Middle Devonian (Givetian) megaspores from Belgium (Ronquières) and Libya (A1-69 borehole)

[Les mégaspores du Dévonien moyen (Givétien) de Belgique (Ronquières) et de Libye (sondage A1-69)]

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Mots-Clefs : Mégaspores ; Dévonien moyen ; Givétien ; Belgique ; Libye ; biodiversité

1 - Introduction

Preliminary results are presented on newly discovered megaspore assemblages recovered from Givetian localities at Ronquières, Belgium, and a borehole (A1-69) drilled in the Ghadames Basin, Libya, by SHELL in 1959. The miospore biostratigraphy of the Ronquières and of A1-69 borehole sections has been published (VILLE de GOYET, 2005; GERRIENNE *et alii*, 2004; LOBOZIAK & STREEL, 1989; LOBOZIAK *et alii*, 1992; STREEL *et alii*, 1990).

2 - Material and methods

Thirty-six samples have been studied to date. Eighteen are from the "Plan Incliné de Ronquières" section. Their weight ranged between 60 to 75 g. Most of the samples found productive are grey sandstone. The eighteen Libyan samples are from the collections of the University of Liège. Their weight ranged from 4 to 23 g. They are grey sandstone and sandy clay.

The Libyan samples were immersed in 40% hydrofluoric acid for 3 to 5 days and the Belgian sediments from 5 to 13 days. The rock dissolution was facilitated by a 0.5-1 mm sieve placed under the sample. In consequence, the sediments were constantly surrounded by acid, and the acid insoluble residue dropped through the sieve mesh to the bottom of the container during processing. The sample is thus not coated by acid-insoluble material.

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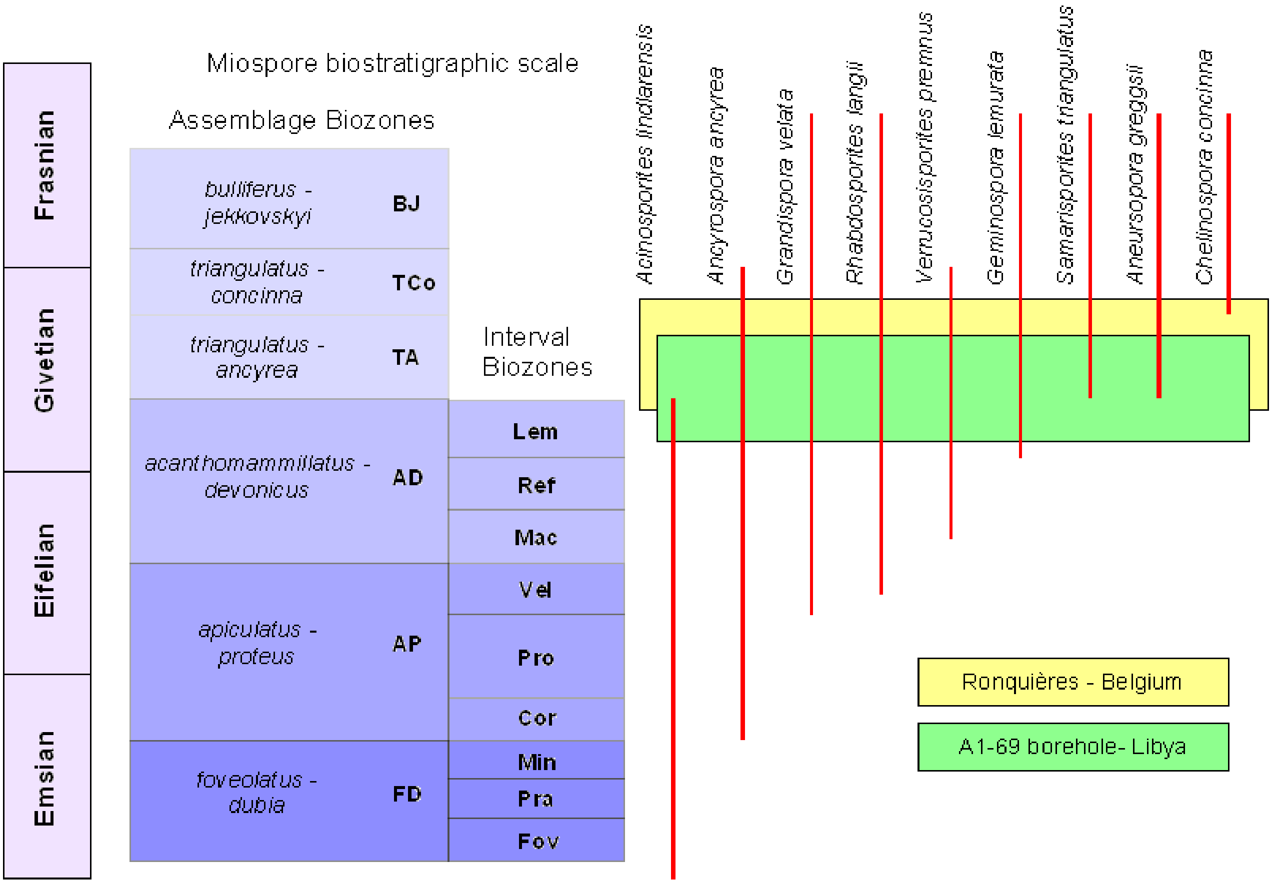

