

Biostratigraphy and sedimentation of the Vidrieros Formation (middle Famennian-lower Tournaisian) in the Gildar-Montó unit (northwest Spain)

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ABSTRACT – *Famennian to lowermost Tournaisian associations of conodonts, ammonoids and trilobites have been recorded from a section of the Vidrieros Formation in the Cantabrian Zone. The faunal associations range from the Lower marginifera to the sulcata conodont Zones. The location of Devonian/Carboniferous boundary in the formation has been discussed and lithological, and faunal changes have been found at the positions of the Enkeberg, annulata and Hangenberg Events. The relationships between Famennian conodont associations along the Cantabrian Zone and the changes in the rate of basin subsidence are outlined.*

RIASSUNTO – [Biostratigrafia e sedimentologia della Vidrieros Fm. (Famenniano medio - Tournaisiano inf.) nella unità di Gildar-Montó (Spagna nordoccidentale)] – *In una sezione stratigrafica della formazione Vidrieros misurata nella Zona Cantabrica è stata rinvenuta una fauna a conodonti di età dal Famenniano al Tournaisiano inferiore. Le associazioni, in termini di biostratigrafia a conodonti, sono più precisamente databili dalla Lower marginifera Zone alla sulcata Zone. Il limite Devoniano/Carbonifero è stato individuato, così come cambiamenti litologici e faunistici in posizione agli eventi Enkeberg, annulata e Hangenberg. Sono infine state sottolineate le relazioni fra le associazioni a conodonti del Famenniano e le variazioni del tasso di subsidenza.*

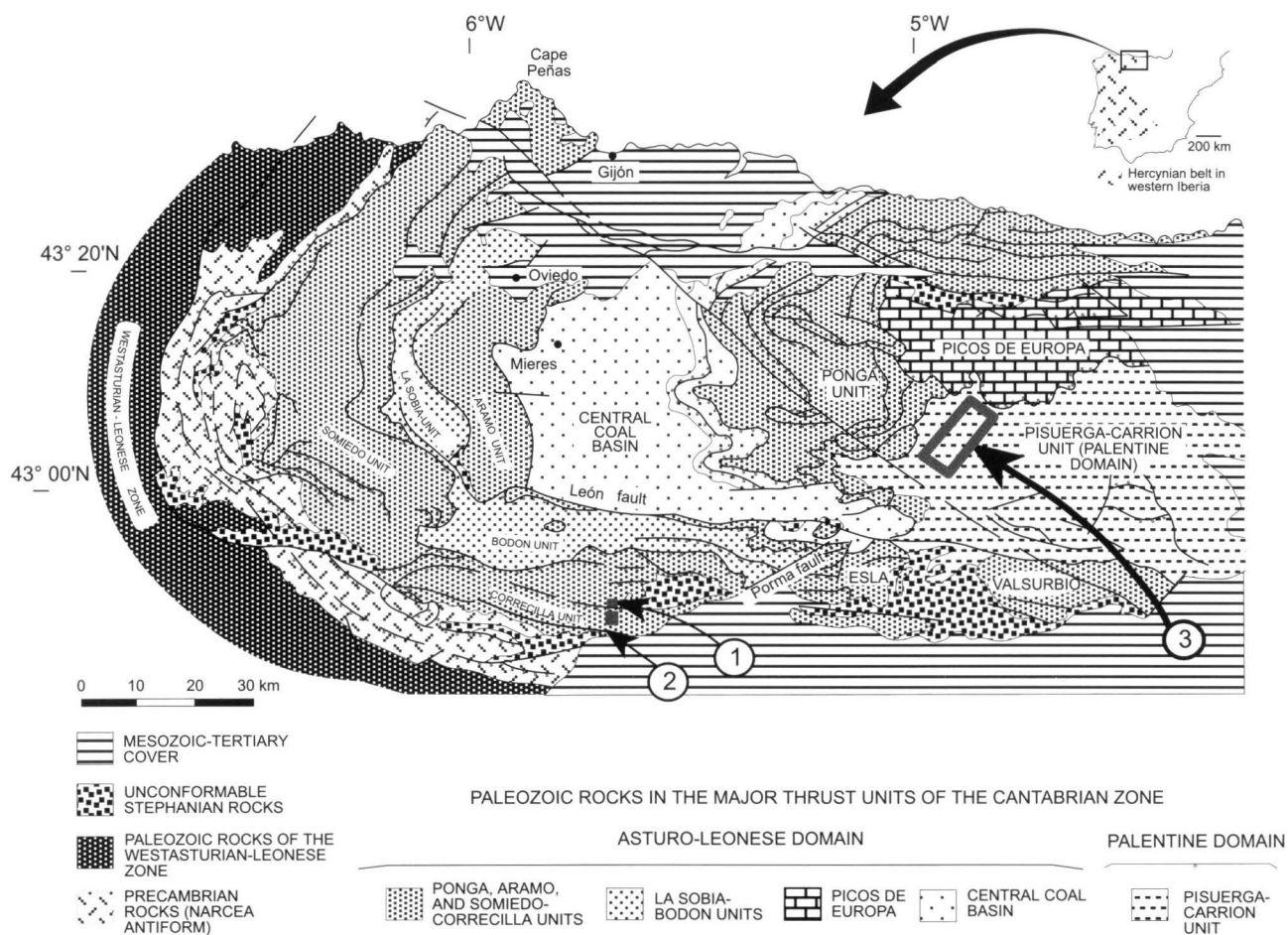
INTRODUCTION

The Cantabrian Zone is the external part of the Hercynian orogenic belt in the northwestern Iberian peninsula. Devonian outcrops of the Cantabrian Zone are subdivided in two domains: Asturo-Leonese and Palentine (Brouwer, 1964) (Text-fig. 1). The Asturo-Leonese domain bordered a hinterland area during the Devonian, the Asturian geanticline of Adrichem Boogaert (1967) or Asturian mainland of García-Alcalde & Menéndez-Alvarez (1988). The Palentine domain is considered an allochthonous unit that represents the southeastern and deeper continuation of the Asturo-Leonese area (Frankenfeld, 1981).

Famennian rocks of the Palentine domain present a succession composed of the upper part of the Cardaño Formation (c. 15 m), the Murcia Quartzites (100 m) and Vidrieros Formation (100 m) of van Veen (1965). A large number of biostratigraphic papers dealing with Palentine Famennian rocks focused on the Gildar-Montó structural unit (Text-fig. 1) of Marquín & Marcos (1984), from which associations of ammonoids, conodonts, ostracods and trilobites have been described. The upper Cardaño Formation and the Murcia Formation contain lower Famennian faunas (Arbizu *et al.*, 1986; Sanz-López *et al.*, 1997). Middle and upper Famennian faunas come from the Vidrieros Formation, composed of shales with interbedded nodular limestones. This unit is overlain by Tournaisian shales and cherts of the Vegamián Formation of Comte (1959).

