EVIDENCE OF WEST EUROPEAN DEFINED MIOSPORE ZONES IN THE UPPERMOST DEVONIAN AND LOWER CARBONIFEROUS OF THE AMAZONAS BASIN (BRAZIL)

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ABSTRACT

Uppermost Devonian and Lower Carboniferous miospore Zones previously defined in western Europe are identified in a borehole in the Amazonas Basin in Brazil. They range with some discontinuity from the uppermost Famennian to the lowermost Visean. Except for a few species which are listed, most of the taxa are common to Euramerica and Gondwana.

MISE EN ÉVIDENCE DE ZONES DE MIOSPORES DÉFINIES EN EUROPE OCCIDENTALE DANS LE DÉVONIEN TERMINAL ET LE CARBONIFÈRE INFÉRIEUR DU BASSIN DE L'AMAZONIE (BRÉSIL).

RÉSUMÉ

Des zones de miospores du Dévonien terminal et du Carbonifère inférieur, antérieurement définies en Europe occidentale, sont identifiées dans un sondage du bassin de l'Amazonie (Brésil). Elles se distribuent, avec quelques discontinuités, du Famennien terminal au Viséen basal. A l'exception de quelques espèces qui sont citées, la plupart des taxons sont communs à l'Euramérique et au Gondwana.

KEY-WORDS : MIOSPORES, LOWER CARBONIFEROUS, GONDWANA, BRAZIL.
MOTS-CLÉS : MIOSPORES, CARBONIFÈRE INFÉRIEUR, GONDWANA, BRÉSIL.

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INTRODUCTION

The results presented below are originated from a miospore analysis of cores from the borehole 2-LF-1-AM, drilled from May 1962 to March 1963 by Petrobras in the Amazonas Basin and they constitute a first contribution to a wider investigation of Devonian and Carboniferous miospore zonations in the Amazonas and Parnaiba Basins.

This first contribution intends to demonstrate the existence of well known West-European characteristic miospores in a region which belongs to Western Gondwana. It also displays some similary of the succession order of their first occurrences and therefore the possibility of stratigraphic correlations, particularly with the elaborated British Isles miospore zonations.

BOREHOLE LOCALIZATION, LITHOSTRATIGRAPHY AND FORMER BIOSTRATIGRAPHY

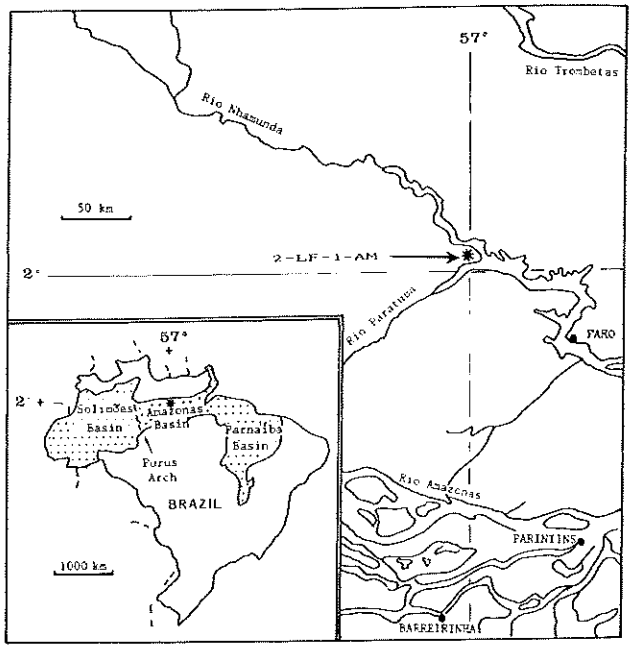

Figure 1 - Location of 2-LF-1-AM borehole.

Localisation du sondage 2-LF-1-AM.

The borehole 2-LF-1-AM was drilled in the Lago do Faro area, latitude 1°57'20" S, longitude 56°58'17" W (fig. 1), in the central western part of the Amazonas Basin. Productive discrete samples are from depth intervals 2485,00/2483,80 m (core 55) and 2256,80/2149,70 m (cores 52, 51 and 29 to 14), that include two distinct Paleozoic formations.

The lowermost stratigraphic unit covered by the sampling is the Oriximiná Formation (2615/2260 m), core 55 being situated in its lower half. The Oriximiná Formation is composed of interbedded sandstones and shale layers, and attains maximum thickness (up to 430 m) just in the region where borehole 2-LF-1-AM has been drilled. It corresponds to the uppermost division of the Curuá Group *sensu* Caputo 1984, and contains Daemon's 1974 biostratigraphic intervals VIII through XI. This Oriximiná Formation overlies conformably upper Devonian glaciogenic beds belonging to the Curiri Formation (an intermediate division of the Curuá Group).

