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THE PIEDRASLUENGAS LIMESTONE, A POSSIBLE MODEL OF LIMESTONE FACIES DISTRIBUTION IN THE CARBONIFEROUS OF THE CANTABRIAN MOUNTAINS

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ABSTRACT

The Piedrasluengas Limestone of Lower Moscovian age, provides a facies model for most of the Carboniferous limestones in the Cantabrian Mountains. Three main facies types are distinguished. 1) a massive mudstone-wackestone-packstone facies, with often algal structures. This facies is interpreted as a biogenetic bank deposit (i. e. not a wave-resistant reef) mainly formed through the trapping of sediment by algae. 2) a well-bedded mudstone to wackestone, which in general is poorly fossiliferous. This facies is interpreted as a «lagoonal» deposit. 3) clastic packstones and grainstones with often abundant fossils. This facies formed in agitated water under littoral to sub-littoral conditions. These facies types can be encountered in a similar development in most limestones in this region.

RESUMEN

La caliza de Piedrasluengas, de edad Moscoviense inferior, puede ser usada como modelo de facies para las calizas carboníferas de la Cordillera Cantábrica. Se distinguen tres tipos principales de facies. 1) una facies de «mudstones-wackestones-packstones» masivos, frecuentemente con estructuras de algas. Esta facies es interpretada como un banco biogenético, es decir no es un auténtico arrecife. Los bancos biogenéticos se originan por la captura de sedimentos mediante organismos sin que estos tengan que ser constructores de arrecifes. Hierbas marinas, algas y otros organismos pueden formar así estructuras biostromales y biohermales. 2) una facies «mudstone-wackestone», pobre en fósiles, bien estratificada, que es interpretada como un depósito «lagunar», formado en depresiones entre los bancos. 3) una facies de «packstones-grainstones» clásticos, frecuentemente con gran abundancia de fósiles. Esta facies fue originada en aguas muy movidas en un ambiente litoral a sublitoral.

Estos tres tipos de facies pueden ser reconocidas en la mayoría de las calizas de esta región.

INTRODUCTION

Limestones form an important part of the Carboniferous sequence in the Cantabrian Mountains. To prove their importance, suffice to mention the Caliza de Montaña (= Escapa Formation), which is several hundreds of metres thick in many

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places, and which forms the impressive Picos de Europa range. Above the Caliza de Montaña, which is of Bashkirian (Namurian) age (BROUWER & VAN GINKEL 1964), a number of limestone-bearing strata occur. The most important of these are the San Emiliano, Lois-Ciguera, Pando, and Sierra Corisa Formations.

From what the present author has seen of these different limestone-bearing sequences and from what is known from published accounts (RÁCZ 1965, DE MEIJER 1969, WINKLER PRINS 1968, VAN LOON 1971) it seems clear that most Carboniferous limestones in the Cantabrian Mountains can be described adequately in terms of a limited number of facies.

A suitable example, containing the most important facies types, is the Piedrasluengas Limestone. This limestone is well exposed in a road section (road Cervera de Pisuerga (Palencia) to Potes (Santander)) in the gorge about one kilometre south of the Puerto de Piedrasluengas (see situation map). Its age as determined by fusulinids is Lower Moscovian (VAN GINKEL 1965).

FACIES DESCRIPTIONS AND INTERPRETATIONS

For convenience the section has been divided into a number of units as described below.

The terminology used for describing the limestones is that of FOLK (1959) and DUNHAM (1962). The former is most useful for the description of thin sections, whilst the latter is more easily applicable in the field.

Unit 1) Sandstone-shale alternation. The sandstone beds are up to 25 cm. thick. They have sharp bases with sole marks and have gradational tops. They are graded and show a regular sequence from massive to laminated and then to rippled and once more to laminated. Although the basal units may be missing, the order of the sequence remains the same. I n t e r p r e t a t i o n: turbidites alternating with shales which represent the background sedimentation. Transitional contact with:

Unit 2) Calcareous shales with a few lenses of fossil debris. The lower part contains some contorted sandstone lenses. I n t e r p r e t a t i o n: probably shallow marine deposits, contorted at the base by slumping. Fairly sharp transition to:

