Conodont faunas from Portugal and southwestern Spain

Part 4. A Famennian conodont fauna near Nerva (Rio Tinto)

M. van den Boogaard and L. J. G. Schermerhorn

Boogaard, M. van den & L. J. G. Schermerhorn. Conodont faunas from Portugal and southwestern Spain. Part 4. A Famennian conodont fauna near Nerva (Rio Tinto). — Scripta Geol., 56: 1 - 14, 1 fig., 4 pls., Leiden, March 1981.

A Middle to Upper *Bispathodus costatus* Zone conodont fauna is described from the top of the Phyllite-Quartzite Group in the Iberian Pyrite Belt. The colour of the conodonts is in agreement with the very-low-grade regional metamorphism in the pumpellyite facies.

M. van den Boogaard, Rijksmuseum van Geologie en Mineralogie, Hooglandse Kerkgracht 17,. 2312 HS Leiden, The Netherlands; L. J. G. Schermerhorn, Freie Universtät Berlin, Institut für Mineralogie, Takustrasse 6, 1000 Berlin 33, Federal Republic of Germany.

Introduction

The pyrite deposits of Rio Tinto, in the Iberian Pyrite Belt, occur in a small anticline of felsic volcanics within a large WNW-trending synclinorium of Carboniferous slates (Upper Viséan and younger). South of this synclinorium runs a long anticline in which the Rio Tinto felsic volcanics recur. Stratigraphi-

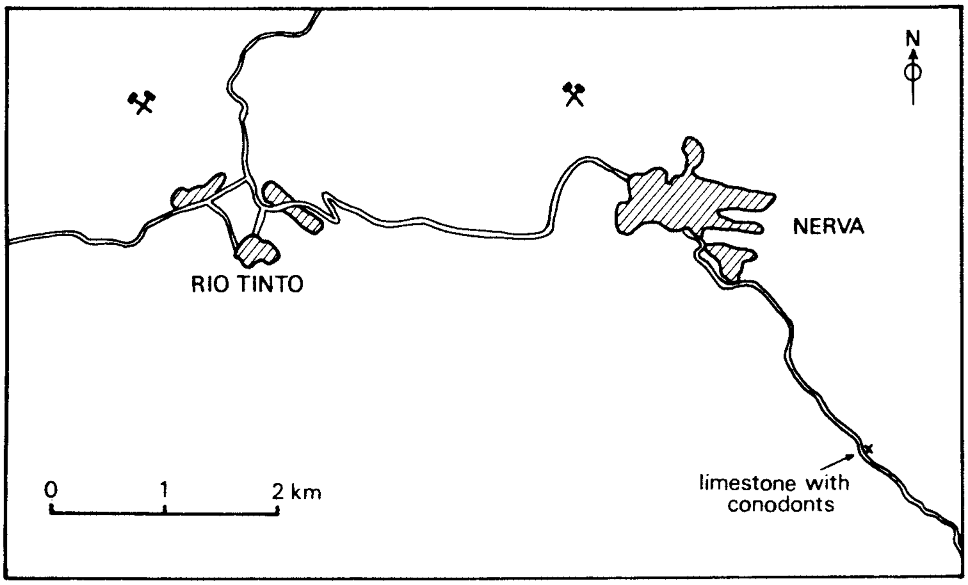


Fig. 1. Location map (after Armengot de Pedro, 1972).

cally below the felsics are mafic volcanics and these overlie phyllites with some quartzite beds, forming the core of the anticline.

In terms of Pyrite Belt stratigraphy (Schermerhorn, 1971), the phyllites in the anticinal core belong to the Phyllite-Quartzite Group (PQ), the volcanics and associated pyrite deposits belong to the Volcanic-Siliceous Complex (VS) and the slates at the top belong to the 'Culm' Group. The downward extent of PQ is not known, its base never being seen, but its top locally contains Famennian fossils (Schermerhorn, 1971; van de Boogaard & Schermerhorn, 1975). This paper describes an occurrence of Late Famennian conodonts near the top of PQ some 5 km ESE of Rio Tinto (Fig. 1).

The general geology of the Iberian Pyrite Belt and of the Rio Tinto area can be gathered from maps and sections published by Schermerhorn (1975), Vázquez, Arteaga & Schermerhorn (1980) and previous authors. The geology of Rio Tinto has been described in detail by Williams (1934), Rambaud Pérez (1969) and García Palomero (1974).

The first discovery of Devonian fossils in the Spanish Pyrite Belt was made by Meseguer Pardo (1944; Meseguer Pardo et al., 1945, p. 246) in the Rio Tinto area, on the road to Sevilla 3 km SE of Nerva, a town 3 km E of Rio Tinto. The fossils occur in slates with limestone nodules and were identified by P. H. Sampelayo as comprising *Clymenia* sp., *Glyphioceras crenistria* Phill. and *Poteriocrinus*. Because of these fossils Meseguer Pardo concluded to a Late Devonian age for these beds although *G. crenistria* is typical for Late Viséan. However, judging from the pictured specimen of *G. crenistria* (Meseguer Pardo, 1944, p. 71) the preservation of this fossil does not allow an identification at generic or specific level (C. H. T. Wagner-Gentis, pers. comm.).

