, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

Under the heading "Group *Veryhachium rabiosum*" in the frequency diagrams of the La Vid Formation the following species and their intermediate forms have been joined: *Veryhachium rabiosum* n. sp.; *Baltisphaeridium raczi* n. sp. and simply bifurcated forms of *Baltisphaeridium molinum* n. sp. The samples in which these forms of *B. molinum* occur, have been marked in the frequency curves (■).

The complexly bifurcated forms of *B. molinum* that are intermediate to *B. denticulatum* (slender forms) have been joined in the "Group *Baltisphaeridium denticulatum*".

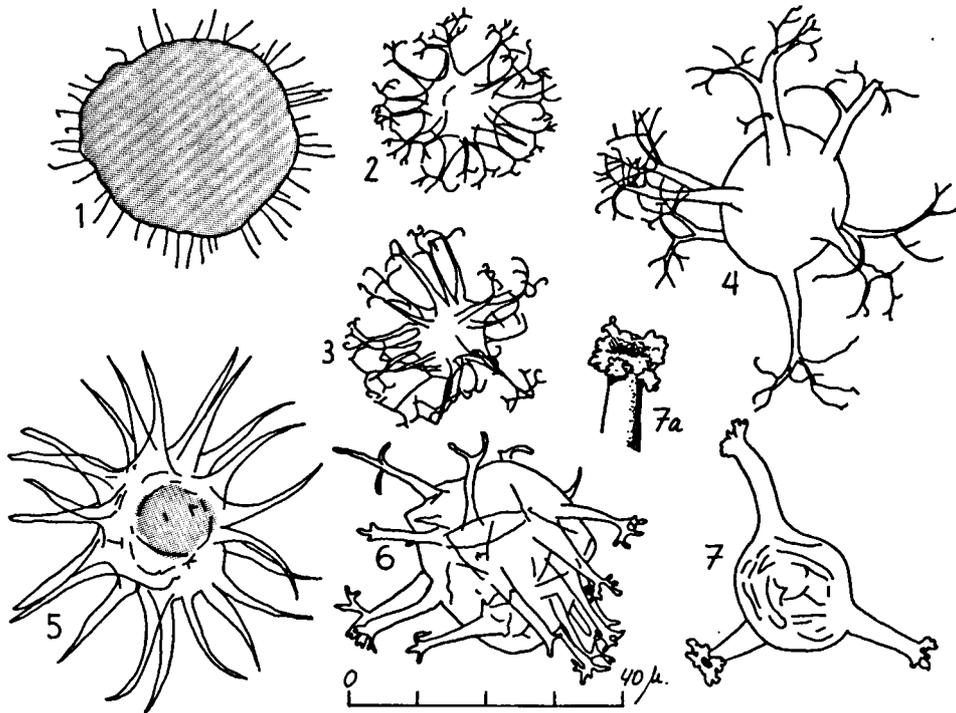


Fig. 22. 1. *B. oligofurcatum* (Eis.); 2 and 3. *B. paraguaferum* n. sp.; 4. *B. ramusculosum* (Defl.); 5. *B. polygonale* (Eis.); 6. *B. robertinum* n. sp.; 7 and 7a. *B. toyetae* n. sp.

*Baltisphaeridium oligofurcatum* (Eis. 1954).

Plate VII: 4; text-figure 22: 1.

*Dimensions.*  $\text{Ø}_i$  = about 35  $\mu$ ;  $\text{Ø}_t$  = about 45  $\mu$ .

*Frequency and provenance.* Very rare in the lower part of the San Pedro Formation.

*Known stratigraphical range.* Upper Visby-Marl, Upper Llandoveryan, Gotland — Eisenack (1954) (holotype); Buildwas Beds, Wenlockian, England — Downie (1963); Lower part of the San Pedro Formation, Ludlovian (part) and older, NW-Spain.

*Baltisphaeridium paraguaferum* n. sp.

Plate II: 3, 4\*; text-figure 22: 2 and 3.

*Dimensions.*  $\text{Ø}_t$  = about 20  $\mu$ .

Central body and basal parts of the processes hollow with uniform walls. The central body is roughly spherical, moderately thin and transparent. The wall is psilate at 1200  $\times$  magnification. The processes are slender pilars that are several times irregularly bifurcated at the tips. The extreme parts of the processes are solid. Number of processes in optical section 15 to 25.

*Frequency and provenance.* Rare in the upper part of the San Pedro Formation; rare in the La Vid Shales. Holotype from 0073, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of San Pedro Formation and La Vid Shale Member; upper part of Ludlovian to Emsian (part), NW-Spain.

*Baltisphaeridium polygonale* (Eis. 1931).

Text-figure 22: 5.

*Dimensions.*  $\text{Ø}_i$  = about 25  $\mu$ ;  $\text{Ø}_t$  = about 60  $\mu$ .

The specimens recorded from the investigated part of the column are very transparent and thin walled. Quite often they have a circular opening of about 10  $\mu$   $\text{Ø}$ .

*Frequency and provenance.* Upper part of the San Pedro Formation and lower part of the La Vid Shale Member: very rare.

*Baltisphaeridium ramusculosum* (Defl. 1942).

Plate III: 3 (cf), 4, 5 and 6, 8, 9; text-figure 22: 4.

*Dimensions.* Rather variable,  $\text{Ø}_t$  = up to 80  $\mu$ , small forms dominant.

*Frequency and provenance.* La Vid Shale Member: present in varying amounts.

*Baltisphaeridium raspa* n. sp.

Plate IV: 1\* to 6, 11.

*Dimensions.*  $\text{Ø}_i$  = 10—20  $\mu$ .

Central body and processes hollow, with uniform walls. The central body is roughly spherical, has a moderately thin wall and is moderately transparent. The wall is psilate at 1200  $\times$  magnification.

The processes are simply bifurcated at the tips with branches of the second to third order. Number of processes 10—35 in optical section. Processes 25 % or more of  $\text{Ø}_i$ . The number and length of the processes are rather variable.

*Frequency and provenance.* The species is rare in the La Vid Shales. Holotype from 0075, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shales, Middle Siegenian to Emsian (part), NW-Spain.

Occasionally forms with much longer and less processes occur together with *B. raspa* n. sp.; these differences do not seem to have stratigraphic usefulness.

*Baltisphaeridium robertinum* n. sp.

Plate II: 9\* and 10\*; text-figure 22: 6.

*Dimensions.*  $\text{Ø}_i$  = about 25  $\mu$ ;  $\text{Ø}_t$  = about 50  $\mu$ .

Central body and processes hollow with uniform walls. The central body is roughly spherical, moderately thin walled and moderately transparent. The walls are psilate at 1200  $\times$  magnification. The processes have the form of a slender pillar, irregularly branched at the top. About 10 processes in optical section.

*Frequency and provenance.* Very rare in the upper part of the La Vid Shales; very rare in the La Vid Shale Member. Holotype from 0079, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* San Pedro Formation to La Vid Shale Member, upper part of Ludlovian to Emsian (part), NW-Spain.

*Similar forms.* *B. pilar* has less and longer processes and its central body is not psilate.

*Baltisphaeridium toyetae* n. sp.

Plate I: 14, 15\*; text-figure 22: 7 and 7a.

*Dimensions.*  $\text{Ø}_i = 30\text{--}60\ \mu$ ;  $\text{Ø}_t =$  up to  $200\ \mu$ , usually much smaller.

Central body and processes hollow with uniform walls. The central body is roughly spherical, very thin walled. It has usually wrinkled walls. The walls are psilate at  $1200\times$  magnification. The processes in the form of broad-based pilars show roset-like structures at the tips. Number of processes 2 to 6 (3). The specimens are very transparent.

*Frequency and provenance.* Rare in the La Vid Shale Member. Holotype from 0710, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

*Similar forms.* *B. pilar* n. sp. has processes with different terminal structures and is not psilate.

*Baltisphaeridium trifurcatum* (Eis. 1931) var. *procerum* Sann. 1955.

Plate IV: 14; XV: 4.

*Dimensions.*  $\text{Ø}_t = 70$  to  $100\ \mu$  ( $70\ \mu$ ).

*Frequency and provenance.* Very rare in the La Vid Shale Member, especially near La Vid de Gordón.

## 2. Genus *Micrhystridium* Defl. 1937. emend. D. & S. 1963.

*Micrhystridium malpeinadum* n. sp.

Plate VII: 1\*; text-figure 23.

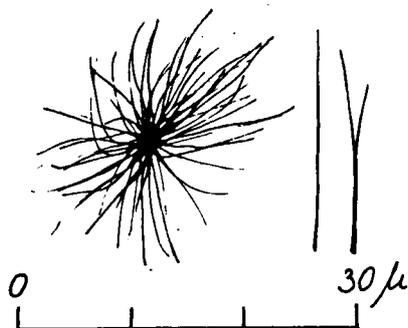


Fig. 23.

*Dimensions.*  $\text{Ø}_t$  = about 20  $\mu$  or smaller.

Central body very small. The numerous filiform processes end in a sharp tip, occasionally they bifurcate. About 40 processes visible in optical section.

*Frequency and provenance.* La Vid Shale Member: rare to very rare. Holotype from 0099, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shales, Middle Siegenian to Emsian (part), NW-Spain.

*Michystridium picorricum* n. sp.

Plate XI: 1, 2\*, 3 (cf); text-figure 24.

*Dimensions.*  $\text{Ø}_i$  = about 15  $\mu$ ;  $\text{Ø}_t$  = 25—40  $\mu$  (30  $\mu$ ).

Central body hollow, subspherical. Numerous processes present. These processes show a great variation in form; 15—20 processes in optical section. The variations in form of the processes seem to have no stratigraphic use in the region investigated.

*Frequency and provenance.* Rare in the La Vid Shale Member. Holotype from 0823, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

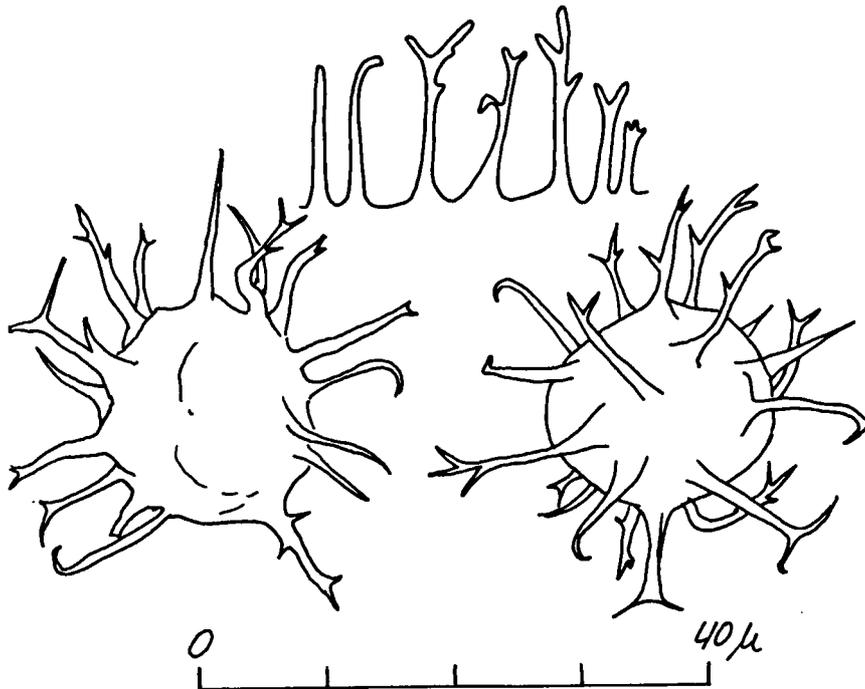


Fig. 24.

Formgroups *V. trispinosum* (Eis); *V. europaeum* St. & W.; *M. stellatum* (Defl.).

Throughout the investigated part of the geological column an interesting series of transitional forms occurs. Various authors have described several members of this series, hereby constructing a division into species which is sometimes very refined. However, there is frequent overlapping within these divisions. Since this series comes to almost 90 % in several horizons it has been attempted to use these transitional species as an aid for comparing the different sections. In order to do so it was necessary to start with an inventory of the species present, which range in frequency from very rare to extremely abundant. This is difficult since most of the forms do not fit precisely into the framework of descriptions of previously distinguished species, but find their place somewhere half-way between several neighboring species. One possibility of little practical value is to create an enormous number of new species. Another possibility is to amplify the existing specific definitions so that the species cover a part of the range of forms. These two procedures are of no use in León as is shown by the results of the test analysis of some sections. In this investigation the following solution has been chosen. The series was divided into three formgroups, namely *V. trispinosum* (Eis.), *V. europaeum* St. & W., and *M. stellatum* (Defl.). These formgroups proved to be sufficiently differentiated from one another to permit correlations among the different sections. Within the formgroups test analyses have been made to check the usefulness of the different variables for correlation of parts of the sections or to indicate facies changes. The following variables have been studied.

- (1) length and form of the processes.
- (2) dimensions of the central body and of the whole shell.
- (3) form of the central body in relation to the length of the processes: spherical central body with short processes; central body spherical, processes long; central body polygonal, and so on.

It has been found that although some small regular changes occur within the sections, these tendencies are too difficult to perceive to warrant safe conclusions. The few conclusions which could be drawn are mentioned under the headings of the formgroups concerned.

Formgroup *Michystridium stellatum* (Defl.)

Plate IX: 8 to 13 and plate X; text-figure 25.

The formgroup comprises the remaining part of the series of transitional forms that are not covered by the definitions of the formgroups *V. trispinosum* and *V. europaeum*.

The central body is subspherical to polygonal. It possesses five or more major processes. The processes are of variable length and form. They are simple and not bifurcated. The wall of the shell is psilate at 1200 × magnification. In this form-

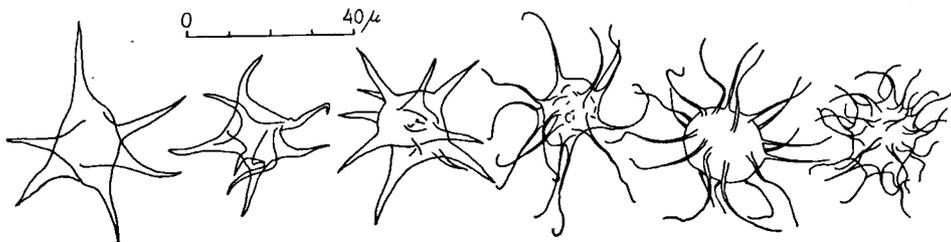


Fig. 25.

group the dominant form is in all samples *Micrhystridium stellatum* Deflandre: Wall and Downie (1963), Plate 113, figs. 1, 2, 4, 5. The forms similar to *V. rhomboidium* Downie 1959: Wall and Downie (1963) Plate 113, fig. 12, occur with greater frequency in the upper part of the La Vid Shale Member than in older sediments. Forms of the complex *M. spiniglobosum* — *M. shinetonense* are very rare to rare in the whole part of the column. Forms similar to *M. filigerum* Valensi 1953, have been met with in greater number in the lower and middle parts of the San Pedro Formation but occur in the younger sediments as well, although in very subordinate numbers.

The variables, such as the length of the processes, the dimensions of the central body and of the total shell, and the form of the processes, have been treated statistically for the two major divisions of the series of transitional forms in some test sections. The variations do not seem to have any stratigraphical usefulness in the region investigated.

Subgroup *Polygonomorphitae* D, E. & S. 1963.

Genus *Veryhachium* Dff. (1954) 1958. emend. D. & S. 1963.

Formgroup *Veryhachium trispinosum* (Eis.).

Plate VIII; text-figure 26.

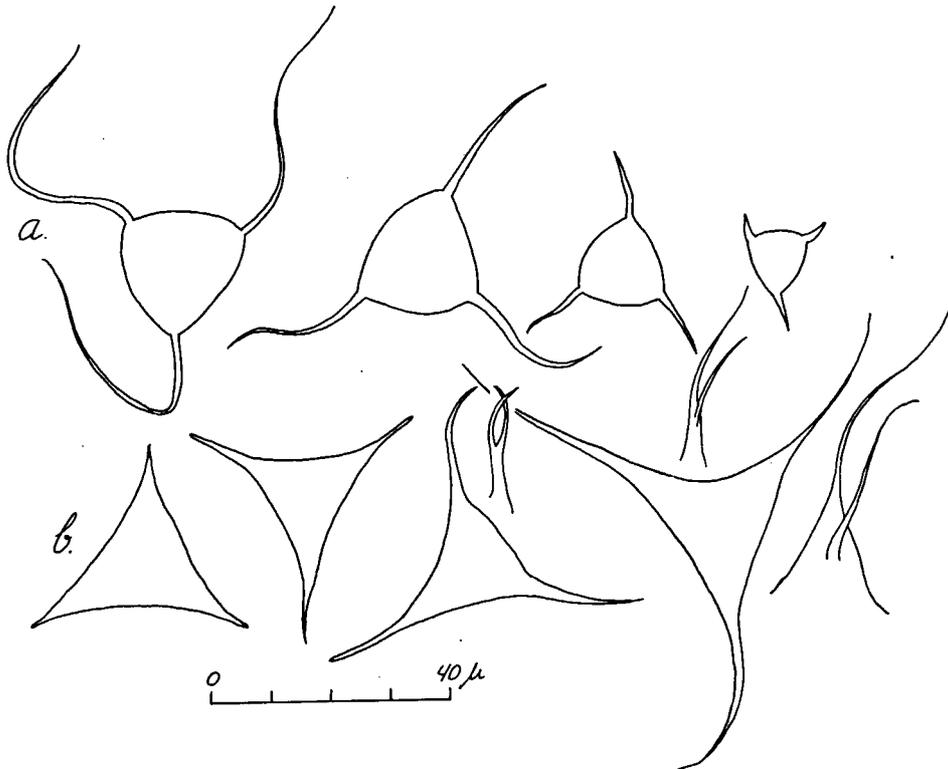


Fig. 26

This formgroup comprises the following series of transitional forms:

*a. Forms with a concave, triangular, often inflated central body.*

Processes of varying length, never branching. Number of processes, three. No secondary observed processes. Clear differentiation in body and processes. Wall psilate at 1800 × magnification. Smallest and most inflated forms have reduced processes.

*b. Forms with a convex, triangular, rarely inflated central body.*

Processes of varying length, rarely branching at tips. Number of major processes, three. Secondary processes may be present. If so, most usually situated near center of central body, may occur near end of processes as well. No clear differentiation in body and processes. At 1800 × magnification a micro-verrucate to micro-rugulate sculpture may be seen at the wall (at lower power it appears to be psilate).

The formgroup of *V. trispinosum* (Eis.) covers the following species and their transitional forms:

- V. reductum* (Deunff 1959),
- V. downiei* Stockmans and Willièrè 1962,
- V. trisulcum* Deunff 1959,
- V. trispinosum* (Eisenack 1931),
- V. geometricum* (Deflandre 1942).

The changes in frequency shown by the formgroup have been recorded in the sediments of the San Pedro Formation and in sediments of comparable age over a distance of more than 80 kms, over the line (Asturias) — Torrestío — La Vid — Corniero. There is a marked tendency for the inflated reduced forms to occur in the San Pedro Formation in greater relative quantity than in the younger formations. The contrary holds true for the large convexly triangular forms which occasionally have secondary appendages. They occur more commonly within the formgroup in associations of the higher part of the column.

Formgroup *Veryhachium europaeum* St. & W.

Plate IX: 4, 6, 7, 8.

This formgroup is composed of many types of shapes. The central body is convexly tetrahedral in outline and provided with four major processes at the corners. It may be thought to be formed by the fusion of the basal parts of these processes. The length of the processes is most generally more than 75 % of the length of an edge of the central body. The surface is psilate at 1200 × magnification. The form of the processes is rather variable and, consequently, the central body is also variable. Secondary appendages may be present at any position of the shell but usually near the central part of the central body. The processes are never branching. Such variables as the length of the processes, the dimensions of the central body and of the total shell, and the form of the processes have been treated statistically for a few test sections. These variations seem to have no stratigraphical usefulness.

The formgroup of *V. europaeum* St. & W. covers the following species and their transitional forms:

- V. europaeum* St. & W. 1960,
- V. europaeum* St. & W.: Wall and Downie (1963),
- V. legrandi* St. & W. 1962,
- V. flagelliferum* Wall and Downie 1963: fig. 4a, b, c.

It does not include forms similar to *P. tetrahedroide* n. sp.

The changes in the relative composition of this formgroup do not seem to have any stratigraphical usefulness in the region investigated.

*a. Forms with processes not situated in one plane; surface smooth; processes simple.*

*Veryhachium inflatissimum* n. sp.

Plate IX: 5\*; text-figure 27: 2, 3, 6.

*Dimensions.*  $\text{Ø}_t$  = up to 80  $\mu$  (60  $\mu$ ).

Shell consisting of four inflated hollow processes that are joined at their base. The processes differ in length and form. They are always simple and end in a round tip. The wall is psilate at 1200  $\times$  magnification. It is thin and transparent, usually wrinkled.

*Frequency and provenance.* Rare to common in the La Vid Shale Member. Holotype from 0712, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale, Middle Siegenian to Emsian (part), NW-Spain.

Forms with psilate walls, transitional to *V. rabiosum* n. sp. have been met with occasionally.

*Veryhachium trispiniflatum* n. sp.

Plate IX: 2, 3\*; text-figure 27: 4.

*Dimensions.*  $\text{Ø}_t$  = about 40  $\mu$  or more.

Central body and processes hollow, more or less inflated, uniformly walled. Form of shell like a centrally constricted inflated triangle. Wall psilate at 1200  $\times$  magnification, very thin and transparent, usually wrinkled. The processes end in a sharp tip.

*Frequency and provenance.* Rare in the La Vid Shales. Holotype from 0077, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shales, Middle Siegenian to Emsian (part), NW-Spain.

*Similar forms.* *V. inflatissimum* n. sp. has four processes with rounded tips; *V. trispinosum* (Eis.) and related forms are not inflated and have a body that is not centrally constricted. *V. reductum* (Dff.) var. *concauum* C. and E. 1962 is smaller and has thin, prolonged tips.

*b. Forms with the processes situated in one plane; processes simple.*

*Veryhachium carminae* n. sp.

Plate XIV: 16, XVI: 1\*, 2, 3; text-figure 28: 1.

*Dimensions.*  $\text{Ø}_i$  = up to 40  $\mu$  (25  $\mu$ ).

Central body and processes hollow with uniform walls. Central body roughly rectangular in outline, more or less inflated. Walls psilate at 1200  $\times$  magnification, always showing a peculiar linear sculpture. The four — occasionally five — processes may attain a length of some 100 % of the diameter of the central body.

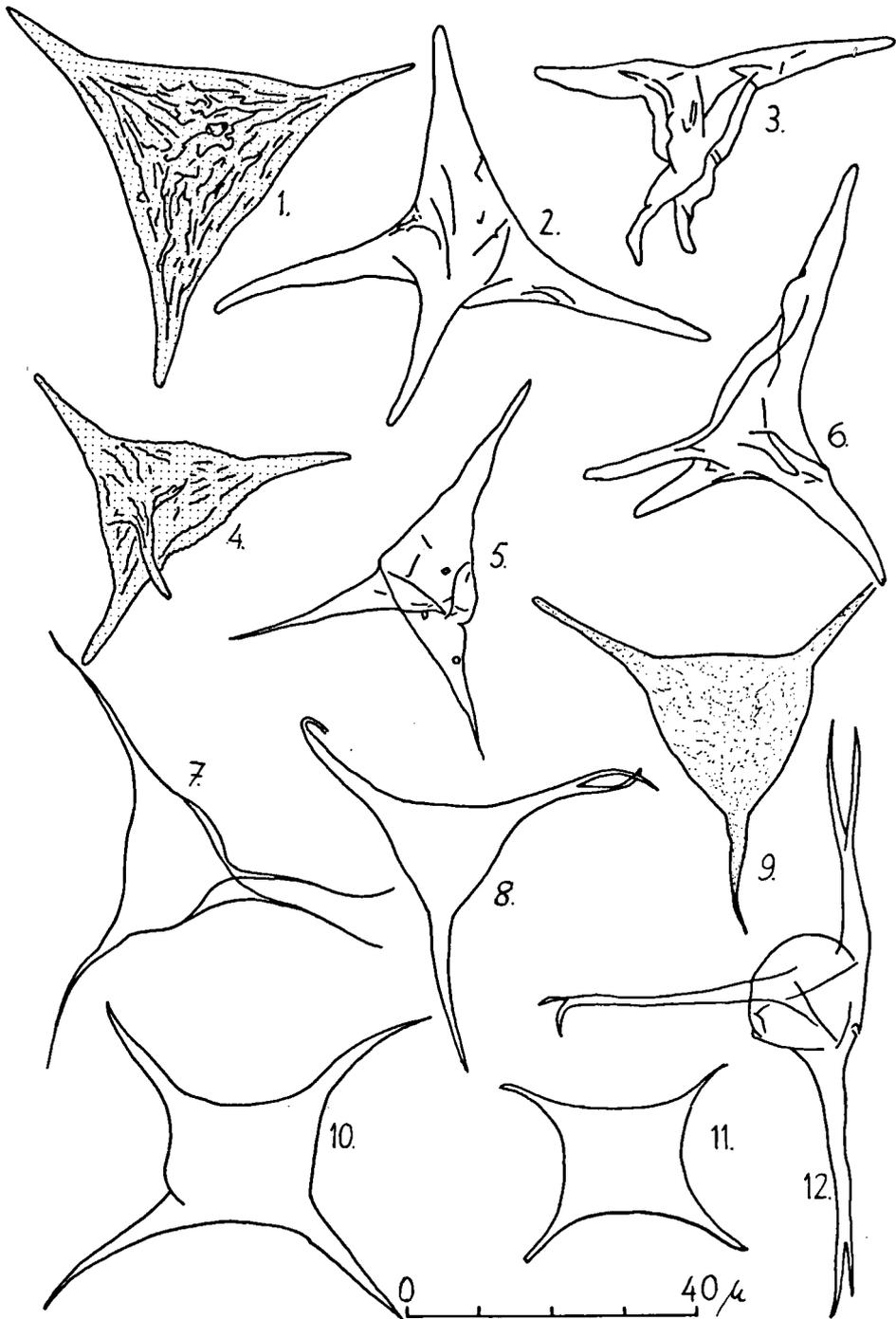


Fig. 27. 1. *V. scabratum* n. sp.; 2 and 3. *V. inflatissimum* n. sp.; 4. *V. scabratum* n. sp.; 5. *V. trispiniflatum* n. sp.; 6. *V. inflatissimum* n. sp.; 7. *V. europaeum* St. & W.; 8. *V. cf. trispinosum* (Eis.); 9. *V. cf. downiei* St. & W., specimen with a microscabrate surface, La Vid Shale Member; 10 and 11. *V. lairdi* Dff. 12. *B. sp.*, from the upper part of the La Vid Shale Member.

*Frequency and provenance.* Frequent to dominant in the San Pedro Formation. Holotype from 0813, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian and Lower Gedinnian (part), NW-Spain.

*Similar forms.* *V. valiente* n. sp. and *V. lairdi* Dff., that possess a similar outline, lack the typical sculpture of *V. carminae* n. sp.

*Veryhachium lairdi* (Defl. 1946) Dff. 1958.

Plate XI: 16; XII: 1, 2; text-figure 27: 10, 11.

*Dimensions.*  $\text{Ø}_t$  = up to 80  $\mu$  (60  $\mu$ ).

Body hollow, subsquare, with moderately thin walls, moderately transparent. The general outline of the central body is a concave square. The wall is psilate at 1200  $\times$  magnification, lacks any kind of ornamentation, and is uniform. Four hollow sharp-tipped processes are situated at the corners, occasionally fifth processus is present, this processus is situated at the center of the body.

*Frequency and provenance.* Rare to very rare in the San Pedro Formation and the La Vid Formation; damaged specimens found in the upper part of the Formigoso Formation near El Tueiro (Villasimpliz).

*Known stratigraphical range.* Chert of Ontario, Upper Niagarian, Canada — Laird 1935; Base of Caradocian, Bretagne, France — Deunff 1958; Tarranonian, Belgium — Stockmans and Willièrè 1963; Ludlovian, eventually Tremadocian (?) to Emsian (part), NW-Spain.

*Similar forms.* *V. valiente* n. sp. has a straight-sided, square central body; *V. carminae* n. sp. has a typical sculpture.

*Veryhachium serpentinum* n. sp.

Plate XII: 5\*; text-figure 28: 3.

*Dimensions.*  $\text{Ø}_t$  = up to 70  $\mu$  (60  $\mu$  or less).

Central body and processes flat, situated in one plane. Walls uniform: scabrate, rugulate or verrucate. The differences in sculpture of the walls do not seem to have stratigraphic usefulness in the region investigated. The central body has a square to rectangular outline with straight sides. The processes are flat and are at base and tip about equal in width.

*Frequency and provenance.* Very rare in La Vid Shales. Holotype from 0823, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

*Veryhachium stelligerum* Dff. 1957.

Plate XI: 12, 13, 14, 15; text-figure 28: 4, 5, 6.

*Dimensions.*  $\text{Ø}_t$  = up to 70  $\mu$  (65  $\mu$ ).

Central body and processes hollow with uniform walls that are moderately thick and transparent. Psilate at  $1200\times$  magnification. Five, occasionally a smaller sixth, processes are present. The processes end in a sharp tip and are simple. The processes are situated in one plane.

*Frequency and provenance.* Very rare in the San Pedro Formation; rare to very rare in the La Vid Formation.

*Known stratigraphical range.* Middle Devonian, Canada — Deunff 1957 (holotype from a loose coral); *V. stelligerum* Dff. var. *robustum* Dff. 1958, base of Caradocian, Bretagne, NW-France — Deunff 1958; Frasnian, Belgium — Stockmans and Willière 1962; San Pedro Formation and La Vid Formation, Ludlovian to Emsian (part), NW-Spain.

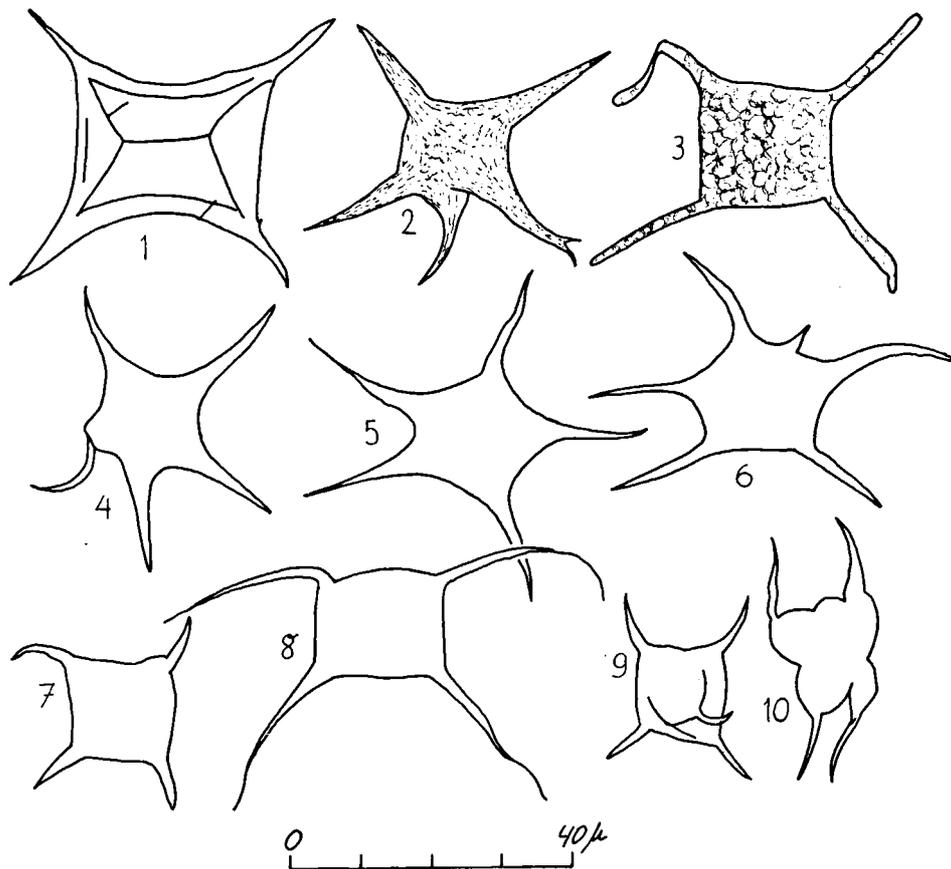


Fig. 28. 1. *V. carminae* n. sp.; 2. *V. stellatum* var. *asperum* n. var.; 3. *V. serpentinatum* n. sp.; 4 to 6. *V. stelligerum* Dff.; 7 and 9. *V. valiente* n. sp.; 8. *V. cf. valiente* n. sp.; 10. *V. ledanoisi* Dff., upper part of the La Vid Shale Member.

*Veryhachium stelligerum* Dff. 1958 var. *asperum* n. var.

Text-figure 28: 2\*.

*Dimensions.*  $\text{O}_t$  = up to 70  $\mu$  (55  $\mu$ ).

Processes simple, occasionally simply bifurcated at the tips. Surface rugulate in a regular pattern, parallel to the direction of the processes.

*Frequency and provenance.* Very rare in the upper part of the San Pedro Formation near La Vid de Gordón. Holotype from 1809, La Vid de Gordón NW-Spain.

*Known stratigraphical range.* Upper part of San Pedro Formation, Ludlovian (part), NW-Spain.

*Veryhachium valiente* n. sp.

Plate XII: 3\*, 4, 6; text-figure 28: 7, 8, 9.

*Dimensions.*  $\text{O}_t$  = up to 40  $\mu$  (30  $\mu$ ).

