Reassessment of Viséan miospore biostratigraphy in the Amazon Basin, northern Brazil

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Abstract

A late Viséan age within the late Hettangian–early Brigantian time span (TC-VF zonal range) is proposed for the highest, shaler, transgressive part of the Foro Formation in well 2-LF-1-AM and equivalent sections of other Amazon Basin boreholes, which in some cases have been misattributed to the underlying Orózimba Formation. Late Tournaisian–middle Viséan macrofossils (CM–TS zonal succession) are now regarded as an admixture in at least the Amazonian regions of northern Brazil. This supports the hypothesis of a regional unconformity separating the late Viséan sequence from the latest Famennian/early late Tournaisian sequence in those areas. Palaeoenvironmental factors of uncertain nature seem to have controlled the presence or absence of miospore index species (either of Euramerican or Gondwanan affinities) in the Amazon Basin. Such erratic nonoccurrences have led to miscorrelations of local miospore successions. Early to middle Viséan sections are either missing or highly condensed in northern Brazil, and a similar situation may occur in North Africa and adjacent regions. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

Unpublished results from recently concluded and ongoing palynological investigations in the subsurface of the Amazon, Solimões and Pará Basin basins (northern Brazil) confirm the occurrence of Viséan miospore assemblages in those areas, as already pointed out in the earlier literature (Daenens and Coutteiras, 1971; Daenens, 1974, 1976; Andrade and Daenens, 1974). In the Amazon Basin (Fig. 1), such assemblages characterize mainly the upper, shaler part of the Foro Formation, and less frequently, correlative sections in a few wells which have been improperly assigned by Petróbras geologists to the underlying Orózimba Formation. In the Solimões Basin (Jandatuba Sub-basin), Viséan sandy strata are lumped incongruously with Devonian shales into a single rock unit, the Jandatuba Formation. In the Pará Basin, miospores of Viséan age are restricted to the Foro Formation. In all three basins, the Viséan corresponds almost invariably to the so-called biostratigraphic interval XII of Petróbras' earlier zonal scheme (Daenens and Coutteiras, 1971; Daenens, 1974).
Continued palynological research in northern Brazilian basins (especially the Amazon Basin) has added considerable accuracy to the dating and correlation of regional Viséan miocene assemblages. Furthermore, it has also provided new insights into facies control and compositional variations of the palynoflora, which may be seen in the understanding of coeval assemblages in other Gondwanan areas. During earlier phases of this review, Viséan dat- ings in Brazil relied mainly on local identifications of eristic Lycopsida spp., sometimes joined by some Tournaisian holdovers which are usually unknown in the later Viséan (LOBozki et al., 1991, 1993). These assemblages suggest ages not older than early to middle Viséan (zones Pu-TS in the sense of Clayton, 1985 and Higgs et al., 1988a). As the re- sult of additional work, however, certain sections in northern Brazilian basins (with or without Lycopsida spp.) are now admitted to bear miocenes of indistinguishable late Viséan age, including zonal or characteristic species shared with Western Europe (e.g., Diasnoenopteris fragilis, Perioploites ter- stullatus, Rossoporta argentinii, Watzlizoporella spp., etc.) and Gondwana (e.g., Reticulatisporites magnidiscus and 'Hymenozonosteles' dolitintii sensu Duemom, 1974). In such cases, age assignments as young as late Hettlerian or early Asbian to Brigantian are ac- ceptable, which suggest a probable correlation of the Brasilian sections with at least part of the TC through Vf miocene zonal succession of Western Europe (Clayton et al., 1977, 1978; Clayton, 1985). Lithological and electric marker correlations in at least the Amazon Basin indicate that the studied Viséan sections are mutually correlated and, there- fore, coeval.

In nearly all wells analyzed in the course of the present study, late Viséan sediments were found to rest unconformably on strata ranging in age from late Famennian to middle or early late Tournaisian (i.e., equivalent to the VcO through BP-PC miocene zones sensu Strel et al., 1987 and Higgs et al., 1988a). For some time, the only apparent exception to this rule was well 2-LF-1-AM in the Amazon Basin, where late Viséan miocene assemblages had been mistaken for late Tournaisian and early Viséan ones (LOBozki et al., 1991). This problem has been finally clarified by subsequent palynological re-inves- tigations, whose main results are presented herein.

