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DEVONIAN AND LOWER CARBONIFEROUS CONODONTS OF THE CANTABRIAN MOUNTAINS (SPAIN) AND THEIR STRATIGRAPHIC APPLICATION

BY

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SUMMARY

A short review of the literature on the stratigraphy of the Devonian and the Lower Carboniferous of the Cantabrian Mountains precedes the report of the author's stratigraphic and palaeontologic observations in León: the Río Esla area (Gedinnian to Viséan), the central Cantabrian area (Famennian to Viséan), and the Gildar-Montó area (Eifelian to Viséan); in Asturias: the coastal area (Frasnian to Viséan); in Palencia: the Arauz-Polentinos area (Gedinnian to Givetian), the Cardaño-Triollo area (Eifelian to Viséan), and the San Martín-Valsurvio area (Givetian and Famennian to Viséan); and in Santander: the Liébana area (Eifelian to Viséan).
Most of the conodont faunas, which were extracted from calcareous formations, could be arranged in the zonal succession established in Germany, and thus supplied new data about several formations in the Cantabrian Mountains.
The presence of the transgressive Ermita Formation in Asturias and Palencia is demonstrated. The age of this unit ranges maximally from uppermost Famennian to lowermost Tournaisian. The Cardaño Formation ranges from middle or upper Givetian to upper Frasnian. The Vidrieros Formation ranges from the upper part of the lower Famennian to the lowermost Tournaisian.
A synthesis of the stratigraphic data delimits the Palentine facies area, which is clearly separated from the Asturo-Leonese facies area by positive areas. The following palaeogeographic units are distinguished: the Asturo-Leonese Basin, the Palentine Basin, and the Asturian Geanticline. The development of these units from the Middle Devonian to the Lower Carboniferous is demonstrated by eight facies-pattern maps. The sedimentation on the Asturian Geanticline was limited and probably incomplete. An epeirogenetic uplift of this geanticline took place in late Frasnian to early Famennian times. This uplift is correlated with the deposition of the quartzitic Murcia Formation in the sheltered Palentine Basin. The uplifted area was covered by the Ermita transgression in the late Famennian to early Tournaisian.
After a break in the sedimentation, a local transgression resulted in the Vegamián Formation in the upper Tournaisian. In most of the area the Alba transgression began in the uppermost Tournaisian or lower Viséan. In the Palentine Basin the deposition of the Alba Formation started in the upper Viséan.
The chapter on systematics deals mainly with the most important zonal guide forms of the conodonts. Three new elements are described: *Icriodus eslaensis* n.sp. from the middle to upper Givetian, *Siphonodella*? n.sp. *a*, probably from the upper Tournaisian, and n.gen. *A* n.sp. *a*, a simple compound conodont from the upper Gedinnian or lower Siegenian.

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INTRODUCTION

The present study formed part of a geological investigation of the southern Cantabrian Mountains which has been carried out since 1950 by staff members and students of the University of Leiden, starting in northern Palencia. This study was gradually extended westwards, and in 1964 reached the westernmost occurrence of the Devonian, in the southern part of the "Asturian Knee". The provisional geological map of the southern slope of the Cantabrian Mountains (de Sitter, 1962) provides a general picture of the area. As part of a more detailed stratigraphic and palaeontologic investigation of the area directed by prof. Dr. A. Brouwer (Department of Stratigraphy and Paleontology), the present author started a study of conodonts in 1959.

Initially, conodont faunas were obtained from Devonian rocks from the Río Esla area, where the author carried out stratigraphic fieldwork in the Esla autochthone from 1959 to 1961, but they were not very abundant in this area. Samples provided by Mr. I. B. H. M. Rubbens in 1959 from the Pico Gildar, situated more to the north, indicated a more promising area for the study of conodonts. The results of sampling to the west of this area, near the watershed, contributed to a new stratigraphic interpretation of Palaeozoic sections in the region between the San Isidro pass and Tarna pass (van Adrichem Boogaert *et al.*, 1963). Sampling and surveying of the surroundings of the Pico Gildar and, more to the east, the Cardaño-Triollo area, provided the basis for a conodont stratigraphy of these regions. In 1965 a final field trip was made to obtain additional data to complete a synthesis of the stratigraphic observations already compiled.

Acknowledgements.— During the preparation of this thesis the author received special help and advice from many persons. Sincere thanks are extended to Dr. W. Ziegler (Geologisches Landesamt Nordrhein-Westfalen, Krefeld, Germany), who guided the author's first step in conodont techniques and systematics. Thanks are also due Prof. Dr. O. H. Walliser (Göttingen, Germany) for the discussion of problems with respect to nomenclature and Lower Devonian conodont stratigraphy. Dr. P. Bender (Marburg/Lahn, Germany) kindly showed the author the conodont collections of the University of Marburg. The author is also very grateful to Dr. J. G. Binnekamp, Mr. J. A. van Hoeflaken, Mr. J. A. Kutterink, Mr. R. W. Lanting, Dr. N. Sjerp, and Dr. J. van Veen for providing samples or putting field data at his disposal. Mrs. I. Seeger-Wolf assisted with the English text.

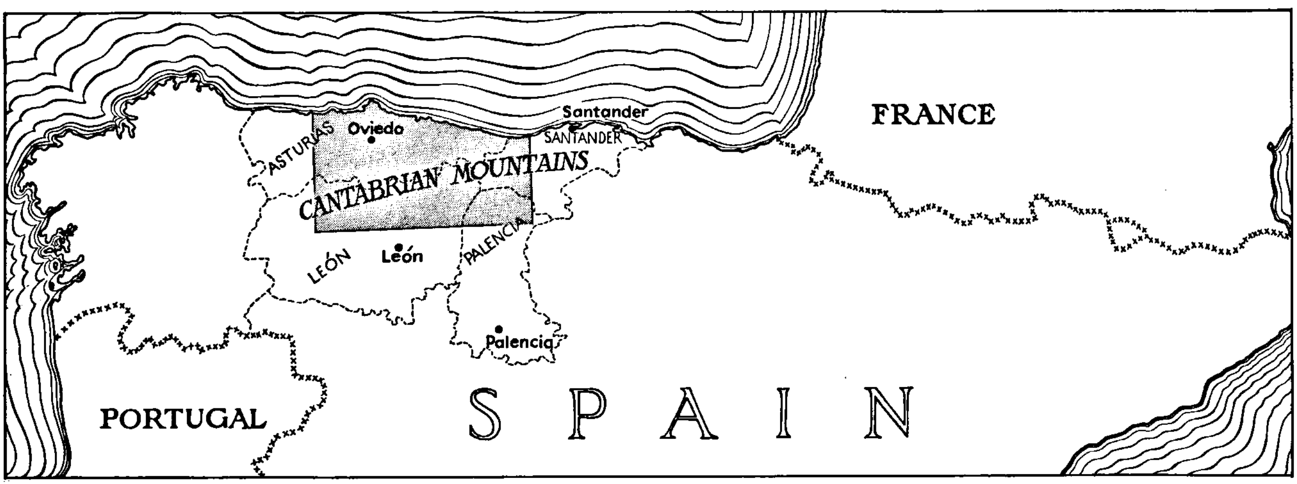

Fig. 1. Situation map of the Cantabrian Mountains (1 : 6,000,000). The shaded quadrangle shows the general region of the study.

CHAPTER I

GENERAL OUTLINE OF THE STRATIGRAPHY OF THE DEVONIAN AND LOWER CARBONIFEROUS OF THE CANTABRIAN MOUNTAINS

The Cantabrian Mountains (Fig. 1) have long attracted the attention of geologists, to whom they offer excellent exposures, fossil and mineral riches, and interesting structures. Many papers on this mountain chain have been published in the course of the last century. Publications dealing with a modern stratigraphic analysis of the area or parts of it are of direct importance for this paper. A review of these publications is given below.

LEÓN

The stratigraphy of the Lower Palaeozoic and the Devonian in the northern part of Léon, with the exception of the northeasternmost part, is based on the work of Comte (1959), who distinguished as Devonian and Lower Carboniferous units:

Griotte de Puente de Alba		
Couches de Vegamian		Viséen
	lacune	
Grès de l'Ermitage		Strunien
	lacune	
Schistes de Fueyo		Famennien
Grès de Nocedo		
Calcaires de La Portilla	Calcaires de Valdoré	Frasnien
		Givetien
Grès et Schistes de Huergas		Eifelien
Calcaires de Santa Lucia		Emsien
Calcschistes et Calcaires de La Vid		Siegenien
Grès de San Pedro (partie supérieure)		Gedinnien

The importance of the hiatus below the transgressive "Grès de l'Ermitage" gradually increases in a north-northeasterly direction to such an extent that finally this sandstone directly overlies Cambrian formations. Comte traced these units in northern León from the Río Luna, in the west, to the Río Esla, in the east. The age of the units has been established mainly by their brachiopod fauna.

Most of the units introduced by Comte are now accepted as formations in the sense of the principles stated by the International Subcommission on stratigraphic nomenclature (Hedberg, 1961). A few slight changes have been introduced, however. The "Calcaires de Valdoré", mentioned only for the Río Esla area, are considered as the upper part of the La Portilla Formation. Van Ginkel (1965, p. 183) called the "Grès de l'Ermitage" the Ermita Formation. He redefined the Vegamián Formation and the Alba Formation (= "Griotte de Puente de Alba"), and recognized these formations in León, Palencia, and Asturias. For the historic but confusing names "Caliza de Montaña" and "Calcaire des Cañons", Brouwer & van Ginkel (1964, p. 309) proposed the formal name of Escapa Formation. Smits (1965) described an aberrant development of the upper Emsian and the lower Couvinian near Caldas de Luna as the Caldas Formation.

Special attention has been paid by Wagner (1957, 1963), Wagner-Gentis (1963), and Kullmann (1961, 1962, 1963a) to the cephalopods of the Alba Formation, which indicate that this formation ranges in age from Lower Viséan to Upper Viséan. Lower Namurian goniatites were found in the lowermost beds of the Caliza de Montaña or in the transitional beds between the Alba Formation and this limestone.

Higgins (1962) reported on conodonts of the Alba Formation in León and Palencia. In an investigation of the Devonian-Carboniferous transition in the southern part of the Río Bernesga region, Higgins *et al.* (1964) identified Tournaisian conodonts.

New data on the stratigraphy of León, near the watershed, reported by van Adrichem Boogaert *et al.* (1963), revealed the presence of the Ermita Formation overlying Ordovician quartzites. The Lower Palaeozoic age of these quartzites had already been correctly estimated by Julivert (1960) and Martínez Alvarez (1962) in Asturias. Sjerp (1967) has recently presented further details about the stratigraphy of this area.

Rupke (1965) published data on the structure of the Río Esla area, in which he dealt with the stratigraphy of the "Esla nappe", the "Esla autochthone", and the "Las Salas zone" (in the northern part of the area studied).

In the northeasternmost area of León, in the Valdeón, there is a Devonian sequence which differs strongly from the sequence known from the Río Luna-Río Esla region. Julivert (1960) mentioned some cephalopods from this northeastern area, where the Devonian consists of nodular and argillacous limestones, shales, and quartzites. This author also assigned the formations south of the Pico Gildar to the Devonian. Fossil evidence, including foraminifers, has shown these rocks to be of Westfalian age (van Ginkel, 1965).

Kullmann (1960, 1961) described a section in a part of the Valdeón which he called the Montó area, ranging in age from lower Famennian to upper Viséan and dated by cephalopods. He named the Devonian nodular limestones the "Montó Schichten". Budinger & Kullmann (1964) traced this section into the Frasnian. Van Adrichem Boogaert (1965) mentioned Givetian conodonts from a section west of Pico Gildar and from a spot sample.

ASTURIAS

The framework of Devonian and the Lower Carboniferous stratigraphy in Asturias was provided by Barrois (1882). He distinguished the following "zônes", which can be considered as formations:

Assise du Griotte (Marbre à *Goniatites*)	Carbonifère inférieur
Grès de Cué	Famennien

Calcaire de Candas avec *Spirifer Verneuli*	Frasnien
Grès à *Gosseletia*	Givétien
Calcaire de Moniello avec *Calceola sandalina*	Eifélien
Calcaire d'Arnao à *Sp. cultrijugatus*	
Calcaire de Ferrones à *Athyris*	Coblenzien sup.
Schistes et calcaires de Nieva à *Sp. hystericus*	Coblenzien inf.
Grès ferrugineux de Furada	Taunusien

The subsequent work of Delépine (1928a, 1932a, 1932b) and Comte (1959) provided new palaeontologic evidence, which led to a revised stratigraphic classification as presented by Comte (1959, p. 298). Comte supplied a comparison with the Devonian formations of northern León, as follows:

Grès culminants de Candas	? Grès de l'Ermitage
Calcaires de Candas	Calcaires de Valdoré (sauf l'assise terminale)
	Calcaires de La Portilla
Grès du Naranco	Grès et Schistes de Huergas
Calcaires de Moniello (*s.l.*)	Calcaires de Santa Lucia
Complexe de Rañeces	Complexe de La Vid
Grès de Furada (partie supérieure)	Grès de San Pedro (partie supérieure)

Llopis Lladó (1958a, 1962) also used a classification based on the units of Barrois, and Radig (1961, 1964) and Poll (1963) employed a modified version of Barrois's units in their papers on the stratigraphy of the Asturian Devonian. Almela *et al.* (1956) and García-Fuente (1959) gave a short description of the Devonian stratigraphy in the explanation of their maps (1: 50,000). Llopis Lladó (1960) published a stratigraphic analysis of the area south of Oviedo, in which he described facies changes in the Emsian and Eifelian showing continental influences in the east.

The same author presented new evidence concerning the Silurian-Devonian boundary in the Furada sandstone and the distribution of the Lower Devonian in Asturias (Llopis Lladó, 1965).

The upper part of the Devonian sequence has been the subject of much controversy. In the eastern part of Asturias the Alba Formation (= the Griotte), of Viséan age, is underlain by a thick sequence of quartzites. The ages assigned to this quartzitic formation have varied from Carboniferous (Schulz, 1858; Hernández-Pacheco & Hernández-Pacheco, 1935) or Devonian (Barrois, 1882), to Silurian (*s.l.*) (Hernández Sampelayo, 1928; Delépine, 1932a; Llopis Lladó, 1958b; Julivert, 1960; Martínez Alvarez, 1962). Lotze (1957) postulated a Tournaisian age (lower limit not mentioned) for this quartzitic formation, which he called "Tina Serie".

Hernández Sampelayo and Delépine, however, produced palichnologic evidence, consisting of bilobites, pointing to a Silurian (*s.l.*) age for these quartzites (the trace fossils *Cruziana furcifera* d'Orbigny and *Cruziana rugosa* (Rouault) are typical for the Ordovician according to Seilacher, 1962). Hernández Sampelayo & Kindelan (1950, p. 60) proposed a Lower Devonian age for the upper part of the quartzitic formation in northeastern Asturias, which is locally conglomeratic and ferruginous.

Further to the west in Asturias, in the Cabo Peñas area where the Alba Formation is underlain by a somewhat ferruginous sandstone, there have also been uncertainties about the age of this unit. To avoid confusion with other stratigraphic units, Radig (1961) named this sandstone Piñeres Sandstone. Altevogt (1963) and Radig (1964) found fossil evidence for an upper Frasnian age of this sandstone. Delépine (1928b, 1937, 1943) studied the Alba Formation, from which he describe dupper Viséan goniatites.

Lys & Serre (1958) published the first report on conodonts from the Cantabrian Mountains. They described from the Alba Formation a fauna which they assigned to the upper Viséan. Buddinger & Kullmann (1964) showed by means of conodonts and cephalopods that in Perlora this formation ranges in age from lower to upper Viséan. They mentioned the occurrence of Tournaisian conodonts together with conodonts generally recognized as lower Viséan, in a section incorporating the Devonian/Carboniferous transition near Entrago. They assigned a Tournaisian age to this fauna, but van Adrichem Boogaert (1965, p. 168) suspected that it contains a stratigraphic admixture.

PALENCIA

In the northeastern part of the province of Palencia, de Sitter (1955) distinguished Devonian successions referred to as "la serie de Ventanilla", "la serie de Polentinos", and "la serie de San Julian" (Barruelo-Mudá area).

The Serie de Ventanilla was discussed in more detail by Kanis (1956), who described small bioherms ranging in age from Emsian to Frasnian. Brouwer (1964a) presented a description of these reefs and of the biostromes of the Devonian in León. Other data on the Serie de San Julian were provided by Wagner (1955), Wagner & Wagner-Gentis (1963), Frets (1965), and de Sitter & Boschma (1966).

Kullmann (1960) described a Devonian sequence in the valley of the Arroyo Arauz, northwest of Polentinos, which he dated by means of cephalopods. These rocks, which consist mainly of shales, argillacious limestones, and nodular limestones, range in age from the Siegenian to Frasnian. Part of the Emsian strata is called "Arruz Schichten".

Binnekamp (1965) published data on the stratigraphy of the Lower Devonian of the Polentinos and Arauz areas, and described as formations, dated by means of brachiopods:

Lebanza Formation (limestone)	Siegenian Gedinnian
Carazo Formation (quartzite, sandstone and shale)	Silurian

Frets (1965) recognized these formations in the Barruelo-Mudá area. Van Veen (1965), in tracing the stratigraphy of the region between Polentinos and Cardaño de Arriba, distinguished as formations lying above those described by Binnekamp:

Alba Griotte Formation (nodular, spotted limestone)	Viséan
Vegamián Formation (black shale and chert)	Tournaisian
Vidrieros Formation (nodular limestone)	Famennian
Murcia Quartzite Formation	
Cardaño Formation (nodular limestone)	Frasnian
Gustalapiedra Formation (dark limestones and shales)	Givetian Couvinian
Abadia Formation (shales and limestones)	Emsian

East of the Ventanilla area, Koopmans (1962) studied the stratigraphy of the Valsurvio region. He distinguished:

Red shale-griotte horizon	Lower Carboniferous	Griotte
Camporredondo formation (quartzite and sandstone)		Crémenes sandstone
	Upper Devonian	
Valcovero formation (shale and limestone)		Portilla limestone
Hornalejo formation (shale and sandstone)	Middle Devonian	Huergas shale and sandstone
Otero formation (limestone)		Sta Lucia limestone
Compuerto formation (shale and limestone)	Lower Devonian	La Vid shale and limestone

The third column shows Koopmans' correlation of his units with those of the Río Esla area. (The term Crémenes sandstone was provisionally used for the sandstone between the La Portilla and the Alba Formation in this area.) In the northern part of the Valsurvio area the sequence becomes thinner and less complete than in the south because of the progressive development of stratigraphic gaps.

GENERAL REMARKS

The Middle and Upper Devonian formations of the Arauz-Polentinos and the Cardaño-Triollo areas in Palencia and the Montó-Gildar area in northeastern León do not correlate well with those of the Río Luna-Río Esla region in León and the Valsurvio area in Palencia. This led Brouwer (1964b) to distinguish two facies types in the Devonian of the Cantabrian Mountains:

a) The Asturo-Leonese facies (elsewhere also referred to as Leonide, Asturo-Leonian, Asturo-Leonesean, or Asturo-Leonesian facies), consisting of sandstones, detrital limestones, and biostromes, and containing a fauna of predominantly brachiopods, bryozoans, crinoids, corals, and stromatoporoids. This facies occurs in Asturias, the greater part of León, and the Valsurvio and Ventanilla areas in Palencia.

b) The Palentine facies (elsewhere also referred to as Palencian or Palentian facies), consisting mainly of shales and argillacious and nodular limestones. Only one prominent quartzitic unit is present, i.e. the Murcia Formation. The fauna has a more pelagic character than the Asturo-Leonese facies. As characteristic elements it contains cephalopods, conodonts, tentaculites, and a few solitary corals. This facies occurs in the northwestern part of Palencia, the northeastern part of León, and the southwestern part of Santander. The facies of the Barruelo-Mudá area corresponds in the Lower and Middel Devonian mostly with the Palentine facies type. In the Upper Devonian, however, affinities to the Asturo-Leonese facies can be observed.

In the Lower Devonian the difference between the two facies types is not very pronounced, but in the higher part of the Devonian a differentiation of the sedimentary basin into two facies areas becomes evident. Brouwer (1964b) argued that this difference in facies corresponds more or less with the difference between the Rhenan facies and the Bohemian (or Hercynian) facies in northwestern Europe. Kullmann (1965) gave an interesting account of the difference between the coral faunas of these two areas. He pointed out that the cephalopod and coral fauna of the Palentine facies area (his "Montó-Arruz-Zone") are impoverished faunas.

A general review of the structural history of the Cantabrian Mountains and their relationship with the Pyrenees and the Celtiberic fold-belt has been given by de Sitter (1965).

CHAPTER II

STRATIGRAPHIC AND PALAEONTOLOGIC OBSERVATIONS

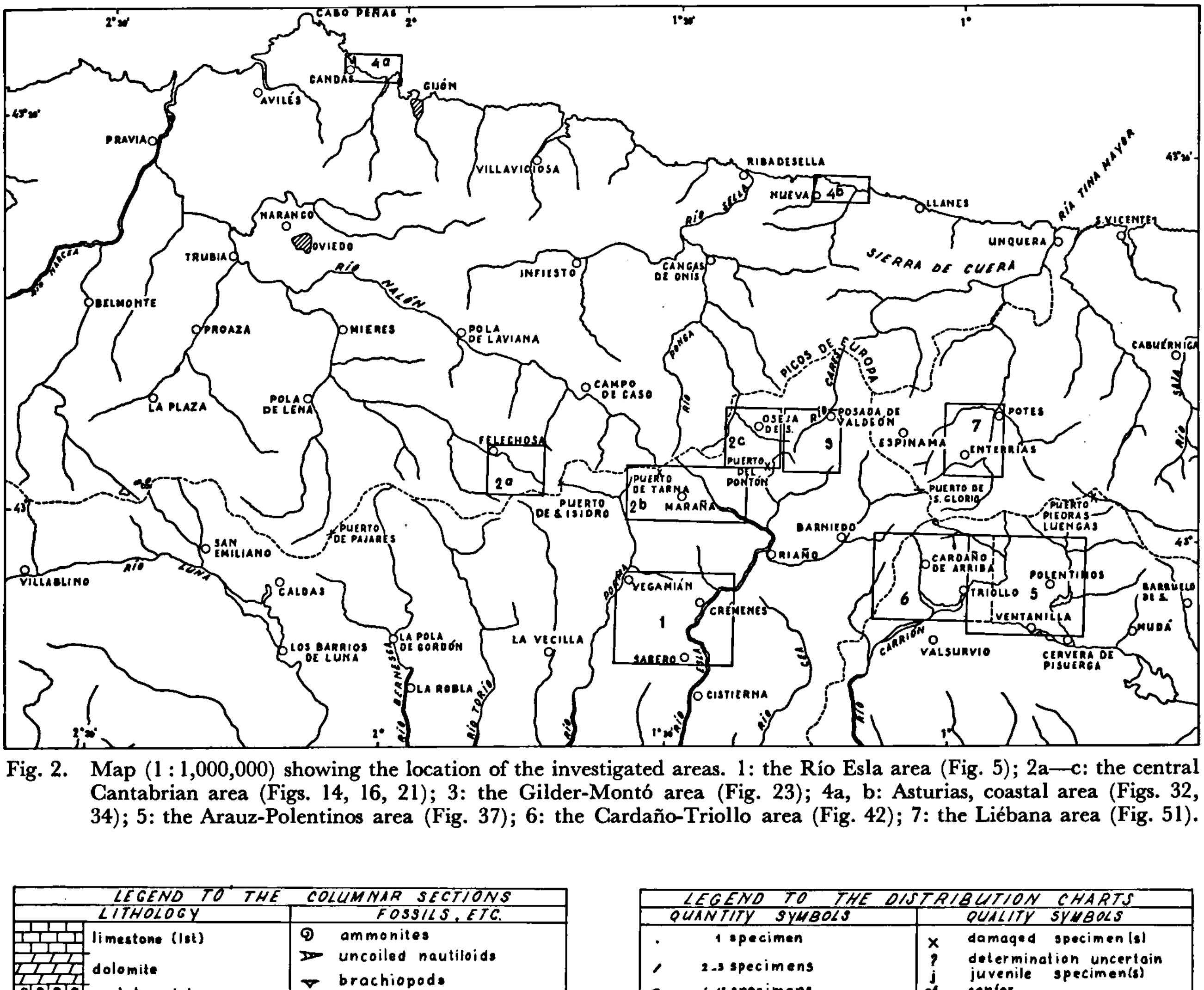

Fig. 2. Map (1 : 1,000,000) showing the location of the investigated areas. 1: the Río Esla area (Fig. 5); 2a—c: the central Cantabrian area (Figs. 14, 16, 21); 3: the Gilder-Montó area (Fig. 23); 4a, b: Asturias, coastal area (Figs. 32, 34); 5: the Arauz-Polentinos area (Fig. 37); 6: the Cardaño-Triollo area (Fig. 42); 7: the Liébana area (Fig. 51).

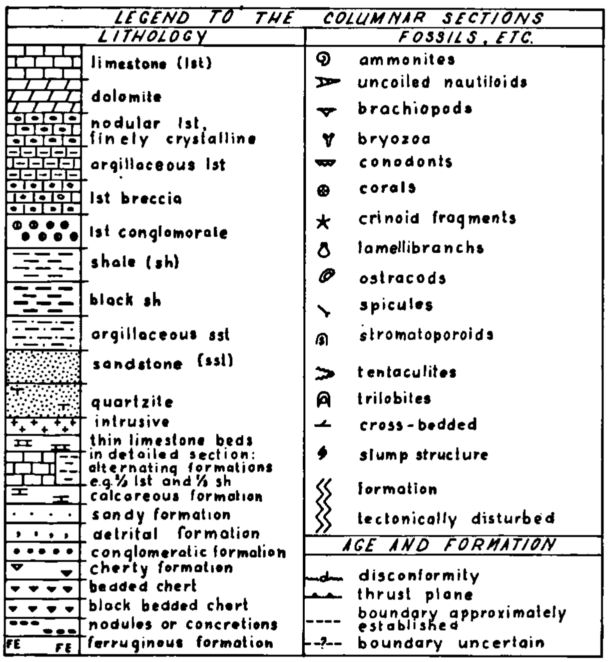

Fig. 3. Legend to the stratigraphic sections.

LEGEND TO THE DISTRIBUTION CHARTS

QUANTITY SYMBOLS		QUALITY SYMBOLS	
.	1 specimen	x	damaged specimen(s)
/	2–5 specimens	?	determination uncertain
		j	juvenile specimen(s)
o	6–15 specimens	cf	confer
●	16–50 specimens	↑	probably reworked or partly reworked specimen(s)
■	> 50 specimens	↓	probably leaked specimen(s)
+	qualitative determination only		

Fig. 4. Legend to the distribution charts. The samples from sections are consistantly indicated by capital letters and sample numbers and spot samples by lower-case letters and sample numbers, with the exception of the Río Esla and the Liébana areas.

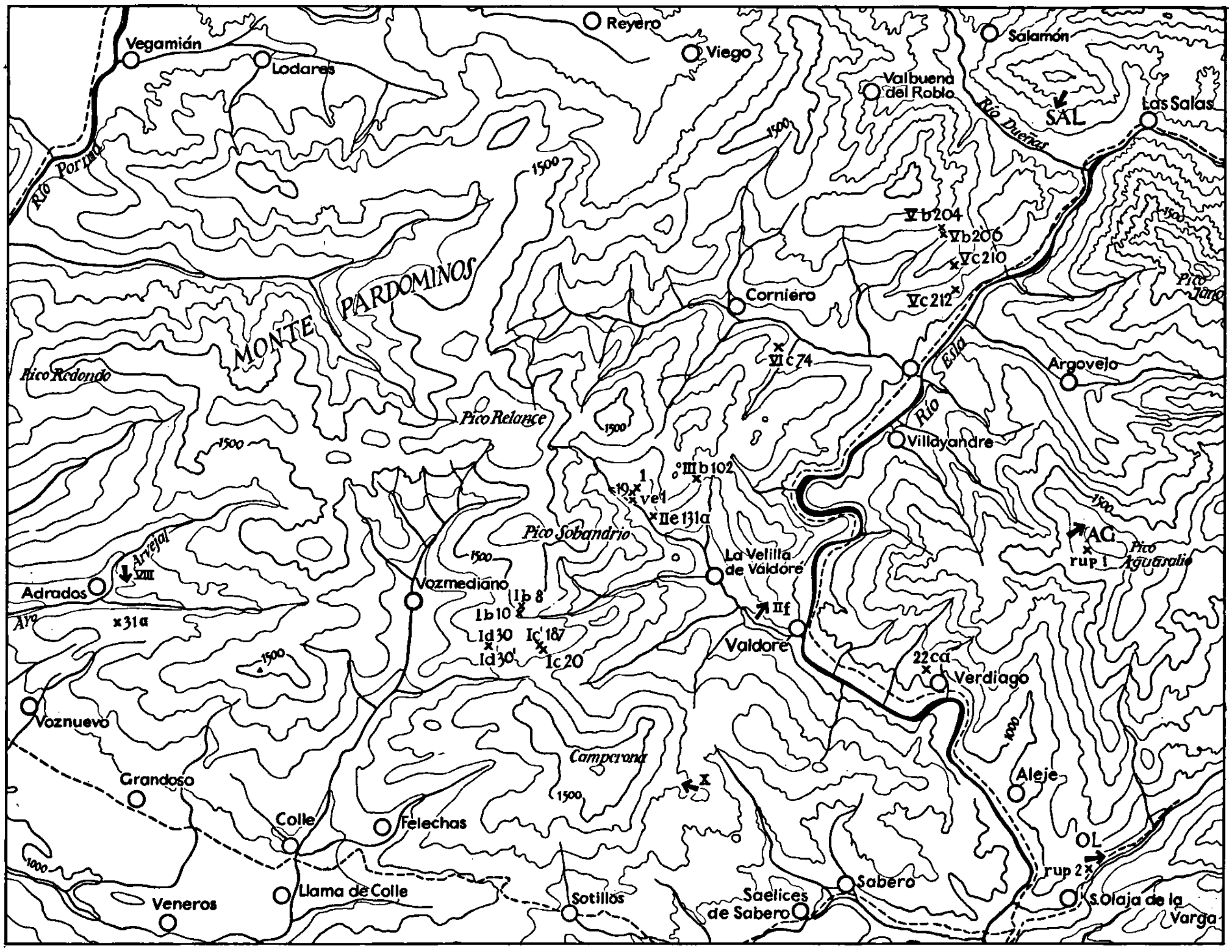

Fig. 5. Locality map (1 : 100,000) of the Río Esla area. The arrows indicating the section sites point toward the youngest part of the sequence.

LEÓN

The Río Esla area

locality map, Fig. 5
composite section, Fig. 6
sections, Figs. 7—12
distribution chart, Enclosure no. 1
Table 1

The Devonian of the Río Esla area is of the Asturo-Leonese facies type. It contains a rich macrofauna, among which brachiopods, corals, and stromatoporoids are the most conspicuous elements. An extensive description of this area has been given by Rupke (1965). The dating of the stratigraphic sequence takes into account the work of Comte (1959) and of Dr. Th. F. Krans (pers. comm.) who is making a study of the spiriferids from this region.

The conodont content of the Devonian limestones is on the average low. The conodonts recovered from the detrital limestones were in general badly preserved. The delicate posterior part of the expanded pulp cavity of the icriodids was often damaged or had broken off, which made their determination difficult if not impossible.

The Lower Carboniferous Alba Formation, on the contrary, yielded rich, well-preserved faunas.

Sections VIII (Fig. 7), IIf (Fig. 9) and X (Fig. 10) were taken in the Esla autochthone, and sections AG (Fig. 11) and OL (Fig. 12) in the Esla nappe (Rupke, 1965). This nappe contains a more complete development of the Upper Devonian than the Esla autochthone. Above the La Portilla Formation there is a sequence of about 275 m of sandstones and shales in which a prominent, detrital limestone band is intercalated, i.e. the Crémenes Limestone. Samples rup 1 and rup 2 were taken from this limestone. The sharp contact between the Alba Formation and the karst surface of the Ermita Formation in section AG is shown in Fig. 13. Section SAL (Fig. 8) was taken in the Las Salas zone (Rupke, 1965), where the Ermita Formation lies on top of the La Vid Formation.

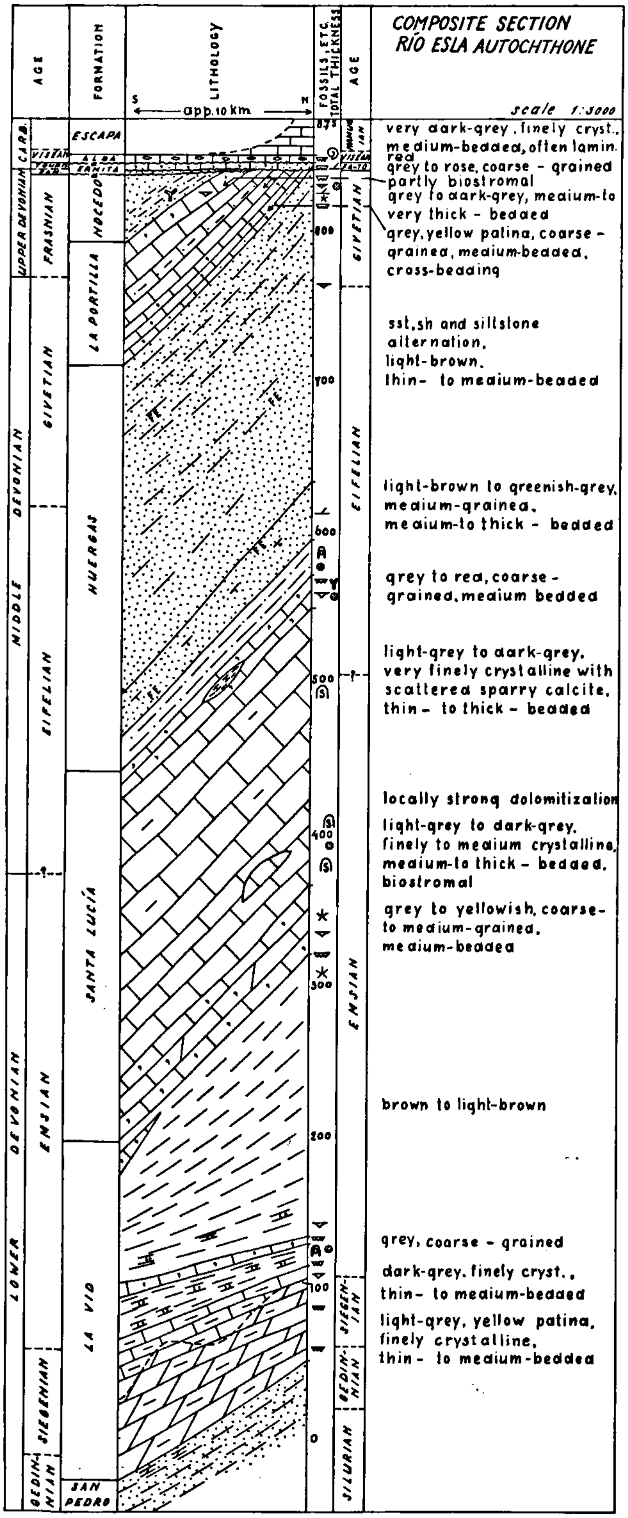

Fig. 6. Composite section of the Río Esla autochtone.

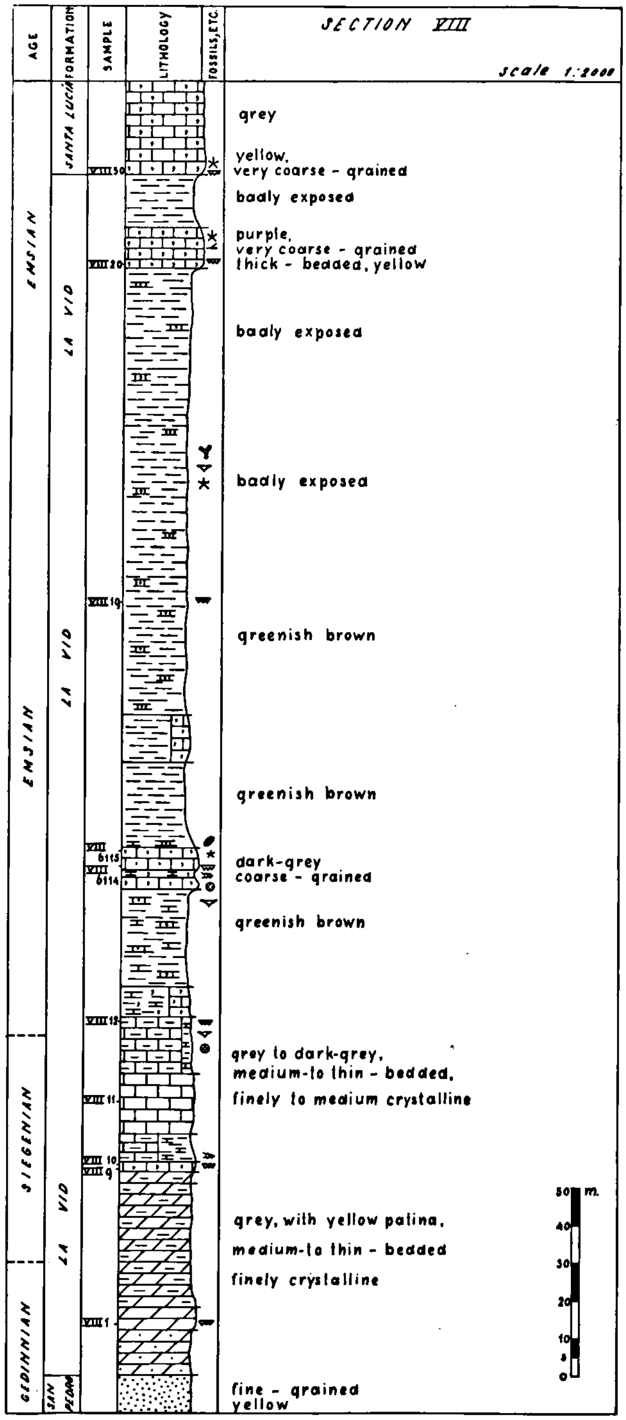

Fig. 7. Section VIII.

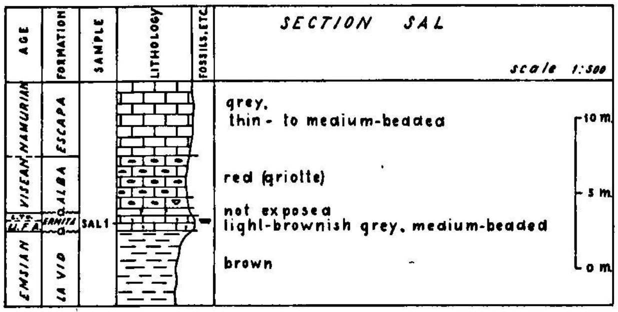

Fig. 8. Section SAL.

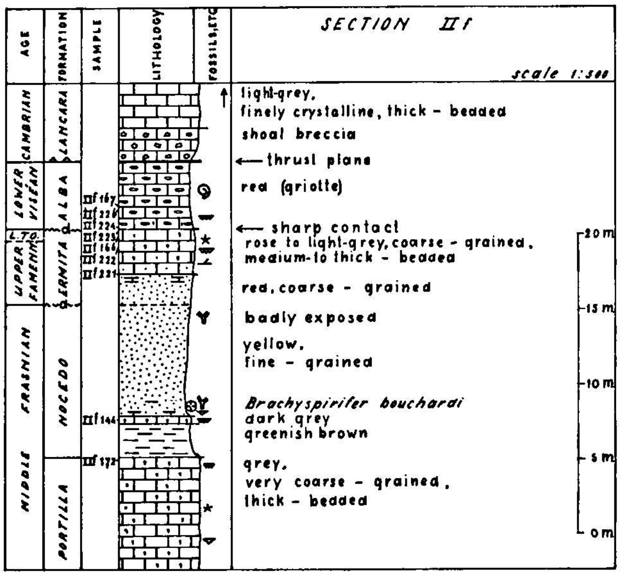

Fig. 9. Section IIf.

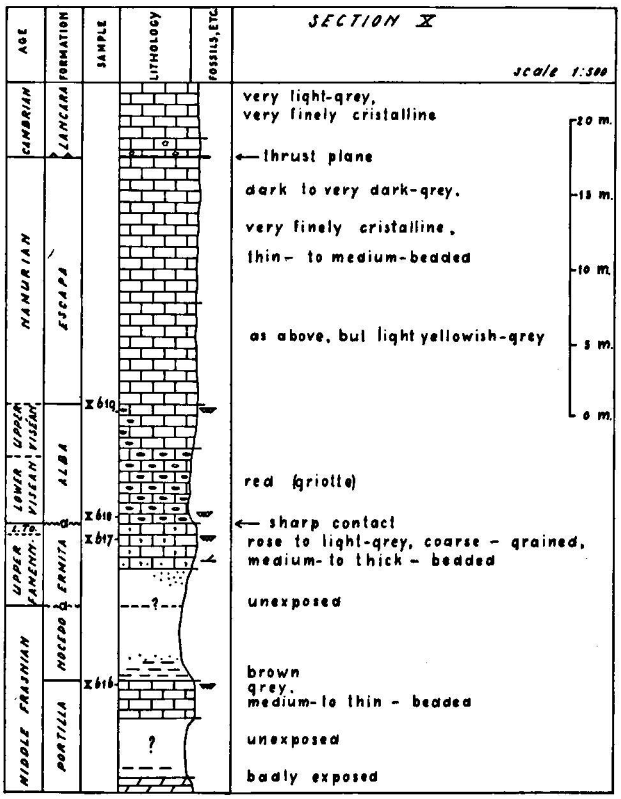

Fig. 10. Section X.

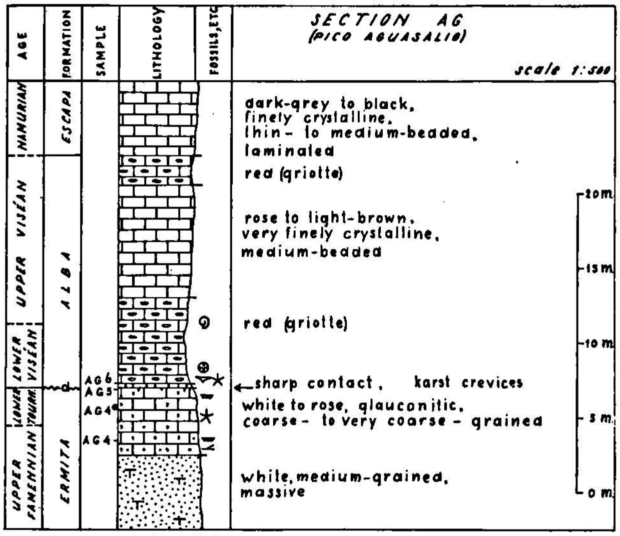

Fig. 11. Section AG.

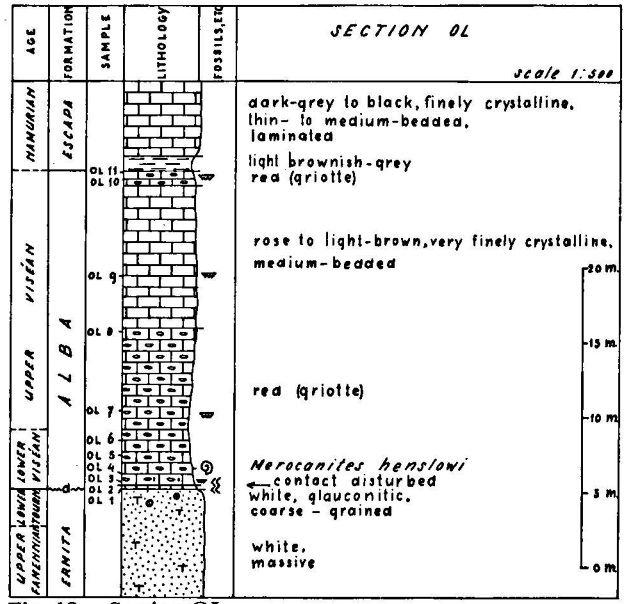

Fig. 12. Section OL.

