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COMPARISON BETWEEN EUSTATIC T-R CYCLES AROUND THE DEVONIAN-CARBONIFEROUS BOUNDARY AND THE DISTRIBUTION OF THE OSTRACODE TAXON *PSEUDOLEPERDITIA* GR . *VENULOSA*

by

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(4 figures)

ABSTRACT.- The stratigraphic range bars of the palaeocopid ostracode taxon *Pseudoleperditia* gr. *venulosa* form distinct clusters in the latest Devonian (Strunian) and Early Carboniferous (Tournaisian). These clusters are correlated with the transgressive phases of the presumably eustatic Late Devonian/Early Carboniferous transgression-regression (T-R) cycles, which have been distinguished in the literature. This peculiar correlation pattern corroborates the sigmoidal pattern of Late Devonian ostracode range bars established by Lethiers (1983) and Colin & Lethiers (1988). Most likely, transgression or sea level rise resulted in the creation of new ecological niches stimulating the geographical expansion of *P.* gr. *venulosa*, whereas regression or sea level fall destroyed these niches causing the transitory or eventually final disappearance of this taxon.

INTRODUCTION

Regional stratigraphic range charts of complete ostracode assemblages can serve for the recognition and correlation of macro-ecological events. This principle was first worked out by Lethiers (1983) for Late Devonian and Early Carboniferous ostracodes, and subsequently refined and adapted for Post-Paleozoic ostracodes by Van Harten & Van Hinte (1984) and Van Harten (1988).

Lethiers (1983) ordered the range lines of individual species of a regional ostracode assemblage in an epicontinental sea on the basis of first appearance and disappearance. The resulting range charts "assume a distinct sigmoidal pattern, reflecting phases of installation, stabilisation and renewal of faunas during transgressive-regressive cycles" (Colin & Lethiers, 1988: 33). The sigmoidal pattern is possibly related to the third order cycles of Vail *et al.* (1977) (cf. Lethiers, 1983; Colin & Lethiers, 1988).

According to Lethiers (1983) and Van Harten (1988), the short range lines at both ends of the sigmoid reflect the unstable conditions and rapid faunal turnover at the beginning and end of a marine transgression on a continental platform, whereas the longer bars in the central portion of the sigmoid correlate with the more stabilized environment in the remaining part of the transgressive cycle (fig. 1). Because of the close correlation of the sigmoidal distribution of range lines with eustatic sea level changes (Colin & Lethiers, 1988) we can use these sigmoids as "chronoecological signals" (Van Harten & Van Hinte, 1984; Van Harten, 1988).

The sigmoidal distribution of range bars is the result of the differential "preference" of individual taxa for a particular range of environmental conditions in terms of lowstand phase, transgressive phase, highstand phase and/or regressive phase in a transgression-regression (T-R) cycle. This implies that

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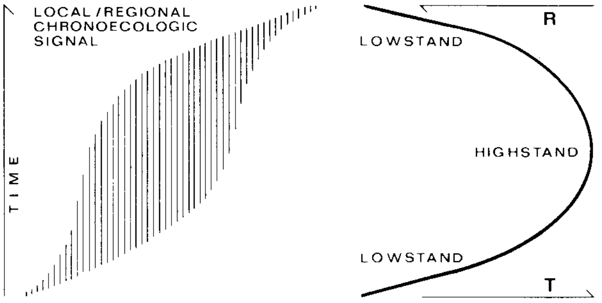

Fig. 1.- Comparison of the sigmoidal distribution of ostracode range bars with the idealized T-R cycle according to Lethiers (1983) and Colin & Lethiers (1988).

the range bars of an imaginary taxon A from different parts of the globe will form a cluster coinciding with, for instance, the lowstand phase of a given T-R cycle X. This principle is tested here on the distribution pattern of the Late Devonian/Early Carboniferous (Strunian-Tournaisian) palaeocopid ostracode taxon *Pseudoleperditia* gr. *venulosa*.

