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LATE PALAEOZOIC CALCAREOUS ALGAE IN THE PISUERGA BASIN (N-PALENCIA, SPAIN)

BY

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ABSTRACT

The calcareous algae were important rock-builders in the deposition of the many limestone members of the Pisuerga Basin. Systematic descriptions are given of 12 species. The following species are new: *Clavaporella reinae*, *Clavaphysoporella endoi*, *Epimastopora camasobresensis*, *Psuedo-epimastopora?impera* and *Vermiporella hispanica*.

The algal associations in the Pisuerga Basin may be classified into six distintive zones, one of which can be subdivided into two subzones. Many of these zones are readily comparable with those distinguished elswhere in the Cantabrian Mountains and can be directly correlated with the foraminiferal faunas associated with them. While five of these zones contain associations of definitely Carboniferous algal floras, the uppermost contains both Carboniferous and Permian elements. A brief discussion of ecological aspects is made.

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INTRODUCTION

The Pisuerga Basin is one of the most intensively studied areas of the Cantabrian-Asturian Mountains. Papers have been published on the sedimentology, tectonics, palaentology and stratigraphy of the region (for full references see de Sitter and Boschma, 1966). Little attention, however, had been given to the limestonebuilding algae. The only exceptions are the publications of Nederlof (1959), Van Ginkel (1960), Brouwer and van Ginkel (1964) where they have received some attentions, and also those of Frets (1965), and de Sitter and Boschma (1966) in which the role of algae in sedimentation has been discussed in some detail.

The material, which forms the basis of this study, was obtained from Dr. A. C. van Ginkel (Leiden), who kindly made available to the author his collection of thin sections. Material was also generously donated by Mr. D. C. Frets.

STRUCTURAL UNITS AND STRATIGRAPHY

The Pisuerga Basin can be subdivided into four principal structural units. These are the Casavegas and Redondo synclines situated in the north of the area, the Castilleria area around the summits of the Sierra Corisa, and a fourth unit to the south of the Castilleria region. In this latter area most of the limestones are reefoid in appearence and hence have been called "reef limestones".

The composition of all the units is variable. They contain mainly limestones, shales and sandstones with locally occuring coal seams. It is apparent from the literature (Wagner 1955, 1959; Wagner and Wagner-Gentis 1963; Nederlof 1959; de Sitter 1962; de Sitter and Boschma 1966; Brouwer and van Ginkel 1964; van Ginkel 1965) that there is not as yet complete agreement on the litho-stratigraphic terminology. There is, however, general agreement on the individual limestone members, which have been named after local features. The material on which the present work has been based, was obtained from the following limestone members (fig. 1):

A. The area south of the Sierra Corisa Limestone Member (reef limestones)

Orbó limestone	Loc. *
Arbejal limestone	Loc. P 63
Rabanal limestone	Loc. P 23
Perapertú limestone	Loc. P 70
Mudá limestone	Loc. P 76

B. The Castilleria area

Vañes limestone	Loc. P 36
Sierra Corisa limestone	Loc. P 22

C. Casavegas syncline

Urbaneja limestone	loc. P 2
Lores limestone	Loc. P 10
Maldrigo limestone	Loc. P 7
Camasobres limestone	Loc. P 4

* Locality numbers of van Ginkel (1965).

D. Redondo syncline

Abismo limestone	Loc. P 73
Agujas limestone	Loc. P 72
Caloca = Albas limestone	Loc. P 3
Piedrasluengas limestone	Loc. P 1

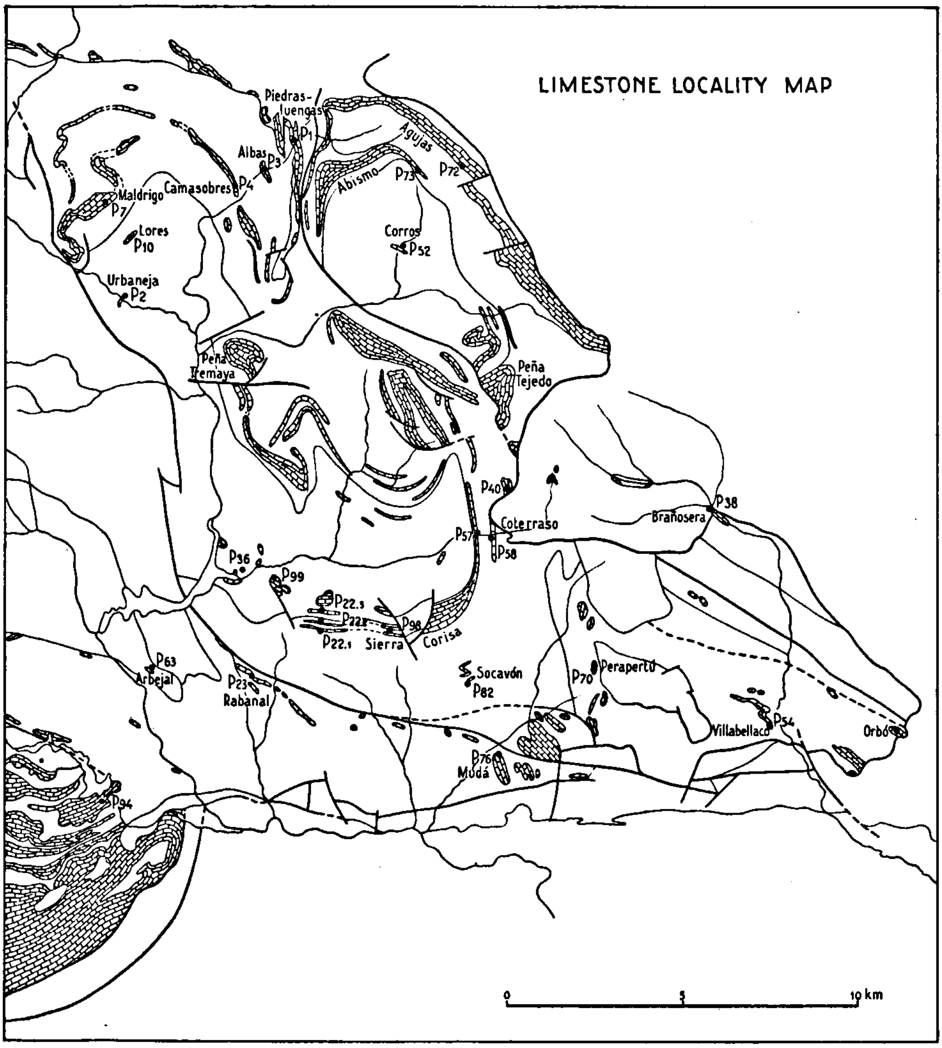

Fig. 1. Limestone locality map (de Sitter & Boschma, 1966)

The fusulinid faunas of these limestones have been classified by van Ginkel (1965) in zones:

Protriticites zone	(not sub-divided)
Fusulinella zone	subzone B3
	subzone B2
	subzone B1
	subzone A
Profusulinella zone	subzone B
	subzone A
Millerella zone	(not sub-divided)

These faunas can be compared with similar ones in the Russian Carboniferous type sequences where they occur in levels ranging from Bashkirian to Kasimovian.

The algal floras described in the present paper are from the same samples as the fusulinids. Therefore direct correlation with the fusulinid zones is possible. Thus the biostratigraphic subdivision of the calcareous algae is based primarily on the foraminiferal zonation (fig. 2).

<table>
<tr><th>ZONE OF FORAMINIFERA</th><th>SUBZONE</th><th colspan="2">ZONE OF CALCAREOUS ALGAE</th><th colspan="2">CHRONOSTRATIGRAPHY</th></tr>
<tr><td>PROTRITICITIS</td><td></td><td colspan="2">VI</td><td>URALIAN to PERMIAN</td><td></td></tr>
<tr><td rowspan="4">FUSULINELLA</td><td>B 3</td><td colspan="2">V</td><td rowspan="5">MOSKOVIAN</td><td rowspan="3">UPPER</td></tr>
<tr><td>B 2</td><td rowspan="2">IV</td><td>B</td></tr>
<tr><td>B 1</td><td>A</td></tr>
<tr><td>A</td><td colspan="2" rowspan="2">III</td><td rowspan="2">LOWER</td></tr>
<tr><td rowspan="2">PROFUSULINELLA</td><td>B</td></tr>
<tr><td>A</td><td colspan="2">II</td><td rowspan="2">BASHKIRIAN</td><td>UPPER</td></tr>
<tr><td>MILLERELLA</td><td>PS. ANTIQUA</td><td colspan="2">I</td><td>LOWER</td></tr>
</table>

Fig. 2. Zonal subdivision of the late Palaeozoic Foraminifers and Calcareous Algae in Northern Spain

CALCAREOUS ALGAE IN THE PISUERGA BASIN AND IN THE AREA BETWEEN THE RIO BERNESGA AND THE RIO PORMA

Biostratigraphic classification and zonation

The sequence in the Pisuerga Basin (prov. Palencia) represents a more complete section of Upper Carboniferous deposits than that in the Bernesga-Porma area (prov. León)), 80 km to the west. The limestone members of the latter area have yielded floras representing the three zones and part of the fourth (Rácz, 1964). In Palencia, however, as many as six algal zones can be recognized.