Fig. 13. Contact between the Ermita and Alba Formations in section AG. Karst crevices in the top of the calcareous Ermita Formation are filled with red detrital material belonging to the base of the Alba Formation.

Table 1 Alphabetic index of the distribution chart of the Río Esla area (Enclosure 1)

45	*Elictognathus lacerata* (Branson & Mehl)	43	*Pol. communis carina* Hass
55	*Gnathodus antetexanus* Rexroad & Scott	44	*Pol.* cf. *P. communis communis* Branson & Mehl
59	*G. bilineatus* (Roundy)	24	*Pol. decorosa* Stauffer
58	*G. commutatus commutatus* (Branson & Mehl)	36	*Pol. inornata* E. R. Branson
65	*G. commutatus cruciformis* Clarke	11	*Pol. linguiformis linguiformis* Hinde
62	*G. commutatus homopunctatus* Ziegler	6	*Pol. linguiformis linguiformis* Hinde (with large pulpcavity)
63	*G. commutatus multinodosus* Higgins	32	*Pol. longipostica* Branson & Mehl
64	*G. commutatus nodosus* Bischoff	35	*Pol. nodomarginata* E. R. Branson
51	*G. cuneiformis* Mehl & Thomas	25	*Pol. normalis* Miller & Youngquist
54	*G.* cf. *G. cuneiformis* Mehl & Thomas	42	*Pol. pura subplana* Voges
56	*G. delicatus* Branson & Mehl s.l.	21	*Pol. varca* Stauffer
60	*G.* cf. *G. girtyi* Hass	33	*Pseudopolygnathus dentilineata* E. R. Branson
49	*G. punctatus* (Cooper)	38	*Ps. fusiformis* Branson & Mehl
52	*G. semiglaber* Bischoff	37	*Ps. multistriata* Mehl & Thomas
53	*G. typicus* Cooper	40	*Ps. triangula inaequalis* Voges
23	*Icriodus alternatus* Branson & Mehl	48	*Ps. triangula pinnata* Voges
26	*I.* cf. *I. alternatus* Branson & Mehl	57	*Scaliognathus anchoralis* Branson & Mehl
16	*I. corniger* Wittekindt	46	*Siphonodella cooperi* Hass
15	*I.* cf. *I. corniger* Wittekindt	47	*Si. obsoleta* Hass
9	*I. curvatus* Branson & Mehl	39	*Si. sulcata* (Huddle)?
22	*I. cymbiformis* Branson & Mehl	41	*Si.*? n.sp. *a*
20	*I. eslaensis* n.sp.	27	*Spathognathodus aculeatus* (Branson & Mehl)
19	*I. expansus* Branson & Mehl	18	*Sp. bipennatus* Bischoff & Ziegler
17	*I. lastericrescens latericrescens* Branson & Mehl	61	*Sp. campbelli* Rexroad
4	*I. latericrescens latericrescens* Branson & Mehl (*sensu* Ziegler, 1956)	28	*Sp. costatus costatus* (E. R. Branson)
		29	*Sp. costatus spinulicostatus* (E. R. Branson)
8	*I. latericrescens bilatericrescens* Ziegler	30	*Sp. costatus* (E. R. Branson) subsp. indet.
10	*I. nodosus* (Huddle)	1	*Sp.* sp. indet.
14	*I. symmetricus* Branson & Mehl	2	*Sp. inclinatus wurmi* Bischoff & Sannemann
13	*I.* sp. *a*	31	*Sp. stabilis* (Branson & Mehl)
5	*Neoprioniodus excavatus* (Branson & Mehl)	12	*Sp. steinhornensis steinhornensis* Ziegler
3	*Pelekysgnathus serrata* Jentzsch	7	*Sp. steinhornensis* Ziegler subsp. indet.
34	*Polygnathus communis communis* Branson & Mehl	50	*Sp.* cf. *S. strigosus* (Branson & Mehl)

The central Cantabrian area

locality maps, Figs. 14, 16, 21
sections, Figs. 15, 17—20, 22
distribution chart, Enclosure no. 2
Table 2

The central Cantabrian area lies near the watershed of the Cantabrian Mountains. Sections FE and OS actually lie in southern Asturias, but they are discussed here because they link up directly with the stratigraphy of León.

Although very little Devonian is present, the central Cantabrian area is considered to belong to the Asturo-Leonese facies area because of the detrital lithology of the Ermita Formation.

The sections investigated in this region show that the Ermita Formation rests directly on Lower Palaeozoic. For a detailed description of this area, the reader is referred to Sjerp (1967).

Sections RI (Fig. 17) and MA (Fig. 18) were taken in the "Mampodre-Fontasguera-Ten subarea" (Sjerp, 1967, Fig. 41). The Ermita Formation is calcareous throughout in section RI. The Vegamián Formation in section MA contains two calcareous beds; this is the only place where we were able to extract conodonts from this formation. Sections FE, U, PO, and OS (Figs. 15, 19, 20, 22) were taken in the "Isidro-Tarna-Ponton subarea" (Sjerp, 1967, Fig. 41).

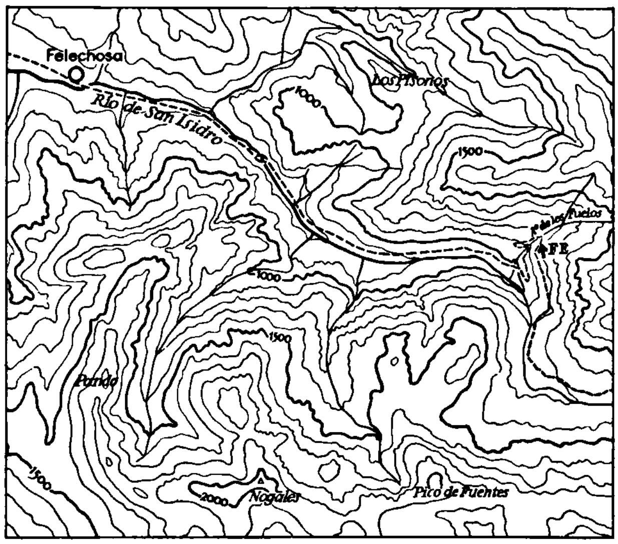

Fig. 14. Locality map (1 : 100,000) of the western part of the central Cantabrian area. The arrow indicating the section site points toward the youngest part of the sequence.

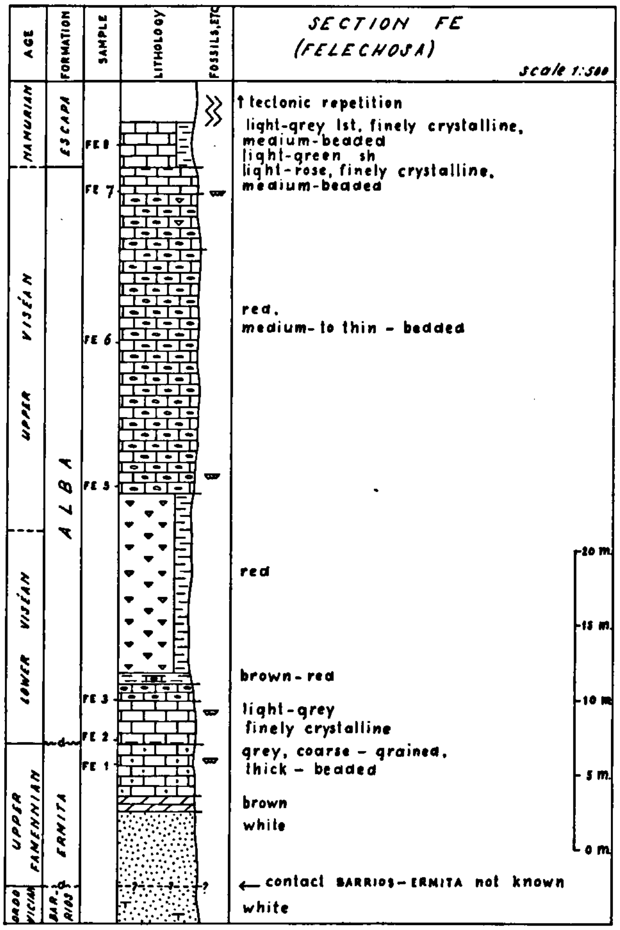

Fig. 15. Section FE.

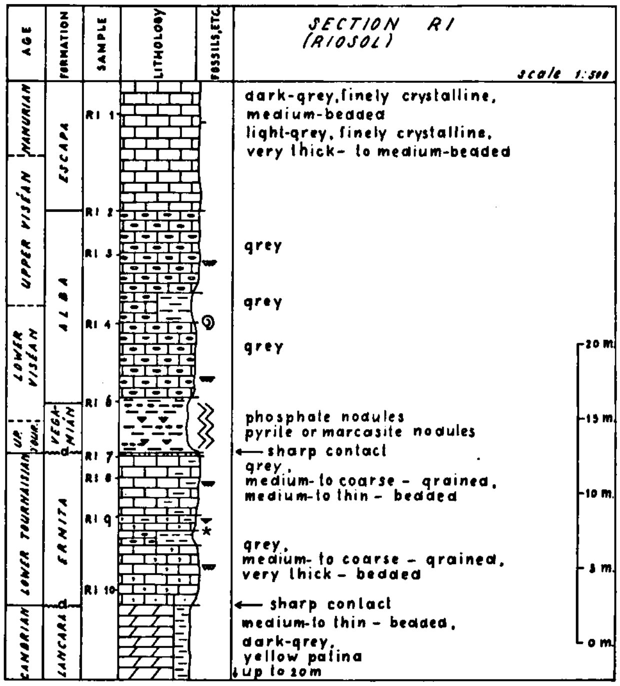

Fig. 17. Section RI.

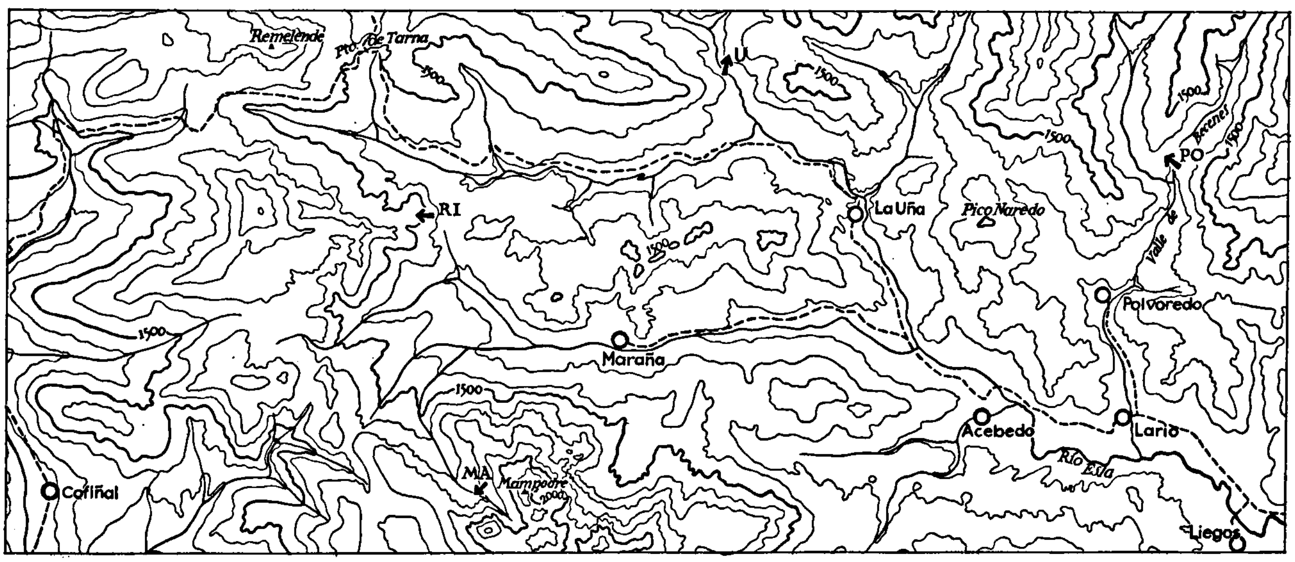

Fig. 16. Locality map (1 : 100,000) of the central part of the central Cantabrian area. The arrows indicating the section sites point toward the youngest part of the sequence.

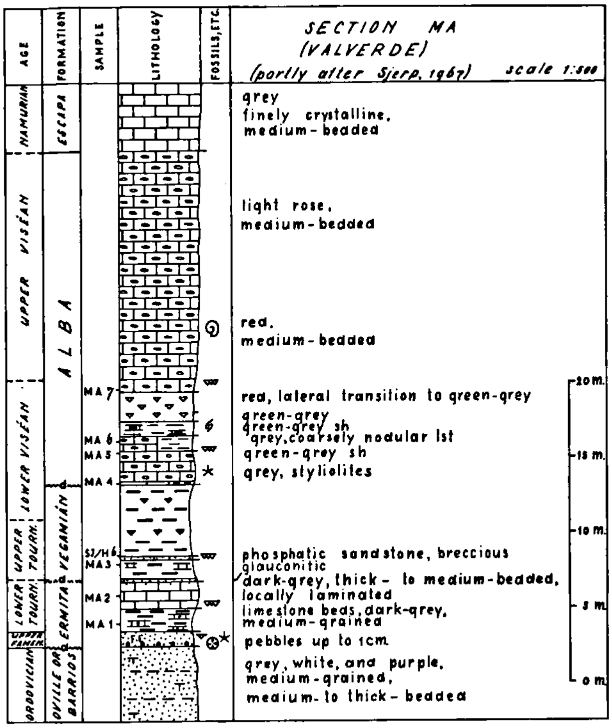

Fig. 18. Section MA.

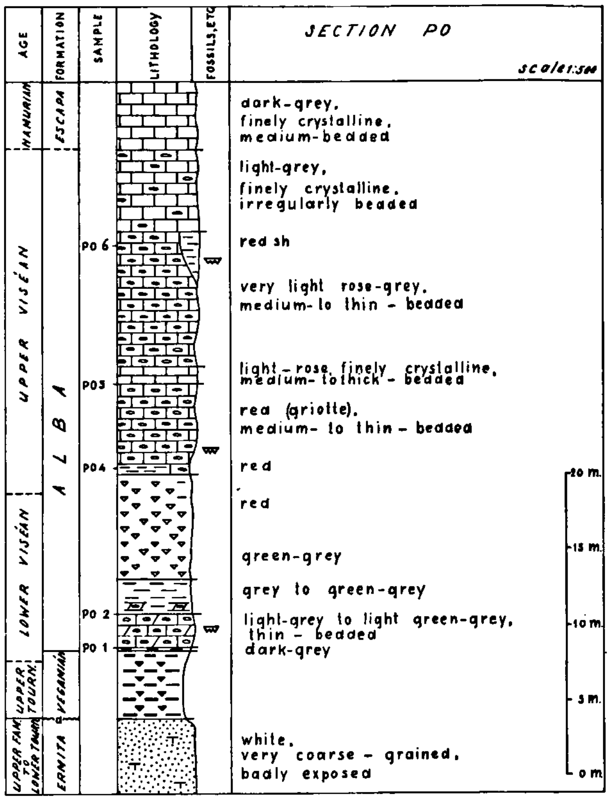

Fig. 20. Section PO.

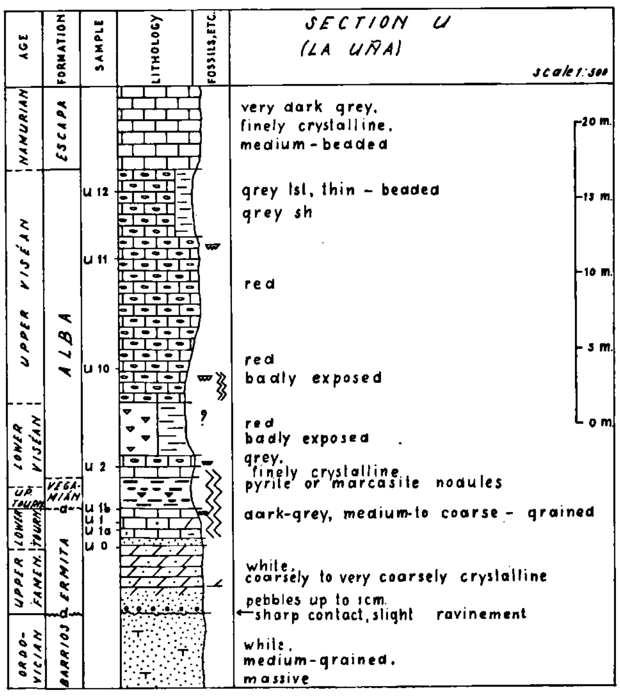

Fig. 19. Section U.

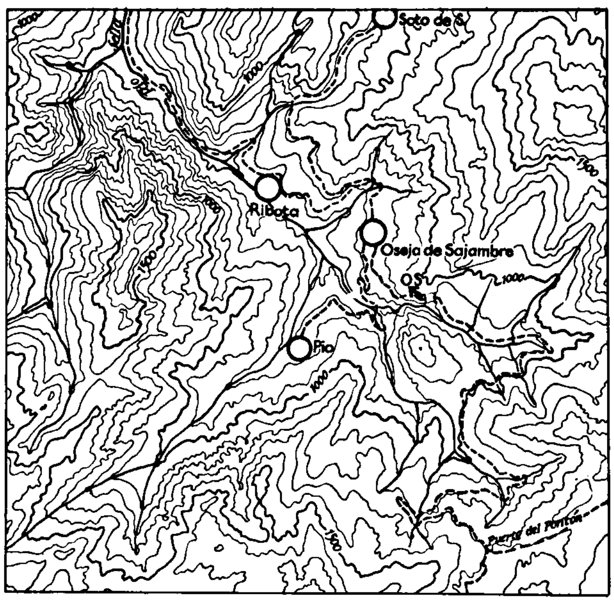

Fig. 21. Location map (1 : 100,000) of the eastern part of the central Cantabrian area. The arrow indicating the section site points toward the youngest part of the sequence.

Table 2 Alphabetic index of the distribution chart of the central Cantabrian area (Enclosure 2)

41	*Cavusgnathus unicornis* Youngquist & Miller	11	*Pol. inornata* E. R. Branson
29	*Gnathodus antexanus* Rexroad & Scott	8	*Pol. longipostica* Branson & Mehl
22	*G.* cf. *G. antetexanus* Rexroad & Scott	9	*Pol. nodomarginata* E. R. Branson
35	*G. bilineatus* (Roundy)	25	*Pol. symmetrica* E. R. Branson
33	*G. commutatus commutatus* (Branson & Mehl)	20	*Pol. pura subplana* Voges
38	*G. commutatus cruciformis* Clarke	13	*Pseudopolygnathus dentilineata* E. R. Branson
34	*G. commutatus homopunctatus* Ziegler	7	*Ps. fusiformis* Branson & Mehl
36	*G. commutatus multinodosus* Higgins	14	*Ps. multistriata* Mehl & Thomas
39	*G. commutatus nodosus* Bischoff	23	*Ps. triangula pinnata* Voges
27	*G. cuneiformis* Mehl & Thomas	16	*Siphonodella cooperi* Hass
30	*G.* cf. *G. cuneiformis* Mehl & Thomas	17	*Si. isosticha* (Cooper)
32	*G. delicatus* Branson & Mehl s.l.	18	*Si. obsoleta* Hass
40	*G. girtyi* Hass	19	*Si.?* n.sp. *a*
26	*G. punctatus* (Cooper)	1	*Spathognathodus aculeatus* (Branson & Mehl)
28	*G. semiglaber* Bischoff	37	*Sp. campbelli* Rexroad
31	*G. typicus* Cooper	2	*Sp. costatus costatus* (E. R. Branson)
24	*Hindeodella segaformis* Bischoff	3	*Sp. costatus spinulicostatus* (E. R. Branson)
10	*Polygnathus communis communis* Branson & Mehl	4	*Sp. costatus* (E. R. Branson) subsp. indet.
12	*Pol.* cf. *P. communis communis* Branson & Mehl	5	*Sp. stabilis* (Branson & Mehl)
21	*Pol. delicatula* Ulrich & Bassler	6	*Sp. strigosus* (Branson & Mehl)
15	*Pol. flabella* Branson & Mehl		

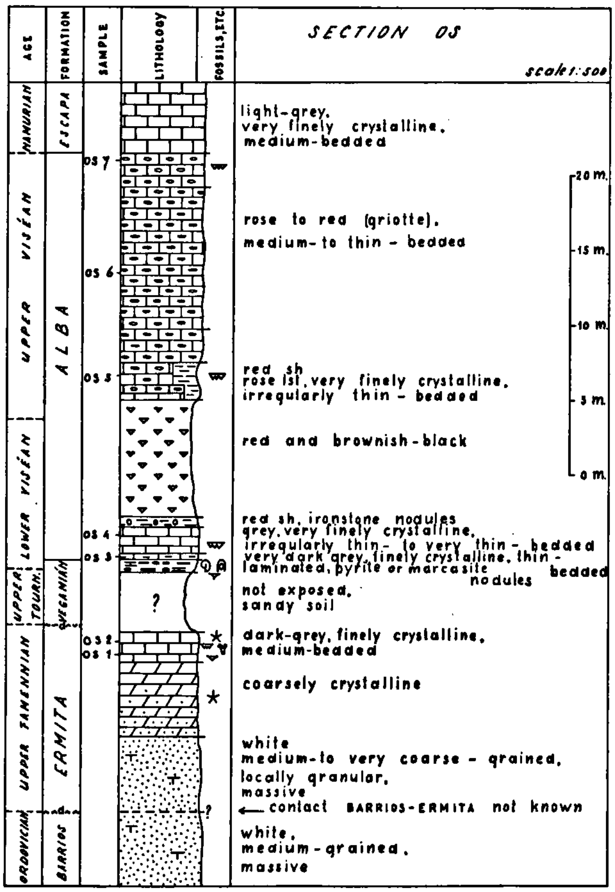

Fig. 22. Section OS.

The Gildar-Montó area

locality map, Fig. 23
composite section, Fig. 24
sections, Figs. 25—30
distribution chart, Enclosure no. 3
Table 3

This area is situated on the southern slope of the Valdeón valley. The Devonian of this area belongs to the Palentine facies type, in which cephalopods and locally lamellibranchs are the characteristic macro-

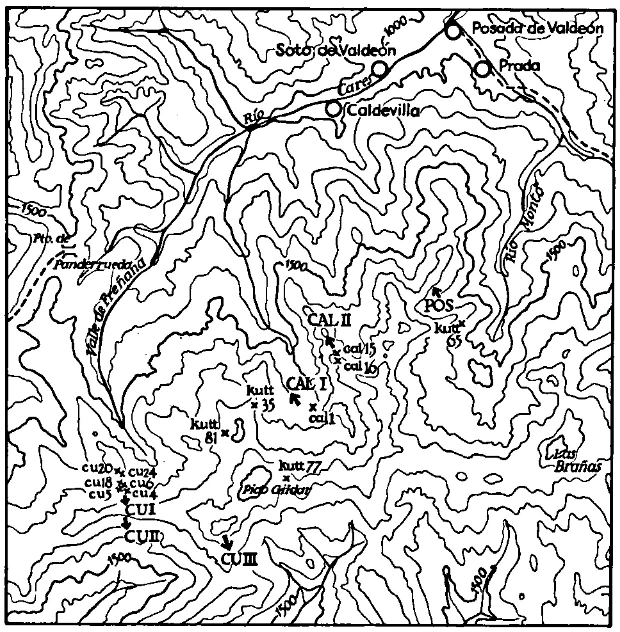

Fig. 23. Locality map (1 : 100,000) of the Gildar-Montó area. The arrows indicating the section sites point toward the youngest part of the sequence.

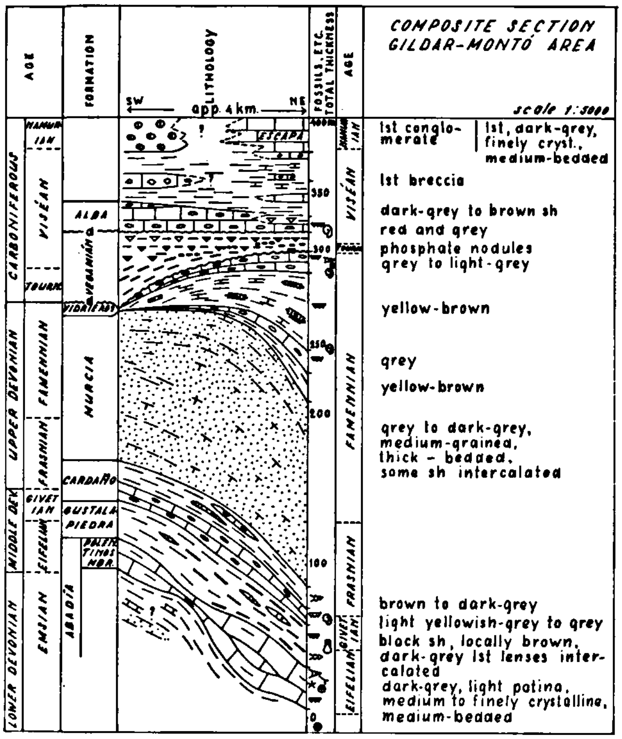

Fig. 24. Composite section of the Gildar-Montó area.

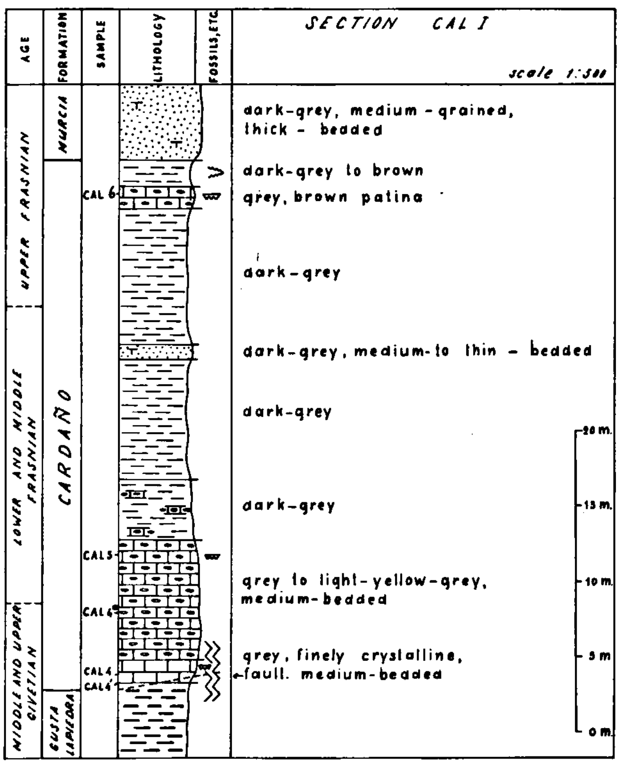

Fig. 25. Section CAL I.

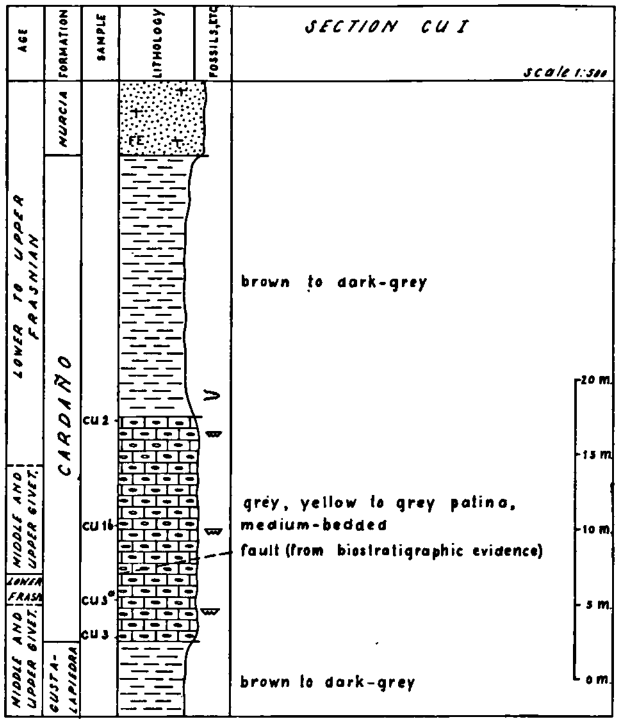

Fig. 26. Section CU I.

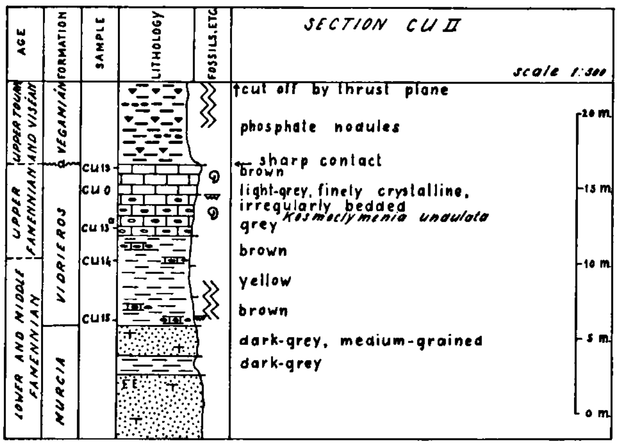

Fig. 28. Section CU II.

fossils. Kutterink (in prep., Leidse Geol. Med.) will give a structural description of the area.

The oldest lithostratigraphic unit in this area is a limestone band which, because of its lithologic properties and its place in the sequence, is considered to be the Polentinos Member of the Abadía Formation. Six of the seven samples taken from this limestone did not contain conodonts; the seventh, sample cal 1, yielded two specimens, one of which could be tentatively identified as a juvenile specimen of *Icriodus corniger*. Higher in the succession the nodular limestones generally yielded rich, well-preserved conodont faunas. Fig. 31 shows a slump of dark-grey, laminated, quartzitic sandstone in the Vegamián Formation near section CAL II.

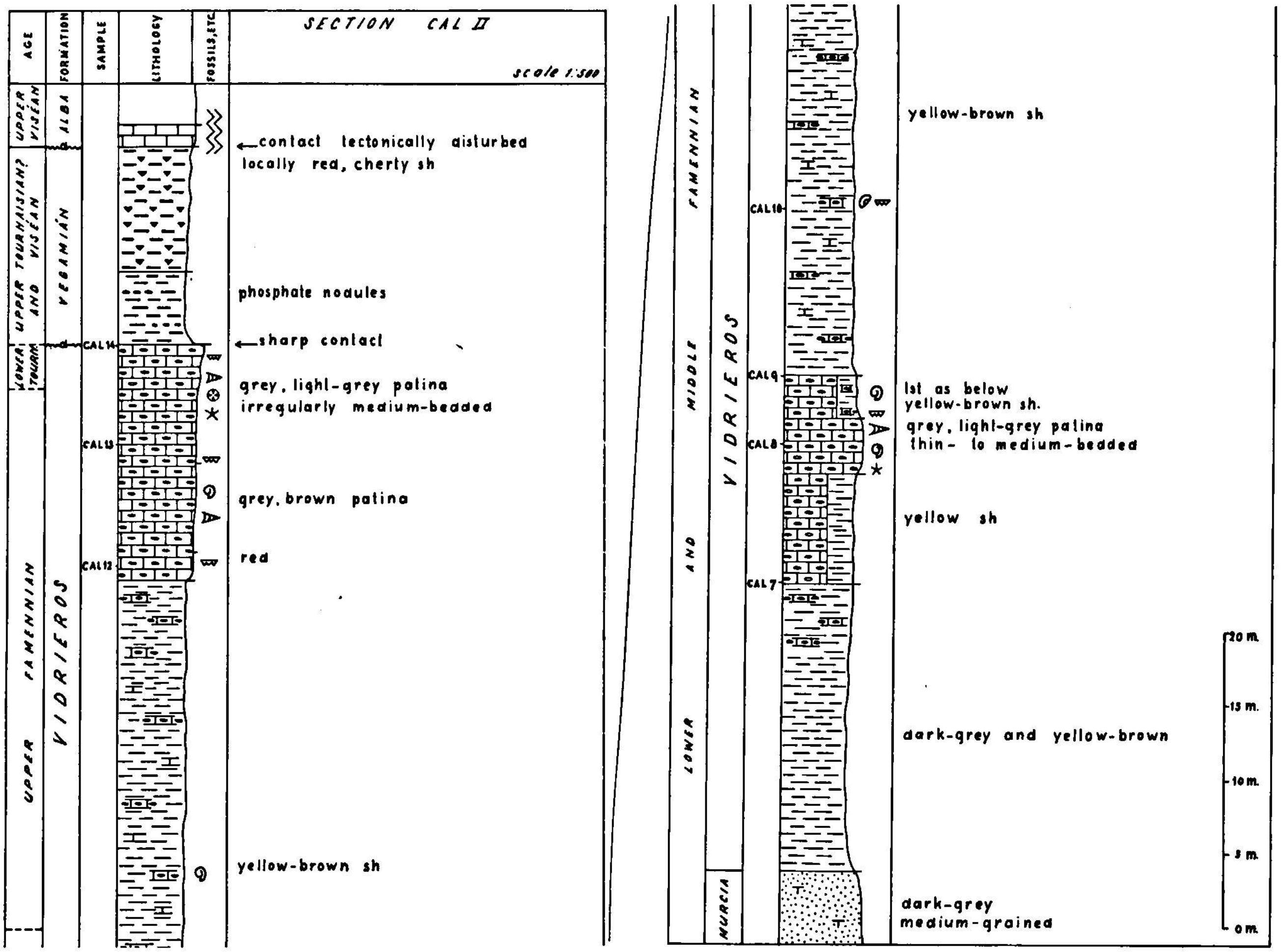

Fig. 27. Section CAL II.

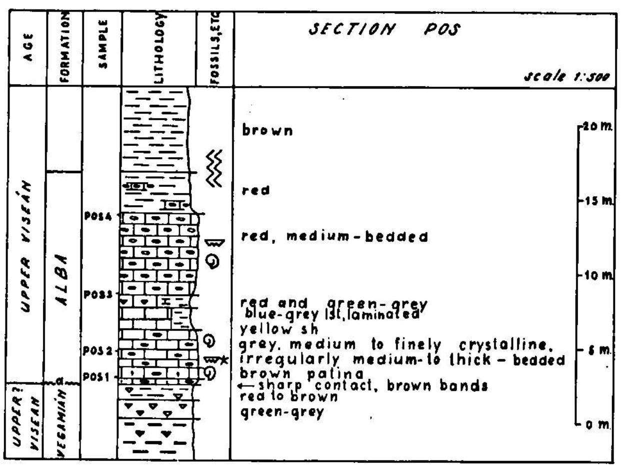

Fig. 30. Section POS.

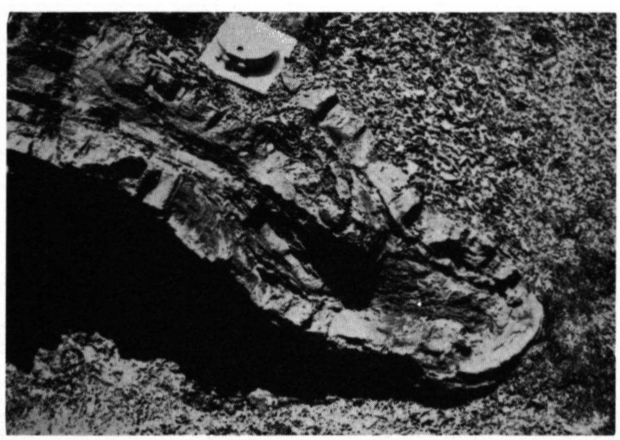

Fig. 31. Slump of dark-grey, laminated, quartzitic sandstone in the Vegamián Formation near section CAL II (Photo by Kutterink).

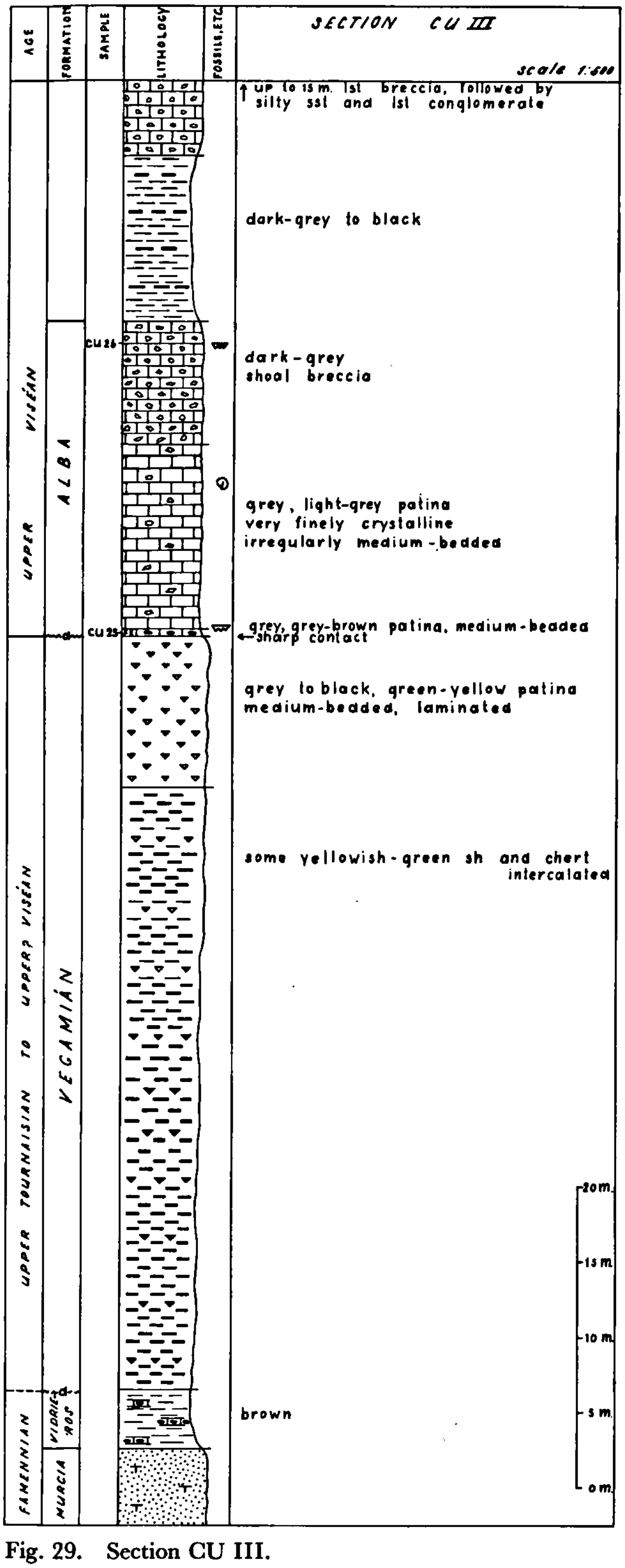

Fig. 29. Section CU III.

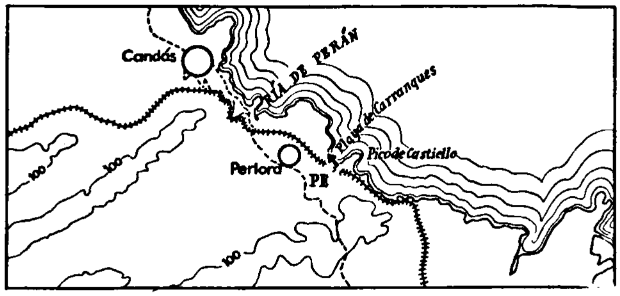

Fig. 32. Locality map (1 : 100,000) of the western part of Asturias, coastal area. The arrow indicating the section site points toward the youngest part of the sequence.

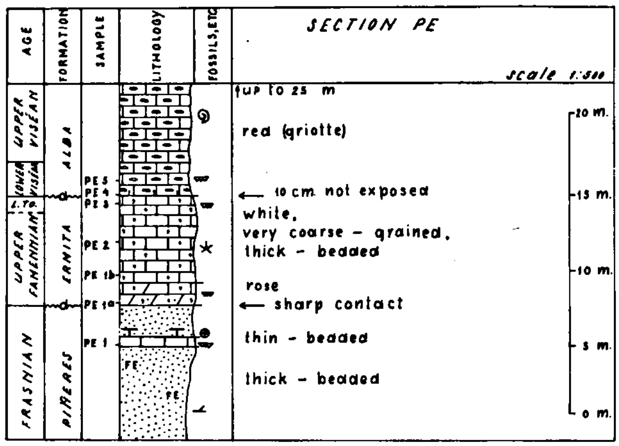

Fig. 33. Section PE.

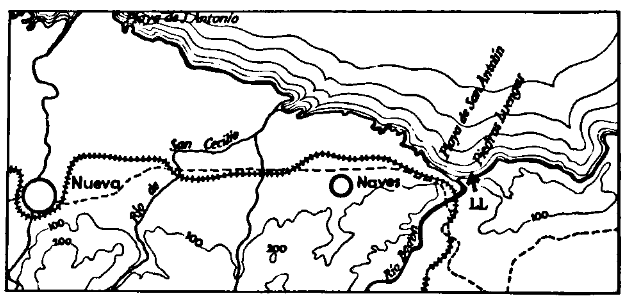

Fig. 34. Locality map (1 : 100,000) of the eastern part of Asturias, coastal area. The arrow indicating the section site points toward the youngest part of the sequence.

Table 3 Alphabetic index of the distribution chart of the Gildar-Montó area (Enclosure 3)

26	*Ancyrodella curvata* (Branson & Mehl)	20	*Pol. asymmetrica ovalis* Ziegler & Klapper
25	*Ancyrodella lobata* Branson & Mehl	53	*Pol. communis communis* Branson & Mehl
28	*Ancyrognathus asymmetrica* (Ulrich & Bassler)	66	*Pol.* cf. *P. communis communis* Branson & Mehl
27	*Ancyrognathus triangularis* Youngquist	17	*Pol. cristata* Hinde
77	*Cavusgnathus unicornis* Youngquist & Miller	23	*Pol. decorosa* Stauffer
71	*Gnathodus bilineatus* (Roundy)	62	*Pol. delicatula* Ulrich & Bassler
70	*G. commutatus commutatus* (Branson & Mehl)	21	*Pol. dengleri* Bischoff & Ziegler
75	*G. commutatus cruciformis* Clarke	45	*Pol. diversa* Helms
72	*G. commutatus homopunctatus* Ziegler	38	*Pol. glabra glabra* Ulrich & Bassler
74	*G. commutatus nodosus* Bischoff	65	*Pol. inornata* E. R. Branson
67	*G. cuneiformis* Mehl & Thomas	4	*Pol. linguiformis linguiformis* Hinde
69	*G. delicatus* Branson & Mehl s.l.	10	*Pol. linguiformis mucronata* Wittekindt
76	*G. girtyi* Hass	63	*Pol. longipostica* Branson & Mehl
68	*G. typicus* Cooper	46	*Pol. nodocostata nodocostata* Branson & Mehl
31	*Icriodus alternatus* Branson & Mehl	61	*Pol. nodomarginata* E. R. Branson
1	*I. corniger* Wittekindt	29	*Pol. normalis* Miller & Youngquist
12	*I. curvatus* Branson & Mehl	22	*Pol. ordinata* Bryant
14	*I. cymbiformis* Branson & Mehl	8	*Pol. pennata* Hinde
3	*I. eslaensis* n.sp.	47	*Pol. pennatuloidea* Holmes
15	*I. expansus* Branson & Mehl	9	*Pol. pseudofoliata* Wittekindt
11	*I. nodosus* (Huddle)	6	*Pol.* cf. *P. robusticostata* Bischoff & Ziegler
13	*I. symmetricus* Branson & Mehl	39	*Pol. subserrata* Branson & Mehl
78	*Mestognathus beckmanni* Bischoff	36	*Pol.* cf. *P. triphyllata* (Ziegler)
41	*Palmatolepis distorta* Branson & Mehl	5	*Pol. varca* Stauffer
40	*Pal. glabra glabra* Ulrich & Bassler	7	*Pol. xyla* Stauffer
43	*Pal. glabra elongata* Holmes	64	*Pseudopolygnathus fusiformis* Branson & Mehl
42	*Pal. glabra pectinata* Ziegler	18	*Schmidtognathus peracuta* (Bryant)
49	*Pal. gracilis gracilis* Branson & Mehl	55	*Spathognathodus aculeatus* (Branson & Mehl)
60	*Pal. gracilis sigmoidalis* Ziegler	48	*Sp. amplus* (Branson & Mehl)
34	*Pal. hassi* Müller & Müller	73	*Sp. campbelli* Rexroad
35	*Pal. minuta minuta* Branson & Mehl	56	*Sp. costatus costatus* (E. R. Branson)
44	*Pal. perlobata schindewolfi* Müller	57	*Sp. costatus spinulicostatus* (E. R. Branson)
37	*Pal. quadrantinodosa marginifera* Ziegler	58	*Sp. costatus ultimus* Bischoff
32	*Pal. subrecta* Miller & Youngquist	54	*Sp. jugosus* (Branson & Mehl)
24	*Pal. transitans* Müller	52	*Sp. inornatus* (Branson & Mehl)
33	*Pal. unicornis* Miller & Youngquist	16	*Sp.* cf. *S. sannemanni sannemanni* Bischoff & Ziegler
2	*Paltodus* sp.	50	*Sp. stabilis* (Branson & Mehl)
30	*Polygnathus amana* Müller & Müller	51	*Sp. strigosus* (Branson & Mehl)
19	*Pol. asymmetrica asymmetrica* Bischoff & Ziegler	59	*Sp. supremus* Ziegler

ASTURIAS, COASTAL AREA

locality maps, Figs. 32, 34
sections, Figs. 33, 35
distribution chart, Fig. 36
Table 4

Along the Asturian coast a few sections were studied for comparison with the formations in León. The Devonian in this area belongs to the Asturo-Leonese facies type. Section PE (Fig. 33) from the Playa de Carranques near Perlora contains a clearly distinguishable, detrital limestone band separating the Piñeres Sandstone and the Alba Formation. In analogy with other parts of the Cantabrian Mountains we assign this limestone band to the Ermita Formation, which in this case is almost completely calcareous. From the base of the Alba Formation (sample PE 4) an abundant, mixed fauna was obtained. Attrited conodonts and conodonts encrusted with iron oxide were found together with light-brown to amber, undamaged specimens. Only rarely is a mixed fauna so distinctly represented.

