"Palaeozoic Palynology in the Third Millenium: new directions in acritarch, chitinozoan and miospore research"

Commission Internationale de Microflore du Paléozïque (CIMP)

Guide-Book

Second day

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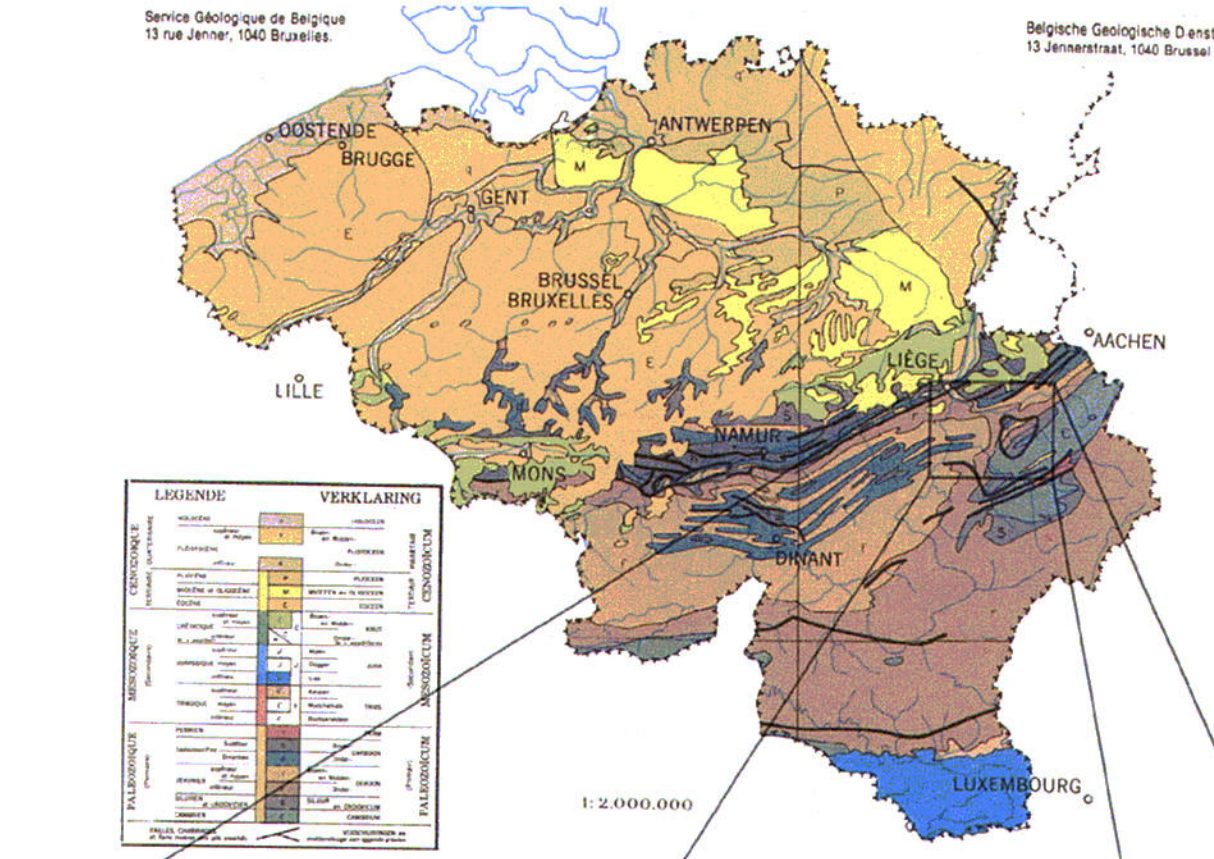
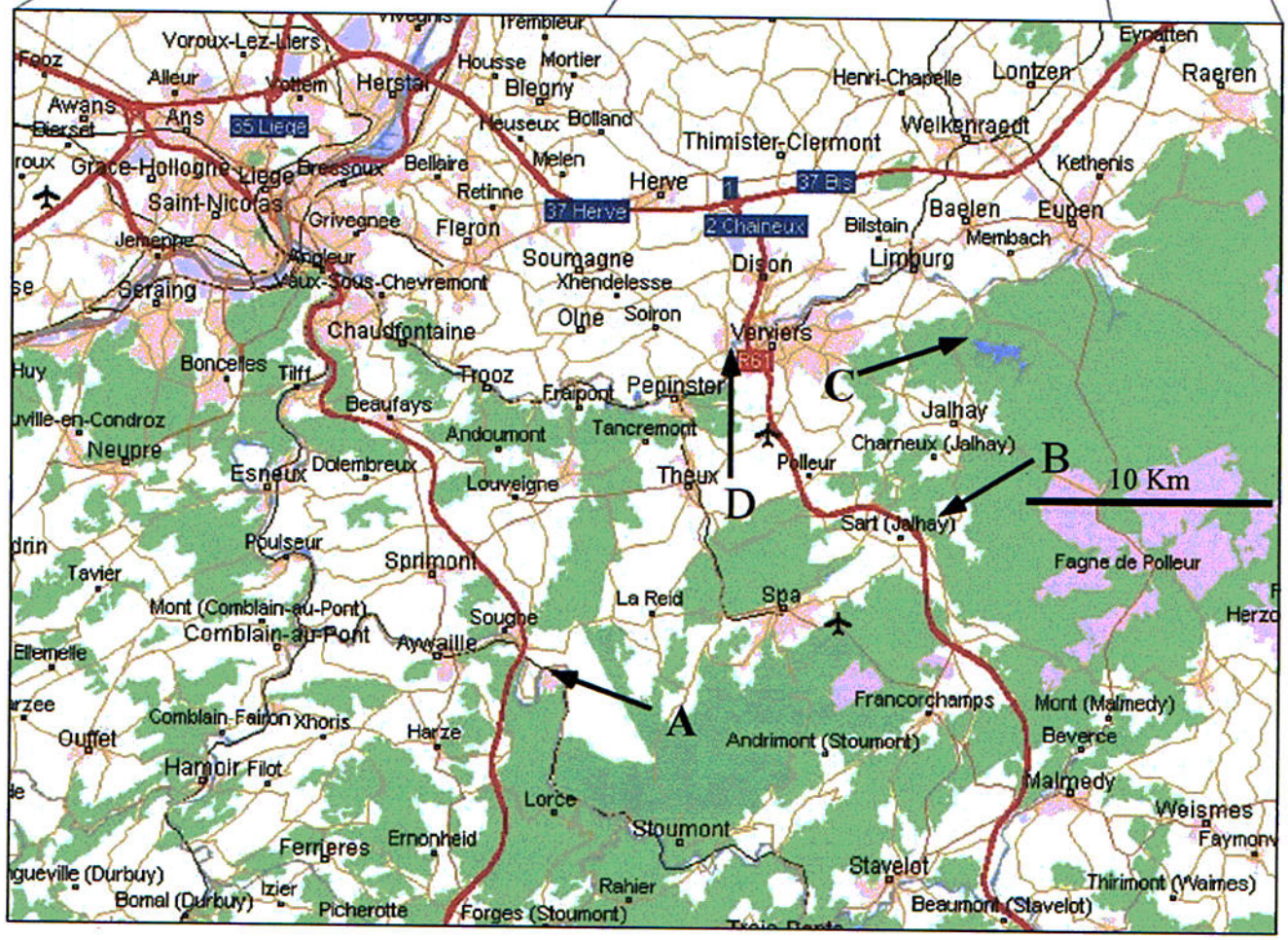
Geology, Palaeobotany and Palynology of the North-eastearn part of the Ardenne, Belgium

P. Steemans
M. Vanguestaine
P. Gerrienne

University of Liège - Paleobotany, Paleopalynology & Micropaleontology (PPM)
Allée du 6 Août, Bât. B-18, parking 40
B - 4000 Liège 1 BELGIUM
FAX : 00 32 (0)4 366 53 38
EMail: P.Gerrienne@ulg.ac.be, P.Steemans@ulg.ac.be, M.Vanguestaine@ulg.ac.be
http://paleolink.geolo.ulg.ac.be/



Belgium geological map



Localisation of the outcrops

A - Stop 1 - Nonceveux

B - Stop 2 - Solwaster

C - Stop 3 - Gilenne

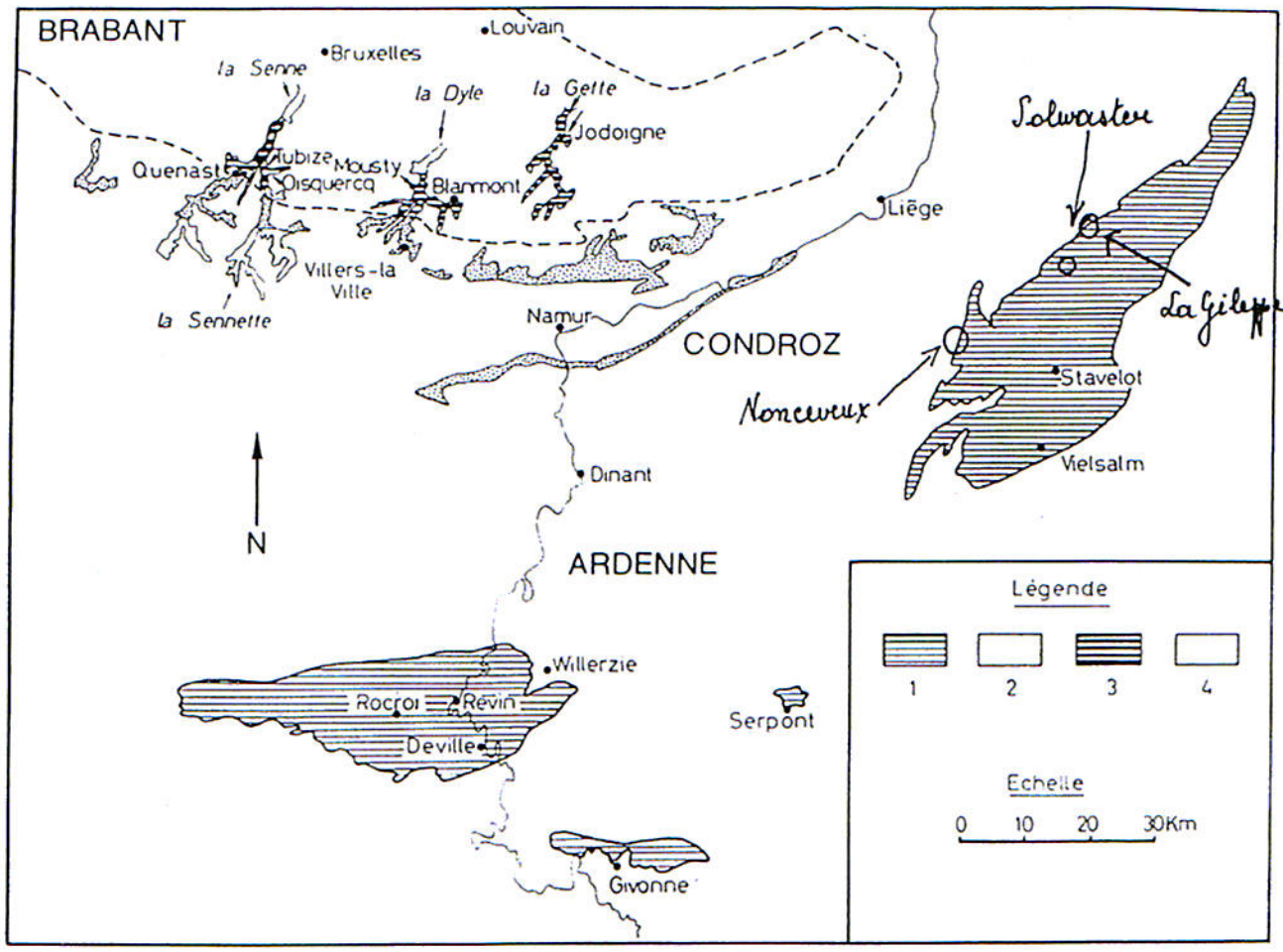


Fig. 1.- Localisation des affleurements de Paléozoique Inférieur en Belgique et les régions limitrophes (d'après Beugnies *et al.*, 1976, modifié).

Légende: 1. Cambro-Ordovicien de l'Ardenne (Ordovicien non démontré dans les Massifs de Givonne et de Serpont); 2. Siluro-Ordovicien du Condroz et du Brabant; 3. Cambrien supposé, partiellement démontré, du Brabant; 4. post-Silurien. La ligne en tirets discontinus indique la limite du Cambrien dans le Massif du Brabant sous la couverture méso- et cénozoique.

Vanguestaine, 1992
Annales Société Géologique de Belgique

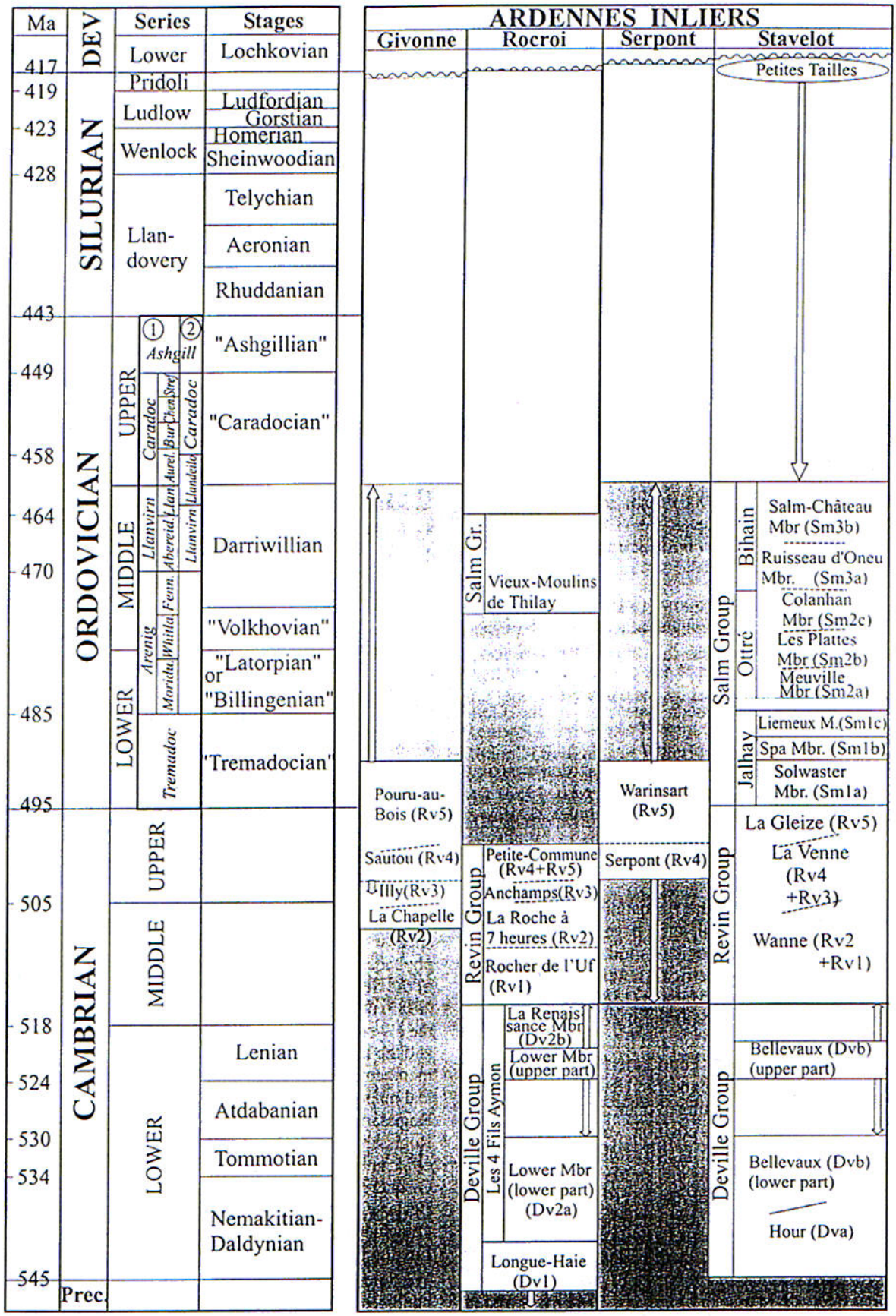


Figure 6. Chronostratigraphical position of the Lower Palaeozoic lithostratigraphic units in the Ardennes inliers (detail of fig. 3).

Verniers et al., 2002
Geologica Belgica 4

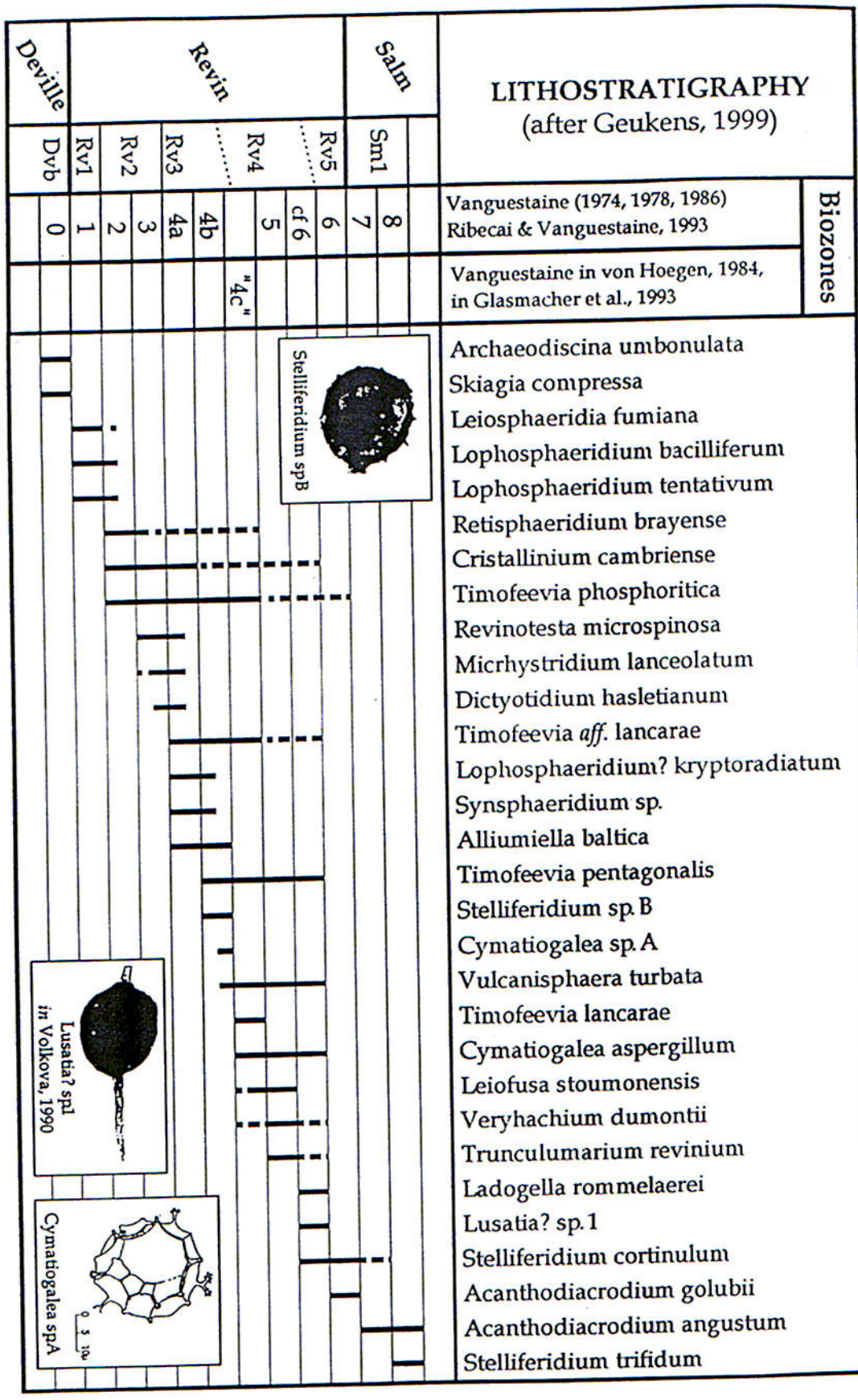


Abb. 9: Auswahl diagnostischer Acritarchen aus der Stavelot-Venn-Antiklinale.