The remaining samples are all included in the Faro Formation (2260/2129 m), a sandy/shaly unit that rests conformably on the Curuá Group and is unconformably overlain by sandstones of the Middle Carboniferous Monte Alegre Formation. It also displays maximum thickness (up to 330 m) in the 2-LF-1-AM region, and comprises Daemon's biostratigraphic interval XII. The biostratigraphic intervals VIII to XII are correlated by Daemon 1974 with the late Famennian to Visean time interval (fig. 2).

BIOSTRATIGRAPHIC RESULTS

In the lowermost sample, miospores are rare, dark and damaged. They are more abundant and better preserved in other samples. Nevertheless, between 2231,60 and 2190,00 m, samples are barren or, at best, have only poor assemblages of morphologically simple miospores without any stratigraphic significance.

Selected species are listed on fig. 2. They do not represent all the miospores observed but only the most significant ones for our purpose. The other miospores are morphologically simple forms including *Apiculiretusispora* and more elaborated, coarsely ornamented *Convolutispora* and *Verrucosisporites* and cingulizonate *Densosporites* and *Krauseliporites*.

The 35 taxa listed on fig. 2 are nearly all also known in western Europe and many are guide-species of the detailed palynozonations most often in use in this area. On fig. 3 are shown the main biohorizons (first and/or last occurences) used by Higgs *et al.* 1988.

Amongst the few spores recognized in the lowermost sample (core 55 : 2485,00/2483,80 m) are *Rugospora radiata, Retispora lepidophyta* and *Hymenozonotriletes explanatus*. The latter occurs higher but coexists with the two others in the palynozonation of western Europe (Streel *et al.* 1987). This first occurence marks the base of the LE (*R. lepidophyta-H. explanatus*) Biozone. The absence of *Verrucosisporites nitidus*, a characteristic miospore of the next younger biozone, allows us to re-