The main quartzite body in section LL (Fig. 35) on the Piedras Luengas beach is considered to be the Ordovician "Quartcita Armoricana" (= Barrios Formation). We follow here Hernández Sampelayo (1928), Delépine (1932a), Llopis Lladó (1958b), and others. We do not accept the concept of the Tina Serie (Lotze, 1957), for which no palaeontologic proof has been put forward (see also Ch. I, p. 132). The uppermost 12 m of the quartzite, which consists of very coarse-grained quartzite, is assigned to the Ermita Formation, in analogy with the northern part of León. Further arguments for this classification are given in Chapter IV (p. 160). The completely unconsolidated sandy and argillacious beds intercalated between the coarse-grained quartzite and the Vegamián Formation, are remarkable. This unit yielded no macrofossils, and palynological examination gave negative results. Provisionally, we assign this unit to the Ermita Formation. The Alba Formation, which overlies the Vegamián Formation, begins with a lens of soft, grey clay.

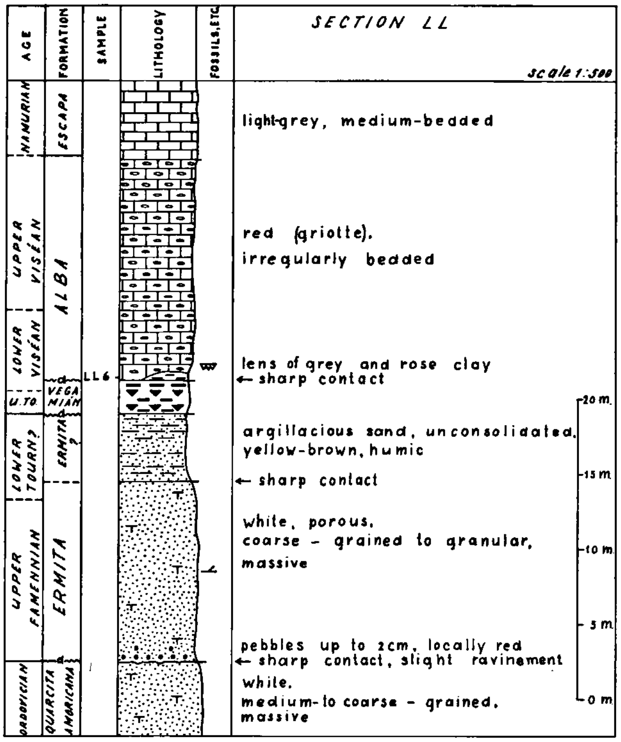

Fig. 35. Section LL.

PALENCIA

The Arauz-Polentinos area

locality map, Fig. 37
composite section, Fig. 38
sections, Figs. 39, 40
distribution chart, Fig. 41
Table 5

The Devonian of the Arauz-Polentinos area is of the Palentine facies type. In the Gedinnian and Siegenian brachiopods are abundant, but in the younger stages cephalopods and trilobites are the most characteristic macrofossils. The area has been described by Binnekamp (1965), van Veen (1965), and de Sitter & Boschma (1966).

The oldest conodont fauna (sample ar 1) comes from a very locally developed, detrital limestone lens in the upper part of the Carazo Formation (Member c). Samples bk 13 and pol 23 were taken from a nodular limestone lens or tongue in the upper part of the Abadía Formation. This limestone occurs only 3.5 km west-northwest of Polentinos in a tectonically very disturbed area. The Polentinos Member of the Abadía Formation yielded few conodonts. Of the eleven samples studied, only two (pol 9 and pol 11) yielded a usable fauna. The Gustalapiedra Formation in this area is in general badly exposed, which hampers its investigation. The locality of section POL II (Fig. 40) is the only well-exposed outcrop of the Cardaño Formation in this area.

DISTRIBUTION CHART ASTURIAS (COASTAL AREA)

SECTION	SAMPLE	1 Icriodus alternatus	2 Icriodus cymbiformis	3 Polygnathus decorosa	Spathognathodus sp.	4 Polygnathus delicatula	5 Spathognathodus aculeatus	6 Spathognathodus costatus costatus	7 Spathognathodus costatus spinulicostatus	8 Spathognathodus costatus ultimus	9 Spathognathodus costatus subsp. indet. (broken specimens)	10 Spathognathodus inornatus	11 Spathognathodus stabilis	12 Polygnathus communis communis	13 Polygnathus nodomarginata	14 Polygnathus longipostica	15 Polygnathus inornata	16 Polygnathus cf. P. communis communis	17 Polygnathus communis carina	18 Pseudopolygnathus dentilineata	19 Siphonodella obsoleta	Siphonodella sp. indet. (broken specimens)	20 Pseudopolygnathus triangula pinnata	21 Scaliognathus anchoralis	22 Gnathodus punctatus	23 Gnathodus cuneiformis	24 Gnathodus semiglaber	25 Gnathodus delicatus s.l.	26 Gnathodus cf. G. cuneiformis	27 Gnathodus antetexanus	28 Gnathodus typicus	ZONE OR AGE
LL (Fig. 35)	LL 6											/	O											·		/	/	/	/	·		anchoralis Zone
PE (Fig. 33)	PE 5												●													/	O		O	●	/	anchoralis-bilineatus Interregnum
	PE 4													Oj			●	·	/	O↑	· j	/	●		/? x	●	●	■				anchoralis Zone
	PE 3						/				/		/	O		/	/															kockeli-dentilineata Zone
	PE 2					O	/j	/	/	·				/	·? x																	Middle to Upper costatus Zone
	PE 1b					/		/				·	·	O	·																	
	PE 1a					O	/	·			/	/	/	O	/	/? x				· cf												
	PE 1	O	/	●	·																											Frasnian

Fig. 36. Distribution chart of Asturias, coastal area.

Table 4 Alphabetic index of the distribution chart of Asturias, coastal area (Fig. 36)

27	*Gnathodus antetexanus* Rexroad & Scott	15	*Pol. inornata* E. R. Branson
23	*G. cuneiformis* Mehl & Thomas	14	*Pol. longipostica* Branson & Mehl
26	*G.* cf. *G. cuneiformis* Mehl & Thomas	13	*Pol. nodomarginata* E. R. Branson
25	*G. delicatus* Branson & Mehl s.l.	18	*Pseudopolygnathus dentilineata* E. R. Branson
22	*G. punctatus* (Cooper)	20	*Ps. triangula pinnata* Voges
24	*G. semiglaber* Bischoff	21	*Scaliognathus anchoralis* Branson & Mehl
28	*G. typicus* Cooper	19	*Siphonodella obsoleta* Hass
1	*Icriodus alternatus* Branson & Mehl	5	*Spathognathodus aculeatus* (Branson & Mehl)
2	*I. cymbiformis* Branson & Mehl	6	*Sp. costatus costatus* (E. R. Branson)
12	*Polygnathus communis communis* Branson & Mehl	7	*Sp. costatus spinulicostatus* (E. R. Branson)
17	*Pol. communis carina* Hass	8	*Sp. costatus ultimus* Bischoff
16	*Pol.* cf. *P. communis communis* Branson & Mehl	9	*Sp. costatus* (E. R. Branson) subsp. indet.
3	*Pol. decorosa* Stauffer	10	*Sp. inornatus* (Branson & Mehl)
4	*Pol. delicatula* Ulrich & Bassler	11	*Sp. stabilis* (Branson & Mehl)

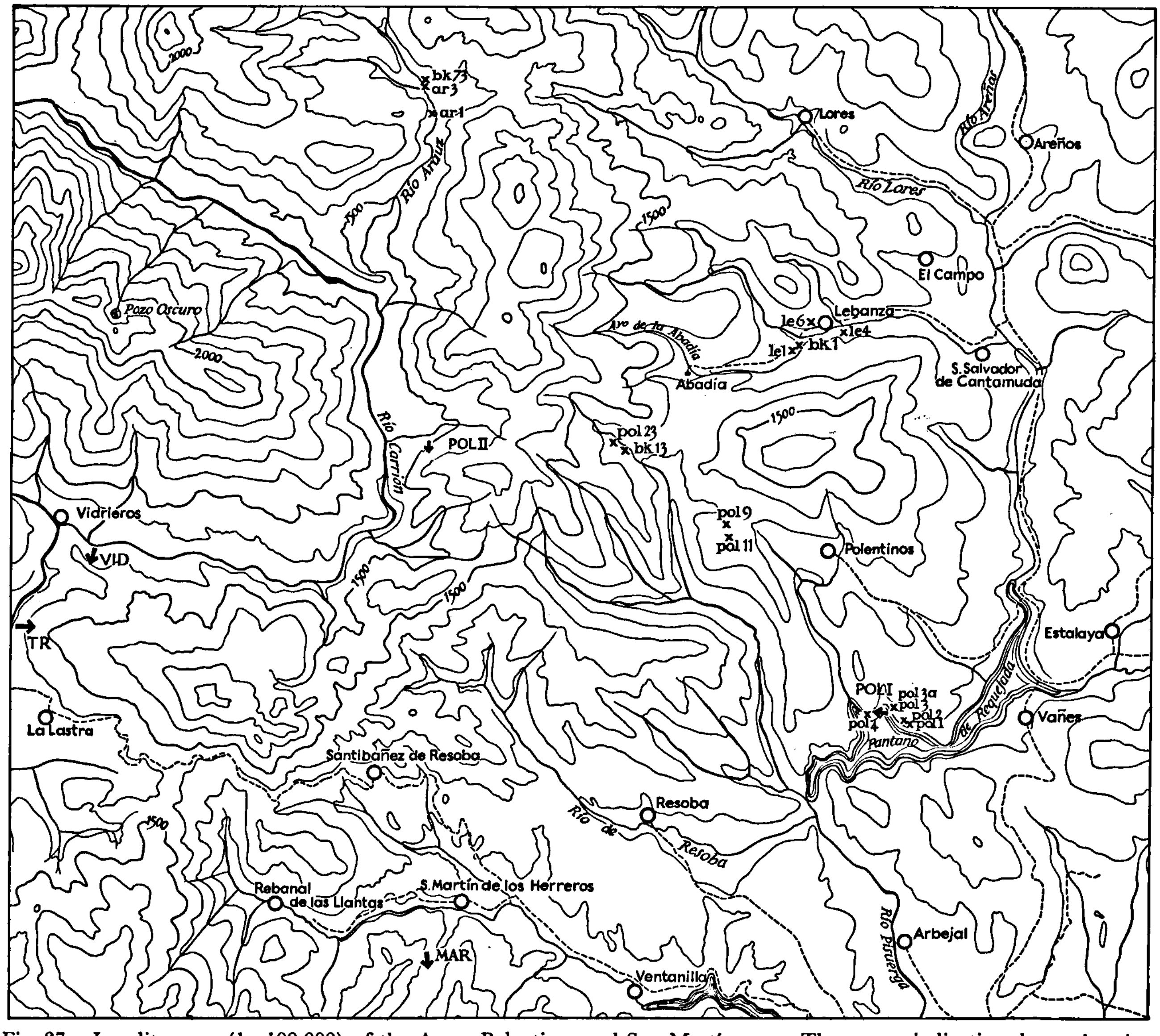

Fig. 37. Locality map (1 : 100,000) of the Arauz-Polentinos and San Martín areas. The arrows indicating the section sites point toward the youngest part of the sequence.

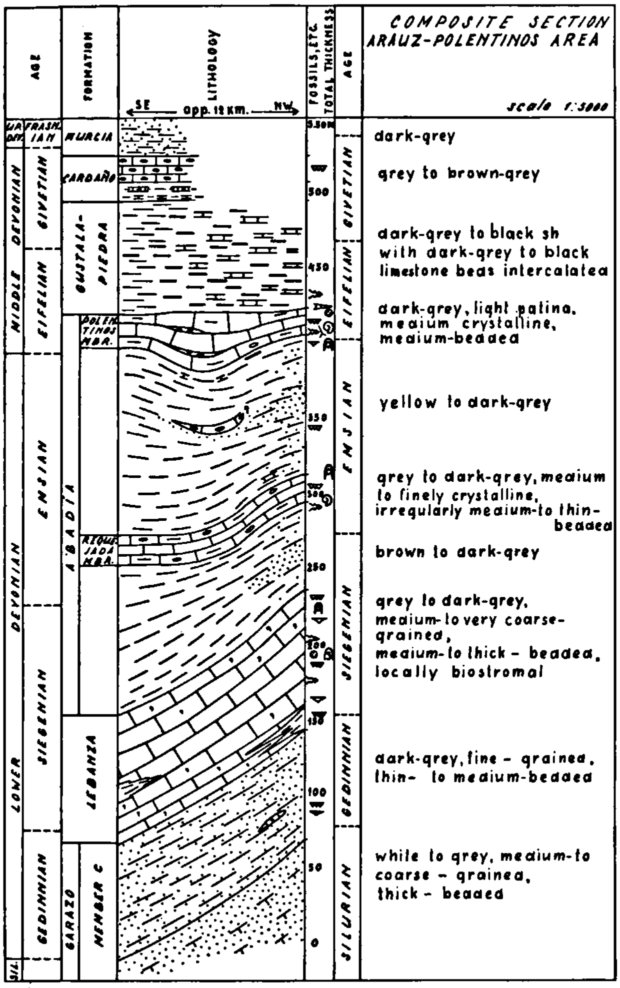

Fig. 38. Composite section of the Arauz-Polentinos area.

Table 5 Alphabetic index of the distribution chart of the Arauz-Polentinos area (Fig. 41)

6	*Hindeodella priscilla* Stauffer
18	*Icriodus corniger* Wittekindt
23	*I. cymbiformis* Branson & Mehl
22	*I. eslaensis* n.sp
15	*I. expansus* Branson & Mehl
3	*I. latericrescens latericrescens* Branson & Mehl (*sensu* Ziegler, 1956)
4	*I. latericrescens bilatericrescens* Ziegler
14	*I. nodosus* (Huddle)
1	*I. woschmidti* Ziegler
8	*Neoprioniodus bicurvatus* (Branson & Mehl)
9	*Ozarkodina typica denckmanni* Ziegler
7	*Pelekysgnathus serrata* Jentzsch
12	*Plectospathodus* sp. indet.
19	*Polygnathus angusticostata* Wittekindt
20	*Pol. angustipennata* Bischoff & Ziegler
17	*Pol. linguiformis linguiformis* Hinde
21	*Pol. varca* Stauffer
16	*Pol. webbi* Stauffer
10	*Spathognathodus inclinatus wurmi* Bischoff & Sannemann
11	*Sp. steinhornensis steinhornensis* Ziegler
2	*Sp. steinhornensis* Ziegler subsp. indet.
13	*Trichonodella symmetrica* (Branson & Mehl)
5	n.gen. *A* n.sp. *a*

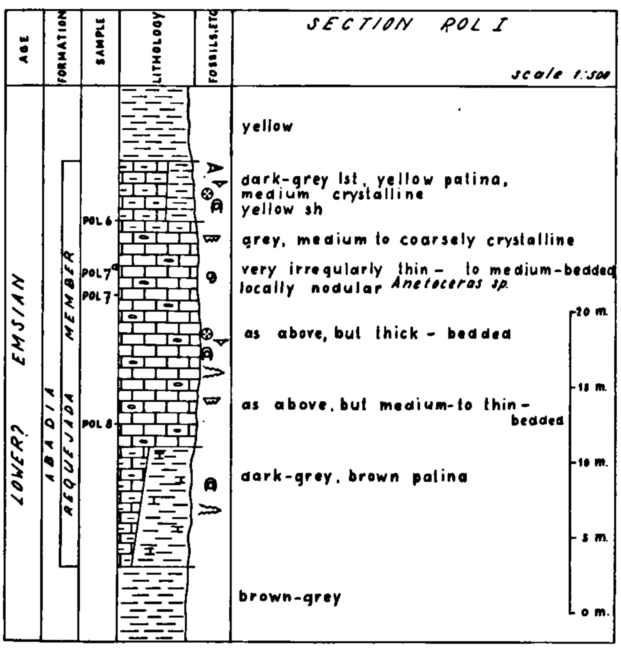

Fig. 39. Section POL I.

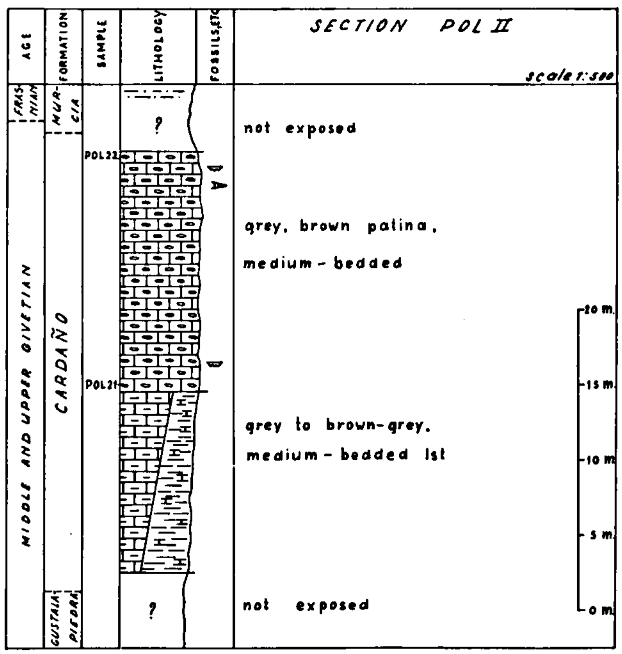

Fig. 40. Section POL II.

DISTRIBUTION CHART ARAUZ - POLENTINOS AREA

Unit	SAMPLE	1 Icriodus woschmidti	2 Spathognathodus steinhornensis subsp. indet.	3 Icriodus latericrescens latericrescens (sensu Ziegler, 1956)	4 Icriodus latericrescens bilatericrescens	Icriodus sp. indet. (broken specimens)	5 n.gen. A n.sp. a	6 Hindeodella priscilla	7 Pelekysgnathus serrata	8 Neoprioniodus bicurvatus	9 Ozarkodina typica denckmanni	10 Spathognathodus inclinatus wurmi	11 Spathognathodus steinhornensis steinhornensis	12 Plectospathodus sp. indet.	13 Trichonodella symmetrica	14 Icriodus nodosus	15 Icriodus expansus	16 Polygnathus webbi	17 Polygnathus linguiformis linguiformis	Polygnathus sp. indet. (broken specimens)	18 Icriodus corniger	19 Polygnathus angusticostata	20 Polygnathus angustipennata	21 Polygnathus varca	22 Icriodus eslaensis	23 Icriodus cymbiformis	DISTACODIDAE	other PRIONIODIDAE and PRIONIODINIDAE	ZONE OR AGE
Section POL II (Fig. 40)	POL 22					/										· cf			O					O	O	/		O	varca Zone s.l.
	POL 21																		/	/				/ ? x	·			O	varca Zone s.l.?
Abadía Formation: Polentinos Member	ar 3					·															· j ?		· x ?				O		lower bidentatus Zone?
	pol 9					O														·	O	· j x ?					/	·	upper? corniger Zone
	pol 11					O															/						●	/	corniger Zone
Abadía Formation: nodular limestone lens or tongue	pol 23					·													· x	·									Conod.-Bereich XI? (upper Emsian?)
	bk 13															/	/	·	·								·	+	
Abadía Formation: Section POL I (Fig. 39)	POL 6			/	O	●					/ x ?		O			·											O	+	Conod.-Bereich X or XI (lower? Emsian)
	POL 7a				O	O									·												O		
	POL 7			O	/	O					/		O														●	/	
	POL 8			O	O	●																					O		
Abadía Formation: Requejada Member	bk 73					·					·		O	· j x													O		
	bk 6												/														/		
uppermost part of the Lebanza Formation	pol 3a			/		●						· j															/	+	middle Siegenian
	pol 3			/		O			/																		●		
	le 1			·		/																							
	bk 1			/	/	/																					/		
middle part of the Lebanza Formation	le 6		· j	/		●			O																		/		lower Siegenian?
lower part of the Lebanza Formation	pol 2		: ? j	O	/	O			■																		■	/	lower Siegenian to upper Gedinnian
	le 4		/ j	O	/					·																	●	/	
lowermost part of the Lebanza Formation	pol 1		/ j	O	/	●	/	·	●		·																●		
limestone lens in the Carazo Formation, Member c	ar 1	O	/ x ?			O																					/		woschmidti Zone

Fig. 41. Distribution chart of the Arauz-Polentinos area.

The Cardaño-Triollo area

locality map, Fig. 42
composite section, Fig. 43
sections, Figs. 44—47
distribution chart, Enclosure no. 4
Table 6

The Devonian of the Cardaño-Triollo area also belongs to the Palentine facies type. The area has been described in detail by van Veen (1965). The formations are often strongly isoclinally folded and affected by cleavage (Fig. 48). Conodonts recovered from the cleaved limestones are sometimes strongly deformed (Plate 2, Figs. 5, 6). Some of these deformed faunas are bleached to a light-grey colour. Because of tectonic complications it was impossible to obtain a complete, reliable section of the Vidrieros Formation. The basal part of this unit is so little calcareous in the northern part of the area that no adequate conodont faunas could be extracted there. In the uppermost part of the Vidrieros Formation in section TR, samples were taken close together to obtain data concerning the Devonian/Carboniferous boundary (see Ch. III, pp. 157—158).

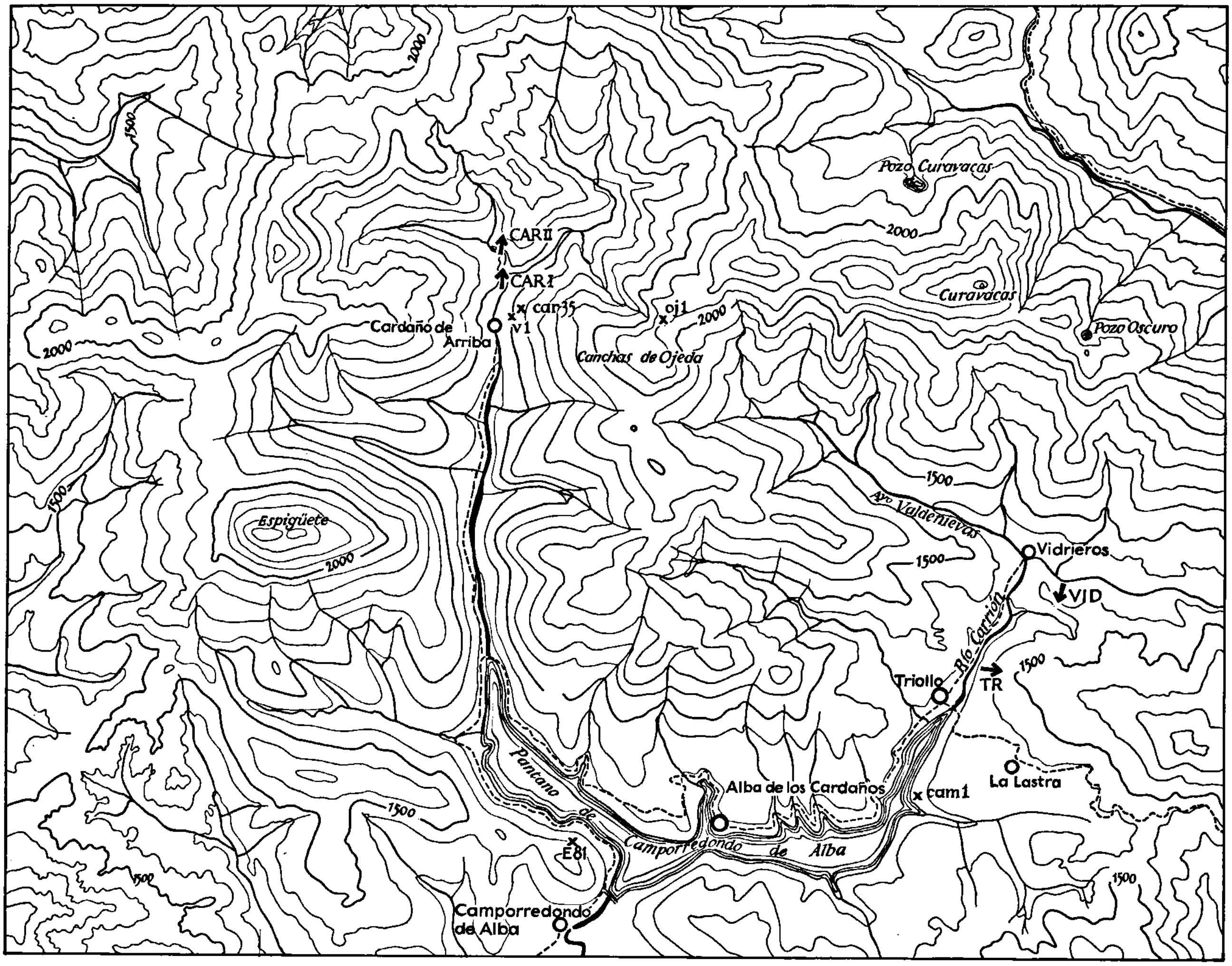

Fig. 42. Location map (1 : 100,000) of the Cardaño-Triollo area. The arrows indicating the section sites point toward the youngest part of the sequence.

Table 6 Alphabetic index of the distribution chart of the Cardaño-Triollo area (Enclosure 4)

30 *Ancyrodella buckeyensis* Stauffer
25 *Ancyrodella curvata* (Branson & Mehl)
20 *Ancyrodella lobata* Branson & Mehl
14 *Ancyrodella rotundiloba rotundiloba* (Bryant)
32 *Ancyrodella asymmetrica* (Ulrich & Bassler)
26 *Ancyrognathus triangularis* Youngquist
4 *Belodus* sp.
73 *Gnathodus bilineatus* (Roundy)
74 *G. commutatus commutatus* (Branson & Mehl)
80 *G. commutatus cruciformis* Clarke
77 *G. commutatus homopunctatus* Ziegler
79 *G. commutatus multinodosus* Higgins
78 *G. commutatus nodosus* Bischoff
72 *G. delicatus* Branson & Mehl s.l.
75 *G. girtyi* Hass
64 *G. kockeli* Bischoff
65 *G.* sp. A Collinson, Scott & Rexroad
29 *Icriodus alternatus* Branson & Mehl
1 *I. corniger* Wittekindt
22 *I. curvatus* Branson & Mehl
2 *I. cymbiformis* Branson & Mehl
8 *I. eslaensis* n.sp.
18 *I. expansus* Branson & Mehl
17 *I. nodosus* (Huddle)
5 *I.* cf. *I. obliquimarginatus* Bischoff & Ziegler
21 *I. symmetricus* Branson & Mehl
48 *Palmatolepis distorta* Branson & Mehl
28 *Pal. gigas* Miller & Youngquist
41 *Pal. glabra glabra* Ulrich & Bassler
40 *Pal. glabra elongata* Holmes
35 *Pal. gracilis gracilis* Branson & Mehl
31 *Pal. hassi* Müller & Müller
42 *Pal. minuta minuta* Branson & Mehl
53 *Pal. minuta schleizia* Helms
44 *Pal. perlobata schindewolfi* Müller
49 *Pal. perlobata sigmoidea* Ziegler
43 *Pal. quadrantinodosa marginifera* Ziegler
50 *Pal. rugosa ampla* Müller
27 *Pal. subrecta* Miller & Youngquist
23 *Polygnathus amana* Müller & Müller

Table 6 Continued

36	*Pol. communis communis* Branson & Mehl	34	*Pol. subserrata* Branson & Mehl
12	*Pol. cristata* Hinde	7	*Pol. varca* Stauffer
19	*Pol. decorosa* Stauffer	52	*Scaphignathus velifera* Ziegler
16	*Pol. dengleri* Bischoff & Ziegler	9	*Schmidtognathus hermanni* Ziegler
38	*Pol. diversa* Helms	10	*Sch. peracuta* (Bryant)
6	*Pol.* cf. *P. eiflia* Bischoff & Ziegler	11	*Sch. wittekindti* Ziegler
71	*Pol. flabella* Branson & Mehl	66	*Pseudopolygnathus dentilineata* E. R. Branson
39	*Pol. glabra glabra* Ulrich & Bassler	60	*Ps. fusiformis* Branson & Mehl
47	*Pol. glabra bilobata* Ziegler	67	*Ps. multistriata* Mehl & Thomas
70	*Pol. inornata* E. R. Branson	55	*Spathognathodus aculeatus* (Branson & Mehl)
3	*Pol. linguiformis linguiformis* Hinde	45	*Sp. amplus* (Branson & Mehl)
62	*Pol. longipostica* Branson & Mehl	69	*Sp. anteposicornis* Scott
33	*Pol. nodocostata nodocostata* Branson & Mehl	76	*Sp. campbelli* Rexroad
51	*Pol.* ex. gr. *P. nodocostata* Branson & Mehl	56	*Sp. costatus costatus* (E. R. Branson)
61	*Pol. nodomarginata* E. R. Branson	57	*Sp. costatus spinulicostatus* (E. R. Branson)
24	*Pol. normalis* Miller & Youngquist	63	*Sp. costatus ultimus* Bischoff
68	*Pol.* cf. *P. obtecta* Branson & Mehl	58	*Sp. costatus* (E. R. Branson) subsp. indet.
13	*Pol. pennata* Hinde	54	*Sp. inornatus* (Branson & Mehl)
37	*Pol.* cf. *P. pennatuloidea* Holmes	59	*Sp. stabilis* (Branson & Mehl)
15	*Pol.* cf. *P. rugosa* Huddle	46	*Sp. strigosus* (Branson & Mehl)

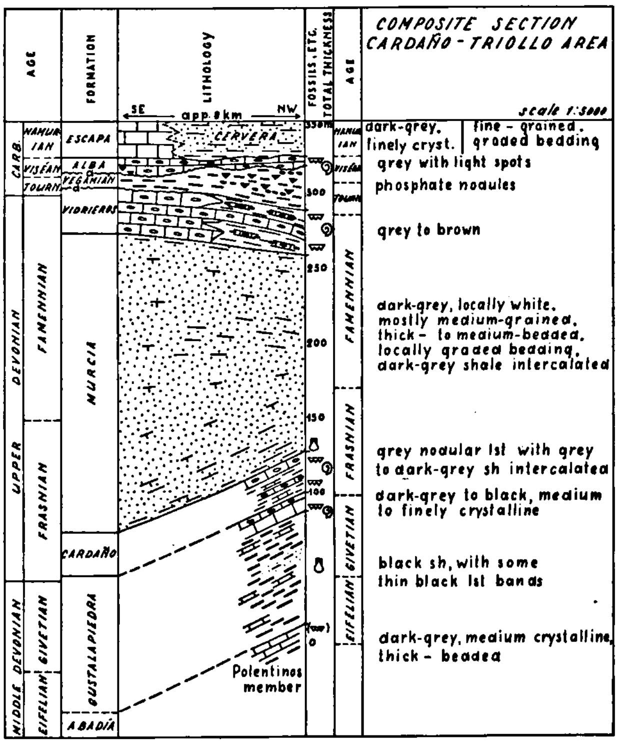

Fig. 43. Composite section of the Cardaño-Triollo area.

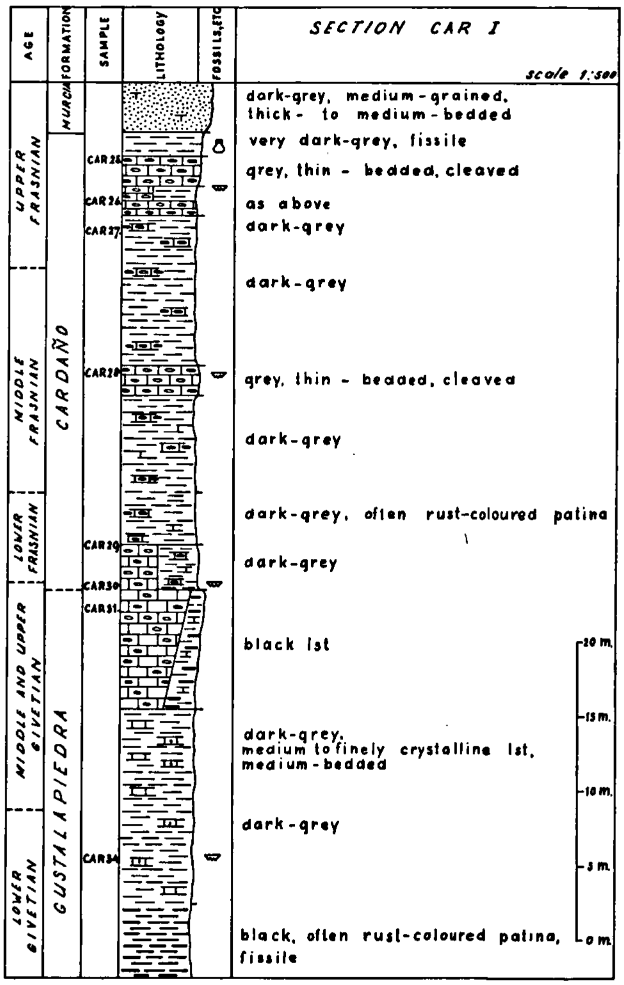

Fig. 44. Section CAR I.

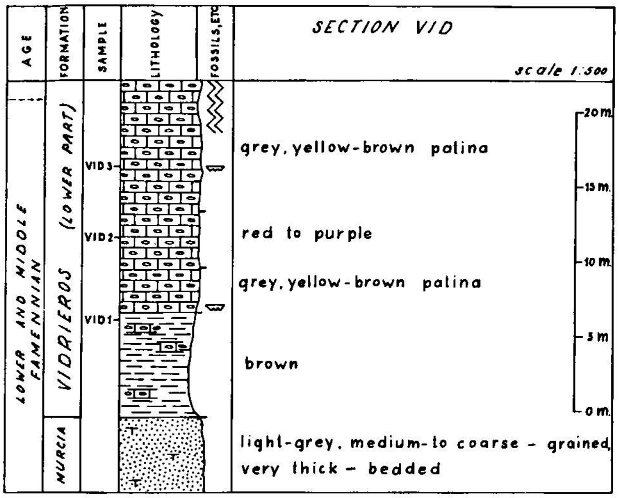

Fig. 45. Section VID.

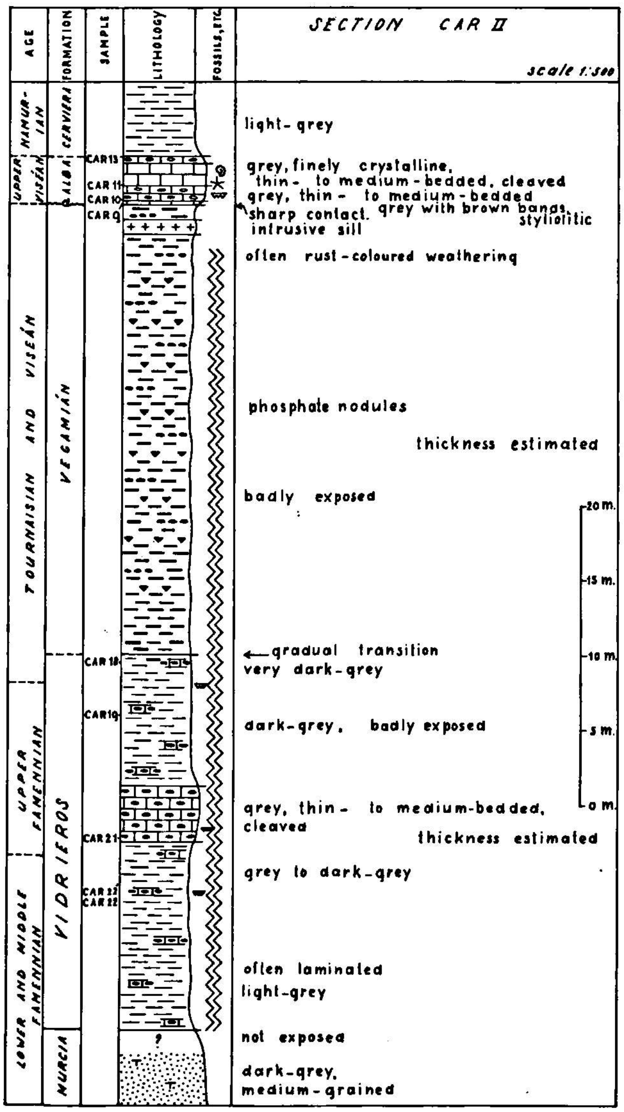

Fig. 46. Section CAR II.

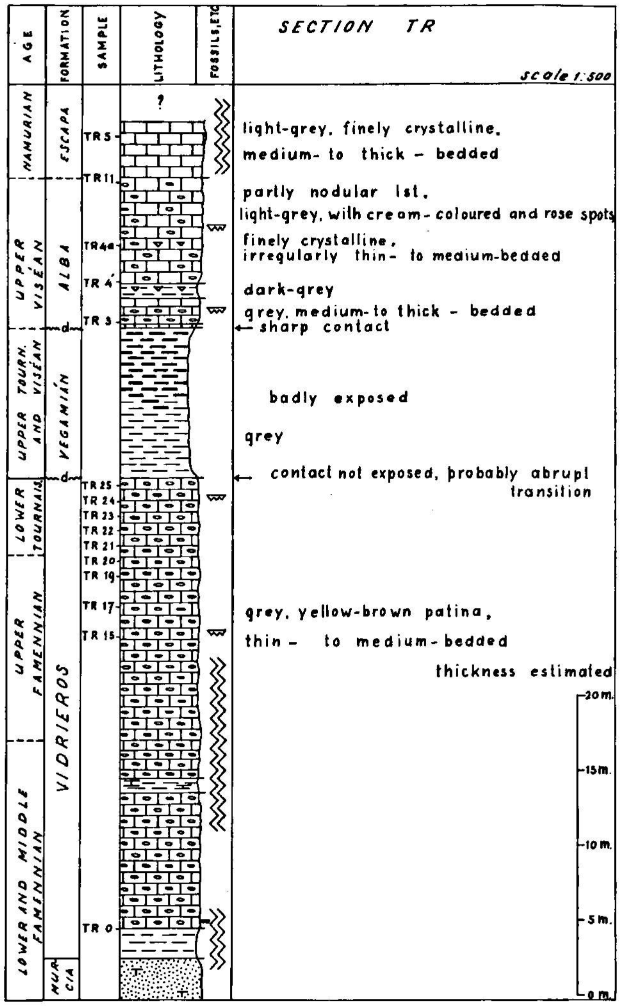

Fig. 47. Section TR.

Fig. 48. Cleaved nodular limestone of the Vidrieros Formation in section CAR II. The handle of the hammer lies perpendicular to the cleavage plane.

The San Martín-Valsurvio area

locality map, Figs. 37, 42
section, Fig. 49
distribution chart, Fig. 50

Only a few observations were made in this region, which is part of the Asturo-Leonese facies area. The properties of the Devonian/Carboniferous transition were studied near San Martín de los Herreros and around the Pantano de Camporredondo; for a full description, the reader is referred to Kanis (1956) and Koopmans (1962).

The Alba Formation in section MAR (Fig. 49) begins almost directly with limestone. South of Triollo, near the Pantano de Camporredondo, this formation starts with 2 m of red, somewhat cherty shale overlying a few metres of quartzitic sandstone of the Ermita Formation. The shale is followed by 4 m of red, nodular limestone (griotte). Sample cam 1 comes from the basal part of this limestone. The succession continues with 4 m of grey, nodular limestone on which the dark, fine-grained, well-bedded limestone of the Escapa Formation follows.

We have taken this opportunity to present a revised version of the conodont fauna mentioned by Koopmans (1962, p. 146) from locality E 81 in the Valcovero Formation.

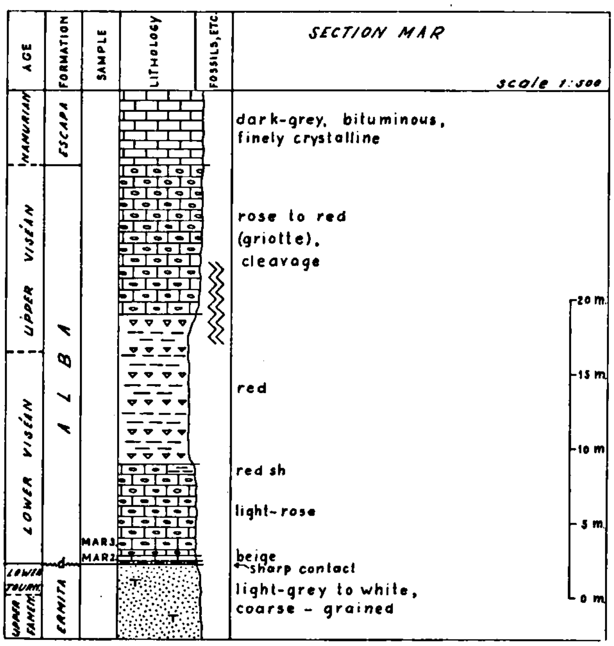

Fig. 49. Section MAR.

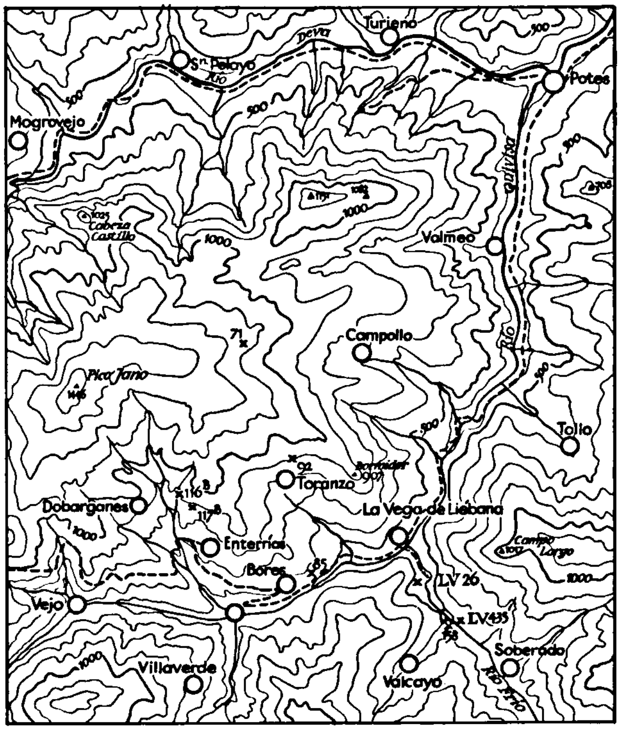

Fig. 51. Locality map of the Liébana area.