Unit 3) Irregularly bedded limestone with a brecciated appearance. This brecciation is mainly due to intensive pressure solution, accompanied by dolomitization, in a coarse wackestone-packstone. The clasts are mainly brachiopods, crinoid columnals, solitary corals, and poorly preserved oncolites. I n t e r p r e t a t i o n: shallow marine because of the oncolites. Gradual transition to:

Unit 4) Massively weathering, nearly pure limestone with numerous algal structures. Sporadic crinoid columnals, solitary corals, brachiopods, and sphinctozoan sponges have been found. The algal structures vary from stromatolites to anastomosing patterns of algal tubes. A large part of this unit does not readily show any of

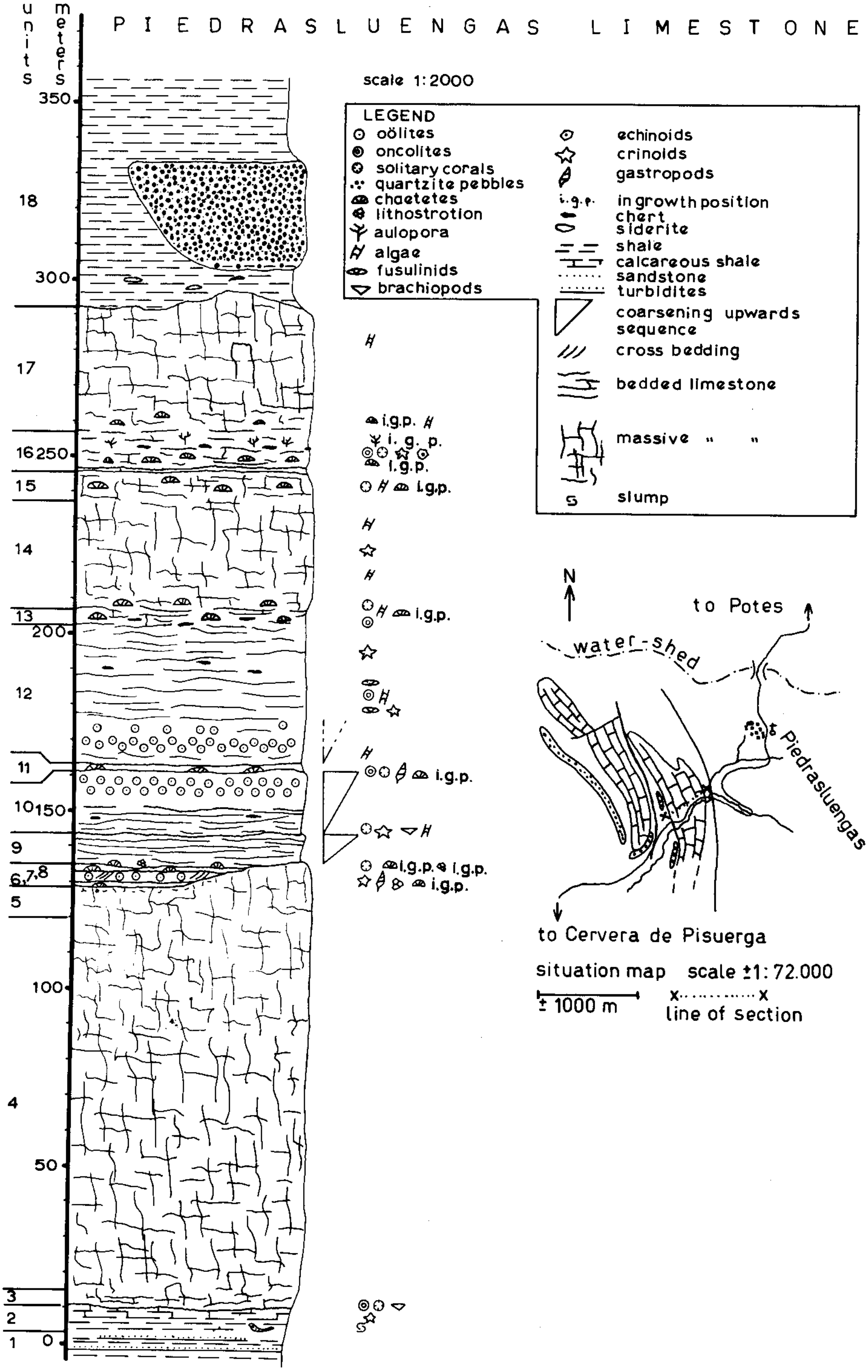
units
meters
PIEDRASLUENGAS LIMESTONE
scale 1:2000
350
300
250
200
150
100
50
0
18
17
16
15
14
13
12
11
10
9
6,7,8
5
4
3
2
1
LEGEND
oölites
oncolites
solitary corals
quartzite pebbles
chaetetes
lithostrotion
aulopora
algae
fusulinids
brachiopods
echinoids
crinoids
gastropods
in growth position
chert
siderite
shale
calcareous shale
sandstone
turbidites
coarsening upwards sequence
cross bedding
bedded limestone
massive " "
slump
i.g.p.
N
to Potes
water-shed
Piedrasluengas
to Cervera de Pisuerga
situation map scale ±1:72.000
± 1000 m
line of section

