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MIDDLE DEVONIAN TO LOWER CARBONIFEROUS MIOSPORE STRATIGRAPHY IN THE CENTRAL PARNAIBA BASIN (BRAZIL)

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(4 figures and 2 plates)

ABSTRACT.- The miospore assemblages of samples from three boreholes drilled by Petrobras in the central part of the Parnaíba Basin are studied. They range in age from Middle Devonian marine beds to Late Devonian and Early Carboniferous, mainly continental beds.

The Devonian/Carboniferous boundary is emphasized and the age of Devonian glacial beds known in this region is discussed.

All data are compared to former local biostratigraphy and referred to the Western European palynostratigraphy.

RESUME.- Les assemblages de miospores provenant d'échantillons de trois sondages forés par Petrobras dans la partie centrale du Bassin du Parnaíba sont étudiés. Il s'étagent de sédiments marins d'âge Dévonien moyen à des sédiments continentaux d'âge Dévonien supérieur et Carbonifère inférieur.

La limite Dévonien/Carbonifère est mise en évidence et l'âge des couches dévoniennes à caractère glaciaire, connues dans cette région, est discuté.

Toutes les données sont comparées à la biostratigraphie connue antérieurement dans cette région et correspondent à la palynostratigraphie ouest-européenne.

INTRODUCTION

The results presented below derive from a miospore analysis of cores from boreholes 1-TB-1-MA (Testa Branca wildcat), 2-PM-1-MA (Pindare Mirim stratigraphic test) and 1-PA-1-MA (Palestina wildcat) drilled in 1956, 1958 and 1981 respectively by Petrobras in the central part of the Parnaíba Basin, formerly known as Maranhão Basin, in northeastern Brazil (Fig.1).

They constitute a second contribution to a wider investigation of Devonian and Carboniferous miospore zonation in the Amazonas and Parnaíba Basins proposed by Petrobras. The first one concerned uppermost Devonian and Lower Carboniferous of the Amazonas Basin (Loboziak, Streel, Caputo and Melo, 1991).

The present contribution aims to identify, in terms of the Western European miospore stratigraphy, a sequence of rocks ranging from middle Devonian to early Carboniferous and belonging to the successive formations Itaim, Pimenteira, Cabeças, Longá and Poti. Some of these formations contain strong evidence of deposition under glacial conditions (Caputo, 1985; Caputo & Crowell, 1985) and are therefore in the center of controversies about the existence of a late Devonian glaciation.

Boreholes lithostratigraphy

In the borehole 2-PM-1-MA, productive samples are from 1729,8-1726,8 m (core 49) in the

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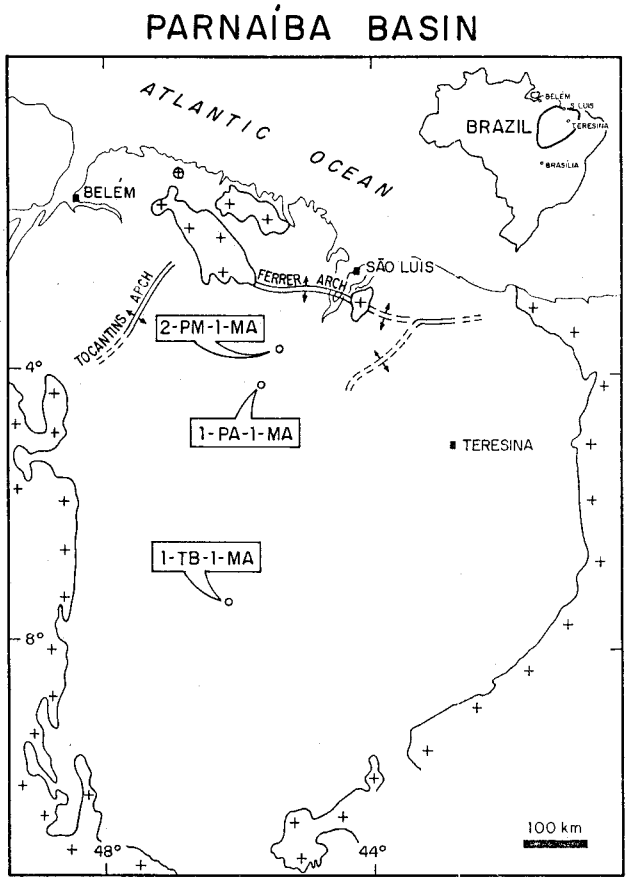

Fig. 1.- Location of the boreholes in the Parnaíba Basin.

Itaim Fm, from 1648,1-1646,0 m to 1326,4-1325,4 m (cores 48 to 42) in the Pimenteira Fm, from 1256,4-1253,4 m and 1198,6-1195,6 m (cores 38/40) in the Cabeças Fm, from 1097,9-1094,7 m (core 35) in the Longá Fm, and from 1037,4 - 1034,4 m to 794,4 - 793,4 m (cores 34 to 29) in the Poti Fm. Core numbers 44/46, 42/43, 38/40 and 32/33 correspond only to 4 samples.

The same borehole was also figured by Daemon (1974, fig.2) with a somewhat different lithostratigraphy where core 40 would belong to the Pimenteira Fm.

In the borehole 1-TB-1-MA, productive samples are from 822,4-818,4 m (core 15) to 742,8-738,5 m (core 13) and belong to the Longá Fm and lowest part of the Poti Fm.

Only one sample was studied from 1-PA-1-MA borehole. It is issued from core 3 at 1692-1674 m and belongs to the Cabeças Fm.

