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THE GIVETIAN-FRASNIAN BOUNDARY AT THE SOUTHERN BORDER OF THE INDE SYNCLINORIUM[1]

by

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(5 figures)

RESUME.- Les investigations biostratigraphiques des conodontes et des brachiopodes dans la «Grenzschiefer» Formation mettent en évidence un niveau de condensation. *Ancyrodella binodosa* et *A. lobata* apparaissent simultanément et indiquent que la Lower P. asymmetricus Zone est comprimée. La limite Givetien/Frasnien est présumée se situer dans la partie inférieure de la «Grenzschiefer» Formation. Des craquelures de dessication, des rides de stratification, une dolomitisation précoce et la présence d'ooids enveloppées par une couche superficielle représentent un régime intertidal. Les biostromes sont interprétés comme des récifs frangeants. Ils reposent sur une plate-forme carbonatée documentée par les carrières du Synclinorium de l'Inde, du Massif de la Vesdre et du Bassin de Dinant.

ABSTRACT.- Investigations in biostratigraphy by conodonts and brachiopods have shown that there must be condensation within the «Grenzschiefer» Formation. The joint occurrence of *Ancyrodella binodosa* and *Ancyrodella lobata* in one carbonate layer points to a condensed Lower *asymmetricus* Zone. the Givetian-Frasnian boundary is proposed to be situated in the lower part of the «Grenzschiefer» Formation. Shrinking pores, ripple-bedding, early diagenetical dolomites and superficial ooids are markers of shallow marine, sometimes intertidal sedimentation below the Grenzschiefer formation. The biostromal build-ups below and above, represent fringing reefs situated on a carbonate platform. the extension of the carbonate platform is documented by outcrops in the Inde Synclinorium, Vesdre massif and Dinant Synclinorium.

1.- INTRODUCTION

Recent biostratigraphical investigations were carried out to locate the Givetian-Frasnian boundary at the southern border of the Inde Synclinorium. Numerous determinations have been made up to now, but cannot be correlated with the current standard zonation by conodonts of Bultynck (1982). Figure 1 shows the position of the Givetian-Frasnian boundary at the southern border of the Inde Synclinorium worked out by the previous authors. Kayser (1870) made the first attempts using a lithological correlation with the limestones of the Eifelkalk-Synclines. Fourty years later Holzapfel (1910) placed the Givetian-Frasnian boundary at the base of the Grenzschiefer, namely at the entry of *Manticoceras intumescens.* Dubrul (1939) correlated the Grenzschiefer with the «F2a» unit of the Belgian lithostratigraphical zonation. Compared to the new results in biostratigraphy, Dubrul has given a very exact stratigraphical position for the Grenzschiefer. Schmidt & Schröder (1962) looked for the Givetian-Frasnian boundary 50 meters below the that the Belgian Fromelennes formation was included in the lower part of the Upper Devonian. Krebs & Ziegler (1965) attempted a boundary determination by conodonts for the first time, and the upper parts of the Lower *asymmetricus* Zone were discussed. However, the lack of index conodonts did not allow an exact dating. Contradictions in the correlation with other regions have existed. Results and proposals about the stratigraphical position of the Grenzschiefer are discussed by Kasig (1968), who agreed to its Lower Frasnian age. The last occurrence of *Stringocephalus burtini*, 50 meters below the Grenzschiefer, was proposed by him as an uppermost Givetian index.