Fig. 1

these algal structures but polishing often reveals the pseudostromatic structures and textures.

Because of the predominance of these structures the whole of unit 4 is classified as an algal bound mudstone or wackestone (for nomenclature see DE MEIJER 1969), with large patches of real boundstone. It is striking that calcareous algae are rare to absent in this unit. Non-calcareous algae, however, are abundant in the boundstone parts (DE MEIJER, pers. comm.). Laterally, this unit interfingers, after some 100 -150 m, with fairly regularly bedded micrites to pelmicrites, which may show some vague cross-stratification (see Pl. 1, fig. 1). No clear algal structures were recognized in these bedded strata.

In the whole of unit 4 there is no trace of any coarse sediment or of winnowing of the calcareous mud. Nor is there any such coarse grained sediment at the transition to the bedded part. I n t e r p r e t a t i o n: this, mainly algal, limestone, over a hundred metres thick, passes laterally into bedded micrites within a distance of 75 - 150 m. It can thus safely be called an algal bioherm. The important question now arises whether it was a true reef or a biogenetic bank. The distinction between these two forms of organic construction was clearly stated by BAARS (1963), whose definitions are given below in an adapted form.

A reef is a deposit due to prolific i n s i t u biologic activities. In this deposit the organisms are organically bound into (at least potentially) a wave-resistant framework. In most recent examples they are accompanied by important quantities of reef debris. This reef debris often greatly exceeds the reef proper in volume.

A biogenetic bank is also due to prolific i n s i t u biological activity, but it does not possess a rigid framework. Typically they are mound-shaped shoals of muddy, skeletal elements, held in place by organisms like marine grasses, algae, etc.. They grow through the trapping of sediment. Their formation is not unlike that of consolidated dunes, which grow through the trapping action of vegetation. Although some binding does occur in most cases, because of the extremely rapid diagenesis of limestones, they are not originally wave-resistant structures. Recent examples mentioned by BAARS (1963) are the Rodrigues and Tavernier banks on the inner shelf behind the Florida Keys. The latter are examples of true reefs, which in this case protect the inner shelf against the ocean waves.

The bedded micritic limestones are interpreted as having been deposited in a slightly protected environment. A greater depth of water is the most likely cause of this protected character. A lagoonal environment is envisaged for this part of unit 4.

The muddy character of the whole complex indicates a rather quiet environment. Water depth did not exceed a few tens of metres as is indicated by the algae. Transitional contact with:

Unit 5) Massive micritic limestone. No clear algal structures were observed in this wackestone-packstone. One small quartzite pebble was found. In the upper part numerous cracks filled with quartz sand occur. Some fossils contain residual bitumen. I n t e r p r e t a t i o n: the quartz sand filled cracks are erosional features, which indicate an early lithification of the top part of the biogenetic bank. Whether this erosion was subaerial or submarine could not be ascertained, but water depth probably was extremely shallow. Sharp, irregular contact with:

Unit 6) Irregularly bedded, somewhat mottled pelsparite to pelmicrite, which contains a fair amount of insoluble material. At the base of this unit, or at the very top of unit 5, a few chaetetid corals occur in position of growth. This unit wedges out after some 20-30 m, against the top of unit 5 (see Pl. 1, fig. 2). I n t e r p r e t a t i o n: because of the observable geometry of this unit it seems likely that it was deposited in a shallow pond or lagoon on top of the biogenetic bank. Sharp, irregular contact with:

