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MIOSPORES, THE *LEMURATA* AND *TRIANGULATUS* LEVELS AND THEIR FAUNAL INDICES NEAR THE EIFELIAN/GIVETIAN BOUNDARY IN THE EIFEL (F.R.G.)[1]

by

Stanislas LOBOZIAK[2], Maurice STREEL[3] & Karsten WEDDIGE[4]

(5 figures, 3 tables and 2 plates)

ABSTRACT.- 42 productive samples taken from the Eifelian Freilingen Formation to the Givetian Kerpen Formation in the Hillesheim Syncline (Eifel, F.R.G.) contain abundant and well preserved miospores from the Oppel Zones *acanthomammillatus-devonicus* and *triangulatus-ancyrea*. The incoming of *Geminospora lemurata* and *Samarisporites triangulatus*, which are important key-species, is demonstrated and illustrated. All miospore data are compared to conodont, trilobite and brachiopod zonations. They are all included in the *ensensis-obliquimarginatus* and *ensensis-bipennatus* conodont standard Zones. The traditional Ardenne and Eifel boundaries of the base of the Givetian Stage and the levels still in discussion in the Commission on Devonian Stratigraphy are mentionned.

RESUME.- 42 échantillons productifs, prélevés de la Formation eifelienne Freilingen à la Formation givétienne Kerpen dans le Synclinal de Hillesheim (Eifel, R.F.A.) contiennent des miospores abondantes et bien conservées appartenant aux Zones d'Oppel *acanthomammillatus-devonicus* et *triangulatus-ancyrea*. La première apparition de *Geminospora lemurata* et de *Samarisporites triangulatus*, qui sont des espèces-clef importantes, est démontrée et illustrée. Toutes les informations sur les miospores sont comparées aux zonations basées sur les conodontes, trilobites et brachiopodes. Elles sont toutes comprises dans les Zones standard de conodontes *ensensis-obliquimarginatus* et *ensensis-bipennatus*. Les limites traditionnelles, en Ardenne et dans l'Eifel de la base de l'Etage Givétien et les niveaux encore en discussion dans la Commission de Stratigraphie du Dévonien sont mentionnés.

1.- INTRODUCTION

This analysis concerns miospores from the Eifelian/Givetian Boundary beds and their stratigraphic significance. The upper part of the Eifelian in particular is a relatively less calciferous interval within the limestone sequences of the Eifel region (fig. 1). Thus, it partly reveals complete microfloras with sufficient preservation as Streel (1986) has already mentioned, after usual palynological techniques being applied. In the Eifel region are the reference localities of the internationally accepted base of the Eifelian Stage as well as one of the traditional German base of the Givetian Stage. Faunas are rich and very well known.

2.- LOCATION OF THE MIOSPORE SAMPLES

The miospore bearing samples were taken in classical outcrops within the Hillesheim Syncline (Topographic map-sheet n° 5606 Dollendorf, 1/25000) : A display of the involved formations is shown on figure 5. A first set of samples, taken in

1 Manuscrit reçu en juin 1990.

2 Paléobotanique, Univ. Sc. et Techn. Lille, URA 1365 CNRS, F-59655 Villeneuve d'Ascq, France.

3 Paléontologie, Université, 7, place du Vingt-Août, B-4000 Liège, Belgique.

4 Senckenberg-Museum, Senckenberg-Anlage 25, D-6000 Frankfurt am Main 1, F.R.G.

1987, concerns the interval from the Freilingen Formation to the Loogh Formation. Preliminary results were given as a document submitted to the I.U.G.S. Devonian Subcommission Meeting at Washington (U.S.A.) in July 1989. A second set of samples was taken in 1989 in the upper part of the Lahr Member and in the lowermost part of the Müllert Member of the Ahbach Formation in order to duplicate the sampling in a critical rock interval. A third set of samples, collected both in 1987 and 1989, concerns the Cürten and Kerpen Formations which are stratigraphically higher than the former-ones.

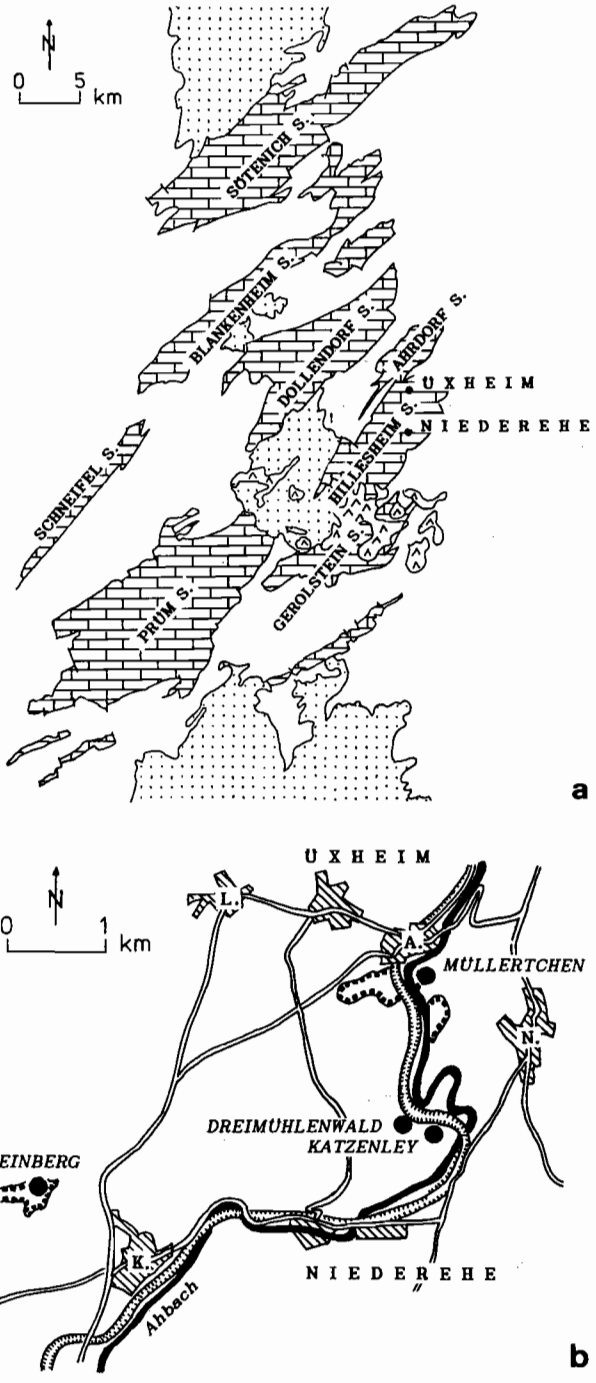


Fig. 1.- The localities of miospores samples from Hillesheim Syncline of Eifel Region.

a) The Eifel synclines filled by Middle and Upper Devonian (= limestone signature), surrounded by Lower Devonian (= blank), and covered by Triassic (= dots) or volcanics (= peaks); b) The studied sections near the villages Uxheim, Niederehe, Kerpen (= K.), Leudersdorf (= L.), Ahütte (= A.), and Nohn (= N.).

2.1.- The first set of samples corresponds to the following formations (fig. 2)

1.- Freilingen Formation with samples n° 30-32, 34, 35 and 40 from the Weinberg Quarry, west of Kerpen village (R 51000 / H 75680; further locality references in Struve 1988:128, Stop A 16). The marls are predominantly obscured in the abandoned quarry.

2. Ahbach Formation with samples n° 14-26 from the Müllertchen Quarry, south of Ahütte village (R 54940 / H 77960; e.g. Struve, 1982:119, Stop 16; Hotz, Kräusel & Struve 1955:111-116). Nearly the whole marly sequence is exposed.

3. Loogh Formation, lowermost part, with samples n° 9-11 from the abandoned railway cut Dreimühlenwald northeast of Niederehe village (R 54830 / H 76590; e.g. Struve 1988:138-140, Stop A 17c). The marls are slightly obscured by surface debris.

Sampling is unfortunately not homogeneous

- because of the unfavourable exposure conditions of the pure marly sequences (fig. 2 : Bohnert Member 1-4 of Freilingen Fm., lower- and uppermost parts of the Müllert Member of the Ahbach Fm.) or
- because of intercalating reefal limestones of Ahbach Fm. (fig. 2 : most of Hallert Member and Lahr Member 1-3).

