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BIOSTRATIGRAPHIC CHART OF THE FAMENNIAN STAGE (UPPER DEVONIAN) IN THE TYPE LOCALITIES OF BELGIUM: A PRELIMINARY REPORT

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COORDINATED AND PRESENTED BY M. C. MOUND[3]

ABSTRACT—A complete biostratigraphic chart of the Famennian stage (Upper Devonian) in the type localities in the Dinant Basin in Belgium is proposed for the first time. This preliminary report is based chiefly on conodonts and spores; the lower Famennian draws also upon the brachiopod-based zonation of Sartenaer. Information concerning the vertical ranges of the foraminifera is derived from faunas studied by Conil. The authors emphasize the vertical distribution of lithologic facies, which have been considered characteristic of the lithologic subdivisions ("*assises*") of Mourlon (1875). The following proposals are to adopt certain modifications in the stratigraphy: 1) to fix a new limit between lower and upper Famennian at a level where many biozones are observed to change. This new limit could have an interregional value inasmuch as it coincides with the *to* IIα–*to* IIβ cephalopod zones of the orthostratigraphic German scale; 2) to change previous notations to ones having chronostratigraphic value; and 3) to use the term "*assise*" now in the sense of a biostratigraphic unit with appropriate notations.

INTRODUCTION

ALTHOUGH the concept of the Belgian Famamneian has become increasingly important in biostratigraphy in recent years, a complete biostratigraphic subdivision of this stage has not been defined heretofore. Generally, Belgian geologists have agreed with the stratigraphic scale used by Mourlon (1875) and use the notation "Fm" with the subdivisions as ratified by 1929 by the Geological Council of Belgium. In this essentially lithological subdivision, only the lower part (lower Famennian) shows a biostratigraphical succession; this having been based on the evolution of the rhynchonellids (Gosselet 1888, and Sartenaer 1957, 1960).

The aim of this report is to present a first attempt in constructing a micropaleontological composite chart based on conodonts and spores in conjunction with previously published brachiopod data from the lower Famennian. New data have been provided by Sartanaer (personal communication) especially for this report. Brachiopods from the *C. letiensis*-group (see text-fig. 2) are found within the zone including *Evanescirostrum* and *Basilicorhynchus* (cf. the upper *crepida* Zone). *P. gontheri* does not extend to the top of the *P. dumonti* Zone and is transitional between *P. omaliusi* and *P. dumonti*. Though not yet validated by spores or conodonts, *C. nux nux* is believed to be equivalent to *Eopraphorhynchus triaequalis triaequalis*. This scale is intended for the entire Famennian stage; such a goal is possible because the present authors have studied and precisely determined the stratigraphy of this stage in the type localities of the Dinant Basin in Belgium. A more detailed paper dealing with local problems of stratigraphy in Belgium has been recently presented by Bouckaert, Streel, & Thorez (in press). The currently known distribution of foraminifera and algae have been added to the general chart. This latter information was provided by Conil.

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HISTORICAL REVIEW

1855.—Dumont proposed the name "Famennian System" for the lower part of his Condrusian System (1848). This meant the Dumont's Famennian exactly replaced the "Psammites du Condroz" s.l. introduced by d'Omalius d'Halloy (1839). D'Halloy's term referred to the shaly facies of middle and upper Frasnian, the shaly facies of lower Famennian, and the arenaceous facies of an upper Famennian and the "Assise d'Etroeungt" now belonging to the Tournaisian.

1860, 1880.—From this scheme, Gosselet excluded the Frasnian and proposed the following subdivisions for those shaly units which are exposed in the southern part of the Dinant Basin (especially in the northern part of France):

FAMENNIAN
- Upper
  - Schistes d'Etroeungt with *Spirifer distans* and *S. strunianus*
  - Schistes de Sains with *Camarotoechia letiensis*
- Lower
  - Schistes de Mariembourg with *Rhynchonella dumonti*
  - Schistes de Senzeilles with *R. omaliusi*

Gosselet contended that the arenaceous portions of the "Psammites du Condroz" exposed in the northern part of the Dinant Basin were equivalent to the upper part of the shaly facies in the southern area located in northern France and southwestern Belgium.

