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PALYNOMORPH DISTRIBUTION IN A SILICICLASTIC LAYER NEAR THE FRASNIAN/FAMENNIAN BOUNDARY AT TWO SHELF FACIES LOCALITIES IN BELGIUM [1]

by

Maurice STREEL & Michel VANGUESTAINE [2]

RESUME

Entre le dernier calcaire contenant la zone à conodontes frasnienne, *linguiformis* et le premier calcaire contenant la zone à conodontes famenienne, *triangularis* inférieure, une séquence de 26 échantillons prélevés dans 150 cm de sédiments siliciclastiques à Hony est comparée à une séquence de 11 échantillons prélevés dans 30 cm de sédiments comparables, à Sinsin.

Dans les deux sections examinées, le total des palynomorphes contenus dans ces sédiments est très variable, de quelques centaines à quelques centaines de mille par gramme de roche.

Cette variation n'est pas aléatoire, mais reflète principalement le taux de sédimentation. Les proportions relatives de miospores et d'acritarches épineux sont également variables et traduisent surtout des variations dans la distance qui séparait le site de sédimentation du paléorivage.

Ces variations évoluent de manière assez semblable dans chacun des profils. Cette similitude résulte plutôt de l'intervention d'un même enchaînement sédimentaire que d'un réel synchronisme comme le démontre l'étude de la composition des assemblages d'acritarches.

On en conclut que les sédiments étudiés représentent un intervalle de temps non négligeable à prendre en compte dans la définition de la limite Frasnien/Famennien.

ABSTRACT

Between the uppermost limestone bed containing the Frasnian *linguiformis* conodont Zone and the lowermost limestone bed containing the Famennian Lower *triangularis* conodont Zone a series of 26 samples in 150 cm of siliciclastics at Hony and a series of 11 samples in 30 cm of siliciclastics at Sinsin are compared.

In both sections, the total amount of palynomorphs is variable, ranging from a few hundreds to a few hundred thousands in one gram of rock.

This variation is not governed by chance but rather reflects the sedimentation rate. The relative proportions of miospores and spiny acritarchs are also variable and are a function of the distance between the site of deposition and the shore-line.

Both variables are developed in a similar pattern in both sections. This similarity is due to a similar behaviour of the sedimentation sequence rather than to a synchronism between the two deposits as shown by the study of the acritarch assemblages.

It is concluded that the investigated sediments represent a rather important time-span that should be taken into account when defining the Frasnian/Famennian boundary level.

MOTS CLE

Palynomorphes, limite, Frasnien, Famennien.

KEY WORDS

Palynomorphs, boundary, Frasnian, Famennian.

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[1] These data have been submitted to the Rennes meeting (August 1988) of the Subcommission on Devonian (IUGS) with the title : Palynomorph distribution in the 'extinction layer' near the Frasnian/Famennian boundary in the shelf facies in Belgium.

[2] Université de Liège, Laboratoire de Paléopalynologie, Place du Vingt-Août 7, B-4000 Liège.

SEDIMENTATION RATE		very low	low	high	very high
Total palynomorphs :		200,000	20,000	2,000	200
SHORE PROXIMITY: Outer offshore		S	M A		
Inner offshore	miospores < spin. acrit. — 8x	Q	O B		
Medium	miospores < spin. acrit. — 4x	R P N	I C		
Nearshore	miospores > spin. acrit.		H D	E	
Very nearshore	miospores only			G	F

Table 1 : environmental conditions as deduced from the palynological composition of siliciclastics from Hony and Sinsin.

1. INTRODUCTION

The two localities of Hony and Sinsin, which are considered in this paper, are located in the north-east of the Dinant Synclinorium (Belgium). The Hony railroad cut is on the north side of the tracks about 100 m east of the railroad stop at Hony. The Sinsin roadcut is on the north side of main highway N4 the junction with secondary highway N929, west of the Pont de Nettinne, near the village of Sinsin. We refer the reader to Sandberg *et al.*, 1988 for description of the sections and their faunas as well as an interpretation of facies.

