MIDDLE-UPPER DEVONIAN MICROSPORES FROM THE GHADAMIS BASIN (TUNISIA-LIBYA): SYSTEMATICS AND STRATIGRAPHY

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Abstract


Fifty-five miospores (including 7 new species and 3 new combinations) that range from Emsian to late Frasnian are identified, and 46 illustrated from 4 boreholes in the Ghadamis Basin. Their stratigraphic distribution is given and correlations made with established chronostratigraphic schemes. The Old Red Sandstone Continent miospore zonation can obviously be applied to this part of the Gondwanaland. The similarity of the miospore assemblages in both continents since at least the Emsian, suggests a close proximity of these continents during the Middle and Upper Devonian.

Introduction

Recent works in northeast Libya (Paris et al., 1985; Strel et al., 1988) have shown that the first occurrence of many of the characteristic species of the miospore zonations recently developed in the Old Red Sandstone Continent (Richardson and McGregor, 1986), particularly in the Ardenne–Rhenish regions (Strel et al., 1987) are observed in the same sequence on the northern border of Gondwanaland. Therefore, unless accurate faunas provide contradictory data, there is no reason not to apply these biostratigraphies to correlations between the two palaeocontinents.

Accepting as a first step the identifications of miospores provided so far in western Libya (Massa and Moreau-Benoit, 1976; 1985; Moreau-Benoit, 1979; 1980; 1984), Strel et al. (1988, table I) have challenged their stratigraphic interpretation, restricting to the Eifelian Stage the palynozones 4–6, previously dated as Eifelian to the Upper Givetian, and to the early Givetian, the palynozones 7 and 8, previously dated as Frasnian by Massa and Moreau-Benoit, 1976.

As these late dates were used in recent North African palynological contributions (Abdesselam-Rouighi, 1986; Schrank 1987, and others), we wanted to study Ghadamis Basin material to compare it with the preliminary works in north-eastern Libya. D. Massa who has worked on the Palaeozoic of western Libya for many years had provided us (M.S.) with core samples of supposed Upper Silurian to Upper Devonian age. He had received permission to mention in his own publications the names of the boreholes and the depths of samples. We want to thank him very much for kindly extending these data to us.

The present paper will concern the systematic results on the more important taxa em-
countered in this material and the stratigraphic consequences when they are compared with the Old Red Sandstone Continent zonations. Lateral correlations in Gondwanaland will be discussed in a later contribution.

**Material studied**

The map (Fig. 1) locates the boreholes sampled. Borehole A1-69, drilled by SHELL in 1959 (x = 29° 03' 50", y = 13° 40' 13") will constitute, by the exceptional amount of cores available, our main reference. It is here studied between 2103 ft (641 m) and 650 ft (198 m), giving 33 productive samples. Three other boreholes where cores are much more rare were also sampled. They are D1-26: 7999 ft (2440 m), C1-49: 1170 m and MG1: 2221 m, 2232.6 m and 2234 m. The electric logs available for borehole A1-69 are too poor to allow any correlations with the corresponding Awaynat Wannin Formations (D. Massa, pers. commun., 1987). Samples from borehole MG1, which is located on the Tunisian side of the Tunisian/Libyan border, and borehole C1-49 are all in Awaynat Wannin Formations II and III, supposed to belong to the Givetian and Frasnian Stages. Accurate faunal data are not yet available.

On the same map (Fig. 1) is also located the MOBIL boreholes studied by Moreau-Benoit, 1984 and Massa and Moreau-Benoit, 1985. The material studied by Massa and Moreau-Benoit, 1976 and Moreau-Benoit, 1979 and 1980 were all the samples available from about thirty boreholes aggregated in two composite sections, one for northern Tripolitania, one for southern Tripolitania and Fezzan, both in the Ghadamsis Basin. The detailed location of these samples is not yet available (D. Massa, pers. commun., 1987).

**Systematics**

In most samples, miospores are very abundant, diversified and in a very good state of preservation. We have though that it was not necessary for the purpose of this paper to provide a complete analysis of all observed taxa. On the contrary, we have given some priority to the characteristic species of the Old

![Fig.1. Location map of boreholes investigated in this paper.](image-url)
Red Sandstone Continent biozonation. However, we have also focused our attention on several frequent taxa restricted to the northern margin of Gondwanaland whose narrow stratigraphic range enhances the local biozonation.

Reference slides are stored in the Paleobotanical laboratory of the Université des Sciences et Techniques de Lille, à Villeneuve d’Ascq, France.

Letters and numbers following the slide numbers are England Finder numbers.

Species are listed below in alphabetic order of genera.