Central body and processes hollow, with uniform walls. Central body rectangular to square with straight sides. Four appendages at each corner, situated in the same plane. Occasionally a fifth appendage, situated near the center of the central body, is present. The processes end in a sharp tip. The wall is psilate at 1200  $\times$  magnification, moderately thick and moderately transparent.

*Frequency and provenance.* Rare in the very upper part of the San Pedro Formation; common to rare in the La Vid Shales. Holotype from 0081, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of San Pedro Formation and La Vid Formation, Upper Ludlovian to Emsian (part), NW-Spain.

*Similar forms.* Differs from *V. lairdi* Dff. by the straight sides of the central body.

c. *Forms with the processes not situated in one plane; surface not smooth.*

Formgroup *V. rosendae*.

In the La Vid Shale Member a series of transitional forms occurs, in outline similar to the complex *V. trispinosum* — *V. europaeum*, etc.

The walls of these forms are covered with very thin hairs of about 2  $\mu$  long, distributed in a more or less irregular pattern all over the shell.

This complex has been divided into several species:

*V. rosendae* n. sp., congruent to *V. trispinosum* (Eis.) three processes.

*V. helenae* n. sp., congruent to *V. trisulcum* Dff.

*V. leonense* n. sp., congruent to *V. europaeum* St. & W., four processes.

*V. bernardinae* n. sp., five or more processes; inflated.

*V. ceratioides* St. & W. has four processes, too, but these processes are shorter than those of *V. leonense* n. sp.

The species mentioned here have been joined in the frequency diagrams under the heading "Group *V. rosendae*".

The variations in composition of this group do not seem to have stratigraphic usefulness in the region studied; the most common species in the La Vid Shale Member of the León region is *V. rosendae* n. sp., followed by *V. bernardinae* n. sp.

*Veryhachium bernardinae* n. sp.

Plate XIII: 2 (damaged specimen), XIV: 18\*; text-figure 29.

*Dimensions.*  $\text{Ø}_t$  = up to 45  $\mu$  (30  $\mu$ ).

Central body and basal part of the processes hollow with uniform walls. Central body inflated provided with 5 or more processes that may attain 100 % or more of the diameter of the central body.

Walls haired, hairs up to 2  $\mu$  or more of length. Hairs thin and simple, not bifurcated. Wall thin moderately transparent.

*Frequency and provenance.* Rare to frequent in the La Vid Shales. Holotype from 0074, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shales, Middle Siegenian to Emsian (part), NW-Spain.

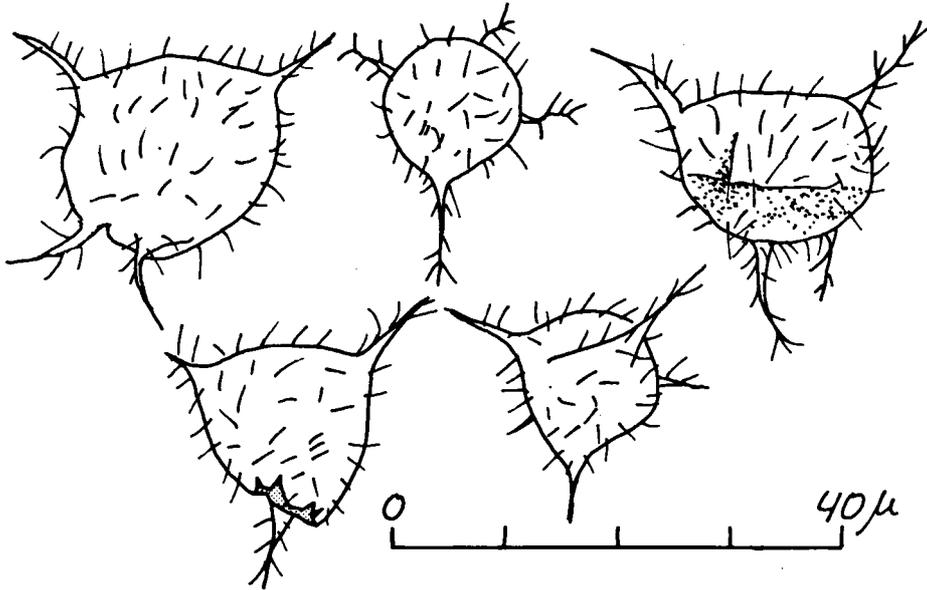


Fig. 29.

*Veryhachium ceratioides* Stockmans & Willièrè 1960.

*Dimensions.*  $\text{Ø}_t$  = up to 40  $\mu$  (30  $\mu$ ).

Central body inflated tetrahedral; central body and processes hollow, uniformly walled. Wall covered with numerous hairs (to 2  $\mu$  of length) in a regular pattern. The processes may attain up to 25 % of the length of a side of the body. Walls thin moderately transparent.

*Frequency and provenance.* Very rare in the upper part of the La Vid Shales.

*Known stratigraphical range.* Frasnian, Belgium — Stockmans & Willièrè (1960), (1962); upper part of the La Vid Shales, Emsian (part), NW-Spain.

*Veryhachium helenae* n. sp.

Plate XIII: 10, 11\*, 12, 13; text-figure 30: 14, 16.

*Dimensions.*  $\emptyset_t$  = up to 30  $\mu$ .

General outline of *V. helenae* n. sp. same as for reduced forms of *V. trispinosum* (Eis.). *V. trispinosum* is psilate, whereas *V. helenae* has a uniform cover of thin hairs in an irregular pattern. Wall thin and transparent.

*Frequency and provenance.* Very rare to rare in the La Vid Shales. Holotype from 0077, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* As for *V. rosendae* n. sp.

*Veryhachium leonense* n. sp.

Plate XIII: 3\*, 4, 5; text-figure 30: 17, 18.

*Dimensions.*  $\emptyset_t$  = up to 60  $\mu$ , usually much smaller.

General outline of *V. leonense* n. sp.: same as for *V. europaeum* St. & W. Wall thin and transparent, covered with numerous thin hairs.

*Frequency and provenance.* Rare to common in the La Vid Shale Member. Holotype from 0710, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shales, Middle Siegenian to Emsian (part), NW-Spain.

*Veryhachium rosendae* n. sp.

Plate XIII: 6, 7, 8\*, 9, 16, 17, 18; text-figure 30: 10, 11, 12, 15 (cf.), 19 (cf.).

*Dimensions.*  $\emptyset_t$  = up to 30  $\mu$ .

General outline of the species same as for *V. reductum* (Dff.). *V. reductum* is psilate, whereas *V. rosendae* n. sp. is uniformly covered with thin hairs. The very tips of the reduced processes may branch. Wall thin and transparent.

*Frequency and provenance.* Rare to common in the La Vid Shales. Holotype from 0074, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Formation, Middle Siegenian to Emsian (part), NW-Spain.

*Veryhachium asturiae* n. sp.

Plate XIII: 14\* and 15\*; text-figure 30: 2.

*Dimensions.*  $\emptyset_t$  = up to 50  $\mu$  (30—40  $\mu$ ).

Central body and processes hollow with uniform walls. Walls thin and transparent, psilate at 1200  $\times$  magnification. The body has the form of a tetrahedron. Short processes situated at the corners of the central body. The processes are several times irregularly branched.

*Frequency and provenance.* Very rare to rare in the upper part of the San Pedro Formation, especially near Oblanca de Luna and Torrestío. Holotype from 1143, Torrestío, NW-Spain.

*Known stratigraphical range.* San Pedro Formation (part), Ludlovian (part), NW-Spain.

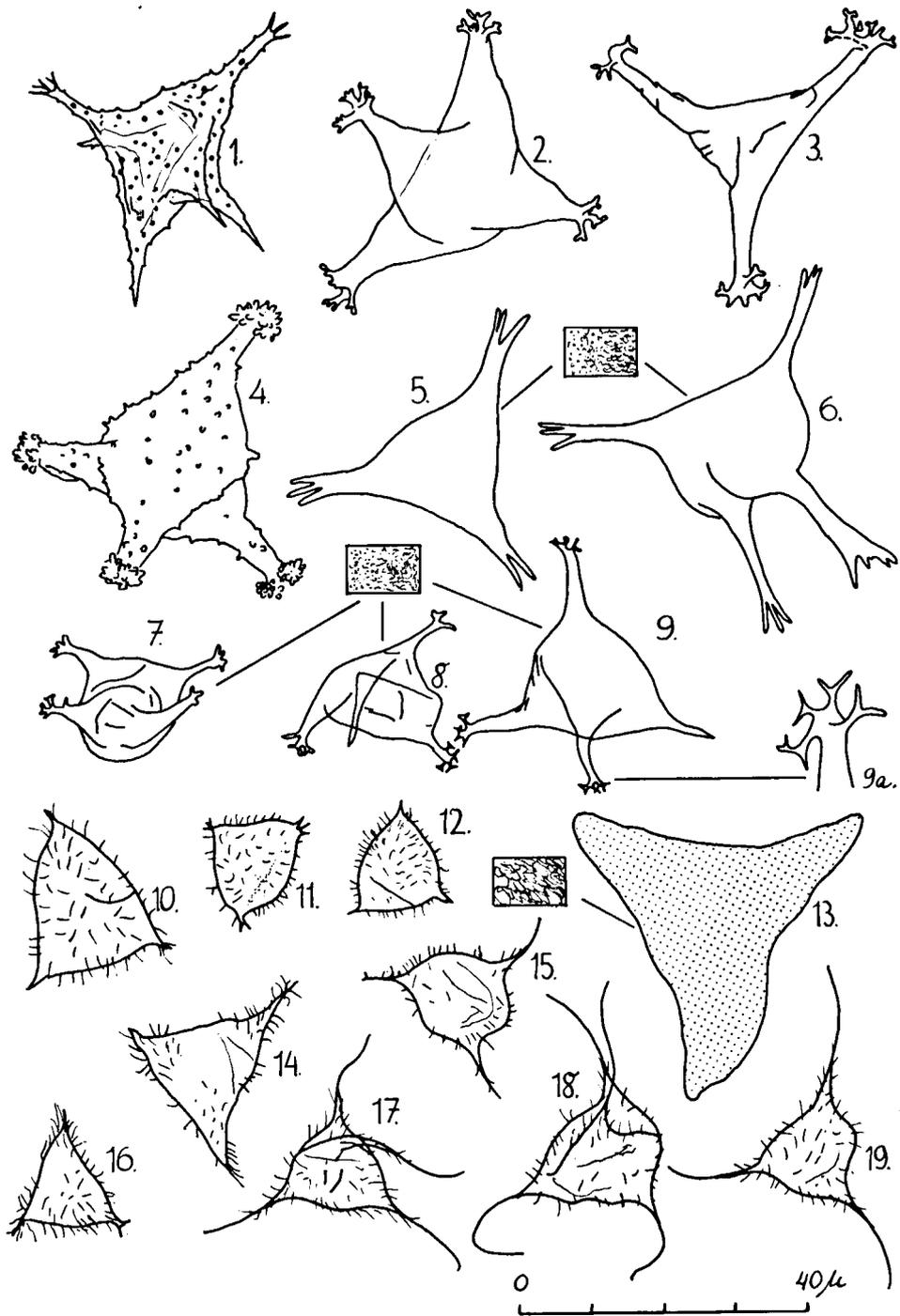


Fig. 30. 1. *V. tolontolum* n. sp.; 2. *V. asturiae* n. sp.; 3. *V. torrestionense* n. sp.; 4. *V. cazurrum* n. sp.; 5 and 6. *V. thyræ* n. sp. 7 to 9. *V. josefæ* n. sp.; 10 to 12. *V. rosendæ* n. sp.; 13. *V. cochinum* n. sp.; 14. *V. helenæ* n. sp.; 15. *V. cf. rosendæ* n. sp.; 16. *V. helenæ* n. sp.; 17 and 18 *V. leonense* n. sp.; 19. *V. cf. rosendæ* n. sp.

*Veryhachium cochinum* n. sp.

Plate XII: 11\*; text-figure 30: 13.

*Dimensions.*  $\varnothing_t$  = up to 50  $\mu$  (40  $\mu$ ).

Test subtriangular, hollow, inflated with more or less concave sides. Wall rather thick (about 1  $\mu$ ), simple, moderately transparent. Surface rugulate to scabrate in an irregular pattern.

*Frequency and provenance.* Very rare in the upper part of the San Pedro Formation. Holotype from 1160, Oblanca de Luna, NW-Spain.

*Known stratigraphical range.* Upper part of the San Pedro Formation, Ludlovian (part) to Lower Gedinnian (part), NW-Spain.

?*Veryhachium cazurrum* n. sp.

Plate XIII: 1\*; text figure 30: 4.

*Dimensions.*  $\varnothing_t$  = up to 60  $\mu$  (50  $\mu$ ).

Central body and processes hollow with uniform walls that are thin and transparent. The walls are echinate (1  $\mu$ ) and simple. The body has the form of a tetrahedron with processes situated at the corners. The processes have roset-like branched structures at the tips.

*Frequency and provenance.* Very rare in the upper part of the La Vid Shale Member near La Vid de Gordón and Santa Lucía de Gordón. Holotype from 0021, Santa Lucía de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of the La Vid Shale Member, approximately Emsian, NW-Spain.

*Veryhachium estrellitae* n. sp.

Plate XI: 8\*; text-figure 31.

*Dimensions.*  $\varnothing_t$  = up to 50  $\mu$  (40  $\mu$ ).

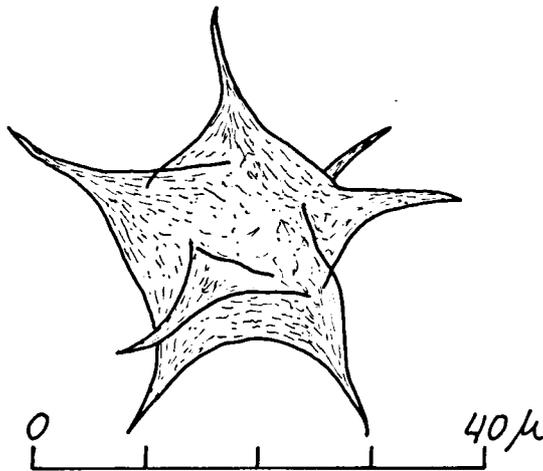


Fig. 31.

*Frequency and provenance.* Very rare in the San Pedro Formation, section La Vid de Gordón. Holotype from 0807, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Restricted to the middle part of the San Pedro Formation, Ludlovian (part), near La Vid de Gordón, NW-Spain.

*Similar forms.* This species differs from forms with the same outline by its scabrate surface.

*Veryhachium josefae* n. sp.

Plate XII: 9\*, 12; XIII: 19; text-figure 30: 7, 8, 9.

*Dimensions.*  $\text{Ø}_t = 20\text{--}30 \mu$  (20  $\mu$ ).

Central body and processes hollow with uniform walls that are psilate to scabrate, thin and moderately transparent. The body has the form of a tetrahedron with relatively thin processes (25—100 % of the length of a side of the body), situated at the corners. The processes may be irregularly branched at the tips, but are often simple and then end in a sharp tip.

*Frequency and provenance.* Very rare in the San Pedro Formation. Holotype from 1166, Oblanca de Luna, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian to Lower Gedinnian (part), NW-Spain.

*Veryhachium scabratum* n. sp.

Plate XI: 9\*, 10, 11; text-figure 27: 1, 4.

*Dimensions.*  $\text{Ø}_t$  up to 80  $\mu$  (55  $\mu$ ).

Central body and processes hollow with not uniform walls. Central body inflated triangular to tetrahedral with short, stout processes situated at the corners. The wall has a rough, scabrate to rugulate structure that is approximately parallel to the sides of the body. Towards the tips of the processes the sculpture grades into a psilate surface. The walls are thick to moderately thick (about 1  $\mu$  or more), rather transparent. The processes have a length of 10—100 % of the side of the body.

*Frequency and provenance.* Very rare to rare in the San Pedro Formation; less rare near Torrestío. Holotype from 1140, Torrestío, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian to Lower Gedinnian (part), NW-Spain.

*Veryhachium thyrae* n. sp.

Plate XII: 10\* 13; text-figure 30: 5, 6.

*Dimensions.*  $\text{Ø}_t =$  up to 60  $\mu$  (40  $\mu$ ).

Central body and processes hollow with uniform walls. Central body of a roughly tetrahedral form, occasionally inflated triangular. The processes are situated at the corners and may attain a length up to 200 % (100 % or less) of a side of the central body. Processes simply bifurcated at the tips. Walls simple, thin (< 1  $\mu$ ), uniformly scabrate to rugulate in a regular pattern parallel to the direction of the processes.

*Frequency and provenance.* Very rare in the San Pedro Formation, common in the lower part, especially near Oblanca de Luna. Holotype from 1160, Oblanca de Luna, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian, NW-Spain.

*Similar forms.* *V. trispinoramosum* St. & W. 1962 is not rugulate, its processes bifurcate distinctly.

*Veryhachium tolontolum* n. sp.

Plate XIII: 20; text-figure 30: 1.

*Dimensions.*  $\text{Ø}_t =$  up to 60  $\mu$  (50  $\mu$ ).

Central body and processes hollow with uniform walls. Central body roughly polygonal. Walls moderately thin and transparent, echinate in an irregular pattern. Processes simple to simply bifurcated, ending in a sharp tip.

*Frequency and provenance.* Very rare to rare in the upper part of the San Pedro Formation; absent in the lower part of the La Vid Carbonate Member; very rare in the very upper part of the La Vid Carbonate Member. Holotype from 1150, Torrestío, NW-Spain.

*Known stratigraphical range.* Upper part of San Pedro Formation to upper part of La Vid Carbonate Member, Upper Ludlovian to lower part of Middle Siegenian, NW-Spain.

*Veryhachium torrestionense* n. sp.

Plate XV: 1\*; text-figure 30: 3.

*Dimensions.*  $\text{Ø}_t =$  up to 50  $\mu$  (40  $\mu$ ).

Central body and processes hollow with uniform walls. Walls thin and transparent with a microrugulate sculpture in a regular pattern. Central body triangular, faintly inflated; processes terminating in a several times irregularly branching tip.

*Frequency and provenance.* Very rare in section Torrestío, San Pedro Formation. Holotype from 1142, Torrestío, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian (part), NW-Spain.

Subgroup *Prismatomorphitae* D., E. & S. 1963.

Genus *Polyedryxium* Dff. 1954.

?*Polyedryxium asperum* n. sp.

Plate XVII: 11\*, XVIII: 3, 6; text-figure 32: 10, 11.

*Dimensions.*  $\text{Ø}_t =$  15—40  $\mu$  (40  $\mu$ ).

Central body hollow, cubical. Each edge of the central body continues in a flat plane. The general outline of the total shell is cubic. The boundaries of the planes are roughly crenate. All walls are thin and transparent.

*Frequency and provenance.* Rare in the upper part of the La Vid Shales, especially near Geras de Gordón. Holotype from 0710, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of the La Vid Shale Member, Emsian (part), NW-Spain.

*Polyedryxium decorum* Dff. 1955.

Plate XVIII: 5.

*Dimensions.*  $\text{\O}_t =$  about  $45 \mu$ .

*Frequency and provenance.* La Vid Shale Member, very rare.

*Known stratigraphical range.* Prepared from a loose coral, *Favosites turbinata* Billings, that occurs in the Onondaga and Hamilton Formations (Index Fossils of North America, 1947: p. 107), Canada — Deunff (1955, 1957); La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

*Polyedryxium embudum* n. sp.

Text-figure 32: 5\*.

*Dimensions.*  $\text{\O}_t =$  up to about  $40 \mu$  ( $25 \mu$ ).

Central body cubic, hollow with crests at the edges. The crests may attain up to 200 % of the length of an edge of the central body. The boundaries of the planes are smooth; the walls are simple and psilate at  $1200 \times$  magnification. No appendages. The walls are thin and transparent.

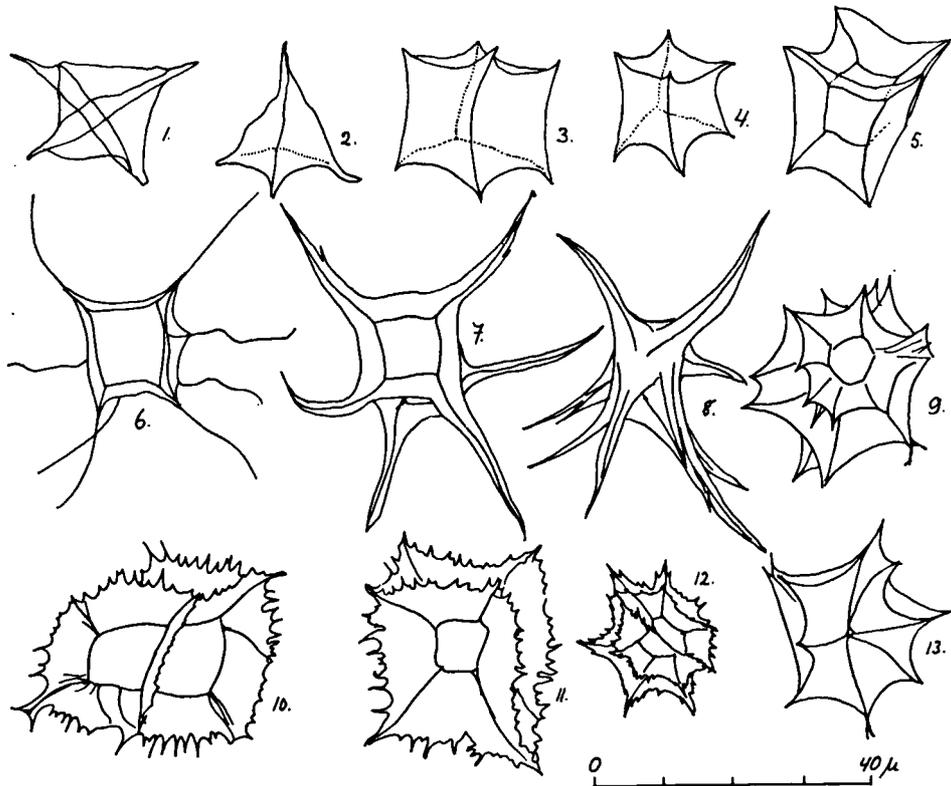


Fig. 32. 1 and 2. *P. tetrahedroide* n. sp.; 3 and 4. *P. rabians* n. sp.; 5\*. *P. embudum* n. sp.; 6 and 7. *P. pharaonis* Dff.; 8. *P. pseudopharaonis* St. & W.; 9\*. *P. helenaster* n. sp.; 10 and 11. (?)*P. asperum* n. sp.; 12. *P. evolutum* Dff.; 13. *P. helenaster* n. sp.

*Frequency and provenance.* Rare in the La Vid Shales. Holotype from 0072, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shales, Middle Siegenian to Emsian (part), NW-Spain.

*Similar forms.* *P. cuboides* Dff., has irregularly crenate boundaries. *P. rabians* n. sp. lacks the crests; *P. pharaonis* Dff. has long processes at the corners of the central body.

*Polyedryxium evolutum* Dff. 1955.

Text-figure 32: 12.

*Dimensions.*  $\text{Ø}_t$  = up to 25  $\mu$ .

The forms recovered from the La Vid Shales differ from those described by Deunff (1955) by their smaller dimensions.

*Frequency and provenance.* Very rare in the upper part of the La Vid Shale Member, especially near Corniero and La Vid de Gordón.

*Known stratigraphical range.* Same as for *P. decorum* Dff. 1955.

*Polyedryxium helenaster* n. sp.

Plate XVIII: 10\*, 11; text-figure 32: 9\*, 13.

*Dimensions.*  $\text{Ø}_t$  = 20 to 30  $\mu$ .

Central body polygonal, small or absent. The numerous planes are of a single layer; psilate at 1200  $\times$  magnification. The planes have smooth boundaries and are thin and transparent.

*Frequency and provenance.* Very rare to rare in the La Vid Shales. Holotype from 0710, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shales, Middle Siegenian to Emsian (part), NW-Spain.

*Similar forms.* *P. helenaster* n. sp. differs from similar forms by the smooth, not crenate, boundaries of the planes.

*Polyedryxium pharaonis* Dff. 1955.

Plate XV: 12; text-figure 32: 6, 7.

*Dimensions.*  $\text{Ø}_t$  = 40 to 80  $\mu$  (60  $\mu$ ). The specimens recovered from the La Vid Shales are smaller than those described by Deunff (1955). The processes are rather variable in form; the observed variations do not seem to have stratigraphic usefulness in the region investigated.

*Frequency and provenance.* Very rare in the upper part of the La Vid Shales.

*Known stratigraphical range.* As for *P. decorum* Dff. 1955.

*Polyedryxium pseudopharaonis* Stockmans & Willièrè 1962.

*P. cf. pharaonis* Dff. 1955: Deunff (1955a): fig. 17.

Plate XV: 8; text-figure 32: 8.

*Dimensions*  $\text{Ø}_t$  = 20—70  $\mu$  (60  $\mu$ ).

Central body cubic, not forming a clearly differentiated part of the shell. Central body usually very reduced in dimensions or even absent. The eight or more processes are situated at the corners of the central body. They are fundamentally formed by three planes coming from the central body. At the intersecting-line of these planes a thin nerve is present. The processes may bifurcate and have rarely secondary appendages. The boundaries of the planes are smooth. The shell is psilate at 1200 × magnification. All walls are thin and transparent. The processal planes are never reduced.

*Frequency and provenance.* Rare in the upper part of the La Vid Shales.

*Known stratigraphical range.* Recorded from a loose coral, *Favosites turbinata* Billings, that occurs in the Onondaga and Hamilton Formations (Index Fossils of North America, 1947: p. 107), Canada — Deunff (1955); Frasnian, Belgium — Stockmans and Willière (1962); upper part of the La Vid Formation, Emsian (part), NW-Spain.

*Polyedryxium rabians* n. sp.

Plate XV: 10, 11, 12, 13\*, 14, 15, 16; text-figure 32: 3, 4.

*Dimensions.*  $\text{Ø}_t$  = up to about 25  $\mu$  (10—15  $\mu$ ).

Shell cubic. The walls are of one layer; they are psilate at 1200 × magnification. The intersecting edge of the shell is smooth. Rarely the shell is slightly extended at the corners, but these extensions are never longer than some 10—20 % of the  $\text{Ø}_t$ . The walls are thin and transparent.

*Frequency and provenance.* San Pedro Formation: very rare, at the top somewhat more common than at the base; La Vid Shale Member; rare to common. Holotype from 0099, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* San Pedro Formation and La Vid Formation, Ludlovian to Emsian (part), NW-Spain.

*Similar forms.* Similar to very reduced forms of *P. pharaonis* Dff. 1955, but these have longer processes with crests at the edges of the central body.

*Polyedryxium tetrahedroide* n. sp.

Plate XV: 4 to 7\*; text-figure 32: 1, 2.

*Dimensions.*  $\text{Ø}_t$  = up to 60  $\mu$  (20—30  $\mu$ ).

Body hollow, tetrahedral. The four planes intersect with a smooth, straight or slightly hollow edge. The walls of the shell are of one layer; they are thin and transparent. Surface psilate at 1200 × magnification. At the corners the shell may be extended, thus forming a kind of processus-like structures that may attain a length of up to 100 % of the length of an edge of the central body.

The observed variations in outline and dimensions do not seem to have stratigraphic usefulness in the region investigated.

*Frequency and provenance.* Common to rare in the San Pedro Formation. Rare to very rare in the basal part of the La Vid Shales. Holotype from 0434, Los Barrios de Luna, NW-Spain.

*Known stratigraphical range.* San Pedro Formation to basal part of the La Vid Shales, approximately Ludlovian to Siegenian, NW-Spain.

Subgroup *Netromorphitae* D., E. & S. 1963.

1. Genus *Anthatractus* Dff. 1954.

*Anthatractus insolitus* Dff. 1955.

Plate XIX; 8; text-figure 33: 2.

*Dimensions*. Maximal length about 45  $\mu$ .

*Frequency and provenance*. La Vid Shale: very rare in the upper part.

*Known stratigraphical range*. Recorded from a loose coral, *Favosites turbinata* Billings, that occurs in the Onondaga and Hamilton Formations, approximately Couvinian and younger (Index Fossils of North America, 1947, p. 107), Canada — Deunff (1955, 1957); La Vid Formation, Emsian (part), NW-Spain.

2. Genus *Deunffia* Downie 1960.

*Deunffia monacantha* (Deunff 1959).

Plate XIX: 6; text-figure 33: 11.

*Dimensions*. Maximal length 50  $\mu$  (30  $\mu$ ).

*Frequency and provenance*. Very rare in the middle part of the San Pedro Formation near Oblanca de Luna.

*Known stratigraphical range*. Base of Caradocian, Breton, France — Deunff (1958) 1959; San Pedro Formation (part), NW-Spain.

*Deunffia cf. monospinosa* Downie 1960.

Plate XIV: 8; text-figure 33: 3.

*Dimensions*. Length up to 25  $\mu$  (15—20  $\mu$ ).

Very similar to *D. monospinosa* Downie, except for the different dimensions and the very fine scabrate structure of the wall parallel to the longitudinal axis of the body.

*Frequency and provenance*. *D. cf. monospinosa* Downie occurs very rarely in the lower and middle parts of the San Pedro Formation, Ludlovian, near Oblanca de Luna.

*Known stratigraphical range*. Buildwas Shales, Wenlockian, England — Downie 1960 (holotype); San Pedro Formation, Ludlovian, NW-Spain.

3. Genus *Leiofusa* Eis. 1938.

*Leiofusa banderilla* Cmr. 1964.

Plate XIX: 2; text-figure 33: 8.

*Dimensions*. Maximal breadth 25 to 40  $\mu$ , maximal length 100 to 150  $\mu$ .

*Frequency and provenance*. Frequent to rare in the San Pedro Formation; rare to very rare in the La Vid Shales.

*Known stratigraphical range*. San Pedro Formation to La Vid Shales, Ludlovian to Emsian (part), NW-Spain.

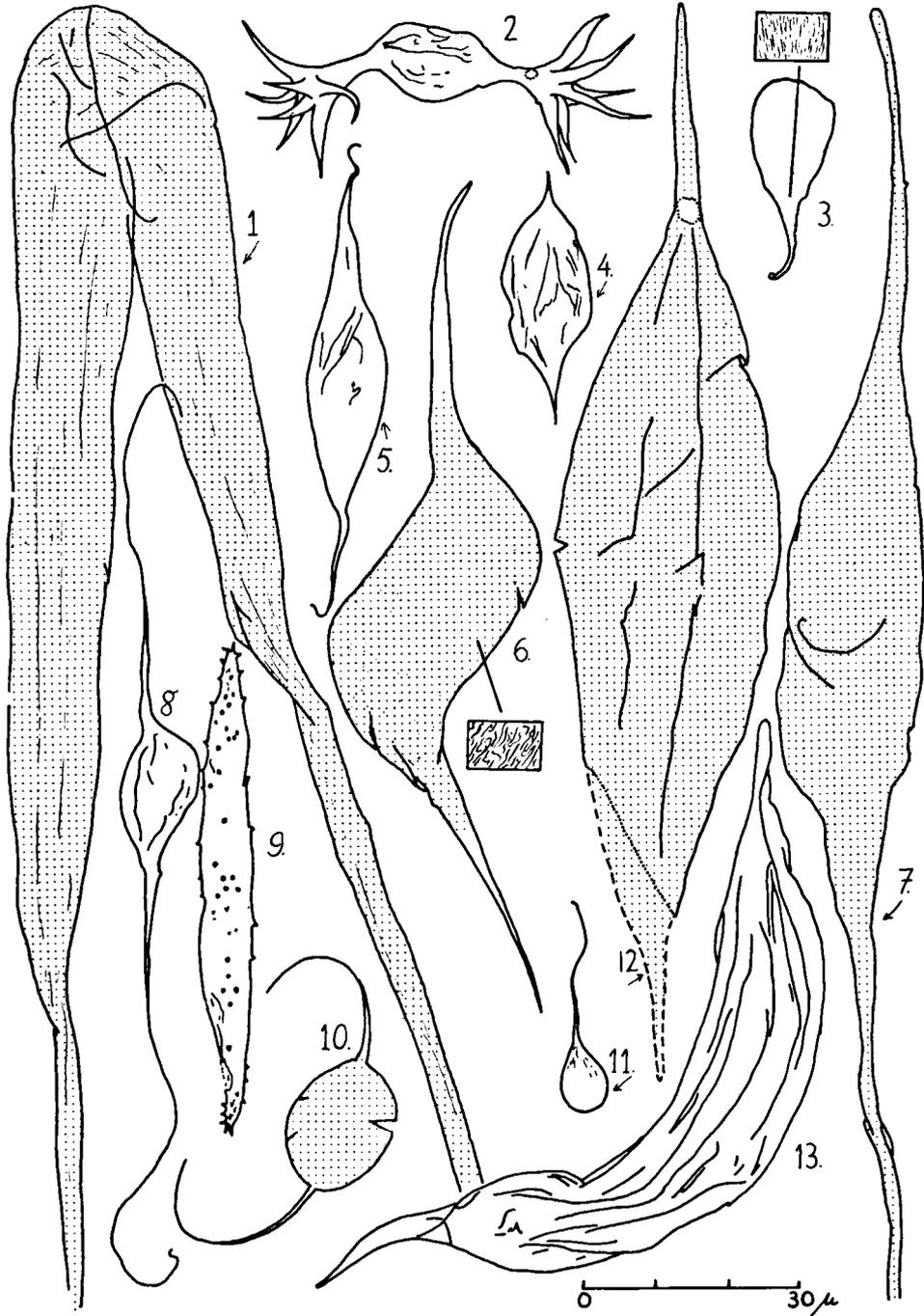


Fig. 33. 1\*. *L. blanca* n. sp.; 2. *A. insolitus* Dff.; 3. *D. cf. monospinosa* Downie; 4. *L. cf. tumida* Downie; 5. *L. filifera* Downie; 6. *L. cantabrica* Cmr.; 7. *L. estrecha* Cmr.; 8. *L. banderilla* Cmr.; 9. *L. fastidiosa* n. sp.; 10. *L. bernesa* Cmr.; 11. *D. monacantha* (Dff.); 12\*. *L. elenae* n. sp.; 13. *L. striatifera* Cmr.

