The occurrence of reworked miospores in a Westphalian C microflora from South Limburg (the Netherlands) and its bearing on paleogeography

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5 figures, 2 tables, 7 plates

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ABSTRACT

Routine analysis of miospore assemblages near the base of the Upper Westphalian C of South Limburg (the Netherlands) has yielded a rich microflora consisting of some eighty species, which normally occur in Westphalian C sediments, and some fifty species, which apparently have been derived from Middle Devonian to Lower Westphalian strata. The composition of these reworked miospore assemblages strongly suggests that the Ardenno-Rhenish Massif has been their source. This implies that also the Upper Westphalian sediments in the southern part of the Netherlands may have been derived from that area. This hypothesis is in contradiction with previous opinions, which favoured a northeastern origin for the bulk of the Westphalian sediments in Germany and the Netherlands. From the inferred transport ways of the sediments, from the actual distribution of Upper Westphalian sediments and from the fact that the Upper Westphalian of northwestern Germany cannot be correlated into the same detail as the Lower Westphalian with that of the Campine and the Netherlands, it is deduced that two separated Upper Westphalian basins with sediment supply from the Ardenno-Rhenish Massif – and to some extend from the Brabant Massif into the basin North of that Massif – have existed.

RÉSUMÉ

Une analyse de routine d'assemblages de miospores de la base du Westphalien C supérieur du Sud Limbourg (Pays-Bas) a montré une riche microflore consistant en quelque 80 espèces qui apparaissent normalement dans les sédiments du Westphalien C et quelque 50 espèces qui proviennent apparemment de strates mésodévoniennes à Westphalien inférieur. La composition de ces assemblages de miospores remaniées suggère fortement qu'elles proviennent du Massif ardenno-rhénan. Celà implique aussi que les sédiments du Westphalien supérieur du sud des Pays-Bas peuvent provenir de cette région. Cette hypothèse est en contradiction avec des opinions précédentes en faveur d'une origine nord-orientale de la masse des sédiments Westphaliens en Allemagne et aux Pays-Bas. Du trajet de transport supposé des sédiments, de la distribution actuelle des sédiments du Westphalien supérieur et du fait que le Westphalien supérieur de l'Allemagne nord–occidentale ne peut être corrélé avec celui de Campine et des Pays-Bas d'une manière aussi précise qu'au Westphalien inférieur, on déduit que deux bassins séparés ont existé au Westphalien supérieur avec un apport sédimentaire provenant du Massif ardenno-rhénan et, dans une certaine mesure, du Massif de Brabant au nord de celui-ci.

1. INTRODUCTION

The exploration borehole SM-XLV is located near the village of Jabeek in South Limburg (the Netherlands; fig. 1). It was drilled in 1922 and penetrated the Carboniferous near the top of the Westphalian C at -789.22 m (-727.2 m sealevel). At total depth ($\pm$ -1355 m) the topmost Westphalian B has been reached. Samples from the majority of coal seams and from a large number of fossiliferous rocks have been stored with the collections of the Geological Bureau of the Netherlands Geological Survey at Heerlen. Recent information on this material has been published by VAN AMEROM (1972; macroflora), BLESS, CALVER & JOSTEN (1972; miospores, lithostratigraphy), BLESS & WINKLER PRINS (1972; fauna from Aegir Marine Band at some 1350 m boredepth) and VAN WIJHE & BLESS (1974; miospores).

During a routine analysis it was noticed that a shale of undoubted Westphalian C age (miospore preparation 143) contained several typically pre-Westphalian elements of probably Devonian and Dinantian age. A more detailed investigation of the sample revealed the existence of several more pre-Westphalian spores, which had been left as unidentified during the first study. The relatively large amount of these presumably reworked spores (about 2½%) stimulated further study, the results of which are presented in this paper.

Reworked spores commonly occur in all kinds of sediments. OWENS (1972) described a reworked Lower Tournaisian miospore assemblage from Permo-Triassic deposits of South Devon (England). He suggested that they occurred there in discrete rock fragments enclosed in the matrix of the sediment (a green mudstone). Spores derived from Devonian and Dinantian strata occur in Lower Permian deposits of the Yukon Territory (Canada; c.f. BARSS 1967). Paleozoic spores are known to occur in Cenozoic glacial tills (e.g. WINSLOW 1962). TURNAU (1970) published on Namurian and Westphalian spores from coal pebbles in Lower Cretaceous to Oligocene strata of Poland. Similar coal pebbles occur also in the Cretaceous of the Netherlands (first author, unpublished data). The relatively high number of reworked spores and pollen in many Cenozoic sediments can be easily detected by means of fluorescence techniques (VAN GIJZEL 1967). But especially in Paleozoic sediments, where this technique is no longer useful, it may be difficult to distinguish between the proper spore contents and reworked material. PEPPERS (1964) suggested that the occurrence of certain spore genera in clastic sediments well above their known vertical ranges in coal in North America might be attributed to redeposition. As far as the Westphalian of Northwestern Europe is concerned, there is no published information on the frequency of derived spores. We suppose, that in general only a few, isolated specimens occur then and when in a sample, which have a recognizably much older age.

Normally, spores derived from older strata will have been destroyed by oxidation processes during the weathering of the rocks, during transport or before being re-embedded. Only under exceptional
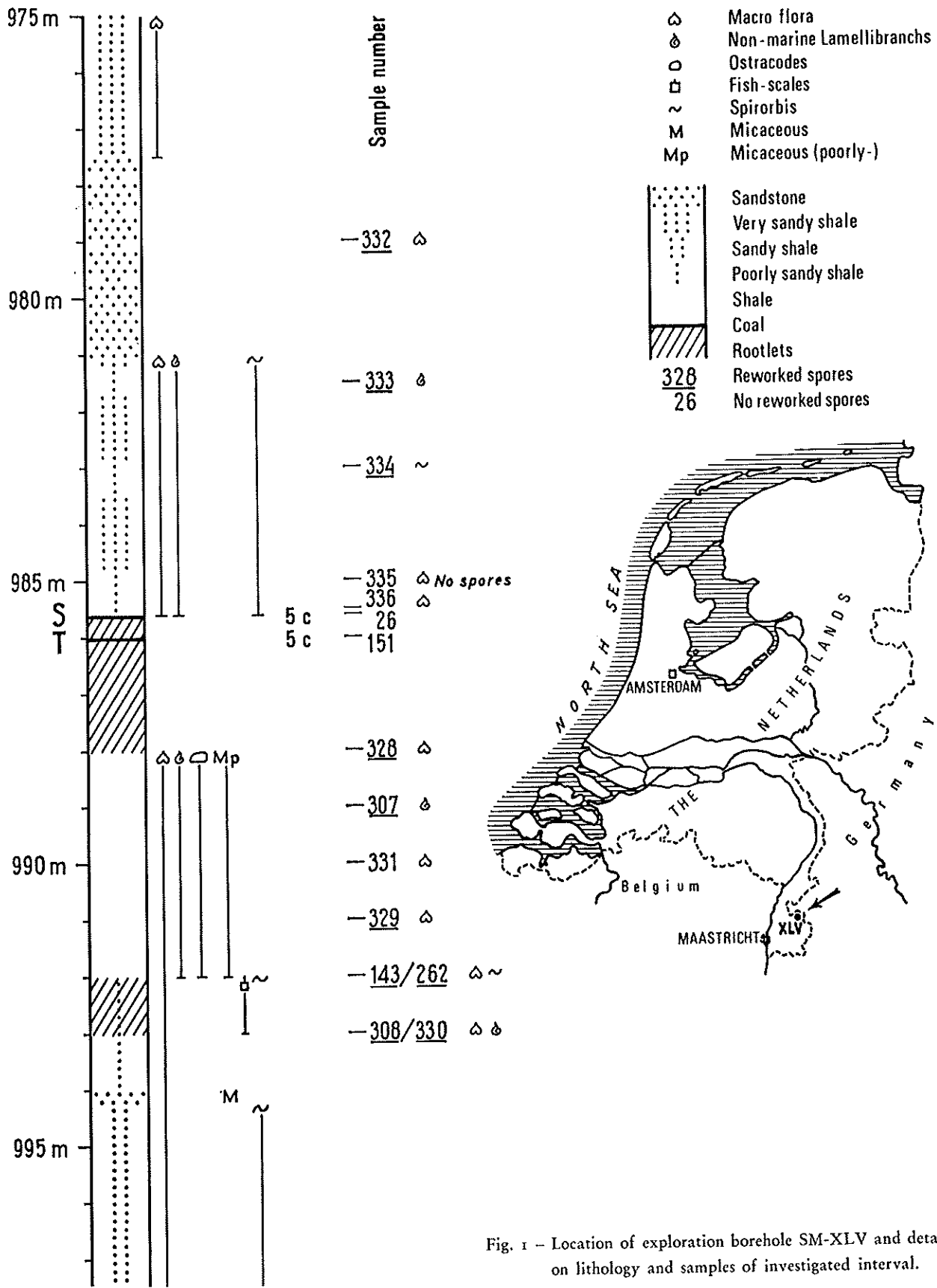
2

975 m

980 m

985 m

S
T

990 m

995 m

Sample number

◊ Macro flora
◊ Non-marine Lamellibranchs
○ Ostracodes
▢ Fish-scales
~ Spirorbis
M Micaceous
Mp Micaceous (poorly-)

Sandstone
Very sandy shale
Sandy shale
Poorly sandy shale
Shale
Coal
Rootlets
328 Reworked spores
26 No reworked spores

—332 ◊

—333 ◊

—334 ~

—335 ◊ No spores
—336 ◊
5 c —26
5 c —151

—328 ◊

—307 ◊

—331 ◊

—329 ◊

—143/262 ◊ ~

—308/330 ◊ ◊

◊ ◊ ~

◊ ◊ ○ Mp

▢ ~

M ~

NORTH SEA

AMSTERDAM

NETHERLANDS

Germany

THE

Belgium

MAASTRICHT XLV

Fig. 1 – Location of exploration borehole SM-XLV and details
on lithology and samples of investigated interval.

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circumstances, when for example the distance between source area and place of redeposition was relatively short and the time necessary for oxidation under presumably aerial conditions was reduced to a minimum – this includes a quick redeposition – one might expect that numerous spores may have survived the weathering from the original sediment, the transport and the redeposition.

All the available samples between 975 and 1000 m boredepth have been examined for reworked spores. With one exception (fig. 1), they have yielded a rich microflora. The reworked elements are concentrated in three horizons separated by horizons which did not yield recognizable reworked spores. It is suggested that several more horizons above and below the studied interval contain reworked spores. But analysis of shale samples from about every fifty meters in the same borehole has not revealed any more. There is no apparent difference in color, translucency or general preservation between the presumably Westphalian C and pre-Westphalian C spores. Therefore, one can only speculate about the real percentage of reworked material, since the bulk of the microflora is made up by long-ranging forms such as *Florinites, Lycospora, Crassispora, Calamospora* and less characteristic genera such as *Granulatisporites, Leiotriletes, Punctatisporites, Lophotriletes* and *Apiculatisporis.* Our aim was in the first place to detect guide species for different pre-Westphalian ages. A second problem that should be solved is to find a possible nearby source area. Finally, the sudden increase of reworked spores in the microflora has to be related to some event that worked as a trigger mechanism for the process suggested above of rapid weathering, transport, redeposition and burial.

2. ACKNOWLEDGEMENTS

3. SAMPLE DETAILS

Fifteen samples between 979.00 and 993.00 m boredepth have been studied. This interval belongs to the basal part of the *Vestispora fenestrata* miospore assemblage of VAN WIJHE & BLESS (1974), which is the equivalent of the *Torispora securis* assemblage of SMITH & BUTTERWORTH (1967). Below this interval some 350 m of Lower Westphalian C sediments occur. The Westphalian A and B in the area presumably add up to some 1800 m thickness.

The two coal seams "S" and "T", which occur in the studied interval, have been tentatively correlated by the first author with coal seam 30 of the Neeroeteren 117 Borehole in the Campine (Belgium) using palynological (mio- and megaspores; published by PIERART 1958 and SOMERS 1971) and macrofloral (after BLESS, CALVER & JOSTEN 1972) evidence[*].

The following samples have been treated for miospores (fig. 1). Dr. H. W. J. VAN AMEROM, Curator of the geological collections at the Geological Bureau of Heerlen, has kindly provided us a revised list of their fossil contents.

979.00 m – Sample GB40327, miospore preparation 332, very sandy, greyish shale with *Annularia radiata.*

981.50 m – Sample GB22607, miospore preparation 333, sandy to very sandy, light greyish shale with *Naiadites* aff. *daviesii.*

983.00 m – Sample GB609, miospore preparation 334, sandy greyish shale with *Spirorbis pusillus* and diminuted plant debris.

985.00 m – Sample GB223, miospore preparation 335, poorly sandy, light greyish shale with sideritic concretion and with *Alethopteris davreuxi*; this was the only sample that did not yield any spores!

985.50 m – Sample GB3416, miospore preparation 336, dark-greyish shale with *Reticulopteris muensteri.*

985.60 - 985.65 m – coal seam S, miospore preparation 26

986.00 - 986.05 m – coal seam T, miospore preparation 151

988.00 m – Sample GB2522, miospore preparation 328, poorly sandy, greyish shale with *Zeilleria avoldensis.*

989.00 m – Sample GB23014, miospore preparation 307, greyish shale with *Naiadites* sp.

990.00 m – Sample GB41241, miospore preparation 331, greyish shale with *Lepidodendron* gr. *loricatum* and *Naiadites* aff. *alatus.*

991.00 m – Sample GB18113, miospore preparation 329, greyish to dark-greyish shale with *Lepidophyllum triangulare.*

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[*] During the preparation of the manuscript, the second author has found reworked spores of presumably Middle Devonian age (*Retusotriletes* sp., *Ancyrospora* sp., *Dibolisporites echinaceus, Grandispora ?macrotuberculata,* cf. *G. ?macrotuberculata* conspecific with specimen of plate 5, fig. 10) in a sample of fine-grained sandstone at some three meters above coal seam 30 of the Neeroeteren 117 Borehole of the Campine. This confirms the correlation as proposed above. It equally means that the reworked spores are not confined to the South Limburg area but extend into the Campine. It is important to note that this reworked spore assemblage from the Campine is similar to that from South Limburg, since it is an argument for suggesting that both came from the same source. We are indebted to Dr. A. DELMER (Service géologique de Belgique, Brussels) who has put samples from the Neeroeteren 117 Borehole at our disposal.
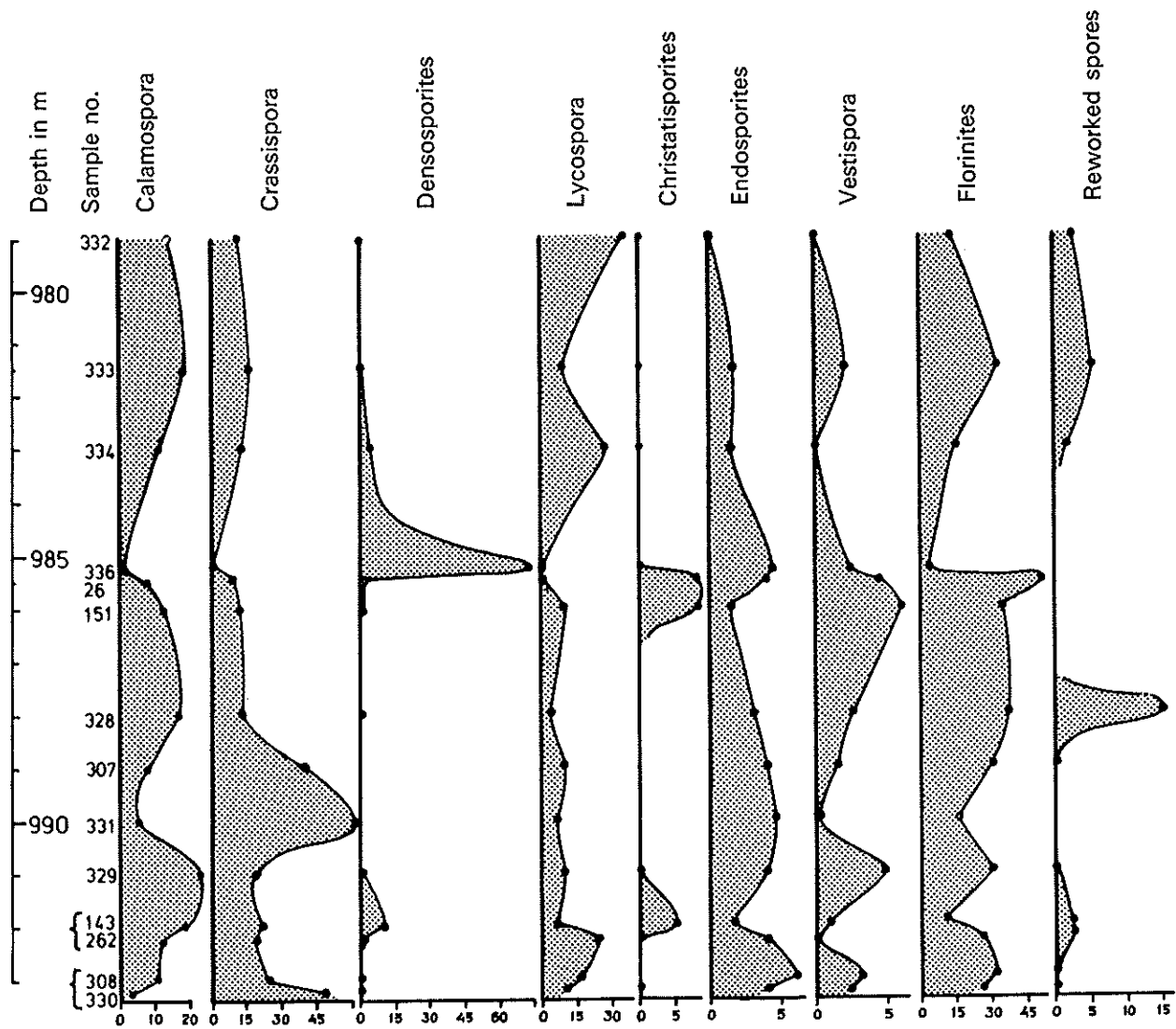
Fig. 2 – Quantitative occurrence of some spore genera in studied interval. Note that reworked spores are restricted to three distinct horizons.