1882.—Mourlon studied in detail the "Psammites du Condroz" which he considered to be upper Famennian. The type localities are situated in the Ourthe Valley, south of Liege, in the northeastern part of the Dinant Basin. There the arenaceous facies (Psammites du Condroz) are underlain by shales. Mourlon compared these facies to those of the southern part of the Dinant Basin (Schiste de Senzeilles and Schistes de Mariembourg). Thereupon, Mourlon subdivided the upper Famennian into four lithological zones or "assises" named in descending stratigraphic sequence: Evieux, Montfort, Souverain-Pré, and Esneux.

1882.—Mourlon subsequently proposed new subdivisions and notations (Fa1, Fa2, Fa3) for the upper Famennian, but his scheme has not been followed generally by Belgian geologists (for additional details, see *Lexique Stratigraphique International,* v. I Europe, p. 174).

Mourlon allowed for some lateral variation of the arenaceous facies of the "Assise d'Esneux," but never accepted Gosselet's interpretations (1880) regarding the equivalence and synchronism of the facies between northern France and the northeastern part of the Dinant Basin (Ourthe Valley). In the type localities in the Ourthe Valley, Mourlon recognized two distinct and successive phases of sedimentation: a lower shaly phase succeeded by an arenaceous one (Psammites du Condroz"; see also Mourlon, 1895).

In the northeastern part of the Dinant Basin the two major facies are locally separated by a more or less calcareous shaly facies containing knobby limestone ("Souverain-Pré" or "Schistes d'Haversin").

1892.—Publication of a geological map of the country by the Belgian government showing the following stratigraphical sequence for the Famennian Stage:

UPPER FAMENNIAN (Fa2)	d–assise de Comblain au Pont c–assise d'Evieux b–assise de Montfort a–assise de Souverain-Pré
LOWER FAMENNIAN (Fa1)	c–assise d'Esneux b–assise de Hariembourg a–assise de Senzeilles

1900.—The "Assise de Comblain au Pont" considered in 1892 as the uppermost part of the Famennian, was dated as Tournaisian by C. Dorlodot on the basis of the Carboniferous aspect of its fossil content.

1919.—Kaisin placed the "Assise d'Exneux" and the "Assise de Souverain-Pré" in the upper Famennian with the notation Fa2a. This interpretation was adopted by Mailleux & Asselberghs (1922) and Cornet (1923). Not all geologists agreed, however, for Fourmarier

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EXPLANATION OF PLATE 93

All photographs are ×1000 and unretouched

FIGS. *1–4—Retusotriletes punctatus* Chibrikova, 1959. *1, 2,* Proximal and distal surfaces respectively in plane of focus. Bev. 55 slide 2444/419. *3,* Specimen showing slight expansions at the end of the trilete rays. Bev. 55 slide 2444/459. *4,* Specimen with fold showing the thickness of the distal exine. Bev. 38g2, slide 2431/667.

5—Punctatisporites irrasus Hacquebard, 1957. Bev. 47/8, slide 2450/591.

6—Spinozonotriletes cf. *S. tenuispinus* Hacquebard, 1957. Go. 37, slide 2393/679.

7,8—Spinozonotriletes cf. *S. uncatus* Hacquebard, 1957. *7,* Specimen showing distal ornamentation of spines. Bev. 55, slide 2444/513. *8,* Specimen showing proximal surface. Bev. 45/10, slide 2440/160.

9,10—Hymenozonotriletes microsetus Kedo, 1963. *9,* Specimen showing distal ornamentation of spines. Ch. E, slide 3549/665. *10,* Specimen showing proximal surface. Ch. B, slide 3542/418.

11,12—Archaeozonotriletes gracilis Kedo, 1957. *11,* Specimen showing thin folded proximal surface. Bev. 55, slide 2444/379. *12,* Specimen with folds showing the thickness of the distal exine. In addition, two phase contract views of the ornamentation at the equator (same specimen). Bev. 47/9, slide 2450/139.