The base of the Vidrieros Formation was dated as lower Famennian (doII β) by Schindewolf & Kullmann (1958), and Kullmann (1960), according to ammonoid faunas. Later, Budinger & Kullmann (1964) reported a sequence of conodont zones between the Famennian doII β and doVI, and Adrichem-Boogaert (1967) recognised Famennian and lower Tournaisian conodonts from several sections of the Vidrieros Formation (Text-fig. 2). Later, Becker (1976, 1981 and 1982) analysed some Famennian ostracod faunas, Smeenk (1983) indicated the presence of trilobites of Famennian doII β -doIII α age, and Arbizu (1985) and Arbizu *et al.* (1986) reported trilobites of the Famennian doIII and ammonoids of the doII β . Later, Montesinos & Arbizu (1988) determined trilobite species of the lower part of the Famennian doIV, as well as associations of Famennian ammonoids.

Only the western and southern parts of the Asturo-Leonese domain present lower Famennian rocks (External zone of the Asturo-Leonese domain after van Loevezijn, 1986), consisting of 75-150 m of dark nodular shales and sandstones with intercalations of conglomerates (Fueyo Formation of Comte, 1936), and 5 to 75 m of alternating sandstones and shales (Ermita Formation of Comte, 1936) with upper Famennian conodonts (Higgins *et al.*, 1964; García-Alcalde & Menéndez-Alvarez, 1988). The Ermita Formation overlies or interfingers with the Fueyo Formation and rests disconformably on a varied substrate, which is older towards the Asturian mainland. The siliciclastic upper part of the Ermita Formation is covered or



Text-fig. 1 - Geological map of the Cantabrian Zone with location of stratigraphic sections referred: section 1 is a typical section of the Asturian-Leonese domain. Sections 2 are located in the External part of the Asturian-Leonese domain (van Loevezijn, 1986). This External part includes rocks of the western and southern parts of the Somiedo-Correcilla and Esla units. Area 3 is the position of the Gildar-Montó unit.

substituted locally by 1 to 12 m of bioclastic limestones (Baleas Formation of Wagner *et al.*, 1971) with conodonts of the *expansa* to *sulcata* Zones (García-Alcalde & Menéndez-Alvarez, 1988; Menéndez-Alvarez, 1991).

The present paper describes the conodont content and distribution of the Vidrieros Formation in the stratigraphic section of Peña Quebrada, Palentine domain (Text-fig. 1). Conodont associations are correlated with the conodont zonal subdivision proposed by Ziegler & Sandberg (1984, 1990). The Peña Quebrada section has a great regional interest, because several important faunal groups, such as ammonoids, conodonts, ostracods and trilobites, have been studied there. In this paper, the referred faunas are checked (ammonoids by Montesinos, and trilobites by Arbizu), and new conodont data are provided (Sanz-López and García-López). The results are compared

with the biostratigraphical frame known for the Famennian of the Cantabrian Zone.

THE STRATIGRAPHIC SUCCESSION

The Peña Quebrada section is located south of the locality of Caldevilla, in the high hills at the southern Valdeón valley (León) (Text-fig. 1). This succession was described by Montesinos & Arbizu (1988), and it corresponds to: the F outcrop in the Montó area of Kullmann (1960), the section described in Budinger & Kullmann (1964), section CALII of Adrichem-Boogaert (1967), and locality 110/3 of Becker (1981). In this paper, we follow the subdivision of the Peña Quebrada succession made by Montesinos & Arbizu (1988) (Text-figs. 2-3).

Unit 1 overlies above sandstones of the Murcia

Formation and is composed of 13 m of black shales with some green siltstones (Text-fig. 2). The upper part of the unit contains calcareous nodules and brown shales increasing in abundance upward.

Unit 2 is composed of 9 m of brown shales. At the lower part, it has 0,4 m of black shales interlayered, and above, the shales have an increasing content of calcareous nodules and carbonate beds. The uppermost part of the unit is partly covered, but it corresponds to 4 m of nodular limestones illustrated by Adrichem-Boogaert (1967).

Unit 3, 21 m thick and predominantly shaly, contains brown, grey and greenish shales with some decimetrically, bedded nodular carbonates.

Unit 4, 27 m thick, is composed of shales with more intercalations of calcareous beds than unit 3. Unit 4 contains some levels of black shales rich in ammonoids; the most important of these levels is located around bed Vi-29.

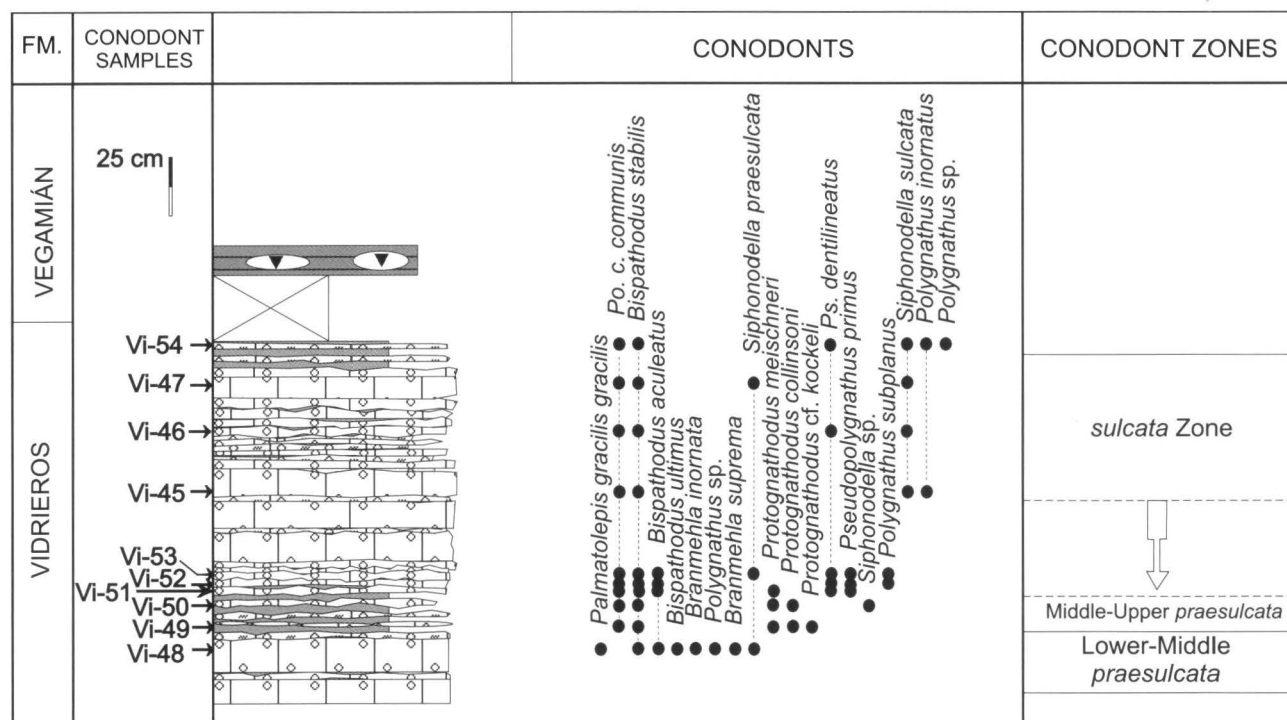
Unit 5 is composed, in ascending order, of: a) 1,5 m of nodular red limestones, decimetrically bedded, with centimetric beds of red marls; b) 6 m of grey and brown nodular limestones in beds 5 to 20 cm thick, separated by grey to green shales and marls with carbonate nodules; c) 7 m of centimetric beds of grey nodular limestones with discontinuous levels of shales and marls; d) 38 cm of green marls with five levels of

carbonate nodules; e) 4 m of nodular limestones with marls in its uppermost part and separated by 60 cm unexposed from the following black shales with phosphate nodules of the overlying Vegamián Formation (Text-fig. 4).