A very detailed sampling has been carried out in both sections in the siliciclastic occuring between the uppermost limestone containing the Frasnian *linguiformis* conodont Zone and the lowermost limestone containing the Famennian Lower *triangularis* conodont Zone (See fig. 2 and 3). A few cubic centimetres of sediment from each sample were macerated following standard palynological techniques using an 11μm sieve.

The results are based on quantitative and qualitative palynology of the siliciclastics. Concentrations of palynomorphs (expressed as the number of specimens in one gram of rock) were measured by the method of introducing a known amount of exotic modern spores which are tabulated with the "autochtonous" palynomorphs.

Three types of palynomorphs are tabulated : **miospores** assumed to be produced by land plants, **spiny acritarchs** assumed to belong to marine phytoplankton, **other palynomorphs** including leio- and lophospheres (non spiny acritarchs) and related forms of unknown crigin. The systematic analysis of the contents of each sample is beyond the scope of this paper, which will deal only with the quantitative behaviour of the main palynomorph groups. However, a reassessment of the position of the limit between Acritarch Assemblage Zones Vf and Vg as defined by Vanguestaine *et al.*, 1983, will be attempted in both sections.

In these two sections, the totals of palynomorphs recorded in the samples are very variable, ranging from a few hundred to a few hundred thousands in each gram of rock. The relative proportion of miospores/spiny acritarchs is also variable.

Jekhowsky (1963) was one of the first palynologists to fully understand the distribution of palynomorphs in sediments of marine environments. We reproduce here (Fig. 1) some of his statements based mainly on the experience gained by French palynologists working in the petroleum research in the North African Devonian at that time.

Basically, he stated that the abundance of spores and pollen in sediment decreases abruptly (more or less logarithmically) as one moves offshore. He also noted that marine acritarchs increase in abundance in the same direction to a maximum at some distance from the shore-line (and then also decrease). Moreover he showed how the concentration in palynomorphs depended on the rate of sedimentation.

A first glance at the quantitative results obtained for Hony and Sinsin clearly demonstrates that most samples originates from that part of the shelf basin where a dominance of miospores is progressively replaced offshore by a dominance of acritarchs (middle shelf at Hony, outer shelf at Sinsin according to Sandberg *et al.*, 1988). Somewhat independently within this facies range, the concentration of all palynomorphs varies from very high (between 200 and 20 thousands/one gram) to very low (less than 200/one gram) values which are interpreted inversely as very low to very high sedimentation rates (Table 1). The ratio miospores/spiny acritarchs is interpreted as reflecting mainly the distance from the shoreline. The exclusive presence or strong dominance of miospores reflects very nearshore to nearshore conditions. On the other hand, a dominance of spiny acritarchs reflects more offshore conditions (See table 1).

In both sections, the application of these last criteria to the contents of each samples leads to the recognition of sequences of different siliciclastic types characterized by their quantitative palynological composition. These are indicated by the letters A to I in fig. 2 and M to S in fig. 3. In table 1, anal-

