On some occurrences of *Diplognathodus* in Carboniferous strata of Western Europe and North Africa

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Boogaard, M. van den. On some occurrences of *Diplognathodus* in Carboniferous strata of Western Europe and North Africa. – Scripta Geol., 69: 19-29, 1 fig., 1 pl., October 1983.

The occurrence is reported of *Diplognathodus coloradoensis, D. orphanus* and *D. ellesmerensis* in some localities in Western Europe and one locality in North Africa.

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Introduction

Species of the genus *Diplognathodus* may be useful for stratigraphic correlation of Carboniferous strata because some of them are probably stratigraphically short-ranging (e.g. *D. coloradoensis* according to Landing & Wardlaw, 1981, pp. 1255-1256). Because still little is known about the distribution of representants of the genus outside North America I thought it useful to relate the few occurrences of *D. coloradoensis, D. orphanus* and *D. ellesmerensis* I encountered during my investigation of Carboniferous limestones from Western Europe and North Africa.

Acknowledgements

Thanks for placing the samples at my disposal are due to Drs C.F. Winkler Prins, H.A. van Adrichem Boogaert, M.J.M. Bless, and A.C. van Ginkel. The information concerning the Cinderhill sample given by Dr W.H.C. Ramsbottom is much appreciated. Thanks also go to Mr J.G.M. Raven for making the SEM photographs.

Localities

Casasuertes, Spain

Samples C 3 and C' 16 were taken by H.A. van Adrichem Boogaert in 1961 and some years later given to the present author for investigation. The sample locality of C 3 is about 2.5 km north of Casasuertes, Leon, Spain (coord.: 43°05'N 4°57'W). The sample locality of C' 16 is directly southwest of Casasuertes along the road (coord.: 43°04'N 4°57'W). The samples are from the Panda Limestone Member of the Yuso Group. For regional geology see Savage (1967, fig. 10 and Enclosure 1) and Savage & Boschma (1980, sheet Yuso 1977).

Van Ginkel (1965, appendix 1) recorded from the Panda Limestone the following Foraminifera (his samples L 21, L 408 and L 426): *Fusulina agujasensis* van Ginkel, 1965, *Fusulinella* ex gr. *bocki* Moeller, 1878, *Fusulina rossoschanica kamerlingi* van Ginkel, 1965, *Hemifusulina* ex gr. *moelleri* Rauser-Chernoussova, 1951, and *Fusulinella pandae* van Ginkel, 1965. According to van Ginkel (1965, appendix 2) these fusulinids indicate a Podolsky (Late Moscovian) age.

Conodont fauna of the Panda Limestone at both localities: Sample C 3 contains *Diplognathodus ellesmerensis* Bender, 1980 (1 specimen) and *Idiognathodus delicatus* Gunnell, 1931 (1 sp.). Sample C' 16 contains *Diplognathodus ellesmerensis* (6 sp.) and *Idiognathodus delicatus* (7 sp.). Nine other samples from the Panda Limestone only yielded *I. delicatus* and some ramiform elements. The conodont content of this limestone is very low, on an average 6 conodonts per kg.

Verdegosa Hill, Spain

Samples SMR 5 and WP 8223 were taken by C.F. Winkler Prins 2500 m southeast of San Salvador de Cantamuda (Palencia, Spain) on the slope of Verdegosa Hill (coord.: 42°57'N 4°28'W) from a thin limestone bed which lies below the Verdeña Limestone. The Leonian disconformity (see Wagner et al., 1977) is thought to lie between the sampled limestone and the Verdeña Limestone. The age of the latter limestone is middle Cantabrian (basal Kasimovian) (Wagner et al., 1977). According to C.F. Winkler Prins (personal communication) the thin limestone bed is most likely of Myachkovsky (Late Moscovian) age. Conodont content of sample SMR 5: *Diplognathodus coloradoensis* (1 sp.), *Idiognathodus delicatus* (17 sp.). Weight of dissolved sample 2.6 kg. Sample WP 8223: *Diplo-*

gnathodus coloradoensis (1 sp.), *Idiognathodus delicatus* (26 sp.), *Idiognathodus* sp. (1 sp.), *Streptognathodus* sp. (1 sp.). Weight of sample 2 kg.