Biostratigraphic results

Well 2-PM-1-MA

Marine organic-walled microfossils are abundant in the lower half of this sequence: acritarchs are frequent in cores 49 to 48, less numerous in 47, 44/46 and 42/43 and absent higher; chitinozoans are frequent in core 47. Thus the Itaim and Pimenteira formations have marine character which contrasts with the more continental nature of the next Cabeças to Poti formations in the studied area. In the Pimenteira Fm, amorphous organic matter dominated kerogen is abundant.

Miospores are well preserved, often of yellow colour. They are more abundant and diversified in continental than in marine beds. Fig.2 represents a part of the continental taxa. These are almost all known in Western Europe and allow some accurate correlations with the Ardenne-Rhenish regions for the Devonian (after Streel *et al.*, 1987) and Ireland for the Lower Carboniferous (after Higgs *et al.*, 1988). Some other taxa not listed are nevertheless figured on plates.

In the lowermost core (49), *Acinosporites acanthomammillatus* is the most interesting species because its first occurrence corresponds to the base of the AD (A. *acanthomammillatus-D. devonicus*) Oppel Zone in the Ardenne-Rhenish basins. The absence of the characteristic miospores *Hystricosporites reflexus* and *Geminospora lemurata,* whose first occurrences mark the middle and upper part of this Oppel Zone AD, would suggest that these samples belong to the lower part (Interval Zone Mac) of this Oppel Zone. However, no hystricospores have been encountered in this borehole, neither in the continental nor in the marine facies, so that we suspect some ecological/sedimentological control of this absence must have operated. Therefore we prefer to name pre Lem Interval Zone the lower and middle parts of the AD Oppel Zone. This pre Lem Interval Zone corresponds, in the type Eifel area, to the conodont-based *costatus* to Lower *ensensis* Zones, all of Eifelian to lowermost Givetian age. We have no criteria to distinguish between the almost equivalent *velatus-langi* and *devonicus-naumovii* assemblage zones of Richardson & McGregor (1986).

Containing a more diversified microflora, core 47 has also *Geminospora lemurata* but lacks the characteristic species of the next higher TA (*S. triangulatus-A. ancyrea* var. *ancyrea*) Oppel Zone. Therefore it belongs to upper part of the AD Oppel Zone (= Lem Interval Zone). A recent work in the Eifelian/Givetian transitional layers in the Eifel area (Loboziak, Streel and Weddige, 1991) clearly demonstrates that the first occurrence of *G. lemurata* is within the *ensensis-obliquimarginatus* conodont standard Zone and very close to the first occurrences of *Polygnathus ensensis ensensis* and *P. hemiansatus,* which are the best candidate levels of the Eifelian/Givetian boundary proposed by the Subcommission on Devonian Stratigraphy. Therefore core 47 will be probably

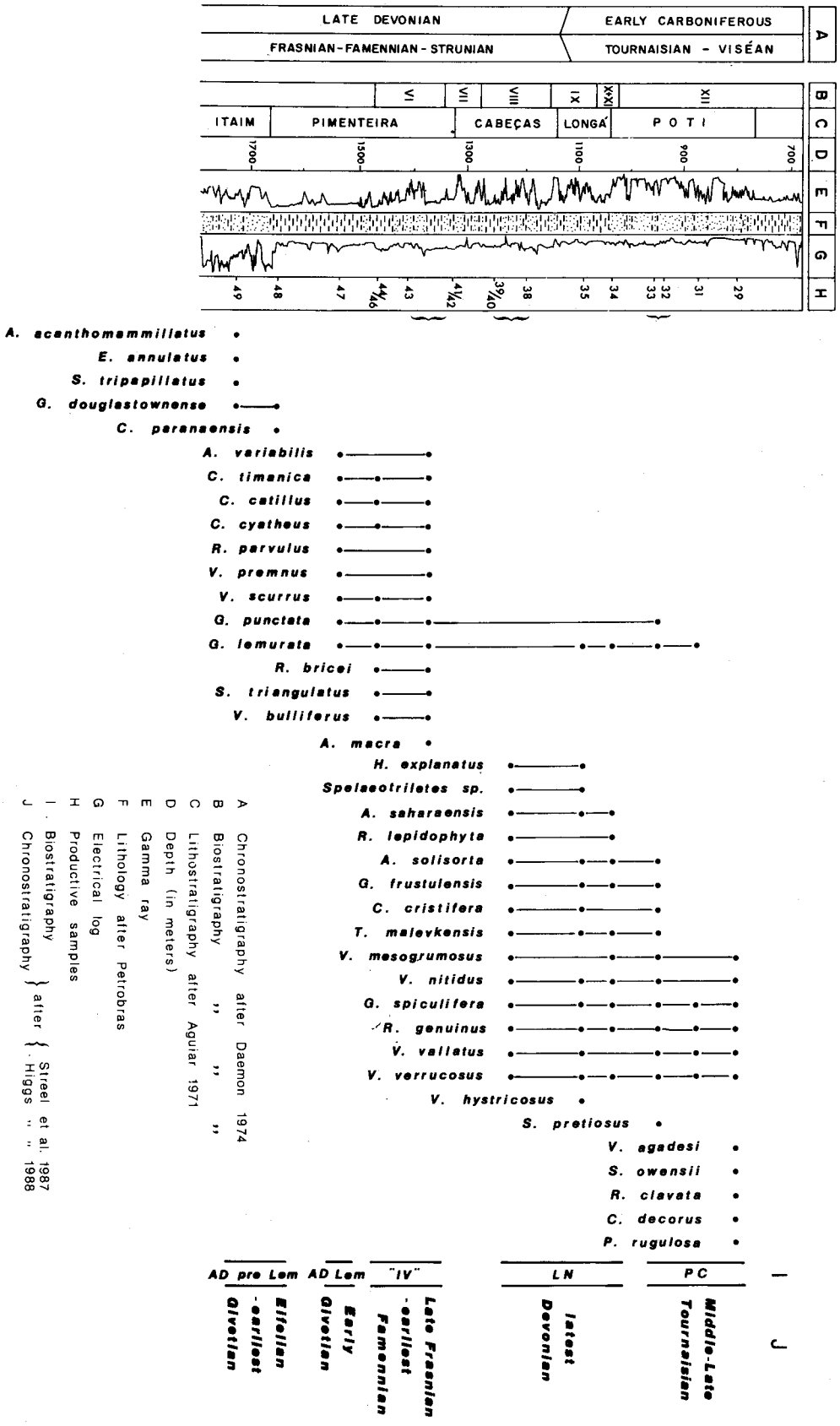

Fig. 2.- Miospore distribution in 2-PM-1-MA borehole.

