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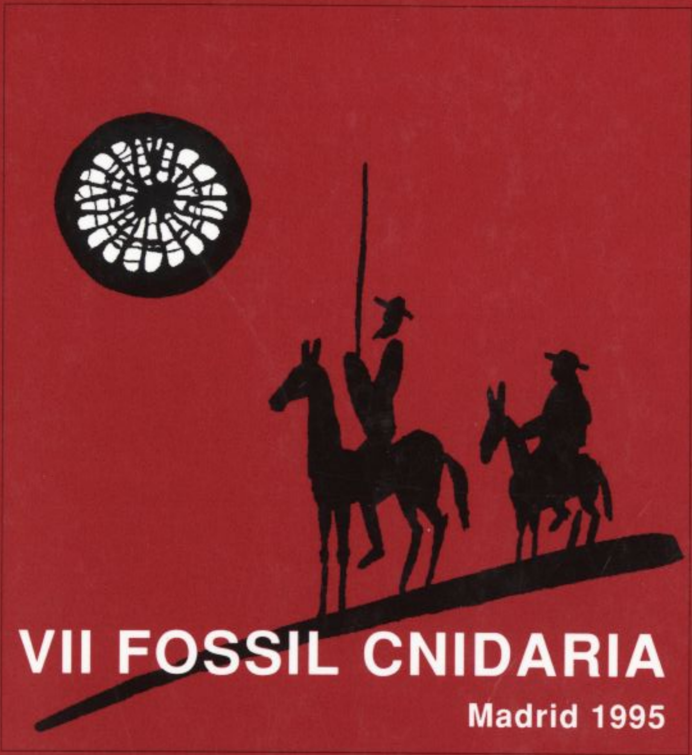

FIELD TRIP A
DEVONIAN AND CARBONIFEROUS REEFAL FACIES FROM CANTABRIAN ZONE (NW SPAIN)

BY

Luis PEDRO FERNÁNDEZ, Esperanza FERNÁNDEZ-MARTÍNEZ, Isabel MÉNDEZ-BEDIA, Sergio RODRÍGUEZ and Francisco SOTO

WITH THE COLLABORATION OF

Santiago FALCES and José Carlos GARCÍA-RAMOS

EDITED BY **Antonio PEREJÓN**

September 5-11, 1995

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FIELD TRIP A

Devonian and Carboniferous reefal facies from the Cantabrian zone (NW Spain)

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Introduction

The aim of this excursion is to show the Devonian and Carboniferous reefal development in the Cantabrian Mountains. For this purpose, several selected localities, mostly in reefal facies, will be visited.

In spite of the abundance of coral and stromatoporoid faunas in the Devonian of the Cantabrian Zone, these faunas have been studied in detail only recently.

The oldest publications about Devonian corals and stromatoporoids in the Cantabrian Mountains (VERNEUIL & ARCHIAC, 1845; PRADO & VERNEUIL, 1850; PRADO, 1855; GROSCH, 1912a; ALMELA & REVILLA, 1850) include no descriptions or figurations. The first papers containing some descriptions of the taxa were written by MALLADA, 1875; BARROIS, 1882 and BARGATZKY, 1883.

Since the second half of the XX Century a great number of papers, including some descriptions and figures of the taxa, has been published. Among others, ALTEVOGT, 1963, 1965, 1967; KULLMANN, 1965, 1967, 1968, 1975; SLEUMER, 1969; OEKENTORP, 1975; Soto, 1977, 1978, 1982b, 1983; BIRENHEIDE & SOTO, 1977, 1981, 1992; MÉNDEZ-BEDIA, 1984; FERNÁNDEZ-MARTÍNEZ, 1994. Most of these works deal with rugose corals and in a lesser number with tabulate corals and stromatoporoids. Currently, a work team on Devonian reefal organisms (E. Fernández-Martínez; I. Méndez-Bedia and F. Soto) is carrying out a detailed and continuous study of these fossils.

From a sedimentological point of view, the Devonian formations showing an important reefal development have been studied by several authors (MOHANTI, 1972; REIJERS, 1972, 1984, 1985; COO, 1974; MÉNDEZ-BEDIA, 1976; FRY & BERESKIN, 1977; REIJERS *et al.*, 1984; FRANKENFELD, 1981; RAVEN, 1983; among others). Presently research on formation, composition and evolution of cantabrian devonian reefs is being carried out by the work team mentioned above in collaboration with two sedimentologists from Oviedo University (L. P. Fernández-González and J. C. García-Ramos). The goal of this research is to widen and to complete the knowledge of the reefal development in the Cantabrian Zone.

Carboniferous corals from Cantabrian Mountains were first studied during the XIX Century by BARROIS, 1882. During the first half of the XX Century almost no studies were done on calcareous facies with corals. Only the work of Grosch, 1912b on specimens collected by the climber O. Schulze in the Picos de Europa deals with rugose corals. Modern research on Carboniferous corals in the Cantabrian Mountains begin with works of GROOT, 1963, 1971 and KULLMANN, 1966, 1968. Studies on Carboniferous corals were impeled in recent years after the monographies of BOLL, 1985 and RODRÍGUEZ, 1984. Recent studies (RODRÍGUEZ, 1985; KULLMANN & RODRÍGUEZ, 1986, 1994; RODRÍGUEZ *et. al,* 1986; RODRÍGUEZ & MORENO-EIRIS, 1987; RODRÍGUEZ & RAMÍREZ, 1987, among others) give a general view but much work is still to done for a comprehensive knowledge of the Carboniferous coral assemblages from the Cantabrian Mountains.

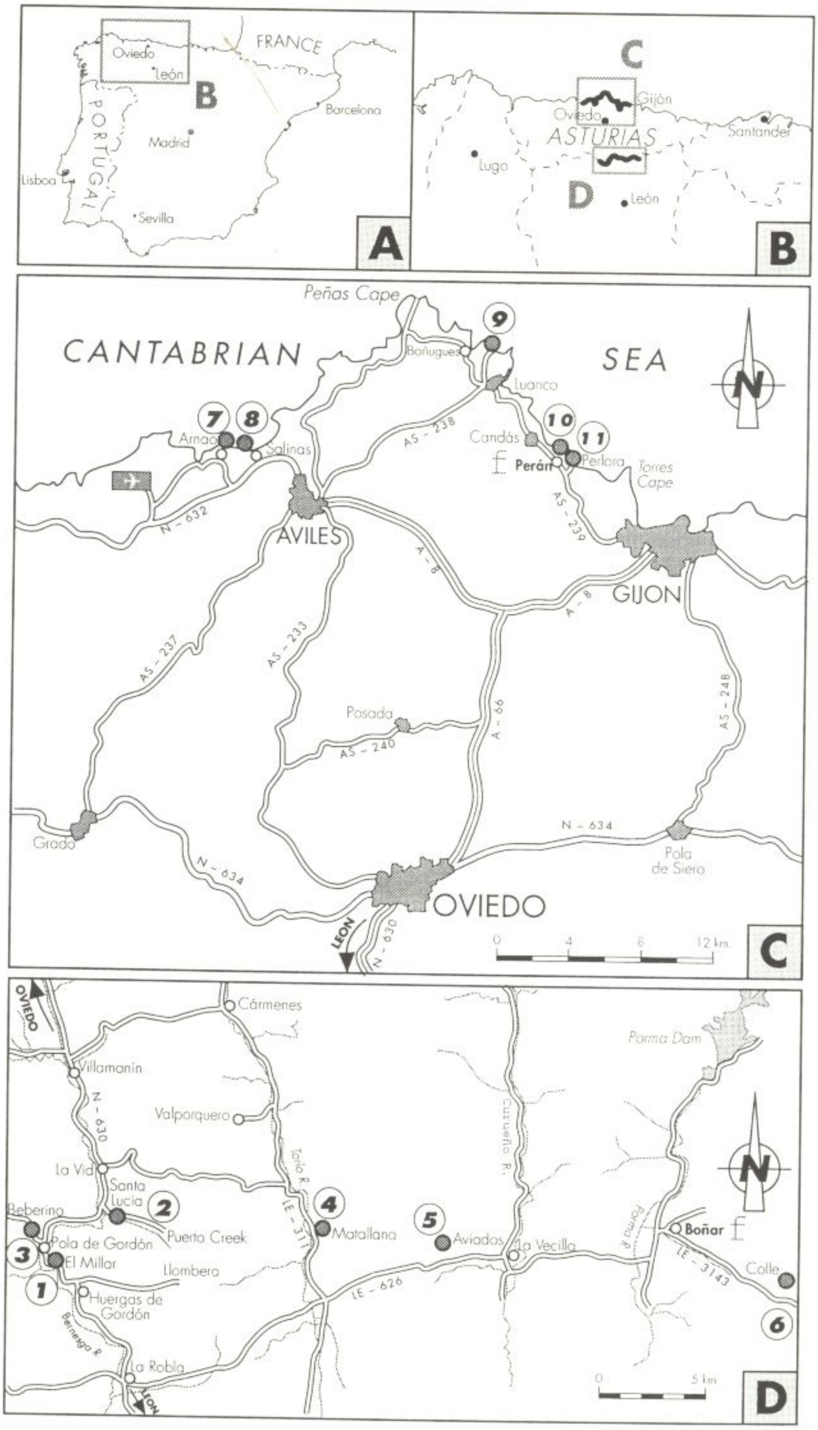


Fig. 1.–Geographical location maps. A: Cantabrian Mountains. B: Studied areas. C: Localities in the northern slope of the Cantabrian Zone. D: Localities in the southern slope of the Cantabrian Zone.

General notes

During this field trip a general scope of the Devonian and Carboniferous rocks containing reefal fauna will be given.

Firstly, some different Devonian bioconstructions, upper Emsian, Givetian and Frasnian in age, are described in this guide.

On the basis of the faunal content and some sedimentological observations of these reefal levels, different paleoecological interpretations are made on the most favourable environmental conditions for their development.

Some representative locations of different reefal formations on the southern slope of the Cantabrian Mountains will be visited in the three first days. They are Colle (La Vid Group); El Millar, El Puerto creek and Aviados (Santa Lucía Formation); Beberino and Matallana (Portilla Formation). The 4th and 5th days will be spent on the northern slope of the Cantabrian Zone where five localities will be visited: Plataforma de Arnao (Aguión Formation); Arnao locality and Moniello inlet (Moniello Formation); Perán (Candás Formation) and Carranques beach (Perán and Piñeres Formations) (Fig. 1 A-D).

The last days will be devoted to visit some carboniferous outcrops ranging from Namurian to Upper Moscovian in age. For this purpose, some localities in Ponga, Liébana and Picos de Europa areas will be described (Fig. 13).

Permission to visit some places on private land has been obtained for the purpose of this excursion. Anyone making subsequent visits to any of the localities described here should ensure that they have the necessary permission where appropiate.

Every care must be taken to observe the geological code-of-practice. Some risk is always involved in geological localities particularly in steep cliff sections. It is responsability of the participating delegates to be suitably insured. Neither the leaders of this excursion nor the symposium organizers can accept any responsability whatever for injuries substained during the excursion.

Most of the localities to be visited are considered to be excellent examples destined to show our regional geology. Please, we advice you to use the hammer as little as possible. Usually, there is a lot of loose material which can be collected.

ACKNOWLEDGEMENTS

This work has been financed by the CICYT, within the framework of the project PB 92-1008 tittled "Devonian reefs of the Cantabrian Zone (Cantabrian Mountains, NW Spain): formation patterns, composition and evolution". We would like to thank also to the "Dirección General de Patrimonio y Promoción Cultural de la Junta de Castilla y León" for finantial contributions. Sincere thanks are also extended to our colleagues Drs. J. L. García-Alcalde and M. Arbizu Senosiaín of the Geological Department of Oviedo and Drs. A. Perejón and E. Moreno-Eiris and Mr. P. Cózar of the Paleontological Department of Madrid, for their comments and help in the work field.

The Cantabrian zone

GEOLOGICAL AND STRATIGRAPHICAL SETTING

Introduction

The Paleozoic rocks of the Iberian Peninsula represent the westernmost part of the European Hercynian belt (Fig. 2). The Iberian Hercynian segment crops out extensively in the western part of the Peninsula forming the so called Iberian Massif. In this massif, several zones with characteristic stratigraphical, structural and paleogeographical features were noticed by LOTZE, 1945 and JULIVERT *et al.*, 1972 (Fig. 3). The main aim of the present field trip is to show the Devonian and Carboniferous reefal development in one of these zones, the Cantabrian Zone.

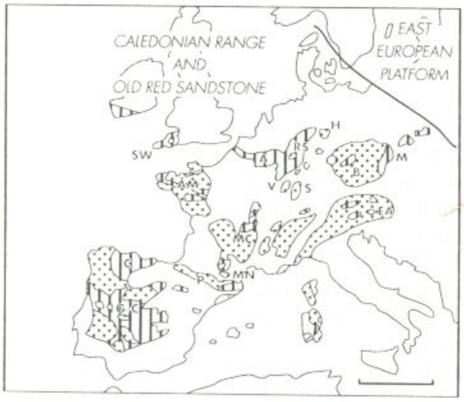


Fig. 2.–Sketch map of Europe showing the Hercynian Orogen and major outcrops of Paleozoic sediments (vertical lines) and Hercynian igneous and metamorphic rocks (stippled). A: Ardennes, AM: Armorican massif, B: Bohemia, C: Cantabrian Zone, EA: Eastern Alpine Zone, G-C: Galicia-Castille Zone, H: Harz, M: Moravia, MC: Massif Central, MN: Montagne Noire, P: Pyrenees, RS: Rhenish Schiefergebirge, S: Schwarzwald, SW: South-west England, and V: Vosges (after BURCHETTE, 1981).

This zone is the most external part of the Hercynian belt in which the structures describe an arc, the Asturian Arc, with its concavity towards the east (Fig. 4).

Stratigraphical Setting

In the Cantabrian Zone the Paleozoic sequence rests on a dominantly Precambrian succession, cropping out in its western boundary but not exposed within the Cantabrian Zone itself.

Stratigraphically, the Paleozoic is characterized by an incomplete, thin Cambrian-Ordovician sedimentary sequence, a Siluro-Devonian succession of variable thickness and a well developed Carboniferous sequence.

According to its relationships with orogeny, the Paleozoic succession can be divided into a pre-orogenic and a syn-orogenic sequence (Fig. 5).

The pre-orogenic sequence displays a wedge shape, thinning out towards the east, from where the sediments derived (Fig. 5). It consists of an alternation of marine carbonate siliciclastic formations laid down in a shallow water stable shelf environment. The age of the pre-orogenic sequence range from Cambrian to the end of the Devonian or the Lower Carboniferous.

The syn-orogenic sequence comprises several clastic wedges of Upper Carboniferous age (Fig. 5). These wedges represent the fillings of topographic depressions formed at the front of the thrust sheets. The sediments deposited in these foredeep throughs were supplied from the growing mountain chain that was being intensively eroded in more internal zones.

Tectonical Setting

From a tectonic point of view, the Cantabrian Zone is featured by the presence of a large number of thrusts and folds. The pattern of the thrust systems, characteristic of a thin-skinned tectonic, together with the ge-

Fig. 3.–Hercynian and alpine outcrop distribution in the Iberian Peninsula and zone division of the Iberian Massif (after DALLMEYER & MARTÍNEZ-GARCÍA, 1990).

neral lack of metamorphism and plutonism and the low level of strain indicate deformation under shallow crustal conditions.

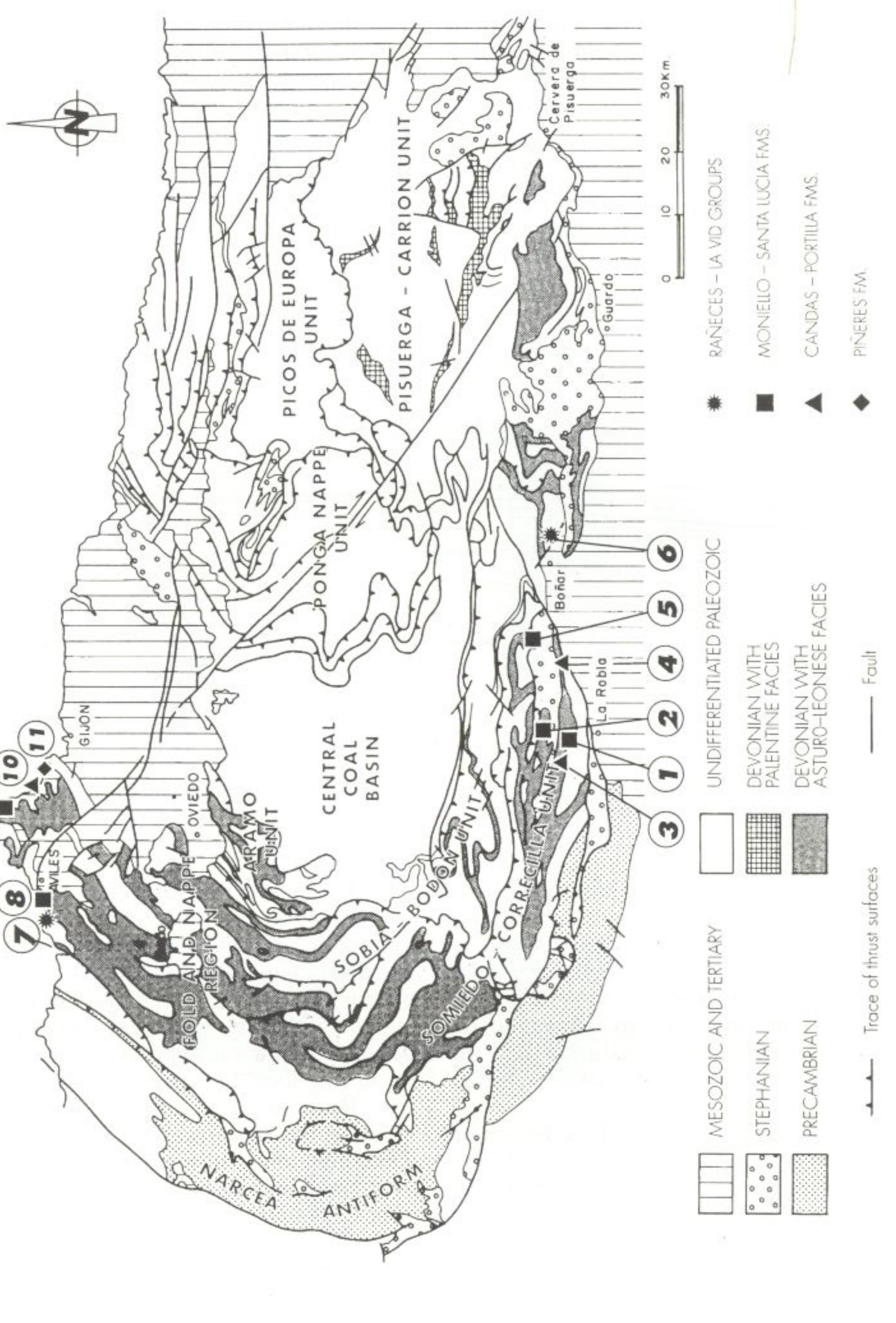
The thrusts split from a generalized décollement surface sited near the base of the Paleozoic sequence. Geometrically there are two major systems in the cross-section (Fig. 6 BB'). The first to develop, Lower Westfalian in age, was in the westernmost units (Somiedo-Correcilla, Sobia-Bodón and Aramo units). The second thrust system, Westfalian to Stephanian in age, started its development beneath this earlier system and caused a thickening of the orogenic wedge and the progression of the deformation towards the foreland, producing successive thrusts (basal thrusts of the Central Coal Basin and those of the nappes in the Ponga Unit). The comparison between the cross-sections BB' and AA' (Fig. 6) shows the structural differences existing along various directions throughout the Asturian Arc.

Concerning the folds, there are two sets of folds in the Cantabrian Zone. The longitudinal or arched set, which runs parallel to the thrust traces, and the transverse or radial set which is transverse to the first one. These sets probably correspond to frontal and lateral structures of the thrusts, respectively.

Several faults, having very long traces and affecting several units can be observed in the Cantabrian Zone. Among these, it is noteworthy the León and Ventaniella faults (Fig. 4). The León fault has an E-W trend, with a long history during variscan times and even played during the Alpine deformation. This gave way to a N-S shortening involving a reactivation of variscan fractures and a development of new ones. The Ventaniella fault, which crosses the Cantabrian Zone in a NW-SE direction, has been interpreted as a post-variscan wrench fault.

There are a large number of references dealing with the geology of the Cantabrian Zone. General synthesis on the structure can be found in JULIVERT, 1981, 1983; JULIVERT *et al.*, 1977; JULIVERT & ARBOLEYA, 1986; PÉREZ-ESTAÚN *et al.*, 1988; PÉREZ-ESTAÚN & Bastida, 1990. Summaries on biostratigraphy can be found in TRUYOLS *et al.*, 1990; GARCÍA-ALCALDE *et al.*, 1990; SÁNCHEZ DE POSADA *et al.*, 1990; TRUYOLS & GARCÍA-ALCALDE, 1981; TRUYOLS & SÁNCHEZ DE POSADA, 1981. General synthesis on paleogeography can be found in JULIVERT, 1978 and GARCÍA-ALCALDE, 1995.

Fig. 4.–Structural sketch map of the Cantabrian Zone showing the distribution of Devonian outcrops with Asturian-Leonese and Palentine facies and localities mentioned in the text (modified after JULIVERT, 1971). 1: El Millar, 2: El Puerto creek, 3: Beberino, 4: Matallana, 5: Aviados, 6: Colle, 7: Plataforma de Arnao, 8: Arnao, 9: Moniello inlet, 10: Perán, 11: Carranques.


NARCEA ANTIFORM
FOLD AND NAPPE REGION
SOMIEDO
CORRECILLA UNIT
SOBIA - BODON UNIT
ARAMO UNIT
CENTRAL COAL BASIN
PONGA NAPPE UNIT
PICOS DE EUROPA UNIT
PISUERGA - CARRION UNIT
GIJON
OVIEDO
AVILES
La Robla
Boñar
Guardo
Cervera de Pisuerga
0 10 20 30Km
1 2 3 4 5 6 7 8 9 10 11
MESOZOIC AND TERTIARY
STEPHANIAN
PRECAMBRIAN
UNDIFFERENTIATED PALEOZOIC
DEVONIAN WITH PALENTINE FACIES
DEVONIAN WITH ASTURO-LEONESE FACIES
RAÑECES – LA VID GROUPS
MONIELLO – SANTA LUCIA FMS.
CANDAS – PORTILLA FMS.
PIÑERES FM.
Trace of thrust surfaces
Fault

THE DEVONIAN OF THE CANTABRIAN ZONE

Introduction

During the Devonian time, Iberian was situated in the northwestern boundary of Gondwana and moved northward reaching about 30ºS in Givetian time. As in other parts of the world, the Iberian Devonian developed in a regressive context.

The original surface of the Devonian sedimentary basin is difficult to estimate nowadays without the aid of palinspastic reconstructions. Towards the west, from the Narcea Antiform, and towards the south almost all the Devonian outcrops have been eroded or are covered by the Mesozoic-Tertiary of the Duero Basin. However, towards the interior of the Asturian Arc the distribution of Devonian rocks is better known (Fig. 4).

From Late Ordovician to Late Devonian an Asturian Uplift, called "Cantabrian Geanticlinal" (ADRICHEM BOOGAERT, 1967), was located towards the interior of the Asturian Arc, which acted as the main source area of sediments. This paleogeographic setting caused variations in the Siluro-Devonian deposition. Thus, the most complete succession is in the most external part of the Asturian Arc whereas it is almost absent in the internal region (Fig. 7).

Stratigraphically, the Devonian of this zone has been divided into two different facies domains: the Asturian-Leonese Domain and the Palentine Domain (BROUWER, 1964) (Fig. 4).

The first zone is characterized by an alternation of detrital and carbonate formations, principally with benthic fauna, deposited in a shallow marine platform. In some of these carbonate successions important reefal episodes were developed.