PREVIOUS AND NEW BIOSTRATIGRAPHICAL DATA

Many references on the distribution of several fossil groups are found in the literature about the Vidrieros Formation, particularly for the Peña Quebrada section. Unfortunately, the field numbers from different authors are missing on the beds. In spite of this, we try to integrate the previous ammonoid, conodont, ostracod and trilobites data (Text-fig. 2) with the new data (Text-fig. 3) from our section. Furthermore, we discuss other previous data from neighbouring sections.

Unit 1 contains ammonoids that indicate a Famennian doII α / β age. Arbizu *et al.* (1986) and Montesinos & Arbizu (1988) determined *Cheiloceras* cf. *amblylobum* and *Ch. planilobum* (Text-fig. 3). Adrichem-Boogaert (1967) obtained a conodont association (sample CU15) of the *marginifera* Zone in the lower part of the formation in a neighbouring section. Furthermore, Arbizu (1985) found the trilobite *Trimeroccephalus sponsor* in another section and



Text-fig. 4 - Detailed section and conodont faunas of the uppermost part of the Vidrieros Formation at the Peña Quebrada. For the explanation of lithological symbols see Text-fig. 2.

considered *Trimeroccephalus* aff. *caecus* collected by Smeenk (1983) to be *T. caecus*.

In unit 2, Kullmann (1960) determined *Lobotornoceras bilobatum*, *Cheiloceras*? sp., *Sporadoceras biferum biferum*, *S. b. sulciferum*, *S. latilobatum* and *Dimeroceras lentiforme lentiforme* (= *Paratornoceras acutum*) in the Gildar-Montó area. On the other hand, Montesinos & Arbizu (1988) determined *Cheiloceras planilobum* and reported *Lobotornoceras* sp., *Lobotornoceras* sp. A (= *L. bilobatum sensu* Kullmann, 1960), *Sporadoceras* sp. and *S. latilobatum* above bed Vi-8 (Text-fig. 3) that indicate the *Maeneceras biferum* ammonoid Zone. Above bed Vi-14 *S. biferum sulciferum* and *S. biferum* sp. A were found, and above bed Vi-17, *S. b. biferum*, *Maeneceras pompeckji*, and *Maeneceras* aff. *pompeckji* occur.

The studied conodont samples from unit 2 contain few elements and the species are long ranging (Text-fig. 3). However, the finding of the typical form of *Palmatolepis glabra lepta* (a juvenile specimen from Vi-8 and some from Vi-13) and the presence of *Palmatolepis distorta*, show that these samples are no older than the Lower *marginifera* Zone. Additionally, Budinger & Kullmann (1964) determined *Palmatolepis quadrantinodosa inflexoidea* in their sample 3. Furthermore, the presence of ammonoids corresponding to the *M. biferum* Zone from bed Vi-9 suggests the correlation of the upper beds to the upper part of the Lower *marginifera* Zone (Becker, 1993). The conodont samples from Vi-13 present a notable abundance of *Icriodus cornutus* and the *Polygnathus nodocostatus* group.

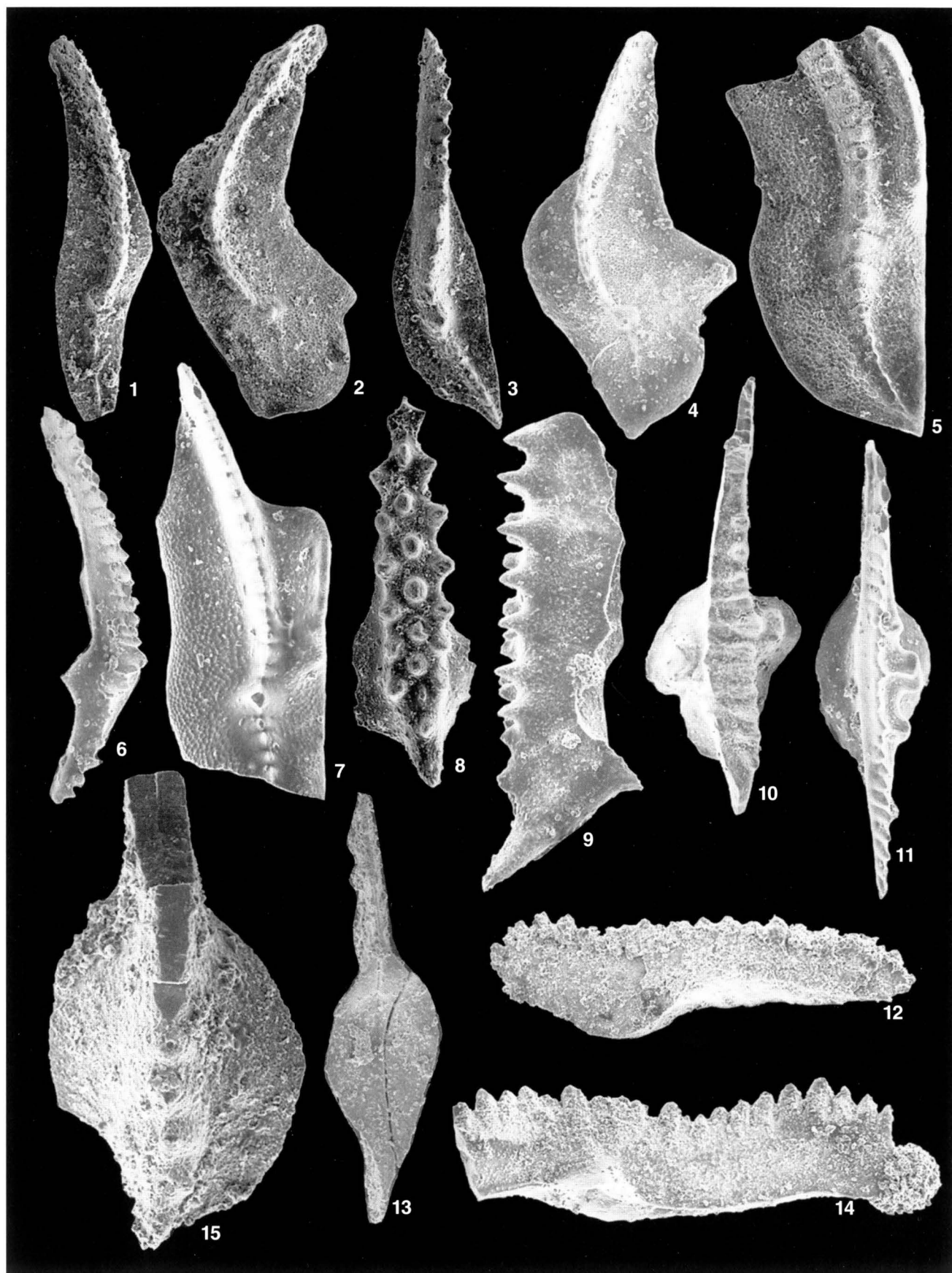
The basal part of unit 3 (sample Vi-18) is tentatively correlated with the Upper *marginifera* Zone, according to the presence of *Polygnathus glaber bilobatus*, *Palmatolepis rugosa* cf. *ampla* and *Bispathodus stabilis* Morphotype 1. Upwards, the number of conodonts is drastically reduced, coinciding with the prevalence of shaly sedimentation. We found only *Palmatolepis perlobata schindewolfi*, *Palmatolepis gracilis gracilis* and