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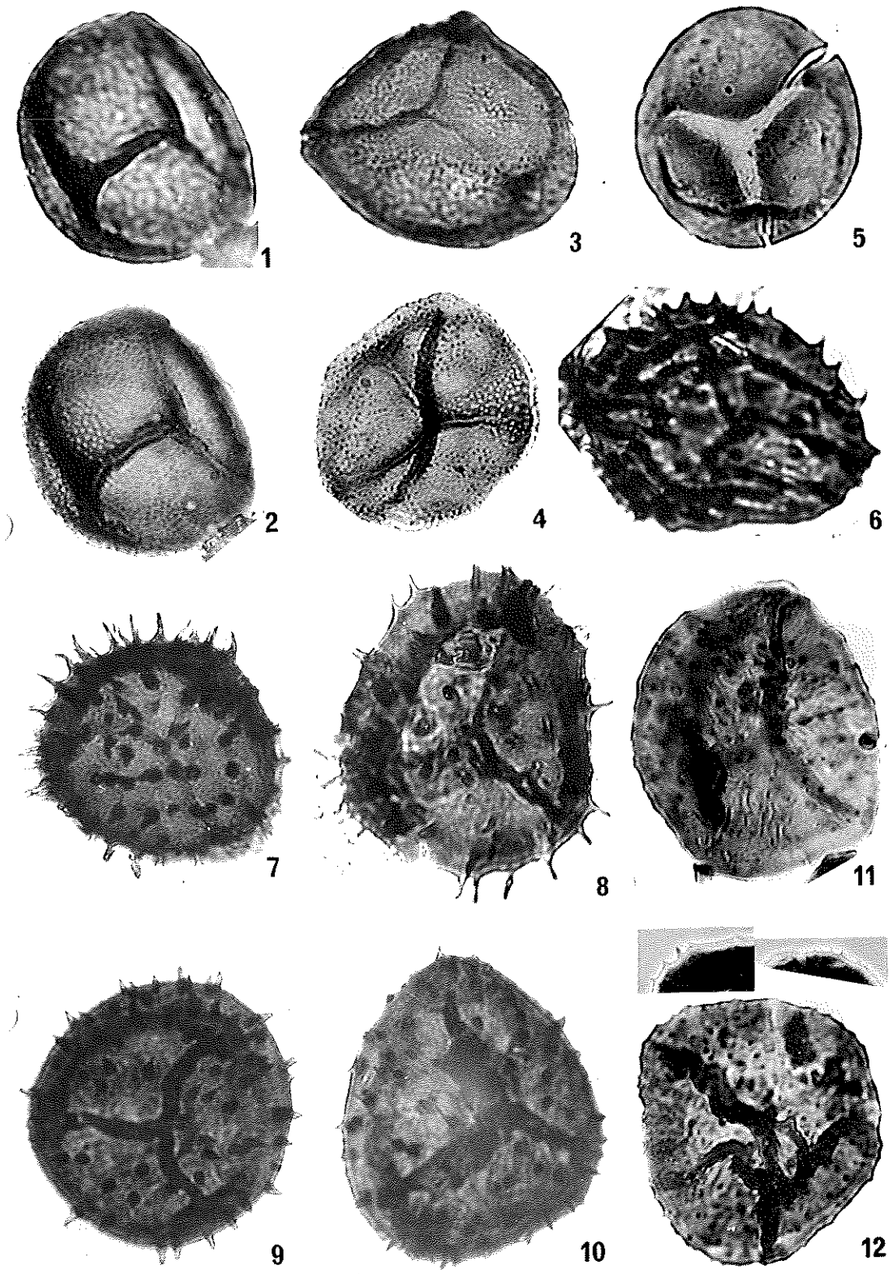