Unit 7) This unit consists of well washed and sorted oosparitic and mottled pelsparitic grainstones, with some vague cross-stratification. They contain crinoids, «bellerophontid» gastropods, and «lithostrotionid» corals which are not in position of growth. I n t e r p r e t a t i o n: this unit was deposited in shallow, agitated water. Sharp, irregular contact with:

Unit 8) Irregularly bedded wackestones-packstones-grainstones with much insoluble material, and numerous chaetetid corals in growth position. I n t e r p r e t a t i o n: this unit was deposited in shallow, rather quiet water. Sharp, irregular contact with:

Unit 9) The base of this unit is of the same overall composition as unit 8, but differs from it in containing «lithostrotionid» corals in position of growth, and abundant solitary corals. It grades into regularly bedded, well sorted pelsparitic grainstones, the upper part of which tend to become packstones-grainstones with much insoluble residue. The lower part of this unit still wedges out against the top of unit 5, like 6, 7 and 8 do. I n t e r p r e t a t i o n: the increase in sorting and winnowing from bottom to top in this unit suggests an increase in wave activity in this direction, i.e. a coarsening upwards sequence. This may be interpreted as a beach-like environment. The poorer sorting in the upper part is regarded as indicating that, before the beach was completed, the energy of the water decreased. Another possible explanation is that the fine material represents a later infiltration from above. Very sharp and regular contact with:

Unit 10) Irregularly bedded wackestone-packstone with some indications of boundstone. The lower part is rather rich in insoluble material and dolomite. The importance of these constituents decreases towards the top, as the unit changes to a well bedded packstone-grainstone with some chert concretions. At about 153 m it changes into a massively weathering, bio-oosparitic to pelsparitic grainstone, which shows vague mottling at the top. I n t e r p r e t a t i o n: this unit, too, shows a clear increase in sorting, winnowing and median grain size towards the top. This is again taken to indicate an increase in water energy from bottom to top as is found in recent beach deposits. Sharp contact with:

Unit 11) The lowermost part of this unit is wackestone - packstone, rich in insoluble material and also containing some dolomite. At the contact numerous chaetetid corals are preserved in position of growth. «Bellerophontid» gastropods, solitary corals and oncolites also occur. Towards the top the same pattern as in units 9 and 10 is repeated: decrease in insoluble material and dolomite content; increase in sorting, winnowing and median grain size; bedding becomes more regular. However, this sequence is much less well developed than below. I n t e r p r e t a t i o n: poorly developed coarsening upwards sequence from a littoral environment. Probably a gradational contact with:

Unit 12) Irregularly bedded wackestone-packstone with some interbedded grainstones. No regular sequence could be discerned. I n t e r p r e t a t i o n: the alternation of well winnowed and poorly winnowed sediments indicates important changes in water agitation during deposition of this unit. The oosparitic grainstones and the algae are proof, however, that the environment of deposition remained very shallow. Gradational contact with:

Unit 13) Irregularly bedded wackestone-packstone with numerous oncolites, some chaetetid corals in position of growth, and a few chert concretions. I n t e r p r e t a t i o n: the oncolites indicate very shallow water (sub-tidal) and the poor sorting rather sluggish water movements. Gradational contact with:

Unit 14) Massively weathering wackestone-packstone with some indistinct indications of algal boundstone structures and textures. In the upper part it has a brecciated appearance which seems to be of sedimentary origin. I n t e r p r e t a t i o n: this unit is at least partly a biogenetic bank deposit. Gradational contact with:

Unit 15) Poorly bedded packstone-grainstone with abundant chaetetid corals in position of growth. I n t e r p r e t a t i o n: this unit probably represents the gradual transition from the quiet mud deposition on the biogenetic bank, to calcarenites deposited in more agitated water. Sharp contact with:

Unit 16) The basal layer consists of a well bedded packstone-grainstone with some indistinct cross-stratification. This grades into an irregularly bedded wackestone with over 50 % of chaetetid corals in growth position. The middle and upper parts of this unit consist of irregularly bedded wackestone-packstone with some insoluble material. Auloporid corals in position of growth, oncolites and some chert concretions occur in this part. I n t e r p r e t a t i o n: this unit was deposited in very shallow water with sluggish water movements. Gradational contact with:

Unit 17) Massively weathering wackestone-packstone with some indistinct algal structures and textures. I n t e r p r e t a t i o n: probably part of a biogenetic bank. Sharp, irregular contact with:

Unit 18) Shale with some sideritic concretions, and a pebbly mudstone to conglomerate lens. I n t e r p r e t a t i o n: quiet, probably relatively deep marine environment with slides of conglomeratic material into an area with predominant shale deposition.

