

Updating Frasnian miospore zonation from the Boulonnais (Northern France) and comparison with new data from the Upper Palaeozoic cover on the Brabant Massif (Western Belgium)

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ABSTRACT. Accurate palyno-analysis by S. Loboziak (from 1980 to 1983) of 28 samples from the Upper Givetian to the Middle Frasnian Blacourt, Beaulieu and Ferques Formations and of 44 samples of the Upper Frasnian to the Lower Famennian Hydrequent Formation are re-evaluated. *Chelinospora concinna*, *Verrucosporites bulliferus*, *Cirratiradites jekhowskyi*, *Lophozonotriletes media* first occurrences are major criteria for Lower and Middle Frasnian, well calibrated by conodonts. *Cymbosporites acanthaceus*, *Rugospora bricei*, *Grandispora gracilis*, *Diducites plicabilis*, *Corbulispora vimineus* first occurrences allow to subdivide the Upper Frasnian where conodonts are poorly present. *Samarisporites triangulatus* versus *Auroraspora pseudocrista* taxonomy and stratigraphic significance are discussed.

The reconnaissance borehole Nieuwkerke-De Seule (95W152), near the limit of the Upper Palaeozoic subcrop on the Brabant Massif (West Flanders, Belgium, 75 km east of the Boulonnais), which has intersected conodont-dated Givetian/Frasnian boundary at the transition between the Bois de Bordeaux and Bovesse Formations, contained poorly preserved miospores attributed to the *triangulatus–concinna* (TCo) Opper Zones. In the nearby Nieuwkerke-Noordhoek borehole (95W153), strata also assigned to the Bovesse Formation yielded better preserved miospores which demonstrate a close succession of *triangulatus–concinna* (TCo) and *bulliferus–jekhowskyi* (BJ) Opper Zones at the transition Lower–Middle Frasnian, also known in the Beaulieu Formation in the Boulonnais.

Samples from the Heuveland groundwater monitoring well (95W175), 10 km north of Nieuwkerke, contain the *bricei–acanthaceus* (BA) Opper Zone suggesting a late Frasnian age, also known in the Hydrequent Formation in the Boulonnais area and in the Booisshot Formation in the Booisshot borehole (59E146) from the Campine Basin (Belgium).

International correlation using Frasnian miospore zonation is attempted between the Pripyat Depression in Belarus, the Timan–Pechora province in Russia and North-West China.

KEYWORDS: biostratigraphy, Opper Zones, Boulonnais, Flanders, Russia, China.

1. Introduction

Former accurate palyno-analysis from the Upper Givetian to the Lower Famennian in the Boulonnais (Northern France), made some forty years ago, had to be re-evaluated. Consequently, stratigraphic correlations, across the French–Belgium Boundary, between the Boulonnais and boreholes in West and East Flanders have to be revised. Some international correlations with Central and Eastern Europe and North-West China will also be made possible.

1.1. History

Frasnian miospores from the Boulonnais (Northern France) were first described and illustrated from one sample collected in the Beaulieu Formation believed to belong to the Lower Frasnian (Taugourdeau-Lantz, 1960). Most taxa were tentatively identified by comparison with the rich Upper Devonian miospore drawings from the Russian Platform (Naumova, 1953). Several species were updated and re-illustrated in further papers (Taugourdeau-Lantz, 1967a, b), a first palyno-stratigraphic chart covering the whole Frasnian being given in Taugourdeau-Lantz (1967a). The stratigraphic chart, illustration and description of miospores were again updated (Taugourdeau-Lantz, 1971).

A new section showing in succession the Blacourt Formation and the Beaulieu Formation was then made available in the railway track Caffiers–Ferques allowing, among other fossils, ten conodont faunas to be identified (Brice et al., 1979). These new detailed stratigraphic data have encouraged us to restudy the miospores produced in three papers concerning respectively the Givetian–Lower Frasnian (Loboziak & Streel, 1980) and the Middle–Upper Frasnian to Lower Famennian (Loboziak & Streel, 1981; Loboziak et al., 1983). All taxa received an identification number (from 1 to 79, see Table 1)

reused in a next paper (Loboziak & Streel, 1988) establishing a succession of four formal Opper Zones: *Samarisporites triangulatus–Rhabdosporites langi* (TLa) renamed (Streel et al., 1987), *S. triangulatus–Ancyrospora ancyrea ancyrea* (TA), *S. triangulatus–Chelinospora concinna* (TCo), *Verrucosporites bulliferus–Cirratiradites jekhowskyi* (BJ), *V. bulliferus–Lophozonotriletes media* (BM) and two informal Zones (IV and V), that were not defined in that paper. These two unformal zones were characterised and subdivided by Streel (2009) as *Rugospora bricei–Cymbosporites acanthaceus* (BA) and *Knoxisporites dedaleus–Diducites versabilis* (DV) Opper Zones.

The former TLa Zone, now renamed TA Zone, is typified by the composition of sample G-02 at the base of the Blacourt Formation in the Griset quarry; the TCo Zone is typified by the composition of sample H26 in the upper part of the same formation in the Ferques railroad trench; the BJ Zone is typified by the composition of sample sequence Q52 to Q56 in the Beaulieu Formation in the Ferques railroad trench; the BM Zone is typified by the composition of samples VW5 and VW8 in the Ferques Formation in the Bois quarry (Loboziak & Streel, 1981). The BA Zone, mainly studied in the 23 m of shales above the dolomitic bed (Loboziak et al., 1983, fig. 1) in the Hydrequent Formation in the “Briqueterie de Beaulieu” quarry, is more complex, requiring probably several characteristic samples to typify the subdivisions A to E (Fig. 1). The base of the DV Zone in the same quarry, could be typified by sample 109 (this paper).

1.2. Correlation with other microfossils

The base of TA Zone probably occurs in or below the conodont Middle *varcus* Zone (FIV on Fig. 1), the base of the TCo Zone ranging from the conodont (FV) Upper *varcus* to the Lower *asymmetricus* Zone (Bultynck in Streel et al., 1987). BJ and BM

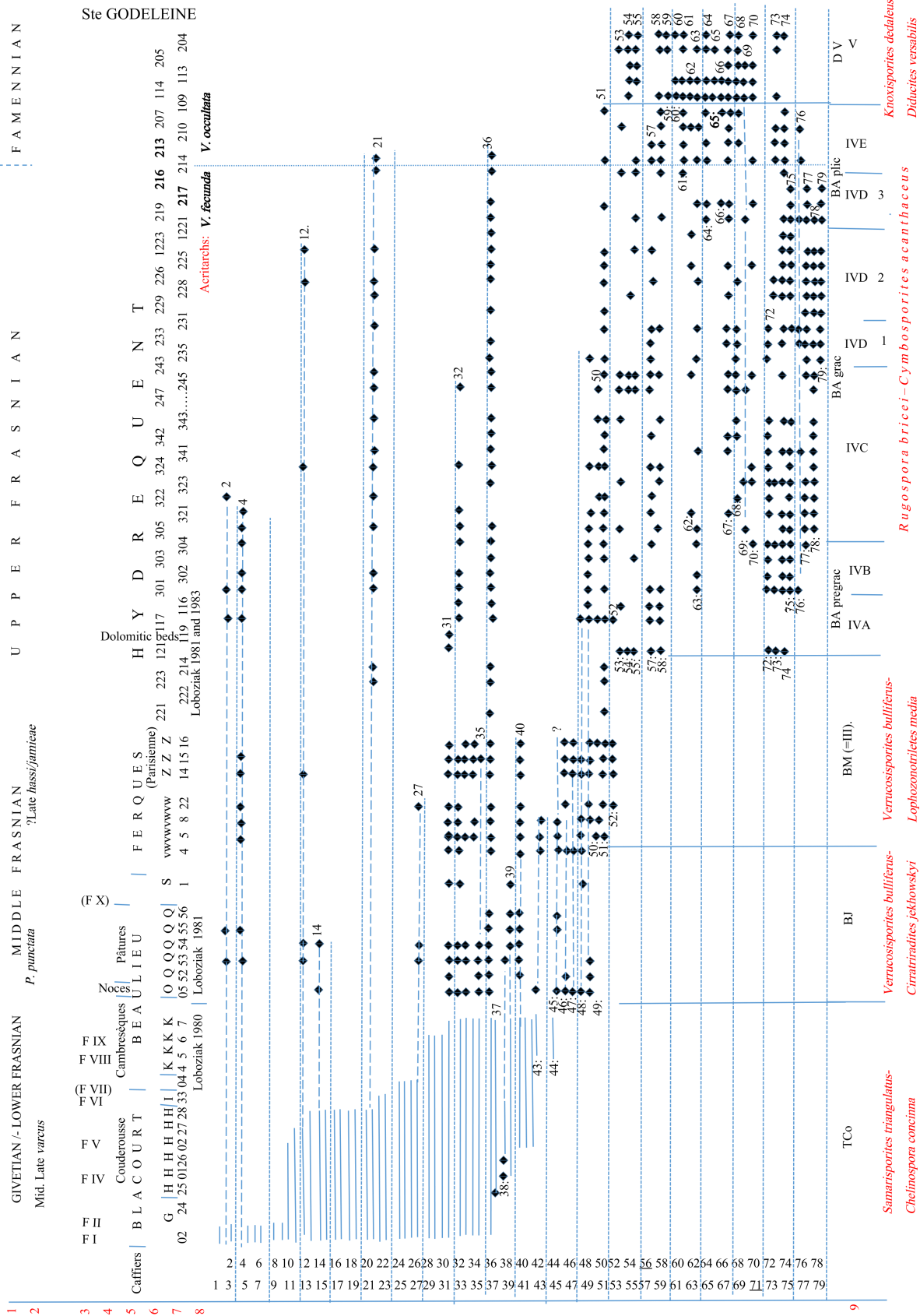


Figure 1. 1: chronostratigraphy; 2, 3: conodont faunas (Brice et al., 1979); 4, 5, 6: lithostratigraphy (note that there is no scale for the thickness of the formations); 7: samples with miospores; 8: period of miospores analysis by S. Loboziak; 9: miospore zones. Taxa 56 and 71 are not displayed.