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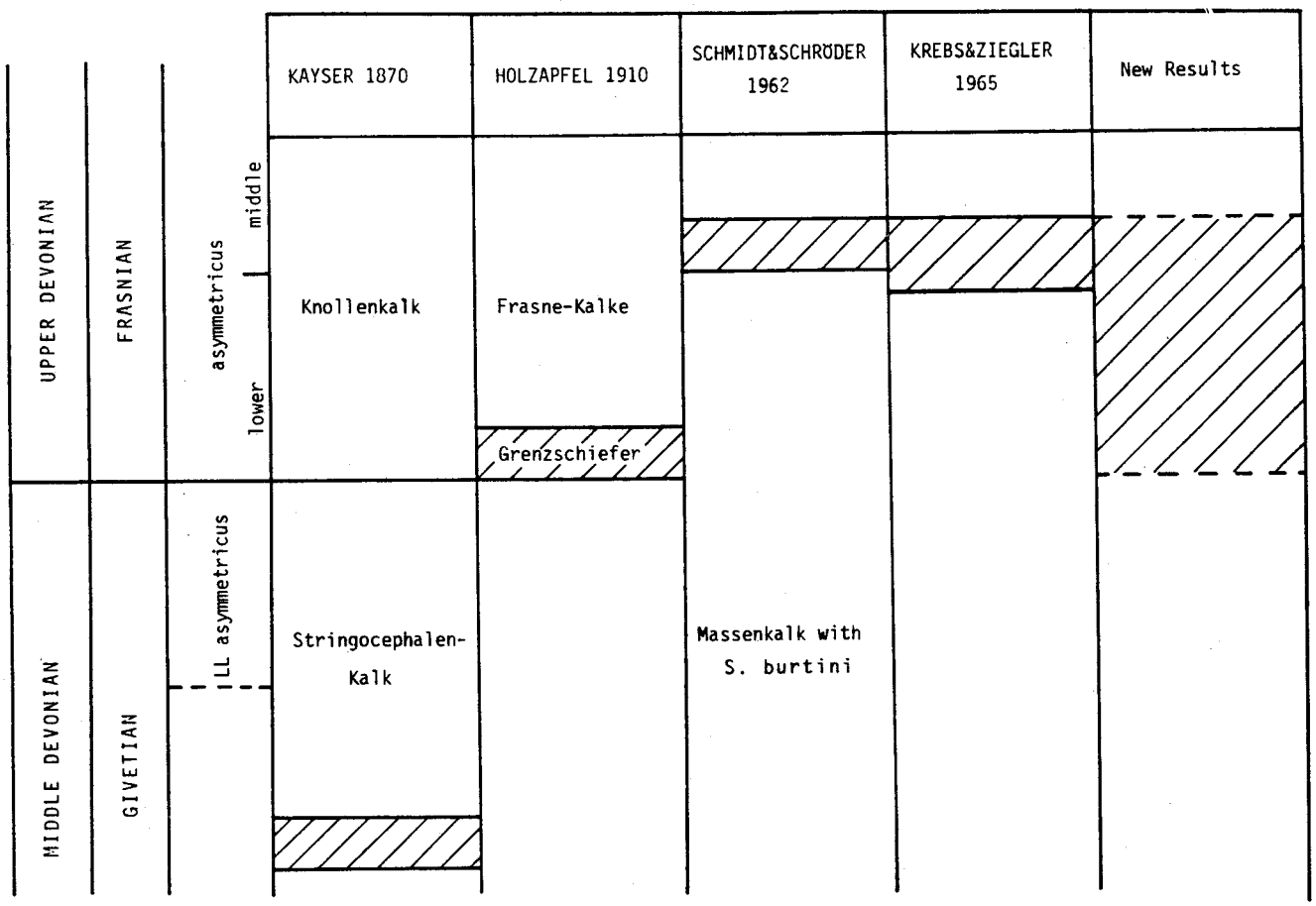


Fig. 1.- History of the Givetian-Frasnian boundary in the Aachen region.

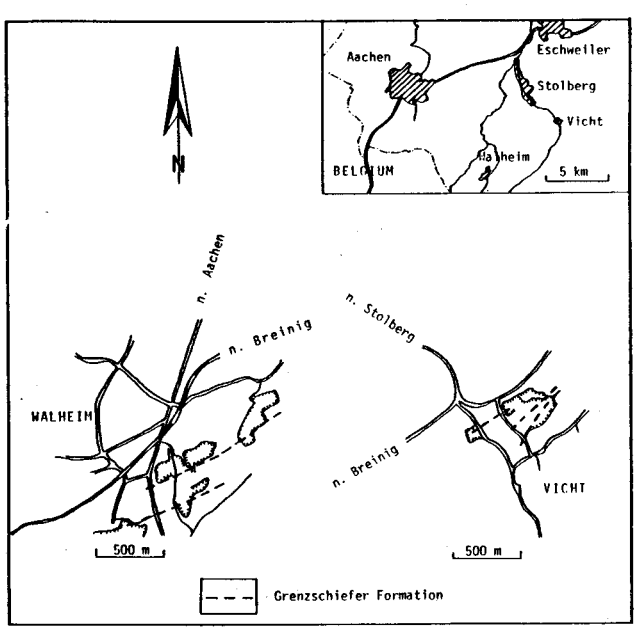


Fig. 2.- Location of investigated outcrops.