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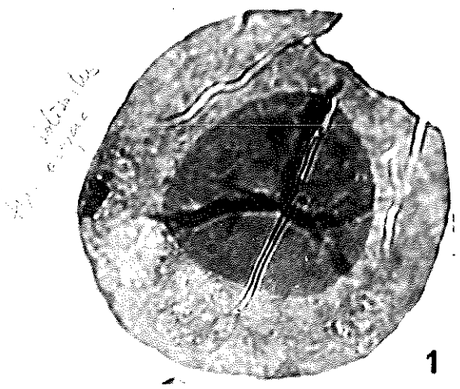
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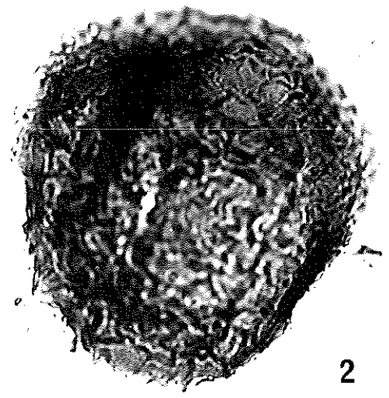
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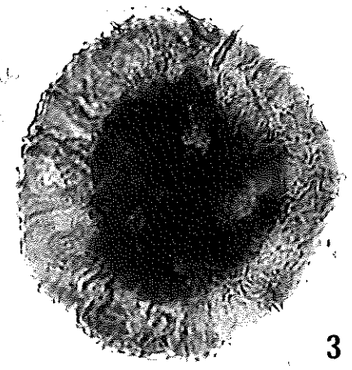
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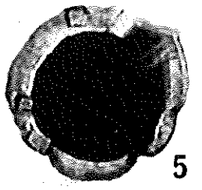
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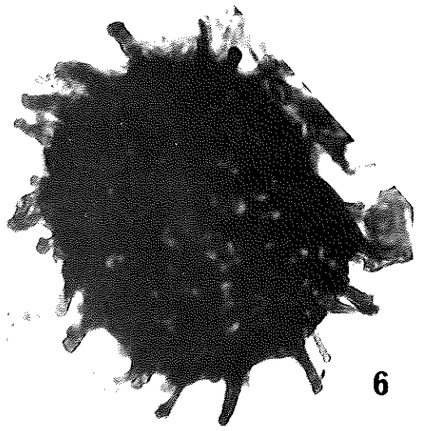
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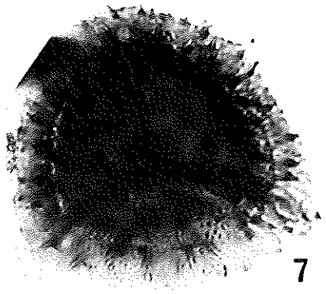
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(1934) Donnay & Ramelot (1948), and Gelliere (1954) placed both of these subdivisions within the upper part of the lower Famennian.

1929.—The classification of Mourlon's "assises" was ratified by the Belgian Geological Council. The "Assise de Souverain-Pré" was transferred from the base of the upper Famennian (its position since 1892) to the upper part of the lower Famennian. The indices were thus again changed, as, for example, the Assise d'Evieux formerly noted as Fa2c now became Fa2b. The "Assise de Comblain au Pont" was transferred simultaneously to the base of the Tournaisian.

Sequences as of 1929

UPPER FAMENNIAN
- Fa2b: Assise d'Evieux with psammites, shales, nodular limestone, "macignos"
- Fa2a: Assise de Montfort with psammites, micaceous sandstones; locally organoclastic limestones and dolomitic beds

LOWER FAMENNIAN
- Fa1b-1c: Assise de Mariembourgh: stratified psammitic beds (*cf.* assise d'Esneux) and shales; locally the so-called "macignos" of Souverain-Pré.
- Fa1b: With Shales, often violet in color.
- Fa1a: Assise de Senzeilles.

The term "macigno" is a misleading term which primarily refers to a formation in Italy. This rock name was later adopted by Cailleux (1935, Roches carbonatées de France) and means an arenaceous rock with an argillaceous and calcareous matrix. In the "Assise d'Evieux" the beds referred to "macigno" by different Belgian geologists are, in fact, arenaceous rocks with an altered dolomitic matrix. One of us (Thorez, 1963) demonstrated petrographically that dolomitic beds occur very frequently in the upper Famennian, as "macigno" but also in the form of shales, which had been previously confused with true shales. He considered this dolomite to be physicochemical in origin (on the basis of petrographical, structural and textural characteristics) which was deposited in a lagoonal or restricted environment.

Organoclastic limestones are rarely mentioned in the upper Famennian beds. Such lithologies occur in the marine part of the upper Famennian and contain typically marine faunas (southern part of the Ourthe Valley and Meuse Valley: Thorex *in* Bouckaert & Ziegler, 1965; Bouckaert, Conil & Thorez, 1967).

The macigno in the Assise de Souverain-Pré is, in fact, largely a knobby organoclastic limestone. The calcareous part of the rock is rich in marine organisms (Thorez, 1963). This knobby facies has been considered as an intraformational conglomerate by Belliere (1951).

1952.—The "Fa" notation is proposed to be changed to "Fm"; some authors continue to use "Fa."

1957.—Sartenaer, in detailing the Rhynchonellid succession, proposed a more complete subdivision of the lower Famennian in the Dinant Basin.