Subsequently, the occurrence was visited by Rambaud Pérez (1969, p. 115) and Armengot de Pedro (1972, p. 1) but except for some crinoid ossicles they did not discover any other fossils.

In 1970 these limestones were sampled by W. P. F. H. de Graaff and L. J. G. Schermerhorn. A deep gully along the road exposes bluish grey phyllites carrying steeply dipping layers, lenticles and nodules of medium grey, very fine-grained limestone, in a zone 25 - 30 m wide across the strike. This is at the top of PQ and about 70 m north runs the contact of the phyllites with the overlying mafic volcanics at the base of VS in the north flank of the anticline. The limestones contain crinoid stem fragments but no other macrofossils were seen. However, the phyllites in the limestone zone contain many macrofossils of various types, including solitary rugose corals.

Acknowledgements

Thanks are due to Dr C. E. S. Arps for suggestions concerning a part of the text, to Mr E. de Stoppelaar for assistance in preparing the scanning electron micrographs.

Palaeontology

A limestone sample of 6500 g has been dissolved with formic acid and the residue was found to contain about 4000 conodonts. They are listed in Table 1. Van den Boogaard and Kuhry (1979) have put the Linnean terms for separate elements (form species) between quotations marks, a custom which is continued in this paper. The specimens are stored in the Rijksmuseum van Geologie en Mineralogie, Leiden, with registration numbers RGM 295 509 - 295 568.

In the following part one of us (M. v. d. B.) will make some remarks upon several of the conodont species.

'*Bispathodus costatus*' (Branson, 1934)
Pl. 1, figs. E, F.

1934 *Spathodus costatus* n. sp. — Branson, p. 303 - 304, pl. 27, fig. 13.
1974 *Bispathodus costatus* (Branson) — Ziegler, Sandberg & Austin, p. 102 - 103, pl. 1, figs. 1, 2, 9; pl. 2, figs. 13 - 15.

Most of our specimens have the large *bispathodus*-like basal cavity that reaches the posterior tip of the blade: the form described as Morphotype 1 by Ziegler et al. The form with the somewhat expanded *aculeatus*-like basal cavity, described as Morphotype 2 from Germany by Ziegler et al., also is present in the Nerva fauna.

'*Bispathodus* cf. *B. ultimus*' (Bischoff, 1957)
Pl. 1, figs. A, B.

1957 *Spathognathodus ultimus* n. sp. — Bischoff, p. 57 - 58, pl. 4, figs. 24 - 26.
1974 *Bispathodus ultimus* (Bischoff) — Ziegler, Sandberg & Austin, p.104, pl. 2, fig. 12.