Riblert, Servais and Vanguestaine, 2002
Courier Forschungsinstitut Senckenberg 235

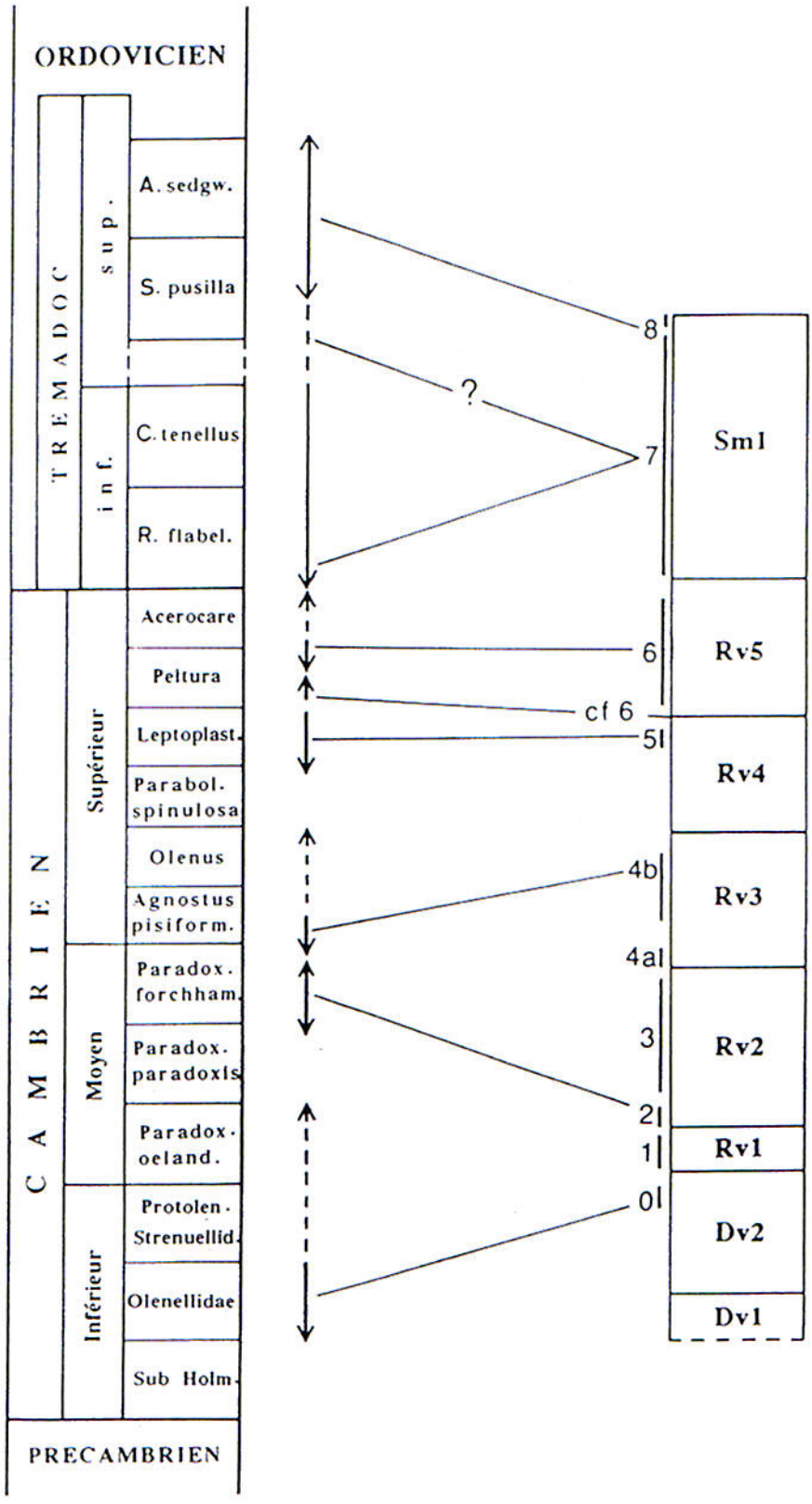


Fig. 6.- Datation des groupes de Deville, de Revin et de la Salm d'après Vanguestaine, ce travail (zone 0), Martin & Dean, 1988, Ribecai & Vanguestaine, 1992 (zone 2, 4b, 5 et 6), Rasul, 1979, Molyneux & Rushton, 1988 (zones 7 et 8). La zone dénommée cf6, correspond à un niveau de Hockay, Vanguestaine *in* Bless & Felder, 1989, que nous corrélons avec la zone de même nom dans le Massif de Rocroi (Meilliez & Vanguestaine, 1983; Vanguestaine, 1986).

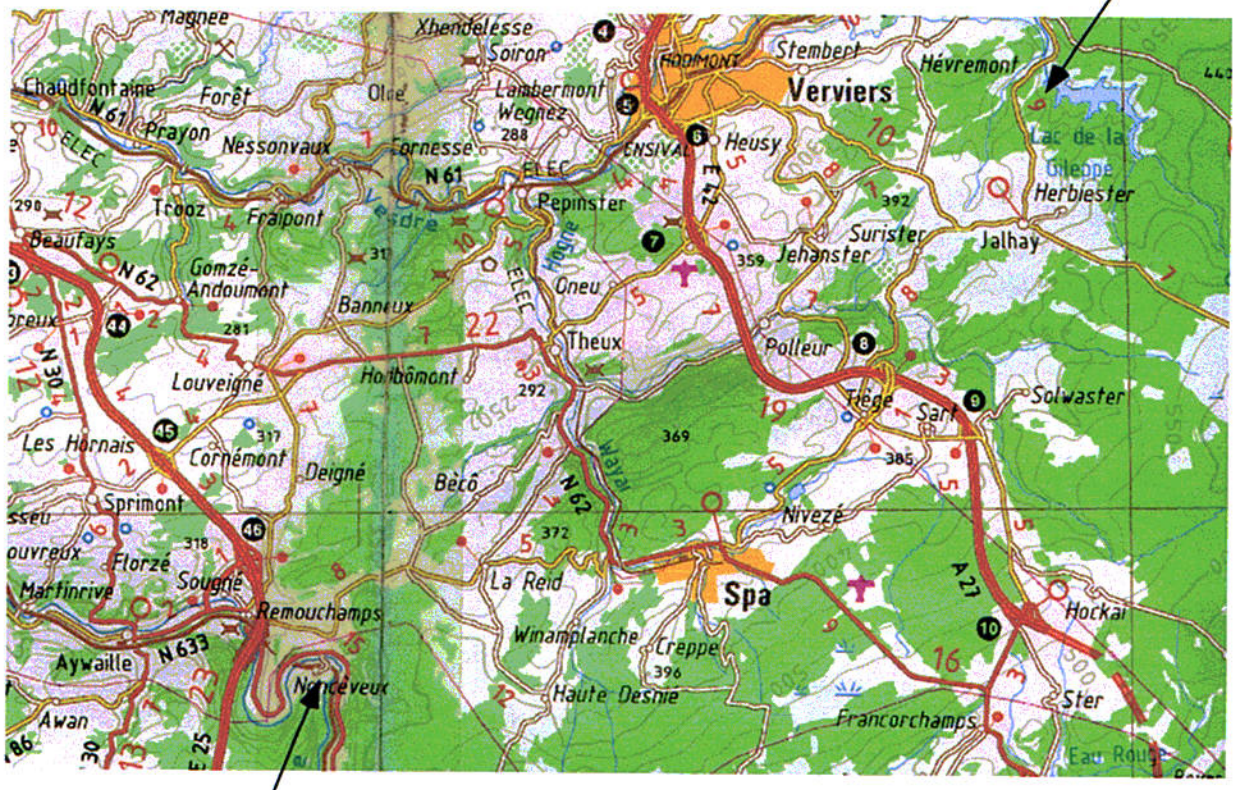
Vanguestaine, 1992
Annales Société Géologique Belgique

Part II

The Lower Devonian in the Northeastern part of the Ardenne

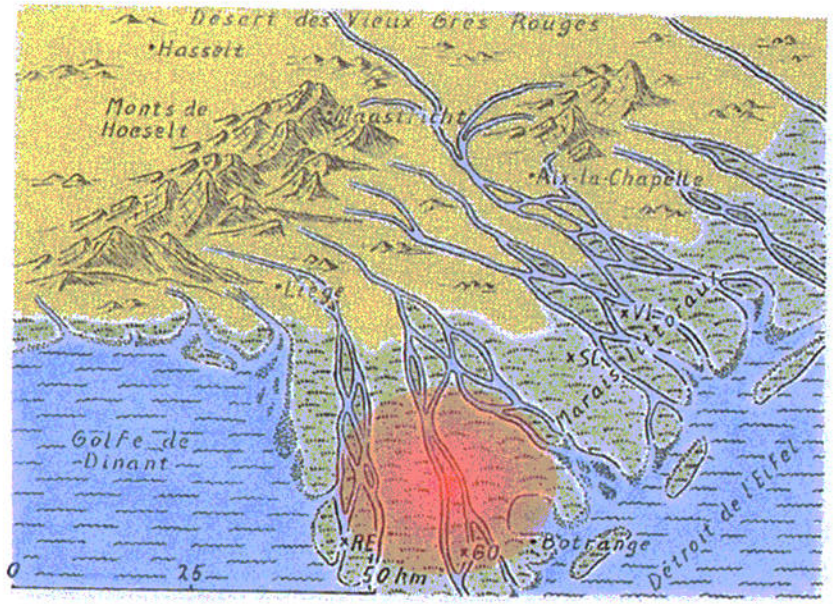
Stop 1 (Nonceveux) and stop 3 (Gileppe)

Gileppe

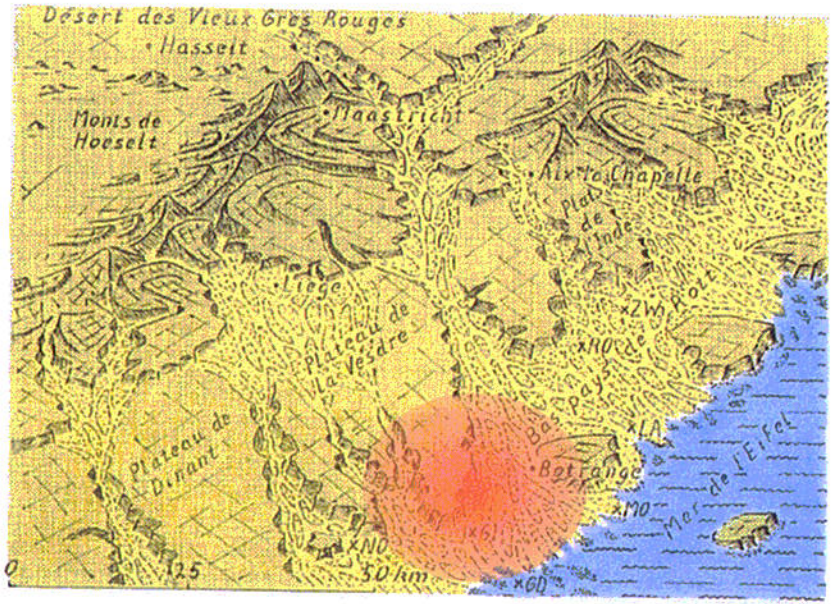


Nonceveux

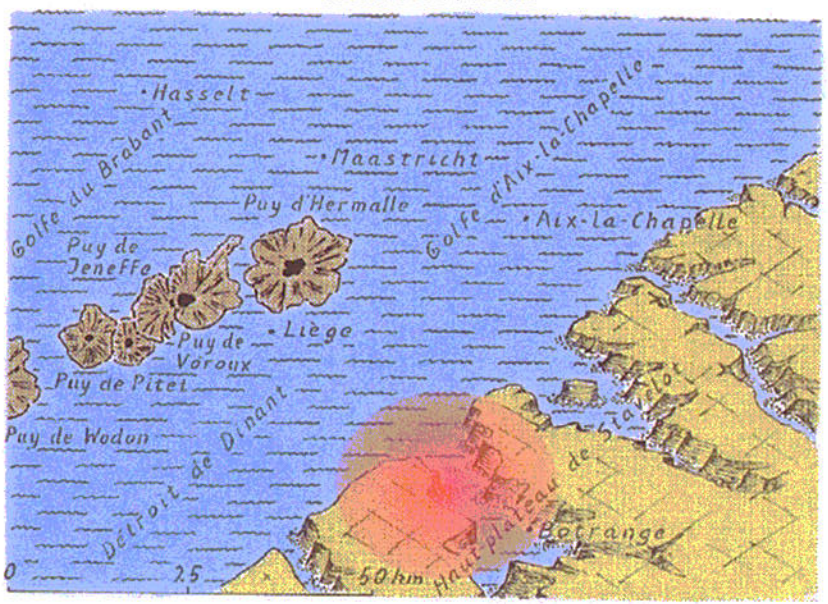
Fig.1: Localisation of the outcrops in the Lower Devonian



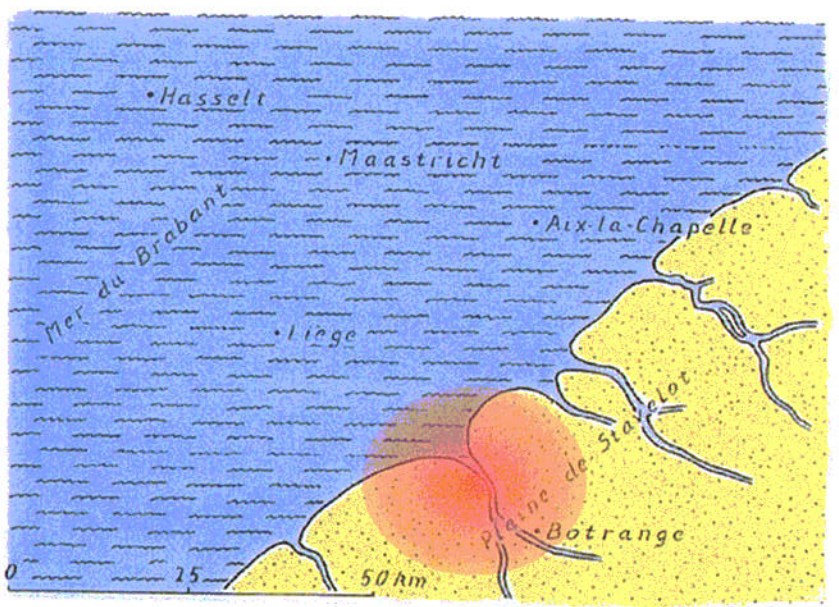
Middle Devonian



Lower Devonian



Early Silurian



Late Ordovician

Fig.2:
Paleogeographic reconstruction of the visited areas (Bless & Fernandez Narvaiza, 2000)

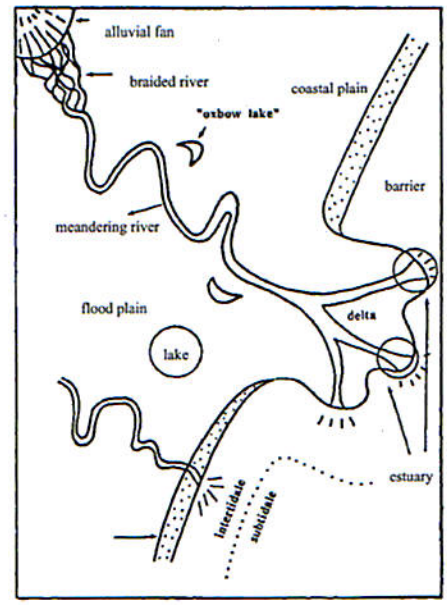


Fig. 3:
Sedimentary environment observed in the Lower Devonian from Nonceveux and Gileppe (after Goemare et al. 1993)

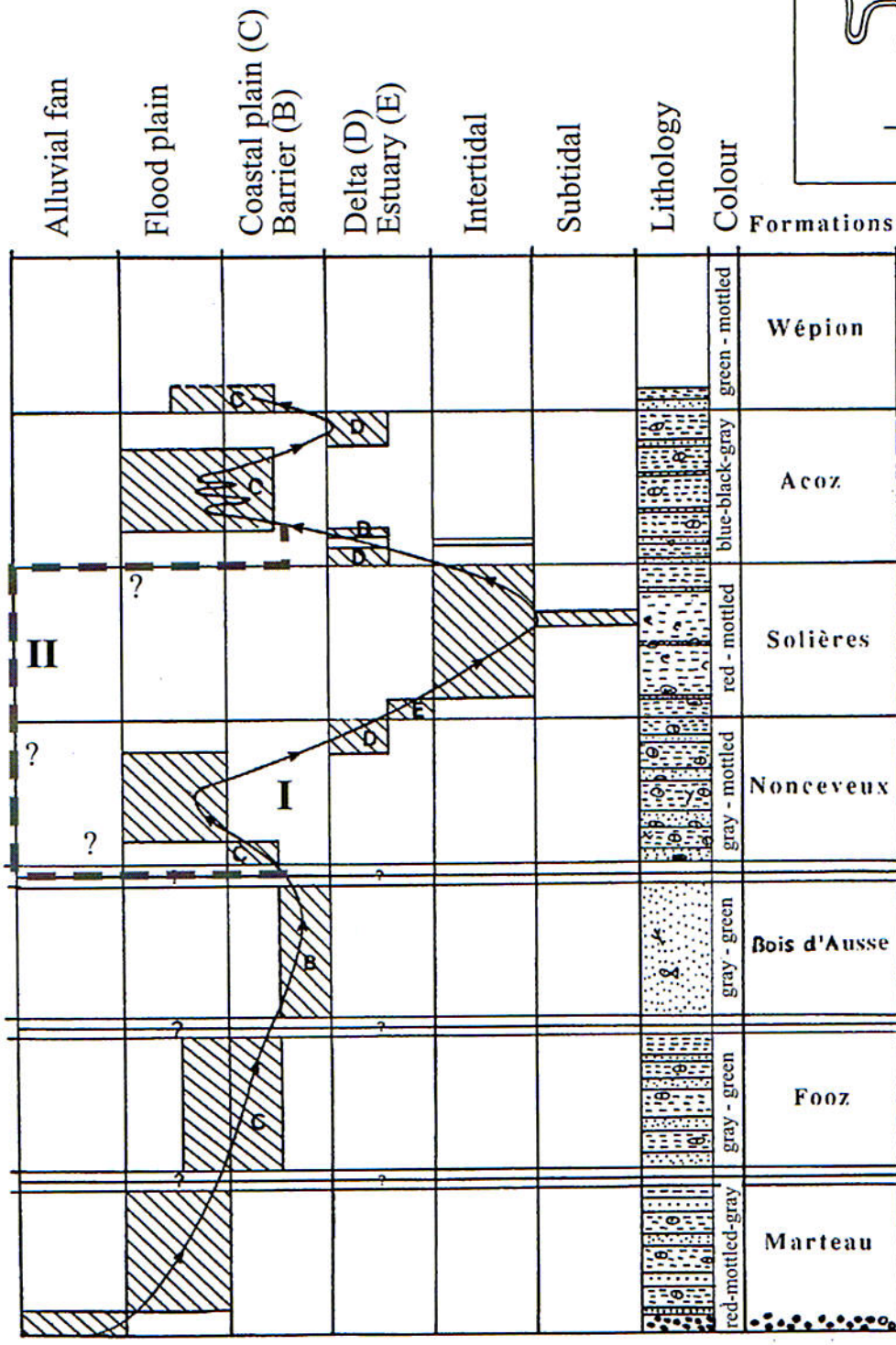


Fig. 4:
Vertical evolution of the sedimentary facies (No scale). After Goemare et al. (1993)