1965.—Bouckaert & Ziegler tentatively subdivided the entire Famennian into twelve conodont zones. For the first time it became evident that the lowest part of the "Psammites du Condroz" (sensu Mourlon) in the Ourthe Valley could be correlated with the upper part of the shaly facies from the southern sections. Use of these conodont zones amply demonstrated that some of the arenaceous deposits were time equivalents of the shales, thus restating the ear-

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EXPLANATION OF PLATE 94

All photographs are ×1000 and unretouched

FIG. *1*—cf. *Auroraspora solisortus* Hoffmeister, Staplin & Malloy, 1955. Bev. 49/10, slide 2457/718.
2—*Perotrilites* cf. *P. perinatus* Hughes & Playford, 1961. Bev. 46/3, slide 2454/226.
3—*Hymenozonotriletes versabilis* Kedo, 1957. Bev. 49/10, slide 2457/449.
4—*Endosporites* gr. *minutus* Hoffmeister, Staplin & Malloy, 1955. Bev. 55, slide 2444/175.
5—id. Svp 1, slide 2446/344.
6—*Raistrickia* sp. Neves & Dolby, 1967. PCh. 9, slide 2596/265.
7—*Hymenozonotriletes pusillites* Kedo, 1957. Tn 316, slide 1207/425.

lier conjectures of Gosselet (1888) and Leriche (1931). The chief contribution of this paper, however, was to implement international correlation.

1965.—Beugnies considered the "Assise de Souverain-Pré" as a characteristic level between the upper and lower portions of the Famennian Stage. This view was based on rhynchonellid zonations and, in part, on conodont data derived from spot samples. The author applied the notation "Fm2a," thereby considering this level as representing the base of the Upper Famennian.

RESULTS OF NEW INVESTIGATIONS AND DISCUSSION

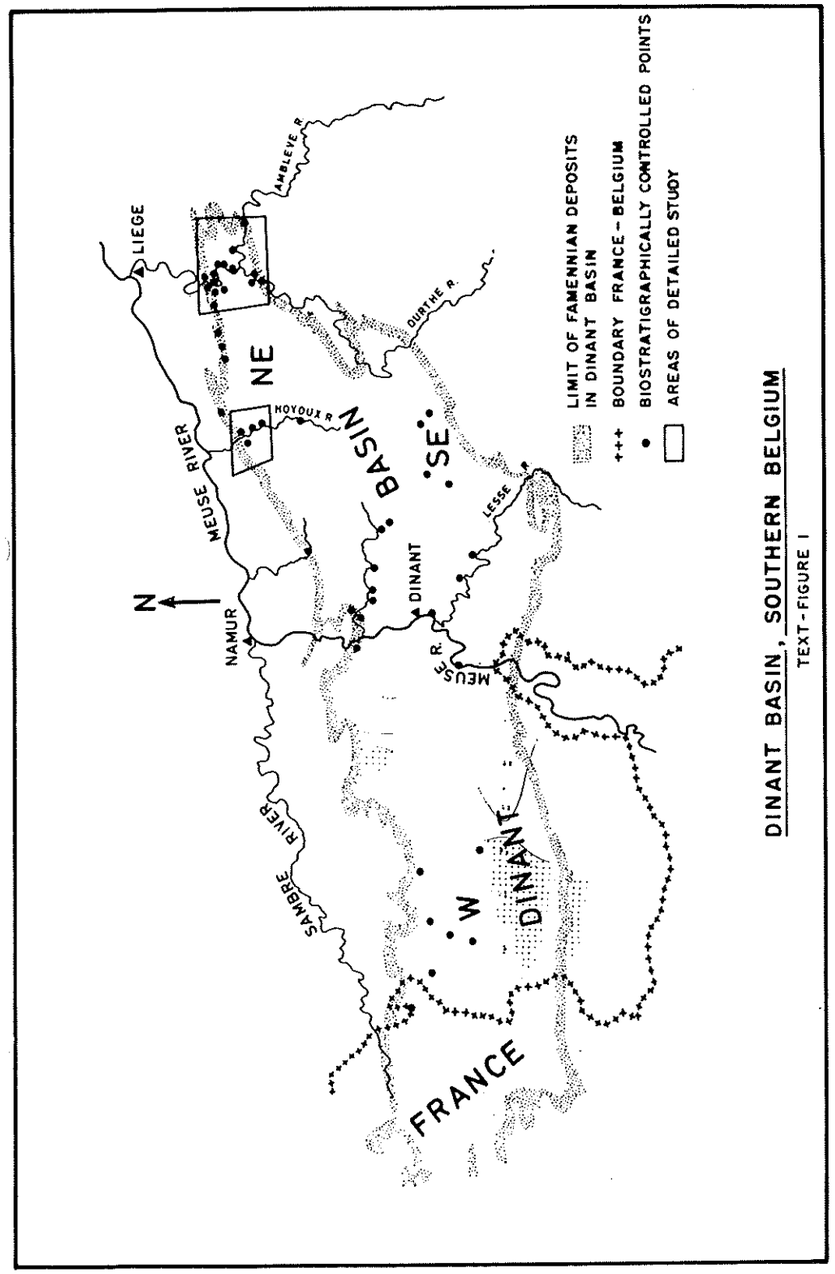
Discussion of the important questions of the Frasnian–Famennian and Famennian–Tournaisian boundaries is beyond the intent and scope of this preliminary study.