Calcareous Algal Zone I. — The upper part of the Escapa (Caliza de Montaña) Formation in the Bernesga-Porma area is included in this zone (Rácz, 1964). The characteristic microflora of this zone (in both the Bernesga-Porma area and the Pisuerga Basin) although rather poor, is sufficiently distinctive to permit its separation from the algal assemblage of Zone II. *Ungdarella uralica* MASLOV is the most important species in Algal Zone I. It occurs together with some long-ranging forms as *Donezella lutugini* MASLOV and *Girvanella* sp. These have only been found in the Pisuerga Basin in the Mudá Limestone Member.

Calcareous Algal Zone II. — The characteristic algal association of this zone is present in both the Bernesga-Porma area and the Pisuerga Basin. Commonly occuring species are *Epimastopora bodoniensis* RÁCZ, *Donezella lunaensis* RÁCZ, *Beresella hermineae* RÁCZ, *Anthracoporella* cf. *spectabilis* PIA and *Mellporella anthracoporellaformis* RÁCZ. This association has been found very completely developed in the Perapertú and Arbejal limestones, and partly represented in the Rabanal limestone. However, *Archaeolithophyllum johnsoni* RÁCZ, which is locally of importance as a rock builder in the San Emiliano Formation (Bernesga-Porma area), has not been found in the Pisuerga Region.

Calcareous Algal Zone III. — *Dvinella comata* CHVOROVA and *Amorfia jalinki* RÁCZ also occur commonly in the Pisuerga Basin and the Bernesga-Porma area. However two species, *Ivanovia tenuissima* CHVOROVA and *Ungdarella conservata* KORDE which occur in the Pisuerga Basin, have not been found in León. These two species are often important rock-building elements. *Uraloporella sieswerdai* RÁCZ and *Epimastopora rolloensis* RÁCZ on the other hand, which locally form an important part of the algal association in the Bernesga-Porma area, have not been found in the Pisuerga Basin. The algal association characteristic of Zone III has been found in the Piedrasluengas limestone, the Albas limestone and the Orbó limestone. The Rabanal limestone yields a mixed association of algae belonging to both Zones II and III. Therefore it is probable that the Rabanal limestones represents an intermediate position between the Perapertú limestones and the Piederasluengas limestones. Thus demostrating the continuity of the reef growth in this area during the deposition of the Ruesga Group sediments. The fact that no difference in age could be determined, on the basis of algae, between the Piedrasluengas and the Albas limestones, demonstrates that the hiatus, as indicated by the Curavacas conglomerate unconformity between these two limestones, represents a very small time interval. The same conclusion is further supported by the foraminiferal evidence (van Ginkel, 1965).

The limestones from the lower part of the Lois-Ciguera Formation (Lena Formation, van Ginkel, 1965) in the Bernesga-Porma area are considered by the present author to belang to Zone III.

Calcareous Algal Zone IV. — The Calcareous Algal Zone IV is incomplete in the Bernesga-Porma area (Rácz, 1964), but in the Pisuerga Basin sedimentation was continuous. The Pisuerga Basin material shows that Zone IV can be subdivided into Subzones IV A and IV B. The lower Subzone IV A is characterized by the presence of *Komia abundans* KORDE, *Eugonophyllum mulderi* RÁCZ, *Epimastopora camasobresensis* sp. nov. *Macroporella ginkeli* RÁCZ and *Zaporella cantabriensis* RÁCZ. This association has been found in the Camasobres limestone and in the lower part of the Agujas limestone.

Archaeolithophyllum missouriense JOHNSON, which is found in the Bernesga-Porma area, has not been recognized in the Pisuerga Basin. *Epimastopora camasobresensis* sp. nov. on the other hand has not been found in the province León.

The following association of limestone-building algae is typical of Subzone IV B: *Komia abundans* KORDE, *Eugonophyllum mulderi* RÁCZ, *Clavaporella reinae* sp. nov., and *Anchicodium* sp.

Komia abundans KORDE and *Eugonophyllum mulderi* RÁCZ and are common in both Subzone IV A and IV B, but *Epimastopora camasobresensis* sp. nov. and *Macroporella ginkeli* RÁCZ are restricted to Subzone IV A. Algal associations, characteristic, for Subzone IV B have been found in the Abismo limestone, the Maldrigo limestone, in the lower part of the Sierra Corisa limestone and in the upper part of the Agujas limestone.

The upper part of the Lois-Ciguera Formation (Lena Formation) in the Bernesga-Porma area yields algae typical of Subzone IV A. Calcareous algae characteristic of Subzone IV B and younger have not been found, due to the fact that the upper part of the succession is absent.

Calcareous Algal Zone V. — This Zone is characterized by the presence of *Anthracoporella spectabilis* PIA (plate V, fig. 27), *Clavaporella reinae* sp. nov., *Eugonophyllum johnsonii* KONISHI and WRAY. It is interesting that *Anthracoporella* is the most frequent species in this zone, while it has not been found in older zones, with the exception of an occassional occurence in Zone II. Caclareous algae typical of Zone V, have been found in the Lores limestone, and the upper part of the Sierra Corisa limestone.

Calcareous Algal Zone VI. — The calcareous aglae in Zone VI, belong to two different groups, namely of "Carboniferous" and "Permian" types. In the Carboniferous of the Cantabrian Mountains the first group contains the genera *Anchicodium*, *Anthracoporella*, *Eugonophyllum* and *Girvanella*. These already have been found in older zones. The second group is characterized by calcareos algae, which occur for the first time in the Cantabrian Mountains. These are the genera *Clavaphysoporella*, *Gyroporella*, *Ottonosia* and *Pseudoepimastopora*. The only previous record of these fossil algae, has been from deposits of Permian age.

The same samples also contain fusulinid assemblages, characterized by the presence of *Stafella mochaensis* VAN GINKEL, *Stafella* cf. *moelleri* OZAWA and *Stafella* sp. (2), which belong to the Protriticites zone of Kasimovian age (van Ginkel, 1965). However, it should be borne in mind that this fauna is not restricted to the Kasimovian, but the species can occur in much younger post-Carboniferous strata.

Still there remains a contradiction in the simultaneous occurrence of the two groups of algae which may have been brought about in three different ways:

1. The Permian types could represent the early appearence of a typical association. A comparable situation has been found in the Bernesga-Porma area where certain types of *Anthracoporella*, *Archaeolithophyllum* and *Epimastopora* have been found at lower stratigraphic levels than in other parts of the world (Rácz, 1964).
2. The Carboniferous types may be reworked material brought in and mixed with the later, and hence indigerous, Permian flora.
3. The Carboniferous types may have continued some time in the Permian.

The calcareous algal association of Zone VI has been found in the Vañes limestone (loc. P 36) and the Urbaneja limestone.

No Zone	Associations of Calcareous Algae
VI	*Anchicodium* sp. *Anthracoporella spectabilis* *Clavaphysoporella endoi* *Eugonophyllum johnsonii* *Gyroporella* cf. *nipponica* *Girvanella* sp. *Ottonosia* cf. *laminata* *Pseudoepimastopora ? impera*
V	*Anchicodium* sp. *Anthracoporella spectabilis* *Clavaporella reinae* *Eugonophyllum johnsonii*
IV B	*Anchicodium* sp. *Clavaporella reinae* *Eugonophyllum mulderi* *Komia abundans* *Vermiporella hispanica*
IV A	*Archaeolithophyllum missouriense* *Eugonopnyllum mulderi* *Epimastopora camasobresensis* *Komia abundans* *Macroporella ginkeli* *Vermiporella hispanica* *Zaporella cantabriensis*
III	*Amorfia jalinki* *Dvinella comata* *Epimastopora rolloensis* *Ivanovia tenuissima* *Mellporella beundermani* *Pseudokomia cansecoensis* *Ungdarella conservata* *Zaporella cantabriensis*
II	*Anthracoporella* cf. *spectabilis* *Archaeolithophyllum johnsoni* *Beresella herminae* *Epimastopora bodoniensis* *Epimastopora* sp. *Donezella lunaensis* *Mellporella anthracoporellaformis*
I	*Ortonella myrae* *Ungdarella uralica*

Fig. 3. Characteristic zone-associations of Carboniferous Calcareous Algae in Northern Spain

Figure 2 shows the comparison between the zonal subdivisions based on fusulinids and algae. The Millerella Zone corresponds to the Calcareous Algal Zone I; and subzone A of the Profusulinella Zone is approxymately equivalent to the Calcareous Algal Zone II. The boundary between the zones of Profusulinella and Fusulinella can not be recognized using the calcareous algae, because Algal Zone III contains the upper part (B) of Profusulinella and the lower part (A) of Fusulinella Zone. The zonal boundaries based on the fusulinids and the calcareous algae do not correspond.