DISCUSSION OF THE PIEDRASLUENGAS LIMESTONE AS A WHOLE

This whole limestone sequence is of a very shallow, marine origin as is proven adequately by the abundant calcareous algae and algal structures. Although the overall micritic character of the limestones probably indicates rather quiet conditions, the coarsening upwards sequences with oosparitic grainstones show that littoral conditions with agitated water did also exist. Lateral shifting of the different facies realms produced some rhythmicity as is indicated by units 9 and 10.

The massive mudstone-wackestone-packstone facies possesses at least some indications of algal binding in the form of pseudostromatic structures and textures. In unit 4 this has produced a real bioherm. In the case of units 14 and 17 it only produced some vague biostromes. Because of the lack of debris and/or talus zones at the rim of the bioherm, it is considered unlikely that it was originally a wave-resistant structure, i.e. it was a biogenetic bank and not a reef.

Contained as it is between siliciclastic sediments, which were deposited in slightly deeper water, the limestone shows a somewhat symmetrical development with often well washed littoral deposits in the middle and biogenetic bank deposits above and below.

Three main facies groups can be distinguished in the Piedrasluengas Limestone: 1) the massive, mostly micritic biogenetic bank facies, which may occasionally form distinct bioherms instead of the normal biostromes; 2) the well bedded micritic «lagoonal» facies, which is normally unfossiliferous; 3) the clastic, fossiliferous limestones which may be differentiated as follows —3a) the oosparitic - pelsparitic grainstone facies which originated in agitated waters and which probably indicates littoral to sub-littoral conditions, —3b) the clastic wackestone-packstone facies, with occasional mudstone and grainstone patches. This facies often contains numerous corals, foraminifera, calcareous algae, brachiopods, crinoids, etc., and is intermediate between the other three, but most closely associated with 3a.

THE RELEVANCE OF THESE FACIES TYPES FOR DESCRIBING THE OTHER CARBONIFEROUS LIMESTONES IN NW SPAIN

These three facies groups can, in the author's opinion, adequately describe most of the Carboniferous limestones in the Cantabrian Mountains. To substantiate this claim a few examples of each type will be mentioned below.

In the Valdeteja Member of the Escapa Formation (= Caliza de Montaña) the occurrence of biohermal structures is mentioned by WAGNER (1962) and WINKLER PRINS (1968). WAGNER thought them to be reefs. WINKLER PRINS doubted this, and in the light of the descriptions given above it seems likely that they are biogenetic banks. However, this does not mean that they cannot have formed an effective barrier zone. The basic difference, it can not be stressed too much, is the presence or absence of a wave-resistant structure, and whether it was formed through sediment trapping or through secretion.

In the Picos de Europa, in the valleys of the rivers Sella, Cares and Deva, similarly massive, micritic limestones dominate the scene.

In the Mesao Limestone Member of the Pando Formation a biogenetic bank is present according to VAN LOON (this volume).

In the Sierra Corisa Formation most of the limestones consist mainly of these biogenetic bank deposits.

According to DE MEIJER (1969), more than 90 % of the limestones of the Lois-Ciguera Formation are of algal origin. That biogenetic banks are important in this formation and in the San Emiliano Formation was already mentioned by RÁCZ (1965). He also thinks that true reefs are present in the area studied by him. Although this possibility cannot be excluded, it is unlikely that they are very important.

This may suffice to indicate the importance of the biogenetic bank facies type in the Carboniferous limestones of Northwest Spain.

The bedded, unfossiliferous micrites occurring laterally off the biogenetic bank, and which are here interpreted as lagoonal or quiet basinal deposits, are similar to the limestones of the Vegacervera Member of the Escapa Formation (WINKLER PRINS 1968). They are also present in the Agujas Limestone Member of the Sierra Corisa Formation.