Plate 1

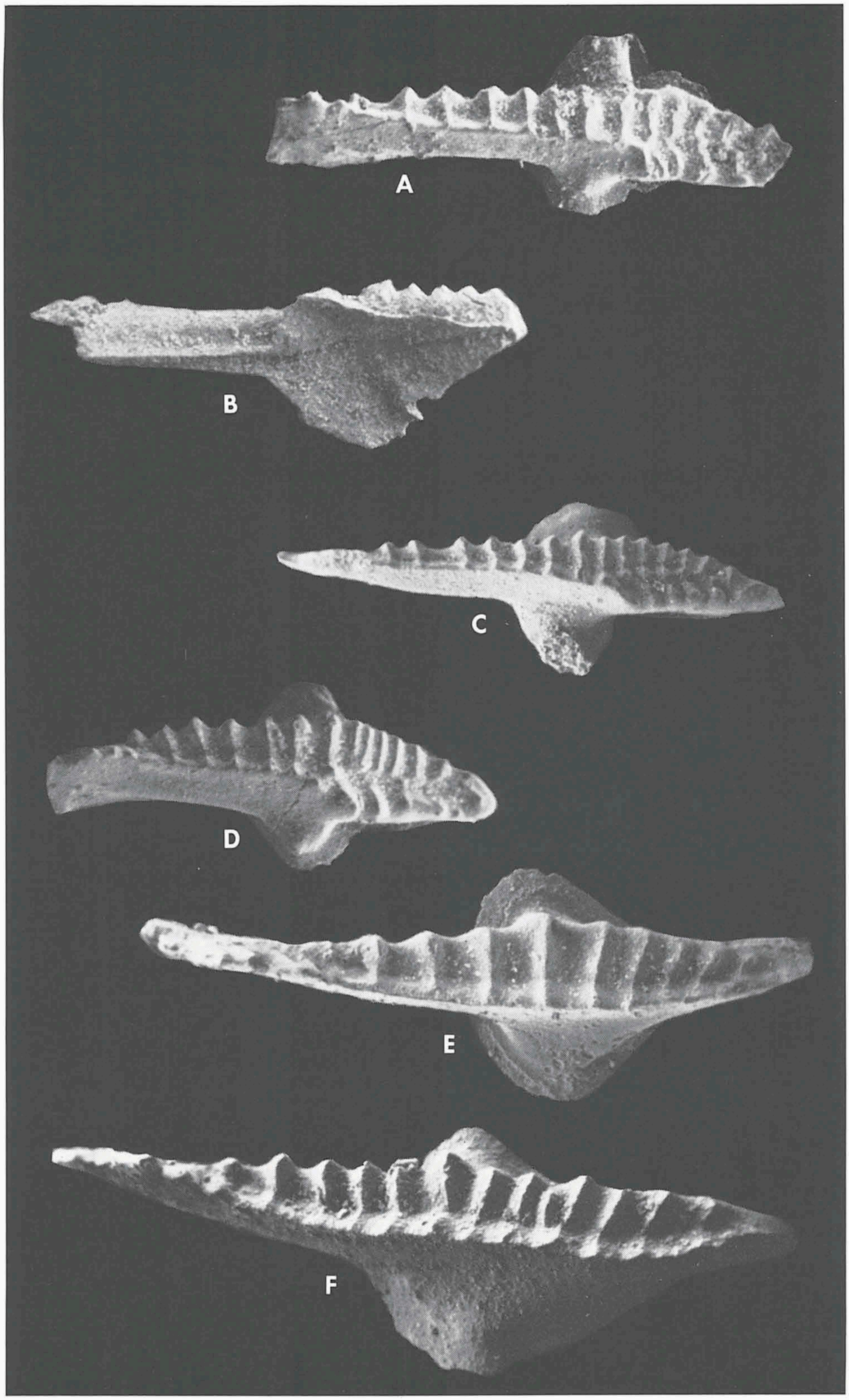


Table 1. Natural species and form ('. . .') species present in the Nerva sample.

	Number of specimens
'*Bispathodus costatus*' (Branson, 1934)	1364
'*Bispathodus* cf. *B. ultimus*' (Bischoff, 1957)	15
'*Bispathodus ziegleri*' (Rhodes, Austin & Druce, 1969)	683
Palmatolepis (Tripodellus) gracilis Branson & Mehl, 1934: P element	357
Palmatolepis (Tripodellus) sigmoidalis Ziegler, 1962: P element	69
Palmatolepis (Tripodellus) sp.: O element	52
Palmatolepis (Tripodellus) sp.: N_1 element	50
Palmatolepis (Tripodellus) sp.: N_2 element	47
Palmatolepis (Tripodellus) sp.: A_1 element	16
Palmatolepis (Tripodellus) sp.: A_2 element	18
Palmatolepis (Tripodellus) sp.: A_3 element	11
'*Polygnathus communis communis*' Branson & Mehl, 1934	136
'*Polygnathus* cf. *P. inornatus*' Branson, 1934	13
'*Pseudopolygnathus nodomarginatus*' (Branson, 1934)	240
'*Pseudopolygnathus marburgensis trigonicus*' Ziegler, 1962	2
'*Pseudopolygnathus*' sp.	2
'*Spathognathodus inornatus*' (Branson & Mehl, 1934)	17
'*Spathognathodus strigosus*' (Branson & Mehl, 1934)	14
'*Spathognathodus supremus*' Ziegler, 1962	89
'*Spathognathodus*' sp., juv. forms & '*Bispathodus*' sp., juv. forms	73
Simple cones	50
Ozarkodinan elements	202
Prioniodinan elements	128
Other non-platform elements	364

The specimens in our fauna possess a large slightly asymmetrical *bispathodus*-like basal cavity with a fold on the right side, as described for '*B. ultimus*' by Ziegler et al., 1974. The left lateral row does not extend to the anterior margin of the basal cavity as in typical '*B. ultimus*', but is more like that of '*B. ziegleri*'. However, because of the basal cavity which differs from that of '*B. ziegleri*' these specimens are provisionally referred to as cf. '*B. ultimus*'.

'*Bispathodus ultimus*' s.s. occurs in the Middle and Upper *B. costatus* Zone (Ziegler et al., 1974).

Plate 1

Fig. A. '*Bispathodus* cf. *B. ultimus*' (Bischoff, 1957). Oral view, specimen RGM 295 566, × 50.
Fig. B. '*Bispathodus* cf. *B. ultimus*' (Bischoff, 1957). Aboral view, specimen RGM 295 566, × 52.
Fig. C. '*Bispathodus ziegleri*' (Rhodes, Austin & Druce, 1969). Oral view, specimen RGM 295 567, × 50.
Fig. D. '*Bispathodus ziegleri*' (Rhodes, Austin & Druce, 1969). Oral view, specimen RGM 295 567, × 50.
Fig. E. '*Bispathodus costatus*' (Branson, 1934). Oral view, specimen RGM 295 565, × 105.
Fig. F. '*Bispathodus costatus*' (Branson, 1934). Oral view, specimen RGM 295 565, × 80.

Plate 2

'Bispathodus ziegleri' (Rhodes, Austin & Druce, 1969)
Pl. 1, figs. C, D.