*Leiofusa bernesa* Cmr. 1964

Plate VI: 10. XVIII: 2; text-figure 33: 10.

*Dimensions.* Maximal breadth 25 to 30  $\mu$ , maximal length about 60  $\mu$ .

*Frequency and provenance.* Dominant to common in the San Pedro Formation, rare in the La Vid Carbonate Member.

*Known stratigraphical range.* San Pedro Formation and La Vid Carbonate Member, Ludlovian to Lower Siegenian, NW-Spain.

Forms where the polar spine is almost entirely absent have been met with, these forms seem to be restricted to the lower part of the San Pedro Formation.

*Leiofusa blanca* n. sp.

Plate XIX: 4\*; text-figure 33: 1\*.

*Dimensions.* Length about 300  $\mu$ ; maximal breadth 20—30  $\mu$ .

The shell is hollow and has a psilate surface. It shows a few very fine parallel lines in the direction of the axis of the body.

*Frequency and provenance.* Very rare in the upper part of the San Pedro Formation near Oblanca de Luna. Holotype from 1143, Oblanca de Luna, NW-Spain.

*Known stratigraphical range.* Ludlovian (part) to Lower Gedinnian (part), NW-Spain.

*Leiofusa cantabrica* Cmr. 1964.

Plate XVIII: 9; text-figure 33: 6.

*Dimensions.* Maximal breadth 25  $\mu$ , maximal length 125  $\mu$  or more.

Central body hollow, dorsoventrally compressed, fusiform. At each pole a broad based, rather thick spine is present. The wall of the central body is fossulate, the direction of the fossulae is approximately parallel to the longitudinal axis of the body. The wall of the spines is psilate at 1200  $\times$  magnification, there is no distinct limit between the two kinds of sculpture. The wall is moderately transparent, thin and simple.

*Frequency and provenance.* Rare in the San Pedro Formation, common in the upper part of the San Pedro Formation near Oblanca de Luna, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian, NW-Spain.

*Leiofusa elenae* n. sp.

Text-figure 33: 12\*.

*Dimensions.* Length about 150  $\mu$  or more.

Body flat, hollow, fusiform in outline, dorsoventrally compressed, bearing a thick hollow spine at each pole. The wall is psilate at 1200  $\times$  magnification, it is moderately transparent and thin. The wall is simple.

*Frequency and provenance.* Very rare in the lower part of the San Pedro Formation near Torrestío. Holotype from 1143, Torrestío, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian, NW-Spain.

*Leiofusa estrecha* Cmr. 1964.

Plate XVIII: 1, XIX: 3; text-figure 33 : 7.

*Dimensions.* Breadth 30  $\mu$  or more; length 270  $\mu$  or more; wall about 1  $\mu$  thick.

*Frequency and provenance.* Very rare in the upper part of the Formigoso Formation; rare in the San Pedro Formation.

*Known stratigraphical range.* Upper part of the Formigoso Formation and San Pedro Formation, Tremadocian (?) (part) to Ludlovian, NW-Spain.

*Leiofusa fastidiona* n. sp.

Plate VI: 6\*; XIX: 5; text-figure 33: 9.

*Dimensions.* Length about 70  $\mu$  or more.

Body dorsoventrally compressed, hollow, very elongated fusiform. The wall is psilate at 1200  $\times$  magnification; except for a great number of small echinae (smaller than 1  $\mu$ ) that are irregularly distributed over the body. The echinae occur in a relatively greater number at the poles.

*Frequency and provenance.* In varying amounts present in the La Vid Shale Member. Holotype from 0072, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shales, Middle Siegenian to Emsian (part), NW-Spain.

*Leiofusa filifera* Downie 1959.

Plate XVIII: 8; text-figure 33: 5.

*Dimensions.* Length 100 to 150  $\mu$ , rarely more.

*Frequency and provenance.* Very rare in the San Pedro Formation.

*Known stratigraphical range.* Wenlock Shales, England — Downie 1959, 1963; San Pedro Formation, Ludlovian to Lower Gedinnian (part), NW-Spain.

*Leiofusa striatifera* Cmr. 1964.

Plate XVIII: 7, XIX: 1; text-figure 33: 13.

*Dimensions.* Length 100—150  $\mu$ .

*Frequency and provenance.* Rare in the San Pedro Formation.

*Known stratigraphical range.* San Pedro Formation, Ludlovian, NW-Spain.

*Similar forms.* *L. squama* Deunff 1961, Tremadocian, Sahara, has less pronounced striae and is smaller. *L. elenae* n. sp. is flat, while *L. striatifera* is clearly hollow and inflated and has more and more pronounced striae.

*Leiofusa cf. tumida* Downie 1959.

Plate XIX: 9, 10; text-figure 33: 4.

*Dimensions.* (a) Length about 40  $\mu$  (San Pedro Formation); (b) Length about 15  $\mu$  or less (Upper part of La Vid Formation).

*Frequency and provenance.* (a) Very rare in the lower and middle parts of the San Pedro Formation; (b) Very rare in the upper part of the La Vid Formation.

*Known stratigraphical range.* Wenlock Shales, England — Downie 1959 (holotype); Wenlock Shales, England — Downie 1963 (pp. 633—635: small forms); San Pedro Formation, Ludlovian NW-Spain.

Subgroup *Herkomorphae* D., E. & S. 1963.

Genus *Cymatiosphaera* O. Wetzel 1933, emend. Defl. 1954.

The following species of *Cymatiosphaera* occur throughout the San Pedro Formation and La Vid Formation, with exception of the La Vid Carbonate Member. None of the species was limited to a particular section or range.

*Cymatiosphaera nebulosa* (Deunff 1954), Plate XVII: 9, 10.

*Cymatiosphaera pavementum* (Deflandre 1933), Plate XVII: 19, 20.

*Cymatiosphaera cf. mirabilis* Deunff 1959, Plate XVII: 2, 3.

*Cymatiosphaera wenlockia* Downie 1959, Plate XVII: 12?, 13, 15, 17.

*Cymatiosphaera flosdevonica* Stockmans & Willièrè 1960, Plate XVII: 18.

The specimens belonging to this group were generally rather susceptible to coloration with safranin (1 % in alcohol).

These species, plus the hereafter described, have been joined in the „Group *Cymatiosphaera*” in the frequency diagrams of the individual sections.

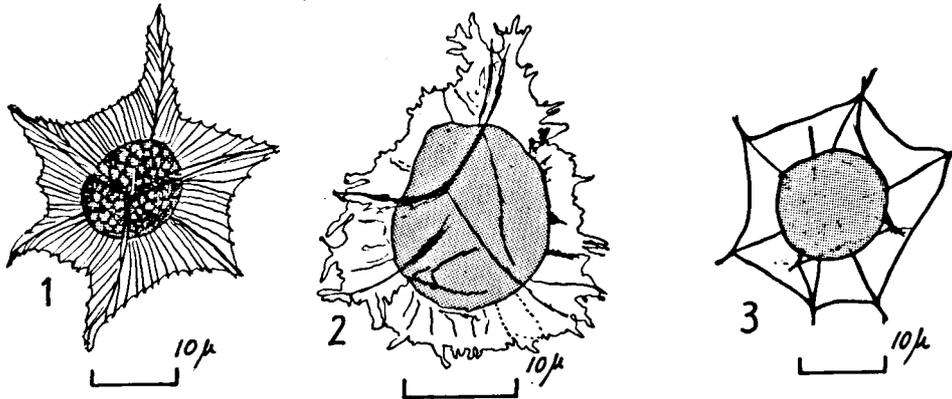


Fig. 34. 1. *C. carminae* n. sp.; 2. *C. franjada* n. sp.; 3. *C. peligrosa* n. sp.

*Cymatiosphaera carminae* n. sp.

Plate VI: 9, XIV: 10\*; text-figure 34: 1.

*Dimensions.*  $\text{Ø}_t$  = up to 40  $\mu$  (30  $\mu$ ).

Central body hollow, roughly spherical, single walled. Surface irregularly rugulate to granulate or verrucate. The central body is surrounded by a set of planes that intersect each other according to the body-diagonals of a cube. The planes have thin parallel nerves that give them a striate appearance. Except for the sculpture caused by the nerves of the planes, they are psilate at 1200  $\times$  magnification. All walls are thin and transparent.

*Frequency and provenance.* Rare in the upper part of the La Vid Shales, especially in section La Vid de Gordón. NW-Spain. Holotype from 0099, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of the La Vid Shale Member, Emsian (part), NW-Spain.

*Cymatiosphaera franjada* n. sp.

Plate XVII: 16\*; text-figure 34: 2.

*Dimensions.*  $\text{Ø}_t = 30\text{--}40 \mu$ .

Central body subspherical with a smooth surface that is divided into numerous irregularly polygonal areas. Crests about 30 % of  $\text{Ø}_{cb}$  high; they have an irregularly crenate boundary. The central body is not transparent; the crests are transparent and have a smooth surface.

*Frequency and provenance.* Very rare in the middle and upper parts of the La Vid Shale Member. Holotype from 0100, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Middle and upper parts of the La Vid Shale Member, Emsian (part), NW-Spain.

*Cymatiosphaera peligrosa* n. sp.

Plate XVII: 4, 5, 6\*, 7, 8; text-figure 34: 3.

*Dimensions.*  $\text{Ø}_i = \text{about } 20 \mu$ ;  $\text{Ø}_t = 35\text{--}40 \mu$ .

Central body subspherical, not transparent. Surface probably smooth. Numerous crests present, dividing the central body into irregularly polygonal areas; crests 20 to 50 % of  $\text{Ø}_{cb}$  high. Crests smooth with a crenate boundary. A spine is present at the junctions of the crests.

*Frequency and provenance.* Common in the very upper part of the La Vid Shale Member, especially near Santa Lucía de Gordón. Holotype from 0024, Santa Lucía de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of the La Vid Shale Member, Emsian (part), NW-Spain.

Subgroup *Pteromorphitae* D., E. & S. 1963.

1. Genus *Pterospermopsis*, W. Wetzel 1952.

*Pterospermopsis bernardinae* n. sp.

Plate XVI: 13\*; text-figure 35: 3.

*Dimensions.*  $\text{Ø}_t = 20 \mu$ .

Central body smooth, not transparent. Equatorial lamella with numerous radial not bifurcated nerves. The boundary of the lamella is smooth.

*Frequency and provenance.* Very rare in the middle and upper parts of the La Vid Shale Member. Holotype from 0024, Santa Lucía de Gordón, NW-Spain.

*Known stratigraphical range.* Upper and middle part of the La Vid Shales, Emsian (part), NW-Spain.

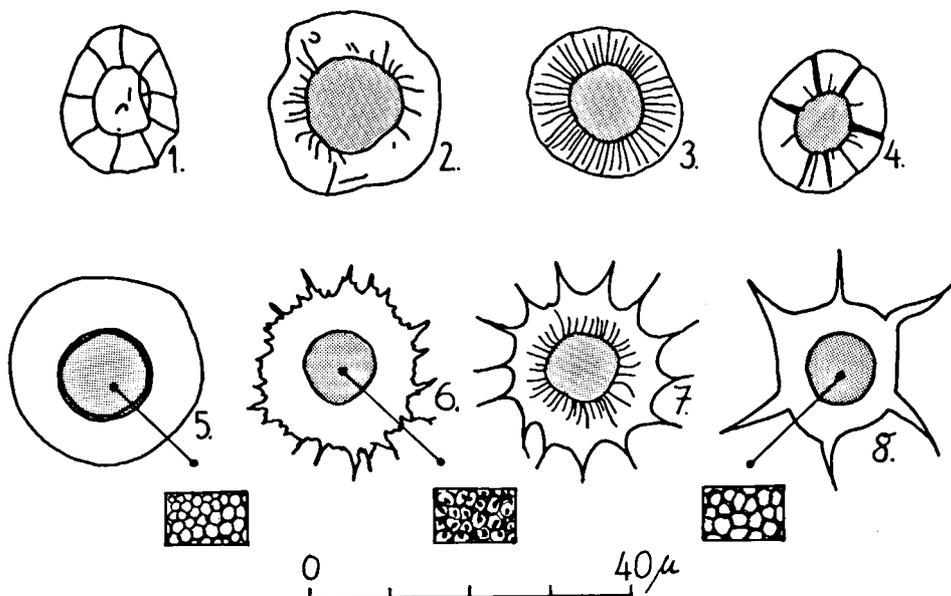


Fig. 35. 1. *P. cf. helios* Sarjeant; 2. *P. onondagaensis* Dff.; 3. *P. bernardinae* n. sp.; 4. *P. guapita* n. sp.; 5. *P. hermosa* n. sp.; 6. *P. rajada* n. sp.; 7. *P. carminae* n. sp.; 8. *P. chiquitina* n. sp.

*Pterospemopsis carminae* n. sp.

Plate XVI: 16\*; text-figure 35: 7.

*Dimensions.*  $\text{Ø}_{\text{cb}} = 20$  to  $25 \mu$ ;  $\text{Ø}_{\text{t}} = 30$  to  $35 \mu$ .

Central body smooth medium transparent. The central body is dorsoventrally compressed. Equatorial lamella smooth, very transparent. It has 14 to 20 (14) sharp tipped radial points. Near the central body a few radially directed nerves are visible.

*Frequency and provenance.* La Vid Shale Member: very rare. Holotype from 0025, Santa Lucía de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

*Pterospemopsis chiquitina* n. sp.

Plate XVI: 14\*, 15; text-figure 35: 8.

*Dimensions.*  $\text{Ø}_{\text{cb}} = 8$  to  $10 \mu$ ;  $\text{Ø}_{\text{t}} = 30$  to  $40 \mu$ .

Central body dorsoventrally compressed, medium transparent with a verrucate sculpture. The equatorial lamella produces into 5 to 8 (6) radial, not bifurcated points. The lamella is smooth and transparent.

*Frequency and provenance.* Very rare to rare in the La Vid Shale Member. Holotype from 0025, Santa Lucía de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

*Pterospermopsis guapita* n. sp.

Plate XVI: 11\*; text-figure 35: 4.

*Dimensions.*  $\text{Ø}_t$  = about 20  $\mu$ .

Central body smooth, not transparent to medium transparent. Equatorial lamella smooth and transparent with a subcircular smooth boundary. A few radially directed rather thick nerves and some thinner and shorter ones sustain the equatorial lamella.

*Frequency and provenance.* Rare to common in the fossiliferous part of the La Vid Carbonate Member and the La Vid Shale Member. Holotype from 0825, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Middle Siegenian to Emsian (part), NW-Spain.

*Pterospermopsis cf. helios* Sarjeant.

Plate XVI: 5; text-figure 35: 1.

*Dimensions.*  $\text{Ø}_t$  = about 15  $\mu$ .

*Frequency and provenance.* Very rare in the San Pedro Formation near Corniero.

*Pterospermopsis hermosita* n. sp.

Plate XVI: 12\* and 18\*; text-figure 35: 5.

*Dimensions.*  $\text{Ø}_t$  = 20 to 30  $\mu$ .

Central body dorsoventrally compressed, little transparent. The central body has a verrucate sculpture. The wall is rather thick and is of one layer. The equatorial lamella is thin and transparent. It is smooth and has a circular, smooth boundary.

*Frequency and provenance.* Upper part of the La Vid Shale Member: very rare. Holotype from 0825, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of the La Vid Shale Member, Emsian (part), NW-Spain.

*Pterospermopsis onondagaensis* Dff. 1955.

Plate XVI: 9, 10; text-figure 35: 2.

*Dimensions.*  $\text{Ø}_t$  = about 30  $\mu$  or less.

*Frequency and provenance.* Upper part of the San Pedro Formation to La Vid Shale Member: very rare to rare.

*Known stratigraphical range.* Onondaga Formation, approximately Couvinian and younger, Canada — Deunff (1955); Tarranonian, Belgium — Stockmans and Willière (1963); Wenlock Shales, Wenlockian, England — Downie (1963); Upper Ludlovian to Emsian (part), NW-Spain.

*Pterospermopsis rajada* n. sp.

Plate XVI: 17\*; text-figure 35: 6.

*Dimensions.*  $\text{Ø}_{cb}$  = about 10  $\mu$ ;  $\text{Ø}_t$  = 20 to 30  $\mu$ .

Central body dorsoventrally compressed, medium transparent. Wall of the central body with verrucate sculpture. The verrucae are very low and have a small central depression. The equatorial lamella is transparent and smooth; it has an irregularly crenate boundary.

*Frequency and provenance.* Upper and middle parts of the La Vid Shale Member: very rare to rare. Holotype from 0825, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Middle and upper parts of the La Vid Shale Member, Emsian (part), NW-Spain.

2. Genus *Helios* n. gen.

Acritarchs having an ellipsoidal hollow test without an inner body. A lamella, sustained by radial processes, is present. The position of the lamella is not equatorial. No openings observed.

Type species *Helios aranaides* n. sp.

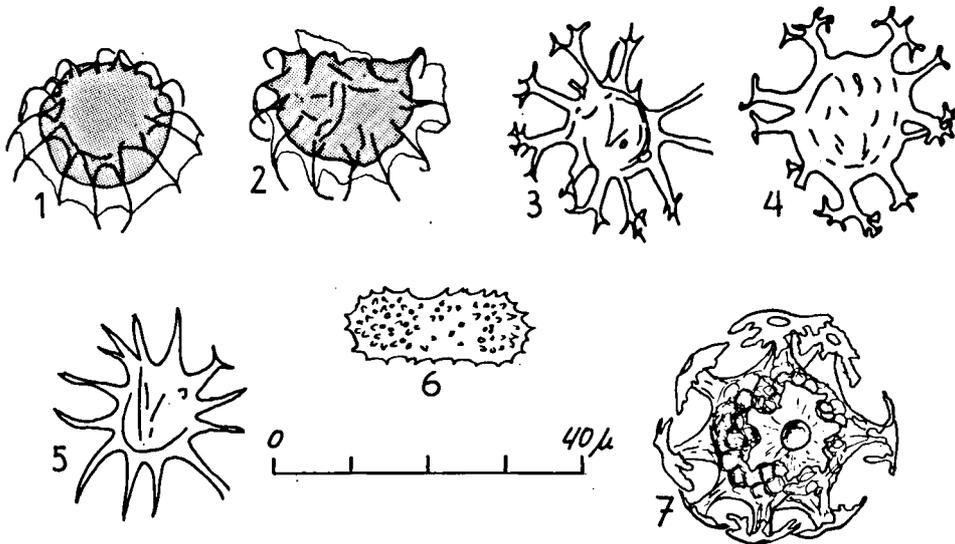


Fig. 36. 1 and 2. *H. aranaides* n. sp.; 3 and 4. *S. radiofurcatus* n. sp.; 5. *S. radians* n. sp.; 6. *L. pepino* n. sp.; 7 ?*H. huecospinosum* n. sp.

*Helios aranaides* n. sp.

Plate V: 9; XIV: 7\*; text-figure 36: 1, 2.

*Dimensions.*  $\text{O}_t = 20$  to  $30 \mu$ .

Central body hollow, inflated, moderately thin walled and transparent. The body has an ellipsoidal form. Near one pole a ring of about sixteen broad based processes each ending in a long hair are present. Between the processes a very thin smooth lamella is present. The wall of the body and the processes are psilate at  $1200 \times$  magnification.

*Frequency and provenance.* Rare in the San Pedro Formation. Holotype from 1143, Torrestío, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian to Lower Gedinnian (part), NW-Spain.

### 3. Genus *Sol* n.g.

Acritarchs having an ellipsoidal shell, dorsoventrally compressed, without a clearly discernible inner body. An equatorial lamella surrounds the test. The equatorial lamella has typically dentate boundaries. No openings observed.

Type species *Sol radians* n. sp.

*Sol radians* n. sp.

Plate XVI: 7, 8\*; text-figure 36: 5.

*Dimensions.*  $\text{O}_t =$  up to 30  $\mu$  (30  $\mu$ ).

Central body absent. The radial processes are predominantly simple, occasionally simply bifurcated at the tips. 10—20 (20) radial processes may be seen. Surface psilate at 1200  $\times$  magnification. At least the central part of the shell is double walled.

*Frequency and provenance.* Very rare in the San Pedro Formation near Torrestío, NW-Spain. Holotype from 1148, Torrestío, NW-Spain.

*Known stratigraphical range.* Upper part of San Pedro Formation, Ludlovian to Lower Gedinnian (part), NW-Spain.

*Sol radiofurcatus* n. sp.

Plate XVI: 4\*; text-figure 36: 3, 4.

*Dimensions.*  $\text{O}_t$  up to 30  $\mu$  (20  $\mu$ ).

Central body absent; the radial processes are bifurcated. Bifurcations 1st to 3d (3d) order. 10 to 18 (13) radial processes. Surface psilate at 1200  $\times$  magnification.

*Frequency and provenance.* Very rare in the San Pedro Formation near Torrestío, NW-Spain. Holotype from 1148, Torrestío, NW-Spain.

*Known stratigraphical range.* Upper part of San Pedro Formation, Ludlovian to Lower Gedinnian (part), NW-Spain.

Subgroup *Diacromorphitae* D., E. & S. 1963.

Genus *Lophodiacrodium* Timofeev 1958, emend. G. & M. Defl. 1962.

*Lophodiacrodium pepino* n. sp.

Plate IV: 17; V: 3\*, 10; text-figure 36: 6.

*Dimensions.* Shell about 20  $\times$  40  $\mu$ , spines 1—3  $\mu$  long.

Central body and spines hollow, thin walled and moderately transparent. The numerous small spines have sharp tips. They have a broad base and are about as long as broad. The distribution of the spines over the body shows maxima at the poles. In optical section about 25 spines visible. Walls psilate at 1200  $\times$  magnification.

*Frequency and provenance.* Rare in the San Pedro Formation; common to rare in the La Vid Shale Member. Holotype from 0823, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* San Pedro Formation to La Vid Shale Member, approximately Ludlovian to Emsian (part), NW-Spain.

Microfossils referable to *Dinophyceae*.

Genus *Hystrichosphaeridium* Defl. 1937, restr. Eis. 1958.

?*Hystrichosphaeridium huecospinosum* n. sp.

Plate VI: 2\*; text-figure 36: 7.

*Dimensions.*  $\text{Ø}_t$  = up to 35  $\mu$ , usually smaller.

Central body and processes hollow with not uniform walls. The central body is roughly spherical, has a thin wall with a granulate sculpture and is very transparent. The processes are hollow and are open at the end. The roset-like structures at the end of the processes may be joined forming a kind of "outer shell". The wall of the processes is psilate or verrucate, the "outer shell" has a granulate surface. 5 to 13 (8) processes in optical section.

*Frequency and provenance.* Rare in the upper part of the La Vid Shales. Holotype from 0099, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of the La Vid Shales, Emsian (part), NW-Spain.

Subgroup Uncertain.

1. Genus *Cepillum*.

Acritarchs with an inflated discoid body at the polar regions provided with processes. Neither inner body nor openings observed.

Type species. *Cepillum puercoespinoide* n. sp.

*Cepillum puercoespinoide* n. sp.

Plate VII: 7; text-figure 37: 6.

*Dimensions.*  $\text{Ø}_t$  = about 30  $\mu$ .

Central body discoid, hollow. At the poles numerous short broad based, hollow processes are present. The wall is psilate at 1200  $\times$  magnification.

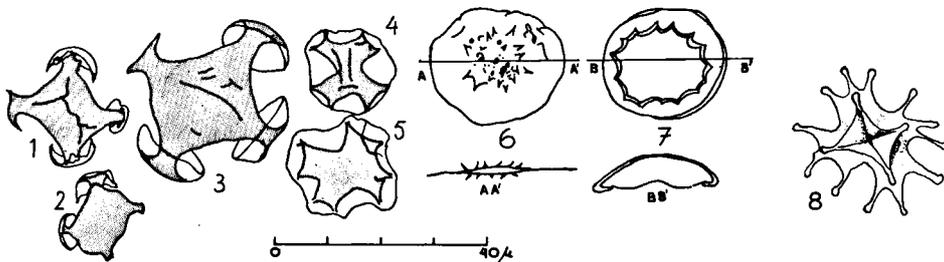


Fig. 37. 1 to 3. *Q. fantasticum* n. sp.; 4 and 5. *Q. incisum* n. sp.; 6. *C. puercoespinoide* n. sp.; 7. *Acritarch* sp. III; 8. *P. exoticum* n. sp.

*Frequency and provenance.* Very rare in section Argovejo, upper part of San Pedro Formation. Holotype from 0081, Argovejo, NW-Spain.

*Known stratigraphical range.* Upper part of the San Pedro Formation, Ludlovian (part) to Lower Gedinnian (part), NW-Spain.

## 2. Genus *Leoniella*.

Central body and processes hollow. Central body roughly spherical, dorsoventrally compressed. At the equatorial plane flat processes are present.

Type species *Leoniella carminae* n. sp.

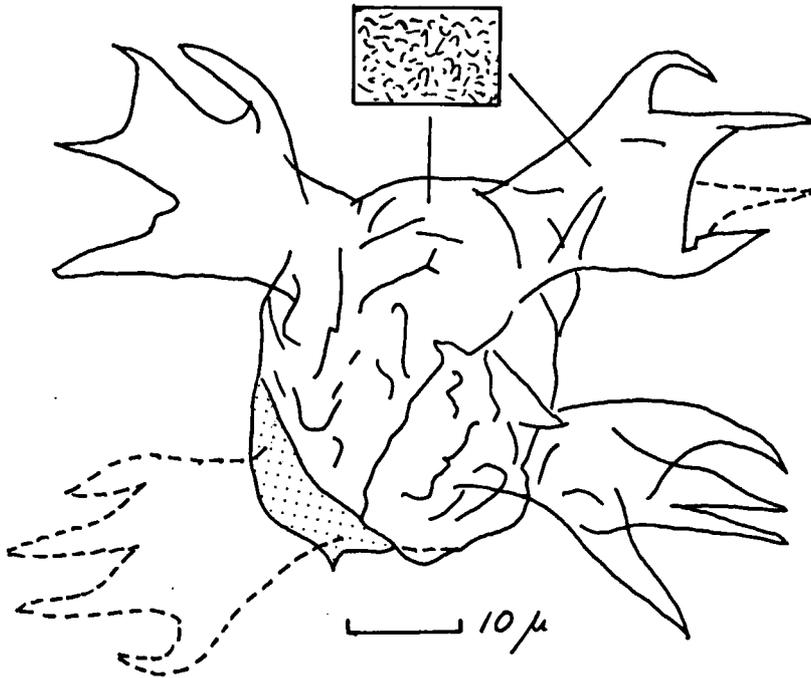


Fig. 38.

*Leoniella carminae* n. sp.

Plate XXVII: 1\*; text-figure 38.

*Dimensions.*  $\text{O}_t = 70\text{--}120 \mu$  ( $80 \mu$ ).

Central body and processes hollow with uniform walls. Central body subspherical, dorsoventrally compressed, with four processes situated at the equatorial plane. Wall irregularly scabrate, moderately transparent and moderately thick. The processes are compressed parallel to the equator of the central body. They end in four sharp tipped fingers.

*Frequency and provenance.* Very rare in the middle part of the San Pedro Formation. Holotype from 1147, Torrestio, NW-Spain.

*Known stratigraphical range.* Middle part of the San Pedro Formation, Ludlovian (part), NW-Spain.

### 3. Genus *Polyplanifer* n. g.

Microfossil of unknown affinities, made up by an equatorial plane in the center cut by the tops of a set of two pyramids, that are joined at their apexes.

Type species *Polyplanifer exoticum* n. sp.

*Polyplanifer exoticum* n. sp.

non: ?*Polyedryxium exoticum*: Cramer (1963).

Plate XIV: 6\*, 11; text-figure 37: 8.

*Dimensions.*  $\text{Ø}_t = 15 \text{ to } 30 \mu (20 \mu)$ .

Equatorial plane flat, made up by four symmetrical sets of sharp triangular structures, joined at their tops. The exterior parts of the triangular structures have three knob-tipped short appendages each. The center of the equatorial plane is cut by a set of two open-based, hollow, sharp tetragonal pyramids, joined at their apexes. The basal corners of these pyramids end in short knob-tipped appendages. The walls are thin and transparent, they are of one layer and psilate at 1200  $\times$  magnification.

*Frequency and provenance.* Very rare in the La Vid Shales. Holotype from 0823, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shale Member, Middle Siegenian to Emsian (part), NW-Spain.

### 4. Genus *Quadraditum* n. g.

Microfossil of uncertain affinities. It consists of an originally subspherical to ellipsoidal outer shell, formed by a very thin transparent smooth membrane that envelopes a flat subsquare central body. This central body is hollow, moderately transparent to not transparent and is smooth.

Type species *Quadraditum fantasticum* n. sp.

*Quadraditum incisum* n. sp.

Plate XIV: 1\*, 2; text-figure 37: 4, 5.

*Dimensions.*  $\text{Ø}_t = \text{up to } 30 \mu (20 \mu)$ .

Central body moderately transparent and moderately thick, psilate at 1200  $\times$  magnification. The central body has the form of an X. Enveloping membrane very thin and transparent, smooth, attached at the eight corners of the equatorial plane.

*Frequency and provenance.* Rare in the La Vid Shales. Holotype from 0074, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* La Vid Shales, Middle Siegenian to Emsian (part), NW-Spain.

*Quadratum fantasticum* n. sp.

Plate XIV: 3\*; 4; text-figure 37: 1, 2, 3.

*Dimensions.*  $\text{Ø}_t$  = up to 40  $\mu$  (10–15  $\mu$ ).

Central body moderately thin and moderately transparent, psilate at 1200  $\times$  magnification. The central body has a square outline. Enveloping membrane very thin and transparent, smooth, attached at the corners of the central body. Membrane usually damaged.

*Frequency and provenance.* Very rare in the San Pedro Formation. Holotype from 1141, Oblanca de Luna, NW-Spain.

*Known stratigraphical range.* San Pedro Formation, Ludlovian to Lower Gedinian (part), NW-Spain.

5. Genus *Triangulina* n. g.

Acritarchs with a triangular somewhat inflated inner body, surrounded by an outer body of approximately the same shape, but with hollow processes at the corners.

Type species *Triangulina alargada* n. sp.

The presence of an inner body excludes the transfer of this genus to the Subgroup *Polygonomorphitae* D., E. & S., 1963.

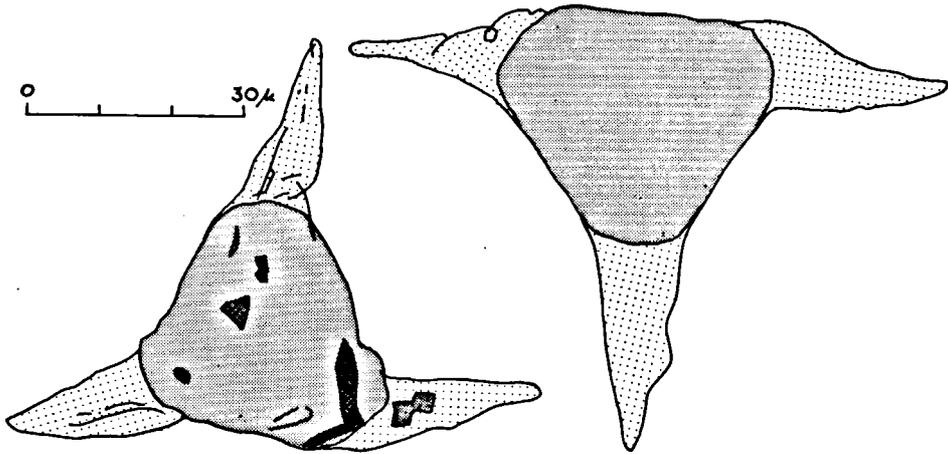


Fig. 39.

*Triangulina alargada* n. sp.

Plate VI: 1, 4\*; text-figure 39.

*Dimensions.*  $\text{Ø}_t$  = up to 100  $\mu$  (80  $\mu$ ).

Inner body thick walled, moderately transparent to not transparent. Inner body with smooth surface, hollow, somewhat inflated. Outer body with thin walls,

transparent. Wall of outer body psilate at 1200 × magnification. The outer body envelopes the inner body tightly except for the corners where it possesses three hollow bold processes. No openings in both shells have been observed.

*Frequency and provenance.* Rare in the upper part of the La Vid Shales. Holotype from 0711, Geras de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of the La Vid Shales, Emsian (part), NW-Spain.

*Tetraporina horologia* (?) (Staplin 1960): Playford 1962, p. 659, Plate 95: 14.

Plate VII: 10, 11.

*Dimensions.*  $\text{Ø}_t$  = about 15  $\mu$ .

*Frequency and provenance.* Very rare in the San Pedro Formation and the La Vid Shale Member.

*Acritarch cf. Veryhachium vandenbergheni* (?) St. & W. 1960 and *V. nasicum* St. & W. 1960. Plate XIV: 14, 15, 17.

*Dimensions.*  $\text{Ø}_t$  = 30—60  $\mu$  (44  $\mu$ ).

This formgroup consists of forms that have an outline similar to the above mentioned acritarchs.

*Frequency and provenance.* Rare to very rare in the upper part of the La Vid Carbonate Member and the La Vid Shale Member.

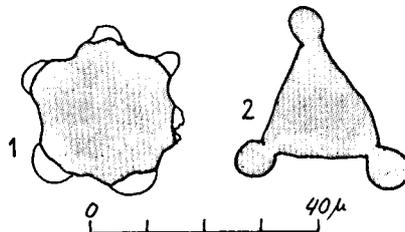


Fig. 40. 1. *Acritarch sp. I*; 2. *Acritarch sp. II*.