**Genus Acinosporites Richardson 1965**

*Acinosporites acanthomammillatus* Richardson 1965 (Plate I, 4)

*Acinosporites apiculatus* (Streel) Streel 1967 (Plate I, 3)

*Acinosporites lindlarenensis* Riegel 1968 (Plate II, 5, 6)

*Acinosporites macrospinosus* Richardson 1965

**Genus Ancyrospora Richardson 1960**

*emend. Richardson 1962*

*Ancyrospora langii* (Taugourdeau-Lantz) Allen 1965 (Plate VIII, 2)

*Ancyrospora nettersheimensis* Riegel 1973 (Plate VIII, 1)

**Genus Archaeozonotriletes Naumova 1953**

*emend. Allen 1965*

*Archaeozonotriletes variabilis* (Naumova) Allen 1965 (Plate I, 19)

**Genus Auroraspora Hoffmeister, Staplin and Malloy 1955**

*emend. Richardson 1960*

*Auroraspora hyalina* (Naumova) Streel in Becker et al., 1974 (Plate III, 3)

**Genus Camarozonotriletes Naumova 1939 ex Ishchenko 1952**

*Camarozonotriletes sextantii* McGregor and Camfield 1976 (Plate I, 11, 12)

*Camarozonotriletes? concavus* sp. nov. (Plate I, 13–15)

**Holotype:** Plate I, 14, borehole A1-69, slide 1483(1) : D31.

**Diagnosis:** Trilete cingulate miospores with subtriangular amb, rounded corners and concave to almost straight, interradial margins. Laesura arms simple, straight, reaching the cingulum. Cingulum, 2–6 µm wide, slightly reduced at corners, slightly darker than central area of the spore. Exine proximally laevigate, equatorially and distally microgranulate. Sculptural elements less than 1 µm wide and high, closely spaced.

**Diameter:** 31–47 µm, mean = 38 µm (28 specimens).

**Derivation of name:** Related to the concave interradial margins.

**Remarks:** In most cases, two slightly separated walls can be detected. Reduction of the cingulum width at corners is not often very conspicuous in this species and attribution to *Camarozonotriletes* is therefore questionable.

**Comparison:** Amongst sculptured species, *C. antiquus* Kedo 1955 has convex interradial margins. *C. parvus* Owens 1971 has a dark proximal area along trilete rays. *C. pusillus* Naumova ex Chibrikova 1959 has ornamentation elements up to 1.5 µm high. *C. sextantii* McGregor and Camfield 1976 has higher and different sculpture.

**Occurrence:** AD pre Lem Zone = Eifelian.

**Genus Chelinospora Allen 1965**

*Chelinospora concinna* Allen 1965

*Chelinospora (Archaeozonotriletes) timanica* (Naumova) comb. nov. (Plate II, 8, 9)

Remarks: The species of Archaeozonotriletes (Naumova) Allen 1965 are smooth. Ch. timanica is distally muronrate.

Genus **Convolutispora** Hoffmeister, Staplin and Malloy 1955

**Convolutispora disparalis** Allen 1965 (Plate I, 5)

Genus **Corystisporites** Richardson 1965

**Corystisporites multispinosus** Richardson 1965 (Plate II, 7)

Genus **Craspedispora** Allen 1965

**Craspedispora ghadamisensis** sp. nov. (Plate II, 1–4, Plate IX, 4)

**Holotype:** Plate II, 1 and Plate IX, 4, borehole A1-69, slide 1700(1): W24

**Diagnosis:** Trilete zonate miospores with subcircular to roundly triangular amb. Laesura arms slightly sinuous, up to 6 μm high, almost reaching the equator. Proximal exine often microfolded, sometimes slightly narrower or absent radially, if present radially may be deflected ont the proximal face. Proximal surface laevigate. Distal surface and zona bearingiform ornaments: thin (1 μm), elongated (up to 4 μm) spines on broad bases (up to 4 μm diameter).

**Diameter:** 70–95 μm, mean = 80 μm (30 specimens)

**Derivation of name:** after the locality of Ghadamis in Libya.

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**PLATE I**

All photographs ×500

1. **Retusotriletes rugulatus** Riegel 1973
   A1-69, slide 1700(1): H29

2. **Emphansisporites annulatus** McGregor 1961
   C1-49, slide 2753(1): Q27

3. **Acinosporites apiculatus** (Streel) Streel 1967
   A1-69, slide 1700(1): E34

4. **Acinosporites oconthomamillatus** Richardson 1965
   A1-69, slide 1483(1): U37

5. **Convolutispora disparalis** Allen 1965
   A1-69, slide 1074(1): F29

6. **Verrucosisporites bulliferus** Richardson and McGregor 1986
   D1-26, slide 2764(2): V34

7. **Verrucosisporites premnus** Richardson 1965
   MG1, slide 2761(1): G36

8. **Verrucosisporites scurrus** McGregor and Camfield 1983
   MG1, slide 2761(1): Q37