	SAMPLE	Icriodus eslaensis	Icriodus cf. I. curvatus	Icriodus cymbiformis	Icriodus expansus	Icriodus nodosus	Polygnathus linguiformis linguiformis	Polygnathus varca	Polygnathus inornata	Polygnathus symmetrica	Pseudopolygnathus triangula pinnata	Spathognathodus stabilis	Gnathodus cuneiformis	Gnathodus cf. G. cuneiformis	Gnathodus antetexanus	Gnathodus semiglaber	Gnathodus delicatus s.l.	Gnathodus commutatus commutatus	Gnathodus bilineatus	Gnathodus cf. G. girtyi	DISTRIBUTION CHART SAN MARTÍN - VALSURVIO AREA ZONE
Alba Formation	CAM 1																· ? ×	·	/	/	bilineatus-delicatus s.l. Zone
Section MAR (Fig. 49)	MAR 3											·	/	/	/	/					anchoralis-bilineatus Interregnum
	MAR 2								/	/	O	O	·	·	/						anchoralis Zone
Valcovero Formation	E 81	O	·	/	· ?	/	/	O×													varca Zone s.l.

Fig. 50. Distribution chart of the San Martín-Valsurvio area.

SANTANDER, THE LIÉBANA AREA

locality map, Fig. 51
composite section, Fig. 52
distribution chart, Fig. 53
Table 7

The Devonian in the Liébana is exposed in a tectonically strongly disturbed, anticlinal structure, surrounded by Upper Carboniferous formations. It belongs to the Palentine facies type. The Devonian formations are too deformed and the outcrops too scarce to allow reliable measurement of complete stratigraphic sections. Mr. R. W. Lanting, who mapped the area, provided a number of samples from which the formations present could be dated roughly and a stratigraphic column could be reconstructed (Fig. 52).
The oldest sample from this area, sample 85, derives from a succession of dark-grey limestones and black shales. Lithologically, this unit shows affinities with the Gustalapiedra Formation, but its isolated occurrence makes it uncertain whether it belongs to this formation. The Alba Formation is absent in the Liébana. Only a few, thin, detrital limestone bands occur in the Potes Formation, i.e. the rock unit that overlies the Vegamián Formation.

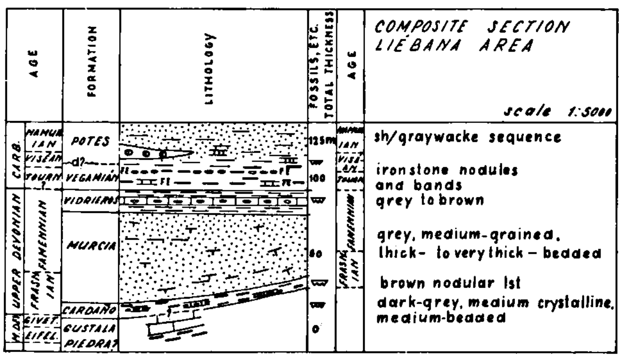

Fig. 52. Composite section of the Liébana area.

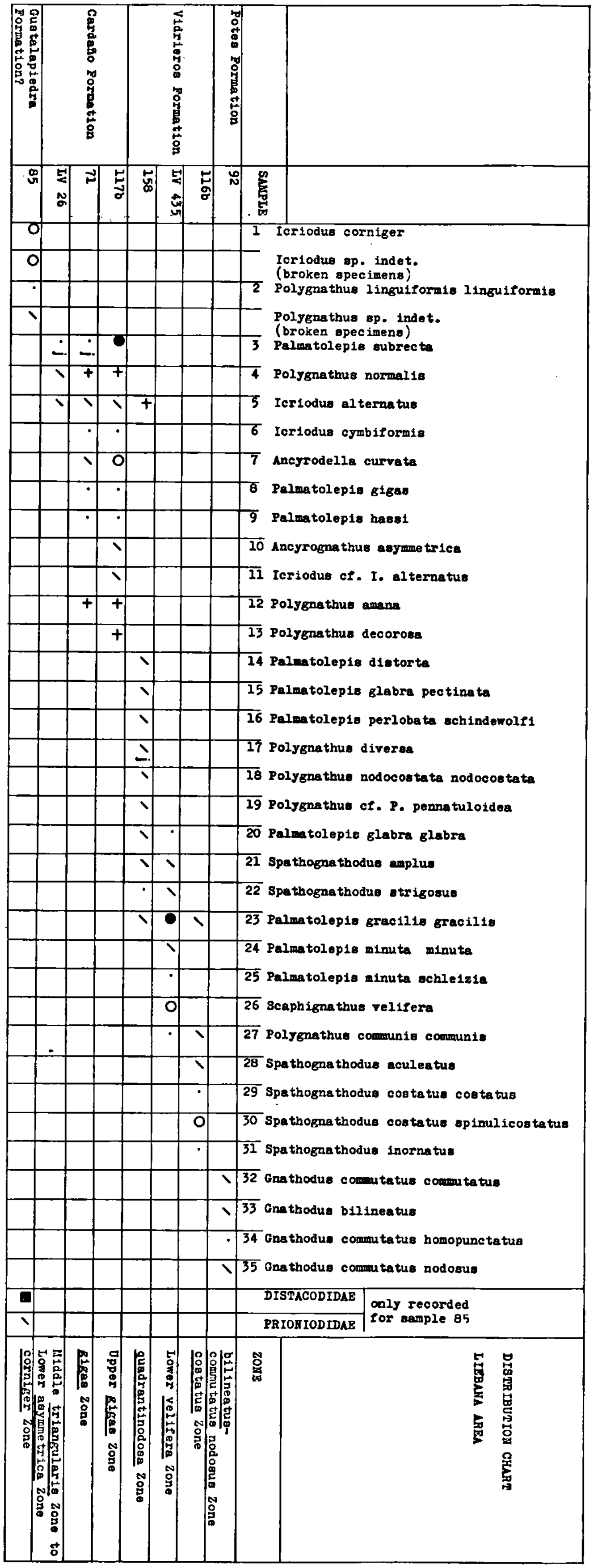

Fig. 53. Distribution chart of the Liébana area.

Table 7 Alphabetic index of the distribution chart of the Liébana area (Fig. 53)

7	*Ancyrodella curvata* (Branson & Mehl)	16	*Pal. perlobata schindewolfi* Müller
10	*Ancyrognathus asymmetrica* (Ulrich & Bassler)	3	*Pal. subrecta* Miller & Youngquist
33	*Gnathodus bilineatus* (Roundy)	12	*Polygnathus amana* Müller & Müller
32	*G. commutatus commutatus* (Branson & Mehl)	27	*Pol. communis communis* Branson & Mehl
34	*G. commutatus homopunctatus* Ziegler	13	*Pol. decorosa* Stauffer
35	*G. commutatus nodosus* Bischoff	17	*Pol. diversa* Helms
5	*Icriodus alternatus* Branson & Mehl	2	*Pol. linguiformis linguiformis* Hinde
11	*I.* cf. *I. alternatus* Branson & Mehl	18	*Pol. nodocostata nodocostata* Branson & Mehl
1	*I. corniger* Wittekindt	4	*Pol. normalis* Miller & Youngquist
6	*I. cymbiformis* Branson & Mehl	19	*Pol.* cf. *P. pennatuloidea* Holmes
14	*Palmatolepis distorta* Branson & Mehl	26	*Scaphignathus velifera* Ziegler
8	*Pal. gigas* Miller & Youngquist	28	*Spathognathodus aculeatus* (Branson & Mehl)
20	*Pal. glabra glabra* Ulrich & Bassler	21	*Sp. amplus* (Branson & Mehl)
15	*Pal. glabra pectinata* Ziegler	29	*Sp. costatus costatus* (E. R. Branson)
23	*Pal. gracilis gracilis* Branson & Mehl	30	*Sp. costatus spinulicostatus* (E. R. Branson)
9	*Pal. hassi* Müller & Müller	31	*Sp. inornatus* (Branson & Mehl)
24	*Pal. minuta minuta* Branson & Mehl	22	*Sp. strigosus* (Branson & Mehl)
25	*Pal. minuta schleizia* Helms		

CHAPTER III

ZONATION AND DATING OF THE STRATIGRAPHIC SEQUENCE BY MEANS OF CONODONTS

THE BIOSTRATIGRAPHIC FRAMEWORK

The conodont zones established in Europe by Böger (1962), Voges (1959, 1960), Walliser (1962, 1964), Wittekindt (1966), and Ziegler (1962b, 1966), proved to be a valuable basis for arranging and dating the conodont faunas obtained from the Cantabrian Mountains. Enclosure 5 shows the conodont zones referred to in this paper. A few remarks about this chart are required. Apart from the *woschmidti* Zone, well-defined conodont zones have not yet been established in the Lower Devonian. A rough subdivision into "Conodont-Bereiche" has been given by Walliser (1962). The upper Givetian *transversa* Zone could not be demonstrated in the Cantabrian Mountains. *Polygnathus linguiformis transversa* Wittekindt, 1966 was never found in our faunas with *Polygnathus varca*, a number of which certainly must have an upper Givetian age. It is conceivable that the distribution of *Polygnathus linguiformis transversa* is restricted to northern Europe. We refer to the combined range of the *varca* Zone and the *transversa* Zone of Wittekindt (1966) as the *varca* Zone *s.l.*
The comparison of the Lower Carboniferous zones with the Tournaisian and Viséan stages, as presented here, is partly after Voges (1959) and Böger (1962) and partly after Conil, Lys, and Mauvier (1964). The latter authors showed that the *anchoralis* Zone is present in the Franco-Belgian Basin in assise Tn 3b (upper Tournaisian). Since a more detailed report on the repartition of conodonts in the Lower Carboniferous of this basin is in preparation (Mauvier & Lys, Mém. Inst. Geol. Univ. de Louvain, in prep.), the correlation of this part of the Carboniferous from the Ardennes and the Kulm facies area may have to be revised to some extent.
The *bilineatus* Range Zone is split up into two assemblage zones. The *bilineatus-delicatus* s.l. Zone is characterized by the concurrence of *Gnathodus bilineatus* and *Gnathodus delicatus* s.l. without *Gnathodus commutatus nodosus*, and can be divided into a lower and an upper part by the presence or absence of *Gnathodus semiglaber* and/or *Gnathodus typicus* and/or *Gnathodus cuneiformis* and/or *Gnathodus antetexanus* (compare *bilineatus* Zone + *semiglaber* + *texanus* of Böger, 1962).
The *bilineatus-commutatus nodosus* Zone is defined by the concurrence of *Gnathodus bilineatus* and *Gnathodus commutatus nodosus;* it can be divided into a lower and an upper part by the presence or absence of *Gnathodus delicatus* s.l.
The relation of these zones to the Viséan and Namurian Stages is tentatively derived from the literature mentioned (see Enclosure 5).

CONODONT ZONES DEMONSTRATED IN THE CANTABRIAN MOUNTAINS

The lowermost Gedinnian *woschmidti* Zone is represented in sample ar 1 from a limestone lens in the upper part of the Carazo Formation (Arauz-Polentinos area) by *Icriodus woschmidti.*

Icriodus latericrescens latericrescens (*sensu* Ziegler, 1956) and *Icriodus latericrescens bilatericrescens* are generally well represented in the Lower Devonian samples discussed below.

The conodont faunas from the lower part of the La Vid Formation (Río Esla area) and the Lebanza Formation (Arauz-Polentinos area) do not contain conodonts diagnostic for one of the Conodont-Bereiche. They are characterized by *Pelekysgnathus serrata*, which is especially abundant in the lower part of the abovementioned units. Its exact range is not known; Jentzsch (1962) indicated a Lower Devonian age in Thüringen, whereas Le Fevre (1965) mentioned it from the "Devonian basal" (Gedinnian) in France and the Sahara. Binnekamp (1965) showed on the basis of brachiopods that the lower part of the Lebanza Formation has an upper Gedinnian to lower Siegenian age and that the upper part has a middle Siegenian age. So *Pelekysgnathus serrata* ranges well into the Siegenian.

Conodont-Bereich X is probably represented in the samples from the uppermost part of the basal limestones of the La Vid Formation (Río Esla area), because in this level *Polygnathus linguiformis linguiformis* (with a large pulp cavity; see Plate 3, Fig. 1) appears for the first time. Bar-type and blade-type conodonts are absent, however.

The faunas from the Requejada Member of the Abadía Formation (Arauz-Polentinos area) may belong either to Conodont-Bereich X or to Conodont-Bereich XI. They lack *Polygnathus linguiformis linguiformis*, but show few bar-type conodonts. The cephalopod content of the Requejada Member, according to Kullmann (1960, Arruz Schichten), points to a lower Emsian age. However, after visiting the Arauz area Prof. Dr. O. H. Walliser (pers. comm.), came to the conclusion that the cephalopods from this unit indicate an upper Emsian age. Until a final solution of this problem has been reached, we shall indicate the age of the Requejada Member as lower? Emsian. In Fig. 38 and Enclosure 6 this member is still placed in the lower Emsian.

Conodont-Bereich XI is represented in the limestone band in the lower part of the predominantly shaly portion of the La Vid Formation (Río Esla area). It is remarkable that only two samples from this level yielded *Polygnathus linguiformis linguiformis*. Bar-type and blade-type conodonts are absent. This Conodont-Bereich is possibly also represented in the nodular limestone lens or tongue in the Abadía Formation (Arauz-Polentinos area).

The upper part of the La Vid Formation and the basal part of the Santa Lucía Formation (Río Esla area) yielded as characteristic species *Icriodus* cf. *I. corniger*. This species, according to Dr. O. H. Walliser (pers. comm.), occurs in the Rhenan upper Emsian to lower Couvinian. Therefore, the upper part of the la Vid Formation and the basal part of the Santa Lucía Formation may probably be placed in the uppermost Emsian in the Hercynian sense.

From the Middle Devonian on, well-defined conodont zones are available. The *corniger* Zone is represented by *Icriodus corniger* in the uppermost part of the Santa Lucía Formation in the Río Esla area, the Polentinos Member of the Abadía Formation in the Arauz-Polentinos area, the Cardaño-Triollo area, and probably in the Gildar-Montó area. The oldest sample from the Liébana area, sample 85, (Gustalapiedra Formation?), also belongs to this zone.

The lower part of the *bidentatus* Zone may be represented in sample ar 3, in which *Icriodus corniger* and *Polygnathus angustipennata* were questionably identified.

The *robusticostata* Zone is probably represented in sample CAR 34 from the Gustalapiedra Formation (Cardaño-Triollo area), which contains *Polygnathus* cf. *P. eiflia* together with *Polygnathus varca*. This zone is probably also represented in spot sample cu 20 from the Gustalapiedra Formation in the Gildar-Montó area, which yielded *Polygnathus* cf. *P. robusticostata* and *Polygnathus varca*.

The *varca* Zone *s.l.* is demonstrated in the basal part of the La Portilla Formation (Río Esla area) by *Polygnathus varca*, *Icriodus latericrescens latericrescens* and *Spathognathodus bipennatus*. Wittekindt (1966) reported *Icriodus latericrescens* from the lower bank with "*Terebratula*" *pumilio* in the *discoides*-Kalk in the Hercynian Givetian, just above the "*walliseri* Horizont". *Spathognathodus bipennatus* is known only from the "*Sparganophyllum*-Kalk", which forms the basal part of the Rhenan upper Givetian ("obere Stringscephalenstufe"). The brachiopod fauna collected from the basal part of the La Portilla Formation points to a middle Givetian age (Dr. Th. F. Krans, pers. comm.).

The *varca* Zone *s.l.* is also well represented in the upper part of the Gustalapiedra Formation and the lower part of the Cardaño Formation in the Gildar-Montó area, in the upper part of the Gustalapiedra Formation in the Cardaño-Triollo area, and in the Cardaño Formation in the Arauz-Polentinos area. In these areas this zone is characterized only by *Polygnathus varca*. It seems probable that the distribution of *Icriodus latericrescens latericrescens* and *Spathognathodus bipennatus* is controlled by the facies. The abundance of *Icriodus eslaensis* in the *varca* Zone *s.l.* is remarkable.

The *hermanni-cristata* Zone comprises the transition from Middle to Upper Devonian. It is most probably represented in sample CAR 30 from the lowermost part of the Cardaño Formation (Cardaño-Triollo area), which contains various species of *Schmidtognathus*. Although sample CU 3a from the Cardaño Formation in the Gildar-Montó area lacks *Schmidtognathus*, it may belong to this zone.

The Lower *asymmetrica* Zone is demonstrated in samples cu 6 and cu 18 from the lower to middle part of the Cardaño Formation in the Gildar-Montó area and in sample CAR 29 from the basal part of the Cardaño Formation (Cardaño-Triollo area).

The *gigas* Zone is well represented in the upper part of the Cardaño Formation in the Gildar-Montó area, in the Cardaño-Triollo area, and in the Liébana area.

The faunas from this zone contain ancyrodellids, *Ancyrognathus triangularis*, *Palmatolepis gigas*, and *Palmatolepis hassi*. The presence of *Ancyrognathus assymmetrica* makes it possible to delimit the Upper *gigas* Zone.

In the Asturo-Leonese facies area aberrant Frasnian conodont faunas were recovered from the coarse-grained, detrital limestones from the uppermost part of the La Portilla Formation (Río Esla area) and the limestone from the uppermost part of the Piñeres Sandstone (Asturias, coastal area). These faunas lack the conodonts diagnostic for the Frasnian zones, such as the genera *Ancyrodella*, *Ancyrognathus*, and *Palmatolepis*. Only icriodids and a few polygnathids are present. The distribution of the first of these Frasnian genera appears to be dependent on the facies. A middle Frasnian age must be assigned to the upper part of the La Portilla Formation in the Río Esla area because of the occurrence in it of *Mucrospirifer bouchardi* (Murchison) (Dr. Th. F. Krans, pers. comm).

The Crémenes Limestone (Río Esla area) also yielded a similarly aberrant fauna. Westbroek (1964) suggests, on the basis of its rhynchonellid fauna, that the age of this limestone could fall around the boundary between the Frasnian and Famennian. Dr. Th. F. Krans (pers. comm.) favours an uppermost Frasnian age on the basis of its spiriferid contents.

The *quadrantinodosa* Zone is well represented in the lower part of the Vidrieros Formation in the Gildar-Montó area, the Cardaño-Triollo area, and the Liébana area. Apart from the occurrence of *Palmatolepis quadrantinodosa marginifera* the concurrence of *Palmatolepis glabra glabra* and *Palmatolepis distorta* points to this zone.

The *velifera* Zone is poorly represented in sample CAR 22 from the Cardaño-Triollo area. A good fauna belonging to this zone is found in sample LV 435 from the Liébana area. The presence of *Palmatolepis glabra glabra* together with *Scaphignathus velifera* in this sample suggests that it belongs to the Lower *velifera* Zone.

The Upper *styriaca* Zone to Lower *costatus* Zone is probably represented in sample CAL 12 from the Vidrieros Formation in the Gildar-Montó area with *Spathognathodus jugosus*. The Lower to Middle *costatus* Zone is indicated in the same area by sample kutt 77.

The Middle to Upper *costatus* Zone is well represented in the upper part of the Vidrieros Formation in the Gildar-Montó area, the Cardaño-Triollo area, and the Liébana area. The samples from this part contain as diagnostic elements *Spathognathodus aculeatus*, *Spathognathodus costatus costatus*, *Spathognathodus costatus spinulicostatus*, *Polygnathus longipostica*, and/or *Polygnathus nodomarginata*. The Middle to Upper *costatus* Zone is also represented in the detrital limestone in the upper part of the Ermita Formation in sections AG, IIf, and X in the Río Esla area; sections FE, U, and OS in the central Cantabrian area; and section PE in the Asturian coastal area. It should be noted that *Palmatolepis gracilis gracilis* is absent in these areas, whereas it is frequent in the Palentine facies area. This appears again to be controlled by the facies.

It is difficult to locate the Devonian/Carboniferous boundary exactly by conodonts. The upper and lower limits of the ranges of the Upper Devonian and the Lower Carboniferous zonal guide forms in Europe are not known precisely. The detailed work of Voges (1959) and Ziegler (1962b, p. 42) leaves a small gap in the sequence not tested for conodonts, corresponding to the uppermost Devonian Hangenbergschiefer. Henningsen (1965) describes a continuous Upper Devonian — Lower Carboniferous succession in calcareous rocks from the Lahn syncline (Germany). This section, however, is highly condensed, the "*Gattendorfia*-Stufe" being only 8 cm thick, and therefore a certain degree of condensation is to be expected in the faunas.

The conodont zonation of the Upper Devonian and the Mississippian of the Upper Mississippi Valley given by Collinson *et al.* (1962) cannot be applied directly to the Cantabrian faunas because several of the zonal forms mentioned are not present in the latter. The important species *Gnathodus kockeli*, originally reported from Germany (Bischoff, 1957), occurred in only one of our lowermost Carboniferous faunas. It is difficult to explain to what extent this absence is related to the facies, because even in the nodular limestones of the Vidrieros Formation this gnathodid was generally missing.

An additional problem in the Asturo-Leonese facies area is presented by the transgressive and regressive nature of the thin Ermita Formation, as a result of which mixed faunas would be expected. Stratigraphic admixtures could be caused by reworking of older, pre-Ermita strata, or stratigraphic leaks may have occurred at the top of the Ermita Formation, which locally shows karst features (Fig. 13). Krebs (1964) has discussed the frequent occurrence of mixed conodont faunas in sequences with hiatusses and in condensed sequences.

Section TR (Fig. 47) in the Vidrieros Formation in the Cardaño-Triollo area is highly suitable for the study of the Devonian/Carboniferous transition in the Cantabrian Mountains. Samples TR 15 — TR 20 yielded an ample amount of conodonts of the *Spathognathodus costatus* group and *Palmatolepis gracilis gracilis*, and with the exception of sample TR 15, they also contain *Pseudopolygnathus fusiformis*. Sample TR 21 provided two specimens of the *Spathognathus costatus* group, *Gnathodus kockeli* and *Gnathodus* sp. A Collinson, Rexroad & Scott, 1961, which indicate either the very uppermost Devonian (*Gnathodus* n. sp. A. Assemblage Zone of Collinson *et al.*, 1962) or, more probably, the lowermost Tournaisian *kockeli-dentilineata* Zone. Sample TR 22 contains no gnathodids, but shows *Pseudopolygnathus dentilineata* and a fair number of *Spathognathodus aculeatus*; it lacks *Polygnathus inornata*. Samples TR 23 — TR 25 also lack all gnathodids. They contain as conspicious elements *Polygnathus inornata* and *Polygnathus longipostica*. The occurrence of one juvenile specimen of *Spathognathodus anteposicornis* in sample TR 23 is remarkable. It is clear from their position in

the succession above sample TR 21 that samples TR 22 — TR 25 should all be placed in the *kockeli-dentilineata* Zone, in spite of the absence of zonal guide forms. *Polygnathus communis communis* is well represented throughout the upper part of section TR.
In this paper we shall consider the faunas with *Polygnathus inornata*, *Polygnathus longipostica*, numerous *Polygnathus communis communis*, and occasionally a few *Spathognathodus aculeatus* and/or *Spathognathodus costatus costatus* as being of lowermost Tournaisian age and belonging to the *kockeli-dentilineata* Zone. The higher Tournaisian zones are again well defined by the genus *Siphonodella*. *Polygnathus inornata* already occurs scantily in the *costatus* Zone.
The *kockeli-dentilineata* Zone so interpreted is represented in the uppermost part of the Vidrieros Formation in section CAL II in the Gildar-Montó area and in sections CAR II and TR in the Cardaño-Triollo area. This zone is also demonstrated in the uppermost part of the detrital limestone of the Ermita Formation in sections AG and IIf (Río Esla area). The few specimens of *Gnathodus* in sample IIf 223 and of *Gnathodus* and *Siphonodella* in sample AG 5 are assumed to have leaked in from the base of the overlying Alba Formation. These conodonts have a late Tournaisian to lower Viséan age, but they only occur in the uppermost samples from the sections and no trace of the conodont zones between the *kockeli-dentilineata* Zone and the *Siphonodella crenulata* Zone was found. The *kockeli-dentilineata* Zone is also represented in section U (central Cantabrian area) and section PE (Asturias, coastal area). In sections MA and RI (central Cantabrian area) all the samples from the limestone in the Ermita Formation appear to belong to the *kockeli-dentilineata* Zone. Unfortunately, these conodont faunas from the Ermita Formation are poor and contain many damaged specimens.
The probably lower part of the *anchoralis* zone is represented in sample SJ/H6 from section MA (central Cantabrian area), which yielded an abundant fauna including gnathodids and siphonodellids. This fauna contains many broken conodonts, among them a great number of reworked specimens.
The *anchoralis* Zone is well represented in the basal part of the Alba Formation in the Río Elsa area, in the central Cantabrian area, in Asturias (coastal area), and in section MAR (San Martín-Valsurvio area). *Scaliognathus anchoralis* is not always present in the samples from this zone, but the concurrence of *Gnathodus semiglaber* and *Gnathodus delicatus* with *Pseudopolygnathus triangula pinnata* and/or *Polygnathus communis communis* are also diagnostic for this zone. The absence or scarcity of siphonodellids in these faunas suggests that they belong to the upper part of the *anchoralis* Zone.
The *anchoralis-bilineatus* Interregnum is represented in the lower part of the Alba Formation in the same areas as those in which the *anchoralis* Zone is demonstrated. These areas belong to the Asturo-Leonese facies area.
The *bilineatus-delicatus* s.l. Zone is represented in the upper part of the Alba Formation in the sections studied in the above-mentioned area. This zone was also demonstrated in the basal and lower part of the Alba Formation in section POS (Lower and Upper *bilineatus-delicatus* s.l. Zone) in the Gildar-Montó area and section TR (Upper *bilineatus-delicatus* sl. Zone) in the Cardaño-Triollo area.
The *bilineatus-commutatus nodosus* Zone is well represented in the upper to uppermost part of the Alba Formation in most of the areas where this part was investigated. The basal part of the Alba Formation in sections CAR II (Cardaño-Triollo area) and CU III (Gildar-Montó area) belongs already to the Lower and Upper *bilineatus-commutatus nodosus* Zone, respectively. The *bilineatus-commutatus nodosus* Zone is also present in a detrital limestone band in the Liébana area.

CHAPTER IV

DISCUSSION OF THE NEW DATA WITH RESPECT TO THE DEVONIAN AND THE LOWER CARBONIFEROUS FORMATIONS IN THE CANTABRIAN MOUNTAINS

The new stratigraphic data mentioned in the preceding chapter have increased our knowledge about the age and distribution of the Cantabrian formations. This material will be discussed on the basis of the time-stratigraphic correlation chart of Enclosure 6, in which the data in the literature and our observations are collected. The vertically ruled parts of the columns on the chart indicate stratigraphic gaps.
The authors whose data are incorporated into this chart are indicated in Table 8.

Table 8 Literature consulted for the construction of the time-stratigraphic correlation chart (Enclosure 5)

column 1. Barrois (1882); Comte (1959); Llopis Lladó (1958a, 1962); Radig (1961, 1962).
column 2. Delépine (1928a); Llopis Lladó (1960).
column 3. Almela *et al.* (1956); Budinger & Kullmann (1964); Delépine (1928a); García-Fuente (1959); Grosch (1912).
column 4. Smits (1965).
column 5. Comte (1959); Higgins *et al.* (1964); Lotze (1961); Wagner (1963).
column 6. Comte (1959); Rupke (1965).
column 7. Koopmans (1962).
column 8. Brouwer (1964a); Kanis (1956).
column 9. van Adrichem Boogaert *et al.* (1963); Julivert (1960); Martínez Alvarez (1962); Sjerp (1967).
column 10. van Adrichem Boogaert *et al.* (1963); Sjerp (1967).
column 11. Delépine (1932a); Hernández Sampelayo (1928); Llopis Lladó (1958b).
column 12. van Adrichem Boogaert (1965); Budinger & Kullmann (1964); Kullmann (1960, 1961).
column 13. van Adrichem Boogaert (1965); van Veen (1965).
column 14. Mr. R. W. Lanting (unpublished).
column 15. Binnekamp (1965); Kullmann (1960); de Sitter & Boschma (1966).
column 16. Frets (1965); Wagner (1962); Wagner & Wagner-Gentis (1963).

DEVONIAN (and Lowermost Tournaisian)

The Asturo-Leonese facies area

Few new data can be added to the fundamental work of Comte (1959) on the Devonian formations of this facies area. The conodont faunas recovered from the La Vid, Santa Lucía, and La Portilla Formations in the Río Esla area do not lead to essential changes concerning their age, the only modification being that the Siegenian/Emsian boundary is placed somewhat lower in the sequence. The correlation of the Asturian with the Leonese Lower and Middle Devonian formations has not yet been completely unravelled, but detailed investigation of the lithology and a modern study of the brachiopod and microfossil contents will solve this problem.
The calcareous part of the Ermita Formation yielded interesting conodont faunas which permit a new view of the definition and distribution of this unit.

The Ermita Formation. — The transgressive Ermita Formation, which Comte (1959) studied throughout the Río Bernesga - Río Esla area and in the upper course of the Río Tuiza, is recognized in various other parts of the Cantabrian mountain chain (see Enclosure 5).

Definition and type section. — This formation was originally defined by Comte as "Grès de l'Ermitage". The type section chosen was located on the eastern bank of the Río Bernesga near the Ermita del Buen Suceso, in the vicinity of the village of Huergas. According to Comte's description, the formation consists here of 140 m of yellowish or rose quartzitic sandstone, in beds of variable thickness (Comte, 1959, p. 193).
However, recent investigation of this area, i.e. the Alba syncline, showed that its stratigraphic and sedimentological properties make it unsuitable as type area of the Ermita Formation. Therefore, we suggest that the type section of this unit be changed to the section south of Camplongo, from which Comte (1959, p. 166) gave his first description of the Ermita Formation. This section consists of 2 to 3 metres of calcareous, yellowish to white sandstone (decalcified in the outcrop).

Lithology and thickness. — The lithology of the formation is very variable. The main constituent is medium- to coarse-grained, quartzitic sandstone. Decalcification has often caused a pronounced porosity. The colour can vary from white, via rose, to a true ferruginous red.
Lenses and layers of coarse-grained, rose or grey limestone are often developed in the upper part of the Ermita Formation in the western and southwestern part of the Cantabrian Mountains. The sandstone passes gradually into this limestone. Locally, the detrital limestone forms the dominant rock type of the formation (section RI, Fig. 17; section PE, Fig. 32). A small layer of dispersed pebbles is often found at the base of the Ermita Formation (section U, fig. 19; section LL, Fig. 35).
The thickness is also variable. In the type area designated by Comte (1959) and near the upper course of Río Curueño and the Río Porma (Mr. H. J. Evers, pers. comm.) a thickness of more than 100 m is attained. In most other areas the Ermita Formation has a thickness of 1 to 40 m. The bedding is usually not distinct, giving a massive appearance to the formation. Occasional crossbedding is observed.

Age. — Comte (1959) described fossiliferous beds at the top of the Ermita, containing as diagnostic elements: *Spirifer verneuili* Murchison, *Cleiothyris royssii* Léveillé, *Camarotoechia letiensis* Gosselet, and *Pugnax moresnetensis* Koninck. He pointed out that especially *Pugnax moresnetensis* indicates an uppermost Famennian (= Strunian) age. In the lower part of the Ermita, in places where this formation attains considerable thickness, Comte found only *Spirifer verneuili* and *Camarotoechia letiensis*, which do not permit an equally precise age determination. In the southern part of the Alba syncline, near Peredilla, he identified, with some reservations, *Cleiothyris lamellosa* Léveillé, which might even indicate Tournaisian affinities (Comte, 1959, p. 315).

The brachiopods from the Ermita Formation near the watershed of the Cantabrian Cordillera, identified by Krans (van Adrichem Boogaert *et al.*, 1963), also indicate an uppermost Famennian age. A subsequently sampled, well-preserved brachiopod fauna from the Riosol area (section RI, Fig. 13)), however, points to a possible lower Tournaisian age (Dr. Th. F. Krans, pers. comm.).

Conodont faunas from the basal part of the Ermita Formation in section PE (Fig. 23) from the Asturian coast indicate an uppermost Famennian age (uppermost to V — to VI). The basal fauna from the Ermita Formation in section RI (Fig. 17) located in the Riosol area points to a lowermost Tournaisian age, which indicates that the base of the Ermita Formation is diachronous. This feature is difficult to study in more detail, because the basal part of the Ermita Formation is rarely calcareous, making it impossible to extract conodonts from it.

In most of the areas studied, the uppermost part of the Ermita Formation extends into the lowermost Tournaisian. Higgins *et al.* (1964) even concluded for the top of their Aviados section a late Tournaisian age. Sample AG 5 from section AG (Fig. 11) in the Río Esla area also seems to point to an upper Tournaisian age, but for the reasons already explained (Ch. III, p. 158), this sample is assumed to be of lowermost Tournaisian age, some younger material having leaked in from the overlying Alba Formation.

Distribution and the underlying and overlying formations. — Because of its transgressive character, the Ermita Formation overlies rocks of widely differing ages. In the southern part of the Cantabrian Mountains it lies on Famennian rocks of the Nocedo Formation. A hiatus between these rocks and the Ermita is here often difficult if not impossible to establish. In all probability the hiatus disappears completely in the southern and southwestern directions.

It is therefore not surprising that in the lithologic succession of the southern Alba syncline the Ermita Formation cannot be discerned. The Upper Devonian in this area consists of a sequence of sandstone and shale with calcareous intercalations. We attribute this kind of lithology to the Nocedo Formation. The Ermita Formation grades into this lithology in the northern part of the Alba syncline, where we suggest that an arbitrary cut-off be drawn between the Ermita Formation and the Nocedo Formation. The hiatus reaches its maximum in the northernmost part of León, near the watershed, where the Ermita overlies the Lower Cambrian dolomites of the Lancara Formation (section RI, Fig. 17). All formations in between can be overlain by the Ermita. Where the Ermita overlies the Ordovician Barrios Quartzite Formation it is often very difficult, and sometimes even impossible, to distinguish the disconformity plane. A thin pebble bed, passing into a more coarse-grained and less quartzitic sequence in the uppermost 20 m, often indicates the presence of the Ermita Formation. This kept in mind, the distribution of the Ermita can be investigated beyond the Río Bernesga-Río Esla region into Asturias. Comte (1959, p. 295) already gave a clue by stating: "Dans la région d'Infiesto, près de Rozapanera et même dans tout le bassin inférieur du Rio Sella, il est fort possible, à en juger par les caractères lithologiques, que des grès des quartzites famenniens transgressifs accompagnent les quartzites siluriens. Dans le même ordre d'idées, des quartzites roses qui couronnent les quartzites siluriens au coeur même des Picos de Europa méritent de retenir l'attention" (In the region of Infiesto, near Rozapanera and even throughout the lower basin of the Río Sella, it is highly possible, judging from the lithological properties, that transgressive Famennian sandstones and quartzites accompany the Silurian quartzites. In the same sense, the rose quartzites that crown the Silurian quartzites in the very heart of the Picos de Europa should be kept in mind).

Although difficult to prove on the basis of fossils because they rarely occur in the rocks in question, Comte's assumption seems to be correct. Where limestone beds were present, the Ermita Formation could be ascertained with conodonts.

In the northeastern part of Asturias, Hernández Sampelayo & Kindelan (1950, p. 60) distinguished on the Lower Palaeozoic quartzites 6—20 m conglomerates and coarse-grained sandstones with a thin bed of coal containing distinguishable plant remains. They assigned this formation to the Lower Devonian on lithological grounds. Our opinion is, however, that these rocks, too, belong to the transgressive Ermita Formation (see Ch. II, p. 145 and Fig. 35).

The conodont faunas mentioned by Budinger & Kullmann (1964, pp. 423—425) from Entrago in Asturias revealed the presence of the Ermita Formation with a calcareous development in this area. Our re-interpretation of the section from this locality suggests that samples 1—3 correspond to the Ermita Formation and samples 4—7 to the Alba Formation.

Sample 4, taken from the base of the Alba Formation which lies disconformably on the Ermita Formation, contains a mixed fauna (cf. samples IIf 224 and OL 1 from the Río Esla area and PE 4 from section PE, Fig. 29). *Pseudopolygnathus dentilineata* and *Pseudopolygnathus triangula inaequalis*, which are forms with thick platforms, are considered to be reworked specimens from older strata (stratigraphic admixture). The rest of the fauna points to the *anchoralis* Zone of uppermost Tournaisian to lower Viséan age. This leaves the established ranges of *Gnathodus delicatus*, *Gnathodus girtyi*, *Gnathodus semiglaber*, and *Gnathodus texanus* unchanged, and explains why "das Unter-Tournai. . . auf Grund von Goniatiten trotz grösster Bemühungen nicht festzustellen war" (Budinger & Kullmann, 1964, p. 416).

The limestone band with a thickness of about 20 m which underlies the griotte of the Alba Formation in the Barranco de Las Xanas (Llopis Lladó, 1960, p. 50, Pl. 5) is thought to be the calcareous part of the Ermita Formation.

There are indications that the Ermita Formation also occurs in the Asturo-Leonese facies of Palencia. The sections of Kanis (1956) and Koopmans (1962) show that the Camporredondo Formation (quartzite and sandstone) in the Ventanilla area and the northern part of the Valsurvio dome becomes thinner towards the north. Koopmans mentioned that at the top of the Camporredondo Formation, locally, microconglomerates or coarse sandstones with a thickness of 1—2 m occur, for example near Besande and south of the Pantano de Camporredondo. In analogy with the development of the Upper Devonian in the Río Bernesga-Río Esla area, it may be assumed that the uppermost part of the Camporredondo Formation corresponds to the Ermita Formation.

Consequently, the lower part, i.e. the bulk of the Camporredondo Formation, (Camporredondo Formation *s.s.*) can be correlated with the Nocedo Formation. Where the quartzitic sandstone that underlies the Viséan griotte (Alba Formation) is only a few metres thick, as in the section taken at San Martín de los Herreros (Kanis, 1956) and in the sections east of Peña Negra, Alba de los Cardaños, and Triollo (Koopmans, 1962), the whole quartzitic unit can be considered as Ermita Formation.

The Ermita Formation is overlain in most parts of eastern Asturias and northern León by the Vegamián Formation. The contact between these formations is sharp and often slightly erosional. Where the Vegamián Formation does not occur, the Ermita Formation is overlain by the Alba Formation. Since the contact between these formations is disconformable, a small amount of erosion took place locally.

To summarize, it may be stated that the Ermita Formation is widely distributed over a large part of the Cantabrian Mountains in León, Asturias, and Palencia. Although the Ermita Formation cannot always be demonstrated with palaeontologic evidence, lithologic criteria are very often available to confirm its presence in a section. The Ermita Formation may vary in age from upper Famennian to lowermost Tournaisian, and is overlain disconformably by the Vegamián Formation or the Alba Formation. The Ermita Formation does not occur in the Palentine facies area.

The Palentine facies area

Conodonts from the Carazo Formation (Member c) and from the Lebanza Formation confirm, or at least do not contradict, the age of these formations as defined by Binnekamp (1965). The distribution of these two formations has been adequately demonstrated by Frets (1965) and van Veen (1965). Lithologic descriptions of the younger formations of the Palentine facies have been published by van Veen (1965) and may be omitted here. Only a few remarks are required with respect to their age and distribution.

The Abadía Formation. — This unit consists of shale and sandy shale with two prominent limestone members, and ranges in thickness from about 100 to 300 m. Van Veen's description (1965) is based on a section along the Río Arauz, which can be considered as type section. The formation there has a thickness of 180 m, and its shaly to sandy part is usually grey to dark-grey. Near the Abadía itself the structures are too complicated to permit reliable measurement of a complete section. Another complete section is located along the northern border of the Pantano de Requejada, 2.75 km south-southeast of Polentinos, for which Mr. J. A. van Hoeflaken reported a thickness of about 295 m for the Abadía Formation. Here, the non-calcareous part of the formation consists of fine, yellow to brown shales without sandy intercalations.

The lowest limestone member is the Requejada Member. This unit is the equivalent of the "Arruz-Schichten" of Kullmann (1960, pp. 465—466). We consider the age of the Requejada Member to be lower? Emsian (see Ch. III, p. 156). The Requejada Member occurs in the Río Arauz-Polentinos area and the Barruelo-Mudá area (Kullmann, 1960, pp. 466, 469).

The upper limestone unit of the Abadía Formation is the Polentinos Member, which is the equivalent of Schicht 5 of Kullmann (1960, p. 465) and Schicht 5 and Schicht 6 ("Encimero Schichten") of Kullmann (1965, p. 45), which, according to Kullmann, are of an Eifelian age. The conodont content of two spot samples point to a lower Eifelian age.

The Polentinos Member is found in the Arauz-Polentinos area, the Cardaño area, and the Gildar-Montó area. Its occurrence in the Barruelo-Mudá area is not known. In the Liébana, rocks of lower Eifelian age can be traced, but these possibly should be assigned to the Gustalapiedra Formation.

The Gustalapiedra Formation. — This unit has been described and defined by van Veen (1965) from the Cardaño area. It consists of dark-grey to black shales and limestones with a thickness of 30 to 70 m.

Since it follows the lower Eifelian Polentinos Member of the Abadía Formation, the lower part of the Gustalapiedra Formation must be of a later Eifelian age. Cephalopods collected by van Veen in the Cardaño area and identified by Kullmann (1963b) range from lower to upper Givetian. The conodont faunas from the upper part of the Gustalapiedra Formation in section CAR I agree well with this Givetian macrofauna.

The Gustalapiedra Formation occurs in the Cardaño area, the Arauz-Polentinos area (Schicht 6 of Kullmann, 1960, p. 465) and the Gildar-Montó area. This unit has not been reported for the Barruelo-Mudá area.

The Cardaño Formation. — The Cardaño Formation has been defined and described from the Cardaño area by van Veen (1965). It consists of grey and brownish calcareous shale, nodular limestone, and bedded limestone, attaining a thickness of 10 to 40 m. Cephalopods found by van Veen in the type area and determined by Kullmann (1963b) point to a Frasnian age. Schicht 7 of Kullmann (1960, p. 465) represents the Cardaño Formation in the northern part of the Arauz area. The conodont faunas recovered from the Cardaño Formation permit a precise age determination of this unit. The Cardaño Formation in section CAR I in the Cardaño area shows a range in age from the lowermost to upper Frasnian (in the German notation: lower to Iα — lower to Iδ). The Frasnian conodont faunas from the Cardaño Formation in the Liébana fit well in the same range. In the Gildar-Montó area the Cardaño Formation starts earlier and ranges from middle to upper Givetian to upper Frasnian (lower to Iδ). The Cardaño Formation in the western Arauz-Polentinos area (section POL II) is exclusively of middle to upper Givetian age. This may be only a local development.

The Cardaño Formation is not known from the Barruelo-Mudá area. A shale of Frasnian age is indicated by the presence of *Aulatornoceras bicostatum* (Hall) mentioned by Wagner & Wagner-Gentis (1963).

The Murcia Formation. — This formation, described by van Veen (1965), consists mainly of light to dark-grey quartzitic sandstones with a variable but mostly small amount of shales intercalated. Some graded beds occur. The thickness of the formation ranges from 40 to probably 200 m.

The lower part of the Murcia Formation yields small lamellibranchs among which specimens of *Buchiola* were provisionally identified by van Veen (1965). They suggest an upper Frasnian age. Because of the lack of fossils, the age of the upper limit of the Murcia Formation can only be deduced from the age of the directly-overlying beds, which belong to the Vidrieros Formation. This unit starts in the upper part of the lower Famennian or the lowermost part of the middle Famennian. The Murcia Formation therefore ranges between the uppermost Frasnian and lower Famennian (upper to Iδ — to IIβ). Its rate of deposition was about 5 to 10 times faster than that of the underlying and overlying nodular limestone formations.

The Murcia Formation can be traced from the Cardaño-Triollo area to the Gildar-Montó area. The presence in this area of two quartzite formations separated by a band of nodular limestone of to IIβ age, as reported by Budinger & Kullmann (1964, p. 419), is not confirmed by our observations. The Murcia Formation also occurs in the Liébana, though in reduced thickness (40—60 m, Mr. R. W. Lanting, pers. comm.). In this area the underlying and overlying Devonian formations also show a reduced thickness, but without evidence of breaks in the sedimentation.

It seems probable that the Moradillo Formation of the Barruelo-Mudá area can be partially correlated with the Murcia Quartzite.