*Acritarch? sp. I.*

Plate XV: 3; text-figure 40: 1.

*Dimensions.*  $\text{Ø}_t$  = about 25  $\mu$ .

Microfossil of organic material, roughly hexagonal in outline. The body is dorsoventrally compressed and not transparent except for the hollow structures near the corners of the body. The surface is smooth, both the transparent and the not transparent part. No internal structures observed.

*Frequency and provenance.* The fossil has been found in only one sample, 0073, of section Geras de Gordón, where it occurs with relatively great frequency ( $\pm 3\%$ ).

*Acritarch? sp. II.*

Plate V: 6; text-figure 40: 2.

*Dimensions.*  $\text{Ø}_t =$  about 30  $\mu$ .

*Frequency and provenance.* The fossil has been found in only one sample, 0101, of section La Vid de Gordón, where it occurs with relatively great frequency ( $\pm 2\%$ ).

*Acritarch sp. III.*

Plate III: 13.

*Dimensions.*  $\text{Ø}_t =$  about 15  $\mu$ .

*Frequency and provenance.* Recorded from San Pedro Formation of section Oblanca de Luna, where it occurs with relative great frequency (5%) in 1170.

*Acritarch? sp. IV.*

Plate XIV: 5; text-figure 37: 7.

*Dimensions.*  $\text{Ø}_t =$  about 25  $\mu$ .

*Frequency and provenance.* Very rare in the San Pedro Formation, upper part.

## 2. CHITINOZOANS

### *General*

As a rule chitinozoans recovered from sediments of the León region were black, opaque, and rather well preserved. The state of preservation of the chitinozoans varies even within one species from sample to sample. Their abundance in the sediment decreases towards the La Vid Formation. Transparent forms are very rare, whereas forms showing casts of cubic crystals are quite common.

No mutual relations between the abundance of acritarchs, chitinozoans, and sporomorphs within the same sample or series of samples have been observed. The good preservation of one group of fossils does not imply an equally good preservation of the other groups. The rather changeable iron content in the rocks of the San Pedro Formation is found to have no influence on the preservation of the microfossils or on the composition of the associations as compared with the associations of the immediately over- and underlying shale layers. There is a marked influence of the tectonisation of the rocks on the recoverable microfossil content. Thin shale partings between thick massive quartzites yield no more than practically indeterminate remains of the microfossils. This is possibly a result of the grinding effect of the coarser components in the sediment during the tectonisation. In the vicinity of faults the preservation of the microplankton is also poor.

All samples have been prepared according the standard technique, on page 258.

The text-figures in the descriptions are schematic drawings. Specimens have not been retouched in any of the photographs. When found necessary some dark shadows in the background have been covered. The figure numbers marked with an asterisk indicate pictures of holotypes.

List of chitinozoans

Phyllum *Protozoa* Goldfuss 1818.  
 Classis ind. Von Siebold 1845.  
 Ordo *Chitinozoida* Eisenack 1931.  
 Familia *Desmochitina* Eisenack 1931: van Oyen and Calandra (1961): p. 14.

1. Genus *Ancyrochitina* Eis. 1955.

*A. ancyrea* (Eis. 1931).  
*A. fragilis* (Eis. 1955) var. *brevis* T. & J. 1960.  
*A. gumersinda* n. sp.  
*A. tumida* T. & J. 1960.  
 ?*A. gordita* n. sp.

2. Genus *Angochitina* Eis. 1931.

*A. devonica* Eis. 1955.  
*A. filosa* Eis. 1955.  
*A. toyetae* n. sp.  
*A. longicolla* Eis. 1959.  
*A. valentini* n. sp.  
*A. valentini* n. sp. var. *aspera* n. var.  
*A. spinosa* (Eis. 1937).  
*A. ramusculosa* n. sp.

3. Genus *Conochitina* Eis. 1937.

*C. brevis* T. & J. 1960.  
*C. communis* Tau. 1961.  
*C. intermedia* Eis. 1955.  
*C. cf. lagenomorpha* Eis. 1955: Taugourdeau and de Jekhowsky (1960): fig. 56.  
*C. gordonensis* n. sp.

4. Genus *Cyathochitina* Eis. 1955.

*C. campanulaeformis* (Eis. 1931).  
 ?*C. dispar* B. and T. 1961.  
 ?*C. elenitae* n. sp.

5. Genus *Clathrochitina* Eis. 1959 emend.

*C. bernesa* n. sp.

6. Genus *Plectochitina* n. g.

*P. carminae* n. sp.  
*P. nodosa* T. & J. 1960.  
*P. saharica* (Tau. 1962).  
*P. pseudoagglutinans* (Tau. 1963).  
*P. rosendae* n. sp.

7. Genus *Desmochitina* Eis. 1931, emend. Eis. 1962.

*D. cingulata* Eis. 1937.  
*D. densa* Eis. 1962.  
*D. elegans* T. & J. 1960.  
*D. elegans* T. & J. 1960 var. *corta* n. var.  
*D. erratica* Eis. 1931.  
*D. leonense* n. sp.  
*D. panzuda* n. sp.  
*D. thyræ* n. sp.  
*D. tinae* n. sp.  
*D. urna* Eis. 1934.

8. Genus *Lagenochitina* Eis. 1931.*L. brevicollis* T. & J. 1960: fig. 110.*L. brevicollis* T. & J. 1960, var. *granulata* n. var.9. Genus *Rhabdochitina* Eis. 1931.*R. magna* Eis. 1931.*R. conocephala* Eis. 1934.10. Genus *Sphaerochitina* Eis. 1955.*S. fungiformis* (Eis. 1931).*S. llorona* n. sp.*S. sphaerocephala* (Eis. 1932).*S. vitrea* Tau. 1962.*S. longicollis* T. & J. 1960.*Descriptions*Genus *Ancyrochitina* Eis. 1955.

Chitinozoans with subcylindrical necks ( $1/2$  to  $2/3$  of the total length) and with funnel-shaped or rarely subspherical body chambers. Bottom of body chamber more or less flat, slightly impressed or inflated. At the arboreal end a relatively small number, 4—10 (5—8), of thick appendages is present. These appendages may be short or large, simple or bifurcated or irregularly branched.

Genotype *Ancyrochitina ancyrea* Eis. 1931.*Ancyrochitina ancyrea* (Eis. 1931)

Plate XX: 25, 26.

*Dimensions.* Length of body 150—200  $\mu$  (150  $\mu$ ).

This species is very variable. The differences seem to have no stratigraphic signification in the region investigated.

*Frequency and provenance.* Formigoso Formation, San Pedro Formation, La Vid Formation: very rare.

*Known stratigraphical range.* The species has been recorded from sediments in age ranging from Lower Silurian to Middle Devonian.

*Ancyrochitina fragilis* (Eis. 1955) var. *brevis* T. and J. 1960.

Plate XX: 8, 22, 23.

*Dimensions.* Length 110—200  $\mu$ .

*Frequency and provenance.* San Pedro Formation: very rare in the lower and middle parts; rare to common in the upper part.

*Known stratigraphical range.* Middle Llandoveryan until Siegenian — Taugourdeau and de Jekhowsky (1960); Upper and Middle Llandoveryan, Sahara — Taugourdeau (1962); approximately Ludlovian to Lower Gedinnian, NW-Spain.

*Ancyrochitina gumersinda* n. sp.

Plate XXII: 16\*; text-figure 41.

*Dimensions.* Length 225 to 250  $\mu$ .

Neck very long, grading into the funnel-shaped body chamber. The body chamber has a more or less inflated bottom. Two or more simple and solid appendages are present. Surface smooth; wall not transparent, no internal structures observed.

*Frequency and provenance.* La Vid Shale Member: very rare near Argovejo in the lower part of the member. Holotype from 1121, Argovejo, NW-Spain.

*Known stratigraphical range.* Approximately Middle Siegenian, NW-Spain.

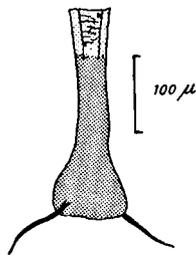


Fig. 41.

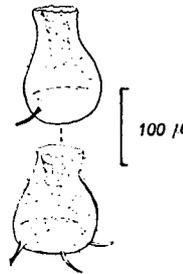


Fig. 42.

*Ancyrochitina tumida* T. & J. 1960.

Plate XX: 9.

*Dimensions.* Length about 150  $\mu$ .

The ramification and number of the appendages is rather variable but seems to have no stratigraphic usefulness in the region investigated.

*Frequency and provenance.* Formigoso Formation: very rare in the upper part; San Pedro Formation: rare; La Vid Formation: rare.

*Known stratigraphical range.* Middle Llandoveryian to Emsian, Sahara — Taugourdeau and de Jekhowsky (1960), approximately Ludlovian (eventually part of Tremadocian) to Emsian (part), NW-Spain.

?*Ancyrochitina gordita* n. sp.

Plate XXII: 11\*; textfigure 42.

*Dimensions.* Length about 150  $\mu$ .

Collar and neck very short, medium transparent with a smooth boundary. Body chamber piriform, grading into the neck. No keel. Prosome rarely present, its length is about equal to that of the neck plus collar; occasionally an ophiostome has been observed. A few short smooth processes that are simple or simply bifurcated at the tips, may be present. Specimens without processes occur also, often still connected to forms with processes.

*Frequency and provenance.* La Vid Shale Member: very rare. Holotype from 0101, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Middle Siegenian to Emsian (part), NW-Spain.

Genus *Angochitina* Eisenack 1931.

The genus consists of flask-shaped forms with spines.

Genotype *Angochitina echinata* Eis. 1931.

*Angochitina devonica* Eis. 1955.

Plate XX: 2, 3; XXI: 18, 19, 20.

*Dimensions.* Length of body 150—200  $\mu$  (180  $\mu$ ).

The forms here recorded have a great resemblance to those reported by Taugourdeau and de Jekhowsky 1960, fig. 37.

*Frequency and provenance.* La Vid Shale Member: very rare to rare.

*Known stratigraphical range.* Lepidocentrus-Marl, approximately Lower Givetian, W. Germany — Eisenack (1955); Middle Devonian, Iowa and Illinois — Collinson and Scott (1958), Dunn (1959); Upper Silurian to Siegenian/Emsian, Sahara — Taugourdeau and de Jekhowsky (1960); Siegenian/Emsian, Sahara — Taugourdeau (1962); Siegenian (part) to Emsian (part), NW-Spain.

*Angochitina filosa* Eis. 1955.

Plate XXI: 1, 2.

*Dimensions.* Length 225—300  $\mu$  (250  $\mu$ ).

*Frequency and provenance.* Formigoso Formation: rare in the upper part; San Pedro Formation: rare in the lower part.

*Known stratigraphical range.* Beyrichia-Limestone, approximately Caradocian, Baltic region — Eis. 1955; Middle and Lower Ludlovian, Gotland — Eis. 1962; Tremadocian (part) to Ludlovian (part), NW-Spain.

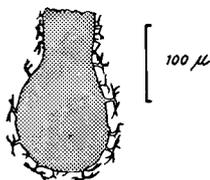


Fig. 43.

*Angochitina toyetae* n. sp.

Plate XXI: 16\* and 17\*; text-figure 43.

*Dimensions.* Length about 200  $\mu$ .

Body chamber ovoid, neck short (1/3 of total length). Opening not differentiated. Wall covered with numerous tiny, manyfold bifurcated to irregularly branched processes. Wall not transparent, no internal structures observed.

*Frequency and provenance.* La Vid Shale Member: very rare in the upper part near Argovejo. Holotype from 1134, Argovejo, NW-Spain.

*Known stratigraphical range.* Emsian (part), NW-Spain.

*Angochitina longicolla* Eis. 1959.

Plate XXI: 9.

*Dimensions.* Total length 250  $\mu$ , neck 150  $\mu$ .

*Frequency and provenance.* San Pedro Formation: very rare in the upper part near Torrestío.

*Known stratigraphical range.* Upper Visby-Marl, Llandoveryan, Baltic region — Eisenack (1959, 1962); approximately Ludlovian to Lower Gedinian, NW-Spain.

*Angochitina valentini* n. sp.

Plate XXI: 3, 4\*, 5, 6; textfigure 44a.

*Dimensions.* Length 200—250  $\mu$  (250  $\mu$ ).

Collar transparent to medium transparent, smooth with a slightly crenate boundary. Neck subcylindrical more or less conical towards the opening. Body chamber ovoidal, piriform; ration neck : belly = about 1 : 1. Surface of neck and belly smooth. Wall not transparent, no internal structures observed.

*Frequency and provenance.* Formigoso Formation: very rare in the lower part; San Pedro Formation: rare to common in the lower part, very rare to rare in the middle part, absent in the very upper part. Holotype from 0854, Aralla de Luna, NW-Spain.

*Known stratigraphical range.* Upper Llandoveryan to Ludlovian, NW-Spain.

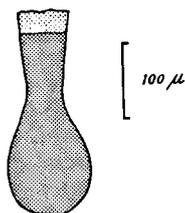


Fig. 44a.

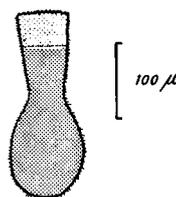


Fig. 44b.

*Angochitina valentini* n. sp. var. *aspera* n. var.

Plate XXI: 7\*; text-figure 44b.

*Dimensions.* Length 200—250  $\mu$  (250  $\mu$ ).

Collar transparent to medium transparent, finely echinate. Boundary crenate. Neck subcylindrical, more or less conical towards the opening. Body chamber ovoidal, piriform; ration length neck : belly = about 1 : 1. Wall of neck and body chamber finely echinate, not transparent. No internal structures observed.

*Frequency and provenance.* San Pedro Formation: rare to common in the lower part; very rare to rare in the upper part, absent in the very top. Holotype from 0854, Aralla de Luna, NW-Spain.

*Known stratigraphical range.* Tremadocian (part) to Ludlovian (part), NW-Spain.

*Angochitina spinosa* (Eis. 1937).

*Conochitina spinosa* Eis. 1937.

*Ancyrochitina spinosa* (Eis. 1937): Dunn 1959.

Plate XX: 1.

*Dimensions.* Length about 150  $\mu$ .

The number of spines as well as their location on the neck and body are rather variable. Specimens with spines that are broken at the base, occur especially in the upper part of the La Vid Shales.

*Frequency and provenance.* La Vid Shale Member: rare to common.

*Known stratigraphical range.* Silurian Crinoidenkalk, East Prussia, Baltic region — Eis. 1937, Cedar Valley Formation, Middle Devonian, Iowa — Dunn 1959; La Vid Shale Member, Siegenian (part) to Emsian (part), NW-Spain.

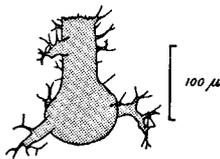


Fig. 45.

*Angochitina ramusculosa* n. sp.

Plate XX: 20\*; text-figure 45.

*Dimensions.* Length of body 150—180  $\mu$  (150  $\mu$ ).

Neck subcylindrical, grading into the piriform to subspherical body chamber. The more or less transparent collar has a crenated boundary and is adorned with numerous tiny spines of different length, varying from simple to simply branched or bifurcated. The body chamber and the neck are sparsely covered with spines of varying length that are simple or simply branched. 3—8 (3—4) major appendages are present. These appendages are very irregularly branched and may be situated at any place of the shell. Wall not transparent, no internal structures observed.

*A. devonica* Eis. 1955 in Eis. 1955: fig. 1: 10—12, has its major appendages situated exclusively at the body chamber: *Ang. milanensis* Coll. & Scott 1958 has more, but smaller, major appendages and has more small spines.

*Frequency and provenance.* San Pedro Formation: very rare in the upper part near Torrestío. Holotype from 1170, Torrestío, NW-Spain.

*Known stratigraphical range.* Upper Ludlovian, NW-Spain.

Genus *Conochitina* Eis. 1931.

Chitinozoans with a generally conoform outline; the maximal diameter lies near the distal end.

Genotype: *Conochitina claviformis* Eis. 1931.

*Conochitina brevis* T. and J. 1960.

Plate XXIV: 16.

*Dimensions.* Length 200—250  $\mu$ , breadth about 150  $\mu$ .

*Frequency and provenance.* Formigoso Formation: rare to very rare; San Pedro Formation: very rare in the lower part at the sections El Tueiro and La Vid de Gordón.

*Known stratigraphical range.* Upper Ordovician to Upper and Middle Llandoveryan, Sahara — Taugourdeau and de Jekhowsky (1960); Upper Ordovician/Lower Silurian, Aquitaine, France — Taugourdeau (1961); Arenigian, Sahara — Benoit and Taugourdeau (1961); approximately Upper Llandoveryan to Lower Ludlovian, NW-Spain.

*Conochitina communis* Tau. 1961.

Plate XXIV: 11.

*Dimensions.* Length about 250  $\mu$ , maximal breadth about 130  $\mu$ .

*Frequency and provenance.* Formigoso Formation: rare in the upper part; San Pedro Formation: rare in the lower part.

*Known stratigraphical range.* Upper Ordovician/Lower Silurian, Aquitaine, SW-France — Taugourdeau (1961); approximately Upper Llandoveryan to Ludlovian (part), NW-Spain.

*Conochitina intermedia* Eis. 1955.

Plate XXIV: 1.

*Dimensions.* Length 150—200  $\mu$ .

*Frequency and provenance.* Formigoso Formation: rare; San Pedro Formation: rare in the lower part.

*Known stratigraphical range.* Beyrichia-Limestone, approximately Caradocian, Estland — Eisenack (1955); Lower and Middle Ludlovian, Gotland — Eisenack (1962); Upper Llandoveryan to Ludlovian, NW-Spain.

*Conochitina cf. lagenomorpha* Eis. 1955: Taugourdeau and de Jekhowsky (1960): fig. 56.

Plate XXII: 18.

*Dimensions.* Length about 100  $\mu$  per unit.

Numerous separate specimens have been met with throughout the La Vid Shales, but only from the lower and middle parts of the member near La Vid de Gordón chains of up to 8 units have been recovered.

*Frequency and provenance.* La Vid Carbonate Member: rare; La Vid Shale Member: present in changing amounts.

*Known stratigraphical range.* Siegenian/Emsian, Sahara — Taugourdeau and de Jekhowsky (1960); Eifelian/Givetian, Sahara — Taugourdeau (1962); Gedinnian (part) to Emsiau (part), NW-Spain.

*Conochitina gordonensis* n. sp.

Plate XXIII: 1, 2\*; XXIV: 17; text-figure 46.

*Dimensions.* Rather variable; length 100—250  $\mu$ .

Neck and body chamber conical, broad. Bottom of body chamber flat, rarely inflated. Surface smooth. Walls not transparent; no internal structures observed.

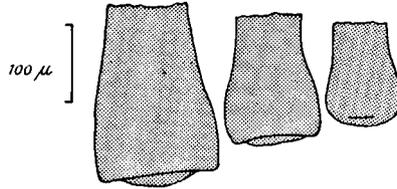
*Frequency and provenance.* Formigoso Formation: rare to common, especially near the top. Holotype from 0916, El Tueiro, NW-Spain.*Known stratigraphical range.* Upper Llandoveryan until Ludlovian, NW-Spain.

Fig. 46.

Genus *Cyathochitina* Eis. 1955.

Chitinozoans with a subcylindrical neck and a conical to campanulaeform body chamber that forms a sharp brim with the (usually flat) polar plane. A (transparent) keel may be present. Surface smooth or finely tuberculate, sometimes with longitudinal grooves.

The difference with the genus *Conochitina* Eis. consists in the rounded transition from the wall of the body chamber to the bottom.Genotype *Cyathochitina campanulaeformis* (Eis. 1931).*Cyathochitina campanulaeformis* (Eis. 1931).

Plate XXIX: 6, 7, 8, 12, 13, 14, 15.

*Dimensions.* Length 200 to more than 300  $\mu$ , maximal breadth 150—200  $\mu$ , rather variable.*Frequency and provenance.* Formigoso Formation: common to frequent; San Pedro Formation: rare in the lower part.*Known stratigraphical range.* Llandeilian to Caradocian, Estland — Eisenack (1962); Ordovician/Silurian, Aquitaine, SW-France — Taugourdeau (1961); Arenigian, Sahara — Benoit and Taugourdeau (1961); Middle and Upper Llandoveryan, Sahara — Taugourdeau (1962); Upper Llandoveryan to Ludlovian (part), NW-Spain.*?Cyathochitina dispar* B. & T. 1961.

Plate XXIII: 8, 13, 14.

*Dimensions.* Length 270—400  $\mu$ , rather variable.*Frequency and provenance.* Formigoso Formation: very rare to rare; San Pedro Formation: very rare to rare, absent in the very upper part; common in section Aralla de Luna, samples 0854 to 0858 (short forms).*Known stratigraphical range.* Arenigian, Sahara — Benoit and Taugourdeau (1961); Upper Llandoveryan to Ludlovian (part), NW-Spain.

?*Cyathochitina elenitae* n. sp.

Plate XXIII: 9\*, 10; text-figure 47.

*Dimensions*: Length 200—350  $\mu$  (300  $\mu$ ), rather variable.

Belly conical, rarely somewhat inflated; the neck grades into the body chamber and has a slightly widened mouth with a simple boundary. Bottom flat, rarely somewhat inflated, if so to a much less extent than ?*C. dispar* B. & T. A small but distinct keel is present, giving the bottom part of the species its determinative outline. Its habitus is slender. The wall has a smooth surface and is not transparent, no internal structures have been observed.

*Similar forms*. ?*C. dispar* B. & T. is larger and has a broad and thick habitus. The outline and dimensions of ?*C. elenitae* n. sp. are transitional between the slender forms of ?*C. dispar* B. & T. and *R. conocephala* Eis.

*Frequency and provenance*. Formigoso Formation: very rare in the upper part; San Pedro Formation: very rare to rare in the lower part, absent in the very upper part. Common near Aralla de Luna. Holotype from 0859, Aralla de Luna, NW-Spain.

*Known stratigraphical range*. Tremadocian (part) to Ludlovian (part), NW-Spain.

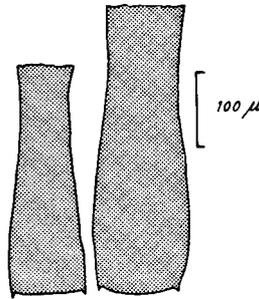


Fig. 47.

Genus *Clathrochitina* Eisenack 1959.

Translation of the german definition: "Chitinozoans with an outline similar to *Ancyrochitina ancyrea* (Eis.), and like these possessing appendages at the arboreal part. The ramifications of the appendages are joined and form a structure that is concentric to the body chamber".

Genotype *Clathrochitina clathrata* Eis. 1959.

The picture of the genotype in Eisenack (1959): Plate 3: 9, shows a chitinozoan with a perforate structure at the basal part of the body chamber. This structure is an homologon of a keel. Benoit and Taugourdeau (1961); Combaz & Poumont, (1961), and Taugourdeau (1962), attribute forms with perforate to reticulate keels, but with outlines quite distinct from *Anc. ancyrea*, to *Clathrochitina*.

It is suggested here that the definition of *Clathrochitina* be emended and altered as follows. Genus *Clathrochitina* Eis. emend.: Chitinozoans of variable outline with a perforate to reticulate keel, or a perforate to reticulate structure homologous to a keel.

*Remarks*. As far as could be made out from the few species of *Clathrochitina* met with in the Spanish Lower Palaeozoic and from the pictures in the papers mentioned above, the keel has, except for the perforations, a solid, not "cell-like" structure.

*Clathrochitina carmenchui* n. sp.

Plate XXII: 8, 9, 10; XXIV: 18\*.

*Dimensions.* Total length 120—180  $\mu$  (150  $\mu$ ).

Collar transparent, smooth, with a simple boundary. Body chamber conical, somewhat convex, grading within very short distance into a perforate keel. The perforations show a roughly vertical lineation. The wall is not transparent, its surface is smooth; no internal structures observed.

*Frequency and provenance.* Common in the upper part of the San Pedro Formation and the lower part of the La Vid Carbonate Member. Holotype from 0814, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Upper part of Ludlovian to Lower Gedinnian (part), NW-Spain.

Genus *Plectochitina* n. g.

Chitinozoans of roughly flask-shaped form with appendages situated at the arboreal end, made up by cell-like structures. Usually these appendages are but one or a few rows of cells thick; the appendages may be solid at the base, and then usually possess a reticulate surface.

The appendages may be bifurcate and anastomating, thus forming a complex net; they may be simple and just linked together; they may be simple and short; or they may be long and scarcely ramified.

*Plectochitina* n. g. differs from *Clathrochitina* Eis. emend. in the structure of its appendages.

Genotype *Plectochitina carminae* n. sp.

Beside the new species described hereafter, within the definition of the genus *Plectochitina* come the following:

*Ancyrochitina longicornis* T. & J. 1960.

*Ancyrochitina nodosa* T. & J. 1960.

?*Clathrochitina* sp. I, T. & J. 1960: fig. 32.

?*Ancyrochitina saharica* Tau. 1962.

?*Ancyrochitina fragilis* Eis. subsp. *pseudoagglutinans* Tau. 1963.

*Plectochitina carminae* n. sp.

?*Clathrochitina* sp. I, T. and J. 1960: fig. 32.

Plate XX: 19, 21\*; text-figure 48.

*Dimensions.* Length of body 100—160  $\mu$  (150  $\mu$ ), extension of appendages about 300  $\mu$ .

Collar transparent, smooth, with a simple boundary. Neck subcylindrical ending in a flask-shaped to spherical or funnel-shaped body chamber with inflated bottom. At the arboreal end it possesses a roughly symmetrical set of anastomating processes. Except for a relatively small solid part at the very base, the processes are entirely made up by small cell-like structures.

The surface of the body is smooth. The wall is not transparent, no internal structures observed.

*Frequency and provenance.* San Pedro Formation: common in the very top layers, just under the dolomitic sandstones, in the green shales near La Vid de Gordón and Aralla de Luna. Holotype from 0813, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Upper Silurian, Sahara, — Taugourdeau and de Jekhowsky (1960); probably Lower Gedinnian, NW-Spain.

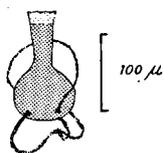


Fig. 48.

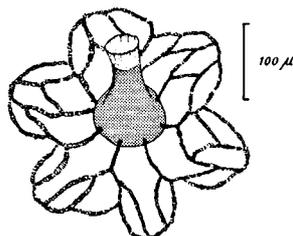


Fig. 49.

*Plectochitina pseudoagglutinans* (Tau. 1963).

?*Ancyrochitina fragilis* (Eis.) subsp. *pseudoagglutinans* Tau. 1963.

Plate XX: 24.

*Dimensions.* Length of body about 150  $\mu$ , rarely more.

*Frequency and provenance.* San Pedro Formation: rare in the upper part.

*Known stratigraphical range.* Middle and Upper Llandoveryan, Sahara — Taugourdeau and de Jekhowsky (1960), Tangourdeau (1963); Ludlovian (part) to Lower Gedinnian, NW-Spain.

*Plectochitina rosendae* n. sp.

Plate XX: 7\*; text-figure 49.

*Dimensions.* Length of body 100—150  $\mu$  (120  $\mu$ ).

Collar medium transparent, smooth, with a crenate boundary. Neck conical, ending in a conical to subspherical body chamber. At the base of the body chamber 3—7 (5) processes are present; they are linked together thus forming a set of rings. Except for the small solid part at the base, the processes are composed of roughly square cell-like structures. The surface of neck and body chamber is smooth, not transparent; no internal structures observed.

*Frequency and provenance.* San Pedro Formation: same as for *P. carminae* n. sp. Holotype from 0813, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Probably Lower Gedinnian, NW-Spain.

Genus *Desmochitina* Eis. 1931, emend. Eis. 1962.

Chitinozoans with vase- to flask-shaped shells, that are often constricted at short distance from the mouth and then grade into a short, cylindrical or plate- to bowl-shaped, neck or collar. The collar may be sharply separated from the body chamber, or may have a gradual transition to the body chamber. In rare occasions the collar is absent.

Genotype *Desmochitina nodosa* Eis. 1931.

*Remarks.* The species of the genus *Lagenochitina* Eis. are distinguished from the genus *Desmochitina* Eis. by their distinct flask-form and by the absence of the constriction near the mouth.

*Desmochitina cingulata* Eis. 1937.

Plate XXII: 17.

*Dimensions.* Length 80—120  $\mu$  (80—90  $\mu$ ).

*Frequency and provenance.* Formigoso and San Pedro Formation: rare to common.

*Known stratigraphical range.* Silurian — Wenlockian or Lower Ludlovian — Baltic region — Eisenack (1937); Upper Ordovician to Llandoveryan, Sahara — Taugourdeau and de Jakhowsky (1960); ?Devonian, Turkey — Taugourdeau and Abdusselamoglu (1962); Middle and Upper Llandoveryan, Sahara — Taugourdeau (1962); approximately Upper Llandoveryan to Lower Gedinnian, NW-Spain.

*Desmochitina densa* Eis. 1962.

Plate XXII: 1, 2, 3.

*Dimensions.* Length about 100  $\mu$ .

*Frequency and provenance.* Formigoso Formation: rare in the upper part; San Pedro Formation: very rare, absent in the very upper part.

*Known stratigraphical range.* Upper Visby-Marl, Llandoveryan, Baltic Region — Eisenack (1962); Tremadocian (part) to Ludlovian (part), NW-Spain.

*Desmochitina elegans* T. & J. 1960.

Plate XXII: 5, 13.

*Dimensions.* Length 180—200  $\mu$  (180  $\mu$ ).

*Frequency and provenance.* Formigoso Formation: very rare; San Pedro Formation: very rare in the lower part, rare in the upper part.

*Known stratigraphical range.* Silurian, except Llandoveryan, to lower part of Lower Devonian, Sahara — Taugourdeau and de Jekhowsky (1960); Upper Llandoveryan to Lower Gedinnian, NW-Spain.

*Desmochitina elegans* T. & J. var. *corta* n. var.

Plate XXI: 14, 15; XXII: 12, 15.

*Dimensions.* Length about 120  $\mu$ .

Variety of *Desmochitina elegans* T. & J. with greatly reduced copula.

*Frequency and provenance.* San Pedro Formation: very rare in the lower part, rare to common in the upper part, absent in the very upper layers.

*Known stratigraphical range.* Tremadocian (part) to Ludlovian, NW-Spain.

*Desmochitina erratica* Eis. 1931.

Plate XXIV: 2, 3 (damaged).

*Dimensions.* Length about 120  $\mu$ .

*Frequency and provenance.* Formigoso Formation: very rare in the lower part; San Pedro Formation: very rare in the middle part. The specimens from the San Pedro Formation have a slightly more slender habitus.

*Known stratigraphical range.* Wenlockian or Lower Ludlovian, erraticum — Eisenack (1931); Middle and Upper Llandoveryan, Sahara — Taugourdeau and de Jehowsky (1960), Taugourdeau (1962); Bohemian region, Silurian — Eisenack (1962). Upper Llandoveryan to Ludlovian, NW-Spain.

*Desmochitina leonensis* n. sp.

Plate XXII: 4\*; text-figure 50.

*Dimensions.* Total length of one unit about 100  $\mu$ .

Copula and body chamber about equal in length. Body chamber subellipsoidal to subspherical; copula bell-shaped. A fine smooth membrane surrounds the copula. The surface of the copula is smooth, showing a number of darker horizontal lines.

*Frequency and provenance.* San Pedro Formation: common in the upper part. Holotype from 0812, La Vid de Gordón, NW-Spain.

*Known stratigraphical range.* Ludlovian (part) to Lower Gedinnian, NW-Spain.

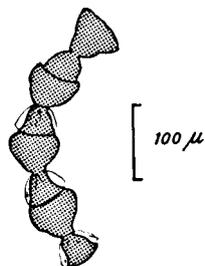


Fig. 50.

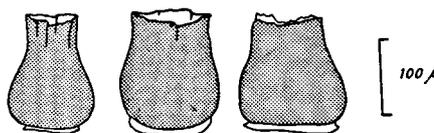


Fig. 51.

*Desmochitina panzuda* n. sp.

Plate XX: 14, 15, 16\*; text-figure 51.

*Dimensions.* Total length without keel 130—150  $\mu$ .

The species has a rather variable form. No collar; neck short, grades into a piriform to broadly flask-shaped body chamber. Keel very pronounced, transparent. Surface smooth; not transparent to transparent at the very top of the body chamber and neck. No internal structures observed.

The observed differences in outline do not seem to have stratigraphic usefulness in the region investigated.

*Frequency and provenance.* San Pedro Formation: rare in the upper part; La Vid Carbonate Member: rare; La Vid Shale Member: rare to dominant, especially at section Argovejo.

*Known stratigraphical range.* Lower Gedinnian to Emsian (part), NW-Spain.

*Desmochitina thyræ* n. sp.

Plate XXIV: 4\*, 5; text-figure 52.

*Dimensions.* Length 200—250  $\mu$ .

Body elongated tear-shape with a short, narrow copula. No keel. Wall smooth, not transparent; no internal structures observed.

*Frequency and provenance.* San Pedro Formation: very rare in the lower part. Holotype from 0859, Aralla de Luna, NW-Spain.*Known stratigraphical range.* Upper part of Tremadocian to lower part of Ludlovian, NW-Spain.*Desmochitina tinae* n. sp.

Plate XX: 13\*; text-figure 53.

*Dimensions.* Length of body about 100  $\mu$ ; length of copula 20—30  $\mu$ .

Neck very short (10 to 25 % of length of body) with a simple boundary. Body chamber ovoidal to subspherical provided with a stout copula. No keel. Wall smooth, not transparent; no internal structures observed.