9. **Synisporites libyicus** Richardson and Ioanides 1973
   A1-69, slide 2039(2): L28

10. **Camarozonotriletes sextantii** McGregor and Camfield 1976
    11, A1-69, slide 2039(1): J32

11–15. **Camarozonotriletes concaucus** nov. sp.
    13, A1-69, slide 1486(1): X50

16–18. **Diatomozonotriletes franklinii** McGregor and Camfield 1982
    16, C1-49, slide 2753(1): W31

19. **Archaeozonotriletes variabilis** (Naumova) Allen 1965
    MG1, slide 2760(1): G39

20. **Lophozonotriletes media** Taugourdeau-Lantz 1967
    A1-69, slide 976(1): H38

21–23. **Lophozonotriletes bouckaertii** nov. sp.
    21, A1-69, slide 650(2): K30

Holotype: Plate II, 1 and Plate IX, 4, borehole A1-69, slide 1700(1): W24

Diagnosis: Trilete zonate miospores with subcircular to roundly triangular amb. Laesura arms slightly sinuous, up to 6 μm high, almost reaching the equator. Proximal exine often microfolded, sometimes slightly narrower or absent radially, if present radially may be deflected onto the proximal face. Proximal surface laevigate. Distal surface and zona bearingiform ornaments: thin (1 μm), elongated (up to 4 μm) spines on broad bases (up to 4 μm diameter).

Diameter: 70–95 μm, mean = 80 μm (30 specimens)

Derivation of name: after the locality of Ghadamis in Libya.
Comparison: Craspedispora craspeda Allen 1965 is smaller and has a laevigate or sparsely sculptured zona. C. arctica McGregor and Camfield 1982 is also smaller and has smaller different ornaments.
Occurrence: AD pre Lem to TA Zones = Eifelian to Givetian.

Genus Cymbosporites Allen 1965

Cymbosporites catillus Allen 1965 (Plate II, 10, 11 and Plate IX, 2)

Cymbosporites cyathus Allen 1965 (Plate II, 12–13 and Plate IX, 3)

Cymbosporites sp. (Plate II, 14)

Genus Densosporites Berry 1937 emend. Potonié and Kremp 1954

Densosporites devonicus Richardson 1960 (Plate IV, 11, 12)

Genus Diatomozonotriletes Naumova 1939 emend. Playford 1963

Diatomozonotriletes franklinii McGregor and Camfield 1982 (Plate I, 16–18)

Remarks: We have observed a large variation in shape and size of ornaments which may vary from coni (1 μm high) to spinae (up to 4 μm high), encompassing the limit between D. franklinii and D. oligodontus Chibrikova 1962. However, the last species is claimed by Chibrikova to have variably developed curvaturae perfectae, a feature that we have not observed in our material.

Genus Emphanisporites McGregor 1961

Emphanisporites annulatus McGregor 1961 (Plate I, 2)

Emphanisporites rotatus McGregor 1961


Geminospora lemurata Balme 1962 emend. Playford 1983 (Plate III, 7, 8, 11-15)

Geminospora punctata Owens 1971 (Plate III, 9, 10, 16–18)

Remarks: The surface of the exoexine possesses fine, densely distributed punctuations (Plate III, 16–18). However, we have only exceptionally noticed the fine radial striations which correspond, according to Owens (1971, p.62) to punctations passing completely through the exoexine.

PLATE II

All photographs x 500

1–4. Craspedispora ghadamensis nov. sp.
   5, 6. Acinosporites lindlaeensis Riegel 1968
   7. Corysispores multispinosus Richardson 1965
   8, 9. Chelinospora timanica (Naumova) nov. comb.
   10, 11. Cymbosporites catillus Allen 1965
   12, 13. Cymbosporites cyathus Allen 1965
   14. Cymbosporites sp.
Genus *Grandispora* Hoffmeister, Staplin and Malloy 1955 emend. Neves and Owens 1966, as restated by Playford 1971

*Grandispora cassidea* (Owens 1971) Moreau-Benoit 1976 (Plate VI, 1 and Plate IX, 26)

*Grandispora doublastownense* McGregor 1973 (Plate VII, 5 and Plate IX, 27)

*Grandispora gabeisensi* sp. nov. (Plate VI, 2–4 and Plate IX, 17–20)

**Holotype:** Plate VI, 2 and Plate IX, 18, borehole A1-69, slide 1596(1) : X30¹.

**Diagnosis:** Trilete, camerate mioespores with subtriangular to roundly triangular amb. Intexinal body conformable to the exoexinal amb. Laesura arms, straight, up to 4 µm high, usually reaching the equator. Intexine laevigate, sometimes with arcuate folds near the margin. Exoexine thinner than intexine, laevigate in contact areas, sculptured proximally, equatorially and distally with coni, spinæ, capilli and biform elements, 3–6 µm high, 0.5–2 µm wide, irregularly spaced.