San Martin de Perapertú, Spain

Samples Wa 318 and Wa 318a were collected by R.H. Wagner and C.F. Winkler Prins in 1977 in an isolated limestone occurrence 1350 m southeast of San Martin de Perapertú (Palencia, Spain) at sample locality 318 of Wagner (1971, text-fig. 4) at the western side of the San Julian Nappe, coord.: 42°54'N 4°21'W. The limestone belongs to the Perapertú Formation which according to Wagner (1971, p. 451) is of Early Moscovian (Vereisky) age. The geology of this area is also mapped on sheet Pisuerga of Savage & Boschma (1980). The strata in which the locality of the sample must be sought are on that map indicated as Culm facies of the Ruesga Group. Conodont fauna of the Perapertú Limestone at loc. 318: Sample 318 contains *Declinognathodus noduliferus japonicus* (Igo & Koike, 1964) (2 specimens), *Idiognathodus sinuosus* Ellison & Graves, 1941 (24 sp.) and *Neognathodus bassleri* (Harris & Hollingsworth, 1933) (3 sp.). From the same outcrop, another limestone block, sample 318a: *Diplognathodus coloradoensis* (Murray & Chronic, 1965) (1 sp.) and *Idiognathodus sinuosus* (13 sp.). Weight of the samples: Wa 318 = 2.020 kg, Wa 318a = 1.580 kg.

Vañes, Spain

Samples 64 Va 1 and 65 Va 1b were collected in 1964 and 1965 by H.A. van Adrichem Boogaert and sample Gin 82-1 by A.C. van Ginkel 1200 m north of Vañes (Palencia, Spain) along the road through the Pisuerga valley in an outcrop of Stephanian A limestone (coord.: 42°55'N 4°29'W) - coord.: 42°55'N 0°48'W (longitude based on Madrid) on sheet Pisuerga in Savage & Boschma (1980). Another sample, 64 Va 2, was collected directly north of Vañes. This latter sample derives from the Castilleria Limestone (see van Ginkel 1972, p. 3), the age of which according to van Ginkel is top Myachkovsky, equates to the N_1 or N_2 Limestone of the C^1_3 (N) of the Donetz basin, or in the West-European zonation middle Cantabrian. Van Ginkel (personal communication) considers the limestones north of Vañes (samples 64 Va 1, 65 Va 1b and Gin 82-1) also to belong to the Castilleria Limestone and not to represent an outcrop of the younger limestones of the Estalaya beds which are basal Kasimovian.
Sample 64 Va 1 contains *Idiognathodus magnificus* Stauffer & Plummer, 1932.
Sample 65 Va 1b contains *Idiognathodus delicatus* Gunnell, 1931 (34 specimens) and *Diplognathodus coloradoensis* (Murray & Chronic, 1965) (3 sp.).
Sample 64 Va 2 contains *Idiognathodus delicatus*.
Sample Gin 82-1 contains *Idiognathodus delicatus*.
A sample from the Estalaya beds (loc. P 36, van Ginkel, 1965, 1972) also yielded *Idiognathodus delicatus* only.

Béchar-Djedid, Algeria

Sample DZ 59 was collected by C.F. Winkler Prins in 1973 immediately south of Béchar-Djedid in Algeria (coord.: 31°33'N 2°13'W). The sample derives from a limestone bed - probably the bed indicated as M1 by Deleau, 1951 - which is

part of the Upper Kenadzian (= lower Westphalian C according to Deleau, 1951, p. 71). Fusulinids from a bed about 100 m stratigraphically below the bed of DZ 59 indicate an early Moscovian age (A.C. van Ginkel, personal communication).

Conodont fauna of sample DZ 59: *Diplognathodus coloradoensis* Murray & Chronic, 1965 (6 sp.), *Diplognathodus orphanus* (Merrill, 1973) (2 sp.), *Idiognathoides sinuatus* Harris & Hollingsworth, 1933 (15 sp.), and *Idiognathodus delicatus* Gunnell, 1931 (19 sp.). RGM 331 667-331 671. Weight of the sample 1.080 kg.

Cinderhill, Great Britain

The fauna of sample Sy 917 was donated to me by M.J.M. Bless and comes from the Mansfield Marine Band from Cinderhill Colliery No. 4 shaft some miles NW of Nottingham (Nottinghamshire, Great Britain). The sample was collected during shaft sinking in 1945 at a depth of 106 feet (W.H.C. Ramsbottom, personal communication). See Edwards and Stubblefield (1948) for section (their fig. 6) and locality (their plate XIV, nr. 55). In their faunal list of the Mansfield Marine Band Edwards and Stubblefield (p. 229) report the occurrence of conodonts indet. in this locality. The fauna of my sample consists of *Idiognathodus magnificus* Stauffer & Plummer, 1932 (306 specimens) and *Diplognathodus coloradoensis* (144 spec.). This fauna differs markedly from the fauna of the Cank horizon just above the base of the Mansfield Marine Band = Aegiranum Marine Band of Stairfoot Brickworks 3 km ESE of Barnsley (Yorkshire), the site of the proposed boundary stratotype for the Westphalian C. The rich fauna*) at Stairfoot Brickworks (more than 4000 platform specimens out of 5.4 kg) is dominated by *Idiognathoides sinuatus* Harris & Hollingsworth 1933 and contains furthermore: *Idiognathoides sulcatus* Higgings & Bouckaert, 1968, *Idiognathodus delicatus* Gunnell, 1931, *Idiognathoides tuberculatus* Nemirovskaya, and a number of tiny specimens which seem morphologically identical to *Paragnathodus commutatus* (Branson & Mehl, 1941), but no *Idiognathodus magnificus* and no *Diplognathodus coloradoensis*.