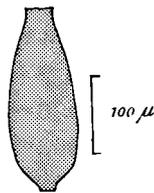
*Similar forms.* *D. pellucida* T. & J. has a much longer neck; *D. urceolata* T. & J. has a narrower copula.*Frequency and provenance.* Formigoso Formation: very rare in the very lower part. Holotype from 0902, El Tueiro, NW-Spain.*Known stratigraphical range.* Upper Llandoveryan, NW-Spain.

Fig. 52.

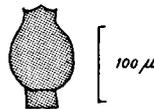


Fig. 53.

*Desmochitina urna* Eis. 1934.

Plate XX: 11, 12, 17, 18; XXII: 7 (distorted by compression).

*Dimensions.* Length of one unit 120—150  $\mu$ .*Frequency and provenance.* Formigoso Formation: very rare in the upper part; San Pedro Formation: rare to common, especially in the upper part near La Vid de Gordón.*Known stratigraphical range.* Silurian of Karlstein, Dworetz, Bohemian region — Eisenack (1937); Lower Arenigian, Sahara — Benoit and Taugourdeau (1961) (*D. cf. urna*); approximately Ludlovian to Lower Gedinian (part), NW-Spain.Genus *Lagenochitina* Eis. 1931.

Chitinozoans with flask-shaped outline; the maximal breadth (diameter) is not near the distal end, but towards the middle of the longitudinal axis. The body chamber grades into the neck. Mouth smooth.

Genotype: *Lagenochitina baltica* Eis. 1931.

*Lagenochitina brevicollis* Taugourdeau and de Jekhowsky (1960): fig. 110.

Plate XXIV: 10.

*Dimensions.* Length 150—200  $\mu$ , maximal breadth 100 — 150 $\mu$ .

The observed specimens all possess an angular outline, no ovoidal forms have been met with. The wall is smooth.

*Frequency and provenance.* Formigoso Formation: rare; San Pedro Formation: very rare in the lower part.

*Known stratigraphical range.* Upper Ordovician, Sahara — Taugourdeau and de Jekhowsky (1960); approximately Upper Llandoveryian to Ludlovian (part), NW-Spain.

*Lagenochitina brevicollis* T. & J. var. *granulata* n. var.

Plate XXIV: 9.

*Dimensions.* Length 150—200  $\mu$ , maximal breadth 100—150  $\mu$ .

This variety possesses a not transparent wall adorned with numerous small granules that are regularly distributed over the shell. The variety has a more rounded outline than *L. brevicollis* T. and J. from the same region.

*Frequency and provenance.* San Pedro Formation: very rare in the upper part.

*Known stratigraphical range.* Ludlovian (part), NW-Spain.

Genus *Rhabdochitina* Eis. 1931.

No original definition of the genus.

*Rhabdochitina conocephala* Eis. 1934.

Plate XXII: 14; XXIII: 7, 11, 12.

*Dimensions.* Length very variable, 200—450  $\mu$  (350  $\mu$ ).

*Frequency and provenance.* Formigoso Formation: common; San Pedro Formation: rare to very rare in the lower part.

*Known stratigraphical range.* Caradocian, Estland — Eisenack (1934); Upper and Middle Llandoveryian, Sahara — Taugourdeau and de Jekhowsky (1960); Upper Llandoveryian to Upper Tremadocian or Lower Ludlovian, NW-Spain.

*Rhabdochitina magna* Eis. 1931.

Text-figure 54.

*Dimensions.* Length up to more than 800  $\mu$ , breadth about 100  $\mu$ ; usually broken.

*Frequency and provenance.* Formigoso Formation: rare in the very lower part.

*Known stratigraphical range.* Llandeillian to Caradocian, Baltic Region — Eisenack (1962); Upper part of Ordovician to Middle Llandoveryian, Sahara — Benoit and Taugourdeau (1961); Upper Llandoveryian, NW-Spain.

Genus *Sphaerochitina* Eis. 1955.

Chitinozoans with a subcylindrical neck and funnel-shaped to broadly mushroom-shaped body chamber. Surface smooth or provided with tiny tubercles or tiny short spines without larger processes.

Genotype *Sphaerochitina sphaerocephala* Eis. 1955.

*Sphaerochitina fungiiformis* (Eis. 1931).

Plate XXI: 8; text-figure 55.

*Dimensions.* Length 120—180  $\mu$ .

*Frequency and provenance.* Formigoso Formation and San Pedro Formation: very rare.

*Known stratigraphical range.* Ordovician, Baltic region — Eisenack (1931); Silurian, Dlouha hora ( $E_2$ ), Bohemian region — Eisenack (1934) (*C. ex aff. fungiiformis*); Upper Llandoveryan to Ludlovian (part), NW-Spain.



Fig. 54.

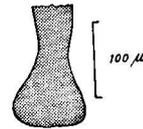


Fig. 55.

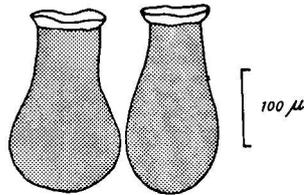


Fig. 56.

*Sphaerochitina llorona* n. sp.

Plate XXII: 3\*; 4, 6; text-figure 56.

*Dimensions.* Length 180—230  $\mu$  (200  $\mu$ ).

Rather variable species. Body chamber oval to piriform, grading into a short neck. Often the neck is absent at all. Collar medium transparent with wide opening and smooth boundary. Surface smooth, wall of body chamber and neck not transparent; no internal structures observed.

*Frequency and provenance.* San Pedro Formation: very rare in the middle part, especially near Oblanca de Luna. Holotype from 1170, Oblanca de Luna, NW-Spain.

*Known stratigraphical range.* Ludlovian (part), NW-Spain.

*Sphaerochitina sphaerocephala* (Eis. 1932).

Plate XX: 4, 5, 6.

*Dimensions.* Length 100—150  $\mu$ .

*Frequency and provenance.* Upper part of the San Pedro Formation, especially near Corniero and the reservoir of Vañes (Province of Palencia): common to rare; La Vid Shales, especially near Argovejo: common to rare.

*Known stratigraphical range.* Silurian, erraticum — Eisenack (1932); Famennian/Frasnian, Sahara — Taugourdeau and de Jekhowsky (1960); Famennian, Sahara — Taugourdeau (1962) (*Sph. cf. sphaerocephala*); Middle and Lower Ludlovian, Gotland — Eisenack (1962); upper part of Ludlovian to Emsian (part), NW-Spain.

*Sphaerochitina vitrea* Tau. 1962.

Plate XXI: 10, 11, 12, 13.

*Dimensions.* Length 150—250  $\mu$  (200  $\mu$ ).

*Frequency and provenance.* Formigoso Formation: rare in the upper part; San Pedro Formation: rare in the lower part.

*Known stratigraphical range.* Middle and Upper Llandoveryan, Sahara — Taugourdeau (1962, 1963); Upper Llandoveryan to Ludlovian (part), NW-Spain.

*Sphaerochitina longicollis* T. & J. 1960.

Plate XXII: 6.

*Dimensions.* Length up to 400  $\mu$ .

*Frequency and provenance.* La Vid Formation: very rare in the lower part.

*Known stratigraphical range.* Upper part of Silurian, Sahara — Taugourdeau and de Jekhowsky (1960); Upper Llandoveryan, Sahara — Taugourdeau (1962); approximately Upper Siegenian, NW-Spain.

## SUMARIO EN ESPAÑOL

El programa sistemático de la preparación del mapa geológico y estructural de las rocas Paleozoicas de la vertiente meridional de las Montañas Cantábricas en el Norte de España por estudiantes de la Universidad de Leiden (Holanda) ha dado impulso a muchas investigaciones estratigráficas. El objeto del presente estudio era investigar si existen microfósiles resistentes a ácidos minerales en los sedimentos pre-Carboníferos de las Montañas Cantábricas en las provincias de Palencia y León. Otro punto de interés era investigar si pueden utilizarse los mencionados microfósiles para fines estratigráficos.

En la zona investigada, la parte noroeste de la provincia de León, fué trazado un cierto número de secciones, de cada una de las cuales se recogió una serie de muestras. Unos 50 gramos o menos fueron tratados en el laboratorio palinológico. El cemento o una de los componentes minerales del sedimento o ambos, fueron disueltos en ácido apropiado: para calizas y margas el ácido clorhídrico o nítrico de 15 % de volumen; para los sedimentos pizarrosos o arenosos una mezcla de ácido fluorhídrico y peróxido de hidrógeno concentrados, con el fin de liberar los microfósiles de la materia mineral. Una vez terminada esta operación, el residuo fué separado en dos fracciones: una ligera y otra pesada. Se hizo esta separación con una mezcla de bromoformo y etanol de un peso específico de 2.0 en una centrifugadora. De la fracción ligera, conteniendo los microfósiles, fué eliminado el bromoformo con alcohol, y el alcohol con agua. Las placas fueron hechas de la manera usual en la palinología. Por lo general los microfósiles no necesitaban una oxidación para hacerlos más transparentes. En algunos raros casos el tratamiento de Schulze era ventajoso, pero por lo general los microfósiles tenían poca resistencia a la oxidación. El tratamiento con bases, a una concentración relativamente débil, era perjudicial en la mayoría de los casos. Por esta razón resulta mejor no neutralizar con base después del tratamiento con ácido. Los microfósiles de esta parte de la columna geológica no asimilaban fácilmente los colorantes. El efecto más grande tenía la coloración con 1 % de azafranina en alcohol.

Esta investigación se ha concentrado exclusivamente en las acritarchas y chitinozoos de las Formaciones de Formigoso, San Pedro y La Vid (Comte, 1959), de la edad del Llandoveryense Superior hasta el Emsiense Superior, en la provincia de León. Los resultados del estudio de las esporomorfias que fueron encontradas en los preparados de una parte de las muestras, no se conocen todavía.

La litoestratigrafía de la provincia de León ha sido esbozada, entre otros, por Comte (1959) y es a su división a la que ha sido adaptado el presente estudio. Están en uso otras divisiones estratigráficas en las regiones adyacentes, pero ya que todas ellas se fundan en su mayor parte sobre las unidades litoestratigráficas, es fácil compararlas (Lotze, 1957; Lotze and Szdzy, 1961; Poll, 1963; Radig, 1961).

El mapa geológico de la vertiente meridional de las Montañas Cantábricas por de Sitter (1962) muestra los rasgos estructurales y geológicos más importantes de esta parte de la cordillera.

Hasta esta fecha no han sido publicadas notas sobre el microplankton del Paleozoico de esta región.

Las frecuencias de los componentes de las asociaciones de acritarchas y chitinozoos en las Formaciones de San Pedro y de La Vid, han sido calculadas y representa-

das en unos diagramas. La repartición general de las especies y formas más comunes de acritarchas y chitinozoas ha sido sumariada en las figures 3 y 13a. Las especies y formas mencionadas en este trabajo han sido descritas o comentadas, una lista de ellas se encuentra en las páginas 280 y 337.

Como conclusión se puede poner que la mayoría de las especies de acritarchas y chitinozoas tienen un alcance por lo general bastante grande, aunque especies de un alcance más corto existen también. Las variaciones en frecuencia del microplankton representadas en diagramas palinológicos usuales pueden utilizarse para correlaciones de unidades más finas en las formaciones.

Las dos clases de microfósiles reciben escasa influencia de los cambios de facies representados en cambios de litología. De las especies más comunes ninguna tiene su punto de aparición o desaparición en el mismo lugar que el cambio de litología. Los cambios de facies ejercen influencia sobre las frecuencias de los distintos componentes de las asociaciones. La preservación depende de la tectonización de los sedimentos, ya que citada preservación es mucho más deficiente en los estratos cerca de fallas grandes o en capas finas de pizarra que se encuentran entre dos capas gruesas de cuarcita o arenisca.

## ABBREVIATIONS AND SYMBOLS USED

### *II. Treatment of samples:*

r/' — rotations per minute.

### *IV. Outline of the vertical distribution:*

#### *lithology.*

|   |  |
|---|--|
| <p><u>SH</u> — shales</p> <p><u>SS</u> — sandstones</p> <p><u>Q</u> — quartzites</p> <p><u>L</u> — limestones</p> <p><u>D</u> — dolomites</p> <p><u>M</u> — marl</p> <p><u>ML</u> — marly limestone</p> <p>st <u>SH</u> — silty shale</p> <p>→ — transition to . . . .</p> <p><u>W; weath</u> — weathered</p> | <p>SH — shaly</p> <p>S — sandy</p> <p>Q — quartzitic</p> <p>st — silty</p> <p>D — dolomitic</p> <p>M — marly</p> <p>fe — ferruginous</p> <p>. . . ./ . . . alternating</p> |
|---|--|

#### *color.*

|  |   |
|--|---|
| <p><u>gn.</u> — green</p> <p><u>gy.</u> — gray</p> <p><u>yw.</u> — yellow</p> <p><u>wh.</u> — white</p> <p><u>bl.</u> — blue</p> <p><u>bk.</u> — black</p> <p><u>bn.</u> — brown</p> | <p>gn. — greenish</p> <p>gy. — grayish</p> <p>yw. — yellowish</p> <p>wh. — light colored</p> <p>bl. — bluish</p> <p>d. — dark</p> <p>l. — light</p> |
|--|---|

#### *thickness.*

|  |  |
|--|--|
| <p>0: &lt;0.3 cm</p> <p>1: 0.3— 1 cm</p> <p>2: 1— 3 cm</p> <p>3: 3—10 cm</p> <p>fiss — fissile</p> | <p>4: 10—30 cm</p> <p>5: 30—100 cm</p> <p>6: &gt; 100 cm</p> <p>mass — massive</p> <p>smass — submassive</p> |
|--|--|

The red layers in the upper part of the La Vid Shale Member have been indicated by a shading of oblique stipples.

### *V. Description of the most common forms, etc.:*

|         |                           |
|---------|---------------------------|
| B. & T. | — Benoit and Taugourdeau. |
| C. & E. | — Cookson and Eisenack.   |
| C. & P. | — Combaz and Poumont.     |
| Cmr.    | — Cramer.                 |

|             |                                   |
|-------------|-----------------------------------|
| D., E. & S. | — Downie, Evitt and Sarjeant.     |
| D. & S.     | — Downie and Sarjeant.            |
| Defl.       | — Deflandre.                      |
| Dff.        | — Deunff.                         |
| Eis.        | — Eisenack.                       |
| O. & C.     | — van Oyen and Calandra.          |
| Sann.       | — Sannemann.                      |
| St. & W.    | — Stockmans and Willière.         |
| T. & Abd.   | — Taugourdeau and Abdusselamoglu. |
| T. & J.     | — Taugourdeau and de Jekhowsky.   |
| Tau.        | — Taugourdeau.                    |

*The descriptions.* Known stratigraphical range. "San Pedro Formation, Ludlovian" — indicates the whole ferruginous part of the sequence. It covers at least the Ludlovian, and may cover a part of the Tremadocian as well. (See "III.: General outline of the formations investigated").

*Frequency and provenance.* "Holotype". The situation of the samples of the sections Torrestío, Oblanca de Luna, Geras de Gordón, Santa Lucía de Gordón, La Vid de Gordón, Corniero, and Argovejo, can be found in the stratigraphical columns of the text-figures.

The samples 0900—0924 (Formigoso Formation) have been taken in section El Tueiro, situated at the left side of the river Bernesga, north of the village Villasimpliz, about 3 km north of the village La Vid. Beginning at the base of the formation, the samples have been taken at about equal distances.

The samples 0846—0862 (0846, basal part of the La Vid Formation; 0847—0860, San Pedro Formation; 0861—0862, top of the Formigoso Formation) have been taken from the second outcrop at the left side of the road from the village Cubillas de Arbas to the village Aralla de Luna.

The samples 0430—0436 have been taken from the first outcrop of the San Pedro Formation north of the village Los Barrios de Luna at the left side of the reservoir of the Luna. The sample with the lowest number is the oldest.

$\emptyset_i$  = diameter of the central body (=  $\emptyset_{cb}$ ).

$\emptyset_t$  = total diameter, including processes.

*Chitinozoans:*

|             |                         |
|-------------|-------------------------|
| <i>Anc.</i> | — <i>Ancyrochitina</i>  |
| <i>Ang.</i> | — <i>Angochitina</i>    |
| <i>Cy.</i>  | — <i>Cyathochitina</i>  |
| <i>Cl.</i>  | — <i>Clathrochitina</i> |
| <i>Co.</i>  | — <i>Conochitina</i>    |
| <i>P.</i>   | — <i>Plectochitina</i>  |
| <i>D.</i>   | — <i>Desmochitina</i>   |
| <i>L.</i>   | — <i>Lagenochitina</i>  |
| <i>Rh.</i>  | — <i>Rhabdochitina</i>  |
| <i>Sph.</i> | — <i>Sphaerochitina</i> |

## REFERENCES

- BENOIT, A., and TAUGOURDEAU, PH., 1961. Sur quelques Chitinozoaires de l'Ordovicien du Sahara. *Rev. Inst. fr. Pétrole*, XVI/12, pp. 1403-1421.
- COLLINSON, C., and SCHWALB, H., 1955. North American Paleozoic Chitinozoa. *Illinois State Geol. Surv.*, 186, 33 p.
- COLLINSON, C., and SCOTT, A. J., 1958. A Chitinozoan faunule of the Devonian Cedar Valley Formation. *Illinois State Geol. Surv.*, 247, 34 p.
- COMBAZ, A., and POUMONT, C., 1963. Observations sur la structure des Chitinozoaires. *Rev. Micropaléont.*, 5/3, pp. 147-160.
- CRAMER, F. H., 1963. Nota provisional sobre la presencia de microplankton y esporomorfos en las rocas sedimentarias del Devónico Inferior en las Montañas Catáblicas. *Estudios Geológicos*, XIX, pp. 215-218.
- 1964. Some Acritarchs from the San Pedro Formation of the Cantabric Mountains in Spain. *Bull. Soc. Géol. Hydr. belge*, (in press).
- COMTE, P., 1959. Recherches sur les terrains anciens de la Cordillère cantabrique. *Mem. Inst. Geol. Min. España*, LX, pp. 1-440, carte géol.
- DEFLANDRE, G., 1942. Sur les microfossiles des calcaires siluriens de la Montagne Noire. *Les Chitinozoaires*. C. R. Acad. Sc., 215, pp. 286-288.
- 1945. Microfossiles des calcaires siluriens de la Montagne Noire. *Ann. Paléontologie*, 31, pp. 41-75.
- DEFLANDRE, G., and DEFLANDRE-RIGAUD, M., 1962. Nomenclature et systématique des Hystrichosphères (sens. lat.). Observations et rectifications. *Rev. Micropaléont.*, 4/4, pp. 190-196.
- DEUNFF, J., 1954a. Sur le microplancton du Gothlandien armoricain. *C.R. Soc. géol. Fr.*, pp. 54-55.
- 1954b. Microorganismes planctoniques (Hystrichosphères) dans le Dévonien du Massif armoricain. *C.R. Soc. géol. Fr.*, pp. 239-242.
- DEUNFF, J., 1954c. Veryhachium, genre nouveau d'Hystrichosphères du Primaire. *C.R. Soc. géol. Fr.*, pp. 305-306.
- 1955. Un microplancton fossile Dévonien à Hystrichosphères du continent Nord-Américain. *Bull. Microsc. appl.* 5, pp. 138-149.
- 1957. Microorganismes nouveaux (Hystrichosphères) du Dévonien de l'Amérique du Nord. *Bull. Soc. Géol. Minér. Bretagne*, 2, pp. 5-14.
- 1958. Microorganismes planctoniques du Primaire breton, I, Ordovicien du Veryhac'h (presqu'île de Crozon). *Bull. Soc. Géol. Minér. Bretagne*, n.s. 2, pp. 1-42.
- 1961. Un microplancton à Hystrichosphères dans le Tremadoc du Sahara. *Rev. Micropaléont.*, 4, pp. 37-52.
- DOWNIE, C., 1958. An Assemblage of Microplancton from the Shineton Shales (Tremadocian). *Proc. Yorksh. geol. Soc.*, 31, pp. 331-350.
- 1959. Hystrichospheres from the Silurian Wenlock Shale of England. *Palaeontology*, 2, pp. 56-71.
- 1960. Deunffia and Domasia, new genera of Hystrichospheres. *Micropaleontology*, 6, pp. 197-202.
- 1963. "Hystrichospheres" (acritarchs) and spores of the Wenlock Shales (Silurian) of Wenlock, England. *Palaeontology*, 6, pp. 625-652.
- DOWNIE, C., EVITT, W. R., and SARJEANT, W. A. S., 1963. Dinoflagellates, hystrichospheres and the classification of acritarchs. *Stanford Univ. Geol. Papers*, 7, 3, pp. 3-16.
- DOWNIE, C., and SARJEANT, W. A. S., 1963. On the interpretation and status of some hystrichosphere genera. *Palaeontology*, vol. 6, pp. 83-96.
- DOWNIE, C., WILLIAMS, G. L., and SARJEANT, W. A. S., 1961. Classification of fossil microplankton. *Nature*, 192, p. 471.

- DUNN, D. L., 1959. Devonian Chitinozoans from the Cedar Valley Formation in Iowa. *Journ. Paleont.*, 33, pp. 1001-1017.
- EISENACK, A., 1931. Neue Mikrofossilien des baltischen Silurs. I. *Paläont. Z.*, 13, pp. 74-118.
- 1937. Neue Mikrofossilien des baltischen Silurs. IV. *Paläont. Z.*, 19, pp. 217-43.
- 1938a. Hystrichosphärideen und verwandte Formen im baltischen Silur. *Z. Geschiebeforsch.*, 14: pp. 1-30.
- 1939. Chitinozoen und Hystrichosphaerideen im Ordovizium des Rheinischen Schiefergebirges. *Seckenbergiana*, 21, pp. 135-152.
- 1948. Mikrofossilien aus Kiesselknollen des böhmischen Ordoviziums. *Senck. leth.*, 28, pp. 105-117.
- 1951. Über Hystrichosphaerideen und andere Kleinformen aus dem baltischen Silur und Kambrium. *Seckenbergiana*, 32, pp. 187-204.
- 1954a. Hystrichosphären aus dem baltischen Gotlandium *Seckenbergiana*, 34, pp. 205-211.
- 1954b. Mikrofossilien aus Phosphoriten des samländischen Unteroligozäns und über die Einheitlichkeit der Hystrichosphaerideen. *Palaeontographica*, (A), 105, pp. 49-95.
- 1955a. Chitinozoen, Hystrichosphären und andere Mikrofossilien aus dem Beyrichia-Kalk. *Senck. leth.*, 36, pp. 157-188.
- 1955b. Neue Chitinozoen aus dem Silur des Balticums und dem Devon der Eifel. *Senck. leth.*, 36, pp. 311-319.
- 1959a. Neotypen baltischer Silur-Hystrichosphären und neue Arten. *Palaeontographica*, (A), 112, pp. 193-211.
- 1959b. Neotypen baltischer Silur-Chitinozoen und neue Arten. *N. Jb. Geol. Paläont. Abh.*, 108, pp. 1-20.
- 1926a. Chitinozoen aus Sedimenten Gotlands. *N. Jb. Geol. Paläont. Mh.*, 4, pp. 218-219.
- 1962b. Neotypen baltischer Silur-Chitinozoen und neue Arten. *N. Jb. Geol. Paläont. Abh.*, 114, pp. 291-316.
- 1963. Hystrichosphären. *Biological Reviews*, Vol. 38, pp. 107-139.
- EVITT, W. R., 1961. Observations on the morphology of fossil dinoflagellates. *Micropaleontology*, Vol. 7, pp. 385-411.
- 1962. A discussion and proposals concerning fossil Dinoflagellates, Hystrichospheres, and Acritarchs. *Proc. N.A.S.*, Vol. 49, pp. 158-64; 298-302.
- DE JEKHOVSKY, B., 1958. Méthodes d'utilisation stratigraphique des microfossiles organiques dans les problèmes pétroliers. *Rev. Inst. fr. Pétrole*, XIII, pp. 1391-1418.
- 1959. Une technique standard de préparation des roches pour l'étude des microfossiles organiques. *Rev. Inst. fr. Pétrole*, XIV, pp. 315-320.
- DE JEKHOVSKY, B., and TAUGOURDEAU, PH., 1959. Sur la présence de nombreux Chitinozoaires dans le Siluro-Dévonien du Sahara. *C.R. Somm. Soc. Géol. France*, 1, pp. 17-18.
- KOZŁOWSKI, R., 1963. Sur la nature des Chitinozoaires. *Acta Palaeont. Polonica*, VIII, pp. 425-449.
- LOTZE, F., 1957. Zum Alter nordwestspanischer Quarzit-Sandstein-Folgen. *N. Jb. Geol. Paläont. Mh. B.* 1957, H. 10, pp. 464-471.
- LOTZE, F., and SDZUY, K., 1961. Das Kambrium Spaniens. *Abh. Akad. Wiss. Lit. Mainz. math.-nat. Kl.* 6, pp. 1-216, and Nr. 8, pp. 409-411.
- VAN OYEN, F. H., and CALANDRA, F., 1963. Note sur les Chitinozoaires. *Rev. Micropaléont.* 6 A/1, 1, pp. 13-18.
- PLAYFORD, G., 1962. Lower Carboniferous Microfloras of Spitsbergen. *Palaeontology*, Vol. 5, pp. 550-618.
- POLL, K., 1963. Zur Stratigraphie des Altpaläozoikums von Belmonte (Asturien, Nordspanien). *N. Jb. Geol. Paläont. Abh.*, 117, pp. 235-250.
- RADIG, F., 1961. Zur Stratigraphie des Devons in Asturien (Nordspanien). *Geol. Rundschau*, 51, pp. 249-267.
- SANNEMANN, D., 1955. Hystrichosphaerideen aus dem Gotlandium und Mittel-Devon des Frankenwaldes und ihr Feinbau. *Senck. leth.*, 36, pp. 321-346.

- SARJEANT, W. A. S., 1961. The hystrichospheres, a review and discussion. *Grana Palynolog.*, 2, pp. 101-109.
- 1964. Taxonomic note on hystrichospheres and acritarchs. *Journ. Paleont.*, Vol. 38, pp. 173-177.
- SCHALLREUTER, R., 1963. Neue Chitinozoen aus ordovizischen Geschieben und Bemerkungen zur Gattung *Illichitina*. *Paläont. Abh.* 1, pp. 293-403.
- DE SITTER, L. U., 1962. The structure of the southern slope of the Cantabrian Mountains: explanation of a geological map with sections, scale 1 : 100.000. *Leidse Geol. Mededel.*, 26, pp. 255-264.
- STAPLIN, F. L., 1961. Reef controlled distribution of Devonian microplankton in Alberta. *Palaeontology*, 4, pp. 392-424.
- STOCKMANS, F., & WILLIÈRE, Y., 1960. Hystrichosphères du Dévonien belge (Sondage de l'Asile d'aliénés à Tournai). *Senck. leth.*, Bd 41, pp. 1-11.
- 1962. Hystrichosphères du Dévonien belge (Sondage de l'Asile d'aliénés à Tournai). *Bull. Soc. Géol. belge*, LXXI, pp. 41-77.
- 1962. Hystrichosphères du Dévonien belge (Sondage de Wépion). *Bull. Soc. Géol. belge*, LXXI, pp. 83-99.
- 1963. Les Hystrichosphères ou mieux les Acritarches du Silurien belge. Sondage de la Brasserie Lust à Courtrai (Kortrijk). *Bull. Soc. Géol. belge*, LXXI, pp. 450-481.
- TAUGOURDEAU, PH., and DE JEKHOVSKY, B., 1960. Répartition et description des Chitinozoaires siluro-dévonieniens de quelques sondages de la C.R.E.P.S., de la C.F.P.A. et de la S.N. Repal du Sahara. *Rev. Inst. fr. Pétrole*, XV, pp. 1190-1259.
- TAUGOURDEAU, PH., 1961. Chitinozoaires du Silurien d'Aquitaine. *Rev. Micropaléont.*, 4, pp. 135-154.
- 1962. Associations de Chitinozoaires dans quelques sondages de la région d'Edjelé, Sahara, *Rev. Micropaléont.*, 4, pp. 229-236.
- 1963. Association de Chitinozoaires sahariens du Gotlandien supérieur (Ludlovien). *Bull. Soc. Géol. France*, 7e série, IV, pp. 806-808.
- TAUGOURDEAU, PH., and ABDUSSELAMOGLU, S., 1962. Présence de Chitinozoaires dans le Siluro-Dévonien turc des environs d'Istanbul. *C.R. Soc. géol. Fr.*, 8., pp. 238-239.
- WAGNER, R. H. 1963. A general account of the Palaeozoic rocks between the rivers Porma and Benesga (León, NW Spain). *Bol. Inst. Geol. Min. España*, 74, 190 pp., geol. map.
- WAGNER, R. H., and WAGNER-GENTIS, C. H. T., 1963. Summary of the stratigraphy of Upper Palaeozoic rocks in NE Palencia, Spain. *Kon. Ned. Akad. Wetensch. Proceedings, Series B*, LXVI, pp. 149-163.
- WALL, D., and DOWNIE, C., 1963. Hystrichospheres from the Permian. *Palaeontology*, 5, pp. 770-784.

The literature by TIMOFEEV was not accessible to the author when this paper was prepared.

## PLATES

*The length of the lines on the photos of Plates I to XIX is 10  $\mu$  unless otherwise indicated.  
The figure numbers marked with an asterisk indicate holotypes*

PLATE I

- 1.\* *Baltisphaeridium pilar* n. sp.
2. Detail of *Baltisphaeridium pilar* n. sp.
- 3.\* *Baltisphaeridium traumaticum* n. sp.
- 4.\* *Baltisphaeridium juliae* n. sp.
5. *Baltisphaeridium traumaticum* n. sp., form with short processes.
6. *Baltisphaeridium malum* n. sp.
7. *Baltisphaeridium erraticum* Eis.
- 8.\* *Baltisphaeridium malum* n. sp.
- 9.\* *Baltisphaeridium gordonense* n. sp.
10. *Baltisphaeridium malum* n. sp., form with relatively long processes.
- 11.\* *Baltisphaeridium borracherosum* n. sp.
- 12.\* *Baltisphaeridium guapum* n. sp.
- 13.\* *Baltisphaeridium carinosum* n. sp.
14. Detail of *Baltisphaeridium toyetae* n. sp.
- 15.\* *Baltisphaeridium toyetae* n. sp.
16. *Baltisphaeridium echinodermum* St. & W.

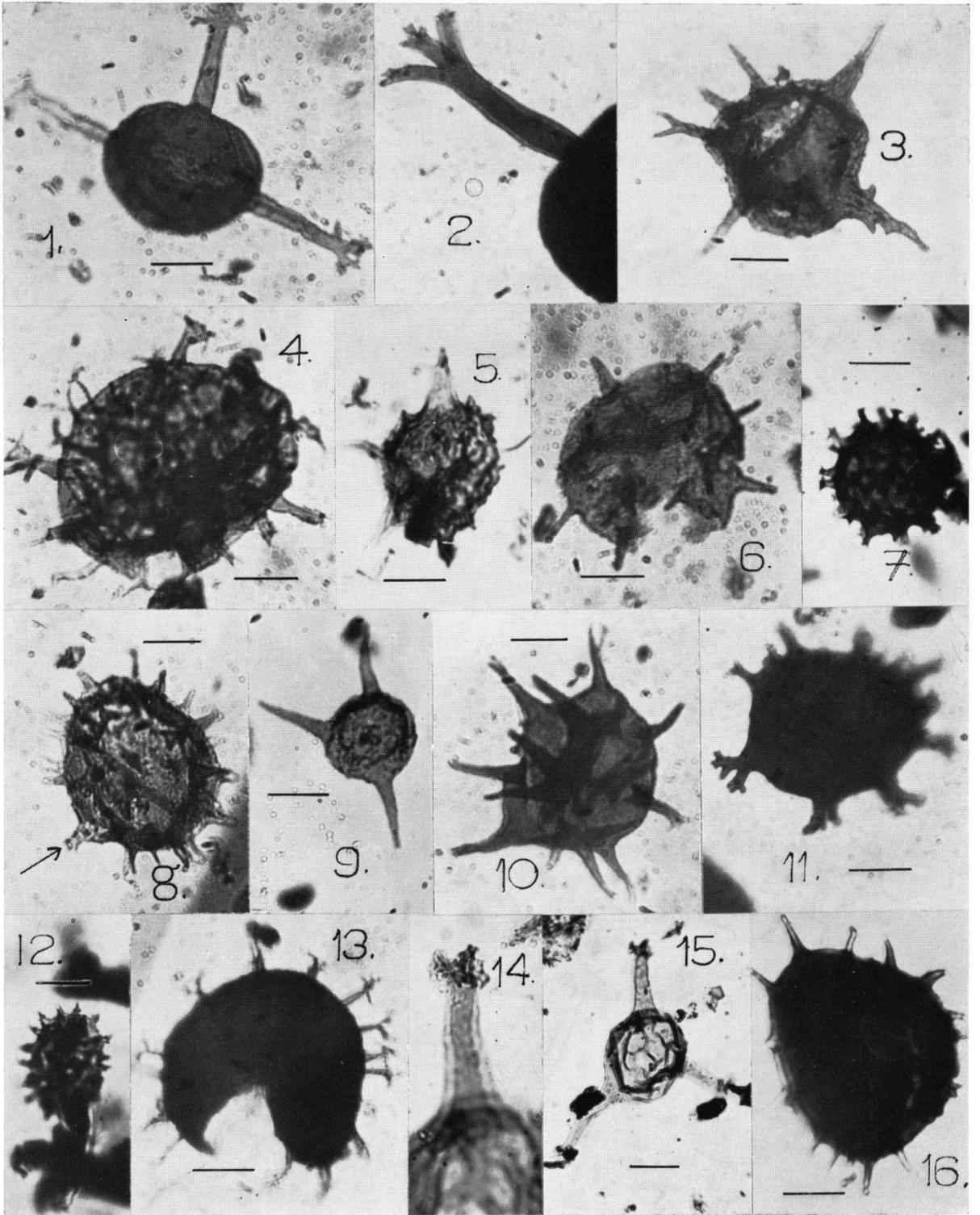


PLATE II

- 1.\* *Baltisphaeridium dedosmuertos* n. sp.
2. Detail of processus of *Baltisphaeridium dedosmuertos* n. sp.
3. *Baltisphaeridium paraguaferum* n. sp.
- 4.\* *Baltisphaeridium paraguaferum* n. sp.
- 5 and 6. *Baltisphaeridium microfurcatum* (Dff.)
- 7.\* *Baltisphaeridium brazosdesnudum* n. sp.
8. *Baltisphaeridium dilatispinosum* Downie.
- 9\* and 10.\* *Baltisphaeridium robertinum* n. sp.
11. *Baltisphaeridium microfurcatum* (Dff.)
13. *Baltisphaeridium microfurcatum* (Dff.)
- 15.\* *Baltisphaeridium lobeznum* n. sp.
- 16.\* *Baltisphaeridium escobaides* n. sp.
17. *Baltisphaeridium cf. arbusculiferum* Downie.
18. *Baltisphaeridium arbusculiferum* Downie.