1969 *Spathognathodus ziegleri* n. sp. — Rhodes, Austin & Druce, p. 238 - 239, pl. 4, figs. 5a - 8d.
1974 *Bispathodus ziegleri* (Rhodes, Austin & Druce) — Ziegler, Sandberg & Austin, p. 104, pl. 2, fig. 16.

Almost all our specimens have the large *aculeatus*-like basal cavity as described by Ziegler et al., 1974. Only a few specimens have a basal cavity which approaches the *bispathodus*-like cavity, a phenomenon already noticed by Ziegler et al.

The species occurs in the Middle and Upper *B. costatus* Zone (Klapper & Ziegler, 1979).

Subgenus *Palmatolepis (Tripodellus)* Sannemann, 1955 — sensu van den Boogaard & Kuhry, 1979
Pl. 2, fig. C; Pl. 3, figs. A - G.

Two species of this subgenus occur in the fauna: *Palmatolepis (Tripodellus) gracilis* Branson & Mehl, 1934 and *Palmatolepis (Tripodellus) sigmoidalis* Ziegler, 1962. Apart from the P elements which could be easily assigned to one of both species do also occur the O *('Tripodellus robustus')*, N_1 *('Palmatodella delicatula')*, N_2 *('Prioniodina smithi')*, A_1 *('Falcodus variabilis')*, A_2 *('Scutula venusta')*, and A_3 *('Scutula bipennata')* elements which seem to be the same for both species (see van den Boogaard & Kuhry, 1979).

'Polygnathus communis communis' Branson & Mehl, 1934
Pl. 2, fig. B; Pl. 4, fig. C.

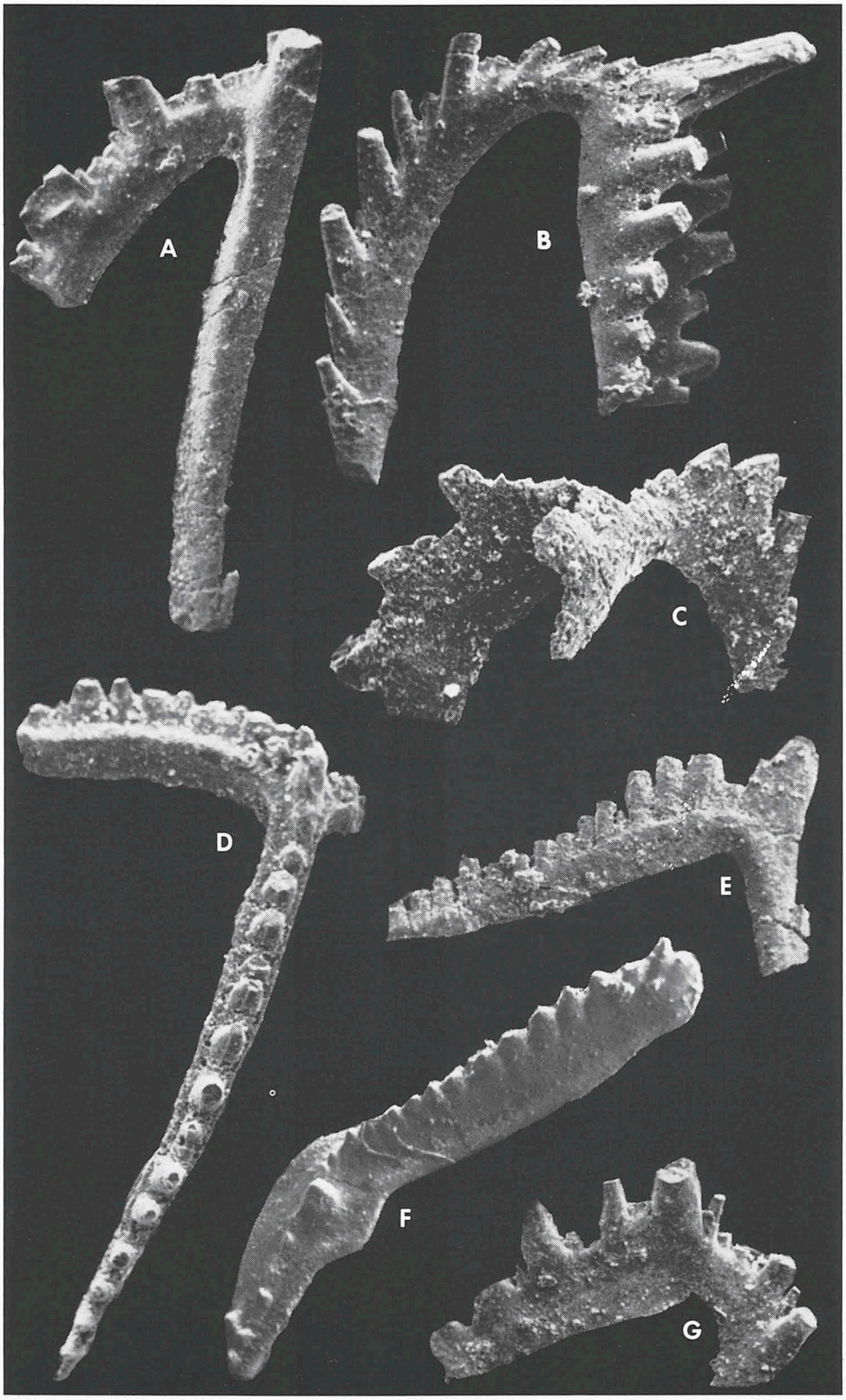
1934 *Polygnathus communis* n. sp. — Branson & Mehl, p. 293, pl. 24, figs. 1 - 4.