Polygnathus communis communis in higher beds (Text-fig. 3). Trilobite remains occur at some levels. Montesinos & Arbizu (1988) reported specimens of *Trimeroccephalus*, whereas Arbizu (1985) determined *Cryphops* sp. gr. *shlosseri* and *Trimeroccephalus procurvus* of Famennian doIII age in an adjacent section. These data coincide with the finding of *Pseudoclymenia* cf. *sandbergeri* (Text-fig. 3), which indicates the *P. sandbergeri* Zone (Famennian doIII α), and of ostracods in sample 110/2b of Becker (1982), which he attributed to Famennian doIII (Text-fig. 2). Upwards, the ostracods from sample 7 of Budinger were doubtfully considered Famennian doIII β by Becker (1982).

According to Kullmann (1960), the lower part of unit 4 contains *Sporadoceras b. biferum*, *Prionoceras* (*Prionoceras*) *sulcatum*, *P. (P.)* cf. *frechi* and *Falciclymenia cyrtostriata*. Conodont faunas are very sparse and Budinger & Kullmann (1964) obtained only *Palmatolepis distorta* and *Scaphignathus velifer* from their sample 9 (Text-fig. 2). This association was correlated by Budinger & Kullmann (1964) with the Lower and the Middle *velifer* Zones (Famennian doIII age), interval which now corresponds to the Uppermost *marginifera* and the Lower *trachytera* Zones of Ziegler & Sandberg (1984). On the other hand, Montesinos & Arbizu (1988) reported the presence of *Protoxyclymenia*? sp. (bed Vi-28, Text-fig. 3) together with the trilobites *Trimeroccephalus* gr. *sponsor* and *Dianops* cf. *vicarius*, and they attributed the association to Famennian doIV. Korn & Price (1987) reported the presence of *Protoxyclymenia* in the *Platyclymenia annulata* ammonoid Zone (Famennian doIV) and its doubtful presence in higher zones. In our section, the *P. annulata* Zone is clearly represented at 0.5 m below Vi-29 (Text-fig. 3), where *Platyclymenia* cf. *annulata*, and *Platyclymenia* sp. A have been found. The upper part of the *P. annulata* Zone could be correlated with sample 10 of Budinger, because the associated ostracod fauna was attributed by Becker (1982) to the lower part of the *hemisphaerica-dichotoma* entomozoan Zone.

EXPLANATION OF PLATE 1

- Fig. 1 - *Palmatolepis glabra lepta* Ziegler & Huddle, 1969, sample Vi-11, x 100.
- Fig. 2 - *Palmatolepis rugosa* cf. *ampla* Müller, 1956, sample Vi-18, x 70.
- Fig. 3 - *Palmatolepis* cf. *gracilis* Branson & Mehl, 1934, sample Vi-13, x100.
- Fig. 4 - *Palmatolepis perlobata schindewolfi* Müller, 1956, sample Vi-17, x 80.
- Fig. 5 - *Palmatolepis glabra pectinata* Ziegler, 1962, broken element, sample Vi-13, x 85.
- Fig. 6 - *Palmatolepis gracilis gracilis* Branson & Mehl, 1934, sample Vi-40, x 50.
- Fig. 7 - *Palmatolepis glabra pectinata* Ziegler, 1962, broken element, sample Vi-13, x 85.
- Fig. 8 - *Icriodus cornutus* Sannemann, 1955, sample Vi-14, x 100.
- Fig. 9 - *Icriodus cornutus* Sannemann, 1955, lateral view of another specimen, sample Vi-13, x 100.
- Fig. 10 - *Bispathodus ultimus mussenbergensis* Luppold, 1984, sample Vi-48, x 50.
- Fig. 11 - *Bispathodus aculeatus* (Branson & Mehl, 1934), sample Vi-40, x 80.
- Figs. 12-13 - *Bispathodus stabilis* (Branson & Mehl, 1934) Morphotype 2 of Ziegler, Sandberg & Austin (1974), lateral and lower view, sample Vi-35, x 70.
- Fig. 14 - *Branmehla bohlenana* (Helms, 1959), sample Vi-35, x 60.
- Fig. 15 - *Protognathodus meischneri* Ziegler, 1959, sample Vi-50, x 150.



Kullmann (1960) determined *Sporadoceras b. biferum*, *S. ungeri*, *Prionoceras (Imitoceras)* sp., *Gonioclymenia hoevelensis*, *Kosmoclymenia undulata*, *K. sedgwicki* and *Cymaclymenia striata* in the upper part of unit 4. The presence of specimens of *Kosmoclymenia* could indicate Famennian doV, an age that agrees with the occurrence of the conodonts *Clydagnathus* cf. *gilwernensis* and *Bispathodus stabilis* Morphotype 2 (sample Vi-35, Text-fig. 3). Morphotype 2 has been reported from the base of the Lower *expansa* Zone (Ziegler & Sandberg, 1984). Also, Becker (1976 and 1982) attributed his ostracod samples 11 and 110/1a to the Famennian doV (see Text-fig. 2).

Unit 5a has yielded the ammonoid *Kosmoclymenia* sp., whereas Kullmann (1960) reported *Sporadoceras hispanicum*, *Kosmoclymenia undulata* and *K. sedgwicki*. Sample Vi-36 (Text-fig. 3) contains *Pseudopolygnathus controversus*, which characterises the interval between the Lower and Middle *expansa* Zones (Sandberg & Ziegler, 1979). Similarly, sample CA12 of Adrichem-Boogaert (1967) containing *Bispathodus jugosus* (Text-fig. 2) can indicate a level above the base of the Lower *expansa* Zone (Ziegler & Sandberg, 1984) and the ostracod fauna of sample 110/1b of Becker (1976) was assigned by him to the upper part of the *hemisphaericadichotoma* entomozone Zone, which is equivalent to the Middle *expansa* conodont Zone. Sample 14 of Budinger & Kullmann (1964) contained *Scaphignathus velifer* and *Branmehla bohlenana*, although possibly the *Scaphignathus* could be a species of *Clydagnathus* similar to that found in our sample Vi-37.