The Vidrieros Formation. — This unit has been defined and described by van Veen (1965). It consists of nodular limestone, calcareous shale, and pure shale with a thickness of 10 to 100 m.

This unit is the equivalent of the "Montó Schichten" of Kullmann (1960, pp. 472—473) from the Gildar-Montó area. On the basis of their cephalopod contents, Kullmann established their range in the Famennian from the *Cheiloceras*-Stufe (to IIβ) to the *Wocklumeria-Kalloclymenia*-Stufe (to VI). Budinger & Kullmann (1964) confirmed this by conodonts.

Our oldest conodont faunas from the Vidrieros Formation in the Cardaño-Triollo area and the Gildar-Montó area range from the upper part of the lower Famennian to the lower part of the middle Famennian (upper to IIβ — lower to IIIα). The conodont faunas mentioned by Frets (1965, p. 121) for localities 3 and 11 near Santibañez de Resoba, may well extend down into the uppermost part of the lower Famennian.

The upper part of the Vidrieros Formation yields conodont faunas of an uppermost Famennian age (uppermost to V — to VI). The uppermost beds of the Vidrieros Formation in the Cardaño-Triollo area and in the northern part of the Gildar-Montó area range into the lowermost Tournaisian.

The Vidrieros Formation can be traced from the Cardaño-Triollo area to the Gildar-Montó area. South of the Pico Gildar and west of Barniedo, the Vidrieros Formation is sometimes non-calcareous locally (section CU III, Fig. 29; Mr. H. Teer, unpublished internal report). The Vidrieros formation is also demonstrated in the Liébana area.

The possible occurrence of the Vidrieros Formation in the Barruelo-Mudá area is supported by evidence reported by Kullmann (1960), who described nodular limestones with a cephalopod fauna pointing to an upper Famennian age (to V) from a locality 500 m west of Mudá. A conodont fauna found 700 m north of Verbios by Frets (1965, p. 121) shows an upper to upper Famennian age (upper to V — to VI). Older Famennian limestones are not known for this region; possibly no full development of the Vidrieros Formation exists in the Barruelo-Mudá area. Wagner & Wagner-Gentis (1963) suspect the existence of a hiatus between the Moradillo quartzite and the Famennian limestone, which they call the Verbios Formation. The type of rock and the biofacies of this Verbios Formation differ strongly from the Ermita Formation.

LOWER CARBONIFEROUS

The sharp lithological and palaeontological difference between the Asturo-Leonese facies and the Palentine facies disappears in the Lower Carboniferous. Nonetheless, a different development can be traced, as indicated by the following discussion of the formations. The Vegamián Formation occurs in the Palentine facies area and in a part of the Asturo-Leonese facies area. The Alba Formation occurs almost everywhere throughout the Cantabrian mountain chain. A revision of the Vegamián and Alba Formations, based on the literature and our observations, is presented below.

The Vegamián Formation

Definition and type area. — The Vegamián Formation was originally designated by Comte (1959, p. 330) as "Couches de Vegamián", consisting of about 15 m black, "anthracitic" shales containing a few phosphate nodules in the type locality, which is situated 1 km south-southwest of Vegamián. Van Ginkel (1965) presented a revision of this formation, which he also distinguished in the Palentine facies area.

Lithology and thickness. — The main constituent of the formation is black shale, but a variety of accessory rock types occur. Phosphate nodules are common in the formation. In the Cardaño area van Veen (1965) observed thin "phosphate bearing lenticular laminae". The occurrence of black, thin-bedded chert is also very common in the Vegamián Formation, in which radiolarians have been found. In the Gildar-Montó area the upper part of the formation is very cherty, lighter in colour, and often finely laminated. Locally, the cherts have a greenish or reddish tinge. At the top of the formation, near Barniedo, concretions of ironstone occur (Mr. J. F. Savage, oral. comm.). Ironstone concretions and laminated ironstone beds are present in the Vegamián Formation in the Liébana. Some localities show the development of pyrite or marcasite concretions, e.g. sections U (Fig. 19) and OS (Fig. 22). Higgins *et al.* (1964) described from the base of the Vegamián Formation near Genicera and Olleros de Alba, a thin sandy bed with phosphatic nodules and near its top, in the neighbourhood of Santiago de las Villas, a sandstone with a conglomeratic base. Section MA (Fig. 18) contains a basal bed with glauconitic sandstone. Van Veen (1965, p. 63) observed two lenses of quartzitic pebbles in the Vegamián Formation. Some slumped beds of laminated quartzitic sandstone are intercalated (Fig. 31).
The black shales often have a brilliant, coally appearance, e.g. in the Gildar-Montó area and in eastern Asturias. When this type of black and very brittle shale is heated, it releases a combustible vapour which smells of bitumen and burns with a yellow flame. In general, the black shales are not calcareous. Only in section MA (Fig. 18) do a true argillacious limestone bed and a calcareous, sandy, breccious bed occur.
The Vegamián Formation is generally thin but shows wide variation, the maximum development being found in the Palentine facies area. Near Cardaño de Arriba, van Veen (1965) found a thickness of 30 m. South of Pico Gildar, a thickness of 50 m was measured (section CU III, Fig. 29).

Age and underlying and overlying formations. — The black shales of the Vegamián Formation generally show few fossils. Wagner (1963, p. 210) mentioned for the upper part near Genicera, *Lingula*, *Orbiculoidea*, trilobites, ostracods, lamellibranchs, and squashed goniatites which seem to belong to *Pericyclus*. The upper part of the black shales in section OS (Fig. 22) yielded small brachiopods, a few trillobite pygidia, ostracods, and badly-preserved cephalopods. Some of the cephalopods belong to the genus *Ammonellipsites* (= *Pericyclus* auct.), pointing to upper Tournaisian or lower Viséan, according to Budinger and Kullmann (1964, p. 421, footnote).
The conodont faunas from the basal sandy beds of the Vegamián Formation near Santiago de las Villas and Genicera point to a middle to upper Tournaisian age, according to Higgins *et al.* (1964). In the upper part of the Vegamián Formation they found *Pseudopolygnathus triangula pinnata*, which ranges from upper Tournaisian to lower Viséan.
The calcareous beds in the lower part of the Vegamián Formation in section MA (Fig. 18) point to an uppermost Tournaisian to lower Viséan age (lower cu IIβ/γ).
In the Palentine facies area, section CAR II (Fig. 46) located near Cardaño de Arriba shows a gradual transition of the underlying Vidrieros Formation into the black shale of the Vegamián Formation. The highest nodular limestones of the Vidrieros Formation which contain conodonts, already have a very dark colour; it follows from this that the Vegamián Formation here begins early in the Tournaisian. Other sections located in the Palentine facies area (e.g. TR, Fig. 47; CAL II, Fig. 27; and CU II, Fig. 28) show a clear lithologic break between the Vidrieros Formation and the black shales of the Vegamián Formation. For the latter, we have no age determinations of the basal portion. The only direct indication for the age of the black shales in the Palentine facies area is given by Budinger & Kullmann (1964, p. 421), who mentioned a few shell fragments from Schicht 6 in the Montó area of *Goniatites* (*Goniatites*) ex gr. *striatus*, belonging to the upper Viséan (cu IIIα-β (?)). It is not known whether this upper Viséan age of the Vegamián Formation also applies to the Cardaño-Triollo area.
The overlying Alba Formation presents a sharp contact with the Vegamián Formation in the Palentine facies area, clearly indicating a break in the sedimentation. Its lower part already has an upper Viséan age (cu III).
In the Asturo-Leonese facies area the Vegamián Formation is also overlain by the Alba Formation, which begins in this area in the uppermost Tournaisian to lower Viséan (cu IIβ/γ). Often, there exists a thin zone of gradual transition between these formations (e.g. Comte, 1959, p. 331). Locally, however, there are sharp contacts with a clear disconformity (e.g. Olleros de Alba and Santiago de las Villas, Higgins *et al.*, 1964).
These considerations show that the upper and lower boundaries of the Vegamián Formation are diachronous, and that its fullest development took place in the Palentine facies area.

Distribution. — The distribution of the Vegamián Formation in the Asturo-Leonese facies area is rather irregular. It has been reported from the central part of the Cantabrian Mountains near the Tarna Pass and the Pontón Pass and from an area southwest and northeast of this central region, in León and Asturias. The Vegamián Formation does not occur in the San Martín-Ventanilla area, the Valsurvio area, or the Río Esla area, nor has it been reported for the western part of León and Asturias. Fig. 65 gives a picture of the possible maximum distribution of the Vegamián Formation as compiled from the literature and our observations. The variation in thickness and the local absence of the formation may have been caused in part by local erosion of this unit prior to the deposition of the overlying Alba Formation. In the larger areas where no trace of the Vegamián Formation is found, it was probably never deposited.

The Vegamián Formation is present throughout the Palentine facies area, and is absent in the central and eastern part of the Barruelo-Mudá area.

Frets (1965) and van Veen (1965) observed that in the Cardaño-Triollo area near the León Line and Cardaño Line, both the Vegamián and Alba Formations are often not developed. Even the Vidrieros Formation is locally absent, in which case the Escapa Formation directly overlies the Murcia Formation. In the Liébana, the Vegamián Formation passes gradually into an undated shale-graywacke sequence, the Potes Formation, containing a conglomerate lens (Mr. R. W. Lanting, pers. comm.).

Depositional environment. — The old belief that relatively deep water is always necessary for the development of black shales has been disproved by the many observations of black mud accumulation in very shallow water (see literature review by Conant & Swanson, 1961). The Vegamián Formation is undoubtly a marine sediment, as shown by its fossil contents. It is clearly a transgressive unit, and must have spread rapidly over a flat area. This transgressive character suggests a shallow-water environment for this formation, a view supported by the occurrence of several conglomerate lenses in the formation and by the fact that the top of the Vegamián Formation can also be a disconformity plane. The anoxic bottom conditions in the Vegamián Sea might be explained by somewhat restricted conditions, combined with high plankton production in the surface water and consequent high oxygen consumption in the waters below.

The Vegamián Formation in many respects closely resembles the Chattanooga Shale extensively described by Conant & Swanson (1961), who proposed as environment for the Chattanooga Shale a shallow quiet sea (probably not deeper than 100 feet, but locally, close to the shore, only a few feet deep). The sediment is believed to have been transported by slow currents over the bottom of the sea. According to these authors, the rate of sedimentation was extremely slow. To summarize, the data on the Vegamián Formation show that this unit is a thin, marine, diachronous formation deposited in a shallow basin of limited extent. It starts in a rather small area in the lower Tournaisian, as can be observed near Cardaño de Arriba. It greatest distribution probably occurred in the upper Tournaisian, when it occupied not only the Palentine facies area but also part of central and northeastern Asturias and part of the Leonese area. In the lower Viséan and lower part of the upper Viséan the deposition of the Vegamián Formation seems to have been restricted to the Palentine facies area. The formation is underlain by the Ermita Formation in the Asturo-Leonese facies area and by the Vidrieros Formation in the Palentine facies area. The overlying formation is the Alba Formation, which, however, is not present in the central part of the Palentine facies area.

The Alba Formation

Definition and type area. — The Alba Formation was originally designated by Comte (1959, p. 40) as "Griotte de Puente de Alba" or "Griotte à *Goniatites crenistria*" (op. cit., p. 330). In the type section near Puente de Alba in the Río Bernesga valley, the formation consists of about 30 m of red nodular limestone (griotte). The formation has been often referred to as "the Griotte" or "Alba Griotte". The present author prefers the name Alba Formation, because of the variable lithology of the unit here described.

Lithology and thickness. — The most diversified development of the Alba Formation shows from top to bottom:

red, nodular limestone (griotte), becoming upwards more calcareous and grey, thus passing into the Escapa Formation:	8 — 22 m
red bedded cherts and shales:	2 — 12 m
grey, nodular or wavy-bedded, finely crystalline limestones:	0.5 — 4 m

This sequence is found in the central Cantabrian Mountains, e.g. sections FE, MA, U, PO, and OS (Figs. 15, 18 — 20, 22). Similar sections are also found in the Río Bernesga, Río Torío, Río Curueño, and Río Porma valleys and section MAR (Fig. 49) in the San Martín area. The Alba Formation begins directly with red marls and red nodular limestones in the type area, the Río Esla area, and in parts of northern Asturias, e.g. section PE (Fig. 33) and LL (Fig. 35). The basal beds of the formation consist of red shales and red cherts in some other areas, e.g. the northern Valsurvio area (locality cam 1), in the Monte del Naranco and the Playa de San Pedro (Radig, 1964) in Asturias. The fossil content of the lower part of the Alba Formation, however, indicates that the base of this unit in the Asturo-Leonese facies area has approximately the same age (cu IIβ/γ) everywhere. Accurate mapping of these basal layers of the Alba Formation might give an interesting palaeogeographical picture.

The Alba Formation generally lacks the typical red colour in the Palentine facies area. In the Cardaño-Triollo area, for example, the formation consists of a light-grey, cream and rose spotted, styliolithic limestone (van Veen, 1965). Only in the northern part of the Gildár-Montó area is the red colour present. In one area in the Asturo-Leonese facies area a grey development of the Alba Formation is known, i.e. in the Riosol area (section RI, Fig. 17.)
The thickness of the Alba Formation varies from about 5 to 40 m, 20 to 30 m being the most common.

Fossil content and age. — Commonly found in the Alba Formation are cephalopods, small solitary corals, and crinoid ossicles.
Radiolarians from the red cherts and shales were mentioned by Delépine (1937), Kanis (1956) and Koopmans (1962). Conodonts are abundant.
The general conclusion to be drawn from cephalopod studies is that the base of the Alba Formation in the Asturo-Leonese facies area lies in the middle *Pericyclus*-Stufe (cu IIβ/γ). The conodont faunas from the basal part of the Alba Formation in that area invariably belong to the *anchoralis* Zone, which was correlated with the cu IIβ/γ by Voges (1959). The cu IIβ/γ has generally been correlated with the lower Viséan, but Böger (1962) and Conil, Lys & Mauvier (1964) produced evidence that this zone extends down into the upper Tournaisian (see Enclosure 5).
The base of the Alba Formation in the Palentine facies area is of upper Viséan age (cu IIIα — cu IIIγ; see Ch. III, p. 158.
In the Barruelo-Mudá area, the Alba Formation is developed as a grey, nodular limestone, e.g. near Villabellaco (Villabellaco Formation of Wagner & Wagner-Gentis, 1963). The base of this formation is here of lower Viséan age, according to Wagner & Wagner-Gentis (1963); Kullmann (1961), however, did not find fossils older than upper Viséan in this area.
The highest part of the Alba Formation is dated as upper Viséan (cu IIIγ) on the basis of cephalopods. The beds, transitional from the Alba Formation to the Escapa Formation, have in some places yielded Namurian A (E_1 and E_2) goniatites described by Kullmann (1962) and Wagner-Gentis (1963). Conodonts have not supplied sufficient information to define the Viséan-Namurian boundary with certainty.
It is evident from the above-mentioned observations that the base of the Alba Formation is diachronous. The upper boundary can also be slightly diachronous. The fullest development of the Alba Formation took place in the Asturo-Leonese facies area.

Distribution and the underlying and overlying formations. — The Alba Formation is a well-known marker bed throughout the Cantabrian mountain chain. It is not deposited in the central and eastern part of the Palentine facies area, e.g. the Liébana and some places near the León line and the Cardaño line. In the northern Cardaño-Triollo area the Alba Formation wedges out locally. It is also absent in some localities in the Asturo-Leonese facies area, but whether this is due to tectonic, sedimentologic, or erosional events is not clear.
The Alba Formation is underlain by the Vegamián Formation or by the Ermita Formation in those parts of the Asturo-Leonese facies area where the Vegamián Formation is absent. In that area it is overlain by the Escapa Formation, with an exception in the southern Alba syncline, where it is followed by a detrical formation of shales and sandstone with conglomerate intercalations (Mr. C. G. van der Meer Mohr, pers. comm.). The overlying formation in the Palentine facies area is the detrital Cervera Formation (van Ginkel, 1965, p. 198). Only in the Triollo area and near Santibañez de Resoba is the Alba Formation overlain by the Escapa Formation.

Depositional environment. — The Alba Formation is clearly a transgressive formation which spread very rapidly over the flat Asturo-Leonese facies area. A very deep-water environment cannot be envisaged for such a deposit. Koopmans (1962, p. 152) reported breccias from the Alba Formation which indeed seem to indicate a shallow-water environment. The radiolarian content of the shales and cherts does not contradict a shallow-water environment (Shackleton Campbell, 1954, pp. D17, D18). The development of a bottom fauna was not inhibited by anoxic conditions, but was perhaps limited by fine mud. The rate of deposition was very slow.
To summarize the data on the Alba Formation, this unit is a thin, diachronous formation deposited in a shallow, transgressive sea; in the lower Viséan, or possibly already in the uppermost Tournaisian, it spread rapidly and widely over the Asturo-Leonese area.
In the upper Viséan it extended to the Palentine facies area except in the centre. The Alba Formation is underlain by the Ermita or the Vegamián Formation in the Asturo-Leonese facies area, and in the Palentine facies area only by the Vegamián Formation. In both areas disconformable contacts with these formations are observed.

CHAPTER V

PALAEOGEOGRAPHIC SYNTHESIS OF THE STRATIGRAPHIC DATA

GENERAL REMARKS

The geologic maps and stratigraphic sections by Almela *et al.* (1956), Comte (1959), García-Fuente (1959), Hernández Sampelayo & Kindelan (1950), Julivert (1960), Kanis (1956), Koopmans (1962), Llopis Lladó (1960, 1962), Martínez Alvarez (1962, 1966), Pastor Gómez (1963), Rupke (1965), de Sitter (1962), de Sitter & Boschma (1966), Sjerp (1967), and van Veen (1965), cover most of the Cantabrian Mountains. Together with our sections and the time-stratigraphic correlation chart of Enclosure 6, they provide a basis on which a palaeogeographic reconstruction can be attempted.

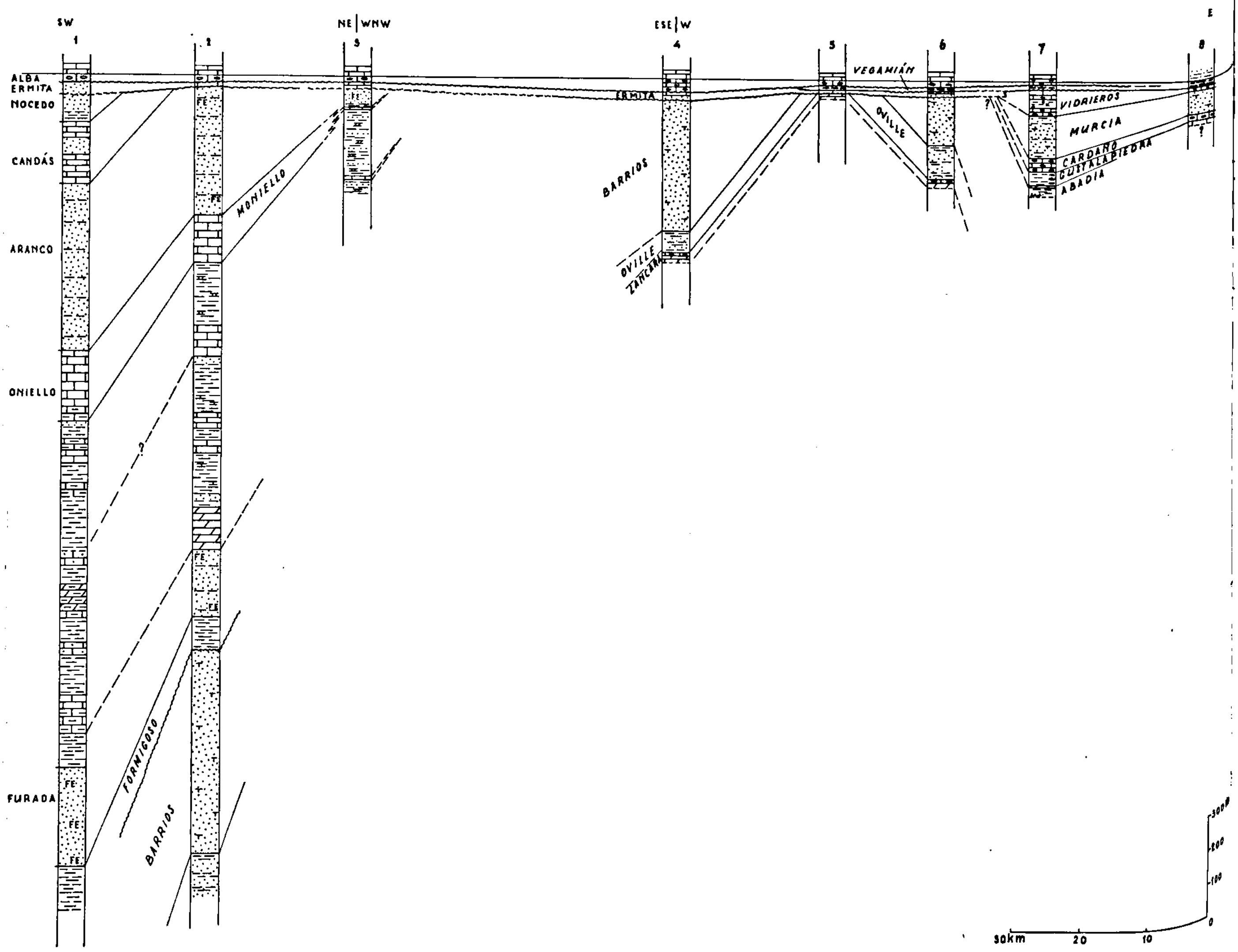

Fig. 54. Schematic stratigraphic cross-section from west to east through the region of the study.

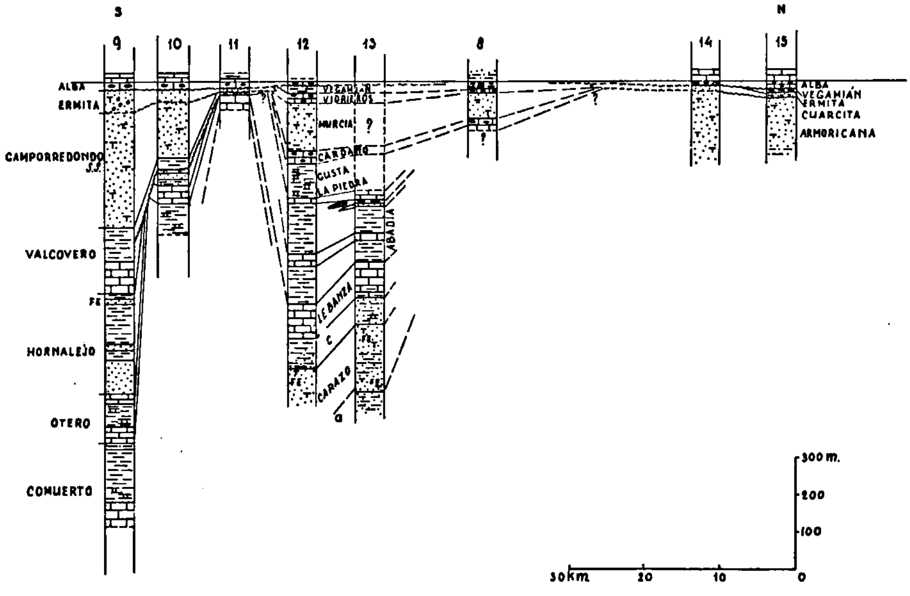

Fig. 55. Schematic stratigraphic cross-section from south to north through the eastern part of the region of the study.

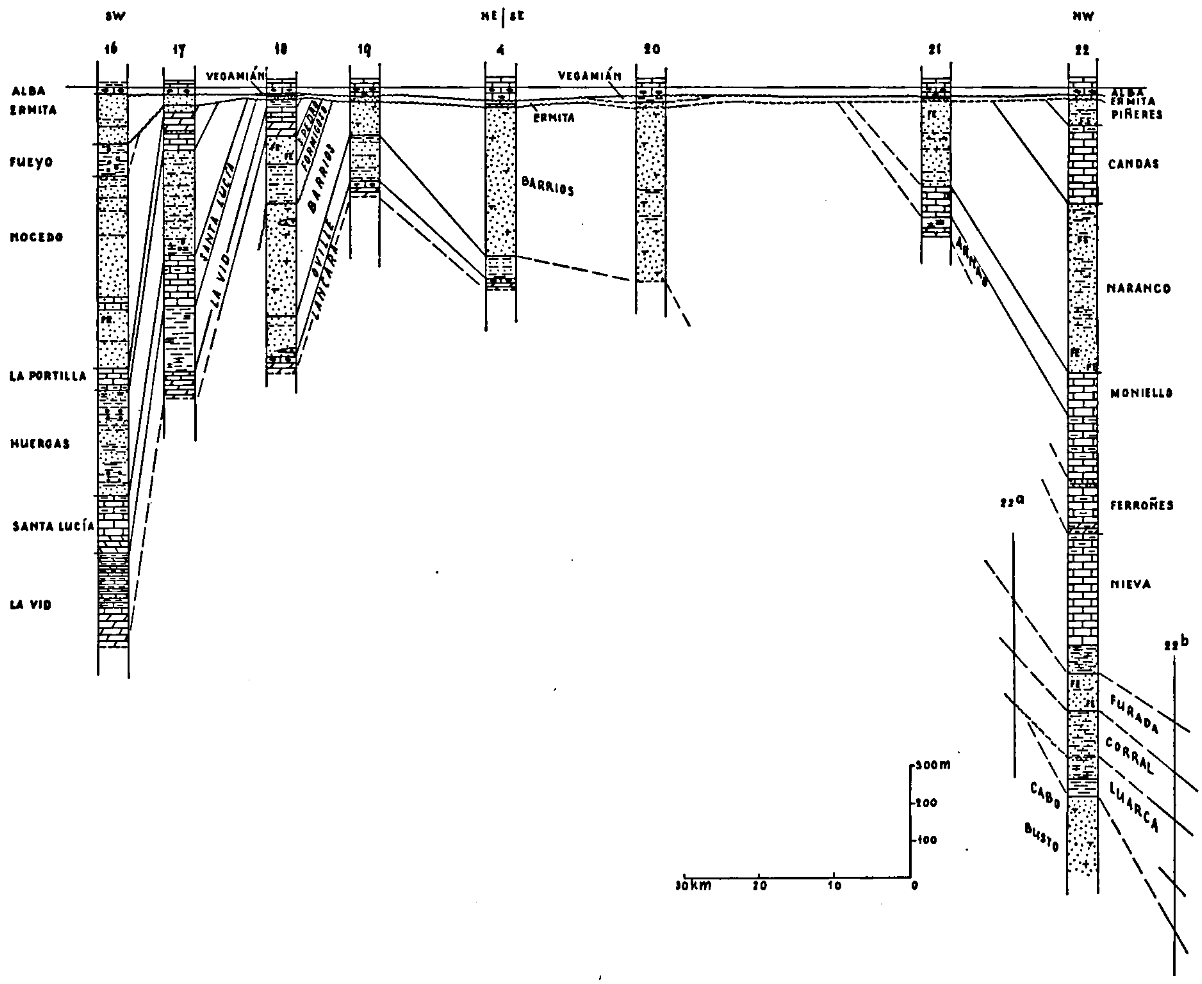

Fig. 56. Schematic stratigraphic cross-section from south to north through the western part of the region of the study.

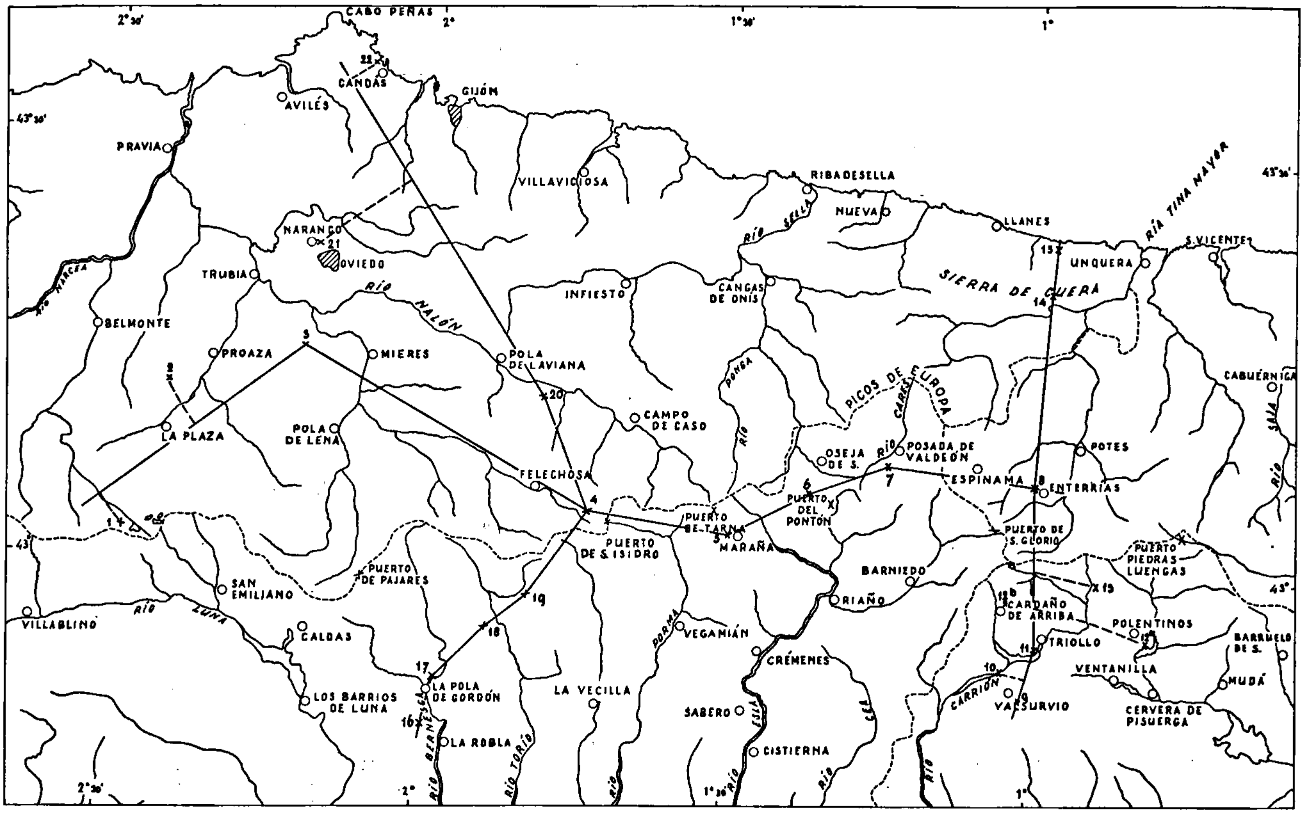

Fig. 57. Map (1 : 1,000,000) showing the location of the stratigraphic cross-sections in Figs. 54—56.

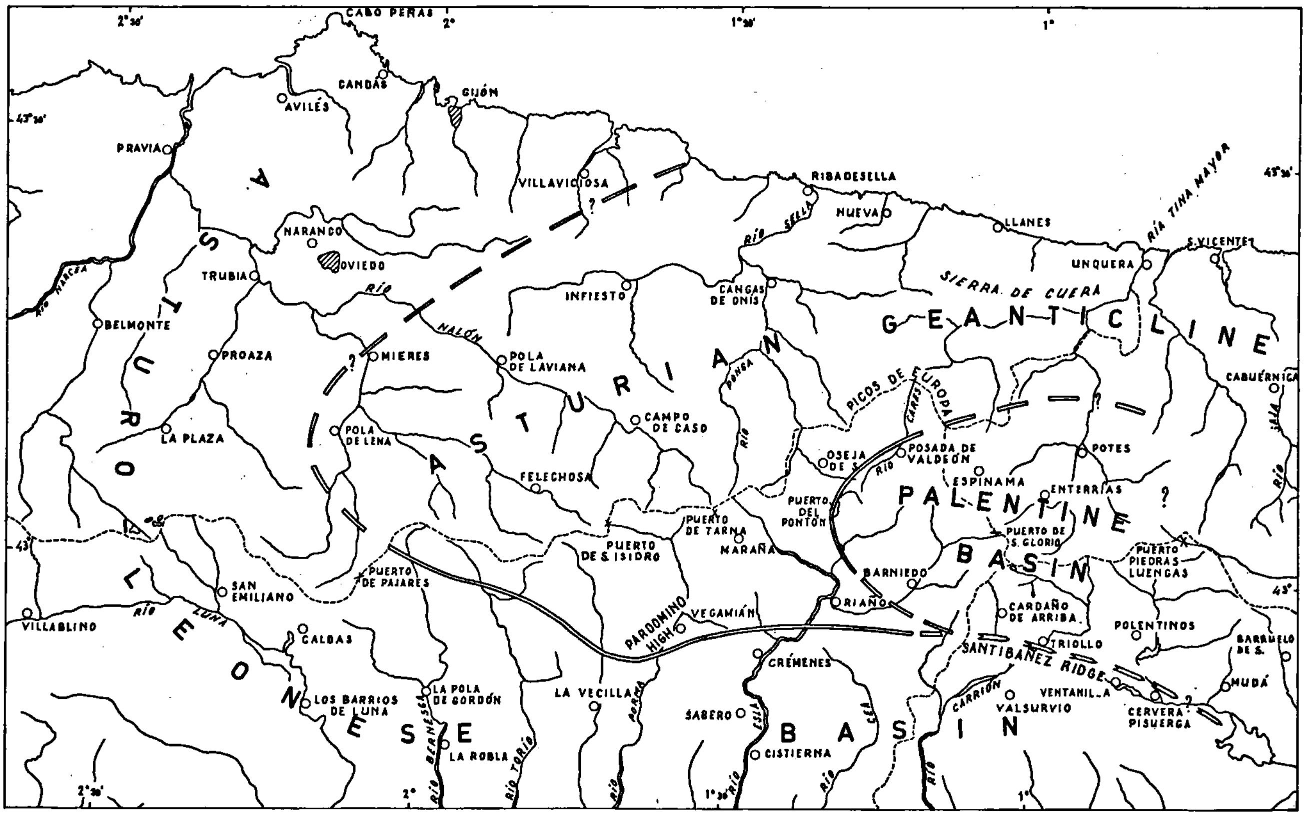

Fig. 58. Map (1 : 1,000,000) showing the main Devonian palaeogeographic units.

Table 9 Literature consulted for the construction of the schematic cross-sections (Figs. 54—56).

columnar section 1.	García-Fuente (1959, p. 20 and "cortes geológicos").
columnar section 2.	Almela *et al.* (1956, Fig. 2).
columnar section 3.	Llopis Lladó (1960, p. 31).
columnar section 4.	Sjerp (1967); Mr. E. J. H. F. Rouffaer (unpublished).
columnar section 5.	this paper (Fig. 17).
columnar section 6.	Julivert (1960, p. 35).
columnar section 7.	this paper (Fig. 24).
columnar section 8.	this paper (Fig. 52).
columnar sections 9—11.	Koopmans (1962, Fig. 10).
columnar section 12.	van Veen (1965, Enclosure 2) and Mr. J. A. van Hoeflaken (unpublished).
columnar section 13.	van Veen (1965, Enclosure 2).
columnar section 14.	Llopis Lladó (1958b, p. 11).
columnar section 15.	Hernández Sampelayo & Kindelan (1950, pp. 58—61).
columnar section 16.	Comte (1959, pp. 186—195).
columnar section 17.	Comte (1959, pp. 174—181).
columnar section 18.	Mr. J. J. K. Poll & Mr. J. L. Liezenberg (unpublished).
columnar section 19.	Mr. E. Oele & Mr. J. van Dillewijn (unpublished).
columnar section 20.	Martínez Alvarez (1962, p. 35).
columnar section 21.	Delépine (1928a) and Llopis Lladó (1960, Fig. 6).
columnar section 22.	Radig (1961, Pl. 11; 1964) and this paper (Fig. 33).
columnar sections 22 a, b.	Radig (1962, Fig. 1).

Two important elements attract special attention:

a. The presence of a pre-Ermita hiatus in the Asturo-Leonese facies area, that reaches its maximum in the central part of the mountain chain (Riosol area).

b. The existence of two facies areas, i.e. the Asturo-Leonese and the Palentine.

Three schematic stratigraphic sections (Figs. 54—56), the locations of which are indicated in Fig. 57, show the importance of these elements. Some of the columnar sections have been shifted along the strike to give straighter section lines. No palinspastic correction of these sections has been attempted.

The area with the big hiatus, where the pre-Ermita Devonian is absent, we shall call the Asturian Geanticline (Fig. 58). The term "geanticline" is used here in the broad sense of "a zone in a mobile belt of the earth's crust which tends to rise" (Schieferdecker, 1959), and not as the counterpart of a full scale geosyncline.

The Asturian geanticline is fringed in the Asturo-Leonese facies area by a zone in which the pre-Ermita hiatus becomes gradually smaller, followed by a zone in which there is no indentifiable break in the sedimentation. In the Palentine facies area a complete, though fairly thin, Devonian is present.

Because the filling of a sedimentary basin is determined primarily by epeirogenetic movements of the basin and the source area, it is not surprising that these isopical zones and facies areas are often bordered by "fundamental lines" or "tectonic hinge lines", which have been demonstrated by the geologists who mapped the area in detail. The most important of these lines is the León line (de Sitter, 1962; de Sitter & Boschma, 1966). Other fundamental lines are the Sabero-Gordón line (Rupke, 1965), the Porma fault (Rupke, 1965; = the Pardomino line of de Sitter (1966), the Cardaño line (van Veen, 1965), and the Pontón line (de Sitter, 1966; Sjerp, 1967).

De Sitter (1966) showed that the León line and the Pardomino-Pontón line divide the Palaeozoic core of the Cantabrian Mountains into four blocks, each having its own tectonic and epeirogenetic development.

THE ASTURIAN GEANTICLINE

The Asturian Geanticline did not arise suddenly in the Famennian. From the stratigraphic picture of the formations around the geanticline it is clear that this area must already have been a high in the Cambrian. Lotze (1961, p. 485) postulated a "Kantabrisch-Iberischer Trog" versus a "Schwellen — z.T. Abtragungsgebiet" of Cambrian age. Comte (1959, pp. 147—155) and Radig (1962) showed that from west to east towards the Asturian Geanticline, the Ordovician and the Silurian become thinner and less complete. In the Río Bernesga area (León) and the Bufarán anticline (Asturias), the Luarca and Castro Formations are missing. Llopis Lladó (1965) indicated that the Furada, Nieva, and Ferroñes Formations (Silurian to Lower Devonian) near Oviedo decrease in thickness considerably from west to east. In this direction the sandstone/shale ratio of the Furada Formation increases. Rupke (1965, pp. 19, 38) mentioned a remarkable difference in thickness for the La Vid Formation in the Río Esla area, where this formation is much thinner in the northerly situated Las Salas zone than in the autochthone or the nappe. Van Veen (1965, p. 53) reported from the Palentine facies area a decrease in thickness, in the northern and northwestern direction, of the Carazo and Lebanza Formations (Silurian and Lower Devonian).

Higher in the Devonian, Llopis Lladó (1960, pp. 44—46) demonstrated that the Arnao and Moniello Limestones wedge out and pass laterally into a red sandy and shaly formation southeast of Oviedo. He compared this deposit with the Old Red Sandstone. It is, however, questionable whether this sediment was deposited under continental conditions. But it is quite probable that the western part of the Asturian Geanticline was an emerged source area in that time. The Caldas Formation of Smits (1965), in which terriginous material is important, fits well into this picture. It can be inferred from Almela *et al.* (1953), García-Fuente (1959), and Llopis Lladó (1960) that this facies with a larger terriginous component has an ample distribution in Asturias.

The sections of Koopmans (1962, p. 169) from the Valsurvio area in the southeastern part of the Cantabrian Mountains show thinning and the development of stratigraphic gaps in the Devonian from south to north. Besides the pre-Ermita hiatus, Koopmans (1962, pp. 173—174) described a pre-upper Valcovero hiatus in some places cutting down as deep as the Lower Devonian. Not the Asturian Geanticline proper but a branch of it, is present in the northern part of this area. We shall call this, in the purely palaeogeographic sense, the Santibañez Ridge (see Fig. 58).

Another, but less conspicuous branch of the Asturian Geanticline is the Pardomino High (Rupke, 1965, pp. 39—41).

The question arises whether the Asturian Geanticline emerged during the Devonian. We observe that:

a. red sandstones and shales of upper Lower Devonian and Middle Devonian age occur southeast of Oviedo (Llopis Lladó, 1960);
b. coarse erosion material is, with the exception of the quartzitic Murcia Formation, absent or very scarce in the Palentine facies area, which abuts on the Asturian Geanticline.
c. the Huergas Formation in the Asturo-Leonese facies area contains terriginous detrital material, with an increasing sandstone/shale ratio towards the Asturian Geanticline, e.g. in the Río Bernesga area (Comte, 1959, p. 188) and the Río Esla area (Comte, 1959, pp. 211—212, and our observations).

Taking these points into account, we conclude that the Asturian Geanticline emerged locally from time to time during the Lower, the Middle, and the lower part of the Upper Devonian, but that strong sub-aerial erosion generally did not take place (Fig. 60). A limited amount of terrigenous, detrital material was supplied by the Asturian Geanticline towards the Asturo-Leonese facies area in upper Eifelian to lower Givetian times and probably also in lower to middle Frasnian times (Fig. 61), contributing to the sandy formations in that area.

We assume that the hiatus on the Asturian Geanticline was mainly the result of non-deposition and possibly submarine erosion, (sublevation, Dunbar & Rodgers, 1957, pp. 12—13), both due to little or no subsidence. The sea floor was probably often above the base level of agradation. Thus, only a thin and incomplete Devonian deposit could be formed.

An epeirogenetic uplift of the Asturian Geanticline causing active, sub-aerial erosion took place in the uppermost Frasnian to lower Famennian, which led to the removal of the inferred thin Devonian, the Silurian, and locally the whole Ordovician and part of the Cambrian. During this interval the Murcia Formation was deposited in the Palentine facies area, where it terminated the sedimentation of nodular limestone (Cardaño Formation). At the same time, the higher part of the Nocedo Formation, the Piñeres Sandstone, and part of the Camporredondo Formation were deposited in the Asturo-Leonese facies area, where sedimentation was then restricted to a peripheral belt around the Asturian Geanticline (Fig. 62). In the southern part of the area the sedimentation continued only south of the Sabero-Gordón line.

This uplift caused by the Bretonic phase (de Sitter, 1962) did not lead to discontinuities in the Palentine facies area. In the San Julián region of the Barruelo-Mudá area a hiatus also developed, in some places reaching as far down as the Silurian (Wagner, 1962; Frets, 1965, p. 150; de Sitter & Boschma, 1966, pp. 230—231).

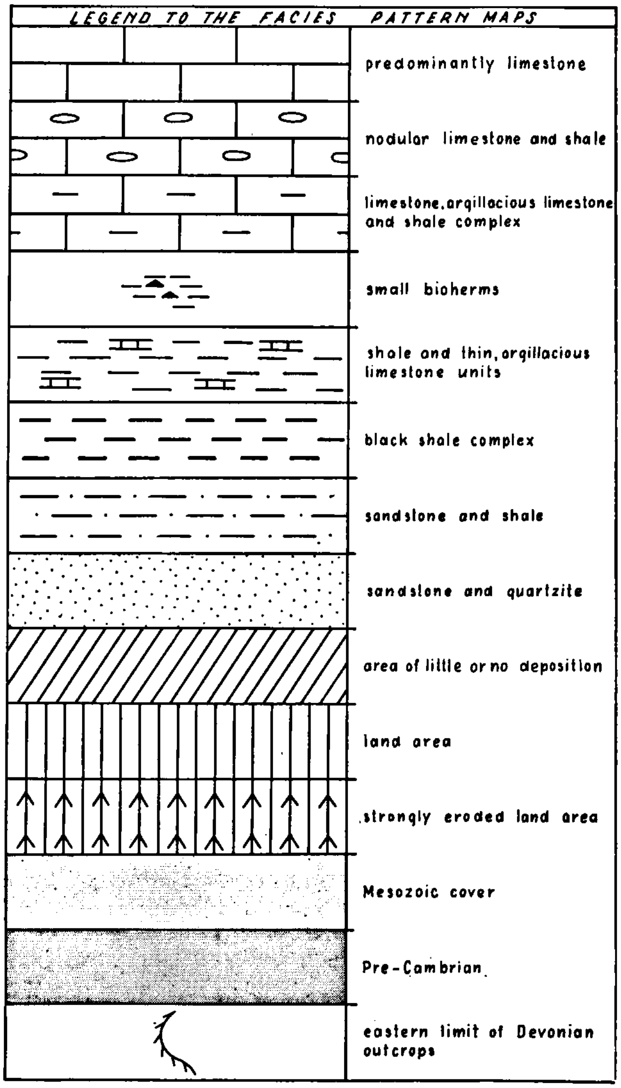

Fig. 59. Legend to the facies-pattern maps (1 : 1,000,000).