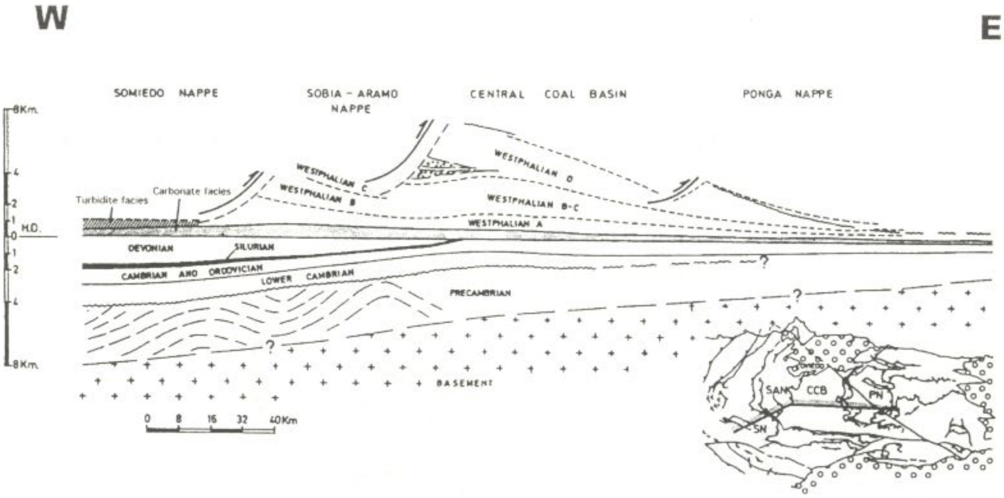


Fig. 5.–Palinspastically restored section through the Cantabrian Zone. The horizontal datum is the boundary between Devonian and Carboniferous (after MARCOS & PULGAR, 1982).

In contrast, the Devonian succession in the Palentine Domain consists of nodular limestones and shales alternation with nectonic and pelagic fauna indicating a quieter and slightly deeper environment than in the previous domain. In the Palentine Domain, reefal development is restricted to the occurrence of rare local biostromal units.

Because of the different reefal development in the Asturian-Leonese and Palentine Domains, only some localities within the first domain will be visited during the present field-trip.

The historical process leading to the knowledge of the stratigraphical succession in the Devonian of the Asturian-Leonese Domain was carried out by different authors in a independent way. Among others, Barrois,

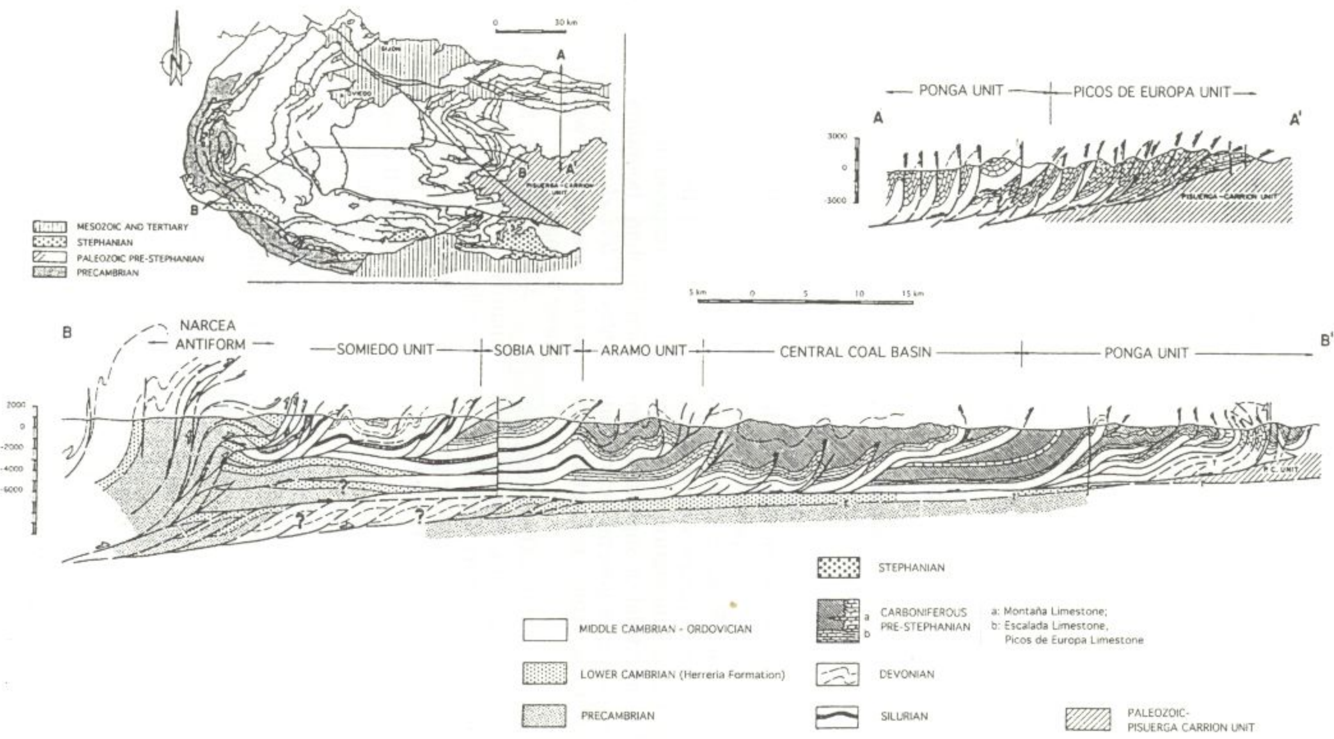


Fig. 6.– Geological cross sections through various parts of the Asturian Arc (after PÉREZ-ESTAÚN *et. al.*, 1988).

1882 studied the Devonian on the northern part of the Cantabrian Zone and COMTE, 1936, 1938, 1959 studied both sides. Because of those studies the lithostratigraphic nomenclature used nowadays is different for the two slopes of the Cantabrian Mountains. Please, pay attention to the Fig. 8 where the equivalent names for the two slopes, is shown.

Main Reefal Episodes

Five reefal episodes with different development took place during the Devonian in the Asturian-Leonese Domain of the Cantabrian Zone (Fig. 8).

First reefal episode. La Vid Group and Rañeces Group

The earliest reef development in the Cantabrian Zone occurs locally in the Lower Devonian (upper Emsian), in the upper part of the La Vid Group (La Vid complex *sensu* COMTE, 1936), on the southern slope of the Cantabrian Zone and in the upper part of the Rañeces Group (named Rañeces Complex by Comte, 1959) on the northern side (Fig. 8). In both groups the sedimentation took place from subtidal to intertidal or supratidal conditions and fossils are in general very abundant. The age of these groups is Lochkovian-upper Emsian.

La Vid Group is a 400-600 m thick, predominantly calcareous, series. Basicaly this group consists of a lower part with dolostones, limestones and shales; a middle part especially shally and an upper part with red limestones and marlstones.

Only a reefal deposit example, sited near the village of Colle **(Stop 6)** has been described in La Vid Group. This reefal episode consists of biostromal levels, less than 1 m thick, mainly built by fasciculate rugose corals. According to Stel, 1975 the growth of these biostromes was due to the temporal oxigenation of anoxic waters by hurricanes and storms.

Rañeces Group includes four distinct lithostratigraphic units: Nieva Fm. (limestones, dolostones and shales); Bañugues Fm. (chiefly dolostones); Ferroñes Fm. (argillaceous and crinoidal limestones and shales) and Aguión Fm. (red or pink coloured crinoidal limestones).

The only known reefal episode in the Rañeces Group is sited in the so called "Plataforma de Arnao" **(Stop 7)**. It is a biostrome, 5 m thick, especially built by tabulate corals and bryozoans. The most suitable environment for the development of this patch reef has been stated as a shallow water platform of moderate energy (ALVAREZ-NAVA & ARBIZU, 1986).

Second reefal episode. Santa Lucía Formation and Moniello Formation

The second and even more important reefal episode took place during the upper Emsian, coinciding with the deposition of the Santa Lucía Fm. (COMTE, 1936) on the southern slope and Moniello Fm. (BARROIS, 1882) on the northern slope of the Cantabrian Mountains (Fig. 8).

These formations are equivalent and they consist of ca. 250 m grey limestones and argillaceous limestones interbedded with thin shaly levels. Towards the outer part of the Asturian Arc they are very fossiliferous while towards the interior part of this arc they are mostly composed of birdseyes and laminated limestones with the presence of mud-craks.

Most of the Santa Lucía and Moniello Fms. correspond to the Emsian. The Emsian/Eifelian boundary is marked by the entry of *Icriodus retrodepressus* and *Arduspirifer intermedius* within the upper part of these formations.

According to MÉNDEZ-BEDIA, 1976 (mainly for the Moniello Fm.) and COO, 1974 (for the Santa Lucía Fm.) carbonate facies in these formations are arranged in parallel stripes describing the Asturian Arc with subtidal facies towards the west and southwest and shallower water, lagoonal and peritidal deposits, towards the core of the Asturian Arc. Intermediate facies, with subtidal and peritidal characteristics in the lower and middle part of the formations respectively, are in between (Figs. 9, 10). In addition, crinoidal bioclastics bars interpreted as open marine facies, have been recognized in the most southern outcrops (COO, 1974). It was within this setting that the growth of the reef structures present in these formations took place. As would be expected on the basis of the above mentioned facies ditribution, the greatest reef development occurred in the outermost zone of the Asturian Arc. In a lesser degree, there are also reefal structures in the zone where the intermediate facies exist. These structures occur mainly in the lower-middle part of the

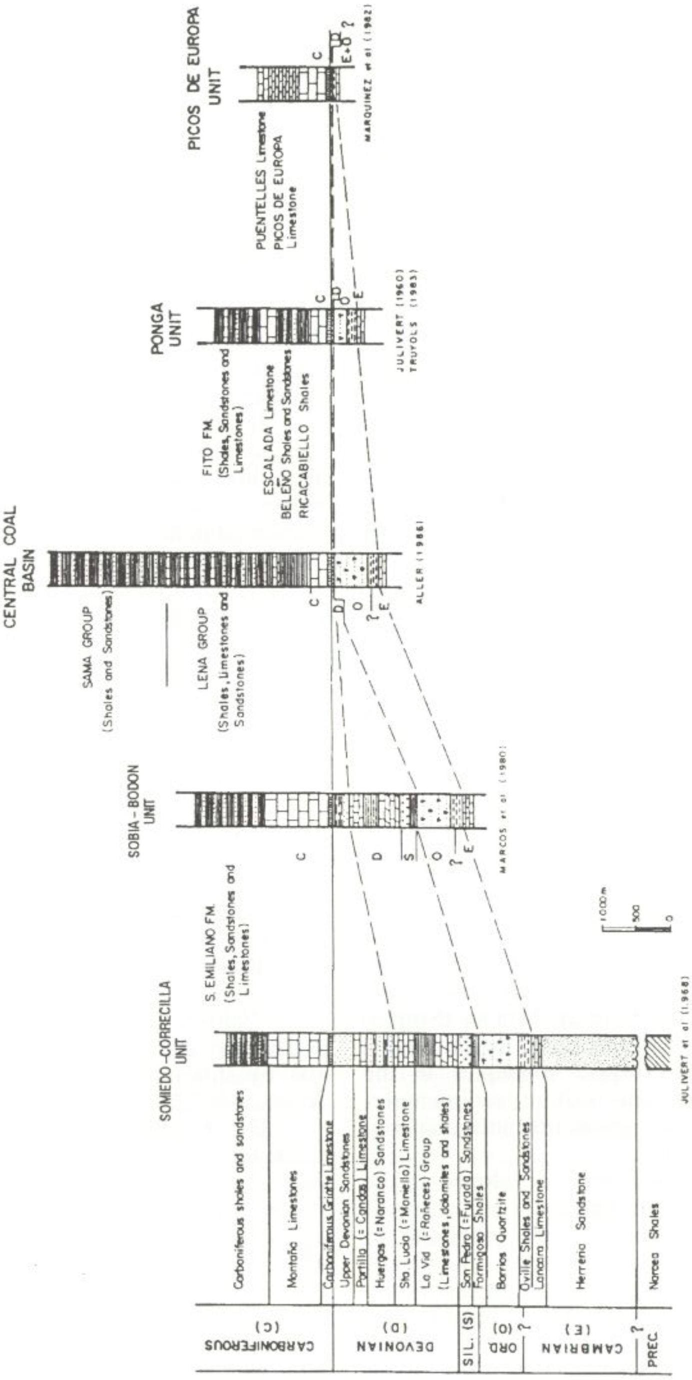


Fig. 7.–Generalized stratigraphic columns of the main tectonic units in the Cantabrian Zone (after PÉREZ-ESTAÚN, *et. al.*, 1988).

formations, although there are some less important reefal deposits in the upper part.

The reef structures mostly consist of biostromes of variable thickness. Some of them are to be visited in El Millar locality **(Stop 1)**, El Puerto creek **(Stop 2)**, Aviados

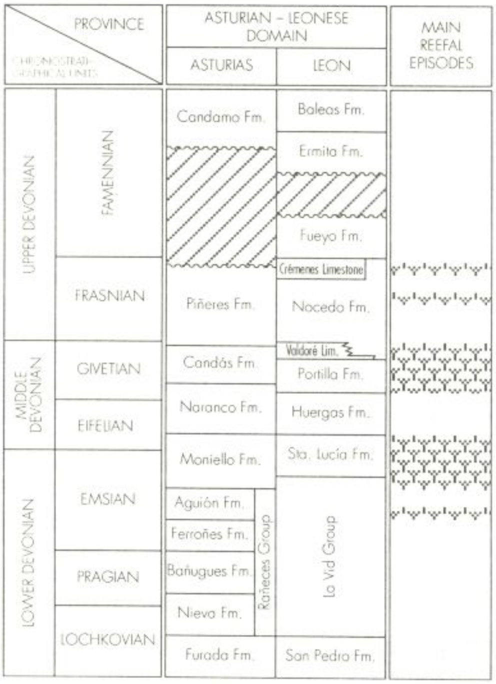


Fig. 8.–Devonian lithostratigraphic units of the Cantabrian Zone and main reefal episodes.

locality **(Stop 5)** and Moniello inlet **(Stop 9)**. There are also bioherms such as those shown in El Puerto creek **(Stop 2)**, Aviados **(Stop 5)** and Arnao **(Stop 8)** localities; the latter, one of the best and bigger examples in the Cantabrian Mountains, exhibits sedimentological and paleoecological attributes common to organic buildups.

The biostromal types developed in the outermost facies are generally indicative of platform environments with moderate to high turbulence. Different types of biostromes have been recognized, among these only two kinds will be shown. On one hand, a hemispherical stromatoporoids and favositids biostrome will be visited in El Millar locality. On the other hand, a laminar and tabular stromatoporoid and favositid biostrome associated with diverse fauna will be seen in El Puerto creek.

However, other minor biostromes built by fasciculate rugose corals, *Mesophyllum (Cystiphylloides)* in El Millar locality and *Synaptophyllum* in Moniello inlet could have developed in less turbulent conditions corresponding to deeper or more protected zones located behind some types of barrier, such as bioherm and bioclastic bars.

The greatest number of bioherms are found in these facies , which are built by stromatoporoids associated to tabulate and rugose corals. In general, the features of these bioherms suggest that they were formed close to the platform margin. Two examples will be seen in Arnao locality and El Puerto creek.

In somewhat more interior zones with characteristics typical of the intermediate facies, biostromes and small bioherms were developed at certain times. These zones are represented in this guide by Aviados locality in which a bioherm and a biostrome are to be visited. Both of them are mainly composed by stromatoporoids and favositids. Additionally, a transported bed with the same fauna composition is found in a very shallow, possibly inter-supratidal environment.

Third reefal episode. Portilla Formation and Candás Formation

The third reefal episode took place during the Givetian reaching locally the Frasnian; it occurs within the Candás Fm. (BARROIS, 1882) on the northern side of the Cantabrian Mountains and the Portilla Fm. on the southern branch (Fig. 8). In this guide, the Portilla Fm. *sensu lato* is considered as being integrated by the Portilla Fm. *sensu stricto* plus Valdoré Limestones (COMTE, 1936, 1938, respectively) which was also considered by different authors (MOHANTI, 1972, REIJERS, 1972, García-Alcalde *et al.*, 1985).

The Portilla and Candás Formations, made up of limestones, argillaceous limestones, marls, shales and sandstones, are Givetian in age though they may locally reach the earliest Frasnian. The stratigraphy and sedimentology of the Portilla Formation have been extensively studied by nume-rous authors (MOHANTI, 1972; REIJERS, 1972, 1984, 1985; REIJERS *et al.*, 1984; FRANKENFELD, 1981 and RAVEN, 1983) while in the case of the Candás Formation investigations have only been carried out in three sections by Fry & Bereskin, 1977, Bereskin, 1978, Raven, 1983, Méndez-Bedia *et. al.*, 1994 and Fernández-Martinez *et. al.*, 1994.

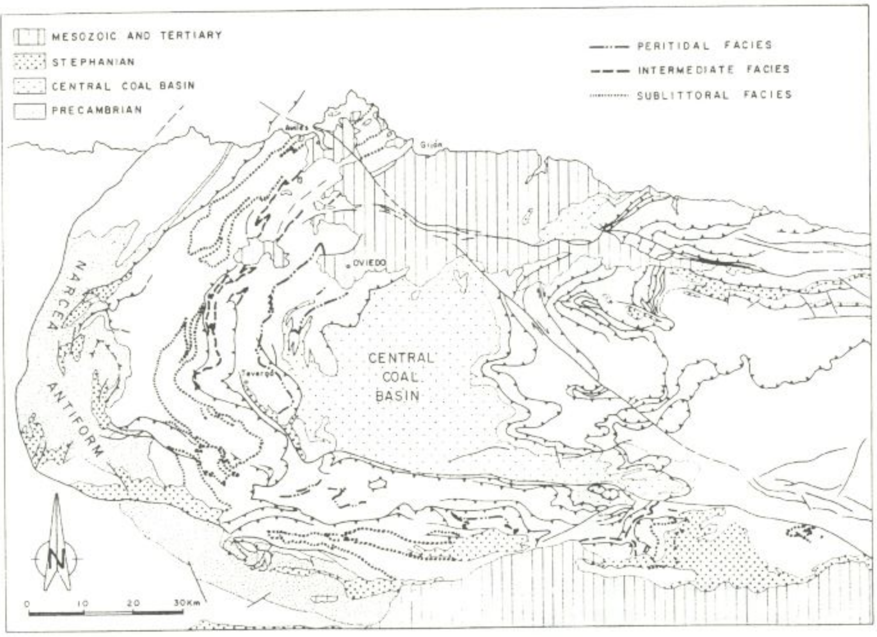


Fig. 9.–Outcrop map and facies distribution of the Moniello and Santa Lucía Formations.

In a general way the Portilla and Candás Formations can be described as being composed of (a) a lower interval of detrital limestones transitionally overlain by (b) a first episode of reef development. This reef-bearing unit is unconformably overlain by (c) an interval of detrital limestones, shales and sandstones, the latter being more abundant in the Portilla Formation. Finally the formations end with (d) a second episode of reef development.

Subdivisions of the formations have been guided by the above mentioned patterns of lithological distribution and some authors separate four members though others, considering the transitional relationships between units (i) and (ii), make them to form the lower member and thus only distinguish three members. From now on and when needed we shall apply the division of both formations in three members.

Sedimentary models for the Portilla Formation (Reijers, 1972, 1985; Raven, 1983) involve a reef-rimmed carbonate platform that consists from north (proximal) to south (distal) of (i) a lagoonal backreef facies belt (peloidal, ostracodal, gastropodal and brachiopodal limestones), (ii) a reef tract with biostromal and biohermal limestones and (iii) a forereef facies belt (bioclastic and oolitic calcarenites) distally grading to deeper-water marls and shales.

Preliminary results from the project PB92-1008 "Devonian reefs in the Cantabrian Zone (Cantabrian Mountains, NW Spain): formation patterns, composition and evolution" on which we are working, are consistent with the overall patterns of Reijers', 1972 facies distribution, though we do not agree with the reef-rimmed platform geometry proposed by Reijers, 1985 as evidences point rather to a ramp model for the Portilla-Candás carbonate platform.

Detailed facies analysis, mainly carried out on superb exposures along coastal cliffs together with sequential analysis are allowing us to develop a detailed model of platform evolution as well as of reef onset and evolution. As a first approximation the succession is formed by a number of basic sequences ranging in thickness from several decimetres to several tens of metres. Each sequence has a sharp to rapidly transitional base and can be split into two subsequences, a lower transgressive one and an upper regressive one. Commonly the transgressive subsequence is very thin or absent and thus the whole sequence reflects a regressive trend. Reefs, when occur, are capping the sequence or forming the upper part of the regressive subsequence (Fig. 11). Though at present there are not enough data, we can temptatively compare these sequences with parasequences or high frequency sequences (Goldhammer *et al.*, 1987; Wagoner *et al.*, 1990). This does not imply to attribute this sequential arrangement to any external driven mechanism, be it eustatic or tectonic.

The ideal reef-bearing sequence is composed, from base to top, by the following facies:

(i) It starts with an interval of rudstones to floatstones formed by fragments of the underlying reef set in a matrix of bioclastic limestones.

(ii) Bioclastic (coral and stromatoporoid) grainstones to packstones that fine upwards. When bioclastic limestones are absent, matrix of the rudstone/floatstone facies becomes muddy upwards.

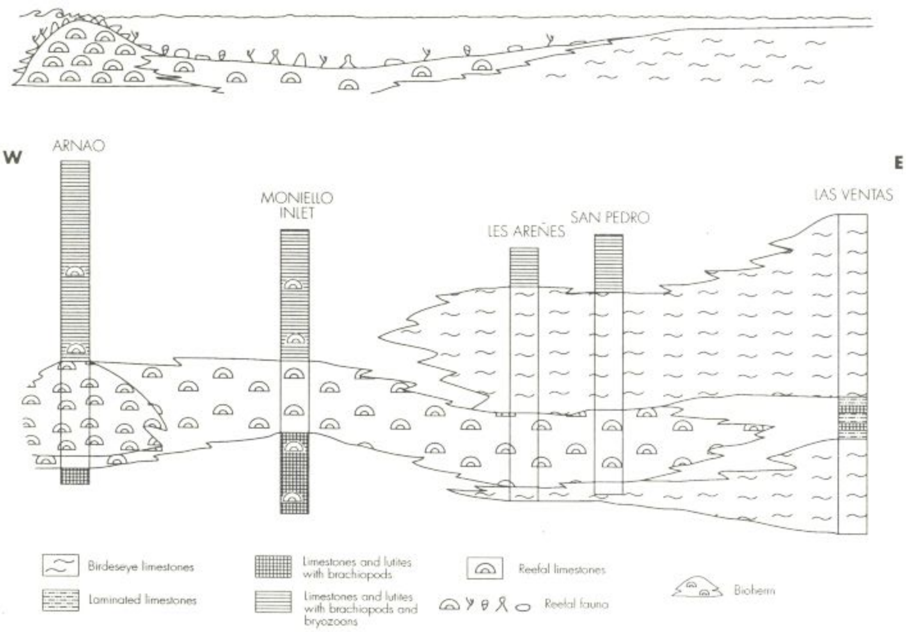


Fig. 10.–Facies distribution in the Moniello Formation from west to east in the northern slope of the Cantabrian Zone.

(iii) Slightly burrowed dark grey mudstones to muddy marls, typically containing tentaculitids and fish fragments. This facies is gradually overlain by the next one.

(iv) This facies is formed by centimetre-thick beds of fine-grained ripple-laminated sandstones alternating with dark grey mudstones to muddy marls. Intercalations of discrete, up to 10, centimetres thick bioclastic wackestone to packstone beds occur. Burrowing is common and faunal content is represented by a more diverse biota than that of the facies (iii) (bryozoans, brachiopods, branching tabulate or rugose corals and thin platy tabulate corals) which appears as transported fragments or as *in situ* individuals and colonies generally growing on bioclastic beds and sometimes giving way to thin (cms-dms) laterally restricted bioherms and biostromes.

(v) Onset of reef development is marked by the occurrence of bafflestones (branching tabulate or rugose corals) or bindstones (thin platy tabulate corals). Matrix in this phase is formed by bioclastic sandy marls to marly mudstones grading into bioclastic muddy or marly fine-grained sandstones. This first facies of reef development is succeeded by a second one consisting of facies (vi).

(vi) Bindstones (thick platy tabulate corals and/or stromatoporoids). Packing of the reef-forming organisms tends to be tighter and matrix evolves to a marly bioclastic limestone with a progressively lower terrigenous content.

(vii) This facies forms the third and last phase of reef development and consists of framestones formed by irregular to massive tabulate corals and/or stromatoporoids with a variable participation of massive rugose corals. This facies is characterized by a well-washed bioclastic packstone to grainstone matrix.