within the lower Givetian. It also belongs to the *lemurata-magnifica* Assemblage Zone of Richardson and McGregor (1986).

In the next higher cores (44/46 and 42/43), the joint occurrence of *Samarisporites triangulatus, Verrucosisporites bulliferus* and *Rugospora bricei,* which enter the stratigraphic column in succession in Western Europe, suggests an Upper Devonian miospore assemblage. *R. bricei* is the youngest of the three species, first occurring at the base of a not yet formally defined zone, called phase IV in the Boulonnais area of the Ardenne-Rhenish regions. The absence of the «Famennian» miospores *Diducites versabilis* and *Knoxisporites dedaleus* allows to assign cores 44/46 and 42/43 to this phase IV, which corresponds to the conodont-based *Ancyrognathus triangularis* to *Palmatolepis triangularis* zones of late Frasnian to earliest Famennian ages.

In cores 38/40, the joint occurrence of *Retispora lepidophyta, Hymenozonotriletes explanatus, Tumulispora malevkensis, Vallatisporites verrucosus, Vallatisporites vallatus, Verrucosisporites nitidus* and *Cyrtospora cristifera* allows to recognize the upper part of the LN (*R. lepidophyta-V. nitidus* Interval Zone, which occurs below but very near the Devonian/Carboniferous boundary. It corresponds to the upper part of the *Retispora lepidophyta* Assemblage Zone defined in Ireland by Van Veen (1981).

The presence of *Spelaeotriletes pretiosus* in cores 32/33, and of *Raistrickia clavata* and *Prolycospora rugulosa* in core 29 allows to place the upper part of the studied stratigraphic section in the PC (*S. pretiosus-R. clavata*) Zone of middle to late Tournaisian age.

Well 1-TB-1-MA

Only three samples have provided characteristic miospores in addition to many specimens with simple morphology. Some of these miospores are given on Fig.3.

Cores 15 and 14 contain a comparable assemblage but differ in having *Retispora lepidophyta* only below (core 15) and *Vallatisporites vallatus* and *Spelaeotriletes* sp. only above (core 14).

Despite the scarcity of the miospore record, we have to conclude to a succession of the two interval Zones LN (*R. lepidophyta-V. nitidus*) and VI (*V. verrucosus-R. incohatus*). The limit between these two zones is known immediately below the Devonian/Carboniferous boundary in the reference sections of Germany (Higgs and Streel, 1984). Therefore core 15 is in the uppermost Devonian and core 14, also from the Longá Fm, belongs to the uppermost Devonian or the lowermost Carboniferous.

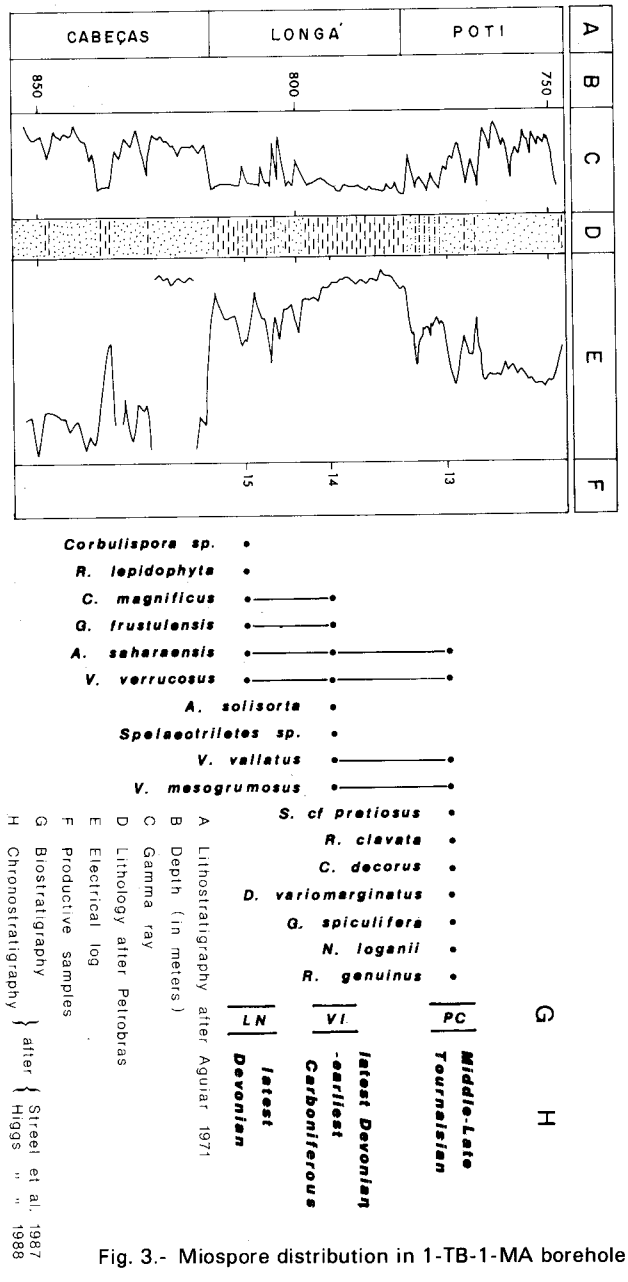

Fig. 3.- Miospore distribution in 1-TB-1-MA borehole.