T-R CYCLES AROUND THE D/C BOUNDARY

The T-R curve around the Devonian/Carboniferous (D/C) boundary (fig. 2) is based on papers by Paproth *et al.*, (1983), Johnson *et al.*, (1986), Sandberg *et al.*, (1986), Flajs & Feist (1988), Van Steenwinkel (1990) and Bless *et al.*, (1993). It is emphasized here that the T-R curve on figure 2 does not involve any absolute time scale. There is no relationship between the vertical length of any part of the curve and the relative amount of time. Furthermore, it is noticed that the regressive phases are characterized by frequent sedimentary gaps or condensed sequences, especially when the conditions changed from a carbonate platform into a siliciclastic depositional environment.

Johnson *et al.*, (1986) described a late Famennian-Early Strunian cycle "IIf", consisting of two subcycles. The lower subcycle starts at the base of the lower *expansa* conodont zone, and the upper subcycle at the base of the upper *expansa* conodont zone. The regressive phase of cycle IIf (a "major regression" according to Sandberg *et al.*, 1986) is placed in the middle *praesulcata* conodont zone (Johnson *et al.,* 1986. Sandberg *et al.*, 1986).

The overall regression during middle *praesulcata* time was interrupted by a short-lived transgression matching the deposition of the Hangenberg Black Shale in the German Sauerland area on the northern border of the Rhenish Slate Mountains (Bless *et al.,* 1993). It seems possible to distinguish several minor subphases (HBS-1 and HBS-2) within this transgression (Bless *et al.,* 1993). The transgression has been correlated with cycle I in the French La Serre section (Flajs & Feist, 1988; Bless *et al.,* 1993).

The D/C boundary has been defined at La Serre in between two minor cycles, which have been interpreted as parts of Cycle II by Flajs & Feist (1988; also cf. Paproth *et al.,* 1991). The minor cycle below the D/C boundary coincides with the upper *praesulcata* conodont zone, whereas the minor cycle above that boundary is characterized by the first appearance of the conodont *Siphonodella sulcata* and the cephalopod *Acutimitoceras acutum* (Bless *et al.,* 1993).

Cycle II of La Serre is perhaps best interpreted as a forerunner of the next T-R cycle that reached its highstand phase in the *crenulata* conodont zone. The base of that cycle presumably matches the base of the *Gattendorfia* cephalopod zone and occurs somewhere within the *sulcata* conodont zone (Sandberg *et al.,* 1986; Van Steenwinkel, 1990; Bless *et al.,* 1993). The base of this cycle also matches the base of Cycle III at La Serre (Bless *et al.,* 1993).

The base of the highest T-R cycle on Figure 2 coincides with the appearance of the conodont *Gnathodus delicatus* and matches the base of the "third sequence ("'Tn2c-Tn3 auctores)" of the Tournaisian transgression *sensu* Paproth *et al.,* (1983: 198).

TAXONOMIC CONCEPT OF *PSEUDOLEPERDITIA* GR. *VENULOSA*
(Fig. 3)

This species group comprises the following taxa :

Bernix venulosa Kummerow, 1939, *Pseudoleperditia tuberculifera* Schneider, 1956 (assigned to *P. venulosa* by Tschigova & Bless, 1976), *Pseudochilina* sp. Green, 1963 (attributed to *Pseudoleperditia* by Jones, 1989), *Pseudoleperditia poolei* Sohn, 1969 (attributed to *P. venulosa* by Tschigova & Bless, 1976), *Pseudoleperditia beckerblessorum* Sohn, 1979 (assigned to *P. venulosa* by Coen, 1982), *Pseudoleperditia gerki* Sohn, 1979, *Pseudoleperditia* sp. 1 Sohn, 1979 (assigned to *P. venulosa* by Coen, 1982), *?Pseudoleperditia* sp. Sohn, 1979, *Pseudoleperditia sibirica* Bushmina, 1981, *Arikloedenia sichuanensis* Wei, 1983 (compared with *P. poolei* by Jones, 1989),

