

THE DEVONO-CARBONIFEROUS TRANSITION IN THE FRANCO-BELGIAN BASIN WITH REFERENCE TO FORAMINIFERA AND BRACHIOPODS

by

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(4 figures and 1 table)

ABSTRACT. - After a brief summary of the most striking evolutionary trends of the Upper Frasnian through Lower Tournaisian foraminifer assemblages in Northwestern Europe, some new biostratigraphic data are discussed mainly from an important section near St. Hilaire (Avesnois area, Northern France) as well as their impact on the problem of the Devonian-Carboniferous boundary in the Franco-Belgian Basin.

RESUME. - Après un bref résumé des tendances évolutives les plus marquées des assemblages de foraminifères du Frasnien supérieur au Tournaisien inférieur du Nord-Ouest de l'Europe, quelques nouvelles données biostratigraphiques sont discutées provenant en particulier d'une importante coupe près de St. Hilaire (Avesnois, Nord de la France) ainsi que leur impact sur le problème de la limite Dévonien-Carbonifère dans le Bassin franco-belge.

The first appearances and the modifications of the Frasnian through Lower Tournaisian foraminifer assemblages reflect significant paleogeographic and ecologic changes in Western Europe (Conil & Lys, 1977, p. 10).

1. In the Franco-Belgian Basin, the **Middle Devonian-Frasnian** foraminifer association is characterized by *Nanicella*. This form has not been observed above the Frasnian-Famennian boundary. Its highest occurrence has recently been recorded from the uppermost Frasnian reef level (red "F2j"-type mudmounds) in southern Belgium, which corresponds to the Upper *P. gigas* Zone (Sandberg & Dreesen, in Johnson *et al.*, 1985 : fig. 2 and p. 577). A fairly similar association (zone 3) has been recorded by Kaldova from the Frasnian in Moravia. However, here it ranges into the Lower Famennian and disappears within the *P. crepida* Zone (Friakova *et al.*, 1985).

2. The next foraminifer zone (zone 4 in Moravia) corresponds to the extinction of a long-ranging foraminifer fauna in the Franco-Belgian Basin, and precedes the quick development of new evolutionary trends leading to the characteristic Carboniferous foraminifer faunas. The root of this new stock consists of a few primitive tournayellids only (Conil & Lys, 1977, tab. 2).

3. Foraminifera reappear in the **Mid-Famennian** and characterize the zone Df3 of Conil *et al.*, (1977) in the shallow Condroz shelf areas (*P. marginifera* Zonal intervals). Here, an important migration concomitant with a short-term transgressive pulse introduced a new, but already rather complex foraminifer assemblage in the Franco-Belgian Basin (Bouckaert, Conil & Thorez, 1967; Dreesen *et al.*, 1985, p. 346). However, the persistence of siliciclastic influx and the general regressive trend during most of the "Fa2bc", are unfavourable for the development of foraminifera in the Franco-Belgian Basin and in the Campine Basin (Bless *et al.*, 1981). Only in a few outcrops, it can be demonstrated that the evolution of *Quasiendothyra* is very slow below the LV spore zone. The following species appear successively : *Q. bella*, *Q. communis* (Conil & Lys, 1968, fig. 126; Bouckaert, 1968 : 47, 51) and *Q. regularis*.