I - Nonceveux outcrop
II - Gileppe outcrop

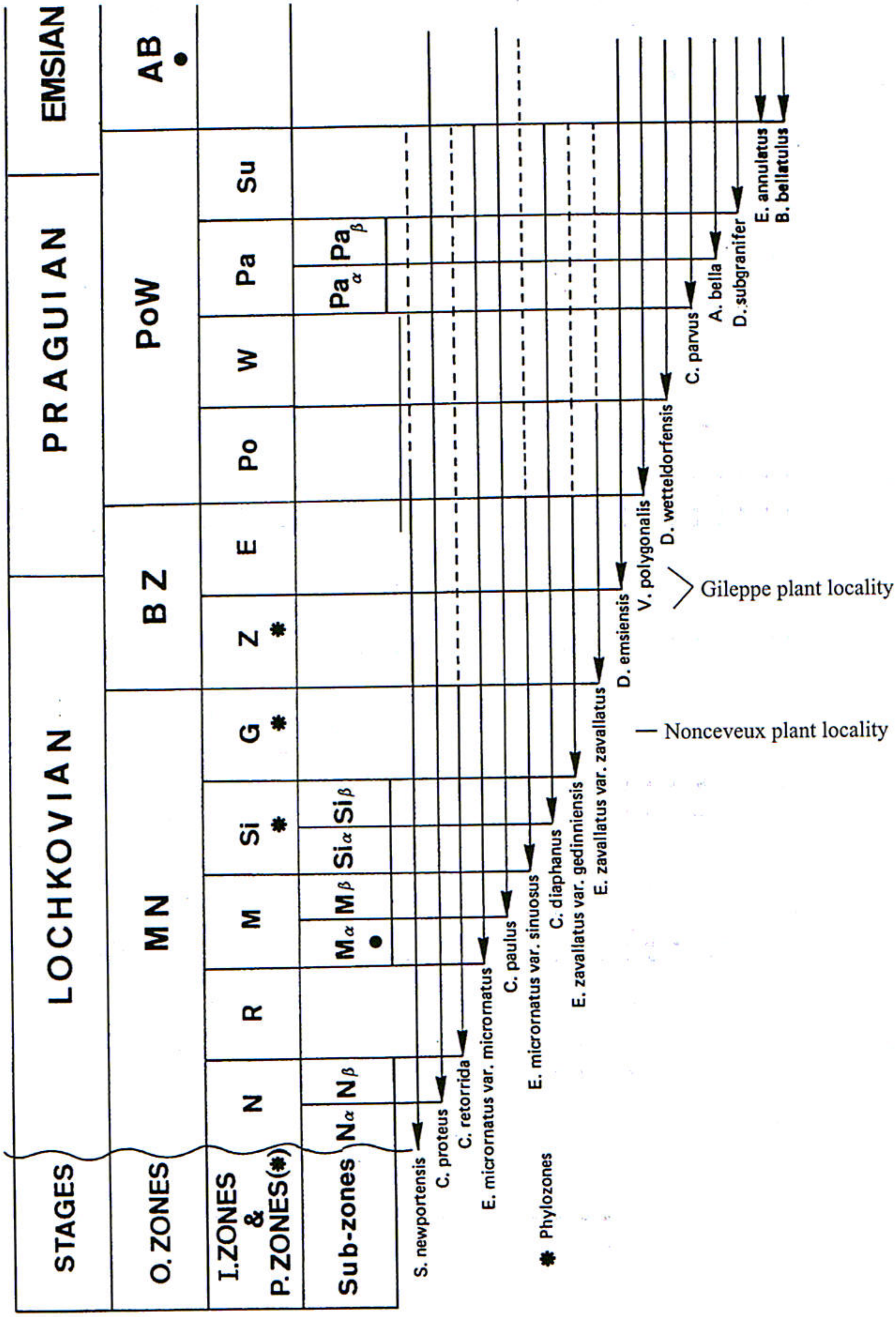


Fig. 5: **Zonation scheme of the Lochkovian - early Emsian (After Steemans, 1989)**

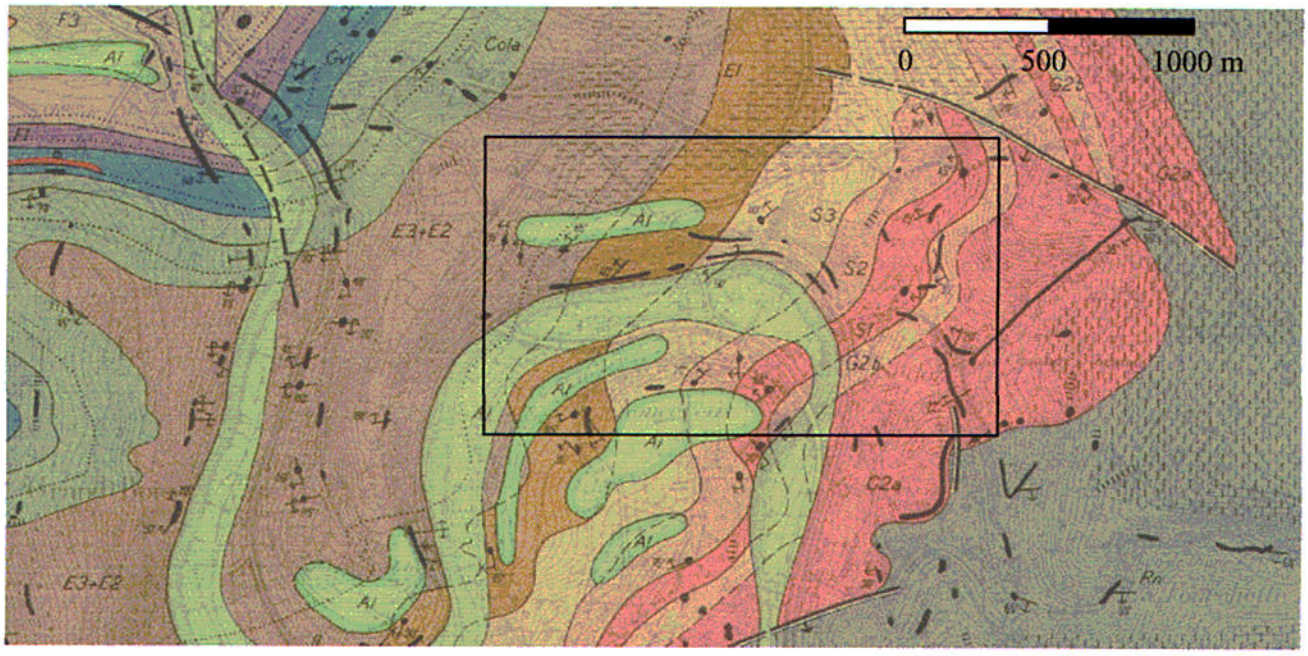


Fig. 6: **Geological map of the Nonceveux outcrop (Fourmarier, 1958)**

G2a - (Gedinnian) Lochkovian - Marteau Formation
G2b - (Gedinnian) Lochkovian - Fooz Formation
S1 - (Siegenian) Lochkovian and Pragian - Bois d'Ausse Formation
S2 - (Siegenian) Pragian - Nonceveux and Solières Formations
S3 - (Siegenian) Pragian and Emsian - Acoz Formation
E1 - Emsian - Wépiçon Formation

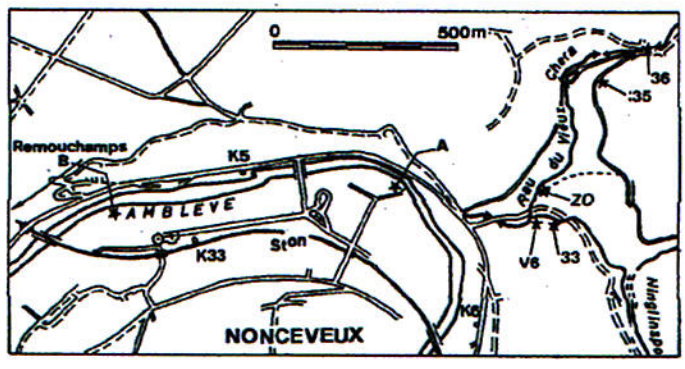


Fig. 7: **Localisation of the outcrops (after Steemans 1986)**

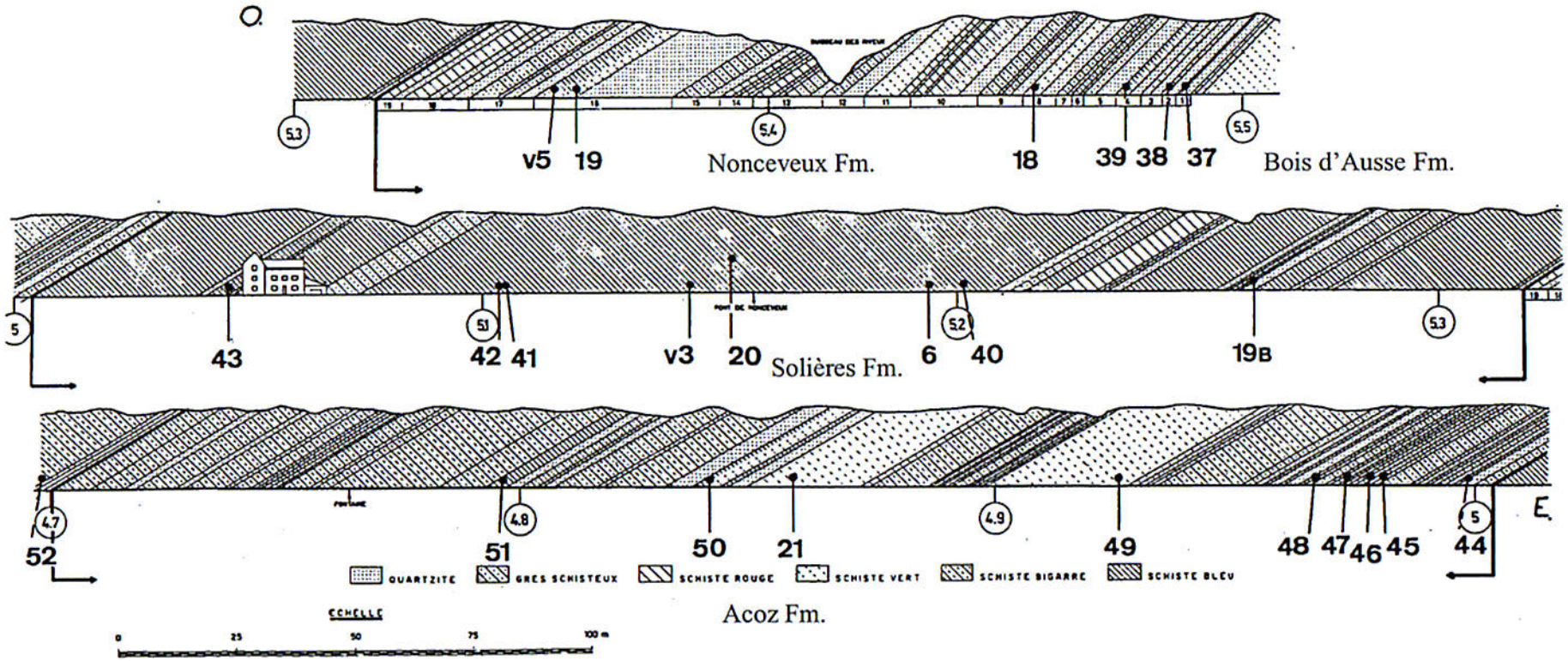


Fig. 8: **Main Nonceveux outcrops, along the Amblève river (after Monseur, 1959; Steemans, 1986)**

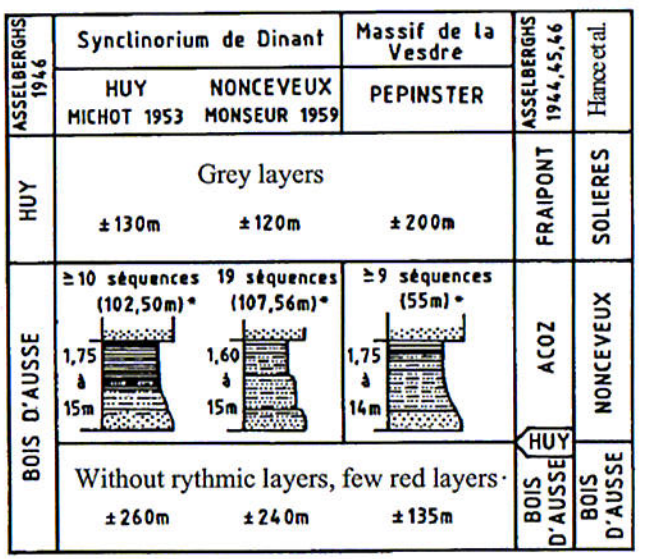


Fig. 9: **Rythmic sequences in the Nonceveux Formation from different localities (Hance et al. 1992)**

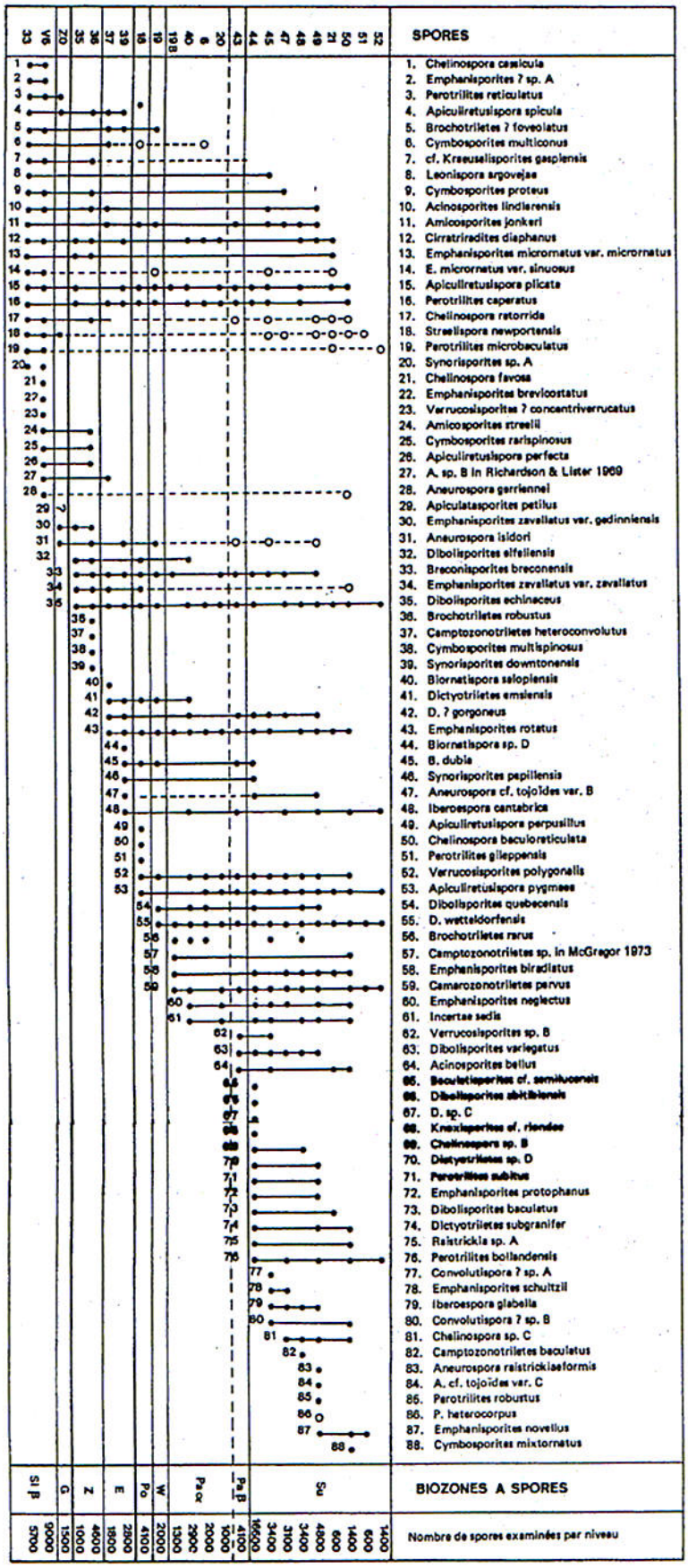
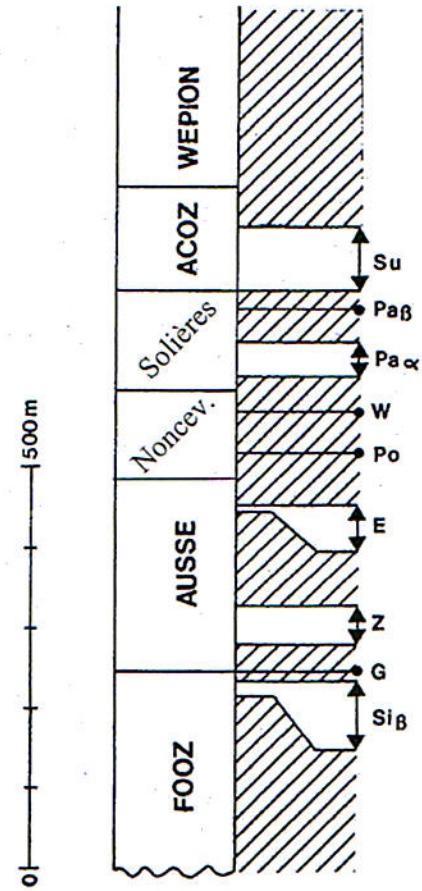


Fig. 10:
Miospores vertical extension in the Nonceveux outcrop

Fig. 11:
Vertical extension of the biozones in the Nonceveux outcrop



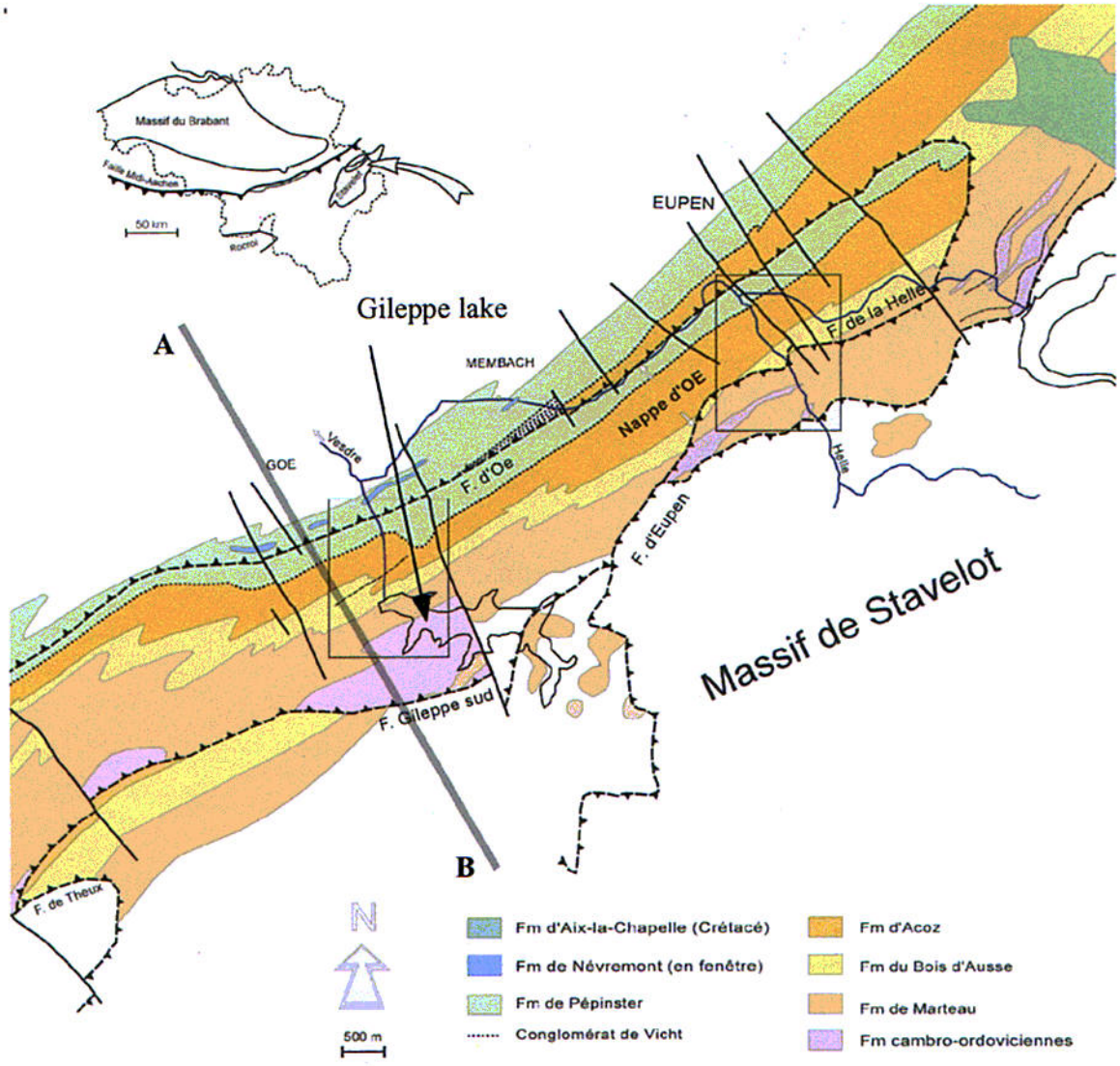
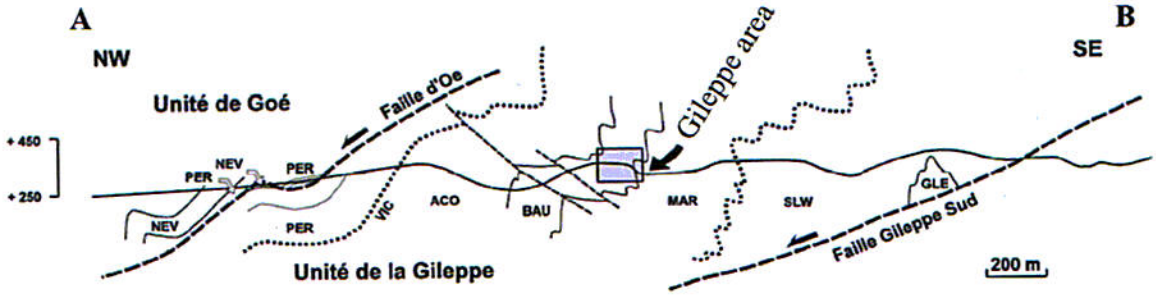


Fig. 12: **Localisation of the Gileppe lake (Goemare et al. 1997)**



NEV - Névremont Fm.
PER - Pépinster Fm.
VIC - Vicht Conglomerat

ACO - Acoz Fm.
BAU - Bois d'Ausse Fm.
MAR - Marteau Fm.