Despite these large gaps in sampling, 22 levels were prolific and diverse enough to bring new and more data from this time span than those analyzed formerly in the Eifel area by Tiwari & Schaarschmidt (1975) and Riegel (1982). Moreover, this is the first investigation of miospores done in sections well dated by conodonts, trilobites, brachiopods, and other faunas. These «Eifel standard sections» are thoroughly the main reference sections for the conodont zonations of Weddige (1977), Weddige & Ziegler (1977) and Weddige (1988) as well as for trilobite or brachiopod zonations having been introduced by Struve during the last three decades.

2.2.- The second set of samples was taken from the Katzenley section in the abandoned railway cut near Dreimühlenwald (fig. 1b) and again from the Müllertchen quarry where they almost duplicate the samples 14 to 18 of the first set (fig. 3 and tables 1 and 2).

2.3.- The third set of samples corresponds to the Curten and Kerpen Formations.

4. Curten Formation, with samples n° 46-48 from the «Waldweg am Felschbach», 1 km south of Kerpen and samples n° 27-29 from the «Hohlweg auf dem Meerbusch», 2 km north-east of Kerpen.
5. Kerpen Formation from the abandoned railway cut sections near Kerpen : sample 44 south-east of Kerpen (near the sportfield) and samples 168-170, east of Kerpen at Rodert Hill (compare Struve, 1988, pages 148-149, text-figs. A18/4-5).

3.- MIOSPORE DISTRIBUTION IN THE INTERVAL FROM THE FREILINGEN FORMATION TO THE LOOGH FORMATION

One single assemblage (Oppel Zone) was encountered in all these samples. Occurrences in the lowermost and subsequent samples of *Acinosporites acanthomammillatus*, *A. macrospinosus,* and *Densosporites devonicus* and the absence in all samples of *Samarisporites triangulatus* allow to determine the Oppel Zone AD (*acanthomammillatus-devonicus*) (Streel *et al.,* 1987).

The following species are also present which first occur elsewhere (for instance in the Old Red Sandstone Continent, see Richardson & McGregor, 1986: fig. 3) in the same time range, amongst others : *Ancyrospora langii, Archaeozonotriletes variabilis, Chelinospora ligurata, C. timanica, Densosporites inaequus, Geminospora lemurata, Grandispora inculta* and *Grandispora naumovii* (both in one sample only and for that reason not in the chart), *Hystricosporites* aff. *reflexus, Verrucosisporites premnus, V. scurrus* and *V.* cf. *uncatus.*

The occurrence of *H.* aff. *reflexus* from the lowermost sample and the first occurrence of *G. lemurata* in sample 22 in the Müllert Member indicate the subsequent Interval Zone **Ref** and **Lem** inside the limits of the Oppel Zone **AD.**

The second set of samples carry a similar assemblage of miospores (Oppel Zone AD). The samples (fig. 3 and tables 1 and 2) were rich enough in miospores content to ascertain that no *G. lemurata* was present.

3.1.- FACIAL CONTROL OF THE MIOSPORE DISTRIBUTION

As to the interpretation of the miospore distribution, it has to be considered that the succession from Freilingen up to Ahbach and Loogh Formations is distinctly shifting in facies (compare e.g. Struve 1988:128-131, 134-140; Weddige, 1988: 108-109, 132-133, 140-142, Text-fig. A14-18/12, Weddige & Struve 1988). The Freilingen Fm. was deposited on the shallow outer shelf under high influence of open-marine faunas, particularly of cosmopolitan conodonts. The following Hallert-Lahr reef (= mud-mounds) obviously represents that barriere which gave rise for special faunas of a sheltered-marine environment. During the Ahbach- and Loogh time interval, the latter are characterized for instance by increasing occurrences of «Pre-» and «Pseudo-» and final «Eu-»Stringocephalids in brachiopods as well as by the lack of cosmopolitan *Polygnathus* representatives in conodonts.

Microfloral distribution might also reflect the facial difference between Freilingen and upper Ahbach miospores and explain the presence of more species and more specimens of these species in the sheltered-marine environment than in the outer shelf environment.

3.2.- THE *GEMINOSPORA LEMURATA* LEVEL

3.2.1.- Biostratigraphical assignments

The first occurrence of *G. lemurata* represents the main palynological limit within the studied stratigraphical interval. The inception of this important cosmopolitan species is now fixed by the findings (Pl. 1) in the Eifelian Müllertchen Quarry in the Müllert Member of the Ahbach Formation. Riegel (1982, fig. 1) shows, on a schematic chart, the first occurrence of *Geminospora antaxios* at the base of the same formation in the Eifel region without mentionning any definite sections. Streel *et al.* (1987, p. 217, footnote) indicate that *G. antaxios* (Chibrikova) Owens *in* Riegel 1982 is believed to belong to the concept of *G. lemurata* Balme emend Playford 1983.

Unfortunately, the Müllert Member is precisely that interval that yields the poorest conodont record of the whole Eifelian stage of the Eifel area. Despite this short-termed deficiency of conodonts, the *lemurata* Level is datable as upper part of lower *ensensis* Zone of conodonts (Weddige 1977), respectively to the *ensensis-obliquimarginatus* Subzone *sensu* Weddige (1984). As to the refinements of the standard conodont zonation (compare fig. 2) :

Firstly, the level is distinctly positioned above the base of the *obliquimarginatus Icriodus*-Zone as well as of the *hemiansatus Polygnathus*-Zone in the sense of the substitutional zonation of Bultynck (1987).

Secondly, it is closely above the main occurrences of *Ozarkodina bidentata* Bischoff & Ziegler, i.e. above the centre of the *obliquimarginatus* &