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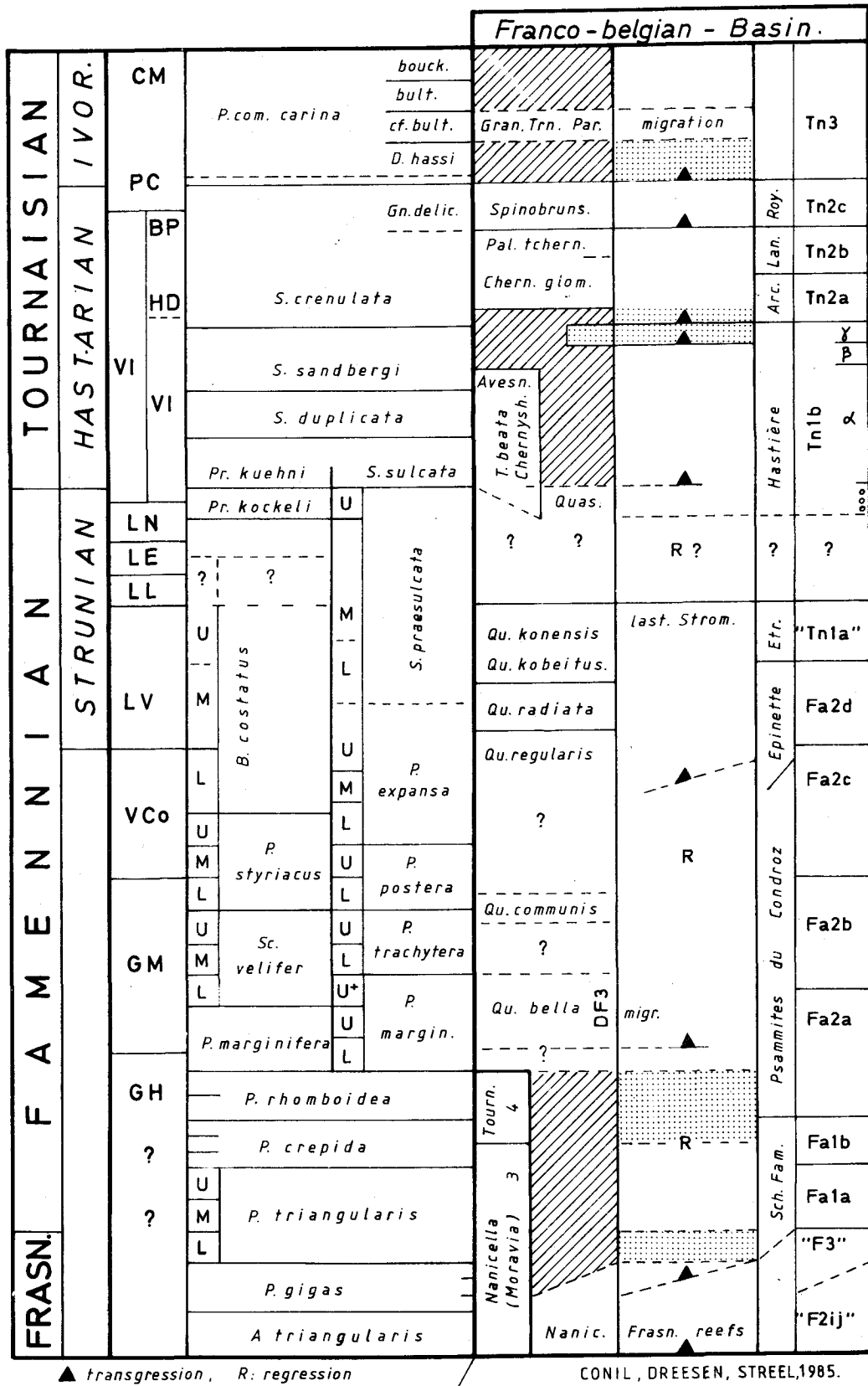


Figure 1. - Tentative correlation chart of miopore, conodont and foraminifer Zones from the Franco-Belgian Basin : transgressions and extinctions are indicated by symbols (see legend below table), ecological events by stippled areas. The shaded areas represent intervals where foraminifera are absent or where only unilocular forms and *Earlandia* occur. Note : Gran-Trn. Par. : *Granuliferella*, *Tournayella*, *Paraendothyra*. (from Conil, Dreesen & Streel, 1985, unpublished).

During this particular stratigraphic interval, the Avesnois area remains predominantly marine, with perhaps one short-term emersion period (Conil, Lys & Paproth, 1964, pl. I, k/l). In this region, foraminifera are known from the VCo spore zone, but only where fossiliferous limestone microfacies prevail. The following taxa have been identified: *Avesnella*, *Rectoavesnella*, *Rectoseptaglomospiranella* (Conil & Lys, 1970, p. 261).

On the other hand, the coeval lagoonal facies in the Ourthe Valley, have yielded abundant *Cryptophyllus* (ostracodes), *Quasiumbella*, *Ellenia* and unilocular foraminifera only (Conil & Lys, 1964, pl. V, "Fm2b").

4. The uppermost Famennian transgression starts in the upper part of the VCo spore zone. The lithological change at this stratigraphic level is more pronounced in the southern part of the Franco-Belgian Basin. At St. Hilaire and Avesnelles (Northern France) it is even possible to follow the transgressive event in detail, as well as the progressive faunal colonisation. The *Quasiendothyra*-tournayellid assemblage, the corals and the stromatopores appear very gradually (Conil *et al.*, 1975, p. 14-16, beds 88-92). Furthermore, due to the considerable thickness of the carbonate deposits, it is possible to study the evolution of the *Quasiendothyra* Zone in great detail, up to the top of the Calcaire d'Étroeungt s.l. (beds 146-190 at Avesnelles; beds 1-8 at St-Hilaire, railway cut):

- diversification of the tournayellids with microgranular wall;
- development of the endothyroids leading to a remarkable differentiation of the wall structure ("*Endothyra*" *parakosvensis struniana* Conil & Lys, 1964);

- rapid evolution of *Quasiendothyra*: *Q. regularis*; *Q. radiata*; *Q. kobeitusana*; *Q. konensis*, large *Klubovella* species with double wall (Conil & Lys, 1967, fig. 9) and large *Quasiendothyra* species with strong chomata and inflated septa (*Q. rafaëli* Grozdilova, 1975: Conil & Lys, 1964, fig. 806). All specimens of *Quasiendothyra* figured in W. Europe come from the Strunian and not from the Calcaire d'Hastièrre (Tn1b). This correction has to be applied in Conil & Lys, 1964, pl. XXXIX, and in Conil, Lys & Paproth, 1964, pl. IX, X. The drawings have been improved in Conil, 1968, table III, in Conil & Graulich, 1970, pl. XI, XII and in Paproth, Conil *et al.*, 1983, p. 216, Hastièrre, remarque). Thus the evolution of *Quasiendothyra* seems to be nearly completed in the LV spore zone, as shown by comparison with the faunas of the Omolon region in NE-Siberia (Shilo *et al.*, 1984). The last representatives of this fauna - apparently very large specimens, according to Reitlinger (1961) - are unknown in Western Europe.

