

An Upper Westphalian C "hinterland" microflora from the Haaksbergen-1 Borehole (Netherlands)

M. J. M. BLESS, S. LOBOZIAK & M. STREEL

ABSTRACT

Some shale samples from the Upper Westphalian C of the Haaksbergen-1 borehole in the eastern Netherlands have yielded a microflora characterized by the occurrence of some species – in one case making up some 5% of the total microflora – which are atypical for the Westphalian of Europe. The implications of their occurrence are discussed.

INTRODUCTION

The Carboniferous interval from 881.70 to 1008.00 m of the Haaksbergen-1 borehole was probably the first outside the South Limburg mining area, that was studied on the occurrence of mio- and megaspores. In 1955, KUYL, MULLER & WATERBOLK (1955, pl. 7) figured several miospores, amongst which we can recognize a.o. *Vestispora fenestrata*, *Microreticulatisporites nobilis*, *Triquitrites sculptilis*, *Laevigatisporites vulgaris*, *Raistrickia saetosa*, *Endosporites globiformis*, *Triquitrites bransonii*, *Crasispora kosankei*, *Lycospora* sp. and *Florinites* sp., which suggest a high Westphalian C or basal Westphalian D age. All these specimens had been recovered from the same shale sample at 947 m. In the same year, DIJKSTRA (1955) figured some megaspores from the same borehole, amongst which *Trilethisporites tuberculatus*, *Pseudovalvisporites flavus* and *Expansisporites westphalensis*. This assemblage also characterizes Upper Westphalian C to Lower Westphalian D strata.

Although the interval was suggested by the above authors and later also by THIADENS (1963) to belong to the Westphalian D, because of the presumed presence of the plant species *Neuropteris ovata*, the palynological investigation by VAN WIJHE & BLESS (1974) showed, that the age of the whole interval is Upper Westphalian C. Revision of the macroflora by VAN AMEROM (Geologisch Bureau, Heerlen, Netherlands; personal communication) led to the conclusion, that the specimens formerly identified as *Neuropteris ovata* in fact belong to a different species of *Neuropteris*. This conclusion was later confirmed by Dr. K.-H. JOSTEN (Geol. Landesamt Nordrhein-Westfalen, Krefeld, Germany) and Prof. J. P. LAVEINE (Université de Lille, France). This

means, that the macroflora is no longer contradicting the palynological results.

The reason for a further note on the Carboniferous interval of this borehole is the occurrence of atypical Upper Westphalian C spores in the sequence between 938 and 947 m and notably between 945.40 and 947.00 m. Up to now, some of these species were considered to be characteristic for older strata in NW Europe, whereas others were presumed to indicate much younger formations.

MEGASPORES

Four samples have been investigated on the occurrence of megaspores. The results are summarized in table 1.

The most common species are *Laevigatisporites glabratus* (ZERNDT) POTONIÉ & KREMP sensu DIJKSTRA, *Triangulatisporites triangulatus* (ZERNDT) POTONIÉ & KREMP, *Tuberculatisporites mamillarius* (BARTLETT) POTONIÉ & KREMP sensu DIJKSTRA and *Lagenosporites rugosus* (LOOSE) POTONIÉ & KREMP. Also *Cystosporites giganteus* (ZERNDT) DIJKSTRA and *Cystosporites varius* (WICHER) DIJKSTRA appear to be common although less abundant than the former species. All these are long-ranging forms with little stratigraphic value.

More interesting is the occurrence of low numbers (1-2%) of *Trilethisporites tuberculatus* (ZERNDT) POTONIÉ & KREMP in the three lowest samples. The base of the biozone of this species is in the highest Upper Westphalian C in N France (upper part of "Faisceau d'Ernestine") and in Germany (Coesfeld-Süd-1 borehole; cf. GREBE 1971) or at the base of the Westphalian D (Campine area of Belgium, No. 9 Coal Seam of 117 borehole).

Equally important is the presence of *Zonalesporites brasserti* (STACH & ZERNDT) POTONIÉ & KREMP in two of the samples. This species disappears in the topmost Westphalian C of N France (highest part of "Faisceau d'Ernestine") and the Campine area (No. 13 Coal Seam of Neeroeteren Formation in 117 borehole; cf. PIERART 1958), but ranges into the

* We are indebted to Drs. R. M. Kosanke (U.S. Geological Survey, Denver Colorado, U.S.A.) and R. A. Peppers (Illinois State Geological Survey, Urbana, Illinois, U.S.A.) for their comments on several miospore species.

SAMPLE	<i>Laevigatisporites glabratus</i>	<i>Pseudovalvisporites flavus</i>	<i>Tuberculatisporites mamillarius</i>	<i>Trilethisporites tuberculatus</i>	<i>Triangulatisporites triangulatus</i>	<i>Zonalesporites brasserti</i>	<i>Valvisporites appendiculatus</i>	<i>Expansisporites westphalensis</i>	<i>Lagenicula horrida</i>	<i>Lagenoisporites rugosus</i>	<i>Cystosporites giganteus</i>	<i>Cystosporites varius</i>	Unidentified	TOTAL NUMBER OF MEGASPORES per 10 gr of coal with granulometry between 2 and 5 mm
373	80	15	27	2					75	1	4		204	
372	6	1	1	35	1	8			6	11		2	72	
378	25	2	4	2	14	7	2	12	2	1	9	1	81	
379	24	1	11	2	10		1	2	13		15	3	82	