2.- BIOSTRATIGRAPHY

The distribution of conodonts within the Grenzschiefer at the quarry of Hahn, near Walheim, is interesting (fig. 3). The highest diversity of conodont-elements occurs just before the predominantly argillaceous sedimentation. The assemblages of conodont elements in the Grenzschiefer of Walheim/Hahn (fig. 4) are comparable to the data from Franhsen quarry (Vicht) (fig. 5). One can observe this phenomen over several kilometers. The number of conodonts reaches 600 per kilogram : 90 % are barlike forms and less than 1 % are Ancyrodellids. The others are Polygnathids and Icriodids (fig. 3). A condensation of the conodont assemblage at this layer is conspicuous : some species, normally restricted to the Lower *asymmetricus* Zone (like *A. binodosa, A. r. rotundiloba*) appear together with species characteristic of the Middle *asymmetricus* Zone (like *A. lobata*). This is confirmed by the joint occurrence of brachiopods such as *G. bisinus* and *S. malaisi* which normally appear at different stratigraphic levels (Bultynck *et al.*, 1987).

Conodonts	C 49	C 51	C 3B	C 57	F 1	F 3	F 5	F 6
barlike elements	14	1	801	6	317	441	440	211
Icriodids	7	1	251	-	315	262	351	107
Polygnathids	2	1	193	-	161	183	158	17
Ancyrodellids	1	-	6	1	14	20	1	-
total number	24	5	1251	7	807	906	950	335
Sample-Weight (in gram)	1985	3822	5387	1445	2940	2429	2311	2618
Conodonts/kg	12	1	232	5	275	373	411	128

Fig. 3.- Frequency and distribution of conodonts at the outcrops of Walheim and Vicht.

When looking for a most convenient conodont criterion to define a worldwide biostratigraphic boundary between Givetian and Frasnian strata, Bultynck (1982) concluded that the first appearance of *A. r. rotundiloba* seemed to be the best index form, even in nearshore environments. A further subdivision of the Lowermost and Lower *asymmetricus* Zone based on the Ancyrodellid faunas at the southern margin of the Dinant Basin is proposed by Bultynck & Jacobs (1982). The authors describe an *A. binodosa* subzone as part of the Lower *asymmetricus* Zone. At The Givetian-Frasnian transition A. r. rotundiloba appears, while different *A. binodosa* morphotypes are still present. However *A. binodosa* is not reported from the *A. r. alata* and *A. rugosa* subzones, which represent the upper parts of the Lower *asymmetricus* Zone.

The lack of *Ancyrodella* species in the Grenzschiefer sections of the Aachen area makes it difficult to date the Givetian-Frasnian boundary. Furthermore, the joint occurrence of *A. binodosa, A. r. rotundiloba, A. r. alata* and *A. lobata* (juvenile form) in one horizon at the Hahn quarry is conspicuous (fig. 4). At the Frahnsen quarry, near Vicht/Stoberg, *A. rugosa* and *P. asymmetricus* appear somewhat later than *A. r. alata* and *A. binodosa* (fig. 5). Therefore the biostratigraphical distribution of the different Ancyrodellids at the studied sections differ somewhat from the data of the type area.

The conodont enriched layers are reworked bioturbated brachiopod coquinas. Conodont elements are rare in the biostromal carbonates below and above the Grenzschiefer. Here only *symmetricus*-like Icriodids have been found.

3.- CORRELATION

The exact correlation of the Grenzschiefer Formation with time equivalent levels of the Verviers Synclinorium and the Dinant Synclinorium is still remarkable. Coen-Aubert (1970) describes thin-bedded haematitic ooid-layers of F2ab age at the Pepinster-Surdents region. In eastern directions they interfinger with reworked crinoidal debris. A conodont assemblage with *A. rugosa* was found in the ferruginous ooid-layer at Pepinster. So we might propose a F2b age for this layer containing reworked corals such as *Disphyllum* sp., *Dendropora* sp., *Thamnopora* sp. Shales are not present in this area and are only known from sections between Go- and Stolberg/Vicht. Coen & Coen-Aubert (1974) described ferruginous ooids and molds of Cyrtospirifer from the Verviers Synclinorium, which are covered by biostromal layers of the «F2cd» with *D. goldfussi* and *Alveolites* sp.

In the Aachen area ferruginous ooids of Frasnian age are only known in the upper parts of the Grenzschiefer formation and could be dated as the lower part of the Middle *asymmetricus* Zone. The best lithostratigraphical marker for the Givetian-Frasnian boundary may be given by the end of the argillaceous sedimentation. In the investigated sections of the Inde Synclinorium as well as in the Verviers Synclinorium, a biostromal growth covers the sediments of the F2ab. There is no doubt about the «F2cd» age of this reefoid episode, which can also be studied in the Dinant Synclinorium (Tsien, 1974).