From the Ourthe Valley towards Aachen (FRG), the colonisation becomes more completed, from the first stromatoporoid "biostrome" level onwards. Limestones become gradually more important towards the top of the Strunian sequence. Micropaleontological analysis of the Tohogne borehole and the Yves-Gomezée road section, has revealed two important details for the biostratigraphic zonations: first, *Protognathodus meischneri* appears near the base of the LV spore zone (Bouckaert & Dusar, 1976, fig. E; Dreesen, Dusar & Groessens, 1976); secondly, *Quasiendothyra kobeitusana* appears within the first "biostrome" (Bouckaert *et al.*, 1978, fig. 87).

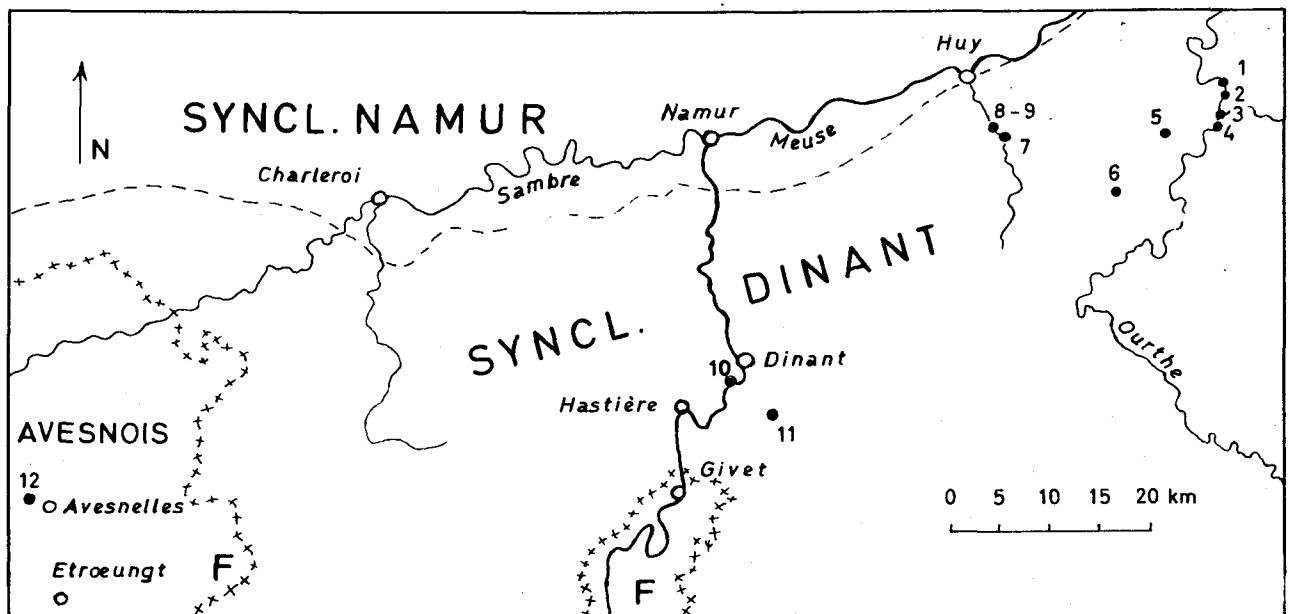


Figure 2. - Localisation of the outcrops.

1. Chanxhe; 2. Rivage, quarries; 3. Rivage, railroad station; 4. Comblain, railroad tunnel, south; 5. Anthisnes (Conil, Lys & Paproth, 1964, p. 52); 6. Jenneret; 7. Modave (ibid. p. 44; Austin, Conil *et al.*, 1970, p. 309); 8-9. Royseux; 10. Anseremme; 11. Gendron-Celles; 12. St-Hilaire (Conil, Lys & Paproth, 1964, p. 24, 4; Conil & Lys, 1970, p. 244).

5. **The Devonian-Carboniferous transition and the Tournaisian transgression.** In spite of detailed studies, micropaleontological evidences are either lacking or unsatisfactory near the lithological boundary between the Etroeungt and Hastière-Avesnelles Formations. The presence of an erosional unconformity, a non-deposition event, or paleontological condensations at this particular level, is still a matter of discussion. In a large part of the Franco-Belgian Basin, the boundary is rather sharp-cut between the Calcaire d'Etroeungt and the Calcaire d'Hastière and especially between the Calcaire d'Etroeungt and the Calcaire Noir d'Avesnelles. Some rare new biostratigraphic data recently suggested that the lowermost part of the Calcaire d'Hastière could be of Devonian rather than of Carboniferous age (Austin, Conil *et al.*, 1970, p. 309; Van Steenwinkel, 1984, p. 58).

This possibility has been reexamined in most of the reference sections in Belgium and in the Avesnois area (France) (fig. 2).