Sample Vi-40 of unit 5b contains *Bispathodus costatus* and *Branmehla suprema* and is correlated with the Upper *expansa* Zone (Famennian doVI). *Gonioclymenia* sp. has been also collected from this bed. The occurrence of *Siphonodella praesulcata* from the unit 5c (Vi-43) indicates the Lower *praesulcata* Zone. This zone and the Middle *praesulcata* Zone must be represented as high as the top of the unit 5c (sample Vi-48) where we have obtained the morphotype *Bispathodus ultimus muessenbergensis* (Text-figs. 3 and 4). Kullman (1960) determined the ammonoids *Prionoceras (Imitoceras) subbilobatum*, *P. (I.) cf. intermedium*, *P. (I.) substriatum*, *Kalloclymenia wocklumensis* and *Cymaclymenia involvens* in the upper part of unit 5.

The presence of *Protognathodus* elements together with the lack of *B. ultimus* and *Palmatolepis* in unit 5d could indicate the lower *Protognathodus* fauna of Ziegler (1969). Only a fragment of *Siphonodella* was obtained from sample Vi-50, and another fragment of *Protognathodus collinsoni* or *P. kockeli* (sample Vi-49) may suggest correlation of this level with the Upper *praesulcata* Zone (Text-figs. 3-4).

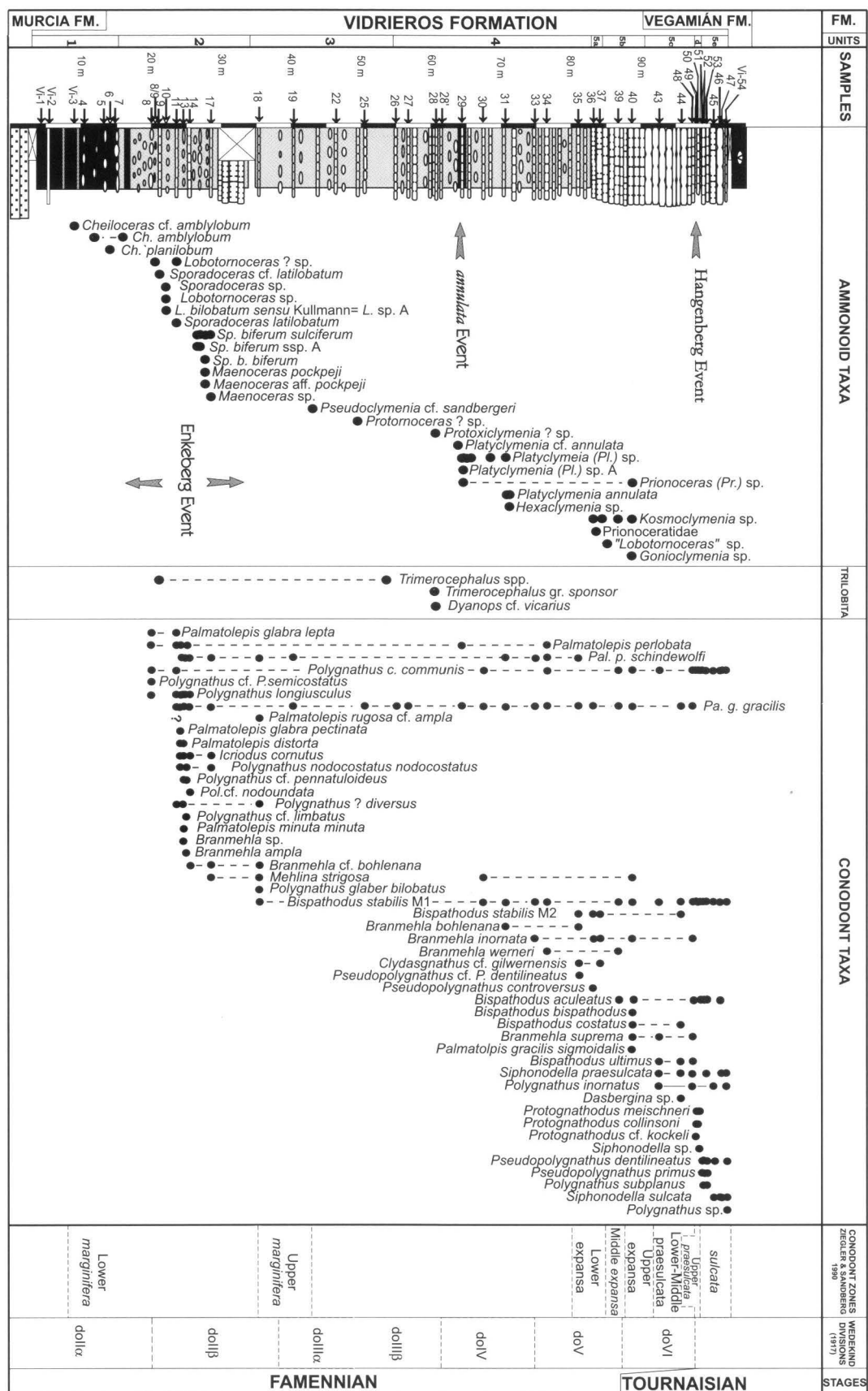
The *sulcata* Zone is recognised between the bed Vi-45 and the top of the Vidrieros Formation, where we have found the diagnostic *Siphonodella sulcata* (Text-figs. 4-5). However, we can consider a lower tentative

beginning for the *sulcata* Zone from sample Vi-51 (base of unit 5e). Unfortunately, elements of *Siphonodella* have not been found among samples Vi-49 and Vi-53. Sample Vi-51 has yielded only an element identified as *Protognathodus meischneri*, genus which has not been found in higher beds. Sample Vi-51, and also that from the higher bed, contains elements of *Pseudopolygnathus dentilineatus* together with *Ps. primus*. The presence of *Ps. primus* morphologies, besides the *Ps. dentilineatus*, has been described in samples from Holy Cross Mountains and correlated with the Tournaisian *sulcata* Zone where environmental conditions controlled the distribution of species (Dzik, 1997). Both forms occur in the *sulcata* Zone from the Central Carnic Alps (Schönlaub *et al.*, 1988) and in a section from the Pyrenees, whereas *Ps. primus* has been reported in the Upper *praesulcata* Zone from other two Pyrenean sections below the occurrence of *S. sulcata* (Perret, 1988). Consequently, we speculate that the base of the Carboniferous could be located just under the bed Vi-51 in our section (Text-figs. 4-5).