The purpose of this paper is, therefore, to up- date the Viséan miocene biozonation of the Amazon Basin, and to consider possible implications for the Viséan stratigraphy of other Gondwanan areas. In this context, a palynological reevaluation of well 2-LF-1-AM is of key importance for the following reasons:

- The latest published study (LOBozki et al., 1991) did not take Gondwanan index species into con- sideration. Moreover, some previous local iden- tifications of Western European taxa can be now reinterpreted in the light of subsequent studies based on additional material from Brazilian basins.
- 2-LF-1-AM was the only known section in the basin where a supposed late Tournaisian/early Viséan transition had been recorded and corre- lated with the CM-Px miocene zones of Western Europe sensu Clayton et al., 1977, 1978 and Higgs et al., 1988a,b). This "bridging" interval is evidently lacking anywhere else in the Amazon and Solimoes basins.
- 2-LF-1-AM is the type section of the Foro For- mation (Lange, 1967; CAPuto et al., 1972), where the unit displays exceptional sedimentary develop- ment. It is also the type section of Daenon's (1974, 1976) biostratigraphic interval XI, i.e., the only known section in Brazil where this problematic unit of alleged early Viséan age has ever been clearly delineated beneath interval XII.
- The 2-LF-1-AM has been investigated in terms of Petrobras and Western European miocene biozonations, it permits direct compar- ison of both zonal schemes. In addition, Petrobras operational palynzones take Gondwanan Viséan index species into consideration. These taxa co-exist with Western European-defined miocene index species of Viséan age in well 2-LF-1-AM, so allowing tentative reinterpretation of miocene zones erected elsewhere in Gondwana and adjac- ent regions on the basis of similar assemblages (e.g., Algeria, Libya and the Middle East).

2. Reevaluation of the Tournaisian-Viséan miocene biostratigraphy in well 2-LF-1-AM

In a previous paper, LOBOZKI et al. (1991, pp. 6-8, fig. 2) presented some biostratigraphic results based on the distribution of the most significant
to Riley, 1993, p. 438) and the whole Ashian, i.e., the British regional stages for the lower and middle parts of the upper Viséan. Therefore, such a late Viséan age, rather than late Tournaissian, can be in part assigned to the interval of well 2-LF-1-AM (cores 29 to 21). Note that in an integrated microfossil-foraminiferous study of the Omel Zemene section (Mukra Masifi, Morocco), Loboznik et al. (1990) demonstrated that the base of the TC Biozone can be somewhat older. It coincides with the boundary of foraminiferal zones C14c and C15, which in Belgium is close to the Molkemac/Lievian regional stage boundary (i.e., the mid part of the middle Viséan).

Due to the presence of *Lycozopsis* spp., a Viséan age is more obvious for the overlying interval comprising cores 16 to 13. In addition to this genus, other main taxa first appearing in the Viséan are also present. For instance, cores 16 and 15 contain *Hyphocyclosporites* *dolomiticus* (shown in the Fig. 2 as *Radizonites* sp. cf. *H. dolomiticus*) and a large reticulate form (= *Dicytozoreites* sp. cf. *R. magnidiscus* in Fig. 2) identical to the eponymous species of the aforementioned *Reticulatisporites* *cf. magnidiscus* Biozone. This form is also recorded, as *Dicytozoreites* sp. no. 2908 in Lanconzi and Magliore (1980, plates II, figs. 2 and 3), from the M4 (upper part) to the M7 subzones of the Grand Erg Occidental. Other taxa present in well 2-LF-1-AM include *Circontrachelites rarus* and *Waltsiopora* sp. (both in the two highest cores 14 and 13) and *Granulatisporites granulatus* (only in core 13).