The top of the sequence is formed by a sharp surface covered by the coral/stromatoporoid rubble of facies (i) that forms the base of the next sequence. Nevertheless, sometimes the top is formed by a thin interval of *in situ* or transported branching tabulate or rugose corals set in a matrix that becomes progressively muddier towards the top [facies (v)]. This interval forms the transition to the dark mudstones of facies (iii) that, in this case, occurs in the base of the next sequence.

Facies (i) and (ii) are interpreted as a trangressive lag and bar deposits respectively. Facies (iii) to (iv) are thought to represent a gradual shifting from outer shelf to inner shelf. This evolution to a higher-energy shallower water environment is reflected by the upward increase in sand content and the apparition of bioclastic limestone beds with ripple lamination in sandstone beds, possibly representing storm? wave action. Facies (v) is characterized by the colonization of sea bed by reef-forming organisms and the gradual diminution of sand content.

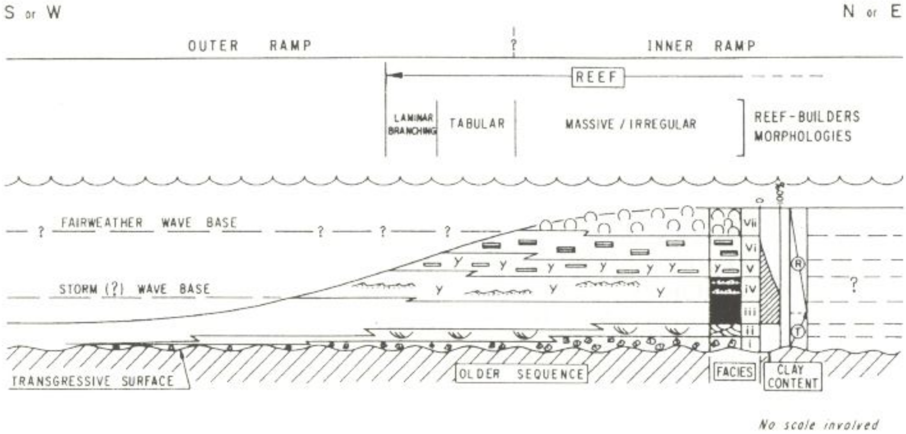


Fig. 11.–Highly idealized model of the facies distribution in the reef-bearing intervals of the Candás-Portilla Formations. Facies relationships are depicted both laterally and vertically along a transgressive-regressive cycle.

Both the textures of the boundstones and the texture of the interstitial matrix reflect a progressive shallowing and an increasing energy from the base to the top of the reefs [facies (v) through (vii)]. The branching delicate morphology of the corals in the bafflestones coupled with the high mud content of the interstitial matrix reflects relatively low energy conditions. Higher up organism morphologies become more robust to withstand with the increasing energy which is also reflected by the texture of the interstitial matrix and the bounding mode of the reef.

Finally, reef demise is provoked by an abrupt deepening of the environment, sometimes with an associated erosional event [facies (i) and (ii)]. The magnitude of this transgressive event coupled with the position observed on the top of a given sequence can account for the deviations from the ideal sequence above described.

This arrangement sharply contrasts with the Raven's, 1983 model of reef onset, evolution and demise that invokes a stop of clastic input leading to reef onset and a gradual deepening as the driven mechanism for reef drowning and demising as clastic (clayey) input renewed. In Raven´s model, though not clearly stated, one can guess that reefs occur in the lower part of a transgressive sequence.

Several reefal facies present in the Candás and Portilla Formations will be seen in Beberino locality (**Stop 3**), Matallana locality (**Stop 4**), Perán locality (**Stop 10**) and Carranques beach (**Stop 11**), in which the above mentioned reef-sequence shows a different development.

Fourth reefal episode. Piñeres Formation

The fourth reefal episode, Frasnian in age, is of minor importance and it took place in the lower part of the Piñeres Fm. (RADIG, 1962) (Fig. 8). This is a fairly siliciclastic series ca. 400 m thick which crops out in the northern slope of the Cantabrian Zone. The lower part of this unit consists of ferruginous and calcareous sandstones and very fossiliferous argillaceous and sandy limestones and marlstones, showing sporadically thin restricted reefal growths (Carranques beach, **Stop 11).**

This formation was deposited in shallow to very shallow neritic conditions and the age of its lower part is Frasnian.

Last reefal episode. Crémenes Limestones

The last reefal episode in the Cantabrian Zone is very local. It took place in the latest Frasnian on the southern slope of this zone and only in the so called Esla region (Aguasalio area). It is developed in the uppermost part of the siliciclastic Nocedo Fm. coinciding with the deposition of a calcareous unit, 15 m thick, named Crémenes Limestones (Fig. 8). Due to the difficult of access to this outcrop, it will not to be visited.

According to Loevezijn (1986a, b) it consists of a thin biostromal unit, developed in a general transgressive sequence at the platform edge with high energy water and well oxigenated bottom conditions. The organism builders are laminar stromatoporoids and alveolitids as well as branching corals.

Reefal extinction

With respect to the causes of the reef extinction in the Cantabrian Zone, they are not clearly stated. According to LOEVEZIJN (1989), it could be related to some epeirogenetic block movements and an uplift of the Asturian Geanticline that, from the Givetian onwards, caused an increase in the terrestrial input and a gradual decline of the shallow marine shelf area. On the contrary, FRANKENFELD (1981) suggested a quick subsidence that drowned the reefs.

THE CARBONIFEROUS OF THE CANTABRIAN ZONE

Introduction

Carboniferous is the most extense system in the Cantabrian Mountains and crops out in all the structural units of this region (Figs. 12, 13), covering more than 20,000 km^2. Carboniferous sediments in the Cantabrian Mountains range in age from Tournaisian to Stephanian (Kasimovian). Partial synthesis of the Carboniferous stratigraphy in Cantabrian Mountains were given by RODRÍGUEZ *et al.*, 1986; RODRÍGUEZ-FERNÁNDEZ & HEREDIA, 1987; SÁNCHEZ DE POSADA *et al.*, 1990; HEREDIA *et al.*, 1990 and MARTINEZ-GARCÍA, 1990. These authors emphasize the division of the Carboniferous rocks in three sequences: Lower Carboniferous (from Tournaisian to Kinderscoutian) is mostly marine and condensed. Middle Carboniferous (Kinderscoutian to Moscovian), mainly marine, but also partly continental in some areas, shows many changes from area to area and even within the same area. Upper Carboniferous is exposed in isolated outcrops, unconformably overlying older rocks and being mainly continental. List of formations with short description is given below (Tables 1-3).

The Lower Succession

Sedimentation in the Cantabrian Mountains during the Lower Carboniferous is mostly condensed. Lowermost Carboniferous is composed of Baleas Fm. and Vegamian Fm. They are absent in many places, and represent the condensed Tournaisian sedimentation in the Cantabrian Mountains. Alba Fm. (= Genicera Fm.) is the most widespread lithostratigraphic unit in the Carboniferous of the Cantabrian Mountains. Its base is Upper Tournaisian and its top is probably Arnsbergian. The coral fauna in this unit is characterized by low generic and specific diversity and low abundance and frequency oc-

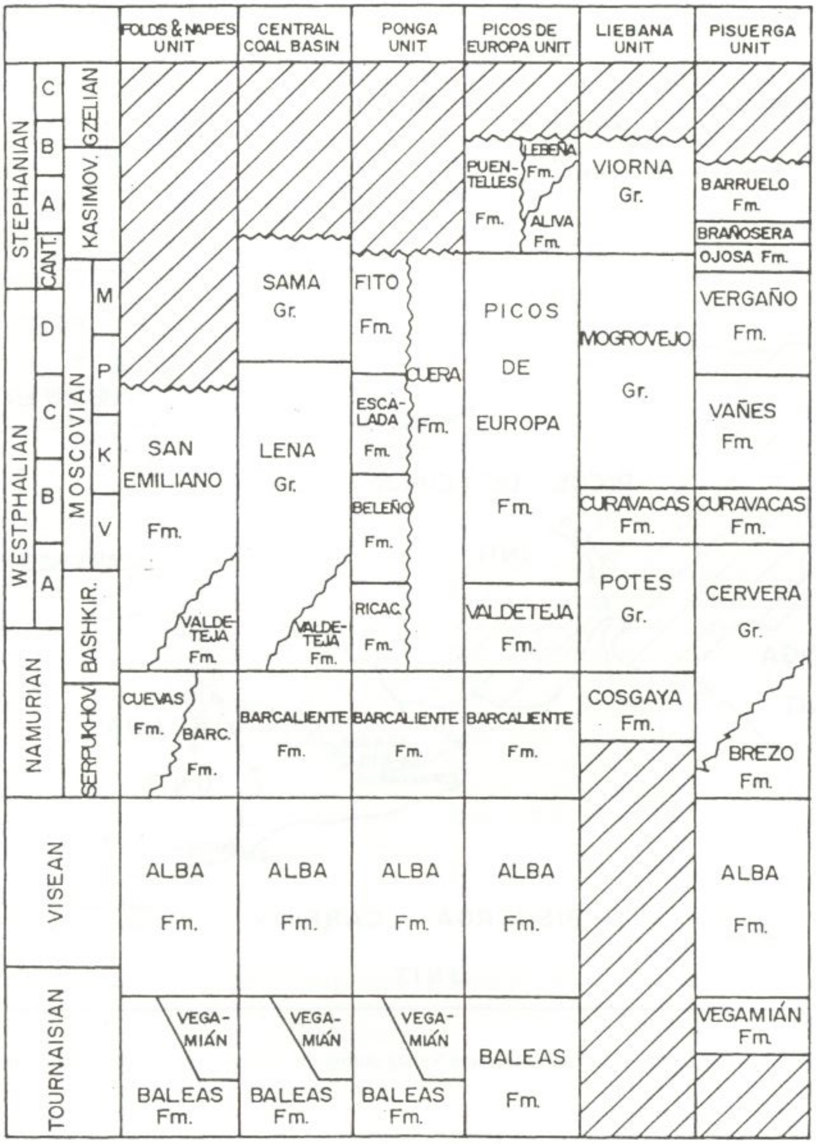


Fig. 12.–Correlation of Carboniferous stratigraphic units in the Cantabrian Mountains.

currence, mostly belonging to the *Cyathaxonia*-fauna (KULLMANN, 1966, 1968; RODRÍGUEZ, 1984; RODRÍGUEZ *et al.*, 1986).

nated limestones, sedimented in shallow, restricted and anoxic environments, follow usually the Alba Fm. Nevertheless, at the in-

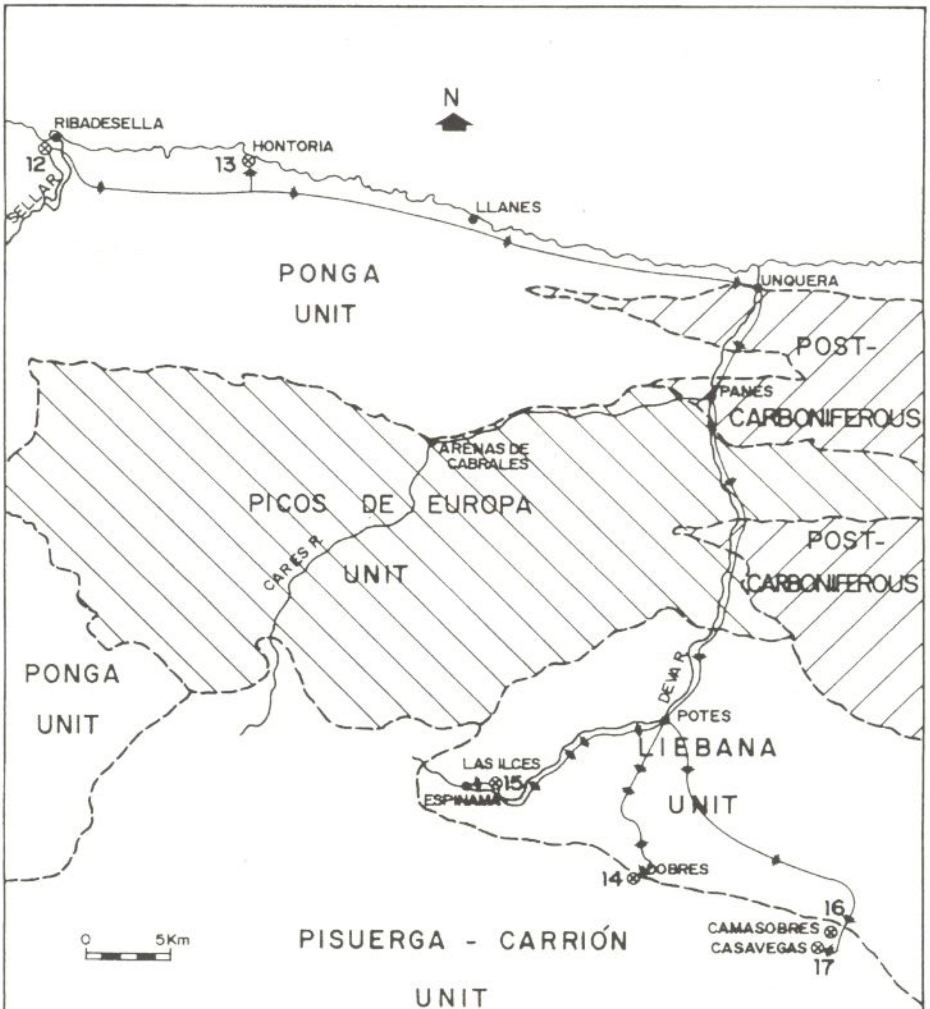


Fig. 13.–Itinerary in Eastern Asturias and Liébana Valley during the last two days (Carboniferous outcrops).

During the Arnsbergian the rate of sedimentation in the Cantabrian Mountains suffered a dramatic increase. Simultaneously, the Hercynic orogenesis began in this region and conspicuous differences are developed in several areas. Barcaliente Fm., consisting of dark grey, non-fosiliferous micritic laminermost of the Somiedo-Correcilla Unit (Figs. 4, 12), it is substituted for the Olaja Beds and the Cuevas Fm., partly turbiditic, and developed in a ramp. In the Palentian unit, the red nodular limestones are followed by bioclastic, partly reefal, massive limestones of Brezo Fm. Only the last unit contains dissepimented rugose corals, typical of shallow water (BOLL, 1985).

The Middle Succession

In most areas of the Cantabrian Mountains (Somiedo-Correcilla and Sobia Bodón Units, Asturian Central Coal Basin, Ponga and Picos de Europa Units) the sinorogenic sedimentation of the Middle Succession begins with the bioclastic and massive limestones (Valdeteja Fm.). Its thickness reaches sometimes 800 m, but it may lack in some regions. The top of the Valdeteja Fm. is sharply diachronic; usually it is Upper Bashkirian, but it can reach the Lower Moscovian. Tabulate and rugose corals occur in this unit, but they are usually scarce.

Mainly terrigenous rocks follow the Valdeteja limestone in most of the areas. The San Emiliano Fm., Lena Group, Sama Group, Ricacabiello, Beleño, Escalada and Fito Fms. reflect a complex paleogeography, with a mixed platform including deltaic, paralic and calcareous facies. Very diverse, but not abundant corals occur in several of those formations (GROOT, 1963; RODRÍGUEZ, 1984; BOLL, 1985; KULLMANN & RODRÍGUEZ, 1986; RODRÍGUEZ *et al.*, 1986).

Limestone sedimentation is continuous during the whole Middle Succession in the Picos de Europa area (Picos de Europa Fm.) and in northwestern Ponga Unit (Cuera limestones). These units, originated in a calcareous platform, locally contain abundant rugose and tabulate corals, as well as chaetetids (RODRÍGUEZ, 1984; RODRÍGUEZ & RAMÍREZ, 1987; KULLMANN & RODRÍGUEZ, 1994). **(Stops 12 and 13)**.

The base of the Middle Succession as well as the Lower Succesion is not recorded in the Liébana Unit. The Cosgaya Fm. (MAAS, 1974), is the oldest lithostratigraphical unit in this region **(Stop 15)**. It is composed of black shales and dark-grey limestones, and yielded abundant rugose and tabulate corals and chaetetids. Germs, 1966 correlated the algal flora with the base of the *Profusulinella* Zone, and dated the Cosgaya Limestone as Bashkirian. Rodríguez, 1984 described the coral fauna and regarded it as Serpukhovian. Later authors (RODRÍGUEZ-FERNÁNDEZ *et al.*, 1986; RODRÍGUEZ-FERNÁNDEZ & HEREDIA, 1987) followed the Germs's (*op. cit.*) opinion. New studies on the foraminifers, conodonts, algae and corals are in progress. Preliminary data confirm a Serpukhovian epoch for the sedimentation of the Cosgaya Fm.

Overlaying the Cosgaya Fm., thick sequences of turbidites crop out overall in Liébana Unit (Potes and Mogrovejo Groups). Calcareous olistolites at the top of the the Potes Group contain corals of Lower Moscovian age (Dobres limestones, RODRÍGUEZ, 1984) **(Stop 14)**. Curavacas conglomerates (up to 2,000 m) separate the lower turbidites (Potes Group) from the upper turbidites (Mogrovejo Group).

At the Palentian Unit, the stratigraphy is very complicated, and numerous local lithostratigraphic units were described, many of them on the basis of very little differences with other units from the same region. A comprehensive synthesis of the main units was given by RODRÍGUEZ-FERNÁNDEZ & HEREDIA, 1987. In order to be clear, we follow here a simplified scheme of such authors (Fig. 12).

The Cervera Fm., also turbidites, follows of the Brezo Fm. (see above, in the chapter of the Lower Succession). That formation includes the local Perapertú and Carmen Formations which contain calcareous olistolites with corals (GROOT, 1963; BOLL, 1985). It is overlied by the conglomerates of Curavacas (Lower Moscovian), and the deltaic deposits of the Vañés Fm. and equivalent units, which contain some calcareous lenses, such as Camasobres Limestone which yielded frequent corals (GROOT 1963; Boll, 1985) **(Stop 16).**

The Upper Succession

It comprises the deposits developed after the Leonese tectonic phase (Uppermost Moscovian), which are usually disconform over the preleonese strata.

In the northern part of the Picos de Europa there are Kasimovian (Cantabrian to Stephanian B) rocks which are included in the Puentellés Formation (Fig. 12). They are mainly limestones at the type area (southeastern Picos de Europa), but show many variations in other areas, with presence of shales, sandstones and conglomerates. The Puentellés Fm. yielded a very peculiar rugose coral assemblage with Permian affinities.

Two local, mainly terrigenous units, the Aliva and Lebeña Formations crop out at the southern Picos de Europa. None of them yielded corals up to date.

A third turbiditic unit (Viorna Group), of Upper Moscovian to Kasimovian epoch, overlaying the Mogrovejo Group is the last Carboniferous unit at the Liébana Valley (Fig. 12).

The deltaic shales, sandstones, conglomerates and coal seams of the Ojosa Fm. follow the Vañés Fm. It contains some calcareous beds which yielded some corals of the *Cyathaxonia*-fauna at Casavegas (RODRÍGUEZ & KULLMANN, 1990) **(Stop 17)**. Some calcareous units with abundant corals (Sierra Corisa Limestone, *cf.* GROOT, 1963 and BOLL, 1985) of the same age as the Casavegas beds, crop out to the southeast, where a calcareous platform is supossed to develop during the Moscovian and Kasimovian.

A transgresive event took place at the end of the Lower Cantabrian, and led to the development of the turbiditic sediments of the Brañosera Fm. They are overlain by the paralic sediments of the Barruelo Fm., the last marine unit in the Carboniferous of the Cantabrian Mountains.

Carboniferous outcrops to be visited

Although Carboniferous corals are present in all the structural units in the Cantabrian Mountains, they are not abundant in most of them and most of the localities are placed in areas which have very difficult access. During the field trip we will visit some of the localities of the units where more diverse corals were recorded. **Stops 12** and **13** are placed in the Ponga Unit (more precisely in the Ribadesella-Llanes coastal area); **Stops 14** and **15** are placed in the Liébana zone of the Pisuerga-Carrión Unit, and **Stops 16** and **17** are placed in the Palentine region of the same unit (Fig. 13). We will visit localities ranging from Namurian to Upper Moscovian. Visean corals are scarce and the only area with interesting outcrops containing abundant corals is placed at the Pico Aguasalio, only accessible after several hours of hard walking. Kasimovian corals are recorded only in the Picos de Europa area. Although some outcrops are easy to reach by car (not so easy by bus), they are poor in corals. The best localities are placed high in the mountains and only accesible after a long walk over in rough land.

Table I.–Formations of the Lower Succession at the Cantabrian Mountains. The last column shows the maximum thickness.

Formation	Author(s)	Lithology	Age	Thick.
Baleas	WAGNER *et al.*, 1971	White, bioclastic limestone	Tournaisian	10 m
Vegamian	COMTE, 1959	Black shales, phosphatic nodules, chert lenses	Middle- Upper Tournaisian	5 m
Alba = Genicera	COMTE, 1959 WAGNER *et al.*, 1971	Red (pink, grey) nodular limestones, chert beds	U. Tournaisian-Arnsbergian	30 m
Olaja	WAGNER *et al.*, 1971	Red to green shales	Lower Namurian	8 m
Barcaliente	WAGNER *et al.*, 1971	Dark grey, micritic, laminated limestones (nonfossiliferous)	Lower Namurian	400 m
Cuevas	BOSCHMA & STAALDUINEN, 1968	Shales, limestones, sandstones and conglomerates (turbiditic)	Lower Namurian	300 m
Brezo	BOLL, 1985	Bioclastic massive limestones	Lower Namurian	400 m

Table II.–Formations of the Middle Succession at the Cantabrian Mountains. The last column shows the maximum recorded thickness.

Formation/Group	Author(s)	Lithology	Age	Thick.
Valdeteja	WAGNER *et al.*, 1971	Light grey, bioclastic, massive limestones	L. Bashkirian - L. Moscovian	800 m
San Emiliano	BROUWER & VAN GINKEL, (1964)	Shales, sandstones, limestones, coal seams	L. Bashkirian - L. Moscovian	1800 m
Lena Group	BARROIS, 1882	Shales, sandstones, limestones, coal seams	U. Bashkirian - U. Moscovian	3000 m
Sama Group	BARROIS, 1882	Shales, sandstones, coal seams	U. Moscovian	2500 m
Ricacabiello	SJERP, 1967	Red (brown, green) shales, Mg and Fe nodules	U. Namurian - U. Bashkirian	70 m
Beleño	VAN GINKEL, 1965	Shales, siltstones, sandstones, scarce limestones	L. Moscovian	500 m
Escalada	VAN GINKEL, 1965	Light coloured massive limestone	Kashirian - Podolian	300 m
Fito	VAN GINKEL, 1965	Shales, sandstones, limestones	U. Moscovian	800 m
Cuera	NAVARRO *et al.* 1986	Massive to bedded limestones, scarce terrigenous beds	U. Bashkirian - U. Moscovian	1200 m
Picos de Europa	MAAS, 1974	Thin bedded to massive limestones	U. Bashkirian - U. Moscovian	600 m
Cervera Group (Perapertú + Carmen = Prioro)	RODRÍGUEZ-FERNÁNDEZ & HEREDIA, 1987	Shales, sandstones, calcareous olistolites, conglomerates	Namurian - Vereyan	2000 m
Cosgaya	MAAS, 1974	Dark-grey, muddy, thin bedded-massive limestone, black shales	Namurian	250 m
Potes Group (Vejo, Deva)	RODRÍGUEZ-FERNÁNDEZ *et al.*, 1986	Shales, sandstones,conglomerates (turbidites), calcareous olistolites	Namurian - Vereyan	2000 m
Curavacas	KANIS, 1956	Conglomerates	U. Vereyan - L. Kashirian	2000 m
Vañés	VAN DE GRAAF, 1971	Shales, sandstones, conglomerates in deltaic sequences. Limestones	Kashirian - Podolian	1200 m
Vergaño	VAN DE GRAAF, 1971	Shales, sandstones, conglomerates in deltaic sequences. Limestones	Podolian - Myachkovian	800 m
Mogrovejo (Pando, Lechada)	RODRÍGUEZ-FERNÁNDEZ *et al.*, 1986	Shales, sandstones, conglomerates (turbidites).	Kasirian - Myachkovian	2500 m

Table III.–Formations of the Middle Succession at the Cantabrian Mountains. The last column shows the maximum recorded thickness.