Fig. 13: **Geological cross section of the Gileppe valley (Hance et al. 1992)**

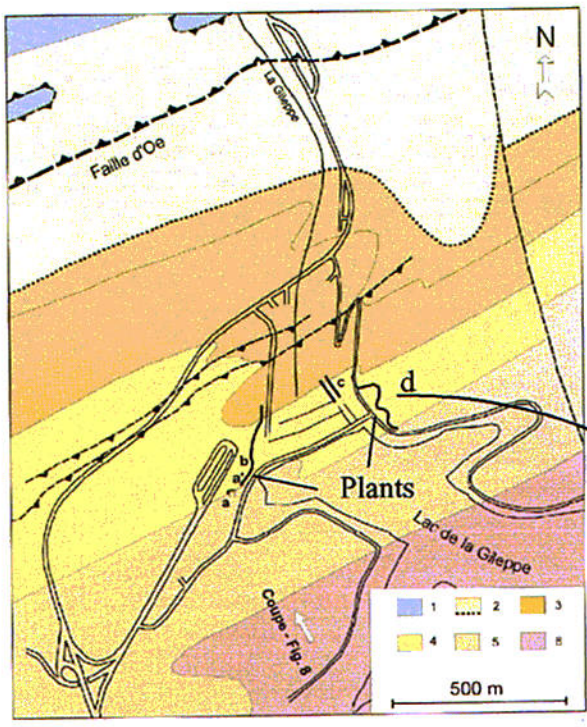


Fig. 14:
Geological map of the northern part of the Gileppe Lake (Goemare et al. 1997)

1 - Névremont Fm.
2 - Vicht Conglomérat
3 - Acoz Fm.
4 - Bois d'Ausse Fm.
5 - Marteau Fm.
6 - Salmian

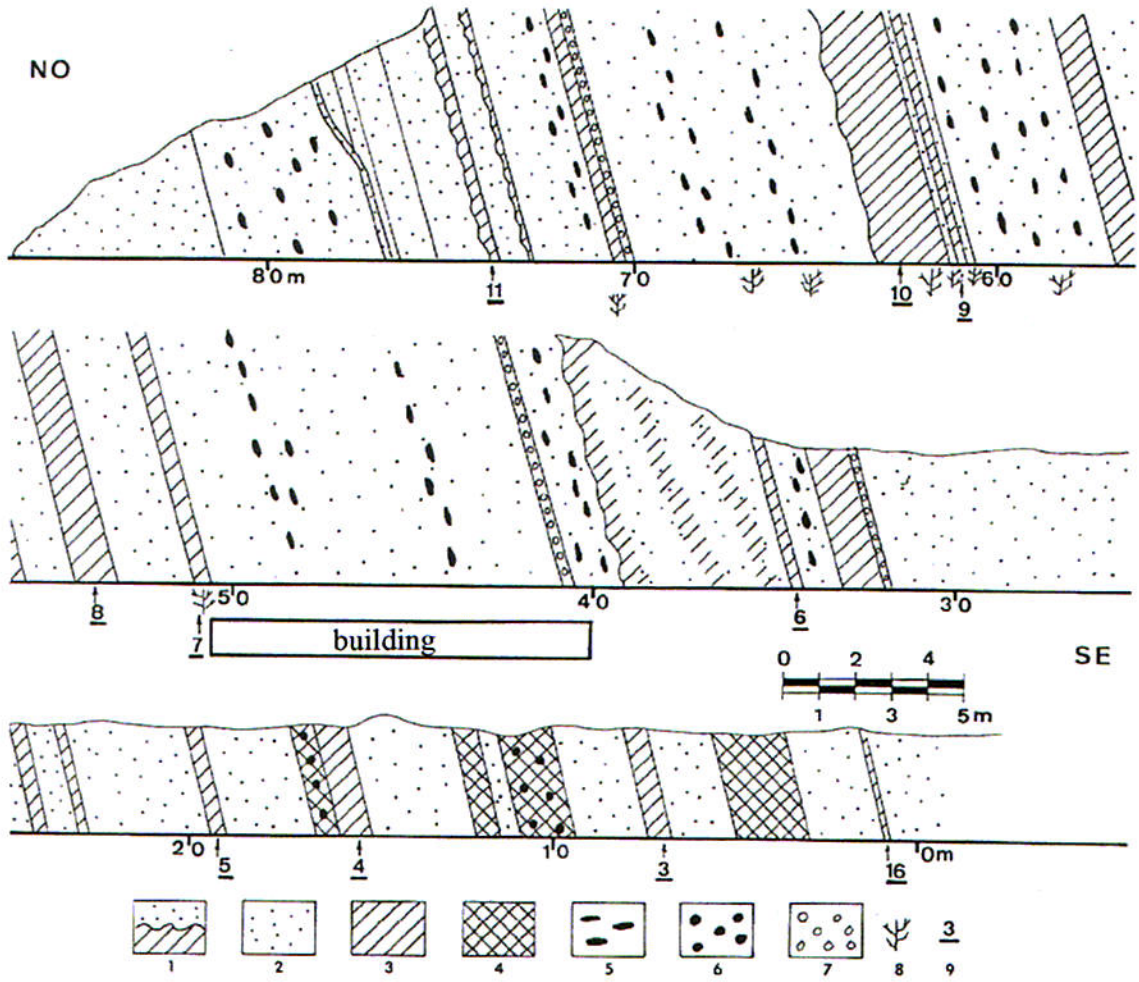


Fig. 15: **NE Gileppe outcrop (Steemans & Gerrienne, 1984)**

1 : erosive contact; 2 : sandstones; 3 : blue shales; 4 : red and mottled shales; 5 : mud chips
6 : carbonate nodules; 7 : conglomerates; 8 : megaflora; 9 : samples

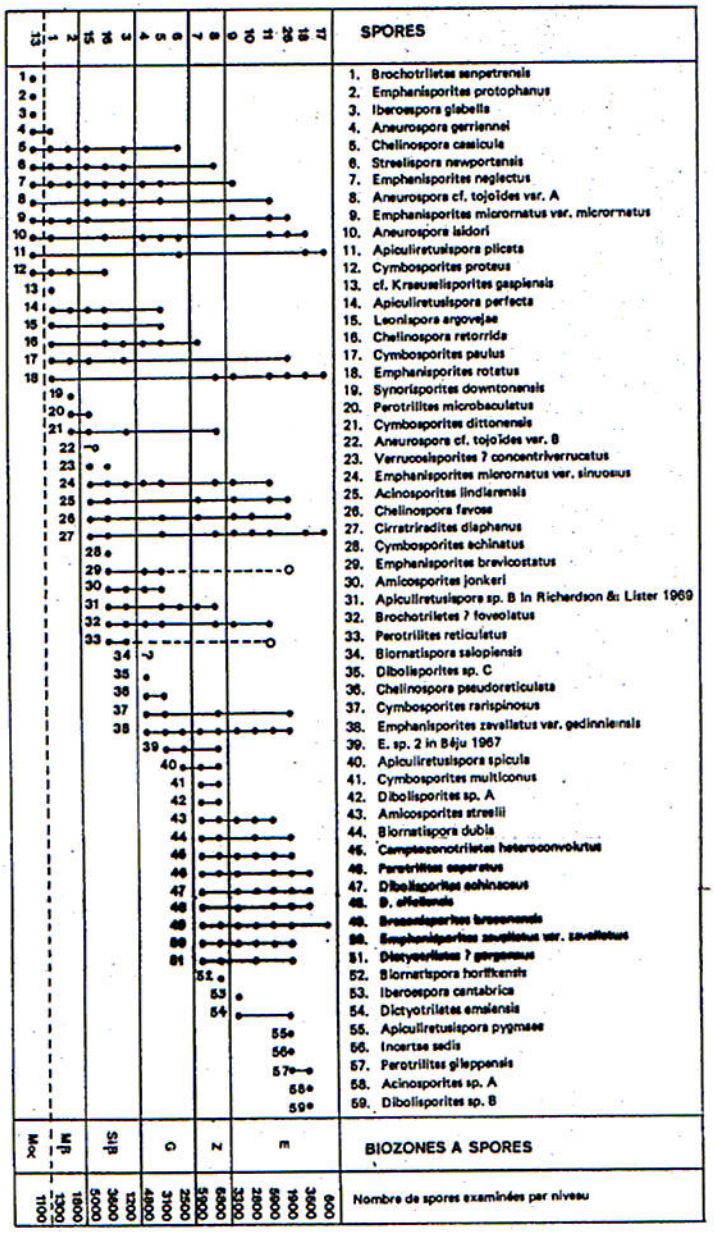


Fig. 16:
Miospore vertical extensions in the Gileppe outcrop (Steemans 1989)

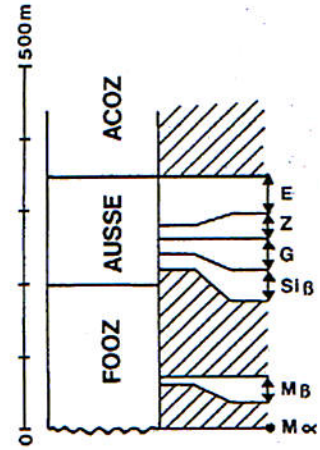


Fig. 17:
Vertical extensions of the biozones in the Gileppe outcrop (Steemans 1989)

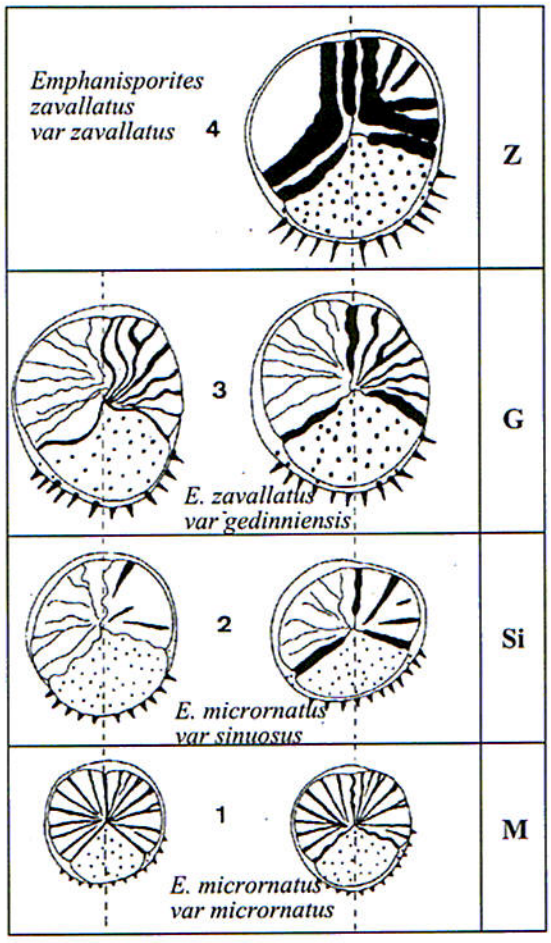
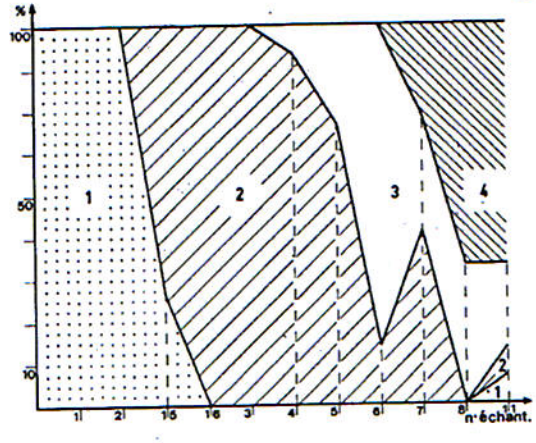


Fig. 18:
Morphological evolution in an *Emphanisporites* phylogenic? succesion



1 : E. micrornatus *var.* micrornatus ; *2* : E. micrornatus v sinuosus ; *3* : E. zavallatus *var.* gedinniensis ; *4* : E. zavallat *var.* zavallatus.

Fig. 19:
% of each species specimens by samples

All from Steemans 1989

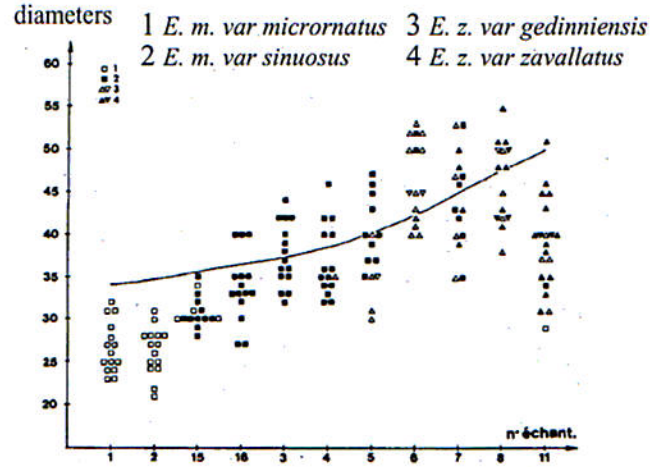


Fig. 20: **Diameter evolution of *Emphanisporites***

ornament length

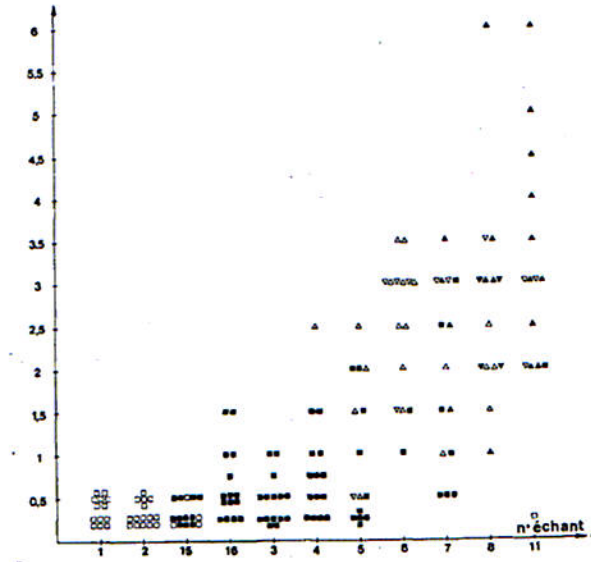


Fig. 21: **Ornament length evolution of *Emphanisporites***

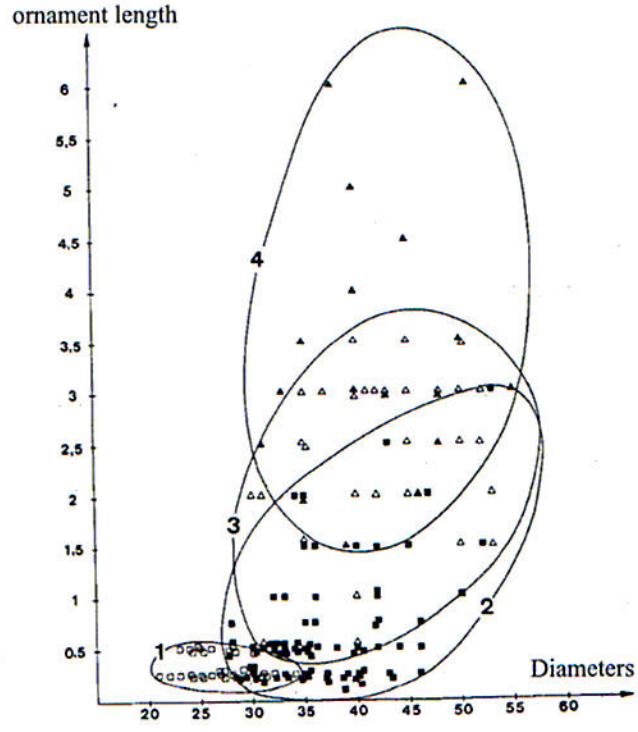
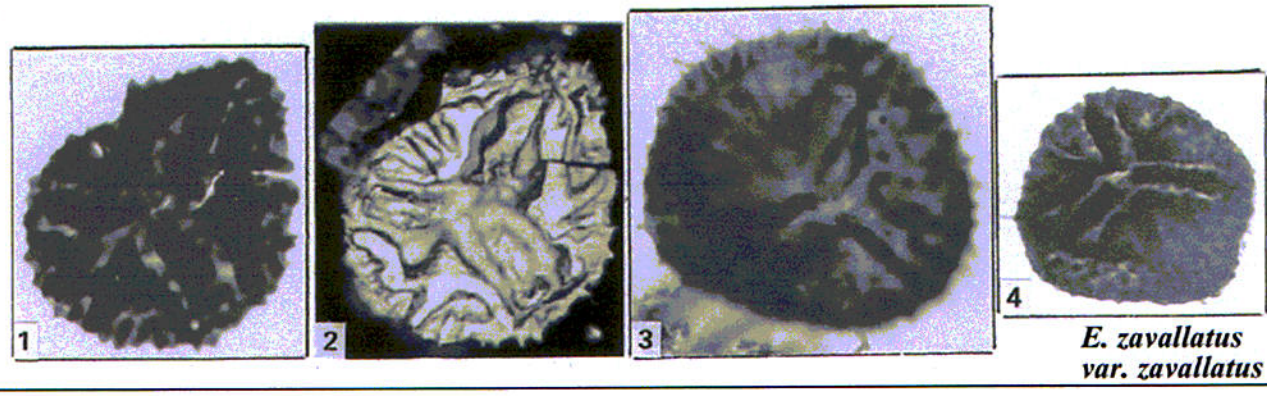
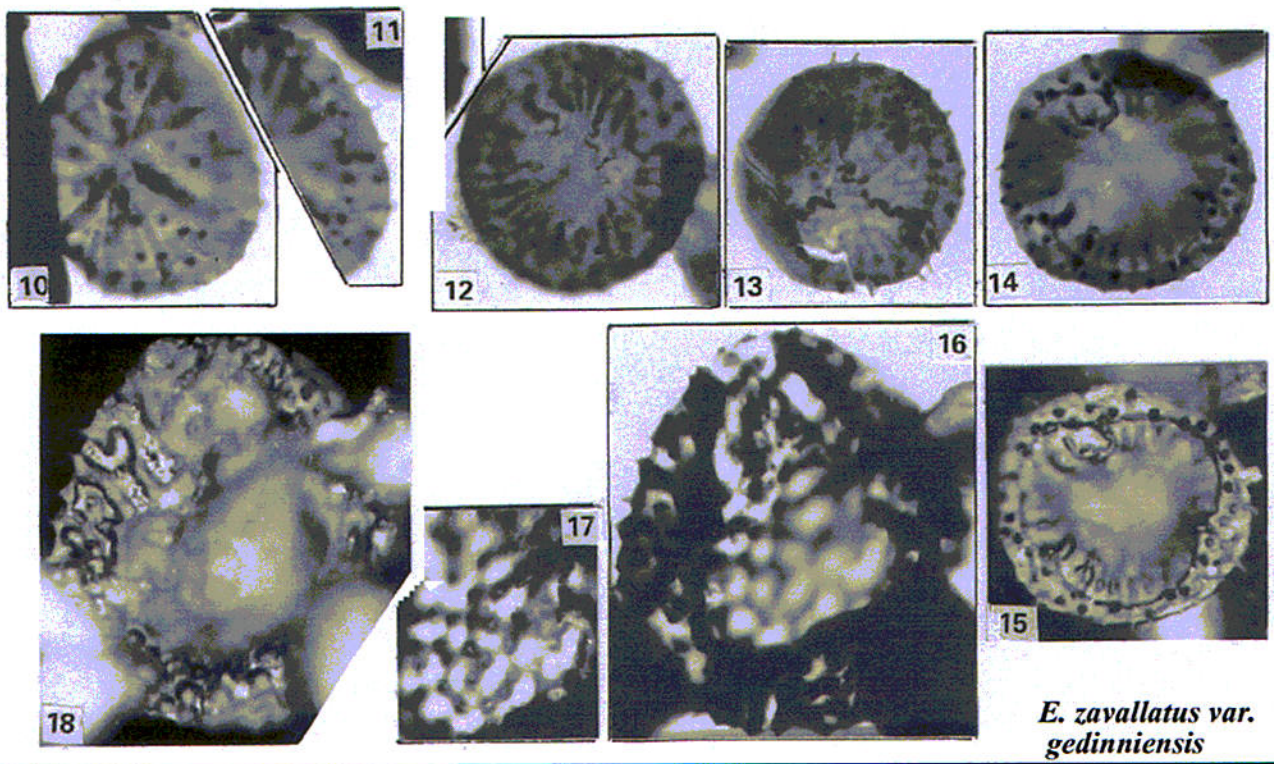