Typical representatives of the genus *Waltsiopora* (see *W. planiglandula* in Riley, 1995, fig. 8) are known to appear at the base of the TC Biozone together with *Peritricites tesellatus*. They still persist above the extinction level of the latter. So, because other index species of the late Viséan or younger intervals are locally absent, the section including core 18 and cores 16–13 (all lacking *P. tesellatus*) can be tentatively attributed to the *Trigratisica venturiana–Rotasiopora fructa* (VF) Biozone. This unit immediately succeeds the NM microfossil Zone in

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PLATE I

The slides from well 2-LF-1-AM (except for 940501) are housed in the palynological collection of the Laboratory of Palaeobotany and Palynology, University of Liège, Belgium. Slide 940501 and materials from other wells are housed in the palynological slide collection of the Heimatmuseum and Palaeontology Society of Portrait before Canada (Direct/Sud/ligne). Rio de Janeiro, Brazil.

Microfossil locations on the slides are based on England Finder's guidebook. Magnification of illustrated specimens: x500.

1. 2. *Radizonites* sp. cf. *Hyphocyclosporites* *dolomiticus*, Darmon, 1974; slide 2913, LW3, well 2-LF-1-AM, core 23 at 2173.10/2180.10 m.
2. Slide 900000: U38, well 1-IX-3-AM, core 24 at 2207.25 m.
3. *Conoceratoides* *rarus* (Brindley) Schopf, Wilson and Brownell, 1945; slide 999648: M2774, well 1-ES-1-P, core 1 at 1274.20 m.
4. Slide E001067 (CS057): W26, well 1-AD-1-AM, core 24 at 3196.17/3162.20 m.
5. *Peritricites tesellatus* (Spath) Neville in Neville et al., 1973; *Rotasiopora* *polystyla* *vicina* and *Jurionites*, 1974 in Lobeznik et al., 1991, plate 1, fig. 4. Slide 21313, 1/27/3, well 2-LF-1-AM, core 21 at 2713.80/2716.10 m.
6. *Dinantiastrites* *fugitilis* *Clayton* in *Nieves* et al., 1973. Slide 960506: 146/1, well 1-IX-3-AM, core 24 at 2720.25 m.
7. *Pseudovacospores* *apparita* Playford, 1971; slide 1311: E39/1, well 2-ES-1-AM, core 13 at 2153.90/2156.00 m.
8. *Waltsiopora* *polynia* (Hollingsworth, *Spath* and *Molyneux* Smith) *Butterworth*, 1967; slide 900749: U121/1, well 1-IA-1-AM, core 23 at 2016.75 m.
9. Slide 990487: P46/2, well 1-ES-1-AM, core 1 at 1273.35 m.
10. *Granulatisporites* *granulatus* Bialas, 1953; slide 940501: S/2/3, well 2-LF-1-AM, core 13 at 2148.51 m.
11. *Lycozopsis* *pallidina* *Bialas*, 1972; slide 940347: V35/1, well 1-UK-1-AM, core 22 at 2927.25 m.
12. Slide 940746: A46/3, well 1-IA-1-AM, core 22 at 2926.45 m.
13. Slide 940405: V35/1, well 1-UK-1-AM, core 22 at 2927.25 m.
14. *Lycozopsis* *pallidina* (Bialas) Schopf, Wilson and Brownell, 1944. Slide 990488: N59/2, well 1-ES-1-PA, core 1 at 1274.20 m.
15. *Lycozopsis* *rubrulines* (Bialas) Schopf, 1972; slide 970067: E55/3, well 1-AD-1-AM, core 24 at 3196.17/3162.20 m.
16. *Lycozopsis nocturna* Butterworth and Williams, 1958; slide 990862: H301/2, well 1-ES-1-PA, core 1 at 2727.70 m.
17. *Dicytozoreites* sp. cf. *Reticulatisporites* *magnidiscus* Playford and Helby, 1968; slide 960506: K36, well 1-IX-3-AM, core 24 at 2207.25 m.
Western Europe, and corresponds to the lower part of the Brigantian Stage in Britain (i.e., the uppermost Viséan).