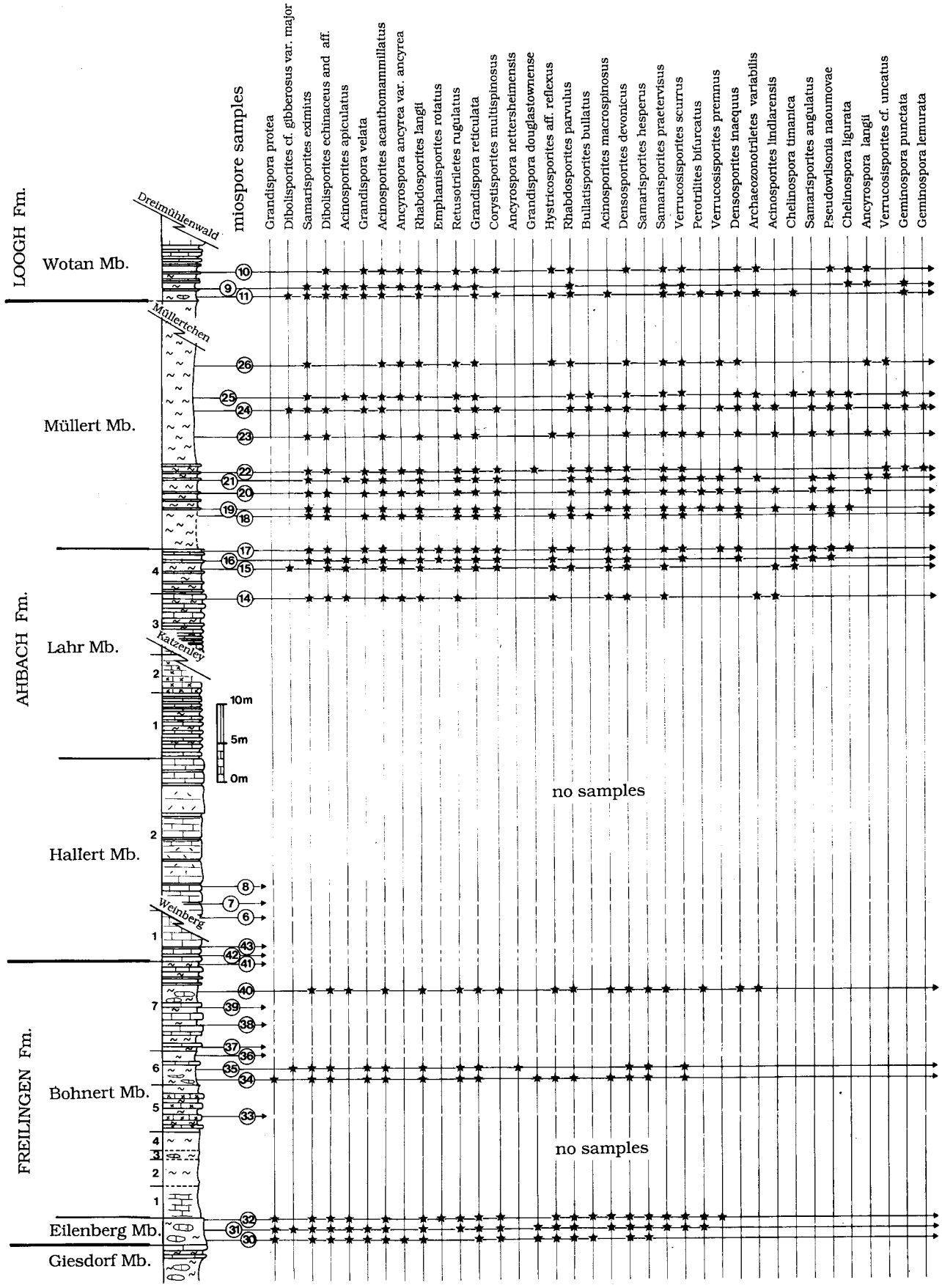


Fig. 2.- Vertical distribution of miospores and associated conodont faunas of Eifelian/Givetian boundary beds in the Hillesheim Syncline, Eifel. The four studied sections Weinberg, Katzenley, Müllertchen, and Dreimühlenwald are combined vertically in the column on the left.

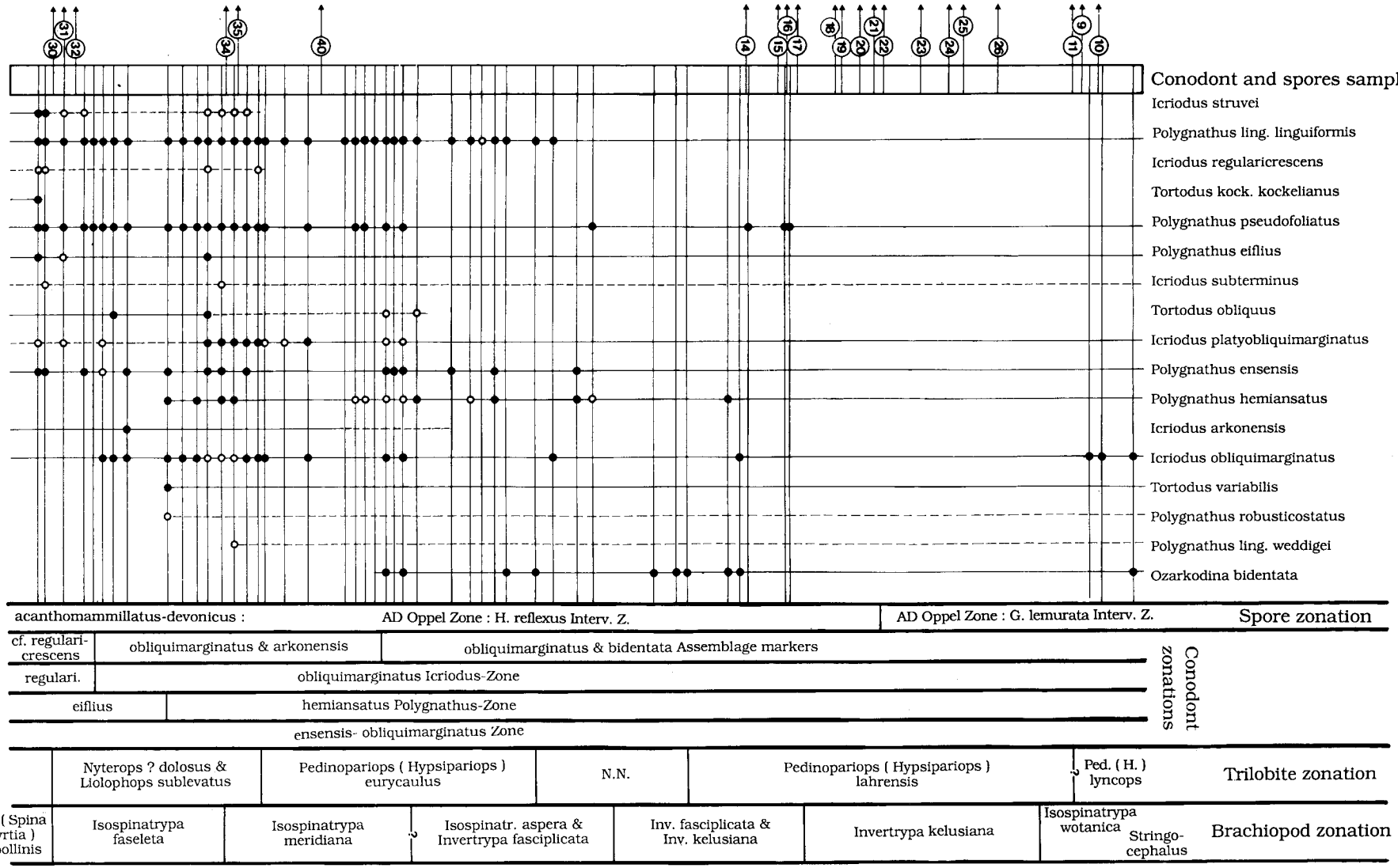

Conodont and spores samples
Icriodus struvei
Polygnathus ling. linguiformis
Icriodus regularicrescens
Tortodus kock. kockelianus
Polygnathus pseudofoliatus
Polygnathus eiflius
Icriodus subterminus
Tortodus obliquus
Icriodus platyobliquimarginatus
Polygnathus ensensis
Polygnathus hemiansatus
Icriodus arkonensis
Icriodus obliquimarginatus
Tortodus variabilis
Polygnathus robusticostatus
Polygnathus ling. weddigei
Ozarkodina bidentata
acanthomammillatus-devonicus :
AD Oppel Zone : H. reflexus Interv. Z.
AD Oppel Zone : G. lemurata Interv. Z.
Spore zonation
cf. regulari-crescens
obliquimarginatus & arkonensis
obliquimarginatus & bidentata Assemblage markers
regulari.
obliquimarginatus Icriodus-Zone
eiflius
hemiansatus Polygnathus-Zone
ensensis- obliquimarginatus Zone
Conodont zonations
Nyterops ? dolosus & Liolophops sublevatus
Pedinopariops (Hypsipariops) eurycaulus
N.N.
Pedinopariops (Hypsipariops) lahrensis
Ped. (H.) lyncops
Trilobite zonation
Sp. (Spina cyrtia) apollinis
Isospinatrypa faseleta
Isospinatrypa meridiana
Isospinatr. aspera & Invertrypa fasciplicata
Inv. fasciplicata & Inv. kelusiana
Invertrypa kelusiana
Isospinatrypa wotanica
Stringo-cephalus
Brachiopod zonation

Table 1.- Repartition of the main miospores in N Mü samples from the Katzenley Section.

MAIN MIOSPORES / MIOSPORE SAMPLES (N Mü)	Samarisporites eximius	Dibolisporites echinaceus and aff.	Acinosporites apiculatus	Acinosporites acanthomammillatus	Ancyrospora ancyrea var. ancyrea	Rhabdosporites langii	Retusotriletes rugulatus	Grandispora reticulata	Corystisporites multispinosus	Hystricosporites aff. reflexus	Rhabdosporites parvulus	Acinosporites macrospinosus	Densosporites devonicus	Samarisporites praetervisus	Densosporites inaequus	Acinosporites lindlarensis	Samarisporites angulatus	Pseudowilsonia naoumovae	Ancyrospora langii
35,05/35,18		●		●	●	●	●					●	●			●			●
33,0/34,9	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	
31,4	●			●		●	●	●	●	●	●		●	●	●				

bidentata Assemblage range zone *sensu* Weddige (1988:104-106, text-fig. A14-18/11).