Identification number	Taxa
1	<i>Aneurospora</i> cf. <i>heterodonta</i> (Naumova) Stree1 1972. = <i>Acinosporites lindlarensis</i> Riegel 1968 (Richardson et al., 1993)
2	<i>Archaeozonotriletes variabilis</i> (Naumova) Allen 1965
3	<i>Brochotriletes</i> sp.
4	<i>Convolutispora disparilis</i> Allen 1965
5	<i>Convolutispora paraverrucata</i> McGregor 1964
6	<i>Dibolisporites</i> cf. <i>gibberosus</i> (Naumova) Richardson 1965
7	<i>Grandispora douglastownense</i> McGregor 1973
8	<i>Rhabdosporites langi</i> (Eisenack) Richardson 1960
9	<i>Verruciretusispora pallida</i> (McGregor) Owens 1971
10	<i>Acanthotriletes</i> cf. <i>horridus</i> Hacquebard 1957 <i>sensu</i> Richardson 1965
11	<i>Aneurospora goensis</i> Stree1 1964 = <i>Geminospora expansa</i> (Naumova) Gao in Obukhovskaya 2000
12	<i>Contagisporites optivus</i> var <i>vorobjevensis</i> (Chibrikova) Owens 1971
13	<i>Ancyrospora ancyrea</i> var <i>ancyrea</i> Richardson 1962
14	<i>Ancyrospora ancyrea</i> var <i>brevispinosa</i> Richardson 1962
15	<i>Ancyrospora loganii</i> McGregor 1973
16	<i>Auroraspora macromanifesta</i> (Hacquebard) Richardson 1960
17	<i>Auroraspora micromanifesta</i> (Hacquebard) Richardson 1960
18	<i>Bullatisporites</i> aff. <i>bullatus</i> Allen 1965
19	<i>Cirratriradites dissutus</i> Allen 1965
20	<i>Cymbosporites</i> cf. <i>cyathus</i> Allen 1965
21	<i>Grandispora inculata</i> Allen 1965
22	<i>Grandispora velata</i> (Eisenack) McGregor 1973
23	<i>Samarisporites inaequus</i> (McGregor) Owens 1971
24	<i>Aneurospora greggsii</i> (McGregor) Stree1 1974
25	<i>Biornatispora reticulata</i> Lele & Stree1 1969
26	<i>Verrucosporites premnus</i> Richardson 1965
27	<i>Verrucosporites</i> cf. <i>uncatus</i> (Naumova) Richardson 1965
28	<i>Dibolisporites echinaceus</i> (Eisenack) Richardson 1965
29	<i>Emphanisporites</i> spp.
30	<i>Retusotriletes rugulatus</i> Riegel 1973 = <i>Scylaspora rugulata</i> (Riegel) Breuer et al. 2007
31	<i>Ancyrospora langii</i> (Taugourdeau-Lantz) Allen 1965
32	<i>Grandispora tomentosa</i> Taugourdeau-Lantz 1967b
33	<i>Hystricosporites</i> spp.
34	<i>Perotriletes ergatus</i> Allen 1965
35	<i>Rhabdosporites parvulus</i> Richardson 1965
36	<i>Samarisporites triangulatus</i> Allen 1965
37	<i>Ancyrospora angulata</i> Tiwari & Schaarschmidt 1975
38	<i>Chelinospora concinna</i> Allen 1965
39	<i>Cirratriradites jekhowskyi</i> Taugourdeau-Lantz 1967b
40	<i>Geminospora lemurata</i> Balme 1962
41	<i>Dibolisporites</i> sp. cf. <i>Lophotriletes atratus</i> (Naumova) <i>sensu</i> Stree1 1974
42	<i>Corystisporites multispinosus</i> Richardson 1965
43	<i>Convolutispora</i> cf. <i>subtilis</i> Owens 1971
44	<i>Verrucosporites</i> cf. <i>grandis</i> McGregor 1960
45	<i>Verrucosporites bulliferus</i> Richardson & McGregor 1986
46	<i>Ancyrospora simplex</i> Guennel 1963
47	<i>Hystricosporites multifurcatus</i> (Winslow) Mortimer & Chaloner 1967
48	<i>Convolutispora tegula</i> Allen 1965
49	<i>Planisporites scaber</i> Taugourdeau-Lantz 1967b
50	<i>Lophozonotriletes media</i> Taugourdeau-Lantz 1967b
51	<i>Pustulatisporites rugulatus</i> (Taugourdeau-Lantz) Loboziak & Stree1 1981
52	<i>Ancyrospora lysii</i> (Taugourdeau-Lantz) Loboziak & Stree1 1981
53	<i>Grandispora</i> cf. <i>tenispinosa</i> (Hacquebard) Playford 1971 in Stree1 1974
54	<i>Samarisporites</i> sp. A in Loboziak & Stree1 1981
55	<i>Diducites poljessicus</i> (Kedo) Van Veen 1981
56	<i>Grandispora</i> sp. A in Loboziak & Stree1 1981 <u>No records</u>
57	<i>Cymbosporites</i> sp. B in Loboziak & Stree1 1981 = <i>C. acanthaceus</i> (Kedo) Obukhovskaya in Obukhovskaya et al. 2000
58	<i>Rugospora</i> cf. <i>flexuosa</i> (Juschko) Stree1 1974 = <i>R. bricei</i> Loboziak & Stree1 1989
59	<i>Knoxisporites dedaleus</i> (Naumova) Stree1 1977
60	<i>Knoxisporites</i> cf. <i>hederatus</i> (Ishenko) Playford 1963
61	<i>Corbulispora</i> sp. in Loboziak & Stree1 1981 = <i>Corbulispora viminea</i> (Nekriata) Obukhovskaya & Nekriata in Obukhovskaya et al. 2000
62	<i>Auroraspora hyalina</i> (Naumova) Stree1 1974
63	<i>Auroraspora macra</i> Sullivan 1968
64	<i>Diducites plicabilis</i> Van Veen 1981
65	<i>Diducites versabilis</i> (Kedo) Van Veen 1981
66	<i>Auroraspora</i> sp. A in Loboziak & Stree1 1981
67	<i>Retusotriletes planus</i> Dolby & Neves 1970
68	<i>Cymbosporites</i> sp. A in Loboziak & Stree1 1981
69	<i>Grandispora gracilis</i> (Kedo) Stree1 1974
70	<i>Auroraspora solisorta</i> Hoffmeister, Staplin & Malloy 1955
71	<i>Densosporites</i> ssp. Loboziak & Stree1 1981 <u>No records</u>
72	<i>Verruciretusispora</i> sp. A in Loboziak, Stree1 & Vanguetaine 1983
73	? <i>Samarisporites</i> sp. B in Loboziak, Stree1 & Vanguetaine 1983
74	<i>Diducites mucronatus</i> (Kedo) Van Veen 1981
75	<i>Cymbosporites</i> sp. C in Loboziak, Stree1 & Vanguetaine 1983
76	<i>Samarisporites</i> sp. C in Loboziak, Stree1 & Vanguetaine 1983
77	<i>Aneurospora</i> sp. A in Loboziak, Stree1 & Vanguetaine 1983
78	<i>Aneurospora</i> sp. B in Loboziak, Stree1 & Vanguetaine 1983
79	<i>Samarisporites</i> sp. D in Loboziak, Stree1 & Vanguetaine 1983

Table 1. Identification numbers of taxa recorded on Figure 1, sorted by number. Taxa are sorted by names in Appendix.

Zones range from the conodont Lower *asymmetricus* Zone to as far as the conodont *Ancyrognathus triangularis* Zone (Brice et al., 1981).

We had attempted to provide a stratigraphic control of the Frasnian/Famennian Boundary (conodonts being poorly present in the Upper Frasnian of the Boulonnais), using acritarchs “dated” by conodonts in the type region from the Ardenne (Vanguestaine, 1986; Martin, 1993; Strel et al., 2000a). The conclusion was that the higher part of the BA Opper Zone (BA plic Subzone, starting with the first occurrence of *Diducites plicabilis* in Strel, 2009) ranges from the conodont upper *Palmatolepis gigas* Zone to the upper *Palmatolepis triangularis* Zone and contains therefore the base of the Famennian Stage (Ziegler & Sandberg, 1990).

The acritarch *Visbysphaera* (?) *fecunda* (Vf) Zone occurs in samples 217-216 of the Upper Frasnian Hydrequent Formation (Loboziak et al., 1983). The Famennian acritarch *Villocapsula globosa* (Vg) Zone is not recorded in that section. If one accepts the synonymy (Vanguestaine et al., 1983) of *Herkomorphytae* sp. A and *V. ? occultata*, as a good marker for the earliest Famennian in Belgium (Martin, 1993), then sample 213 of the Hydrequent Formation might be Famennian. A Frasnian/Famnennian Boundary drawn between samples 216 and 213 would match the top of several miospore species recorded in the Upper Frasnian Hydrequent Formation, i.e. *Cymbosporites* sp. C (75), *Aneurospora* sp. A (77), *A.* sp. B (78) and *Samarisporites* sp. D (79), illustrated and briefly described by Loboziak et al. (1983).

1.3. Comments on the first occurrence (FOB) of main taxa

Most of these papers show the range of each taxon by a line joining the first and last occurrences. This failed in not showing the quantity of data these ranges were built upon and did not enable us to evaluate the likelihood of the “presence” criterion. Figure 1 shows (according to data still available and unmodified), the presence of the selected taxa in each sample (28 samples of the Upper Givetian to the Middle Frasnian Blacourt, Beaulieu and Ferques Formations and 44 samples of the Upper Frasnian to the Lower Famennian Hydrequent Formation, all slides scanned by Stanislas Loboziak at Lille. The corresponding slides have not been revised for the present paper). One can observe then that *C. concinna* (38), *V. bulliferus* (45), *C. jekhowskyi* (39), *L. media* (50) first occurrences are major criteria for the Lower and Middle Frasnian, and that *C. acanthaceus* (57), *R. bricei* (58), *G. gracilis* (69), *D. plicabilis* (64) first occurrences allow the subdivision of the Upper Frasnian.