The specimens conform to the descriptions given by other authors, i. a. Voges (1959). In a number of specimens the rims of the platform are upturned in the anterior part only.

Plate 2

Fig. A. *'Polygnathus* cf. *P. inornatus'* Branson, 1934. Oblique oral view, specimen RGM 295 567, × 100.
Fig. B. *'Polygnathus communis communis'* Branson & Mehl, 1934. Oblique oral view, specimen RGM 295 565, × 210.
Fig. C. *Palmatolepis (Tripodellus) sigmoidalis* Ziegler, 1962: P element. Oblique oral view, specimen RGM 295 566, × 200.
Fig. D. Simple cone. Lateral view, specimen RGM 295 568, × 104.
Fig. E. *'Pseudopolygnathus marburgensis trigonicus'* Ziegler, 1962. Oral view, specimen RGM 295 567, × 210.

Plate 3



'*Polygnathus* cf. *P. inornatus*' Branson, 1934
Pl. 2, fig. A.

1934 *Polygnathus inornata* n. sp. — Branson, p. 309, pl. 25, figs. 8, 26.

The specimens conform to a high degree to the description given by Branson (1934). They differ in having less bent upward platform margins. However, the right anterior margin of the platform is higher than the left margin. According to Klapper (1975) this is the most characteristic morphologic feature of '*P. inornatus*'. Therefore the specimens are referred to cf. '*P. inornatus*'.

'*Polygnathus inornatus*' s.s. occurs in the Lower Carboniferous (Klapper, 1975), but '*P. inornatus*' s.l. already occurs from the base of the Middle *B. costatus* Zone upwards (Klapper & Ziegler, 1979).

'*Pseudopolygnathus marburgensis trigonicus*' Ziegler, 1962
Pl. 2, fig. E.

1962 *Pseudopolygnathus trigonica* n. sp. — Ziegler, p. 101 - 102, pl. 12, figs. 8 - 13.
1979 *Pseudopolygnathus marburgensis trigonicus* Ziegler — Sandberg & Ziegler, p. 182 - 183.

Our two specimens conform to the descriptions given by Ziegler (1962) and Sandberg & Ziegler (1979). According to the latter authors the species occurs in the Middle and Upper *B. costatus* Zone.

'*Pseudopolygnathus nodomarginata*' (Branson, 1934)
Pl. 4, figs. A, B.

1934 *Polygnathus nodomarginata* n. sp. — Branson, p. 310, pl. 25, fig. 10.
1969 *Pseudopolygnathus nodomarginatus* (Branson) — Rhodes, Austin & Druce, p. 212 - 213, pl. 9, figs. 1 - 4; pl. 12, figs. 6 - 8, 10.