Formation	Author(s)	Lithology	Age	Thick.
Puentellés	MARTÍNEZ-GARCÍA, 1981	Algal limestones with shaly and conglomerate intercalations. siliciclastic beds at the base	Kasimovian	800 m
Aliva	MAAS, 1974	Yellow to dark brown silty and muddy shales	U. Moscovian - Kasimovian	500 m
Lebeña	MAAS, 1974	Limestone conglomerates, sandstone beds and shales	Kasimovian	600 m
Ojosa	WAGNER, 1959	Shales, sandstones, conglomerates, coal seams, calcareous mudstones	Myachkovian - Kasimovian	2300 m
Viorna	RODRÍGUEZ-FERNÁNDEZ *et al.*, 1986	Shales, sandstones, conglomerates (turbidites).	U. Moscovian - Stephanian	1500 m
Brañosera	WAGNER & WAGNER-GENTIS, 1952	Turbiditic shales and sandstones. Brecciated limestones	U. Cantabrian	900 m
Barruelo	WAGNER & WAGNER-GENTIS, 1952	Sandstones, shales and coal seams (paralic sediments)	Stephanian	1200 m

Field Trip Itinerary

The geographical position of the localities (=**Stops**) to be visited are indicated on the maps in Figs. 1 (Devonian) and 13 (Carboniferous).

1ST DAY, TUESDAY 5TH SEPTEMBER

10:00 Depart from Oviedo and drive southwards to León province.
11:30 Stop 1. El Millar locality.
14:00 Lunch at Ciñera.
16:00 Stop 2. El Puerto creek.
19:00 Overnight in Boñar village.

2ND DAY, WEDNESDAY 6TH SEPTEMBER

09:00 Depart from Boñar.
09:45 Stop 3. Beberino locality.
12:30 Lunch at La Pola de Gordón
15:00 Stop 4. Matallana locality.
17:00 Visit to Valporquero karst.
19:00 Overnight in Boñar village.

3RD DAY, THURSDAY 7TH SEPTEMBER

09:00 Depart from Boñar.
09:30 Stop 5. Aviados locality.
13:00 Lunch at La Vecilla.
15:00 Stop 6. Colle locality.
16:30 Depart from Colle and drive northwards to Asturias province.
19:00 Overnight in Perán village.

4TH DAY, FRIDAY 8TH SEPTEMBER

09:00 Depart from Candás.
10:00 Stop 7. Plataforma de Arnao.
11:30 Stop 8. Arnao locality.
14:00 Lunch at Salinas.
16:30 Stop 9. Moniello inlet.
19:00 Overnight in Perán village.

5TH DAY, SATURDAY 9TH SEPTEMBER

09:00 Depart from Candás.
09:15 Stop 10. Perán locality.
12:00 Stop 11. Carranques beach.
13:00 Lunch at Perán.
15:00 Depart from Candás to Ribadesella.
17:00 Stop 12. Ribadesella locality.
19:00 Arrival to San Roque village. Overnight at Hostal Europa.

6TH DAY, SUNDAY 10TH SEPTEMBER

08:30 Depart from Andrín.
09:00 Stop 13. Podolian limestones at Hontoria bay.
12:00 Depart from Hontoria and transportation to Santander province.
14:00 Lunch at Panes.
16:30 Stop 14. Dobres limestones at its type locality.
18:00 Stop 15. Cosgaya Fm. at Las Ilces.
20:00 Arrival to Espinama. Overnight at Hostal Remoña (Espinama).

7TH DAY, MONDAY 11TH SEPTEMBER

08:30 Depart from Espinama to Palencia province.
10:30 Stop 16. Camasobres Limestone at its type locality.
11:30 Stop 17 (optional). Casavegas section.
13:00 Lunch at Osorno
15:00 Depart to Madrid
18:30 Arrival to Madrid

Table IV

Table V

1st DAY (5/09/95) EL MILLAR LOCALITY AND EL PUERTO CREEK

STOP 1. EL MILLAR LOCALITY

LOCATION: This locality is sited on the right side of the national road 630, from León to Oviedo, along the Bernesga Valley. The section to be visited is located approximately 900 m north past the crossroad to Huergas de Gordón and Llombera localities. (Figs. 1D, 14).

Mesophyllum (Cystiphylloides) Biostrome

Some biostromes of *Mesophyllum (Cystiphylloides)* are well developed in this locatity (levels 4 to 6 painted on the rock). This reefal type consists of well bedded argillaceous limestones. It is a fasciculate rugose coral bafflestone of less than 0,50 m thickness in which the subgenus *Mesophyllum (Cystiphylloides)* is the only reef building organism. The colonies of *Mesophyllum (Cystiphylloides)* show fasciculate, more or less cylindrical corallites with symmetrical dissepiments with respect to the axis and funnelled callices.

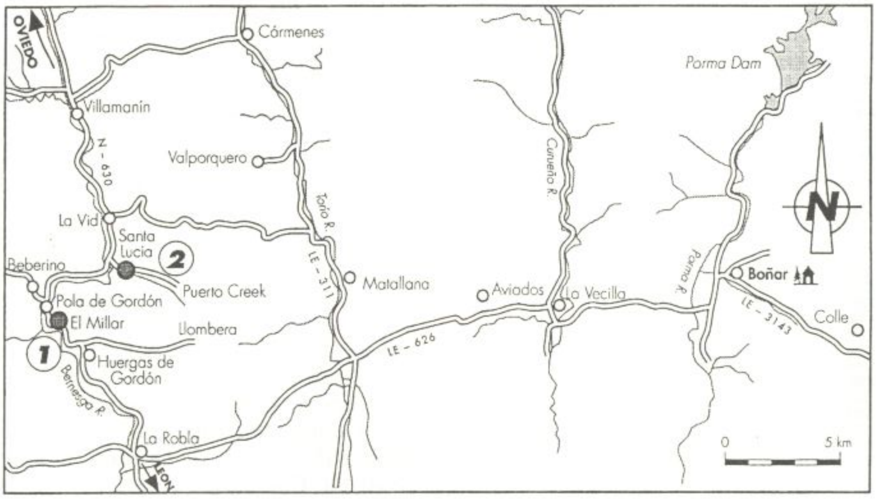


Fig. 14.–Geographical location of El Millar and El Puerto creek localities.

Geological Map of Spain, 1:50,000, sheet 103, La Pola de Gordón. Southern slope of the Cantabrian Zone, Fold and Nappe Region, Somiedo-Correcilla Unit (Fig. 4).

STRATIGRAPHICAL UNIT: Santa Lucía Fm., middle-upper part (Fig. 15).

AGE: Lower Devonian, upper Emsian.

DESCRIPTION: From a geometric point of view, the reef structures of the Santa Lucía Fm. in this locality are formed by biostromes of variable thickness. In this stop we are going to see two different types of biostromes.

The above mentioned form of growth and its association with argillaceous limestones could indicate a quiet environment in the development of this biostrome.

Main faunal components:

Rugose corals: *Mesophyllum (Cystiphylloides) originale ballonifer.*

Hemispherical stromatoporoid and favositid Biostrome

In this case, this biostrome (level 8) is composed of massive grey to thick bedded limestones, sometimes slightly argillaceous, with a packstone-grainstone matrix.

It is a stromatoporoid and favositid framestone alternating with floatstone and some rudstones, especially in those levels with a higher argillaceous content, from 3 to 12 m thickness.

The most significant builders are stromatoporoids and favositids with hemispherical to laminar morfologies, sometimes reaching great sizes. The stromatoporoids, developing mamelons in argillaceous beds, present a great taxonomic diversity. Occasional laminar alveolitids are also present.

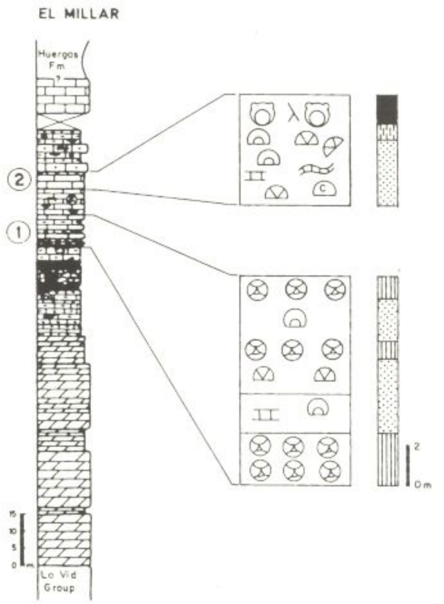


Fig. 15.–Lithostratigraphic succession of the Santa Lucía Formation at El Millar showing the reefal levels mentioned in the text and their faunal content. For explanation of symbols see Tables IV and V.

The presence of grainstone, sometimes packstone, matrix, the basic hemispherical morphologies of the framebuilders and the high taxonomic diversity of stromatoporoids are criteria which have traditionally been interpreted as indicative of well-oxigenated and rather turbulent water. The development of this biostrome could be occasionally influenced by episodes of slight turbidity of waters causing a lesser reef building organism proliferation as can be observed in the more argillaceous levels.

Main faunal components:

Stromatoporoids: *Stromatoporella* cf. *granulata*, *Stromatoporella* spp., *Clathrocoilona* sp.

Rugose corals: *Chalcidophyllum* cf. *gigas,* cf. *Embolophyllum* aff. *harperi.*

Tabulate corals: *Favosites* sp., *Squameofavosites* ex gr. *hispanicus, Squameofavosites* spp., *Alveolites lemniscus, Squameoalveolites* aff. *fornicatus, Caliapora (Luciaella) daedala.*

Commensal traces associated to Tabulate corals: *Phragmosalpinx australiensis, Helicosalpinx* sp.

References: Coo, 1974; Méndez-Bedia, 1976; Méndez-Bedia, Soto & Fernández-Martínez, 1994.

Stop 2. El Puerto Creek

Location: El Puerto creek is situated near Santa Lucía locality, which is placed on the right margin of the national road 630, from León to Oviedo. The section to be visited is sited just after going through Santa Lucía town, along a mining path to Llombera, upstream El Puerto brook (Fig. 1D, 14).

Geological Map of Spain, 1:50,000, sheet 103, La Pola de Gordón. Southern slope of the Cantabrian Zone, Fold and Nappe Region, Somiedo-Correcilla Unit (Fig. 4).

Stratigraphical unit: Santa Lucía Fm., middle and lowest upper part (Fig. 16).

Age: Lower Devonian, upper Emsian.

Description: In this locality, two different deposits bearing reefal organisms will be shown (Fig. 16).

Bioherm of stromatoporoids associated with other organisms

This bioherm (level 23), up to 50 m thick, consists of massive light grey limestones. Recristallization and weathering prevent observation in detail of the internal features of this reef. However, the interpretation is based on the massive aspect of the outcrop and the reefal organisms content. In addition, the matrix where it is possible to be observed is mostly a crinoidal and bryozoan grainstone with some packstone.

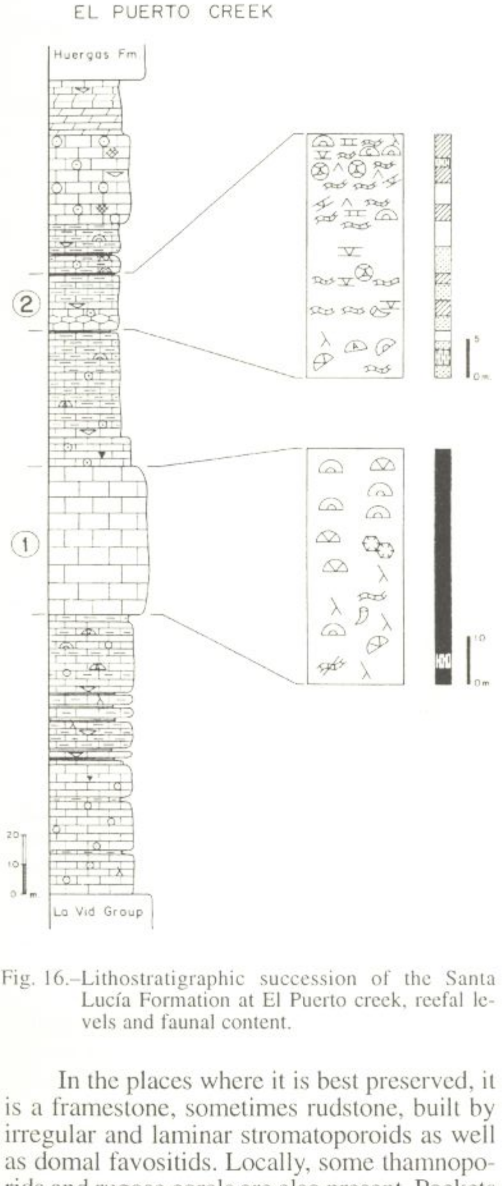


Fig. 16.–Lithostratigraphic succession of the Santa Lucía Formation at El Puerto creek, reefal levels and faunal content.

In the places where it is best preserved, it is a framestone, sometimes rudstone, built by irregular and laminar stromatoporoids as well as domal favositids. Locally, some thamnoporids and rugose corals are also present. Pockets filled up by bioclastic material are visible.

Main faunal components:
Stromatoporoids: *Atelodictyon* sp., *Taleaostroma* sp.
Tabulate corals: *Squameofavosites* sp.

Biostrome of stromatoporoids and favositids associated with diverse fauna

In general, this type of reefal deposits (levels 49 to 54 painted on the rock) is developed in argillaceous limestones interbedded with shaly levels. In the lower part, the limestone matrix is wackestone-packstone becoming packstone-grainstone towards the top.

It deals with some bindstones and rare very thin bafflestones alternating with floatstones and rudstones.

Bindstones, from 0.20 m to 2.50 m thick, are mainly built by stromatoporoids, favositids, alveolitids, caliaporids as well as solitary and fasciculate rugose corals. Stromatoporoids are laminar to tabular with some irregular and hemispherical shapes. Favositids show mostly hemispherical and tabular morphologies; alveolitids are tabular-shaped. Intergrowths between different organisms as well as stromatoporoids growing on bioclastic limestones are common near the top.

Thin bafflestones (about 3 to 12 cm), built by small thamnoporids or branching alveolitids, are developed in some muddy levels.

Main faunal components:
Stromatoporoids: *Actinostroma geminatum, Actinostroma stellulatum, Actinostroma* cf. *conglomeratum, Clathrodictyon ellesmerense, Clathrocoilona* sp., *Stromatoporella* spp., *Taleastroma logansportense, Taleastroma* sp.
Rugose corals: *Chalcidophyllum gigas, Embolophyllum* cf. *aequiseptatum aequiseptatum, Mesophyllum (Cystiphylloides) originale ballonifer, Mesophyllum (Cystiplylloides) monielloense.*
Tabulate corals: *Favosites* cf. *granulosus, Squameofavosites* ex gr. *hispanicus, Squameofavosites* sp., *Alveolites lemniscus, Caliapora (Mariusilites)* cf. *chaetetoides, Caliapora (Luciaella) daedala, Thamnopora* spp., *Aulostegites* sp.

REFERENCES: OEHLERT & OEHLERT, 1897, 1901; GARCÍA-ALCALDE, J.L. *ET. AL.*, 1979.

2nd DAY (6/9/95) BEBERINO AND MATALLANA LOCALITIES.

STOP 3. BEBERINO LOCALITY

LOCATION: Along the national road 630, from León to Oviedo, 9 kms north of La Robla locality, there is a junction where we take the road to Geras and Puerto de Aralla. Approximately 1 km after the crossroad, we came to the village of Beberino. The section to be visited crops out inmediately after going through this locality, along the road to Geras and upstream Casares river (Figs. 1D, 17).

Geological Map of Spain, 1:50,000, sheet 103, La Pola de Gordón. Southern slope of the Cantabrian Zone, Fold and Nappe Region, Somiedo-Correcilla Unit (Fig. 4).

STRATIGRAPHICAL UNIT: Portilla Fm., upper part (Fig. 18).

AGE: Middle Devonian, upper Givetian.

DESCRIPTION: In this locality there is a complete exposure of the entire formation (Fig. 18) though weathering greatly obscures the features of the reefal interval of the lower member. Thus only the upper member will be dealt with. This member only develops reefal deposits in its lower half. This interval is formed by several stacked sequences comprising only reefal deposits. Each sequence begins with a thin interval of bafflestones made up dominatly of branching tabulate corals set in a marly matrix [facies (v)]. Upwards the limestone becomes massive and there is a substitution of the branching corals by massive corals and stromatoporoids forming framestones [facies vii)]. Occasionally, bindstones of platy tabular corals [facies (vi)] are developed between the above mentioned facies (in the second sequence). In some cases the upper limit of the sequence is not abrupt but gradational. This sequence displays features suggesting environmental conditions corresponding to clearer and more agitated waters upwards.

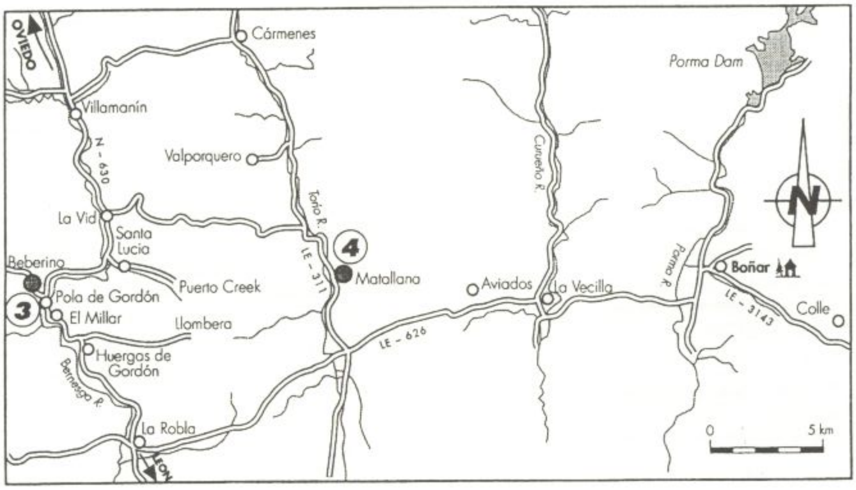


Fig. 17.–Geographical location of Beberino and Matallana localities.

Five reefal sequences of this kind have been observed in this outcrop (numbers 1 to 5 in Fig.18). Between the second and the third of these sequences a transgresive episode recorded in reefal facies seems to be represented. It is composed by facies (vi) and shows an upward increase in clay content passing gradually to the overlying reefal sequence.

Facies (v) is a bafflestone with a slightly marly bioclastic wackestone matrix. Its main faunal components are branching tabulate corals (thamnoporids and alveolitids). Occasionally, some laminar and tabular alve-

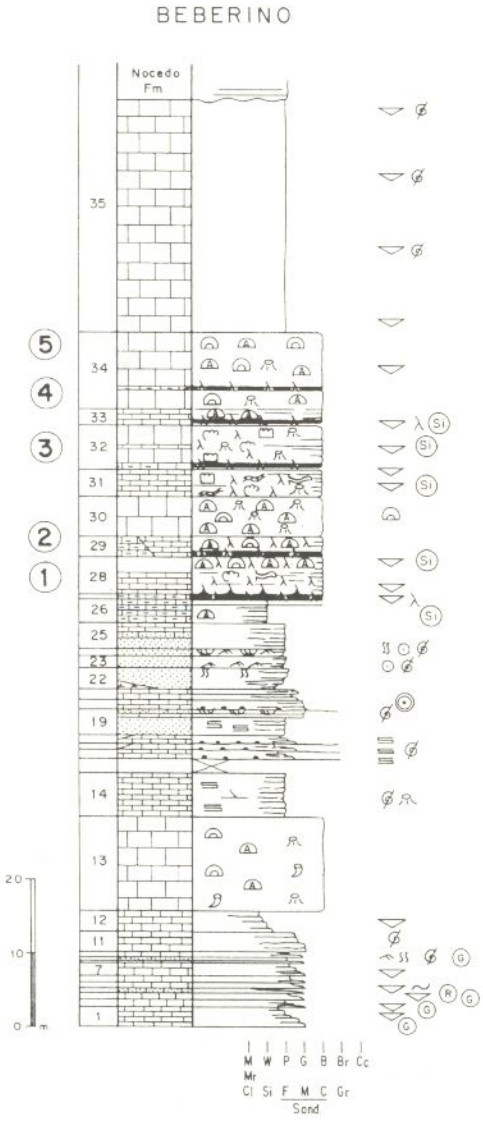


Fig. 18.–Lithostratigraphic succession of the Portilla Formation at Beberino, reefal sequences and faunal content.

olitids as well as rugose corals and chaetetids can be found.

Facies (vi) is a bindstone mainly composed of alveolitids, generally with a tabular morphology. Some phillipsastreids and stromatoporoids are also present.

Organims in facies (vii) are represented by alveolitids, usually irregular in shape, stromatoporoids with irregular to hemispherical shapes and irregular phillipsastreids. They set in a bioclastic packstone matrix. Overgrowths of alveolitids and stromatoporoids are common.

Main faunal components:

Stromatoporoids: *Atelodictyon* cf. *strictum.*

Rugose corals: *Medusaephyllum pradoanum, Phillipsastrea* cf. *rozkowskae, Haplothecia* cf. *filata, Siphonophrentis cantabrica.*

Tabulate corals: *Alveolites parvus, Scoliopora* sp., *Platyaxum (Platyaxum) escharoides, Thamnopora patula, Thamnopora beliakovi, Thamnopora alta.*

Commensal traces associated to Tabulate corals: *Helicosalpinx* sp.

Chaetetids: *Chaetetella (Chaetetella)* sp.

References: Sleumer, 1969; Reijers, 1972; Frankenfeld, 1981.

Stop 4. Matallana Locality

Location: The village of Matallana is located along the regional road LE-311, from León to Oviedo by Piedrafita Mountain Pass in the Torío River valley. The section to be visited crops out on the east side of this road, near the site of Estación de Matallana (Matallana Railway Station), in the so called Alto de la Carrasquera (Figs. 1D, 17).

Geological Map of Spain, 1:50,000, sheet 104 Boñar. Southern slope of the Cantabrian Zone, Fold and Nappe Region, Somiedo-Correcilla Unit (Fig. 4).

Stratigraphical unit: Portilla Fm., upper part (Fig. 19).

Age: Middle Devonian, upper Givetian.

Description: In this locality the Portilla Formation displays more distal features than it does in the Beberino section.

The succesion comprises, possibly, the upper part of the middle member and the entire upper member (Fig. 19). Lack of detailed correlations and of nearby sections preclude further refinements in the interpretation.

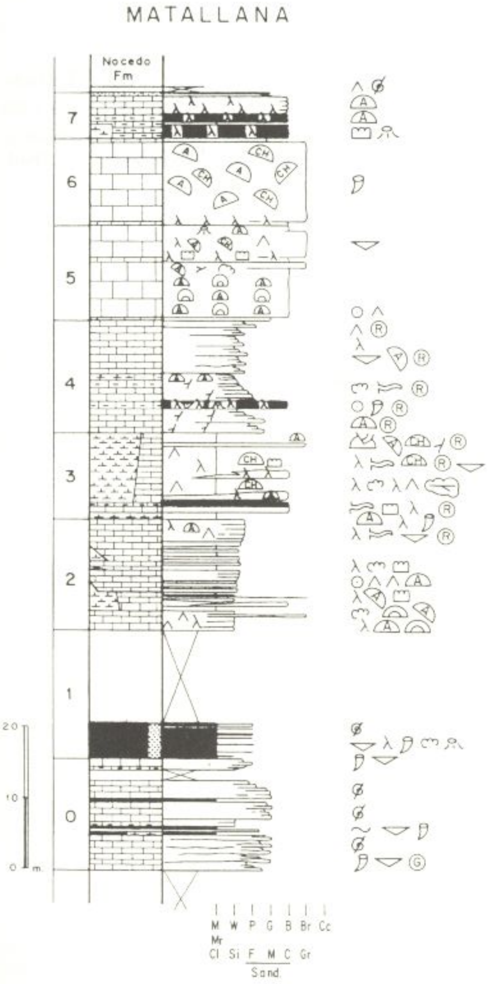


Fig. 19.–Lithostratigraphic succession of the Portilla Formation at Matallana, reefal units and faunal content.

Several units with reefal organisms will be shown. In general, the development of these reefal deposits could have been taken under more distal conditions, which were, occasionally, muddy and of low energy (unit 3).