It might seem surprising that *Samarisporites triangulatus* Allen 1965 (syn.: *S. euglyphus* Taugourdeau-Lantz, 1967b, *Cristatisporites triangulatus* (Allen) McGregor & Camfield, 1982), the eponym species of TA and TCo Opper Zones, is not retained among the taxa listed here above. Its first occurrence is indeed controversial (Richardson & McGregor, 1986, fig. 6; Strel, 2009, fig. 3). It might be, in part, the result of differences of palynologist acceptance of the degree of the equatorial flange reaching its maximum width radially even if it is hardly perceptible in the inter-radial regions (Allen, 1965, p. 706). Compare, for instance, Allen (1965) plate 99, Richardson & McGregor (1986) plate 15, Loboziak et al. (1991) plate 2. It might also be that *Geminospora lemurata* (40) was not recognised in the few samples studied in the Blacourt Formation (Loboziak & Strel, 1980, fig. 1) or maybe confused with *Aneurospora greggsii* (24) (see Strel & Loboziak, 1987, p. 100) showing why *Geminospora lemurata* is recorded as being older than *Samarisporites triangulatus* in the Eifel (Loboziak et al., 1991) as in Canada and European Russia according to Richardson & McGregor (1986).

The stratigraphic range of *S. triangulatus* is also questionable. According to Richardson & McGregor (1986), it occurs in their *optivus-triangulatus* and *ovalis-bulliferus* assemblage Zones corresponding to the TA, TCo, BJ, BM and the lower part of BA Opper Zones. Allen (1982, figs 2 and 3) has recorded many occurrences of this species and possible synonyms in the Northern hemisphere and suggests they range from Upper Givetian to Middle Frasnian.

However, in the Boulonnais, we had noted *S. triangulatus* as high as the top of the Frasnian.

Allen (1982) explains that its stratigraphic value is enhanced by the fact that the characteristic zona with a maximum width radially, can usually be identified even in poorly preserved specimens. It should be noted that such poorly preserved specimens might as well correspond to *Auroraspora pseudocrista* Ahmed 1980 ranging from the uppermost Frasnian into the Famennian and which often demonstrates one or more maximum width radially.

2. The reconnaissance boreholes Nieuwerkerke-De Seule (95W152, renamed 110W7) and Nieuwerkerke-Noordhoek (95W153)

These partly cored boreholes were drilled near the limit of the Upper Palaeozoic subcrop on the Brabant Massif (West Flanders, Belgium, 75 km east of the Boulonnais) (Figs 2 and 3). They are north of the Brabant Parautochthon, and within the Upper Palaeozoic cover of the Brabant Massif unaffected by the Variscan orogeny (Belanger et al., 2012). All facies indications and correlations with the Tournai, Vieux-Leuze and Annapes boreholes suggest a correlation to the lower part of the Bovesse Formation (or Beaulieu Formation in the Boulonnais) of the Frasnian strata in the Nieuwerkerke boreholes (Coen-Aubert et al., 1980; Legrand, 1981; Dusar & Loy, 1986).

Nieuwerkerke-De Seule (95W152) which has penetrated conodont-dated Givetian/Frasnian boundary at the transition between the Mazy Member and the Bovesse Formation (Fig. 4), contained poorly preserved miospores attributed to the *Samarisporites triangulatus-Chelinospora concinna* (TCo) Opper Zone (Tourneur et al., 1989). They are listed on Table 2.

Nieuwerkerke-Noordhoek (95W153) provided three samples from the Bovesse Formation with rather well preserved miospores listed also on Table 2, suggesting proximity to the Lower/Middle Frasnian boundary.

The youngest sample (219 m) contains *Cirratriradites jekhowskyi* (39) with *Chelinospora concinna* (38), both taxa coexisting in the lower part of the *Verrucosisporites bulliferus-Cirratriradites jekhowskyi* (BJ) Opper Zone.

In the sample at 221.5 m, *Retusotriletes rugulatus* (30) and *Verrucosisporites bulliferus* (45) suggests a close proximity to the top of the *Samarisporites triangulatus-Chelinospora concinna* (TCo) Opper Zone and the base of the *Verrucosisporites bulliferus-Cirratriradites jekhowskyi* (BJ) Opper Zone.

In the sample 223.7 m, *Grandispora velata* (22) and *Corystisporites multifurcatus* (42) belong to the *Samarisporites triangulatus-Chelinospora concinna* (TCo) Opper Zone.

3. The Heuvelland groundwater monitoring well (95W175), in Westouter, 10 km north of Nieuwerkerke

This well has also penetrated Frasnian shales covering the Brabant Massif, albeit in a north dipping position resulting in the subcrop of younger strata. One cuttings sample from the interval 260.00–262.00 m, assigned to the Franc-Waret Formation, contains the taxa recorded on Table 3.

Diducites plicabilis (64) and *Grandispora gracilis* (69) belong to the upper part (BA plic) of the Opper Zone BA.

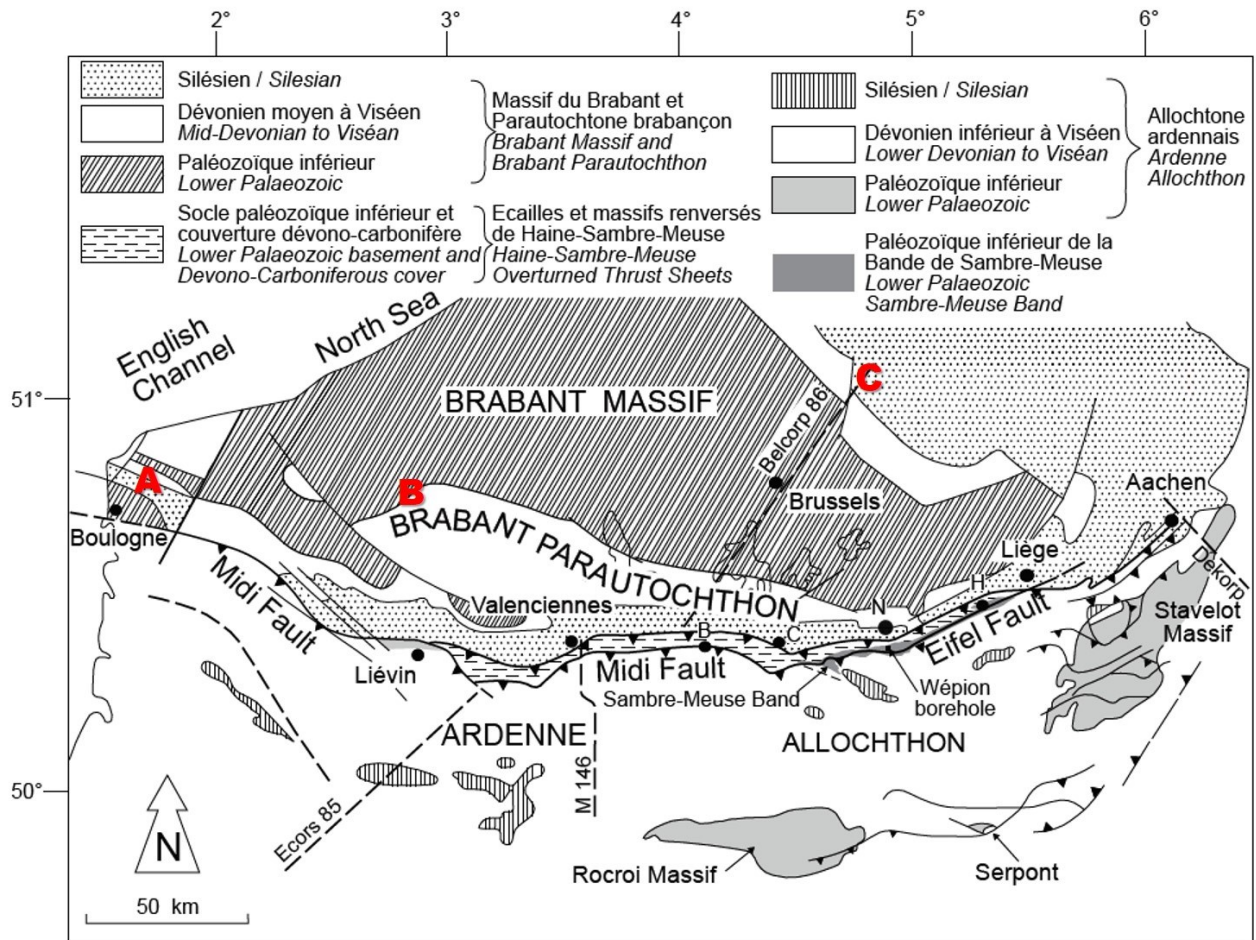


Figure 2. Location of studied boreholes and sections on a tectono-stratigraphic map showing their position in the Devonian cover sequence on the Lower Palaeozoic Brabant Massif (reprinted from Belanger et al., 2012, with permission of Geologica Belgica). A: Ferques section in the Palaeozoic core of the Boulonnais; B: Nieuwerkerke boreholes on the margin of the Brabant Parautochthon south of the Brabant Massif; C: Booischot borehole in Devonian half-graben on the margin of the Variscan Campine basin north of the Brabant Massif.