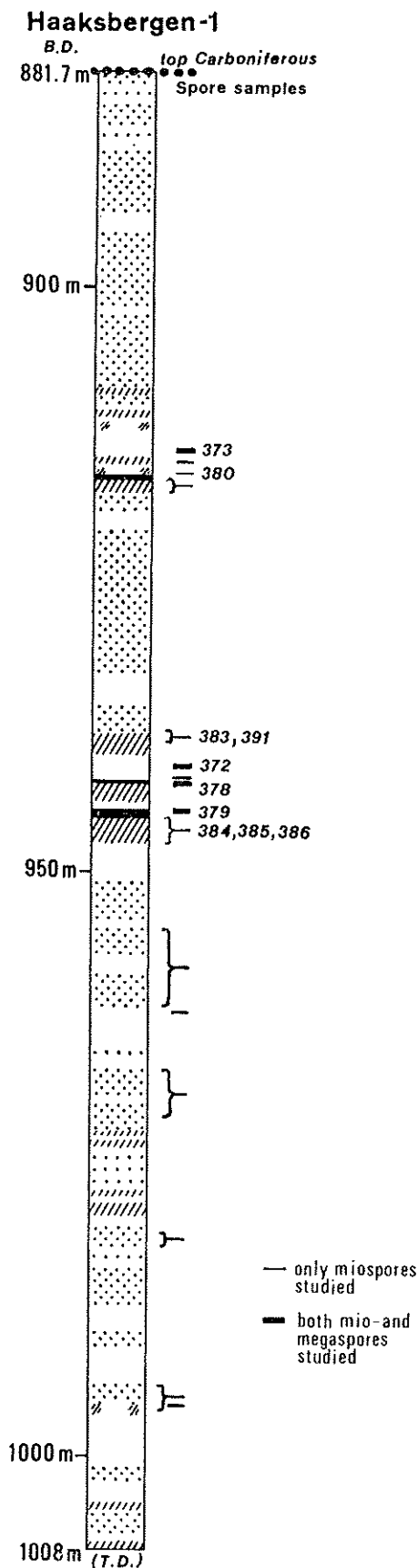
Table 1 — Distribution of megaspores in four samples from Haaksbergen-1 borehole. The number of megaspores per sample refers to 10 gr of coal with granulometry between 2 and 5 mm after maceration by the bromonitric method of ZETZSCHE and KÄLIN.

Upper Westphalian D of the Forest of Dean (SPINNER 1965; WAGNER & SPINNER 1972).

Expansisporites westphalensis (BHARDWAJ) LOBOZIAK is foreall abundant in the Lower Westphalian C, but ranges in N France (lower half of "Faisceau d'Edouard"; cf. LOBOZIAK 1970) (well into the Westphalian D, whereas its highest occurrence in Belgium is the base of the Westphalian D at the No. 9 Coal Seam in the 117 borehole).

Lagenicula horrida ZERNDT is foreall frequent until the Lower Westphalian C in N France (middle part of "Faisceau de Six Sillons"; cf. LOBOZIAK 1970). In the Campine area of Belgium, this species is extremely rare in the Westphalian C, where its highest occurrence is just above the base of the Upper Westphalian C (PIERART 1958). In South Limburg (Netherlands), this species is frequent until the top of the Westphalian B. In the Westphalian C, it is also rare, although DIJKSTRA (1946) recognized it in the two highest Upper Westphalian C coal seams of the XLV (Jabeek) borehole. In the highest coal seam it even constitutes some 27% of the total megaspore assemblage.

Fig. 1 — Upper Westphalian C of Haaksbergen-1 borehole with position of samples which have yielded mio- and megaspores



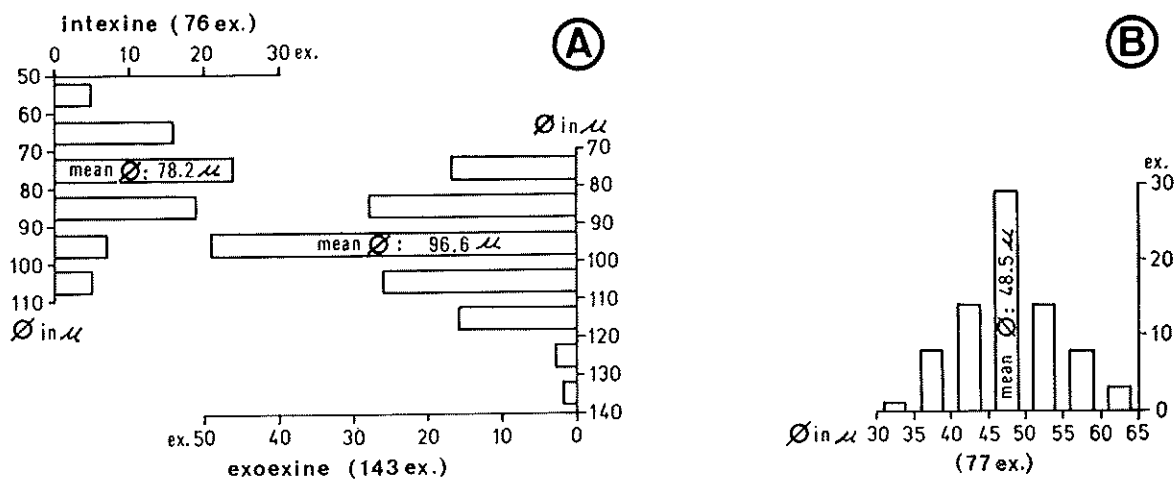


Fig. 2a - Spore size of *Bibarisporites haaksbergenensis* BLESS, LOBOZIAK & STREEL, nov. sp.
 Fig. 2b - Spore size of *Illinites unicus* KOSANKE sensu HELBY 1966

The analysis of the megaspores thus confirms the Upper Westphalian C age of the interval between 914 and 945.40 m.