992.00 m – Sample GB606, miospore preparations 143 and 262, sandy, greyish shale with *Karinopteris* sp. and *Spirorbis pusillus*.

993.00 m – Sample GB1950, miospore preparation 308, poorly sandy, greyish shale with *Rhabdoderma* sp.

Sample GB18192, miospore preparation 330, poorly sandy, greyish shale with *Lepidophyllum triangulare*.

Reworked miospores have been recognized in preparations 332, 333, 334, 328, 307, 329, 143, 262, 308, and 330. They are apparently concentrated in three different horizons. For the sake of simplicity, the horizons are numbered in this paper as follows.

Horizon 1 (preparations 329, 143, 262, 308 and 330) between 991.00 and 993.00 m containing derived miospores.

Horizon 2 (preparation 331) at 990.00 m, without recognized reworked miospores.

Horizon 3 (preparations 307 and 328) between 989.00 and 988.00 m, containing reworked miospores.

Horizon 4 (preparations 151, 26 and 336) between 986.05 and 985.50 m, without reworked miospores.

Horizon 5 (preparations 334, 333 and 332) between 983.00 and 979.00 m, containing reworked miospores.

The statistical analysis of the palynological contents of the samples (fig. 2) clearly shows that this distinction of five horizons on the basis of presence or absence of reworked spores is certainly justified, since three maxima in the procentual distribution of this reworked material can be distinguished.

4. COMPOSITION OF MICROFLORA

As already explained above, there is no difference in colour or preservation between the proper Westphalian C and pre-Westphalian C microflora. It is therefore impossible to give exact figures for the true amount of reworked spores, since the bulk of the recovered microflora consists of long-ranging elements (fig. 2). Therefore, we suggest to distinguish between presumably Westphalian C and presumably pre-Westphalian C elements on the basis of our present knowledge of the range of spores. Some species, such as *Reinschospora triangularis, Reticulatisporites polygonalis, Microreticulatisporites tripar-*

Table I – Occurrence of presumably Westphalian C spores in samples. As explained in the text five horizons are distinguished on the basis of the presence or absence of reworked spores. Only two genera (*Reinschospora* and *Savitrisporites*) occur in all three horizons with reworked spores and have not been recognized in the other horizons. None of the genera or species studied is restricted to the horizons without reworked spores, nor shows any of them higher percentages in the coal samples (151 and 26) than in the other samples.

PRESUMABLY WESTPHALIAN C SPORES	1					2	3		4			5		
HORIZON / PREPARATION NR.	330	308	262	143	329	331	307	328	151	26	336	334	333	332
Leiotriletes			×	×	×				×	×		△	△	△
Punctatisporites	×	×			×	×		×						×
Calamospora	△	△	△	△	△	△	△	△	△	△	△	△	△	△
Granulatisporites		×	△	×	×	×	×		△	△		△	×	△
Cyclogranisporites	×	×		△	×			×	×			×	△	
Verrucosisporites	△	△		△	×	×	×	×	△	△	×	△	△	△
Lophotriletes	×		△		×			×	×	△		×	×	△
Apiculatisporis	×	×	×	×	×	△	△	×		×	△	×	×	
Acanthotriletes			×									×		×
Raistrickia	×	×	×	△	×	×	×	×	△	△	×	×	×	×
Convolutispora florida				×		×		×				×		
Microreticulatisporites	×		×	×								×		×
Dictyotriletes bireticulatus		×	×		×	×								×
Dictyotriletes spp.	×	×	×	×	×	△	×	×	×	△	×	×	×	
Triquitrites bransonii and T. tribullatus		×			×							×		
Triquitrites sculptilis	×	×		×	×			△	△	×	×	×	△	△
Triquitrites velensis		×	×	×				×	×			×		×
Reinschospora	×	×			×		×	×						×
Reticulatisporites polygonalis				×				×		×				
Reticulatisporites reticulatus			×	×		×					×		×	
Savitrisporites	×	×	△	△	×			△				△	△	△
Simozonotriletes	×											×		×
Crassispora	△	△	△	△	△	△	△	△	△	△	×	△	△	△
Densosporites	×	×	△	△	△			×	×	×	△	×	△	△
Lycospora	△	△	△	△	△	△	△	△	△	△	×	△	△	△
Cristatisporites	×		×	△	×				△	△	×	×	×	×
Cirratriradites	×	△	×	△	△	△	△	△	△	△	×	△	△	×
Cingulizonates	×	×	×	×	△	×		×			△	×	×	△
Radiizonates	×	×			×						×	△		×
Endosporites	△	△	△	△	△	△	△	△	△	△	△	△	△	×
Alatisporites	×	×		×	×		×	×			×	×	×	×
Laevigatosporites	×	△	×	×	×		×	×	△	△	△	×	×	×
Punctatosporites	×	×	△	×	×			△	△	△		×	×	
Vestispora costata/tortuosa	×		×		×		△	△	△	△	△	×	△	×
Vestispora magna and V. pseudoreticulata	△	△	×	×	△	×	△	△	×	×	×	×	×	×
Vestispora fenestrata and V. gr. reticulata	×	×	×	△	×				×	×	×			
Florinites	△	△	△	△	△	△	△	△	△	△	△	△	△	△
Schopfipollenites	×		×											×
Reworked spores	×	×	△	△	×		×	△				△	△	△

× less than 1% of assemblage (300 spores counted)
△ 1% or more of assemblage

Table II – Distribution of reworked spores in the horizons distinguished in this paper. The fact that a species has been recognized in only one preparation does not necessarily mean that only one specimen has been found. For example, *Rhabdosporites langi* occurs in only one sample, where four specimens of this species could be observed.

titus and *Dictyotriletes bireticulatus* have been rather arbitrarily attributed to one group or the other. They constitute minor elements in the total spore list, however, so that the question whether they should have been better listed with either the pre-Westphalian C or proper Westphalian C species is not relevant in the end. Finally, it should be kept in mind, that the list of recognized pre-Westphalian C spores is incomplete insofar that a large number of spores of a relatively simple structure – which are certainly no Westphalian species, but which might be attributed to many different genera and species, depending on their presumed age – have not been included in this paper.

Presumably Westphalian C spores, which occur in at least two preparations, have been listed in table I. Some 33 genera represented by about 80 species have been recognized. A few of them need additional comments.

Spores derived from Upper Viséan to Lower Westphalian strata occur mainly in horizons 1 and 5 (table II). Examination of table II learns that most species occur either in horizon 1 or in horizon 5. Only three of the twenty-eight named species occur in two horizons, whereas only five have been recovered from at least two samples. This is in sharp contrast with the Dinantian and Devonian spores, where eleven of the twenty-two named species occur in two or three horizons or in at least two samples. It seems premature, however, to decide whether this means that the Upper Viséan – Lower Westphalian strata have been more incidentally eroded than the older ones.

It should be noted that we have tried to "derive" our reworked spores from the smallest possible number of source rocks. The age of these source rocks has been determined by using concurrent range assemblages (fig. 3). The individual species may have much longer ranges, of course.

4.1. Presumably Westphalian C spores

Dictyotriletes bireticulatus (pl. 3, fig. 7) has been observed in five of the fifteen samples, whereas it has practically disappeared in the Netherlands at the end of the Upper Westphalian B (VAN WIJHE & BLESS 1974). In the same borehole, there is a single occurrence of the species in the Lower Westphalian C at some 200 m below the interval studied here. Of course, the species is known as a rare to sporadic element in the Westphalian C of Belgium (SOMERS

REWORKED SPORES	1	2	3	4	5
UPPER VISÉAN – LOWER WESTPHALIAN					
Punctatisporites sinuatus	2				
P. aff. *aerarius*	1				
Pustulatisporites papillosus				1	
Raistrickia cf. *microhorrida*	1				
Convolutispora cerebra			1		
C. flexuosa var. *major*	1				
Ahrensisporites guerickei	1			2	
A. interitorsus	1				
Tripartites incisotrilobus	1				
T. nonguerickei	1				
T. trifoliolatus	1				
?T. cf. *trilinguis*	1				
Mooreisporites fustis				1	
M. trigallerus	2			1	
Knoxisporites cinctus	1				
K. ex gr. *hageni*					1
K. sp.	1				
Reticulatisporites carnosus	1				
Bellispores nitidus				1	
Monilospora mutabilis	1				
Grumosisporites varioreticulatus	1				
"Anulatisporites" sp.	1				
Densosporites triangularis	1				
Cingulizonates aff. *capistratus*				1	
Radiizonates striatus	2				
Proprisporites aff. *laevigatus*	1			1	
Spelaeotriletes triangulus	1				
cf. *Schopfipollenites ellipsoides* var. *corporeus*	1				
UPPER FAMENNIAN – LOWER TOURNAISIAN					
"Dictyotriletes" fragments	1			1	
"Cristatisporites" echinatus	1	2			
cf. *"C." echinatus*				1	
Samarisporites sp.	3			1	
Grandispora famenensis	1				
Spelaeotriletes cassis	1			1	
S. lepidophytus	2			2	
Auroraspora hyalina	2			2	
Ancyrospora? capillata			1		
UPPER EMSIAN – LOWER FRASNIAN					
Apiculiretusispora cf. *arenorugosa*	1				
Dibolisporites sp.	1				
D. echinaceus s.l.	2			2	
"Anulatisporites" jonkeri	1				
Samarisporites nov. sp. aff. *inusitatus*	3		2	1	
Grandispora douglastownense	2		1	3	
G. ?macrotuberculata			2	2	
cf. *G. ?macrotuberculata*			1		
G. mammillata	1				
G. sp.	1				
Rhabdosporites langi			1		
Ancyrospora ancyrea var. *brevispinosa*	4		1		
DEVONIAN – DINANTIAN (uncertain range)					
Auroraspora macromanifestus	1				
Hystricosporites spp.	2		2	3	
Acritarcha	3		1	3	
Tasmanites spp.	3		1		1
Unknown	1				

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SIEGENIAN	EMSIAN	EIFELIAN	GIVETIAN	FRASNIAN	FAMENNIAN	TOURNAIS.	VISÉAN	

Dibolisp. echinaceus s.l.
Dibolisp. eifeliensis
Apiculirel. arenorugosa
Grandisp. ?macrotuberculata
Grandisp. douglastownense
Hystricosporites spp.
Samarisporites inusitatus
Rhabdosporites langi
Grandisp. mammillata
"Anulatisporites" jonkeri
Aurorasp. macromanifestus
Ancyrospora anc. v. brevispinosa
Grandisp. sp.
Auroraspora hyalina
Samarisp. sp.
Grandisp. famenensis
Spelaeotr. lepidophytus
Ancyrospora? capillata
"Cristatisp." echinatus
Spelaeotr. cassis
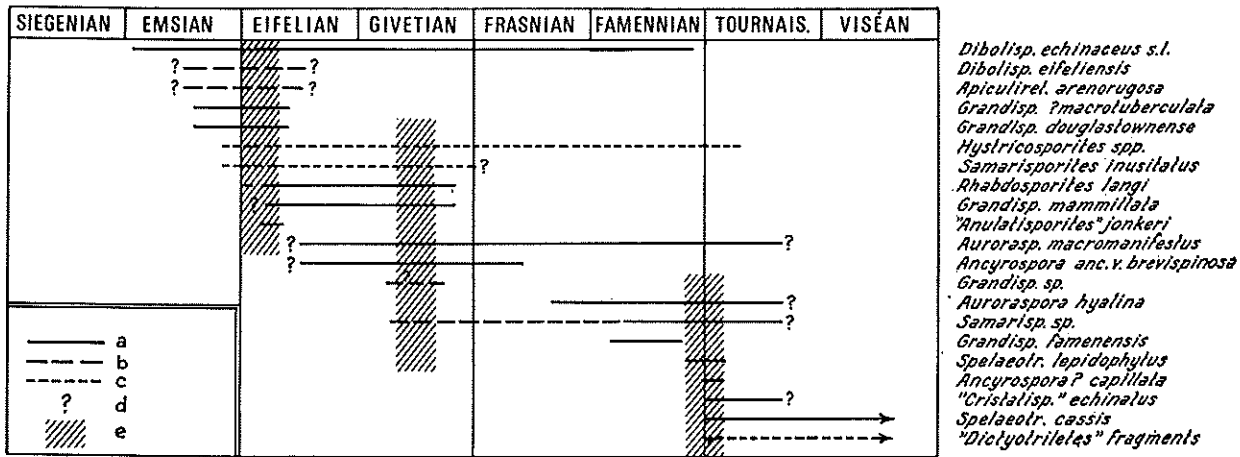*"Dictyotriletes" fragments*

a
b
c
? d
e

Fig. 3 – Concurrent range assemblages of reworked Devonian and Dinantian spores. a: species identified in our material; range based on marine faunas. b: specimen(s) comparable (cf) to species recognized in our material. c: similar, but not conspecific (aff.) specimen recognized in our material. d: exact range not controlled by the occurrence of marine faunas. e: concurrent range assemblages.

1971) and Germany (GREBE 1972). Provisionally, we would like to suggest that the relative frequency of this species in this interval indicates that at least some specimens may have been reworked from older strata.

Three species of *Microreticulatisporites* have been recognized *(M. nobilis, M. sulcatus* and *M. tripartitus).* *M. tripartitus* (pl. 1, fig. 13) has been described by LAVEINE (1962) from the Upper Westphalian A of the Netherlands. The species has since then been recognized by SOMERS (1971) in the Westphalian A-B of the Campine (Belgium) as a rather rare form. It is not impossible, that it has a longer range than known up to now, so that we do not consider that the single specimen from preparation 308 has been reworked.

The genus *Reinschospora* is represented by two species, *R. speciosa* (pl. 1, fig. 21) and *R. triangularis* (pl. 1, fig. 22). They occur only in horizons 1, 3 and 5 in six of the fifteen samples. Specimens of this genus rather infrequently occur during the Westphalian with a somewhat more regular occurrence during the Westphalian B. Especially *R. triangularis* disappears in several basins at the beginning of the Lower Westphalian C (SMITH & BUTTERWORTH 1967; SOMERS 1971). On the other hand, LOBOZIAK (1969) and PEPPERS (1970) recorded the species from much higher strata in France and Illinois. Our own experience is that *Reinschospora* is more regular in clastic sediments rather than in coal. Since the work by SMITH & BUTTERWORTH and SOMERS was mainly on coal material, it may well be that also in the areas studied by those authors *R. triangularis* has a longer range. For that reason, we assign both species as presumably proper Westphalian C elements.

Reticulatisporites polygonalis (pl. 3, figs. 18, 20)

occurs both in the coal (preparation 26) and in the shales. At least part of the material is therefore believed to be Westphalian C. According to SMITH & BUTTERWORTH (1967), LOBOZIAK (1969) and SOMERS (1971) the species practically disappears at the beginning of the Westphalian C. GREBE (1972) and VAN WIJHE & BLESS (1974) noticed some extremely rare specimens in the Upper Westphalian C. The occurrence of the species in preparations 143 and 328 – which both show high percentages of reworked spores – suggests that some specimens may as well have been reworked from older strata.