In core 13, from the Poti Fm, the occurrence of one specimen comparable to *Spelaeotriletes pretiosus,* as well as *Raistrickia clavata* and *Colatisporites decorus* allows to identify the Zone PC (*S. pretiosus-R. clavata*) which ranges through the middle and late Tournaisian.

Well 1-PA-1-MA

Numerous acritarchs and scarce chitinozoans are present in the only one productive sample (core 3) analysed from the Cabeças Formation. This sample is a tillite. Miospores are abundant but poorly preserved. Nevertheless, some characteristic species could be identified. They are: *Aratrisporites saharaensis, Hymenozonotriletes explanatus, Retispora lepidophyta, Rugospora radiata* and specimens of *Spelaeotriletes.*

The absence of *Vallatisporites nitidus* and of *Vallatisporites verrucosus* or *V. vallatus* suggests that this sample belongs to the Interval Zone LE (*R. lepidophyta-H. explanatus*) known in the uppermost Devonian in Germany below the Interval Zone LN.

The Devonian/Carboniferous transition in the boreholes

The latest Devonian miospore assemblages found in the three boreholes are characterized by the presence of *Retispora lepidophyta* and for this reason belong to what is usually called «Strunian», the uppermost part of the Famennian in the Franco-Belgian area.

The degree of abundance of this species and the presence or absence of associated species like *Hymenozonotriletes explanatus, Verrucosisporites nitidus, Vallatisporites verrucosus* and *V. vallatus* generally allow more precision. All uppermost Devonian miospore assemblages in the three boreholes have at least one of these associated species and are considered here to correspond to the upper part of the *Retispora lepidophyta* range which, in Germany, belongs to the conodont Lower to Upper *Praesulcata* Zone.

The first occurrences of *Verrucosisporites nitidus* and of other associated species like *Vallatisporites verrucosus* and *Vallatisporites vallatus* allow to subdivide this upper part of the *Retispora lepidophyta* range into two interval zones widely recognized throughout the world and named LE (*R. lepidophyta-H. explanatus*) and LN (*R. lepidophyta-V. nitidus*). However, cores 38/40 to 34 of borehole 2-PM-1-MA obviously belong to the last interval zone (LN) because all characteristics are present. Hence, the precise age of the related samples of boreholes 1-TB-1-MA and 1-PA-1-MA (where miospores are scarce and badly preserved) is less sure because it is based only on the presence (1-TB-1-MA) or absence (1-PA-1-MA) of only some associated miospores.

The succeeding VI (*V. verrucosus-R. incohatus*) Zone, which in Germany spans the Devonian/Carboniferous boundary, is certainly present in the borehole 1-TB-1-MA, within the Longá Formation.

Comparison with former biostratigraphy in the 2-PM-1-MA borehole

Comparison with Daemon's (1974, fig.2) palynostratigraphy gives the following results: phase IV corresponds to Zone VI and the lowest part of Zone VII (Daemon); Interval Zone LN is included in zones VIII to X + XI (Daemon) and Zone PC is included in Zone XII (Daemon).

Zone VII of Daemon (1974, table 1) contains *R. lepidophyta* but we do not know how the base of this Zone VII is defined. It might be that the first entry of this species occurs somewhere within Zone VII rather than strictly at its base. Indeed, only the next Zone VIII has abundant *R. lepidophyta.* (This taxon is used besides to name the Zone VIII). Interval Zone LE found in core 3 of the borehole 1-PA-1-MA should be included in the upper part of Zone VIII (Daemon).

The limit between Late Devonian and Early Carboniferous, traced by Daemon (table I and fig.2) near the VIII/IX zones boundary, is now higher than the upper part of the *Retispora lepidophyta* range in the Longá Fm or in the lowerpart of the Poti Fm. No limits between the stages Frasnian/Famennian/Strunian, Tournaisian/Viséan have been proposed by Daemon (1974).

Comparison with other stratigraphic schemes in the Parnaíba Basin

Caputo (1985, fig.2) has published a correlation chart between the stages (chronostratigraphy), the biostratigraphic intervals of Andrade & Daemon (1974) and the lithostratigraphy in the Parnaíba Basin.

These relations between the chronostratigraphy and the biostratigraphy have been challenged by Streel (1986, fig.8) on the published evidence both in South America and North Africa. Daemon (1974, fig.4) had indeed compared with some details the North Brazilian and the North African palynozonations. Streel (1986) suggested two stratigraphical gaps within the sequence of the Parnaíba Basin, the first one covering at least most of the Famennian, the second one centered in the Tournaisian.

The present work allows some new insights into this problem as we now know, on one hand, the relations between the chronostratigraphic scale of Western Europe and the standard palynostratigraphy in the Parnaíba Basin through the present paper, and on another hand, the relations between such standard palynostratigraphy and the biostratigraphic intervals of Daemon through the common analyses of the borehole 2-PM-1-MA.