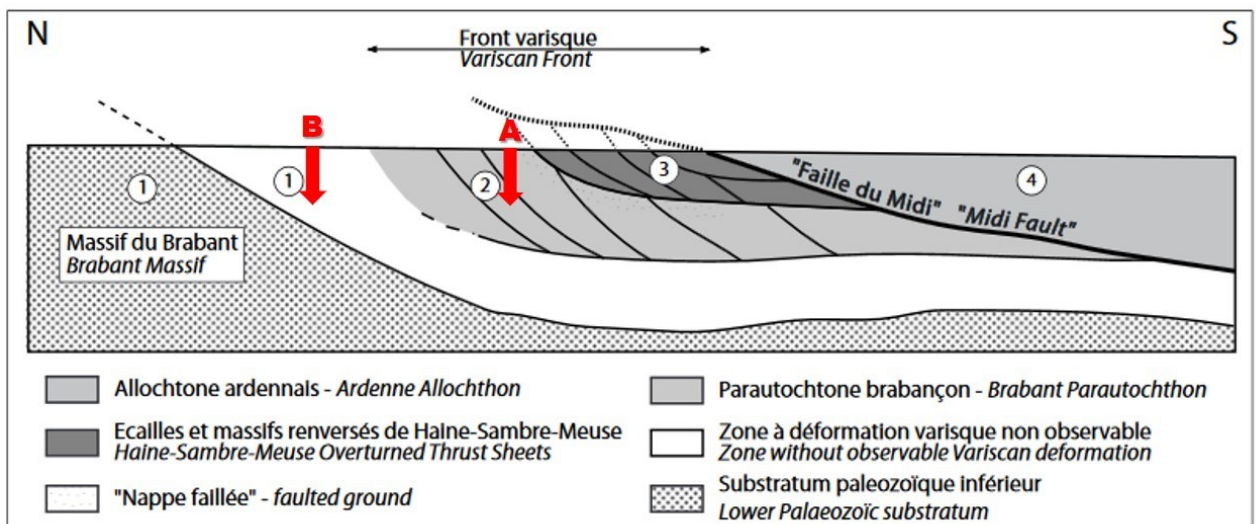


Figure 3. Schematic N-S profile between Brabant Massif and the Variscan Front (reprinted from Belanger et al., 2012, with permission of Geologica Belgica). Ferques section (A on Fig. 2) corresponds to the deformed zone 2; the Nieuwerkerke boreholes (B on Fig. 2) are located in the nearly undeformed northern margin of the Brabant Parautochthon at number 1; Booischot borehole (C on Fig. 2) is located north of the Brabant Massif outside this scheme but in an approximately symmetrical position to the undeformed zone 1 of the Brabant Parautochthon.

Table 2. Main taxa recorded in the boreholes Nieuwkerke-De Seule (95W152) and Nieuwkerke-Noordhoek (95W153). A: Identification numbers of taxa, B: List of taxa. C: Taxa recorded in Nieuwkerke (95W152) after Tourneur et al. (1989). D, E, F: Taxa recorded in the present paper in Nieuwkerke-Noordhoek (95W153): D = 223.7 m, E = 221.5 m, F = 219 m, this paper. FOB key species presences are underlined.

A	B	C	D	E	F
31	<i>Ancyrospora langii</i>	X			
37	<i>Ancyrospora angulata</i>		X		X
13	<i>Ancyrospora ancyrea ancyrea</i>	X			
24	<i>Aneurospora greggsii</i>		X	X	X
	<i>Auroraspora</i> aff. <i>pseudocrista</i>		X		
38	<i>Chelinospora concinna</i>				<u>X</u>
39	<i>Cirratriradites jekhowskyi</i>				<u>X</u>
42	<i>Corystisporites multispinosus</i>	X	<u>X</u>		
6	<i>Dibolisporites</i> cf. <i>gibberosus</i>	X			
28	<i>Dibolisporites echinaceus</i>				X
29	<i>Emphanisporites</i> spp.				X
40	<i>Geminospira lemurata</i>	X	X	X	X
22	<i>Grandispora velata</i>		<u>X</u>		
21	<i>Grandispora inculata</i>		X		
33	<i>Hystricosporites</i> spp.	X	X	X	
34	<i>Perotriletes ergatus</i>	X			
30	<i>Scylaspora rugulata</i>			<u>X</u>	
	<i>Retusotriletes confossus</i>		X		
35	<i>Rhabdosporites parvulus</i>	X			
36	<i>Samarisporites triangulatus</i>	X	X		
	<i>Samarisporites</i> sp. E		X		
45	<i>Verruosporites bulliferus</i>		?	X	
		TCo		?BJ	BJ

Table 3. Miospores recorded in the Heuvelland groundwater monitoring well (95W175).

Miospores
(14) <i>Ancyrospora ancyrea</i> var. <i>brevispinosa</i> Richardson 1962
(31) cf. <i>Ancyrospora langii</i> (Taugourdeau-Lantz) Allen 1965
(24) <i>Aneurospora greggsii</i> (McGregor) Strel 1974
aff. <i>Archaeoperisaccus</i> sp.
<i>Auroraspora pseudocrista</i> Ahmed 1980
(42) <i>Corystisporites multispinosus</i> Richardson 1965
(64) <i>Diducites plicabilis</i> Van Veen 1981
(29) <i>Emphanisporites</i> spp.
(69) <i>Grandispora gracilis</i> (Kedo) Strel 1974
(33) <i>Hystricosporites</i> spp.
<i>Pavonisporites costulatus</i> (Taugourdeau-Lantz) Taugourdeau-Lantz 1971
cf. <i>Lophozonotriletes lebedianensis</i> Naumova 1953
cf. <i>Retusotriletes crassus</i> Clayton et al. 1980
(36) <i>Samarisporites triangulatus</i> Allen 1965
<i>Samarisporites</i> sp. cf. <i>Acanthotriletes hirtus</i> Naumova 1953
(79) <i>Samarisporites</i> sp. D in Loboziak, Strel & Vanguetaine 1983
cf. <i>Teichertospora torquata</i> (Higgs) McGregor & Playford 1990

Samarisporites sp. E and *Pavonisporites costulatus* (Taugourdeau-Lantz) Taugourdeau-Lantz, 1971 are known in the Mid-Late Frasnian from the Booischoot borehole from the Brabant Massif (Strel & Loboziak, 1987). *Pavonisporites costulatus* (Taugourdeau-Lantz) Taugourdeau-Lantz, 1971 was originally recorded as *Lagenoisporites costulatus* by Taugourdeau-Lantz (1960) in the Middle Frasnian in the Boulonnais Region.

Auroraspora pseudocrista Ahmed 1980, *Teichertospora torquata* (Higgs) McGregor & Playford 1990 and *Lophozonotriletes lebedianensis* Naumova 1953 belong to the *torquata-gracilis* assemblage Zone of Richardson & McGregor 1986, ranging from the uppermost Frasnian up to the Famennian.

In conclusion the sample contains the *bricei-acanthaceus* (BA) Opper Zone suggesting an Upper Frasnian age, also known in the Hydrequent Formation in the Boulonnais (France) and in the Booischoot Formation in the Booischoot borehole (59E146) from the Campine Basin (Belgium) (see Coen-Aubert, 2014).

4. The Booischoot borehole (59E146) from the Campine Basin (Belgium)

The Booischoot geological reconnaissance borehole (59E146), drilled in the Campine Basin, north of the Brabant Massif (Figs 2 and 4), encountered at the base of Upper Palaeozoic a thick sequence of red and green conglomerates, assigned to the Booischoot Formation (Lagrou & Coen-Aubert, 2017). The upper part of the Booischoot Formation had been investigated by Strel (1965) and Strel & Loboziak (1987). Between 1002 and 994.5 m, the *Verrucosporites bulliferus*–*Lophozonotriletes media* (BM) Opper Zone recognised by Strel & Loboziak (1987) is correlated in the Boulonnais, with the conodont zones occurring between the Middle *Polygnathus asymmetricus* and *Ancyrognathus triangularis* Zones. Higher in the borehole, Strel & Loboziak (1987) identified between 940 m and 900.5 m the miospore interval Zones IV A, C and E present in the upper part of the Hydrequent Formation from the Boulonnais. Their miospore zonation as well as the distribution of characteristic miospores and acritarchs have been reviewed by Strel et al. (2000a, p. 131, fig. 13). In this paper, the authors correlated the miospore Zones IV B, C and partly D with the Upper *Palmatolepis rhenana* conodont Zone (see Coen-Aubert, 2014; Lagrou & Coen-Aubert, 2017). Strel (2009) had renamed the IV Regional Zone as the *Rugospora bricei*–*Cymbosporites acanthaceus* (BA) Opper Zone and the V Regional Zone as the *Knoxisporites dedaleus*–*Diducites versabilis* (DV) Opper Zone.

5. Nomenclatural notice

Several species of *Samarisporites* first occurring in the BA Zone were illustrated but left in open nomenclature by Loboziak & Strel (1981), Loboziak et al. (1983) and Strel & Loboziak (1987). The opportunity is now taken to regularise their status.

Samarisporites sp. A (54) in Loboziak & Strel, 1981, plate II: 7, 8.

1965. “Gen. nov.” in Strel 1965, plate 1: 4–6.

1974. *Samarisporites* sp. cf. *Hymenozonotriletes acanthyrugosus* Chibrikova 1959 in Becker et al. 1974, pl. 18: 8.

1987. *Samarisporites* sp. A in Strel & Loboziak 1987, plate 1: 7.

Thick, often dark, spherical central body and thin narrow equatorial wing, sometimes slightly expanding in front of the trilete rays. Ornaments are mainly composed, on the distal and equatorial surfaces, of narrow spines, 2–3 µm high. Comparable with *Samarisporites* sp. 2 in Breuer & Steemans (2013), which differs in being significantly bigger.

?*Samarisporites* sp. B (73) in Loboziak, Strel & Vanguetaine 1983, plate 1:11.

Rounded central body and a reticulate ornamentation with a broad mesh (fields are 10 µm in diameter) and high (2–5 µm high) diaphanous muri which might be confused with the equatorial thin membrane and the high lips of the trilete mark. The generic identification remains doubtful.

Samarisporites sp. C (76) in Loboziak, Strel & Vanguetaine 1983, plate 2: 4–6.