Savitrisporites concavus and *S. nux* (pl. 1, figs. 18-20) have been recovered from ten samples from horizons 1, 3 and 5. In six samples, they make up one or more (up to 6% in preparation 143) percent of the microflora. Both species are presumed to be normal Westphalian C elements (cf. VAN WIJHE & BLESS 1974). The fact that they have not been recorded from horizons 2 and 4 is believed to be due to facies conditions. The possibility that the long-ranging *S. nux* (already known from the Namurian A) has been partly reworked from older strata cannot be excluded however.

Simozonotriletes intortus (pl. 1, fig. 31) has been recorded by some authors as being restricted to the Viséan to Lower Westphalian (SMITH & BUTTERWORTH 1967; GREBE 1972), whereas others give a range up to high in the Westphalian (SOMERS 1971). Although the species seems to have its widest distribution in the Viséan to Lower Westphalian, we believe that it ranges up into the Westphalian D as a very rare element.

Specimens assigned to *Cirratriradites* cf. *megaspinosus* by VAN WIJHE & BLESS (1974) are now supposed to belong to two different Middle Devonian species of *Grandispora* (see below).

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Columinisporites ovalis PEPPERS 1964
(pl. 2, fig. 13)

Remarks: A single specimen from preparation 328 shows the unmistakable bean-shaped outline, anastomosing ridges parallel to the length and more closely spaced smaller ridges perpendicular to the primary ones. Some six primary ridges could be observed. The maximum length (58 *µ*) is slightly larger than that given by PEPPERS (1964) and by COURVOISIER & PHILLIPS (1975), who gave a maximum length of 53 *µ*. The specimens of COURVOISIER & PHILLIPS may have been immature forms, since they were prepared from a fructification of *Peltastrobus reedae*.

Occurrence: Up to now only known from higher strata (Upper Pennsylvanian; Spoon to Bond Formations in Illinois) of probably Stephanian age (PEPPERS 1964, 1970; COURVOISIER & PHILLIPS 1975). The genus has been recorded also by ALPERN & DOUBINGER (1973) from the Autunian of France. The specimen has been prepared from a cleaned core fragment, which has been taken some 200 m below top Carboniferous, which is overlain by Triassic rocks. The genus *Columinisporites* had not been found before in any samples macerated in the laboratory of the first author. Therefore, contamination appears to have been impossible. Most probably, the genus has a longer range than presumed before.

4.2. Presumably Upper Viséan – Lower Westphalian spores

Punctatisporites aff. *aerarius* BUTTERWORTH & WILLIAMS 1958
(pl. 3, fig. 2)

Remarks: A few specimens with scabrate surface and exine up to 4 *µ* thick occur in preparation 330. *P. punctatus* has a much thinner exine (1-2 *µ*, cf. SMITH & BUTTERWORTH 1967).
Occurrence: Namurian (SMITH & BUTTERWORTH 1967).

Punctatisporites sinuatus (ARTÜZ) NEVES 1961
(pl. 3, fig. 1)

Remarks: The characteristic folds along the margin and parallel to the laesurae make this a easily distinguished species.
Occurrence: Namurian A – Westphalian A (SMITH & BUTTERWORTH 1967). Namurian C – Lower Westphalian B of France (COQUEL 1974).

Pustulatisporites papillosus
(KNOX) POTONIÉ & KREMP 1955
(pl. 3, fig. 9)

Remarks: Single specimen from preparation 332,

showing verrucae and bacula on distal surface.
Occurrence: Namurian A of Britain (SMITH & BUTTERWORTH 1967). SOMERS (1971) figures a questionable, rather verrucate form of this species from the Upper Westphalian A of Belgium. COQUEL (1974) describes the species from the Westphalian C-D of northern France. But also his specimens apparently are without any bacula.

Raistrickia cf. *microhorrida*
(HORST) POTONIÉ & KREMP 1955
(pl. 3, fig. 3)

Remarks: A single specimen from preparation 143 is here compared with *R. microhorrida*. The bacula have a rather variable shape, some having an expanded base or being fused at their base, whereas others show cone-like, truncate or partate ends.
Occurrence: *R. microhorrida* has been reported from the Namurian A of Mährisch-Ostrau (HORST 1955), Namurian C of Britain (NEVES 1958) and from the Westphalian B of NW France (LOBOZIAK 1969).

Convolutispora cerebra
BUTTERWORTH & WILLIAMS 1958
(pl. 4, fig. 20)

Remarks: This is one of the many species of *Convolutispora* occurring amongst the reworked microflora. *C. cerebra* is characterized by its ornamentation of small lumina and vermiculi, which become radially aligned in the peripheral area. It shows some similarity to *C. crassa* PLAYFORD 1962 from the Dinantian of Spitsbergen. The latter has a much coarser ornament, however. The single specimen from preparation 328 is slightly larger than SMITH & BUTTERWORTH (1967) give as size range for the species. This may be due to different maceration methods.
Occurrence: Viséan of Scotland (LOVE 1960); Namurian of Britain (SULLIVAN & MARSHALL 1966, SMITH & BUTTERWORTH 1967).

Convolutispora flexuosa var. *major*
HACQUEBARD 1957
(pl. 4, fig. 21)

Remarks: Single specimen from preparation 330 with maximum diameter some 100 *µ*. Ornament of thick, flexuose anastomosing muri.
Occurrence: Horton Bluff Group (probably Upper Tournaisian) of Canada (HACQUEBARD 1957). Upper Tournaisian to Upper Viséan of Poland (JACHOWICZ 1970).

Ahrensisporites guerickei
(HORST) POTONIÉ & KREMP 1954
(pl. 3, figs. 8, 15)

Remarks: Recorded from preparations 330, 332

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and 334. They show the distal kyrtomes and granulate ornament typical for this species.

Occurrence: Upper Namurian B to Westphalian B (SMITH & BUTTERWORTH 1967; VAN WIJHE & BLESS 1974). Except for North of France (LOBOZIAK 1969), this species does not occur above Westphalian B.

Ahrensisporites interitorsus (HORST) HORST 1955
(pl. 3, fig. 14)

Remarks: Single specimen from preparation 262 falling within size range of HORST's species. Specimen shows distal muri, which meet before reaching apices. Where they meet there is a distinct thickening.

Occurrence: Namurian A of Mährisch-Ostrau (HORST 1955).

Tripartites incisotrilobus
(NAUMOVA) POTONIÉ & KREMP 1956
(pl. 3, fig. 4)

Remarks: Single specimen from preparation 262, showing narrow equatorial flange connecting lobed auriculae. Diameter about 40 μ.

Occurrence: Dinantian to basal Namurian of Northern Hemisphere (PLAYFORD 1962, 1963).

Tripartites nonguerickei POTONIÉ & KREMP 1956
(pl. 3, fig. 13)

Remarks: Single specimen from preparation 143, showing radial plications and verrucate distal ornament. The size of our specimen is slightly larger than the size range given by SMITH & BUTTERWORTH (1967).

Occurrence: Upper Viséan to Namurian (SMITH & BUTTERWORTH 1967; NEVILLE 1968).

Tripartites trifoliolatus DYBOVA & JACHOWICZ 1957
(pl. 1, fig. 34)

Remarks: Single specimen from preparation 262. Flaring auriculae slightly corroded, amb trifoliate. Apart from slightly smaller size ($\pm$ 35 μ) the specimen is identical to the description of DYBOVA & JACHOWICZ.

Occurrence: Namurian A of Poland (DYBOVA & JACHOWICZ 1957).

?*Tripartites* cf. *trilinguis*
(HORST) SMITH & BUTTERWORTH 1967
(pl. 3, fig. 10)

Remarks: A single specimen from preparation 262 with trifoliate amb and rounded radial crassitudes, which appear to be connected interradially, has been first held for an aberrant *Triquitrites sculptilis*. However, the absence of a distal reticulum, the tripartite outline and the general similarity to the specimen figured by SMITH & BUTTERWORTH (1967, pl. 13, fig. 6) have made us compare it with *T. trilinguis*.

Occurrence: *T. trilinguis* has been described from the Viséan and Namurian (OWENS & BURGESS 1965; SMITH & BUTTERWORTH 1967).

Mooreisporites fustis NEVES 1958
(pl. 3, fig. 6)

Remarks: Single specimen from preparation 333, showing branching bacula at apices and distal pole. *M. inusitatus* lacks the bacula on the distal pole.

Occurrence: Namurian A to Westphalian B (NEVES 1958; SMITH & BUTTERWORTH 1967; GREBE 1972). Also figured from late Westphalian B to early Westphalian C of Canada (BARSS 1967, pl. 24, fig. 3).

Mooreisporites trigallerus NEVES 1961
(pl. 3, figs. 5, 11, 12)

Remarks: Four specimens from preparations 143, 262 and 334, showing concave to straight sides, short laesurae and short bacula at apices.

Occurrence: Namurian A of Britain (NEVES 1961).

Knoxisporites cinctus
(WALTZ) BUTTERWORTH & WILLIAMS 1958
(pl. 3, fig. 19)

Remarks: Single specimen from preparation 262. The size (about 50 μ), the polygonal margin and the laesurae enclosed by three pairs of thick muri, which are connected with the distal muri, are characteristic of the species.

Occurrence: Namurian A of Scotland (SMITH & BUTTERWORTH 1967).

Knoxisporites ex gr. *hageni* POTONIÉ & KREMP 1954
(pl. 3, fig. 21)

Remarks: Single specimen from preparation 333. Diameter about 58 μ, width of cingulum 10-13 μ. On distal surface triradiate bars with small lumen in about polar position. There is a tendency that these bars extend somewhat along the equator without becoming fused along the amb. Size much smaller than range given by POTONIÉ & KREMP (some 70 to 80 μ).

Occurrence: *K. hageni* is known from the Westphalian A-C of Germany (GREBE 1972).

Knoxisporites sp.
(pl. 3, fig. 25)

Remarks: Single specimen from preparation 262.

Reticulatisporites carnosus (KNOX) NEVES 1964
(pl. 3, fig. 24)

Remarks: Width of cingulum 15-25 μ. Although the ornament and size are close to *R. polygonalis*, is it suggested that the width of the cingulum is characteristic of *R. carnosus*. SMITH & BUTTERWORTH (1967) give a range of 10-25 μ for the width of the cingulum of this latter species against 10-15 μ in *R. polygonalis*. The same authors state that the ornament of some specimens of *R. carnosus* is similar to that observed in *R. polygonalis*. Also the outline is typical of *R. carnosus*.

Occurrence: Namurian A to Westphalian A (SMITH & BUTTERWORTH 1967). Also figured from Viséan(?) of Canada (BARSS 1967).

Bellispores nitidus (HORST) SULLIVAN 1964
(pl. 3, fig. 17)

Remarks: Single specimen from preparation 332, showing crenulate margins and distal ornament of radial, foveolate thickenings.

Occurrence: Upper Viséan to Lower Westphalian B (SULLIVAN & MARSHALL 1966; VAN WIJHE & BLESS 1974).

Monilospora mutabilis
(STAPLIN) CLAYTON 1973 emend. (in NEVES *et al.*)
(pl. 4, fig. 10)

Remarks: Single specimen from preparation 262 with cingulum dissected into irregular lobes.

Occurrence: Upper Mississippian of Alberta, Canada (STAPLIN 1960). Spore zones TC, NM and VF (Upper Viséan) of Scotland and Northern England (NEVES *et al.* 1973; cf. also CIMP Newsletter 11, 1975, p. 12).

Grumosisporites varioreticulatus
(NEVES) SMITH & BUTTERWORTH 1967
(pl. 3, fig. 16)

Remarks: Single specimen from preparation 330, showing weakly developed reticulum with low, rounded muri, which sometimes seem to dissolve in separate ornaments. Intexine visible as convex-triangular folded structure below proximal surface, the apices of that triangulum coinciding with the ends of the laesurae. Although our specimen is slightly smaller than the size range of *G. varioreticulatus* (67-110 μ) and apparently better fits in that of *Dictyotriletes maculatus* (IBRAHIM) POTONIÉ & KREMP 1955 (53-70 μ), the ornament seems different from the latter species.

Occurrence: Namurian B to Westphalian B of Britain (SMITH & BUTTERWORTH 1967).

"Anulatisporites" sp.
(pl. 4, figs. 15, 16)

Remarks: Three specimens from preparation 262. Diameter between 60 and 78 μ. Cingulum of uni-

form width in each specimen, laevigate. These specimens, are very similar to the group of species, described as *Anulatisporites* by HUGHES & PLAYFORD (1961) and PLAYFORD (1962, 1963) from the Dinantian of Spitsbergen. They are not conspecific with one of those, however. The genus *Anulatisporites* is considered to be synonymous to *Densosporites* (cf. SMITH & BUTTERWORTH 1967).

Densosporites triangularis KOSANKE 1950
(pl. 3, fig. 26)

Remarks: Central area and inner portion of cingulum minutely foveolate. Foveae on cingulum radially arranged.

Occurrence: Viséan to Namurian of Britain (SMITH & BUTTERWORTH 1967). Some questionable specimens occur in the Westphalian A-B of Germany (GREBE 1972) and Belgium (SOMERS 1971). Spoon and Carbondale Formations of Illinois (PEPPERS 1970).

Cingulizonates aff. *capistratus*
(HOFFMEISTER, STAPLIN & MALLOY)
STAPLIN & JANSONIUS 1964
(pl. 3, fig. 27)

Remarks: Single specimen from preparation 334. Diameter about 48 μ, central area granulate, cingulum two-layered with inner zone much darker than outer zone in which extend many radiating rods from inner zone. Laesurae not observed.

Occurrence: *C. capistratus* has been described from the Chester (Namurian) of the U.S.A. (HOFFMEISTER, STAPLIN & MALLOY 1955).

Radiizonates striatus
(KNOX) STAPLIN & JANSONIUS 1964
(pl. 3, fig. 28)

Remarks: Amb rounded, cingulum consisting of dark inner and light outer zone in which extend many radiating rods from inner zone. Exine laevigate.

Occurrence: Westphalian A of Britain (SMITH & BUTTERWORTH 1967) and Germany (GREBE 1972). Westphalian A to basal Westphalian C of Belgium (SOMERS 1971). The Belgian specimens are less characteristic however and may be considered as representing a broader concept of the species. Namurian C – Lower Westphalian C of northern France (COQUEL 1974).

Proprisporites aff. *laevigatus* NEVES 1961
(pl. 3, figs. 22, 23)

Remarks: Two specimens from preparations 143 and 332, showing all characteristics of species, but having a much smaller diameter. NEVES (1961) gives a size range of 70-115 μ, whereas our speci-

mens are about 45-50 μ.

Occurrence: *P. laevigatus* is known from the Namurian A-B of Britain (NEVES 1961).

Spelaeotriletes triangulus NEVES & OWENS 1966
(pl. 4, fig. 9)

Remarks: Single specimen from preparation 262, showing distinct laterally fused verrucae and coni, which are irregularly distributed on the distal surface.

Occurrence: Upper Namurian A to Namurian C of England (NEVES & OWENS 1966).

cf. *Schopfipollenites ellipsoides* var. *corporeus*
NEVES 1961
(pl. 3, fig. 29)

Remarks: Single specimen from preparation 262. Diameter about 180 μ. Dark annular zone delimits circular inner body. Narrow suture, slightly bent in central part, is aligned with long axis.

Occurrence: *S. ellipsoides* var. *corporeus* ranges in Britain from Namurian B to Westphalian D (SMITH & BUTTERWORTH 1967). Although we have listed the specimen as presumably reworked, it may be a proper Westphalian C element.

4.3. Presumable Upper Famennian –
Lower Tournaisian spores

"Dictyotriletes" fragments
(pl. 4, fig. 11)

Remarks: We assign fragments of exine with an ornament consisting of a rather large reticulum to the genus *Dictyotriletes*. The muri vary in shape and width, and may be interrupted as in the closely related genus *Corbulispora*.

Occurrence: Similar eroded spore fragments, which sometimes are reduced to the muri alone, have been observed in the Dinantian of Bielorussia (KEDO 1963) and the Tn2a (zone TE) of Belgium (STREEL, in press).

"Cristatisporites" echinatus PLAYFORD 1963
(pl. 4, figs. 17, 19)

Remarks: Maximum diameter some 78 to 95 μ. Coni and spines coalescent at equator, longest spines apparently having been eroded. The fact, that the ornament is restricted to the distal and equatorial surface of the spore, makes the assignment of this species to *Cristatisporites* questionable.

Occurrence: Tournaisian of Spitsbergen (PLAYFORD 1963) and Canada (PLAYFORD 1964). Tn1a of Belgium (spore subzone PLs; STREEL in: BBST 1974).

cf. *"Cristatisporites"* echinatus PLAYFORD 1963
(pl. 4, fig. 18)

Remarks: This may be an eroded specimen of the above species.