MIOSPORES

Nineteen samples, regularly distributed through the interval between 914 and 995.80 m (cf. fig. 1), have yielded miospore assemblages characteristic of a high Upper Westphalian C age. *Triquitrites sculptilis* and *T. velensis*, *Vestispora costata-tortuosa*, *V. magna*, *V. fenestrata* and *V. cf. reticulata*, *Punctatosporites granifer* and *Torispora securis* occur throughout the sequence, whereas rare specimens of *Triquitrites bransonii*, *Thymospora pseudothiessenii* and *Laevigatosporites perminutus* seem to become more frequent in the highest samples between 917.50 and 914 m.

Atypical for these high Upper Westphalian C assemblages is the occurrence of some miospore species in several samples of the Haaksbergen-1 borehole - notably at the depth 945.40-947.00 m, where they make up some 5% of the microflora - since these species usually characterize deposits of a younger (Stephanian to Autunian) age.

Although the species *Potonieisporites elegans* is a common form in the Namurian of Great Britain, Spain and N America (cf. NEVES & BELT 1970; NEVES 1972), is the genus *Potonieisporites* foreall characteristic for the Stephanian and Permian (cf. NEVES 1972). The genus was not described from the Westphalian of the paralic northwestern European basins in the principal monographs by SMITH & BUTTERWORTH (1967), LOBOZIAK (1969), SOMERS (1971), GREBE (1972), COQUEL (1974) and VAN WIJHE &

BLESS (1974).

Small species of *Knoxisporites* have their maximum extension during the Visean and Namurian and virtually disappear in the Westphalian of NW Europe. One small species re-appears in the Stephanian-Autunian of France and the U.S.S.R. Only in Canada, BARSS (1967) recognized similar specimens throughout the Westphalian.

Also *Latensina*, *Illinites* and *Centonites* are characteristic for high Stephanian or even younger strata, although KALIBOVA (1970) stated that *Latensina* should be common already in the Upper Westphalian D of the Plzen-Rakovnik-Mseno Basin.

The new - apparently endemic - species *Bibarisporites haaksbergenensis* belongs to a genus, which ranges from the Devonian into the Triassic. But this genus was never described from the Silesian, and seems to have its greatest development in the Permian-Triassic.

The joint occurrence of these genera in the Haaksbergen-1 borehole together with the rare occurrence of *Illinites unicus* in slightly older strata (highest Lower Westphalian C) of the nearby Ruhr area (cf. GREBE 1972) suggests a common source area.

This source area should have formed an ecological niche for special floras of a probably hinterland-upland type consisting of species indicating an eventually more dry habitat. This is illustrated by the abundant occurrence of large zonate miospores (*B. haaksbergenensis*) in the samples 384, 385 and 386, which may be compared with the large zonate miospores of the Middle Devonian upland microflora of LELE & STREEL (1969), and by the fact that the genera *Potonieisporites*, *Centonites*, *Illinites* and *Latensina* fully develop in the Stephanian and Permian when a more arid climate than in the Westphalian existed.

It is suggested that such an environment — which apparently only intermittently yielded a small microflora into the southwestern part of the NW German Basin — existed on the nearby Upper Westphalian Mid-Netherlands High. If this source would have been located on the Ardenno-Rhenish-Harz Massif in the S, we might have expected a wider distribution of these miospores throughout the Westphalian of NW Europe.

Biharisporites haaksbergenensis
BLESS, LOBOZIAK & STREEL, NOV. SP.
Pl. 2, fig. 8; pl. 3, figs. 1-7

Holotype: specimen Haaksbergen 384-A, 41.4 x 102.8

Type level: Upper Westphalian C; light grey shale with rootlets between 945.50 and 947.00 m.

Type locality: Haaksbergen-1 borehole, E Netherlands

Derivatio nominis: Haaksbergen, the location of the borehole.

Diagnosis: These are trilete, camerate miospores with rounded to convexly triangular amb. The central body (intexine) is laevigate with distinctly gaping suturae ending in short protuberances near the equator. Only a few compression folds occur in the central body, this in contrast to the enveloping exoexine. Apparently, there is a loose contact between the intexine and exoexine, since central body has been frequently found isolated from exoexine.

Distal and equatorial regions of exoexine covered by small conical spines of 0.5 to 2 μ , which are bifiform in some cases. Contact area nearly smooth. Suturae distinct, straight to slightly sinuous, extending almost to equator and bordered by prominent labra, which often are flattened by compression and typically enlarge at the distal ends. In many specimens, the distal surface becomes encroached proximally at the distal ends of the suturae under influence of the protuberances on the intexine (pl. 3, fig. 5). Size ranges of exoexine and intexine indicated in fig. 2a.

Discussion: *Biharisporites* is characterized by an intexine — called mesospore by most authors — which is easily detached as explained by a.o. MCGREGOR (1960) and by an exoexine with bifiform ornaments. Our species is distinguished by the protuberances at the end of the trilete rays in the intexine.

Up to now, *Biharisporites* was considered to be a megaspore genus (BHARDWAJ & TIWARI 1970). But it should be noted that also other genera such as *Calamospora* consist of both mega- and miospore species. Size is not a generic character!