1989. Cf. also *Samarisporites triangulatus* in Loboziak & Strel 1989, plate IV: 6–8.

Rounded central body and equatorial wing reaching up to

BOULONNAIS

CAMPINE BASIN

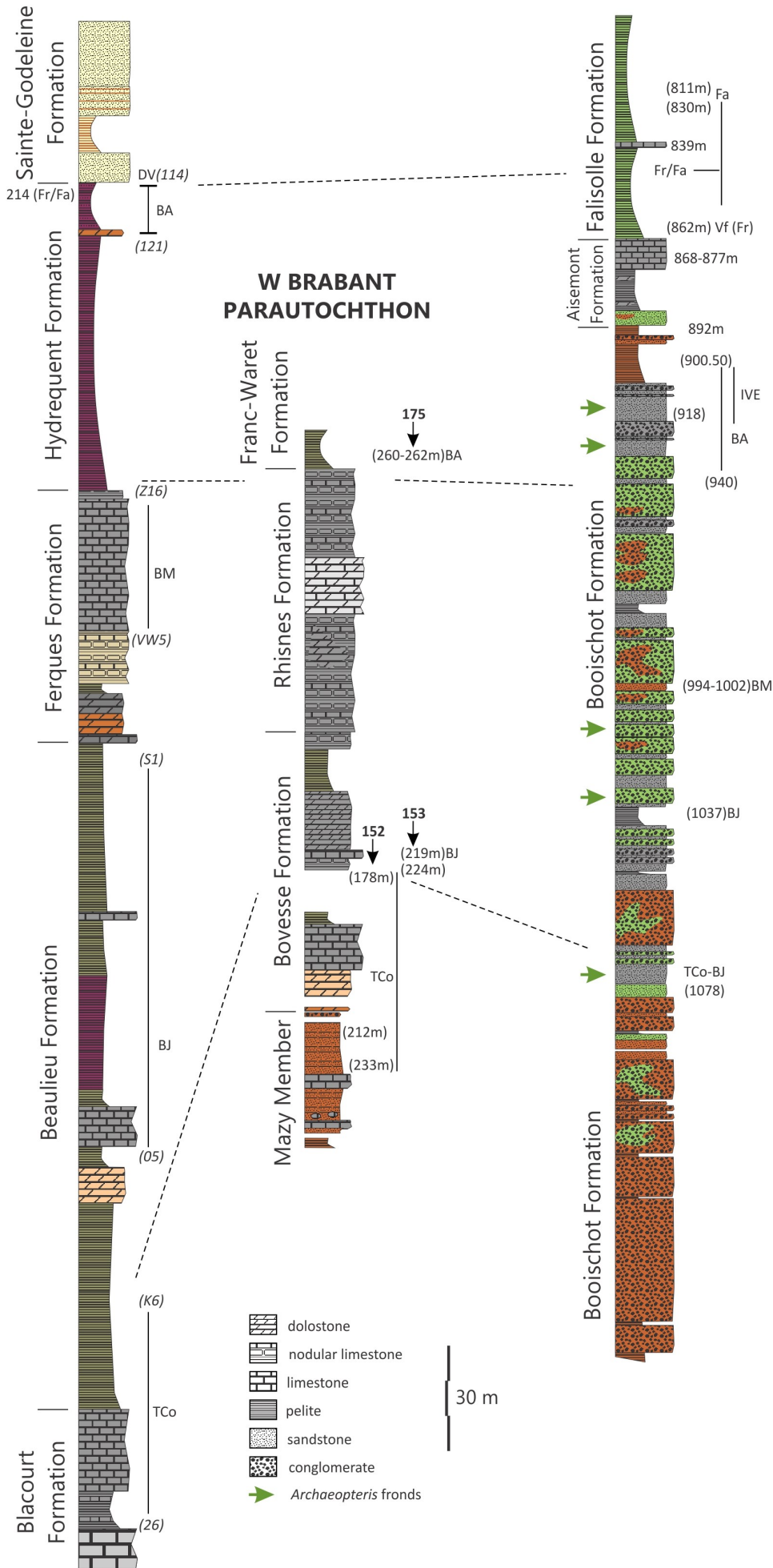


Figure 4. Formation names and lithology after Boulvain et al. (1999), Bultynck et al. (1991), Lagrou & Coen-Aubert (2017), Mansy et al. (2007). Miospore Zones extensions in the Boulonnais between samples (x) located on Figure 1 (lithostratigraphy); in W Brabant, depth in boreholes (this paper); in Campine Basin, depth in Booisshot Borehole, miospores after Streeel (1965), Streeel & Loboziak (1987); acritarch data for Falissolle Formation after Vanguestaine et al. (1983). Green arrows locate after Legrand (1964) abundant fronds of *Archaeopteris fimbriata* versus *A. macilenta*.

one third of the spore radius, expanding in front of the trilete rays. Ornaments are mainly composed, on the distal and equatorial surfaces, of coni reaching sometimes 2–3 μm high and 2 μm wide. This taxon might well be part of a *S. triangulatus sensu lato* morphon yet to be defined (see also Allen, 1982).

Samarisporites sp. D (79) in Loboziak, Strel & Vanguetaine 1983, plate 2: 2-3.

1988. *Samarisporites* sp. D, in Loboziak & Strel 1988, plate 3: 14.

Equatorial margin subtriangular. Ornament of coni (up to 2 μm high and wide) borne on irregular crests that are more or less fused in an imperfect reticulum (mesh 3–6 μm). Ornamentation denser on polar area than on the zona which reaches sometimes to one half of the spore radius.

Samarisporites sp. E in Strel & Loboziak 1987, plate 1: 10.

1965. *Calyptosporites microspinus* Richardson 1962 in Strel 1965, plate II: 10.

1974. *Samarisporites* sp. aff. *S. inusitatus* Allen 1965 in Becker et al. 1974, plate 18: 7.

1981. *Samarisporites triangulatus* Allen 1965 in Loboziak & Strel 1981, plate II: 3.

1989. *Samarisporites* sp. E in Loboziak & Strel 1989, plate IV: 9.

Non *Samarisporites triangulatus* Allen 1965 in Loboziak & Strel 1981, plate II: 4-5.

Rounded central body and equatorial margin subtriangular. Ornament of small verrucae and sometimes coni (up to 2 μm high and wide) borne on irregular crests to form a more or less fused imperfect reticulum (smaller mesh than in *Samarisporites* sp. D.). Compare with *Samarisporites inusitatus* Allen 1965 (see Breuer & Steemans, 2013, fig. 40: B-C) which has an equatorial margin that is less triangular in shape and with rare spines on the verrucae.

Samarisporites triangulatus Allen 1965 in Loboziak & Strel 1981, plate II: 4-5. = *Cristatisporites deliquescens* (Naumova) Arkhangelskaya in Obukhovskaya et al. 2000, plate 1:1, plate 4:2.

1981. *Samarisporites* cf. *triangulatus* Allen 1965 in Loboziak & Strel 1981, plate II: 6.

1987. *Samarisporites* sp. F in Strel & Loboziak 1987, plate 1: 5?-6.

1991. *Samarisporites* sp. F in Loboziak et al. 1991, 2: 1-3.

Rounded central body with thin smooth equatorial zona showing small typical radial expansions.

This taxon might as well (see also *S. sp. C*) be part of a *S. triangulatus sensu lato* morphon yet to be defined (see also Allen, 1982).

Better definition of some taxa formerly attributed to *Samarisporites triangulatus* Allen 1965 (21) suggest that the range of this species in the BM and BA Zone should be revised. Two taxa (without identification number in Fig. 1) should obviously be added to the BM Zone: *Samarisporites* sp. E in Strel & Loboziak (1987) and *Cristatisporites deliquescens* (Naumova) Arkhangelskaya, both occurring in the Ferques Formation from the Boulonnais.

6. International correlations using Frasnian miospore zonations

International correlations using Upper Devonian miospore zonations have been attempted between far-away basins (Strel et al., 2000b). For instance, comparison of the Boulonnais miospores with the Amazon Basin (Melo & Loboziak, 2003), allowed, for the first time, to correlate, using microfossils, SW Gondwanaland and Laurussia.

At a smaller scale, Frasnian and Lower Famennian deposits, containing miospores, are widespread on the territory of the Pripyat Depression in SE Belarus and the Timan–Pechora Province in Russia. Biostratigraphy of these deposits is based also on conodonts in the Timan–Pechora.

A palaeophytogeographic reconstruction (Fig. 5) after Strel et al. (1990) shows, during Frasnian time, Eastern Europe centred on the equatorial belt and Western Europe in the tropical belt. It explains, to some extent, why different miospore zonations can be found in these regions (Strel et al., 2000a). Correlation charts between Western Europe and Eastern Europe have been tentatively published by Loboziak & Strel (1981, 1988) but the most documented chart was published by Avkhimovitch et al. (1993) for the Middle and Upper Devonian and Obukhovskaya et al. (2000) for the Upper Frasnian and Famennian boundary deposits.

Correlations from the Late Givetian until the Mid Frasnian are shown on these charts to be obvious from the *varcus* to *punctata* conodont Zones (Obukhovskaya, 2000; Strel et al., 2000a; Tel'nova, 2008; Telnova et al., 2019) but less obvious from Middle Frasnian to the Lower Famennian within the *Archaeoperisaccus ovalis*–*Verucosisporites grumosus* (OG), *Cristatisporites deliquescens*–*Verrucosisporites evlanensis* (DE) and *Corbulispora vimineus*–*Geminispora vasmjica* (VV) Assemblage–Acme Zones of Eastern Europe.

Subzone SB, in the lower part of the OG Zone, contains *Cristatisporites deliquescens* and is associated with the

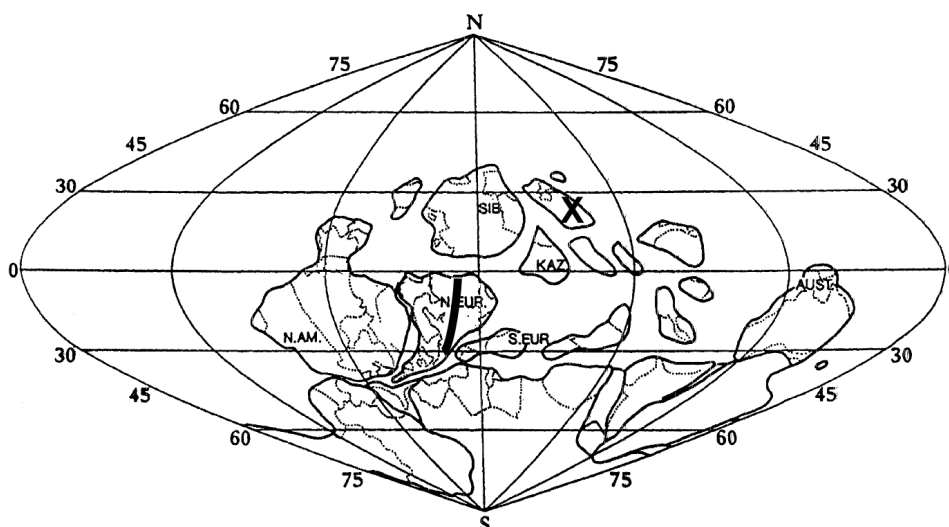


Figure 5. Global palaeogeography during Middle Devonian time after Heckel & Witzke (1979). The map shows (black thick line) the tropical to equatorial transect of Western to Eastern Europe. Black X correspond to the locality studied in North-West China by Stachacz et al. (2020).