The results present in this preliminary report and work in progress are based on a detailed study of different sections and boreholes which together essentially cover all of the Dinant Basin of Belgium. The type sections of the upper Famennian situated in the Ourthe Valley were studied in particular detail. By investigating the three main regions of the Dinant Basin (text-fig. 1), we felt relatively certain that we would have a complete overview of the various facies comprising the Famennian. Detailed lithological studies have been made; sedimentological work is still in progress; and systematic petrographical analyses have been conducted on the different sections.

Conil (1964) identified the *Siphonodella* zone in Belgium, thereby establishing for the first time that the base of the Carboniferous System of the German standard section was to be found in Belgium in the lower part of the *Tn*1b (Assise de Hastière). Bouckaert & Ziegler (1965) located the *costatus* zone in beds presumed to be of lower *Tn*1 age by Conil (1964) but in a facies devoid of any characteristic foraminifera. Streel (1966), incorporating these data in a biostratigraphic study of the spores of the Comblain-au-pont stratotype, dated these beds with *costatus* zone as *Tn*1a (see text-fig. 2). For regional purposes, this author proposed four biozones based on a biometric study of *Hymenozonotriletes lepidophytus* Kedo and traced the boundary between the Famennian and Tournaisian through several geographically separated sections in Belgium. Streel (in press) has also found the *Lepidophytus* zone in the Hangenberg shales of Germany which underlie the Hangenberg limestone (*cu*1) in the Hönnetal (stratotype for the goniatite orthochronological scale). Thus, both conodonts and spores give a precise correlation between the northeastern Dinant Basin and Sauerland. The base of the Carboniferous system (*sensu* Heerlen, 1935) is located near the base of *Tn*1b (Hastière limestone).

It must be pointed out, however, that the correlations between the Comblain-au-pont and Etroeungt stratotypes in northern France have not been defined on conodont and spore data as yet, but are being studied currently. We have also not attempted to correlate the Comblain-au-pont with the base of the Tournaisian at Tournai in this paper. In the three aforementioned prospected regions (text-fig. 1) we have adopted that boundary between the Tournaisian and Famennian proposed by Conil, Pirlet & Lys (1967). Bouckaert & Ziegler (1965) and Bouckaert & Thorez (1966), in the course of working with the Senzeilles stratotype, discussed the problem of the Frasnian–Famennian Boundary and its equivalent in the German succession. The oldest conodonts found in the lower part of the lower Famennian shales with *Camarotoechia lecomptei* indicate a middle-*triangularis* age (*to* 1 δ?). In Germany, this zone is just below the *Manticoceras-Cheiloceras* Stufe. boundary. The conodont distribution in the upper Frasnian stratotype (Matagne Shales) at the type locality of Frasnes should be considered in defining the Frasnian–Famennian boundary. In this preliminary report, it was decided to conserve the limit defined by Sartenaer (1960).