*) Picking of the smaller fractions of the heavy residue of the Mansfield Marine Band sample was slowed down because of the large quantity of pyrite. Therefore part of the finer residue - containing the small and juvenile conodonts - was treated with sodium hypochlorite-hydroxide solution as proposed by Merrill (1980). Much of the pyrite could than afterwards be removed by the magnetic separator. It showed, however, that the treated conodonts differed in colour from the non-treated ones. The latter - we are still speaking of the smaller fraction - are yellowish transparent. The treated ones, at least part of them, are reddish to reddish brown, because of the oxidation of minute particles of pyrite which were dispersed between the lamellae of the conodonts. Therefore in estimating the CAI of conodonts treated with NaClO one may, if the conodonts contain much finely dispersed pyrite, eventually conclude to a higher CAI than really is present.

Palaeontology

Diplognathodus coloradoensis (Murray & Chronic, 1965)
Plate 1, c.

For synonymy see Sweet, 1977, p. 88.

Material – Sample DZ 59 from Béchar-Djedid, Algeria: 6 specimens, RGM 331 667. Sample Sy 917 from Cinderhill Colliery 4, U.K.: 144 spec., RGM 332 959, 332 960. Sample Wa 318a from near San Martin de Perapertú, Spain: 1 spec., RGM 331 630. Sample SMR 5 from Verdegosa Hill, Spain: 1 spec., RGM 332 963. Sample WP 8223 from Verdegosa Hill, Spain: 1 spec., RGM 340 186. Sample 65 Va 1b, north of Vañes, Spain: 3 spec., RGM 332 976.

Remarks – The specimens of the platform elements in all the samples conform to the description as given by Merrill (1973): the unit is in lateral view small, unarched or slightly arched with straight aboral margin. Anterior edge of the blade straight to slightly convex, oral outline highly variable, consisting of up to eight irregular denticles, commonly rather uniform in height except for the anterior and posterior ones which are shorter. Posterior part of the oral edge consists of the spatula-like ridge which is separated from the denticulate blade by a notch in which occur one or two almost suppressed denticles. The spatula is distinctly lower than the blade and ends rather abruptly before it reaches the posterior end of the basal cup. The basal cavity is nearly symmetrical, broad, the outline almost elliptical. None of our specimens has discrete denticles instead of a spatula, but in some specimens the oral edge of the spatula is partly serrate because not all denticles were fused completely up to their tips.

According to Sweet (1977) the known range of the species is Derryan-Desmoinesian. Our specimens are found in strata which range from about the base of the Vereisky to the top of the Myachkovsky (Lower-Upper Moscovian), or - in the West-European subdivision - from the base of Westphalian C to lower (or middle?) Cantabrian.

Diplognathodus ellesmerensis Bender, 1980
Plate 1, a.

1980 *Diplognathodus ellesmerensis* n.sp. - Bender, pp. 9-10, pl. 4. figs; 5-7, 11, 15-21, 23-25.

Material – Panda Limestone near Casasuertes, Spain, sample C 3: 1 specimen, RGM 332 989; sample C' 16: 6 specimens, RGM 332 981, RGM 340 187.

Description – The specimens from the Panda Limestone conform to the description of Bender (1980). They are small. The blade consists of 5 to 7 denticles increasing in length toward the posterior except for the posteriormost which is very small, only little larger than the 2-4 fine denticles in the notch. The blade-like portion - especially its posterior part - is about twice or three times as high

as the posterior portion of the unit. In some specimens the long axes of the denticles of the blade slightly diverge orally thus giving a fan-like appearance to the blade. The denticles on the basal cavity posterior of the notch are low and less laterally compressed than those of the blade. The third denticle from the posterior end is the highest. The broad, symmetrical basal cavity extends from the posterior end to about the aboral midpoint of the blade and is subelliptical in outline. The apex of the basal cavity is under the notch. The aboral side of the unit is straight in lateral view.