In conclusion, the whole interval between core 29 and core 13 is now considered to be of late Viséan age. Some praecloplates, previously assigned by Loboziaik et al. (1991) to the species Schoppofol
tenites ellipsoideus in spite of their smaller size range (about 110–125 μm rather than 200–500 μm), have been recorded from core 24 to core 21. Because Schoppofolletens spp. are virtually unknown below the upper Viséan in the British Isles (Riley, 1993, fig. 8; see also Crepet and Massa, 1993, p. 150), the Brazilian specimens had been regarded in the previous paper as late Tournaisian pre-cursors of the typical late Viséan forms. Their presence in well 2-LF-1-AM is now demonstrated to be in permis-sive agreement with their known range elsewhere in Euramerica.

Tournaisian miospore assemblages in this well are therefore only identified in cores 51 to 53 (2252.0–2327.0 m). In core 53, Spathoerisites balteatus is the only zonal species thus far recognized. In West-ern Europe, its first occurrence defines the base of the S. balteatus–R. polypycha (BP) Biozone (Higgs et al., 1988a, p. 12, 13, fig. 3). This unit ranges from the higher part of the lower crenulata to the baseline upper crenulata conodont Zone of early (but not earliest) middle Tournaisian age (Higgs et al., 1992, p. 157, fig. 3). However, a younger Tournaisian attribution cannot be completely excluded for this core, as unpublished biostratigraphical results from other wells in the Amazon Basin point out to the presence of the succeeding S. pretiosa–R. clavata (PC) Biozone in sections of similar electric-log signature. For this reason, a comprehensive BP–(PC)7 zonal range is suggested for core 53 in Fig. 2. In well 2-LF-1-AM, the PC Zone is only confirmed in cores 52 and 51, due to the presence of Colatisporites decorus, Indotortrilites mitratus and Rastrikiella cf. clavata in the newly studied samples. In Western Eu-rope, this biozone extends from the upper crenulata Zone in the deep water conodont succession to the lower part of the communis carina Zone in the platform conodont succession of late middle to early late Tournaisian age (Higgs et al., 1992, fig. 3, p. 157; Dreessen et al., 1995, fig. 10).

3. Comparison of palynozoic schemes in 2-LF-1-AM

As previously stated, well 2-LF-1-AM is unique to the understanding of the Lower Carboniferous palynostratigraphy in the Amazon Basin, because it has been investigated according to two independent biostratigraphic schemes, viz: that of Petrosa (Daenon, 1974, 1976) and the Western European miospore biozonation (Loboziaik et al., 1991 and the present study). Correlations between both schemes and their implied datings are shown in Fig. 2, and discussed next in further detail.

Biostratigraphic interval XII, within the Faro Forma-tion, corresponds to an upper sandy/silty section containing a distinctive late Viséan papiliferida (cores 13 to 29, within the TC-VF biozone), and to a lower sandy section of uncertain age, but supposed to have been quickly deposited, and which is barren of miospores (cores 30 to 35).

In the upper part of the underlying Oriximinh Formation, biostratigraphic interval XI, formerly assigned to the early Viséan by Daenon (1974, 1976), has its upper boundary near the middle/upper Tour-naisian transition (cores 51 and 52, PC Biozone). Its lower boundary is above core 53, i.e., within the BP–(PC)7 biozone range, and therefore cannot be older than middle Tournaisian.

Biostratigraphic interval X, in the middle part of the Oriximinh Formation, includes core 53 and corresponds to BP or younger biozone of Western Europe (middle Tournaisian).

From the above discussion, it follows that the base of the Viséan section in well 2-LF-1-AM cannot be placed below that of the Faro Formation (which locally coincides with the base of biostratigraphic interval XII). Cores 51 and 52, on the top of interval XI, contain a miospore assemblage not younger than late middle or early late Tournaisian (PC Biozone). The early Viséan age of interval XI and its alleged correlation with Lanzoni and Magroin’s (1969) subzone M4, as proposed by Daenon (1974, 1976), lack sufficient palynological support. In fact, in the way as originally defined, interval XI has no biostratigraphic identity. It cannot be traced away from its reference section in well 2-LF-1-AM to any other boreholes in northern Brazilian basins, with-out invariably merging with older or younger units.
Libyan Hammahad Basin or the Issenjud Formation of the eastern Algerian Illizi Basin (Attar et al., 1980).