Thirdly, it is higher but very close to the inception of the first conodont of *Polygnathus ensensis ensensis* Ziegler & Klapper as it was recently proposed as a most favourable boundary level (Weddige 1989).

Regardless of their less world-wide significance, the actually finest datings of the *lemurata* Level are provided by shorter-termed zones of megafossils, particularly of trilobites with the Zone of *Pedinopariops (Hypsipariops) lahrensis* Struve and brachiopods with *Invertrypa kelusiana* Struve. World-wide stratigraphical significance, however, is assigned to the entry of the shallow-water brachiopod *Stringocephalus* sensu stricto which, according to Struve (1961), characterizes the lowermost Loogh Fm. and the base of the Givetian

Table 2.- Repartition of the main miospores in Müllert and Müx samples from the Müllertchen Quarry.

MAIN MIOSPORES / MIOSPORE SAMPLES	Samarisporites eximius	Dibolisporites echinaceus and aff.	Acinosporites apiculatus	Grandispora velata	Acinosporites acanthomammillatus	Ancyrospora ancyrea var. ancyrea	Rhabdosporites langii	Retusotriletes rugulatus	Grandispora reticulata	Corystisporites multispinosus	Hystricosporites aff. reflexus	Rhabdosporites parvulus	Acinosporites macrospinosus	Densosporites devonicus	Samarisporites praetervisus	Verrucosisporites scurrus	Verrucosisporites premnus	Densosporites inaequus	Archaeozonotriletes variabilis	Acinosporites lindlarensis	Chelinospora timanica	Samarisporites angulatus	Pseudowilsonia naoumovae	Chelinospora ligurata	Ancyrospora langii	Geminospora punctata
Müllert 4	●	●			●	●	●	●		●	●	●	●	●	●		●	●	●			●	●			
Müllert 1	●	●	●		●	●	●	●	●		●	●	●	●	●	●		●		●	●		●		●	
Müllert 3					●		●	●	●			●				●	●				●			●	●	●
Müllert 2	●		●	●	●		●	●		●	●		●	●	●					●	●		●		●	
(Müx)																										
0,3/0,15						●	●						●	●	●			●							●	
0,5/0,35	●	●			●	●	●	●	●	●	●	●		●						●						
0,85/0,75		●	●		●	●	●					●			●										●	

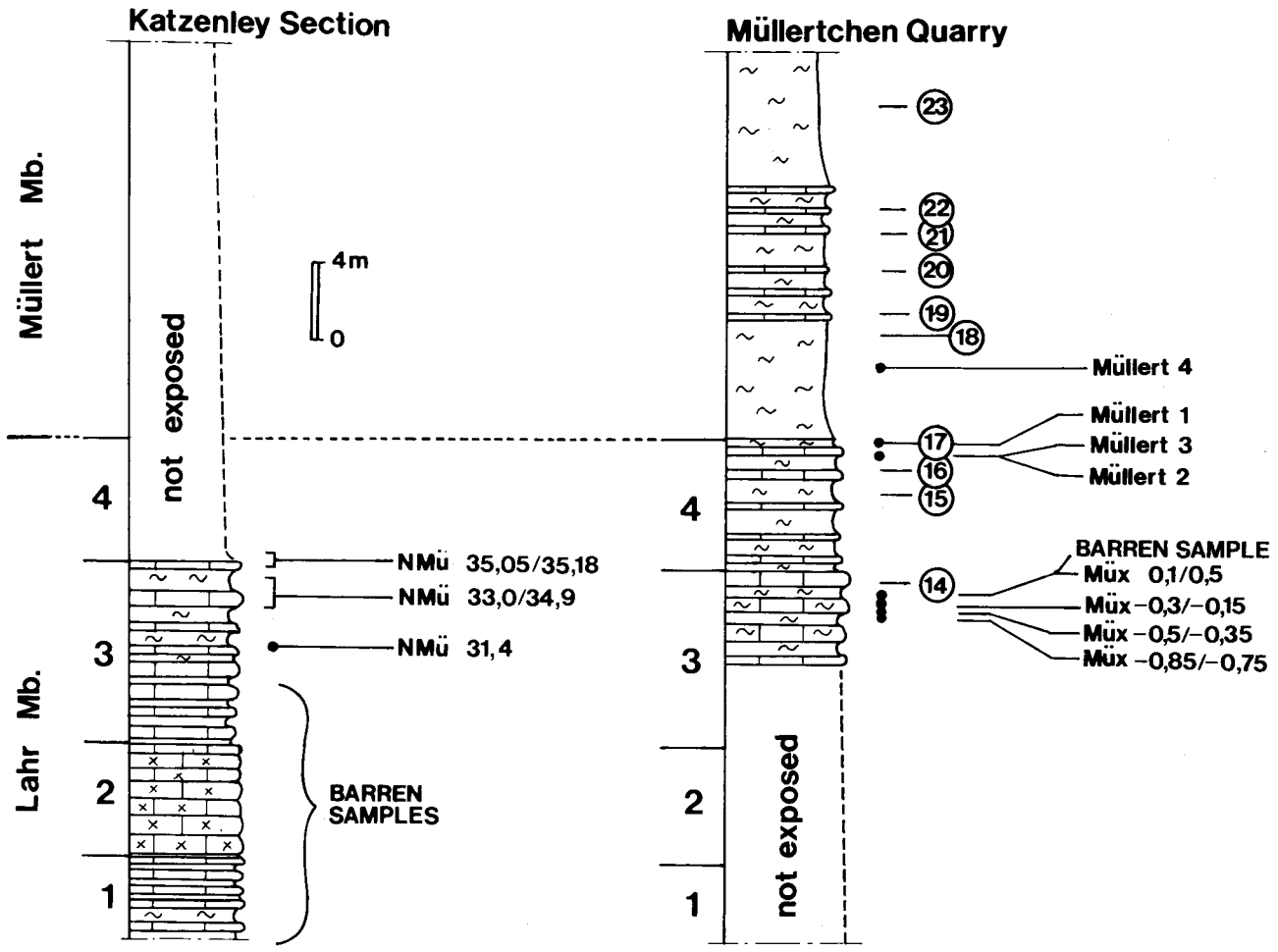


Fig. 3.- Additional sampling in the Ahbach Formation of the Katzenley Section and the Müllertchen Quarry. Samples numbers of first sampling (in circles) refer to distribution chart (fig. 2, left column).

stage in the sense of Beyrich (1837). Thus, the entries of *G. lemurata* and of *Stringocephalus* are nearly coeval.

3.2.2.- Regional comparisons

The basis of *G. lemurata* was crudely demonstrated by McGregor (1981) to occur within the conodont *Polygnathus ensensis* Zone. This record of the miospore in conodont dated section is from the Weatherall Formation in the Beverley Inlet section, Melville Island in the Canadian Arctic. Conodonts are from a single level some 150m below the first occurrence of *G. lemurata*. Five samples otherwise rich in palynomorphs were macerated within this interval which do not contain this species. These five samples and the first sample containing *G. lemurata* originated from a deltaic marine shelf facies. Conodonts indicate an age probably within the *australis* to *ensensis* Zones according to Uyeno (unpublished GSC report, 1980). Although the data of the present work are more precisely documented than those from the Canadian Arctic, they do not contradict.

In the Boulonnais region (Loboziak & Streel, 1980), the first occurrence of *G. lemurata* was demonstrated in the lowermost part of unit H (Membre de Couderousse) of the Formation de Blacourt between Fauna IV and Fauna V of Bultynck (Brice *et al.*, 1976, 1979). Fauna IV is now considered to belong to the Middle *varcus* Zone (Bultynck, personal communication, *in* Loboziak & Streel, 1988: fig. 2). The entry of *G. lemurata* is therefore delayed in the Boulonnais compared to the Eifel and Arctic Canada. The shales of the Membre de Couderousse occur immediately on a reef formation which ends the Membre du Griset of the Formation de Blacourt. These are poor environmental conditions for palynomorphs in marine sedimentation and could explain a sorted assemblage of miospores.