**Diameter:** 70–120 µm, mean 97 µm (17 specimens).

Diameter of intexinal body: 62–85% (commonly 77%) of total spore diameter.

**Derivation of name:** After the Libyan harbour of Gabes.

*Comparison:* *Grandispora inculta* and *G. riegelii* have smaller different ornaments. Other Devonian and Lower Carboniferous spinose *Grandispora* have more widely spaced ornaments.

**Occurrence:** AD pre Lem Zone = Eifelian.

*Grandispora incognita* (Kedo) McGregor and Camfield 1976 (Plate VII, 1 and Plate IX, 24)

*Grandispora inculata* Allen 1965 (Plate V, 6, 7 and Plate IX, 14, 15)

**Remarks:** Expanded diagnosis of this species by McGregor and Camfield 1982, p.45 might include some of the specimens here assigned to *Grandispora riegelii* nov. sp. (see diagnosis below). We propose to limit the *G. inculta* concept to specimens where the distances between the ornaments are at least equal to their basal diameter.

*Grandispora libyensis* Moreau-Benoit 1980 (Plate VII, 3 and Plate IX, 25)

**Remarks:** The holotype of *G. libyensis* was first described as *Spinozontrotiles echinatus* Moreau-Benoit 1967 in the “Schistes bleus (Siegenien moyen)” from Anjou in France. The presence of this species and many other large camerate spores in this formation is not compatible with the present knowledge of

PLATE III

All photographs x 500, except where otherwise stated

1, 2. *Rugospora bricei* nov. sp.

1. Holotype, A1-69, slide 650(1) : Q38¹. 2. Detail of the fig.1, x 1800.

3. *Auroraspore hyalina* (Naumova) Strels in Becket at al., 1974

A1-69, slide 650(2) : L28².


A1-69, slide 1416(1) : E55⁴.

5, 6. *Rhabdosporites minutus* Tiwari and Schaarachmidt 1975


9, 10, 16–18. *Ginospora punctata* Owens 1971

9, A1-69, slide 650(2) : H27¹. 10, A1-69, slide 1322(1) : N50. 16, A1-69, slide 1322(1) : F52³, x 1800. 17, Detail of the fig.9, x 1800. 18, Detail of the fig.10, x 1800.
PLATE IV

(for explanation see p.187)
PLATE V

(for explanation see p.187)
(for explanation see p.187)
PLATE IV (see p.182)

All photographs x 500
1-4. Samarispores eximius (Allen) nov. comb.
5. Samarispores praeteritus (Naumova) Allen 1965
C₁, 49, slide 2753(3): L33².
6-8. Samarispores triangulatus Allen 1965
6, A₁, 69, slide 1277(1): G24⁴. 7, A₁, 69, slide 976(2): R4². 8, D₁, 26, slide 2764(1): Q37².
D₁, 26, slide 2764(2): O4⁰³.
10. Samarispores sp. A in Loboziaik and Streel 1981
D₁, 26, slide 2764(2): V2⁵³.
11, 12. Densoспорis devonicus Richardson 1960
11, A₁, 69, slide 1874(1): P36³. 12, MG1, slide 2775(1): H3⁰.

PLATE V (see p.183)

All photographs x 500
1-5. Grandispora riegelii nov. sp.
6, 7. Grandispora inculta Allen 1965
8, 9. Samarispores angulatus (Tiwari and Schaarschmidt) nov. comb.

PLATE VI (see p.184)

All photographs x 500
MG1, slide 2775(1): Q3⁶³.
2-4. Grandispora gabesensis nov. sp.
5, 6. Grandispora protea (Naumova) Moreau-Benoit 1980
7. Grandispora velata (Eisenack) McGregor 1973
C₁, 49, slide 2753(3): L3³⁴.

PLATE VII (see p.185)

All photographs x 500
1. Grandispora incognita (Kedo) McGregor and Camfield 1976
A₁, 69, slide 1596(1): U2⁸³.
2. Grandispora naumovii (Kedo) McGregor 1973
A₁, 69, slide 1700(1): X3³¹.
A₁, 69, slide 1310(1): D3⁹³.
4. Grandispora megaformis (Richardson) McGregor 1973
A₁, 69, slide 1870(1): N3⁸³.
5. Grandispora douglasianensis McGregor 1973
A₁, 69, slide 1550(2): J3⁵².