4.- CARBONATE FACIES

Below the Grenzschiefer formation about 50 meters of homogeneous laminated limestones are occasionally interrupted by thin biostromal build-ups or their reworked components. the laminites are composed of lime mudstones and of thin bedded grainstone deposits. Most of the grainstones are pelsparites.

Intrapelsparites are rare. Superficial ooids are abundant within the intrapelsparites. Illing (1954) described superficial ooids arising at a low energy level and in an area producing alot of nuclei. Very locally distributed shrinking pores with intraclast fillings, point to an intertidal influence. Sublaminarly arranged, early diagenetical dolomite crystals are due to evaporation and Mg-saturated waters. The laminated limestones contain a low diversity fauna : cyanophyceans, ostracodes and gastropods are dominant. Conodonts are rare within the laminites and are restricted to Icriodids. The biostromal layers are mainly composed of stromatopores, bryozoans and Thamnoporids. The limestones below the Grenzschiefer are characteristic of a shallow marine carbonate platform with occasionally changing energy levels. The Grenzschiefer sedimentation starts with floatstone/packstone deposits interlayered by shales (fig. 4,

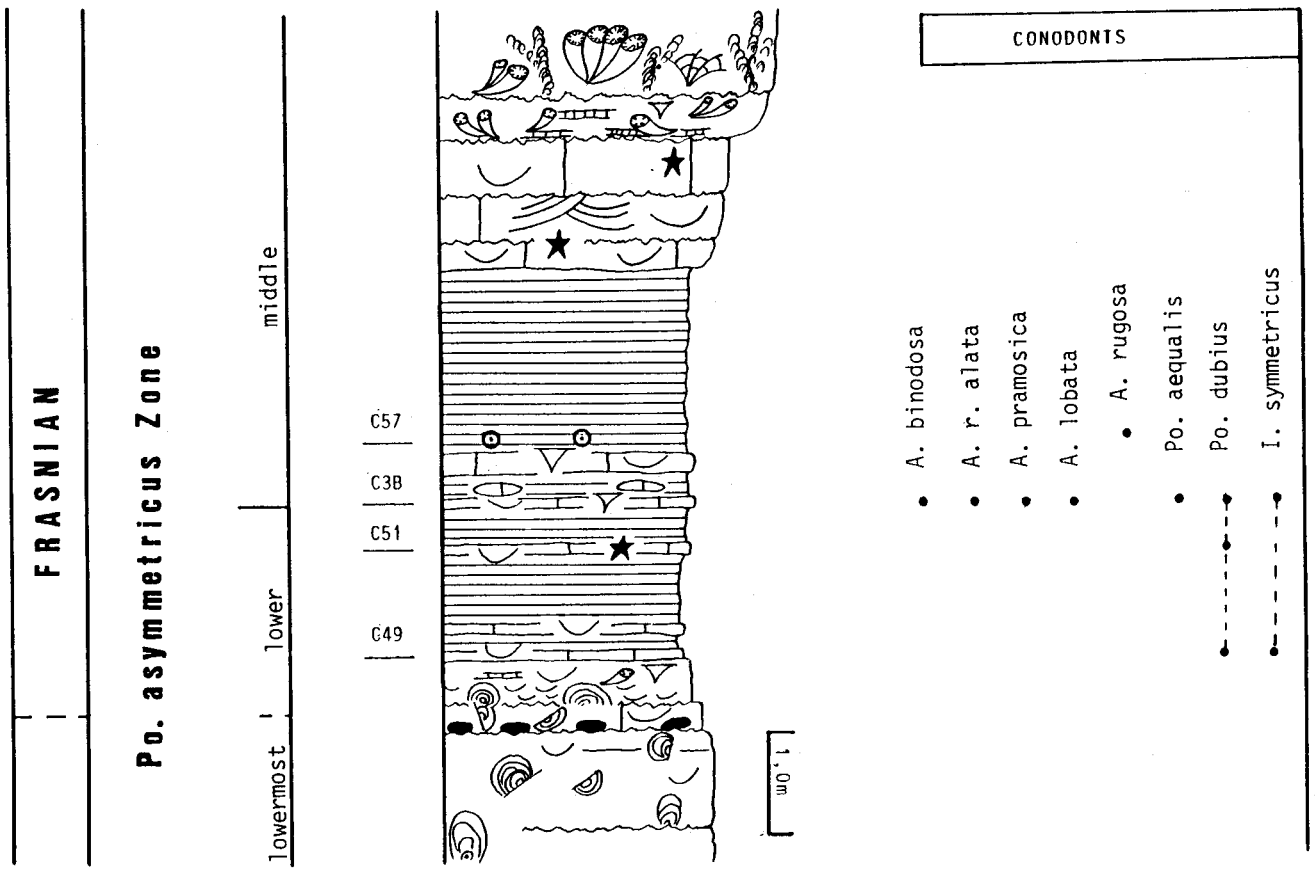
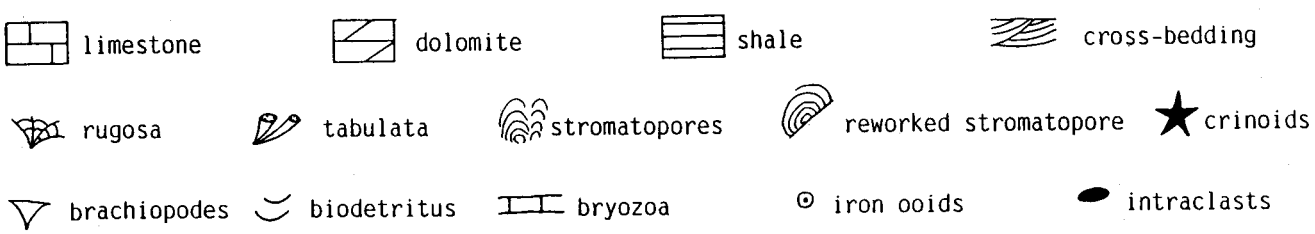