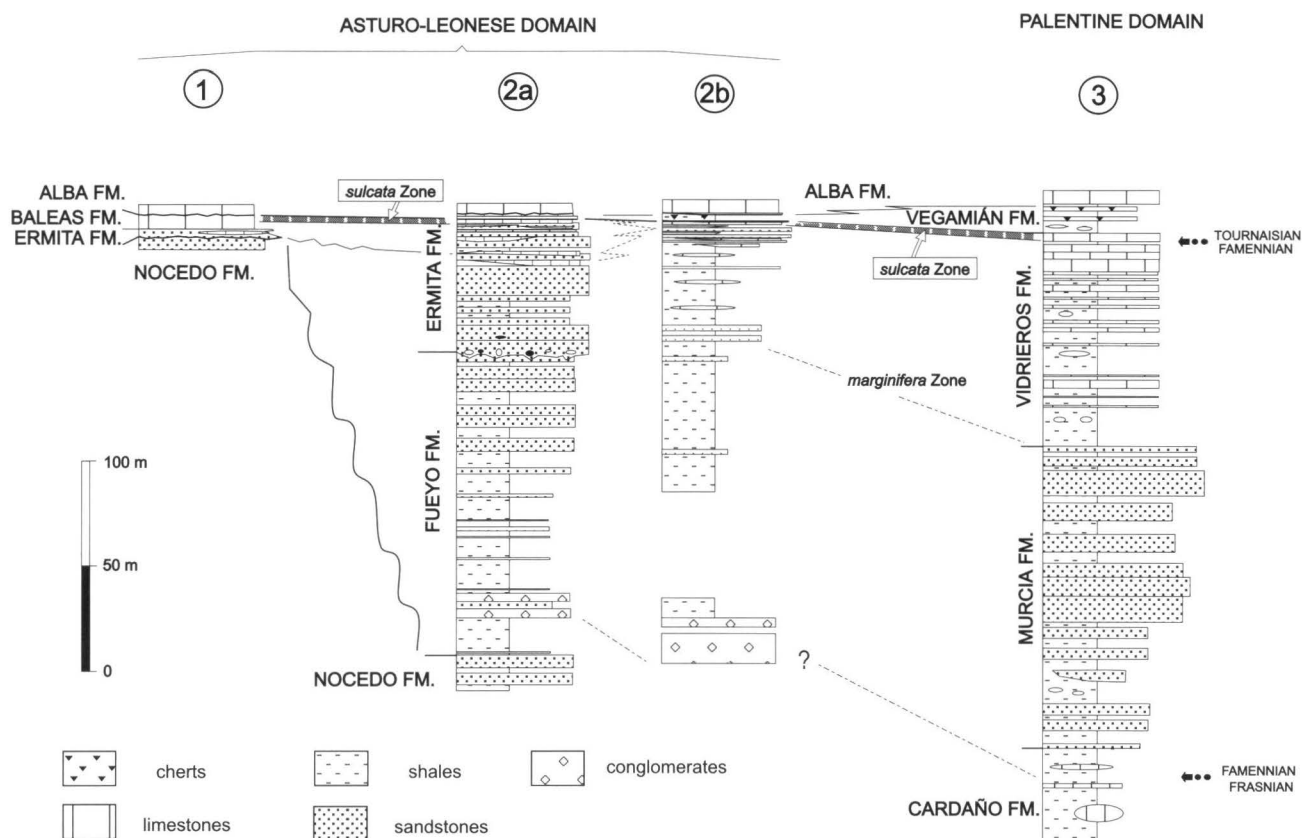
CONODONT BIOFACIES

Upper Famennian conodont biofacies from the Cantabrian Zone were analysed by Raven (1983), and García-Alcalde & Menéndez-Alvarez (1988). Raven (1983) indicated that Famennian conodonts from the Palentine domain were characterised by a large number of *Polygnathus* and *Palmatolepis* species and a low number of *Icriodus* and "*Spathognathodus*", thus indicating deposition on the outer shelf to continental slope. On the other hand, upper Famennian conodonts of the Asturo-Leonese domain are dominated by polygnathids and bispathodids. In this domain, Raven (1983) reported a high percentage of *Polygnathus* and showed about 50% of *P. c. communis* elements and 30% of other polygnathids; García-Alcalde & Menéndez-Alvarez (1988) noted the presence of more than 50% of *Bispathodus* elements in each sample, the absence of *Palmatolepis*, a steady occurrence of siphonodellids and a scarcity of protognathodids. This unusual biofacies, with a polygnathid-bispathodid association, has been related by these authors, with a shallow environment in an extensive flat sea-bottom, with development of crinoidal shoals and far from a siliciclastic supply. The presence of a large number of *P. communis* elements, and species of *Bispathodus* (including *Branmehla*, and *Mehlina*) can be explained because they have been interpreted to be euphotic, normally inhabited near surface layers of sea and had an ubiquitous distribution (Sandberg & Dreesen, 1984). Other abundant polygnathids, as *P. inornatus* and some *Pseudo-polygnathus*, were interpreted to inhabit slightly deeper and less agitated waters than *P. c. communis*, in similar associations from the lower Carboniferous of the British Isles (Austin & Davies, 1984).

Text-fig. 3 - Stratigraphic section of Peña Quebrada showing the ranges of ammonoids, trilobites and conodont taxa collected in this work. The correlated conodont zones are discussed along the text and correspond to the zonation of Ziegler & Sandberg (1984, 1990) and Sandberg *et al.* (1978). For the explanation of lithological symbols see Text-fig. 2.



Text-fig. 2 - Section of the Vahietros Formation at Peña Quebrada. We have tentatively located the probable position of the conodont samples and taxa referred by Budinger & Kullmann (1964), and Adrichem-Boogert (1967), and the conodont zones recognised by these authors. Ostracod associations were studied by Becker (1976, 1981 and 1982) and correlated by him with the Wedekind (1917)'s "Stufen" or divisions. Explanation of lithologic symbols also applies to columnar sections (Text-figs. 2-4).



Text-fig. 5 - Correlation diagram of Famennian stratigraphic sections in the Cantabrian Zone. The location of the sections is shown in the geological map of the Text-fig. 1. Section 1 is a typical section of the Asturian-Leonese domain (Baleas quarry, after García-Alcalde & Menéndez-Alvarez, 1988). Sections 2a and 2b correspond to the External Asturian-Leonese domain (after Rodríguez-Fernández *et al.*, 1985, and van Loevezijn, 1986). Section 3 is a synthesis of Famennian rocks in the Gildar-Montó unit of the Palentine domain.

In our work, we have obtained associations of the palmatolepid-polygnathid biofacies of Sandberg (1976) from the lower part of Vidrieros Formation. Above the sample Vi-11, the quantity of *Polygnathus nodocostatus* group and *I. cornutus* increases. Their presence can be indicative of some shallower conditions than those supposed for the lower Vidrieros Formation, although those conodonts are representative of a more offshore and/or deeper water environment than other species of these genera (Sandberg & Dreesen, 1984). Upwards from the sample Vi-18, the abundance and diversity of elements decrease, and the associations correspond to the palmatolepid-bispathodid biofacies of Sandberg (1976).

The scarcity of conodonts from units 3 and 4 coincides with the fact that only a few associations between the Lower *marginifera* Zone and the Lower *expansa* Zone have been described in different tectonic units of the Palentine domain. Adrichem Boogaert (1967) found an association (VID3, Vidrieros section) assigned to *marginifera* Zone and composed of *Polygnathus glaber bilobatus*, *Palmatolepis perlolata*

sigmoidea and *P. rugosa* cf. *ampla* (Upper *marginifera* to Lower *trachytera* Zones in the present-day zonation), and this association is comparable to that obtained in our sample Vi-18. Another sample from La Lastra-Santibañez de Resoba (73/209) is attributed to the Upper *marginifera* Zone by van den Boogaert & Kuhry (1979). Associations with *Scaphignathus velifer* have been cited by Adrichem Boogaert (1967) from the *velifer* and the Lower *velifer* Zones, and could correspond to the Uppermost *marginifera* to Upper *trachytera* Zones in the Ziegler & Sandberg (1984)'s zonation. These associations come from the sample of the Cardaño de Arriba section (CARII) with *S. velifer* under *Palmatolepis minuta schleizii* and sample LV435 of the Liébana area with *S. velifer*, *P. m. schleizii*, *P. g. gracilis*, *P. m. minuta*, *P. glabra glabra* and *Branmehla ampla*.