Samarisporites sp. cf. *Hymenozonotriletes acanthyrugosus* CHIBRIKOVA 1959
(pl. 6, fig. 6)

Remarks: Diameter about 70 μ. Bilayered zonate spore with loosely distributed coni and small spines (maximum height: 3 μ) at some 3 to 7 μ from each other on the distal surface and along the equator. Zona 4-5 μ in width, but up to 9 μ in radial position.

Occurrence: Quite similar specimens have been recorded from the Lower Famennian of the Campine (Belgium; STREEL 1965, pl. 1, figs. 4, 5; STREEL in: BBST 1974, pl. 18, fig. 8) and the Middle Tournaisian of Tournai (Belgium; second author, unpublished data). *Hymenozonotriletes acanthyrugosus* has been described from the Givetian of Bashkyria (U.S.S.R.; CHIBRIKOVA 1959).

Grandispora famenensis
(NAUMOVA) STREEL 1974(in: BBST)
(pl. 4, fig. 1)

Remarks: Single specimen from preparation 262, showing widely spaced mamillate ornaments, which are about 2-3 μ high and wide. Maximum diameter about 55 μ.

Occurrence: Spore zones GM and VU (Upper Famennian, Fa2a-Fa2c) of Belgium (STREEL in: BBST 1974). Upper part of Lower Famennian in U.S.S.R. (NAUMOVA 1953).

Spelaeotriletes cassis (KEDO) STREEL 1974 (in: BBST)
(pl. 4, figs 7, 8)

synonym: *Spelaeotriletes arenaceus* NEVES & OWENS 1966

Remarks: Several specimens from preparations 329 and 262, showing distal ornament of small, rounded (eroded??) and flat-topped verrucae and coni, which sometimes extend on proximal surface, especially in the radial portions. Maximum diameter 95-108 μ.

Occurrence: Assemblage zone with *Spelaeotriletes lepidophytus* of Bielorussia (KEDO 1957) and Belgium (Tn1a; STREEL in: BBST 1974). Dinantian of Bielorussia (KEDO 1963). Lower Namurian of England (NEVES & OWENS 1966).

Spelaeotriletes lepidophytus
(KEDO) STREEL 1974 (in: BBST)
(pl. 4, figs. 2-6)

Remarks: Several specimens with a well developed reticulum and a few widely spaced superimposed coni on distal surface. Maximum diameter from 49 to 69 μ (varieties *minor* and *tener* of KEDO).

Occurrence: Spore zone PL (Fa2d-Tn1a) of Belgium (STREEL in: BBST 1974) do VI of Germany (PAPROTH & STREEL 1971). Specimens of same age recorded from North America, North Africa, Europe, U.S.S.R., Spitsbergen and Australia (STREEL 1971).

Auroraspora hyalina
(NAUMOVA) STREEL 1974 (in: BBST 1974)
(pl. 4, figs. 12-14)

Remarks: Species often difficult to distinguish from *A. micromanifestus* (HACQUEBARD) RICHARDSON and from small species of *Endosporites* and *Discernisporites* from Dinantian strata.

Occurrence: Upper Frasnian to Middle Tournaisian of Belgium (STREEL in: BBST 1974; STREEL, in press).

Ancyrospora? capillata DOLBY & NEVES 1970
(pl. 7, fig. 10)

Remarks: Only part of a specimen is figured to show the cavate structure, setae on exoexine and multifurcated tips of the processes.

Occurrence: Spore zone PL ($\pm$ Tn1a) of England (DOLBY & NEVES 1970) and South Wales (GAYER *et al.* 1973). Lower Tn1b of Belgium (PAPROTH & STREEL 1971).

4.4. Presumably Upper Emsian – Lower Frasnian spores

Apiculiretusispora cf. *arenorugosa* McGREGOR 1973
(pl. 6, fig. 4)

Remarks: Single specimen from preparation 262, surface covered with small (less than 1 μ) coni and biform ornaments. Curvaturae not seen. Maximum diameter 108 μ.

Occurrence: *A. arenorugosa* occurs in the Emsian and Eifelian of Eastern Canada (McGREGOR 1973).

Dibolisporites sp. cf. *D. eifeliensis* sensu
McGREGOR 1973 non LANNINGER 1968
(pl. 6, fig. 5)

Remarks: A single, dark specimen from preparation 262, showing biform ornaments of 4-7 μ high; base of ornaments rather bulbous (2-5 μ wide). *Anapiculatisporites eifeliensis* LANNINGER 1968 has smaller spines or pilae than the specimens described by McGREGOR. In fact *A. eifeliensis* LANNINGER is close to if not conspecific with *A. burnotensis* STREEL 1967.

Occurrence: *D. eifeliensis* sensu McGREGOR 1973 has been reported from the Emsian and Eifelian of Eastern Canada (McGREGOR 1973) and the Emsian of the Moose River Basin, Canada (McGREGOR, in press; see also CIMP Newsletter 11, 1975).

Dibolisporites echinaceus
(EISENACK) RICHARDSON sensu lato
sensu McGREGOR 1973
(pl. 6, figs. 1-3)

Remarks: McGREGOR (1973, p. 30) stated that there exists "considerable variation in both the size and the shape of the sculptural elements of this species". Our specimens represent two different trends within the species: *D. echinaceus* sensu stricto (pl. 6, fig. 1) with typical biform ornaments as figured by RICHARDSON (1965, p. 569, text-fig. 3, B-C-D) and *Bullatisporites bullatus* ALLEN 1965 with distinct, rounded pilae (up to 4 μ high) bearing a minute spine (pl. 6, fig. 2) or flat-taped pilae bearing large coni (pl. 6, fig. 3).

Distribution: Lower Emsian to Upper Famennian of the Dinant Basin, Belgium (STREEL 1967; STREEL in: BBST 1974).

"Anulatisporites" jonkeri RIEGEL 1973
(pl. 5, fig. 1)

Remarks: Single specimen from preparation 262, with distinct anulus on the distal side. Width of anulus is half length of radius. Surface smooth. Maximum diameter about 49 μ.

Occurrence: Up to now only known from type location: northern Eifel (Germany), Nohn Beds (Lower Eifelian; RIEGEL 1973).

Samarisporites nov. sp. aff. *S. inusitatus* ALLEN 1965
(pl. 6, figs. 10-12)

Remarks: Bilayered zonate spores with rounded to subtriangular amb. Maximum diameter about 75 to 85 μ. Zona one-third of radius. Central spore body rather thick. Raised trilete mark with folds, tapering from apex and extending to equator. Proximal surface smooth. Ornaments on the distal surface consisting of coarse, irregular reticulum with somewhat convolute muri superimposed by sparse, small coni of up to 2 μ. Width of muri 2-3 μ. Height of muri 1-2 μ on central area, becoming thinner towards equator. Lumina rather narrow (2-3 μ diameter).

S. inusitatus ALLEN 1965 from Spitsbergen is smaller and possesses distal coni, which may be fused so that they form an imperfect reticulum. *S.* sp. aff. *S. inusitatus* ALLEN sensu STREEL (in: BBST 1974) from the Campine (Belgium) shows an ornament of less densely distributed distal coni, which sometimes merge into a coarse reticulum. *S.* cf. *inusitatus* ALLEN sensu TAUGOURDEAU-LANTZ

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1971 from the Frasnian of the Boulonnais (France) has distal muri formed by the fusion of coni and verrucae.

Our specimens bear also some ressemblance with *Calyptosporites reticulatus* Tiwari & Schaarschimdt 1975, which has a similar distal ornament. But this latter species possesses also rather long spines of up to 6 μ long superimposed on the muri.

Occurrence: *S. inusitatus* Allen 1965 is known from the Upper Emsian (Heisdorf Beds) to Lower Eifelian (Nohn Beds) of the Eifel (Germany; Riegel in CIMP Newsletter 10, 1975), and from the Upper Givetian of Spitsbergen (Allen 1965).

Grandispora douglastownense McGregor 1973
(pl. 5, figs. 3-8)

Synonym: *Cirratriradites* cf. *megaspinosus* sensu Van Wijhe & Bless 1974 pl. 3, figs. 53, 55 (non fig. 52)

Remarks: Cavate spores. Maximum diameter (without protruding ornaments) between 80 and 110 μ. Distal surface with loosely distributed, prominent spines of up to 12 μ long. No hair-like extensions or bifurcated tips have been observed (eroded??). Our specimens are smaller than the type material from Canada. They show a close ressemblance to *Calyptosporites pilaspinosus* Lanninger 1968 (vide Lanninger, pl. 26, fig. 1) from the Lower Eifelian Heisdorf Beds of the Eifel (Germany), which may be conspecific with *G. douglastownense*. *Ancyrospora nettersheimensis* Riegel 1973 from the same horizon of the Eifel looks equally similar except for the obvious bifurcated spines.

Occurrence: Upper Emsian or Lower Eifelian of Eastern Canada (McGregor 1973). Upper Emsian of Moose River Basin, Canada (McGregor, in press; see also CIMP Newsletter 11, 1975).

Grandispora ?macrotuberculata
(Arkhangelskaya) McGregor 1973
(pl. 5, fig. 11)

Remarks: Large cavate spores with distal ornament consisting of sparsely distributed small coni and spines of up to 4 μ high. Maximum diameter about 150 μ. The rare (non eroded??) spines bear a small hair-like extension. We agree with McGregor (1973, p. 60) that *Calyptosporites proteus* (Naumova) Allen 1965 and *?Samarisporites* sp. *D* Streel 1967 are closely related – if not conspecific – species. Also *Endosporites biornatus* Lanninger 1968 and *Spinozonotriletes arduinnae* Riegel 1973 from the Upper Emsian to Lower Eifelian of the Eifel (Germany) (compare progress reports by Riegel and Streel, Demaret-Fairon & Otazo in CIMP Newsletter 10, 1975) are rather similar or even conspecific species.

Occurrence: Upper Emsian or Lower Eifelian of Eastern Canada (McGregor 1973). Upper Emsian of Moose River Basin, Canada (McGregor, in press: see also CIMP Newsletter 11, 1975).

cf. *Grandispora ?macrotuberculata*
(Arkhangelskaya) McGregor 1973
(pl. 5, fig. 10)

Remarks: A very large, single specimen from preparation 328, showing similar rare ornaments as in the specimens described above. Maximum diameter 210 μ.

Grandispora mammillata Owens 1971
(pl. 5, fig. 9)

Remarks: Single specimen of large, cavate spore from preparation 262 with moderately densely distributed ornaments on distal surface, consisting of conate to mammoid elements of about 3 μ high and wide. Maximum diameter 157 μ.

Occurrence: Givetian(??) of Melville Island, Central Arctic Archipelago (Owens 1971). Lower Eifelian (??) of the Moose River Basin, Canada (McGregor, in press; compare also CIMP Newsletter 11, 1975).

Grandispora sp.
(pl. 5, fig. 2)

Synonym: *Cirratriradites* cf. *megaspinosus* sensu Van Wijhe & Bless 1974 pl. 3, fig. 52 (non figs. 53, 55)

Remarks: Single specimen from preparation 143 of a large, cavate spore, bearing long blunt spines in the distal polar area and coni on the zona. Spines may reach up to 20 μ in length. Their maximum basal width is about 7 μ. Coni are 3-5 μ high and wide and less densely distributed than the spines. This specimen is conspecific with *?Spinozonotriletes* sp. A Owens 1971, pl. XVIII, fig. 2, and with *Calyptosporites* sp. 15305 McGregor & Owens 1966, pl. XIII, figs. 1, 2, both from the Weatherall Formation (Givetian?) of Melville Island, Central Arctic Archipelago.

Rhabdosporites langi (Eisenack) Richardson 1960
(pl. 6, figs. 7-9)

Remarks: Cavate spores with characteristic folds and exoexine covered by small coni and baculae of less than 1 μ high. Size of our specimens between 98 and 140 μ. The specimen figured by Streel (1965; pl. II, fig. 8) from the Frasnian of the Campine Basin, Belgium as *R. langi* is *R. parvulus* Richardson 1965.

Occurrence: Lower Eifelian of the Eifel, Germany (Riegel 1973). Upper Givetian of Namur Syn-

clinorium, Belgium (PIERART 1964; STREEL 1972) and Dinant Synclinorium, Belgium (LELE & STREEL 1969).

Ancyrospora ancyrea
(EISENACK) RICHARDSON var. *brevispinosa*
RICHARDSON 1962
(pl. 7, figs. 1-4)

Remarks: Zonate spore with exoexine variably extended distally and equatorially in the form of a flange bearing spinose processes. Spore body/spore diameter ratio: 85-95%. Length of spinose processes 6 to 15 μ. Most of the spinose processes appear to have been eroded and therefore lost their typical bifurcate tips. But a few distinct bifurcations have still been observed (cf. pl. 7, fig. 3).

Occurrence: Upper Eifelian(?) to Givetian of northeastern Scotland (RICHARDSON 1962, 1965). Givetian of Belgium (LELE & STREEL 1969). Lower Frasnian(?) of the Campine Basin, Belgium (STREEL in: BBST 1974).

4.5. Devonian – Dinantian spores of uncertain range

This group includes several long-ranging elements, which occur throughout the Devonian and/or Dinantian. It might be even discussed, whether some specimens of acritarcha and *Tasmanites* are proper Westphalian elements. Our argument to consider them as Devonian-Dinantian forms is that they have up to now only been recognized in association with undoubted reworked spores of that age. It should be noted, that we have found a specimen of *Veryhachium* sp. (pl.7, fig. 13) that looks rather similar to the specimen figured by STOCKMANS & WILLIÈRE (1962) from the Petit Buisson Marine Band at the base of the Westphalian C of Belgium. We suggest that also the acritarcha described by those authors (only three specimens recognized!!) may as well represent reworked forms. The first author has tried without success to find any acritarcha from the same marine band in the Netherlands.

Auroraspora macromanifestus
(HACQUEBARD) RICHARDSON 1960

Remarks: Poorly preserved specimens of this species have been observed in horizon 1.

Occurrence: From the uppermost Emsian and Eifelian of the Eifel, Germany (TIWARI & SCHAARSCHIMDT 1975), the Eifelian and Givetian of Scotland (RICHARDSON 1965) to the Tournaisian of Eastern Canada (PLAYFORD 1964) and many other regions (STREEL 1971, p. 133).

Hystricosporites spp.
(pl.7, figs. 5-8)

Remarks: Dark, large (maximum diameter 95-120 μ) spores with apical prominence and typically bifurcated appendages of various lengths (10-30 μ) and basal widths (up to 8 μ in pl. 7, fig. 6).

Occurrence: Uppermost Emsian (RIEGEL 1973) to Lower Tn1b (STREEL, in press). Three specimens from the Viséan of Spitsbergen (PLAYFORD 1963) are assumed to have been derived from older rocks.

Acritarcha

A few specimens have been assigned to the following genera:
Solisphaeridium STAPLIN, JANSONIUS & POCOCK 1965 (pl. 7, figs. 11, 12).
Veryhachium DEUNFF 1954 emend. DOWNIE & SARJEANT 1963 (pl. 7, figs. 13, 14).
Goniosphaeridium EISENACK 1969 (pl. 7, fig. 15).
Cymatiosphaera O. WETZEL 1933 emend DEFLANDRE 1954 (pl. 7, fig. 16).