The results of a very detailed sedimentological and paleogeographical study of the upper Famennian in the Dinant Basin is still in progress and will be presented eventually by one of us (Thorez). We feel, however, that it is now possible, based on several lines of biostratigraphic criteria, to demonstrate that some of the generally-used limits in the upper Famennian may be diachronous. This phenomenon is present in some previously-described type locality-sections, particularly those in the Ourthe Valley (Bouckaert, Streel & Thorez, in press). Consequently, in this later work, the boundary between Montfort and Evieux-beds is now proposed to be placed at the top of the Montfo: Formation (facies) at the locality of Montfort. As a result, the old Montfort–Evieux limit and the lower part of Evieux at the locality of Evieux now belong to a biostratigraphical zone which is restricted to the Montfort beds *at Montfort*. In this sense, the diachronous nature of the boundary between the two formations is indicated (text-fig. 2, column 1b) by the oblique line as contrasted with the biostratigraphical horizontal limit here proposed. For the same



TEXT-FIG. 1—Dinant Basin, southern Belgium.

reasons, the base of the Montfort Formation is similarly obliquely drawn, inasmuch as it appears that this limit is also dischronous through different sections in the Ourthe Valley. This boundary was fixed by Mourlon (1875) at the top of a knobby limestone, but in the western region of the Dinant Basin (area of Silenrieux), the top of this knobby limestone contains *Polygnathus styriaca* and a characteristic spore assemblage which satisfactorily serve to typify the top of the Montfort facies in the proposed new type-locality. The *styriaca* zone, however, was not found in the eastern region; this may have been due to environmental conditions.

According to the evidence at hand, *Camarotoechia letiensis* occurs at the same level as the *rhomboidea* zone (where the calcareous facies is present) and we may assume that Esneux arenaceous facies could be the same age as some of the knobby limestones of the NE region or the shales of the SE region (=Souverain-Pré).

Thus far, there does not appear to be sufficient reason to alter the biostratigraphical schema based on brachiopods formerly proposed for the lower Famennian, despite the fact that conodont biostratigraphy here provides an alternative zonation which is both detailed and demonstrably dependable.

CONCLUSIONS

The biostratigraphic chart (text-fig. 2) shows the lower–upper Famennian boundary coinciding with the top of the Mariembourg Formation and provides a sufficiently distinct means of tracing the boundary between lower and upper Famennian. This limit is not only well traced from the biostratigraphical point of view but is also in agreement with the major change in lithological aspect in a large part of the Dinant Basin (NE area, Bock Valley, in the central part of the basin) from the shaly facies into the arenaceous facies, locally underlain by a calcareous formation (*cf.* Souverain–Pré).

This important break is proposed as the boundary between the lower and upper Famennian, in lieu of maintaining that of Mourlon (1875; see column 1a). This practice should simplify interregional correlations because this limit corresponds to the major *to*IIα–*to*IIβ boundary of the German standard. Souverain-Pré and Esneux are transferred, therefore, into the upper Famennian and receive the new notation "*Fa2a*." The authors restrict the "Fa2d" notation to those beds considered by Conil (1964) as intermediate layers (*Tn*1aα & β) between Evieux ss. and Comblain-au-pont (*Tn*1a γ).

DISCUSSION OF BIOSTRATIGRAPHIC CHART (Text-figure 2)

1. All the horizontal solid lines correspond t the limit between successive biozones. Horizon tal dashed lines do not delimit biostratigraphi zones.

2. Vertical fully-traced lines denote strati graphic ranges of fossils.

3. Spores are noted by qualitative and quanti tative vertical distribution.

SPORE TAXONOMY AND DISTRIBUTION

Complete descriptions of spores are planned for a forthcoming bulletin of the Geological So ciety of Belgium. Plates 93 and 94 depict mos of the characteristic species mentioned herein.

1. *Punctatisporites irrasus* Hacquebard, 195 (pl. 93, fig. 5). See also Streel, 1966, Pl. II, fig 26.

2. *Archaeozonotriletes gracilis* Kedo, 195 (pl. 93, figs. 11, 12). See also Streel, in pres pl. 1, fig. 26.

3. *Retusotriletes punctatus* Chibrikova, 195 (pl. 93, figs. 1–4). Trends to *Crassispora bc teata* Sullivan in highest horizons: See Stre 1966, pl. II, figs. 24 and 25.

4. *Spinozonotriletes* cf. *tenuispinus* Hacqu bard, 1957 (pl. 93, fig. 6). See also Streel, press, pl. I, fig. 13.

5. *Perotriletes* cf. *perinatus* Hughes & Pla ford, 1961 (pl. 94, fig. 2).

6. *Hymenozonotriletes versabilis* Kedo, 19 (pl. 94, fig. 3).

7. Cf. *Acanthotriletes hirtus* Naumova, 1953

8. Cf. *Auroraspora solisortus* Hoffmeist Staplin & Malloy, 1955 (pl. 94, fig. 1).

9. *Endospirites* gr. *minutus* Hoffmeist Staplin & Malloy, 1955 (pl. 94, fig. 4).