Figure 3 shows the the proposed zonal scheme, together with the characteristic fossil algae, as found in the Cantabrian Mountains.

The zonal subdivision of the various limestone members in the Pisuerga Basin in given in fig. 4. This shows that while in certain subareas in the Pisuerga Basin sedimentation took place mainly over the same interval, elswhere it is evident that the sedimentation in one sub-basin started or ceased earlier than in other subbains.

Finally is given the position of the various limestones in the Pisuerga Basin and the Bernesga-Porma are, based on the biostratigraphic subdivision proposed.

The distribution chart (fig. 5) shows the algal associations of the described limestone members in the Pisuerga Basin.

Calcareous algae as facies indicators

Most species of calcareous algae found in the Bernesga-Porma area, are also present in the Pisuerga Basin suggesting that similar ecological conditions prevailed in both areas. Certain minor differences have been recognized. For example, representatives of the genera *Archaeolithophyllum*, *Petschoria* and *Uraloporella* have not been found in the Pisuerga Basin. *Ungdarella* abundant in the Pisuerga Basin, is rare or even entirely absent in the Bernesga-Porma area. The same is true of other genera e.g. *Ivanovia*, *Clavaporella*, *Clavaphysoporella*, *Gyroporella*, *Pseudoepimastopora*. *Vermiporella*, *Anchicodium* and *Ottonosia*.

The green algae are proportionately more important than the red algae in the Pisuerga Basin, whereas the reverse is true in the Bernesga-Porma area. Thus, if one accepts the view that red algae are typical of somewhat deeper water sedimentation (Johnson, 1961; Rácz, 1964), then one may conclude that shallower conditions prevailed in the Pisuerga Basin than in the Bernesga-Porma area. The absence of *Archaeolilhophyllum*, *Petschoria* and *Uraloporella* in the Pisuerga Basin suggests that extreme conditions of deposition not occur, because *Archaeolithophyllum* has been found in the Bernesga-Porma region where the sediments indicate a very unquiet environment. *Petschoria* and *Uraloporella* on the other hand, suggest an extremely quiet milieu, because well preserved remains of these have been found in lime mud in the Bernesga-Porma area (Rácz, 1964). The presence of *Anthracoporella* and other dasyclades suggests that in the Pisuerga Basin the carborate sedimentation occured under quiet conditions, practically without any abrupt changes. Therefore it is evident that the Late Palaeozoic sedimentation in the Pisuerga Basin markedly contrasts of sedimentation with the Bernesga-Porma area, in having had a very regular pattern; the limestones have been deposited in shallow to very shallow water, marked by a total absence of turbid conditions.

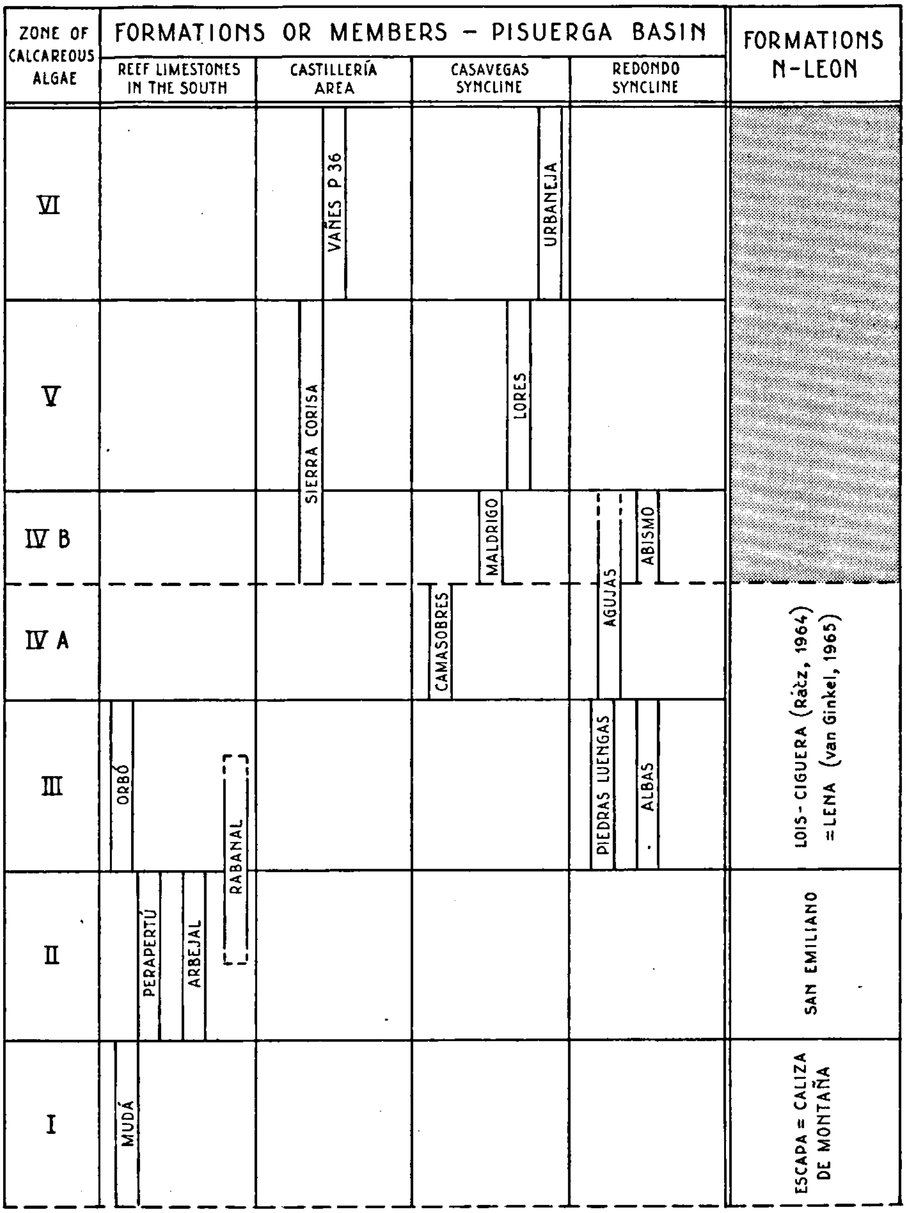

Fig. 4. The position of the various limestone members in the Pisuerga Basin based on their Algal content

Algal species	*See RÁCZ 1964	Limestone members: Mudá	Perapertú	Arbejal	Rabanal	Orbó	Piedrasluengas	Albas	Camasobres	Agujas	Maldrigo	Abismo	Sierra corisa	Brañosera	Lores	Urbaneja	P 36
Anthracoporella spectabilis PIA													×		×		×
Anthracoporella cf. spectabilis PIA	**		×	×													
Beresella hermineae RÁCZ	*		×	×	×												
Clavaphysoporella endoi RÁCZ sp. nov.																	×
Clavaporella reinae RÁCZ sp. nov.										×		×					
Dvinella comata CHVOROVA	*				×	×	×	×									
Epimastopora bodoniensis RÁCZ	*		×	×	×												
Epimastopora camasobresensis RÁCZ sp. nov.									×	×							
Gyroporella cf. nipponica ENDO																×	×
Macroporella ginkeli RÁCZ	*								×	×							
Mellporella anthracoporellaformis RÁCZ	*		×	×													
Pseudoepimastopora ? impera RÁCZ sp. nov.																×	×
Vermiporella hispanica RÁCZ sp. nov.										×		×	×				
Zaporella cantabriensis RÁCZ	*								×	×							
Anchicodium sp.													×	×	×	×	×
Donezella lunaensis RÁCZ	*		×	×													
Donezella lutugini MASLOV	*	×	×	×			×		×				×	×	×		
Ivanovia tenuissima CHVOROVA						×											
Eugonophyllum johnsonii KONISHI and WRAY													×	×	×	×	×
Eugonophyllum mulderi RÁCZ	*								×	×	×	×	×				
Amorfia jalinki RÁCZ	*				×	×	×	×									
Komia abundans KORDE	*								×	×	×	×	×				
Ungdarella conservata KORDE					×		×	×									
Ungdarella uralica MASLOV	*	×	?														
Girvanella sp.	*		×	×					×							×	
Osagia sp.	*		×	×			×	×					×		×	×	×
Ottonosia cf. laminata TWENHOFEL																×	