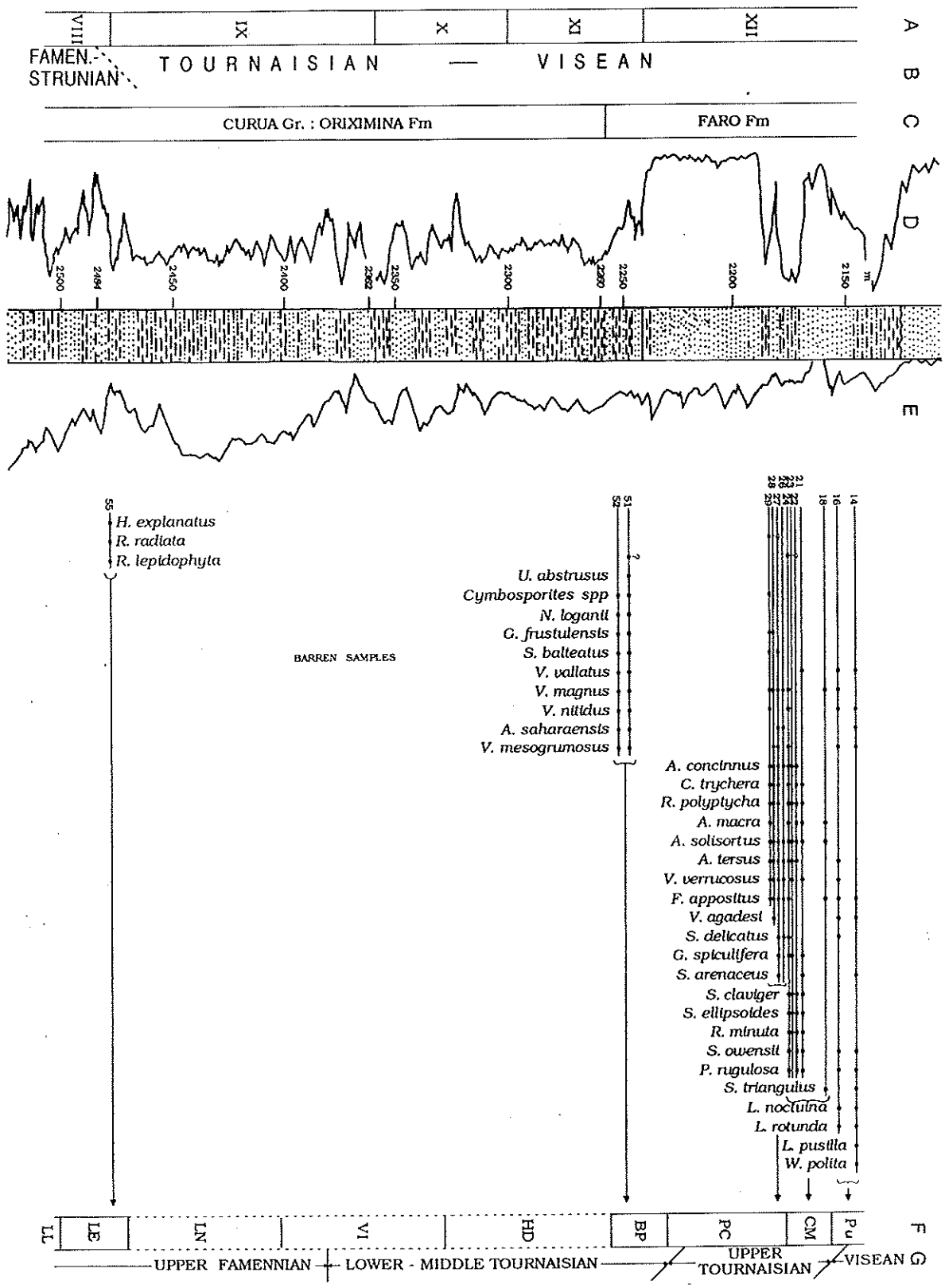

Figure 2 - Miospore distribution in 2-LF-1-AM borehole and comparison with Western European zonation. Key : A, biostratigraphy after Daemon 1974. B, chronostratigraphy after Daemon 1974. C, lithostratigraphy after Caputo 1984. D-E, from the left to the right, gamma ray, lithology and resistivity. F, biostratigraphy after Higgs et al. 1988. G, chronostratigraphy after Higgs *et al.* 1988.

Répartition des miospores dans le sondage 2-LF-1-AM et comparaison avec la zonation de l'Europe de l'Ouest.

strict this lowermost sample to the LE Biozone which corresponds, in the Sauerland (FRG), to the conodont based Lower to Middle *praesulcata* Zone of latest Famennian age (Higgs & Streel 1984).

The younger samples can be compared to the Lower Carboniferous of Ireland where, in contrast with the Sauerland, the sediments belong to a platform system devoid of the conodonts characterizing the Standard

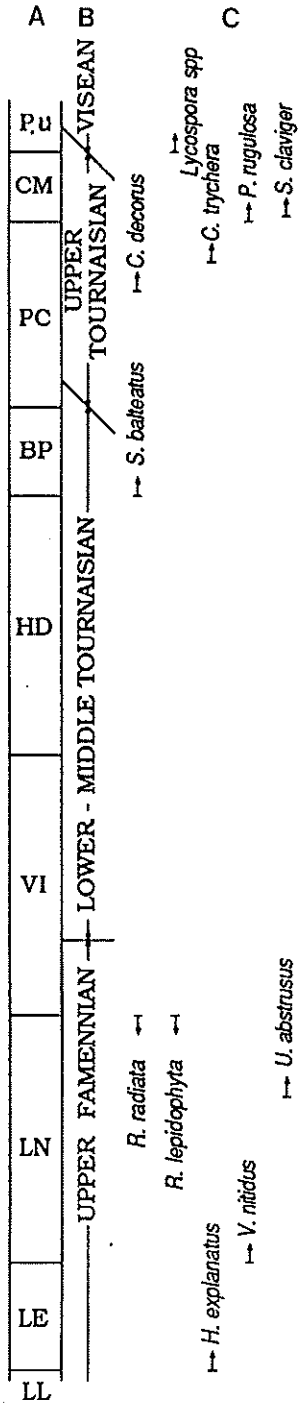

Figure 3 - Main biohorizons of the British Isles palynozonation after Higgs *et al.* 1988. Key: A, biostratigraphy. B, chronostratigraphy. C, main characteristic miospores.

Principaux biohorizons de la palynozonation des Iles Britanniques d'après Higgs et al. 1988.

Lower Carboniferous Zonation (Higgs *et al.* 1988). Therefore dating is less accurate.