PLATE VIII

All photographs x 500
1. Ancyrospora nettersheimensis Riegel 1973
A₁, 69, slide 1700(1): J3⁴.
2. Ancyrospora langii (Taugourdeau-Lantz) Allen 1965
A₁, 69, slide 976(1): Y2⁴³.
3. 4. Hystricosporites miratus Allen 1965
A₁, 69, slide 1373(1): O4².
5. 6. Hystricosporites blessii nov. sp.
5, Holotype, A₁, 69, slide 650(2): H2². 6, A₁, 69, slide 650(2): H3⁵.
Siegenian spores around the Old Red Sandstone Continent (Richardson and McGregor, 1986; Streel et al., 1987). As the Siegenian age of the “Schistes bleus” cannot be challenged, we have to conclude the possibility of laboratory contamination of this assemblage. However, we have no reason to reject the new name given by Moreau-Benoit, 1980. It should however be emphasized that, with the exception of the Anjou material, all the specimens listed in synonymy by Moreau-Benoit 1980, p.33 are of Gondwanan origin if we reject Spinozonotriletes multispinosus Lanninger 1968 which obviously belongs to a different species.

_Grandispora megaformis_ (Richardson) McGregor 1973 (Plate VII, 4 and Plate IX, 16)

_Grandispora naumovii_ (Kedo) McGregor 1973 (Plate VII, 2)

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**PLATE IX**

All photographs x 1800

1. _Acinosporites lindlarensis_ Riegel 1968
   Detail of the Plate II, 5.

2. _Cymbosporites cotillus_ Allen 1965
   Detail of the Plate II, 11.

3. _Cymbosporites cyathus_ Allen 1965
   Detail of the Plate II, 12.

4. _Craspedispora ghadamisensis_ nov. sp.
   Detail of the Plate II, 1, 2.

5–7. _Samarisporites eximius_ (Allen) nov. comb.
   5. Detail of the Plate IV, 1.
   6. Detail of the Plate IV, 2.
   7. Detail of the Plate IV, 3.

8, 9. _Samarisporites praeteritus_ (Naumova) Allen 1965
   Detail of the Plate IV, 5.

10–13. _Grandispora riegeli_ nov. sp.
   10. Detail of the Plate V, 1.
   11. Detail of the Plate V, 2.
   12. Detail of the Plate V, 4.
   13. Detail of the Plate V, 5.

14, 15. _Grandispora inculata_ Allen 1965
   14. Detail of the Plate V, 6.
   15. Detail of the Plate V, 7.

16. _Grandispora megaformis_ (Richardson) McGregor 1973
   Detail of the Plate VII, 4.

17–20. _Grandispora gabesensis_ nov. sp.
   18. Detail of the Plate VI, 2.
   19. Detail of the Plate VI, 3.
   20. Detail of the Plate VI, 4.

21, 22. _Grandispora protea_ (Naumova) Moreau-Benoit 1980
   21. Detail of the Plate VI, 6.
   22. Detail of the Plate VI, 5.

23. _Grandispora velata_ (Eisenack) McGregor 1973
   Detail of the Plate VI, 7.

24. _Grandispora incognitae_ (Kedo) McGregor and Camfield 1976
   Detail of the Plate VII, 1.

25. _Grandispora libyensis_ Moreau-Benoit 1980

   Detail of the Plate VI, 1.

27. _Grandispora douglasianumense_ McGregor 1973
**Grandispora protea** (Naumova) Moreau-Benoit 1980 (Plate VI, 5, 6 and Plate IX, 21, 22)

**Grandispora riegelii** sp. nov. (Plate V, 1–5 and Plate IX, 10–13)

1974: *Calyptosporites* sp. B in Bar and Riegel, plate 1, 13.
1985: *Grandispora* sp. A Riegel in Paris et al., plate 24, 8, 9.
1987: *Grandispora* sp. A Riegel in Schrank, plate 1, 1.

**Holotype:** Plate V, 4 and Plate IX, 12, borehole MG1, slide 2760(1): R33°.

**Diagnosis:** Trilete, camerate miospores with subtriangular to roundly triangular amb. Intexinal body conformable to or slightly more circular than the exocinal amb. Laesura arms straight, up to 6 μm high, generally reaching the equator. Intexine laevigate, sometimes with arcuate folds near the margin. Exoexine thinner than intexine, laevigate in contact areas, sculptured proximo-equatorially and distally with dominant mammillate and biform conical elements, but also granae, verrucae and coni, 1–3 μm wide and high, irregularly distributed, sometimes closely spaced.

**Diameter:** 80–120 μm, mean = 96 μm (30 specimens)

Diameter of intexinal body: 60–89% (commonly 79%) of total spore diameter.