Units 5a-e correspond to a dominantly deep-water carbonate sedimentation of the Vidrieros Formation, and conodont diversity increases in this interval. However, a faunal change is observed in unit 5d, where *Polygnathus communis* and *Bispathodus* are dominant,

and *Protognathodus* is also found. A faunal predominance of *Polygnathus* and the presence of 5-12% of *Protognathodus* elements (shallow water conodont intruders) have been related by Ziegler *et al.* (1988) with shallow-water sedimentation and a global eustatic fall (Johnson *et al.*, 1985). These low diversity faunas have also been interpreted as probable cold-water faunas (Dzik, 1997).

A varied fauna of *Protognathodus* was described by Adrichem-Boogaert (1967) in other locality of the Palentine domain (sample Tr21, section Triollo). Conodonts of the upper *Protognathodus* fauna or *sulcata* Zone (*Protognathodus kuehni* and *Pseudopolygnathus primus*) were reported from a limestone in the southern part of the Asturo-Leonese domain (Higgins *et al.*, 1964; Higgins & Wagner-Gentis, 1982). However, *Protognathodus* was only sparsely present in this domain (van Tongeren in Raven, 1983; García-Alcalde & Menéndez-Alvarez, 1988) and this agrees with a restricted presence of this genus towards nearshore facies (Austin & Davies, 1984).

The base of unit 5e is characterised by the dominance of *Pseudopolygnathus*. Upwards, this unit contains an association dominated by *Polygnathus* and *Siphonodella*. A wide distribution but a low quantity is attributed to *Siphonodella* in the Asturo-Leonese domain by Menéndez-Alvarez (1991). *Siphonodella* is an offshore pelagic to hemipelagic genus (Lane *et al.*, 1980), that increases in abundance towards deeper water.

DISCUSSION AND CONCLUSIONS

The sedimentation of the Vidrieros Formation began probably in the Lower *marginifera* Zone in the Palentine domain (middle Famennian). The same conodont zone was recognised by van Loevezijn (1986) in pebbly sandstones filling channel beds from

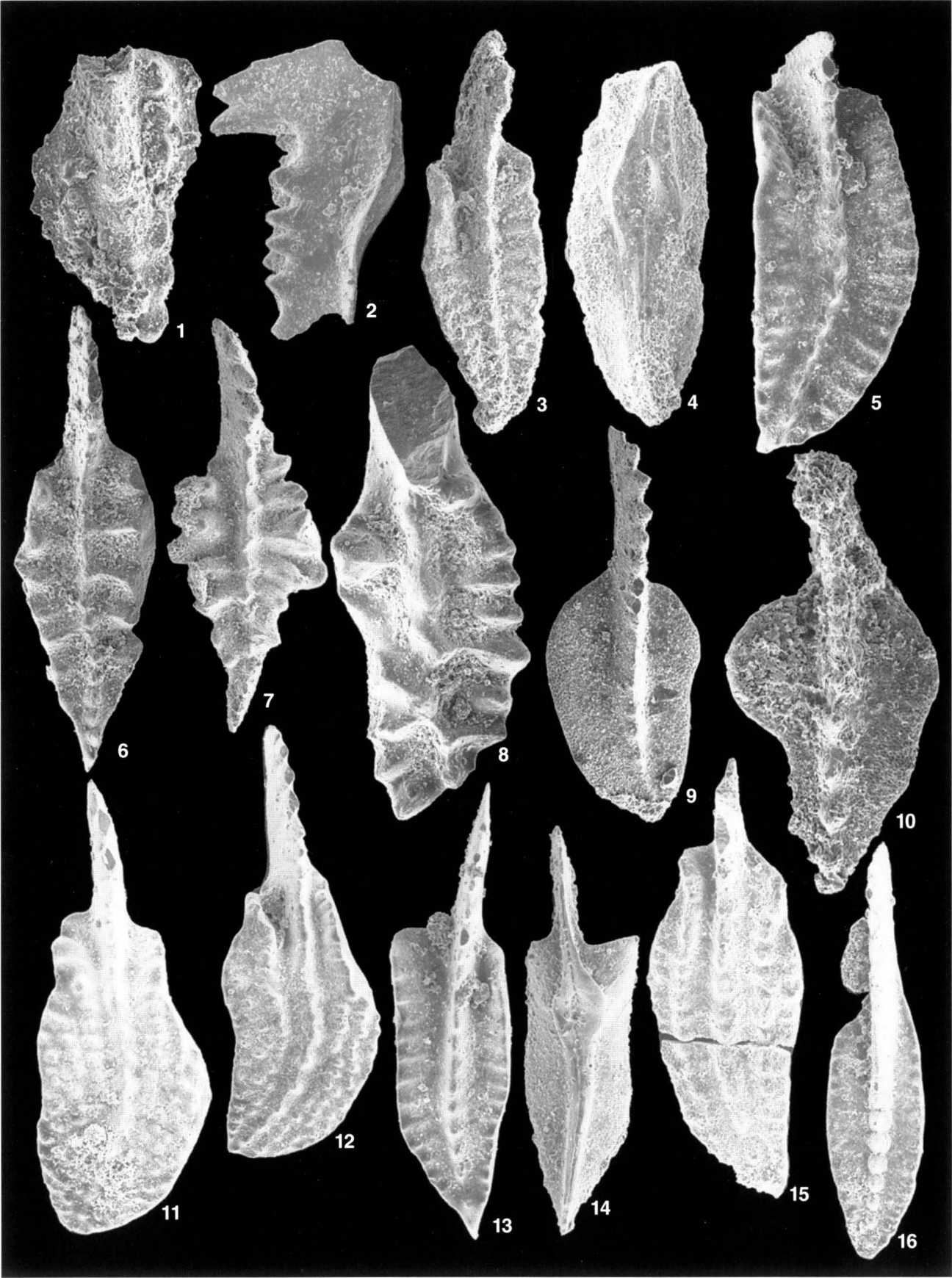
the upper part of the Fueyo Formation (Asturo-Leonese domain, Text-fig. 5).

The sedimentation of the Vidrieros Formation can be interpreted as a deepening episode characterised by fine-grained sediments (marls and shales). It coexisted with the sedimentation of the Ermita Formation in the External Asturo-Leonese domain. Ermita Formation rocks have been interpreted as deposited on a high-energy sandy platform with shoals in a shallow sea (van Loevezijn, 1986). The succession corresponds to a prograding and shallowing-upward sequence, from low-energy facies with storm generated turbidity deposits (Fueyo Formation) to a littoral environment with some fluvial influences in the uppermost part of the Ermita Formation after van Loevezijn (1986). The prograding Famennian sequence has been ascribed by the late author to a high production of clastics in the source area (Asturian mainland), and to a relatively lower rate of subsidence, compared to the lower Famennian. The rate of sedimentation slightly surpassed rate of subsidence.