One single sample taken slightly above the base of the Formation de Blacourt, some 180m below the Membre de Couderousse samples also yielded no *G. lemurata*. This sample is shown immediately below a productive conodont sample belonging to the *ensensis* Zone (Loboziak & Streel 1988: fig. 2). It is assigned now by Bultynck

(personal communication, 1988) to the *ensensis-bipennatus* Subzone. As this time level is distinctly younger than that of the *G. lemurata* in the Eifelian Müllert Member, it should also reveal the miospore. (Unless a time gap between spore sample and conodont sample would be responsible in the French section which seems to be unprobable). The absence of the species is better referred to poor conditions of sedimentary environment and scarce sampling.

McGregor (1979: text-fig. 11) plotted on a Middle Devonian palaeocontinental assembly the geographic occurrences of this species. *G. lemurata* stratigraphic and geographic distribution has been extensively reviewed by Playford (1983). This species is virtually cosmopolitan.

3.2.3.- Conclusions on the *Geminospora lemurata* Level

Now, it is documented herein that the inception of the miospore *Geminospora lemurata* is slightly below the classic «*Stringocephalus* Boundary» *sensu* Beyrich (1837) the level of which was identified in the Eifel region by Struve (1961) based on the occurrence of the first taxonomically true *Stringocephalus* (= *sensu stricto*). The base of the Givet Limestone in the type area of the Belgian Ardenne *sensu* d'Omalius d'Halloy (1862) and Maillieux (1933), which apparently does not bear miospores, is believed to correspond to an upper part of the *ensensis* Zone near the base of the *varcus* Zone after Bultynck (1985). According to the Eifel standard section, the Givetian Boundary of the Ardenne points to a level about 70 m above the *Stringocephalus* Boundary (fig. 4).

It is striking that the inception of *G. lemurata* is very close to that of the first conodont of *Polygnathus ensensis ensensis* Ziegler & Klapper as it was recently proposed as a favourable boundary level (Weddige 1989). The most important advantage of this level is that it is positioned distinctly above an event interval (= «*otomari* Event») which is obviously represented by upper Junkerberg Fm. and by Freilingen Fm. in the Eifel, respectively by the pelagic Odershausen Fm. in the Eastern Rhenish Mountains. On the contrary, two lower candidate levels of the Eifelian/Givetian Boundary are directly connected with the event interval which, in general agreement of the Devonian Subcommission, should be avoided by the boundary definition. Thus, the base of the conodont *Polygnathus-hemiansatus* Bultynck is found within the event interval - exactly, within its gradual end, whereas the «Boundary of the Eastern Rhenish Mountains» was originally defined more or less lithostratigraphically after the first black coloured event sediments of the Odershausen Fm. Consequently,

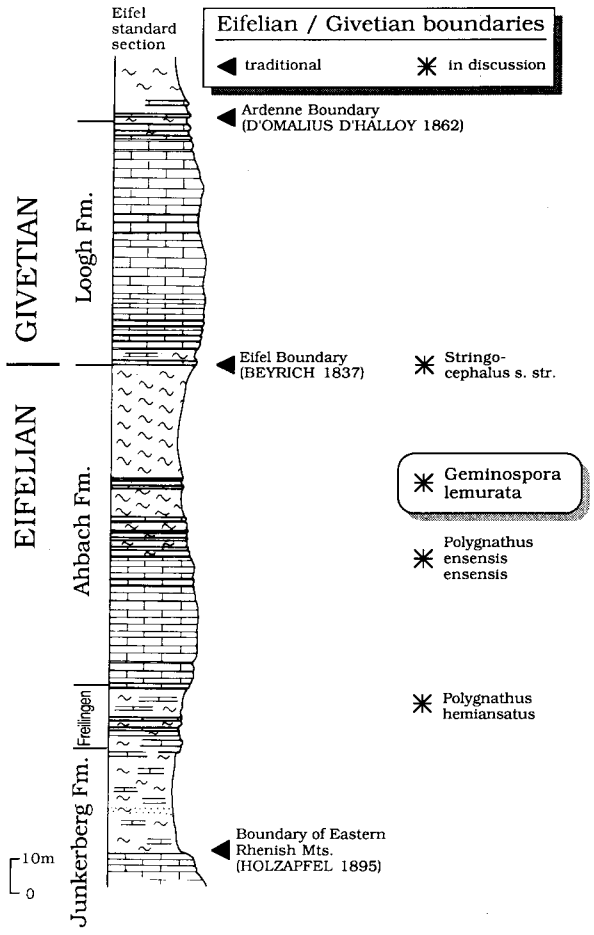


Fig. 4.- The Eifelian/Givetian boundary. The different levels of the traditional usages across the Rhenish Massif and the candidating levels being nowadays in discussion for standardized definition, all referred to the standard section of Hillesheim Syncline, Eifel.

the adjacent position of the *G. lemurata* base would argue for a preference of the «*ensensis* Boundary» from the actual palynological and conodontological viewpoint.

4.- MIOSPORE DISTRIBUTION IN THE CURTEN AND KERPEN FORMATIONS (fig. 5 and table 3)

4.1.- THE ACME OF *GEMINOSPORA LEMURATA* IN THE CURTEN FORMATION

Six samples taken from the base to the top of the Curten Formation carry also an assemblage referable to the Oppel Zone AD. The genus *Geminospora* is well represented and sometimes abundant in all samples. *G. lemurata* is present in all samples but one (table 3). Compared to the irregular distribution of this genus in the Müllert Member of the Ahbach Formation, one can assume that the Acme Zone of *G. lemurata* has