The third facies type distinguished seems to be represented by the Valdeteja Member of the Escapa Formation, which is largely a biosparitic grainstone (WINKLER PRINS 1968). It also fits the descriptions given by RÁCZ of parts of the San Emiliano Formation, and is also recognizable in the limestones of the Sierra Corisa Formation.

CONCLUSIONS

The abundance of calcareous and other algae in the facies types 1 and 3 indicates that these two types originated in shallow water. A tidal to sub-tidal environment seems likely in many cases. Facies type 2 was deposited in a slightly deeper environment.

Although a larger number of detailed studies are needed to substantiate this claim, it is the author's opinion that the biogenetic banks, the «lagoonal» deposits and the associated clastic limestones are typical of the Carboniferous limestones in the Cantabrian Mountains. True reefs are probably rare.

Published accounts by RÁCZ (1965), WINKLER PRINS (1968) and DE MEIJER (1969) give some support to this conclusion, but personal experience with the limestone-bearing sequences provided the basis for the generalizations presented.

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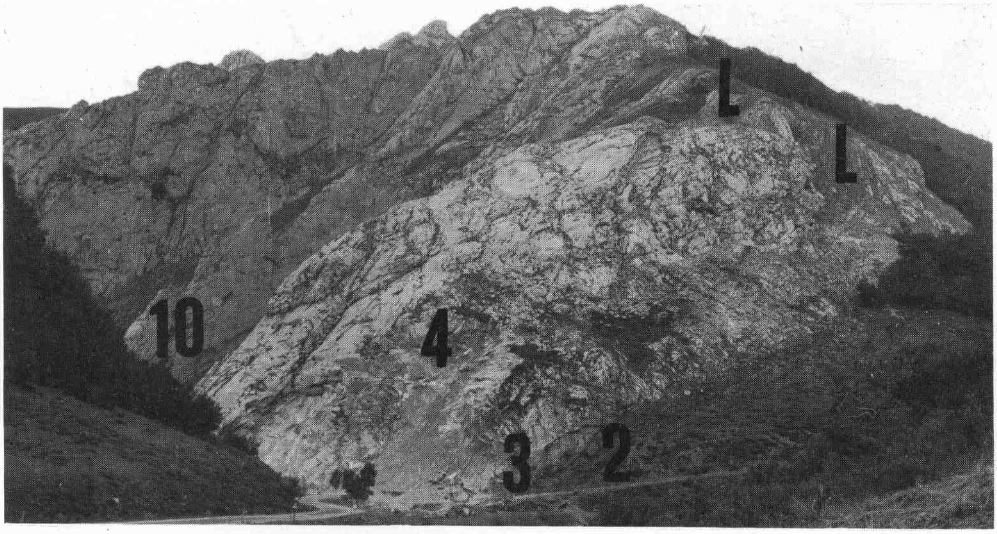

Fig. 1.—General view of the Piedrasluengas Limestone. The numbers correspond to numbers of the units as used on the section. L indicates the «lagoonal» deposits.

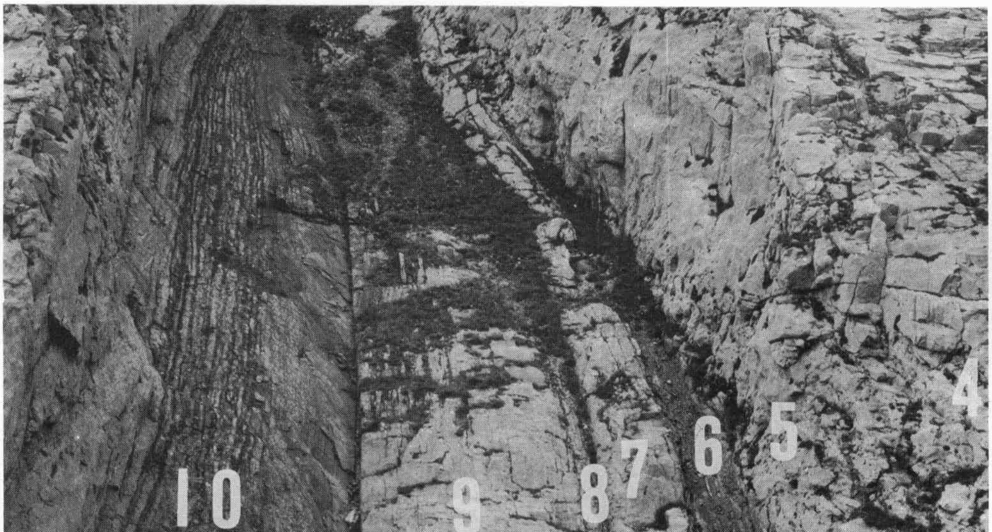

Fig. 2.—Units 4, 5, 6, 7, 8, 9 and 10. Note the wedging of units 6, 7, 8 and the lower part of 9 against the top of unit 5.