Tasmanites spp.
(pl. 7, figs. 17-19)

Remarks: Several specimens with the characteristic thick wall, spheroidal outline and varying number of pores are here included in the genus *Tasmanites*. As stated by MUIR & SARJEANT (1971) the Tasmanitids need a thorough taxonomical revision.
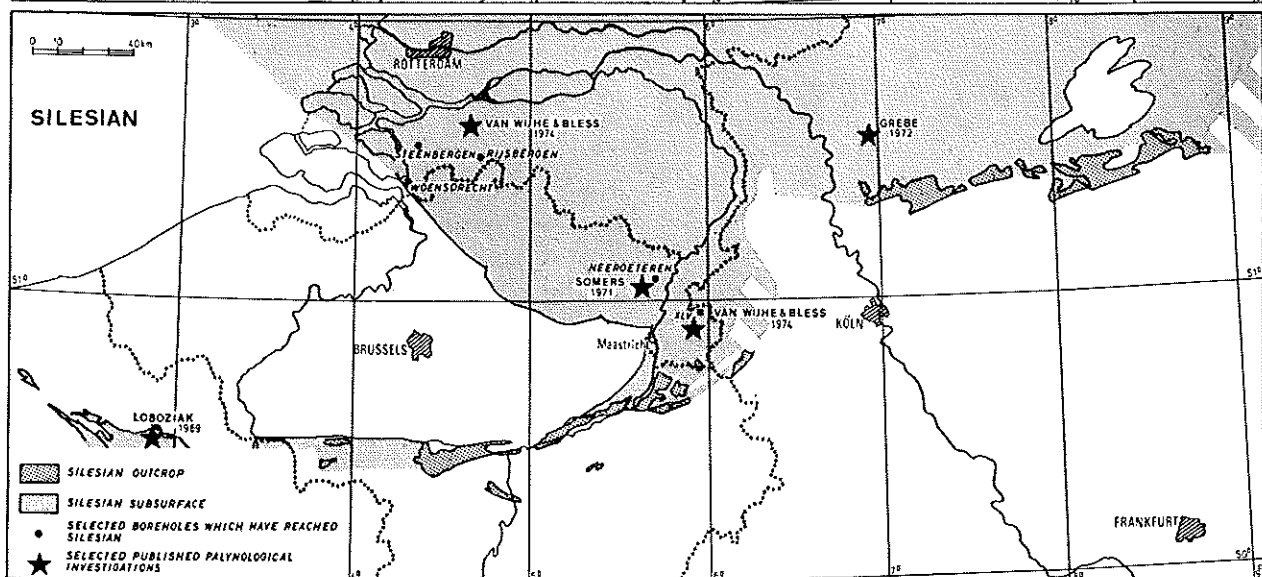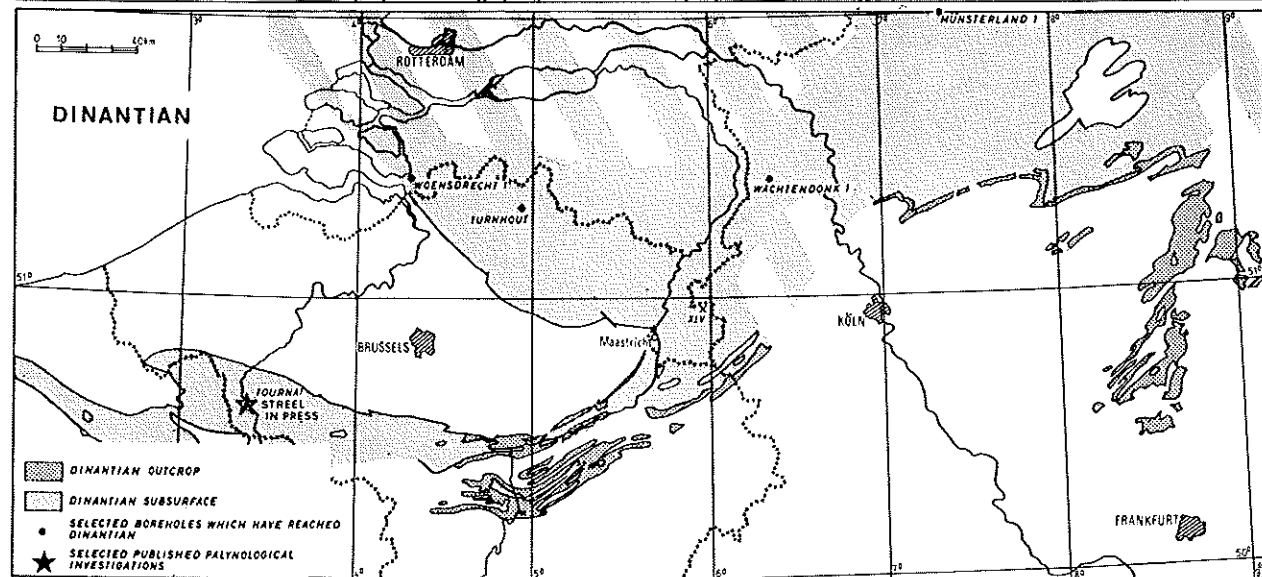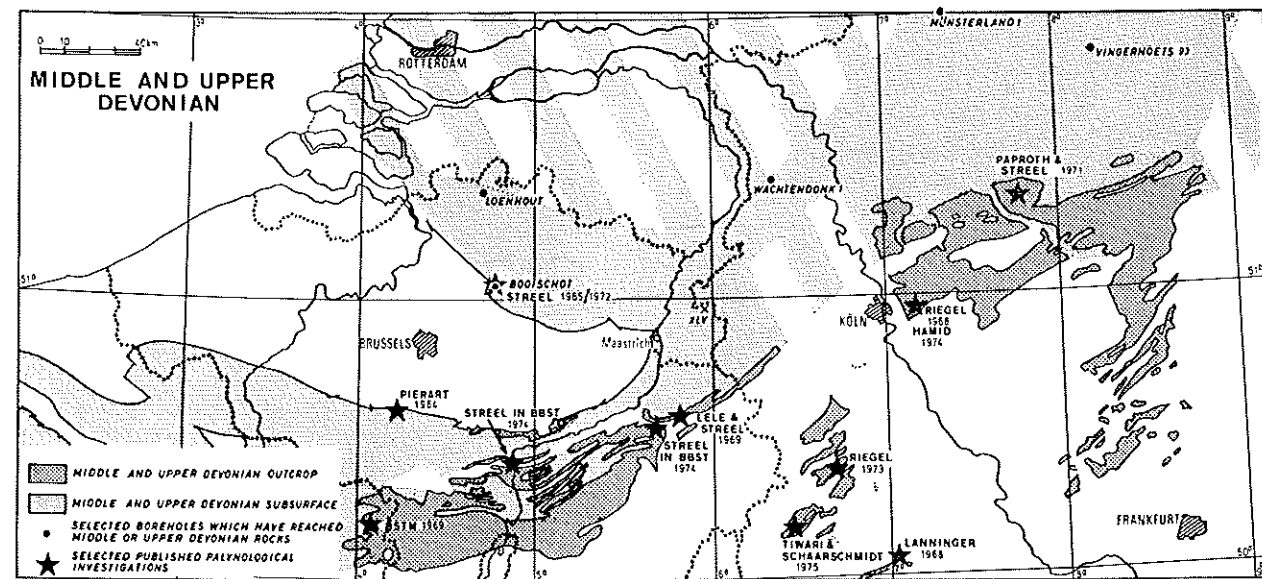
Occurrence: Lower Ordovician to Tertiary. Specimens from the Pleistocene of Great Britain may be reworked from older strata (MUIR & SARJEANT 1971).

Unknown
(pl. 7, fig. 9)

Remarks: Two specimens from preparation 262. Large, hollow globules with a reticulate network. Affinity unknown.

5. SOURCE AREA

From the composition of the microflora in the investigated interval it is clear that we may distinguish between four major groups of spores. First of course, there is the predominant "normal" Westphalian C flora with *Vestispora fenestrata*, *V. magna*, *Triquitrites sculptilis*, *T. velensis* and *Punctatosporites granifer* as markers. The second group is qualitatively well represented by some twenty-eight species of a roughly Namurian (Upper Viséan to Lower Westphalian) age, with several auriculate spores (*Ahrensisporites*, *Mooreisporites* and *Tripartites*) as most relevant forms. The third group of an uppermost Devonian to early Dinantian age is characterized by *Spelaeotriletes lepidophytus* as guide for essentially the "Strunian". The fourth

Map 1 — MIDDLE AND UPPER DEVONIAN

0 10   40km

MIDDLE AND UPPER DEVONIAN

MÜNSTERLAND 1

VINGERHOETS 93

ROTTERDAM

PAPROTH & STREEL 1971

WACHTENDONK 1

LOENHOUT

51°

KÖLN

RIEGEL 1968 HAMID 1974

BRUSSELS

BOOISCHOT STREEL 1965/1972

Maastricht

PIERART 1966

STREEL IN BBST 1974

ELE & STREEL 1969

STREEL IN BBST 1974

RIEGEL 1973

BTM 1969

TIWARI & SCHAARSCHMIDT 1975

LANNINGER 1968

FRANKFURT

MIDDLE AND UPPER DEVONIAN OUTCROP

MIDDLE AND UPPER DEVONIAN SUBSURFACE

• SELECTED BOREHOLES WHICH HAVE REACHED MIDDLE OR UPPER DEVONIAN ROCKS

★ SELECTED PUBLISHED PALYNOLOGICAL INVESTIGATIONS

Map 2 — DINANTIAN

0 10   40km

DINANTIAN

MÜNSTERLAND 1

ROTTERDAM

WOENSDRECHT 1

WACHTENDONK 1

TURNHOUT

51°

KÖLN

BRUSSELS

Maastricht

TOURNAI STREEL IN PRESS

DINANTIAN OUTCROP

DINANTIAN SUBSURFACE

• SELECTED BOREHOLES WHICH HAVE REACHED DINANTIAN

★ SELECTED PUBLISHED PALYNOLOGICAL INVESTIGATIONS

FRANKFURT

Map 3 — SILESIAN

0 10   40km

SILESIAN

ROTTERDAM

VAN WIJHE & BLESS 1974

GREBE 1972

STEENBERGEN-RIJSBERGEN

WOENSDRECHT

51°

NEEROETEREN SOMERS 1971

VAN WIJHE & BLESS 1974

KÖLN

BRUSSELS

Maastricht

LOBOZIAK 1969

SILESIAN OUTCROP

SILESIAN SUBSURFACE

• SELECTED BOREHOLES WHICH HAVE REACHED SILESIAN

★ SELECTED PUBLISHED PALYNOLOGICAL INVESTIGATIONS

FRANKFURT

and last group consists in fact of two assemblages representing the Givetian *(Grandispora* sp.) on the one hand and the Upper Emsian to Lower Eifelian microfloras *(Grandispora douglastownense,* "*Anulatisporites*" *jonkeri, Dibolisporites eifeliensis, Apiculiretusispora* cf. *arenorugosa)* on the other. For the sake of simplicity, they are taken here together as Middle Devonian (including latest Lower and early Upper Devonian) forms. Except for the first group, we may assume that they have all been reworked from older sediments.

The relatively sudden influx of this reworked material, the fact that the reworked assemblages of horizons 1 and 5 are rather well comparable and their similar preservation suggest that they have been derived from the same source area by the same medium. In other words, the source rocks must be found in the same direction from the Jabeek Borehole. In figure 4 we have summarized our actual knowledge of the distribution of Devonian and Carboniferous sediments. These distribution maps show, that transport from the North is rather unlikely, since Devonian and Dinantian sediments are buried under several thousands of meters of Silesian rocks. Moreover, we have not recognized the Dinantian spore assemblages described by BERTELSEN (1972) and BURMANN (1975) from, respectively, Denmark and the Isle of Rügen (German Democratic Republic). Therefore, apart from the fact that a source from a northern continent might have been to far away (chemical and mechanical destruction of spores during long transport), there is also the fact that we cannot compare the known Dinantian microfloras from the North and North-East with our reworked material. On the other hand, one would have expected to have recognized similar high percentages of reworked spores elsewhere in the Netherlands. This is not the case (VAN WIJHE, personal communication; first author, unpublished data).

Two more areas, the Ardenno-Rhenish Massif in the South and East and the Brabant Massif in the West, rest as potential source areas.

The Brabant Massif can be excluded, however, since the Lower and Middle Devonian are practically missing on most places around the Massif. In the North, the boreholes Loenhout and Booischot (fig. 4, map of Devonian rocks) pass directly from Upper Devonian into Silurian sediments (LEGRAND 1968). It was apparently not before late in the Middle Devonian that the transgression and sedimentation on the Massif started from the South.

Therefore, our fourth group of Middle Devonian spores, including an Upper Emsian to Lower Eifelian assemblage, cannot have been derived from the Brabant Massif.

Rests as sole possibility the Ardenno-Rhenish Massif.

We do not know about any publications on Namurian spores from Belgium, the Netherlands or Germany, except for areas much farther to the South-East of the Rhenish Massif (HORST 1955, West Upper Silesia and Mährisch-Ostrau). Spores of that age are either to much carbonized or they have not been studied.

With few exceptions (STREEL, in press) the marine Dinantian rocks have not yielded any miospores along the borders of the Ardenno-Rhenish Massif. The practical absence of Dinantian spores in our borehole is herewith explained.

An extensive bibliography exists already on the uppermost Devonian ("Strunian") microfloras of especially Belgium (cf. STREEL in: BBST 1974) but also of Germany (cf. PAPROTH & STREEL 1971). The occurrence of the guide fossil for that time interval, *S. lepidophytus,* in our material could thus be expected.

The essentially sporeless marine Frasnian and Lower Famennian rocks along the Ardenno-Rhenish Massif could hardly have yielded a recognizable spore flora. The apparent absence of such an assemblage in our material is therefore quite understandable.

Middle Devonian and Emsian spores have been described from three different regions of the Ardenno-Rhenish Massif. STREEL (1964), LELE & STREEL (1969) and ESCHGHI (1969) have published on respectively Givetian and Emsian miospores along the northern border of the Hohe Venn-Stavelot Massif near Aachen. RIEGEL (1968) and HAMID (1974) studied the Middle Devonian spores from the Rhenish Massif near Köln. LANNINGER (1968), RIEGEL (1973) and TIWARI & SCHAARSCHMIDT (1975) investigated the Lower and Middle Devonian microfloras from the Eifel.

ESCHGHI (1969) found rather small (less than 40 μ), non-zonate spores, which appear rather dark and poorly preserved. Also LELE & STREEL (1969) noticed the poorness of zonate forms (about 1%) in their microflora. These latter authors distinguish between "upland" assemblages dominated by zonate spores and "marginal" assemblages of spores with a simple structure. Our reworked Middle Devonian microflora seems to have more in common with the upland assemblage sensu LELE & STREEL than

with a marginal assemblage, so that the Hohe Venn-Stavelot Massif as source for our material can be excluded.

A much better correlation exists with the Emsian and Middle Devonian spores described from the areas near Köln and the Eifel, which have yielded many "upland" elements. Apart from the fact that they contain many zonate species, which in part are conspecific with ours, they also show the tendency to "giantism" characteristic of upland assemblages. Furthermore, their preservation and degree of coalification (related to relative translucency; cf. VAN WIJHE & BLESS 1974, p. 306) are similar to the South Limburg material. A more detailed comparison of the Köln and Eifel assemblages suggests that our material has been most probably derived from a roughly southeastern source in or near the Eifel region.

6. PALEOGEOGRAPHY

VANDENBERGHE (1976) recognized Carboniferous phytoclasts with a low range of reflectivity in the Rupelian Boom Clay of Belgium. This occurrence induced him to suggest that at least part of the Boom Clay had been derived from Northern England, where Carboniferous coals with similar low reflectivity occurred in the outcropping areas surrounding the sedimentation basin of the Boom Clay. That conclusion formed an important complementary information since up to then geologists had assumed that the Boom Clay was of fennoscandinavian origin because of its heavy mineral content. This example clearly shows, that phytoclasts – and reworked spores constitute only a special group of phytoclasts – may be used in the same way as heavy minerals or fossils if we wish to identify the source of any given sediment. Therefore, the assumption, that reworked spore material has been transported by some medium to South Limburg from the South-East implies that also the sediment will have been derived from the same direction.

The hypothesis that the Ardenno-Rhenish Massif may have acted as source for a – large? – part of the Westphalian sediments in the Netherlands and Germany is not new. SCHRÖDER (1975) argumented that the isopach of Westphalian C sediments in northwestern Germany can only be satisfactorily explained by assuming a southern or southeastern origin of these sediments, i.c. the Rhenish Massif. This idea is supported by the fact that marine influences increase towards the North and that the relative abundance of conglomerates and pebble horizons decreases in the same direction.

The principal arguments of those, who favour a sediment supply from the North and North-East (e.g. HEDEMANN & TEICHMÜLLER 1971; HEDEMANN,

FABIAN, FIEBIG & RABITZ 1972) are the occurrence of Silurian lydite pebbles with a.o. the graptolite *Monograptus priodon* in a Lower Westphalian A conglomerate in the Ruhr district (WEHRLI 1938; SCHERP 1956), the South-West dipping crossbeddings in the Westphalian D of Piesberg (North of the Ruhr district) and the sedimentological investigations on Lower Westphalian sandstones in the Ruhr district by WENDT (1965) and MALMSHEIMER (1968). A further argument of this group of geologists is the gradual diminishing of Westphalian conglomerates towards the West. This latter argument has been proven to be unvalid by SCHRÖDER (1975), because they also disappear to the East and North.