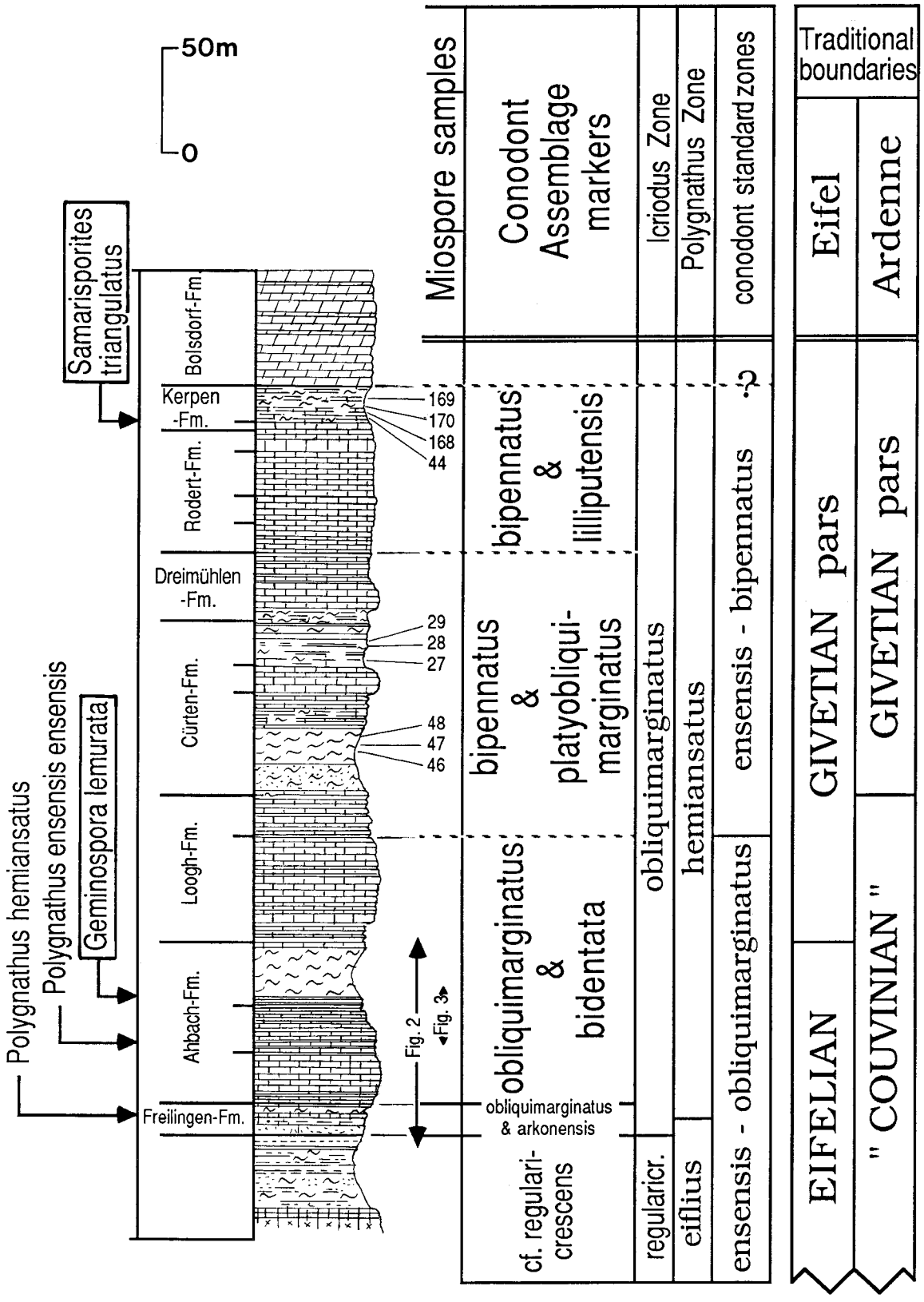
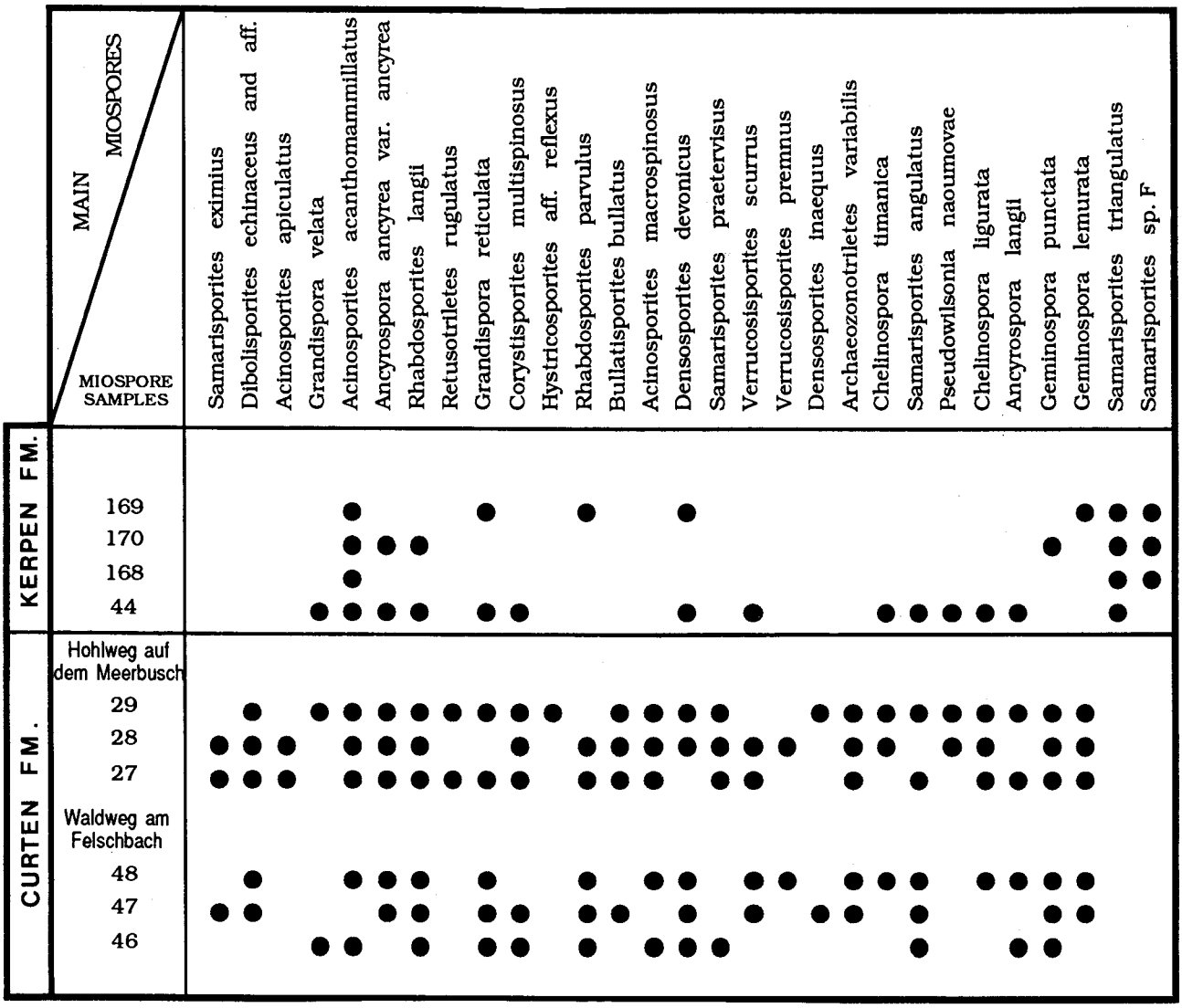


Fig. 5.- Combined sections ranging from the Eifelian to the Givetian in the Hillesheim Syncline with the main lithostratigraphic and biostratigraphic limits.

Table 3.- Repartition of the main miospores in the Curten (Nº 46, 47, 48 and 27, 28, 29) and Kerpen (Sportfield: Nº 44; Rodert Hill: 168, 170, 169) Formations.



been reached in the Curten Formation. The Curten Formation entirely belongs to the *ensensis-bipennatus* conodont standard Zone. These new data almost confirm the opinion of McGregor (1981, fig. 3) that the base of the Acme Zone of *G. lemurata* in U.S.S.R. is near the base of the *varcus* conodont standard Zone but the data of the present work are more accurately documented than those originating from U.S.S.R. and a lower limit in the *ensensis-bipennatus* is now demonstrated.

4.2.- THE *SAMARISPORITES TRIANGULATUS* LEVEL IN THE KERPEN FORMATION

Four samples taken from the Kerpen Formation carry a rather poor assemblage where several species of the AD Oppel Zone are absent but which is characterized by the entry of species of *Samarisporites* with typical radial extensions of the zona including *S. triangulatus* (table 3). The co-occurrence of *Ancyrospora ancyrea* var. *ancyrea* allows to determine the Oppel Zone TA (*triangulatus-ancyrea*) (Streel *et al.*, 1987) which is now dated, for the first time, from what is believed to be the upper part of the *ensensis-bipennatus* Zone (Weddige 1988: p. 150). *Eognathodus bipennatus* is well present in this section and its extinction was used by Bischoff & Ziegler (1957) to characterize the base of the succeeding «*varca*-Subzone». These new data are the lowest record of *S. triangulatus* in a section with faunal indices. In U.S.S.R., the first entry of *S. triangulatus* was shown near the base of the «*varcus* Zone» by McGregor (1981, fig. 3) and high in the *varcus* Zone by Richardson & McGregor (1986, fig. 6 if one excepts the record from the Boulonnais).

The single specimen published in Loboziak & Streel (1980, Pl. II, fig. 11) from the *ensensis*-Zone in the Boulonnais (Northern France) was considered later by Streel *et al.* (1987, p. 219) as an atypical specimen of *S. triangulatus* and therefore excluded from this species.

S. triangulatus stratigraphic and geographic distribution has been extensively reviewed by Allen (1982) who considers the species as a widespread and important miospore from the Givetian to the Frasnian.

Smooth forms (= *Samarisporites* Sp. *F in* Streel & Loboziak, 1987) are also present in these Kerpen samples. The joint incoming of *S. triangulatus* and smooth forms with typical radial extensions (Pl. 2) is new. *Samarisporites* sp. *F* was recorded from Frasnian beds in the Booischot borehole in Belgium (Streel & Loboziak, 1987).

5.- CONCLUSION

The successive incomings of *G. lemurata* and *S. triangulatus* are now demonstrated to occur respectively in the *ensensis-obliquimarginatus* and the *ensensis-bipennatus* conodont standard Zones. Compared to the traditional bases of the Givetian Stage, the lowest incoming is in the uppermost Eifelian (fig. 3), the highest in the basal Middle Givetian (*sensu* Struve 1988, text-fig. A 18/4). If one of the two conodont levels recently favoured for defining the boundary internationaly were selected, both incomings would occur in the Givetian.