The species is abundant in the interval between 945.50 and 947.00 m of the Haaksbergen-1 borehole, where several hundreds of specimens have

been recognized in the samples 384, 385 and 386.

Centonites symmetricus PEPPERS 1964
pl. 2, figs. 6-7

Remarks: Only one specimen has been recovered from a shaly rootlet bed at 938-939 m (samples 383-A). It is a large, hollow globule with a thin wall, consisting of completely transparent segments forming a reticulate network pattern. The specimen is conspecific to that figured by BLESS & STREEL (1976, pl. 7, fig. 9), from the Upper Westphalian C of South Limburg. Careful examination of a specimen of *Centonites symmetricus* (kindly placed at the first authors disposal by Dr. R. A. PEPPERS, Illinois State Geological Survey, U.S.A.) has convinced us, that the Dutch specimens are identical to his species. As also suggested by PEPPERS (pers. comm.), the apparent differences between his and our material seem to be due to differences in preservation and/or maceration techniques. *C. symmetricus* was found once by PEPPERS in the Desmoinesian of Iowa, which is roughly correlated with the Westphalian C of Europe. Otherwise, it characterizes the Missourian in the U.S.A., which might be correlated with late Westphalian D to Stephanian or even Autunian deposits in Europe. LIABEUFF & ALPHERN (1969) figured several specimens from the Middle Stephanian ("Couche de la Vaure") of the St. Etienne Basin of France.

Illinites unicus KOSANKE sensu HELBY 1966
Pl. 2, figs. 3-5

Remarks: Numerous small, striate bisaccate spores have been recovered from the samples 384, 385 and 386. They are attributed here to *Illinites unicus* KOSANKE sensu HELBY 1966 (p. 680)*. HELBY considered *Kosankeisporites elegans* (KOSANKE) BHARDWAJ and *Complexisporites polymorphus* JIZBA as synonyms of *Illinites unicus*. The specimens figured by BARSS (1967) as *Protobaploxypinus* cf. *globus* from Stephanian(?) to Wolfcampian miospore assemblages of Canada seem to belong to the same species.

This species has been recognized by GREBE (1972) from the topmost Lower Westphalian C (Kobold-Loki and Nibelung coal seams) of the NW German Basin. That is the lowermost occurrence — as far as known to us — of the infraturma *Disaccites striatiti*. The base of the epibole of this infraturma is in the highest Stephanian or Lower Autunian of NW Europe (cf. HELBY 1966). In North America, this infraturma characterizes high Pennsylvanian and Permian deposits.

* KOSANKE kindly examined some slides from the 945.50-947.00 m horizon and "saw a couple of specimens of *Illinites*" (letter of July 14, 1977 to third author).

Knoxisporites glomus SHWARTSMAN 1976
Pl. 1, figs. 5-6

Remarks: This species was described from the Upper Moscovian (C1/3) to Permian of the U.S.S.R. and occurs also rarely in the middle Stephanian to Upper Autunian of some intramontaneous basins in Central France. It may be conspecific with *Knoxisporites* sp. A described by CLENDENING (1974) from the Council Grove Group (Lower Permian) of the U.S.A.. The species shows a close affinity to *Knoxisporites stephanephorus* from the Lower Oil Shale Group of Scotland (LOVE 1960) and to *Knoxisporites rotatus* from the Upper Mississippian of the U.S.A. (HOFFMEISTER, STAPLIN & MALLOY 1955). Similar specimens from the Namurian A to Westphalian D of Canada were identified by BARSS (1967) as *Knoxisporites* cf. *stephanephorus*. We found several specimens in sample 385.

Latensina trileta ALPERN 1958
Pl. 2, figs. 1-2

Remarks: This monosaccate species was recognized from the Upper Silesian of the St. Hilaire-1 borehole of Auvergne (France) by ALPERN (1958). The base of the biozone of the species in NW Europe is in the Upper Westphalian. In Canada, the species was recognized by BARSS (1967) under the name *Cordaitina* sp. from the Westphalian C. The epibole ranges in NW Europe from the Middle Stephanian to the Lower Autunian.

Several specimens were recovered from sample 385.

Potonieisporites gelriaensis
BLESS, LOBOZIAK & STREEL, nov. sp.
Pl. 1, figs. 1-4

Holotype: Specimen Haaksbergen 386 - Bstereoscan
Type level: Upper Westphalian C; light grey shale with rootlets between 945.50 and 947.00 m.

Type locality: Haaksbergen-1 borehole, E Netherlands.

Derivatio nominis: Gelria, the latin name for Gelderland, the province where the borehole is located.

Diagnosis: This is a monosaccate, monolete prepollen with subcircular to elliptical outline. The amb of the central body is circular. The wall of the central body is relatively thick. The central area shows a convolute to verrucose ornament of the distal part. The ornaments are densely distributed and of uniform size. They have a polygonal outline and are usually low and flattened. They are separated by shallow, narrow furrows, which at first hand give the impression of a negative reticulum when studied under transparent light. In some specimens (cf. pl. 1, fig. 1), these ornaments are prominent verrucae as shown by the stereo-scanning photographs (cf. pl. 1, fig. 1c). The monolete suture may show a tendency to become dilate or even trilete. The saccus is externally smooth and internally finely alveolate.

Size of holotype: total length 70 μ ; diameter of central body 35 μ .

Remarks: The coarse convolute to verrucose ornament of the central area distinguishes this species. PEPPERS (1964, pl. 7, fig. 15) figured a trilete, monosaccate specimen with a similar ornament on the central area, which may be conspecific to our species.