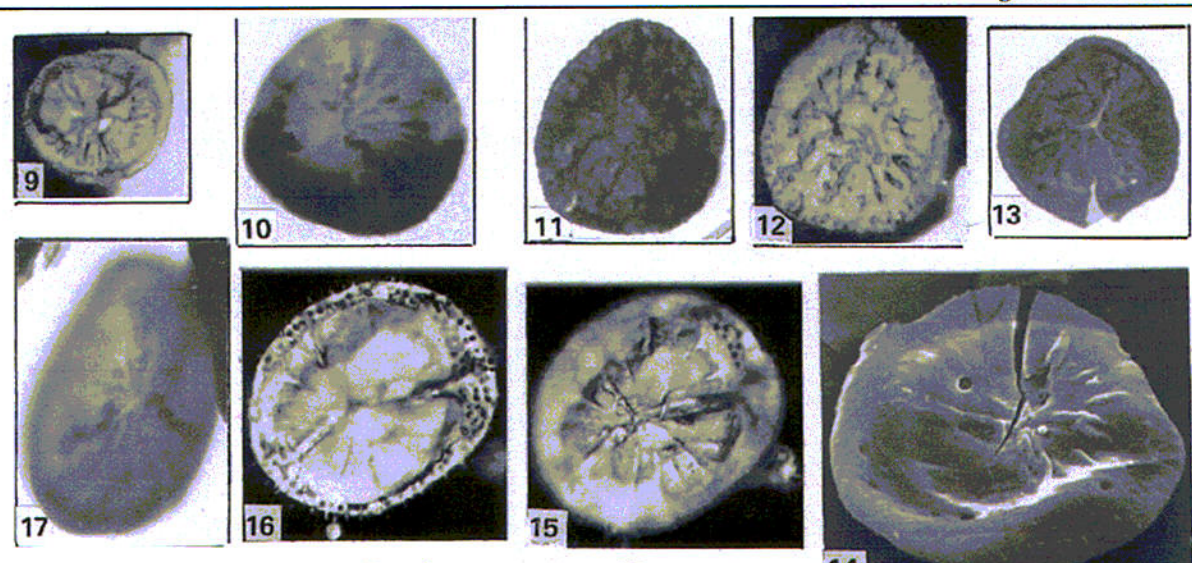
Fig. 22: **Diameters compared to ornament length**



E. zavallatus var. zavallatus



E. zavallatus var. gedinniensis



E. micrornatus var. Sinuosus

E.micrornatus var. micrornatus

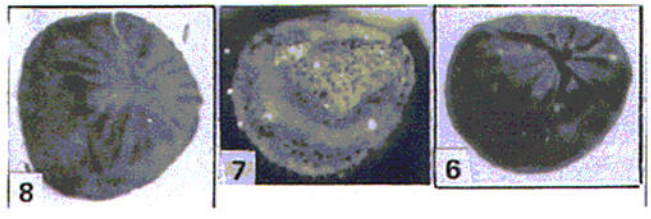
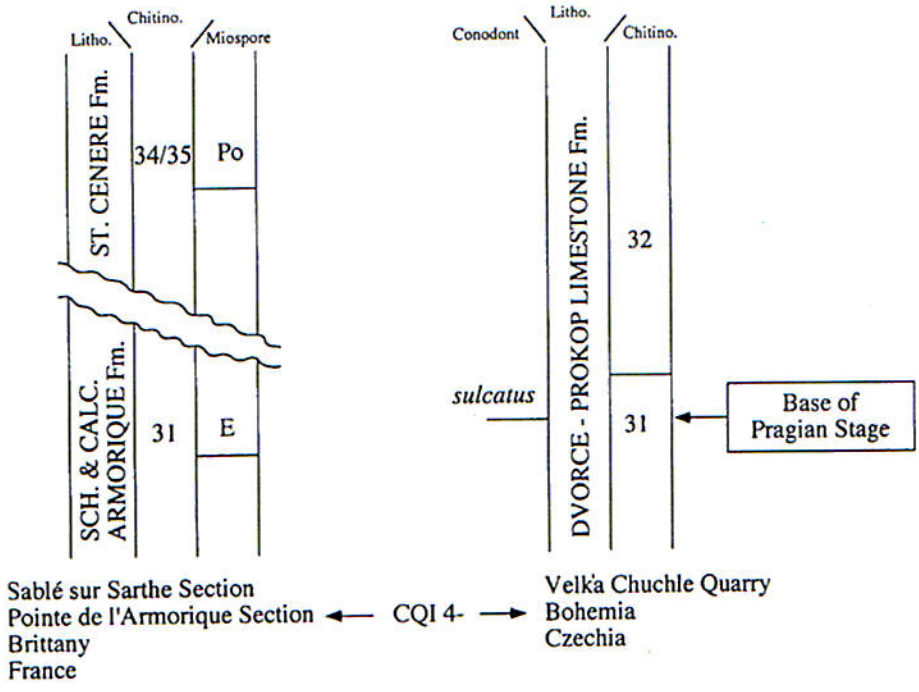


Fig. 23: **Phylogenic? succession in *Emphanisporites***

From Steemans 1986

Devonian miospore stratigraphy and correlation with the global stratotype sections and points (modified after Streel et al., 2000)

The lower limit of the Pragian Stage (Lochkovian / Pragian limit)



No miospores are known from the Global Stratotype Section in the Velka Chuchle Quarry in Bohemia where the first entry of *Eognathodus sulcatus* marks the base of the newly defined Pragian Stage. No zonal criteria were recorded by MCGREGOR (1979c) in the Barrandian region.

Miospores were studied by STEEMANS (1989) in the Ardenne but direct correlation between Bohemia and the Ardenne is very poor.

In Brittany (France), the Saint-Céneré (MOREAU- BENOIT 1976) and the Pointe de I' Armorique sud (MOREAU-BENOIT 1980) sections contain miospores and chitinozoans (PARIS 1981) which allow to bridge correlations between Ardenne and Bohemia.

In Bohemia, the lower limit of the Pragian Stage is within the uppermost part of the Chitinozoa Zone 31 (CHLUPAC & OLIVER 1989). In Brittany, the same zone 31 corresponds to the miospore Interval Zone *Dictyotriletes emsiensis* (E) (STEEMANS 1989).

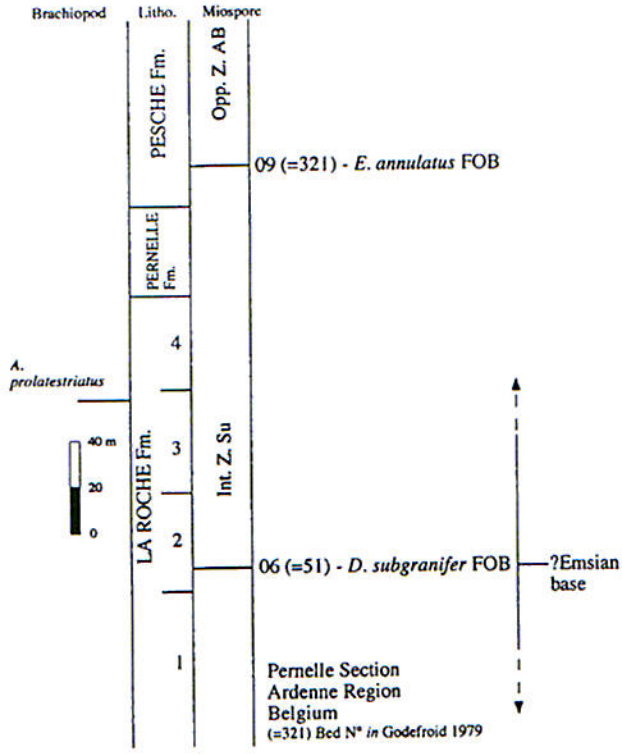
The Interval Zone E was defined (STREEL et al. 1987, STEEMANS 1989) in sample 9 of the Gileppe Lake section, in the Verviers Synclinorium (Belgium). Its base occurs in the Bois d' Ausse Formation about 80 m above the for- mation base. This level is designated here as the *D. emsiensis* FOB. Eight samples (32,900 miospore specimens observed) are known below this FOB, in the lower part of the Bois d' Ausse Formation, which do not contain *D. emsiensis.*

The top of that Interval Zone is defined by the base of the next Interval Zone *Verrucosisporites polygonalis* (Po) in the Nonceveux section, in the Nonceveux Formation of the southeastern part of the Dinant Synclinorium, about 77 m higher than the *D. emsiensis* FOB in that section. This level is designated here

as the *V. polygonalis* FOB. Five samples (11,700 miospore specimens observed) are known below this FOB, in the lower part of the Bois d' Ausse Formation, which do not contain *V. polygonalis.*

The *V. polygonalis* FOB can be recognized at the level of chitinozoa Zones 34/35 (STEEMANS 1989) in the Sable- sur-Sarthe section studied by LE HERISSE (1983), in Brittany,. We believe therefore (Fig. 8) that the *D. emsiensis* FOB is close to the lower limit of the Pragian Stage but we do not known on which side of that limit. This biohorizon is nevertheless a good marker for the base of this stage (Between Brittany and Bohemia: CQI 4- because the conodont fauna occurs in another distant section, in another lithological unit, but with a fauna - chitinozoa - also known in the reference section of the miospore zone.).

The lower boundary of the Emsian Stage (Pragian / Emsian limit)



No miospores are known from the Global Stratotype Section at Zinzilban in Uzbekistan where the first entry of *Polygnathus dehiscens* marks the base of the newly defined Emsian Stage. Miospores were studied by RIEGEL & KARATHANASOPOULOS (1982), STREEL et al. (1981) and STEEMANS (1989) in the Ardenne-Rhine regions but correlation between Uzbekistan and these regions are very poor. In Spain, brachiopods known in Belgium and conodonts known in Uzbekistan coexist in some sections (CARLS & VALENZUELA-RIOS 1993) and allow some correlation to be proposed indirectly between miospores and conodonts.

After BULTYNCK (1993), the Pragian/Emsian Boundary is below the traditional base of the Emsian in the southern Ardenne, characterized by the earliest occurrence of the brachiopod *Brachyspirifer minatus,* according to GODEFROID (1982). That traditional base was more or less equivalent to the limit between the Ulmen Group and the overlying Lower Singhofen Group, Beinhausen Formation in the Eifel (SOLLE 1950) where RIEGEL & KARATHANASAPOULOS (1982) have found the first miospore *Emphanis-*

porites annulatus. But there are no miospores, in the Ulmen Group so that the first occurrence level of this last species is uncertain in the Eifel.

In the Ardenne (southwestern part of the Dinant Synclinorium, Belgium), STREEL et al (1981) and STEEMANS (1989) find the first entry of *E. annulatus* (base of the Oppel Zone AB *Emphanisporites annulatus - Brochotriletes bellatulus)* in sample 09, in the upper part of unit 1 of the Pesche Formation of the Pernelle valley section (GODEFROID 1979, GODEFROID & STAINIER 1982). That level is designated here as the *E. annulatus* FOB. There are 4 samples, in the Pernelle Formation (GODEFROID et al. 1994) below, which lack *E. annulatus.*

At 180 m below the *E. annulatus* FOB, in sample 06 in the lower part of unit 2 of the La Roche Formation (GODEFROID & STAINIER 1982) of the same section, first occurs *Dictyotriletes subgranifer* (base of the Interval Zone Su in STREEL et al. 1987, STEEMANS 1989). That level is designated here as the *D. subgranifer* FOB. There are 3 samples (6,100 miospore specimens observed) in the 30 m thick section below that base, which lack *D. subgranifer.*

The same section contains brachiopods (GODEFROID & STAINIER 1982, table 1) which are also known in Spain. Of particular interest is the first occurrence of *Arduspirifer prolatestriatus* occurring in the upper part of unit 3 of the La Roche Formation i.e. about 65m higher than the *D. subgranifer* FOB. *A. prolatestriatus* is known in Spain (CARLS & V ALENZUELA-RIOS 1993) to first occur stratigraphically higher than the *"dehiscens* Boundary". BULTYNCK et al. mention the occurrence of *Caudicriodus celtibericus* in unit 3 of the La Roche Formation and conclude that this level cannot be older than the *dehiscens* Zone.

We believe therefore that the *D. subgranifer* FOB is nearer the newly defined base of the Emsian than the *E. annulatus* FOB but we do not know on which side of that base.

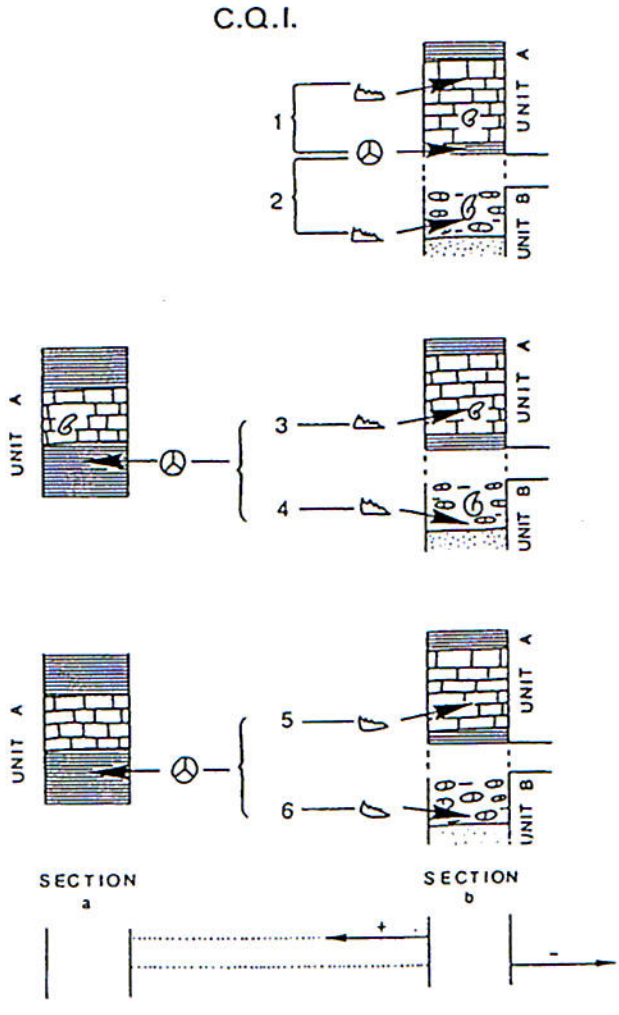


Fig. Quality Index in correlation (CQI) between reference faunal (here conodont) and miospore zones (CQI 1 to 6= best to worst), after Streel & Loboziak (1993, 1994, 1996)

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Devonian lithostratigraphic units (Belgium)

Pierre BULTYNCK[1] & Léon DEJONGHE[2]

(7 figures and 1 table)

1. Royal Belgian Institute of Natural Sciences, Department of Palaeontology, Vautier street 29, B-1000 Brussels, Belgium.
2. Royal Belgian Institute of Natural Sciences, Geological Survey of Belgium, Jenner street 13, B-1000 Brussels, Belgium.

ABSTRACT. This contribution briefly describes seventy Devonian formations from the Dinant and Namur Synclinoria, the Vesdre Nappe and the Theux Window, that were revised or introduced during the previous two decades. The descriptions of the formations are organized in four parts, Lower Devonian, Middle Devonian, Frasnian and Famennian, corresponding to major and minor transgressive and regressive events and demonstrating each typical lithological characteristics. In each part, the following presentation has been adopted: the formations occurring in the Southern part of the Dinant Synclinorium are first described from base upwards, followed by a description of the formations restricted to the central and/or northern part of the Dinant Synclinorium, the Namur Synclinorium, the Vesdre Nappe and the Theux Window.

KEYWORDS: Devonian, Lochkovian, Pragian, Emsian, Eifelian, Givetian, Frasnian, Famennian, Belgium, lithostratigraphy.

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1. Lower Devonian lithostratigraphic units

1.1. Introduction

The Lower Devonian is divided in three stages: Lochkovian, Pragian and Emsian. The Gedinnian and Siegenian stages of the ancient terminology correspond more or less respectively to the Lochkovian and Pragian stages (see Godefroid et al., 1994). Gedinnian and Siegenian were replaced by Lochkovian and Pragian according to the decisions of the IUGS (Bassett, 1985).

The base of the Lochkovian stage is defined at Klonk, Czech Republic (Martinsson (ed.), 1977), the base of the Pragian stage is defined at Velka Chuchle, Prague, Czech Republic (Chlupáč & Oliver, 1989), and the base of the Emsian stage is defined in the Zinzilban Gorge, Uzbekistan (Yolkin et al., 1997). Numerical ages of the Lower Devonian span the interval from 410 ±8/5 Ma to 390 ±5 Ma.

After the main phases of the caledonian orogeny, the Old Red Continent merged in Europe. A new transgression on this continent began at the Latest Pridolian - Early Lochkovian during which the Ardenno-Rhenish geosyncline was mainly fed by arenaceous sediments starting with basal conglomerates. Late Caledonian movements during the "Bolandian phase" was responsible for the emersion and the erosion of part of the Emsian rocks.

The Lower Devonian lithostratigraphic units of Belgium are exposed in the Ardenne Nappe, i.e. in the Dinant and Neufchâteau Synclinoria, the Ardenne Anticlinorium and the Vesdre Nappe (figure 1).