Unit 2 and 4 are dominantly detrital intervals which typically display fining upwards sequences composed of bioclastic packstones to rudstones [facies (i) and (ii)], that evolve to wackestone-mudstones and to marls towards the top of each sequence. Reef-forming organisms are found towards the top of each sequence and tend to give way to thin biostromes [facies (iv) to (v?)].

Unit 3 is mainly formed by incomplete sequences represented by the distal-intermediate terms [facies (iv) to (vi)] of the ideal sequence described in the general part of this guide, corresponding to the reefal features of the Candás and Portilla Fms.

On the whole, these units are characterized by the development of transient low relief constructional episodes which could be envisaged as biostromes or as the distal ends of reef complexes which should be fully developed in a more proximal position. The constructional episodes are mainly bindstones and bafflestones. Tabulates corals are the main faunal components in the three units.

In the first one, laminar, tabular and branching alveolitids are the most common organisms; in the second one *Platyaxum* and thamnoporids are the predominant tabulates. Irregular alveolitids and auloporids are also frequent. Locally some phillipsastreids, solitary rugose corals, chaetetids and rare stromatoporoids appear. A notable occurrence of epizoans as well as frequent intergrowths between different organisms exist.

Tabulate corals, which are also the main faunal components in the unit 4, are represented by thamnoporids and, in a lesser degree, by branching and laminar alveolitids; *Platyaxum* is more scarce than in the previous units. Phillipsastreids and solitary rugose corals also appear.

Unit 5 consists of two sequences that only display reefal deposits. The lower one exhibits a sharp base overlying detrital limestones and is only composed of facies (vii) in which irregular stromatoporoids and alveolitids are the main builders. Branches of tabulate corals and some chaetetids are present. The base of the upper sequence is marked by a thin (1 m) interval of branching tabulate coral bafflestone/floatstone followed by a thick (5.2 m) interval of alveolitid/chaetetid framestone to rudstone. Usually the alveolitids are tabular in shape and they reach a big size. Small chaetetids displaying hemispherical morphologies are common. Thamnoporids, branching alveolitids, auloporids and some rugose corals are also present. Outcrop quality is not good enough to decipher whether the majority of individuals are *in situ* or removilized.

Finally unit 6 forms a sequence quite similar to the upper one of the unit 5, but outcrop quality is also bad.

MAIN FAUNAL COMPONENTS:

Stromatoporoids: *Atelodictyon* cf. *strictum.*

Rugose corals: *Acantophyllum concavum, Heliophyllum chengi, Temnophyllum waltheri, Medusaephyllum pradoanum, Frechastrea* cf. *carinata.*

Tabulate corals: *Alveolites parvus, Platyaxum (Platyaxum) escharoides, Platyaxum (Roseoporella)* sp., *Thamnopora patula, Thamnopora* spp., *Heliolites porosus, Aulopora* sp., *Mastopora* sp.

Chaetetids: *Rhaphidopora* spp.

REFERENCES: SLEUMER, 1969; MOHANTI, 1972; REIJERS, 1972; REIJERS, VAN DER BAAN & VAN DER SLUYS, 1984; MÉNDEZ-BEDIA, SOTO & FERNÁNDEZ-MARTÍNEZ, 1994.

3[rd] DAY (7/9/95)
AVIADOS AND COLLE LOCALITIES

STOP 5. AVIADOS LOCALITY

LOCATION: Aviados is a very small village placed near La Vecilla de Curueño, along the regional road LE-626, from La Robla to Boñar. The section to be visited crops out North of Aviados village, upstream a brook which runs through a gorge in the south flank of Peña Galicia syncline, just past an abandoned coal mine (Figs. 1D, 20).

Geological Map of Spain, 1:50,000, sheet 104, Boñar. Southern slope of the Cantabrian Zone, Fold and Nappe Region, Somiedo-Correcilla Unit (Fig. 4).

STRATIGRAPHICAL UNIT: Santa Lucía Fm., lower-middle part (Fig. 21).

AGE: Lower Devonian, upper Emsian.

DESCRIPTION: In this stop we will see two different kinds of reefal deposits, one of them is a biostrome and the second one is a bioherm. It will also be interesting to observe an alloctonous bed very rich in reefal building organisms.

Accumulation bed of reworked stromatoporoids and favositids

This deposit (level 1 painted on the rock) is a rudstone of 1.50 m. thick with a mudstone matrix. At the bottom, the organisms consist mainly of subspherical to hemispherical stromatoporoids and favositids, the former being sometimes tabular. Upwards, there are mostly stromatoporoids with less abundant favositids, although these are bigger, branching tabulate and some cerioid rugose corals. Most organisms are broken and/or reworked.

This level is intercalated between sediments made up of wackestones and laminated mudstones with scarce birdseyes. On the basis of these features and the reworking of the organisms in the level studied, it may represent a storm deposit in a very shallow, possibly inter-supratidal, environment.

Main faunal components:

Stromatoporoids: *Actinostroma stellulatum, Actinostroma* cf. *verrucosum, Actinostroma* sp., *Atelodictyon fallax, Stromatoporella selwyni, Stromatoporella* sp.

Rugose corals: *Xystriphyllum ?* sp.

Tabulate corals: *Squameofavosites* ex gr. *hispanicus,* usually with commensal traces of *Phragmosalpinx australiensis.*

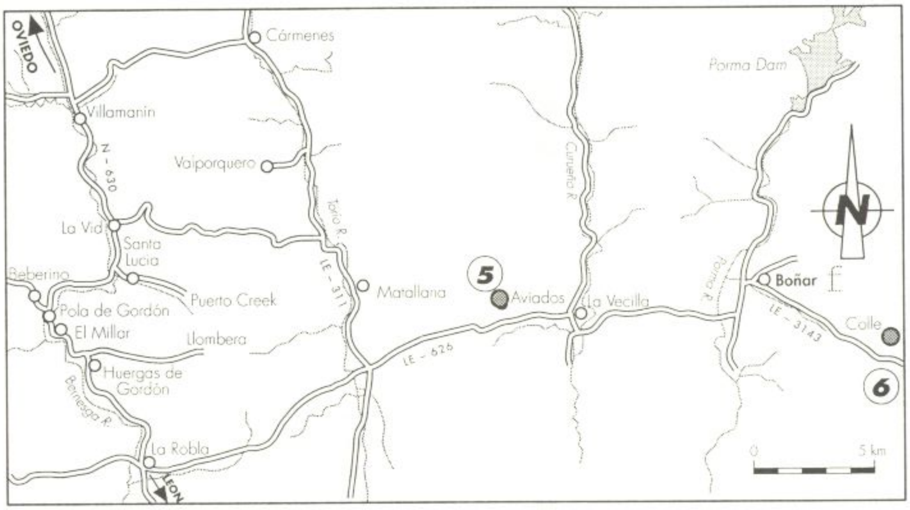


Fig. 20.–Geographical location of Aviados and Colle localities.

Bioherm of stromatoporoids associated with other organisms

In this locality, and near the base of the formation (level 2), we can see an incipient bioherm. This bioherm is developed in grey

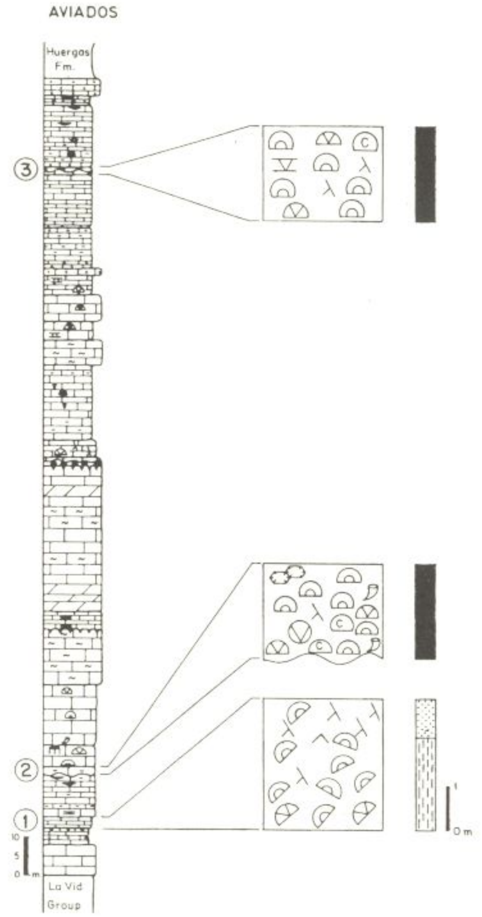


Fig. 21.–Lithostratigraphic succession of the Santa Lucía Formation at Aviados, reefal level and faunal content.

limestones with mud content decreasing progressively from the base upwards. It consists of a framestone of irregular thickness, reaching a maximun of 2 m.

Notice that, in this example, a vertical succession can be seen. Thus, the lower part, with a greater argillaceous content, is mostly built by abundant hemispherical to cylindrical favositids and subspherical stromatoporoids, of small to medium size, with caliaporids accumulated near the base. Towards the top, the faunal diversity and the number of organisms decrease coinciding with the diminishing of argillaceous content. Here, larger stromatoporoids of subhemispherical shape are the dominant builders meaning that going upwards this reefal sequence changes into cleaner water conditions. Abundant rugose corals are found as additional fauna, especially at the base.

Main faunal components:

Stromatoporoids: *Actinostroma verrucosum, Anostylostroma ponderosum, Anostylostroma* cf. *tuntouense, Stromatoporella* sp., *Taleastroma* sp.

Rugose corals: *Tryplasma* sp.

Tabulate corals: *Squameofavosites* ex gr. *hispanicus, Caliapora (Mariusilites)* cf. *chaetetoides, Thamnopora* spp., *Aulopora* sp.

Biostrome of stromatoporoids and favositids

Lithologically, this biostrome (level 4 painted on the rock) consists of argillaceous limestones. Because of the weathering it is not well exposed, but abundant loose reefal fauna can be found. In some places, it appears as a nodular level, each nodule being a reef organism. It is a framestone, 2 m thick, with a packstone, wackestone and mudstone matrix.

The reefal fauna consists, especially, of stromatoporoids and favositids. As additional organisms, some caliaporids, solitary rugose corals and chaetetids can be seen. The stromatoporoids and favositids show medium to large size with varied morphology.

On the basis of the type of matrix and the argillaceous content, this biostrome is supposed to be formed in a slightly turbid water environment.

Main faunal components:

Stromatoporoids: *Taleastroma simplex, Actinostroma stellulatum, Stromatoporella* sp.

Rugose corals: *Mesophyllum (Cystiphylloides) secundum secundum.*

Tabulate corals: *Squameofavosites* ex gr. *hispanicus, Thamnopora* sp., *Caliapora (Mariusilites)* cf. *chaetetoides.*

Commensal traces in tabulate corals: *Phragmosalpinx australiensis.*

REFERENCES: SLEUMER, 1969; COO, 1974; MÉNDEZ-BEDIA, SOTO & FERNÁNDEZ-MARTINEZ, 1994.

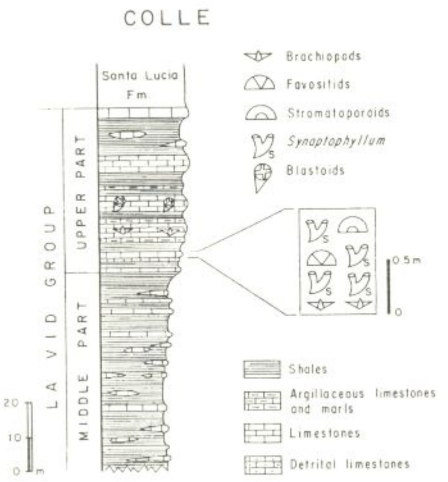


Fig. 22.–Partial lithostratigraphic succession of the La Vid Group at Colle, reefal level and faunal content.

STOP 6. COLLE LOCALITY

LOCATION: Colle village is located on the left side of the regional road LE-3143, from Boñar to Sabero, approximately 5 kms east of the first one. The section be to visited crops out at the slope of a hill where Colle church is situated (Figs.1D, 20).

Geological Map of Spain, 1:50,000, sheet 104, Boñar. Southern slope of the Cantabrian Zone, Fold and Nappe Region, Somiedo-Correcilla Unit (Fig. 4).

STRATIGRAPHICAL UNIT: Upper part of La Vid Group (Fig. 22).

AGE: Lower Devonian, upper Emsian.

DESCRIPTION: Several biostromal levels are developed just at the base of a hill. They are less than 1 m thick, interbedded with shaly and argillaceous sediments. These levels are mainly built by fasciculate rugose corals (*Synaptophyllum)* and, in a lesser proportion, by favositids, alveolitids and stromatoporoids, occasionally of a large size and partly in growth position.

The reef building began with the installation of a pioneer fauna formed by a *Synaptophyllum-Atrypa* association on a bioclastic unit interpreted as storm deposits. According to Stel (1975) the growth of these biostromes was due to the temporal oxigenation of anoxic waters by hurricanes and storms.

MAIN FAUNAL COMPONENTS:

Stromatoporoids: *Stromatopora* sp.

Rugose corals: *Synaptophyllum multiseptatum.*

Tabulate corals: *Favosites* sp.

REFERENCES: BROUWER, 1964; SLEUMER, 1969; STEL, 1975; SOTO, 1982A.

Complementary data: Since the 19th Century, Colle locality is well known because of the quality and wealth of its fossil deposits. The fossils coming from Colle have been cited in the ancient literature like "Sabero fossils" with reference to Sabero locality, a mining village near Colle. Most of this fossils came from the red limestones and marls laiying on the biostromal levels described above. From these red levels more than 200 species of different groups have been cited. Among these fossils groups there are: brachiopods, crinoids, blastoids, corals, stromatoporoids, trilobites, bryozoans, nautiloids, gastropods, bivalves, ostracods, tentaculitoids, conodonts, etc.

4th DAY (8/O9/95) PLATAFORMA DE ARNAO, ARNAO AND MONIELLO LOCALITIES

Stop 7. Plataforma de Arnao

Location: The Plataforma de Arnao is situated on the coast, in an old quarry, close of the town of Avilés, NW of Oviedo. The outcrop is located between Arnao beach and La Vela Cape (Figs. 1C, 23).

Geological Map of Spain, 1:50,000, sheet 13, Avilés. Northern slope of the Cantabrian Zone, Fold and Nappe Region, Somiedo-Correcilla Unit (Fig. 4).

Stratigraphical unit: Aguión Formation, lower part (Fig. 24 A, B).

Age: Lower Devonian, upper Emsian.

Description: The stratigraphic succession (Fig. 24 B), corresponding to the overturned limb of a fold with gently inclined axial surface, can be divided, from bottom to top, into three informal units (Alvarez-Nava & Arbizu, 1986): calcareous unit, marly-shaly unit and unit of green and red marls, all in the 60 basal metres of the Aguión Formation. These three units have been further divided into different horizons in relation to faunal contents.

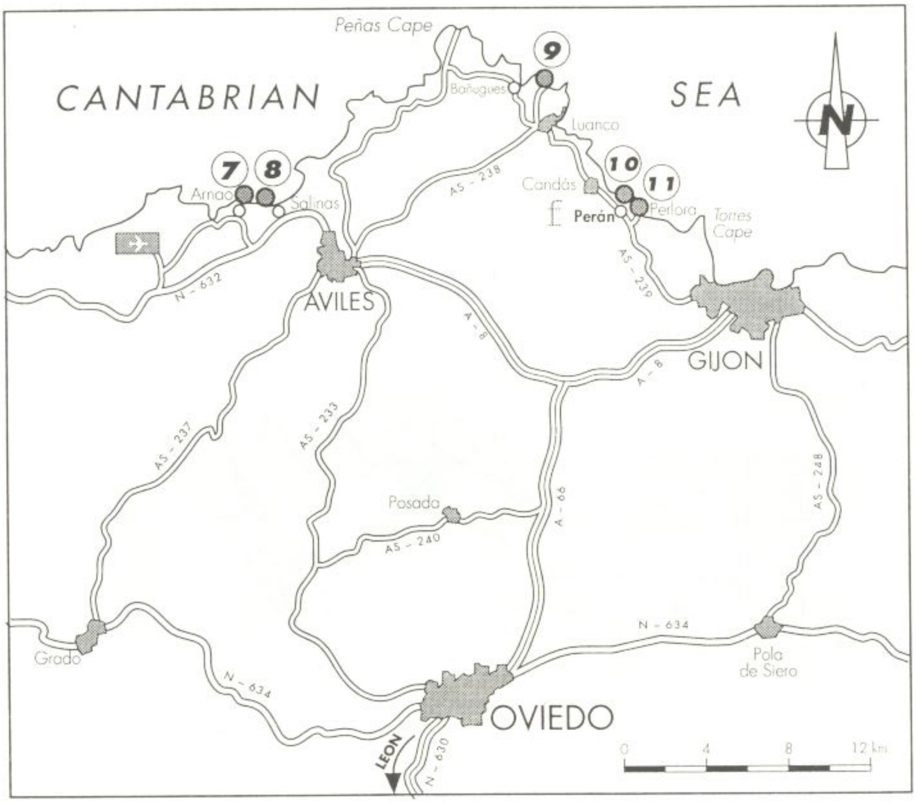


Fig. 23.–Geographical location of La Plataforma de Arnao, Arnao and Moniello inlet localities.

Within the basal calcareous unit a biostromal patch-reef is developed. This calcareous unit is 22m thick and consists of two different horizons (Fig. 24 B). The lower one, 17 m thick, is composed by dominantly bioclastic grey and red massive limestones with crinoid debris, bryozoans and with some corals. The upper horizon, consisting of slightly argillaceous grey limestones, is a biostromal patch-reef, 5 m thick, built up essentially by bryozoans and tabulate corals. In this calcareous unit the communities show an ecological succession represented by four different stages: stabilization, colonization, diversification and domination (Fig. 24 C).

Stabilization stage: It is represented by communities related to bioclastic bars from the lower levels of this unit. The organisms are mainly small tabulates and encrusting bryozoans, sparsely distributed on bioclastic bars formed through stacking of fragmen-

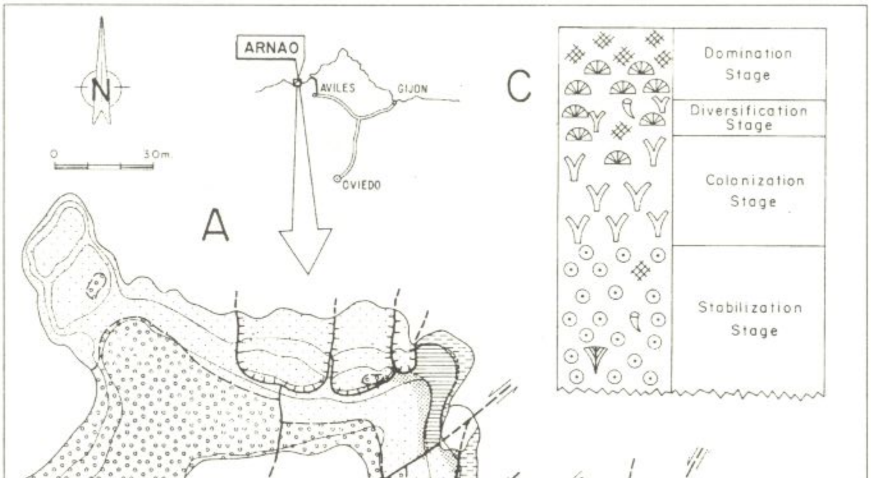


Fig. 24.–A: Location and geological map of La Plataforma de Arnao. B: Stratigraphical succession of the Aguión Formation at La Plataforma de Arnao showing lithological units, their faunal composition and types of communities. C: Stages of reef development in the calcareous unit.

tal remains of other organisms, crinoids and bryozoans especially.

Colonization stage: It is represented by pioneer organisms, namely, branching tabulates and bryozoans colonizing bioclastic bars giving rise to the later growth of patch-reef.

Diversification stage: The number of taxa increased during this stage. However, it is not well developed in the succession and could be, perhaps, represented by a series of levels with a greater variety of organisms, such as low domal alveolitids, laminar bryozoans, compound rugose corals and branching tabulates.

Domination stage: During this stage two different taxa contributed successively to the growth of the reef, forming a bindstone. The former are mainly medium-sized flattened low domal alveolitids, later replaced by large laminar bryozoans. In sheltered zones, below the alveolitids, there was profuse colonization by various different organisms, such as cemented brachiopods, cylindrical and laminar bryozoans as well as auloporids.

The type of matrix, packstone and wackestone, and the argillaceous material content together with the morphology of organisms suggest a shallow water platform of moderate energy as the patch-reef developed.

REFERENCES: ÁLVAREZ-NAVA & ARBIZU, 1986; MÉNDEZ-BEDIA, SOTO & FERNÁNDEZ-MARTÍNEZ 1994; SOTO, MÉNDEZ-BEDIA & FERNÁNDEZ-MARTÍNEZ, 1994.

Complementary data: In the two other units outcroping in the Plataforma de Arnao, marly-shaly and green and red marls units, several communities occur in relation to different environmental conditions. These communities together with those involved in the patch-reef constitute a good example of communities succession in a marine platform (Fig. 24 B).

The community present in the marly-shaly unit consists of large brachiopods with numerous bryozoans (especially fenestellids) and crinoids.

The excellent preservation of the entire fauna together with the type of associated sediments suggest quiet conditions, characteristic of a sheltered area (sublagoon ?).

In the unit of green and red marls there are abundant crinoids, particularly *Trybliocrinus flatheanus* as well as bryozoans and a few brachiopods. Four communities are distinguished in relation to the varying argillaceous content: *Fenestella* Community, *Isotrypa* Community, *Trybliocrinus* and *Anathyris* Community and *Trybliocrinus* Community. These four communities developed in an environment characterized by a gradual increase in terrigenous supply.

In general, the communities in the calcareous unit seem related to the development of a biostromal patch-reef on bioclastic bars; the marly-shaly unit show communities characteristic of sheltered environments. Finally, the communities in the unit of green and red marls are typical of platform environments with highly variable rates of terrigenous supply.

REFERENCES: SCHMIDT, 1931; ARBIZU, ALVAREZ-NAVA, MÉNDEZ-BEDIA & GARCÍA-LÓPEZ, 1993.

STOP 8. ARNAO ORGANIC BUILDUP

LOCATION: This point is situated on the Asturian coast to the west of the Peñas Cape (NW Avilés). The outcrop is located between Arnao and Salinas localities, inmediately to the west of the Requejo headland (Figs.1C, 23).

Geological Map of Spain, 1:50,000, sheet 13, Avilés. Northern slope of the Cantabrian Zone, Fold and Nappe Region, Somiedo-Correcilla Unit (Fig. 4).

STRATIGRAPHICAL UNIT: Moniello Fm., lower-middle part (Fig. 25 A, B).

AGE: Lower Devonian, upper Emsian.

DESCRIPTION: The Arnao outcrop exposes a reef which is the largest bioherm developed in the Moniello Fm., and shows the greatest range of internal structure. It is a dome like reef consisting of massive limestones with an argillaceous content at the base that diminishes gradually upwards. The measured thickness is about 140 m and it exhibits a sharp contact with the surrounding bedded limestones. It is made up of a great variety of reefal limestones types (framestones, bindstones and bafflestones) and the builders can reach great dimensions, e. g. stromatoporoids 2 m in diameter. A vertical paleoecological zonation reflecting different stages in the reef development (Fig. 26) is established on the basis of the faunal assemblages and related facies. These stages correspond to stabilization, colonization, diversification and domination.

Stabilization stage (levels AR-8 to AR-11): The beds inmediately underlying the organic buildup, would represent a shallow and relatively quiet marine environment as suggested by the argillaceous limestones with microfacies characterized by fine-grained skeletal wackestone-packstone which are devoid of calcite cement. In these environment, *Synaptophyllum* rugose corals, helped by some tabular and small subspherical stromatoporoids, would stabilize the sediments below them providing a firm and suitable substrate for the subsequent reef development. Thus, *Synaptophyllum* played the role of stabilizing organisms.

Main faunal components:

Stromatoporoids: *Actinostroma verrucosum, Stromatoporella* sp.

Rugose corals: *Synaptophyllum multiseptatum.*

Tabulate corals: *Squameofavosites* ex gr. *hispanicus, Favosites saginatus, Thamnopora indet.*

Colonization stage (levels AR-12 to AR-14): The reef-building organisms themselves, mainly stromatoporoids and, in lesser number, corals began to develop giving way to a definite organic buildup installation. It is a small domal stromatoporoid framestone. There are in lesser abundance lamelar, subspherical and small branching tabulates and rare dendroid rugose corals. Matrix is a crinoidal and thamnoporid wackestone-packstone.