Figure 1: Biostratigraphic extension of selected species observed in the Ronquières and A1-69 borehole sections. The green and yellow rectangles represent the stratigraphic range of the samples containing megaspores. Biostratigraphic scale after Streel *et alii* (1987).

All residues were washed through a 150 µm sieve. The fraction of the residue less than 150 µm in diameter was re-sieved in order to collect miospores.

Megaspores were located using a dissecting microscope at high magnification (up to 70x). They were picked with a pipette and then placed over a slide on which lines had been engraved. After examination of the upper surface of the megaspore using the SEM, a drop of water was placed on the specimens. This induced the formation of an air bubble under the specimens; so they could be turned over to observe the opposite surface.

3 - Results

3.1. Ronquières

3.1.1. Geographical and geological data

Ronquières is located in the Walloon Brabant Province between the cities of Braine-le-Comte and Nivelles (x=50°36'30"N, y=4°13'30"E). The section is situated at the "Plan Incliné de Ronquières".

The sediments of the Givetian at Ronquières are on the northern flank of the Namur Syncline. The megaspores were isolated from grey sandstones in the Bois de Planti Member of the Bois de Bordeaux Formation (Bultynck & Dejonghe, 2002; Hennebert & Eggermont, 2002). Most of these sediments were deposited in a fluvial to near-shore environment. One megaspore-rich level also yielded the proto-ovule *Runcaria* Stockmans, recently redescribed by Gerrienne *et alii* (2004). This level is no longer accessible.

During Middle Devonian times Belgium was in the Southern Hemisphere on the Euramerican Plate at 20°S.

3.1.2. Stratigraphic palynology

The stratigraphic range of the biostratigraphically most characteristic miospores from the "Plan Incliné de Ronquières" are illustrated in Figure 1. The miospore assemblage includes, among other species, *Acinosporites lindlarensis* Riegel 1968, *Ancyrospora ancyrea* var. *ancyrea* Richardson 1965, *Grandispora velata* (Eisenack) Playford 1971, *Rhabdosporites langii* (Eisenack) Richardson 1960, *Verrucosisporites premnus* (Richardson) Richardson 1965, *Geminospora lemurata* Balme 1962, *Chelinospora concinna* Allen 1965, *Samarisporites triangulatus* Allen 1965 and *Aneurospora greggsii* (McGregor) Streel 1974.