10. *Idem,* but higher value for ratio :cent body diameter-total diameter. (pl. 94, fig. 5).

11. *Archaeozonotriletes famenensis* Naumo 1953.

12. *Hymenozonotriletes microsetus* Ke 1963 (pl. 93, figs. 9, 10).

13. *Spinozonotriletes* cf. *uncatus* Hacqueba 1957 (pl. 93, figs. 7, 8). See also Streel, 1966, II, fig. 27 and work in press, pl. I, fig. 7.

14. *Raistrickia* sp. Neves & Dolby, 1967, pl fig. 4, (pl. 94, fig. 6).

15. *Hymenozonotriletes pusillites* Kedo, 19 (pl. 94, fig. 7).

16. *Hymenozontriletes lepidophytus* Ke 1957, var. typ. See Streel in press, pl. I, fig and 1966, pl. I, figs. 5, 6.

17. *Hymenozonotriletes lepidophytus* v *minor* Kedo, 1963. See Streel 1966, pl. I f 1–3, 7–11, and work in press, pl. I, fig. 5).

18. *Lophozonotriletes raritubercalatus* (Luber, 1941) Kedo, 1957.

19. *Hymenozonotriletes explanatus* (Luber, 1941) Kedo, 1963. See Streel in press, pl. I, fig. 1.

20. *Dictyotriletes trivialis* Naumova *in* Kedo, 1963.

The purpose of this spore distribution chart is twofold:

1. To show the stratigraphic range in well-dated marine sediments of some species originally from other areas. In this respect, each species of the *Spinozonotriletes* types of construction occurring in successive levels as shown by the scale (including forms 2, 11 and 12), seems to have stratigraphic significance and probably reflects some generic evolutionary trends. Such species could provide a sound basis for interregional correlations when taken together with the later-occurring characteristic forms (*Raistrickia* sp., *Hymenozonotriletes pusillites, H. lepidophytus, H. explanatus* and *Dictyotriletes trivialis*).

2. To illustrate the nature of the quantitative data which have allowed precise correlations within the limits of the Dinant Basin (Bouckaert, Streel & Thorez, in press). Semiquantitative data are here provided for this purpose; frequency 100% (present in all samples) but not abundant; abundant (more than 2%); and very abundant (more than 10%). First occurrence (in the evolutionary sense) and extinction of species are considered to be criteria of lesser value. The species mentioned on the chart were selected for their apparent lack of facies restriction in complete *continuous marine successions*. More than 100 species of spores are recorded in the Famennian of Belgium and will be fully described in the future.

We must stress here that some of the stratigraphic ranges of species recorded in Streel (in press) are now out of date as this latter manuscript was submitted for the Second International Conference on Palynology held in Utrecht in 1966.

Specimens illustrated on plates 93 and 94 are deposited in the Université de Liège: Laboratoire de Paléontologie Végétale. Slide designations are locality abbreviations as follows:

Bev. = Beveries Quarry, Ourthe Valley
Go. = LaGombe Quarry, Ourthe Valley
Ch. = Chera Quarry, Amblive Valley
Tn. = Tournai Borehole, Dinant Basin
Pch. = Quarry in the vicinity of Poulseur.

LITHOLOGY

1. Classical stratigraphy (columns Ia and Ib) is compared to the new interpretation of the distribution of taxa. Column Ia refers to the two main classical subdivisions of general interest: the Lower and Upper Famennian. Column Ib defines the position of the Famennian stage in different "assises" (*sensu* Mourlon), in a lithologic sense (*cf.* formation or facies).

Column 4 represents three compiled lithological sections: thickness is not to scale. The NE area refers to the Ourthe Valley (Evieux, Souverain-Pré, Montfort, Richopre, Chanxhe, Rivage-quarry and station, Comblain-au-pont, Comblain-au-Tour). Spot samples have been studied in other quarries and outcrops near the general Ourthe Valley locality. Detailed studies were made also in the Hoyaux Valley and in the valley of the Bock (Crupet, Durnal, Spontin, Ciney,Yvoir). SE area refers to Marche-en-Famenne, Sinsin, Houyet and to the locality of Gendron-Celles, Villers sur Lesse and Haversin. The W area is located in Silenrieux, Beaumont, Senzeilles (text-fig. 1).

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