The basic contributions to their study are those of Dumont (1848), Asselberghs (1946, 1954) and Godefroid et al. (1994). The present synthesis is essentially adapted from Godefroid et al. (1994) who have updated the ancient terminology and descriptions to the concept of lithological formations in the Vesdre Nappe, the Theux Window and the Dinant Synclinorium. However, Godefroid et al (1994) did not review the terminology for the Ardenne Anticlinorium and the Neufchâteau Synclinorium. Revision of the lithostratigraphic units of

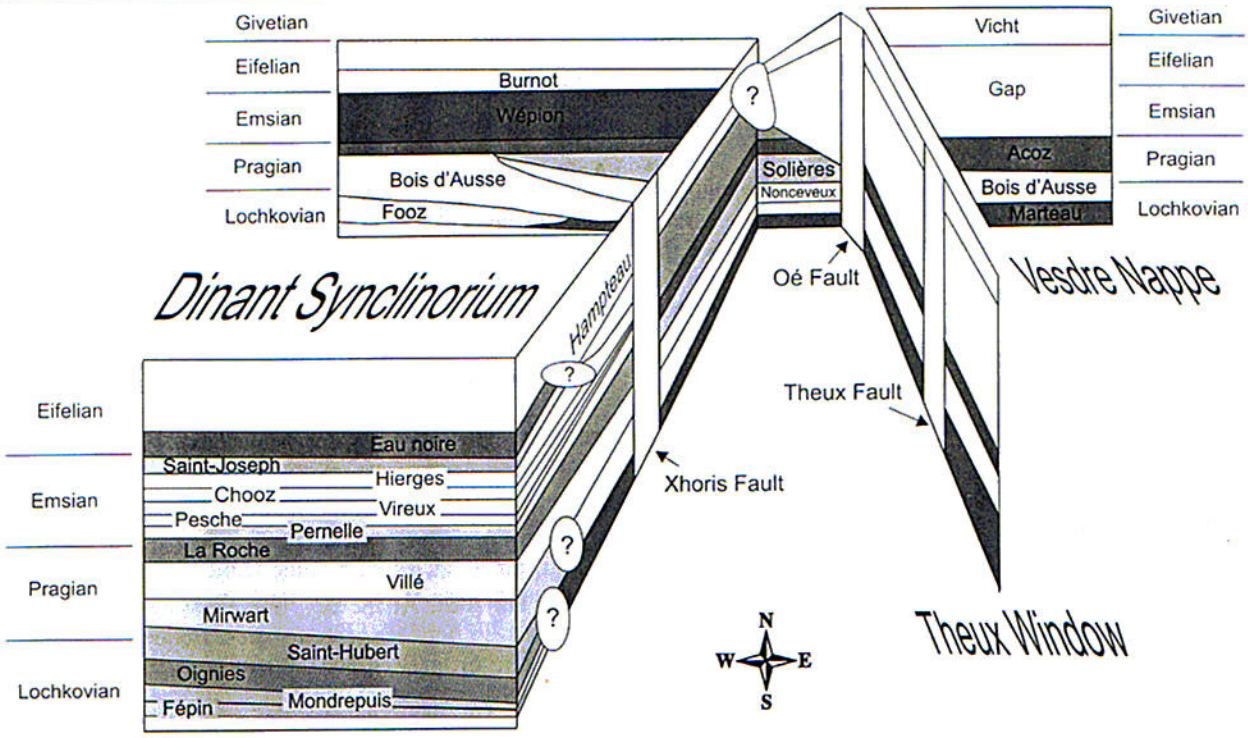

Figure 2. 3D geographical extension of the Lower Devonian formations in the Dinant Synclinorium, The Theux Window and the Vesdre Nappe (after Steemans in Godefroid et al., 1994, modified).

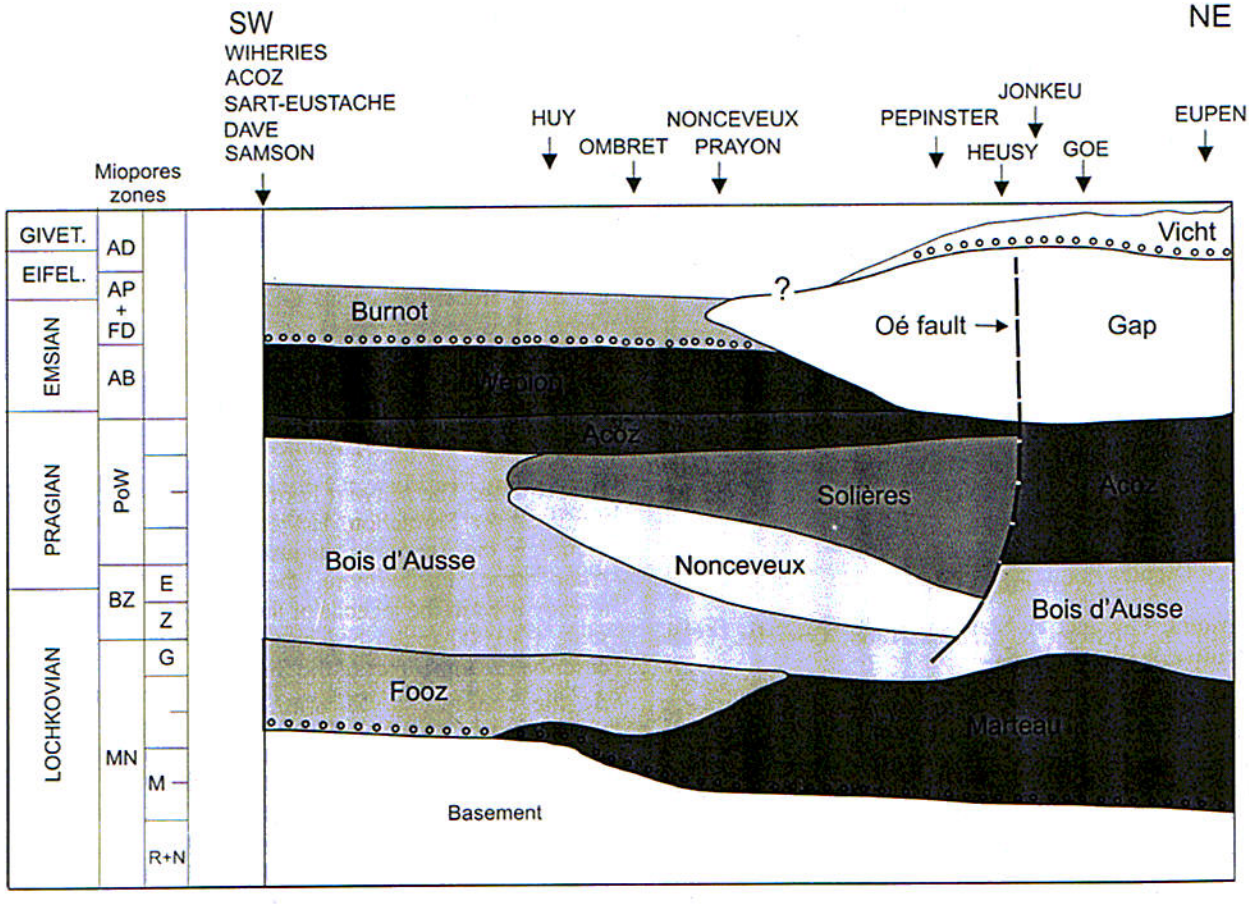

Figure 3. SW-NE schematic cross-section through the Lower Devonian formations at the northern and eastern sides of the Dinant Synclinorium and in the Vesdre Nappe. (after Hance et al., 1992, modified).

100 uppermost meters, the sandstone layers may also contain rare shells.

Stratotypes: Mirwart, sections along the Lhomme river and the Namur-Arlon railway track. Other good section for the upper part at Villé, near La Roche-en-Ardenne.

Area: S and E of the Dinant Synclinorium; Halleux Anticline.

Thickness: 300 m at Couvin, 450 m in the Meuse valley, 600 m at Mirwart, 600 m on the eastern side of the Dinant Synclinorium, > 700 m N at Halleux, 1000 m W of Dochamps.

Age: Lochkovian-Pragian. On the base of miospore zonation, diachronous character from W to E. At Mirwart, top of the Z, E, Po and W Subzones, BZ and PoW Oppel Miospore Biozones (= Lochkovian-Pragian border); at Couvin, in the Pèrnelle valley: Paα Subzone of the PoW Oppel Miospore Biozone (= Pragian). Former Early Siegenian (Sg1) age.

1.2.6. Villé Formation - VIL

Authors: Maillieux & Demanet, 1929; Asselberghs, 1946; Godefroid & Stainier, 1982.

Description: Dark blue shales and slates with intercalations of rust-coloured sandy laminated layers, blue sandstones, often with brown pellicular weathering, and blue carbonate sandstones, often very fossiliferous and strongly weathered at the surface (dissolved; limonitized). Also green and sometimes white sandstones and quartzites. Ripple marks occur frequently at the sandstone layers boundaries.

Stratotype: Villé near La Roche-en-Ardenne.

Area: S and SE sides of the Dinant Synclinorium, up to the Xhoris fault.

Thickness: 30 m S of Couvin, 200 m S of Grupont, 200 m at Amonines, 250-300 m in the La Roche-en-Ardenne area.

Age: Although being very rich in fossils (brachiopods, crinoids, bivalves, corals), no marker guide was up to now identified. A Pragian age is inferred, due to the ages attributed to the neighbouring formations. Former Siegenian (Sg2 or S2) age.

1.2.7. La Roche Formation - LAR

Authors: Dewalque, 1874; Asselberghs, 1946; Godefroid & Stainier, 1982.

Description: At the stratotype, from the bottom to the top, the La Roche Formation is made up of:

- 200 m of dark blue slates with thin layers of light blue sandstones or quartzites. Load casts;
- 100 m of dark blue slates and blue grey silty slates with sandy intercalations and 0.1-1 m thick banks of reddish sandstones. Rare fossils;
- 150 m of dark blue slates progressively richer to the top in thin sandy layers and blue green siltstones, sometimes fossiliferous.

Stratotypes: Lower boundary at La Roche-en-Ardenne, along the Hotton road; upper boundary S of Jupille, at the Hodister crossing.

Area: S and SE sides of the Dinant Synclinorium, up to the vicinity of the Xhoris fault.

Thickness: 215 m S of Couvin, 420 m S of Grupont, about 400 m at Amonines, 400 m at the northern flank of the La Roche Syncline increasing to > 800 m at the southern flank of the syncline.

Age: Probably Pragian, due to the age of the neighbouring formations.

1.2.8. Pèrnelle Formation - PER

Author: Godefroid, 1979, 1994.

Description: The formation begins with the first massive sandstone bank overlying the siltstones of the La Roche Formation. It finishes with the last thick sandstone bank underlying the shales, siltstones and shelly (and also sometimes carbonate) sandstones of the Pesche Formation. The Pèrnelle formation is mainly made up of massive, green blue (brownish if weathered) sandstones and quartzitic sandstones, sometimes fossiliferous, separated by thin dark shaly beds. Locally, the thickness of the dark shales and siltstones increases.

Stratotype: Couvin, Pèrnelle pond, old railway tram trench.

Area: S and SE sides of the Dinant Synclinorium.

Thickness: 39 m at the Pèrnelle pond, about 40 m at Jupille, 45 m S of Grupont, about 60 m in the Meuse valley, 150 at the northern flank of the Halleux Anticline, > 600 m in the Nisramont area.

Age: Late Pragian at the stratotype (Su Subzone of the PoW Oppel Miospore Biozone).

1.2.9. Pesche Formation - PES

Authors: Maillieux, 1910; Asselberghs & Maillieux, 1938; Godefroid, 1979.

Description: Grey or blue grey (greenish or brownish by weathering) shales and siltstones with lenses en layers of sandstones, sometimes containing shells. The sandstones can also be argillaceous or with a carbonate cement and become limonitic by weathering.

Stratotype: Couvin, Pèrnelle pond, old railway tram trench.

Area: S and SE sides of the Dinant Synclinorium, up to the area between the Ourthe valley and Villers-Ste-Gertrude.

Thickness: 160 m in the Meuse valley, ±190 m in the Couvin area, ±375 m in the Lesse valley, ±400 m S of Grupont, ±400 m in the Ourthe valley; 700-800 m in the Hodister area.

Age: On the base of three species of *Brachyspirifer*, the Siegenian (≅ Pragian) - Emsian boundary was defined in

1.2.13. Hampteau Formation - HAM

Authors: Gosselet, 1873; Asselberghs, 1946; Stainier, 1994c.

Description: The Hampteau Fm starts with the occurrence of gravelly or conglomeratic sandstones overlying the red, green and mottled detrital rocks of the Chooz Fm. The rocks are characterized by thick masses of sandstones, coarse-grained to gravelly sandstones with disseminated quartz and sandstone pebbles and conglomerate banks alternating with shales and siltstones. The top of the formation is placed at the last red and green bank underlying the grey shales and siltstones, quickly carbonate bearing, of the St-Joseph Fm. The colour is very variable: red, green, often mottled or greyish green. Some banks contain fossils. The Hampteau Fm is divided into two members, respectively from bottom to top:

- The Hamoûle Member (141 m thick at Hampteau), in which the sandstones contain crinoids and brachiopods. A thin sandy layer is rich in ostracods;
- The Chaieneu Member (432 m at Hampteau), in which pebbles are more abundant within the sandstone beds, conglomerates more frequent and fossils represented by plant remains. A thick level of red shale with burrows is situated close to the bottom.

The boundary between the two members is fixed at the last thick bank with macrofauna.

Stratotype: SE of Hampteau, along the road to La Roche-en-Ardenne.

Area: E side of the Dinant Synclinorium, from Hampteau up to the vicinity of the Xhoris fault.

Thickness: The thickness decreases to the N: 573 m at Hampteau; 360 m in the Aisne valley; 250 m at La Roche à Frène; 45 m at Fagnoul, near the Xhoris fault.

Age: Upper Emsian (*Arduspirifer arduennensis*) for the Hamoûle Member. Emsian/Eifelian boundary or Eifelian for the Chaieneu Member (Pro-Vel Subzones of the AP Oppel Spore biozonation).

1.2.14. Marteau Formation - MAR

Author: Gosselet, 1888; Dejonghe, Hance & Steemans, 1994a.

Description: In the Marteau stratotype, the formation unconformably rests on the Caledonian (Salmian) basement and is overlaid by the sandstones and quartzites of the Bois d'Ausse Fm. At the bottom, occur a conglomerate of 1.5 m thick at Eupen, increasing S of Eupen and in the Amblève valley (Quarreux Member, locally > 10 m thick). These rocks are overlaid by maroon (red) and mottled siltstones and argillaceous fine-grained sandstones, alternating with green, olive or mottled argillaceous sandstones. The maroon (red) colour is widely dominant. Carbonate nodules are concentrated in some beds and responsible for a cellular structure if dissolved. Light-coloured quartzite banks, sometimes gravely, occur in the lower part. In the Gileppe valley, there are coarse-grained to conglomerate bearing kaolinitic sandstones.

Stratotype: Theux Window, Marteau locality, along the Spa-Pépinster railway.

Area: W and N flanks of the Stavelot Massif.

Thickness: 163 m at Eupen.

Age: Lochkovian (Mα-G Subzones of the MN Oppel Miospore Biozonation in the Vesdre Nappe; R subzone in the Theux Window pointing out to an older age to the S than to the N).

1.2.15. Fooz Formation - FOO

Authors: Gosselet, 1873, 1888; Dejonghe, Hance & Steemans al., 1994b.

Description: In the stratotype of Dave, the Fooz Formation unconformably rests on Silurian shales. The formation starts with 1.5 m of conglomerate overlaid by 11.7 m of coarse-grained sandstones locally kaolinitic form the Dave Member. Olive green siltstones and micaceous sandstones surmount it. A frequent cellular structure is due to the dissolution of carbonate nodules. At the top, the Fooz Fm contain a few meters of maroon (red) and mottled siltstones and sandstones. The top of the formation is defined below the first meter-thick blue grey or light beige quartzite bank of the Bois d'Ausse Fm.

Stratotypes: Fooz, left bank of the Meuse. Dave, Bois de Dave, along the Ruisseau des Chevreuils.

Area: N of the Dinant Synclinorium and in the Vesdre Nappe.

Thickness: 150-200 m at the N side of the Dinant Synclinorium. 193 m at Dave (13.2 m for the Dave Member).

Age: Upper Lochkovian (Siα-β Subzones of the MN Oppel Miospore Biozonation).

1.2.16. Bois d'Ausse Formation - BAU

Authors: d'Omalius d'Halloy, 1868; Asselberghs, 1946; Dejonghe, Hance & Steemans, 1994c.

Description: The lower limit is placed at the first grey, blue grey or light-coloured quartzite bank overlying the green siltstones and sandstones of the Fooz Fm. The upper limit is situated below the red rocks of the overlying Acoz Fm. In the Treko valley, three members are distinguished, respectively from bottom to top:

- The Bôlia Member (50 m): grey or beige quartzites with cross-stratification;
- The Tréko Member (20 m): alternating siltstones and green argillaceous sandstones;
- The Masuis Member (30 m): lenticular beige grey quartzite banks with rust-coloured spots and thin grey shale intercalations. In some levels, occurrence of shale pebbles and plants remains.

Stratotypes: Bois d'Ausse, Sart-Bernard, Namur-Arlon railway; Vitrival, Treko valley; Dave, Ruisseau des Chevreuils.

beds. Plant remains and, less frequently, fish remains also occur. Pelitic units may also contain red and green sandstones beds, generally well stratified. To the top, the green sandstones contain more and more pebbles. The siltstone interbeds are cellular and ferruginous. The Wépion Fm is divided into two members, respectively from bottom to top:

- The Grand Ri Member (260 m): blue grey, greenish or reddish sandstones and quartzites, often conglomeratic bearing, forming thick units separated by grey, green or red shales, siltstones and thin sandstone beds.
- The Bois des Collets Member (40 m): green, very coarse-grained and even conglomeratic bearing sandstones. The rocks are cellular and ferruginous (also the green shales interbeds).

Stratotype: Dave and Wépion, Dave quarry, Bois des Collets quarry and surroundings.

Area: N and E flanks of the Dinant Synclinorium, up to the Mormont fault. The Bois des Collets Mbr is observed from Binche to the Fond d'Oxhe.

Thickness: 200 m in the Honelle valley, 223 m at Wépion, 280 m at Acoz, 400 m S of Huy.

Age: Emsian (AB Oppel Miospore Biozone).

1.2.21. Burnot Formation - BUR

Authors: d'Omalius d'Halloy, 1839; Gosselet, 1873; Stainier, 1994e.

Description: The Burnot Fm is mainly made up of red, coarse-grained sandstones and conglomerates with frequent tourmalinite pebbles occurring in lenticular beds interlayered with red and, less frequently, green shales. Plant remains may occur in the shales. The lower limit is fixed above the greenish sandstones, locally gravely, of the Wépion Fm; the upper limit is below the red siltstones and shales containing small pebbles of white quartz and crinoids articles belonging to the Rivière Fm.

Stratotype: Profondeville, N of the Burnot valley and surroundings.

Area: N and E flanks of the Dinant Synclinorium, up to the Xhoris fault.

Thickness: 200 m in the Honelle valley, 330 m S of Acoz, 535 m in the Meuse valley, 350 m in the Huy area.

Age: Probably Emsian. However, up to now, no biostratigraphical attempts for dating this formation have succeeded. It is not impossible that its upper part is of Eifelian age, as it is the case for the Hampteau Fm which is a lateral equivalent.

2. Middle Devonian lithostratigraphic units

2.1. Introduction

The Middle Devonian of the Ardenne was initially subdivided into Couvinian and Givetian stages. In a vote at Sigüenza (Spain) in 1979 a majority of the Devonian Subcommission was in favor of Eifelian as the name for the lower stage of the Middle Devonian. The base of the Eifelian is defined in the stratotype section of Wetteldorf in the Eifel area by the first occurrence of the conodont *Polygnathus costatus partitus* (Werner & Ziegler, eds, 1982). This boundary is well above the base of the Couvinian and is recognized in the upper part of the Eau Noire Fm. Because the underlaying St.-Joseph FM corresponds to the lowest part of the local Couvinian stage this formation is described here together with the Middle Devonian formations. The base of the Givetian is defined in the Global Stratotype Section and Point at Jebel Mech Irdane in the Tafilalt of Morocco and coincides with the first occurrence of the conodont *Polygnathus hemiansatus* (Walliser et al, 1995). This boundary is below the base of the Givet Limestone of the Ardenne as defined by Errera et al (1972) and within the lower part of the Hanonet Formation, representing the uppermost part of the Couvinian (Bultynck & Hollevoet, 1999).

Middle Devonian rocks of the Ardenne are exposed in the Dinant and Namur Synclinoria and in the Vesdre Nappe. The initial stratigraphic subdivisions of the Middle Devonian of the Ardenne were established by Gosselet (1860, 1873) and Maillieux (1912 to 1938). Recently the Middle Devonian formations of the Ardenne were described by Bultynck et al (1991) resulting from discussions within the Belgian Subcommission on Devonian Stratigraphy. The present summary description of the Middle Devonian formations is based on the latter paper.