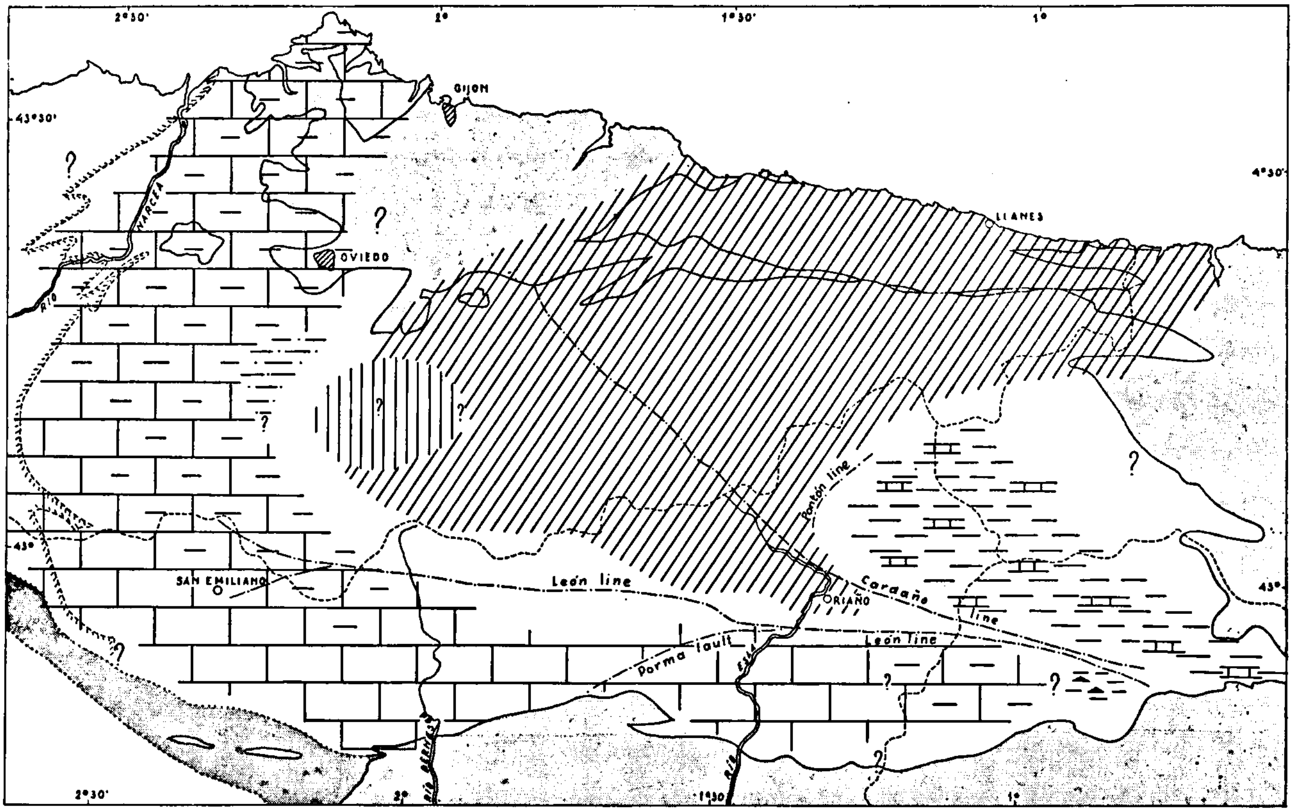

Fig. 60. Facies-pattern map for the upper Emsian to lower Eifelian.

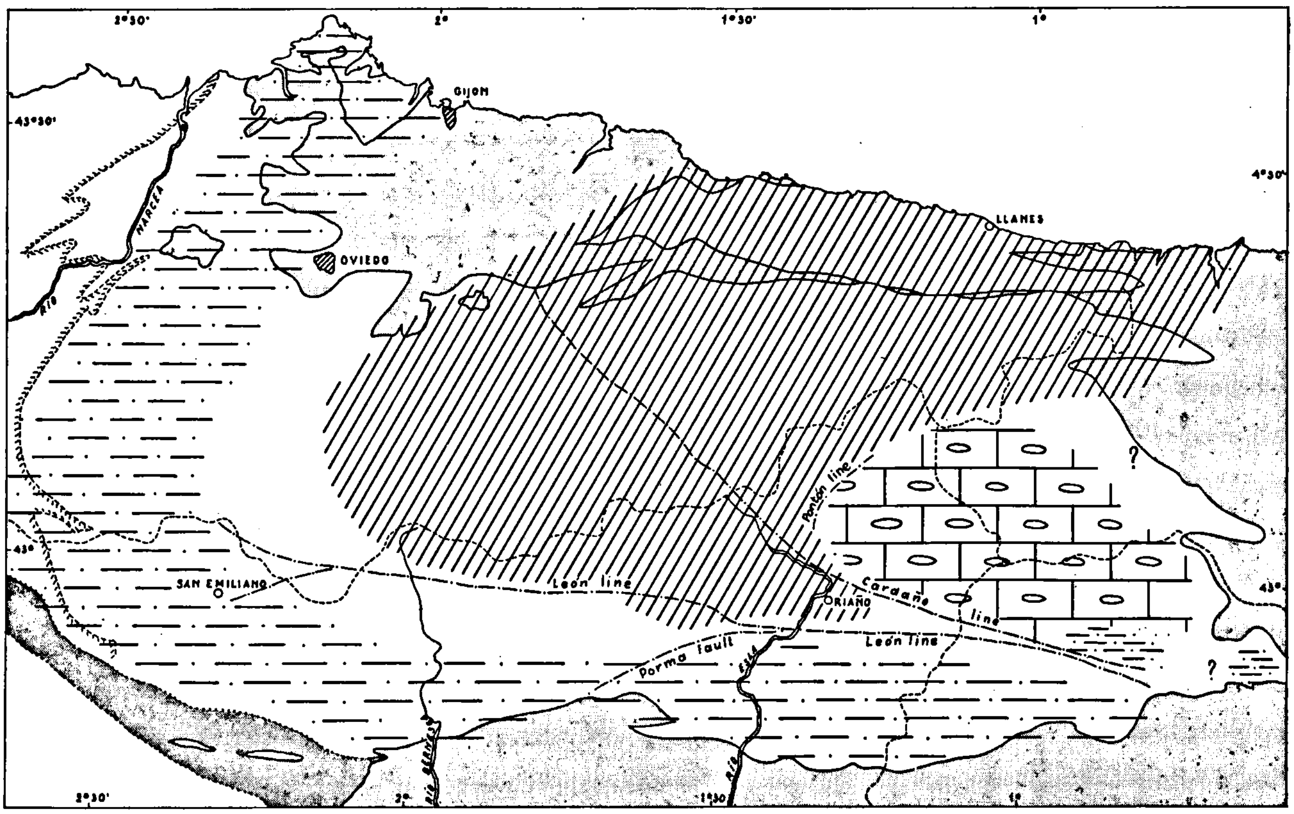

Fig. 61. Facies-pattern map for the middle Frasnian.

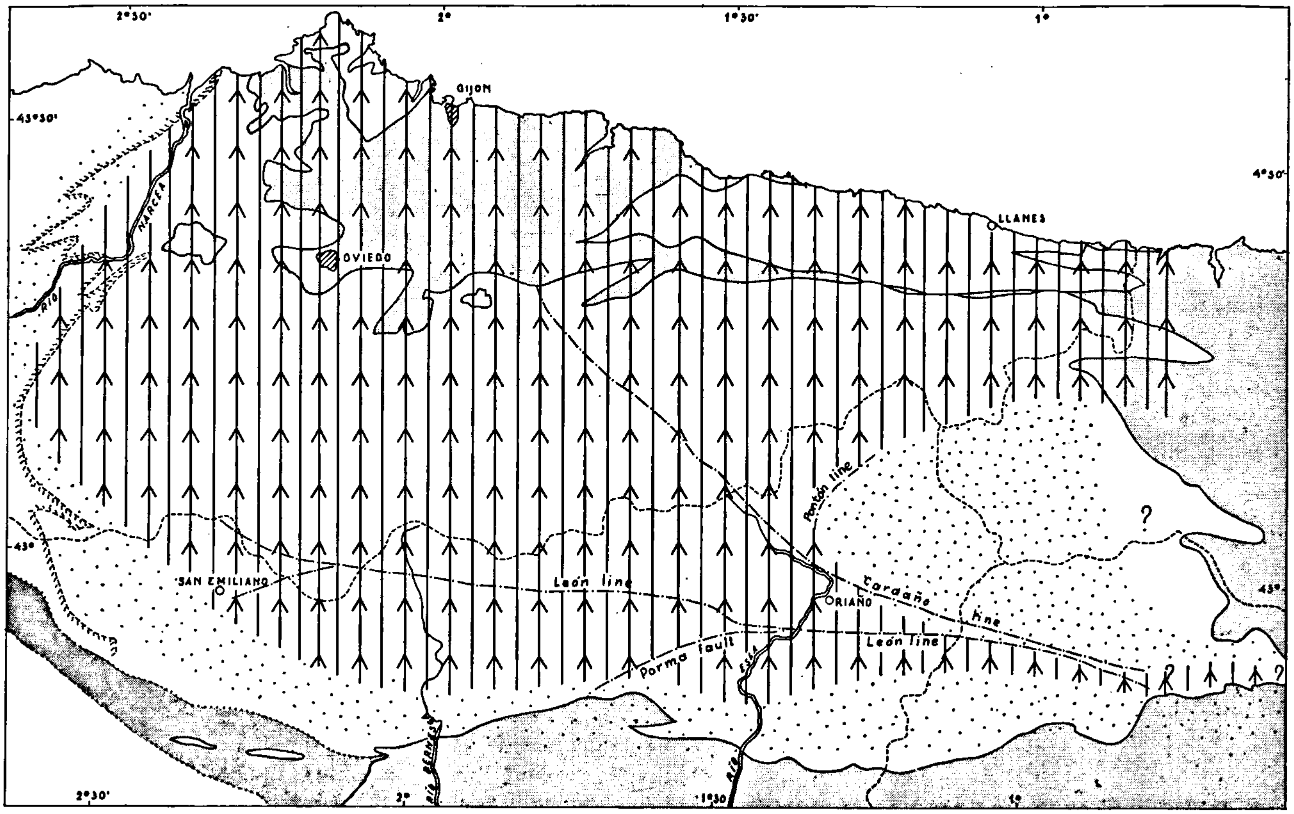

Fig. 62. Facies-pattern map for the lower Famennian.

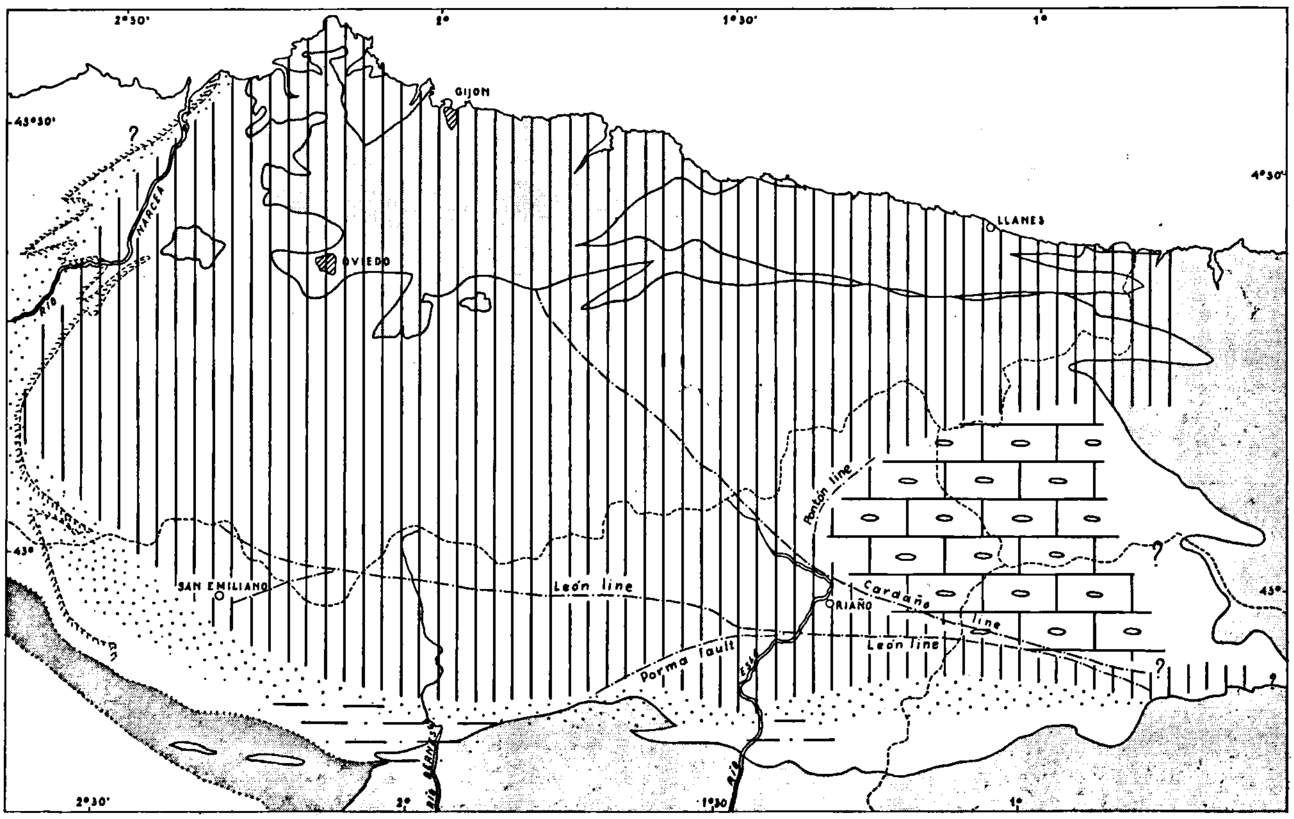

Fig. 63. Facies-pattern map for the middle to upper Famennian.

The discovery of pebbles of San Pedro ferruginous sandstone in and just below the probably uppermost Frasnian Crémenes Limestone (Rupke, 1965, p. 38) in the Esla nappe may confirm our dating of the uplift. We do not, however, accept Rupke's assumption that the movements reached a climax in the upper Famennian. Most of the strong erosion caused by the uplift ceased at the end of the lower Famennian, when the deposition of the Murcia Formation came to an end and the deposition of the nodular limestone (Vidrieros Formation) in the Palentine facies area was resumed (Fig. 63).

The whole Asturian Geanticline must have been peneplained before deposition of the post-hiatus, transgressive Ermita Formation started in the upper Famennian because:

a. ravinement at the base of the Ermita Formation is absent or very slight;
b. no conglomerate is found in the basal part of the Ermita Formation, only a few local beds with scattered, small pebbles being known;
c. the Ermita Formation spread fairly rapidly over the Asturian Geanticline in the uppermost Famennian; only the Riosol area seems to have been reached as late as the lower Tournaisian (Fig. 64).

The question arises whether the inferred thin, incomplete, pre-Ermita Devonian on the Asturian Geanticline belonged to the Asturo-Leonese facies or to the Palentine facies. In view of the situation during the uppermost Devonian, when coarse-grained, clastic sediments of the Ermita Formation, clearly belonging to the Asturo-Leonese facies, were deposited over the whole Asturian Geanticline while in the adjacent Palentine facies area the nodular limestones and calcareous shales of the Vidrieros Formation were being formed (Fig. 64), we may assume that any older Devonian deposits on the Asturian Geanticline also belonged to the Asturo-Leonese facies type.

The behavior of the Santibañez Ridge was probably in general analogous to that of the Asturian Geanticline. The pre-Ermita hiatus here did not reach deeper than the Lower Devonian. The transgressive character of the upper part of the Valcovero Formation in the northern part of the Valsurvio area is remarkable, however.

THE LOCATION, NATURE, AND DEVELOPMENT OF THE DEVONIAN SEDIMENTARY BASINS

From the distribution of the two facies patterns we can distinguish two distinct sedimentary basins: the Asturo-Leonese Basin and the Palentine Basin (Fig. 58).

The Asturo-Leonese Basin

The part of the Asturo-Leonese facies area that formed a sedimentary trough during the Devonian will be called the Asturo-Leonese Basin. This basin fringed the Asturian Geanticline in the west and south. In the southeast it continued south of the Santibañez Ridge. A curving of the basin in a southeasterly direction is suggested by the curving in that direction of the León line in the Pisuerga region. The structures of this region link up with the Celtiberic fold-belt (de Sitter, 1957, 1965; Frets, 1965).

We have seen that the Asturian Geanticline already existed in the Cambrian. It is possible that on its eastern flank there was a land mass on the Ebro block from Cambrian to Devonian times, bounding the sedimentary trough in the northeast and acting as a source area of varying importance.

More positive information about this supposed land mass can be obtained from the Ermita Formation in the northeast of the Cantabrian Mountains (Sierras Planas), where it lies disconformably on the Quarcita Amoricana, as suggested in Ch. IV, p. 160. In this region it is composed of predominantly very coarse, sandy, and partly conglomeratic sediments, in which a thin bed with plant remains occurs. According to Hernández Sampelayo (1928), it can even contain a bed of coal with "tallos vegetales hasta de seis a ocho centimetros de diametro y mas de un metro de longitud" (reeds as much as six to eight centimetres in diameter and with a length of more than one metre). This points to the proximity of a continent along which coastal swamps could develop.

The extension of the Asturo-Leonese Basin in the western and southern directions is not well known. The western part of the Cantabrian Mountains was lifted up to such an extent in pre-Stephanian times that the western limit of the Devonian and Lower Carboniferous is a boundary fixed by erosion. The great thickness of the Lower Devonian and, where present, the Middle Devonian formations, as established by Poll (1963) near Belmonte (Asturias), indicates that the outer limit of the Devonian basin lay beyond that area. The investigation of the Alba syncline and the southwesternmost occurrences of the Devonian is still in full swing, and its outcome must be awaited before reliable conclusions about the southern and western extent of the Asturo-Leonese basin can be reached. Remarkable is the occurrence of the Pre-Cambrian (Mora Formation) between Mora and Villablino (de Sitter, 1961), not far from the southernmost outcrops of the Devonian, which does not suggest an extensive continuation of the Devonian basin in southern direction.

The Asturo-Leonese basin was very shallow. The cross-bedded sandstones, coarse-grained detrital limestones, and biostromal limestones point to an epicontinental environment, well aerated, in the photic zone and above the wave base. The deposits were formed in the sub-littoral zone and to a great extent even from the infra-littoral zone (< 50 m deep). Even emersion has occurred in the Asturo-Leonese Basin. Fossils soils are described by Font-Altaba & Closas (1960, amended by Koopmans, 1962, pp. 137—138) at the top of the La Vid Formation near Portilla de Luna and by Koopmans (1962, p. 137) at the top of the

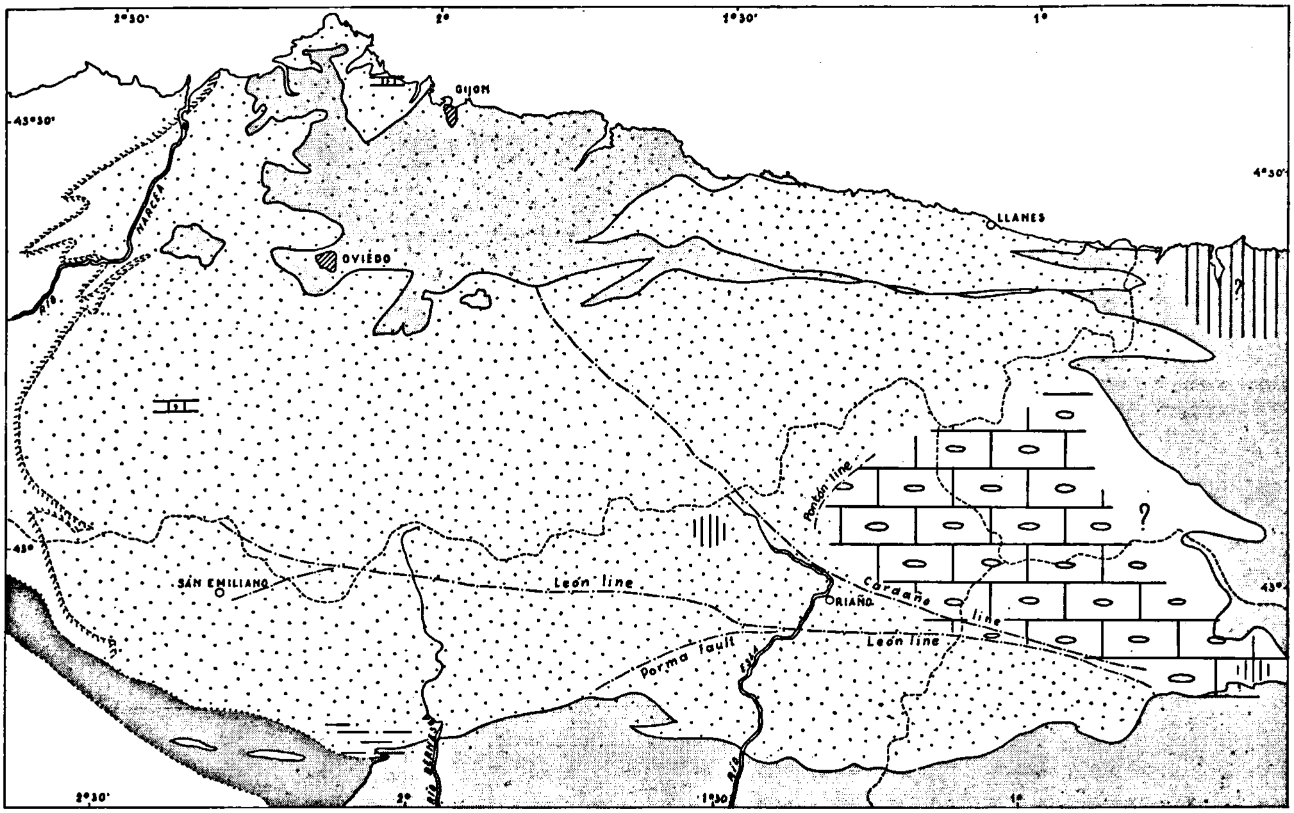

Fig. 64. Facies-pattern map for the uppermost Famennian.

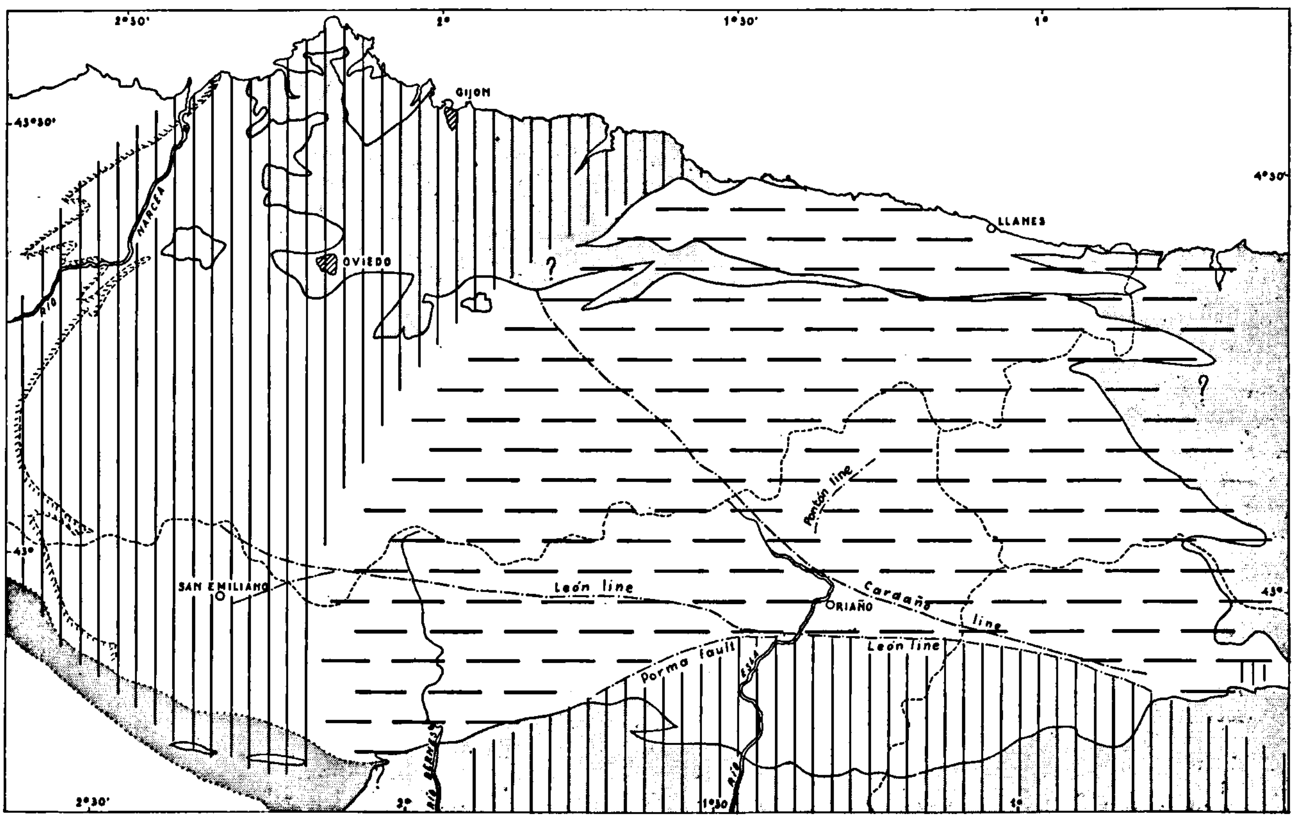

Fig. 65. Facies-pattern map or the upper Tournaisian.

Compuerto Formation in the Valsurvio area. Desiccation cracks are reported from the Santa Lucía Formation of the Esla autochthone (Rupke, 1965, p. 20, Fig. 7) and from the Caldas Formation (Smits, 1965). The subsidence was generally small, which meant that in times of an abundance of reef-building organisms bioherms could develop only rarely. Only in the San Martín-Ventanilla area could bioherms of some importance grow against the Santibañez Ridge (Kanis, 1956, Brouwer, 1964a).

Whether calcareous or sandy and argillacious sediments were deposited depended primarily on the supply of terrigenous material, which is mainly controlled by epeirogenetic factors. We do not know to what extent climatic factors played a role in the supply of terriginous material or reef building.

The Palentine Basin

The sediments of the Palentine facies, with its distinct sedimentary character, were deposited in a clearly limited area that we shall call the Palentine Basin (Fig. 58). This basin is bounded by the Asturian Geanticline in the north and the west and by the Santibañez Ridge in the southwest to south. In the northeastern direction a land area is assumed, as explained above (p. 173).

The Palentine Basin may have had a connection in the southeast with the main Asturo-Leonese basin, because the Barruelo-Mudá area appears to have some properties of an area of facies "spill-over".

It follows that the Palentine Basin was a sheltered area, almost completely surrounded by positive areas. The nature of the sediments, being predominantly shales, calcilutites, and nodular limestones, points to a quiet-water depositional environment. The sea floor was below the wave base. Since the wave action in the sheltered basin would not have been very strong, the wave base must have been high and consequently great water depth was not essential; a depth of more than 50 m does not seem necessary for the deposition of these quiet-water sediments. The fact that in the Palentine Basin no erosion resulted from the uplift of the central Cantabrian area could point, however, to a great depth of the basin. Nevertheless, it is more probable that this basin did not join the uplift of the adjacent areas and remained a relatively shallow, subsiding trough bordered by marginal faults, in which the Murcia Formation could accumulate. A small, deep basin, bordered by positive areas, would show much slumping and grading features, which are rarely found in the Palentine Basin.

The sheltered Palentine Basin was possibly surrounded by a zone of very shallow water in which ocean waves and tidal action were damped out and in which the currents transporting sediment came to a dead end. We visualize the Santibañez Ridge as having been a similar zone. Only in times of general uplift of the Asturian Geanticline and the Santibañez Ridge, as occurred from the uppermost Frasnian to the middle Famennian, did the Palentine Basin become a true embayment (Figs. 62 and 63).

The sheltered character of the Palentine Basin was not yet clearly expressed in the Silurian, Gedinnian, and Siegenian. Members b and c of the Carazo Formation differ considerably from the San Pedro Formation, but the distance between the Río Esla area (the easternmost area of exposure of the San Pedro Formation) and the Cardaño-Triollo area make it impossible to determine the nature and the place of this change in lithology, which was, however, not fundamental. The Lebanza Formation also differs considerably in lithology from the lowermost part of the La Vid Formation; the former, being less argillacious, contains no dolomites and consists to a much greater extent of coarse, detrital, and fossiliferous limestone.

The rich brachiopod fauna does not suggest restricted conditions during the deposition of the Lebanza Formation. Binnekamp (1965, pp. 52—53), however, has pointed out the difference between the brachiopod fauna collected by Comte (1959) in León from the La Vid Formation and the brachiopod fauna from the Lebanza Formation. It therefore seems permissible to distinguish a separate Palentine Basin as early as from upper Gedinnian to lower Siegenian times.

The sheltered conditions of the Palentine Basin are emphasized by:

a. The limited thickness of the deposits, which become thinner towards the Asturian Geanticline in a northern (see Fig. 55) as well in western to southwestern direction (compare Vidrieros Formation in sections CAL II, CU II, and CU III in the Gildar-Montó area).

b. The occurrence of black shales and bituminous limestones in the Gustalapiedra Formation, which points to anoxic conditions. The shales of the Abadía Formation show a darker colour in the centre of the Palentine Basin than at its southern edge.

c. The reefs of the Ventanilla area appear to lie on the southern side of the Santibañez Ridge.

d. The occurrence of impoverished coral and cephalopod faunas in the Palentine Basin (Kullmann, 1965, pp. 58—60).

e. The occurrence of plant remains in the nodular limestones in the Palentine Basin. Wagner & Wagner-Gentis (1963, p. 151) indicated remains of drifted land plants in beds of Middle Devonian age in the Barruelo-Mudá area; van Veen (1965, p. 58) found a few thin stems of wood in the Cardaño Formation in the Cardaño area.

A view of the Palentine facies area as a sheltered basin is not in conflict with the presence of a rich pelagic microfauna. Conodonts are known to be pronouncedly facies-breaking. The number of conodonts per sample is inversely proportional to the rate of sedimentation (Lindström, 1964, p. 68). Especially the slowly-

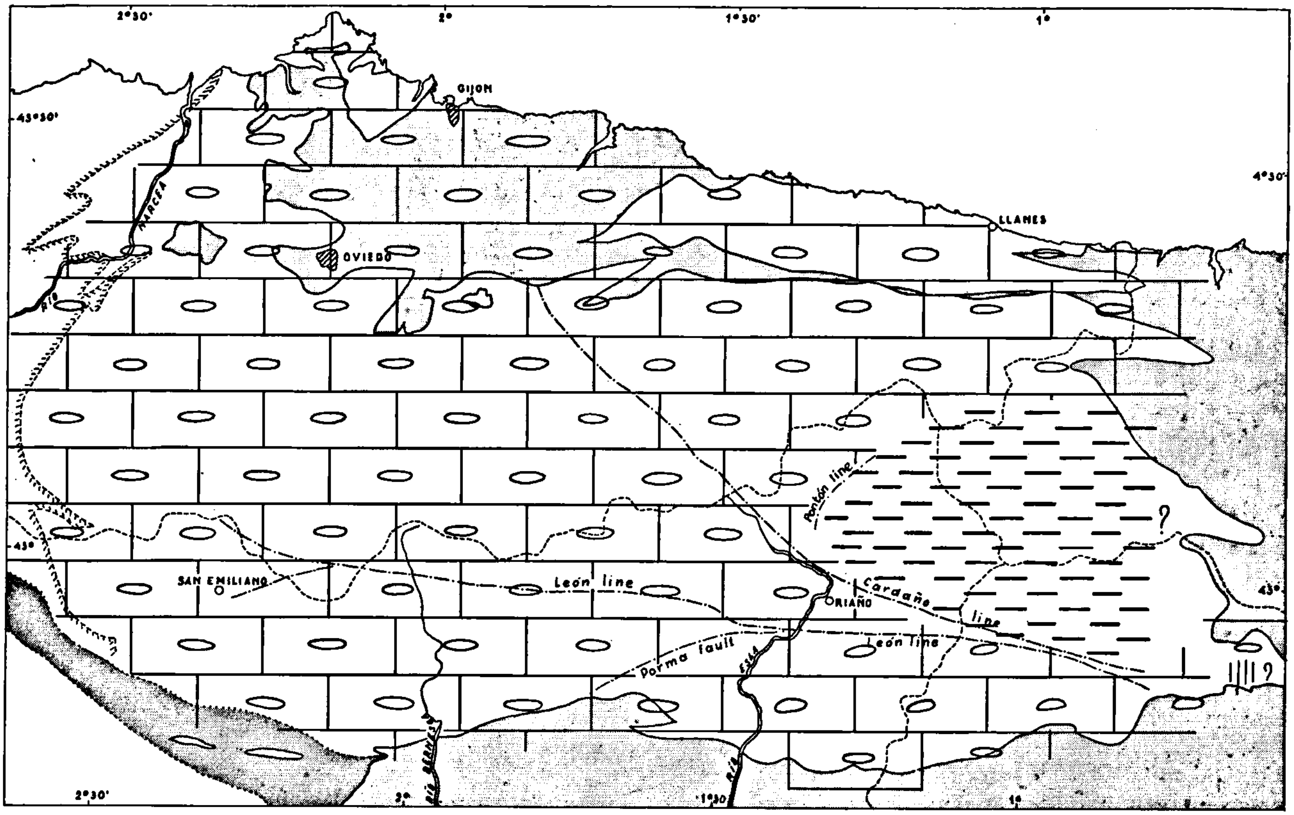

Fig. 66. Facies-pattern map for the lower Viséan.

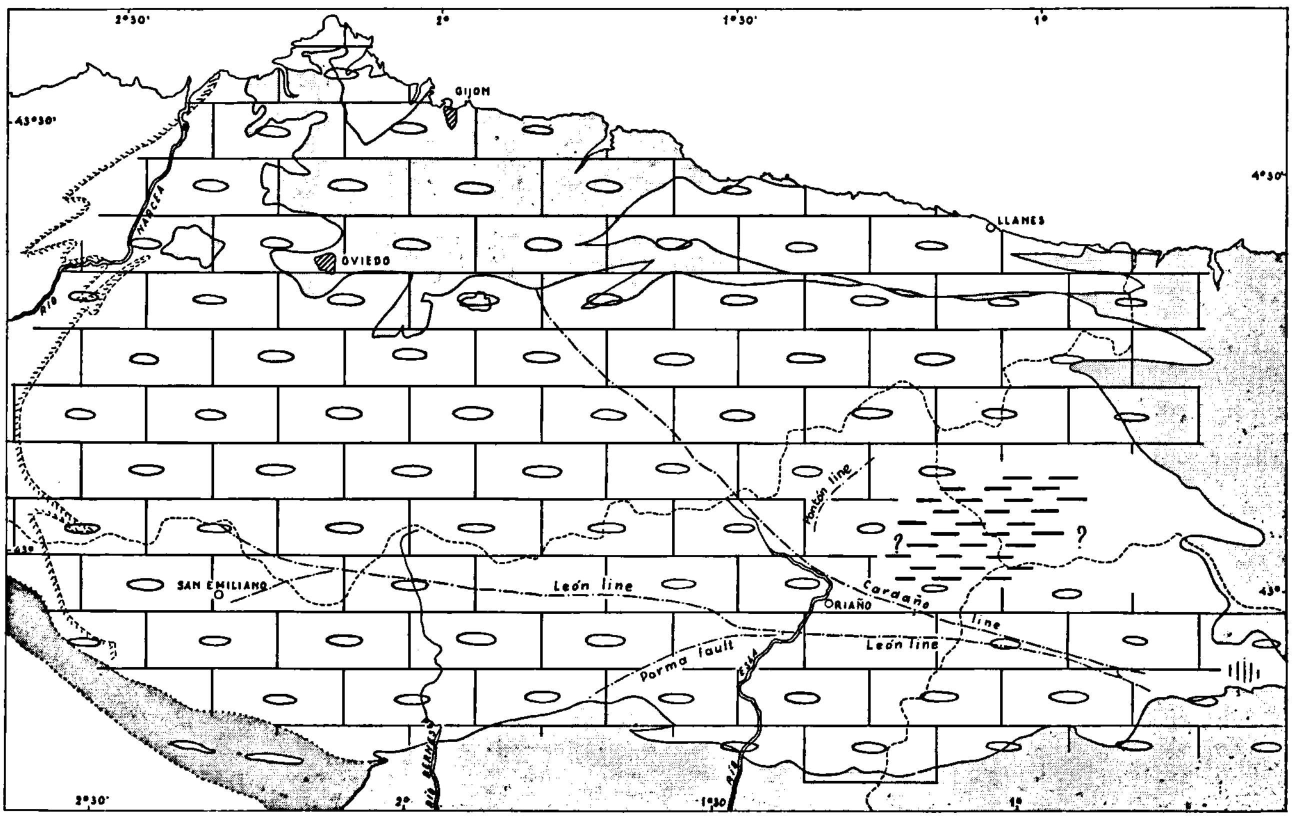

Fig. 67. Facies-pattern map for the upper Viséan.

deposited nodular limestones are rich in conodonts. Bouček (1964, pp. 57, 155) has reported that pelagic tentaculites (Dacryoconarida) are not restricted to one particular facies because of their pelagic mode of life. The scarcity or absence of pelagic elements in the Asturo-Leonese facies might be explained by the small chance of fossilization of their delicate remains in the turbulent environment of that facies and by their "dilution" beyond recovery in the thick sediment sequence.

THE LOWER CARBONIFEROUS DEVELOPMENT OF THE SEDIMENTARY BASINS

As we have seen in the discussion of the Ermita and the Vidrieros Formations, the pattern of the uppermost Devonian sedimentation (Fig. 64) continued in the lowermost Tournaisian. A general regression soon followed. Only in the centre of the Palentine Basin did the sedimentation continue with the deposition of the black shale of the Vegamián Formation.

Later in the Tournaisian, the sea in which the Vegamián Formation was deposited spread over the whole Palentine Basin, reaching the Asturo-Leonese facies area in the upper Tournaisian. There, the black shale complex developed in northeastern and central Asturias, northern León, and in part of the Río Bernesga, Río Torío, and Río Curueño areas (Fig. 65). This picture continued till the uppermost Tournaisian to lowermost Viseán.

Next, a slight regression brought the deposition of the Vegamián black shale to an end locally in the Asturo-Leonese facies area. The deposition of the Vegamián Formation in the Palentine Basin was not affected. Slight erosion of the newly-deposited Vegamián Formation took place in some regions in the Asturo-Leonese facies area, leaving an irregular distributional pattern of this formation, with varying thickness.

With a new rapid general transgression over the very flat surface of the Asturo-Leonese facies area, the red nodular limestone complex of the Alba Formation was deposited (Fig. 66). This transgression started in the lower Viséan or even already in the uppermost Tournaisian (cu IIβ/γ). In the Palentine Basin this transgression had no effect. The deposition of black shales probably continued into the upper Viséan (at least in the Gildar-Montó area: Budinger & Kullmann, 1964, p. 421). In the upper Viséan, after a short break in the sedimentation, the Alba Formation was deposited in the Palentine Basin too, with the exception of the central and eastern part, e.g. the Liébana area (Fig. 67). The San Julián region in the Barruelo-Mudá area was probably still an an island during this period.

The character of the Asturian Geanticline as a high disappeared in the Viséan. The former positive area formed part of the basin in which the Escapa Formation was deposited in the Namurian. Flysch-type sediments were deposited in the Palentine Basin in that time.

CHAPTER VI

CONODONT SYSTEMATICS

In this chapter the most important species characterizing the conodont zones are illustrated and briefly discussed. For the terminology, we refer to Hass (1962). We have, however, followed the recommendation of Scott *et al.* (1962) concerning the orientation of the plate-like conodonts.

The conodonts were recovered from limestone samples (occasionally dolomitic), weighing about 1 kg, with the exception of the Lower Devonian samples, which were generally twice as heavy. Monochloro-acetic acid was used to digest the carbonate. The separation of the heavy fraction was carried out in pure bromoform. Voluminous heavy residues were magnetically separated after Dow (1960). Often found in association with the conodonts were teeth, scales, and dermal plates of fish, phosphatic brachiopod shells; and, occasionally, ostracods and posterior tips of tentaculites.

The enlargement of the photographs (25 or 40 times) is indicated in the explanations of the Plates. Before being photographed, the conodonts were coated lightly with a sublimate of ammonium chloride.

All the conodont faunas from the samples mentioned in this paper are to be found in the Rijksmuseum van Geologie en Mineralogie, Hooglandse Kerkgracht 17, Leiden, The Netherlands. The illustrated specimens have been registered separately.

Genus ANCYRODELLA Ulrich & Bassler, 1926

Ancyrodella curvata (Branson & Mehl, 1934)

Plate 1, Fig. 1

1934a *Ancyrognathus curvata* n.sp. — Branson & Mehl, p. 241, Pl. 19, Figs. 6, 11.

1956 *Ancyrodella curvata* (Branson & Mehl) — Bischoff, p. 118, Figs. 9—11.

For further synonymy, see Glenister & Klapper (1966, p. 798).

Remarks. This *Ancyrodella* has on its outer side a posteriorly-directed lobe with secondary carina and secondary keel. This species is abundant in our Frasnian faunas. Relations with other Frasnian ancyrodellids can be found in Ziegler (1962a, Fig. 2).

Ancyrodella rotundiloba (Bryant, 1921)
Ancyrodella rotundiloba rotundiloba (Bryant, 1921)
Plate 1, Fig. 3

1921 *Polygnathus rotundilobus* n.sp. — Bryant, p. 26, Pl. 12, Figs. 1—6, Text-fig. 7.

1956 *Ancyrodella rotuntiloba* (Bryant) — Hass, Pl. 4, Fig. 21.

1966 *Ancyrodella rotundiloba rotundiloba* (Bryant) — Glenister & Klapper, p. 799, Pl. 85, Figs. 9—13.

Remarks. The illustrated specimen is fairly juvenile. The adult forms are covered with many regularly-placed, rounded nodes. Relations with other Frasnian ancyrodellids can be found in Ziegler (1962a, Fig. 2).

Genus ANCYROGNATHUS Branson & Mehl, 1934
Ancyrognathus asymmetrica (Ulrich & Bassler, 1926)
Plate 1, Fig. 2

1926 *Palmatolepis asymmetrica* n.sp. — Ulrich & Bassler, p. 50, Pl. 7, Fig. 18.

1958 *Ancyrognathus asymmetrica* (Ulrich & Bassler) — Ziegler, pp. 45—47, Pl. 10, Figs. 10, 11.
For further synonymy, see Glenister & Klapper (1966, p. 801).

Remarks. Some of the broader specimens in our material tend towards *Ancyrognathus calvini* (Miller & Youngquist, 1947) but the keel angle, which does not surpass 90°, and the posterior lobes, which are not very rounded, distinguish them from that species. Relations with other Frasnian ancyrognathids can be found in Ziegler (1962a, Fig. 5).

Ancyrognathus triangularis Youngquist, 1945
Plate 1, Fig. 4

1945 *Ancyrognathus triangularis* n.sp. — Youngquist, p. 356, Pl. 54, Fig. 7.
For synonymy, see Glenister & Klapper (1966, p. 802).

Remarks. The available specimens lie well within the variability range given by Ziegler (1958). Relations with other Frasnian ancyrognathids can be found in Ziegler (1962a, Fig. 5).