5.1. **Calcaire d'Hastière** (Belgium; Paproth *et al.*, 1983). Systematically, the first layers of the Calcaire d'Hastière contain an impoverished population of Strunian-type Foraminifera with *Quasiendothyra*, in association with *Cryptophyllus* (fig. 3). The same layers yield locally, at least in their lower part, a macrofauna (Brachiopods, Trilobites) with clear Devonian affinities.

In general the Strunian brachiopod fauna has the aspect of a transitional fauna. Devonian elements (majority) are mixed with Carboniferous elements (minority). In the different brachiopod groups, the transition from Devonian to Carboniferous forms takes place at quite different times. But as a whole the Strunian brachiopod fauna is very characteristic and can easily be recognized all over the world. In the Franco-Belgian Basin there is a very sharp upper boundary of Strunian-type associations, the principal guide forms like *Phacops (Omegops)*, *Sphenospira julii*, *Eobrachythyris struniana*, *Araratella moresnetensis*, and *Whidbornella caperata* all disappearing at about the same level i.e. within the first meter of the Calcaire d'Hastière, but unfortunately there is no sharp lower boundary of the Hastarian-type macrofauna. This missing of an immediate replacement of the Strunian by a Carboniferous macrofauna is principally due to the scarcity of macrofossils in the Calcaire d'Hastière, but also to the gradual incoming of its characteristic elements. So, *Unispirifer* and *Tylothyris* occur already in the Calcaire d'Etroeungt whereas others like *Syringothyris* and *Brachythyris* are only found well up in the Calcaire d'Hastière. Consequently, on the basis of the macrofauna, the Devonian-Carboniferous boundary has to be traced by using a negative criterium, namely by the disappearance of the Devonian fauna, rather than by a positive one which would be the beginning of the Carboniferous fauna.

Table 1. - Occurrence of some selected macrofossils in the Calcaire d'Etroeungt and in the basal meter of the Calcaire d'Hastière

	Calcaire d'Etroeungt 2,6,8,9,10,11: topmost 1-2 m	Calcaire d'Hastière (basal 1 m)
* <i>Phacops (Omegops) sp.</i>	6,8,9,10,11	8,9
* <i>Sphenospira julii</i>	1,2,6,8,10,11	8,9
* <i>Eobrachythyris struniana</i>	2,8	8,9
* <i>Kitakamithyris microgemma</i>	1	
<i>Cyrtospirifer</i>	1,8,11	
<i>Unispirifer</i>	1	
* <i>Araratella moresnetensis</i>	1,2,3,8,10,11	8
<i>Centrorhynchus</i>	1,3,6,11	
<i>Rugosochonetes</i>	1,3,6,8	8,9
<i>Nigeroplica nigra</i>	3,6,8,11	8,9
* <i>Hamlingella goergesi</i>	1	
* <i>Whidbornella caperata</i>	1,8	8
* <i>Aulacella interlineata</i>	3,11	
<i>Schuchertella</i>	6,8	
<i>Streptorhynchus</i>	1,8	8

1. Chanxhe (Conil, Lys & Paproth, 1964, p. 50, pl. VIII bed 147, 15 m below the top of the Calcaire d'Etroeungt).
2. Rivage quarries (ibid. pl. IX).
3. Rivage railroad station (ibid. p. 46, pl. IX-X, bed 160, 7 m below the top of the Calcaire d'Etroeungt).
6. Jenneret (ibid., p. 53 a; emend. Conil, 1968, pl. III).
8. Royseux railroad station (Austin, Conil *et al.*, 1970, p. 309, Huy 15/104-105). Bed 108 contains *Unispirifer*, *Tylothyris laminosa*, *Schuchertella*.
9. Royseux road section (ibid., p. 309, Huy 2/82-83).
10. Anseremme, railway cut (Conil, Lys & Paproth, 1964, p. 30).
11. Gendron-Celles, quarry near the road (ibid., p. 36).

* Guides which have never been found in beds younger than Strunian.

5.2. **Calcaire Noir d'Avesnelles** (Avesnois area, N. France). The transition of the Calcaire d'Etroeungt to this formation is even sharper. A black and pure limestone, poor in macrofossils, succeeds the argillaceous sediments which are rich in corals and stromatoporoids (fig. 4). The foraminifer fauna with *Quasiendothyra* disappears, while the basal part of the Calcaire d'Avesnelles contains, over 2 m, an association of tournayellids and *Cryptophyllus*. Immediately above, the association of tournayellids contains many *Tournayellina beata* (Conil & Lys, 1970, pl. 13*). The transition from black biomicrites to black pelsparites (beds 21/22) does not affect the foraminifer association.

* The specimen figured in Conil & Lys (1970) as a Strunian one comes in fact from the upper part of the Calcaire d'Avesnelles (pl. 12, fig. 120, RC 6364 (6909), Avesnes 1/21). N.B. The bed member 19 of the plate 13 has to be changed into 21.