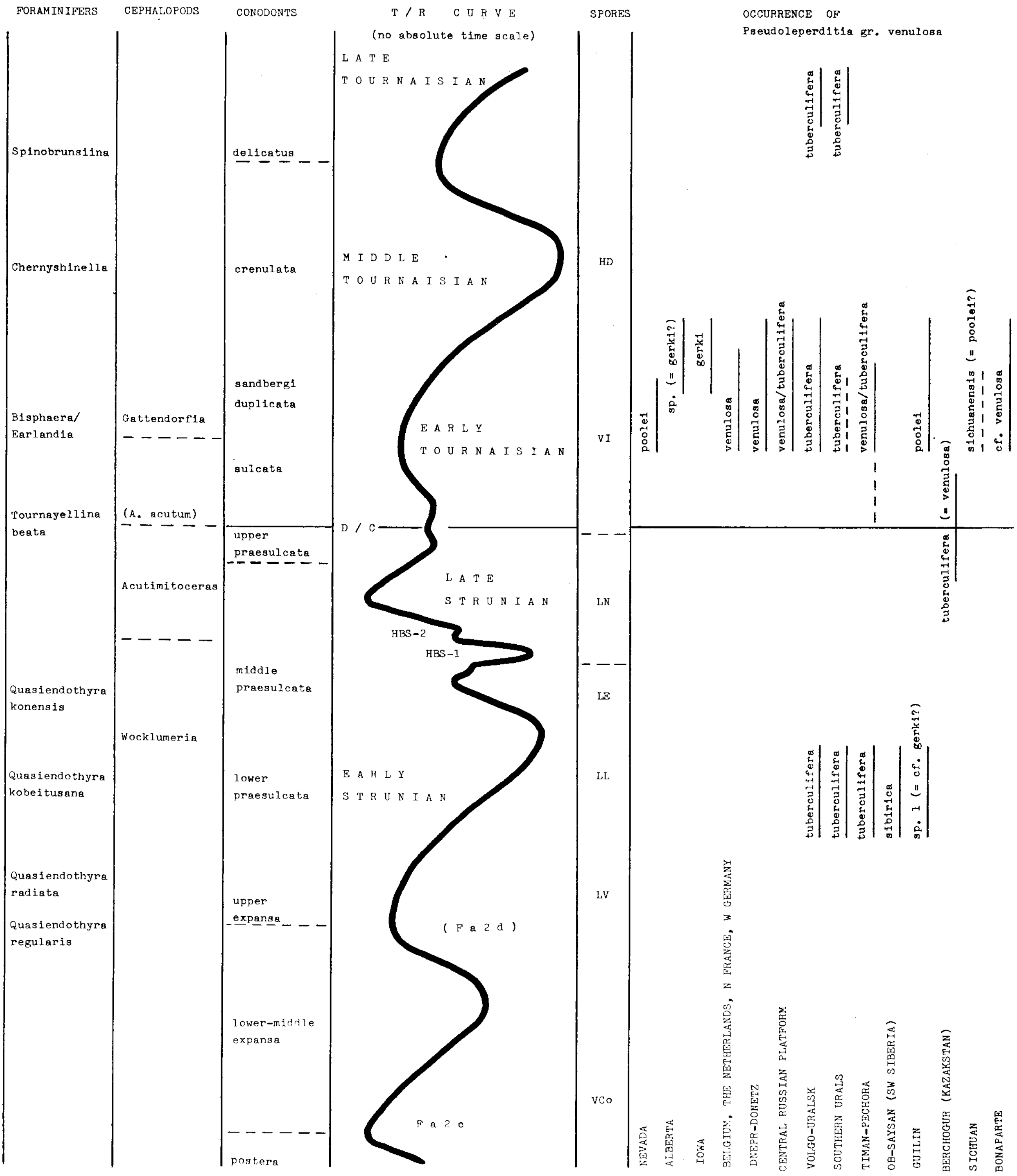

Fig. 2.- Biostratigraphical dating of T-R cycles around the D/C boundary and distribution of the palaeocopid ostracode *Pseudoleperditia* gr. *venulosa*. T-R cycles partly after Bless *et al.* (1993), complemented with data from Johnson *et al.* (1986) and Paproth *et al.* (1983). Note that range bars of *P.* gr. *venulosa* form distinct clusters matching the transgressive phases of the T-R cycles. Species names of *Pseudoleperditia* as used by original authors are shown.