These comparisons are made on Fig.4. Here, column 1 is the stratigraphic chart proposed by Caputo (1985). Column 2 is the Parnaíba Basin stratigraphic chart proposed by Streel (1986) after Daemon (1974). Column 3 shows the correlation between Daemon (1974) and this paper, considering boreholes 2-PM-1-MA, 1-TB-1-MA and 1-PA-1-MA. They suggest that the chrono/bio/lithostratigraphic correlations proposed by Caputo (1985) in the Devonian are largely confirmed. For instance, a latest Frasnian age for Zone VI of Daemon is correct. We have no evidence that this

Explanations of plates

All palynological material is housed in the collections of the Laboratory of Palaeobotany and Palaeopalynology, University of Liège. Illustrated specimens magnification x500. The numbers assigned to palynological slides correspond to those of the borehole cores. The miospores locations in the slides are based on England Finder graticules.

PLANCHE I

1.- *Grandispora douglastownense* McGregor 1973
Slide 49(2): M41[3].

2.- *Grandispora mammillata* Owens 1971
Slide 47(2): D23.

3.- *Acinosporites acanthomammillatus* Richardson 1965
Slide 49(1): Z44.

4.- *Craspedispora paranaensis* Loboziak, Streel and Burjack 1988
Slide 48(3): U34.

5.- *Chelinospora ligurata* Allen 1965
Slide 43/43: R21.

6.- *Chelinospora timanica* (Naumova) Loboziak and Streel 1989
Slide 47(4): V49[4].

7.- *Rhabdosporites parvulus* Richardson 1965
Slide 42/43(1): E27.

8.- *Acinosporites eumammillatus* Loboziak, Streel and Burjack 1988
Slide 42/43(1): N33[2].

9.- *Cymbosporites cyathus* Allen 1965
Slide 42/43(1): P22[1].

10.- *Cymbosporites catillus* Allen 1965
Slide 47(2): H393.

11, 12.- *Verrucosisporites bulliferus* Richardson and McGregor 1986
11.- Slide 44/46(3): O20[3].
12.- Slide 42/43(1): G28.

13.- *Geminospora lemurata* (Balme) *emend.* Playford 1983
Slide 42/43(1): P37.

14, 15.- *Geminospora punctata* Owens 1971
14.- Slide 42/43(1): U32[1].
15.- Slide 42/43: S383.

16.- *Samarisporites triangulatus* Allen 1965
Slide 44/46: O39.

17.- *Verrucosisporites scurrus* McGregor and Camfield 1982
Slide 42(1): H21.

18.- *Chelinospora paravermiculata* Loboziak, Streel and Burjack 1988
Slide 47(2): S29.

19.- *Rugospora bricei* Loboziak and Streel 1989
Slide 42/43(1): H28[2].

20.- *Archaeozonotriletes variabilis* (Naumova) Allen 1965
Slide 42/43(1): T27.

21.- *Auroraspora macra* Sullivan 1968
Slide 42/43(1): H30[1].

22.- *Synorisporites tripapillatus* Richardson and Lister 1969
Slide 49(2): C34[4].

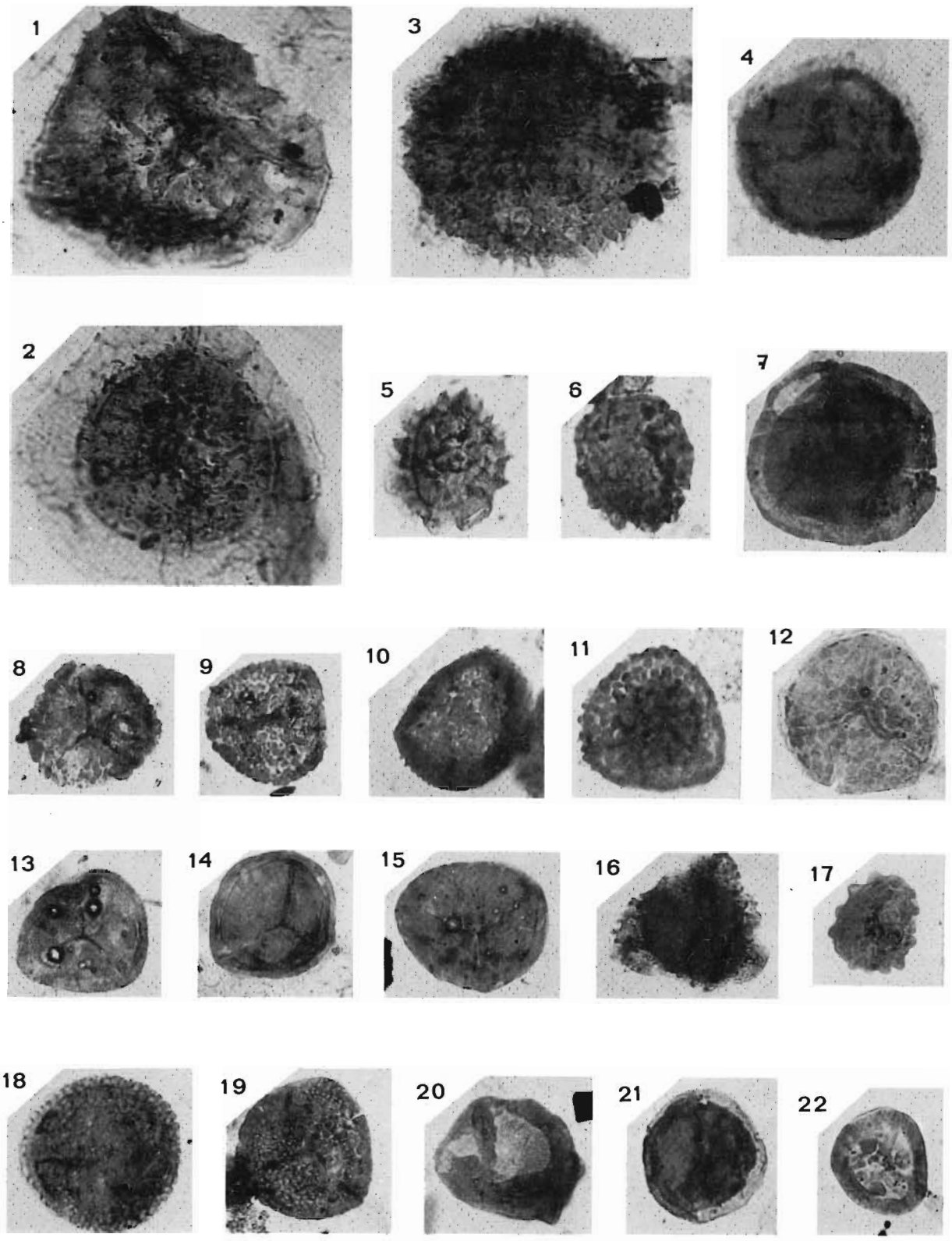
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PLANCHE II