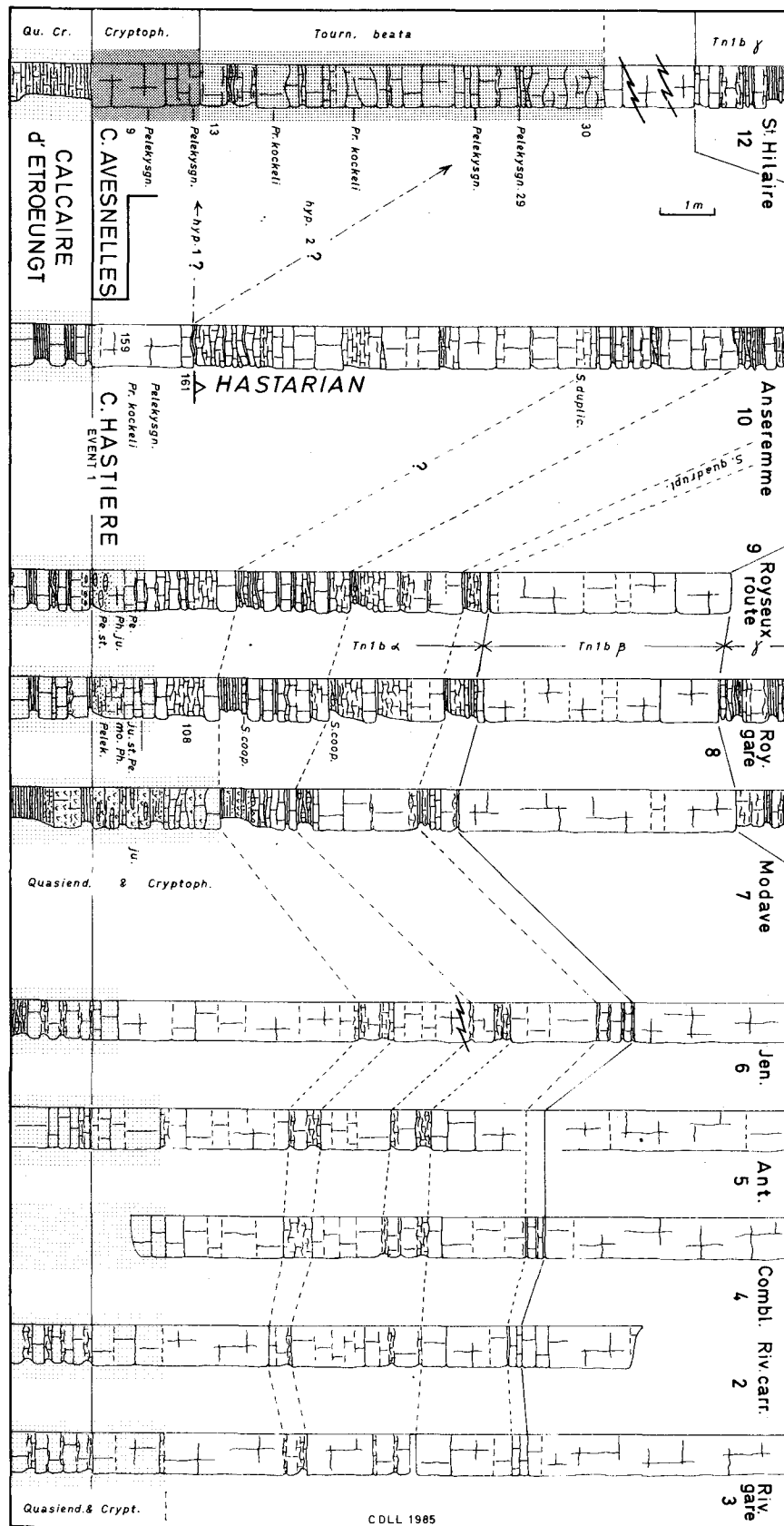


Figure 3. - Stratigraphic correlation of the major sections in the Franco-Belgian Basin displaying the Devonian-Carboniferous transition.
 Jen. : Jenneret; Tav. : Tavier; Combl. : Comblain-au-Pont; Riv. : Rivage (Conil, 1968, pl. III);
 ju : *Sphenospira julii*; mo : *Araratella moresnetensis*; Pelek : *Pelekysgnathus*; Ph : *Phacops*; Qu. Cr. : *Quasiendothyra*,
Cryptophyllus; st : *Eobrachythyris struniana*; s : *Siphonodella*.