Fig. 4.- Lithology and conodont - biostratigraphy at the Walheim quarry.



5). The transition from the carbonate platform sedimentation to the Grenzschiefer is not uniform. at the Friesenrath-Walheim and Hahn quarries a biostromal build-up is first covered by reworked reef-tali and then followed by Tempestite like coquinas. The latter seem to be deposited periodically and are sometimes interrupted by very thin *Alveolites* layers. Higher up towards to the Grenzschiefer sedimentation sensu stricto, the thin «biostromal» layers and the coquinas disappear, whereas argillaceous deposits become dominant. In contradiction to the strongly reworked, bioturbated coquinas of the limestone layers, there are no macrofossil records in the shales. Most probably a balance of sedimentation and erosion favoured the condensation in the limestone layers where conodonts and bones were concentrated by their higher specific gravity and distinct current velocities.

Geochemical analyses by Scheps (1982) have shown maxima of P_2O_5 concentrated on the limestone beds of the lower part of the Grenzschiefer. A positive correlation with the layers containing conodonts and bones is conspicuous. The los SiO_2, Al_2O_3 and K_2O contents of the carbonate layers at the base of the Grenzschiefer are in contradiction with the supposed condensation. Accumulation of coquinas and subsurface erosion of the pelitic fraction winnowing may be the reason for this phenomenon. High Ba contents together with decreasing Sr contents of the shales are also striking. Turekian & Wedepohl (1961) have given average contents of 580 ppm of Ba and of 300 ppm of Sr in shales. The Grenzschiefer shale contain levels of 500 ppm of Ba and less than 100 ppm of Sr. Similar results, with very low Sr content are documented by Veevers (1969) in intertidal lagoons of the