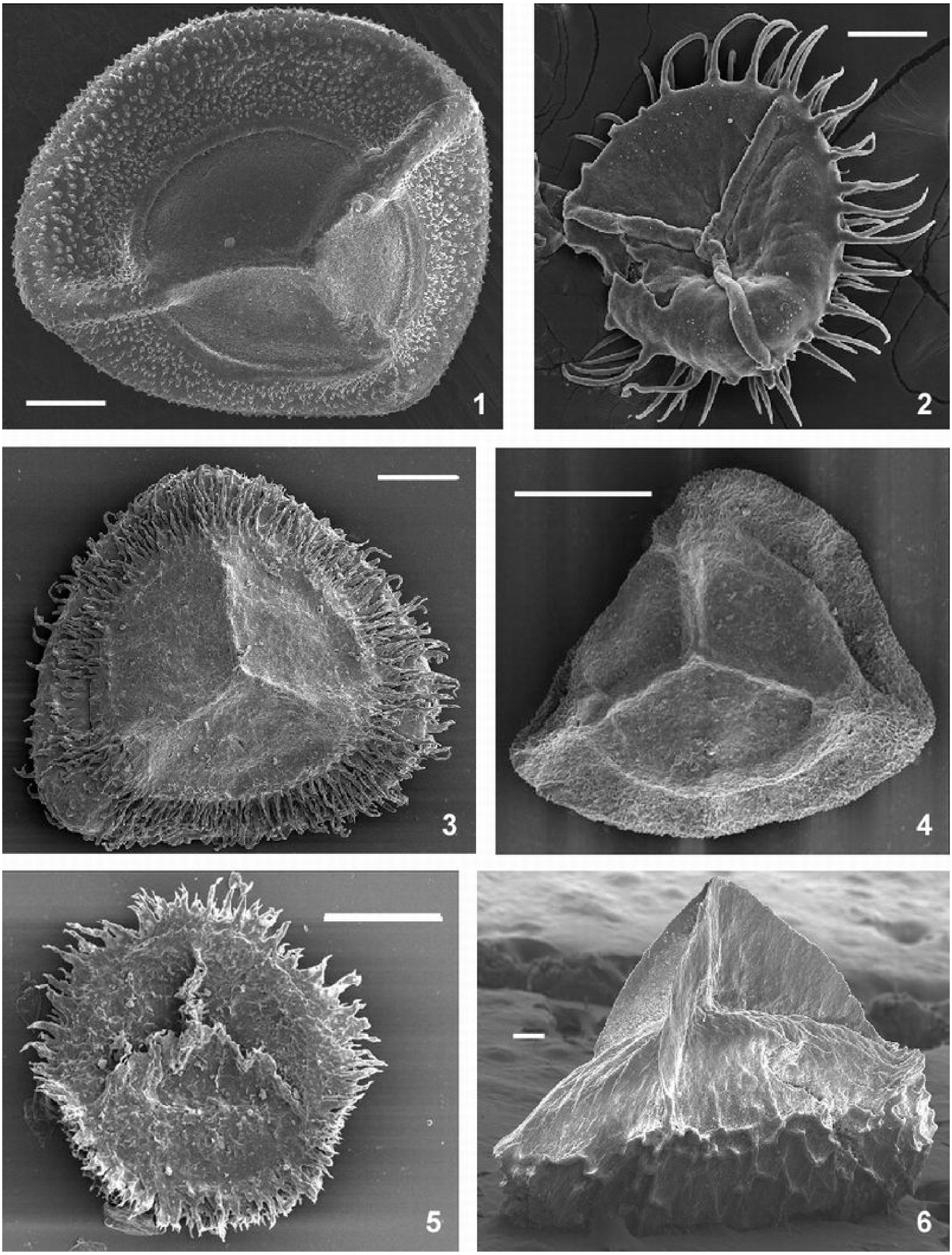

Plate 1: Some selected miospores from the Ronquières and A1-69 borehole sections (scale bars = 100 µm):
figure 1. *Contagisporites optivus* (CHIBRIKOVA 1959) var. *optivus* OWENS 1971. Libyan specimen;
figure 2. *Heliotriletes longispinosus* FUGLEWICZ et PREJBISZ 1981. Libyan specimen ;
figure 3. *Biharisporites* sp. Belgian specimen;
figure 4. *Contagisporites optivus* (CHIBRIKOVA 1959) var. *optivus* OWENS 1971. Belgian specimen;
figure 5. *Corystisporites multispinosus* RICHARDSON 1965. Belgian specimen;
figure 6. Undetermined specimen showing a large gula. Libyan specimen.

Those species indicate that the sediments of Ronquières range from the uppermost part of the Lem Interval Zone (*G. lemurata* Interval Zone) of the AD Oppel Zone (*A. acanthomammillatus - D. devonicus* Oppel Zone) to the lowermost part of the TCo Oppel Zone (*S. triangulatus - C. concinna* Oppel Zone) (STREEL *et alii*, 1987). The Ronquières locality is thus middle to late Givetian in age.

3.1.3. Megaspore assemblage description

Nineteen megaspore morphotypes were recognized. The specimens are black and have been altered by thermal diagenesis and damaged by pyritization. This megaspore assemblage is the richest ever described of Givetian age (VILLE de GOYET, 2005).

The megaspores are 200 to 800 µm in diameter. Most are circular; a few others are subtriangular in outline. The labra of the trilete mark can be very high (up to 35 µm) to nonexistent and curvaturae may or may not be present. Their ornamentation can consist of grana, coni, spinae, large appendices, or of a reticulum. The maximum length of the ornamentation ranges from 1.5 to 71.6 µm.