Fig. 5 Distribution of calcareous algae in limestones of the Pisuerga Basin

** This form is described as *A. spectabilis* PIA (Rácz, 1964)

SYSTEMATIC DESCRIPTIONS*

Explanation of symbols used by Dasycladaceae:

D = outer diameter of calcareous body
d = inner diameter of calcareous body
w = thickness of calcareous wall
w_u = thickness of calcareous wall in the upper part of a segment
w_l = thickness of the calcareous wall in the lower part of a segment
p = diameter of cylindrical branches (pores)
p_f = thickness of the branches (thicker extreme end)
p_a = thickness of the branches (thinner extreme end)
p_m = thickness of the branches in the middle
l = length of the body (fragment, segment, annulation)
t = thickness of interpores
n = number of branches in a whorl in transverse section

Phylum RHODOPHYCOPHYTA Papenfuss, 1946

Family Uncertain

Genus Ungdarella MASLOV, 1950

Ungdarella conservata KORDE, 1951

Plate I, fig. 1

1951, *Ungdarella conservata* KORDE — Korde, Trudy MOIP, Serie geol., 1, pp. 180.
1962, *Ungdarella conservata* KORDE — Maslov, Trudy geol. Inst. SSSR, no. 53, pp. 98.

Description

Thallus. A branched thallus of variable thickness, nonsegmented.

Tissue. A hypothallus and a perithallus can be distinguished. Both of these have a cell structure.

Hypothallus. The hypothallus, which is much thinner than the perithallus, consists of a single layer of large cells. In axial section the cells are elongated: 25—75μ in length and 40—100μ in breadth. In some cases a dichotomous branching of the hypothallus was observed.

Perithallus. This outer part of the thallus consists of rectangular cells. These are smaller than those of the hypothallus. Commonly the cells form rows, which run parallel to the outer surface of the thallus.

Reproductive organs. These were not observed.

Dimensions.	Length of the thallus:	a few millimeters
	Thickness of the thallus:	380—750μ
	Thickness of the hypothallus:	40—100μ
	Hypothallic cell length:	25— 75μ
	Hypothallic cell breadth:	40—100μ
	Thickness of the perithallus:	180—300μ
	Perithallic cell length and breadth:	25— 50μ

Biostratigraphic position. Calcareous Algal Zone III.
Locality. Type material is found in the Piedrasluengas limestone in loc. P 1.
Depository. This type is deposited in the Geological Museum, Leiden. (R.M.G.M. 130001, 130002).
Figured specimen. Slide nr. R.M.G.M. 130001.

* In this article, descriptions are only give of the species of calcareous algae not found in the Bernesga-Porma area. Descriptions of the fossil algae from this area can be found on pp. 85—108 of this isseu.

Phylum CHLOROHYCOPHYTA Papenfuss, 1946
Family DASYCLADACEAE Kützing orth. mut. Stizenberger, 1860
Genus Clavaporella KOCHANSKY and HERAK, 1959
Clavaporella reinae RÁCZ spec. nov.
Plate I, II, fig. 2, 3, 4, 5, 6.

Description. Thallus. The thallus is slightly curved and composed of ovoidal segments. The connection between segments is slight, giving the impression that each segment forms an independent unit. Each segment can be divided in longitudinal section into two parts. The rounded upper parts of the segments contain thick, mostly irregularly arranged branches (pores). The lower parts contain no branches. In transverse section the thallus is polygonal or irregurarly circular with several bulbs on the outer surface.

Central stem. The middle part of the body is cylindrical and filled with lime matrix.

Calcareous wall and branches. Usually the upper part of the segment, containing branches, has a much thicker wall than that of the lower part. The branches set obliqueley to the central stem, have a definite widening towards the distal part. They can be straight, but curved ones were also observed.

Reproductive organs. Not observed.

Measurements (in μ)

No slide R.M.G.M.	D	d	wu	wl	pm	pf	l (segm.)
130003	1870	1000	435	20	40	60	2000
130004	1000	562	220	28	58	74	2200
130004	1000	512	258	22	48	70	1500
130005	1376	875	250	36	70	100	2300
130005	1325	787	324	40	75	120	1480

Remarks. The present species is very similar to *Clavaporella caliciformis* KOCHANSKY and HERAK, but differs considerably in size, and is therefore regarded as constituting a new species.
Biostratigraphic position. Calcareous Algal Zone IV, subzone IV B.
Locality. Type material is found in the Abismo limestone, in loc. P 73.
Depository. Holotype and paratypes are deposited in the Geological Museum, Leiden. (R.M.G.M. 130003—130008).
Figured specimens. Slide nr. R.M.G.M. 130004, 130005.

Genus Clavaphysoporella ENDO, 1958

Clavaphysoporella endoi RÁCZ spec. nov.

Plate II, fig. 7, 8, 9, 10.

Description. T h a l l u s. The algal body is cylindrical, straight or undulating. The thallus consists of annulations in longitudinal section. This, however, can not always be observed. In transverse section the thallus is polygonal or irregularly circular, with some branches in a whorl.

C e n t r a l s t e m. Cylindrical, usually filled with material of the matrix.

C a l c a r e o u s w a l l a n d b r a n c h e s. Consequently due to the annulation the calcareous wall can vary in thickness. The length of the branches also vary. The branches are often curved upward, in longitudinal section. Usually they are thicker at the distal part than at the proximal one, and have a perpendicular or oblique position to the central stem. Bifurcation of branches was not observed.

Measurements (in μ)

No slide R.M.G.M.	D	d	w	pa	pf	l (annul.)
130010	875	250	375	65	50	250
130009	600	190	220	150	65	158
130009	725	254	217	125	60	226
130011	800	200	400	130	68	——

Remarks. Clavaphysoporella endoi spec. nov. is morphologically similar to *Clavaphysoporella fluctuosa* ENDO from Japan. It is, however, much smaller than the Japanese species.

Biostratigraphic position. Calcareous Algal Zone VI.

Locality. Type material is found in the Vañes limestone in loc. P 36.

Depository. Holotype and paratypes are deposited in the Geological Museum, Leiden (R.M.G. 130009—130011).

Figured specimens. Slide nr. R.M.G.M. 130009, 130010, 130011.

Genus Epimastopora PIA, 1922

Epimastopora camasobresensis RÁCZ spec. nov.

Plate II, III, fig. 11, 12, 13

Description. T h a l l u s. Only fragments in longitudinal and tangential section are present. The calcareous wall contains relatively thick branches which are densely arranged.

B r a n c h e s. Only primary branches were observed. The branches can be nearly cylindrical or wedge-shaped, in longitudinal section. The branches vary in length. The broadening by the wedge-shaped branches is in the most cases from the proximal to the distal end. Usually the margins are nog straight, but sinous. In tangential section the branches appear as polygonal cells, having from 4 to 7 sides, which vary in size. The cell walls (interpores) are distinct and of uniform thickness.

Measurements (in μ)

No slide R.M.G.M.	w	pa	pf	t
130012	375	100	130	40
130013	500	75	115	40
130013	440	80	125	36
130014	410	75	110	40
130014	380	77	115	45

Remarks. The new species is very similar to *Epimastopora bodoniensis* RÁCZ, however, there are differences between the two species, both with respect to size of the branches and the thickness of the interpores.
Biostratigraphic position. Calcareous Algal Zone IV, subzone IV A.
Locality. Holotype and paratypes are found in the Camasobres limestone, in loc. P 4.
Depository. Type material is deposited in the Geological Museum, Leiden. (R.M.G.M. 130012—130014.)
Figured specimens. Slide nr. R.M.G.M. 130012, 130014.)

Genus Gyroporella, GÜMBEL, em. BENECKE, 1876
Gyroporella cf. *nipponica* ENDO and HASHIMOTO
Plate III, IV, fig. 14-19

1955, *Gyroporella nipponica* ENDO and HASHIMOTO — Proc. Japan. Acad. v. 31, no. 12, pp. 705—706.

Description. Thallus. The thallus is long, cylindrical, slightly undulating, containing a relatively thick central stem and a densely branched calcareous wall.

Central stem. This portion of the alga is cylindrical and usually filled with calcite cement.