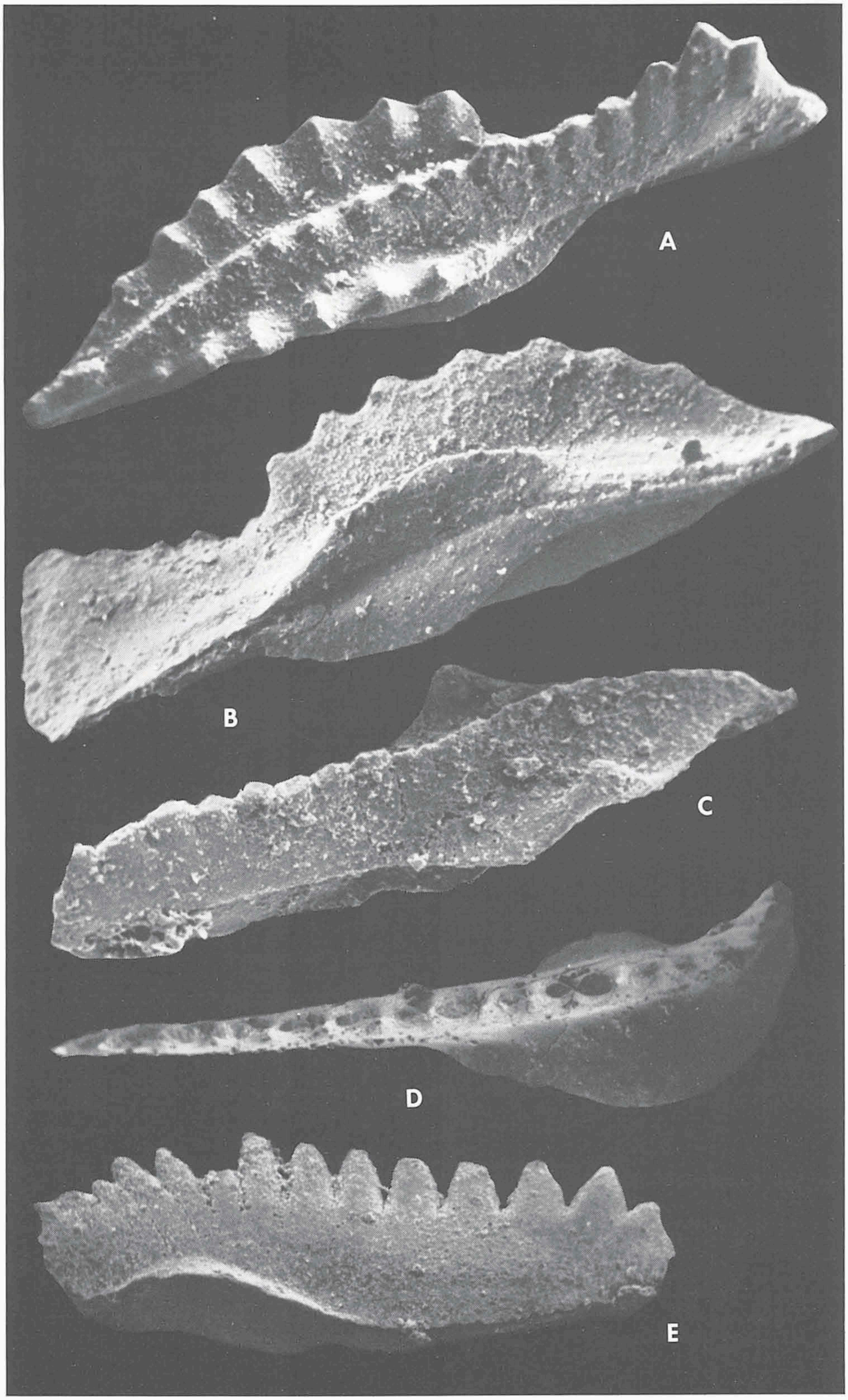
The specimens conform to the description given by Branson (1934). He already pointed out that the aboral surface of this species resembles that of '*Pseudopolygnathus*'. Reason for Rhodes, Austin & Druce (1969) to assign

---

Plate 3

Fig. A. *Palmatolepis (Tripodellus)* sp., N_2 element. Specimen RGM 295 566, × 100.
Fig. B. *Palmatolepis (Tripodellus)* sp., A_3 element, right anterior branch was broken off. Specimen RGM 295 566, × 100.
Fig. C. *Palmatolepis (Tripodellus)* sp., A_2 element. Specimen RGM 295 566, × 105.
Fig. D. *Palmatolepis (Tripodellus)* sp., O element. Specimen RGM 295 566, × 100.
Fig. E. *Palmatolepis (Tripodellus)* sp., N_1 element. Specimen RGM 295 566, × 52.
Fig. F. *Palmatolepis (Tripodellus) gracilis* Branson & Mehl, 1934, P element. Oblique oral view, specimen RGM 295 566, × 58.
Fig. G. *Palmatolepis (Tripodellus)* sp., A_1 element. Specimen RGM 295 566, × 100.

Plate 4



the species to the genus *'Pseudopolygnathus'*, an opinion shared by Nicoll and Druce (1979). As long as we do not know the apparatus of *'P. nodomarginatus'* and its evolutionairy history it may be best to place *nodomarginatus* provisionally in the genus *'Pseudopolygnathus'*. According to Ziegler (1962) *'Ps. nodomarginatus'* occurs in the Middle and Upper *B. costatus* Zone.

Simple cones
Pl. 2, fig. D.

The specimens of the Nerva fauna are identical to those described by van den Boogaard and Schermerhorn (1975) from Cabezas del Pasto and those from the Pomarão area (van den Boogaard, 1963).

Van den Boogaard and Kuhry (1979, p. 15) stated that they regarded it as extremely unlikely that the simple cones they met in their faunas, which are conspecific with those from Nerva, and *Icriodus* belonged to a common apparatus and therefore opposed to Nicoll's (1977) concept of the *Icriodus* apparatus. Since, Nicoll kindly showed me many photographs of his specimens. From these photographs appears that the simple cones found together with *Icriodus* are much smaller than the *Icriodus* elements. Consequently in my opinion these simple cones will hardly be found in the residues as they probably will pass all sieves used in common practice or will not be present at all in the faunas because of being transported to other places than the much heavier *Icriodus* elements.

The simple cones from Nerva do have a shape different from those in the *Icriodus* apparatus and undoubtedly belong to another type of apparatus, also because — as stated by van den Boogaard & Kuhry (1979) — they very often occur in faunas without any *Icriodus* elements.

'Spathognathodus supremus' Ziegler, 1962
Pl. 4, figs. D, E.

1962 *Spathognathodus supremus* n. sp. — Ziegler, p. 114 - 115, pl. 13, figs. 20 - 26.