Remarks – Landing & Wardlaw (1981) comprehended forms with a low denticulated posterior process (i.a. their pl. I, 10) within the variation of the species *Diplognathodus coloradoensis*. I believe that my specimens belong to *D. ellesmerensis* Bender, 1980 for they and apparently also Bender's specimens are rather uniform in shape and comprise no forms transitional towards *D. coloradoensis*.

In the Canadian Arctic Archipelago *Diplognathodus ellesmerensis* was found in Atokan strata (Bender, 1980, fig. 3). Bender did not yet publish his results of the investigation of the younger strata of the Canadian Arctic so at the moment we do knot know whether *D. ellesmerensis* ranges into the Desmoinesian or not. The Spanish specimens are found in strata of Podolsky age.

Diplognathodus? orphanus (Merrill, 1973)
Plate 1, b.

1973 *Spathognathodus orphanus* n.sp. – Merrill, p. 309, pl. 3, figs. 45-56.
1977 *Diplognathodus? orphanus* (Merrill) – Sweet, p. 107-108, *Diplognathodus*-Plate 1, figs. 3a-c.

Material – sample DZ 59 from Béchar-Djedid, Algeria: 2 specimens (RGM 331 667).

Description – In lateral view the oral outline of the platform element is slightly arched, the aboral outline almost straight. The broad gnathodiform basal cavity occupies more than half of the total length of the unit by extending beyond the posterior part of the blade. In one specimen it also extends beyond the posteriormost denticle of the carina. The denticles of the blade are higher and more laterally compressed than those above the basal cavity, the carina. The blade denticles are fused over about 2/3 of their length. Those of the carina are shorter, somewhat broader and fused over half their length resulting in a row of denticles of which the free tips are as high as their fused parts. Between the posteriormost denticle of the blade and the anteriormost denticle of the carina occurs a suppressed denticle located somewhat in front of the apex of the basal cavity. This point is comparable to the notch of some other species of *Diplognathodus*. The length of the denticles of the blade is not the same for both specimens. In one (see Pl. 1, fig. b) the two posteriormost denticles have the greatest lateral width, whereas in the other specimen those of the middle part have the greatest lateral width. The denticles of the carina are almost equal, they increase slightly in inclination toward the posterior end causing the posterior side of the poste-

riormost denticle to stand at a right angle to the aboral side of the unit. The basal cavity is deep, wide and subsymmetrical; its upper surface is smooth. In oral view the unit is almost straight.

Remarks – The two Algerian specimens only differ from the holotype of *D. orphanus* in that the denticles above the basal cavity are more fused, less discrete; I nevertheless assign these specimens to *D.? orphanus* because they are very similar to a specimen from the Lower Mercer Limestone of Ohio (Merrill, 1973, pl. 3, fig. 52).

D? orphanus (Merrill, 1973) is only tentatively assigned to *Diplognathodus* by Sweet (1977) because the free blade has an arcuate lateral profile and no vertically truncate anterior end. Also the posterior end lacks conspicuous truncation and the fixed blade consists of a series of discrete denticles. Of course, a definite incorporation of *D? orphanus* in the genus *Diplognathodus* can only be made when the composition of the multielement apparatus justifies so. The other elements of the *D.? orphanus* apparatus still being unknown, a tentative assignment seems the only logical thing to do. In my opinion the morphology of the platform element strongly suggests a close relation to the platform elements of *Diplognathodus* because of the presence of a denticle row which is divided into two distinctly different segments, the presence of a notch, be it a small one, and the fact that the denticles above the basal cavity are not always discrete. In a number of the specimens pictured by Merrill (1973) the denticles of the carina are clearly fused over part of their length.

The age of the specimens of Merrill is mid- to uppermost Atokan. The age of the specimens of Béchar-Djedid is lower Westphalian C. This latter age might well correspond with uppermost Atokan or lower Desmoinesian, depending on the stratigraphic correlation table one uses. It, therefore, seems that the specimens from North America do not differ in age much from the Algerian ones, if at all.

Concluding remarks

Merrill (1973) reports that the abundance maximum for *Diplognathodus coloradoensis* seems to have occurred early in Desmoinesian time. Whether the high percentage of *D. coloradoensis* in sample Sy 917 (base Westphalian C) is due to this abundance maximum or caused by favourable local circumstances remains an open question. However, it corroborates those international correlations of the Carboniferous subdivision in which the base of Westphalian C is correlated with the base of the Desmoinesian (see i.a. Bless & Massa, 1982). If so, it means that the ranges of *Idiognathoides sinuatus* and *Diplognathodus orphanus* which also occur at the base of the Westphalian C would extend into the early Desmoinesian.