This species was recognized in the samples 379, 380, 384 and 385.

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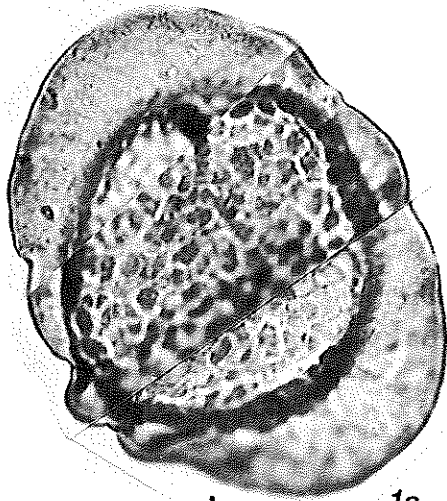
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The stereoscanning photographs of plates 1 to 4 have been made with the Cambridge Stereoscan S2 at the University of Liège.

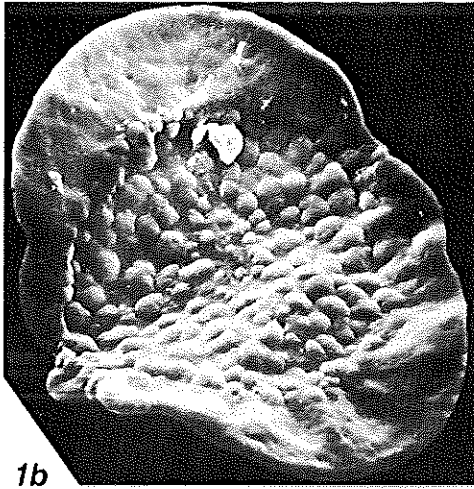
All the specimens are stored with the palynological collections of the Geologisch Bureau, Heerlen. The coordinates cited are those of the Leitz Ortholux microscope no. 717603 at the Geologisch Bureau of Heerlen.

PLATE 1

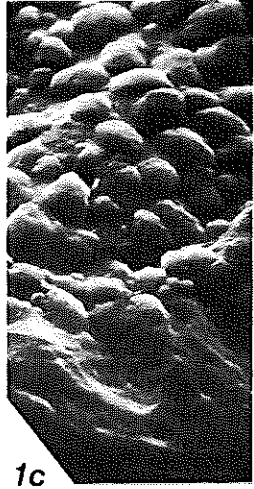
- 1 *Potonieisporites gelriaensis* BLESS, LOBOZIAK & STREEL, nov. sp.
Holotype, Haaksbergen 386 - Bstereoscan
a: transparent light (x 1000)
b: proximal view, stereoscanning microscope; trilete mark faintly visible (x 1000)
c: detail of fig. 1b, showing contact between smooth saccus and verrucose central area
- 2 *Potonieisporites gelriaensis* BLESS, LOBOZIAK & STREEL, nov. sp.
Haaksbergen 385 - Bstereoscan
a: transparent light (x 500)
b: proximal view, stereoscanning microscope (x 500)
c: detail of fig. 2b, showing trilete mark and very large flattened verrucae
- 3 *Potonieisporites gelriaensis* BLESS, LOBOZIAK & STREEL, nov. sp.
Haaksbergen 385-A, 39.1 x 109.0 (x 1000)
- 4 *Potonieisporites gelriaensis* BLESS, LOBOZIAK & STREEL, nov. sp.
Haaksbergen 385-C, 39.0 x 99.0 (x 1000)
- 5 *Knoxisporites glomus* SHWARTSMAN 1976
Haaksbergen 385-D, 47.8 x 101.4 (x 1000)
- 6 *Knoxisporites glomus* SHWARTSMAN 1976