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BIBLIOGRAPHY

ALLEN, K.C., 1982. *Samarisporites triangulatus* Allen 1965, an important Devonian miospore, and its synonymous species. *Pollen et spores,* 24 (1): 157-166.

BEYRICH, E., 1837. Beiträge zur Kenntnis der Versteinerungen des Rheinischen Uebergangsgebirge. F. Dümmler, Berlin, 1: 1-44.

BISCHOFF, G. & ZIEGLER, W., 1957. Die Conodontenchronologie des Mitteldevons und des tiefsten Oberdevons. *Abh. hess. L.-Amt Bodemforsch.,* 22: 1-136.

BRICE, D., BULTYNCK, P., COLBEAUX, J.P., LETHIERS, F., MISTIAEN, B., ROHART, J.C. & BIGEY, F., 1976. Une nouvelle coupe dans le Dévonien de Ferques. *Ann. Soc. Géol. Nord,* 96 (2) : 135-155.

BRICE, D., BULTYNCK, P., DEUNFF, J., LOBOZIAK, S. & STREEL, M., 1979. Données biostratigraphiques nouvelles sur le Givétien et le Frasnien de Ferques (Boulonnais-France). *Ann. Soc. Géol. Nord,* 98: 325-344.

BULTYNCK, P., 1985. Lower Devonian (Emsian) - Middle Devonian (Eifelian and lowermost Givetian) conodont successions from the Ma'der and the Tafilalt, southern Morocco. *In* Ziegler, W. & Werner, R. (eds.): Devonian Series Boundaries - results of world-wide studies. *Cour. Forsch.-Inst. Senckenberg,* 75: 261-286.

BULTYNCK, P., 1987. Pelagic and neritic conodont successions from the Givetian of pre-Sahara Morocco and the Ardennes. *Bull. Inst. roy. Sci. nat. Belg.,* 57: 149-181.

d'OMALIUS d'HALLOY, J.B., 1862. Abrégé de Géologie, 7e édition, Bruxelles, 626 pp.

HOLZAPFEL, E., 1895. Das Obere Mitteldevon im Rheinischen Gebirge. *Abh. preuss. geol. L.-Anst.,* N. F., 16: 1-459.

HOTZ, E.E., KRAUSEL, W. & STRUVE, W., 1955. Die Eifel-Mulden von Hillesheim und Ahrdorf. *Beih. geol. Jb.,* 17: 45-192.

LOBOZIAK, S. & STREEL, M., 1980. Miospores in Givetian to lower Frasnian sediments dated by conodonts from the Boulonnais, France. *Rev. Palaeobot. Palynol.,* 29: 285-299.

LOBOZIAK, S. & STREEL, M., 1988. Synthèse palynostratigraphique de l'intervalle Givétien-Famennien du Boulonnais (France). *In* Brice, D. (ed.): Le Dévonien de Ferques, Bas-Boulonnais (N. France). *Paléontologie-Sédimentologie-Stratigraphie-Tectonique. Biostratigraphie du Paléozoïque,* Rennes, 7 : 71-77.

MAILLIEUX, E., 1933. Roches et fossiles de la Belgique, 2e édition, Bruxelles.

McGREGOR, D.C., 1979. Spores in Devonian stratigraphical correlation. *In:* HOUSE, M.R., SCRUTTON, C.T. & BASSETT, M.G. (eds.): The Devonian System, Palaeontological Association; Special Paper, 23 : 163-184.

McGREGOR, D.C., 1981. Spores and the Middle-Upper Devonian boundary. *Rev. Palaeobot. Palynol.,* 34: 25-47.

PLAYFORD, G., 1983. The Devonian miospore genus *Geminospora* Balme 1962 : a reappraisal based upon topotypic *G. lemurata* (type species). *Mem. Assoc. Australas. Paleontol.,* 1: 311-325.

RICHARDSON, J.B. & McGREGOR, D.C., 1986. Silurian and Devonian spore zones of the Old Red Sandstone region. *Geol. Surv. Can. Bull.,* 364: 1-79.

RIEGEL, W., 1982. Palynological aspects of the Lower/Middle Devonian transition in the Eifel Region. *In* Ziegler, W. & Werner, R. (eds.): On Devonian Stratigraphy and Palaeontology of the Ardenno-Rhenish Mountains and related Devonian Matters. *Cour. Forsch.-Inst. Senckenberg,* 55: 279-292.

STREEL, M., 1986. Biostratigraphie par spores du Dévonien ardenno-rhénan. *Ann. Soc. Géol. Nord,* 105: 85-95.

STREEL, M., HIGGS, K., LOBOZIAK, S., RIEGEL, W. & STEEMANS, Ph., 1987. Spore stratigraphy and correlation with faunas and floras in the type marine Devonian of the Ardenne-Rhenish regions. *Rev. Palaeobot. Palynol.,* 50: 211-229.

STREEL, M. & LOBOZIAK, S., 1987. Nouvelle datation par miospores du Givétien-Frasnien des sédiments non marins du sondage de Booischot (Bassin de Campine, Belgique). *Bull. Soc. belge Géol.,* 96 (2): 99-106.

STRUVE, W., 1961. Zur Stratigraphie der südlichen Eifeler Kalkmulden (Devon : Emsium, Eifelium, Givetium). *Senckenbergiana lethaea,* 35: 291-346.

STRUVE, W., 1982. The Eifelian within the Devonian frame, history, boundaries, definitions. *In* Ziegler, W. & Werner, R. (eds.): On Devonian Stratigraphy and Palaeontology of the Ardenno-Rhenish Mountains and related Devonian Matters. *Cour. Forsch.-Inst. Senckenberg,* 55: 401-432.

STRUVE, W., 1988. Geologic Introduction. Main Weinberg Quarry, Hillesheim Syncline. Western part of Ahbach section, Hillesheim Syncline. *In* Ziegler, W. (ed.) : 1st International Senckenberg Conference and 5th European Conodont Symposium (ECOS V). Contributions I. part 1: Guide to Field Trips. Field Trip A: Eifel Hills. *Cour. Forsch.-Inst. Senckenberg,* 102: 88-102, 128-131, 134-140, 143-149.

TIWARI, R.S. & SCHAARSCHMIDT, F., 1975. Palynological studies in the Lower and Middle Devonian of the Prüm Syncline, Eifel (Germany). *Abh. Senckenberg Naturforsch. Ges.,* 534 : 1-129.

UYENO (unpublished. GSC. report, 1980).

WEDDIGE, K., 1977. Die Conodonten der Eifel-Stufe im Typusgebiet und in benachbarten Faziesgebieten. *Senckenbergiana lethaea,* 58: 271-419.

WEDDIGE, K., 1984. Zur Stratigraphie und Paläogeographie des Devons und Karbons von NE-Iran. *Senckenbergiana lethaea,* 65: 179-223.

WEDDIGE, K., 1988. Eifel Conodonts. *In* Ziegler, W. (ed.) : 1st International Senckenberg Conference and 5th European Conodont Symposium (ECOS V), Part 1: Guide to Field Trips. Fied Trip A: Eifel Hills. *Cour. Forsch.-Inst. Senckenberg,* 102: 103-110, 116-118, 132-133, 140-142, 150.

WEDDIGE, K., 1989. Focusing on «serrated *ensensis*» 1-2. Washington (SDS, internal report).

WEDDIGE, K. & ZIEGLER, W., 1977. Correlation of Lower/ Middle Devonian boundary beds. *Newsl. Stratigr.,* 6: 67-84.

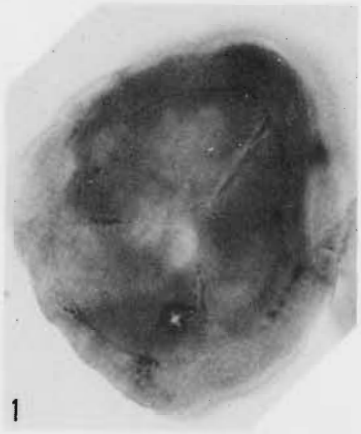
PLATE 1

Figs. 1-4 : *Geminospora punctata* Owens 1971

1-2. Müllert Mb., slide 25 (1) : O 42 /3; 1. x1000; 2. x1800.
3-4. Wotan Mb., slide 9 (1) : Q 46; 3. x1000; 4. x1800.