Contagisporites optivus (CHIBRIKOVA) var. *optivus* OWENS 1971 (Pl. 1, fig. 4), and *Corystisporites multispinosus* RICHARDSON 1965 (Pl. 1, fig. 5) have been identified from this assemblage.

3.2. Borehole A1-69

3.2.1. Geographical and geological data

The A1-69 borehole is located in the Ghadames Basin of northwestern Libya (X=29°03'50", Y=13°40'13"E). The 18 samples studied are from the interval 1,074 feet (327 m) to 1,486 feet (453 m).

The samples are from the Ouenine II Formation of the Aywanat Wanin Group (MASSA, 1988). The Ouenine II Formation consists of more than 80 m of a greyish green finely bedded argillaceous sequence with three interbedded sandy units. It is a typical deltaic facies.

The paleogeographic position of Libya during the Middle Devonian was at 40°S on the northern margin of the Gondwana plate.

3.2.2. Stratigraphic palynology

The stratigraphic range of the most characteristic miospores in borehole A1-69 is shown on Figure 1.

The miospore assemblage includes, among other species, *A. lindlarensis, Grandispora protea* (NAUMOVA) MOREAU-BENOIT 1980, *Emphanisporites rotatus* (MCGREGOR) MCGREGOR 1973, *Grandispora megaformis* (RICHARDSON) MCGREGOR 1973, *R. langii* (EISENACK) RICHARDSON 1960, *Grandispora libyensis* MOREAU-BENOIT 1980, *V. premnus* (RICHARDSON) RICHARDSON 1965 and *S. triangulatus*. This indicates that the Libyan sediments range from the uppermost part of the Lem Interval Zone to the TA Oppel Zone (*S. triangulatus - A. ancyrea* Oppel Zone). They are thus middle to late Givetian in age. Hence the samples from Ronquières and Libya are contemporaneous.

3.2.3. Megaspore assemblage description

Twelve megaspore morphotypes have been differentiated. Megaspores range in color from light orange to dark brown and are very well preserved. A few specimens have been altered by pyrite.