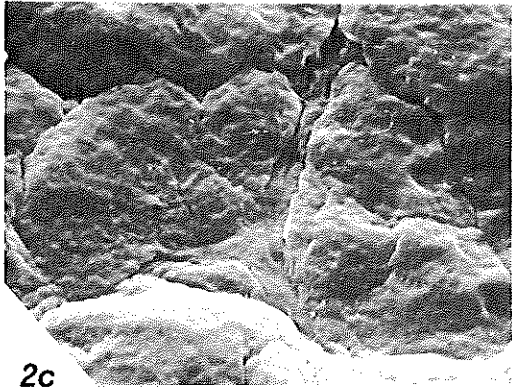
1a



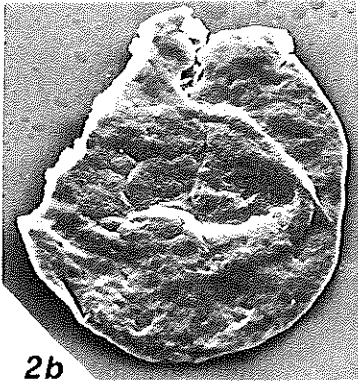
1b



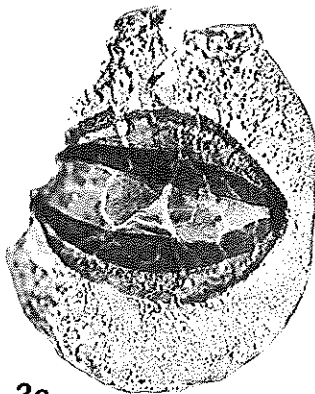
1c



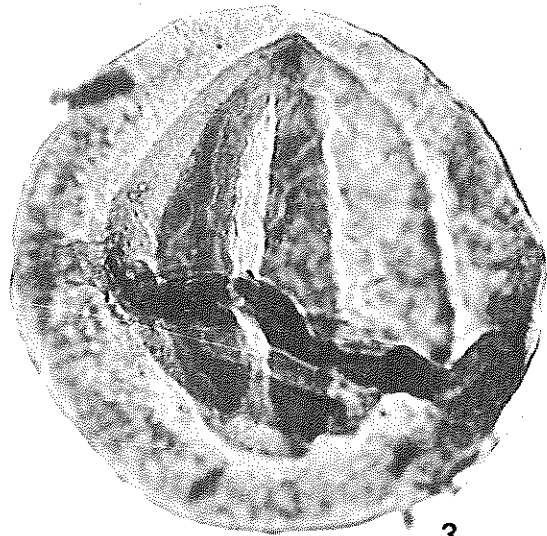
2c



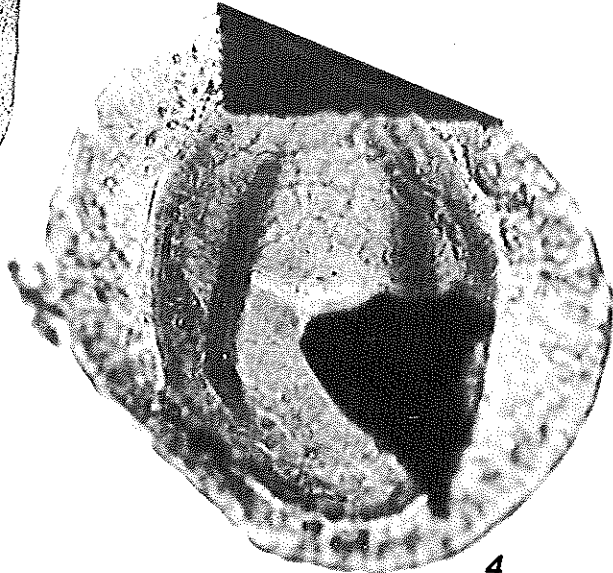
2b



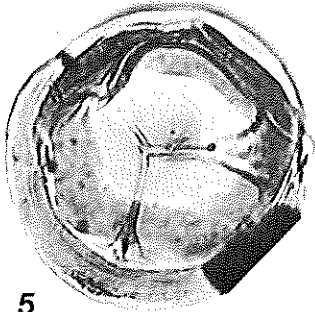
2a



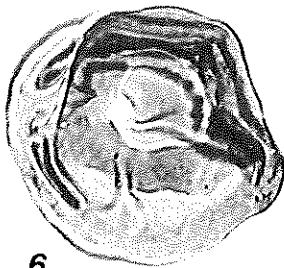
3



4



5



6

PLATE 2

- 1 Haaksbergen 385-C, 40.9 x 112.9 (x 1000)
Latensina trileta ALPERN 1958
- 2 Haaksbergen 385-A, 26.8 x 105.6 (x 1000)
Latensina trileta ALPERN 1958
- 3 Haaksbergen 385-A, 27.3 x 105.0 (x 1000)
Illinites unicus KOSANKE sensu HELBY 1966
- 4 Haaksbergen 386-B, 40.2 x 95.0 (x 1000)
Illinites unicus KOSANKE sensu HELBY 1966
- 5 Haaksbergen 384-A, 22.7 x 102.8 (x 1000)
Illinites unicus KOSANKE sensu HELBY 1966
- 6 Haaksbergen 384-B, 48.3 x 92.8 (x 1000)
Two specimens of the same species are visible
Centonites symmetricus PEPPERS 1964
Specimen from the collections of Dr. R. A. PEPPERS from the Upper Pennsylvanian of North America (x 500)
- 7 *Centonites symmetricus* PEPPERS 1964
Haaksbergen 383-A, 33.0 x 113.2 (x 500)
- 8 *Biharisporites haaksbergenensis* BLESS, LOBOZIAK & STREEL, nov. sp.
Haaksbergen 384 - 1stereoscan (specimen marked 2-3 on slide)
a: proximal view (x 500)
b: detail of fig. 8a, showing contact between proximal and distal sides
c: detail of fig. 8a, showing ornamentation