The specimens assigned to this species all conform to Ziegler's description.

According to Ziegler (1962) and Klapper and Ziegler (1979) this species is found in the Middle and Upper *B. costatus* Zone.

Plate 4

Fig. A. *'Pseudopolygnathus nodomarginatus'* (Branson, 1934). Oral view, specimen RGM 295 565, × 155.
Fig. B. *'Pseudopolygnathus nodomarginatus'* (Branson, 1934). Aboral view, specimen RGM 295 565, × 155.
Fig. C. *'Polygnathus communis communis'* (Branson & Mehl, 1934). Oblique oral view, specimen RGM 295 565, × 210.
Fig. D. *'Spathognathodus supremus'* Ziegler, 1962. Oral view, specimen RGM 295 567, × 100.
Fig. E. *'Spathognathodus supremus'* Ziegler, 1962. Lateral view, specimen RGM 295 567, × 100.

Age of the limestone

According to Ziegler (1962) and Klapper & Ziegler (1979) *'Bispathodus ziegleri'*, *'Pseudopolygnathus marburgensis trigonicus'*, *'Pseudopolygnathus nodomarginatus'* and *'Spathognathodus supremus'* occur in the Middle and Upper *B. costatus* Zone only. Therefore we may assume that the Nerva limestones were deposited during Middle and/or Upper *B. costatus* Zone times (part of the *Wocklumeria* Stufe in the German standard, Late Famennian). The opinion of Meseguer Pardo (1944) that the Nerva limestones represent Late Devonian deposits is thus confirmed.

Conodont colour and metamorphism

The colour of the conodonts is greyish black. Their surface is in the process of changing from smooth and vitreous to pitted and grainy. This means according to Epstein, Epstein & Harris (1977) that these conodonts were affected by metamorphism at a temperature of 300° or more, to maybe 400°C.

This fits the data on regional metamorphism quite well. The rocks in the Iberian Pyrite Belt were affected by very-low-grade (sub-greenschist facies) and low-grade (lower greenschist facies) metamorphism (Schermerhorn, 1975a). The Nerva area lies within the pumpellyite facies, close to the greenschist facies which covers the northern part of the Iberian Pyrite Belt (Schermerhorn, 1975b). Mafic (and intermediate) rocks are well represented in the area and pumpellyite is a frequent constituent in them, together with actinolite and sometimes prehnite. To the north, however, across a pumpellyite-out isograd, the mafics no longer carry pumpellyite. From the field relations and experimentally determined stability relations, the boundary between the pumpellyite facies and the greenschist facies is a reaction curve at approximately 350°C which is a little affected by pressure. The pumpellyite-facies metamorphism of the Nerva rocks took place at P-T values near the pumpellyite-out isograd and close to the invariant point which represents the lower stability limit of the pumpellyite-actinolite subfacies. Evaluation of the P-T conditions under which metamorphism took place, indicate a temperature of almost 350°C and a load pressure of 2.5 to 3 kb (Schermerhorn, 1975b).

Palaeoecology

Sandberg (1976) could discern five different biofacies in the *Polygnathus styriacus* Zone in the Western United States by means of percentages of platform elements. In the fauna of his deepest facies, his palmatolepid-bispathodid biofacies which occurred on the continental rise and slope, *Palmatolepis* dominates over *'Polygnathus'*, and *'Bispathodus'* is also present in great number. In our fauna *'Bispathodus'* is by far the most frequent form (67.1% of the platform elements). Because *Palmatolepis* still dominates over *'Polygnathus'* (13.9 against 12.7%), the Nerva fauna represents a biofacies similar to Sandberg's palmatolepid-bispathodid biofacies.

The lithology of the Nerva beds appears to be rather similar to that of the somewhat older Nascedios Formation in the Pomarão area (van den Boogaard, 1967). The conodont faunas from the Nascedios Formation (*Polygnathus styriacus* Zone) also belong to the palmatolepid-bispathodid biofacies. (Mean of 15 samples: *Palmatolepis* 61.1%; *'Polygnathus'* 9.2%; *'Bispathodus'* 10.6%; *'Spathognathodus'* 18%; *'Pseudopolygnathus'* 0.8%; *'Icriodus'* 0.3%).

Because of this similarity of lithology with the Nascedios Formation and because of the predominance of *Palmatolepis* over *'Polygnathus'* we assume that the Nerva limestones have been deposited in a rather deep-water environment comparable to that of the continental rise and slope as described for the Devonian of the Western United States (Sandberg, 1976).

References

Armengot de Pedro, J., 1972. Hoja 938, Nerva. — Inst. Geol. Minero España, Mapa Geológico de España 1:50.000.

Bischoff, F., 1957. Die Conodonten-Stratigraphie des rhenoherzynischen Unterkarbons. — Abh. hess. Landesamt Bodenforsch., 19: 1 - 64.

Boogaard, M. van den, 1963. Conodonts of Upper Devonian and Lower Carboniferous age from southern Portugal. — Geologie Mijnbouw, 42: 248 - 259.