**Derivation of name:** After the name of the German palynologist Walter Riegel.

**Comparison:** *Grandispora inculta* Allen 1965 is smaller and bears only coni. *G. inculta* Allen 1965 in McGregor and Camfield 1982, p.45, text-fig.66, pl.11, 2, has a similar ornament to *G. riegelii* but these elements are more spaced, commonly 1–2 μm apart.

**Occurrence:** AD pre Lem-TCo Zones = Eifelian to early Frasnian.


Ghana: shales of Accra.

Cyrenaica: borehole E1-82

Western desert near the Libyan-Egyptian border: Foram-1 well, at 2490 m.

**Grandispora tomentosa** Taugourdeau-Lantz 1957

**Grandispora velata** (Eisenack) McGregor 1973 (Plate VI, 7 and Plate IX, 23)

**Genus Hystricosporites** McGregor 1960

**Hystricosporites blessii** sp. nov. (Plate VIII, 5, 6)

1974: *Hystricosporites* sp. A Streehl in Becker et al., p.27, pl.22, 3–5.

**Holotype:** Plate VIII, 5, borehole A1-69, slide 650(2): H22.

**Diagnosis:** Trilete, camerate miospores with rounded amb. Laesura arms with flexous folds which may form an apical prominence (up to 35 μm high). Intexinal body, laevigate, thin, often folded. Exoexine thicker (4 μm), with laevigate contact areas. Remaining parts of the exoexine bearing very long processes with bifurcate terminations (32–54 μm). The processes may have a bulbous base (6–13 μm), taper markedly in their lower part but are more or less parallel sided in their upper part (2–4 μm). They expand (up to 10 μm) immediately below the bifurcate terminations (up to 20 μm).

**Diameter:** Maximum equatorial diameter excluding the projecting ornaments: 57–86 μm, mean = 76 μm (10 specimens).

**Derivation of name:** after the name of the Dutch ostracodologist Martin J.M. Bless.

**Comparison:** All other *Hystricosporites* with bifurcate processes have smaller ratio: length of processes/diameter of the body.

**Occurrence:** BM−IV Zones = Frasnian. ?TA−IV = ?Givetian−Frasnian in the Boisschot borehole in Belgium.
*Hystricosporites mitratus* Allen 1965 (Plate VIII, 3, 4)

**Genus Lophozonotriletes** (Naumova) Potonié 1956

*Lophozonotriletes media* Taugourdeau-Lantz 1967 (Plate I, 21–23)

*Lophozonotriletes bouckaertii* sp. nov. (Plate I, 21–23)


*Diagnosis*: Trilete miospores with rounded amb. Laesura arms straight or slightly sinuous, up to 3 μm high, reaching the inner side of the equatorial structure. Contact areas laevigate. Remainder of the surface bearing closely spaced, sometimes fused, verrucae. Low verrucae of irregular shape and size, up to 5 μm wide, up to 2 μm high, partly confluent at their bases, forming short rugulæae. Such rugulæae accentuate the thickness of the exine when seen at the equator.

*Diameter*: 44–64 μm, mean = 53 μm (7 specimens).

*Derivation of name*: after the name of the Head of the Belgian Geological Survey, Jos Bouckaert.

*Remarks*: We use the *Lophozonotriletes* concept as emended by Van der Zwan, 1980.

*Comparison*: This species differs of other species of *Lophozonotriletes* by the high density and the variation in shape and size of its ornamentation.

*Occurrence*: Zone IV = late Frasnian.

**Genus Retusotriletes** Naumova 1953 emend. Streele 1964

*Retusotriletes rugulatus* Riegel 1973 (Plate I, 1)

**Genus Rhabdosporites** Richardson 1960

*Rhabdosporites langii* (Eisenack) Richardson 1960 (Plate III, 4)

*Rhabdosporites minutus* Tiwari and Schaarschmidt 1975 (Plate III, 5, 6)

*Rhabdosporites parvulus* Richardson 1965.

**Genus Rugospora** Neves and Owens 1966

*Rugospora brucei* sp. nov. (Plate III, 1, 2)


*Holotype*: Plate III, 1, 2, borehole A1-69, slide 650(1): Q38³.

*Diagnosis*: Trilete miospores with subtriangular to roundly triangular amb. Laesura arms straight to slightly sinuous, up to 2 μm high, reaching the equator. Wall more or less separated into two layers, at least on the distal side except near the equator, the outer layer partly attached to the inner layer. Surface of outer layer usually smooth, thickness indiscernable, presumably very thin. Folding results in a more or less rugulate condition of the spore. Distal rugulæae (1–1.5 μm wide), randomly to rarely radially arranged.

*Diameter*: 32–54 μm, mean = 45 μm (17 specimens).

*Derivation of name*: After the name of the French palaeontologist Denise Brice.