Amongst the more abundant and diversified miospores found in the next two productive samples (cores 52 and 51 at 2256,80/2252,00 m) is *Spelaeotriletes balteatus* whose first occurrence in Western Europe delineates the base of the BP (*S. balteatus-R. polyptycha*) Biozone. The absence of *Spelaeotriletes pretiosus*, a characteristic miospore of the next younger Biozone, allows us to restrict these two samples to the BP Biozone of Middle Tournaisian age. We note that Higgs *et al.* 1988, on their fig. 3, mention the first occurrence of *Vallatisporites vallatus* at the base of the BP Biozone, but indicate page 80 the presence of this species below (VI Biozone). Moreover, Van Veen 1981, on his fig. 2, notes *V. vallatus* in the uppermost part of his *Retispora lepidohyta* Assemblage Zone in Ireland.

The next stratigraphic sequence bearing miospores is thicker (cores 29 to 14, between 2190,00 and 2149,70 m). Most of the miospores here were not identified below. (Note that more than 60 m of barren sediments occur between cores 51 and 29).

The first occurrence of *Schopfites claviger* in core 24 (at 2180,20/2180,10 m) indicates the base of the CM (*S. claviger-A. macra*) Biozone and the first occurrence of *Lycospora* spp. in core 16 (at 2159,90/2156,60 m), the base of the Pu (*L. pusilla*) Biozone. Below core 24 (cores 29 to 25), *Crassispora trychera*, a characteristic taxon of the upper part of the older PC Biozone, is nearly always present. Therefore, this thick stratigraphic sequence (cores 29 to 14) has to be referred to the interval ranging from the upper part of the PC Biozone into the lower part of the Pu Biozone, covering most of the Upper Tournaisian and part of the Lower Visean.

COMPARISON WITH FORMER BIOSTRATIGRAPHY IN THE SAME BOREHOLE

Comparison with Daemon's 1974, fig. 2 palynostratigraphy gives the following results : zone XII (Daemon) includes Biozones Pu, CM and upper PC ; zone XI (Daemon) includes Biozones BP ; zone VIII (Daemon) includes Biozone LE. The geochronological interpretation given by Daemon 1974, although less accurate, is entirely confirmed by our study. Compared bio-, litho- and chronostratigraphic data will be discussed in another paper.

GONDWANAN ASPECT OF THE MIOSPORE ASSEMBLAGE

A few species only known so far from the Gondwana have been identified : *Arastrisporites saharaensis, Valla-*

tisporites agadesi, Spelaeotriletes owensii, Granulatisporites frustulensis and *Grandispora spiculifera*. The first three species were described from North Africa (Loboziak & Alpern 1978 ; Loboziak *et al.* 1986), the last two ones from Australia (Balme & Hassel 1962; Playford 1976). They are rare and alone to represent the Gondwanan aspect of these asemblages. Consequently, the difference between the Gondwanan and Euramerican miospore assemblages during the Lower Carboniferous is not conspicuous.

CONCLUSION

Recent research on miospores from the Ponta Grossa Formation in the southern part of Mato Grosso State, Paraná Basin (Burjack *et al.* 1988), has already shown that the middle Devonian-Frasnian miospore zonation of southern Euramerica (mainly the Ardenne-Rhenish basins, Streel *et al.* 1987) could be applied to the Brazilian basins.

We now demonstrate that this is also true for the Lower Carboniferous when compared to the Irish zonation of Higgs *et al.* 1988. However a few miospores identified in Brazil are not known from western Europe. But it is apparent that the distinction in the Lower Carboniferous Gondwanan and Euramerican palynofloras is less marked than in the Upper Carboniferous.