Main faunal components:

Stromatoporoids: *Actinostroma verrucosum, Stromatoporella* sp., *Stromatopora* sp.

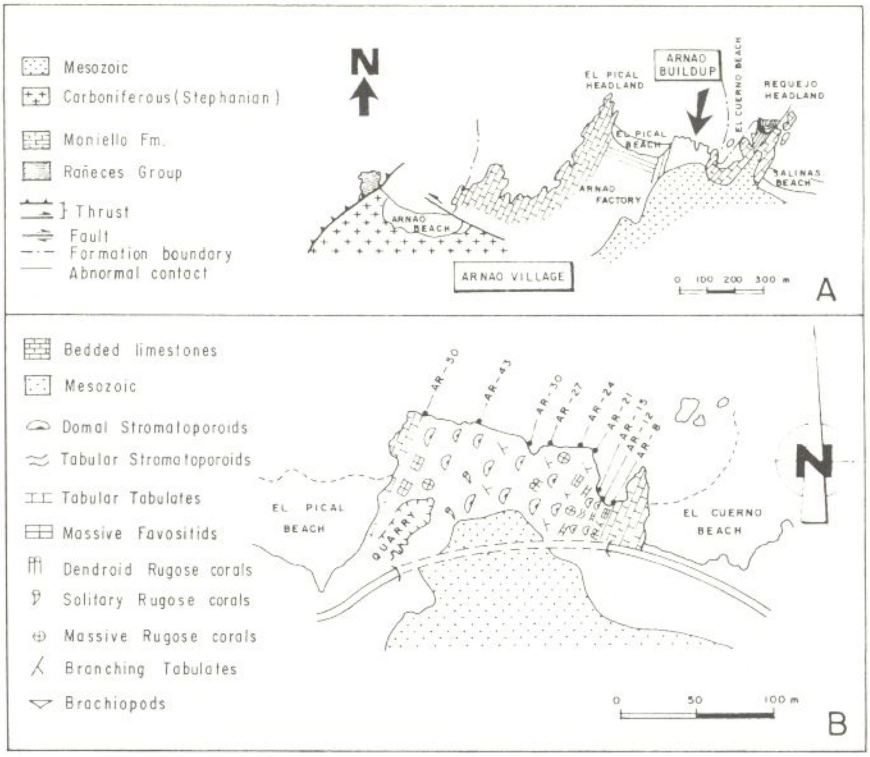


Fig. 25.–A: Stratigraphical position of Arnao buildup. B: Schematic section of Arnao buildup showing location of the different levels.

Rugose corals: *Synaptophyllum multiseptatum.*

Tabulate corals: *Squameofavosites* ex gr. *hispanicus, Favosites robustus, Alveolites lemniscus, Thamnopora* indet.

Diversification stage (levels AR-15 to AR-26): Development of a great taxa variety, as well as growth habit diversity involving different functions of the organisms in de ge domal stromatoporoid framestone, lamelar tabulate bindstone and branching tabulate bafflestone. In general, the matrix is a medium-grained wackestone-packstone.

Main faunal componentes:

Stromatoporoids: *Actinostroma verrucosum, Actinostroma* cf. *stellulatum, Stromatoporella* sp., *Stromatopora* sp.

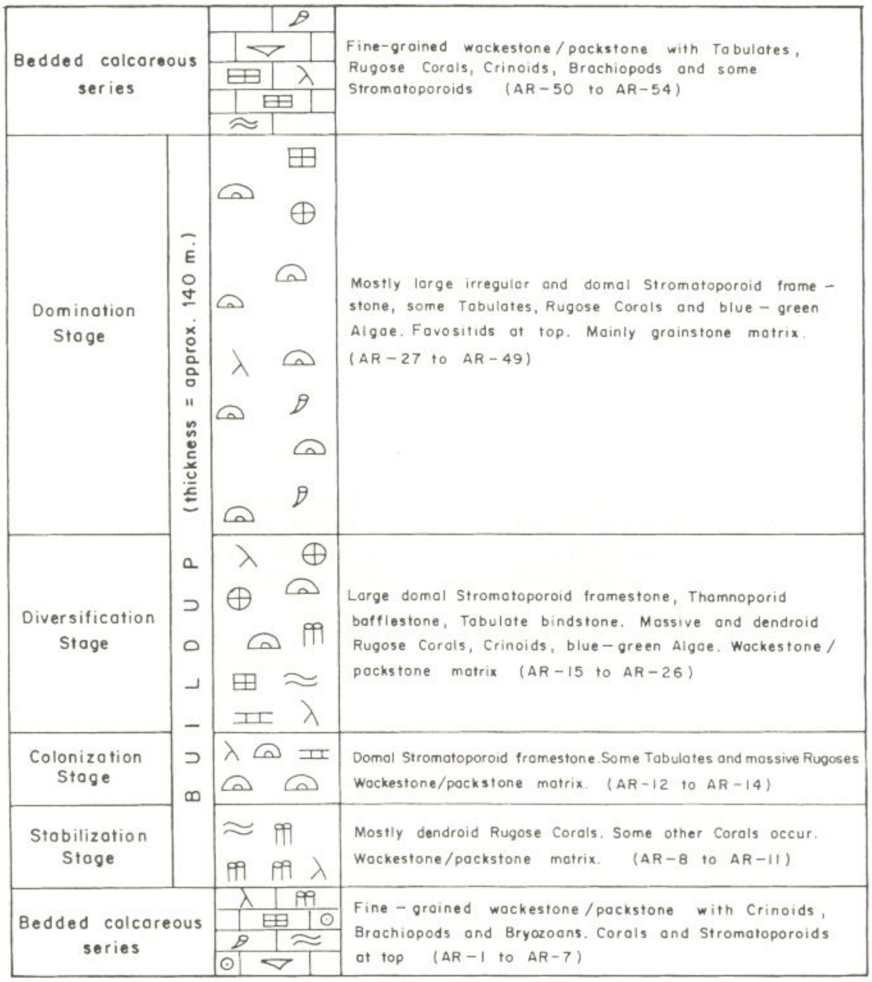


Fig. 26.–Vertical developmental stages in Arnao buildup indicating fauna distribution and related facies.

buildup process (builders, trappers, binders, etc.). Between the reef-building organisms spaces inhabited by gastropods, brachiopods, bivalves, etc. existed. The rock types are lar-

Rugose corals: *Xystriplyllum* sp., *Acinophyllum aff. stokesi, Mesophyllum (Cystiphylloides)* cf. *monielloense.*

Tabulate corals: *Squameofavosites* ex

gr. *hispanicus, Alveolites lemniscus, Thamnopora* indet.

Domination stage (levels Ar-27 to Ar-49): Considerable reduction in the taxa number in relation to the previous stage, as well as in the growth habits. Stromatoporoids became the most dominant group and they are especially represented by two different forms. These organisms show an increasing tendency to an encrusting growth habit which in some cases may reflect competition for space. The rock type is a large (up to 1 m) irregular and domal stromatoporoid framestone. Frequently, throughout the most part of this unit, growth of a solitary rugose coral (*Lyrielasma* sp.) within tabular stromatoporoids (*Actinostroma-Stromatoporella)* is observed and interpreted as a symbiotic relationship. The matrix is mostly a crinoidal-thamnoporid grainstone and occasionally, packstone.

Main faunal components:

Stromatoporoids: *Actinostroma* cf. *stellulatum, Actinostroma verrucosum, Stromatoporella* sp.

Rugose corals: *Xystriphyllum* sp. and *Lyrielasma* sp.

Tabulate corals: *Squameofavosites* ex gr. *hispanicus, Thamnopora* indet.

This organic buildup grew on a site close to the platform margin where the most favourable conditions for its development existed. The first stage took place in a shallow and relatively quiet marine environment. As the reef grew it reached shallower and clearer waters; the last domination stage could represent a change in environmental conditions towards an increase of water turbulence due to the buildup into the high energy surf zone. This evolution is reflected by the change in the reef builder shapes, from branching to massive and encrusting growth habit organisms, as well as the gradual diminution in the argillaceous material content upwards.

The end of the organic buildup could be caused by deepening of the sea water due probably to basin subsidence. In these environmental conditions the overlying bedded argillaceous limestones characterized by fine-grained wackestones-packstones with subspherical *Favosites,* some tabular stromatoporoids, thamnoporids, crinoids, brachiopods and trace fossils were deposited.

REFERENCES: MÉNDEZ-BEDIA, 1976; SANCHEZ DE LA TORRE & MANJÓN, 1976; MÉNDEZ-BEDIA, 1984; MÉNDEZ-BEDIA & SOTO, 1984; SOTO & MÉNDEZ-BEDIA, 1985; FERNÁNDEZ-MARTÍNEZ, 1986; MÉNDEZ-BEDIA, SOTO & FERNÁNDEZ-MARTÍNEZ, 1994; SOTO, MÉNDEZ-BEDIA & FERNÁNDEZ-MARTÍNEZ, 1994.

STOP 9. MONIELLO INLET

LOCATION: This locality is situated on the Asturian coast to the east of the Peñas Cape, between Luanco and Bañugues villages. Following the secondary road from Peñas Cape to Luanco, 1 km before reaching Luanco, take the first turning on the left, this ends in Moniello Headland (Figs.1C, 23).

Geological Map of Spain, 1:50,000, sheet 14 (Gijón). Northern slope of the Cantabrian Zone, Fold and Nappe Region, Somiedo-Correcilla unit (Fig. 4).

STRATIGRAPHICAL UNIT: Moniello Formation, middle part (Figs. 27, 28).

AGE: Lower Devonian, upper Emsian.

DESCRIPTION:

The Moniello Formation in this locality, which is the stratotype of this formation, consists of 250 m of limestones and dark grey argillaceous limestones with interbedded thin grey lutite levels. It is characterized by a rich content in benthic fauna (brachiopods, bryozoans, crinoids, rugose and tabulate corals, stromatoporoids, etc.) mostly somewhat silicified. From a lithological and faunistic point of view, three informal members are distiguished (Figs. 27, 28): Lower Member, about 86 m thick, constituted by limestones and lutites with a predominance of brachiopods; Middle Member, about 65 m thick, made of limestones and argillaceous limestones with abundant reefal fauna; and Upper Member, about 120 m thick, consisting of limestones and lutite levels with numerous brachiopods and bryozoans. The type of lithofacies (packstones, wackestones and occasional grainstones) and biofacies (local development of reef-building organisms) suggest, in general, that they were deposited in a shallow and quiet marine platform with short periods of agitation. There also existed suitable conditions for the development of some biostromes.

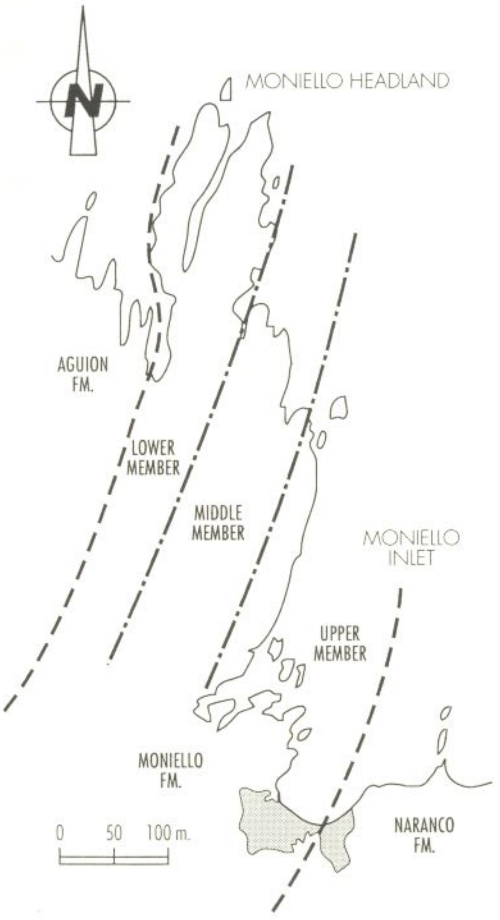


Fig. 27.–Schematic geological map showing the three members of the Moniello Formation in the type section (Moniello inlet).

The Middle Member, which will be shown in this stop (levels 858 to 885 on the rock), is characterized by the abundance of reef-building organisms. It consists of well-bedded limestones and argillaceous limestones alternating with thin lutite levels bearing stromatoporoids with different morphologies (irregular, subspherical, globular and laminar), massive (favositids) and branching (thamnoporids) tabulate corals as well as fasciculate and solitary rugose corals. Some stromatoporoids and tabulate corals are overturned and broken. The dominance of the different types of organisms is related to the

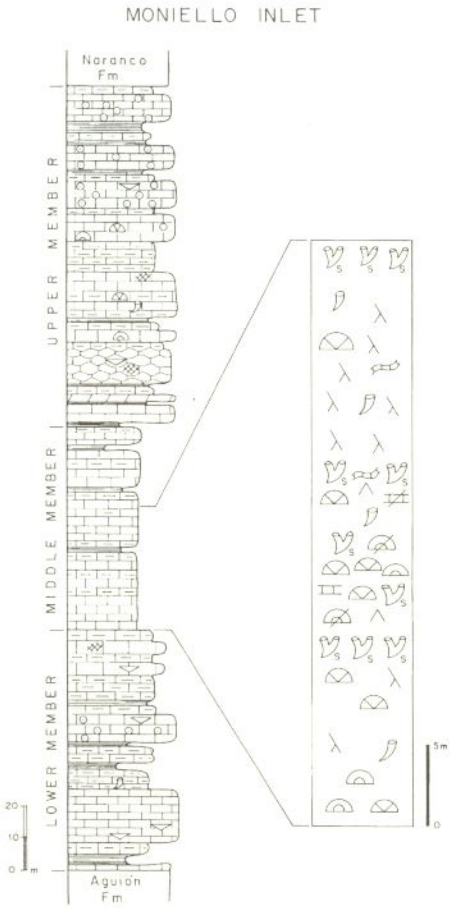


Fig. 28.–Lithostratigraphic succession of the Moniello formation at Moniello inlet, reefal levels and faunal content.

muddy content present in the environment. It is noticeable the occurrence of several biostromes built by fasciculate rugose corals belonging to the genus *Synaptophyllum* as well as levels yielding rich stromatoporoid and tabulate coral fauna.

In general, these materials are laterally equivalent to the Arnao reef, located farther to the west and described in the stop 8 (Figs. 23, 25B, 26). The environment is interpreted as corresponding to sheltered zones of the platform.

MAIN FAUNAL COMPONENTS:

Stromatoporoids: *Actinostroma verrucosum*, *Actinostroma* sp., *Atelodictyon* cf. *fallax*, *Clathrodictyon* sp., *Stromatoporella* cf. *granulata*, *Stromatoporella selwyni*, *Stromatoporella* sp., *Taleastroma simplex*, *Taleastroma logansportense*, *Stromatopora* sp.

Rugose corals: *Synaptophyllum multiseptatum*, *Mesophyllum (Cystiphylloides) monielloense*, *Mesophyllum (Cystiphylloides) secundum secundum*.

Tabulate corals: *Squameofavosites* ex gr. *hispanicus*, *Favosites styriacus*, *Favosites robustus*, *Alveolites lemniscus*, *Heliolites barrandei*, *Heliolites* aff. *tomensis*, *Thamnopora* spp.

Chaetetids: *Rhaphidopora magna*.

REFERENCES: RADIG, 1962; MÉNDEZ-BEDIA, 1976; ARBIZU *ET AL.* ,1979; GARCÍA-ALCALDE *ET AL.*, 1979.

5th DAY (9/09/95) PERAN LOCALITY AND CARRANQUES BEACH

Stop 10. Peran Locality

Location: This locality is situated on the Asturian coast to the east of the Peñas Cape, passed the village of Candás, following the regional road, As-239, to Gijón (Figs. 1C, 29).

The succession to be visited, which is the stratotype of the Candás Formation, crops out in the northwestern limb of a syncline (Perlora Syncline), whose core consists of Namurian limestones. The sequence of the Candás Formation in both limbs of the syncline is similar, but in general is better exposed in this section.

Geological Map of Spain, 1:50,000, sheet 14 (Gijón). Northern slope of the Cantabrian Zone, Fold and Nappe Region, Somiedo-Correcilla unit (Fig. 4).

Stratigraphical unit: Candás Formation, type-locality, lower-middle part (Fig. 30).

Age: Middle Devonian, upper Givetian.

Description: This locality displays the best outcrops of the Candás Fm. allowing a detailed study of internal organization of recfal units and their relationships within the sequential framework of the formation (Fig. 30). Two units (labelled C and I) exhibiting several reef sequences with different development will be shown in detail.

Other units (D and E) with very rich re-

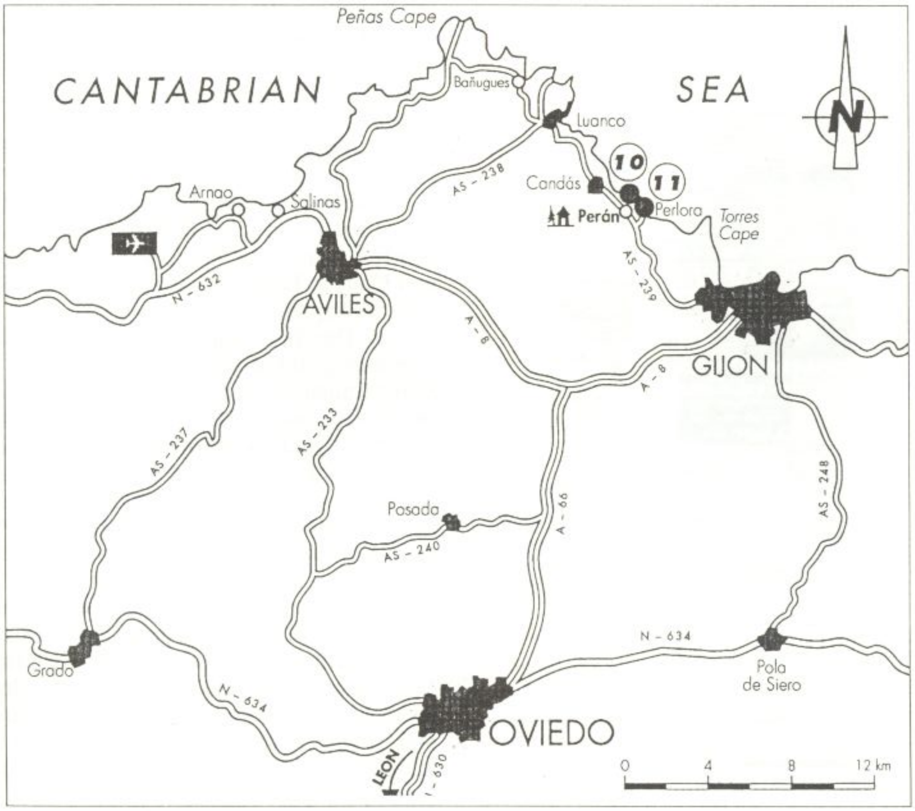


Fig. 29.–Geographical location of Perán and Carranques localities.

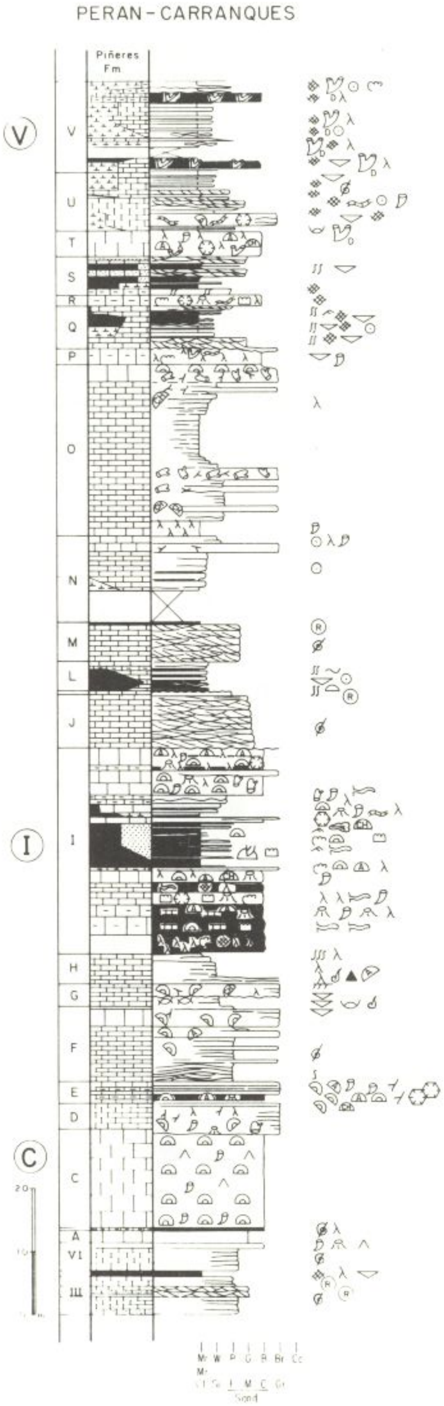


Fig. 30.–Lithostratigraphic succession of the Candás Formation at Perán-Carranques, reefal units and faunal content.

efal fauna will be looked at. These units are formed by an alternation of destructional deposits [facies (i)] and thin reefal intervals. Their meaning is unclear and lack of information about its lateral evolution precludes any interpretation.

Unit C permits us to study a well developed stromatopoid framestone [facies (vii)] overlying a first reef phase of branching tabulate coral bafflestone sets in marly matrix [facies (v)]. Stromatoporoids in facies (vii) can reach very large sizes and they show mostly irregular shapes. Cavities among the main builders are filled with stromatoporoids, thamnoporids, and rugose corals debris. Some solitary rugose corals are also present. There are some examples of symbiosis between solitary rugose corals and stromatoporoids.

Main faunal components:

Stromatoporoids: *Atelodictyon* cf. *strictum, Taleastroma* sp., *Amphipora* sp., *Stachyodes* sp.

Rugose corals: *Endophyllum* sp., *Phillipsastrea* cf. *hennahi.*

Tabulate corals: *Thamnopora* indet.

Unit I displays the best developed reef-bearing sequences we know in the Portilla and Candás Formations. It can be divided in several sequences.

* The first sequence (subunits I.1-I.2, numbers painted on the rock) begins on a sharp transgresive surface overlain by a thin interval of outer shelf dark grey mudstones [facies (iii)]. This in turn passes gradually to reef deposits that in this case consists of the facies (v) and (vi). In general, this sequence is constituted by branching tabulate bafflestones, stromatoporoid/coral bindstones and floatstones.

Bafflestones are mainly made up of thamnoporids and branching alveolitids with fairly common rugose corals. Bindstones show a very different development. Most of them are composed of alveolitids (laminar and tabular in shape), stromatoporoids (with tabular and low domal morphologies) and small phillipsastreids (domal in shape). The latter being at times overturned and colonized by stromatoporoids. Occasionally, floatstones containing chaetetids are present. These three kinds of deposits are intermixed.

* The second sequence (subunits I.3-I.4) has a sharp base and consists of facies (v) and (vi). In this sequence it is noticeable

the presence of bindstones made up of alveolitids (tabular and hemispherical in shape), chaetetids, phillipsastreids (low domal) and other cerioid rugose corals. Interbedded between these bindstones, some marly beds are especially rich in thamnoporids, alveolitids of the genus *Platyaxum* and fenestellids.

* The third sequence (mostly subunit I.5) has a erosive base and consists of facies (vii) deposits. It is a framestone built by large domal stromatoporoids, laminar to tabular alveolitids, as well as domal and irregular phillipsastreids. Thamnoporids occur most frequently in muddy beds. Chaetetids are also abundant through all the sequence.

* The fourth sequence (top of subunit I.5, subunit I.6 and part of subunit I.7) is the best developed. It starts (top of subunit I.5) with the transgressive rudstone deposits of facies (I) containing stromatoporoids, chaetetids, alveolitids, etc. This deposits pass to outer shelf mudstones [facies (iii)].

Through subunit I.6 it is possible to see the shallowing upwards trend from these outer shelf deposits to inner shelf ones [facies (iv)]. The organisms present in the subunit I.6 are tabular stromatoporoids, platy to irregular alveolitids, abundant *Platyaxum*, auloporids and chaetetids, among others. In these beds intergrowths of different organisms are very usual.