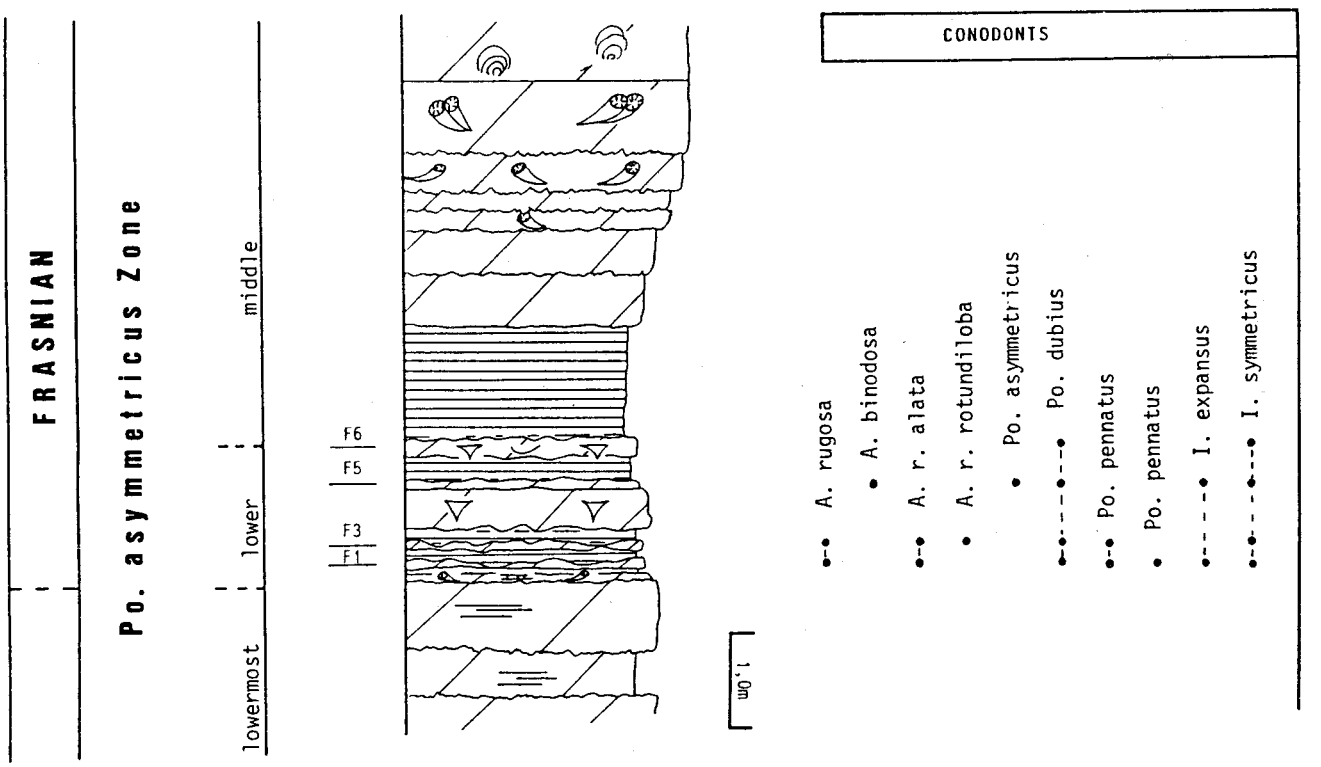


Fig. 5.- Lithology and conodont - biostratigraphy at the Franhsen quarry.

Upper Devonian and Lower Carboniferous in NW Australia.

5.- PALEOGEOGRAPHY

The question concerning the autochthonous character of the Inde Synclinorium still remains unsolved. It is difficult to unravel the paleogeography of the investigated area. Even in the Northern part of the Inde Synclinorium there is a lack of information about the Givetian-Frasnian transitional beds.

At that particular time, the Brabant Massif (with its peninsula shape) became gradually covered by the Frasnian transgressions (Kimpe *et al.*, 1978). Worldwide investigations of Devonian eustatic fluctuations show two different transgressive phases in lower Frasnian time (Johnson *et al.*, 1985) : one at the end of the Lower *asymmetricus* Zone, the other at the beginning of the Middle *asymmetricus* Zone. The sediments of the Grenzschiefer formation cannot be interpreted as deep water deposits. In opposition to the more offshore sediments of the Nismes formation (Dinant Basin), the Grenzschiefer sediments were deposited in a slightly subsiding platform area. Sedimentation and erosion was nearly held in equilibrium. Basinward currents led to accumulation in the distal areas, exposed today, at the southern margin of the Dinant Synclinorium. In the paleogeographical reconstruction of the Givetian and Frasnian of the Verviers Synclinorium, even Cnudde *et al.* (1986) considered a comparison of the basal Frasnian in the Eastern part of the synclinorium with the Nismes formation of the southern Dinant Synclinorium. At the end of the Lower *asymmetricus* Zone, the first Frasnian transgression reached a maximum with the reworking of ferruginous ooids and their transport offshore by the combined effect of high-energy storm waves and current activity, as proposed by Dreesen (1982) for the Gomper oolithic ironstone level. By that time the palaeorelief became more and more smooth with the result that the next transgressive phase of the Middle *asymmetricus* Zone took place in an area of greater conformity. This is documented by the nearly overall F2cd reef growth arising in the Southern part of the Dinant Synclinorium (Tsien, 1976) as well as in the «Vesdre Massif» (Coen-Aubert, 1974) and in the Southern part of the Inde Synclinorium. Towards the shore the build-ups become less dominant (Tsien, 1977).

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