García-Alcalde (1998) has discussed the characteristics of global Devonian events in the Cantabrian Mountains. Some events refer to the Vidrieros Formation: lower Condroz (base of Vidrieros Formation), upper step of the Enkeberg, *annulata* and Hangenberg Events. We make a few points regarding this subject from our study section. The change of black shales of the basal Vidrieros Formation (oxygen depleted sedimentation) to brown shales is marked by a black level above bed Vi-7 (Text-fig. 3). This bed is located between the disappearance of cheiloceratids and the entries of *Sporadoceras* and *Maeneceras*, and could correspond to the transgressive pulse Middle Ile of Johnson & Sandberg (1989). This change is similar to the lithological change or first step of the Enkeberg Event (Becker, 1993). The end of this event is defined by the first appearance of Clymeniina, which is located within unit 3 in the Vidrieros Formation (Text-fig. 3).

EXPLANATION OF PLATE 2

- Fig. 1 - *Protognathodus* cf. *kockeli* Bischoff, 1957, sample Vi-49, x 120.
- Fig. 2 - *Clydagnathus* cf. *gilwernensis* Rhodes, Austin & Druce, 1969, sample Vi-35, x 100.
- Fig. 3 - *Siphonodella praesulcata* Sandberg, 1972, sample Vi-44, x 75.
- Fig. 4 - *Siphonodella praesulcata* Sandberg, 1972, lower view of another specimen from sample Vi-48, x 100.
- Fig. 5 - *Siphonodella sulcata* (Huddle, 1934), sample Vi-46, x 100.
- Fig. 6 - *Pseudopolygnathus dentilineatus* E.R. Branson, 1934, sample Vi-51, x 75.
- Fig. 7 - *Pseudopolygnathus primus* Branson & Mehl, 1934, sample Vi-53, x 50.
- Fig. 8 - *Pseudopolygnathus primus* Branson & Mehl, 1934, sample Vi-51, x 70.
- Fig. 9 - *Polygnathus subplanus* Voges, 1959, sample Vi-52, x 100.
- Fig. 10 - *Polygnathus glaber bilobatus* Ziegler, 1962, sample Vi-18, x 130.
- Fig. 11 - *Polygnathus* cf. *nodoundatus* Helms, 1961, sample Vi-14, x 60.
- Fig. 12 - *Polygnathus pennatuloides* Holmes, 1928, sample Vi-13, x 70.
- Fig. 13 - *Polygnathus inornatus* E.R. Branson, 1934, sample Vi-54, x 120.
- Fig. 14 - *Polygnathus inornatus* E.R. Branson, 1934, lower view of another specimen from sample Vi-54, x 100.
- Fig. 15 - *Polygnathus nodocostatus nodocostatus* Branson & Mehl, 1934, sample Vi-13, x 100.
- Fig. 16 - *Polygnathus longiusculus* Çapkinoglu, 1997, sample Vi-14, x 80.



The *annulata* Event (Walliser, 1984) could be located around bed Vi-29, where black shales and limestones present a great quantity of platyclymenids.

Unit 5a corresponds to dominantly carbonate sedimentation in the Vidrieros Formation, established from the Middle *expansa* to the Lower-Middle *praesulcata* Zones (upper Famennian). This unit could be related to a lower subsidence rate with respect to the lower Vidrieros sedimentation or to a deeper water sedimentation. For the southern Asturo-Leonese domain, upper Famennian conodonts have been obtained from a bed in black shales and lime mudstones considered as a lateral change within the Ermita Sandstones (Raven, 1983; van Loevezijn, 1986). Also, a large number of samples from the Middle *expansa* to the Lower *praesulcata* Zones has been studied from the top of the Ermita Formation and the lower part of the Baleas Formation (Higgins *et al.*, 1964; Higgins & Wagner-Gentis, 1982; Menéndez-Alvarez, 1991). A generalised very low subsidence rate and a decrease in the supply of siliciclastics have been interpreted for the Asturian-Leonese domain during this interval (van Loevizjn, 1986), when a widespread and thin sedimentary wedge is buried to the unconformity developed on the Asturian mainland.

The Hangenberg Event can be recognised at the base of the shaly unit 5d of the Vidrieros Formation, where a lithological change is observed together with a turnover of the conodont genera. The thickness of the unit 5d (text-fig. 3) suggests an extremely low rate of subsidence if we suppose similar time durations for the upper Famennian conodont zones. An average duration of 0,5 m.y. has been employed for Famennian conodont zones, though an age of 0,1 m.y. was proposed by Middle *praesulcata* Zone by Sandberg & Ziegler (1996). Likewise, condensed carbonate sedimentation is also observed in some sections of the Asturo-Leonese domain (Text-fig. 5) in the *praesulcata* and *sulcata* Zones (García-Alcalde & Menéndez-Alvarez, 1988). Condensation seems to be more pronounced for the Upper *praesulcata* Zone, which is difficult to recognise. Probably, Upper *praesulcata* Zone corresponds to about a meter thickness of the Baleas Formation, judging from the data of García-Alcalde & Menéndez-Alvarez (1988). Consequently, uppermost Famennian seems to correspond to a very slow generalised subsidence of the Cantabrian mainland and basin. The presence of a condensed sedimentation, gaps in deposition or changes in lithology have been considered for shallow-marine environments (Walliser, 1996), and can be interpreted as a result of a fall of sea level during the Hangenberg Event and related to the regressive global eustatic Ilf cycle (Johnson *et al.*, 1985).

The lower Carboniferous boundary was defined by the entry of *S. sulcata* (Paproth *et al.*, 1991; Sandberg *et al.*, 1978). *S. sulcata* is often found in Cantabrian condensed limestones and its entry has been used to correlate the position of the basal Carboniferous in

the Asturo-Leonese domain (García-Alcalde & Menéndez-Alvarez, 1988). The first finding of *S. sulcata* comes from sample Vi-45 in the Vidrieros Formation of the Peña Quebrada section, although the presence of *Ps. primus* from the sample Vi-51 could suggest a Tournaisian age for the unit 5e of the Vidrieros Formation.

The Peña Quebrada succession contains limestone and marls (with conodonts from the *sulcata* Zone, sample Vi-54) just below the Vegamián Formation. The contact between the Vidrieros and Vegamián Formations is interpreted as a transitional boundary, with progressive deepening sedimentation. Nevertheless, detachment surfaces are developed at these levels in the succession. A gradual transition between Vidrieros and Vegamián Formations was also interpreted by Adrichem Boogaert (1967) in another section of the Palentine domain. However, this contact had been interpreted as an erosional disconformity by van Veen (1965), who was probably influenced by the commonly described disconformity at the base of Vegamián Formation in several sections of the Asturo-Leonese domain (Higgins & Wagner Gentis, 1982; Raven, 1983).

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