Subsequent objection to such conclusions by Abdessalem-Rougui and Coquel (1997) does not provide any credible alternative. On the contrary, in addition to their poor lithological correlations, these authors concede that available radiometric identifications from the Algerian Sahara (i.e., Bollondoceras hedrarense (Bisat), Dhuprakoceras subglobosum (Lièvrehich), etc.) cannot be confirmed from either the illustrations by Pareyo (1961) or the faunal list given by Dubois et al. (1959). Consequently, no recognition of the middle Illizi/late Illizian boundary is possible on the basis of available faunal evidence, contrary to the statement of Abdessalem-Rougui and Coquel (1997, p. 51).

Stride and Lobobiak (1994, p. 269) conclude that Palynozonites XIV and XIII in western Libya as well as Palynozonites IV in eastern Algeria are poorly dated. They suggest that either sedimentary condensation or a gap possibly occurs beneath the so-called Col- lennis beds, a late Illizian faunismo reliably dated by foraminifers in the Illizi Basin. Therefore, the proposed earliest Illizian age was one possible alternative for the above-mentioned palynozones. But, of course, another acceptable possibility is that they are late Illizian, and in this case, the sedimentary condensation or gap could occur somewhere between Palynozones XIII and XII in western Libya and between Palynozones IV and Ill in eastern Algeria. The latter alternative is more consistent with the stratigraphic data, and is further substantiated by a break in the palynological content of those biozones (Attar et al., 1980, table IV, Abdessalem-Rougui and Coquel, 1997, fig. 4).

Juggling from palynological data provided by Massa et al. (1980), Palynozonites XIII is obviously of late Illizian age, as demonstrated by the presence (ibid., plate V, fig. 22) of Diatomozonites fragilis. This species is also known from the base of Palynozonites IV in Berehile BN, in the south-eastern part of the Illizi Basin (Abdessalem-Rougui and Coquel, 1997, fig. 4). Furthermore, the late Illizian age of that section is confirmed by the first occurrence, a few metres higher, of Reticulatisporites cancellatus (ibid., plate III, fig. 4), also referred to as Reticulatisporites cf. magnidiorus in Daenou (1974, plate VIII, figs. 5 and 6) and Dicyotylitrites sp. n. 2908 in Lanzoni and Magloire (1969, plate II, figs. 2 and 3). (see also Ravi et al., 1994, p. 14). The joint occurrence of Spelaeocharites pretiosus and micropores of late Illizian age, either in the Illizi and Hammamad Basin or in northern Brazilian basins, may be the result of rerecking.

Lycoporeus spp. have been found in neither Palynozonites XIII of the Hammamad Basin nor Palynozonites V of the Illizi Basin. However, new observations made in Brazil on erratic occurrences of Lycoporeus spp. within micropore assemblages of late Illizian age lead us now to admit that most of the M'tar and Issenjud formations might be of late Illizian age. The lower part of these formations is clearly of early late Tournaisian age, based on micropores (PC zone) and faunal evidence (Massa and Vacher, 1979). It does not mean that we accept the conclusion of Coquel and Massa (1993, p. 149) that “l’arrivée tardive, au Viséen terminal, de Lycopora pusilla, dans l’ensemble Illizi-Rhadames, est un fait rigoureusement établi”. Their statement lacks biot stratigraphic support, because older Illizi strata have never been reliably dated in those regions. Nevertheless, such misconception about the Viséen palynology of eastern Algerian and western Libyan basins has had a direct bearing on the viewpoints of authors concerned with other basins in North Africa and the Middle East. For this reason, we maintain that, “

\[\text{1}^2\text{The alleged presence of Dicranofractites fragilis (characteristic of late Illizi species) in the middle part of the upper Tournaisian (Massa et al., 1980, p. 433, fig. 4, 5) is, from our viewpoint, unacceptable. This problem may be due to incongruous biozones, including mixed strata with disparate ages, or still, the rerecking of Tournaisian micropores into late Illizi assemblages.}"