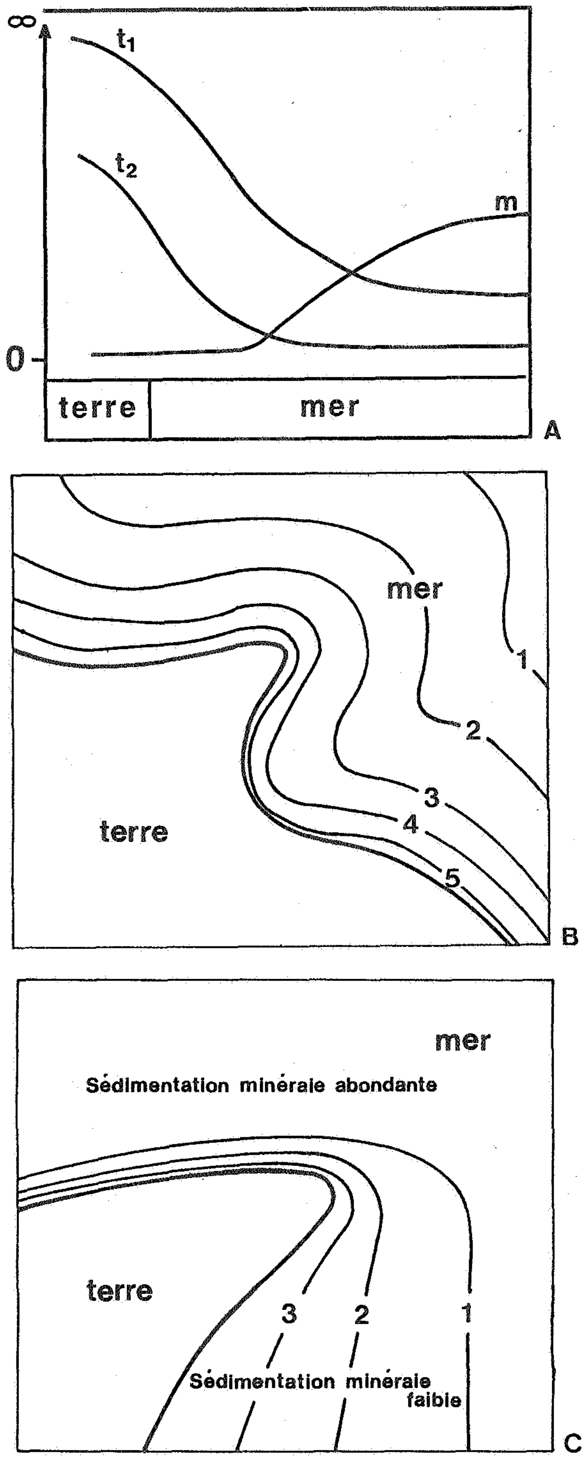

Figure 1. :

A : compared lateral distribution of terrestrial originating (t1 = long ranging, t2 = short ranging) and marine originating (m) organic-walled microfossils from the continent to the sea.
B : isoconcentration lines of t decreasing seawards from the shoreline in an ideal condition of uniform mineral sedimentation rate.
C : isoconcentration lines of t, deformed by a change in the mineral sedimentation rates.
After Jekhowsky, 1963.

ogous types are grouped together, allowing the identification of ten categories of environmental conditions in these samples.

2. HONY RAILROAD CUT (see fig. 2)

A preliminary quantitative and qualitative palynological analysis of part of this section was given in Streel *et al.*, 1987b. These initial results are incorporated into the present paper (see fig. 2).

From A to D, the sedimentation rate of the mudstone is low but the distance from the shoreline gradually decreases. The environment changes gradually from outer offshore to nearshore. In the (fissile) shale, the sedimentation rate increases to high (E), very high (F) and returns to high (G) values with very near-shore conditions in the two higher levels.

The "increased shallowing" (Sandberg *et al.*, 1988) in the upper part of limestone 48t indicated by a change in conodont biofacies, is intensified in the overlying mudstone (which is interpreted as upwardly "decreasing storm layers" by Sandberg *et al.*, 1988), reaching their acme in the shaly part of the section. We interpret these (fissile) shales as resulting from a very sudden discharge and sedimentation of mudstone. As a consequence they are poor in organic matter and show rare bioturbations due to the lack of a benthic fauna (Byers, 1974) for which there might have been not enough time to develop.

This very sudden high rate of sedimentation (F) decreases (G) before the return of the carbonate deposits of bed 48b, where a conodont biofacies, comparable to that of the highest part of bed 48t, is present. The overlying mudstone returns from nearshore (H) to medium distance (I) from the shoreline.