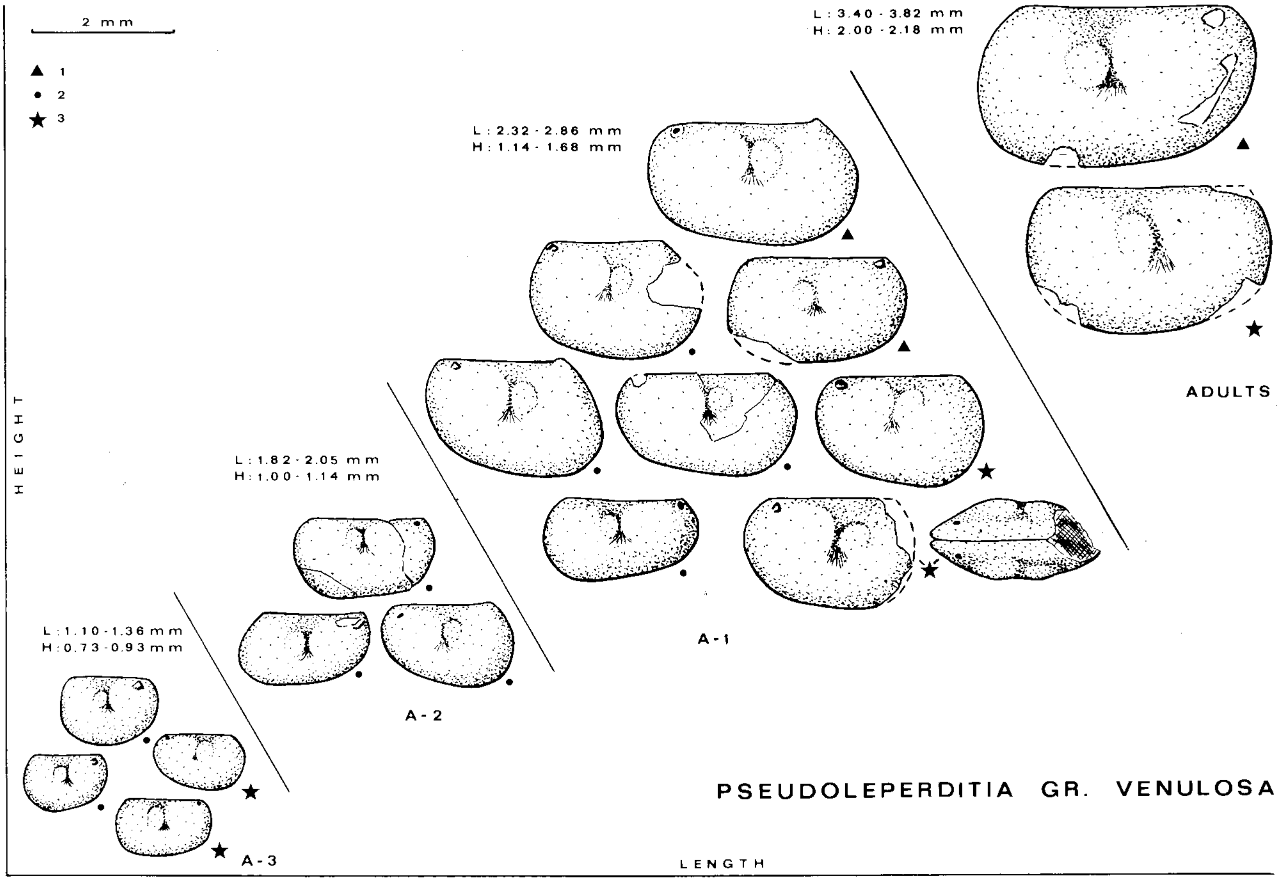

Fig. 3.- Size dispersion diagram for *Pseudoleperditia* gr. *venulosa*. The presence of both adults and juvenile instars (A-1, A-2, A-3) in samples suggests parautochthonous assemblages. It is emphasized here that dimorphism can occur already in the last juvenile instar (A-1). This phenomenon has also been observed in other palaeocopid ostracodes, for instance in the genus *Hollinella* (cf. Bless, 1969). 1: specimens from "Tn1b" of La Folie (to the East of Visé, Belgium). 2: specimens from "Tn1b-Tn2a" of Maastricht-Kastanjelaan (Netherlands). 3: specimens from "Tn1b" of Süchteln-Sittard (Germany).

Pseudoleperditia sp. 1 Wang, 1988 (similar to *P. gerki* according to Wang, 1988) and *Pseudoleperditia* cf. *venulosa* (Jones, 1989).

Hercynoprimitia nodosa Blumenstengel, 1969 from the Late Frasnian of the German Harz Mountains was assigned to *Pseudoleperditia* by Sohn (1979). It is regarded as the ancestor of *P.* gr. *venulosa*. The record of "*Bernix*" aff. *venulosa* from the Late Famennian in NE Siberia (Kolyma Massif; Bushmina, 1979) should not be taken into account, since this (juvenile) specimen was later assigned to *Kozlowskiella (Illativella) ordinaria* by Bushmina *et al.* (1986).

P. gr. *venulosa* presumably preferred the open marine shelf environment (fig. 4; Bless, 1983). Specimens have been found mainly in massive limestones, in limestone nodules embedded in (silty) shales, and even in slightly sandy, micaceous shales. The frequent association of juvenile and adult specimens points to parautochthonous assemblages (cf. fig. 3).

STRATIGRAPHIC DISTRIBUTION OF *PSEUDOLEPERDITIA* GR. *VENULOSA*

(Fig. 2)

P. gr. *venulosa* appears in the Early Strunian of the Volgo-Uralsk area (beds with the foraminifer *Quasiendothyra kobeitusana;* Tschigova, 1985 : 157), the Southern Urals (Litvin Horizon with *Q. kobeitusana* and cephalopod *Wocklumeria*; Kotchetkova, 1975), Timan-Pechora area (beds with conodont *Bispathodus costatus,* some 25 m below beds with apparently "LE" spore assemblage; Tschigova, 1985: 189), Ob-Saysan region in SW Siberia (Kuznetsk and Rudnyi Altai, beds with conodonts *Icriodus costatus* and *Polygnathus parapetus* ; Bushmina & Kononova, 1981) and Guilin (Southern China, lower *praesulcata* conodont zone, Nanbiancun Formation; erroneously