WEHRLI (1938) stated already that a southern origin for the graptolite-bearing lydite could not be excluded. The Buntsandstein conglomerate of the Vosges contains also graptolite-bearing lydite pebbles and similar pebbles have been observed in Quaternary deposits of the River Meuse in the Netherlands by the first author. WEHRLI's supposition that the same species *M. priodon* or even species of the same (according to him Upper Silurian) age do not occur in the Vosges conglomerate seems incorrect. NOEL (1905, p. 65) described *M. priodon*? (specimen not figured by that author) from the Vosges conglomerate. Revision of both WEHRLI's and NOEL's specimens may prove that they are conspecific. In the second place there is no difference between the peculiar conservation of the graptolites of both places, which consists of white quarz. And finally, BULMAN (1955) figures a specimen of *M. priodon* from the Lower Silurian of Scotland, so that WEHRLI's statement that species of the same "Upper Silurian" age do not occur in the Vosges conglomerate, which should contain only Lower Silurian graptolites is incorrect.

The South-West dipping of the crossbeddings of the Piesberg area of a Westphalian D age are extremely local phenomena, which do not permit overall conclusions.

The studies of both WENDT (1965) and MALMSHEIMER (1968) on Lower Westphalian A sediments of the Ruhr district have not given any evidence for the source of these sediments. The cumulative direction-frequency diagram of MALMSHEIMER (1968, fig. 24) shows a preference direction towards the North-West, rather than to the South-West, which would mean a southeastern rather than a northeastern origin of the sediments. As stated by WENDT, the Finefrau conglomerates have their main distribution in the southern Ruhr district and pinch out towards the North. Furthermore, also the Finefrau sandstone seems to disappear in the easternmost parts of the Ruhr district. The regional western to southwestern directions of transport may also indicate local streams parallel to the northern border of the Rhenish Massif.

A southern to southeastern origin has also been assumed for the Namurian conglomerates in the

Aachen area and in Belgium, which have been studied by HAHNE & SEIDEL (1936) and KLERKX (1960, 1966). These conglomerates have been derived from local erosion of the borders of the Ardenno-Rhenish Massif as shown by the occurrence of abundant lydite and radiolarite pebbles of late Dinantian age. The source rocks of these are locally completely eroded during Namurian times (PAPROTH & WOLF 1973; FOURMARIER, BINTZ & LAMBRECHT 1968).

Also BLESS (1973) suggested a southwestern to southeastern origin for Lower Westphalian A sediments of South Limburg after studying isopach lines of the Finefrau Nebenbank Marine Band.

Summarizing all these arguments, we may presume that the hypothesis that the Ardenno-Rhenish Massif, and more especially the Eifel area sensu lato was the source for a – large? – part of the Westphalian sediments in the Netherlands has become more and more acceptable. The progressive erosion of the Ardenno-Rhenish Massif as a function of continuing uplift becomes firstly visible in the Namurian conglomerates containing late Dinantian radiolarites, which have been essentially derived from the borders of the Massif. The Lower Westphalian may then have been a period of relative rest, what is reflected in the decrease of the sandy component of the sediments during that time and in the uniformity of the basin conditions, which have resulted in rather comparable sections of Lower Westphalian rocks in South Limburg, Belgium and Germany (cf. PASTIELS 1964; BACHMANN, HERBST & KIMPE 1970).

A renewed, accentuated uplift of the Massif during the Upper Westphalian gave way to an erosion of all pre-Upper Westphalian – Devonian

and Carboniferous – sediments. This resulted in an increase of the sandy percentage of the sediments (cf. VAN WIJHE & BLESS 1974), an influx of reworked spores of the above said ages, and most probably in the creation of two different depositional environments fed by at least two different sources and transport ways.

This latter hypothesis is supported by the inferred transport directions during essentially the Westphalian C (fig. 5) and by the fact that we are unable to establish detailed correlations between the Westphalian C sections of the Campine and South Limburg on the one hand and the northwestern German area on the other, this in contrast with the Lower Westphalian sections of these areas.

Also, it is not impossible that the upheaval of the Ardenno-Rhenish Massif and the subsequent folding along its borders became so strong, that Lower Westphalian sediments in the Liège and Aachen areas have been already in part erdoded during the Upper Westphalian, or that at least deposition had stopped in that area.

The hypothesis, that the areas say North of the Brabant Massif and North of the Rhenish Massif have become separate basins during the Upper Westphalian, is also supported by the actual distribution of Upper Westphalian sediments. The Krefeld High and its prolongation in the Maasbommel High, Zandvoort Ridge and IJmuiden High may have formed a neutral or even initial erosional belt separating these basins during the Upper Westphalian. There are indications that the Krefeld High may have been a mobile block as far back as the late Middle Devonian. PAPROTH & WOLF (1973) suggested that this was an eastern
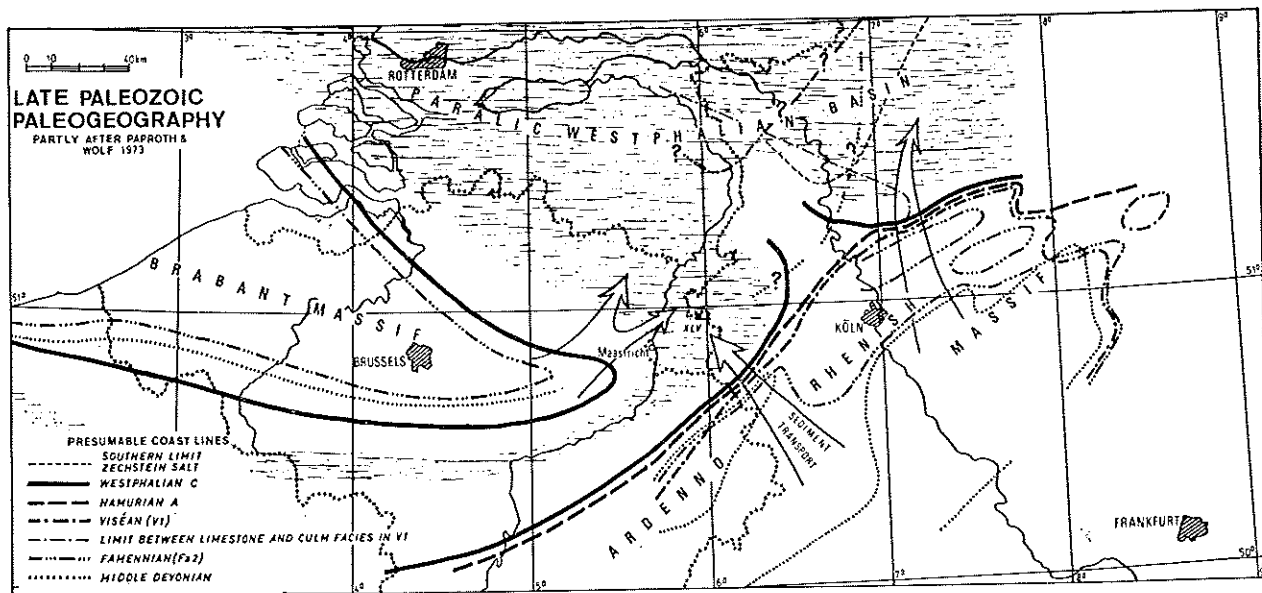

Fig. 5 – Late Paleozoic paleogeography. Arrows indicate inferred sediment transport directions.

outlier of the Old Red Continent, what would explain the nearby Schwarzbachtal Conglomerate. The line formed by these highs may have been also coincident with the southern border of an Upper Famennian high of the same authors. This Upper Famennian high might have plaid the same role as the Brabant Massif further to the South with in between them the later Upper Westphalian basin as an area of accentuated subsidence. It is finally noteworth, that the line formed by these highs is coincident with the boundary between Limestone and Culm facies during the Lower Viséan (cf. PAPROTH & WOLF 1973).

Our information about movements of this belt during the Upper Carboniferous is scarce. VAN WIJHE & BLESS (1974) draw the attention on the Hardenberg-2 and Tubbergen-8 boreholes at the southwestern edge of the later Ems Low. Both boreholes show a reduced Westphalian B-C. This fact fits rather well in the hypothesis of a positive belt along the line Krefeld-Zandvoort during the Upper Westphalian. Before the Stephanian sedimentation took place, either erosion or non-deposition of Upper Westphalian sediments must have occurred at least along the western edge of the later Ems Low (HEDEMANN & TEICHMÜLLER 1971). It seems more reasonable to assume that the same happened on this belt, rather than to believe that first some 1500 to 2000 m of Upper Westphalian sediments have been deposited and then subsequently eroded again during late Stephanian or Permian times as suggested by PATIJN (1964) and HEYBROEK (1974).

Inverse movements of this belt may have taken place during the Permian, when it was covered by Rotliegend and Zechstein. But at least the Krefeld High may have been even then a positive element, as shown by the suggested southern boundary of the primary distribution of Zechstein salts (BOIGK, STAHL, M. & R. TEICHMÜLLER 1971; BARTENSTEIN & TEICHMÜLLER 1974).

Although it may be dangerous to speculate about the real figures of relative uplift during the Westphalian C for the Ardenno-Rhenish Massif, it may be interesting to quote PAPROTH & WOLF (1973; personal communication). They suggest that the total cover on the Nehden Beds (Lower Famennian) in the Paffrath Syncline North-East of Köln may have been only some 200 m. In their opinion the total cover on the Emsian in the Eifel area may have been in the order of some 500 m. From our reworked spore assemblages it can be deduced that this cover must have been largely removed during the Upper Carboniferous erosion. This means, that the total uplift must have been at least more or less equal to the total erosion, this is some 500 m uplift at some 50 km of the northern edge of the Massif, what still would be a rather low relief. The subsequent erosion of that part of the Ardenno-Rhenish Massif and the suggested erosion of the Brabant Massif would have been enough to fill the Upper Westphalian Basin along the northern border of the Brabant Massif (maximum thickness of Upper Westphalian rocks some 1000 m).

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PLATES AND EXPLANATIONS

The coordinates cited are those of the Leitz Ortholux microscope no. 717603 at the Geological Bureau of Heerlen.

PLATE I

1   *Leiotriletes adnatus* (KOSANKE) POTONIÉ & KREMP 1955
262E, 35.5 x 104.2, Westphalian A - Stephanian B.

2   *Calamospora parva* GUENNEL 1958
262F, 44.5 x 111.3, Viséan - Westphalian D.

3   *Granulatisporites granulatus* IBRAHIM 1933
262E, 33.8 x 96.8, Viséan - Stephanian A.

4   *Lophotriletes microsaetosus* (LOOSE) POTONIÉ & KREMP 1955
262E, 23.6 x 98.0, Namurian A - Autunian.

5   *Cyclogranisporites aureus* (LOOSE) POTONIÉ & KREMP 1955
262E, 25.5 x 96.6, Westphalian A - Upper Stephanian.

6   *Lophotriletes mosaicus* POTONIÉ & KREMP 1955
262E, 36.2 x 101.3, Westphalian A - Upper Stephanian.

7   *Apiculatisporis latigranifer* (LOOSE) IRMGRUND 1960
262G, 30.3 x 111.9, Westphalian B - Upper Stephanian.

8   *Calamospora microrugosa* (IBRAHIM) SCHOPF, WILSON & BENTALL 1944
262F, 36.0 x 109.6, Tournaisian - Upper Stephanian.

9, 10   *Raistrickia superba* (IBRAHIM) SCHOPF, WILSON & BENTALL 1944
Upper Namurian – Autunian.
Fig. 9: 262F, 38.2 x 97.9; Fig. 10: 262F, 48.3 x 96.1.

11   *Raistrickia saetosa* (LOOSE) SCHOPF, WILSON & BENTALL 1944
262F, 51.3 x 104.5, Namurian - Upper Stephanian.

12   *Microreticulatisporites nobilis* (WICHER) KNOX 1950
262F, 36.0 x 109.6, Westphalian A-D.

13   *Microreticulatisporites tripartitus* LAVEINE 1962
308B, 47.5 x 108.7, Westphalian A-B (-C?).

14-16   *Dictyotriletes densoreticulatus* POTONIÉ & KREMP 1955
Westphalian B-C.
Fig. 14: 262A, 42.8 x 95.2; Fig. 15: 143C, 43.9 x 109.1;
Fig. 16: 55.5 x 103.0.

17   *Convolutispora florida* HOFFMEISTER, STAPLIN & MALLOY 1955
262G, 28.0 x 94.6, Namurian A - Westphalian C.

18-20   *Savitrisporites nux* (BUTTERWORTH & WILLIAMS) SMITH & BUTTERWORTH 1967
Viséan - Westphalian D.
Fig. 18: 262G, 27.5 x 97.2, distal focus; Fig. 19: 262G, 48.8 x 109.6;
Fig. 20: 262F, 43.8 x 109.8.

21   *Reinschospora speciosa* (LOOSE) SCHOPF, WILSON & BENTALL 1944
308B, 30.2 x 102.5, Westphalian A-C.

22   *Reinschospora triangularis* KOSANKE 1950
307C, 51.0 x 111.0, Westphalian A - Stephanian.

23, 24, 26   *Triquitrites sculptilis* BALME 1952
Westphalian A-D.
Fig. 23: 262F, 48.6 x 96.1; Fig. 24: 262F, 48.2 x 111.2; Fig. 26: 262E, 45.1 x 101.0.

25   *Triquitrites bransonii* WILSON & HOFFMEISTER 1956
308A, 40.5 x 105.0, Westphalian B-D.

27-30   *Triquitrites velensis* (BHARDWAJ) VAN WIJHE & BLESS 1974
Westphalian C-D.
Fig. 27: 262E, 38.0 x 98.3; Fig. 28: 262G, 41.0 x 99.1; Fig. 29: 143C, 43.0 x 100.1;
Fig. 30: 262G, 33.8 x 111.9.

31   *Simozonotriletes intortus* (WALTZ) POTONIÉ & KREMP 1954
330D, 49.6 x 93.3, Viséan – Westphalian C.

32   *Triquitrites* aff. *velensis* (BHARDWAJ) VAN WIJHE & BLESS 1974
308C, 34.0 x 99.1; distal surface rugulate-corrugate, otherwise like *T. velensis*.

33   cf. *Triquitrites velensis* (BHARDWAJ) VAN WIJHE & BLESS 1974
262G, 42.8 x 100.5, possibly aberrant specimen.

34   *Tripartites trifoliolatus* DYBOVA & JACHOWICZ 1957
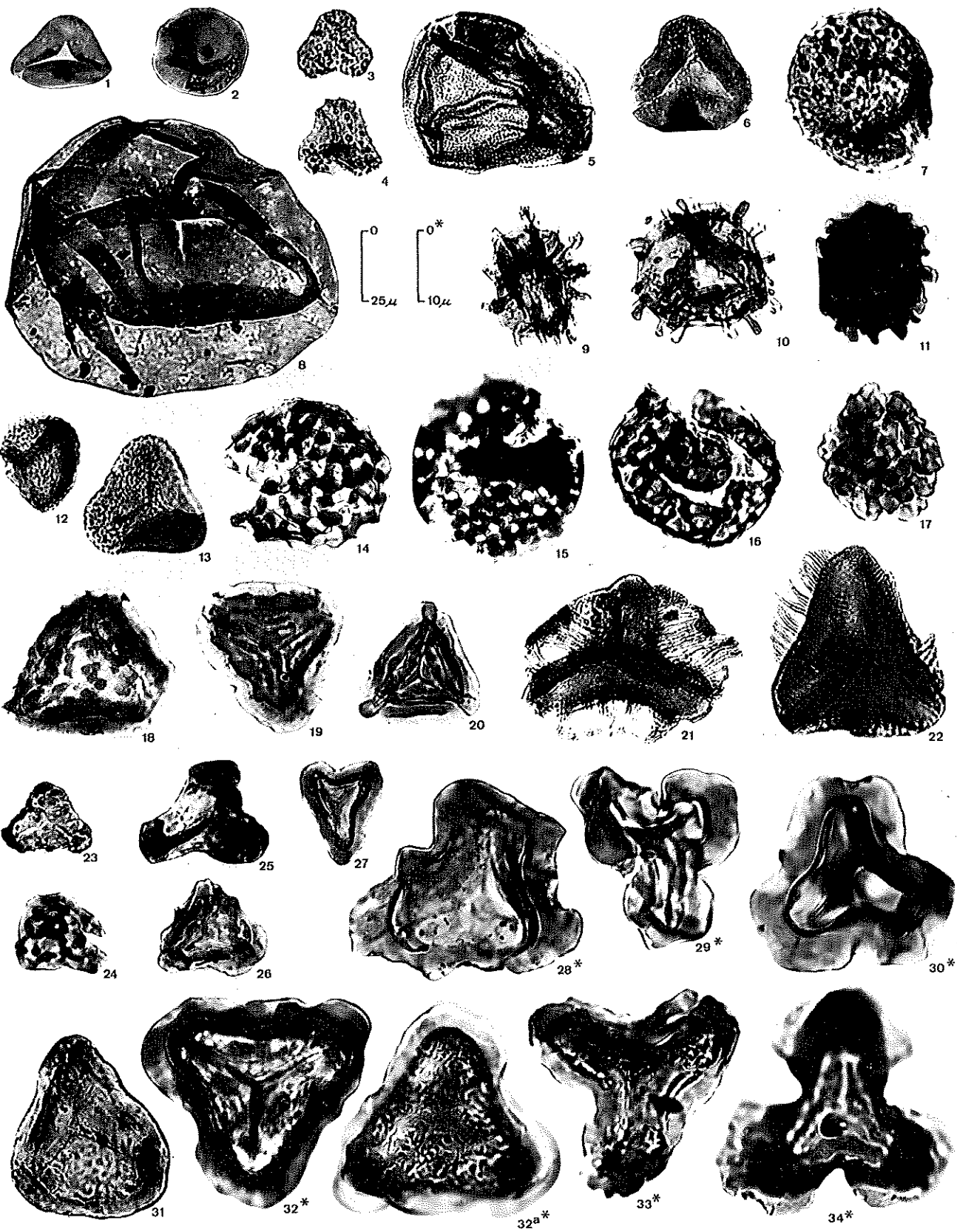262G, 31.8 x 112.3, Namurian A.