Cross-sections of Middle Devonian formations of the Dinant Synclinorium are shown in figure 4 (southern and south-eastern border) and figure 5 (southern and northern border).

2.2. Descriptions

2.2.1. St-Joseph Formation - STJ

Authors: Bultynck & Godefroid, 1974; Bultynck, 1991a.

Description: The most striking characteristics are the light-greyish shelly and crinoidal limestones, occasionally silty, intercalated in a chiefly grey-greenish silty shaly succession. The macrofauna is essentially composed of brachiopods.

Stratotype: Nismes, hamlet St-Joseph, local road to Regniésart.

Hypostratotype: Olloy-sur-Viroin, cut along path 200 m south-west of the village church.

Area: Southern and south-eastern flank of the Dinant-Synclinorium up to Hotton-Hampteau; from Villers-Ste-Gertrude on the St-Joseph Fm and the overlaying Eau Noire Fm cannot be clearly separated.

Thickness: About 40 m between Couvin and Olloy-sur-Viroin, 160 m in the Wellin-Halma area, about 50 m at Grupont and 30 m near Marche.

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Palaeobotanical data from Nonceveux and La Gileppe

Introduction

Apart from badly preserved specimens with terminal sporangia tentatively referred to *Cooksonia* from Lahonry quarry (early Lochkovian; spore zone R according to Steemans, 1989; Fairon-Demaret, pers. comm.), the oldest non-animal macrofossils from Belgium are found at Nonceveux (outcrop indicated ZO on map on fig. 7) and La Gileppe (outcrops indicated a', b and d on map on fig. 14).

Localities at La Gileppe are rather exceptional, as they gather on a restricted area well preserved representatives of three kingdoms: Fungi, Protista and Plantae. Those plants, as those from Nonceveux, are early land plants: they exhibit small size and simply branched leafless axes, with simple anatomical construction.

The age of the Nonceveux locality is late Lochkovian (Interval spore zone G; Steemans, 1989), and the La Gileppe localities all range from latest Lochkovian to earliest Pragian (Assemblage spore zone BZ; Steemans, 1989).

The data and the descriptions given hereafter are taken from Leclercq (1942), Steemans (1989), Gensel & Andrews (1984), Gerrienne (1983; 1990a et b; 1992), Taylor & Taylor (1993) and Kenrick & Crane (1997).

Kingdom Fungi

Prototaxites Dawson (locality a' at La Gileppe); figs 25 and 26

The genus *Prototaxites* was established by Dawson in 1859 for large silicified trunks found at several Lower Devonian localities in Gaspé, Canada. Some of the trunks were one meter wide and up to two meters long. Those trunks are made of intermixed large and small longitudinal cells that Dawson interpreted as vascular cells (tracheids). Hence, he allied the specimens to the gymnosperms and called them *Prototaxites*. Later, Dawson changed his mind and re-interpreted *Prototaxites* as an algae. Recently, the genus has been redescribed by Hueber (2001). *Protataxites* is now considered as a giant fungus. It consists of a terrestrial sporophore, very large: up to 1.25 m in diameter, 8.8 m tall; its internal tissue is made of three hyphal elements: skeletal hyphae, thick-walled, large, unbranched; generative hyphae, thin-walled, large, profusely branched; binding hyphae, thin-walled, small, profusely branched. Some presumably fertile cells (protobasidia) have been described, but unfortunately spores are not preserved.

Stratigraphic range: from Early to Late Devonian.
Other occurrences include Great Britain, Germany, Libya, Saudi Arabia and North America.

Kingdom Protista

Pachytheca Hooker (locality ZO at Nonceveux; localities a' and d at La Gileppe); fig. 24

Pachytheca was first regarded as an animal, later as a seed, and now as a probable green (?) algae (Protista). An individual consists of a single spherical body 1,5 - 5 mm in diameter. It is composed of an inner zone called the medulla and an outer zone called the cortex. The medulla is made of multicellular filaments extending in all directions. These filaments extends into the cortex where they are radially aligned. Some spheres exhibit a small papilla believed to represent a site of attachment.

Stratigraphic range: Late Silurian to Early Devonian.
Other occurrences include Great Britain, Germany, Belgium, Spitsbergen, Australia and North America.

Kingdom Plantae

Incertae Sedis
Psilophytites gileppensis Gerrienne (locality d at La Gileppe); fig. 30

The genus *Psilophytites* is used for "spiny" vegetative axes of early land plants. The emergences ("spines") of this plant are long and narrow; its axes are equally or unequally branched. An axillary organ (very spiny axis) occurs at the angle of some axis divisions. Due to the lack of fertile parts, the affinities of the genus are impossible to assess (Gerrienne, 1992).

Stratigraphic range: latest Lochkovian to earliest Pragian.
La Gileppe is the type locality of the species. No other occurrences have been reported.

Rhyniopsida (sensu Kenrick & Crane, 1997)

cf. *Huvenia* sp. Hass & Remy (locality b at La Gileppe); fig. 31

The main axis of *Huvenia* bifurcate or trifurcate isotomously. Axes are generally naked; some bear spines or hemispherical projections. The central vascular strand is composed of S-type tracheids (similar to those of *Rhynia* and *Stockmansella*; see Kenrick & Crane, 1997 and references therein). The sporangia are borne singly at various points along the main axis on small, subordinate branches. The sporangia are fusiform with a mucronate tip; they are borne terminally in a shallow depression, and open along numerous helical slits.

Stratigraphic range: Pragian-Emsian. The type locality is located in the Rheinische Schiefergebirge (Germany) and is given as Pragian; another species of the same genus has been described from the late Emsian of the same area (Schultka, 1991).
Comments on Belgian occurrence: the specimens (La Gileppe locality b; Lochkovian/Pragian boundary; spore zone Z/E) are all vegetative and are thus only tentatively referred to the genus.

Lycophytina (sensu Kenrick & Crane, 1997)

Gosslingia breconensis Heard (locality d at La Gileppe); fig. 29

The main axes are pseudomonopodially branched (isotomously distally), circinate at the apex, and naked. Small, subordinate axes occur on one side, just below dichotomies of the main axis. The xylem (remains of the stele) is elliptical and shows exarch maturation. The xylem cells (tracheids) are of the G-type (Kenrick & Crane, 1997). The sporangia are isovalvate, oval to reniform, and borne on short stalks in one or two opposite rows over a loose, branched, fertile zone. In situ spores are mainly subtriangular, azonate, apiculate, and 36-50 μm across; they bear small spines and cones over the surface.

Stratigraphic range: Late Lochkovian (La Gileppe) to Emsian. The type locality is Brecon Beacons Quarry (Wales; Pragian) (Heard, 1927; Edwards, 1970).
Other occurrences of the genus (with different species) include Germany (Schweitzer, 1979; Schweitzer, 1983) and Wyoming, United States (Tanner, 1982).

Lycophytina (sensu Kenrick & Crane, 1997)

Zosterophyllum fertile Leclercq (locality ZO at Nonceveux); fig. 28

The main axes are naked and branch isotomously. The xylem (remains of the stele) is weakly elliptical and has probably an exarch maturation. The sporangia are reniform, isovalvate and borne on short stalks; they are hellically arranged, mostly over a compact, unbranched fertile zone. In situ spores have been compared with the genus *Retusotriletes*.

Stratigraphic range: late Lochkovian to early Emsian. The type locality is Nonceveux (Belgium; late Lochkovian, spore zone G).
Other occurrences of the species include another locality in Belgium (Marchin; early Emsian, spore zone AB; Gerrienne, 1983) and localities in Wales (Croft & Lang, 1942; Edwards, 1969).

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Figure caption

Figure 24. *Pachytheca* sp. (Nonceveux; La Gileppe, localities a' and d). Scale bar = 0.5 mm. Figure from Gerrienne (1990a).

Figure 25. *Prototaxites* sp. (La Gileppe, locality a'). Scale bar = 100 μm. Figure from Gerrienne (1990a).

Figure 26. *Prototaxites* sp. (La Gileppe, locality a'). Scale bar = 100 μm. Figure from Gerrienne (1990a).

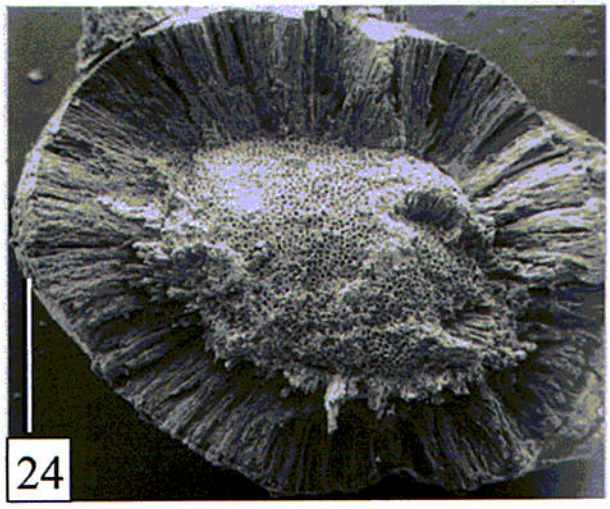
Figure 27. Habit and habitat of *Prototaxites* in Early Devonian times. Figure from Hueber (2001).

Figure 28. *Zosterophyllum fertile* (Nonceveux). Scale bar = 2 mm. Figure from Leclercq (1942).

Figure 29. *Gosslingia breconensis* (La Gileppe, locality d). Scale bar = 1 cm. Figure from Edwards (1970).

Figure 30. *Psilophytites gileppensis* (La Gileppe, locality d). Scale bar = 5 mm. Figure from Gerrienne (1992).

Figure 31. *Huvenia kleui* (La Gileppe, locality b). Scale bar = 1 cm. Figure from Hass & Remy (1991).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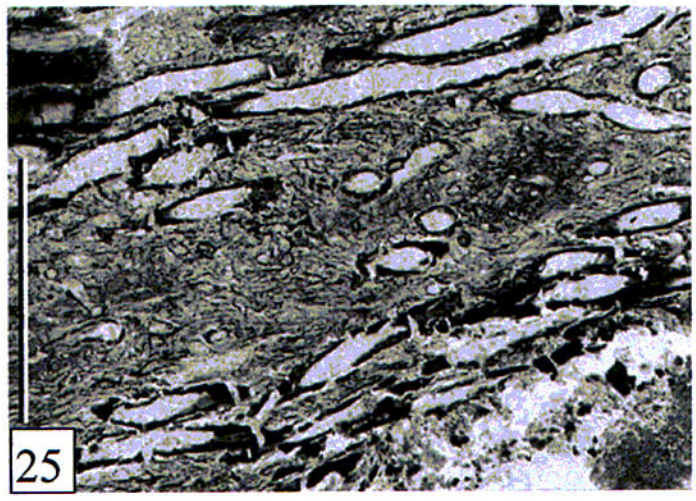
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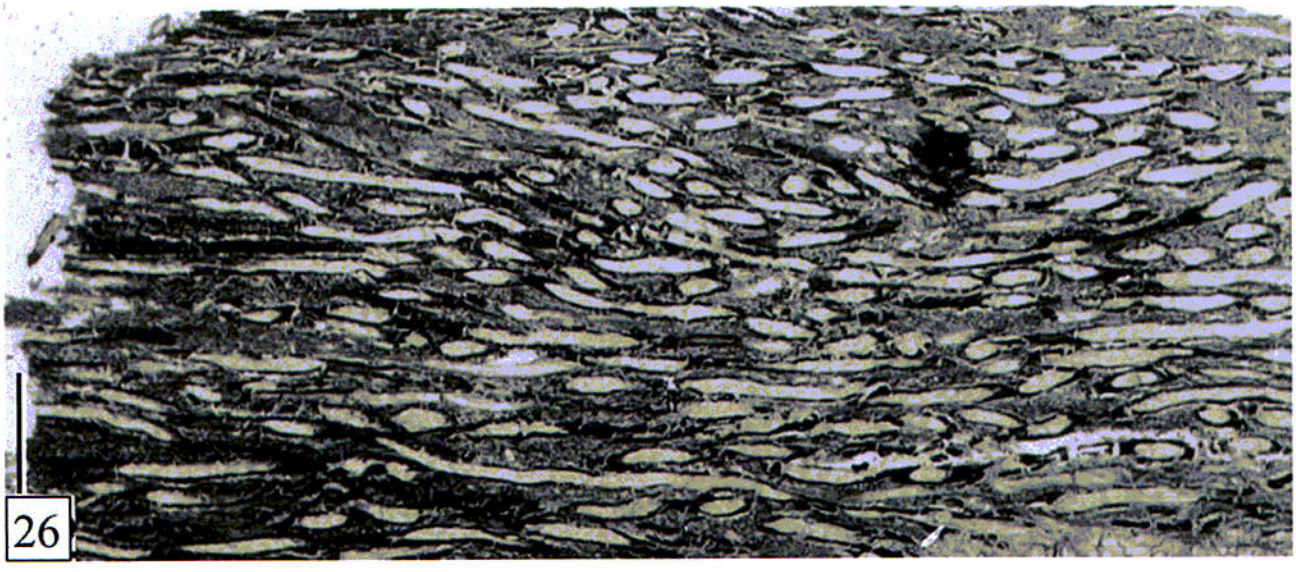
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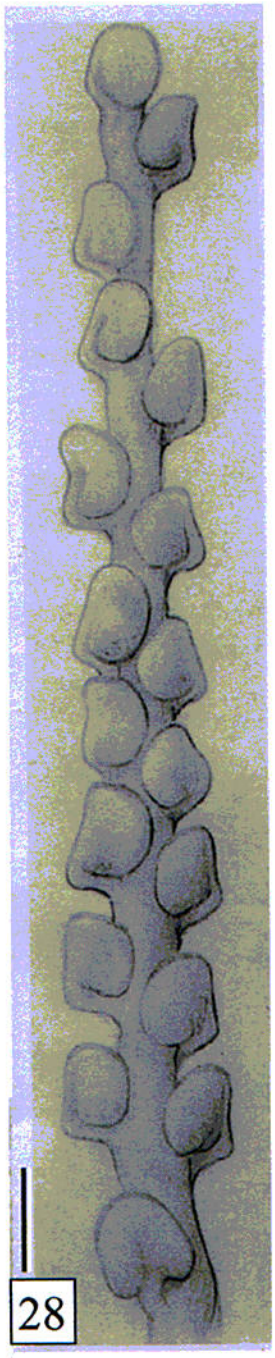

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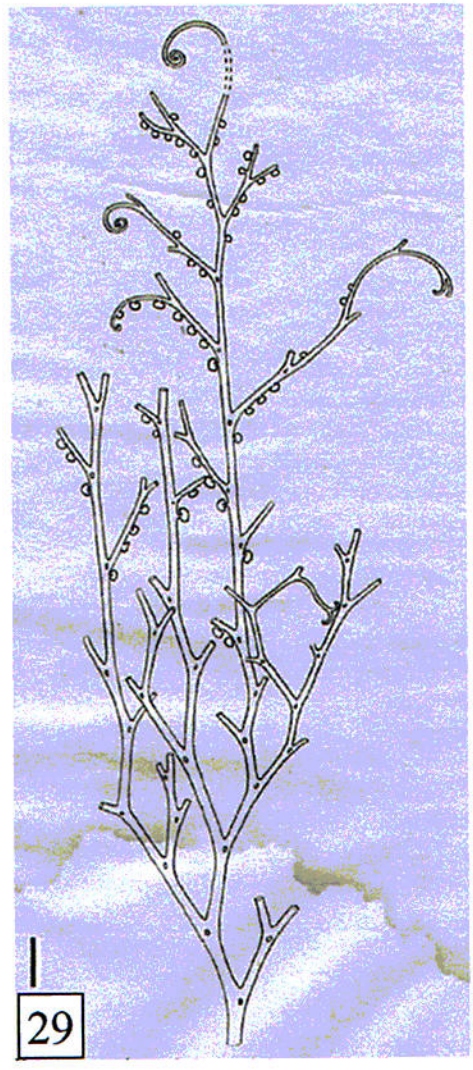

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Part III

The Frasnian in the northeastern part of the Ardenne

Stop 4 (Lambermont)

Structural and micropaleontological analysis of the Aisemont and Lambermont formations at Lambermont (Vesdre Nappe, Belgium)

Yves Vanbrabant[1,*], Sarah Geeninckx[2] et Michel Vanguestaine[3]

(9 figures, 1 tableau)

ABSTRACT

The Lambermont site, where shale and limestone layers of the Aisemont and Lambermont formations outcrop, is studied on the structural point of view. A sequence of a progressive deformation is established from field observations. This sequence is characterised at first by a compressive phase followed by a tensile phase. During the compression, two shortening stages can be distinguished: firstly, minor ramp structures develop within the limestone beds. This episode is also marked by the development of a significant detachment level composed of flats and ramps with an apparent offset is estimated to at least 138 m. Secondly, these early structures undergo a strongly north-facing folding and a cleavage plane development. The consecutive deformation of the detachment level induces the creation of a tectonic window. The latter mechanism constitutes for this region a new development process of such structures. The trajectory of the detachment level is specified thanks to a micropaleontologic analysis, which makes it possible to discriminate on basis of Palynofacies method two shale members. Finally, during the tensile phase, a series of longitudinal normal faults cut the early structures developed during the compressive phase.

KEYWORDS: folded detachment level, tectonic window, longitudinal post-folding normal faults, Palynofacies

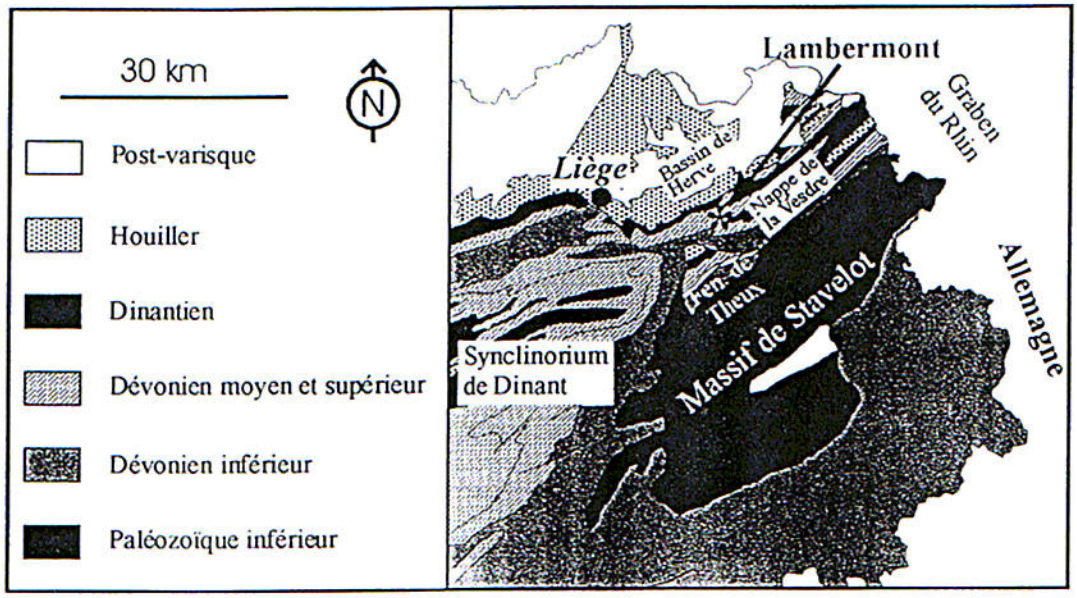

Figure 1 Simplified geological map of the NE Belgium with the location of the Lambermont site

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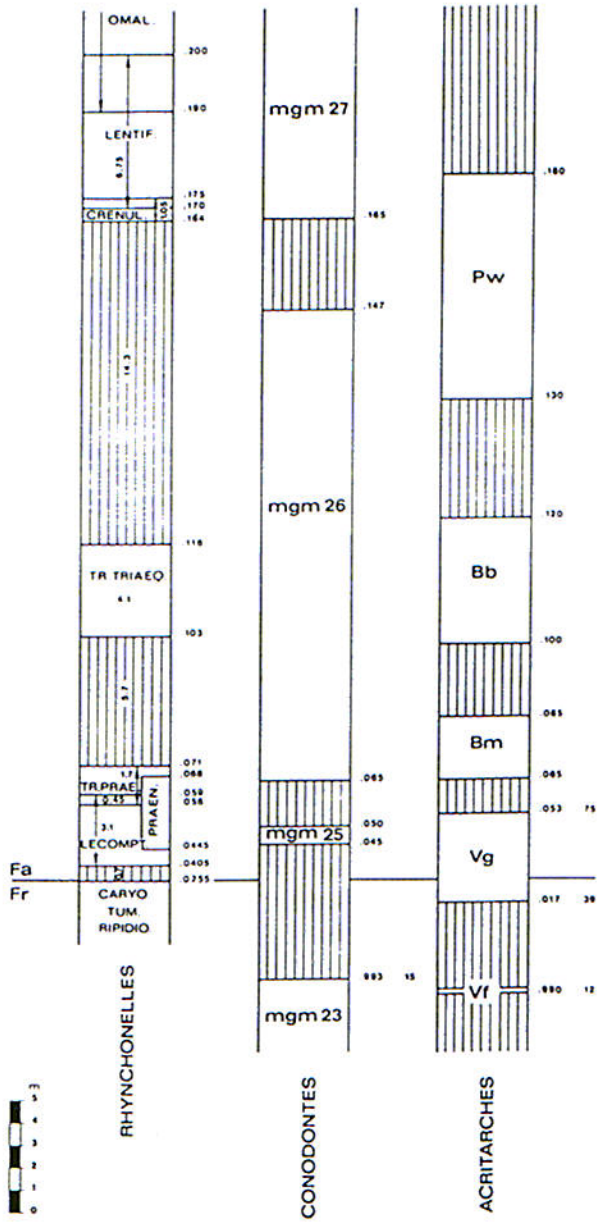

Figure 3

Succession et extension des Zones à Rhynchonelles, Conodontes et Acritarches au contact Frasnien-Famennien de l'ancien stratotype de Senzeilles.