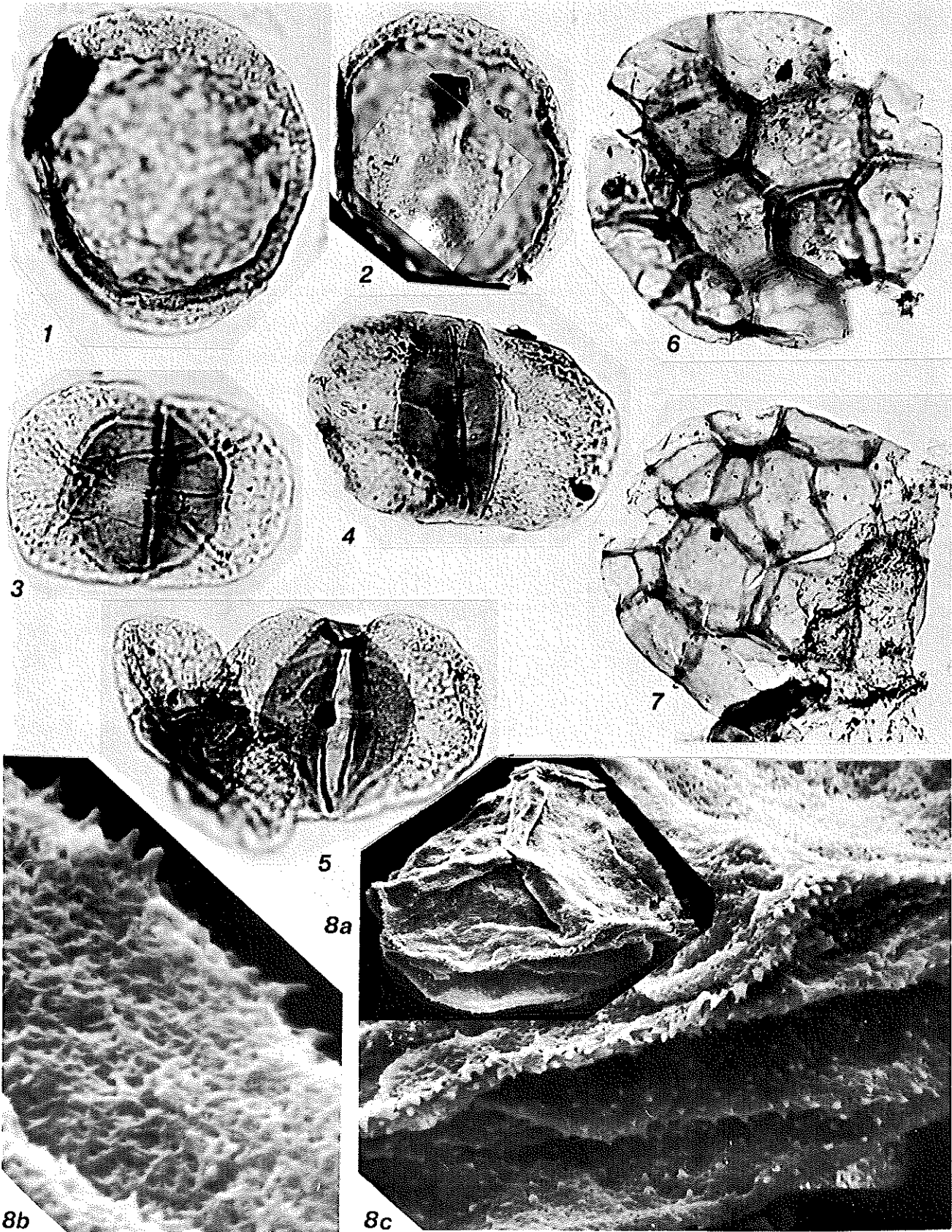


PLATE 3

1-7

Biharisporites haaksbergenensis BLESS, LOBOZIAK & STREEL, nov. sp.

- 1: Haaksbergen 386-A, 27.1 x 100.4 (x 500)
Isolated intexine with distinct protuberances at distal ends of suturae
- 2: Haaksbergen 386-B, 52.7 x 103.0 (x 500)
Isolated intexine with distinct protuberances at distal ends of suturae
- 3: Haaksbergen 386-A, 45.8 x 103.2 (x 500)
Intexine with distinct protuberances at distal ends of suturae visible below weathered or overmacerated exoexine
- 4: Haaksbergen 384 - 1stereoscan (specimen marked 5ter-6ter on slide) (x 500)
Intexine with gaping suturae faintly visible below slightly weathered or overmacerated xoexine
- 5: Haaksbergen 384-A, 41.4 x 102.8 (x 500)
Holotype, showing encroaching of distal side on proximal surface at distal ends of suturae
- 6: Haaksbergen 384-B, 44.0 x 94.4 (x 500)
- 7: Haaksbergen 386 - Bstereoscan
 - a: transparent light (x 500)
intexine visible in lower left
 - b: distal view, stereoscanning microscope; intexine visible in lower left (x 500)
 - c: detail of fig. 7b, showing ornamentation