Calcareous wall and branches. The calcareous wall consists of relatively large branches. The distal parts of the branches in transverse section are expanded. The forms of the expanded parts vary, from clavate to angularly. The branches in longitudinal section are ovate or cup-shaped. The distance between successive branches in both sections is constant and the branches themselves are perpendicular or nearly so to the central stem.

Measurements (in μ)

No. slide R.M.G.M.	D	d	w	pa	p	t	n
130015	1000	500	250	65	115	18	32
130015	1220	560	330	70	140	25	24
130015	1750	1025	264	68	170	25	60
130016	1350	585	332	64	165	20	—
130016	1550	800	325	67	164	23	—

Remarks. *Gyroporella nipponica* Endo and Hashimoto is known from Upper Permian deposits of Japan. The present specimens are very similar to the Japanese species, but differ in the smaller diameter of the branches and the number of the branches in a whorl. These differences do not warrant the errection of a new species.
Biostratigraphic position. Calcareous Algal Zone VI.
Locality. The species is found in the Vañes limestone, in loc. P 36 and in the Urbaneja limestone, in loc. P 2.
Depository. The material is deposited in the Geological Museum, Leiden. (R.M.G.M. 130015, 130016.)
Figured specimens. Slide nr. R.M.G.M. 130015, 130016.

Genus Pseudoepimastopora Endo, 1960

Pseudoepimastopora ? impera Rácz spec. nov.

Plate IV, fig. 20, 21, 22

Discription. Thallus. Thallus is short cylindrical, unbranched, contains a moderately thick central part and a thin calcareous wall which consists a dense packing of branches.

Central stem. This portion of the plant is almost circular in transverse section and filled with matrix material.

Calcareous wall and branches. The calcareous wall consists of large primary branches and recristallized interpores. Most of the branches in transverse section may be divided into two parts, one expanded proximal part, and a much thinner distal part. Usually the expanded proximal part is cup-shaped or globular, while the distal part is almost cylindrical. The change between the two parts of a branch occur midway, or nearer the distal end. The branches are perpendicular to the central stem. Because of the form of the branches, the interpores also have an irregular form.

Measurements (in μ)

No. slide R.M.G.M.	D	d	w	pa	pf	t	n
130017	2000	1600	200	165	100	50 28	32
130017	1780	1380	200	160	95	52 26	30
130009	2110	1720	190	174	112	60 35	36
130009	2000	1610	195	172	108	62 34	34

Remarks. The present species can be distinct from *Pseudoepimastopora japonica* Endo and *Pseudoepimastopora pertunda* Endo in having a regular pattern of the branches and the kind of arrangement of the branches. Further the dimensions of *Pseudoepimastopora? impera* spec. nov. also differ from the two Japanese species.
Biostratigraphic position. Calcareous Algal Zone VI.

Locality. Holotype and paratypes are found in the Vañes limestone, in loc. P 36 and in the Urbaneja limestone, in loc. P 2.
Depository. The material is deposited in the Geological Museum, Leiden. (R.M.G.M. 130017, 13009.)
Figured specimens. Slide nr. R.M.G.M. 130017, 130009.

Genus Vermiporella STOLLEY, 1893
Vermiporella hispanica RÁCZ spec. nov.
Plate IV, V, fig. 23-26

Description. T h a l l u s. The tahllus is cylindrical, moderately thick, commonly sinuous and branches at a large angle.

C e n t r a l s t e n. This portion of the alga is cylinderical, structureless and filled with the matrix (mostly sparry calcite).

C a l c a r e o u s w a l l a n d b r a n c h e s. The calcareous wall is uniform in thickness. The branches are cylindrical and having a little variation in thickness. They are regularly arranged, and have a perpendicular or oblique position to the central stem.

Measurements (in μ)

No. slide R.M.G.M.	D	d	w	p	t	n
130018	875	570	152	20	15	64
130018	900	573	163	40	15	58
130019	1125	735	190	35	17	66
130020	950	570	190	43	18	60

Biostratigraphic position. Calcareous Algal Zone IV (subzones IV A and IV B).
Locality. Type material is found in the Agujas limestone, in loc. P 72.
Depository. The holotype and paratypes are deposited in the Geological Museum, Leiden. (R.M.G.M. 130018-130020.)
Figured specimens. Slide nr. R.M.G.M. 130019, 130020.

Family CODIACEAE (Trevisan) Zanardini, 1843
Genus Anchicodium JOHNSON, 1946
Anchicodium sp.
Plate V, VI, fig. 28-30

Description. T h a l l u s. Only fragments of cylindrical and blade-like forms have been found. The tissue of the algal fragments can be divided into a central portion (medulla) and an outer portion (cortex) in tranverse section.

M e d u l l a. The central portion of the species consists of a spongy mass of small, twisted, sometimes branched pseudofilaments.

C o r t e x. This portion, surrounding the medulla, consists of elongated cells and intercellular spaces. The cortical cells can be regularly or irregularly arranged.

Usually the inner end of them are thinner than the outer one. Most of the cells are perpendicular or nearly perpendicular to the outer surface. Occasionally these can form a tufty structure.

Measurements.	Thickness of the fragments:	490—900 μ
	Thikness of the cortex:	150—250 μ
	Thickness of cortical cells (outer end):	16—20 μ
	Interspaces between cortical cells:	17—22 μ

Biostratigraphic position. Calcareous Algal Zones V and VI.
Locality. This species has been found in the Lores limestone, in loc. P 10 and in the Urbaneja limestone, in loc. P 2.
Depository. The material is deposited in the Geological Museum, Leiden. (R.M.G.M. 130021, 130022).
Figured specimen. Slide nr. R.M.G.M. 130021.

Genus Eugonophyllum KONISHI and WRAY, 1961
Eugonophyllum johnsonii KONISHI and WRAY, 1961
Plate VI, fig. 31-34

1961. *Eugonphyllum johnsonii* KONISHI and WRAY — Journ. Pal. v. 35, no. 4 pp. 659—666.

Description. T h a l l u s. Only undulating, blade-like fragments have been found. The fragments may be several millimeters in length and in thickness vary between 250—775μ. The blades differenciated into medulla, subcortex and outer cortex.

M e d u l l a. In most cases the medulla has no definite structure, but sometimes, fine, twisted pseudofilaments can be detected.

S u b c o r t e x. Usually a well preserved layer of anastomosing urticles and interspaces. Urticles have a diamteter of 35—63 μ, and are arranged perpendicular to the outer surface.

O u t e r c o r t e x. This outer portion of the cortical cells is usually a recrystallized one.

The length of the subcortex and the outer cortex together, varies between 100—130 μ.

P e r f o r a t i o n s. Occassionally perforations in the fragments have been found. These openings may have had connection with the reproduction process. The perforations in transverse sections appear as a half circle.
Biostratigraphic position, Calcareous Algal Zones V and VI.
Locality. The species is found in the Lores limestone, in loc. P 10, in the Vañes limestone, in loc. 36 and in the Urbaneja limestone, in loc. P 2.
Depository. The material is deposited in the Geological Museum, Leiden. (R.M.G.M. 130023, 130024).
Figured specimens. Slide nr. R.M.G.M. 130023, 130024.

Genus Ivanovia CHVOROVA, 1946
Ivanovia tenuissima CHVOROVA, 1946
Plate VII, fig. 35-39

1946. *Ivanovia tenuissima* CHVOROVA — Acad. Sci. SSSR (Doklady) v. 53, no. 8, pp. 737—739.

Description. T h a l l u s. Only fragments have been found. The fragments form straight, curved or sinous blades, which vary in thickness. The tissue consists of a central portion (medulla) surrounded by an outer cover (cortex) in transverse section.

M e d u l l a. Due to the strong recrystallisation no structure can be observed.

C o r t e x. This portion consists of cortical cells and interspaces. The cells have a cylindrical or nearly cylindrical form. The structure of the cortex is very often indistinct, preventing any detailed study of the cells.

Measurements.	Thickness of the fragments	200—600 μ
	Thickness of the cortex	64—100 μ
	Diameter of the cortical cells	17— 45 μ
	Interspaces between successively cells	14—18 μ

Biostratigraphic position. Calcareous Algal Zone III.
Locality. The species is found in the Orbó limestone.
Depository. Type material is deposited in the Geological Museum, Leiden. (R.M.G.M. 130025-130027).
Figured specimens. Slide nr. R.M.G.M. 130025, 130026.

Phylum SCHIZOPHYTA (Falkenberg) ENGLER, 1892
Section POROSTROMATA PIA, 1927
Genus Girvanella NICHOLSON and ETHERIDGE, 1880
Girvanella sp.
Plate VIII, fig. 40

Description. T i s s u e. The tissue consists of short, loosely arranged tubes, which are surrounded by thin walls. The tubes are mostly undulating, but straight specimens also occur. Branching of the tubes was not observed. Their diameter has some variation.