*Comparison*: *Rugospora radiata* (Kedo) Byvsheva 1985 syn.: *R. flexuosa* (Juschko) Streele in Becker et al., 1974, non *R. flexuosa* (Juschko) Byvsheva 1985, has thicker and longer rugulæae, most commonly radially arranged, on the distoequatorial margin.

*R. flexuosa* (Juschko) Byvsheva 1985 which has narrow chaotically placed distal rugulæae is based on poorly published material.


**Genus Samarisporites** Richardson 1965

*Samarisporites* (al. Calyptosporites) *angulatus* (Tiwari and Schaarschmidt) nov. comb. (Plate V, 8, 9)

Remarks: Type material from the Eifel area as well as our material clearly shows a structure with a thick (Sacamereate) central area characteristic of Samarisporites.

Samarisporites (al. Perotrilites) eximius (Allen 1965) comb. nov. (Plate IV, 1–4 and Plate IX, 5–7)

Basionym: Perotrilites eximius Allen 1965, Palaeontol. 3: 731; pl.102, figs.11–13.

Remarks: Sections made through the type material from Spitsbergen by Allen, 1965, clearly shows the distally thick structure of the central area, characteristic of Samarisporites.

Samarisporites praetervisus (Naumova) Allen 1965 (Plate IV, 5 and Plate IX, 8, 9)

Samarisporites triangulatus Allen 1965 (Plate IV, 6–8)

Samarisporites sp. A in Loboziak and Streele 1981 (Plate IV, 10)

Samarisporites sp. E in Streele and Loboziak 1987 (Plate IV, 9)

Genus Synorisia porites Richardson and Lister 1969

Synorisia porites libycus Richardson and Ioannides 1973 (Plate I, 10)

Genus Verrucosphorites Ibrahim 1933 emend. Smith 1971

Verrucosphorites bulliferus Richardson and McGregor 1986 (Plate I, 6)

Verrucosphorites premnus Richardson 1965 (Plate I, 7)

Verrucosphorites scurrus McGregor and Camfield 1982 (Plate I, 8, 9)

Verrucosphorites cf. uncat us Richardson 1965.

Stratigraphic results on borehole A1-69

The stratigraphic range of the most characteristic miospores in borehole A1-69 is given on the chart, Fig.2. On the right hand part of this figure, we have mentioned the species which were utilised to define the comparable biozonation in the Ardenne-Rhenish regions (Streel et al., 1987) that we use as a reference scale.

The first stratigraphically significant species which occurs at 2039 ft (622 m) is Grandispora protea. In the Ardenne-Rhenish zonation, this species marks the base of the Interval Zone AP Pro (apiculatus–proteus Oppel Zone, proteus Interval Zone).

This species is not present in the lowermost sample at 2103 ft (641 m) but this sample provided only a rather poor assemblage of spores. In the sample from 2039 ft (622 m), the coexistence of Camarozonotriletes sextantii and G. protea suggests that the basal part of zone AP Pro has been encountered.

In the lowermost sample at 2103 ft (641 m), the presence of Emphanisporites annulatus and C. sextantii and the absence of large apiculate and spinose zonate-pseudosaccate spores are comparable with the annulatus–sextantii Assemblage Zone of Richardson and McGregor 1986.

The entry of Densosporites devonicus and Acinosporites acanthomammillatus respectively in 1874 ft (572 m) and 1870 ft (570 m) marks the base of the Interval Zone AD Mac (Acanthomammillatus–devonicus Oppel Zone, macrospinosis Interval Zone). The true first appearance of Grandispora velata should probably be searched for in the unsampled interval 1950 ft (595 m)–1874 ft (572 m).

Geminispora lemurata first occurs in the sample at 1480 ft (451 m). Geminispora punctata occurs below this level. Therefore the 1480 ft (451 m) level should not be far from the base of the Interval Zone AD Lem (acanthe
mammillatus–devonicus Oppel Zone, lemurata Interval Zone).

The successive first occurrences of Samarisporites triangulatus, Chelinospora concinna and Lophozonotriletes media correspond respectively to the bases of the Oppel Zones TA (triangulatus–ancyrea), TCo (Triangulatus–concinna) and BM (bulliferus–media). The lack of sample between 1074 ft (328 m) and 976 ft (298 m) does not allow the recognition of the first occurrence of Verrucosisporites bulliferus which marks the base of the Bj (bulliferus–jehowychskyi) Oppel Zone in the Ardenne–Rhenish regions.

The uppermost sample at 650 ft (198 m) contains, amongst other miospores, Auroraspora hyalina and Rugospora bricei (syn.: R. c. flexuosa in Loboziaik and Streek, 1981). Both species occur within Zone IV in the Boulonnais area in northern France (Loboziaik et al., 1983). The lack of sample between 920 ft (281 m) and 650 ft (198 m) prevents us to locate the base of that Zone (IV) in the borehole A1-69.