Overlying them (subunit I.7) reefal deposits occur developing a succesion from facies (v) through (vii), though this does not take place in a single way but with recurrences of the facies (v) and (vi). In a general way, the organisms are quite similar to those present in the sequences mentioned above (see Fig. 30).

The remaining of subunit 7 is formed by several incomplete sequences only comprising reefal deposits. The top of this subunit is marked by a spectacular erosional surface covered by a thin veneer of rudstones [facies (i)] which is succeeded by calcarenites [facies (ii)] that mark the beginning of the middle member of the formation.

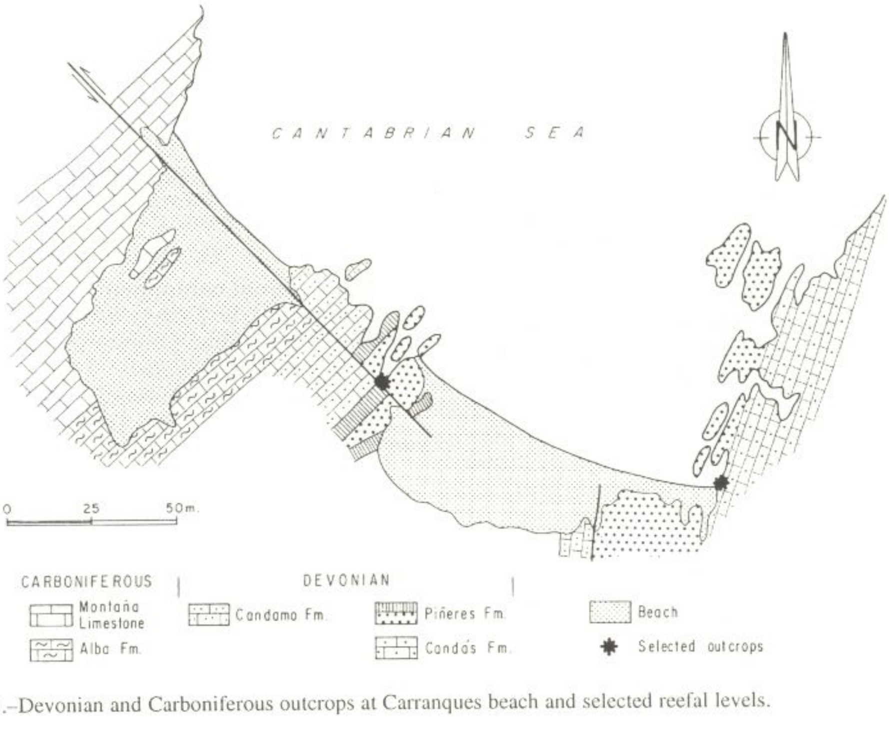


Fig. 31.–Devonian and Carboniferous outcrops at Carranques beach and selected reefal levels.

Main faunal components:

Stromatoporoids: *Atelodictyon* cf.*strictum, Taleastroma* sp., *Hermatostroma* sp.

Rugose corals: *Charisphyllum altevogti, Heliophyllum chengi, Breviphrentis kullmanni, Siphonophrentis cantabrica, Acanthophyllum* cf. *concavum, Mesophyllum (Mesophyllum) secundum secundum, Phillipsastrea* cf. *hennahi, Hexagonaria* cf. *mirabilis, Medusaephyllum pradoanum, Sinaxis bulbosa, Xystrigona* sp.

Tabulate corals: *Alveolites parvus, Spongioalveolites* sp., *Platyaxum (Platyaxum) escharoides, Platyaxum (Roseoporella)* sp., *Thamnopora patula, Thamnopora beliakovi, Thamnopora alta,*

Commensal traces in Tabulate corals: *Helicosalpinx* sp.,

Chaetetids: *Rhaphidopora* sp., *Chaetetella (Chaetetella)* sp.

REFERENCES: RADIG, 1962; ALTEVOGT, 1963, 1967; BERESKIN, 1978; RAVEN, 1983; GARCÍA-LÓPEZ, 1987.

STOP 11. CARRANQUES BEACH

LOCATION: This beach is situated to the east of the Peñas Cape, SE of Candás village, corresponding to one of the beaches located in the council estate of Perlora (Figs. 1C, 29, 31). The succession cropping out in this locality belongs to the southeastern limb of the Perlora Syncline (Fig. 31).

Geological map of Spain, 1:50,000, sheet 14 (Gijón). Northern slope of the Cantabrian Zone, Fold and Nappe Region, Somiedo-Correcila unit (Fig. 4).

STRATIGRAPHICAL UNITS: Candás Formation, uppermost part (Figs. 30, 31), and Piñeres Formation, uppermost part (Figs. 31, 32).

AGE: Middle Devonian, upper Givetian, for the top of the Candás Formation and Upper Devonian, upper Frasnian, for the top of the Piñeres Formation.

DESCRIPTION OF THE TOP OF THE CANDÁS FORMATION: The uppermost levels of the Candás Formation, which are better exposed here than in Perán locality, consist of outer shelf mudstones that pass to distal toes of reefal units. They are composed of facies (v) deposits which at outcrop scale appear as biostromes (Fig. 30, unit V). These bafflestone deposits, ca. up to 1 m thick, are mainly built by the fasciculate rugose coral *Disphyllum*, although thamnoporids, in a lesser proportion, also occur. The morphology of the *Disphyllum* colonies, with very long, not very branching corallites, are common in this type of environment.

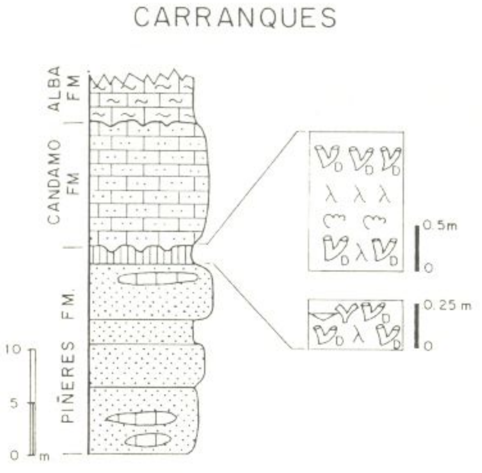


Fig. 32.–Schematic lithostratigraphic succession of the Piñeres Formation at Carranques, reefal levels and faunal content.

Main faunal components:

Rugose corals: *Disphyllum caespitosum lazutkini, Disphyllum caespitosum furcatum, Aristophyllum occidentale.*

Tabulate corals: *Thamnopora* spp.

REFERENCES: RADIG, 1962; ALTEVOGT, 1963, 1967.

DESCRIPTION OF THE TOP OF THE PIÑERES FORMATION: The uppermost part of the Piñeres Fm., locally exhibits minor biostromal development. In this locality, two reefal levels with an intermediate bioclastic bed can be observed (Fig. 32).

The first one, about 0.3 m thick, is a bafflestone composed mainly of small *Disphyllum* with thin corallites. As accompanying fauna there exist thamnoporids, branching bryozoans and occasional brachiopods. They are set in a bioclastic, locally marly, wackestone.

The second biostrome, up to 1.5 m thick and with an argillaceous matrix, is built by *Disphyllum* which is bigger than in the precedent one. In a lesser degree, some thamnoporids, alveolitids and fenestellids are found. Close to the base a discontinuous level with abundant laminar to tabular alveolitids is developed.

Main faunal components:

Rugose corals: *Disphyllum cylindricum, Disphyllum geinitzi, Disphyllum caespitosum pashiense, Disphyllum rugosum magnum, Tabulophyllum gorskii.*

Tabulate corals: *Thamnopora* indet.

REFERENCES: RADIG, 1962; ALTEVOGT, 1963, 1967; AADRICHEM-BOOGAERT, 1967; GARCÍA-ALCALDE *ET AL.*, 1985.

STOP 12. RIBADESELLA

LOCATION: Ponga Unit, Ribadesella-Llanes area (Fig. 13). Ribadesella is an old fishing village, converted in a summer tourist resort, with a famous beach. The locality to be visited is placed at the west end of the village, in a small quarry southwards from the road to Gijón (Fig. 33). (National topographic map of Spain, 1:50,000 scale, sheet 31).

STRATIGRAPHICAL UNIT: Cuera limestones (Fig. 12).

AGE: Lower Moscovian

DESCRIPTION: The small quarry of Ribadesella shows subhorizontal marls and limestones. The section begins with 8-10 m of marl containing common dissepimented solitary and colonial rugose corals and chaetetids, and scarce syringoporoids which have been studied recently. 10-12 m of massive to well bedded limestone containing less abundant corals follow up to the top of the quarry.

Solitary rugose corals usually show well preserved apex, but calyx is usually crushed, and some of them show eroded surfaces. All features indicate short or no transport. Many of them show several directions in their development, rejuvenescences and other signs of stress. Some of them are strongly curved. Colonial corals are all fasciculate. They occur as single branches of large size colonies or as fragments of small colonies. All of

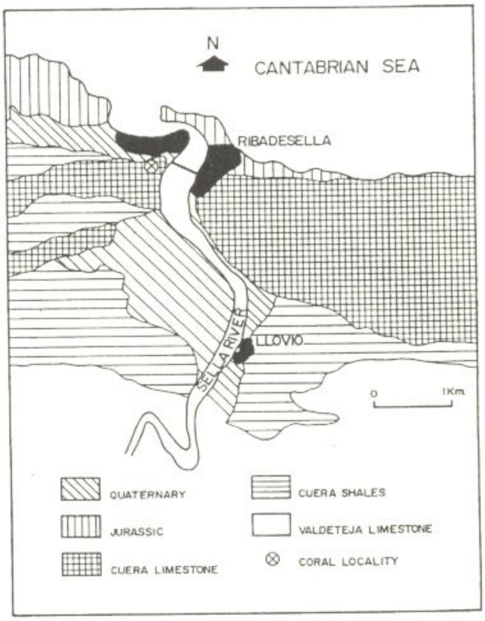


Fig. 33.–Location of the Ribadesella coral locality.

them show clear features of being transported. Chaetetids are usually middle to large colonies growing around solitary or fragments of colonial corals. Most of them show subspherical shape. Syringoporoid are less abundant and grow usually on lateral surfaces of large solitary corals.

MAIN FAUNAL COMPONENTS:

Rugose corals: *Pseudozaphrentoides* sp., *Neokoninkophyllum* sp., *Kionophyllum* sp.

Tabulate corals: *Multithecopora hontoriense.*

Chaetetids: *Chaetetes* spp.

6th DAY (10/09/95)
HONTORIA, DOBRES AND LAS ILCES LOCALITIES

STOP 13. HONTORIA BAY

LOCATION: Ponga Unit, Ribadesella-Llanes area (Fig. 13). Hontoria is a small village placed 15 km eastwards from Ribadesella. It is close to a sheer coast (Fig. 34). The locality to be visited is placed at the upper levels of the Huelga beach section (Villa, 1985) (Fig. 35), at the northwest end of the bay (National topographic map of Spain, 1:50,000 scale, sheet 31). This locality was first reported by BARROIS, 1882 and subsequently mentioned by MALLADA, 1898, DELEPINE, 1928, 1943. More recently, brachiopods (MARTÍNEZ-CHACÓN, 1979), rugose corals (RODRÍGUEZ, 1984), fusulinaceans (VILLA, 1985) and tabulate corals (RODRÍGUEZ & RAMÍREZ, 1987) have been studied.

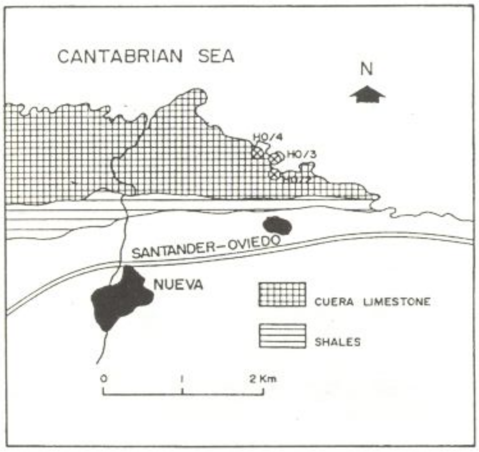


Fig. 34.–Location of the Playa de la Huelga section. HO/2. Hontoria 2 coral beds, HO/3. Hontoria 3 coral beds, HO/4. Hontoria 4 coral beds.

STRATIGRAPHICAL UNIT: Cuera limestones (Fig. 12).

AGE: Podolian (Upper Moscovian, Middle Carboniferous).

DESCRIPTION: The Huelga beach section shows more than 1500 m of mainly calcareous beds, from Serpukhovian to Uppermost Moscovian (Fig. 35). In this stop we will visit three levels of the upper part of the section containing abundant rugose and tabulate corals as well as chaetetids. They were named by RODRÍGUEZ, 1984 and RODRÍGUEZ & RAMÍREZ, 1987 as Hontoria/2 (HO/2), Hontoria/3 (HO/3) and Hontoria/4 (HO/4) (Fig. 34). All of them are placed in sheer cliffs, and the access to HO/2 and HO/3 is not easy; be careful!.

Hontoria/2

Placed 800 m above the base of the Cuera limestones (Navarro *et al.*, 1986), between shaly beds (Fig. 35). This locality is composed of light brown, thinly bedded clastic limestones and grey massive limestones which yielded abundant corals and chaetetids. Clastic limestones show irregular lower and upper bounding surfaces and low-angle cross to planar stratification. They are composed of graded bioclasts (crinoids, bryozoans, corals, brachiopods, etc). Algal structures (micritic envelopes, oncolites) are common. Scarce rugose corals of the genus *Amygdalophylloides* and tabulate corals (*Neomultithecopora*) occur in these beds.

Grey massive limestones occur over and as lateral change of the clastic limestones. They are not well stratified and composed mainly of colonies of Chaetetids, tabulate and rugose corals. Some of those colonies are in living position, but many of them are overturned and broken. Bryozoans, brachiopods, gastropods and crinoid stems are also common.

Main faunal components (Fig. 36):

Rugose corals: *Petalaxis wagneri, Petalaxis maccoyana.*

Tabulate corals: *Donetzites milleporoides.*

Chaetetids: *Chaetetes* spp.

Hontoria/3

Placed 20 m above HO/2, it can be divided into two units (Fig. 35). The lower unit is mainly composed of 5-6 m of black marly limestones containing abundant brachiopods, tabulate and rugose corals (solitary and colonial), bryozoans, echinoderms and bivalves, most of them in life position. Some thin, usually discontinuous beds are built by syringoporids and aphroid rugosa. Presence of

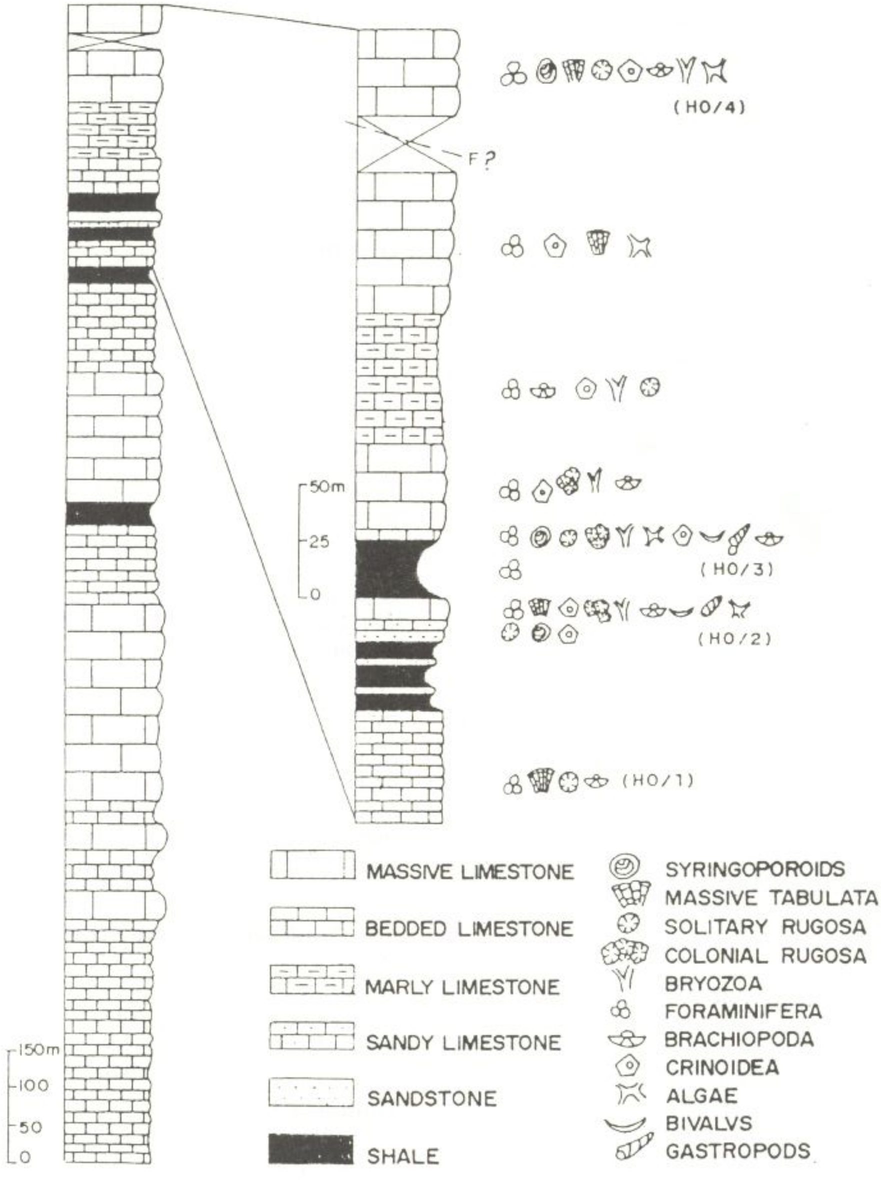


Fig. 35.–Playa de la Huelga section, with location of the coral beds (after RODRÍGUEZ & RAMÍREZ, 1987).

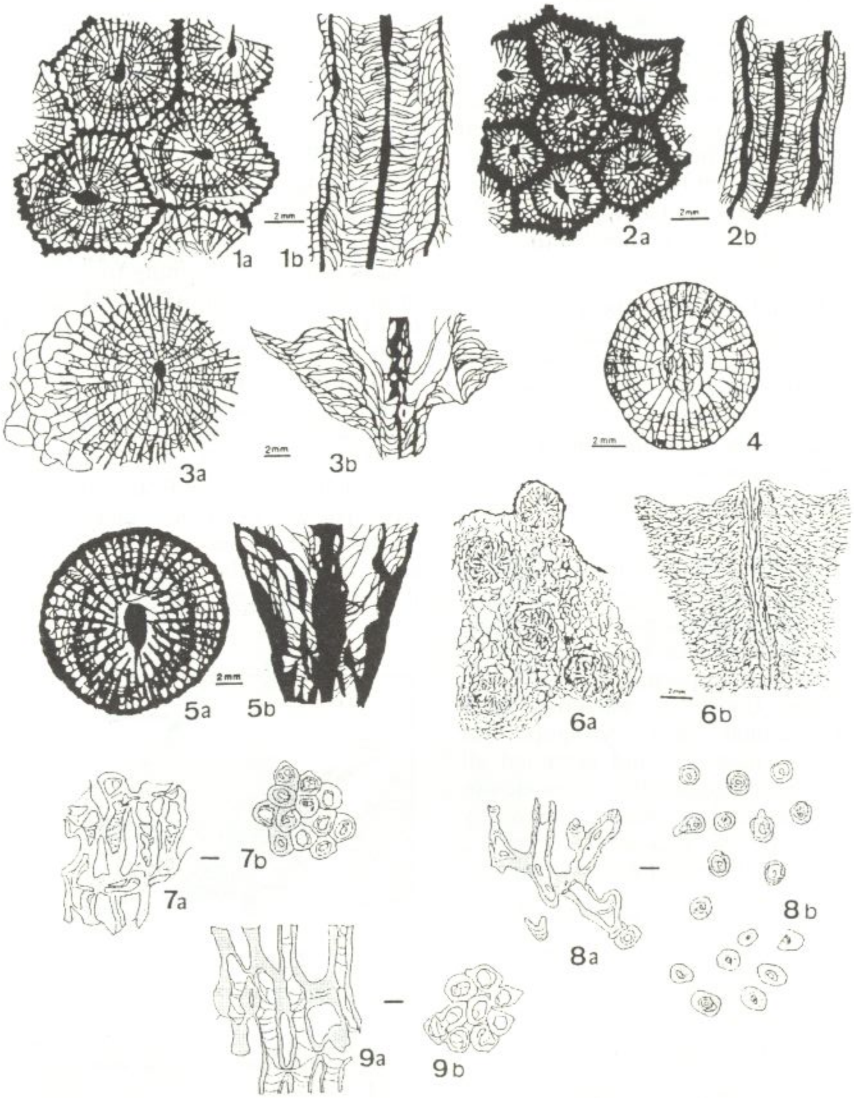


Fig. 36.–Rugose and tabulate corals from Hontoria. 1. *Petalaxis wagneri* GROOT; a. transverse section, b. longitudinal section. 2. *Petalaxis perapertuensis* GROOT; a. transverse section, b. longitudinal section. 3. *Axolithophyllum hontoriense* RODRÍGUEZ; a. transverse section, b. longitudinal section. 4. *Corwenia longiseptata* FOMICHEV; transverse section. 5. *Amygdalophylloides ivanovi* DOBROLYUBOVA; a. transverse section. b. longitudinal section. 6. *Ivanovia podolskiensis* DOBROLYUBOVA; a. transverse section. b. longitudinal section. 7. *Neomultithecopora submasiva* RODRÍGUEZ & RAMÍREZ; a. longitudinal section. b. transverse section. 8. *Multithecopora hontoriense* RODRÍGUEZ & RAMÍREZ; a. longitudinal section, b. transverse section. 9. *Neomultithecopora cantabrica* RODRÍGUEZ & RAMÍREZ; a. longitudinal section, b. transverse section. Scale bars=2mm.

large tracks (up to 10 cm wide and several meters long) is conspicuous.

The upper unit is composed of 12-15 m of grey, breccioid, bioclastic limestones. At least four levels, each of them containing different dominant bioclasts, can be distinguished here. Crinoids, chaetetids and massive and phaceloid tabulate as well as phaceloid rugose corals and fusulinids (*Pseudostaffella*) are the dominant bioclasts. Bryozoans, echinoderms, algae and brachiopods are also common. Some beds are composed of nodular structures (algae?).

Main faunal components (Fig. 36):

Rugose corals: *Ivanovia podolskiensis, Corwenia longiseptata, Amygdalophylloides ivanovi, Bothrophyllum pseudoconicum, Axolithophyllum hontoriense.*

Tabulate corals: *Multithecopora hontoriense, Donetzites milleporoides.*

Chaetetids: *Chaetetes* spp.

Hontoria/4

Placed about 150 m above HO/3 (Fig. 35) it is composed of light grey, bioclastic, massive limestones, commonly containing abundant oncolites. Some beds are built by chaetetid and syringoporoid colonies growing together. Ususally, chaetetids grew with multicolumnar habit; syringoporoids grew over the chaetetids and occupied all free spaces. In some cases they grew downwards. Solitary corals occur commonly being covered by chaetetid colonies. Brachiopods and crinoids are also frequent.

Main faunal components (Fig. 36):

Rugose corals: *Amygdalophylloides ivanovi, Bothrophyllum pseudoconicum.*

Tabulate corals: *Neomultithecopora cantabrica, Neomultithecopora submasiva.*

Chaetetids: *Chaetetes* spp.

REFERENCES: BARROIS, 1882; MALLADA, 1898; DELEPINE, 1928; MARTÍNEZ-CHACÓN, 1979; RODRÍGUEZ, 1984; VILLA, 1985; RODRÍGUEZ & RAMÍREZ, 1987.

STOP 14. DOBRES

LOCATION: Liébana Unit (Fig. 13).Dobres coral localities are placed along the road from Bárago to Dobres. These villages are placed in the Rio Frío valley, a southern lateral branch of the Liébana valley (Fig. 37), in the southeastern area of the Picos de Europa, at Santander province.

STRATIGRAPHICAL UNIT: Dobres limestones, Potes Group (Fig. 12).

AGE: Lower Moscovian (Vereyan-Kashirian).