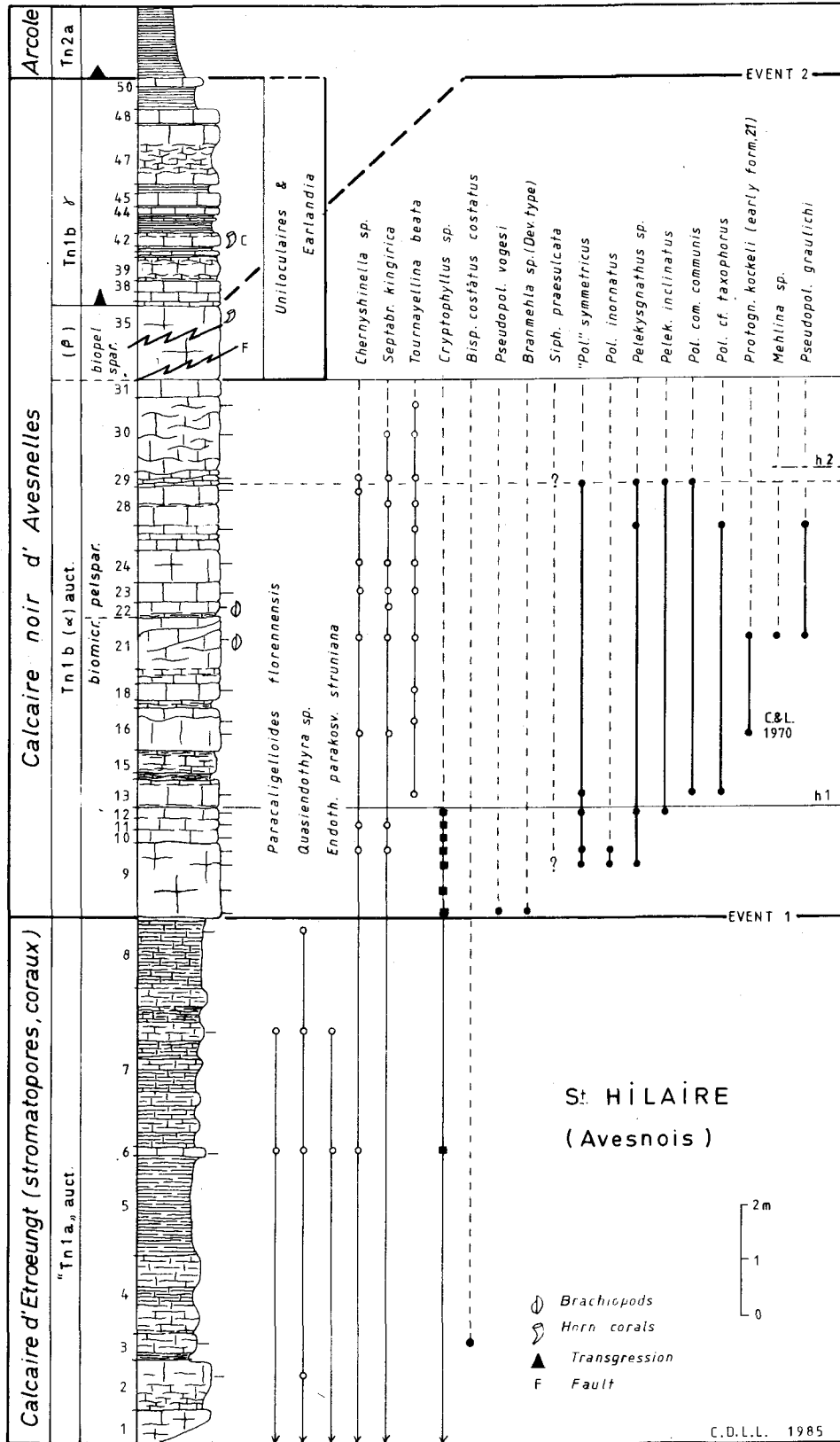


Figure 4. - Columnar section of the St-Hilaire railway cut.

Note the succession of 3 micropaleontological associations : *Quasiendothyra* + *Cryptophyllus*; *Tournayellidae* + *Cryptophyllus*; *Chernyshinella* + *Tournayellina beata*.

h1, h2 : hypothesis of correlation with the base of the Hastarian. Bed 42 c : *Cyathaxonia cornu*.

Tournayellina beata is essentially known from the Tournaisian in the USSR, and does not occur below the Upinsky Horizon, except for one isolated specimen from the C1ta of the Donbass area (personal communication of O.A. Lipina). The lowest occurrence of this species corresponds also to the Lower Hastarian in the Netherlands (Bless, Boonen *et al.*, 1981, pl. 12, fig. 5-7) and to the Hastarian in Turkey; (Dil 1976, pl. 2, fig. 23).

The same species has been listed under the name of *Tournayellina primitiva* in the Southern Urals (Berchogur; Barskov, Simakov *et al.*, 1984**, p. 210) above Devonian miospores (LN) and below *Siphonodella sulcata*. The conodont fauna collected by Conil and Lentz in the section of St-Hilaire is listed on fig. 4. This occurrence of a Devonian-type conodont association is quite unexpected, and would imply a correlation of at least the 8 lower meters of the Calcaire d'Avesnelles with the basal bed of the Calcaire d'Hastière (fig. 3).

Two possible explanations can be forwarded here. The first idea is that most of the Calcaire Noir d'Avesnelles is of Tournaisian age, according to the foraminifer assemblage (beds 13-30), which is well known in the Tournaisian of other countries; in that case conodonts could possibly have been reworked from the Devonian into the Lower Tournaisian.