The limestone-deficient interval between beds 48t and 48b at Hony is obviously not an "extinction layer" as far as the (micro)flora is concerned. However, the 35-cm-thick shale bed immediately below bed 48b might well represent some echo of a Frasnian/Famennian event as recently proposed again by McLaren (1988). Such an event would certainly be far more "instantaneous" than the major break in spore development (Richardson & McGregor, 1986) invoked by McLaren (1988, page

2), a limit poorly defined as argumented [3] in Streel *et al.* (1987a, p. 220). We have not seen any sharp change in the miospore assemblages in these sections. The change in acritarch populations from Assemblage Zone Vf to Assemblage Zone Vg (After Streel *et al.*, 1987b) is also found within this shaly interval but not necessarily at its base as erroneously mentioned by Sandberg *et al.* (1988, p. 282).

3. SINSIN ROADCUT (see fig. 3)

Low (M and O) to very low (N and P to S) rates of sedimentation characterise the interval between limestone beds 10a and 12 in this section, which are supposed to have been deposited in an outershelf setting where the percentage of the conodont *Palmatolepis* is still significant (Sandberg *et al.*, 1988, p. 284). The "extinction layer" would be the 17-cm-thick bed of dark-olive-grey mudstone immediately below limestone 12.

4. COMPARISON BETWEEN THE TWO SECTIONS

Palynological samples 4 to 9, corresponding to 15 cm of sediment (3 cm of black mudstone and the lower 12 cm of dark-olive-grey mudstone) are comparable to samples 1 to 11 (82 cm) at Hony : indeed, the ratio of miospores/spiny acritarchs (thickened lines in figs. 2 and 3) evolves in a similar fashion in both sections.

If this similarity implies contemporaneity, then the correlation suggested by the conodont biofacies between the highest part of bed 48t at Hony and the nodular limestone bed 11 at Sinsin, could be approximately confirmed.

However, the boundary Vf/Vg occurs in the Sinsin section between samples 4 and 5, which means that most of the samples 4 to 9 are in the Vg Zone, whereas all samples 1 to 11 in the Hony section are in the Vf Zone. This suggests that apparent similarity does not imply contemporaneity but rather a comparable sedimentological behaviour.

The "extinction layer" of Sandberg *et al.*, 1988 in the Sinsin section, i.e. the 17-cm-thick bed of dark-olive-grey mudstone, is younger than most of the "extinction layer" of the same authors in the Hony section. If the Sinsin section is held to represent a continuous sedimentation, then the last carbonate bed with a *linguiformis* conodont Zone fauna at Hony is older than the last carbonate bed containing the *linguiformis* Zone fauna at Sinsin. If not, a gap, corresponding to one metre of mudstones in the Hony section, is present on top of limestone bed 11 at Sinsin. Palynological samples 10 and 11 were taken at Sinsin, in the 5 cm of dark-olive-grey mudstone immediately below limestone bed 12. Their very high content of spiny