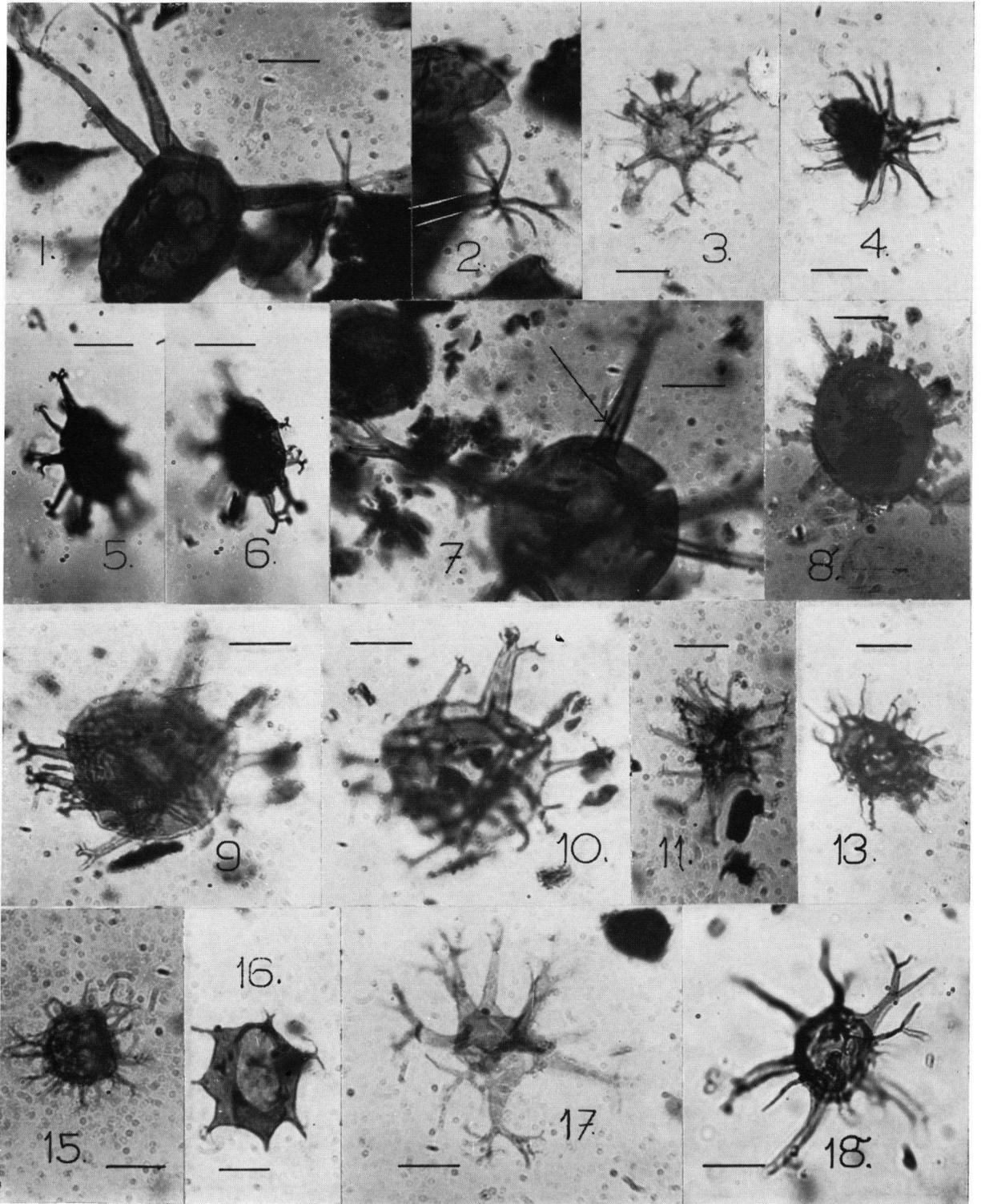


PLATE III

- 1 and 2. *Baltisphaeridium cf. arbusculiferum* Downie.
3. *Baltisphaeridium cf. ramusculosum* (Defl.)
4. *Baltisphaeridium ramusculosum* (Defl.)
- 5 and 6. *Baltisphaeridium ramusculosum* (Defl.)
7. *Baltisphaeridium cf. lobeznum* n. sp.
8. *Baltisphaeridium ramusculosum* (Defl.)
9. *Baltisphaeridium ramusculosum* (Defl.)
10. *Baltisphaeridium arbusculiferum* Downie.
11. *Baltisphaeridium arbusculiferum* Downie.
12. *Baltisphaeridium cf. fissile* St. & W.
13. *Acritarch* sp. III.
15. *Baltisphaeridium denticulatum* St. & W. var. *sanpetri* n. var.
- 16.\* *Baltisphaeridium denticulatum* St. & W. var. *sanpetri*, n. var.
17. Processus of *Baltisphaeridium denticulatum* St. & W.

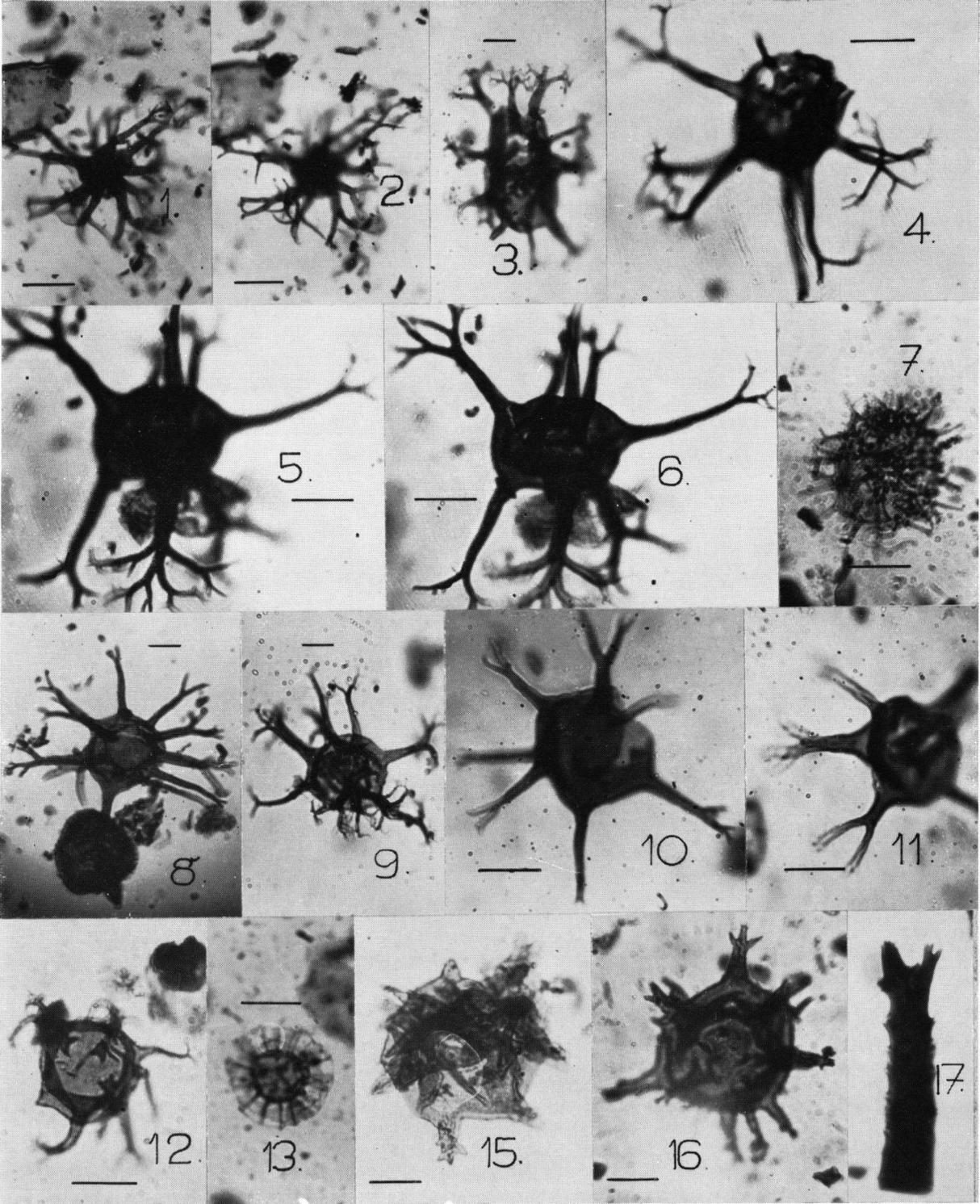


PLATE IV

- 1.\* *Baltisphaeridium raspa* n. sp.
2. *Baltisphaeridium raspa* n. sp.
3. *Baltisphaeridium raspa* n. sp.
- 4 and 5. *Baltisphaeridium raspa*, n. sp., form with relatively long processes.
- 6 and 11. *Baltisphaeridium raspa* n. sp., form with relatively long processes.
7. ?*Baltisphaeridium carminae* n. sp.
8. *Baltisphaeridium* cf. *astartes* Sann.
9. *Baltisphaeridium* cf. *astartes* Sann.
- 10.\* *Baltisphaeridium guillermi* n. sp.
- 12\* and 13.\* ?*Baltisphaeridium carminae* n. sp.
14. *Baltisphaeridium trifurcatum* (Eis.) cf. var. *procerum* Sann.
- 15.\* *Baltisphaeridium cantabricum* n. sp.
16. *Baltisphaeridium cantabricum* n. sp.
17. *Lophodiacrodium pepino* n. sp.

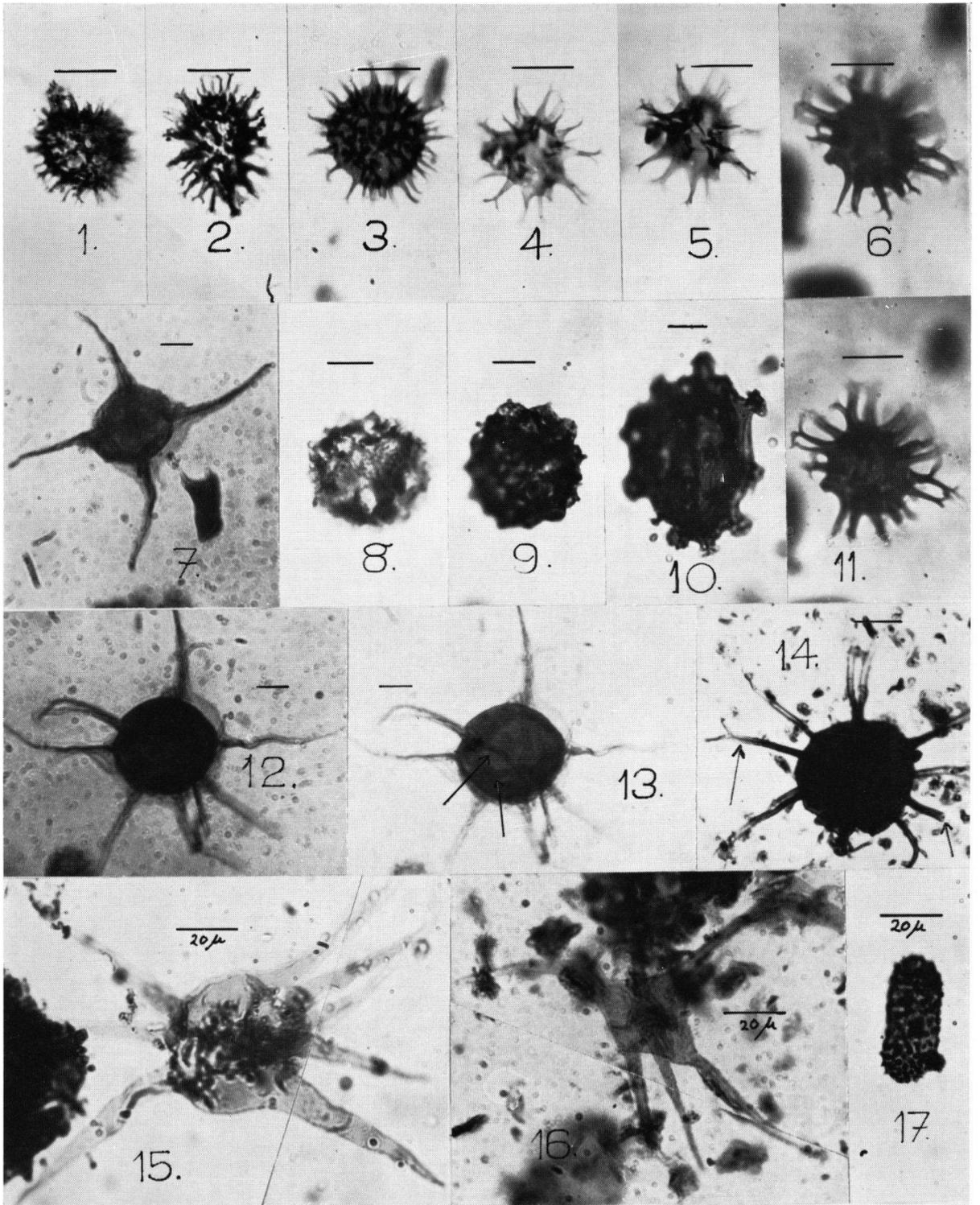


PLATE V

- 1.\* *Baltisphaeridium duplex* n. sp.
2. *Baltisphaeridium duplex* n. sp.
- 3.\* *Lophodiacrodium pepino* n. sp.
4. ?*Baltisphaeridium duplex* n. sp.
5. ?*Baltisphaeridium duplex* n. sp.
6. *Acritarch* sp. II.
- 7.\* *Veryhachium rabiosum* n. sp.
- 8.\* *Baltisphaeridium raczi* n. sp.
9. *Helios aranaides* n. sp.
10. *Lophodiacrodium pepino* n. sp.

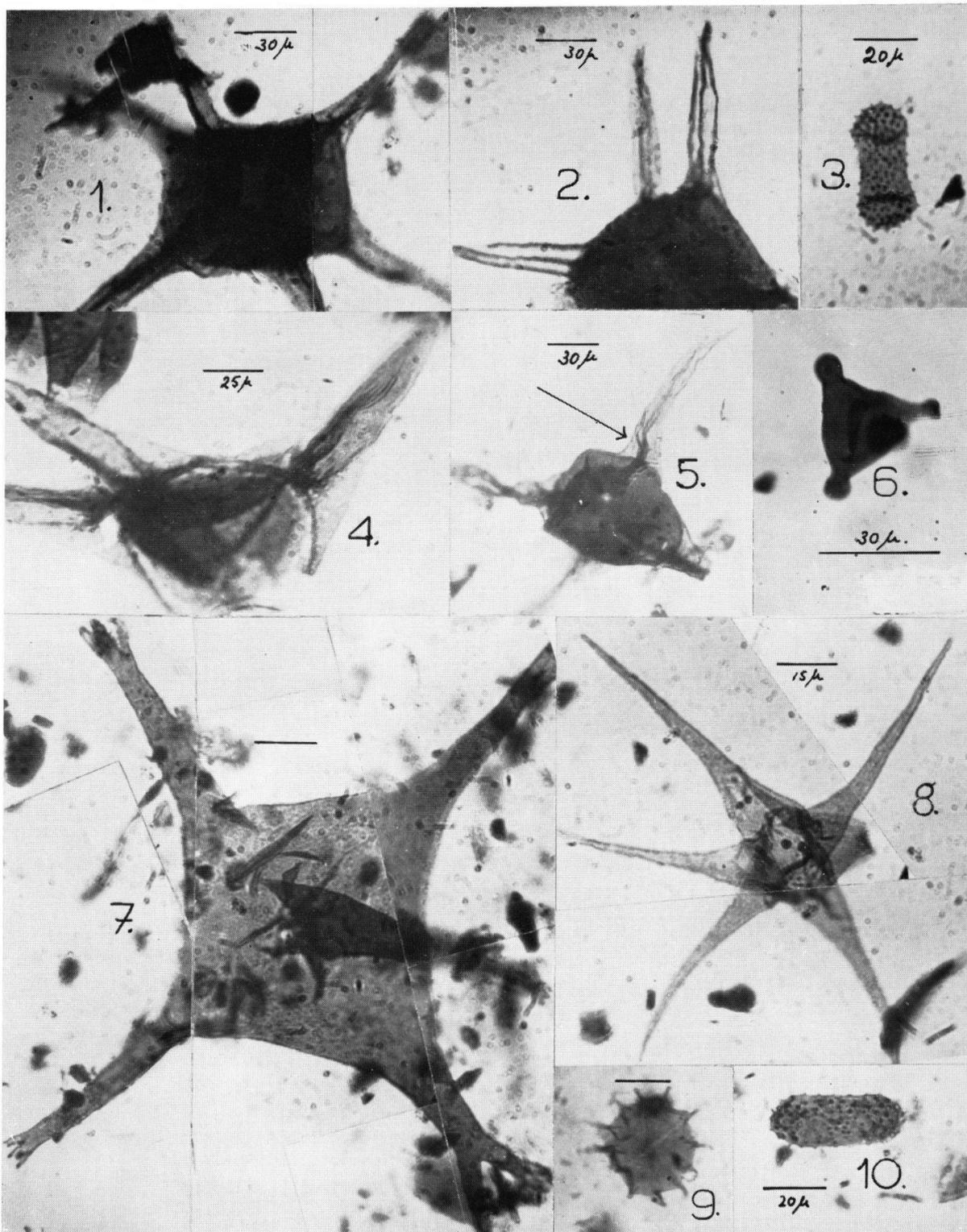


PLATE VI

1. *Triangulina alargada* n. sp.
- 2.\* *?Hystrichosphaeridium huecospinosum* n. sp.
3. *Veryhachium cf. rabiosum* n. sp., very simple form.
- 4.\* *Triangulina alargada* n. sp.
- 5.\* *Baltisphaeridium molinum* n. sp.
- 6.\* *Leiofusa fastidiona* n. sp.
7. *Baltisphaeridium molinum* n. sp.
8. *Veryhachium rabiosum* n. sp., transitional form.
9. *Cymatiosphaera carminae* n. sp.
10. *Leiofusa bernesga* n. sp.
11. *Cymatiosphaera*, sp., damaged specimen.

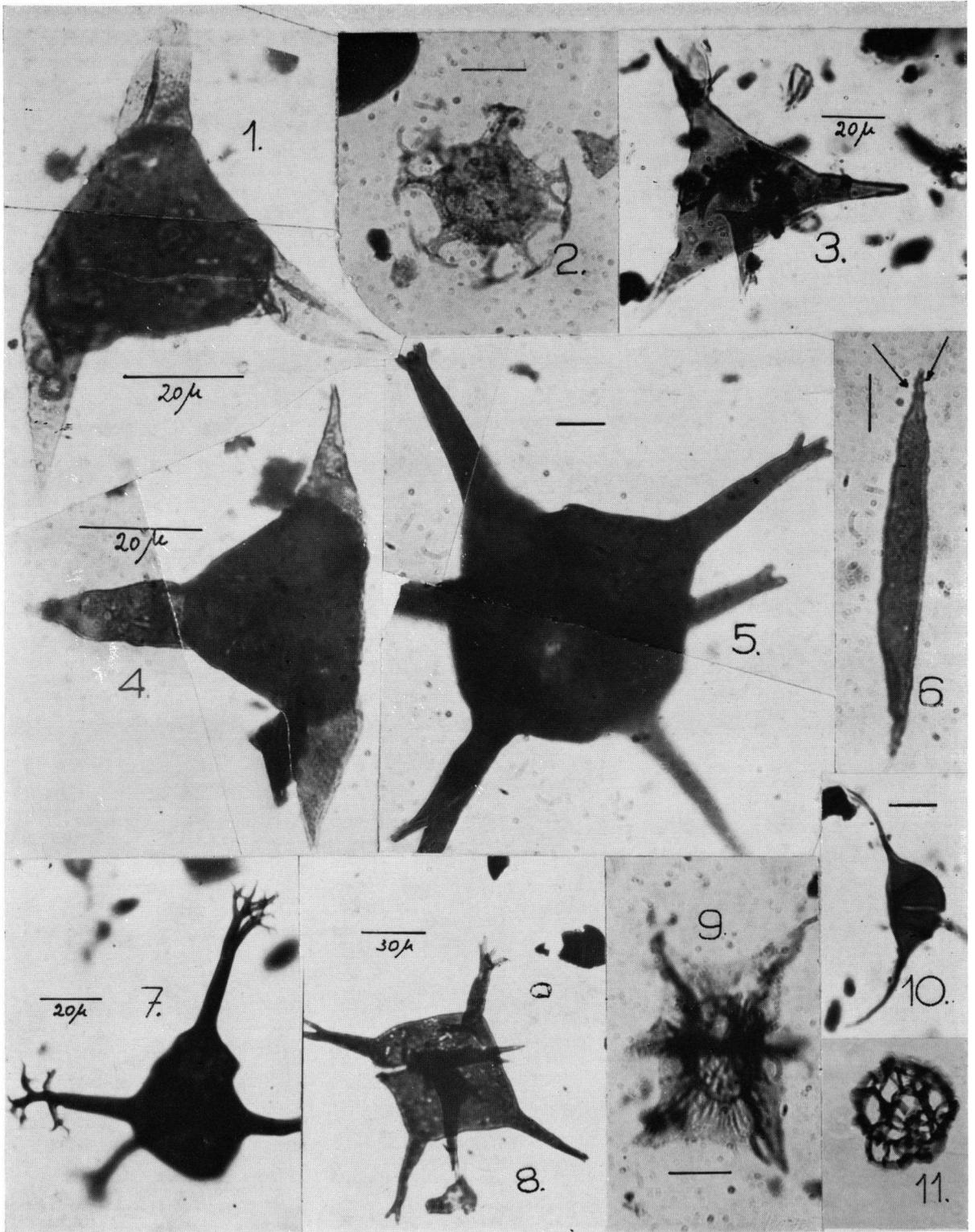


PLATE VII

- 1.\* *Micrhystridium malpeinadum* n. sp.
2. *Baltisphaeridium oligofurcatum* (Eis.)
3. *Baltisphaeridium lobeznum* n. sp.
4. *Baltisphaeridium polygonale* (Eis.)
5. *Veryhachium rabiosum* n. sp., transitional to *Baltisphaeridium raczi* n. sp.
6. *Baltisphaeridium denticulatum* St. & W., form with rather short processes.
- 7.\* *Cepillum puercoespinoide* n. sp.
8. *Veryhachium rabiosum* n. sp., transitional to *Baltisphaeridium raczi* n. sp.
9. *Veryhachium rabiosum* n. sp., transitional to *Baltisphaeridium molinum* n. sp.
10. *Tetraporina horologia?* (Staplin 1960): Playford 1962.
11. *Tetraporina horologia?* (Staplin 1960): Playford 1962.

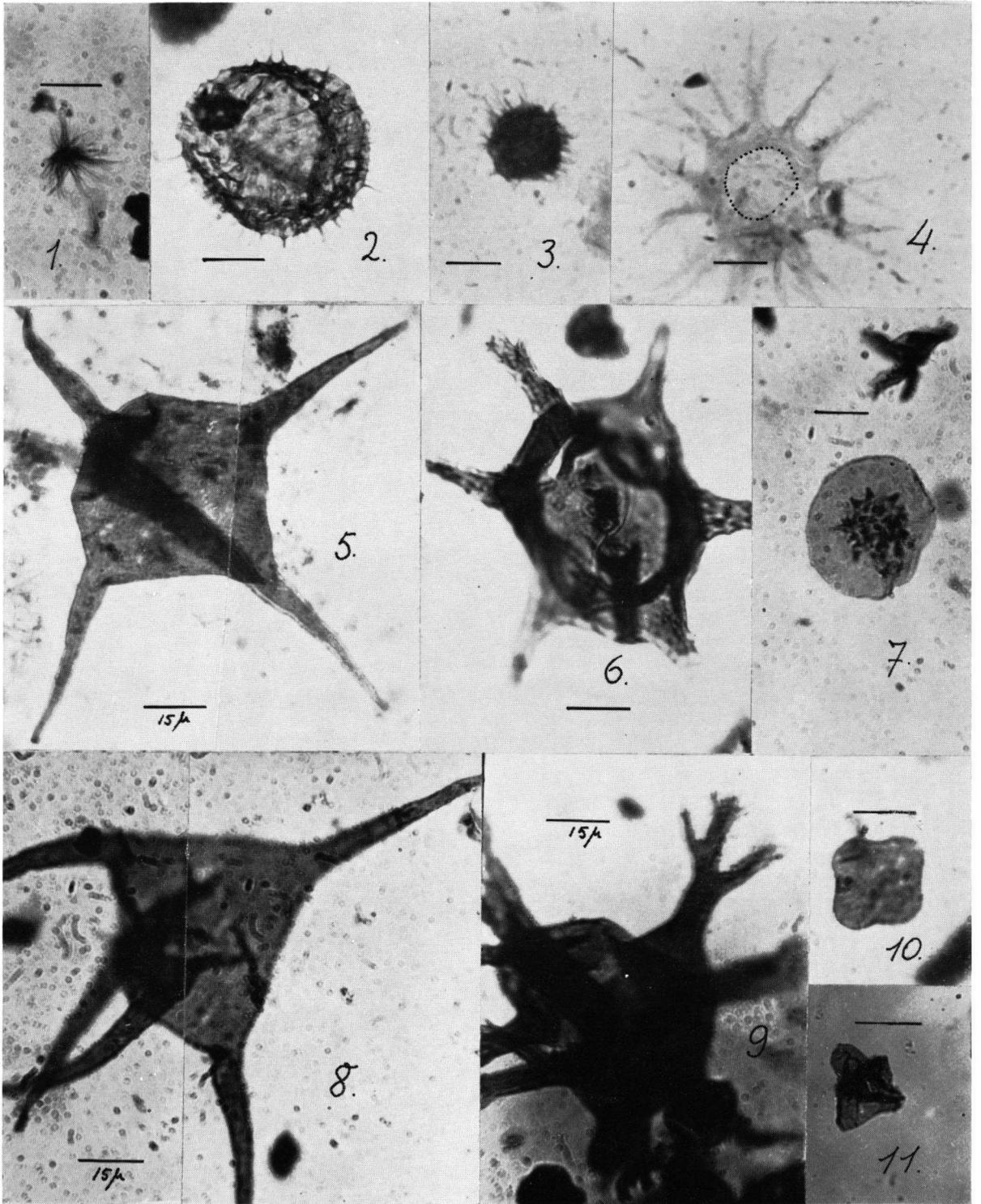


PLATE VIII

Formgroup *Verhachium trispinosum* (Eis.)

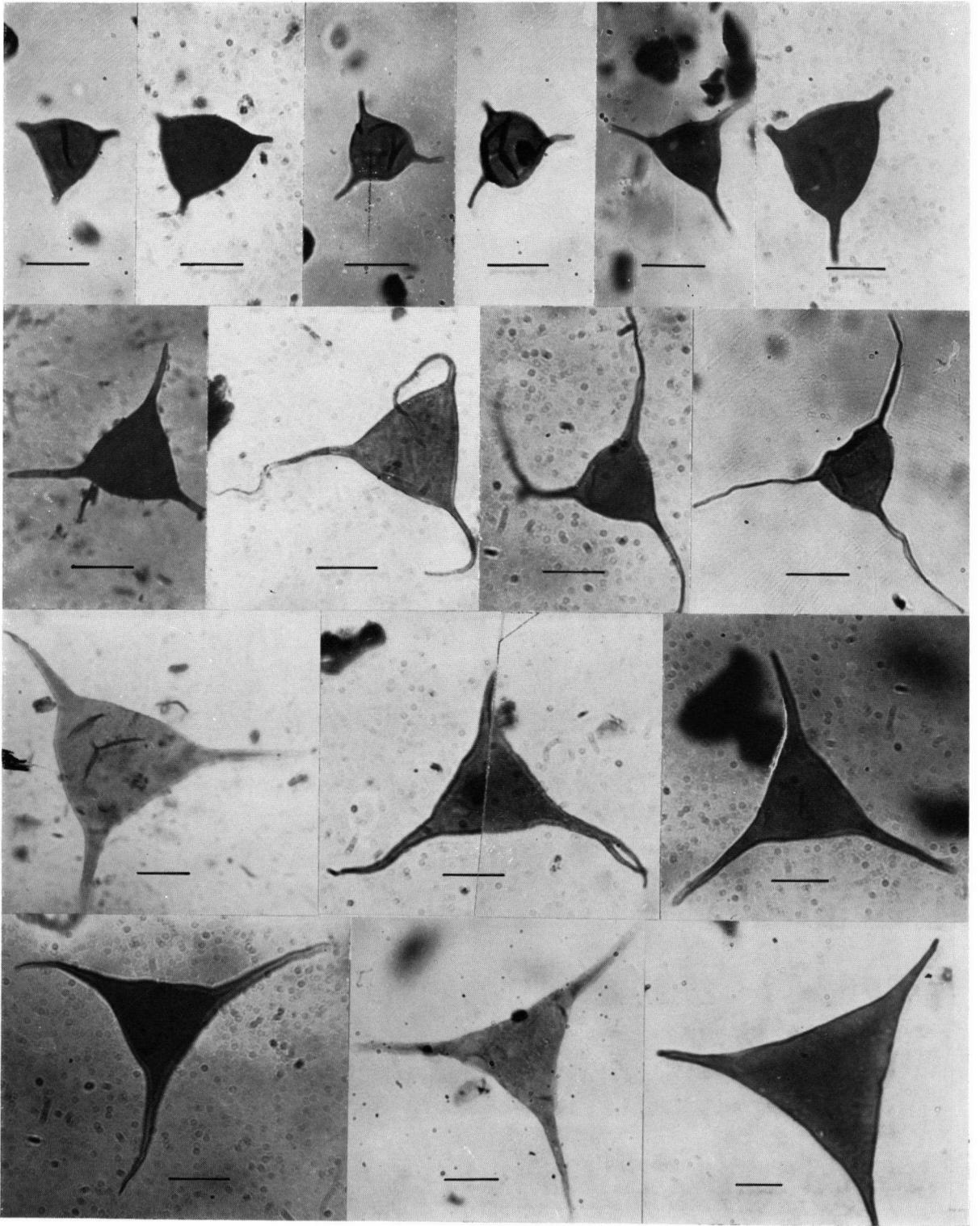


PLATE IX

1. *Veryhachium geometricum* (Defl.), formgroup *Veryhachium trispinosum*
2. *Veryhachium trispiniflatum* n. sp.
- 3.\* *Veryhachium trispiniflatum* n. sp.
4. *Veryhachium europaeum* St. & W.
- 5.\* *Veryhachium inflatissimum* n. sp.
6. *Veryhachium europaeum* St. & W.
7. *Veryhachium europaeum* St. & W.
- 8 to 13. Formgroup *Micrhystridium stellatum* Defl.