Figs. 5-9 : *Geminospora lemurata* Balme 1962 emend Playford 1983

5. Müllert Mb., slide 22 (3) : T 49 /1; x1000.
6-7. Müllert Mb., slide 22 (1) : T 48 /3; 6. x1000; 7. x1800.
8-9. Müllert Mb., slide 22 (2) : M 50 /4; 8. x1000; 9. x1800.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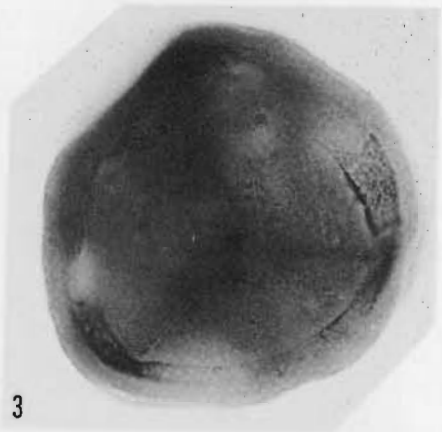
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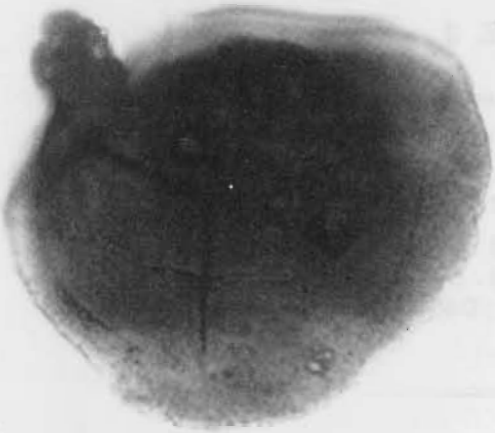
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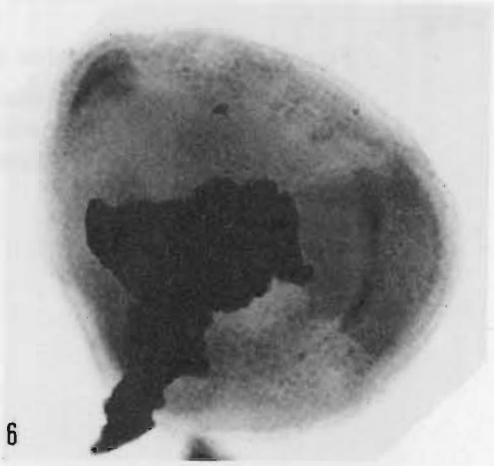
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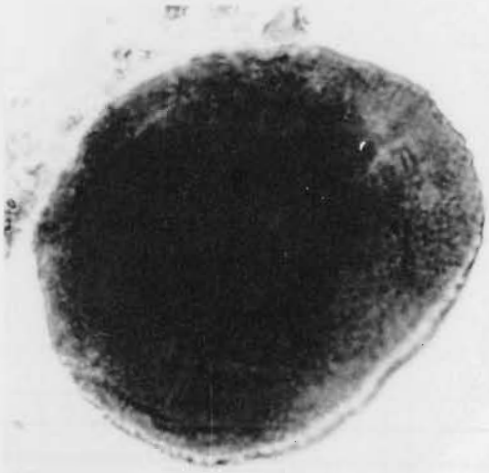
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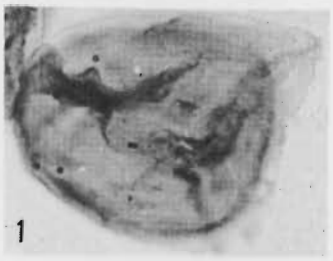
PLATE 2

Figs 1-3 : *Samarisporites* sp. *F in* Streel & Loboziak 1987
Kerpen Fm., slide 168 (2) : H 25/2; 1-2. x1000; 3. x1560.

Figs. 4-12 : *Samarisporites triangulatus* Allen 1965
4-6. Kerpen Fm., slide 168 (2) : D33; 4-5. x1000; 6. x1560.
7-9. Kerpen Fm., slide 44 (1) : E43/3; 7-8. x1000; 9. x1560.
10-12. Kerpen Fm., slide 44 (2) : D40/3; 10-11. x1000; 12. x1560.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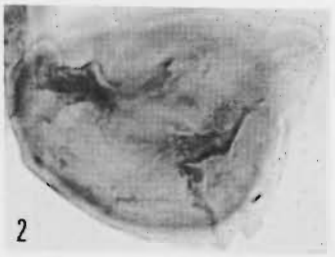
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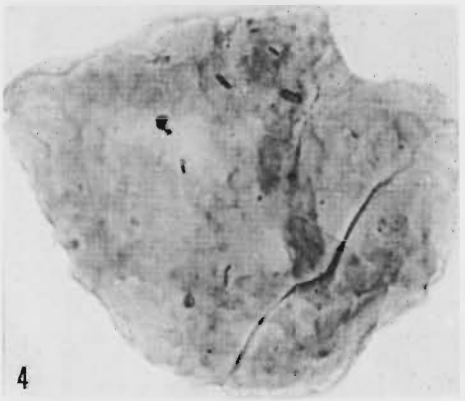
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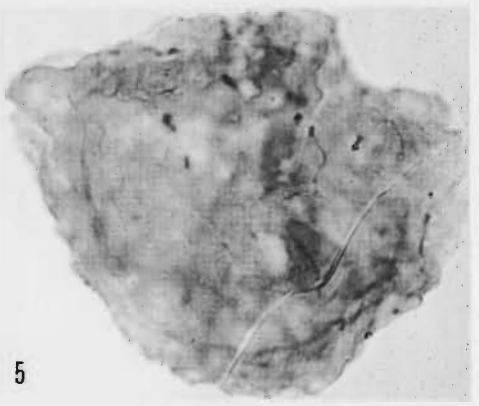
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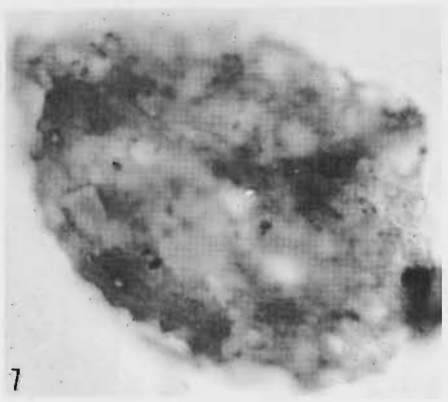
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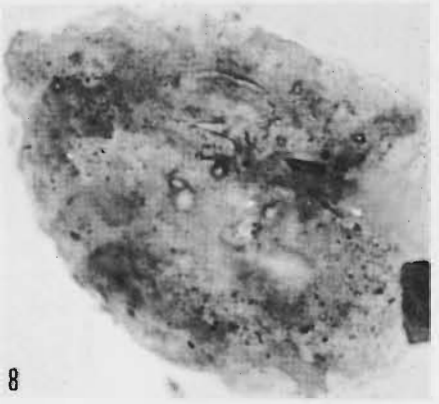
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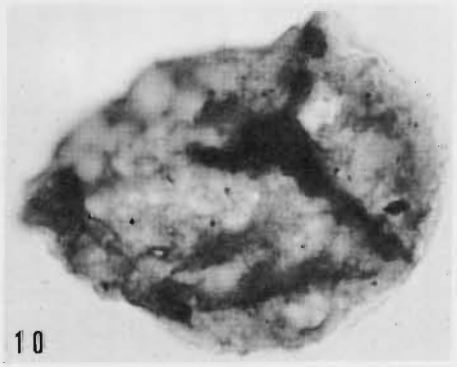
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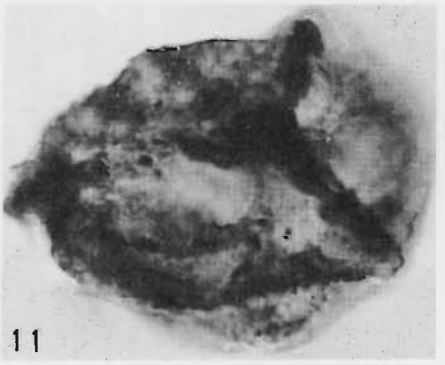
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