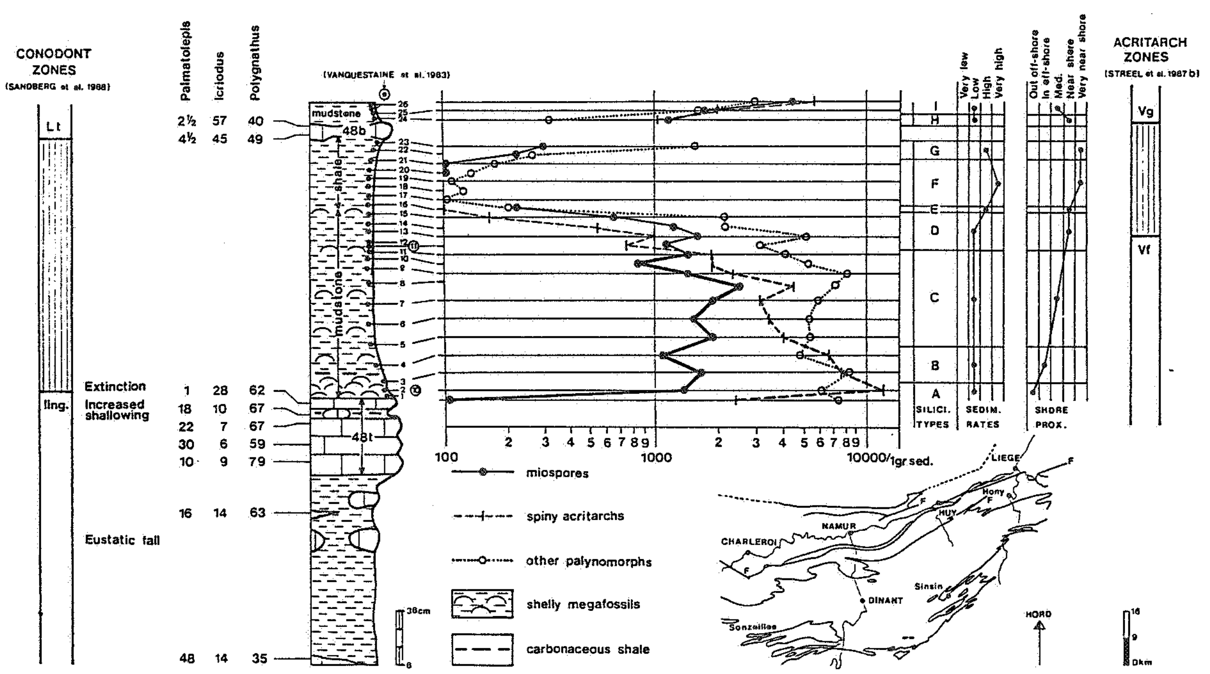

Figure 2 : Palynomorph stratigraphic distribution near the Frasnian/Famennian boundary at the Hony railroad cut. Lithology and conodont zones and biofacies after Sandberg *et al.*, 1988. Acritarch zones after Vanguestaine *et al.*, 1983 and Streel *et al.*, 1987b. See text and table 1 for explanation on siliciclastic types, sedimentation rates and shore-proximity scale. On the map, the thick lines show the outcropping Frasnian/Famennian transitional beds.

[3] The limit between the *ovalis-bulliferus* and the *torquata-gracilis* Assemblage Zones of Richardson & McGregor (1986) is poorly defined. Most of the species assumed to first occur for the same time in the Hanover Shale Formation in the reference section of western New York State, U.S.A. are known to first occur in five successive Interval Zones, crossing the Frasnian/Famennian boundary, in the Boulonnais, in northern France.

acritarchs probably reflects the lowest rate of sedimentation observed in these sections. The very sudden change to a high rate of sedimentation (F) noted in the shale at Hony is not recorded in the Sinsin section which is some 40 km distant. This shaly interval recognised at Hony might be missing at Sinsin.

5. DISCUSSION AND CONCLUSION

The "extinction layer" (which precedes the beginning of the Lower *triangularis* Conodont Zone) is rather complex : sedimentation rates differ greatly not only from one locality to the other but also within each locality. Sandberg *et al.* (1988, p. 283) "believe that mass extinction begins just above bed 48t and is over by the end of the interbedded storm layers, about 100 cm above the top of bed 48t" at Hony. The quantitative palynological study suggests, on the contrary, that the "increased shallowing" detected in the Limestone 48t on conodont evidence continues throughout this 100 cm thick mudstone deposit. The event, if any (Sandberg *et al.*, 1988, p. 297, suggest an actual extinction occurring "in far less than 20,000 years and more likely within a few years or days"), develops rather in the upper part of the siliciclastic interval.

This event is not traceable in the Sinsin section unless we accept that it corresponds to the major change in the acritarch populations (the limit Vf/Vg). In this case, it would here coincide with the extinction base suggested by the conodonts. Consequently, if the Vf/Vg limit is a time-line between these sections, the change in conodont biofacies is not synchronous between these sections or, alternatively, the lowest 100 cm of mudstone in Hony are lacking in Sinsin. Time would thus be better represented by the rocks at Hony than by those at Sinsin. We reach here again (See also Paproth and Streel, 1984, p. 5) the difficulties which arise when placing a Stage boundary at a level where the "guide fossils" themselves record a change in the biofacies.