Genus GNATHODUS Pander, 1856
Gnathodus antetexanus Rexroad & Scott, 1964
Plate 2, Fig. 3

1964 *Gnathodus antetexanus* n.sp. — Rexroad & Scott, pp. 28—29, Pl. 2, Figs. 7—10.

1965 *Gnathodus texanus* Roundy—Budinger, pp. 60—62, Pl. 3, Figs. 7—8 only [*non* Fig. 2 = *G. typicus*, *nec* Fig. 3 = *G. semiglaber*, *nec* Figs. 9, 10 = *G.* cf. *G. cuneiformis*]; Text-fig. 17 [form A only].
For further synonymy, see Rexroad & Scott (1964).

Remarks. This species has a less reduced cup than *Gnathodus texanus*. It has been repeatedly described as *Gnathodus texanus* by European authors. The latter was not found in the Cantabrian Viseán.
There are transitional forms of *Gnathodus antetexanus* to *Gnathodus typicus* and slender forms of *Gnathodus semiglaber.*

Gnathodus bilineatus (Roundy, 1926)
Plate 2, Figs. 4—6

1926 *Polygnathus bilineata* n.sp. — Roundy in Roundy *et al.*, p. 13, Pl. 3, Fig. 10.

1953 *Gnathodus bilineatus* (Roundy) — Hass, p. 78, Pl. 14, Figs. 25—29.

1965 *Gnathodus bilineatus* (Roundy) — Budinger, pp. 53—56, Pl. 2, Figs. 1—8; Text-figs. 15, 16.

1965 *Gnathodus delicatus* Branson & Mehl — Budinger, pp. 56—57, Pl. 2, Fig. 12. [*non* Figs. 9—11, 13 = *G. delicatus* s.l.].
For further synonymy, see Budinger (1965).

Remarks. The long, sharp, transversely-ridged parapet on the inner side of the cup, which runs alongside the carina, reaches the posterior tip of the conodont. This distinguishes the species from *Gnathodus delicatus* s.l., which has a shorter and more nodular parapet or only a row of nodes on the inner side of the cup. The parapet of this species does not reach the posterior tip.

Gnathodus commutatus (Branson & Mehl, 1941)

1941 *Spathognathodus commutatus* n.sp. Branson & Mehl, p. 98, Pl. 19, Figs. 1—4.

1957 *Gnathodus commutatus commutatus* (Branson & Mehl) — Bischoff, p. 23, Pl. 4, Figs. 2—6, 15.

Gnathodus commutatus cruciformis Clarke, 1960
Plate 2, Fig. 8

1958 *Gnathodus commutatus nodosus* Bischoff—Lys & Serre, pp. 891—892, Pl. 9, Fig. 4, [*non* Fig. 3 = *G. commutatus commutatus*].

1960 *Gnathodus cruciformis* n.sp. — Clarke, p. 25, Pl. 4, Figs. 10—12.

1965 *Gnathodus commutatus cruciformis* Clarke—Budinger, p. 49, Pl. 4, Figs. 10, 11; Text-fig. 12.

Remarks. One transverse ridge on each side of the cup is characteristic for this species. Transitional forms to *Gnathodus commutatus nodosus* are common.

Gnathodus commutatus nodosus Bischoff, 1957
Plate 2, Fig. 7

1957 *Gnathodus commutatus nodosus* n.subsp. — Bischoff, p. 23, Pl. 4, Figs. 12, 13.
For synonymy, see Budinger (1965).

Remarks. The cup normally bears a prominent node on both sides of the carina, but sometimes only one of these nodes is present. By elongation of the nodes to a ridge, *Gnathodus commutatus cruciformis* developed from this species.

Gnathodus cuneiformis Mehl & Thomas, 1947
Plate 2, Figs. 9, 10

1947 *Gnathodus cuneiformis* n.sp. — Mehl & Thomas, p. 10, Pl. 1, Fig. 2.
For synonymy, see Rexroad & Scott (1964, p. 29).

Remarks. This species has along both sides of the carina a low row of nodes, only anteriorly fused to form a parapet which is concave towards the carina. The parapet on the inner side extends slightly further forward than the one on the other side. The cup is slender and rather symmetric. For comparisons with *Gnathodus girtyi*, see there.

Gnathodus cf. *G. cuneiformis* Mehl & Thomas, 1947
Plate 2, Figs. 11, 12

1965 *Gnathodus girtyi* Hass—Budinger, pp. 57—58, Pl. 3, Fig. 12 [*non* Fig. 11 = *G.* cf. *G. girtyi, nec* Pl. 2, Figs. 14—16 = *G. girtyi*].

1965 *Gnathodus texanus* Roundy—Budinger, pp. 60—62, Pl. 3, Figs. 9, 10 [*non* Fig. 2 = *G. typicus, nec* Fig. 3 = *G. semiglaber, nec* Figs. 7, 8 = *G. antetexanus*]; Text-fig. 17 [form B only].

Remarks. Gnathodids with two rows of nodes or parapets of unequal size along the carina are here classified as *Gnathodus* cf. *G. cuneiformis.* Among others, a number of fairly juvenile specimens had to be placed in this species.

Gnathodus delicatus Branson & Mehl, 1938 s.l.
Plate 2, Figs. 13—15

1938b *Gnathodus delicatus* n.sp. — Branson & Mehl, p. 145, Pl. 34, Figs. 25—27.

1964 *Gnathodus delicatus* Branson & Mehl — Higgins in Higgins *et al.*, p. 226, Pl. 5, Fig. 24.

1965 *Gnathodus delicatus* Branson & Mehl — Budinger, pp. 56—57, Pl. 2, Figs. 9—11, 13 [*non* Fig. 12 = *G. bilineatus*].
For further synonymy, see Rexroad & Scott (1964, pp. 29—30).

Remarks. Gnathodus delicatus has great variability. The older representatives of this species have a fairly slender cup (Pl. 2, Fig. 13), whereas the younger ones tend to have a broad cup (Pl. 2, Figs, 14, 15). *Gnathodus perplexus* Branson & Mehl, 1938, p. 145, Pl. 34, Fig. 24, included in Rexroad & Scott's synonymy for *Gnathodus delicatus*, is also a broad variant. For criteria to distinguish this broad type from *Gnathodus bilineatus*, see there.

Collinson, Scott & Rexroad (1962) found *Gnathodus delicatus* in the Mississippi Valley restricted to late Kinderhook and early Valmeyer times. Budinger & Kullmann (1964) and Budinger (1965) reported this species as high as the upper Viséan cu IIIγ. Its highest occurrence in our material is the Upper *bilineatus-delicatus* s.l. Zone of approximately cu IIIα—cu IIIβ age.

It might prove possible to split this species into two subspecies, if enough material from complete sections were studied. An indication for this is the occurrence of two maxima in its distribution in section OL (one in the lower part of the *anchoralis* Zone and the other in the *bilineatus-delicatus* s.l. Zone). For the present, we shall classify the whole group as *Gnathodus delicatus* s.l.

Gnathodus girtyi Hass, 1953
Plate 2, Fig. 16

1953 *Gnathodus girtyi* n.sp. — Hass, p. 80, Pl. 14, Figs. 22—24.

1957 *Gnathodus girtyi* Hass—Bischoff, pp. 24—25, Pl. 4, Figs. 16—23.

1960 *Gnathodus clavatus* n.sp. — Clarke, p. 25, Pl. 4, Figs 4—9.

1965 *Gnathodus girtyi* Hass—Budinger, pp. 57—58, Pl. 2, Figs. 14—16 [*non* Pl. 3, Fig. 11 = *G.* cf. *G. girtyi, nec* Fig. 12 = *G.* cf. *G. cuneiformis, nec* Fig. 13 = *G. typicus?*]; Text-fig. 17 [form D only].

Remarks. Gnathodus girtyi has a high parapet on either side of the carina. The cup has a low, broad bulge at its outer side; *Gnathodus cuneiformis* has lower, incomplete parapets which are anteriorly concave towards the carina and is more symmetric than the former species.

Gnathodus kockeli Bischoff, 1957
Plate 2, Figs. 17, 18

1957 *Gnathodus kockeli* n.sp. — Bischoff, p. 25, Pl. 3, Figs. 27—32.

1959 *Gnathodus kockeli* Bischoff—Voges, pp. 281—282, Pl. 33, Figs. 26, 27.

1964 *Gnathodus kockeli* Bischoff—Higgins in Higgins *et al.*, Pl. 5, Fig. 27.

Remarks. For description and comparison with *Gnathodus commutatus homopunctatus*, see Voges (1959). *Gnathodus kockeli* is rarely represented in the lower Tournaisian conodont faunas of the Cantabrian Mountains.

Gnathodus punctatus (Cooper, 1939)
Plate 2, Fig. 19

1939 *Dryphenotus punctatus* n.sp. — Cooper, p. 386, Pl. 41, Figs. 42, 43, Pl. 42, Figs. 10, 11.

1959 *Gnathodus punctatus* (Cooper) — Hass, p. 395, Pl. 47, Figs. 11—18.
For synonymy, see Budinger (1965, pp. 58—59).

Remarks. Characteristic for this species is the short parapet on the inner side of the cup curving away from the carina posteriorly.

Gnathodus semiglaber Bischoff, 1957
Plate 2, Figs. 20, 23

1957 *Gnathodus bilineatus semiglaber* n.subsp. — Bischoff, p. 22, Pl. 3, Figs. 1—10, 12—14.

1959 *Gnathodus semiglaber* (Bischoff) — Voges, p. 284, Pl. 33, Figs. 38, 39.

1965 *Gnathodus semiglaber* Bischoff—Budinger, pp. 59—60, Pl. 3, Figs. 1, 4—6, Text-fig. 17 [forms D, E].

1965 *Gnathodus texanus* Roundy—Budinger, pp. 60—62, Pl. 3, Fig. 3 [*non* Fig. 2 = *G. typicus, nec* Figs. 7, 8 = *G. antetexanus, nec* Figs. 9, 10 = *G.* cf. *cuneiformis*].
For further synonymy, see Rexroad & Scott (1964, p. 30).

Remarks. Gnathodus semiglaber has a low asymmetrical cup whose broad outer side is scantily ornamented. Its posterior tip is broad and often bears three rows of small nodes. This species is very variable. There are transitions to *Gnathodus antetexanus, Gnathodus cuneiformis,* and *Gnathodus typicus.*

Gnathodus typicus Cooper, 1939
Plate 2, Fig. 21

1939 *Gnathodus typicus* n.sp. — Cooper, p. 388, Pl. 42, Figs. 77, 78.

1965 *Gnathodus texanus* Roundy—Budinger, pp. 60—62, Pl. 3, Fig. 2 [*non* Fig. 3 = *G. semiglaber, nec* Figs. 7, 8 = *G. antetexanus, nec* Figs. 9, 10 = *G.* cf. *G. cuneiformus*].

1965 [?] *Gnathodus girtyi* Hass—Budinger, pp. 57—58, Pl. 3, Fig. 13 [*non* Fig. 11 = *G.* cf. *G. girtyi, nec* Fig. 12 = *G.* cf. *G. cuneiformis, nec* Pl. 2, Figs. 14—16 = *G. girtyi*].
For further synonymy, see Rexroad & Scott (1964, pp. 31—32).

Remarks. Gnathodus typicus has a short, high parapet on the inner side of the slender cup; the outer side bears a few small nodes. Transitions to *Gnathodus delicatus and Gnathodus semiglaber* exist.

Gnathodus sp. A Collinson, Scott & Rexroad, 1962
Plate 2, Fig. 22

1961 *Gnathodus* cf. *G. commutatus* (Branson & Mehl) — Scott & Collinson, pp. 123—124, Pl. 1, Figs. 23—27.

1962 *Gnathodus* n.sp., A — Collinson, Scott & Rexroad, p. 8, Chart 3.

1964 *Gnathodus* sp. A — Higgins in Higgins *et al.*, p. 227, Pl. 5, Fig. 28.

Remarks. We think that the smooth gnathodids from the lower Tournaisian sample TR 21 are *Gnathodus* sp. A. In our material the cup is not sub-circular but oval, its long axis usually making a small angle with the longitudinal direction of the conodont.

Genus ICRIODUS Branson & Mehl, 1938
Icriodus corniger Wittekindt, 1966
Plate 1, Figs. 5, 6

1966 *Icriodus corniger* n.sp. — Wittekindt, p. 629, Pl. 1, Figs. 9—12.

Remarks. The sharp postero-lateral flange of the expanded pulp cavity is characteristic. In some specimens this flange bears a low ridge consisting of a few fused nodes.

Icriodus cf. *I. corniger* Wittekindt, 1966
Plate 1, Figs. 7, 8

Material. 4 complete and 5 indentifiable damaged specimens.
Description. Oral view: Fairly slender, slightly curved conodont, widest at the middle. The nodes on the posterior part are smaller and more closely set, giving a compressed appearance. The median row of nodes (carina) extends further backward, with a ridge of 2 to 3 fused denticles, the posterior denticle being the largest and sometimes cusp-like. The lateral rows of nodes consist of 8 to 11 discrete nodes. Lateral view: The posterior edge makes a right angle with the oral side of the conodont or slants backwards slightly. Aboral view: The expanded pulp cavity is widest posteriorly, tapering toward the anterior part. A postero-lateral flange is weakly but distinctly developed at the outer side. At the inner side a faint anteriorly-directed spur is indicated.
Distribution. Spain. — The upper part of the La Vid Formation and the basal part of the Santa Lucía Formation in the Río Esla area. One specimen was found in the upper part of the Santa Lucía Formation. Belgium. — Upper Emsian (Rhenan sence) to Lower Couvinian (pers. comm. Prof. Dr. O. H. Walliser, Göttingen, Germany).

Icriodus eslaensis n.sp.
Plate 1, Figs. 9—12

1938 *Icriodus cymbiformis* Branson & Mehl? — Stauffer, p. 430, Pl. 52, Figs. 11, 13.

1940 *Icriodus cymbiformis* Branson & Mehl — Stauffer, p. 425, Pl. 60, Figs. 56—58, 68, 37 [?] [*non* Fig. 51 = *I. cymbiformis*].

1940 *Icriodus expansus* Branson & Mehl — Stauffer, p. 425, Pl. 60, Figs. 70, 71, 59 [?], 64 [?] [*non* Figs. 40, 47—48, 60—63 = *I. expansus*].

1965 *Icriodus* cf. *I. obliquimarginatus* Bischoff & Ziegler — van Adrichem Boogaert, p. 166, Table 2; p. 175, Table 9.

Derivatio nominis. After the Río Esla area, where this species was first recognized.
Holotype. Specimen AB 9, illustrated in Pl. 1, Fig. 9.
Locus typicus. La Velilla de Valdoré.
Stratum typicum. The basal part of the La Portilla Formation in the Río Esla area.
Material. 225 specimens.
Diagnosis. A small slender species of *Icriodus* with the median row of nodes (carina) extended posteriorly past the short lateral rows of nodes. The extended part consists of 4 to 5 fused denticles, which increase in height posteriorly.
Description. Oral view: The conodont is relatively small, uncurved and slender, with sub-parallel sides. The median row of nodes consists of 10 to 13 nodes. In the posterior part, where it extends beyond the lateral row of nodes, it consists of 4 to 5 fused denticles, which increase in height posteriorly. The last denticle is the largest and often cusp-like. The lateral rows of nodes do not reach the anterior tip. They usually consists of 4 to 5 descrete nodes, but their number can vary from 3 to 7. The lateral nodes tend to alternate slightly with respect to those of the median row. Some of them, on one or both sides, may be suppressed, giving an irregular appearance to some specimens. Lateral view: The conodont is not arched. Its posterior edge is slightly inclined backward. Aboral view: The

pulp cavity is moderately expanded posteriorly. In some specimens a faint antero-lateral spur is indicated. The expanded pulp cavity tapers rapidly anteriorly.
Distribution. Spain. — The species occurs in the *varca* Zone *s.l.* (middle to upper Givetian) in the Cantabrian Mountains. U.S.A. — Stauffer (1938, 1940) reported this species from the Olentangy shale in Ohio and Ontario and in clays above the Cedar Valley limestone in Minnesota.
Remarks. Icriodus angustus Stewart & Sweet, 1965 differs from this species in that its median row of nodes does not reach the anterior tip and its oral ornamentation forms transverse ridges.
Icriodus obliquimarginatus seems to be related to the new species. The former is, however, considerably more slender and has a more irregular oral surface in which the nodes of the lateral rows are sometimes connected with the nodes of the median row by small ridges. Furthermore, it has a more widely expanded pulp cavity with an antero-lateral spur. Juvenile specimens of *Icriodus eslaensis* n.sp. conform to the description of *Icriodus cymbiformis*. We agree with Bischoff & Ziegler (1957, p. 62), who suppose that this small icriodid represents juvenile forms of various species of *Icriodus*.

Icriodus latericrescens Branson & Mehl, 1938

Remarks. This species has been reported from the Lower and Middle Devonian. Its main distribution and abundance occur in the Lower Devonian, where Ziegler (1956) distinguished three subspecies. Philip (1965) and Wittekindt (1966) propose placing the Lower Devonian forms in a separate, homeomorphous species. The fact that in Europe *Icriodus latericrescens* has been found in the Lower Devonian and in the Givetian (part of the *varca* Zone), but never in the Eifelian, seems to support this view. In the United States, however, this species is reported from the lower part of the Middle Devonian as well (Branson & Mehl, 1938).
The older Lower Devonian forms of *Icriodus latericrescens* are generally broad and massive, i.e. "*Icriodus latericrescens* (*sensu* Ziegler, 1956)". The species shows a tendency to become more slender and to have more closely set rows of nodes toward the upper part of the Lower Devonian (Pl. 1, Figs. 13—15, 18, 20). Where this tendency continues we may see the slender Middle Devonian forms, i.e. "*Icriodus latericrescens* (*sensu* Branson & Mehl)" as a normal evolution of the same species. There seems to be only an arbitrary boundary between the "*sensu* Ziegler" and the "*sensu* Branson & Mehl" forms.
It has not yet been explained why *Icriodus latericrescens* is so rarely found in the Middle Devonian in Europe. Perhaps the species became more facies-dependent in that epoch. *Icriodus* is known to have its own facies preferences, since it is sometimes the only plate-like genus present in conodont faunas.

Icriodus latericrescens latericrescens Branson & Mehl, 1938
Plate 1, Figs. 13—17

1938a *Icriodus latericrescens* n.sp. — Branson & Mehl, pp. 164—165, Pl. 26, Figs. 30—37.
1938 *Icriodus latericrescens* Branson & Mehl — Stauffer, p. 430, Pl. 52, Figs. 30, 34.
1947 *Icriodus latericrescens* Branson & Mehl — Youngquist, p. 102, Pl. 25, Fig. 25.
1952 [?] *Icriodus latericrescens* Branson & Mehl — Graves, p. 612, Pl. 81, Fig. 9, [*non* Figs. 14—16 = *I. latericrescens beckmanni*?].
1952 *Icriodus curvatus* Branson & Mehl — Graves, Pl. 81, Figs. 10, 11.
1956 *Icriodus latericrescens* Branson & Mehl — Stewart & Sweet, p. 268, Pl. 33, Figs. 2, 6, 7.
1956 *Icriodus latericrescens latericrescens* Branson & Mehl — Ziegler, p. 100, Pl. 6, Figs. 14—17.
1958 *Icriodus latericrescens latericrescens* Branson & Mehl, Bischoff & Sannemann, p. 95, Pl. 12, Fig. 8.
1962 *Icriodus latericrescens latericrescens* Branson & Mehl — Jentzsch, p. 967, Pl. 1, Fig. 16.
1964 *Icriodus latericrescens* Branson & Mehl — Orr, pp. 9—10, Pl. 2, Figs. 8—10.
1966 *Icriodus latericrescens latericrescens* Branson & Mehl — Clark & Ethington, p. 679, Pl. 83, Figs. 6, 7, 10, 11, 14.
1966 *Icriodus latericrescens* Branson & Mehl — Wittekindt, pp. 629—630, Pl. 1, Figs. 6—8.

This subspecies of *Icriodus latericrescens* has one spur, which points postero-laterally.
Description. See Ziegler (1956: "*sensu* Ziegler") and Wittekindt (1966: "*sensu* Branson & Mehl").
The Lower Devonian forms of this subspecies are mostly somewhat smaller than representatives of *Icriodus latericrescens bilatericrescens*. There are transitional forms between these subspecies.
Characteristic for the Givetian forms (Pl. 1, Figs. 16, 17) are the poorly-developed median row of nodes and the strong spur, often covered with a double row of small nodes.

Icriodus latericrescens bilatericrescens Ziegler, 1956
Plate 1, Figs. 18—20

1956 *Icriodus latericrescens bilatericrescens* n.subsp. — Ziegler, pp. 101—102, Pl. 6, Figs. 6—13.
1958 *Icriodus latericrescens bilatericrescens* Ziegler—Bischoff & Sannemann, p. 96, Pl. 12, Fig. 5.
1958 *Icriodus latericrescens* cf. *latericrescens* Ziegler—Bischoff & Sannemann, pp. 95—96, Pl. 12, Figs. 10, 11.
1962 *Icriodus latericrescens bilatericrescens* Ziegler—Jentzsch, p. 966, Pl. 1, Figs. 12, 14, 24.
1962 *Icriodus latericrescens* cf. *bilatericrescens* Ziegler—Jentzsch, p. 966, Pl. 1, Figs. 10, 13, 15.
1962 *Icriodus woschmidti* Ziegler—Jentzsch, p. 967, Pl. 1, Figs. 17, 20—22.
1965 *Icriodus bilatericrescens* Ziegler—Philip, p. 103, Pl. 9, Figs. 30—32.
1966 *Icriodus latericrescens bilatericrescens* Ziegler—Clark & Ethington, p. 679, Pl. 83, Figs. 12, 13, 15.
1966 *Icriodus pesavis* Bischoff & Sannemann — Clark & Ethington, p. 680, Pl. 83, Fig. 5.

This subspecies of *Icriodus latericrescens* has two spurs, one pointing postero-laterally, the other in the opposite direction.

Description. See Ziegler (1956).

Remarks. The variation of the oral ornamentation, which ranges from widely-set transverse rows of nodes to closely-set rows, resembles that of *Icriodus latericrescens latericrescens.* A few of the specimens with a well-developed postero-lateral spur bear two or even three rows of fused, small nodes on the spur (Pl. 1, Fig. 19). Juvenile forms generally a poorlydeveloped antero-lateral spur and may resemble *Icriodus latericrescens latericrescens. Icriodus latericrescens bilatericrescens* is not known from the Middle Devonian.

Icriodus woschmidti Ziegler, 1960
Plate 1, Fig. 21; Plate 2, Fig. 1

1960a *Icriodus woschmidti* n.sp. — Ziegler, p. 185, Pl. 15, Figs. 16—18, 20—22.

1962 [*non*] *Icriodus woschmidti* Ziegler—Jentzsch, p. 967, Pl. 1, Fig, 17—23 [Figs. 17, 20—22 = *I. latericrescens bilatericrescens*].

1964 *Icriodus woschmidti* Ziegler—Walliser, pp. 38—39, Pl. 9, Fig. 22; Pl. 11, Figs. 14—22.

Remarks. Characteristic features are the very widely separated transverse rows of three fused nodes forming ridges and the cusp-like posterior denticle on the oral surface. A postero-lateral spur and an oppositely directed antero-lateral spur are present. The very wide spacing of the transverse rows of nodes distinguishes this species from *Icriodus latericrescens bilatericrescens.*

Icriodus sp. *a*
Plate 2, Fig. 2

Remarks. This species appears to be related to *Icriodus latericrescens bilatericrescens.* Instead of the antero-lateral and postero-lateral spurs, broad flanges are developed in these directions. The expanded pulp cavity is exceptionally wide. The oral side of the conodont is fusiform, being widest in the centre. The lateral rows of nodes are developed as ridges connected with the median row. In the lateral view the oral surface of the conodont is arched. The flanges of the posterior part of the expanded pulp cavity are reminiscent of *Icriodus corniger*, which has, however, a different oral ornamentation and its greatest width posteriorly. Only three specimens of *Icriodus* sp. *a* were found in our material, all in sample 19 from the Río Esla area. We shall therefore wait to present it as a new species until more material is available for study.

Genus PALMATOLEPIS Ulrich & Bassler, 1926

The phylomorphogenetic development of *Palmatolepis,* which genus is of great stratigraphic value in the Upper Devonian, can be found in Helms (1963).

Palmatolepis distorta Branson & Mehl, 1934
Plate 2, Fig. 24

1934a *Palmatolepis distorta* n.sp. — Branson & Mehl, p. 237, Pl. 18, Figs. 13, 14.
For synonymy, see Glenister & Klapper (1966, p. 809).

Remarks. Palmatolepis distorta is strongly sigmoidal. It has a ridge on the outer side of the platform, close to the blade. For comparisons with *Palmatolepis glabra pectinata*, see Ziegler (1962b).

Palmatolepis gigas Miller & Youngquist, 1947
Plate 2, Fig. 27

1947 *Palmatolepis gigas* n.sp. — Miller & Youngquist, p. 512, Pl. 75, Fig. 1.

1956 *Palmatolepis rhenana* n.sp. — Bischoff, p. 129, Pl. 8, Figs. 26—28, Pl. 10, Fig. 7.

1963 *Palmatolepis gigas* Miller & Youngquist—Klapper & Furnish, pp. 406—407.
For further synonymy, see Glenister & Klapper (1966, p. 810).

Remarks. The slender patform, posteriorly pointed, the long inner lobe, and the high free blade, characterize this species. Relations with other Frasnian palmatolepids can be found in Ziegler (1962a, Fig. 8).

Palmatolepis glabra Ulrich & Bassler, 1926
Palmatolepis glabra glabra Ulrich & Bassler, 1926
Plate 2, Fig. 25

1926 *Palmatolepis glaber* n.sp. — Ulrich & Bassler, p. 51, Pl. 9, Figs. 18—20.

1934a *Palmatolepis glabra* Ulrich & Bassler — Branson & Mehl, p. 233, Pl. 18, Fig. 26 [*non* Figs. 9, 22 = *P. glabra pectinata*].

1960b *Palmatolepis glabra glabra* Ulrich & Bassler—Ziegler, p. 7, Pl. 1, Figs. 11—13.

For further synonymy, see Glenister & Klapper (1966, p. 811).

Remarks. This species has no inner lobe. Most of the specimens in our material were fairly small.

Palmatolepis glabra elongata Holmes, 1928
Plate 2, Fig. 26

1928 *Palmatolepis elongata* n.sp. — Holmes, p. 33, Pl. 11, Fig. 33.

1960b *Palmatolepis glabra elongata* Holmes—Ziegler, p. 8, Pl. 1, Figs. 10, 14.

For further synonymy, see Glenister & Klapper (1966, pp. 811, 814).

Remarks. This is a very slender subspecies of *Palmatolepis glabra* with a small, lobe-like outer platform.

Palmatolepis gracilis Branson & Mehl, 1934
Palmatolepis gracilis gracilis Branson & Mehl, 1934
Plate 2, Figs. 28, 29

1934a *Palmatolepis gracilis* n.sp. — Branson & Mehl, p. 238, Pl. 18, Fig. 8 [*non* Fig. 2 = *P. glabra elongata* Holmes, *nec* Fig. 5 (= Nothognathella?)].

1956 *Palmatolepis* (*Deflectolepis*) *deflectens* n.sp. — Müller, p. 32, Pl. 11, Figs. 28—39.

1959 *Palmatolepis deflectens* Müller—Helms, p. 648, Pl. 6, Fig. 20.

1962b *Palmatolepis deflectens deflectens* Müller—Ziegler, p. 56, Pl. 3, Figs. 17—22.

1962 *Palmatolepis gracilis gracilis* Branson & Mehl — Mehl & Ziegler, pp. 204—205.

For further synonymy, see Glenister & Klapper (1966, pp. 814—815).

Remarks. This *Palmatolepis* has an extremely reduced platform. Some forms transitional to *Palmatolepis minuta* occur. Specimen AB 42, illustrated in Pl. 2, Fig. 29 has a bifurcated posterior tip. This seems to be a pathologic anomaly.

Palmatolepis quadrantinodosa Branson & Mehl, 1934
Palmatolepis quadrantinodosa marginifera Ziegler, 1960
Plate 2, Fig. 30

1960b *Palmatolepis quadrantinodosa marginifera*, n.subsp. — Ziegler, pp. 11—12, Pl. 1, Fig. 6; Pl. 2, Figs. 6—8.

1962b *Palmatolepis quadrantinodosa marginifera* Ziegler—Ziegler, p. 75, Pl. 7, Figs. 6—9.

For further synonymy, see Glenister & Klapper (1966, p.820).

Remarks. This species has a broad, rounded posterior part and a prominent ridge on the outer platform parallel to the blade.

Palmatolepis rugosa Branson & Mehl, 1934
Palmatolepis rugosa ampla Müller, 1956
Plate 2, Fig. 31

1956 *Palmatolepis (Palmatolepis) ampla* n.sp. — Müller, p. 28, Pl. 9, Figs. 35, 36.

1960c *Palmatolepis rugosa ampla* Müller—Ziegler in Kronberg *et al.*, p. 38, Pl. 1, Figs. 3—5; Text-figs. 12, 13.

1962b *Palmatolepis rugosa ampla* Müller—Ziegler, p. 78, Pl. 8, Fig. 6.

Remarks. The ornamentation of this species is less pronounced than that of the other subspecies of *Palmatolepis rugosa*. The inner posterior part of the platform is very large.

Palmatolepis subrecta Miller & Youngquist, 1947
Plate 2, Fig. 32

1947 *Palmatolepis subrecta* n.sp. — Miller & Youngquist, p. 513, Pl. 75, Figs. 7—10.

For synonymy, see Glenister & Klapper (1966, p. 823).

Remarks. The posterior part of the platform is arched downward. Relations with other Frasnian palmatolepids can be found in Ziegler (1962a, Fig. 8). *Palmatolepis subrecta* is abundant in our Frasnian material.

Palmatolepis transitans Müller, 1956
Plate 2, Fig. 33

1956 *Palmatolepis (Manticolepis) transitans* n.sp. — Müller, p. 18, Pl. 1, Figs. 1, 2.

1956 *Palmatolepis (Manticolepis) cruciformis* n.sp. — Müller, p. 9, Pl. 2, Fig. 9.

1957 *Palmatolepis transitans* Müller—Bischoff & Ziegler, p. 81, Pl. 16, Figs. 23—27.

1958 *Palmatolepis transitans* Müller—Ziegler, p. 66, Pl. 1, Figs. 9, 11—13; Pl. 2, Figs. 1—3, 8.

Remarks. Palmatolepis transitans developed from *Polygnathus asymmetrica asymmetrica.* Relations with upper Givetian and Frasnian polygnathids and palmatolepids can be found in Ziegler (1962a, Fig. 8).

Genus PELEKYSGNATHUS Thomas, 1949

Pelekysgnathus serrata, Jentzsch, 1962
Plate 2, Figs, 34, 35

1962 *Pelekysgnathus serrata* n.sp. — Jentzsch, pp. 970—971, Pl. 2, Figs. 7, 8; Pl. 3, Figs. 6, 9, 15.

1965 *Pelekysgnathus serrata* Jentzsch—Le Fevre, p. 49.

Remarks. This species appears to have developed from *Icriodus*. It is a small, blade-like conodont with a long, posteriorly-widening pulp cavity.

Genus POLYGNATHUS Hinde, 1879

Polygnathus asymmetrica Bischoff & Ziegler, 1957
Polygnathus asymmetrica asymmetrica Bischoff & Ziegler, 1957
Plate 2, Fig. 36

1957 *Polygnathus dubia asymmetrica* n.subsp. — Bischoff & Ziegler, pp. 88—89, Pl. 16, Figs 20—22; Pl. 21, Fig. 3.

1958 *Polygnathus dubia asymmetrica* Bischoff & Ziegler—Ziegler, Pl. 1, Figs. 4—6, 8, 10.

1964 *Polygnatus asymmetrica asymmetrica* Bischoff & Ziegler—Ziegler, Klapper & Lindström. p. 423.

For further synonymy, see Glenister & Klapper (1966, p. 828).

Remarks. Ziegler, Klapper & Lindström (1964) have pointed out that *Polygnathus dubia* Hinde, 1879 is a *nomen dubium.* They proposed that *Polygnathus robusticostata* Bischoff & Ziegler, 1957 be recognized as the new types species of *Polygnathus.* Furthermore, they proposed a new subspecific name for *Polygnathus dubia dubia*, i.e. *Polygnathus asymmetrica ovalis* Ziegler & Klapper.
The genus *Palmatolepis* developed from *Polygnathus asymmetrica* in the lowermost Frasnian. Relations with palmatolepids can be found in Ziegler (1962a, Fig. 8).

Polygnathus communis Branson & Mehl, 1934
Polygnathus communis communis Branson & Mehl, 1934
Plate 2, Fig. 37

1934b *Polygnathus communis* n.sp. — Branson & Mehl, p. 293, Pl. 24, Figs. 1—4.

1964 *Polygnathus communis communis* Branson & Mehl — Rexroad & Scott, p. 33, 34, Pl. 2, Figs. 17, 18.

For further synonymy, see Rexroad & Scott (1964).

Remarks. The earliest known occurrence of *Polygnathus communis communis* in the Cantabrian Mountains is in the *quadrantinodosa* Zone. The illustrated specimen comes from this zone. It already has the characteristic excavation behind the pulp cavity.

Polygnathus communis carina Hass, 1959
Plate 2, Fig. 43

1959 *Polygnathus communis* Branson & Mehl *carina* n.var. — Hass, p. 391, Pl. 47, Figs. 8, 9.

1964 *Polygnathus communis carina* Hass—Rexroad & Scott, p. 34, Pl. 2, Figs, 24, 25.

Remarks. Two or more nodose ridges ornament the anterior side of the platform of this subspecies of *Polygnathus communis.*

Polygnathus cf. *P. communis communis*
Branson & Mehl, 1934
Plate 2, Fig. 38

1959 *Polygnathus communis* Branson & Mehl, 1934? — Voges, p. 290.

Remarks. Conodonts closely resembling *Polygnathus communis communis* but lacking the characteristic excavation behind the pulp cavity were classified as *Polygnathus* cf. *P. communis communis.*

Polygnathus cristata Hinde, 1879
Plate 2, Fig. 41

1879 *Polygnathus cristatus* n.sp. — Hinde, p. 366, Pl. 17, Fig. 11.

1957 *Polygnathus cristata* Hinde—Bischoff & Ziegler, pp. 86—87, Pl. 15, Figs. 13, 16; Pl. 17, Figs. 12, 13.

1966 *Polygnathus cristata* Hinde—Ziegler, pp. 670—671, Pl. 4, Figs. 17—23; Pl. 5, Figs. 1—5.

For further synonymy, see Orr (1964, p. 13).

Remarks. This species has a broad, oval platform ornamented with large unfused nodes.

Polygnathus cf. *P. eiflia* Bischoff & Ziegler, 1957
Plate 2, Fig. 42

1965 *Polygnathus pennata* Hinde—van Adrichem Boogaert, p. 169, Table 5.

Remarks. Wittekindt (1966, p. 633) stresses in a new definition of *Polygnathus eiflia* the importance of the asymmetric platform and the narrow, constricted anterior part. Because of the slenderness of the posterior part of the platform in our specimens, we have classified them as *Polygnathus* cf. *P. eiflia.*

Polygnathus inornata E. R. Branson, 1934
Plate 2, Figs. 39, 40

1934 *Polygnathus inornata* n.sp. — E. R. Branson, p. 309, Pl. 25, Figs. 8, 26.

1938b *Polygnathus lobata* n.sp. — Branson & Mehl, p. 146, Pl. 34, Figs. 44—47.

For further synonymy, see Klapper (1966, pp. 19—20).

Remarks. Polygnathus inornata has a short blade and a thick, elongated platform with upturned margins. The ornamentation is restricted to faint transverse ridges on the margins. The pulp cavity is usually small. For comparisons with *Polygnathus longipostica,* see there. Klapper (1966) has indicated the great variability range of *Polygnathus inornata.*

Polygnathus linguiformis Hinde, 1879
Polygnathus linguiformis linguiformis Hinde, 1879
Plate 2, Fig. 44; Plate 3, Fig. 1

1879 *Polygnathus linguiformis* n.sp. — Hinde, p. 367, Pl. 17, Fig. 15.

1966 *Polygnathus linguiformis* Hinde—Philip, pp. 448—449, Pl. 2, Figs. 29—40.

1966 *Polygnathus linguiformis linguiformis* Hinde—Wittekindt, pp. 635—636, Pl. 2, Figs. 10—12.

For further synonymy, see Orr (1964, p. 16, 18) and Wittekindt (1966).

Remarks. The illustrated specimen, AB 57, shown here in Pl. 3, Fig. 1 derives from the lowest fauna (sample VIII 12) with *Polygnathus linguiformis linguiformis* from the Río Esla area. It has an Emsian (most probably lower Emsian) age. Remarkable is its very large and wide, *Pseudopolygnathus*-like pulp cavity. Philip (1966) also found this characteristic mark in lower Emsian specimens of *Polygnathus linguiformis* of southeastern Australia. He pointed out that in the Lower Devonian of Europe, Prof. Dr. O. H. Walliser observed forms with an enlarged pulp cavity occurring together with forms with a small pulp cavity. Samples VIII 12 and Ib 8, both from the Río Esla area, contain only specimens of *Polygnathus linguiformis linguiformis* with a large pulp cavity. All higher Emsian and Middle Devonian specimens of this species have a normal, small pulp cavity.

Polygnathus linguiformis mucronata Wittekindt, 1966
Plate 3, Fig. 2

1966 *Polygnathus linguiformis mucronata* n.subsp. — Wittekindt, p. 636, Pl. 2, Figs. 13—15.

Remarks. Only one specimen of this subspecies with its pointed posterior tip lacking transverse ribbing was found in the Gildar-Montó area.

Polygnathus longipostica Branson & Mehl, 1934
Plate 3, Figs. 3, 4

1934b *Polygnathus longipostica* n.sp. — Branson & Mehl, p. 294, Pl. 24, Figs. 8—11.

For synonymy, see Rexroad & Scott (1964, p. 36—37).

Remarks. This species is related to *Polygnathus inornata,* from which it can be distinguished by its more slender form, longer free blade, more pronounced ornamentation of the platform, and unusually large pulp cavity. The carina of mature specimens ends posteriorly with a large denticle. The lowest occurrence of *Polygnathus longipostica* in our material was in the uppermost Devonian Middle to Upper *costatus* Zone. These high Devonian specimens were mostly fairly small.

Klapper (1966, p. 21) presented a comparison of *Poly-*

gnathus inornata, Polygnathus longipostica and *Polygnathus symmetrica.* He points out that *Polygnathus longipostica* stands more or less midway between *Polygnathus inornata* and *Polygnathus symmetrica.* We found *Polygnathus symmetrica* only rarely in our material. Our concept of *Polygnathus longipostica* is probably somewhat wider because we followed the definition and synonymy of Rexroad & Scott (1964).

Polygnathus nodomarginata E. R. Branson, 1934
Plate 3, Fig. 5

1934 *Polygnathus nodomarginata* n.sp. — E. R. Branson, p. 310, Pl. 25, Fig. 10.

1956 *Polygnathus nodomarginata* E. R. Branson — Bischoff & Ziegler, p. 157, Pl. 12, Fig. 6.

1959 *Polygnathus nodomarginata* E. R. Branson—Helms, pp. 651—652, Pl. 3, Fig. 1.

Remarks. The unusually large pulp cavity and the long, thick platform of *Polygnathus nodomarginata* suggest that this species stands more or less midway between *Pseudopolygnathus fusiformis* and *Polygnathus longipostica.*

Polygnathus varca Stauffer, 1940
Plate 3, Fig. 6

1940 *Polygnathus varcus* n.sp. — Stauffer, p. 430, Pl. 60, Figs. 49, 53[?], 55.

1957 *Polygnathus varca* Stauffer—Bischoff & Ziegler, pp. 98—99, Pl. 18, Figs. 32—35; Pl. 19, Figs. 7—9.

For further synonymy, see Wittekindt (1966, pp. 639—640).

Remarks. This species has a very long free blade and small, often asymmetric platform. The pulp cavity is situated at the very anterior part of the platform. For comparisons with *Polygnathus xyla,* see Wittekindt (1966).

Genus PSEUDOPOLYGNATHUS Branson & Mehl, 1934

Pseudopolygnathus dentilineata E. R. Branson, 1934
Plate 3, Fig, 8

1934 *Pseudopolygnathus dentilineata* n.sp — E. R. Branson, p. 317, Pl. 26, Fig. 22.

For synonymy, see Klapper (1965, pp. 14—15).

Remarks. The narrow, elongated platform of *Pseudopolygnathus dentilineata* is ornamented with a row of nodes or transverse ridges on each side of the carina. The right side of the platform is more fully developed.

Pseudopolygnathus fusiformis Branson & Mehl, 1934
Plate 3, Fig. 7

1934b *Pseudopolygnathus fusiformis* n.sp. — Branson & Mehl, p. 298, Pl. 33, Figs. 1—3.

For synonymy, see Rexroad & Scott (1964, pp. 38—39).

Remarks. This species has an elongated and very reduced platform. The margins of the platform are ornamented with low nodes. For relations with *Polygnathus nodomarginata,* see there.

Pseudopolygnathus triangula Voges, 1959
Pseudopolygnathus triangula pinnata Voges, 1959
Plate 3, Figs. 9, 10

1959 *Pseudopolygnathus triangula pinnata* n.subsp. — Voges, pp. 302—303, Pl. 34, Figs. 59—66; Pl. 35, Figs. 1—6.

For synonymy, see Budinger (1965, p. 76).

Remarks. The triangular, transversely-ribbed platform of this species has on its inner, anterior tip a typical lobe. The pulp cavity is relatively small for a pseudopolygnathid.

Genus SCALIOGNATHUS Branson & Mehl, 1941

Scaliognathus anchoralis Branson & Mehl, 1941
Plate 3, Fig. 11

1941 *Scaliognathus anchoralis* n.sp. — Branson & Mehl, p. 102, Pl. 19, Figs. 29—32.

For synonymy, see Budinger (1965, p. 77).

Remarks. This remarkable species is easily recognized by its cross-like to blunt arrow-like shape.

Genus SCAPHIGNATHUS Ziegler, 1960

Scaphignathus velifera Ziegler, 1960
Plate 3, Fig. 12

1959 *Scaphignathus velifera* Ziegler—Helms, p. 655, Pl. 2, Fig. 19; Pl. 5, Figs. 20, 28.

1960b *Scaphignathus velifera* n.sp. — Ziegler, p. 403, Pl. 3, Fig. 1—6.

1962b *Scaphignathus velifera* Ziegler—Ziegler, pp. 102—103, Pl. 11, Figs. 19—24.

1965 *Scaphignathus velifera* Ziegler—Budinger, p. 78, Pl. 4, Fig. 17.

Remarks. This species has a very high, short free blade, which is slightly offset laterally with respect to the platform in adult specimens. The narrow, elongated platform consists of two lateral rows of denticles. In adult forms one of these lateral rows extends somewhat further anteriorly than the other. A median row of low nodes is developed in mature specimens.

Genus SCHMIDTOGNATHUS Ziegler, 1965

Schmidtognathus peracuta (Bryant, 1921)
Plate 3, Fig. 13

1921 *Polygnathus peracutus* n.sp. — Bryant, p. 25, Pl. 10, Fig. 12.

1934 *Polygnathus peracuta* Bryant—Huddle, p. 97, Pl. 8, Fig. 8

1966 *Schmidtognathus peracuta* (Bryant) — Ziegler, p. 668, Pl. 1, Figs. 1—10.

For further synonymy and description, see Ziegler (1966)

Remarks. The genus *Schmidtognathus* is characterized by its usually fairly big, asymmetric pulp cavity. On the outer side of this cavity a constriction (fold) is present. The platform is *Polygnathus*-like. *Schmidtognathus peracuta* has a strongly arched, slender platform ornamented with longitudinally arranged rows of nodes.

Genus SIPHONODELLA Branson & Mehl, 1944

Siphonodella cooperi Hass, 1959
Plate 3, Fig. 14

1959 *Siphonodella cooperi* n.sp. — Hass, p. 392, Pl. 48, Figs. 35—36.