1.- *Radiizonates genuinus* (Jushko) Loboziak and Alpern 1978
Slide 38/40(1): Q30[3].

2.- *Auroraspora solisorta* Hoffmeister, Staplin and Malloy 1955
Slide 38/40(1): U31[3].

3.- *Verrucosisporites nitidus* (Naumova) Playford 1964
Slide 34(1): W42[3].

4.- *Verrucosisporites gobbettii* Playford 1962
Slide 38/40(1): S40[2].

5.- *Convolutispora insolusa* Playford 1978
Slide 38/40(1): O36[4].

6.- *Velamisporites magnus* (Hughes and Playford) Playford 1971
Slide 38/40(1): S29[4].

7.- *Vallatisporites verrucosus* Hacquebard 1957
Slide 38/40(1): H36.

8.- *Vallatisporites vallatus* Hacquebard 1957
Slide 38/40(1): G27[2].

9.- *Granulatisporites frustulensis* (Balme and Hassel) Playford 1971
Slide 34(1): V23[1].

10.- *Spelaeotriletes pretiosus* (Playford) Neves and Belt 1970
Slide 30/33(1): G37[3].

11.- *Gorgonispora convoluta* (Butterworth and Spinner) Playford 1976
Slide 38/40(1): K38[4].

12.- *Grandispora spiculifera* Playford 1976
Slide 38/40(1): Z34.

13.- *Tumulispora malevkensis* (Naumova) Turnau 1978
Slide 38/40(1): L24.

14.- *Retispora lepidophyta* (Kedo) Playford 1976
Slide 38/40(1): R28[2].

15.- *Aratrisporites saharaensis* Loboziak, Clayton and Owens 1986
Slide 34(1): K31.

16.- *Cyrtospora cristifera* (Luber) Van der Zwann 1979
Slide 38/40(1): X33[1].

17.- *Dictyotriletes fimbriatus* (Winslow) Kaiser 1970
Slide 38/40(1): Q20.

18.- *Cristatisporites* sp.
Slide 34(1): R37[1].

19.- *Hymenozonotriletes explanatus* (Luber) Kedo 1963
Slide 38/40: M38[2].

20.- *Raistrickia baculosa* Hacquebard 1975
Slide 38/40(1): Y36[4].

21.- *Raistrickia* cf. *spathulata* (Winslow) Higgs 1975
Slide 38/40(1): M37[3].