Zonation à Rhynchonelles de Sartenaer (1960) complétée par des informations subséquentes de Sartenaer (1968b et 1973). Zones à Pampoecilorhynchus lecomptei, P. praenux, Eoparaphorhynchus triaequalis praetriaequalis, E. triaequalis triaequalis, E. lentiformis, Tenuisinurostrum crenulatum, Ptychomaletoechia omaliusi. *Interzones stériles en hachuré vertical.*

Zonation à Conodontes d'après Bouckaert & Ziegler (1965) et Mouravieff (1974). Interzones stériles en hachuré vertical ; 15 : distance en m par rapport au pont rouge du niveau 7 de Mouravieff (1974) ; 101.045 à 101.165 : niveaux à Conodontes de Bouckaert & Ziegler (1965).

Zonation à Acritarches (Zones à Visbysphaera (?) fecunda, Villosacapsula globosa, B. medium, B. basiconstrictum, Puteoscortum willieraeae). *Lacunes d'observation ou interzones en hachuré vertical ; distances métriques par rapport au pont rouge (12 à 75) et kilométriques selon les bornes du chemin de fer (101.990 à 101.180).*

Vanguestaine et al., 1983.
Annales Société Géol. Belg.

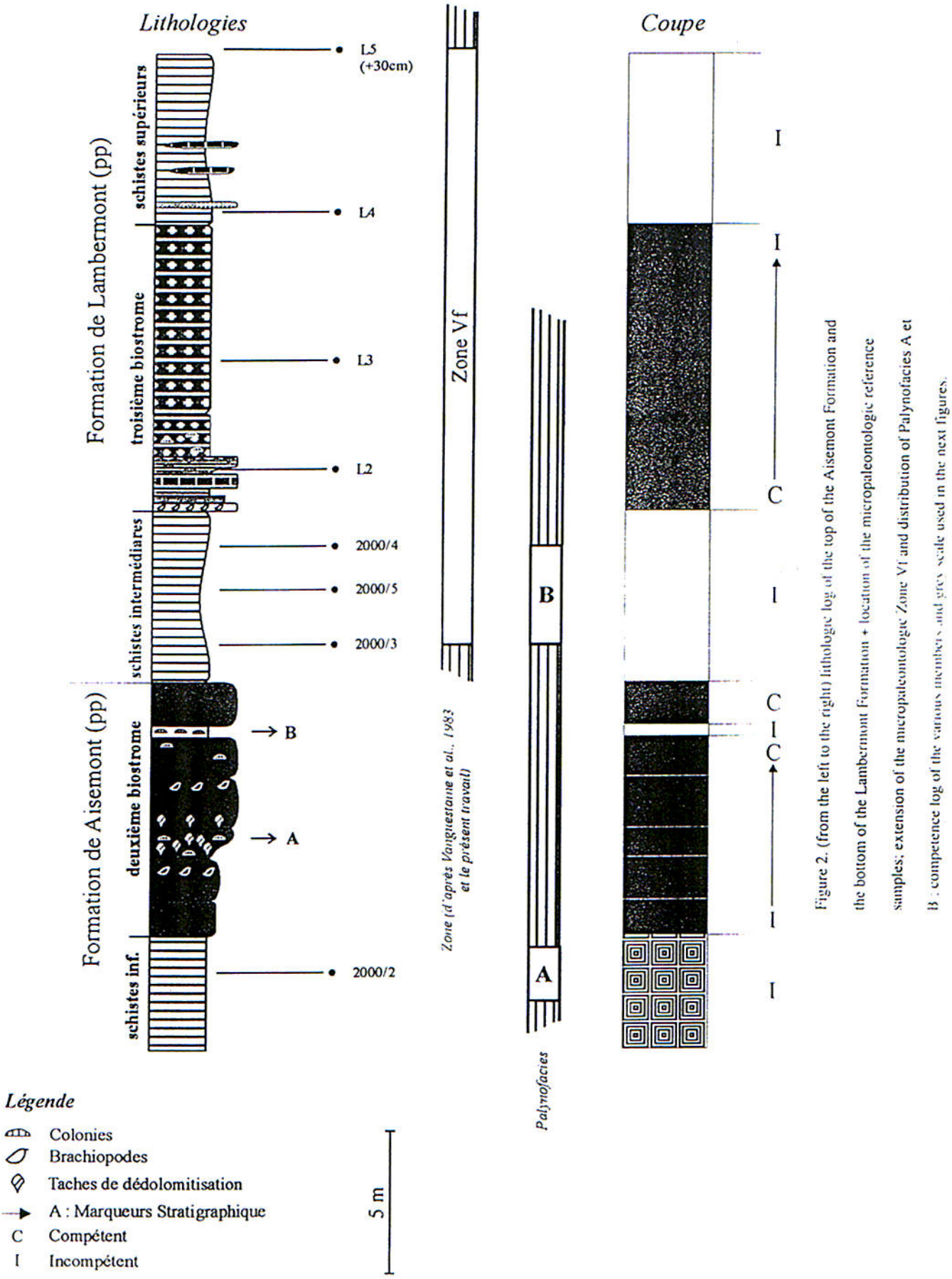

Figure 2. (from the left to the right) lithologic log of the top of the Aisemont Formation and the bottom of the Lambermont Formation + location of the micropaleontologic reference samples; extension of the micropaleontologic Zone Vf and distribution of Palynofacies A et B ; competence log of the various members and grey scale used in the next figures.

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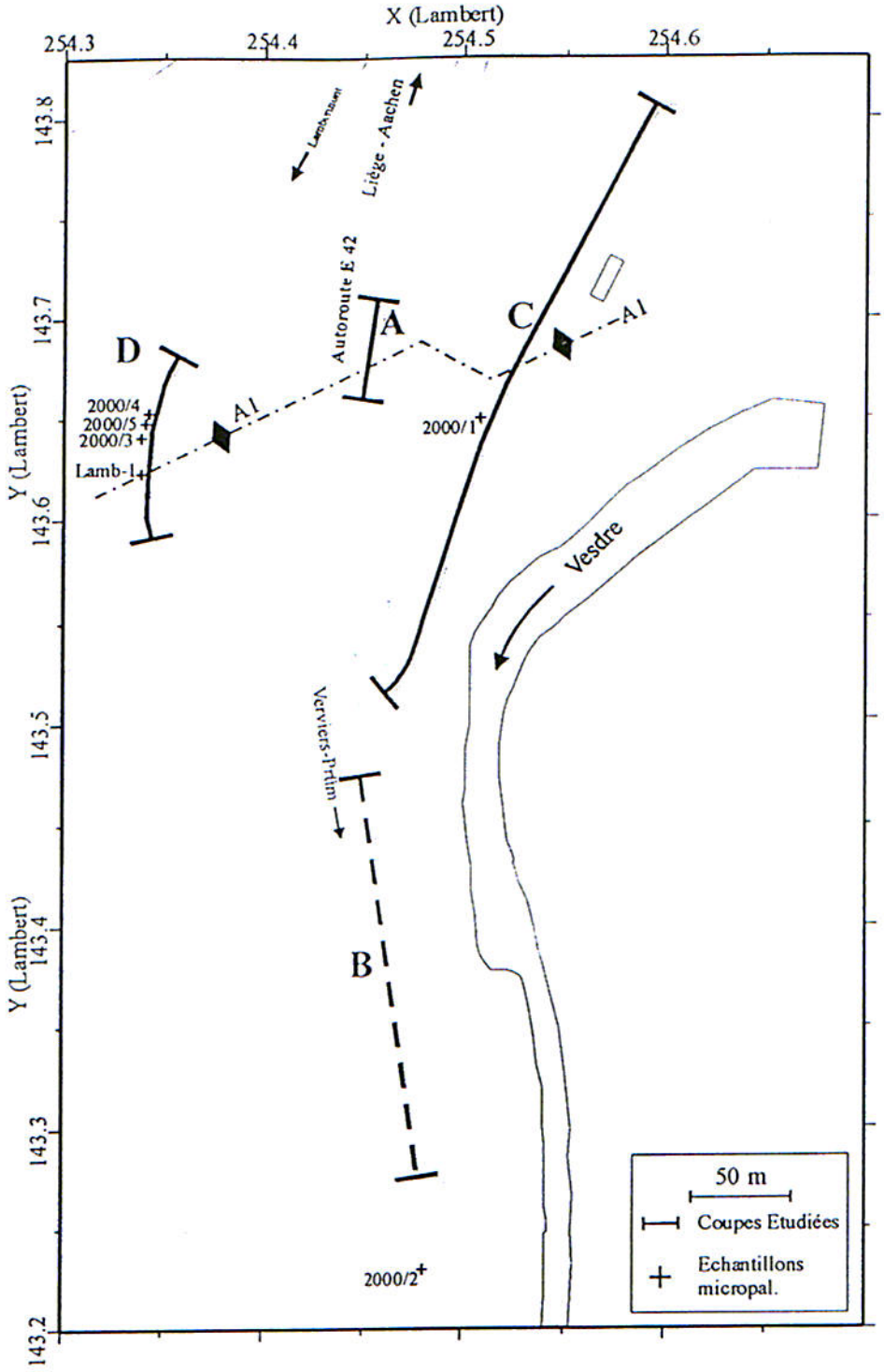
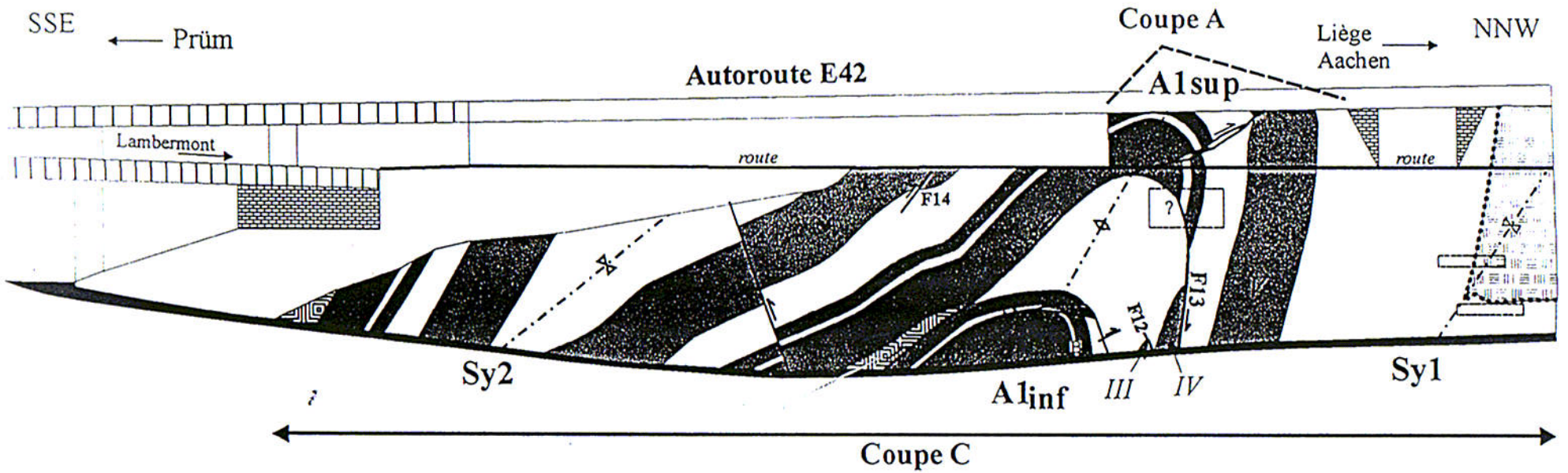
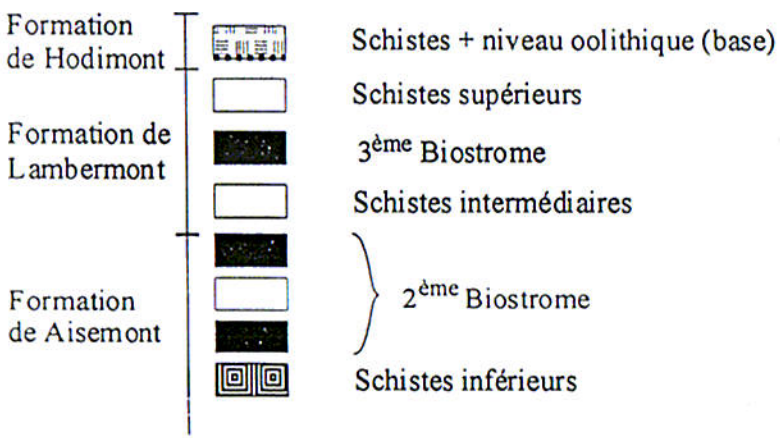


Figure 3. Location map of the fourth studied sections (A-D) along the E42-motorway. The various micropaleontologic samples are also represented. X- and Y-axes represent the Lambert co-ordinates of the study area.





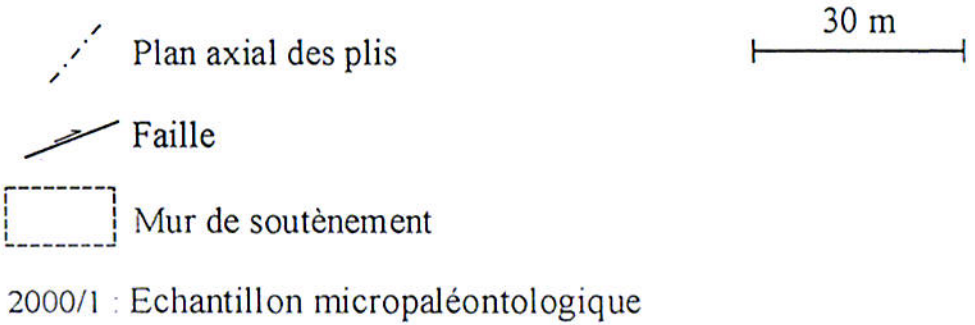


Figure 8. Lambermont section C and A. The structure is composed of two synclines Sy1 and Sy2 separated by the anticline A1. The latter can be divided in two parts: the lower one (A1inf) and the other one (A1sup). This section exhibits a folded detachment level (F13), which induces the tectonic repetition of the second biostrome. The sampling point of the micropaleontologic specimen L2000/1 is also represented.

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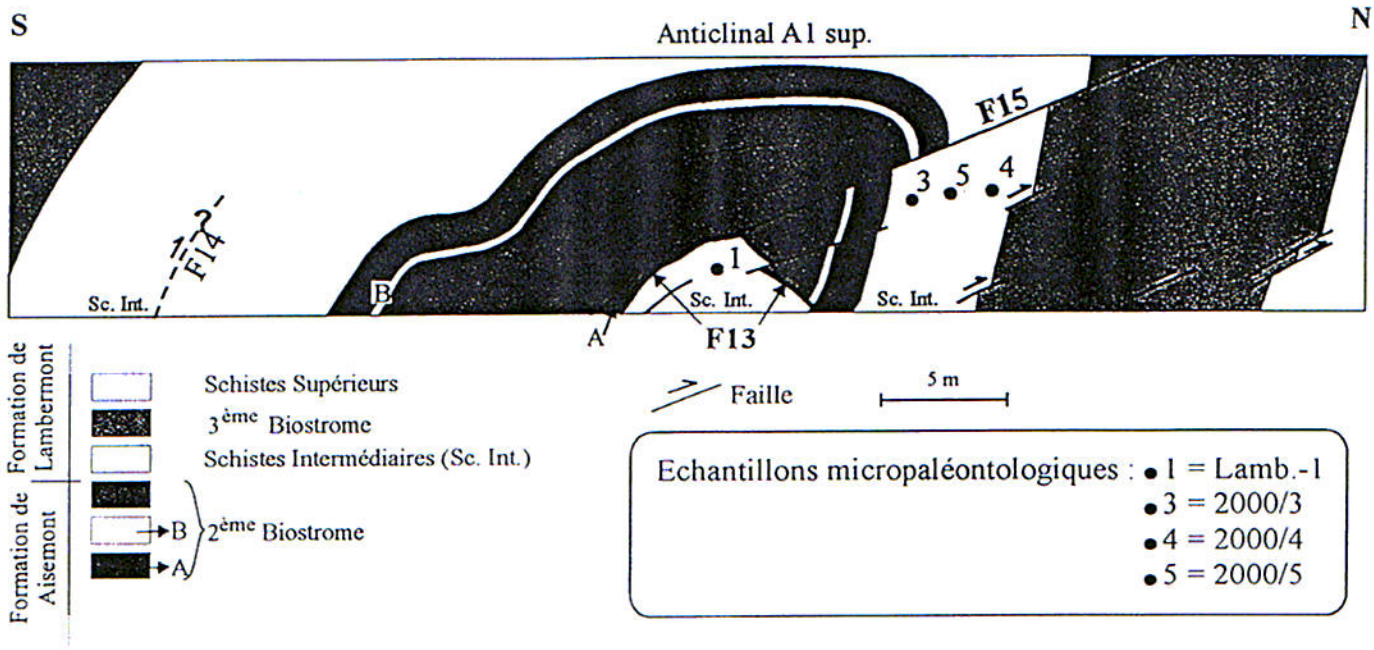

Figure 9. Lambermont section D. The intermediate shale member outcrops along both limbs and within the hinge of the anticline. The latter location is due to the folding of the detachment level F13, which induce the development of a small-scale tectonic window. The sampling points of the micropaleontologic specimens Lamb.-1, L2000/3, L2000/4 and L2000/5 are also represented.

Tableau

	Micrhystridium	Visbysphaera	Autres Acritarches épineux	**Total Acritarches épineux**	Sphaeromorphes	Gorgonisphaeridium	Spores	Scolécodontes	Chitinozoaires	**Total Sphaerom. et al.**	Indéterminés	**Palynofacies**
Lamb.-1	43	17	10	**70**	12	12	4			**28**	2	
L2000/4	59	6	8	**73**	11+9	4	2			**26**	1	**B**
L2000/5	69	8	4	**81**	9+3	1+2	1	1	1	**18**	1	
L2000/3	61	14	8	**83**	8	3	4	1	1	**17**		
L2000/1	20	4		**24**	30+36	3	4	2		**75**	1	
L2000/2	21		2	**23**	15+38	5	5	6	1	**70**	7	**A**
Bellevaux/7	4		3	**7**	15+54	0+1	5+11	-	1+2	**89**	4	
Bellevaux/3	1		1	**2**	9+58	2	3+6	5	1+13	**97**	1	