Table 4. Correlation between late Frasnian miospore assemblages in Western and Eastern Europe. Miospore zonation after Avkhimovitch et al. (1993). Conodont after the “standard” zonation of Ziegler & Sandberg (1990). Substage limits based on SDS members votes (SDS Subcommittee Devonian Stratigraphy Newsletter 22, 2007).

Miospore zonations		Conodont (Fig. 6)	Ages	FOB key species?
Western Europe	Eastern Europe			
DV	VV	<i>triangularis</i>	Famennian	
BA plic-E	VV	<i>triangularis</i>	Famennian	<i>Corbulispora vimineus</i> (61)
BA grac	DE GS	<i>linguiformis</i>	Upper Frasnian	
BA pregrac	DE AS	<i>rhenana</i>	Upper Frasnian	<i>Cymbosp. acanthaceus</i> (57)
BM/BA ?	OG MR	<i>rhenana</i>	Upper Frasnian	<i>Diducites mucronatus</i> (74)
BM/BA ?	OG CVe	Early <i>rhenana</i>	Upper Frasnian	<i>Grandispora gracilis</i> (69)
BM	OG SB	<i>hassi</i>	Middle Frasnian	<i>Cristatisporites deliquescens</i>

conodont Upper *Polygnathus asymmetricus* and *Ancyrognathus triangularis* Zones i.e. more or less the *hassi-jamieae* level of the “standard” conodont zonation (Ziegler & Sandberg, 1990). Subzone CVe, in the middle part of the OG Zone, contains *Grandispora gracilis* (69) and is associated to the conodont Lower *gigas* Zone or early *rhenana* level. Subzone MR in the upper part of the OG Zone, contains *Diducites mucronatus* (74) associated with the conodont *gigas* Zone.

Subzone AS, in the lower part of the DE Zone, contains *Cymbosporites acanthaceus* (57) and is associated with the conodont *gigas* Zone. Subzone GS, in the upper part of the DE Zone is referred to the conodont Uppermost *gigas* Zone or *linguiformis* level (see Fig. 6).

VV Zone shows the appearance of the first index species *Corbulispora vimineus* (61) and is correlated with conodonts of the *Palmatolepis triangularis* Zone.

Consequently it is proposed here (Table 4) that a correlation exists between part of the *Verrucosporites bulliferus-Lophozonotrites media* (BM) Opperl Zone, all of the

Rugospora bricei-Cymbosporites acanthaceus (BA) Opperl Zone and part of the *Knoxisporites dedaleus-Diducites versabilis* (DV) Opperl Zone in Western Europe with the *Archaeoperisaccus ovalis-Verrucosporites grumosus* (OG), *Cristatisporites deliquescens-Verrucosporites evlanensis* (DE) and part of the *Corbulispora vimineus-Geminispora vasjamica* (VV) Assemblage-Acme Zones of Eastern Europe, covering the range from the conodont *hassi* Zone to the *triangularis* Zone.

The transition from the *Rugospora bricei-Cymbosporites acanthaceus* (BA) Opperl Zone and the *Knoxisporites dedaleus-Diducites versabilis* (DV) Opperl Zone of Western Europe crossing the Frasnian-Famennian Boundary is tentatively recognised in the lowermost part of the Honggelelung Formation in the Bulongguoer section of the Junggar Basin in NW China (Stachacz et al., 2020). The Frasnian/Famennian Boundary is dated by Zircon-U-Pb (371.5 ± 0.9 Ma) immediately below the Honggelelung Formation, in the Zhulumute Formation in the same region (Zheng et al., 2020).

7. Conclusions

The correlation proposed on Table 4 at the transition BM/BA dated Upper Frasnian by the *rhenana* conodont Zone in Eastern Europe points to the inability in the Ferques and Hydrequent Formation succession between the La Parisienne Member (or Gris Member?) and the Dolomitic Beds (Brice et al., 1981) to trace the exact base of the Upper Frasnian in the Boulonnais. An initial examination at the many recorded ranges of taxa (Fig. 1) suggests, first of all, a sampling gap between these formations. Obviously, it suggests also a significant change in the vegetation cover occurring at that level which introduces the basal Famennian miospores characteristics of the DV Zone. Such a deep change in the vegetation cover might well have a climate origin (Streel et al., 2000a; Huang et al., 2018) corresponding more or less to the Lower Kellwasser Event (LKW) starting at the base of the Upper *rhenana* conodont Zone (Becker et al., 2016).

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	Old zonation	Standard zonation
FAM.	U	<i>triangularis</i>
	M <i>P. triangularis</i>	
	L	
FRASNIAN	U (+)	<i>linguiformis</i>
	U <i>gigas</i>	<i>rhenana</i>
	L	
	<i>Ag. triangularis</i>	<i>jamieae</i>
		<i>hassi</i>
GIVETIAN	U	<i>punctata</i>
	M	
	L <i>asymmetricus</i>	<i>transitans</i>
		<i>falsiovalis</i>
	L (+)	
		<i>disparalis</i>
		<i>hermanni cristatus</i>
	<i>varcus</i>	
	<i>ensensis bipennatus</i>	

Figure 6. Conodont zonations after Klapper & Ziegler (1979), Ziegler & Sandberg (1990). Redrawn from Avkhimovitch et al. (1993, fig. 4).

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Appendix. Identification numbers of taxa recorded on Figure 1, sorted by taxa name.

- Acinosporites lindlarensis* Riegel 1968 (Richardson et al. 1993) = 1
Aneurospora cf. *heterodonta* (Naumova) Strel 1972 = *Acinosporites lindlarensis* Riegel 1968 (Richardson et al. 1993) = 1
Ancyrospora ancyrea var. *brevispinosa* Richardson 1962 = 14
Acanthotriletes cf. *horridus* Hacquebard 1957 sensu Richardson 1965 = 10
Ancyrospora ancyrea var. *ancyrea* Richardson 1962 = 13
Ancyrospora angulata Tiwari & Schaarschmidt 1975 = 37
Ancyrospora langii (Taugourdeau-Lantz) Allen 1965 = 31
Ancyrospora loganii McGregor 1973 = 15
Ancyrospora lysii (Taugourdeau-Lantz) Loboziak & Strel 1981 = 52
Ancyrospora simplex Guenel 1963 = 46
Aneurospora goensis Strel 1964 = *Geminospora expansa* (Naumova) Gao in Obukhovskaya 2000 = 11
Aneurospora greggsii (McGregor) Strel 1974 = 24
Aneurospora sp. A in Loboziak, Strel & Vanguetaine 1983 = 77
Aneurospora sp. B in Loboziak, Strel & Vanguetaine 1983 = 78
Archaeozonotriletes variabilis (Naumova) Allen 1965 = 2
Auroraspora hyalina (Naumova) Strel 1974 = 62
Auroraspora macra Sullivan 1968 = 63
Auroraspora macromanifesta (Hacquebard) Richardson 1960 = 16
Auroraspora micromanifesta (Hacquebard) Richardson 1960 = 17
Auroraspora solisorta Hoffmeister, Staplin & Malloy 1955 = 70
Auroraspora sp. A in Loboziak & Strel 1981 = 66
Biornatispora reticulata Lele & Strel 1969 = 25
Brochotriletes sp. = 3
Bullatisporites aff. *bullatus* Allen 1965 = 18
Chelinospora concinna Allen 1965 = 38
Cirratriradites dissutus Allen 1965 = 19
Cirratriradites jekhowskiyi Taugourdeau-Lantz 1967b = 39
Contagisporites optivus var. *vorobjevensis* (Chibrikova) Owens 1971 = 12
Convolutispora cf. *subtilis* Owens 1971 = 43
Convolutispora disparilis Allen 1965 = 4
Convolutispora paraverrucata McGregor 1964 = 5
Convolutispora tegula Allen 1965 = 48
Corbulispora sp. in Loboziak & Strel 1981 = *C. viminea* (Nekriata) Obukhovskaya & Nekriata in Obukhovskaya et al. 2000 = 61
Corbulispora viminea (Nekriata) Obukhovskaya & Nekriata in Obukhovskaya et al. 2000 = 61
Corystisporites multispinosus Richardson 1965 = 42
Cymbosporites acanthaceus (Kedo) Obukhovskaya in Obukhovskaya et al. 2000 = 57
Cymbosporites cf. *cyathus* Allen 1965 = 20
Cymbosporites sp. A in Loboziak & Strel 1981 = 68
Cymbosporites sp. B in Loboziak & Strel 1981 = *C. acanthaceus* (Kedo) Obukhovskaya in Obukhovskaya et al. 2000 = 57
Cymbosporites sp. C in Loboziak, Strel & Vanguetaine 1983 = 75
Densosporites ssp. Loboziak & Strel 1981 No records = 71
Dibolisporites cf. *gibberosus* (Naumova) Richardson 1965 = 6
Dibolisporites echinaceus (Eisenack) Richardson 1965 = 28
Dibolisporites sp. cf. *Lophotriletes atratus* (Naumova) sensu Strel 1974 = 41
Diducites mucronatus (Kedo) Van Veen 1981 = 74
Diducites plicabilis Van Veen 1981 = 64
Diducites poljessicus (Kedo) Van Veen 1981 = 55
Diducites versabilis (Kedo) Van Veen 1981 = 65
Emphanisporites spp. = 29
Geminospora lemurata Balme 1962 = 40
Geminospora expansa (Naumova) Gao in Obukhovskaya 2000 = 11
Grandispora cf. *tenuispinosa* (Hacquebard) Playford 1971 in Strel 1974 = 53
Grandispora douglstownense McGregor 1973 = 7
Grandispora gracilis (Kedo) Strel 1974 = 69
Grandispora inculta Allen 1965 = 21
Grandispora sp. A in Loboziak & Strel 1981 No records = 56
Grandispora tomentosa Taugourdeau-Lantz 1967b = 32
Grandispora velata (Eisenack) McGregor 1973 = 22
Hystricosporites multifurcatus (Winslow) Mortimer & Chaloner 1967 = 47
Hystricosporites spp. = 33
Knoxisporites cf. *hederatus* (Ishenko) Playford 1963 = 60
Knoxisporites dedaleus (Naumova) Strel 1977 = 59
Lophozonotriletes media Taugourdeau-Lantz 1967b = 50
Perotriletes ergatus Allen 1965 = 34
Planisporites scaber Taugourdeau-Lantz 1967b = 49
Pustulatisporites rugulatus (Taugourdeau-Lantz) Loboziak & Strel 1981 = 51
Retusotriletes planus Dolby & Neves 1970 = 67
Retusotriletes rugulatus Riegel 1973 = *Scylaspora rugulata* (Riegel) Breuer et al. 2007 = 30
Rhabdosporites langi (Eisenack) Richardson 1960 = 8
Rhabdosporites parvulus Richardson 1965 = 35
Rugospora bricei Loboziak & Strel 1989 = 58
Rugospora cf. *flexuosa* (Juschko) Strel 1974 = *R. bricei* Loboziak & Strel 1989 = 58
Samarisporites inaequus (McGregor) Owens 1971 = 23
Samarisporites sp. A in Loboziak & Strel 1981 = 54
?Samarisporites sp. B in Loboziak, Strel & Vanguetaine 1983 = 73
Samarisporites sp. C in Loboziak, Strel & Vanguetaine 1983 = 76
Samarisporites sp. D in Loboziak, Strel & Vanguetaine 1983 = 79
Samarisporites triangulatus Allen 1965 = 36
Scylaspora rugulata (Riegel) Breuer et al. 2007 = 30
Verruciretusispora pallida (McGregor) Owens 1971 = 9
Verruciretusispora sp. A in Loboziak, Strel & Vanguetaine 1983 = 72
Verrucosporites bulliferus Richardson & McGregor 1986 = 45
Verrucosporites cf. *grandis* McGregor 1960 = 44
Verrucosporites cf. *uncatus* (Naumova) Richardson 1965 = 27
Verrucosporites premnus Richardson 1965 = 26