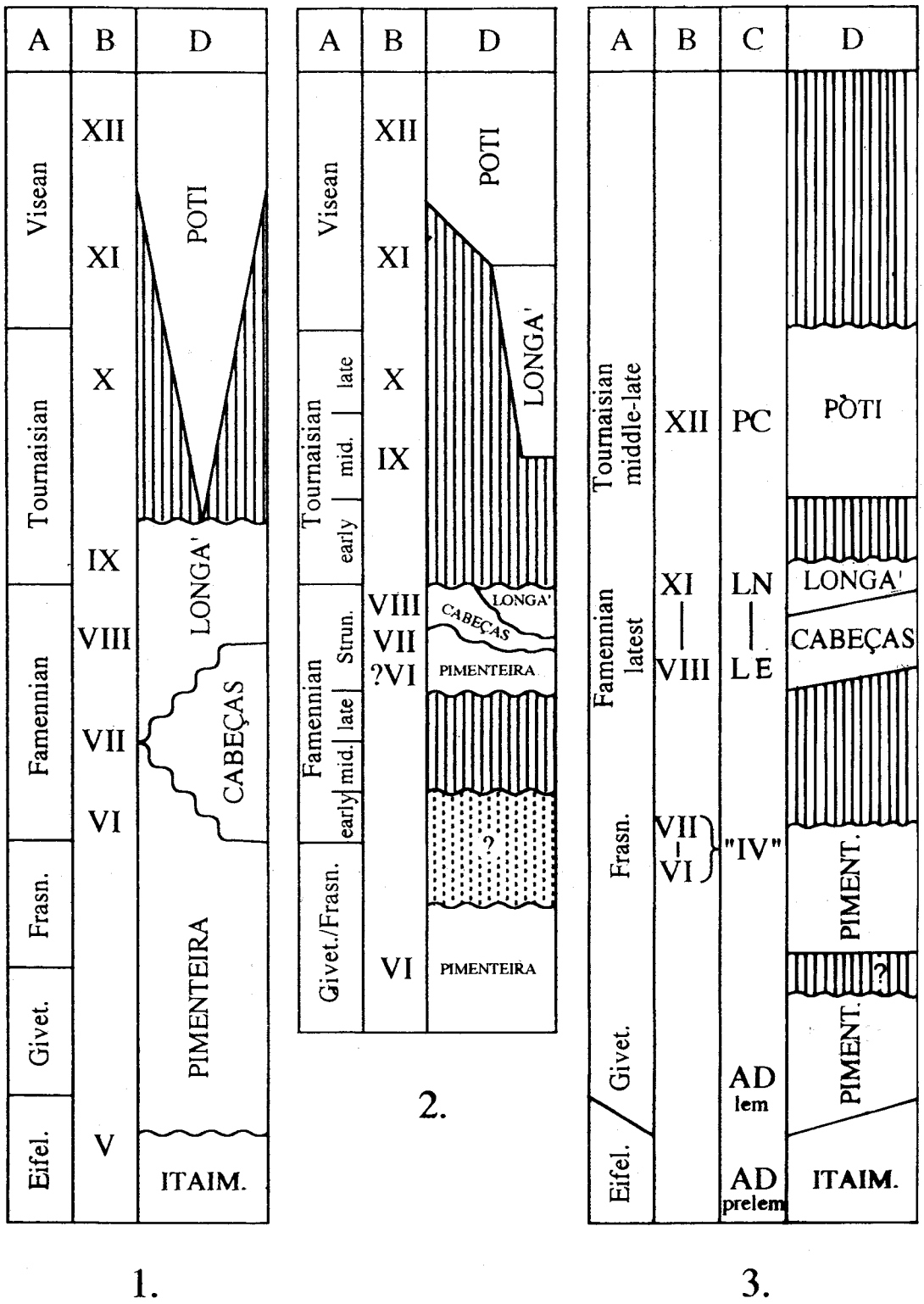

Fig. 4.- Comparison of former stratigraphic schemes (1 and 2) with the new results of the present paper (3).
1. after Caputo (1985), 2. after Streel (1974) A. chronostratigraphy, B. biostratigraphy after Daemon (1974), C. biostratigraphy, in the present paper, D. lithostratigraphy.

zone could also correspond to the «Strunian» as suggested by Streel (1986). However, if *R. lepidophyta* first occurs near the base of the Zone VII, marking the base of the «Strunian», then a large gap would be confirmed.

The Carboniferous part of the correlations proposed by Caputo (1985) and Streel (1986) is not confirmed because Zone XII, the youngest of Daemon's zones, has not a Viséan age but a middle to late Tournaisian age. A gap in the early Tournaisian may be present at the base of the Poti Fm in this borehole.

Age of the glacial evidences

The uppermost part of the Cabeças Fm and the Poti Fm are considered by Caputo (1985) and Caputo & Crowell (1985) to have been deposited under glacial and periglacial conditions as deduced from the rock texture, striated pebbles, striated pavements, varve-like sediments, exotic blocks and wide distribution of diamictites in three large basins (Solimões, Amazonas and Parnaíba Basins) in Northern Brazil. Tillites, first identified by Kegel (1953), occur in the uppermost Cabeças Fm.

The Cabeças Fm and Poti Fm are respectively dated as middle Famennian and Viséan by Caputo & Crowell (1985, fig.5). However, evidence provided in the present work suggests that their ages are latest Famennian and middle-late Tournaisian respectively. There is also still a possibility that most of the Famennian is missing within the upper Pimenteira and lower Cabeças Formations in this area or, at least, strongly condensed and devoid of plant microfossils.

The latest Famennian age of the Cabeças Fm in the central Parnaíba Basin is now controlled by the presence of LE (*R. lepidophyta-H. explanatus,* well 1-PA-1-MA) and LN (*R. lepidophyta-V. nitidus*) interval zones, which characterize the Devonian Hangenberg shales *sensu lato* in Western Germany. These shales are known to correspond to the upper IIf regression of Johnson *et al.* (1986) or the event 12 of Sandberg *et al.* (1986). The LE interval zone may be correlated, for the first time, with a glacial event in South America.

CONCLUSION

This study of miospores of Devonian and Carboniferous Parnaíba Basin allows the following conclusions:

- the Western European miospore stratigraphy can be applied to the Parnaíba Basin as well as to the Amazonas Basin;
- the Itaim Formation belongs to the Eifelian;
- where fully developed, the Pimenteira Formation ranges in age from the latest Eifelian or earliest Givetian to the latest Frasnian or earliest Famennian at least;
- occurrences of *Retispora lepidophyta* in samples belonging to the upper part of Zone VII of Daemon (1974) might suggest that a sedimentary gap is present between the Pimenteira and Cabeças Formations in the studied area, corresponding to the lower and middle parts of the Famennian;
- in the studied boreholes, the Cabeças Formation is of late Famennian age, the Longa Formation (LN and VI interval zones) spans the Devonian/Carboniferous boundary (well 1-TB-1-MA), and the Poti Formation ranges into the middle-late Tournaisian. An early Tournaisian gap possibly occurs in the Poti Formation, but is not yet confirmed;
- the glaciogenic sediments of the upper Cabeças Formation in the Parnaíba Basin belong to the late Famennian LE Interval Zone. They correspond to at least a part of a worldwide regression (Hangenberg Event) well-known almost at the top of the Devonian system.