In other correlations (i.a. Winkler Prins, 1981) the base of the Westphalian C is correlated with some level in the upper Atokan. In this latter case there is no need to extend the ranges of *Idiognathoides sinuatus* and *Diplognathodus orphanus* into the Desmoinesian. The high frequency of *D. coloradoensis* in sample Sy 917 than has no relation to the abundance maximum in early Desmoinesian time.

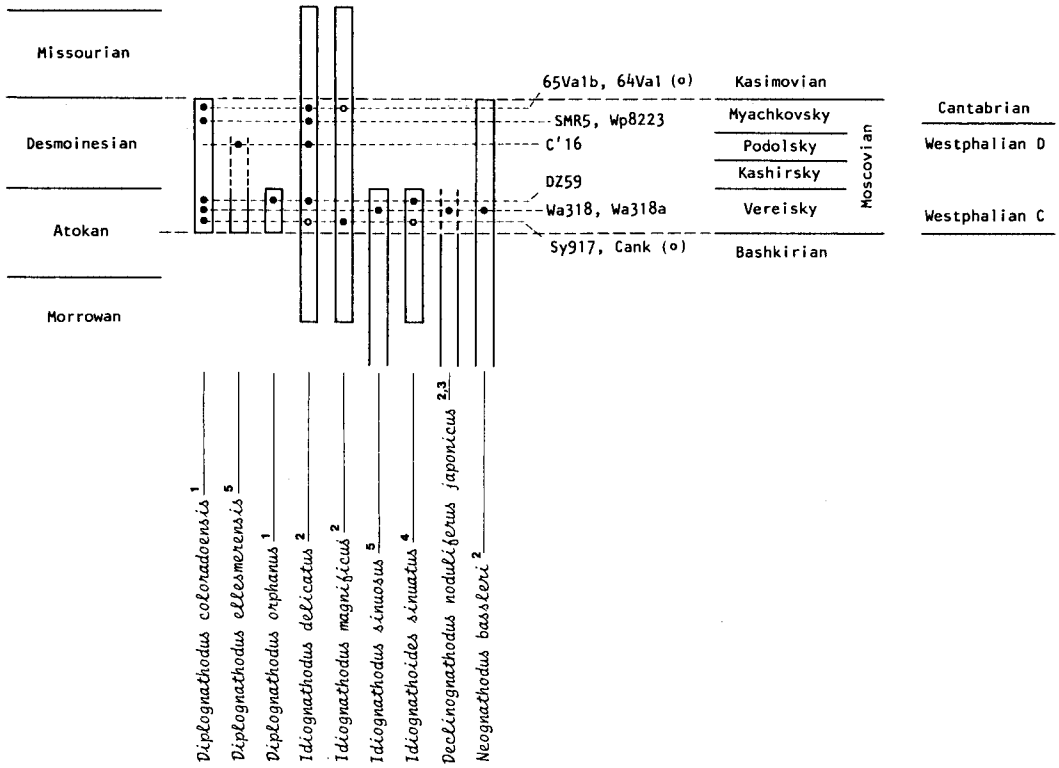

Fig. 1. Approximate stratigraphic position of the investigated samples compared with the American as well as the West and East European subdivisions. Known ranges of several conodont species: 1 = range according to Sweet (1977); 2 = range according to Sweet (1975); 3 = according to Barskov & Aleksejev, 1975 in Bender (1980); 4 = Nemirovskaya (1974), Barskov & Aleksejev (1975); 5 = range according to Bender (1980). Broken lines indicate extension of the known range. The presence of one of those species in a sample is indicated by dots or open circles (samples 64Va1 and Cank).

In Fig. 1 the last mentioned correlation is used.

All investigated samples containing *D. coloradoensis* have a Moscovian age. Thus it looks as if *D. coloradoensis* is an index fossil for Moscovian strata. However, *D. coloradoensis* is a conodont species rather seldom found in Moscovian strata and therefore not finding it in older or younger strata may not mean that it did not exist.

Much more investigation of Carboniferous strata is needed before we will know whether species of *Diplognathodus* can be used for stratigraphic zonation.

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Manuscript received 15 April 1983.

Plate 1

Fig. a. *Diplognathodus ellesmerensis* Bender, 1980. Panda Limestone near Casasuertes, Spain; sample C' 16 (X 200).

Fig. b. *Diplognathodus orphanus* (Merrill, 1973). Béchar-Djedid, Algeria; sample DZ 59 (X 150),

Fig. c. *Diplognathodus coloradoensis* (Murray & Chronic, 1965). Béchar-Djedid, Algeria; sample DZ 59 (X 150).

Plate 1