In this borehole, the first occurrences of the characteristic species are distributed in the same stratigraphic sequence as in the Ardenne–Rhenish reference biozonation. As no other biostratigraphic data nor any lithostratigraphic correlation are available in this borehole, we have no reason to challenge the geological ages deduced from this biozonation. The section ranges from the Emsian to the late Frasnian and there is no miospore evidence for the presence of the Famennian Stage in the uppermost part of the borehole.

The base of the Eifelian Stage in the type area of the Eifel occurs between the entry of Grandispora protea and the entry of G. velata. In this borehole A1-69, the base of the Eifelian Stage is somewhere between 2030 ft (619 m) and 1874 ft (572 m).

There is as yet no internationally accepted position for the base of the Givetian. Most of the proposals however are within the range of the conodont ensensis zone. Spores are not known in the classic region of Givet in the Ardenne due to adverse sedimentary conditions. However, in the Eifel, spores are present.

Geminorspora lemurata first occurs, in this region, within the ensensis zone which implies not far from the proposed bases of the Givetian stage.

In the borehole A1-69, G. lemurata occurs in sample 1480 ft (451 m).

The range of the TCo zone spans the base of the Frasnian stage in the Ardenne (Streeel et al., 1987) and the stage boundary cannot therefore be defined accurately using miospores. In this borehole A1-69, the Givetian/Frasnian boundary is taken between 1109 ft (338 m) and 976 ft (298 m).

In conclusion, it appears that the Eifelian and early Givetian stages are represented in this borehole by a much thicker sequence of rocks than the Upper Devonian, a situation also matched in eastern Libya (Streeel et al., 1988).

Comparisons with the other boreholes

Borehole C1-49

The sample at 1170 m carries Synorisporites libycus, Emphanisporites annulatus, Diatomozonotriletes franklinii, Emphanisporites rotatus, Grandispora protea, Acinosporites lindlarenensis, Samarisporites eximius, S. praetervisus, Grandispora velata and Craspedispora ghadamensis.

Borehole MG1

Samples at 2221 m, 2232.6 m and 2234 m carry Emphanisporites annulatus, Diatomozonotriletes franklinii, Emphanisporites rotatus, Samarisporites eximius, Acinosporites macrospinurus, Densoisporites devonicus, Acinosporites anathomammillatus, Grandispora riegeli, Verrucosisporites cf. uncatus, V. scurrus, Geminorspora punctata, Grandispora inculata, Verrucosisporites prennus, Grandispora libyensis, Chelinospora timanica, Archaeozonotriletes variabilis and Grandispora cassidea. In the Eifel region, V. cf. uncatus first occurs about at the same level as Geminorspora lemurata (Streeel et al., 1987).
Borehole D1-26


These results allow comparisons to be drawn between the borehole A1-69 biostratigraphy and the limited number of samples from the three other boreholes. They are given on the chart (Fig.2). The samples from boreholes C1-49 and MG1 are Eifelian, the sample from borehole D1-26 is Frasnian.

If the samples investigated in the boreholes C1-49 and MG1 do really belong to the Awaysat Wanin Formation II and III (D.Massa, pers. commun., 1987), we have to conclude that these formations are there of Eifelian age.

A similar conclusion was also suggested by Streel et al. (1988, table 1) based only on a stratigraphical interpretation of the then published miospores in western Libya.

Conclusions

The study of 55 species of miospores (including 7 new species) taken from 4 boreholes of the Ghadamis Basin leads to the following conclusions:

1) In borehole A1-69, the first occurrences of the characteristic miospores are distributed in the same stratigraphic sequence as in the Ardenne-Rhenish reference biozonation. Chronostratigraphic correlations made through this biozonation give an Emsian to late Frasnian age for the 33 samples studied between 2103 ft (641 m) and 650 ft (198 m) in this borehole.

2) The Eifelian and early Givetian Stages are represented in this borehole by a much thicker sequence of rocks than the Upper Devonian, a situation also noticed in eastern Libya.

3) The samples belonging to the Awaysat Wanin Formations II and III in the boreholes C1-49 and MG1 are Eifelian.

The 55 species of miospores studied represent most of the species present in these assemblages. We have not taken into account Laevigate and apiculate, sometimes retusoid, miospores where the lack of characteristic features does not permit specific determination. We have also neglected a few specimens which probably belong to new species but which were present in too small numbers.

From these 55 species almost 90% are also found in the Old Red Sandstone Continent. This remark is important as it shows that, since the Emsian at least, the respective position of Gondwanaland and Old Red Sandstone Continent have been close enough to allow the general exchange of terrestrial plants (see also Young, 1987).

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