Species listed

Acinosporites acanthomammillatus Richardson 1965
Aratrisporites saharaensis Loboziak, Clayton and Owens 1986
Archaeozonotriletes variabilis (Naumova) Allen 1965
Auroraspora macra Sullivan 1968
Auroraspora solisorta Hoffmeister, Staplin and Malloy 1955
Chelinospora timanica (Naumova) Loboziak and Streel 1989
Colatisporites decorus (Bharadwaj and Venkatachala) Williams *in* Neves *et al.* 1973
Craspedispora paranaensis Loboziak, Streel and Burjack 1988
Cymbosporites catillus Allen 1965
Cymbosporites cyathus Allen 1965
Cymbosporites magnificus (McGregor) McGregor and Camfield 1982
Cyrtospora cristifera (Luber) Van der Zwann 1979
Densosporites variomarginatus Playford 1962
Diducites versabilis (Kedo) Van Veen 1981
Emphanisporites annulatus McGregor 1961
Geminospora lemurata (Balme) *emend.* Playford 1983
Geminospora punctata Owens 1971
Grandispora douglastownense McGregor 1973

Grandispora spiculifera Playford 1976
Granulatisporites frustulensis (Balme and Hassel) Playford 1971
Hymenozonotriletes explanatus (Luber) Kedo 1963
Hystricosporites reflexus Owens 1971
Knoxisporites dedaleus (Naumova) Streel 1977
Neoraistrickia loganii (Winslow) Coleman and Clayton 1988
Prolycospora rugulosa (Butterworth and Spinner) Turnau 1978
Radiizonates genuinus (Jushko) Loboziak and Alpern 1978
Raistrickia clavata Hacquebard *emend.* Playford 1964
Retispora lepidophyta (Kedo) Playford 1976
Rhabdosporites parvulus Richardson 1965
Rugospora bricei Loboziak and Streel 1989
Rugospora radiata (Jushko) Byvsheva 1985
Samarisporites triangulatus Allen 1965
Spelaeotriletes owensii Loboziak and Alpern 1978
Spelaeotriletes pretiosus (Playford) Neves and Belt 1970
Synorisporites tripapillatus Richardson and Lister 1969
Tumulispora malevkensis (Naumova) Turnau 1978
Vallatisporites agadesi Loboziak and Alpern 1978
Vallatisporites hystricosus (Winslow) Byvsheva 1985
Vallatisporites vallatus Hacquebard 1957
Vallatisporites verrucosus Hacquebard 1957
Verrucosisporites nitidus (Naumova) Playford 1964
Verrucosisporites premnus Richardson 1965
Verrucosisporites scurrus McGregor and Camfield 1982

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BIBLIOGRAPHY

AGUIAR, G.A., 1971.- Revisão Geologica da bacia Paleozoica do Maranhão. *Soc. Brasileira de Geologia* (An. 25è Congr.), 3: 113-122.

ANDRADE, S.M. & DAEMON, R.F., 1974.- Litoestratigrafia do flanco sudoeste da bacia do Parnaíba (Devoniano e Carbonifero). *Soc. Brasileira de Geologia* (An 28è Congr.), 2: 129-137.

CAPUTO, M.V., 1985.- Late Devonian glaciation in South America. *Palaeogeo. Palaeoclim. Palaeoecol.,* 51: 291-317.

CAPUTO, M.V. & CROWELL, J.C., 1985.- Migration of glacial centers across Gondwana during Paleozoic Era. *Geol. Soc. America Bull.,* 96: 1020-1036.

DAEMON, R.F., 1974.- Palinomorfos-Guias do Devoniano Superior e Carbonifero Inferior das Bacias do Amazonas e Parnaíba. *An. Acad. Brazil Cienc.,* 46(3-4): 549-587.

HIGGS, K., CLAYTON, G. & KEEGAN, J.B., 1988.- Stratigraphic and systematic palynology of the Tournaisian rocks of Ireland. *The Geol. surv. of Ireland,* Special paper 7: 1-93.

HIGGS, K. & STREEL, M., 1984.- Spore Stratigraphy at the Devonian/Carboniferous boundary in the Northern «Rheinisches Schiefergebirge», Germany. *Cour. Forsch.-Inst. Senckenberg,* 67: 157-179.

JOHNSON, J.G., KLAPPER, G. & SANDBERG, C.A., 1986.- Late Devonian eustatic cycles around margin of old Red Continent. *Ann. Soc. géol. Belgique,* 109: 141-147.

KEGEL, W., 1953.- Contribuicão para o estudo do Devoniano da Bacia do Parnaíba. Rio de Janeiro (Brazil), Depart. Nat. da Producão Min., Divisão de Geol. e Min., 135: 38 p.

LOBOZIAK, S., STREEL, M., CAPUTO, M.V. & de MELO, J.H.G. (1991).- Evidence of West European defined Miospore zones in the uppermost Devonian and Lower Carboniferous of the Amazonas Basin (Brazil). *Geobios,* 24(1): 5-11.

LOBOZIAK, S., STREEL, M. & WEDDIGE, K., 1991.- Miospores, the *lemurata* and *triangulatus* levels and their faunal indices near the Eifelian/Givetian boundary in the Eifel (F.R.G.). *Ann. Soc. géol. Belgique,* 113: 1-15.

RICHARDSON, J.B. & McGREGOR, D.C., 1986.- Silurian and Devonian spore zones of the Old Red Sandstone Continent and adjacent regions. *Geol. Survey Canada,* 364: 1-79.

SANDBERG, C.A., GUTSCHICK, R.C., JOHNSON, J.G., POOLE, F.G. & SANDO, W.J. (1986).- Middle Devonian to late Mississippian event stratigraphy at Overthrust Belt Region, Western United States. *Ann. Soc. géol. Belgique,* 109: 205-207.

STREEL, M., 1986.- Miospores contribution to the Upper Famennian-Strunian event stratigraphy. *Ann. Soc. géol. Belgique,* 109: 75-92.

STREEL, M., HIGGS, K., LOBOZIAK, S., RIEGEL, W. & STEEMANS, Ph., 1987.- Spore stratigraphy and correlation with faunas and floras in the type marine Devonian of the Ardenne-Rhenish regions. *Rev. Palaeobot. Palynol.,* 50: 211-229.

VAN VEEN, P.M., 1981.- Aspects of late Devonian and early Carboniferous palynology of Southern Ireland. The change in composition of palynological assemblages at the Devonian/Carboniferous boundary. *Rev. Palaeobot. Palynol.,* 34: 67-97.