The same species has also been recorded in both the Illizi Basin, from the base of Palynozonites IV (Attar et al., 1980, table IV, plate 3, fig. 1), and the Hammamad Basins (Massa et al., 1980, plate V, fig. 1)
the absence of confirmed lower and middle Viséan micropale assemblages, without Lycocarpia, a belated first occurrence of this genus in North Africa is not supported by available data" (Strelzov and Lobozbek, 1994, p. 269).

Probably based on inaccurate palynological dat-
ings (BEICIP/NOC, 1972, western Libya Explora-
tion Study: unpubl. rept.), Whittredge and Kelling (1982, p. 1091 and 1093) assumed that deltac sedi-
ments making up the M’Tar Formation (656 m thick) could have been stacked continuously over a time span of 15 Ma. They ascribed (p. 1106) the virtual absence of plant remains in the M’Tar Formation to the very low subsidence rate which supposedly persisted during its deposition. However, an average subsidence rate of less than 1 mm in 15 years is very unlikely for deltac systems. Indeed, now admitting that the bulk of the M’Tar Formation was probably deposited during the late Viséan, we believe that sedi-
mentary accumulation was discontinuous and much faster than previously considered.

4.3. Cyrenaica, northeast Libya

When Clayton and Lobozbek (1985) and Lobozbek and Clayton (1988) studied the Early Carboniferous paleontology of several boreholes in northeast Libya, there were no local faunal datings which they could count upon. Therefore, their age inferences rested on a comparison with assemblages XII and XIV of western Libya (Massa et al., 1980). They attributed the micropale assemblage from interval 7941–8185 ft of well A1-37 to the Viséan, based on the abundance of Araspirisporus subravenisis in the lowermost part of the studied section. The presence or absence of micropale species such as Spleuconesites pretiosus and Valiatiospores valiatia provided the only arguments to differentiate early Viséan from late Viséan strata.

On the other hand, those authors overlooked the significance of Diatomoxonites fragilis, present in several samples of A1-37. We now propose a late Viséan age for all of these, considering that the occurrence of Spleuconesites pretiosus and Val-
iiatiospores valiatia in cores below 8131 ft is pos-
sibly due to reworking. However, this contradicts Vachard et al. (1993) who, using foraminifers and conodonts, assigned a late Tourmaiss or earliest Viséan age to sample CCY-1 within this section.

4.4. Tim Merzou and Agades Basins of northern Niger

In the Tim Merzou Basin, the Talak Formation, of indubitable late Viséan age, was shown by Co-
ques et al. (1995) to encroach on the Farazkhet Formation (dated as Tourmaiss–early Viséan on the basis of megafossils) and further away on the granitic basement. The lowest point samples from the Talak Formation contain rare specimens of Spleuconesites pretiosus. Their presence in the upper Viséan was not explained by those authors. Such micropale may have been reworked from the Farazkhet Formation. In addition, there occur some recycled Devonian palynomorphs (Grandiospora inculta, chitinozoans), which probably derived from fluvial and glacio-
marine sediments documented by Valsardou and Dars (1971) and Lang et al. (1991).

A late Viséan assemblage containing Lycocarpia pusilla has been recorded from coals in the Agades Basin (Lobozbek and Alpern, 1978).

4.5. Middle East

Early Carboniferous micropale were reported by Clayton (1995) from a few boreholes in Saudi Aza-
bia. Although the studied samples were rather scanty, no early or middle Viséan micropale have been found in those boreholes, which contain only middle Tourmaiss and late Viséan–Namurian assemblages. Reworked micropale of latest Devonian age were also recorded amidst the late Viséan–Namurian pal-
nyxofauna.