Measurements.	Diameter of the tubes	17—25 μ (commonly 20 μ)
	Thickness of the wall	3—6 μ (commonly 4 μ)

Biostratigraphic position. Calcareous Algal Zone VI.
Locality. Urbaneja limestone, in loc. P 2.
Deposition. Type material is deposited in the Geological Museum, Leiden. (R.M.G.M. 130028).
Figured specimens. Slide nr. R.M.G.M. 130028.

Genus Ottonosia TWENHOFEL, 1919
Ottonosia cf. *laminata* TWENHOFEL, 1919
Plate VII, fig. 41

1919. *Ottonosia laminata* TWENHOFEL — Am. Journ. Sci. 4th Series, v. 48, pp. 350—351.

A few fragments have been found, which are closely comparable with the species *Ottonosia laminata* described by Twenhofel from the Lower Permian of Kansas. Unfortunately, most of the fragments are strongly recrystallized, so a detailed study of the structure was not possible.

Biostratigraphic position. Calcareous Algal Zone VI.
Locality. Urbaneja limestone, in loc. P 2.
Depository. The material is deposited in the Geological Museum, Leiden. (R.M.G.M. 130028).
Figured specimen. Slide nr. R.M.G.M. 130028.

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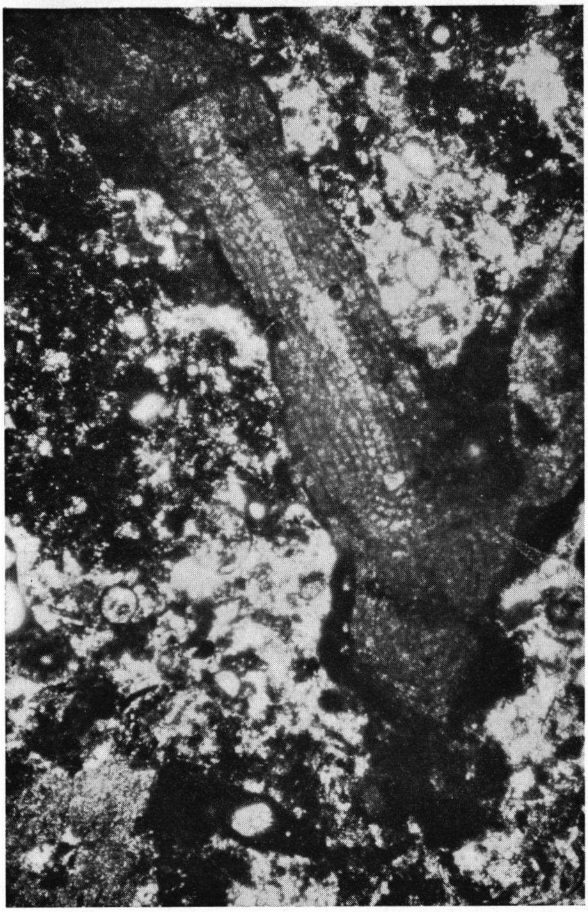
PLATES

PLATE I.

1.	*Ungdarella conservata* KORDE Nearly a longitudinal section of a branching fragment. Note the thin hypothallus and the outer perithallus.	20 ×
2.	*Clavaporella reinae* sp. nov. Holotype. Longitudinal section, showing the connection between two segments, form of the thallus and the arrangement of the pores.	20 ×
3.	*Clavaporella reinae* sp. nov. Longitudinal section of a fragment of a segment, showing the characteristic arrangement of the pores.	20 ×
4.	*Clavaporella reinae* sp. nov. Slightly oblique transverse section of the thallus.	20 ×
5.	*Clavaporella reinae* sp. nov. Slightly oblique longitudinal section of segments.	20 ×



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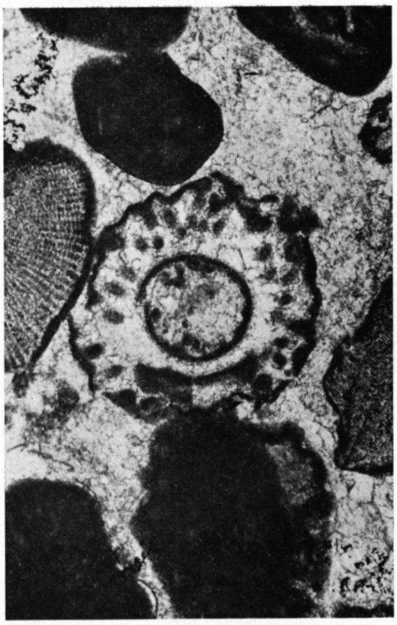

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PLATE II.

6. *Clavaporella reinae* sp. nov. 20 ×
   Slightly oblique longitudinal section of segments.

7. *Clavaphysoporella endoi* sp. nov. 20 ×
   Oblique-longitudinal section of the thallus.

8. *Clavaphysoporella endoi* sp. nov. 20 ×
   Oblique-transverse section (in the middle of photograph).

9. *Clavaphysoporella endoi* sp. nov. 20 ×
   Oblique-transverse section.

10. *Clavaphysoporella endoi* sp. nov. 20 ×
    Oblique-transverse section.

11. *Epimastopora camasobresensis* sp. nov. 20 ×
    Fragments of the species in longitudinal and tangential sections.

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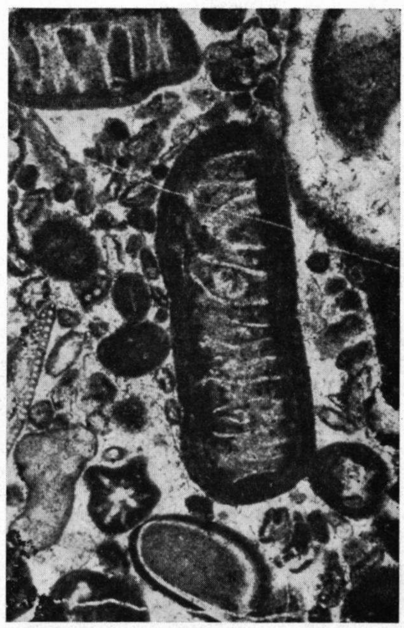

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PLATE III.

12. *Epimastopora camasobresensis* sp. nov. 20 ×
Fragments of the species in longitudinal and tangential sections.

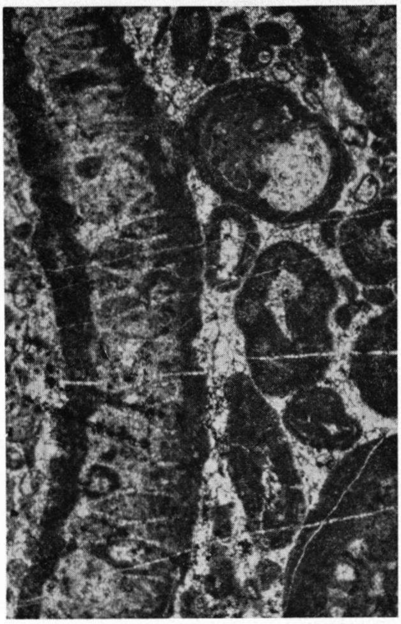
13. *Epimastopora camasobresensis* sp. nov. 20 ×
Fragments of the species in longitudinal and tangential sections.

14. *Gyroporella* cf. *nipponica* ENDO and HASHIMOTO 20 ×
Slightly oblique longitudinal section of the species, showing the form and arrangement of the branches.

15. *Gyroporella* cf. *nipponica* ENDO and HASHIMOTO 20 ×
Transverse section.

16. *Gyroporella* cf. *nipponica* ENDO and HASHIMOTO 20 ×
Transverse section.

17. *Gyroporella* cf. *nipponica* ENDO and HASHIMOTO 20 ×
Nearly tangential section.