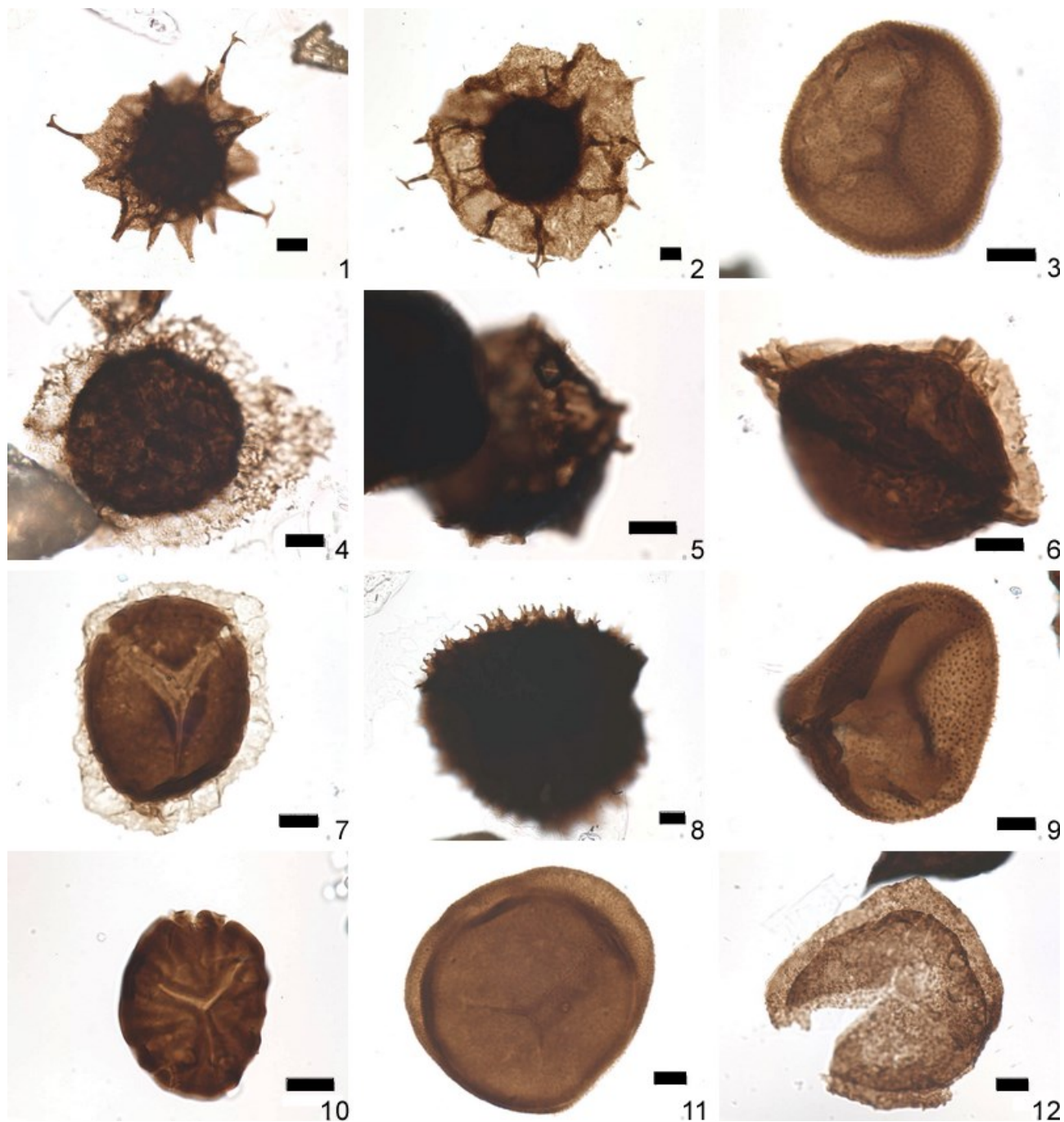


Plate 1a. Miospores recorded in the borehole Nieuwkerke-Noordhoek (95W153).

- 1, 2: *Ancyrospora angulata* (37) 1:223, 7, H50-3-4, 2:219,0, G45-2.
 3: *Aneurospora greggsii* (24) 221, 5 L36-0.
 4: *Auroraspora* aff. *pseudocrista* Ahmed 1980: 223,7, R40-1-4.
 5: *Chelinospora concinna* (38) 219,0, N43-4.
 6, 7: *Cirratiradites jekhowskyi* (39) 219,0, 6:M42-3, 7:T52-4.
 8: *Corystisporites multispinosus* (42) 223, 7, F55-4.
 9: *Dibolisporites echinaceus* (28) 219,0, R43-0.
 10: *Emphanisporites* spp (29) 219,0, W41-4.
 11, 12: *Geminospora lemurata* (40) 11:221,5, M4-,0. 12:223,7, H53-1-2.

Scale bar = 10 μ m.

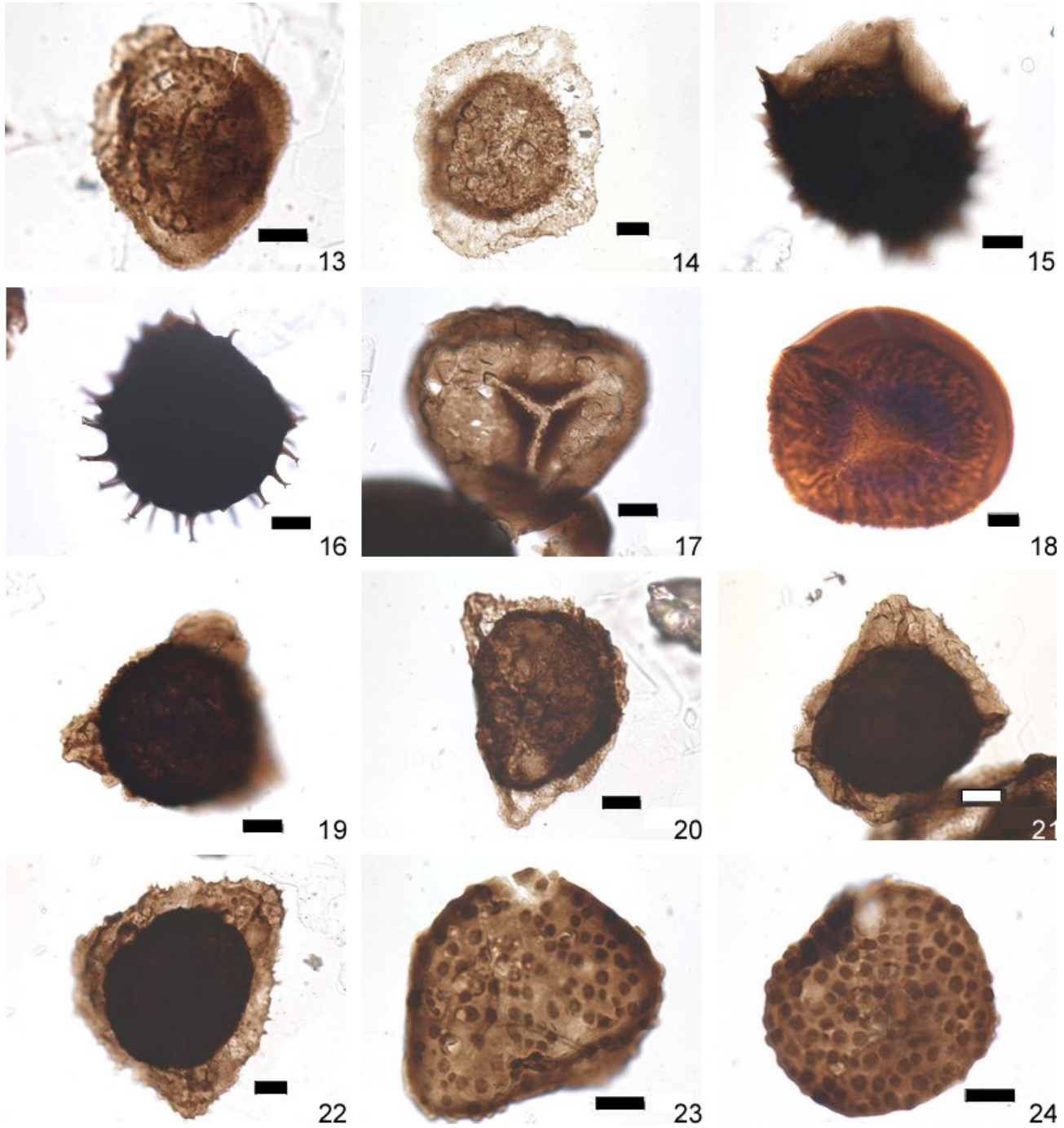


Plate 1b. Miospores recorded in the borehole Nieuwkerke-Noordhoek (95W153) (continued).