SPECIES LISTED

Anapiculatisporites concinnus Playford, 1962
Anapiculatisporites tersus Playford, 1963
Aratrisporites saharaensis Loboziak, Clayton & Owens, 1986
Auroraspora macra Sullivan, 1968
Auroraspora solisortus Hoffmeister, Staplin & Malloy, 1955
Crassispora trychera Neves & Ioannides, 1974
Foveosporites appositus Playford, 1971
Grandispora spiculifera Playford, 1976
Granulatisporites frustulensis (Balme & Hassel) Playford, 1971
Hymenozonotriletes explanatus (Luber) Kedo, 1963
Lycospora noctuina Butterworth & Williams, 1958
Lycospora pusilla (Ibrahim) Somers, 1972
Lycospora rotunda (Bharadwaj) Somers, 1972
Neoraistrickia loganii (Butterworth & Spinner) Turnau, 1978
Reticspora lepidophyta (Kedo) Playford, 1976
Rugospora minuta Neves & Ioannides, 1974
Rugospora polyptycha Neves & Ioannides, 1974
Rugospora radiata (Juschko) Byvsheva, 1985
Schopfipollenites ellipsoides (Ibrahim) Potonié & Kremp, 1954
Schopfites claviger (Sullivan) Higgs, Clayton & Keegan, 1988
Schopfites delicatus (Higgs) Higgs, Clayton & Keegan, 1988
Spelaeotriletes arenaceus Neves & Owens, 1966
Spelaeotriletes balteatus (Playford) Higgs, 1975
Spelaeotriletes owensii Loboziak & Alpern, 1978
Spelaeotriletes triangulus Neves & Owens, 1966
Umbonatisporites abstrusus (Playford) Clayton, 1971
Vallatisporites agadesi Loboziak & Alpern, 1978
Vallatisporites vallatus Hacquebard, 1957
Vallatisporites verrucosus Hacquebard, 1957
Velamisporites magnus (Hughes & Playford) Playford, 1971
Verrucosisporites mesogrumosus (Kedo) Byvsheva, 1985
Verrucosisporites nitidus (Naumova) Playford, 1964
Waltzispora polita (Hoffmeister, Staplin & Malloy) Smith & Butterworth, 1967

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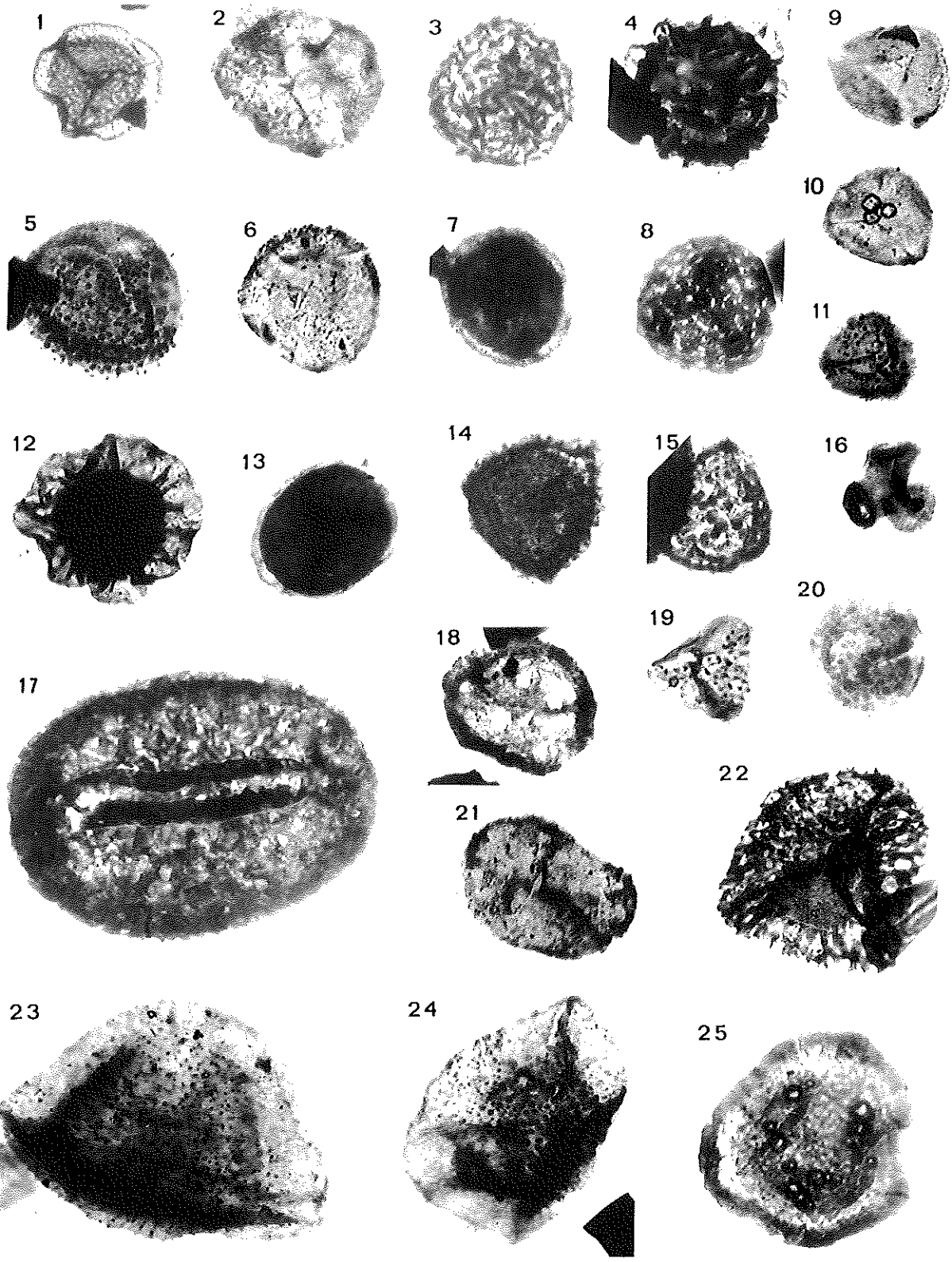
PLATE 1