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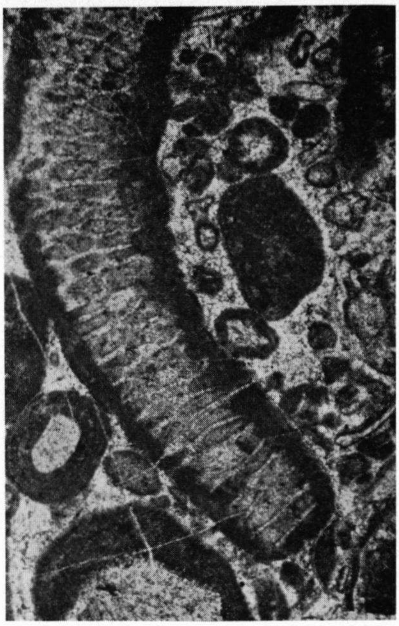

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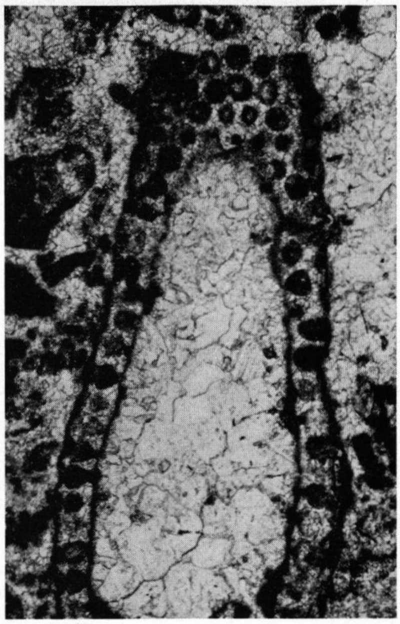

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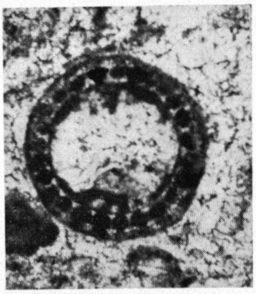

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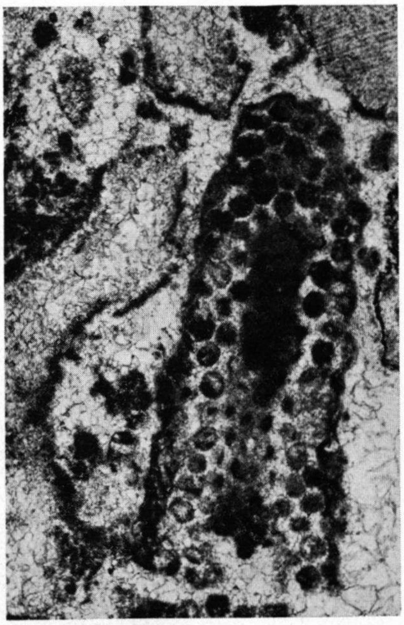

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PLATE IV.

18. *Gyroporella* cf. *nipponica* ENDO and HASHIMOTO — 20 ×
    Oblique-longitudinal section.

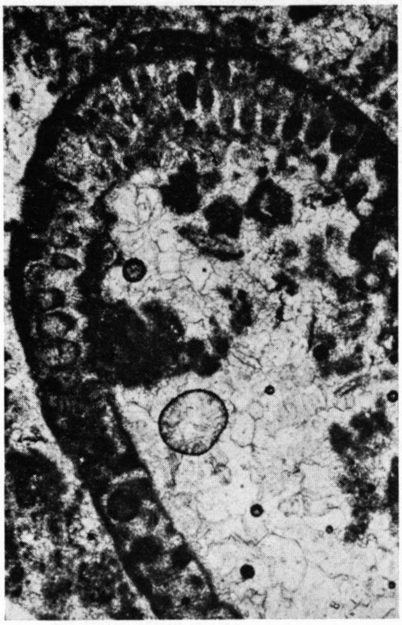
19. *Gyroporella* cf. *nipponica* ENDO and HASHIMOTO — 20 ×
    Oblique-longitudinal section.

20. *Pseudoepimastopora* ? *impera* sp. nov. — 20 ×
    Transverse section. Note the calcareous wall with many branches.

21. *Pseudoepimastopora* ? *impera* sp. nov. — 20 ×
    Oblique-transverse section.

22. *Pseudoepimastopora* ? *impera* sp. nov. — 20 ×
    Oblique-transverse section.

23. *Vermiporella hispanica* sp. nov. — 20 ×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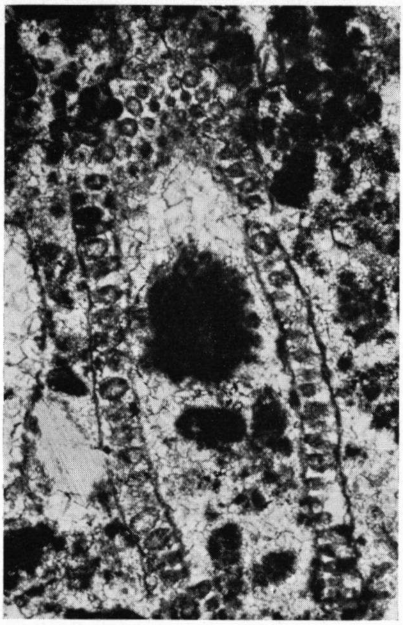
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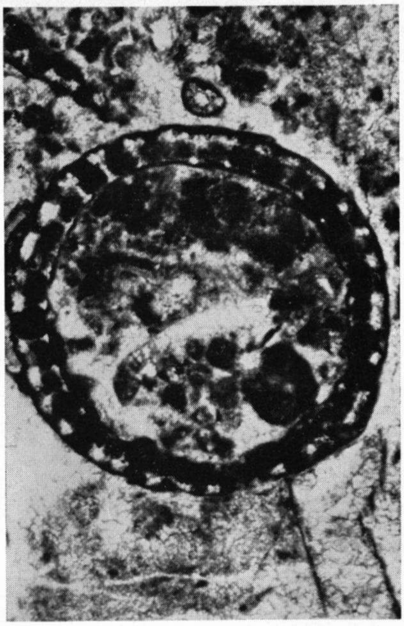
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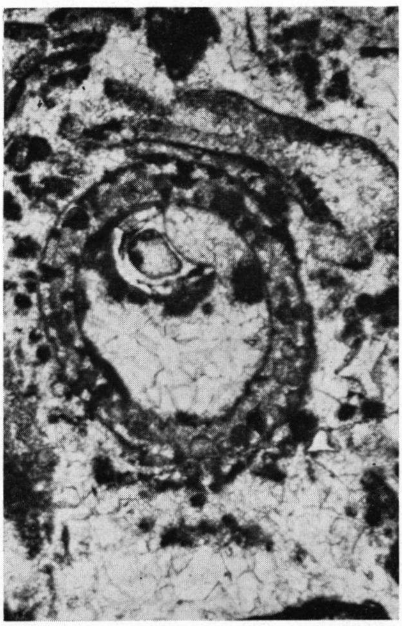
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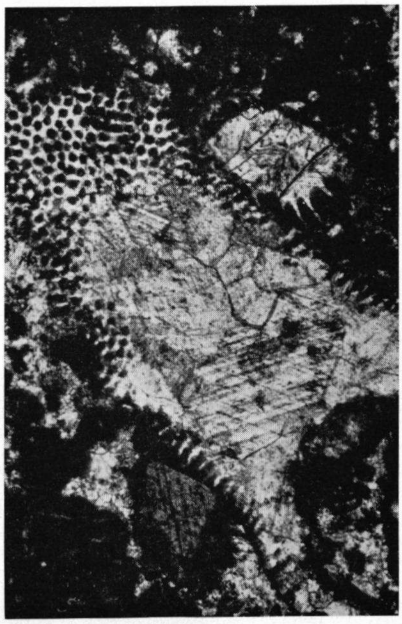
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PLATE V.

24.	*Vermiporella hispanica* sp. nov.	20 ×
25.	*Vermiporella hispanica* sp. nov.	20 ×
26.	*Vermiporella hispanica* sp. nov.	20 ×
27.	*Anthracoporella spectabilis* PIA Several sections.	20 ×
28.	*Anchicodium* sp. At the left side of the thallus the cortex is shown.	20 ×