For synonymy, see Klapper (1966, p. 16).

Remarks. The elongated slender platform of this species bears two or three rostral ridges on its anterior part. The outer platform is ornamented with transverse ridges, the inner with nodes.

Siphonodella sulcata (Huddle, 1934)?
Plate 3, Fig. 16

1934 *Polygnathus sulcata* n.sp. — Huddle, p. 101, Pl. 8, Figs. 22—23.

1962 *Siphonodella sulcata* (Huddle) — Collinson *et al.*, p. 6, Chart 2.

Remarks. One specimen in our material has an affinity with *Siphonodella:* This is a single prominent rostral ridge on the outer side of the platform. The ornamentation consists of transverse ridges. The aboral side has a big and long *Polygnathus*-like or *Pseudopolygnathus*-like pulp cavity and a broad keel. We classify this specimen as *Siphonodella sulcata?*

Siphonodella obsoleta Hass, 1959
Plate 3, Fig. 15

1959 *Siphonodella obsoleta* n.sp. — Hass, p. 392, Pl. 47, Figs. 1—2.

For synonymy, see Klapper (1966, p. 17).

Remarks. Siphonodella obsoleta normally has two, but sometimes up to four, rostral ridges. The single rostral ridge on the outer side of the platform continues posteriorly on the outer margin. The inner side of the platform is ornamented with nodes, the outer side is smooth to nearly smooth.

Siphonodella? n.sp. *a*
Plate 3, Figs. 17, 18

Material. 10 more or less damaged specimens.
Diagnosis. Platform conodont with a long, wide pulp cavity over most of the length of the platform. The oral side is ornamented with low transverse ridges. The upturned margins of the platform tend to form rostral ridges.
Description. Oral view: The thick, slightly curved platform is constricted anteriorly. The margins are upturned and tend to form rostral ridges, particularly on the outer, more broadly-developed side of the platform. The platform is ornamented with low, somewhat irregular, transverse ridges. The carina consists of fused, round nodes. The blade is unknown. Lateral view: The conodont is slightly arched. Aboral view: The pulp cavity is long and very wide and has flaring lips. It runs over most of the length of the platform, and is deepest anteriorly, where the pulp cavity closes rather abruptly and continues as a groove in the keel of the blade.
Remarks: Siphonodella? n.sp. *a* is provisionally classified in the genus *Siphonodella* because it seems to be related to *Siphonodella sulcata,* which also has a widely flared pulp cavity. The latter has a regularly ornamented platform with strong, straight, transverse ridges. Because of the scarcity and bad preservation of our material, we leave the nomenclature open.
Distribution. Spain. — *Siphonodella?* n.sp. *a* was found in the Cantabrian Mountains in the Vegamián Formation, sample SJ/H6 (lower part of the *anchoralis* Zone, Section MA, Fig. 18), and in the basal part of the Alba Formation, sample AG 6 (*anchoralis* Zone, section AG, Fig. 11). In both cases the species was found in a fauna including numerous reworked elements. It is very probable that *Siphonodella?* n.sp. *a* from the abovementioned localities is also reworked.

Genus SPATHOGNATHODUS Branson & Mehl, 1941

Spathognathodus aculeatus (Branson & Mehl, 1934)
Plate 3, Fig. 19

1934a *Spathodus aculeatus* n.sp. — Branson & Mehl, p. 186, Pl. 17, Figs. 11, 14.

1934 *Spathodus tridentatus* n.sp. — E. R. Branson, p. 307, Pl. 27, Fig. 26.

1959 *Spathognathodus aculeatus* (Branson & Mehl) — Helms, p. 657, Pl. 3, Fig. 8.

For further synonymy, see Klapper (1966, p. 24).

Remarks. Spathognathodus aculeatus has one to five, but mostly three, denticles situated parallel to the blade, above the pulp cavity. In some specimens the anterior lateral denticle is the largest, thus showing a transition to *Spathognathodus anteposicornis* Scott.

Spathognathodus bipennatus Bischoff & Ziegler, 1957
Plate 3, Fig. 21

1957 *Spathognathodus bipennatus* n.sp. — Bischoff & Ziegler, pp. 115—116, Pl. 21, Fig. 31.

1966 [non] *Spathognathodus bipennatus nevadensis* n.subsp. — Clark & Ethington, p. 687, Pl. 84, Figs. 1, 6, 8, 10, 11 (= *Eognathodus* Philip, 1965).

Remarks. This species has a blade consisting of a double row of denticles in its central and posterior part. The pulp cavity has two laterally flaring lips.

Spathognathodus costatus (E. R. Branson, 1934)
Spathognathodus costatus costatus (E. R. Branson, 1934)
Plate 3, Figs. 20, 22

1934 *Spathodus costatus* n.sp. — E. R. Branson, pp. 303—304, Pl. 27, Fig. 13.

1956 *Spathognathodus costatus* (E. R. Branson) — Bischoff & Ziegler, p. 166, Pl. 13, Fig. 3.

1962b *Spathognathodus costatus costatus* (E. R. Branson) — Ziegler, pp. 107—108, Pl. 14, Figs. 1—6, 8—10.

For further synonymy, see Ziegler (1962b)

Remarks. In *Spathognathodus costatus costatus* a parallel row of denticles accompanies the blade from the middle of the anterior half to the posterior tip. The denticles of this row may be developed as short transverse ridges.

Spathognathodus costatus spinulicostatus (E. R. Branson, 1934)
Plate 3, Figs. 23, 24

1934 *Spathodus spinulicostatus* n.sp. — E. R. Branson, p. 305, Pl. 27, Fig. 19.

1957 *Spathognathodus spinulicostatus spinulicostatus* (E. R. Branson) — Bischoff, p. 57, Pl. 4, Fig. 27.

1962b *Spathognathodus costatus spinulicostatus* (E. R. Branson) — Ziegler, p. 108, Pl. 14, Figs. 11—18.

For further synonymy, see Ziegler (1962b).

Remarks. This subspecies of *Spathognathodus costatus* has, besides a row of denticles on one side of the blade, a shorter second row on the posterior part of the other side of the blade.

Spathognathodus costatus ultimus Bischoff, 1957
Plate 3, Fig. 25

1957 *Spathognathodus spinulicostatus ultimus* n.subsp. — Bischoff, pp. 57—58, Pl. 4, Figs. 24—26.

1962b *Spathognathodus costatus ultimus* Bischoff—Ziegler, p. 109, Pl. 14, Figs. 19, 20.

For further synonymy, see Ziegler (1962b).

Remarks. This subspecies is distinguished from *Spathognathodus costatus spinulicostatus* by the development of transverse ridges on both sides of the blade.

Spathognathodus jugosus (Branson & Mehl, 1934)
Plate 3, Fig. 26

1934a *Spathodus jugosus* n.sp. — Branson & Mehl, pp. 190—191, Pl. 17, Figs. 19, 22.

1956 *Spathognathodus jugosus* (Branson & Mehl) — Bischoff & Ziegler, p. 167, Pl. 13, Figs. 8—10.

For further synonymy, see Klapper (1966, p. 24).

Remarks: Spathognathodus jugosus developed from *Spathognathodus stabilis* as judged from its generally slender outline and long, wide pulp cavity. The posterior part of the blade consists of a double row of small denticles which are mostly fused by transverse ridges. In some mature specimens a third row of small nodes may be present between the two main rows.

Spathognathodus steinhornensis Ziegler, 1965
Spathognathodus steinhornensis steinhornensis Ziegler, 1956
Plate 3, Fig. 27

1952 *Spathognathodus aculeatus* Branson & Mehl — Graves, p. 612, Pl. 81, Fig. 3 [*non* Figs. 1, 4, 5].

1956 *Spathognathodus steinhornensis* n.sp. — Ziegler, pp. 104—105, Pl. 7, Figs. 3—10.

1958 *Spathognathodus steinhornensis* Ziegler—Bischoff & Sannemann, pp. 106—107, Pl. 13, Figs. 2, 3, 7, 9.

1964 *Spathognathodus steinhornensis steinhornensis* Ziegler—Walliser, p. 85.

1965 *Spathognathodus steinhornensis* Ziegler—Philip, pp. 111—112, Pl. 10, Figs. 1—12.

1966 [?] *Spathognathodus steinhornensis* Ziegler—Clark & Ethington, p. 686, Pl. 84, Fig. 2.

Remarks. Walliser (1964, p. 85) has demonstrated that this species is extremely variable. He distinguished three subspecies:
Spathognathodus steinhornensis eosteinhornensis (uppermost Silurian), *Spathognathodus steinhornensis remscheidensis* (lowermost Devonian), and *Spathognathodus steinhornensis steinhornensis* (higher in the Lower Devonian). These subspecies show so many transitional forms that only in large faunas can an adequate separation be made according to the mean of the distribution of their properties. The illustrated specimen derives from a sample of lower? Emsian age. The blade is rather irregularly denticulated and the wide, posteriorly placed pulp cavity is asymmetrically cardiform.

n.gen. *A* n.sp. *a*
Plate 3, Figs. 28, 29; Fig. 68 in text.

Material. 3 specimens.
Diagnosis. Simple type of compound conodont with one denticle behind the main cusp. Cusp and denticle are laterally compressed. The long, narrow pulp cavity has two apices, the highest one pointing into the main cusp, the lower one into the posterior denticle. The surface of the conodont is ornamented with fine longitudinal striations.

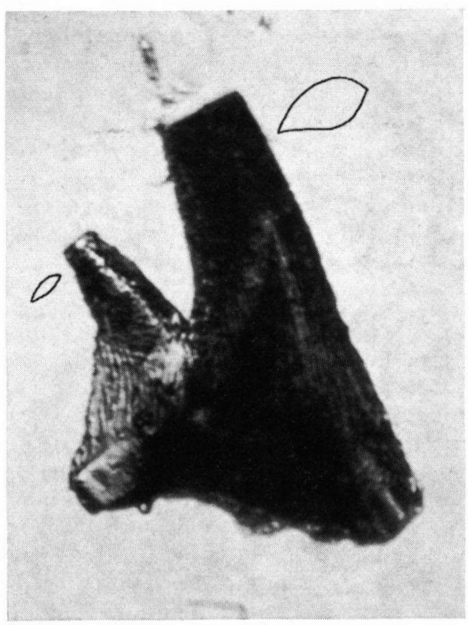

Fig. 68. n.gen. *A* n.sp. *a*. Specimen AB 84 (sample pol 1, Arauz-Polentinos area), photographed in transmitted light (200 ×) showing the pulp cavity with two apices and the fine longitudinal striation.

Distribution. Spain. — The lowermost part of the Lebanza Formation (sample pol 1) in the Arauz-Polentinos area of the Cantabrian Mountains. The age of this part of the Lebanza Formation is upper Gedinnian to lower Siegenian.
Remarks. Dr. M. Lindström (pers.comm) pointed out that the new genus has some resemblance to *Multioistodus* Cullison, 1938, which is known only from the lower and middle Ordovician. *Multioistodus*, however, does not have a pulp cavity with two apices.
Our scanty material of this new genus shows two different forms. One specimen (Pl. 3, Fig. 28) is somewhat shorter and more flattened than the other two (Pl. 3, Fig. 29). Until more material becomes available, we prefer to refrain from making a more detailed classification and to leave the nomenclature open.

SAMENVATTING

Een kort overzicht van de litteratuur betreffende de stratigrafie van het Devoon en het Onder-Karboon van het Cantabrisch Gebergte gaat vooraf aan de stratigrafische en paleontologische waarnemingen van de auteur in León: het Río Esla gebied (Gedinnien tot Viséen), het centrale Cantabrische gebied (Famennien tot Viséen) en het Gildar-Montó gebied (Eifelien tot Viséen); in Asturië: het kustgebied (Frasnien tot Viséen); in Palencia: het Arauz-Polentinos gebied (Gedinnien tot Givetien), het Cardaño-Triollo gebied (Eifelien tot Viséen) en het San Martín-Valsurvio gebied (Givetien en Famennien tot Viséen); in Santander: het Liébana gebied (Eifelien tot Viséen).
Uit de kalksteenformaties uit deze gebieden zijn conodontenfaunas gewonnen, waarvan de meeste konden worden ingepast in de opeenvolging van conodontenzones vastgesteld in Duitsland. Aldus werden nieuwe gegevens over een aantal formaties uit het Cantabrisch Gebergte verkregen.
Er wordt aangetoond, dat de Ermita-Formatie ook in Asturië en Palencia voorkomt. Deze eenheid heeft maximaal een bereik van het bovenste Famennien tot het onderste Tournaisien. De Cardaño-Formatie heeft een bereik van het middelste of bovenste deel van het Givetien tot bovenin het Frasnien. De Vidrieros-Formatie heeft een bereik van het bovenste deel van het lagere Famennien tot het onderste Tournaisien.
Een synthese van de stratigrafische gegevens bakent het Palentijnse faciesgebied af. Het is duidelijk gescheiden van het Asturo-Leonese faciesgebied door positieve gebieden. Als paleogeografische eenheden worden onderscheiden het Asturo-Leonese Bekken, het Palentijnse Bekken en de Asturische Geanticlinaal. Aan de hand van acht kaartjes van het faciespatroon wordt de ontwikkeling van deze eenheden van het Midden-Devoon tot het Onder-Karboon behandeld. De sedimentatie op de Asturische Geanticlinaal was beperkt en waarschijnlijk incompleet. Een epeirogenetische opheffing van dit gebied had plaats in het bovenste Frasnien tot onderin het Famennien. Deze opheffing wordt gecorreleerd met de afzetting van de kwartsitische Murcia-Formatie in het beschutte Palentijnse Bekken. Het opgeheven gebied werd bedekt door de Ermita-transgressie in het bovenste Famennien tot onderste Tournaisien.
Na een onderbreking van de sedimentatie bracht een lokale transgressie in het hogere Tournaisien de Vegamián-Formatie. De Alba-transgressie begon in het grootste deel van het gebied in het bovenste Tournaisien of onderin het Viséen. In het Palentijnse Bekken ving de afzetting van de Alba-Formatie bovenin het Viséen aan.
Het systematische gedeelte behandelt de belangrijkste gidsvormen voor de conodontenzones. Als nieuwe elementen worden beschreven *Icriodus eslaensis* n.sp. uit het middelste tot bovenste deel van het Givetien, *Siphonodella*? n.sp. *a*, waarschijnlijk bovenuit het Tournaisien en n.gen. *A* n.sp. *a*, een eenvoudig samengestelde conodont bovenuit het Gedinnien of onderuit het Siegenien.

SUMARIO

Una reseña corta de la literatura acerca de la estratigrafia del Devónico y Carbonífero Inferior de la Cordillera Cantabrica precede las observationes estratigráficas y paleontológicas del autor en las regiones siguientes en León: la región del Río Esla (Gedinense hasta Viseense), la región central cantábrica (Fameniense hasta Viseense) y la región de Gildar-Montó (Eifeliense hasta Viseense); en Asturias: la región de la costa (Frasniense hasta Viseense; en Palencia: la región de Arauz-Polentinos (Gedinense hasta Givetiense), la región de Cardaño-Triollo (Eifeliense hasta Viseense) y la región de San Martín-Valsurvio (Givetiense y Fameniense hasta Viseense); en Santander: la región Lebaniega (Eifeliense hasta Viseense).
Se han extraido faunas de conodontes de las formationes de caliza de estas regiones, la mayoría de las cuales se podían correlacionar con aquellas de la sucesión zonal establecida in Alemania. Así se obtuvieron nuevos datos acerca de unas formationes en la Cordillera Cantabrica. Queda demostrado que la Formatión de Ermita tambien existe en Asturias y Palencia. Este unidad se extiende maximamente desde la parte más

alta del Fameniense hasta la parte más baja del Tournaisiense. La Formatión de Cardaño se extiende del Givetiense medio o superior hasta el Frasniense superior. La Formatión de Vidrieros se extiende de la parte superior del Fameniense inferior hasta el Tournaisiense más bajo.
Una síntesis de los datos estratigráficos delimita la región de la facies palentina. Claramente está separada de la región de la facies astur-leonesa por regiones positivas. Como unidades paleogeográficas se distinguen la Cuenca Astur-Leonesa, la Cuenca Palentina y el Geanticlinal Asturiano. Por medio de ocho facies-mapas está demostrada la evolutión de estas unidades desde el Devónico Medio hasta el Carbonífero Inferior.
La sedimentatión en el Geanticlinal Asturiano estaba limitada y problamente incompleta. Una elevatión epirogenética de este geanticlinal tenía lugar en la parte más alta del Frasniense hasta el Fameniense inferior. Esta elevatión está correlationada con la depositión de la Formatión cuarcitica de Murcia en la Cuenca Palentina protejida. La región elevada estaba cubierta por la transgression de Ermita en el Fameniense superior más alto hasta el Tournaisiense más bajo.
Después de una interuptión en la sedimentatión una transgressión local llevó la Formatión de Vegamián en el Tournaisiense superior. En la mayor parte de la región la transgressión de Alba empezó en la parte más alta del Tournaisiense o en el Viseense inferior. En la Cuenca Palentina la sedimentatión de la Formatión de Alba empezó en el Viseense superior.
La parte sistemática trata especialmente de las formas más importantes de las zonas de conodontes. Como nuevos elementos están descritos *Icriodus eslaensis* n. sp. del Givetiense medio y superior, *Siphonodella*? n.sp. *a*, probablemente del Tournaisiense superior y n.gen. *A* n.sp. *a*, un conodonte simple del Gedinense superior o el Siegeniense inferior.

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PLATES

PLATE 1

Fig. 1 *Ancyrodella curvata* (Branson & Mehl)
Specimen AB 1 (sample cal 15, Gildar-Montó area). × 25. 1a, oral view; 1b, aboral view.

Fig. 2 *Ancyrognathus asymmetrica* (Ulrich & Bassler)
Specimen AB 3 (sample CU 4, Gildar-Montó area). × 25. 2a, oral view; 2b, lateral view; 2c, aboral view.

Fig. 3 *Ancyrodella rotundiloba rotundiloba* (Bryant)
Specimen AB 2 (sample CAR 29, Cardaño-Triollo area). × 25. Oral view of fairly juvenile specimen.

Fig. 4 *Ancyrognathus triangularis* Youngquist.
Specimen AB 4 (sample CAR 26, Cardaño-Triollo area). × 25. 4a, oral view; 4b, aboral view.

Figs. 5,6 *Icriodus corniger* Wittekindt

Fig. 5, specimen AB 5 (sample Vc 210, Río Esla area). × 40. 5a, oral view; 5b, aboral view.

Fig. 6, specimen AB 6 (sample 85, Liébana area). × 40. 6a, oral view; 6b, aboral view.

Figs. 7,8 *Icriodus* cf. *I. corniger* Wittekindt

Fig. 7, specimen AB 7 (sample VIII 20, Río Esla area). × 40. 7a, oral view; 7b, aboral view.

Fig. 8, specimen AB 8 (sample VIII 30, Río Esla area). × 40. 8a, oral view; 8b, aboral view.

Figs. 9-12 *Icriodus eslaensis* n.sp.

Fig. 9, *holotype*, specimen AB 9 (sample IVc 74, Río Esla area). × 40. 9a, oral view; 9b, aboral view; 9c, lateral view.

Fig. 10, specimen AB 9a (sample Id 30, Río Esla area). × 40. Small specimen. 10a, oral view; 10b, lateral view.

Fig. 11, specimen AB 10a (sample CAL 4, Gildar-Montó area). × 40. Specimen with faintly indicated spur. 11a, oral view; 11b, aboral view; 11c, lateral view.

Fig. 12, specimen AB 10 (sample CAL 4, Gildar-Montó area). × 40. Oral view of broad specimen.

Figs. 13-17 *Icriodus latericrescens latericrescens* Branson & Mehl

Fig. 13, specimen AB 11 (sample pol 1, Arauz-Polentinos area). × 40. 13a, oral view; 13b aboral view.

Fig. 14, specimen AB 12 (sample bk 1, Arauz-Polentinos area). × 40. Oral view.

Fig. 15, specimen AB 13 (sample VIII 6114, Río Esla area). × 40 area. Oral view.

Fig. 16, specimen AB 14 (sample Id 30, Río Esla area). × 40. Oral view.

Fig. 17, specimen AB 15 (sample IVc 74, Río Elsa area). × 40. 17a, oral view; 17b, aboral view.

Figs. 18-20 *Icriodus latericrescens bilatericrescens* Ziegler

Fig. 18, specimen AB 16 (sample pol 1, Arauz-Polentinos area). × 40. Oral view.

Fig. 19, specimen AB 17 (sample pol 2, Arauz-Polentinos area). × 40. Oral view. Damaged specimen with well-developed spur.

Fig. 20, specimen AB 18 (sample POL 8, Arauz-Polentinos area). × 40. 20a, oral view; 20b, aboral view.

Fig. 21 *Icriodus woschmidti* Ziegler
Specimen AB 19 (sample ar 1, Arauz-Polentinos area). × 40. 21a, oral view; 21b aboral view.

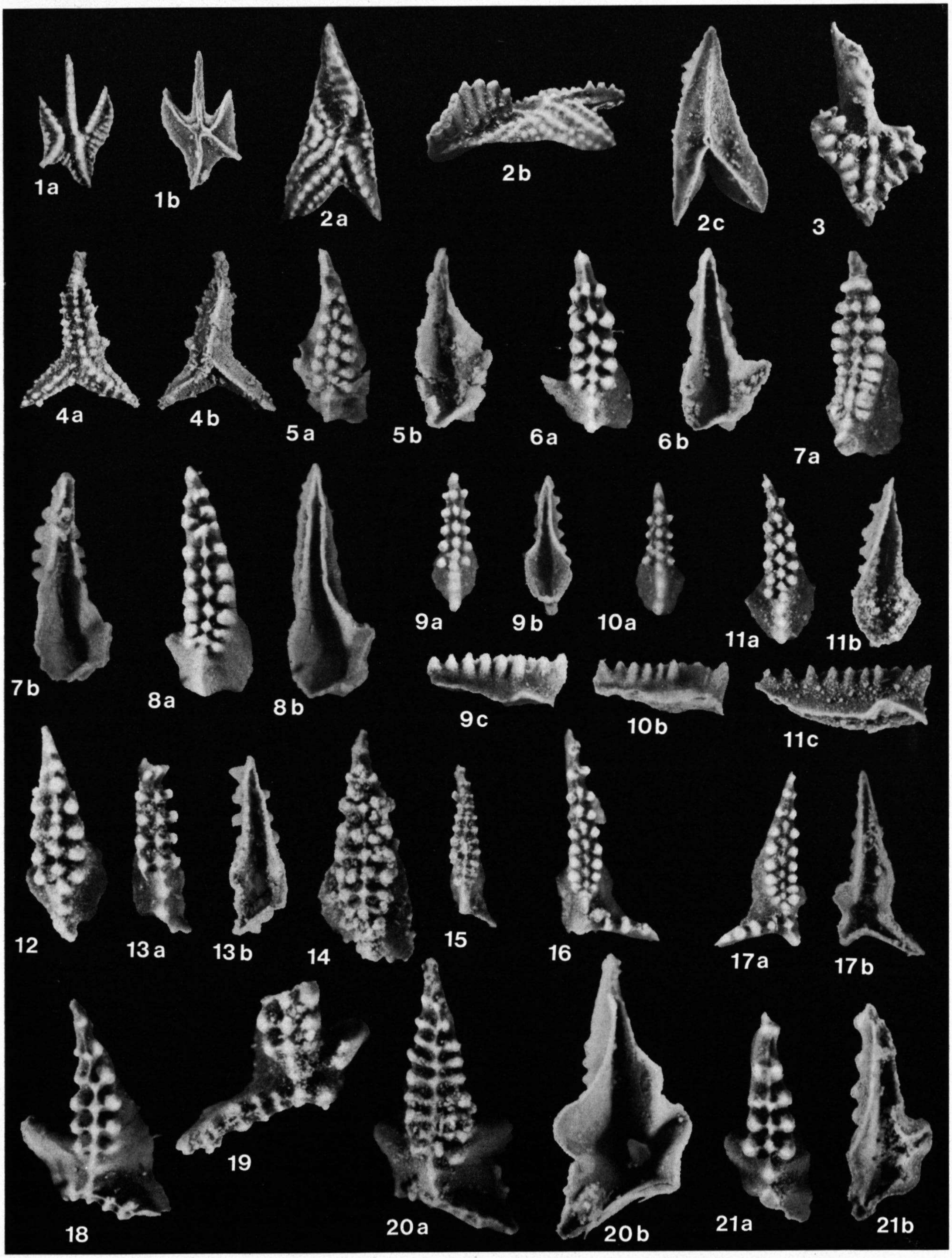
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PLATE 2

Fig. 1 *Icriodus woschmidti* Ziegler
Specimen AB 20 (sample ar 1, Arauz-Polentinos area). × 40. Anterior tip broken off. 1a, oral view; 1b, lateral view.

Fig. 2 *Icriodus* sp. *a*
Specimen AB 21 (sample 19, Río Esla area). × 40. 2a, oral view; 2b, aboral view.

Fig. 3 *Gnathodus antetexanus* Rexroad & Scott
Specimen AB 22 (sample OL 3, Río Esla area). × 25. 3a, oral view; 3b, aboral view.

Figs. 4-6 *Gnathodus bilineatus* (Roundy)
Fig. 4, Specimen AB 23 (sample POS 3, Gildar-Montó area). × 25. Oral view.

Figs. 5,6, specimens AB 23a and AB 23b (sample CAR 13, Cardaño-Triollo area). × 25. Oral view. These specimens have been deformed by cleavage.

Fig. 7 *Gnathodus commutatus nodosus* Bischoff
Specimen AB 25 (sample CU 25, Gildar-Montó area). × 25. Oral view.

Fig. 8 *Gnathodus commutatus cruciformis* Clarke
Specimen AB 24 (sample CU 25, Gildar-Montó area). × 25. Oral view.

Figs. 9, 10 *Gnathodus cuneiformis* Mehl & Thomas

Fig. 9, specimen AB 26 (sample OL 1, Río Esla area). × 25. 9a, oral view; 9b aboral view.

Fig. 10, specimen AB 27 sample) OL 1, Río Esla area). × 25. Oral view of large specimen. Blade partly broken off.

Figs. 11, 12 *Gnathodus* cf. *G. cuneiformis* Mehl & Thomas

Fig. 11, specimen AB 28 (sample OL 2, Río Esla area). × 25. Oral view.

Fig. 12, specimen AB 28a (sample OL 2, Río Esla area). ×25. oral view.

Figs. 13-15 *Gnathodus delicatus* Branson & Mehl s.l.

Fig. 13, specimen AB 29 (sample OL 1, Río Esla area). × 25. Oral view.

Fig. 14, specimen AB 30 (sample OL 5, Río Esla area). × 25. Oral view.

Fig. 15, specimen AB 30a (sample TR 4′, Cardaño-Triollo area). × 25. Oral view.

Fig. 16 *Gnathodus girtyi* Hass
Specimen AB 31 (sample POS 3, Gildar-Montó area). × 25. Oral view. Blade broken off.

Figs. 17, 18 *Gnathodus kockeli* Bischoff

Fig. 17, specimen AB 32 (sample TR 21, Cardaño-Triollo area). × 25. Oral view.

Fig. 18, specimen AB 32a (sample TR 21, Cardaño-Triollo area). × 25. Oral view. Anterior part of blade broken off.

Fig. 19 *Gnathodus punctatus* (Cooper)
Specimen AB 33 (sample OL 1, Río Esla area). × 25. Oral view. Anterior part of blade broken off.

Figs. 20, 23 *Gnathodus semiglaber* Bischoff

Fig. 20. specimen AB 34a (sample FE 3, central Cantabrian area). × 25. Oral view. Blade broken off.

Fig. 23, specimen AB 24 (sample OL 2, Río Esla area). × 25. Oral view.

Fig. 21 *Gnathodus typicus* Cooper
Specimen AB 35 (sample OL 4, Río Esla area). × 25. Oral view. Blade broken off.

Fig. 22 *Gnathodus* sp. A Collinson, Scott & Rexroad
Specimen AB 36 (sample TR 21, Cardaño-Triollo area). × 25. Oral view.

Fig. 24 *Palmatolepis distorta* Branson & Mehl
Specimen AB 37 (sample CU 15, Gildar-Montó area). × 25. Oral view.

Fig. 25 *Palmatolepis glabra glabra* Ulrich & Bassler
Specimen AB 39 (sample CU 15, Gildar-Montó area). × 25. Oral view.

Fig. 26 *Palmatolepis glabra elongata* Holmes
Specimen AB 40 (sample CU 15, Gildar-Montó area). × 25. Oral view.

Fig. 27 *Palmatolepis gigas* Miller & Youngquist
Specimen AB 38 (sample CAR 25, Cardaño-Triollo area). × 25. Oral view of small specimen showing many affinities with *Palmatolepis hassi*.

Figs. 28, 29 *Palmatolepis gracilis gracilis* Branson & Mehl

Fig. 28, specimen AB 41 (sample CAL 8, Gildar-Montó area). × 40. Lateral view.

Fig. 29, specimen AB 42 (sample CAL 8, Gildar-Montó area). × 40. Oral view. The bifurcated posterior tip is considered to be a pathologic anomaly.

Fig. 30 *Palmatolepis quadrantinodosa marginifera* Ziegler
Specimen AB 43 (sample CU 15, Gildar-Montó area). × 25. Oral view.

Fig. 31 *Palmatolepis rugosa ampla* Müller
Specimen AB 44 (sample VID 3, Cardaño-Triollo area). × 25. Oral view.

Fig. 32 *Palmatolepis subrecta* Miller & Younguist
Specimen AB 45 (sample cu 4, Gildar-Montó area). × 25. oral view.

Fig. 33 *Palmatolepis transitans* Müller
Specimen AB 46 (sample cu 6, Gildar-Montó area). × 25. Oral view.

Figs. 34, 35 *Pelekysgnathus serrata* Jentzsch

Fig. 34, specimen AB 47 (sample pol 1, Arauz-Polentinos area). × 40. 34a, lateral view; 34b, aboral view.

Fig. 35, specimen AB 48 (sample VIII 1, Río Esla area). × 40. Lateral view.

Fig. 36 *Polygnathus asymmetrica asymmetrica* Bischoff & Ziegler
Specimen AB 49 (sample cu 6, Gildar-Montó area). × 25. Oral view. The anterior part of this specimen is missing.

Fig. 37 *Polygnathus communis communis* Branson & Mehl
Specimen AB 50 (sample CAL 7, Gildar-Montó area) × 40. Small specimen. Anterior part of blade broken off. 37a, oral view; 37b, aboral view.

Fig. 38 *Polygnathus* cf. *P. communis communis* Branson & Mehl
Specimen AB 52 (sample OL 1, Río Esla area). × 40. Anterior part of blade broken off. 38a, oral view; 38 b, aboral view.

Figs. 39, 40 *Polygnathus inornata* E. R. Branson

Fig. 39, specimen AB 55 (sample CAL 14, Gildar-Montó area). × 25. 39a, oral view; 39b aboral view.

Fig. 40, specimen AB 56a (sample PE 4, Asturias, coastal area). × 25. Oral view of reworked, attrited specimen.

Fig. 41 *Polygnathus cristata* Hinde
Specimen AB 53 (sample CAR 30, Cardaño-Triollo area). × 25. Oral view. Anterior part of this specimen is missing.

Fig. 42 *Polygnathus* cf. *P. eiflia* Bisschoff & Ziegler
Specimen AB 54 (sample CAR 34, Cardaño-Triollo area). × 40. Oral view. Blade broken off.

Fig. 43 *Polygnathus communis carina* Hass
Specimen AB 51 (sample OL 1, Río Esla area). × 25. Blade broken off. 43a, oral view; 43b, aboral view.

Fig. 44 *Polygnathus linguiformis linguiformis* Hinde
Specimen AB 57a (sample CU 3, Gildar-Montó area). × 25. Oral view.

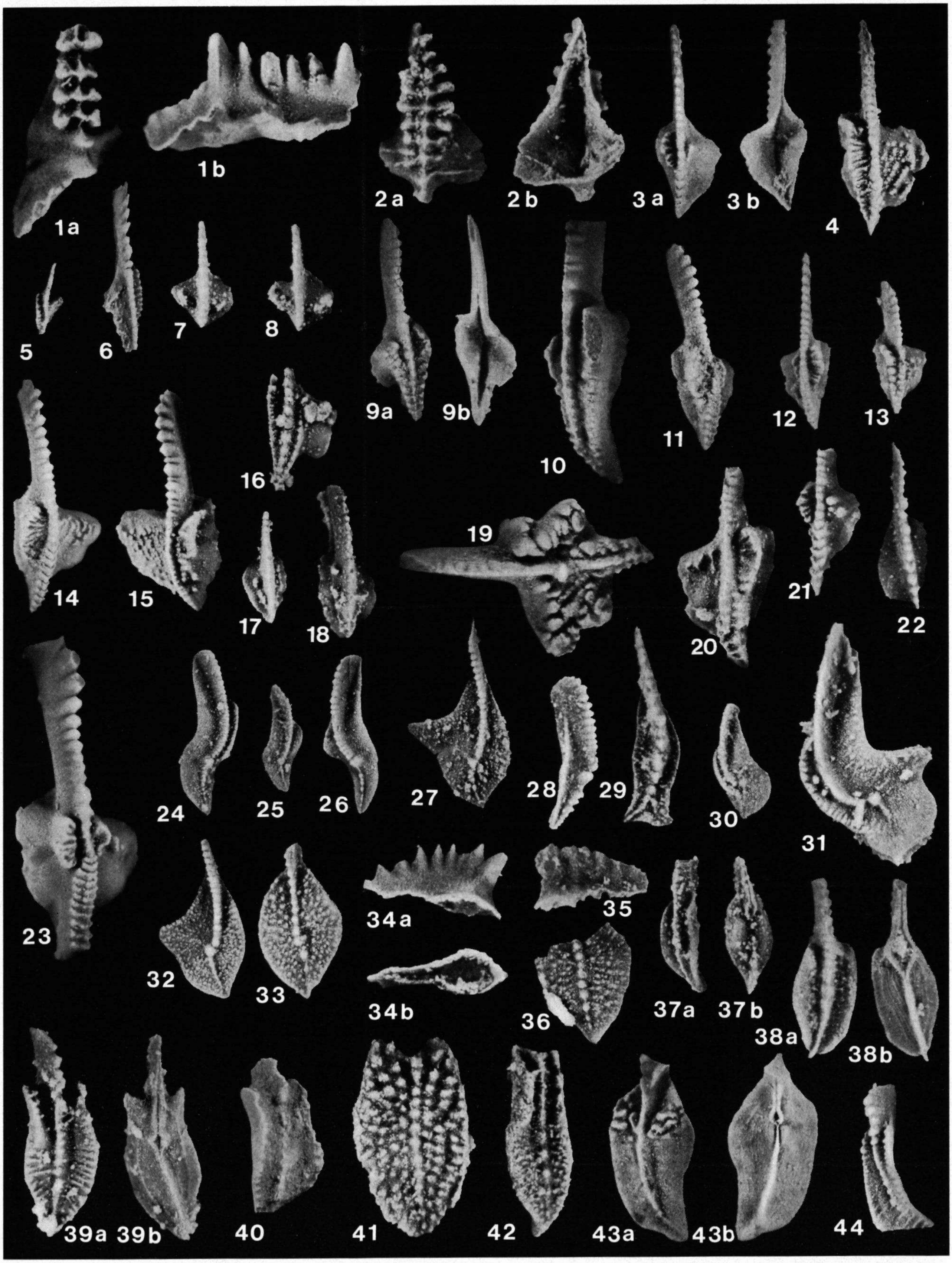
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PLATE 3

Fig. 1 *Polygnathus linguiformis linguiformis* Hinde
Specimen AB 57 (sample VIII 12, Río Esla area). × 25. This specimen has an exceptionally large pulp cavity. la, aboral view; 1b, oral view.

Fig. 2 *Polygnathus linguiformis mucronata* Wittekindt
Specimen AB 58 (sample CAL 4, Gildar-Montó area). × 25. Oral view. Blade broken off.

Figs. 3, 4 *Polygnathus longipostica* Branson & Mehl
Fig. 3, specimen AB 59 (sample CU 0, Gildar-Montó area). × 25. 3a, oral view; 3b, aboral view.
Fig. 4, specimen AB 60 (sample CAL 14, Gildar-Montó area). × 25. 4a latero-oral view; 4b, aboral view.

Fig. 5 *Polygnathus nodomarginata* E. R. Branson
Specimen AB 61 (sample CU 0, Gildar-Montó area). × 25. 5a, oral view; 5b, aboral view.

Fig. 6 *Polygnathus varca* Stauffer
Specimen AB 62 (sample CU 16, Gildar-Montó area). × 25.

Fig. 7 *Pseudopolygnathus fusiformis* Branson & Mehl
Specimen AB 64 (sample CU 13, Gildar-Montó area). × 25. Oral view of small specimen showing affinities with *Polygnathus nodomarginata*.

Fig. 8 *Pseudopolygnathus dentilineata* E. R. Branson
Specimen AB 63 (sample AG 4, Río Esla area). × 25. Oral view of large, slightly damaged specimen.

Figs. 9, 10 *Pseudopolygnathus triangula pinnata* Voges
Fig. 9, specimen AB 65 (sample FE 2, central Cantabrian area). × 25. Oral view.
Fig. 10, specimen AB 66 (sample OL 1, Río Esla area). × 25. 10 a, oral view; 10b, aboral view.

Fig. 11 *Scaliognathus anchoralis* Branson & Mehl
Specimen AB 67 (sample OL 2, Río Esla area). × 25. Oral view.

Fig. 12 *Scaphignathus velifera* Ziegler
Specimen AB 68 (sample LV 435, Liébana area). × 25. 12a, lateral view; 12b, oral view.

Fig. 13 *Schmidtognathus peracuta* (Bryant)
Specimen AB 69 (sample CAR 30, Cardaño-Triollo area). × 25. 13a, Latero-oral view; 13b, aboral view.

Fig. 14 *Siphonodella cooperi* Hass
Specimen AB 70 (sample SJ/H6, central Cantabrian area). × 25. 14a, oral view; 14b, aboral view.

Fig. 15 *Siphonodella obsoleta* Hass
Specimen AB 73 (sample IIf 224, Río Esla area). × 25 Oral view.

Fig. 16 *Siphonodella sulcata* (Huddle)?
Specimen AB 71 (sample IIf 223, Río Esla area). × 25. 16a, oral view; 16b, latero-oral view; 16c, aboral view.

Figs. 17, 18 *Siphonodella*? n.sp. *a*
Fig. 17, specimen AB 75 (sample SJ/H6, central Cantabrian area). × 35. 17a, oral view; 17b, aboral view.
Fig. 18, specimen AB 76 (sample SJ/H6, central Cantabrian area). × 25. 18a, oral view; 18b, aboral view.

Fig. 19 *Spathognathodus aculeatus* (Branson & Mehl)
Specimen AB 77 (sample FE 1, central Cantabrian area). × 25. 19a, oral view; 19b, lateral view.

Figs. 20, 22 *Spathognathodus costatus costatus* (E. R. Branson)
Fig. 20, specimen AB 79 (sample CAL 13, Gildar-Montó area). × 25. 20a, lateral view; 20b, oral view.
Fig 22, specimen AB 79a (sample CU 0, Gildar-Montó area). × 25. Oral view.

Fig. 21 *Spathognathodus bipennatus* Bischoff & Ziegler
Specimen AB 78 (sample IVc 74, Río Esla area). × 25. Oral view.

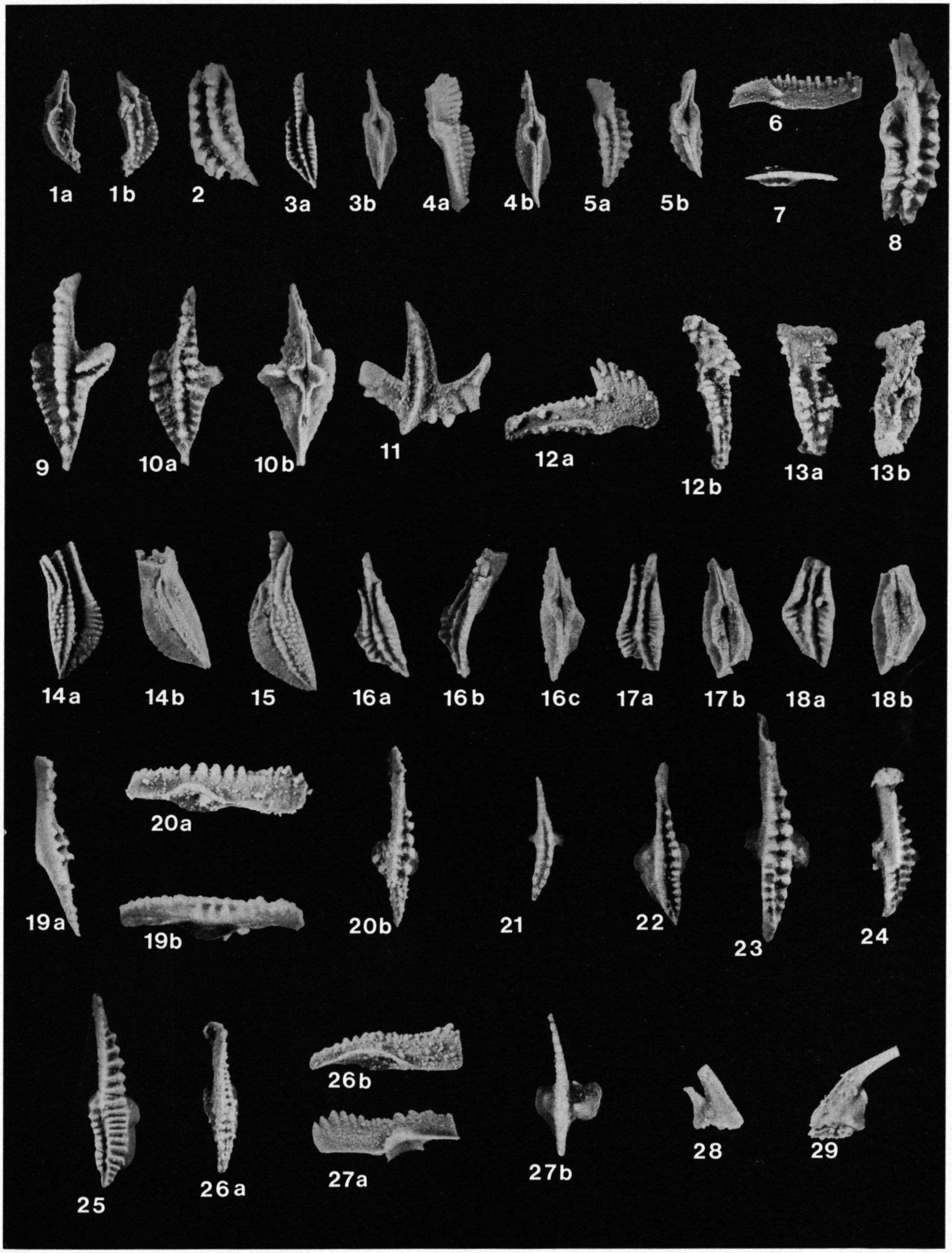
Figs. 23, 24 *Spathognathodus costatus spinulicostatus* (E. R. Branson)
Fig. 23, specimen AB 80 (sample CU 0, Gildar-Montó area). × 25. Oral view.
Fig. 24, specimen AB 80a (sample CU 13, Gildar-Montó area). × 25. Oral view.

Fig. 25 *Spathognathodus costatus ultimus* Bischoff
Specimen AB 81 (sample CU 13, Gildar-Montó area) × 25. Oral view.

Fig. 26 *Spathognathodus jugosus* (Branson & Mehl)
Specimen AB 82 (sample kutt 77, Gildar-Montó area). × 25. 26a, oral view; 26b, lateral view.

Fig. 27 *Spathognathodus steinhornensis steinhornensis* Ziegler
Specimen AB 83 (sample bk 6, Arauz-Polentinos area). × 25. 27a, lateral view; 27b, oral view.

Figs. 28, 29 n.gen. *A* n.sp. *a*
Fig. 28, specimen AB 84 (sample pol 1, Arauz-Polentinos areal. × 40. Lateral view.
Fig. 29, specimen AB 85 (sample pol 1, Arauz-Polentinos area). × 40. Lateral view.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