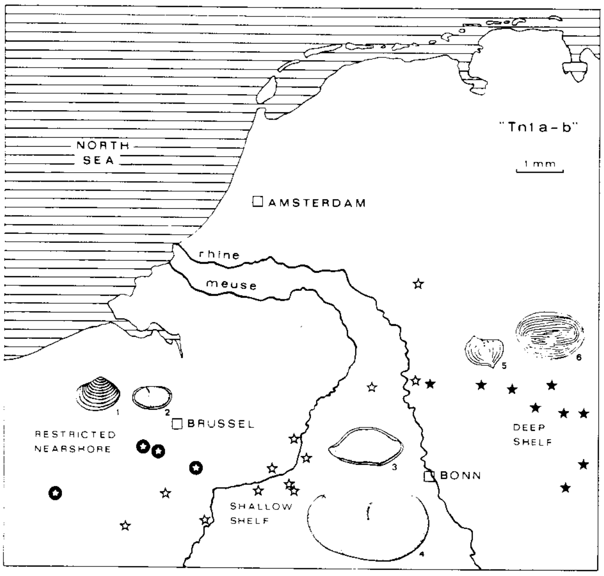

Fig. 4.- Distribution of latest Strunian/early Tournaisian ("Tn1a-Tn1b" time equivalent) ostracode assemblages in NW Europe, suggesting increasing distance from the shoreline and deepening of the epicontinental sea from West to East. Based on Becker & Bless (1974), Becker *et al.* (1974), Bless (1983), Bless *et al.* (1981), Coen (1982), Crasquin (1984, 1986), Kummerow (1939), Lethiers & Bouquillon (1986) and unpublished data. *P.* gr. *venulosa* is restricted to assemblages with *Bairdia*. 1: *Cryptophyllus* spp.; 2: Kloedenellacean ostracodes (*Blessites, Knoxiella, Amicus, Marginia, Quasiknoxiella,* etc.); 3: *Bairdia* spp.; 4: *P.* gr. *venulosa;* 5: *Ungerella* spp.; 6: *Richterina* gr. *latior.*

dated as middle *praesulcata* zone; compare data by Wang, 1988 and Li *et al.,* 1988).

There is only one record from the late Strunian *Acutimitoceras* zone (Berchogur, Kazakstan; Barskov *et al.,* 1984). There is also one certain record from the basal Tournaisian (Berchogur, Kazakstan, beds with *Acutimitoceras* and *Siphonodella sulcata*; Barskov *et al.,* 1984). In the Timan-Pechora area, *P.* gr. *venulosa* may be present in the basal Tournaisian (beds with the conodonts *Bispathodus tridentatus* and *Patrognathus variabilis:* Tschigova, 1985: 191). But a slightly younger age seems more likely after comparison with the data from other regions (see below).

The maximum biogeographical expansion of *P.* gr. *venulosa* took place slightly above the D/C boundary from the *sulcata* or *duplicata* conodont zones onwards : Kinderhookian of North America (Nevada, Iowa and Alberta; cf. Green, 1963; Sohn, 1969, 1979; Jones, 1989), and Early to Middle Tournaisian of Western Europe ("Tn1b-Tn2a" of N. France, Belgium, SE. Netherlands, W. Germany; cf. Kummerow, 1939; Becker & Bless, 1974; Becker *et al.,* 1974; Bless *et al.,* 1981; Crasquin, 1984; unpublished data), the former Soviet Union (Malevka and Upinsk of Dnepr-Donetz, Central Russian Platform, Volgo-Uralsk, Timan-Pechora (cf. Tschigova, 1977, 1985), Southern China (Chuanbutou Formation of Guilin; cf. Wang, 1988) and NW. Australia (Burt Range Formation of Bonaparte Basin; cf. Jones, 1989). This taxon presumably also occurs in the Early Tournaisian (?) Yanguang Formation of N Sichuan (SW. China; cf. Wei *et al.,* 1983 : 30; Jones, 1989 : 15, 28-29), and perhaps in the Early Tournaisian Kynov Horizon of the S. Urals (cf. Ivanova *et al.,* 1975 : 134; this record was not mentioned by Kotchetkova, 1975!).

The available biostratigraphical evidence indicates that in all these Carboniferous cases *P.* gr. *venulosa* occurs at a level slightly above the D/C boundary. The Narrow Canyon Limestone in Nevada (cf. Poole *et al.,* 1967), the Hastière Limestone in Belgium (cf. Van Steenwinkel, 1990) and the Burt Range Formation in the NW Australian Bonaparte Basin (cf. Jones, 1989) are separated from the underlying Devonian strata by a sedimentary gap that presumably covers the middle *praesulcata* to basal *sulcata* conodont zones. Moreover, the first occurrence of *P.* gr. *venulosa* is slightly above the base of the Burt Range Formation in the Bonaparte Basin (cf. Jones, 1989 : figs. 4-5). *P.* gr. *venulosa* occurs in the *duplicata* and *crenulata* conodont zones at Guilin (Wang, 1988: 212). Ostracode assemblages with *P.* gr. *venulosa* and *Shivaella microphtalma* are associated with the conodonts *Siphonodella duplicata, S. obsoleta* and *S. quadruplicata* in the Volgo-Uralsk area (cf. Tschigova, 1985 : 88-91). The earliest record in this area (apart from the above-mentioned occurrence in the Early Strunian) is some 15 m above a bed with spores apparently of the VI zone (cf. Tschigova, 1985 : 84-85).