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Within the figure the following labels appear:

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PLATE II

1   *Crassispora kosankei* (POTONIÉ & KREMP) BHARDWAJ 1957
262E, 34.0 x 92.9, Namurian A – Stephanian C.

2-4   *Densosporites sphaerotriangularis* KOSANKE 1950
Lower Namurian – Stephanian B.
Fig. 2: 262E, 47.6 x 94.7; Fig. 3: 262G, 36.2 x 102.4; Fig. 4: 262B, 26.5 x 102.4.

5   *Lycospora rotunda* (BHARDWAJ) SOMERS 1972
262G, 42.3 x 94.7, Viséan – Stephanian C.

6   *Cingulizonates loricatus* (LOOSE) BUTTERWORTH & SMITH 1964
308B, 42.8 x 109.0, Namurian C – Westphalian D.

7   *Cristatisporites solaris* (BALME) BUTTERWORTH & SMITH 1964
262E, 45.3 x 98.9, Namurian A – Stephanian B.

8   *Cristatisporites indignabundus* (LOOSE) STAPLIN & JANSONIUS 1964
262G, 31.1 x 112.7, Westphalian A-D.

9   *Cirratriradites saturni* (IBRAHIM) SCHOPF, WILSON & BENTALL 1944
262G, 42.0 x 112.5, Namurian B – Stephanian B.

10   *Alatisporites hexalatus* KOSANKE 1950
330C, 48.2 x 95.9, Westphalian A – Lower Stephanian.

11   *Alatisporites pustulatus* (IBRAHIM) IBRAHIM 1933
330D, 45.0 x 107.6, Westphalian A – Lower Stephanian.

12   *Endosporites globiformis* (IBRAHIM) SCHOPF, WILSON & BENTALL 1944
262G, 43.8 x 96.1, Westphalian A – Autunian.

13   *Columinisporites ovalis* PEPPERS 1964
328A, 48.7 x 104.3, Stephanian of U.S.A.

14   *Punctatosporites granifer* POTONIÉ & KREMP 1956
262B, 23.4 x 98.8, Westphalian B – Upper Permian.

15   *Laevigatosporites vulgaris* (IBRAHIM) POTONIÉ & KREMP 1956
262G, 33.6 x 112.0, Viséan – Tertiary.

16   *Vestispora* cf. *pseudoreticulata* SPODE 1967
262F, 24.1 x 108.7, Westphalian A-D (operculum).

17, 18   *Vestispora fenestrata* (KOSANKE & BROKAW) SPODE 1967
Westphalian C-D.
Fig. 17: 262B, 28.0 x 98.0; Fig. 18: 262G, 26.3 x 107.5.

19   *Vestispora sp.*
143C, 34.0 x 103.4. Rather coarse reticulum of primary muri, with lumina of regular size.

20, 22   *Vestispora magna* (BUTTERWORTH & WILLIAMS) SPODE 1967
Westphalian B-D.
Fig. 20: 262A, 30.9 x 104.2; Fig. 22: 330D, 43.5 x 101.0.

21, 23   *Vestispora pseudoreticulata* SPODE 1967
Westphalian A-D.
Fig. 21: 308C, 44.4 x 106.0; Fig. 23: 330B, 47.0 x 92.5.

24   *Florinites* cf. *florini* IMGRUND 1960 sensu SMITH & BUTTERWORTH 1967
262E, 31.9 x 104.6, Westphalian A-D.

25   *Florinites mediapudens* (LOOSE) POTONIÉ & KREMP 1956
262E, 37.8 x 104.5, Westphalian A – Autunian.

26   *Florinites triletus* KOSANKE 1950
262C, 30.0 x 111.5, Westphalian B – Stephanian.

27   *Schopfipollenites ellipsoides* (BRAHIM) POTONIÉ & KREMP 1954
262F, 30.7 x 109.1, Namurian A – Stephanian B.
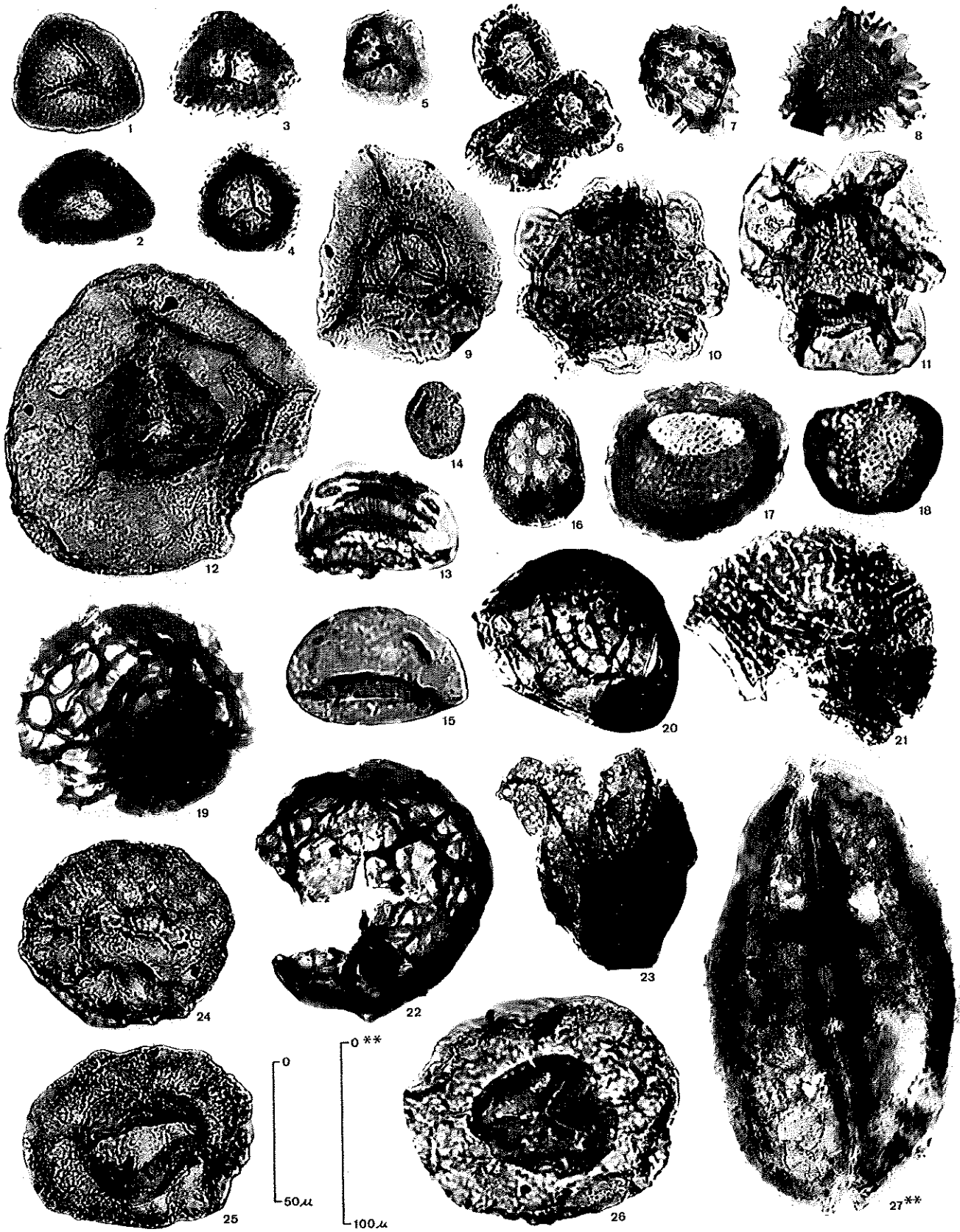
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PLATE III

1   *Punctatisporites sinuatus* (ARTÜZ) NEVES 1961
         262G, 28.2 x 102.1, Namurian A – Westphalian A.

2   *Punctatisporites* aff. *aerarius* BUTTERWORTH & WILLIAMS 1958
         330A, 47.5 x 105.0.

3   *Raistrickia* cf. *microhorrida* (HORST) POTONIÉ & KREMP 1955
         143, 53.3 x 100.6.

4   *Tripartites incisotrilobus* (NAUMOVA) POTONIÉ & KREMP 1956
         262F, 47.9 x 104.9, Dinantian – basal Namurian.

5, 11, 12   *Mooreisporites trigallerus* NEVES 1958
         Namurian A.
         Fig. 5: 334D, 35.1 x 94.4; Fig. 11: 143C, 47.0 x 110.3; Fig. 12: 262E, 33.9 x 94.5.

6   *Mooreisporites fustis* NEVES 1958
         333B, 30.4 x 109.3, Namurian A – Westphalian B.

7   *Dictyotriletes bireticulatus* (IBRAHIM) SMITH & BUTTERWORTH 1967
         262B, 30.4 x 106.4, Namurian A – Westphalian D.

8, 15   *Ahrensisporites guerickei* (HORST) POTONIÉ & KREMP 1954
         Namurian A – Westphalian C.
         Fig. 8: 332D, 35.4 x 97.0; Fig. 15: 330C, 51.5 x 111.9.

9   *Pustulatisporites papillosus* (KNOX) POTONIÉ & KREMP 1955
         332B, 27.3 x 111.4, Namurian A (?– Westphalian A).

10   *?Tripartites* cf. *trilinguis* (HORST) SMITH & BUTTERWORTH 1967
         262F, 44.4 x 101.6.

13   *Tripartites nonguerickei* POTONIÉ & KREMP 1956
         143C, 45.5 x 93.1, Upper Viséan – Namurian C.

14   *Ahrensisporites interitorsus* HORST 1943
         262F, 34.0 x 104.5, Namurian A.

16   *Grumosisporites varioreticulatus* (NEVES) SMITH & BUTTERWORTH 1967
         330A, 26.9 x 97.5, Namurian A – Westphalian B.

17   *Bellispores nitidus* (HORST) SULLIVAN 1964
         332A, 46.5 x 112.0, Upper Viséan – Westphalian B.

18, 20   *Reticulatisporites polygonalis* (IBRAHIM) SMITH & BUTTERWORTH 1967
         Westphalian A-C.
         Fig. 18: 143C, 46.0 x 107.1; Fig. 20: 334C, 48.0 x 110.6.

19   *Knoxisporites cinctus* (WALTZ) BUTTERWORTH & WILLIAMS 1958
         262G, 34.5 x 106.9, Namurian A.

21   *Knoxisporites* ex gr. *hageni* POTONIÉ & KREMP 1954
         333D, 24.0 x 105.0, Westphalian A-C.

22, 23   *Proprisporites* aff. *laevigatus* NEVES 1961
         Fig. 22: 332D, 47.3 x 95.5; Fig. 23: 143C, 55.2 x 100.9.

24   *Reticulatisporites carnosus* (KNOX) NEVES 1964
         262G, 36.4 x 111.0, Namurian A – Westphalian A.

25   *Knoxisporites* sp.
         262A, 28.7 x 106.1.

26   *Densosporites triangularis* KOSANKE 1950
         262F, 46.7 x 104.5, Viséan – Westphalian B.

27   *Cingulizonates* aff. *capistratus* (HOFFMEISTER, STAPLIN & MALLOY) STAPLIN &
         JANSONIUS 1964
         334B, 32.2 x 96.0.

28   *Radiizonates striatus* (KNOX) STAPLIN & JANSONIUS 1964
         262E, 28.3 x 101.2, Westphalian A-B.

29   cf. *Schopfipollenites ellipsoides* var. *corporeus* NEVES 1961
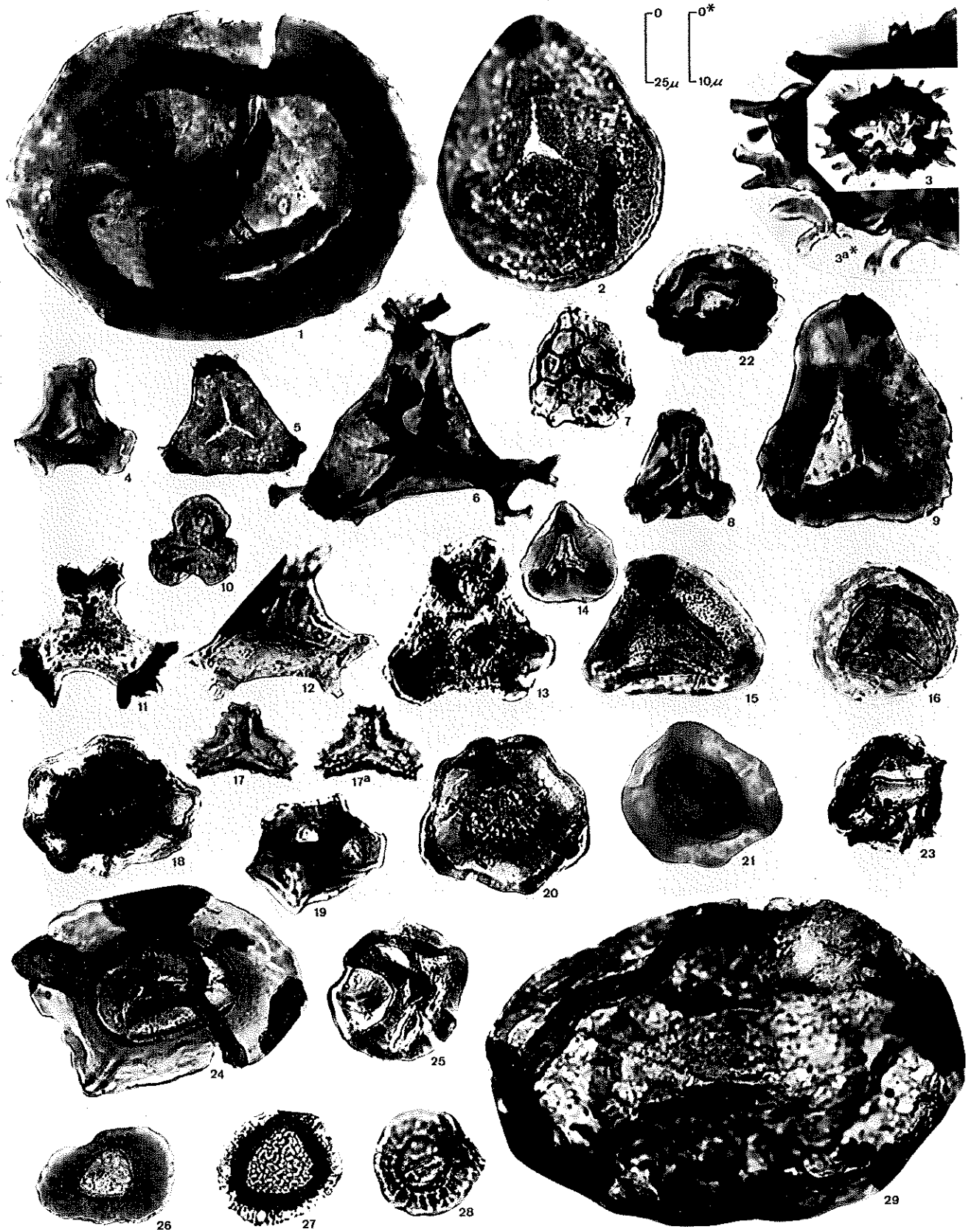   262B, 38.9 x 104.3.

PLATE IV

1   *Grandispora famenensis* (Naumova) Streel 1974
262B, 30.0 x 105.5, Famennian.

2-6   *Spelaeotriletes lepidophytus* (Kedo) Streel 1974
Uppermost Famennian to basal Tournaisian.
Fig. 2: 262F, 40.3 x 108.7; Fig. 3: 143C, 54.1 x 102.8; Fig. 4: 262G, 27.8 x 101.8;
Fig. 5: 262E, 26.2 x 95.5; Fig. 6: 143C, 50.4 x 102.6.