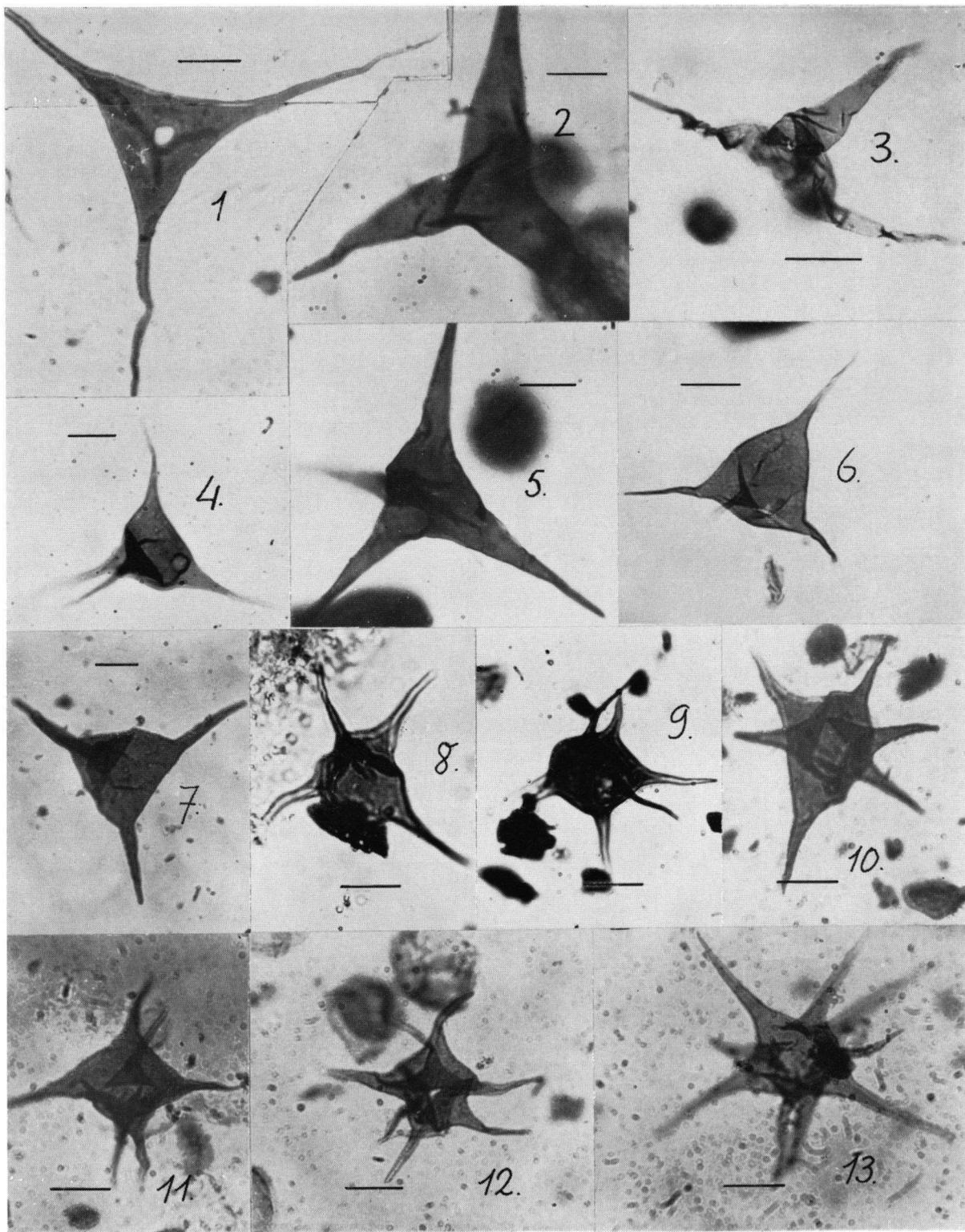


PLATE X

Formgroup *Micrhystridium stellatum* Defl.

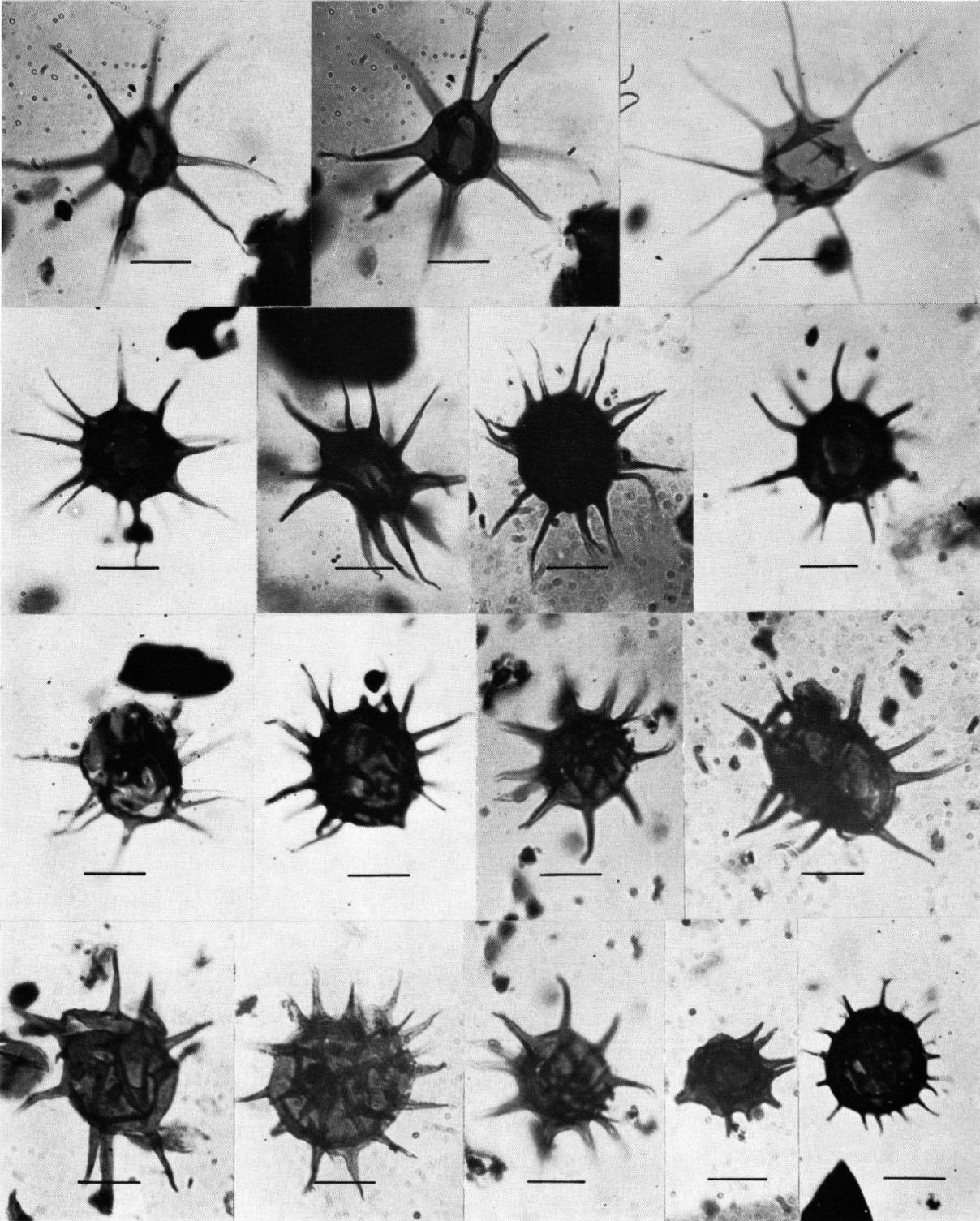


PLATE XI

1. *Micrhystridium picorricum* n. sp.
- 2.\* *Micrhystridium picorricum* n. sp.
3. *Micrhystridium picorricum* n. sp.
4. *Micrhystridium shinetonense* Downie (formgroup *Micrhystridium stellatum* Defl.).
5. *Micrhystridium* sp. (formgroup *Micrhystridium stellatum* Defl.)
6. *Micrhystridium cf. radians* St. & W. (formgroup *Micrhystridium* Defl.) stellatum.
7. *Micrhystridium stellatum* (Defl.) (formgroup *Micrhystridium stellatum* Defl.)
- 8.\* *Veryhachium estrellitae* n. sp.
- 9.\* *Veryhachium scabratum* n. sp.
10. *Veryhachium scabratum* n. sp.
11. *Veryhachium scabratum* n. sp.
12. *Veryhachium stelligerum* Dff.
13. *Veryhachium stelligerum* Dff.
14. *Veryhachium stelligerum* Dff.
15. *Veryhachium stelligerum* Dff.
16. *Veryhachium lairdi* Dff.

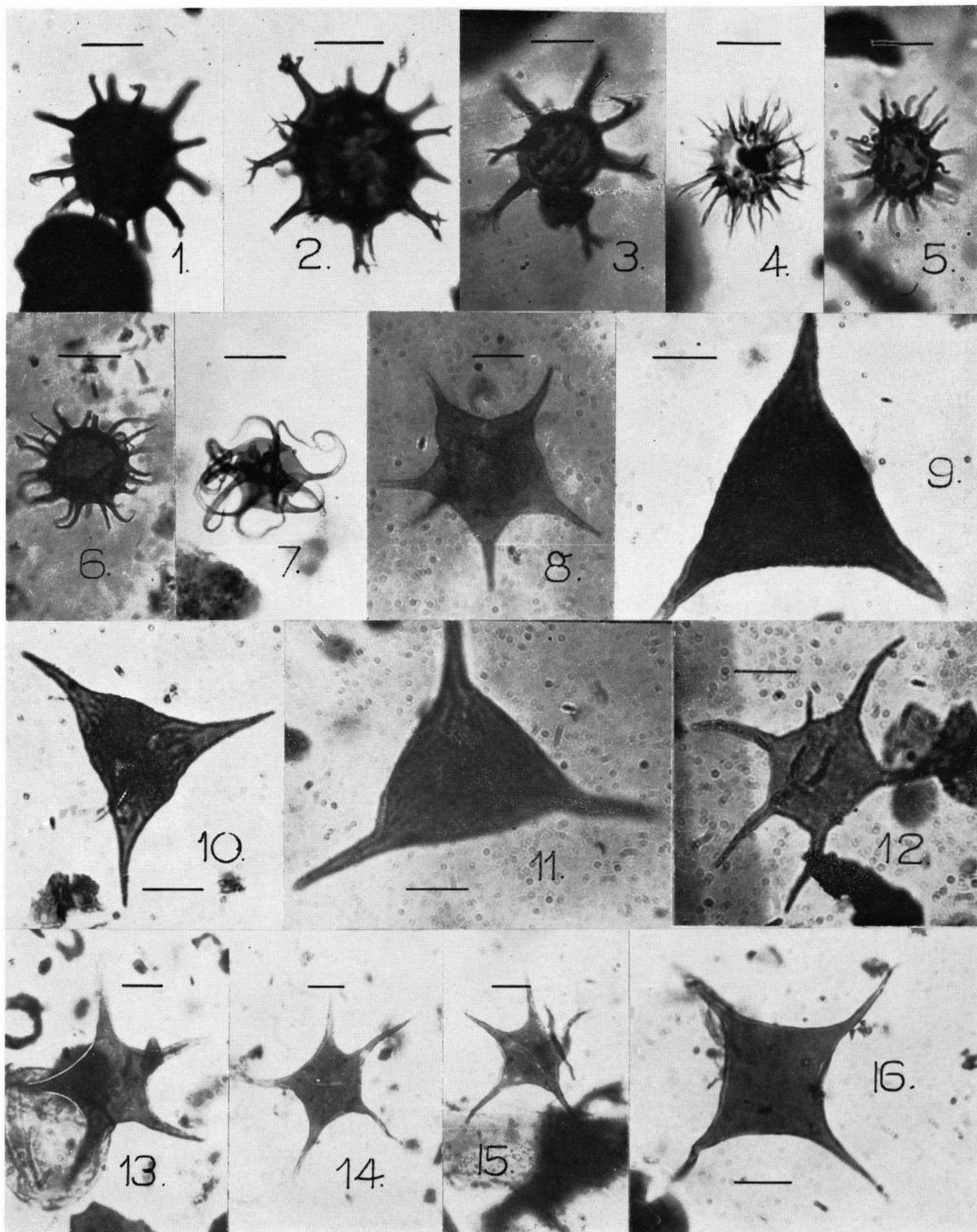


PLATE XII

1. *Veryhachium lairdi* Dff.
2. *Veryhachium lairdi* Dff.
- 3.\* *Veryhachium valiente* n. sp.
4. *Veryhachium valiente* n. sp.
- 5.\* *Veryhachium serpentinatum* n. sp.
6. *Veryhachium valiente* n. sp.
7. *Veryhachium ledanoisi* Dff.
8. *Baltisphaeridium* sp.
- 9.\* *Veryhachium josefae* n. sp.
- 10.\* *Veryhachium thyrae* n. sp.
- 11.\* *Veryhachium cochinum* n. sp.
12. *Veryhachium josefae* n. sp.
13. *Veryhachium thyrae* n. sp.

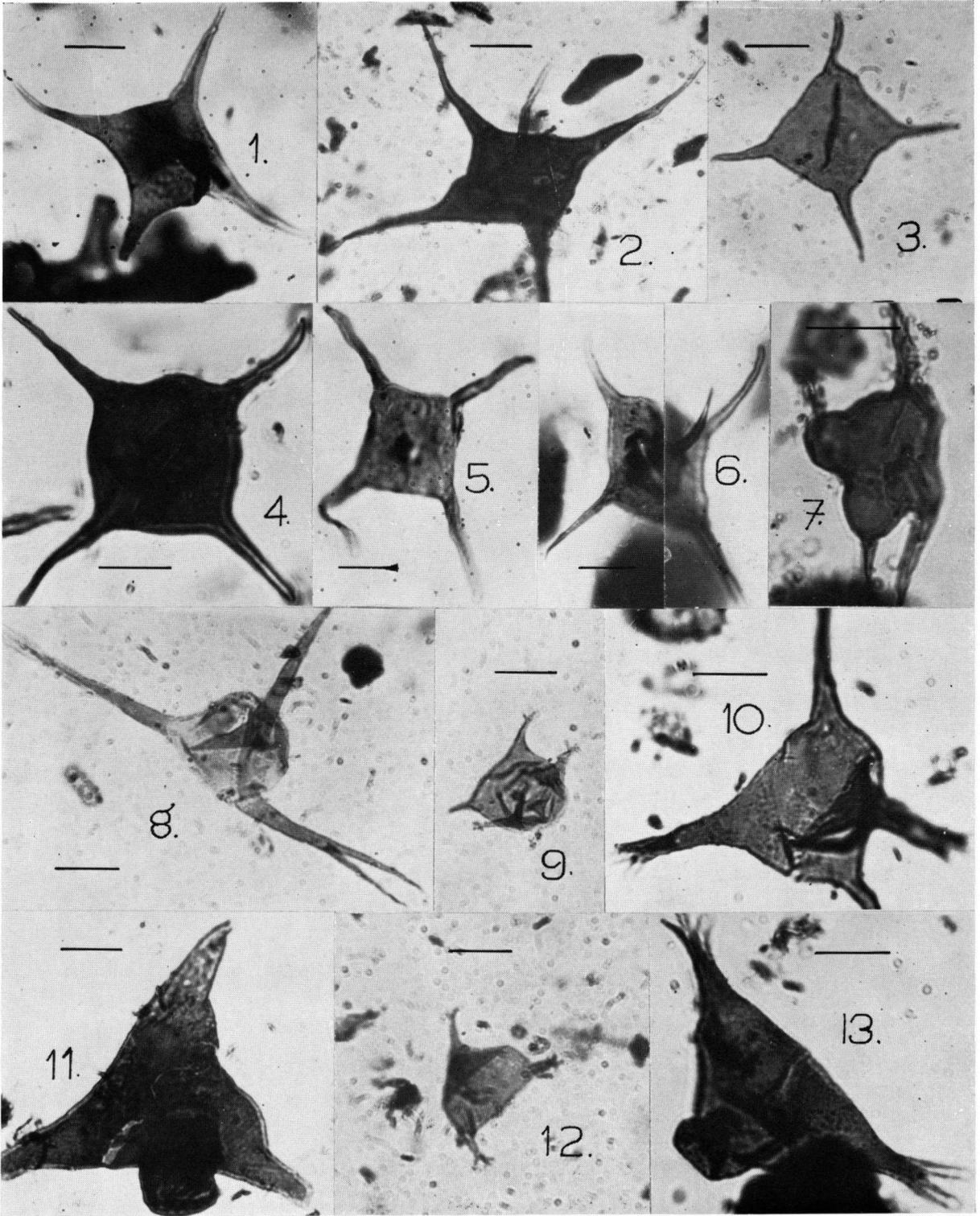


PLATE XIII

- 1.\* *Veryhachium cazurrum* n. sp.
2. *Veryhachium bernardinae* n. sp., damaged specimen.
- 3.\* *Veryhachium leonense* n. sp.
4. *Veryhachium leonense* n. sp.
5. *Veryhachium leonense* n. sp.
6. *Veryhachium rosendae* n. sp.
7. *Veryhachium rosendae* n. sp.
- 8.\* *Veryhachium rosendae* n. sp.
9. *Veryhachium rosendae* n. sp.
10. *Veryhachium helenae* n. sp.
- 11.\* *Veryhachium helenae* n. sp.
12. *Veryhachium helenae* n. sp.
13. *Veryhachium helenae* n. sp.
- 14.\* *Veryhachium asturiae* n. sp.
- 15.\* *Veryhachium asturiae* n. sp.
16. *Veryhachium rosendae* n. sp.
17. *Veryhachium cf. rosendae* n. sp.
18. *Veryhachium rosendae* n. sp.
19. *Veryhschium josefae* n. sp.
- 20.\* *Veryhachium tolontolum* n. sp.

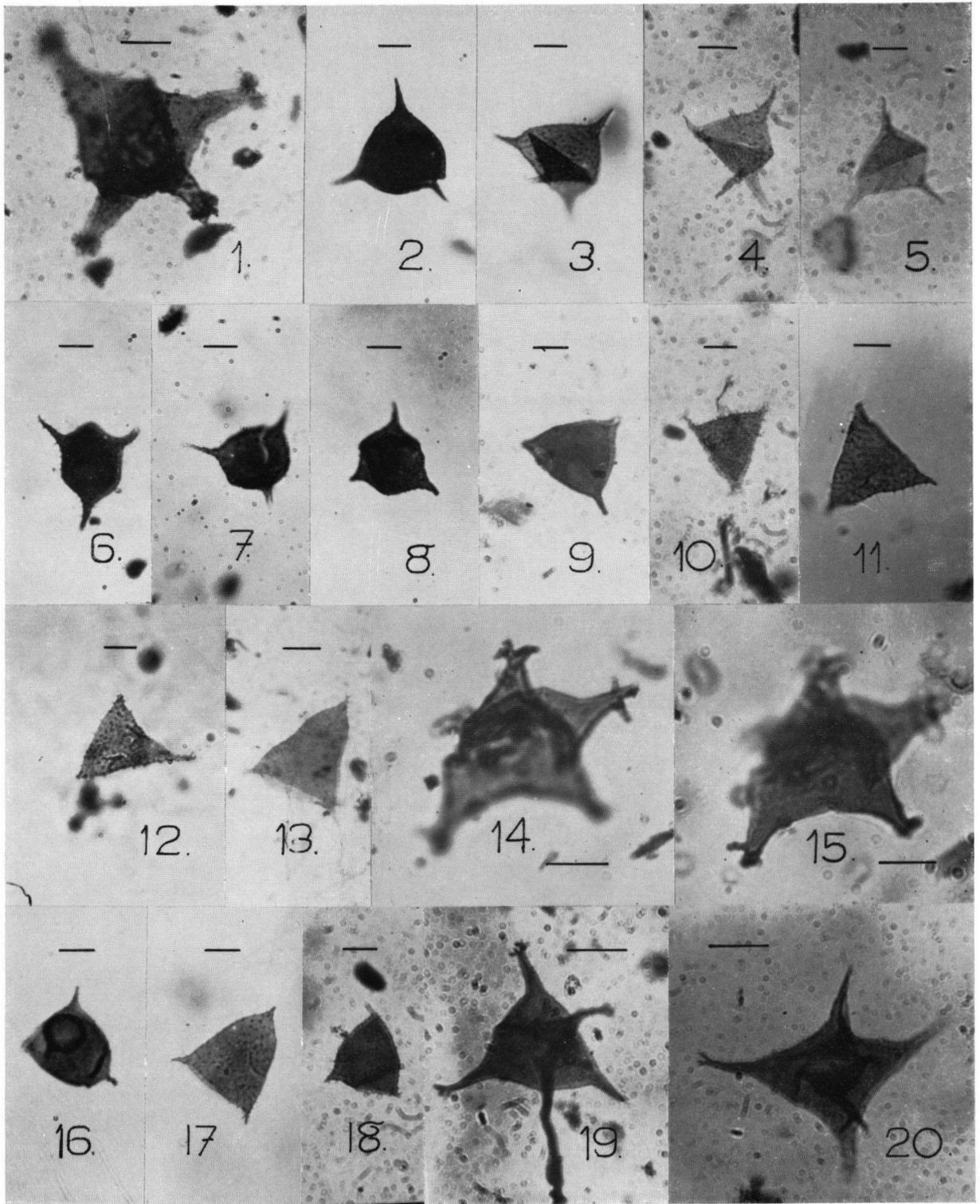


PLATE XIV

- 1.\* *Quadraditum incisum* n. sp.
3. *Quadraditum incisum* n. sp.
- 3.\* *Quadraditum fantasticum* n. sp.
4. *Quadraditum fantasticum* n. sp.
5. *Acritarch* sp. IV
- 6.\* *Polyplanifer exoticum* n. sp.
- 7.\* *Helios aranaides* n. sp.
8. *Deunffia* cf. *monospinosa* Downie.
- 10.\* *Cymatiosphaera carminae* n. sp.
11. *Polyplanifer exoticum* n. sp.
12. ?*Cymatiosphaera* sp., damaged specimen.
13. ?*Cymatiosphaera* sp., damaged specimen.
14. Cf. ?*Veryhachium vandenbergheni* St. & W., etc.
15. Cf. ?*Veryhachium vandenbergheni* St. & W., etc.
16. *Veryhachium carminae* n. sp.
17. Cf. ?*Veryhachium vandenbergheni* St. & W., etc.
- 18.\* *Veryhachium bernardinae* n. sp.

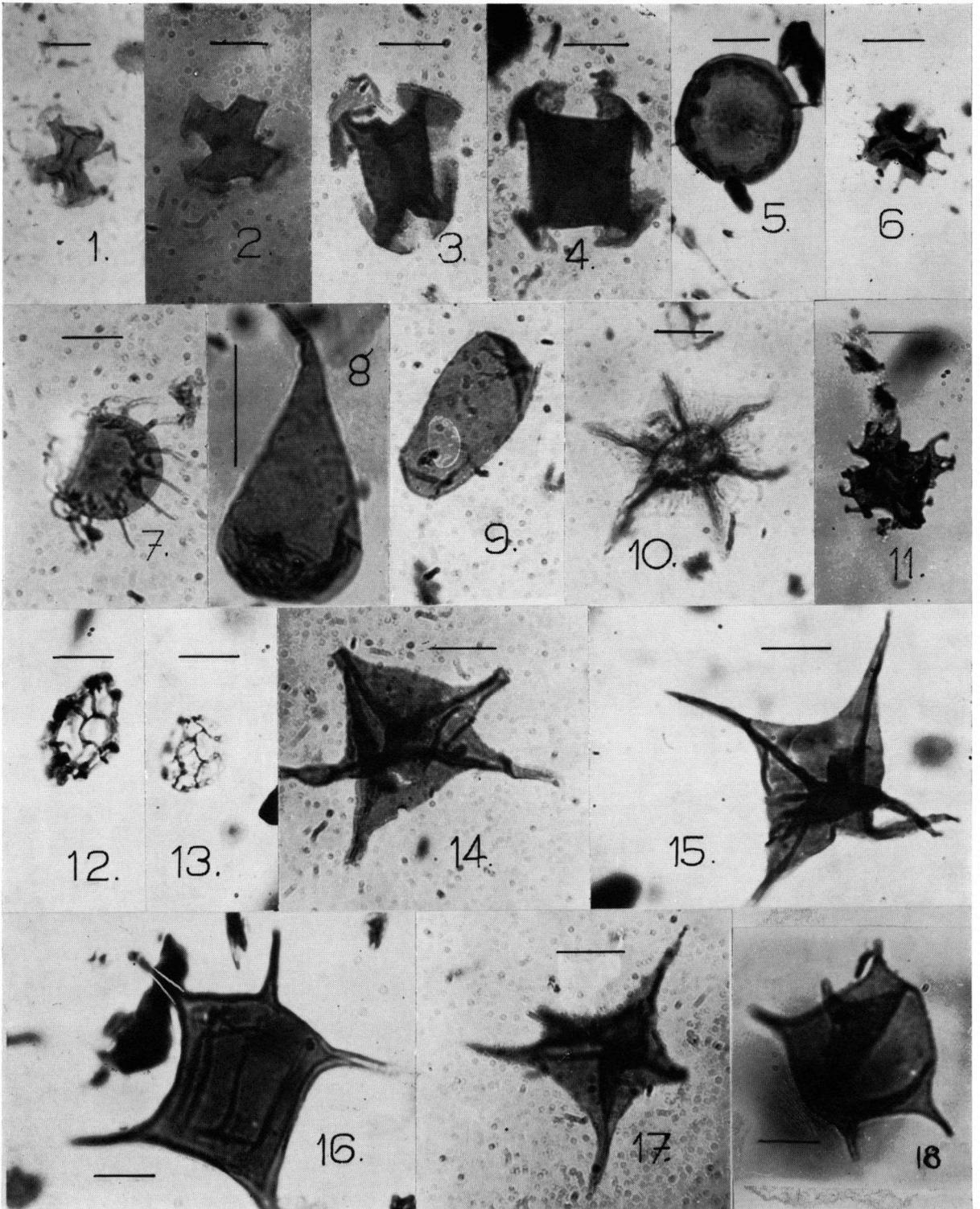


PLATE XV

- 1.\* *Veryhachium torrestionense* n. sp.
2. *Baltisphaeridium trifurcatum* (Eis.) cf. var. *procerum* Sann.
3. *Acritarch* sp. I.
4. *Polyedryxium tetrahedroide* n. sp.
5. *Polyedryxium tetrahedroide* n. sp.
6. *Polyedryxium tetrahedroide* n. sp.
7. *Polyedryxium tetrahedroide* n. sp.
8. *Polyedryxium pseudopharaonis* St. & W.
- 9.\* ?*Baltisphaeridium valentinum* n. sp.
10. *Polyedryxium rabians* n. sp.
11. *Polyedryxium rabians* n. sp.
12. *Polyedryxium pharaonis* Dff.
- 13.\* *Polyedryxium rabians* n. sp.
14. *Polyedryxium rabians* n. sp.
15. *Polyedryxium rabians* n. sp.
16. *Polyedryxium rabians* n. sp.

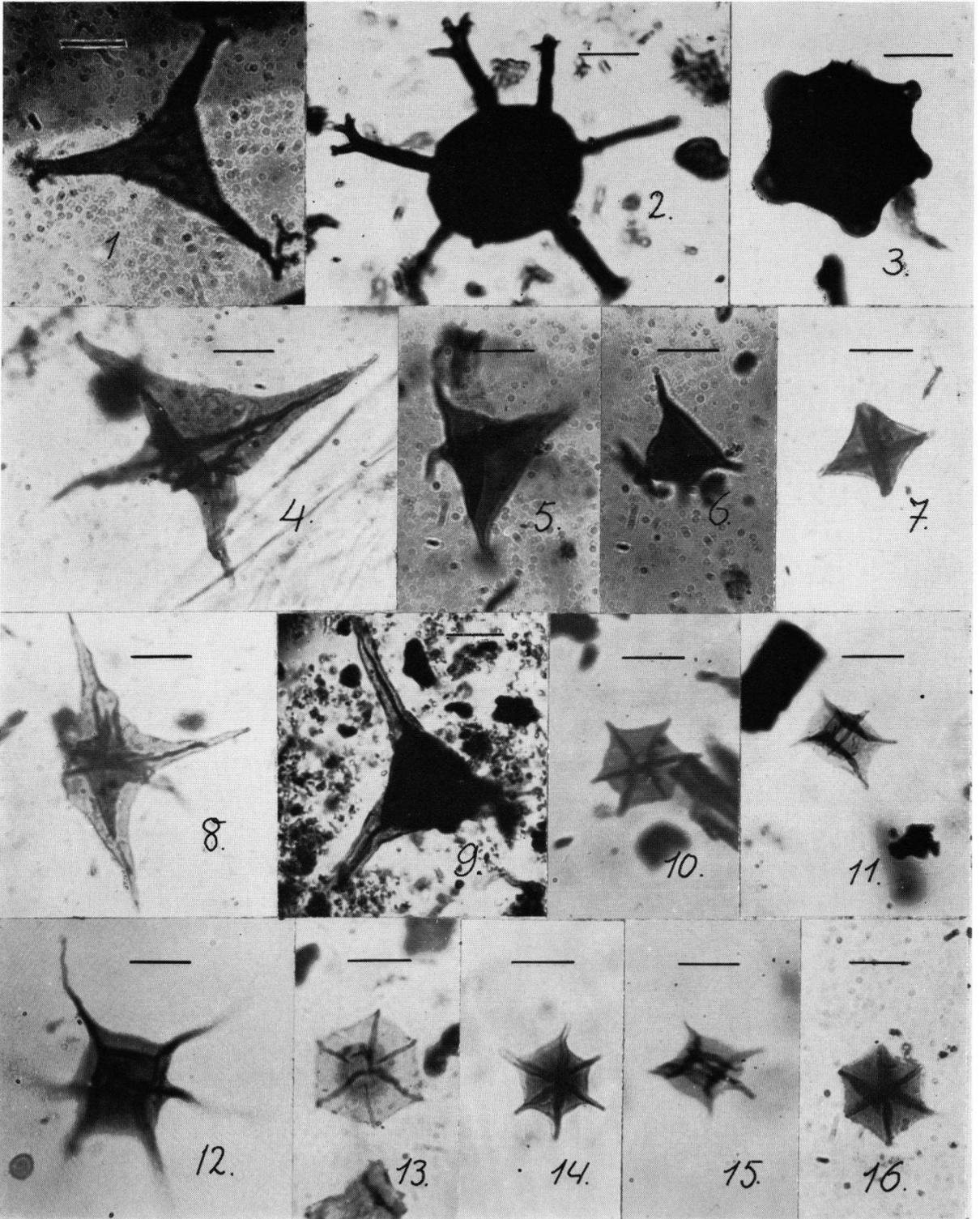


PLATE XVI

- 1.\* *Veryhachium carminae* n. sp.
2. *Veryhachium carminae* n. sp.
3. *Veryhachium carminae* n. sp.
- 4.\* *Sol radiofurcatum* n. sp.
5. *Pterospermopsis cf. helios* Sarjent.
6. *Pterospermopsis carminae* n. sp.
7. *Sol radians* n. sp.
- 8.\* *Sol radians* n. sp.
9. *Pterospermopsis onondagaensis* Dff.
10. *Pterospermopsis onondagaensis* Dff.
- 11.\* *Pterospermopsis guapita* n. sp.
- 12\* and 18\*. *Pterospermopsis hermosita* n. sp.
- 13.\* *Pterospermopsis bernardinae* n. sp.
- 14.\* *Pterospermopsis chiquitina* n. sp.
- 15.\* *Pterospermopsis chiquitina* n. sp.
- 16.\* *Pterospermopsis carminae* n. sp.
- 17.\* *Pterospermopsis rajada* n. sp.

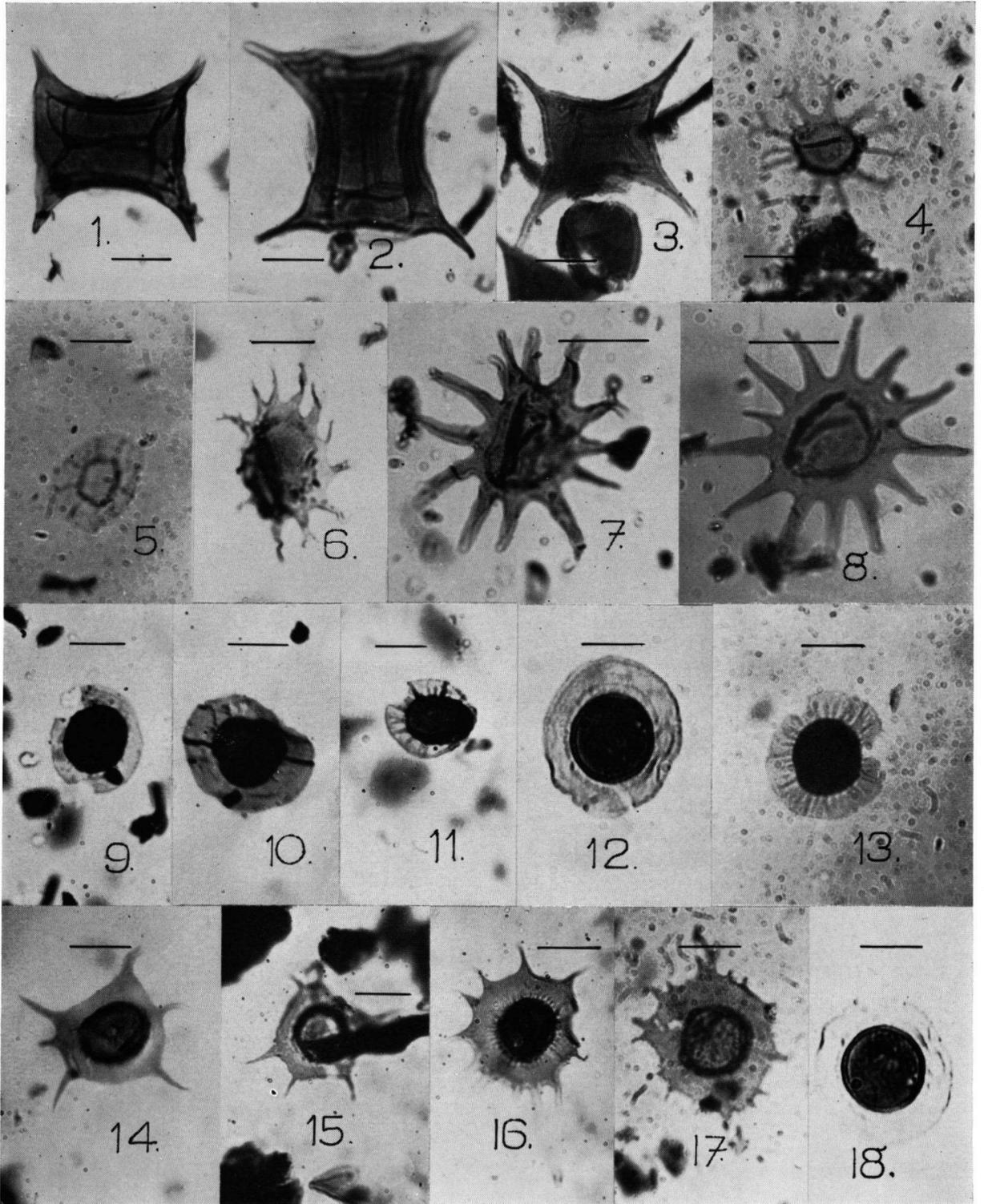


PLATE XVII

- 1.\* *Leoniella carminae* n. sp.
2. *Cymatiosphaera cf. mirabilis* Dff.
3. *Cymatiosphaera cf. mirabilis* Dff.
4. *Cymatiosphaera peligrosa* n. sp.
5. *Cymatiosphaera peligrosa* n. sp.
- 6.\* *Cymatiosphaera peligrosa* n. sp.
7. *Cymatiosphaera peligrosa* n. sp.
8. *Cymatiosphaera peligrosa* n. sp.
9. *Cymatiosphaera nebulosa* (Dff.)
10. *Cymatiosphaera nebulosa* (Dff.)
- 11.\* *?Polyedryxium asperum* n. sp.
12. *Cymatiosphaera wenlockia* Downie
13. *Cymatiosphaera wenlockia* Downie
14. *Cymatiosphaera ?wenlockia* Downie
15. *Cymatiosphaera wenlockia* Downie
- 16.\* *Cymatiosphaera franjada* n. sp.
17. *Cymatiosphaera wenlockia* Downie
18. *Cymatiosphaera flosdevonica* St. & W.
- 19 and 20. *Cymatiosphaera pavimentum* (Defl.)