Bôogaard, M. van den, 1967. Geology of the Pomarão region (southern Portugal). — Doctor's Thesis Univ. Amsterdam: 1 - 113.

Boogaard, M. van den & B. Kuhry, 1979. Statistical reconstruction of the *Palmatolepis* apparatus (Late Devonian conodontophorids) at the generic, subgeneric, and specific level. — Scripta Geol., 49: 1 - 57.

Boogaard, M. van den & L.J.G. Schermerhorn, 1975. Conodont faunas from Portugal and southwestern Spain. Part. 2. A Famennian conodont fauna at Cabezas del Pasto. — Scripta Geol., 28: 1 - 36.

Branson, E.B. & M.G. Mehl, 1934. Conodonts from the Bushberg Sandstone and equivalent formations of Missouri. — Univ. Missouri Stud., 8, 4: 265 - 299.

Branson, E.R., 1934. Conodonts from the Hannibal Formation of Missouri. — Univ. Missouri Stud., 8, 4: 301 - 334.

Epstein, A.G., J.B. Epstein & L.D. Harris, 1977. Conodont Color Alteration — An Index to Organic Metamorphism. — Geol. Survey Prof. Paper, 995: 1 - 27.

García Palomero, F., 1974. Caracteres estratigráficos del anticlinal de Riotinto. — Studia Geol. (Salamanca), 8: 93 - 124.

Klapper, G., 1975. In: W. Ziegler (ed.), Catalogue of Conodonts. — Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, II: 293 - 297.

Klapper, G. & W. Ziegler, 1979. Devonian conodont biostratigraphy. — Spec. Paper Palaeont., 23 (The Devonian System): 199 - 224.

Meseguer Pardo, J., 1944. Devoniano en la provincia de Huelva. — Not. Com. Inst. Geol. Minero España, 12: 69 - 73.

Meseguer Pardo, J., I. Prieto, I. Roso de Luna & J. Pérez Regodón, 1945. Investigación de nuevos yacimientos de cobre en las provincias de Sevilla y Huelva. — Bol. Inst. Geol. Minero España, 58: 229 - 364.

Nicoll, R.S., 1977. Conodont apparatuses in an Upper Devonian palaeoniscoid fish from the Canning Basin, Western Australia. — BMR Jour. Australian Geol. Geophys., 2: 217 - 228.

Nicoll, R.S. & E.C. Druce, 1979. Conodonts from the Fairfield Group, Canning Basin, Western Australia. — Bureau Mineral Resources Bull., 190: 1 - 134.

Rambaud Pérez, F., 1969. El sinclinal Carbonífero de Rio Tinto (Huelva) y sus mineralizaciones asociadas. — Mem. Inst. Geol. Minero España, 71: 1 - 229.

Rhodes, F.H.T., R.L. Austin & E.C. Druce, 1969. British Avonian (Carboniferous) conodont faunas, and their value in local and intercontinental correlation. — Bull. Br. Mus.Nat. Hist. (Geol.), suppl. 5: 1 - 305.

Sandberg, C.A., 1976. Conodont biofacies of Late Devonian *Polygnathus styriacus* Zone in Western United States. — Geol. Assoc. Canada, Spec. Pap., 15: 171 - 186.

Sandberg, C.A. & W. Ziegler, 1979. Taxonomy and biofacies of important conodonts of Late Devonian *styriacus*-Zone, United States and Germany. — Geol. Palaeontol., 13: 173 - 212.

Schermerhorn, L.J.G., 1971. An outline stratigraphy of the Iberian Pyrite Belt. — Bol. Geol. Minero, 82: 239 - 268.

Schermerhorn, L.J.G., 1975a. Spilites, regional metamorphism and subduction in the Iberian Pyrite Belt: some comments. — Geologie Mijnbouw, 54: 23 - 35.

Schermerhorn, L.J.G., 1975b. Pumpellyite-facies metamorphism in the Spanish Pyrite Belt. — Pétrologie, 1: 71 - 86.

Vázquez, F., R. Arteaga & J. Schermerhorn, 1980. Depósitos minerales del suroeste de la Península Ibérica. — Bol. Geol. Minero, 91: 45 - 94.

Voges, A., 1959. Conodonten aus dem Untercarbon I und II *(Gattendorfia-* und *Pericyclus*-Stufe) des Sauerlandes. — Paläont. Z., 33: 266 - 314.

Williams, D., 1934. The geology of the Rio Tinto mines, Spain. — Trans. Inst. Mining Metall., 43: 593 - 640.

Ziegler, W., 1962. Taxionomie und Phylogenie Oberdevonischer Conodonten und ihre stratigraphische Bedeutung. — Abh. hess. Landesamt Bodenforsch., 38: 1 - 166.

Ziegler, W., C.A. Sandberg & R.L. Austin, 1974. Revision of *Bispathodus* group (Conodonta) in the Upper Devonian and Lower Carboniferous. — Geol. Palaeontol., 8: 97 - 112.

Manuscript received 12 December 1980.