7, 8   *Spelaeotriletes cassis* (Kedo) Streel 1974
Tournaisian to Lower Namurian.
Fig. 7: 329A, 31.4 x 107.3; Fig. 8: 262B, 31.9 x 111.8.

9   *Spelaeotriletes triangulus* Neves & Owens 1966
262G, 36.4 x 96.1, Namurian.

10   *Monilospora mutabilis* Staplin emend Clayton 1973
262F, 33.4 x 106.4, Upper Viséan.

11   *"Dictyotriletes"* fragment
262G, 34.5 x 107.2.

12-14   *Auroraspora hyalina* (Naumova) Streel 1974
Upper Frasnian – Middle Tournaisian.
Fig. 12: 262B, 27.7 x 105.5; Fig. 13: 262G, 50.9 x 111.9; Fig. 14: 262E, 37.3 x 94.5.

15, 16 *"Anulatisporites"* sp.
Fig. 15: 262C, 29.1 x 93.6; Fig. 16: 262A, 28.5 x 105.9.

17, 19 *"Cristatisporites"* echinatus Playford 1963
Tournaisian.
Fig. 17: 262F, 32.0 x 91.0; Fig. 19: 328C, 35.9 x 100.3.

18   cf. *"Cristatisporites"* echinatus Playford 1963
334C, 31.4 x 91.5.

20   *Convolutispora cerebra* Butterworth & Williams 1958
328C, 23.0 x 111.0, Upper Viséan – Namurian.

21   *Convolutispora flexuosa* var. *major* Hacquebard 1957
330D, 40.7 x 100.5, Upper Tournaisian – Upper Viséan.
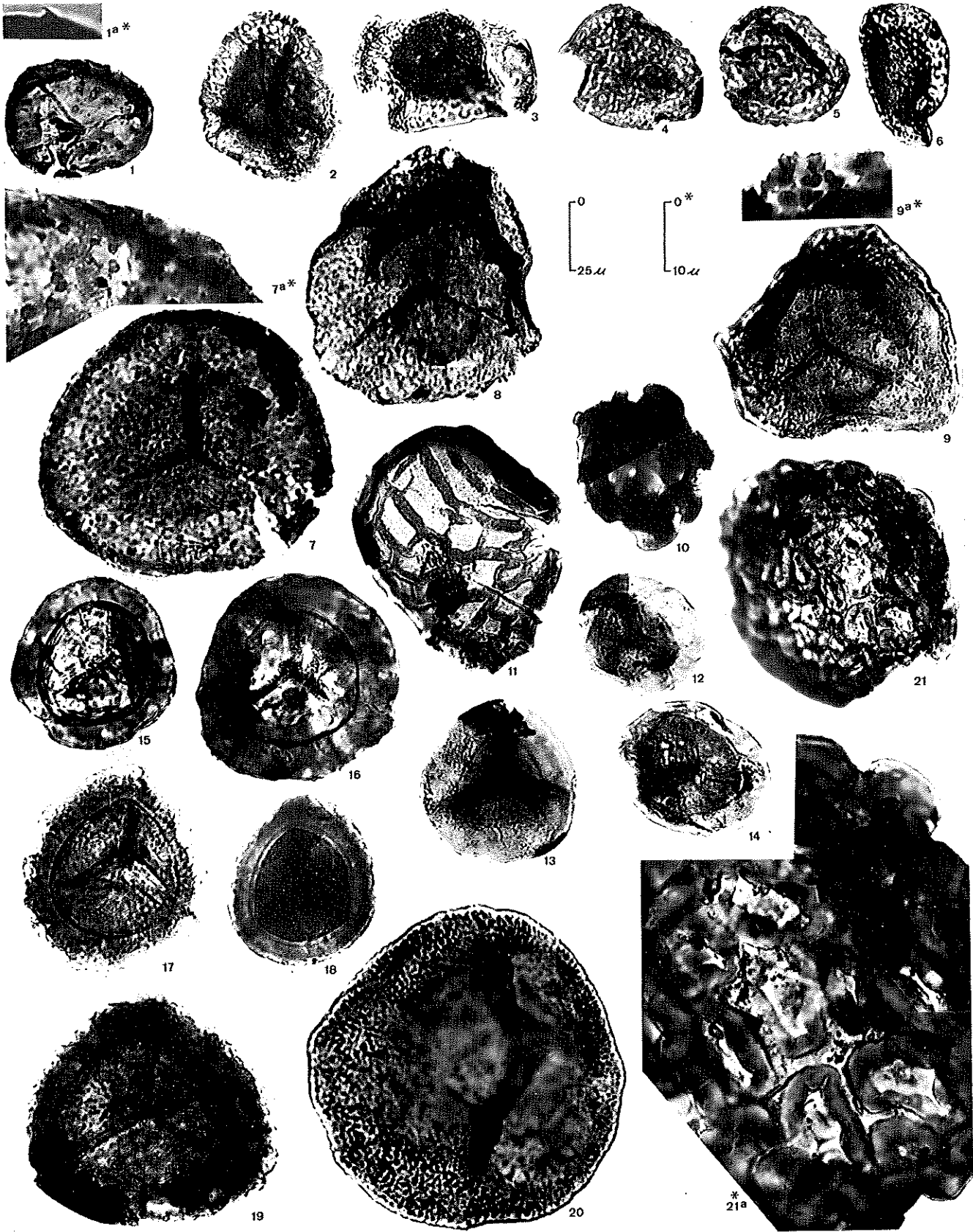
32

PLATE V

1   *"Anulatisporites" jonkeri* RIEGEL 1973
      262D, 26.6 x 110.6, Lower Eifelian.

2   *Grandispora* sp.
      143B, 58.5 x 100.6, Givetian(?).

3-8   *Grandispora douglastownense* McGREGOR 1973
      Upper Emsian – Lower Eifelian.
      Fig. 3: 143C, 43.0 x 108.2; Fig. 4: 330A, 50.2 x 91.5; Fig. 5: 334A, 37.0 x 100.3;
      Fig. 6: 328D, 44.0 x 104.5; Fig. 7: 143B, 41.9 x 109.0; Fig. 8: 333D, 21.7 x 103.7.

9   *Grandispora mammillata* OWENS 1971
      262B, 48.2 x 110.3, Lower Eifelian (?) – Givetian(?).

10   cf. *Grandispora ?macrotuberculata* (ARKHANGELSKAYA) McGREGOR 1973
      328A, 34.3 x 111.2.

11   *Grandispora ?macrotuberculata* (ARKHANGELSKAYA) McGREGOR 1973
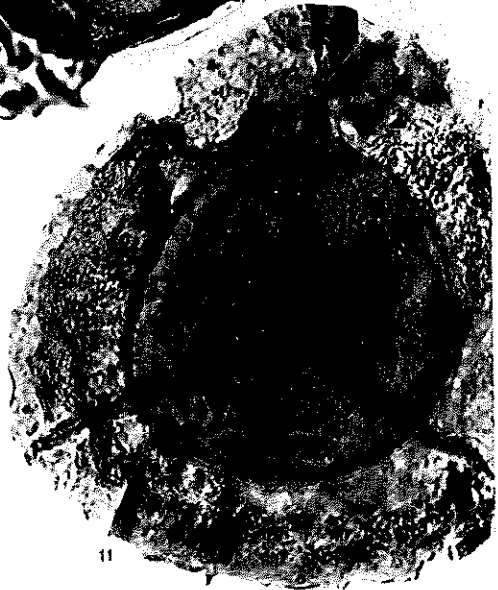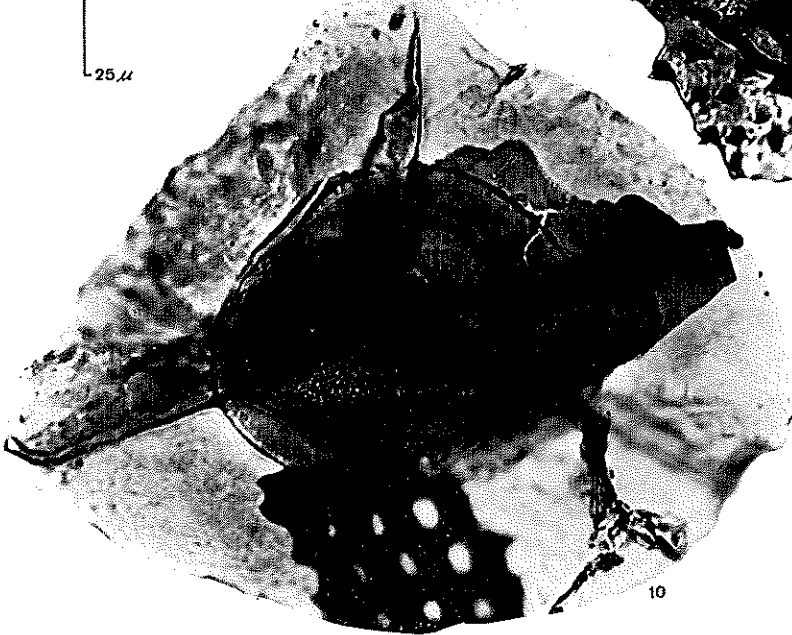   328B, 47.3 x 97.1, Upper Emsian – Lower Eifelian.
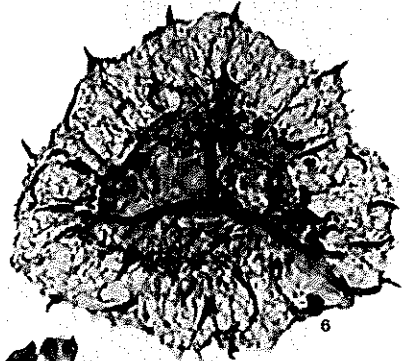
PLATE VI

1-3   *Dibolisporites echinaceus* (EISENACK) RICHARDSON sensu McGREGOR 1973
Lower Emsian – Upper Famennian.
Fig. 1: 143C, 54.0 x 99.6; Fig. 2: 262D, 44.5 x 107.1; Fig. 3: 262E, 25.6 x 98.9.

4   *Apiculiretusispora* cf. *arenorugosa* McGREGOR 1973
262F, 50.2 x 100.7, Emsian – Eifelian.

5   *Dibolisporites* sp. cf. *D. eifeliensis* sensu McGREGOR 1973 non LANNINGER 1968
262B, 34.0 x 97.0, Emsian – Eifelian.

6   *Samarisporites* sp. cf. *Hymenozonotriletes acanthyrugosus* CHIBRIKOVA 1959
143C, 37.4 x 103.5.

7-9   *Rhabdosporites langi* (EISENACK) RICHARDSON 1960
Lower Eifelian – Upper Givetian.
Fig. 7: 328A, 49.1 x 109.6; Fig. 8: 328A, 48.5 x 110.3; Fig. 9: 328A, 32.0 x 108.5.

10-12   *Samarisporites* nov. sp. aff. *S. inusitatus* ALLEN 1965
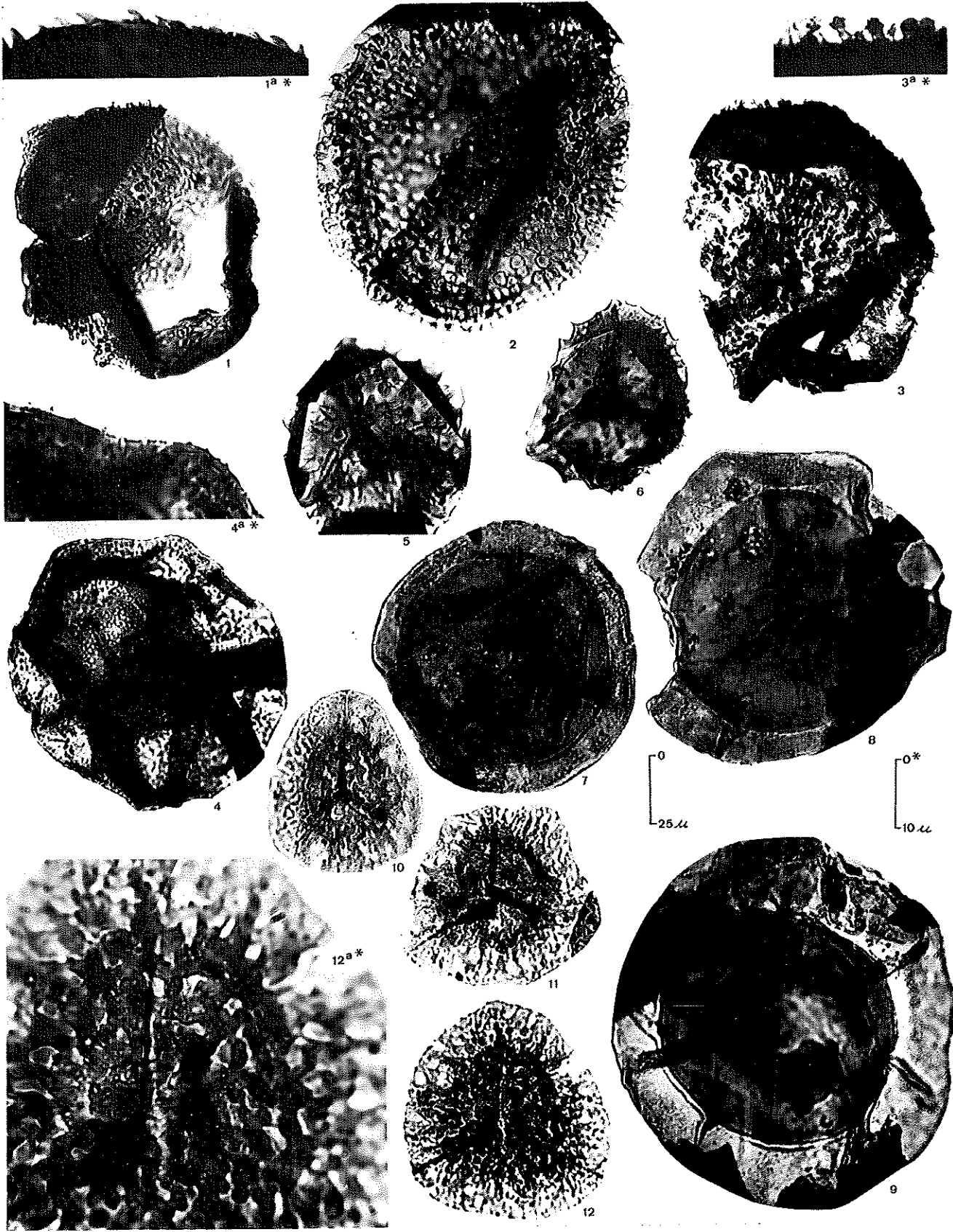Fig. 10: 307C, 36.3 x 108.5; Fig. 11: 308B, 27.0 x 98.3; Fig. 12: 307D, 44.5 x 98.5.

PLATE VII

1-4   *Ancyrospora ancyrea* (EISENACK) RICHARDSON var. *brevispinosa* RICHARDSON 1962
Upper Eifelian(?) – Lower Frasnian(?)
Fig. 1: 262B, 34.0 x 94.7; Fig. 2: 262G, 35.7 x 109.1; Fig. 3: 262D, 42.8 x 104.1;
Fig. 4: 262D, 30.3 x 100.0.

5-8   *Hystricosporites* sp.
Uppermost Emsian – Lower Tournaisian.
Fig. 5: 262D, 38.9 x 93.5; Fig. 6: detail of incomplete specimen, 328A, 23.0 x
110.9; Fig. 7: 262B, 22.9 x 99.3; Fig. 8: 328A, 28.4 x 98.0.

9   Unknown.
262B, 42.5 x 109.4.

10   *Ancyrospora? capillata* DOLBY & NEVES 1970
328A, 28.9 x 103.0, Lower Tournaisian.

11, 12   *Solisphaeridium* spp.
Fig. 11: 328A, 22.7 x 107.7; Fig. 12: 262C, 39.8 x 90.9.

13, 14   *Veryhachium* spp.
Fig. 13: 334D, 29.8 x 97.9; Fig. 14; 332D, 24.3 x 91.2.

15   *Goniosphaeridium* sp.
262F, 51.8 x 105.6.

16   *Cymatiosphaera* sp.
143C, 46.0 x 100.7.

17-19   *Tasmanites* spp.
Fig. 17: 262E, 34.7 x 93.5 (fig. 17: equarorial focus); Fig. 18: 328A, 46.8 x 107.5;
Fig. 19: 262B, 38.0 x 103.5.

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5

6

7a*

7

8

9

10

10a*

11

12

13

14

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17

17a

18

19

0
0*
25μ
10μ