13: *Grandispora inculta* (21) 223,7, J38-3.

14: *Grandispora velata* (22) 223,7, G57-0.

15, 16: *Hystricosporites* spp (33) 15 :219,0, L44-3, 16 :223,7, H39-3.

17: *Retusotriletes confossus* (Rich.) Strel 1967, 223,7, F51-0.

18: *Scylaspora rugulata* (Riegel) Breuer et al. 2007 (30) 221,5, G33-0.

19, 20: *Samarisporites triangulatus* (36) 223,7, 19:L37-12,20:J35-4.

21, 22: *Samarisporites* sp. E, 223,7, 21:U37-0, 22:L38-50.

23, 24: *Verrucosiporites bulliferus* (45) 221,5, 23:G48-3, 24:T46-3.

Scale bar = 10 μ m.

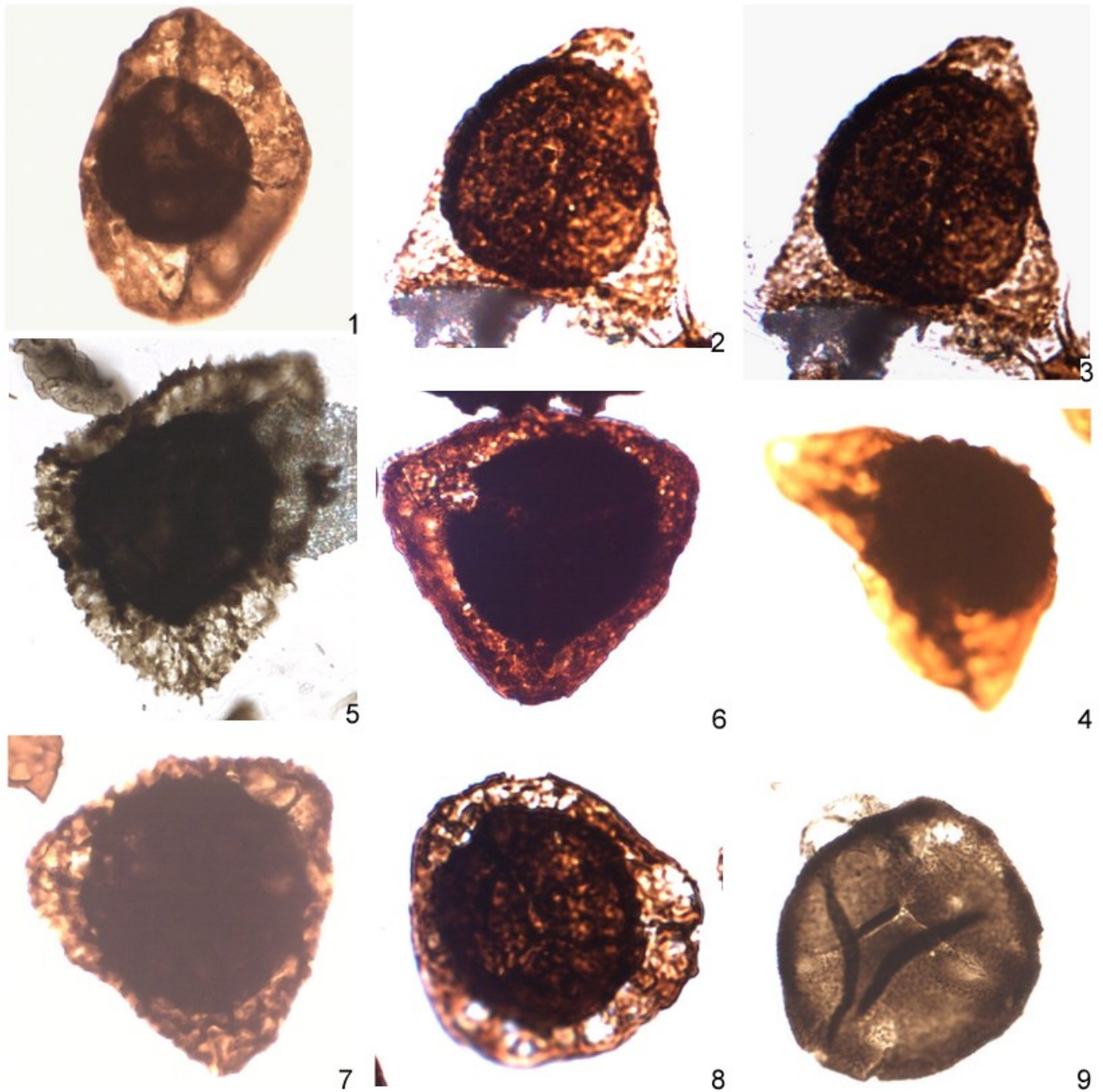


Plate 2a. Miospores recorded in the Heuvelland groundwater monitoring well (95W175).

1: aff. *Archaeoperisaccus* sp. H31-2.

2, 3, 4: *Auroraspora pseudocrista* Ahmed 1980 2,3: H41-2 4:048-3.

5, 6, 7: *Samarisorites* sp. D (79) in Loboziak, Strel & Vanguetaine 1983, 5:M33-1, 6:O46-3, 7:E44-2.

8: cf. *Teichertospora torquata* (Higgs) McGregor & Playford 1990, 8:O46-2.

9: *Aneurospora greggsii* (McGregor) Strel 1974 (24), W46-1.

All figures are at a magnification 700x unless otherwise stated.

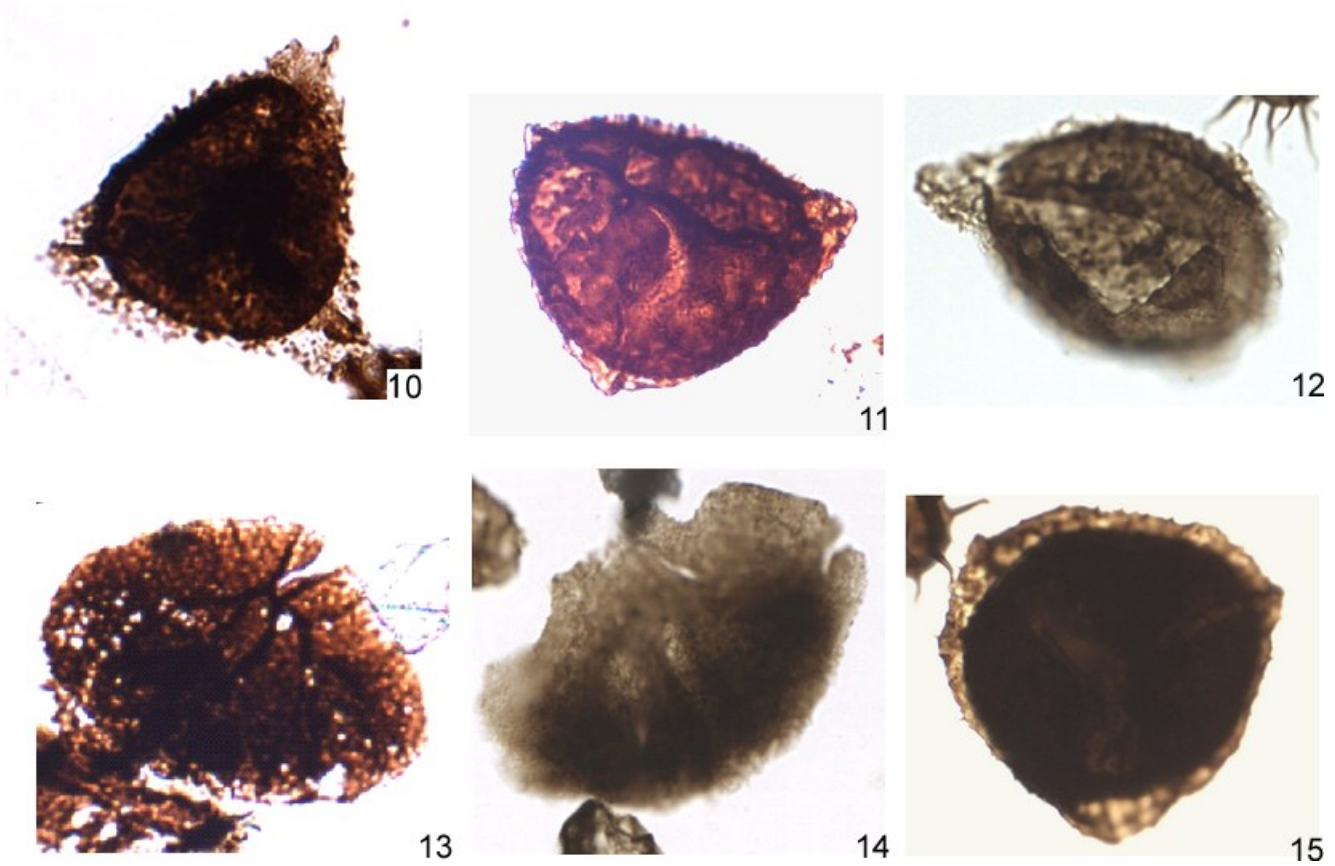


Plate 2b. Miospores recorded in the Heuvelland groundwater monitoring well (95W175) (continued).

10, 11: *Samarisporites triangulatus* Allen 1965 (36), 10:U48-4, 11:G44-4.

12: *Diducites plicabilis* (64), E47-3.

13, 14: *Pavonisporites costulatus* (Taugourdeau-Lantz) Taugourdeau-Lantz 1971, 13:N46-2, 14:V30; (x250).

15: *Grandispora gracilis* (69), O46-4.

All figures are at a magnification 700x unless otherwise stated.