All palynological material is housed in the collections of the Laboratory of Palaeobotany and Palaeopalynology, University of Liège. Illustrated specimens magnification x 500. *Les préparations palynologiques sont conservées dans les collections du Laboratoire de Paléobotanique et Paléopalynologie de l'Université de Liège. Grossissement des individus illustrés x 500.*

Fig. 1 - *Retispora lepidophyta* (KEDO) PLAYFORD, 1976. Slide 24(1) : N35[2].
Fig. 2 - *Rugospora radiata* (JUSCHKO) BYVSCHEVA, 1985.
Fig. 3 - *Rugospora minuta* NEVES & IOANNIDES, 1974. Slide 23(1) : U36[2].
Fig. 4 - *Rugospora polyptycha* NEVES & IOANNIDES, 1974. Slide 21(1) : L2[7].
Fig. 5 - *Schopfites claviger* (SULLIVAN) HIGGS, CLAYTON & KEEGAN, 1988. Slide 24(1) : P28[2].
Fig. 6 - *Spelaeotriletes balteatus* (PLAYFORD) HIGGS, 1975. Slide 51(3) : R37[3].
Fig. 7 - *Grandispora spiculifera* PLAYFORD, 1976. Slide 21(2) : W28[2].
Fig. 8 - *Foveosporites appositus* PLAYFORD, 1971. Slide 14(1) : M25.
Fig. 9 - *Prolycospora rugulosa* (BUTTERWORTH & SPINNER) TURNAU, 1978. Slide 14(1) : G29[3].
Fig. 10 - *Lycospora pusilla* (IBRAHIM) SOMERS, 1972. Slide 14(1) : Y30[3].
Fig. 11 - *Lycospora rotunda* (BHARADWAJ) SOMERS, 1972. Slide 14(1) : M29[3].
Fig. 12 - *Auroraspora solisortus* HOFFMEISTER, STAPLIN & MALLOY, 1955. Slide 21(1) : T38[4].
Fig. 13 - *Auroraspora macra* SULLIVAN, 1968. Slide 18(1) : S19[3].
Fig. 14 - *Vallatisporites vallatus* HACQUEBARD, 1957. Slide 21(1) : G32[2].
Fig. 15 - *Vallatisporites verrucosus* HACQUEBARD, 1957. Slide 21(1) : Q37[2].
Fig. 16 - *Waltzispora polita* (HOFFMEISTER, STAPLIN & MALLOY) SMITH & BUTTERWORTH, 1967. Slide 14(1) : K42[4].
Fig. 17 - *Schopfipollenites ellipsoides* (IBRAHIM) POTONIÉ & KREMP, 1954. Slide 21(1) : E31.
Fig. 18 - *Crassispora trychera* NEVES & IOANNIDES, 1974. Slide 29(1) : L38[1].
Fig. 19 - *Anapiculatisporites concinnus* PLAYFORD, 1962. Slide 28(1) : U38[1].
Fig. 20 - *Verrucosisporites nitidus* (NAUMOVA) PLAYFORD, 1964. Slide 16(1) : V38[3].
Fig. 21 - *Aratrisporites saharaensis* LOBOZIAK, CLAYTON & OWENS, 1986. Slide 51(3) : E43.
Fig. 22 - *Vallatisporites agadesi* LOBOZIAK & ALPERN, 1978. Slide 14(1) : J19[2].
Fig. 23 - *Spelaeotriletes arenaceus* NEVES & OWENS, 1966. Slide 14(1) : J27.
Fig. 24 - *Spelaeotriletes triangulus* NEVES & OWENS, 1966. Slide 14(1) : J36.
Fig. 25 - *Spelaeotriletes owensii* LOBOZIAK & ALPERN, 1978. Slide 14(1) : Y40[1].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