DESCRIPTION: Dobres limestones are placed in the turbidites of the Potes Group and they are composed of large massive blocks (olistolites) coming from the platform in the Palentine Unit (Piedrasluengas limestone). A mountain road climbs from Bárago (600 m above the sea level) up to Dobres (950 m above the sea level), and cross the Dobres limestones by means of two tunnels. At least five levels with corals (BD/1 to BD/5) were located at the road section and surrounding cliffs by RODRÍGUEZ, 1984. We will visit the BD/4 bed, placed in the area between the tunnels. From this location we have a spectacular panoramic view of the Río Frío valley and the Dobres limestones.

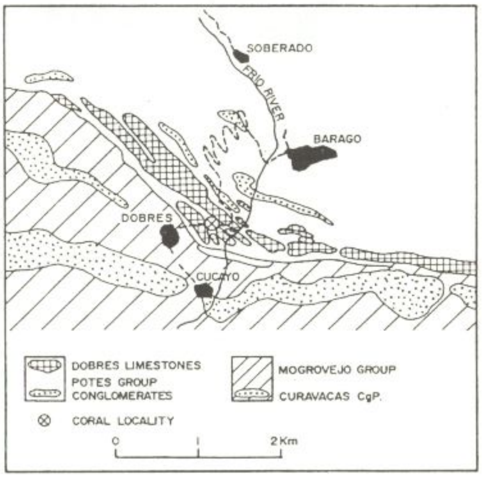


Fig. 37.–Location of the Dobres coral locality.

BD/4 beds are composed of:

– 2 m of grey massive limestone with oncolites, chaetetids and rugose corals.

– 1 m of black muddy limestone (wackestone to packstone) containing algal structures (oncolites, algal envelopes), chaetetids, bryozoans, rugose corals and fusulinids (*Profusulinella* and *Eofusulina*). Rugose corals are especially abundant, but not diverse in this bed; they are nicely preserved.

– 1m of grey massive limestone which yielded rugose corals, chaetetids and algal structures.

Most corals from BD/4 are geyerophyllids. Scarce cyathopsids and aulophyllids occur about 30 m above BD/4 in breccioid limestones.

MAIN FAUNAL COMPONENTS (Fig 38):
Rugose corals: *Amygdalophylloides liebanense, Kionophyllum variabile, Spirophyllum multilamellatum.*
Chaetetids: *Chaetetes* sp.

REFERENCES: RODRÍGUEZ, 1984.

STOP 15. LAS ILCES

LOCATION: Pisuerga-Carrión Unit, Liébana Area (Fig. 13). Las Ilces is a small village placed at the northern rand of the Deva river (Liébana Valley, Santander province), 6 km westwards from Fuente Dé, at the Deva source (Fig. 39). The locality to be visited is placed 500 m to the west of Las Ilces, at km 17.600 of the road from Potes to Fuente Dé.

STRATIGRAPHICAL UNIT: Cosgaya Formation (Fig. 12).

AGE: Serpukhovian, Lower Namurian.

DESCRIPTION: The Cosgaya Formation is a mainly terrigenous unit, regarded as deltaic deposits. Nevertheless, it contains limes-

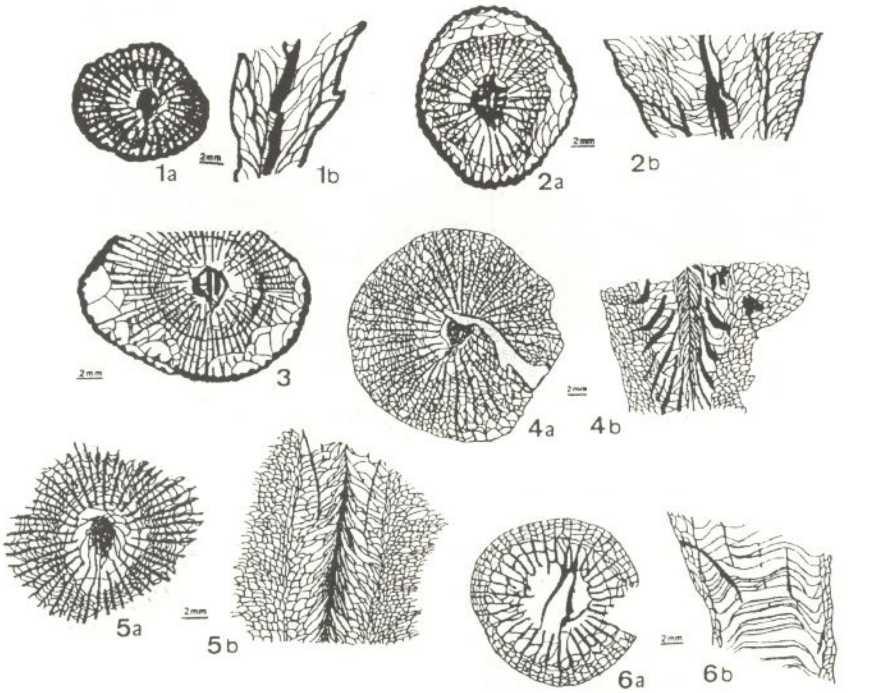


Fig. 38.–Rugose corals from Dobres. 1. *Amygdalophylloides liebanensis* RODRÍGUEZ, a. transverse section, b. longitudinal section. 2. *Kionophyllum irregulare* RODRÍGUEZ; a. transverse section, b. longitudinal section. 3. *Axolithophyllum quiringi* (WEISSERMEL); transverse section. 4. *Pseudoamygdalophyllum dobrense* RODRÍGUEZ; a. transverse section, b. longitudinal section. 5. *Spirophyllum multilamellatum* (GROOT); a. transverse section, b. longitudinal section. 6. *Fomichevella sotoi* RODRÍGUEZ; a. transverse section, b. longitudinal section. The last coral is also (and mainly) recorded in the Cosgaya Fm. Scale bars = 2 mm.

tone beds in the middle and upper part. These limestones are regarded as having originated

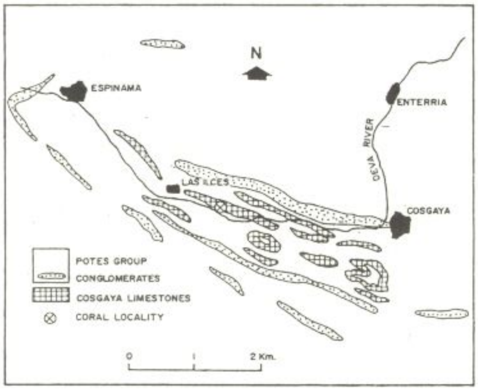


Fig. 39. Location of the Las Ilces coral locality.

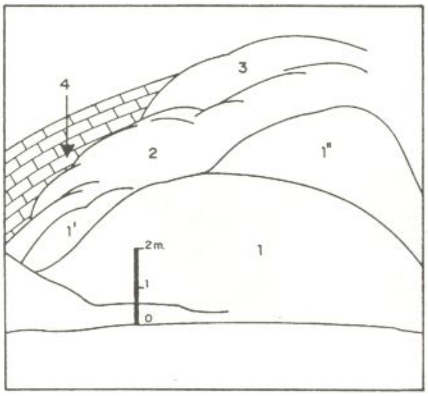


Fig. 40.–Development of bioherms at Las Ilces. The buildup is composed of several phases of growth, with diverse components. 1 is mainly composed of algae and syringoporoids. Rugose corals of the gemera Siphonodendron, Caninostrotion, Fomichevella and Dorlodotia are also common. 1' and 1" are mainly composed of chaetetids, algae and syringoporoids. Rugose corals are scarce. 2 is mainly composed of algae and syringoporoids. Chaetetids are scarce. 3 is composed of algae and syringoporoids. 4: Lateral and upper beds are composed of silty limestones with abundant algal oncolites, rugose and tabulate corals. They are characterized by high organic matter content and presence of iron sulfides.

in the areas between the branches of the delta. They are mainly organogenic limestones of algal origin. Some buildups containing algae and corals can be identified in the middle part of the formation; limestones at the upper part are mainly bioclastic beds (RODRÍGUEZ, 1984).

A bioherm composed of massive limestone (bindstone-bafflestone) and built mainly by algae, microbial structures, syringoporoids and rugose corals crops out at the northern side of the road from Potes to Fuente Dé (Fig. 40). Some small buildups placed over the main framework are composed also of chaetetids. Lateral beds of the bioherm are mainly composed of packstones containing abundant solitary and colonial corals. Some biostromes built mainly by algae and colonial corals also occur.

The bioherm is crossed by numerous calcite veins and preservation of corals is not especially good, but corals in lateral beds are better preserved. Corals are abundant and diverse, and show a high level of endemism (none of the species were found out of the Cosgaya Formation)

MAIN FAUNAL COMPONENTS (Fig. 41):

Rugose corals: *Dibunophyllum bolli, Fomichevella sotoi, Caninostrotion perejoni, Siphonodendron? liebanense, Dorlodotia* sp., *Kizilia transeptata, Semenophyllum ilcense, Semenophyllum irregulare, Kionophyllum cosgayense, Kionophyllum* sp.

Tabulate corals: *Multithecopora* sp.

Chaetetids: *Chaetetes* spp.

REFERENCES: MAAS, 1974; RODRÍGUEZ, 1984.

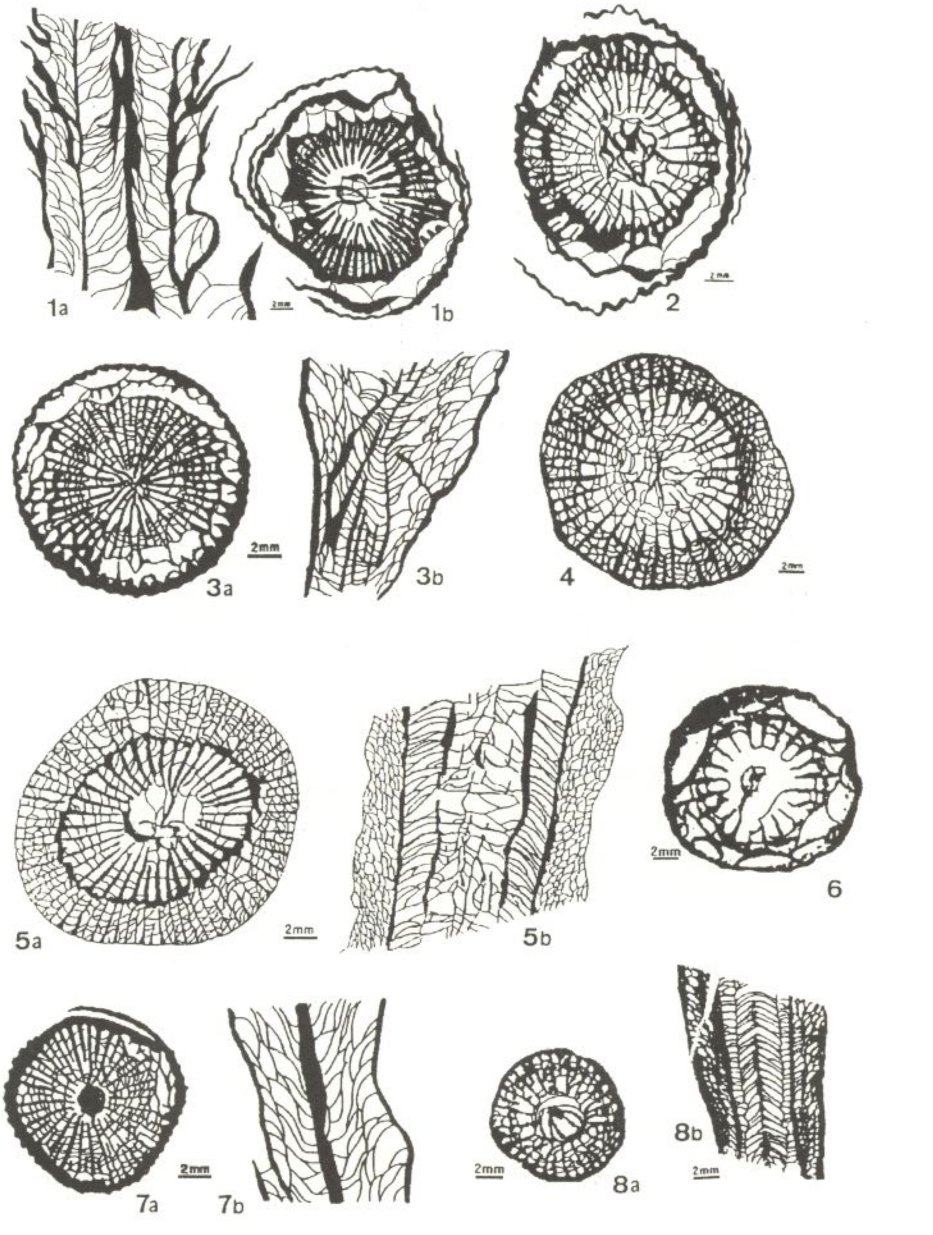


Fig. 41.–Rugose corals from Las Ilces. 1. *Semenophyllum ilcense* RODRÍGUEZ; a. longitudinal section, b. transverse section. 2. *Semenophyllum irregulare* RODRÍGUEZ; transverse section. 3. *Kizilia transeptata* RODRÍGUEZ; a. transverse section, b. longitudinal section. 4. *Dibunophyllum bolli* RODRÍGUEZ; transverse section. 5. *Caninostrotion perejoni* RODRÍGUEZ; a. transverse section, b. longitudinal section. 6. *Dorlodotia* sp.; transverse section. 7. *Kionophyllum cosgayense* RODRÍGUEZ; a. transverse section, b. longitudinal section. *Siphonodendron? liebanense* (RODRÍGUEZ); a. transverse section, b. longitudinal section. Scale bars = 2 mm.

7th DAY (11/09/95) CAMASOBRES AND CASAVEGAS LOCALITIES

STOP 16. CAMASOBRES

LOCATION: Pisuerga-Carrión Unit, Casavegas syncline (Fig. 13). Camasobres is a small village located on the road from Potes to Cervera de Pisuerga, 6 km to the south from Piedrasluengas pass (Fig. 42).

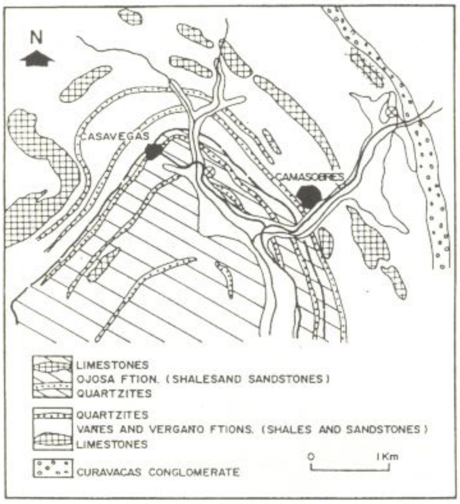


Fig. 42.–Location of the Camasobres and Casavegas coral localities.

The coral locality is placed at the Camasobres Limestone, 1 km northwards from Camasobres. It is broadly described by BOLL (1983, 1985)

STRATIGRAPHICAL UNIT: Camasobres Limestone, Vergaño Formation (Fig. 12).

AGE: Moscovian (Kashirian- Podolian).

DESCRIPTION: Vergaño Formation is mainly composed of conglomerates, sandstones and shales. It is regarded as having originated in a complex deltaic system. Two discontinuous limestone members, the Camasobres Limestone and the Maldrigo Limestone, Podolian in age, occur in this formation, being regarded as influence of a calcareous platform placed southwards. Both contain corals, but only in Camasobres Limestone are they common. The Camasobres Limestone is composed of massive and middle bedded grey limestones. They are composed mainly of bioclastic beds containing algae, fusulinids, brachiopods, crinoids, chaetetids, tabulate and rugose corals.

Rugose corals are dominant in some of the lower beds. A bioclastic bed is composed mainly of large fragments of cyathopsids (*Pseudozaphrentoides*). Chaetetids and Syringoporoids are dominant in the upper levels. Partial dolomitization of the rock is conspicuous. Many of the fossil components of the rock are partially silicified.

MAIN FAUNAL COMPONENTS (Fig. 44):
Rugose corals: *Pseudozaphrentoides rabanaliensis, Spirophyllum multilamellatum, Fomichevella volgensis.*
Tabulate corals: *Multhitecopora* spp.
Chatetids: *Chaetetes* sp.

REFERENCES: GROOT, 1963; BOLL, 1983, 1985.

STOP 17. CASAVEGAS (Optional)

LOCATION: Pisuerga-Carrión Unit, Casavegas syncline (Fig. 13). The Casavegas locality is placed at km 2 on the road from Camasobres village to Casavegas village (Fig. 42), 7 km southwest of the Piedrasluengas Pass (Pisuerga valley, Palencia province).

STRATIGRAPHICAL UNIT: Ojosa Formation (Fig. 12).

AGE: Upper Moscovian (Myachkovian).

DESCRIPTION: Ojosa Formation is composed of at least 2,300 m of shales, sandstones and conglomerates, with occasional coal and calcareous beds in coarsening-upwards sequences. It is regarded as being formed by a prograding delta in an area with a high rate of subsidence (WAGNER & WINKLER-PRINS, 1985). Some of the sequences commence with fossiliferous

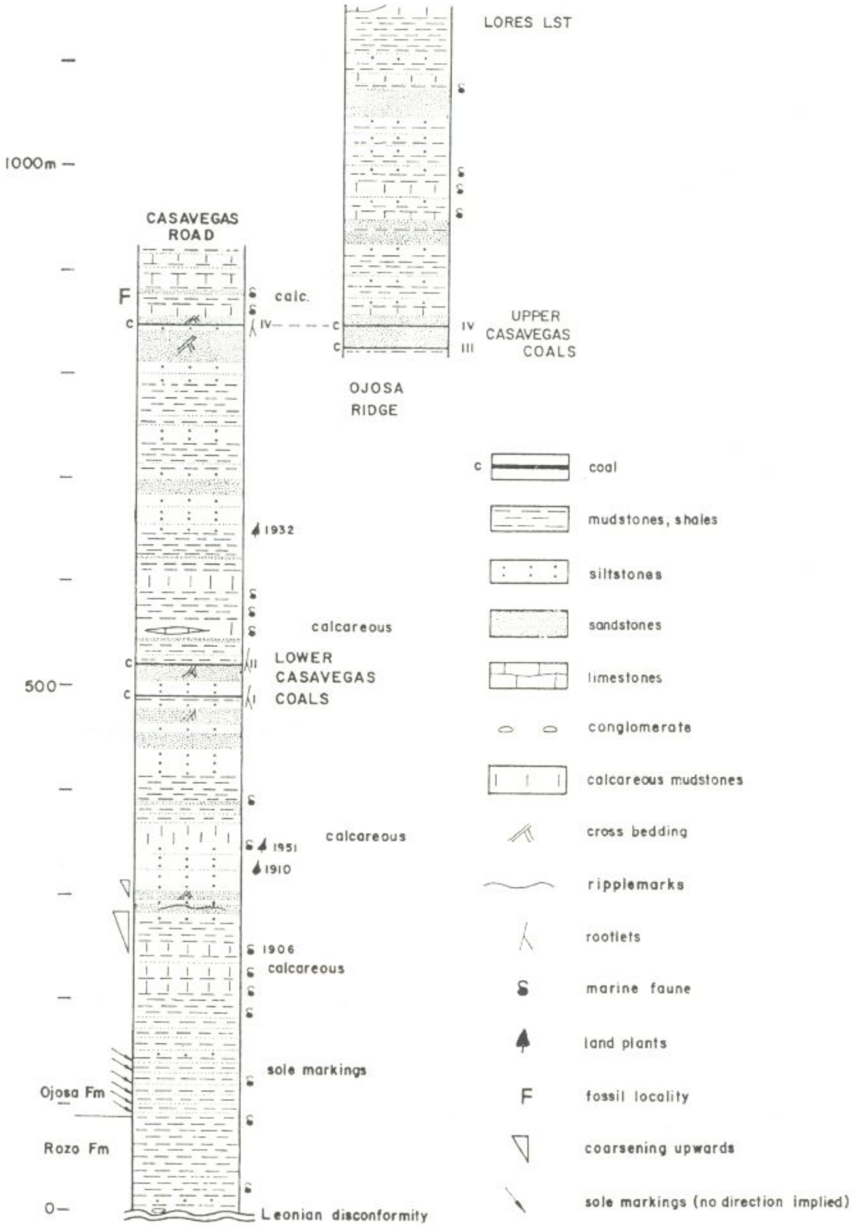


Fig. 43.–Stratigraphic column of the Ojosa Formation at Casavegas (after WAGNER & WINKLER-PRINS, 1985).

mudstones to wackestones which contain brachiopods, bryozoans, gastropods and occasionally rugose corals.

The Casavegas locality is located in one of the calcareous beds placed at the beginning of one sequence, just 20 m above one of the main coal beds in the Ojosa Formation (upper Casavegas coals) (Fig. 43). These beds are composed of silty limestones, marls and shales with conspicuous bioturbation (*Zoophycos*). Corals are scarce in most of the points where the bed crop out, but locally they are common. These corals belong typically to the *Cyathaxonia*-fauna (RODRÍGUEZ

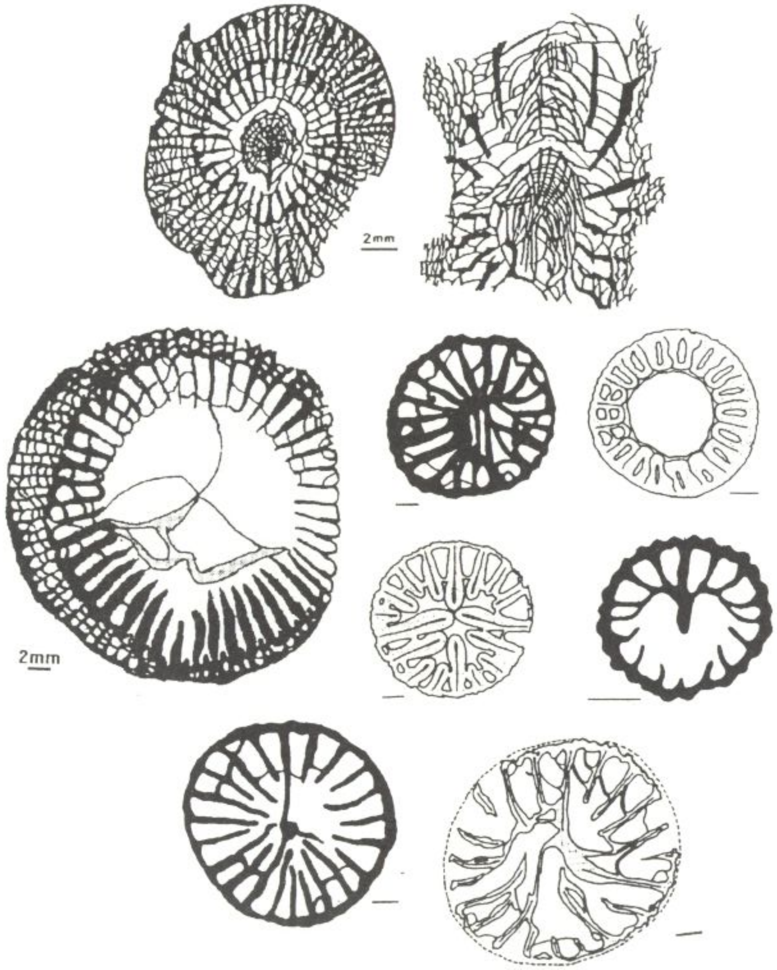


Fig. 44.–Rugose corals from Camasobres (1-2) and Casavegas (3-8). 1. *Asturiphyllum semenoffi* RODRÍGUEZ; a. transverse section, b. longitudinal section. 2. *Pseudozaphrentoides rabanaliensis* GROOT, 3. *Zaphrentites clithria* GROOT. 4. *Amplexocarinia? palentina* RODRÍGUEZ & KULLMANN. 5. *Calophyllum cantabricum* (GROOT). 6. *Lophophyllidium minus* GROOT. 7. *Sochkineophyllum accelerans* RODRÍGUEZ & KULLMANN. 8. *Ufimia alternans* GROOT. Scale bars = 1 mm except for 1 and 2.

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& Kullmann, 1990) and they can be related to those of the same age in other areas of the Cantabrian Mountains (Picos de Europa, Kullmann & Rodríguez, 1994).

Main faunal components (Fig. 44):
Rugose corals: *Amplexocarinia? palentina, Cyathaxonia cornu, Zaphrentites clithria, Calophyllum cantabricum, Sochkineophyllum accelerans, Ufimia alternans, Lophophyllidium minus.*

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