The second idea is that an important part of the Calcaire Noir d'Avesnelles (beds 9-29) is of Devonian age, according to the conodont faunas, and would belong to the Upper *praesulcata* subzone, at least from the bed 16; therefore it could be correlated with the lowest part of the Calcaire d'Hastière (beds 159-161). Thus the "Tournaisian" foraminifer assemblage here observed (beds 13-30) would occur in the Uppermost Devonian. However this low range has never been recorded before in other countries. Anyway, the microfaunal assemblages and the Devonian-Carboniferous boundary occur between two events; the first one corresponds to a widespread extinction of the Strunian stromatoporoids in Europe, the second one introduces the second Tournaisian sequence and could correspond to the "Unilocular foraminifer zone" of the USSR. (Tn1b γ -Tn2a; Shilo, Bouckaert *et al.*, 1984, p. 140, fig. 4).

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** The specimens of *Berchogur* are practically identical to the specimens of *St-Hilaire*, as it has been verified on the original material by Simakov & Conil.

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REFERENCES

- AUSTIN, R., CONIL, R., RHODES, F. & STREEL, M., 1970. Conodontes, spores et foraminifères du Tournaisien inférieur dans la vallée du Hoyoux. *Ann. Soc. géol. Belg.*, 93 : 305-315.
- BARSKOV, I.S., SIMAKOV, K.V., ALEKSEEV, A.S., BOGOSLOVSKY, B.I., BYVSHEVA, T.V., GAGIEV, M.H., KONONOVA, L.N., KOCHETKOVA, N.M., KUSINA, L.F. & REITLINGER, E.A., 1984. Devonian-Carboniferous transitional deposits of the Berchogur section, Mugodzary, USSR. *Cour. Forsch.-Inst. Senckenberg, Frankfurt a. Main*, 67 : 207-230.
- BLESS, M.J.M., BOONEN, P., BOUCKAERT, J., BRAUCKMANN, C., CONIL, R., DUSAR, M., FELDER, P.J., FELDER, W.M., GOKDAG, H., KOCKEL, F., LALOUX, M., LANGGUTH, H.R., VAN DER MEER MOHR, C.G., MEESEN, J.P.M.Th., OP HET VELD, F., PAPROTH, E., PIETZNER, H., PLUM, J., POTY, E., SCHERP, A., SCHULTZ, R., STREEL, M., THOREZ, J., VAN ROOIJEN, P., VANGUESTAINE, M., VIESLET, J.L., WIERSMA, D.J., WINKLER PRINS, C.F. & WOLF, M., 1981. Preliminary report on Lower Tertiary-Upper Cretaceous and Dinantian-Famennian rocks in the boreholes Heugem-1/1a and Kastanjelaan-2 (Maastricht, the Netherlands). *Meded. Rijks Geol. Dienst*, 35-15 : 333-415.
- BOUCKAERT, J., 1968. Etude géologique des retenues de l'Eau d'Heure et de la Plate-taille. *Serv. géol. Belg.*, Prof. Pap., 1968, 5 : 1-49.
- BOUCKAERT, J., CONIL, R., DUSAR, M. & STREEL, M., 1978. Stratigraphic interpretation of the Tohogne borehole (Province of Luxembourg). Devonian-Carboniferous transition. *Ann. Soc. géol. Belg.*, 100 : 87-101.
- BOUCKAERT, J. & DUSAR, M., 1976. Description du sondage de Tohogne. *Serv. géol. Belg.*, Prof. Pap., 1976, 8 : 1-10.
- BOUCKAERT, J., CONIL, R. & THOREZ, J., 1967. Position stratigraphique de quelques gîtes famenniens à Foraminifères. *Bull. Soc. belg. Géol.*, LXXV : 159-175.
- BOUCKAERT, J. & GROESSENS, E., 1976. *Polygnathus paprothae*, *Pseudopolygnathus conili*, *Pseudopolygnathus graulichii* : espèces nouvelles à la limite Dévono-Carbonifère. *Ann. Soc. géol. Belg.*, 99 : 587-599.
- CONIL, R., 1968. Le Calcaire carbonifère depuis le Tn1a jusqu'au V2a. *Ann. Soc. géol. Belg.*, 90 : B687-726.
- CONIL, R. & GRAULICH, J.M., 1970. Les sondages d'études et d'injection du Viaduc 62 (Welkenraedt) de l'autoroute E. 5. *Serv. géol. Belg.*, Prof. Pap., 1970, 4 : 68.
- CONIL, R., GROESSENS, E., LEJEUNE, M., PEL, J. & TSIEN, H.H., 1975. Second international symposium on fossil corals and reefs. Guidebook, Excursion C. *Serv. géol. Belg.*
- CONIL, R., GROESSENS, E. & STREEL, M., 1974. Guidebook Excursion H, Avesnois. *Intern. Symp. Namur*, 1974 : 1-12.