Micropale assemblages comparable to those from the Upper Devonian and Lower Carboniferous of the Saharan Platform were recorded by Ravi et al. (1994) in northeast Syria. Faunal controls are missing, but their “upper Viséan” is very similar in its overall composition to the late Viséan micropale assemblages of the Algerian Sahara (Grand Erg Oc-
cidentale), as evidenced by the common occurrence of Dicyctites sp. n° 2908 and Radicipites sp. n° 2922. The “middle assemblage” is apparently of Early Carboniferous age, due to the absence of Retipora lepidophyta. The presence of species like Cy-
tosporia cristifera, Condylasporites spathulatus, Dic-
tyctites gracilis, and their joint occurrence with

Araspirisporus subravenisis and Radicipites genu-
inus, are features shared with several Tourmaissi sections of Western Ghondwan. Therefore, they are by no means incompatible with such age assignments, contrary to the belief of Ravi et al. (1994, p. 11).

The lower part of this “middle assemblage” is ob-
viously of Tourmaissi age. On the other hand, its upper part, which contains Spleuconesites giganteus, is seemingly of undifferentiated Viséan age and still requires more precise dating.

5. Conclusions

Based on new micropale determinations from well 2-LF-1-AM, including both Ghondwan and Eu-
erranean taxa, Petraobas operational palynozones can be now more precisely correlated with the micropale biozonation of Western Europe.

The present review confirms the late Viséan age assigned by Petraobas palynologists to biostati-
graphic interval XII in northern Brazilian basins (TC-VF zonal range). In principle, this assignment is consistent with the late Holoerian–early Brigian-
tian span in Western Europe. However, the age of micropale assemblages from interval XII is more likely restricted to the younger part of that interval, due to the joint occurrence of such species as Di-
atomoxonites fragilis, Rotospora ergoninul and Pterosporites reversus, followed by disappearance of the latter one, within productive sections usually no more than a few tens of metres thick.

Our micropale results from the Amazon Basin also point out to serious inconsistencies in the definition of the underlying interval XI, which is apparently devoid of any Viséan micropale. In the way as originally devised, the “type” interval XI, now dated as middle to early Tourmaiss (BP-PC zonal range), is hardly distinguishable from the underlying interval X in its palynological content. The unit lacks stratigraphic identity, because it cannot be traced away from 2-LF-1-AM to any other boreholes as a discrete biozone. Similar problems may affect equivalent ‘transi-
tional’ intervals in North Africa, e.g., M3–M4 sub-
tones of Lanzonii and Maghber (1929), or zones XII to lower XIII sensu Massa et al. (1980). In both in-
stances, micropale biostratigraphy seems to have been

constrained by pre-existing, lithologically-based re-
gional correlations involving distinct units with dif-
ferent ages (Strelzov and Lobozbek, 1994).

There is a serious need for revised micropale conoal schemes in the so-called ‘lower Viséan’ of North Africa and adjacent regions, with potential implications for the allowed diachronism between first appearances of Lycocarpia spp. in Euarmeria and Ghondwan. Early to middle Viséan strata may be missing over much of North Africa and the Middle East, as they are apparently in northern Brazilian basins. Nevertheless, palaeoecologic control seems to have had a major bearing on local distributions of Lycocarpia spp. and other micropale taxa of either Ghondwan or Euramerian affinities, regardless of their stratigraphic position within Viséan sections.

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Appendix A. Species listed

Araspirisporus subravenisis Lobozbek, Clayton and Owen, 1986
Austrosporites soliferae Hofmaeijer, Shpilin and Melly, 1955
Cyrtosporites layriae hookeri, Wilen and Bentz, 1944
Chitinozoa dacilina (Bhandarkar and Venkatakumar) Williams in New et al., 1973
Chitinoza species (Wisdom) Phylacofasti and Sandwoc-
vast, 1985
Camouspora tycherae Neves and Imamura, 1974
Camospora cristifera (Lienes) Van der Zwan, 1979
Diatomoxonites fragilis Clayton in Nev et al., 1973
Diatomoxonites gracilis Byeberg, 1979
Diatomoxonites igneus Playford, 1971
Diatomoxonites johnsonii Allen, 1965
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