Most of the megaspores are circular, but some are subtriangular in outline. The labra of the trilete mark of some specimens are very high (up to 47.9 µm). The contact area is either poorly defined or is well marked by a circular thickening, a depression, or ornamentation. All megaspores from this borehole are ornamented. The length of the ornament ranges from 3.6 to 186.3 µm.

Only *Contagisporites optivus* var. *optivus* (Pl. 1, fig. 1) and *Heliotriletes longispinosus* FUGLEWICZ et PREJBISZ 1981 (Pl. 1, fig. 2) have been identified. Some megaspores from this borehole are so well preserved that we are able to see the ultrastructure of the outer wall and to distinguish differences between the exine layers.

We found some very large megaspores with a maximum diameter of 1000 µm and a length of up to 2000 µm. Some of these megaspores possess a hologula that may reach 1000 µm. They have a spinate or reticulate ornamentation on the central body. The hologula is smooth (Pl. 1, fig. 6).

4 - Discussion

Sediments from both localities are coeval and deposited in very similar paleoenvironments: continental to deltaic for Ronquières and clearly deltaic for the A1-69 borehole. The palaeoclimate of each region was discrete, however, warm and arid in Belgium and warm temperate and wet in Libya (SCOTESE, 2001).

Cross-plot of maximum ornamentation length / maximum diameter of the megaspores from the two areas reveal marked differences. Most of the Libyan megaspores are located in a group characterised by large scale ornamentation (above 50 µm) and sizes ranging from 300 to 450 µm, while in most of the specimens of the Belgian material the length of the ornament ranges from 0 to 50 µm.

The megaspore assemblages from the 2 localities contain many morphotypes as yet undescribed. And they are very different from each over. Indeed, *C. optivus* var. *optivus* is the only species present in both localities. In contrast to the disparate megaspore assemblages, there are many more correspondences in the respective miospore assemblages (42% of miospore species of Ronquières were also recovered from the Libyan borehole). The coefficient of similarity (CLARK & HARTEBERG, 1983) is moderate to high for miospores (20.83%), but very low for megaspores (3.23%). As the two localities are on widely separated palaeoplates, this difference in coefficients could reflect the fact that because of their smaller size miospores are more easily transported by wind. DILCHER *et alii* (1992) concluded that many Devonian heterosporous plants were probably aquatic. On the contrary, miospore-producers lived in many different biotopes ranging from dry to humid. The fact that megaspores are rarely transported by wind and that they may be produced by a plant living in a restricted aquatic biotope might force a high level of endemism. The presence of processes (spinate, bifurcate processes) on most of them (81% of all specimens) may corroborate the hypothesis regarding functional morphology proposed by DILCHER *et alii* (1992) for the processes of Devonian spores. They suggest that the morphological characters of megaspores may have been developed to provide buoyancy, movement or attachment for some plants living permanently, temporarily or for a particular phase of their life cycle in an aquatic environment. Alternatively, these processes may have been used to facilitate the adherence of the microspores.

Very large megaspores, comparable to those we collected from the Libyan borehole, are extremely rare in sediments older than Carboniferous (CHALONER, 1967; TRAVERSE, 1988) with the exception of that reported in the Bois de Bordeaux Formation by STOCKMANS and STREEL (1969). TEM study of specimens will help to determine whether or not our megaspores possess an ultrastructure indicating lycopsid affinities (CHALONER, 1980; BRACK-HANES, 1981).

5 - Conclusions

Those results show that:

1) static dissolution of sediments allows isolation of some fragile large palynomorphs;

2) the biodiversity of Givetian megaspores is greater than that assumed previously. A total of 30 different morphotypes have been recognized from Ronquières and from the borehole A1-69 from Libya, with only one species common to both localities;

3) evolution in the size of megaspores occured earlier and took place more rapidly than expected;

4) process morphology could be either an adaptation to an aquatic environment (DILCHER *et alii*, 1992) and/or due to climatic factors.

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