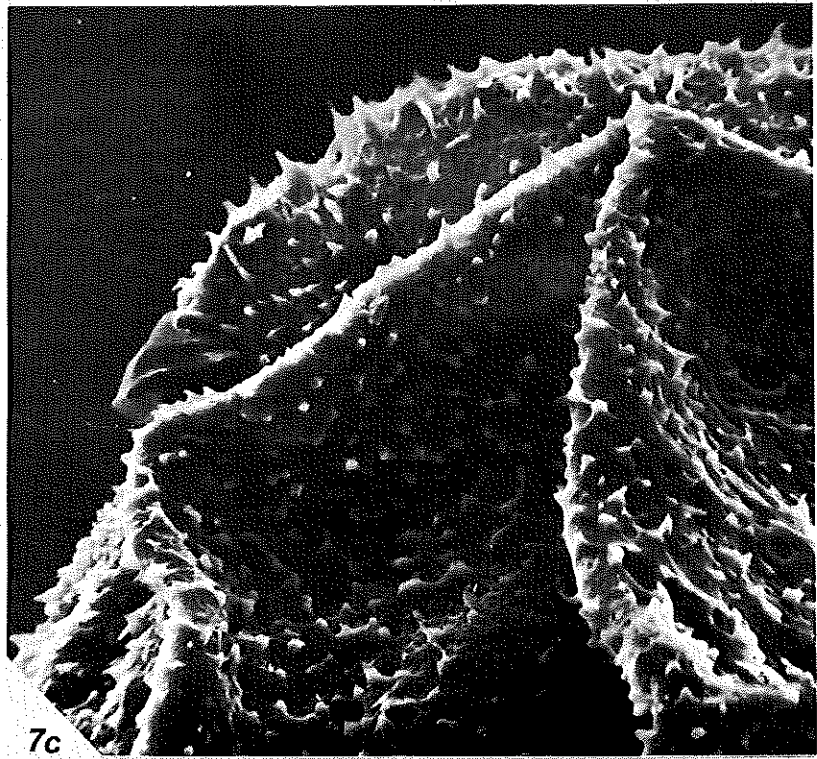
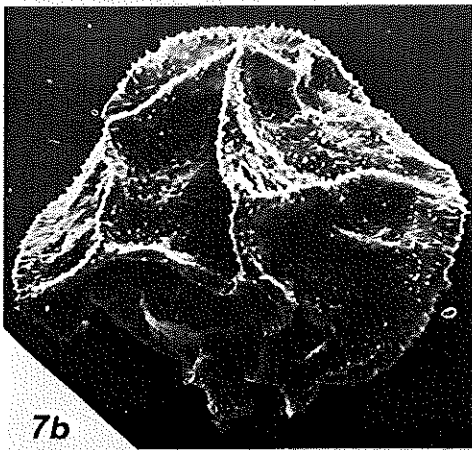
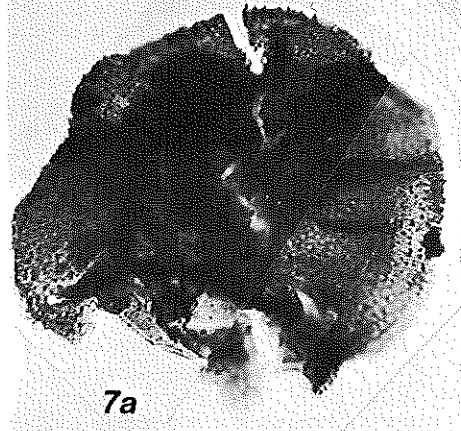
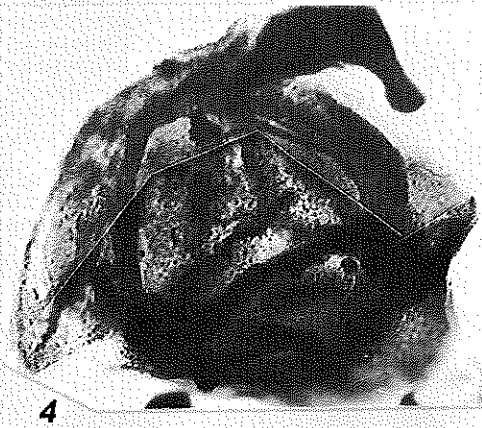
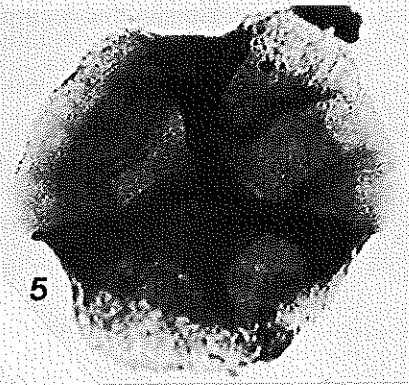
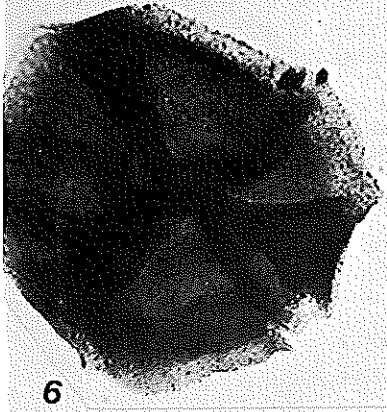
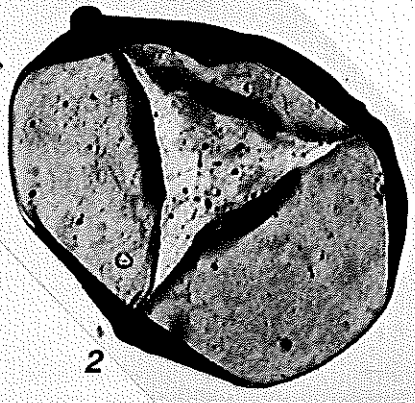
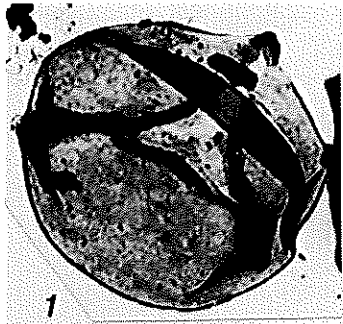


PLATE 4

- 1 *Trilethisporites tuberculatus* (ZERNDT) POTONIÉ & KREMP
Haaksbergen 378, proximal view, stereoscanning microscope (x 50)
- 2 *Trilethisporites tuberculatus* (ZERNDT) POTONIÉ & KREMP
Haaksbergen 378, distal view, stereoscanning microscope (x 50)
- 3 *Zonalesporites brasserti* (STACH & ZERNDT) POTONIÉ & KREMP
Haaksbergen 378, proximal view, stereoscanning microscope (x 50)
- 4 *Expansisporites westphalensis* (BHARDWAJ) LOBOZIAK
Haaksbergen 372, proximal view, stereoscanning microscope (x 50)
- 5 *Lagenicula horrida* ZERNDT
Haaksbergen 378, proximal view, stereoscanning microscope
a (x 50)
b: detail of fig. 5a, showing large tapering spines (x 200)
- 6 *Lagenicula horrida* ZERNDT
Haaksbergen 378, proximal view, stereoscanning microscope
a: (x 50)
b: detail of fig. 6a, showing ornament of small spines on contact area (x 200)