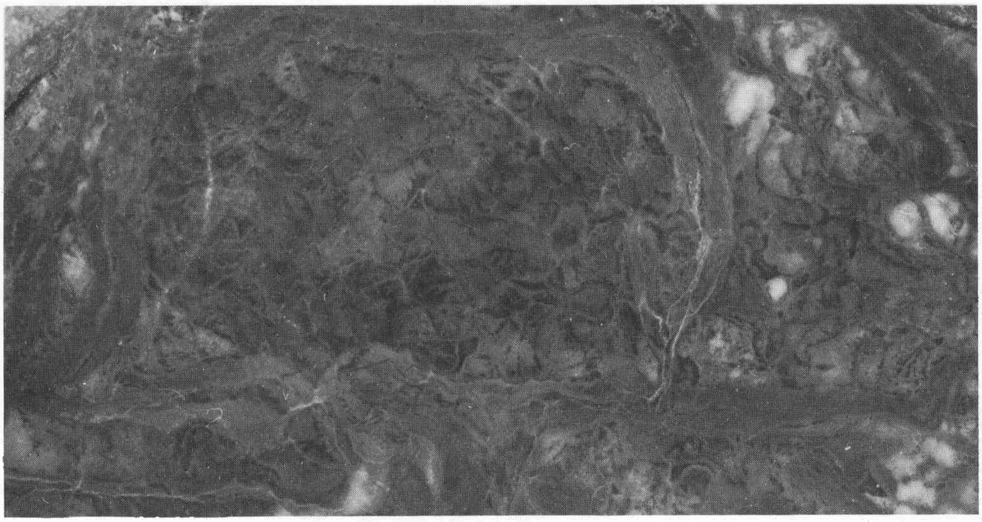

Fig. 3.—Boundstone from unit 4, x 1.7.

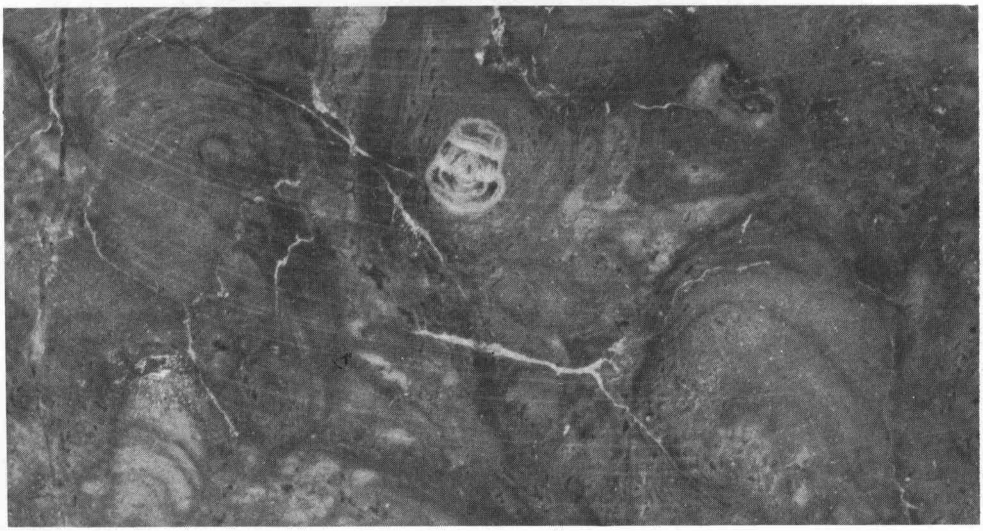

Fig. 4.—Boundstone from unit 4. In the centre an encrusted sphinctozoan sponge, x 1.1.