P. gr. *venulosa* disappears in the Late Kinderhookian or basal Osagian in North America (cf. Sohn, 1979: fig. 1), which coincides with the disappearance of this taxon in the following localities : W. Europe (slightly above the base of the "Tn2a" in the SE. Netherlands; cf. Bless *et al.*, 1981), the former Soviet Union (no record from Cheperet Horizon; cf. Tschigova, 1985), China (species disappears somewhere in Lower *crenulata* conodont zone; cf. Li *et al.,* 1988) and NW. Australia (taxon restricted to Burt Range Formation, including "Mid-Tournaisian Breccia"; cf. Jones, 1989) .

P. gr. *venulosa* re-appears in the Late Tournaisian Kizel deposits of the Volgo-Uralsk area (Tschigova, 1985: 94-95) and the S. Urals (Ivanova *et al.,* 1975; Kotchetkova, 1975). There are no records from younger strata. The record of *P.* sp. 1 from the Early Visean at Horion-Hozémont, Belgium (cf. Sohn, 1979: 1253-1254) is based on a misdating of the Early Tournaisian Hastière Limestone at that locality (cf. Coen, 1982).

CONCLUSIONS

The range bars of *P.* gr. *venulosa* are concentrated in three distinct clusters (fig. 2). The lower one can be correlated with the Early Strunian *Quasiendothyra kobeitusana* foraminifer zone and lower *praesulcata* conodont zone. This coincides with the transgressive phase of the upper IIf T-R cycle in Johnson *et al.* (1986).

There is no undoubted record of *P.* gr. *venulosa* from the middle *praesulcata* conodont zone (coinciding with the major regression phase in Johnson *et al.,* 1986, and Sandberg *et al.,* 1986), although there must have been an environmental refuge for this taxon, since it re-appears in the late *praesulcata* conodont zone (in beds with cephalopod *Acutimitoceras*) at Berchogur (Kazakstan). This re-appearance coincides with the acme of a minor T-R cycle, that can be considered as a forerunner of the major Early-Middle Tournaisian transgression.

The main biogeographical expansion of *P.* gr. *venulosa* clearly matches the early part of the transgressive phase of this Early-Middle Tournaisian T-R cycle as described by Van Steenwinkel (1990). This impression would not change if some of the former Soviet datings would turn out to include the basal portion of the *sulcata* conodont zone as well. This taxon must have found a refuge again from the late "Tn2a" onwards, that is before the highstand phase of the eustatic cycle was reached.

P. gr. *venulosa* re-appeared once more - and presumably for the last time - during the T-R cycle starting at the end of the Middle Tournaisian ("Tn2c" time equivalent) in the Russian Kizel deposits of the Volgo-Uralsk area and S. Urals.

The obvious relationship between zones of maximum biogeographic expansion of *P.* gr. *venulosa* and three successive major transgressive phases around the D/C boundary suggests that the transgressions somehow acted as the trigger for these expansions, perhaps through the creation of new ecological niches on the open marine shelf. These niches were presumably destroyed during maximum deepening, for instance during the Middle Tournaisian highstand phase, and during the regressive phase.

The repeated clustering of range bars of *P.* gr. *venulosa* and their repeated coincidence with the transgressive phase of the T-R cycles points to a relatively narrow range of preferred ecological conditions. Perhaps the range bars of this taxon always occupy a comparable position in the sigmoidal pattern of range bars independent from time and region? If this assumption might be true, it may be possible to use the occurrence of *P.* gr. *venulosa* for the reconstruction and correlation of regional T-R cycles.

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