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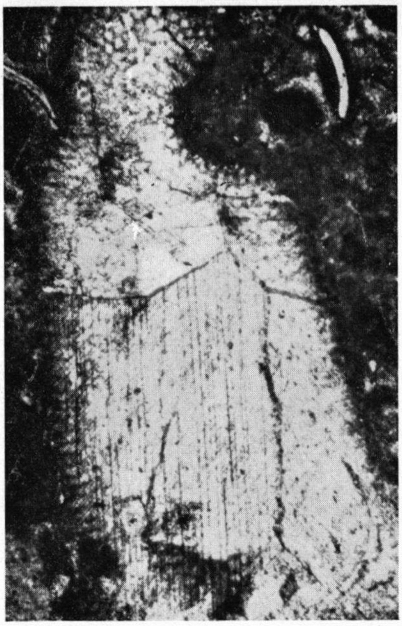
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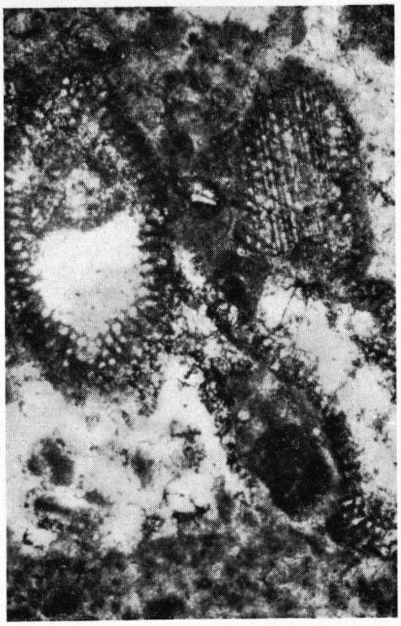
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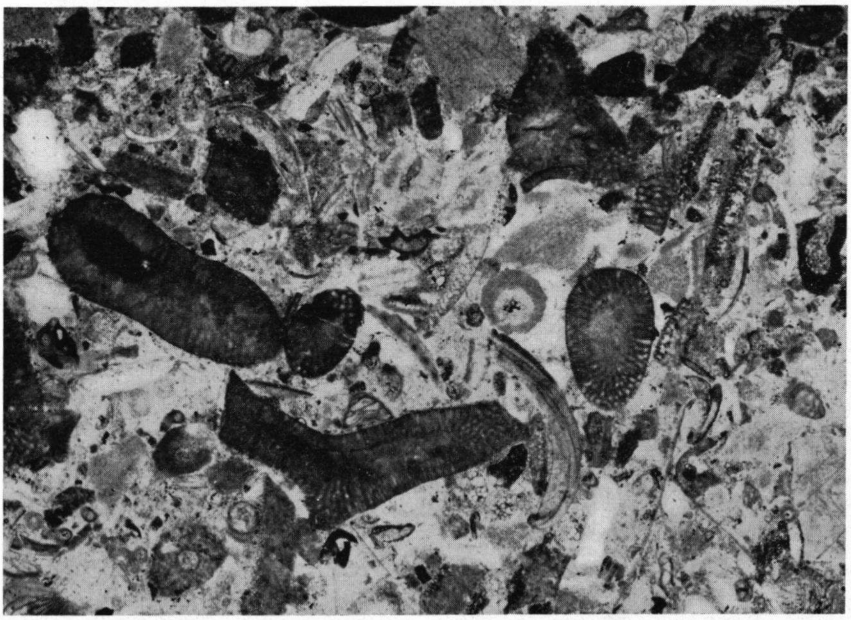
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PLATE VI.

29. *Anchicodium* sp. 20 ×
Several sections.

30. *Anchicodium* sp.
At the right side of the thallus the structure of the cortex is visible.

31. *Eugonophyllum johnsonii* Konishi and Wray 20 ×
Two fragments with clearly cortex-structures.

32. *Eugonophyllum johnosnii* Konishi and Wray 20 ×
Section, showing the narrowing at the place of the perforation.

33. *Eugonophyllum johnsonii* Konishi and Wray 20 ×
Sections of fragments of different thickness. At the left side of the photograph a dasycladacean alga is visible.

34. *Eugonophyllum johnsonii* Konishi and Wray 20 ×
Sections of fragment of different thickness.

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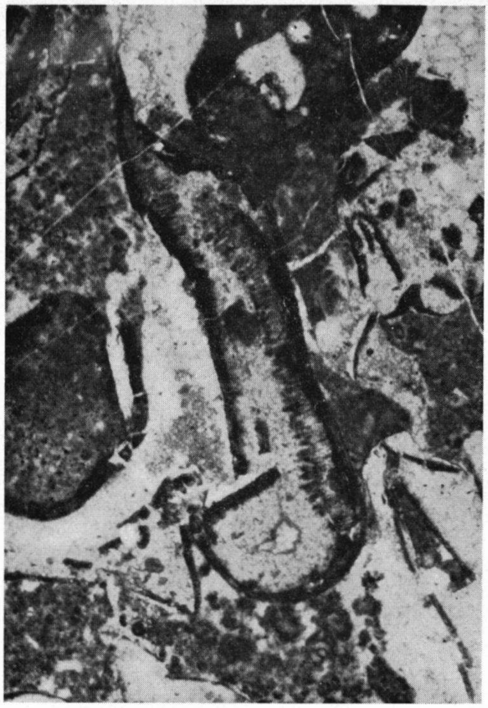

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PLATE VII.

35. *Ivanovia tenuissima* CHVOROVA	20 ×
36. *Ivanovia tenuissima* CHVOROVA	20 ×
37. *Ivanovia tenuissima* CHVOROVA	20 ×
38. *Ivanovia tenuissima* CHVOROVA	20 ×
39. *Ivanovia tenuissima* CHVOROVA	20 ×
41. *Ottonosia* cf *iaminata* TWENHOFEL. Badly preserved fragment of the species.	20 ×

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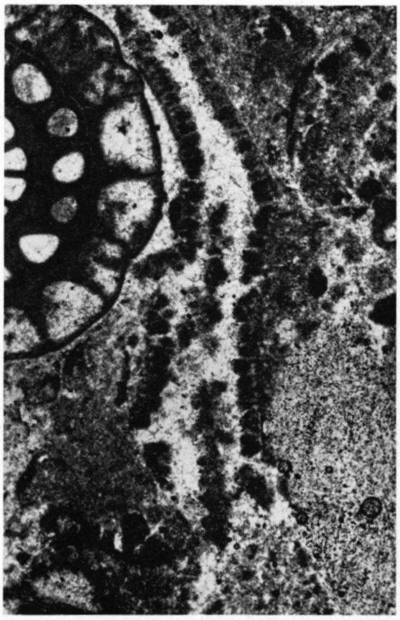

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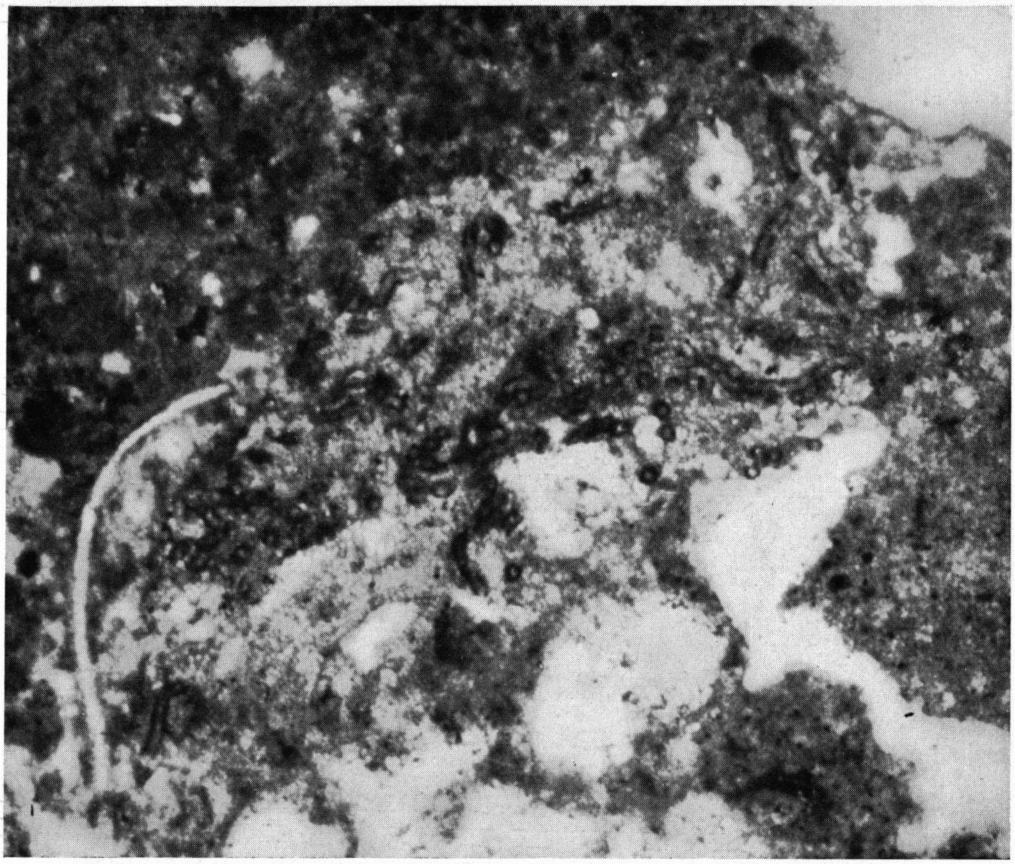
PLATE VIII.

40. *Girvanella* sp. 75 ×
Tubes in several sections.



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