In support of our point we quote some sentences from Poulton (1987) : "The ultimate dream of the event-stratigrapher, and of any geologist, that events can be proven to be contemporaneous worldwide is, ironically, at risk. This proof can only be achieved where a biostratigraphic, or chronostratigraphic scale is held entirely separately from any scale based on lithological or other physical "events". Extinction may be included in these physical, nonevolutionary events. Clearly, the basal boundary of any interregional chronostratigraphic unit, such as the stage or system, must be defined in a continuous sequence, otherwise its age is lost in a hiatus of unknown duration, and its correlatability becomes impossible".

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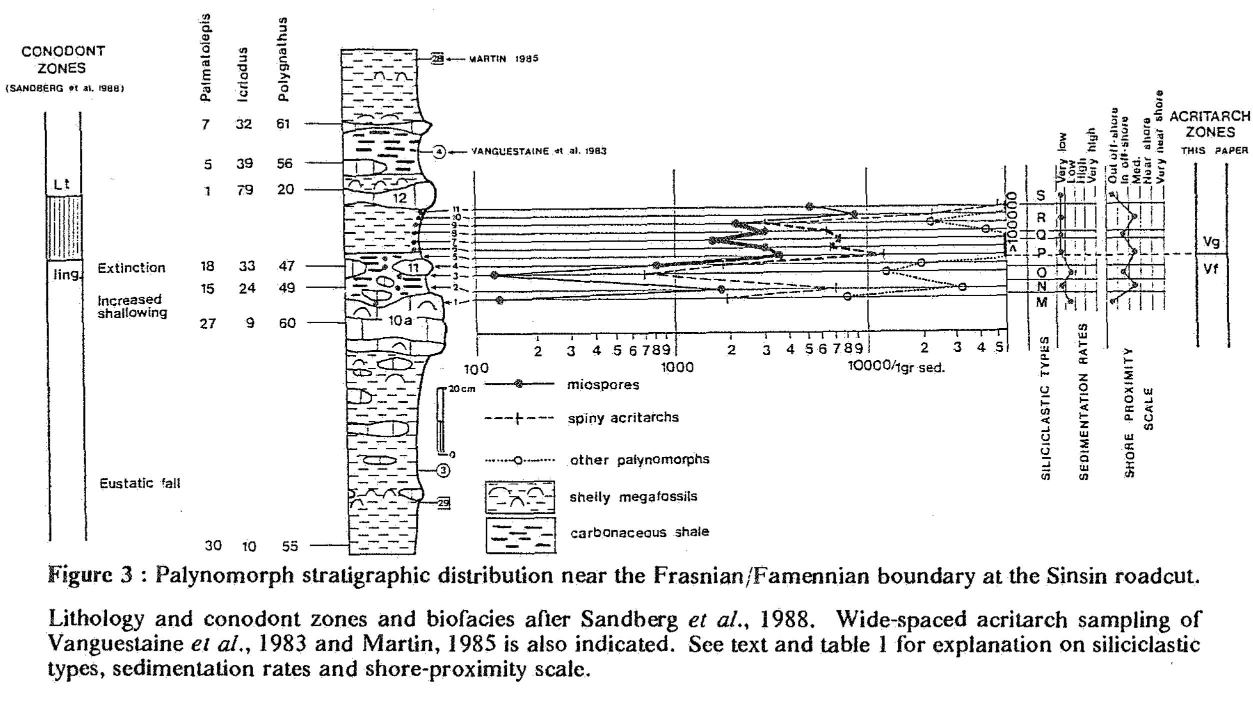

Figure 3 : Palynomorph stratigraphic distribution near the Frasnian/Famennian boundary at the Sinsin roadcut.

Lithology and conodont zones and biofacies after Sandberg *et al.*, 1988. Wide-spaced acritarch sampling of Vanguestaine *et al.*, 1983 and Martin, 1985 is also indicated. See text and table 1 for explanation on siliciclastic types, sedimentation rates and shore-proximity scale.

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