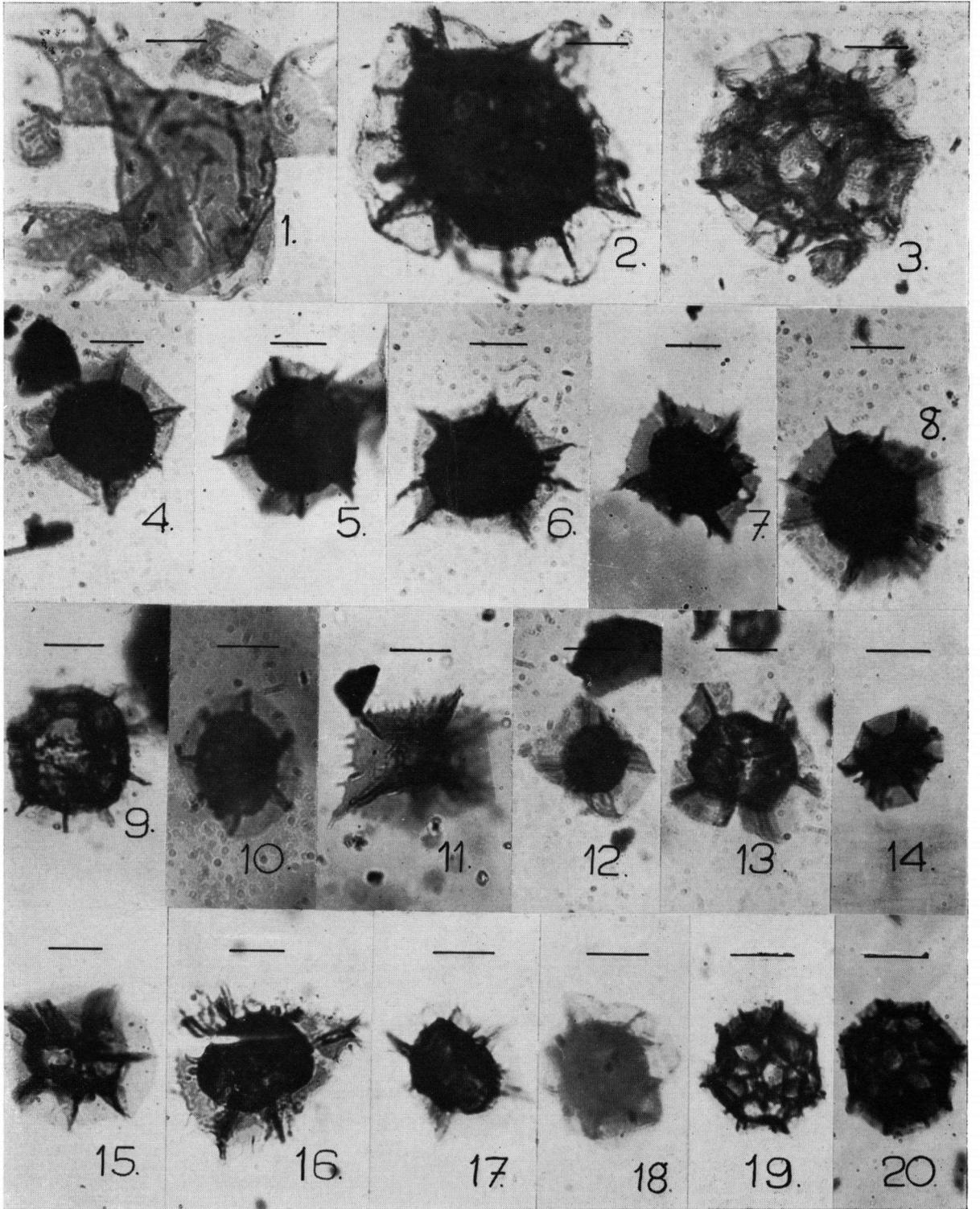


PLATE XVIII

1. *Leiofusa estrecha* Cmr.
2. *Leiofusa bernesga* Cmr., form with exceptionally long spines.
3. ?*Polyedryxium asperum* n. sp.
4. *Cymatiosphaera* sp., very rare in the La Vid Shale Member.
5. *Polyedryxium decorum* Dff.
6. ?*Polyedryxium asperum* n. sp.
7. *Leiofusa striatifera* Cmr.
8. *Leiofusa filifera* Downie
9. *Leiofusa cantabrica* Cmr.
- 10.\* *Polyedryxium helenaster* n. sp.
11. *Polyedryxium helenaster* n. sp.

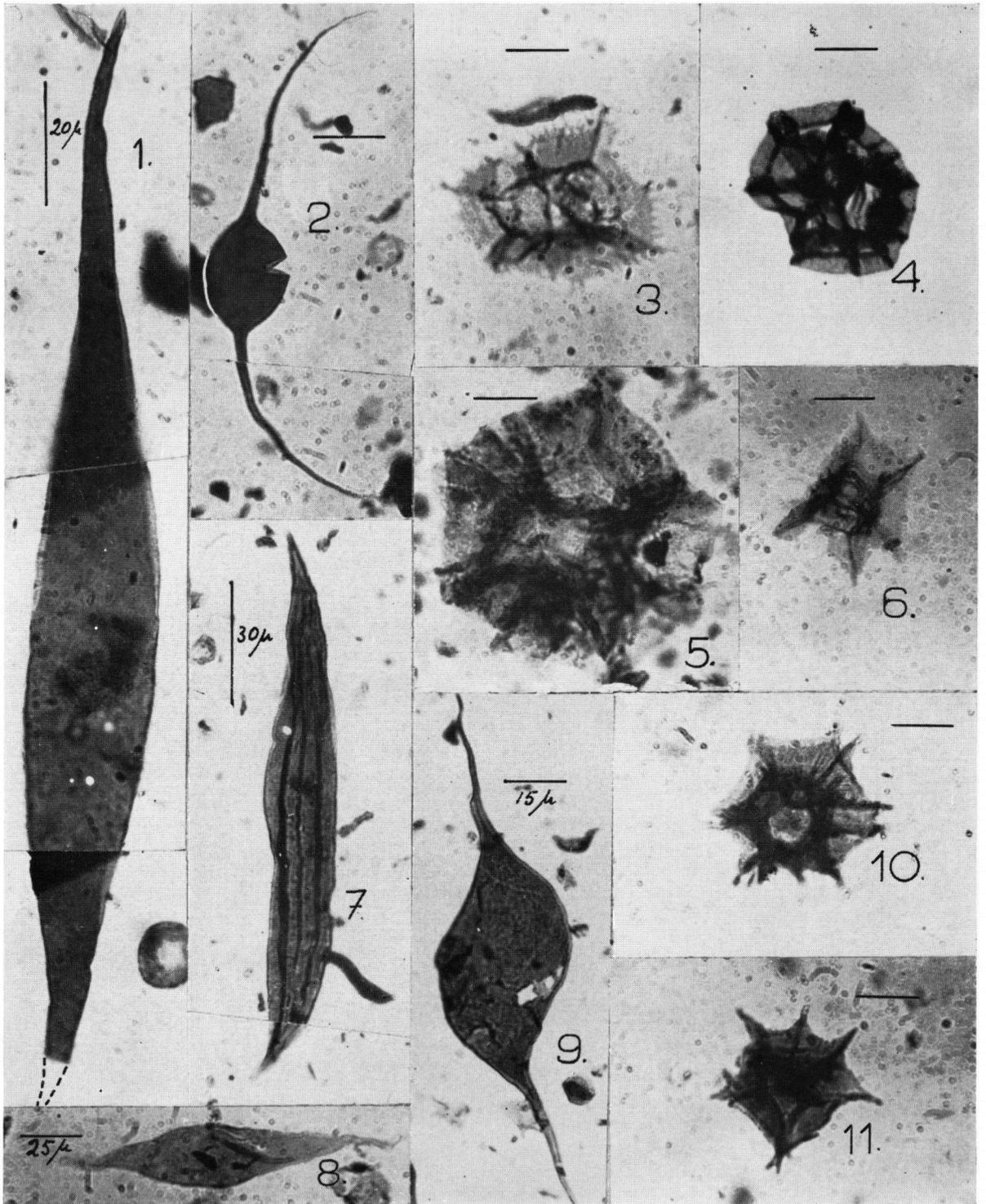


PLATE XIX

1. *Leiofusa striatifera* Cmr.
2. *Leiofusa banderilla* Cmr.
3. *Leiofusa estrecha* Cmr.
- 4.\* *Leiofusa blanca* n. sp.
5. *Leiofusa fastidiona* n. sp.
6. *Deunfia monacantha* (Dff.)
7. ?*Conocgitina* sp., top of Formigoso Formation.
8. *Anihatractus insolitus* Dff.
9. *Leiofusa* cf. *tumida* Downie
10. *Leiofusa* cf. *tumida* Downie.

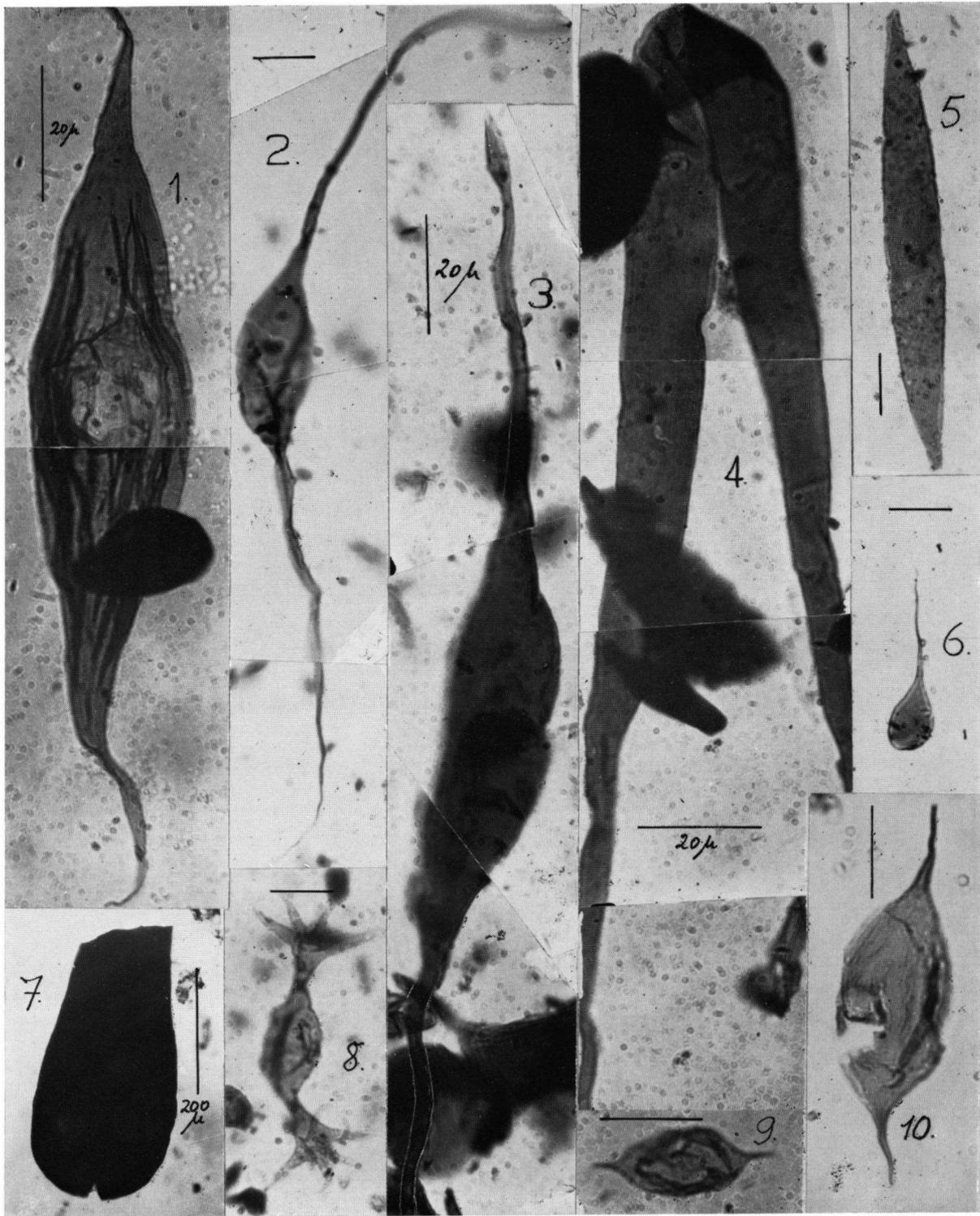


PLATE XX

1. *Angochitina spinosa* (Eis.)
2. *Angochitina devonica* Eis.
3. *Angochitina devonica* Eis., specimen with broken spines.
4. *Sphaerochitina sphaerocephala* (Eis.)
5. *Sphaerochitina sphaerocephala* (Eis.)
6. *Sphaerochitina sphaerocephala* (Eis.)
- 7.\* *Plectochitina rosendae* n. sp.
8. *Ancyrochitina fragilis* (Eis.) var. *brevis* T. & J.
9. *Ancyrochitina tumida* T. and J.
10. *Plectochitina saharica* (Tau.)
11. *Desmochitina urna* Eis.
12. *Desmochitina urna* Eis.
- 13.\* *Desmochitina tinae* n. sp.
14. *Desmochitina panzuda* n. sp.
15. *Desmochitina panzuda* n. sp.
16. *Desmochitina panzuda* n. sp.
17. *Desmochitina urna* Eis.
18. *Desmochitina urna* Eis.
19. *Plectochitina carminae* n. sp.
- 20.\* *Angochitina ramusculosa* n. sp.
- 21.\* *Plectochitina carminae* n. sp.
22. *Ancyrochitina fragilis* (Eis.) var. *brevis* T. & J.
23. *Ancyrochitina fragilis* (Eis.) var. *brevis* T. & J.
24. *Plectochitina pseudoagglutinans* (Tau.)
25. *Ancyrochitina ancyrea* (Eis.)
26. *Ancyrochitina ancyrea* (Eis.)

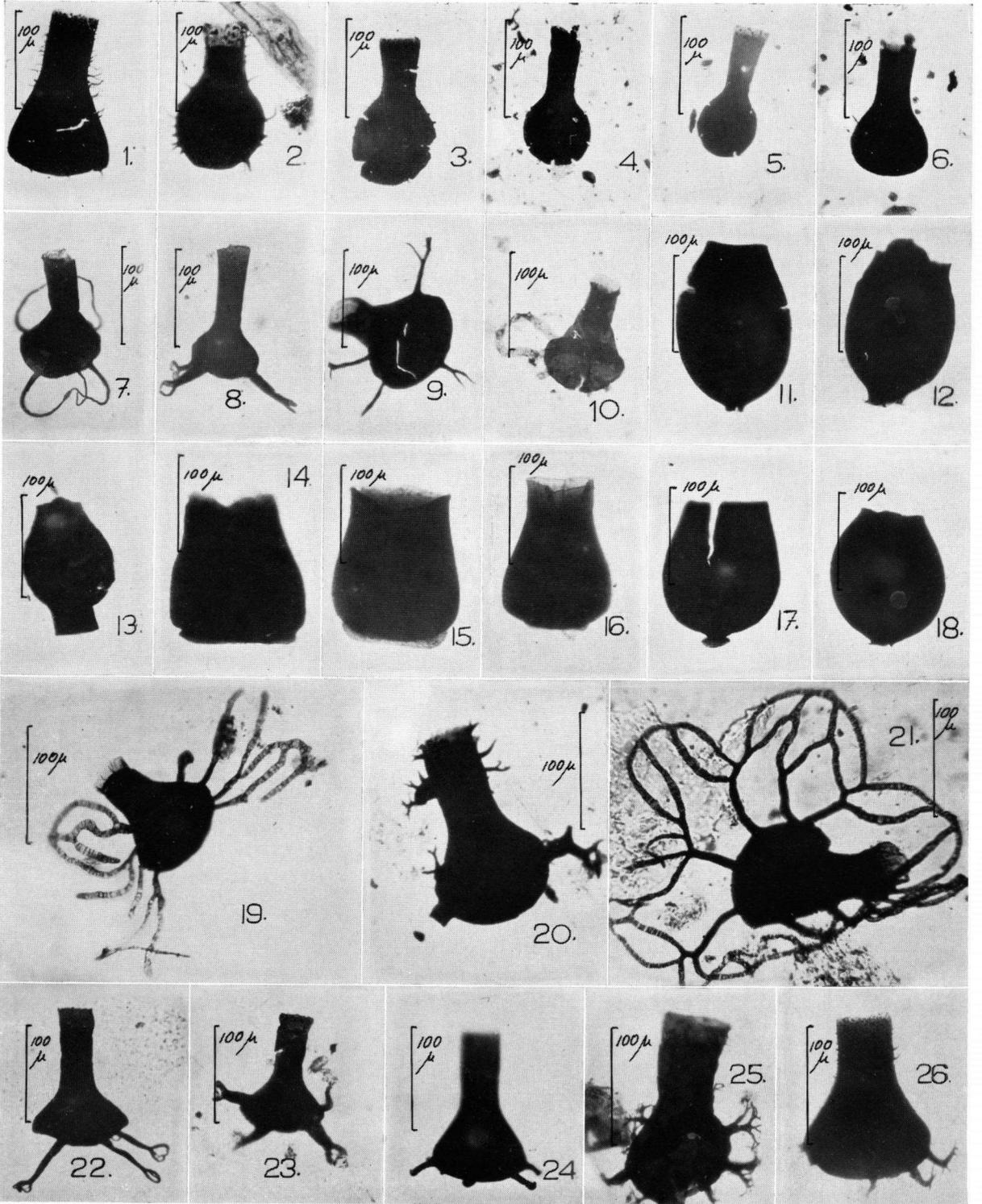


PLATE XXI

1. *Angochitina filosa* Eis.
2. *Angochitina filosa* Eis.
3. *Angochitina valentini* n. sp.
- 4.\* *Angochitina valentini* n. sp.
5. *Angochitina valentini* n. sp.
6. *Angochitina valentini* n. sp.
- 7.\* *Angochitina valentini* n. sp. var. *aspera* n. var.
8. *Sphaerochitina fungiformis* (Eis.)
9. *Angochitina longicolla* Eis.
10. *Sphaerochitina vitrea* Tau.
11. *Sphaerochitina vitrea* Tau.
12. *Sphaerochitina vitrea* Tau.
13. *Sphaerochitina vitrea* Tau.
14. *Desmochitina elegans* T. & J. Var. *corta* n. var.
15. *Desmochitina elegans* T. & J. var. *corta* n. var.
- 16\* and 17.\* *Angochitina toyetae* n. sp.
18. *Angochitina* cf. *devonica* Eis.
19. *Angochitina devonica* Eis.
20. *Angochitina devonica* Eis.

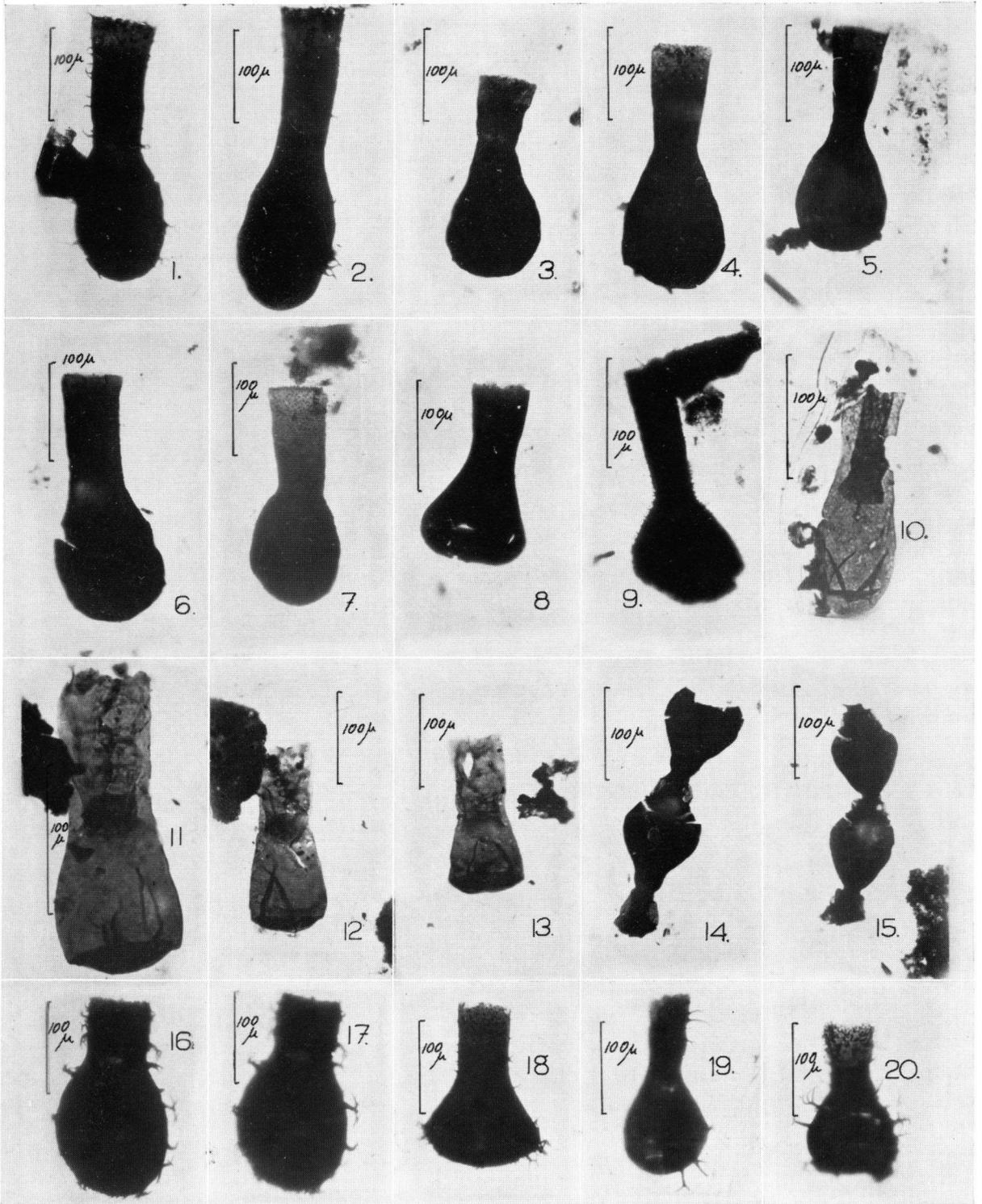


PLATE XXII

1. *Desmochitina densa* Eis.
2. *Desmochitina densa* Eis.
3. *Desmochitina densa* Eis.
- 4.\* *Desmochitina leonensis* n. sp.
5. *Desmochitina elegans* T. & J.
6. *Sphaerochitina longicollis* T. & J.
7. Chain of *Desmochitina urna* Eis., somewhat compressed
8. *Clathrochitina carmenchui* n. sp.
9. *Clathrochitina carmenchui* n. sp.
10. *Clathrochitina carmenchui* n. sp.
- 11.\* ?*Ancyrochitina gordita* n. sp.
12. *Desmochitina elegans* T. & J. var. *corta* n. var.
13. *Desmochitina elegans* T. & J.
14. *Rhabdochitina conocephala* Eis.
15. *Desmochitina elegans* T. & J. var. *corta* n. var.
- 16.\* *Ancyrochitina gumersindae* n. sp.
17. *Desmochitina cingulata* Eis.
18. *Conochitina cf. lagenomorpha* Eis. 1955: T. & J. 1960, fig. 56.

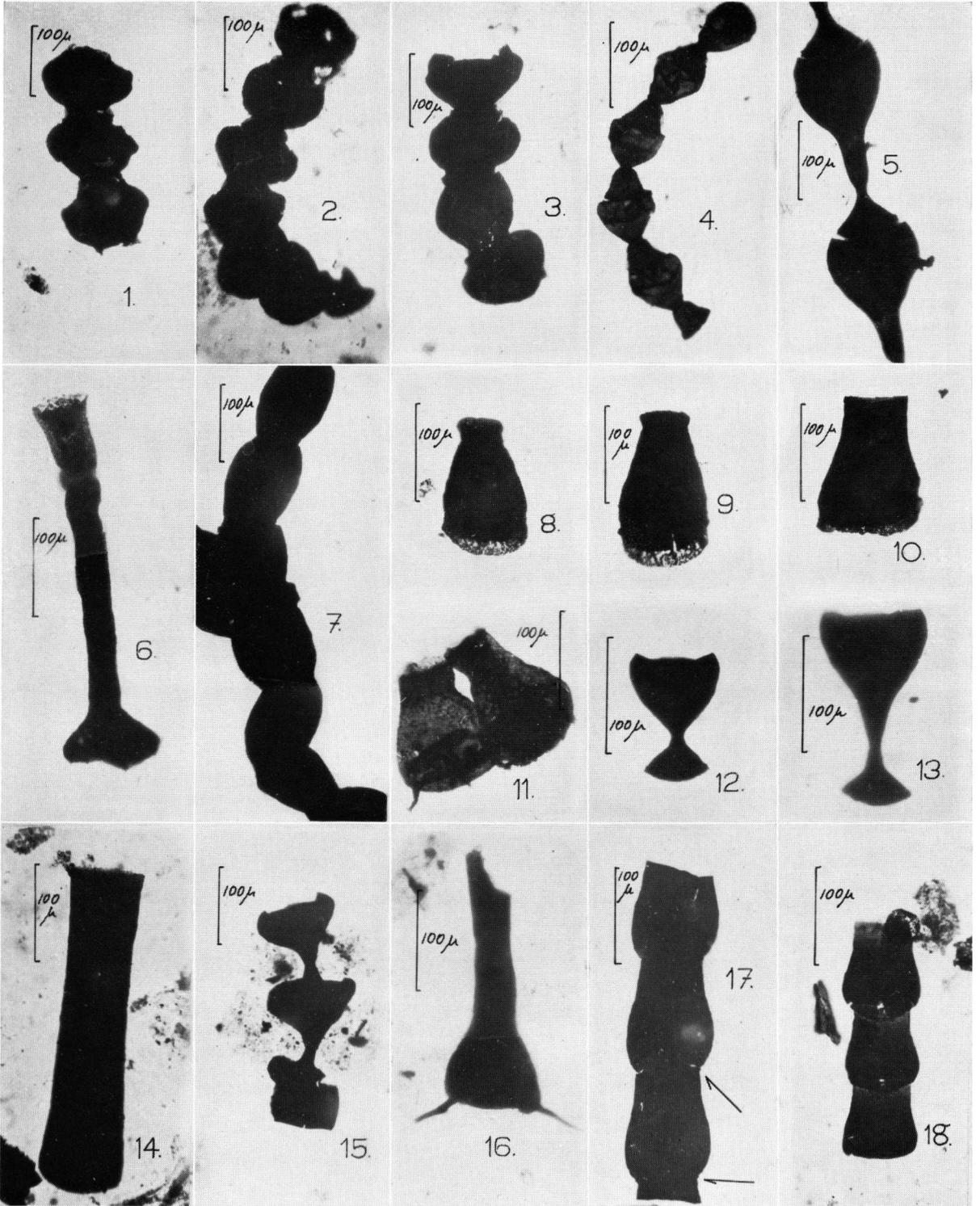


PLATE XXIII

1. *Conochitina gordonensis* n. sp.
- 2.\* *Conochitina gordonensis* n. sp.
- 3.\* *Sphaerochitina llorona* n. sp.
4. *Sphaerochitina llorona* n. sp.
6. *Sphaerochitina llorona* n. sp.
7. *Rhabdochitina conocephala* Eis.
8. ?*Cyathochitina dispar* B. & T.
- 9.\* ?*Cyathochitina elenitae* n. sp.
10. ?*Cyathochitina elenitae* n. sp.
11. *Rhabdochitina conocephala* Eis.
12. *Rhabdochitina conocephala* Eis.
13. ?*Cyathochitina dispar* B. & T.
14. ?*Cyathochitina dispar* B. & T.

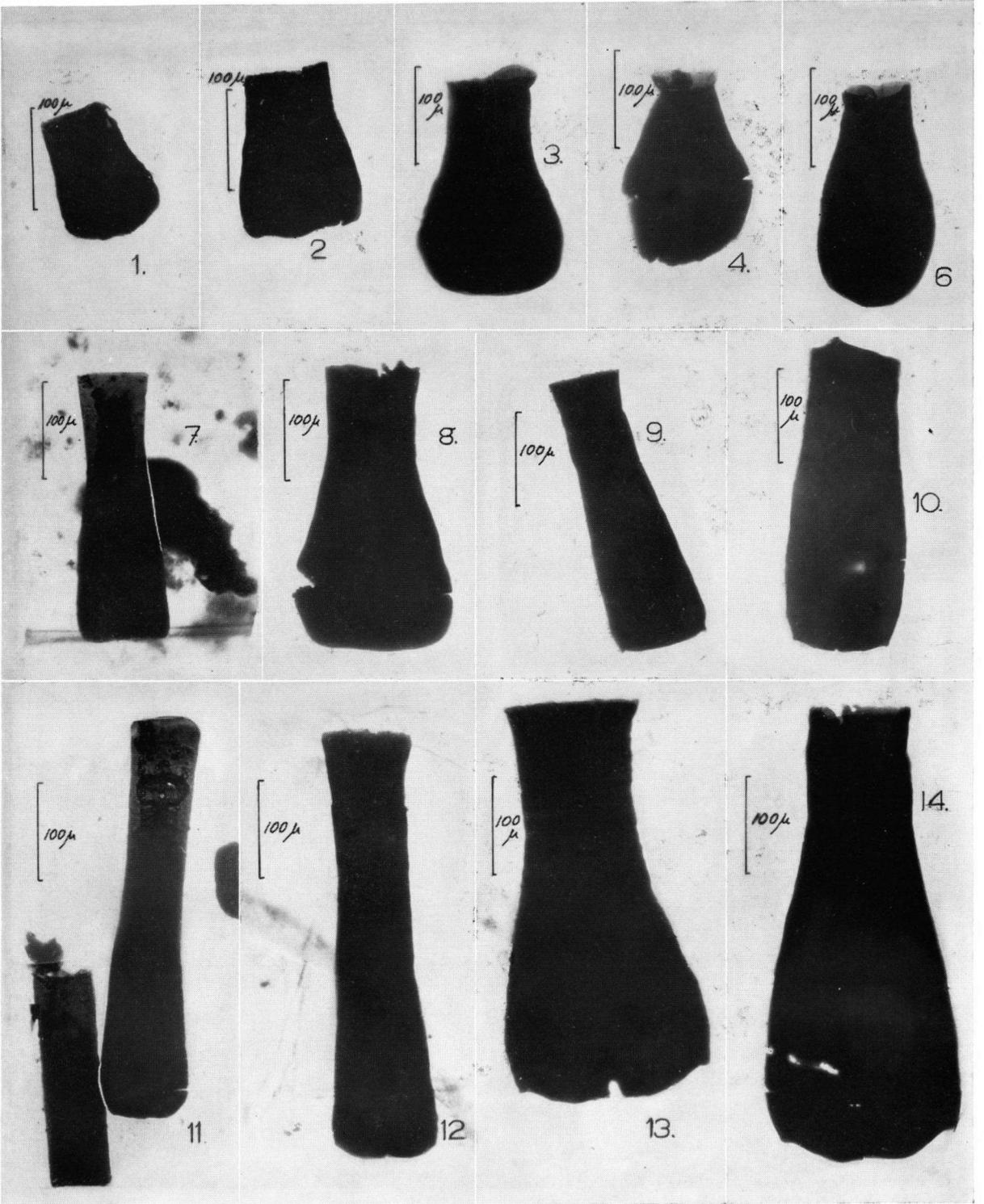


PLATE XXIV

1. *Conochitina intermedia* Eis.
2. *Desmochitina erratica* Eis.
3. *Desmochitina erratica* Eis.
- 4.\* *Desmochitina thyrae* n. sp.
5. *Desmochitina thyrae* n. sp.
6. *Cyathochitina campanulaeformis* (Eis.)
7. *Cyathochitina campanulaeformis* (Eis.)
8. *Cyathochitina campanulaeformis* (Eis.)
9. *Lagenochitina brevicollis* T. & J. var. *granulata* n. var.
10. *Lagenochitina brevicollis* T. & J. 1960, fig. 110.
11. *Conochitina communis* Tau.
12. *Cyathochitina campanulaeformis* (Eis.)
13. *Cyathochitina campanulaeformis* (Eis.)
14. *Cyathochitina campanulaeformis* (Eis.)
15. *Cyathochitina campanulaeformis* (Eis.)
16. *Conochitina brevis* T. & J.
17. *Conochitina gordonensis* n. sp.
- 18.\* *Clathrochitina carmenchui* n. sp.