- CONIL, R. & LYS, M., 1964. Matériaux pour l'étude micropaléontologique du Dinantien de la Belgique et de la France (Avesnois). *Mém. Inst. géol. Univ. Louvain*, XXIII : 1-372.
- CONIL, R. & LYS, M., 1967. Aperçu sur les associations de foraminifères endothyroïdes du Dinantien de la Belgique. *Ann. Soc. géol. Belg.*, 90 : B395-412.
- CONIL, R. & LYS, M., 1968. Utilisation stratigraphique des foraminifères du Dinantien. *Ann. Soc. géol. Belg.*, 91 : 491-558.
- CONIL, R. & LYS, M., 1970. Données nouvelles sur les foraminifères des couches de passage du Famennien au Tournaisien dans l'Avesnois. *Congrès et Coll. Univ. Liège*, 55 : 241-265.
- CONIL, R. & LYS, M., 1977. Les transgressions dinantiennes et leur influence sur la dispersion et l'évolution des foraminifères. *Mém. Inst. géol. Univ. Louvain*, 29 : 9-55.
- CONIL, R. & LYS, M., 1980. Le Strunien. *In* : Les Etages français et leurs stratotypes. BRGM, Orléans, 109 : 26-35.
- CONIL, R., LYS, M. & PAPROTH, E., 1964. Localités et coupes-types pour l'étude du Tournaisien inférieur (Révision des limites sous l'aspect micropaléontologique). *Mém. Acad. Roy. Belg., Cl. Sc., Mém. 4^o, 2e sér.*, XV, 4 : 1-105.
- DIL, N., 1976. Assemblages caractéristiques de foraminifères du Dévonien supérieur et du Dinantien de Turquie (Bassin Carbonifère de Zonguldak). *Ann. Soc. géol. Belg.*, 99 : 373-400.
- DREESEN, R., BLESS, M.J.M., CONIL, R., FLAJS, G. & LASCHET, Ch., 1985. Depositional environment, paleoecology and diagenetic history of the "Marbre Rouge à crinoïdes de Baelen" (Late Upper Devonian, Verviers synclinorium, Eastern Belgium). *Ann. Soc. géol. Belg.*, 108 : 311-359.
- DREESEN, R., DUSAR, M. & GROESSENS, E., 1976. Biostratigraphy of the Yves-Gomezée road section. *Serv. géol. Belg., Prof. Pap.* 1976, 6 : 20 p.
- FRIAKOVA, O., GALLE, A., HLADIL, J. & KALVODA, J., 1985. A Lower Famennian fauna from the top of the reefoid limestones at Mokra (Moravia, Czechoslovakia). *Newsl. Stratigr.* 15 (1) : 43-56.
- JOHNSON, J.G., KLAPPER, G. & SANDBERG, C.A., 1985. Devonian eustatic fluctuations in Euramerica. *Geol. Soc. of America Bull.*, 96 : 567-587.
- MOURAVIEFF, N. & BULTYNCK, P., 1967. Quelques foraminifères du Couvinien et du Frasien du bord sud du Bassin de Dinant. *Bull. Soc. belg. Géol.* LXXV (2) : 153-156.
- PAPROTH, E., CONIL, R., BLESS, M.J.M., BOONEN, P., BOUCKAERT, J., CARPENTIER, N., COEN, M., DELCAMBRE, B., DEPRIJCK, Ch., DEUZON, S., DREESEN, R., GROESSENS, E., HANCE, L., HENNEBERT M., HIBO, D., HAHN, G. & R., HISLAIRE, O., KASIG, W., LALOUX, M., LAUWERS, A., LEES, A., LYS, M., OP DE BEEK, K., OVERLAU, P., PIRLET, H., POTY, E., RAMSBOTTOM, W., STREEL, M., SWENNEN, R., THOREZ, J., VANGUESTAINE, M., VAN STEENWINKEL, M. & VIESLET, J.L., 1983. Bio- and lithostratigraphic subdivisions of the Dinantian in Belgium. A review. *Ann. Soc. géol. Belg.*, 106 : 185-239.
- REITLINGER, E.A., 1961. Quelques questions de systématique des Quasiendothyridae (in russian). *Probl. de Micropal., Inst. Géol. Ac. Sc. URSS*, 5 : 31-68.
- SHILO, N.A., BOUCKAERT, J., AFANASJEVA, G.A., BLESS, M.J.M., CONIL, R., ERLANGER, O.A., GAGIEV, M. H., LAZAREV, S.S., ONOPRIENKO, Yu.I., POTY, E., RAZINA, T.P., SIMAKOV, K.V., SMIRNOVA, L.V., STREEL, M. & SWENNEN, R., 1984. Sedimentological and Paleontological atlas of the Late Famennian and Tournaisian deposits in the Omolon region (NE-USSR). *Ann. Soc. géol. Belg.*, 107 : 137-247.
- THOREZ, J., STREEL, M., BOUCKAERT, J. & BLESS, M.J.M. 1977. Stratigraphie et paléogéographie de la partie orientale du Synclinorium de Dinant (Belgique) au Famennien supérieur : un modèle de bassin sédimentaire reconstitué par analyse pluridisciplinaire sédimentologique et micropaléontologique. *Meded. Rijks Geol. Dienst, N.S.* 28 (2) : 17-32.
- VAN STEENWINKEL, M., 1984. The Devonian-Carboniferous boundary in the vicinity of Dinant, Belgium. *Cour. Forsch.-Inst. Senckenberg, Frankfurt a. Main*, 67 : 57-69.
- ZIEGLER, W. & SANDBERG, C.A., 1984. Important candidate sections for stratotype of conodont-based Devonian-Carboniferous boundary. *Cour. Forsch.-Inst. Senckenberg, Frankfurt a. Main*, 67 : 231-239.